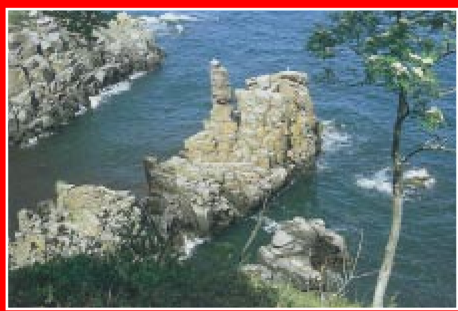
BALTIC SEA ENVIRONMENT PROCEEDINGS

No. 75

RED LIST OF MARINE AND COASTAL BIOTOPES AND BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

Including a comprehensive description and classification system
for all Baltic marine and coastal biotopes



HELSINKI COMMISSION
Baltic Marine Environment Protection Commission
1998

PREFACE

The *RED LIST OF MARINE AND COASTAL BIOTOPES AND BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT* is the first comprehensive attempt by the Helsinki Commission to classify all marine and coastal biotopes and to assess the condition and the status of threat for the different marine and coastal biotopes and biotope complexes in each of the nine riparian Baltic Sea states. By doing so HELCOM implements the will of the Environmental Ministers of the Contracting Countries who decided at HELCOM's 20th anniversary in 1994 that "the status of endangerment of different coastal and marine biotopes and nature types in the Baltic Sea Area shall be evaluated with a view to compiling a Red Data Book of Threatened Biotopes of the Baltic Sea Area."

The assessment has been made by numerous experts on marine and coastal ecology and taxonomy from all Baltic Sea riparian states and by the members of the HELCOM EC-NATURE Red List Project Group (see below). This group met four times on the Isle of Vilm, Germany and once in St Petersburg, Russia. The meetings were chaired by the project leaders Henning von Nordheim and Dieter Boedeker who also functioned as final compilors and editors; nevertheless, the authors of the different national introductory chapters bear the whole responsibility for the content of their contributions. Financially, the assessment was supported by HELCOM and the German Federal Agency for Nature Conservation.

A Red List primarily represents a status report compiled on the basis of best currently available knowledge, some of which has been retrieved from more or less isolated reports and surveys and from some short or long term studies. Consequently, a revised version of this Red List should be issued as soon as enough additional or new information on Baltic biotopes and biotope complexes is available. This will require also future co-operation of all specialists and colleagues, a co-operation that the editors experienced for this Red List in a very open, friendly and productive manner. For this the editors wish very much and cordially to thank all of the contributors.

HELCOM

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INTRODUCTION AND SCIENTIFIC CONCEPT FOR THE RED LIST OF MARINE AND COASTAL BIOTOPES AND BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

Henning von Nordheim & Dieter Boedeker

1. Introduction

The basin of the Baltic Sea represents an old depression zone between the Precambrian Baltic Shield in the north-west and the Phanerozoik East European Platform in the south-east (Fig. 1). Compared with these geological structures the Baltic Sea itself is very young and its evolution was initiated by the melting of the ice sheet of the last glacial period and the associated sea level rise. This process started 15,000 years ago in the southernmost Baltic Sea and 9,000 BP in the Bothnian Bay (Winterhalter *et al.*, 1981). Several changes in the waterbody of the Baltic Sea, from fresh to salt water conditions, have occurred since then.

The development of the present Kattegat area has been governed by the interaction of eustatic sea level rise and isostatic response to glacier unloading following the melting of the last ice sheet. Geologically, the Kattegat region is located at the boundary between the Fennoscandian Shield and the Danish Basin. The surface of the pre-quarternary in the region is characterized by a large topographic depression with a south-east to north-west extending axis (Lykke-Andersen *et al.,* 1993). Since the middle Pleistocene the basin has almost filled with fluvial/lacustrine and marine sediments with a thickness up to more than 200 m.

Today the Baltic Sea is one of the largest brackish water systems in the world, almost totally embraced by the European continent. The shaping of the coastlines by hydrodynamic processes began about 5,700 years ago (Janke *et al.*, 1993) with the ending of the Littorina transgression. In the southern parts of the Baltic Sea including the Kattegat, where glacial deposits form the coast, eroding cliffs and accumulative coasts exist side by side. In the northern parts of the Baltic Sea area, where bedrock occurs, land upheaval rates up to 9 mm per annum can be observed and coastal erosion is much weaker. Consequently large accumulative forms like spits are not present.

The Kattegat is relatively shallow with depths averaging 23 m and directly connected to the considerably deeper Skagerrak in the north and to the Baltic Proper in the south through the Danish Straits and the Belt Sea (Fig. 2).

Parts of the Kattegat have been under marine influence since 14,000 BP while large areas in the western part of the Kattegat were dry land until the beginning of the Holocene transgression. During the Holocene hydrographic conditions and sedimentation patterns changed several times. A major change is probably related to the opening of the Danish Straits.

The seabed sediments in the central and western part of the Kattegat are dominated by sand, muddy sand and lag deposits consisting of clay/glacial till, often with a thin cover of sand or mud (Nielsen *et al.*, 1992). Along the Swedish west coast mud and lag deposits dominate. Recent sedimentation rates show large regional variations from 3 cm/year at Skagen to less than 5 mm/year in the southern Kattegat. In shallow areas, 10-25 m (Christiansen *et al.*, 1993), no or very little sedimentation takes place.

The Baltic Sea bottom consists of a series of large basins separated by several submarine elevations, so-called sills. This fact and the very narrow and shallow connections between the Belt Sea, the Øresund and the Kattegat restrict the exchange of water between the Baltic Sea and the North Sea. Especially the inflow of comparatively more saline and oxygen rich North Sea water is limited to relatively rare occasions. In the Baltic Sea a permanent halocline is situated between an upper water body with low salinity and a lower water body of distinctly higher salinity. The halocline prevents vertical mixing and thus the transport of oxygen to the lower water body. Major inflows of higher salinity water that strengthen the halocline layer and bring oxygen to the lower water body regularly occur at intervals of few to several years. In the periods between these inflows, oxygen deficiency increases and spreads to include large areas and water masses below the halocline. A similar situation can develop in the Belt Sea, Øresund and the Kattegat. Due to these highly variable hydro-physical conditions with respect to oxygen as well as to salinity specific biotopes and a

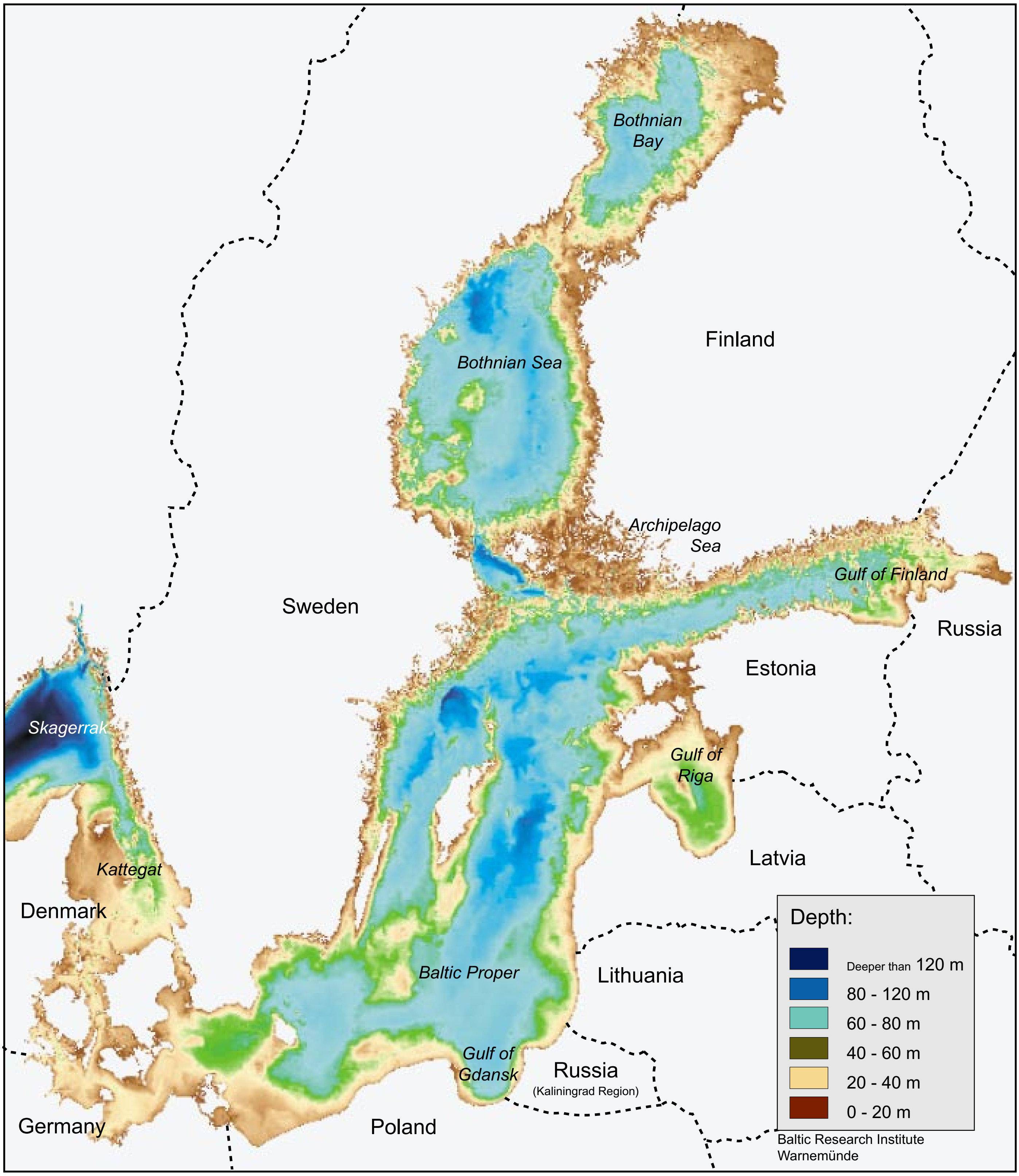

Figure 1:
Bathymetry of the Baltic Sea
(Seifert & Kaiser, 1995. Graphics by F. Tauber)

Figure 2:
HELCOM map of the water catchment area of the Baltic Sea, Belt Sea and Kattegat (including the Øresund)

flora and fauna consisting of few but specially adapted species have developed in the Baltic Sea area and especially in the Baltic Proper. Any human activity that causes conflicts with the environment can have a severe impact to the ecosystem.

The coastal zone of the Baltic Sea, Belt Sea and Kattegat is of significant ecological importance because of its high biodiversity and the constant change of landscapes due to morpho-dynamic processes. But the coast is also of high economic value. This fact often leads to conflicts between conservation interests and economical exploitation or other human activities or interests. As a result, ecological and cultural qualities of coastal and marine areas are under permanent potential or actual pressure which may have negative effects on aquatic and terrestrial ecosystems.

The present Red List provides the public for the first time with a comprehensive survey and classification system of marine and coastal biotopes (biotope types) and a list of the most important biotope complexes of the entire Baltic Sea area. It describes the status of and threat factors for the different marine and coastal biotopes and biotope complexes in an overall assessment for the Baltic Sea, the Belt Sea and the Kattegat as well as for each of the 9 riparian Baltic Sea States (Table 4 and Table 5). The assessment is based on the expertise of marine and coastal ecologists as well as taxonomy experts from all Baltic Sea states who met five times between 1995 and 1998 as a HELCOM EC-NATURE Project Group.

This Red List can be a useful tool and important instrument in nature conservation and policy making. As it was already stated for a similar Red Data Book for the Trilateral Wadden Sea Area, the present lists can function as:

“- *an information source for political decision makers, officials and the public;*
- *a signal to politicians and the general public to increase support for nature conservation;*
- *a guideline and reference system for environmental impact assessment in physical planning processes; means to justify measures of biotope and species protection;*
- *an efficiency control for measures of nature and environmental protection;*
- *means of facilitating the identification of high priority species and biotope types that require immediate protection measures;*
- *means to assist the implementation of international nature conservation conventions, etc. (e.g., EC Fauna-Flora-Habitat Directive);*
- *means of detecting gaps in our knowledge concerning species distribution, quality status of biotopes, threat factors, etc.;*

Red Lists are thus of equal importance for protected and unprotected areas...” (von Nordheim *et al.,* 1996 a).

2. Definitions

This book and its classification system applies for an area that is defined as the water body of the Baltic Sea according to the Helsinki Convention including the internal waters and rivers as far as backwater effects can be observed. In cases where the extent of coastal biotopes and biotope complexes is difficult to define, a strip, up to a width of 10 kilometres, inland from the coastal mean water line, is taken into account according to the HELCOM Guidelines for the identification of coastal ecosystems and their inland limits (HELCOM 1994, Annex 15).

Biotopes or biotope types are defined by Blab *et al.* (1995) as the spatial components of an ecosystem characterized by “specific ecological, unique and more or less constant environmental conditions”. Their plant and animal communities constitute a major part of, and form to a large degree, the characteristic environment and thus are important indicators for the geographical limits of the biotope types. To make the present Red Data Book suitable for practical use, i.e. mapping of biotopes in the field, only biotopes down to a practical minimum size are defined (e.g., different types of dunes). Small “microsystems” representing components of a biotope and which might be found in several biotopes are refered to as **biotope elements** (Riecken *et al.,* 1994). These are not assessed in this paper (for example decomposing macrophytes in shallow water areas or on different types of beaches).

A **biotope complex** can be described as a typical, ecological coherent complex of different specific biotopes in a characteristic spatial distribution composition as well as habitats that eventually reflect regional peculiarities. The border of adjacent biotope complexes are generally sharp, since ecological parameters often limit the spatial extent of a biotope complex, e.g., the typical salinity (estuaries), sand supply (dunes, beaches etc.) or geological origin (fjords or fjards). Larger regional **landscape units** (Riecken *et al.,* 1994), like fjords or solitary islands, are included in the Red List of biotope complexes as far as they meet the above definition.

3. Classification of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat

The classification system for the complete list of marine and coastal biotopes presented in this book has been agreed upon following intensive discussions between the experts of the HELCOM Project Group. The question was, what ecological parameters should be used as basis for distinction of different biotopes. Several experts were invited by the Project Group and scientific papers dealing with classification systems especially for marine biotopes were studied. Mr Connor (Joint Nature Conservation Committee, GB) presented the EU-Life funded BioMar-Project on *A Classification System for Benthic Marine Biotopes* (Connor *et al.*, 1995a) as well as the results of a respective BioMar-Life workshop held in Cambridge, November 1994 (Hiscock, 1995; Connor *et al.*, 1996).

Mr Pahlsson, Sweden, presented the results of a Nordic Working Group to enlarge Annex I of the *Habitats Directive (EEC-Directive 92/43)*. The Nordic Council of Ministers is responsible for a current project of characterizing threatened and representative coastal biotopes of the Nordic countries. An introduction to the *EC-CORINE Habitat Classification System* was given by Mr Devillers (a consultant working for the European Commission). Detailed background information to the *German Red Data Book of Biotopes* (Riecken *et al.*, 1994) and *The Red List of Biotopes and Biotope Complexes of the Wadden Sea Area* (Ssymank & Dankers, 1996) was provided by Mr Riecken (Federal Agency for Nature Conservation, Bonn). Mr Boilot from the European Topic Centre for Nature Conservation in Paris introduced the new *Classification of the Palaeartic Region*, a system that is the result of the revision of the terrestrial part of the CORINE Classification System (CORINE BIOTOPES MANUAL, 1991). Recently CORINE has been revised further and is now part of the *European Union Nature Information System (EUNIS).*

The experts of the HELCOM Project Group welcomed the revision of CORINE and expressed their view that EUNIS should be enlarged by the Baltic biotopes listed in the present *Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat*. For this reason the Project Group proposed additional biotopes to the European Environment Agency in Copenhagen via HELCOM at an early stage of the work in June 1996. Project Group members from EU countries expressed their view, that in a revised version of the Habitats Directive at Annex I at least the *"heavily endangered"* biotopes according to the present HELCOM Red List should be included.

All the classification approaches mentioned above were not designed for detailed differentiation of biotopes and for compilation of a Red List of threatened biotopes and also could not be applied for such a diverse area like the Baltic Sea. As a result the Project Group decided for practical reasons to develop the classification and code system by due consideration of two major aspects:

1. to use a common understandable language when describing the biotopes as habitats of communities of marine and coastal fauna and flora;
2. to enable and provide a basis for a Baltic wide mapping of biotopes and biotope complexes (Connor *et al.*, 1995a).

This led to the present substratum-based approach for the description of marine benthic biotopes. Further, a differentiation was made if a certain biotope occurs within the photic zone or in the aphotic zone. If it occurs in the photic zone it is further distinguished between biotopes covered by macrophyte vegetation, or types with little or no macrophyte vegetation. All terrestrial coastal biotopes are basically differentiated on a descriptive geomorphological basis and further by either specific substratum type or different vegetational criteria. Two exceptions from this approach were made for *coastal wetlands and meadows*, where aspects of vegetation types and landscape (geomorphological) types are mixed, and for *coastal lakes, pools and glo-lakes*, where salinity is used as basis for classification. Figure 3 illustrates the most important ecological and geomorphological terms used for zonal differentiation and descriptions of biotopes in this book.

4. Criteria System and Categories for Assessing the Degree to which a Certain Biotope or Biotope Complex is under Threat

Table 1 is applicable to natural biotopes consisting of specific geomorphological features and typical faunal and floral community structures which in viewing the past 10 to 20 years, ideally 100 to 150 years have been found to be either *"completely destroyed"*, or got *"immediately threatened"*, *"heavily endangered"*, *"endangered"* or *"potentially endangered"* in a certain survey area. By covering such a large span of years, unintentional records of only natural fluctuations in the state of biotopes and biotope complexes can largely be excluded. The assessment and categorization of a biotope or biotope complex is primarily

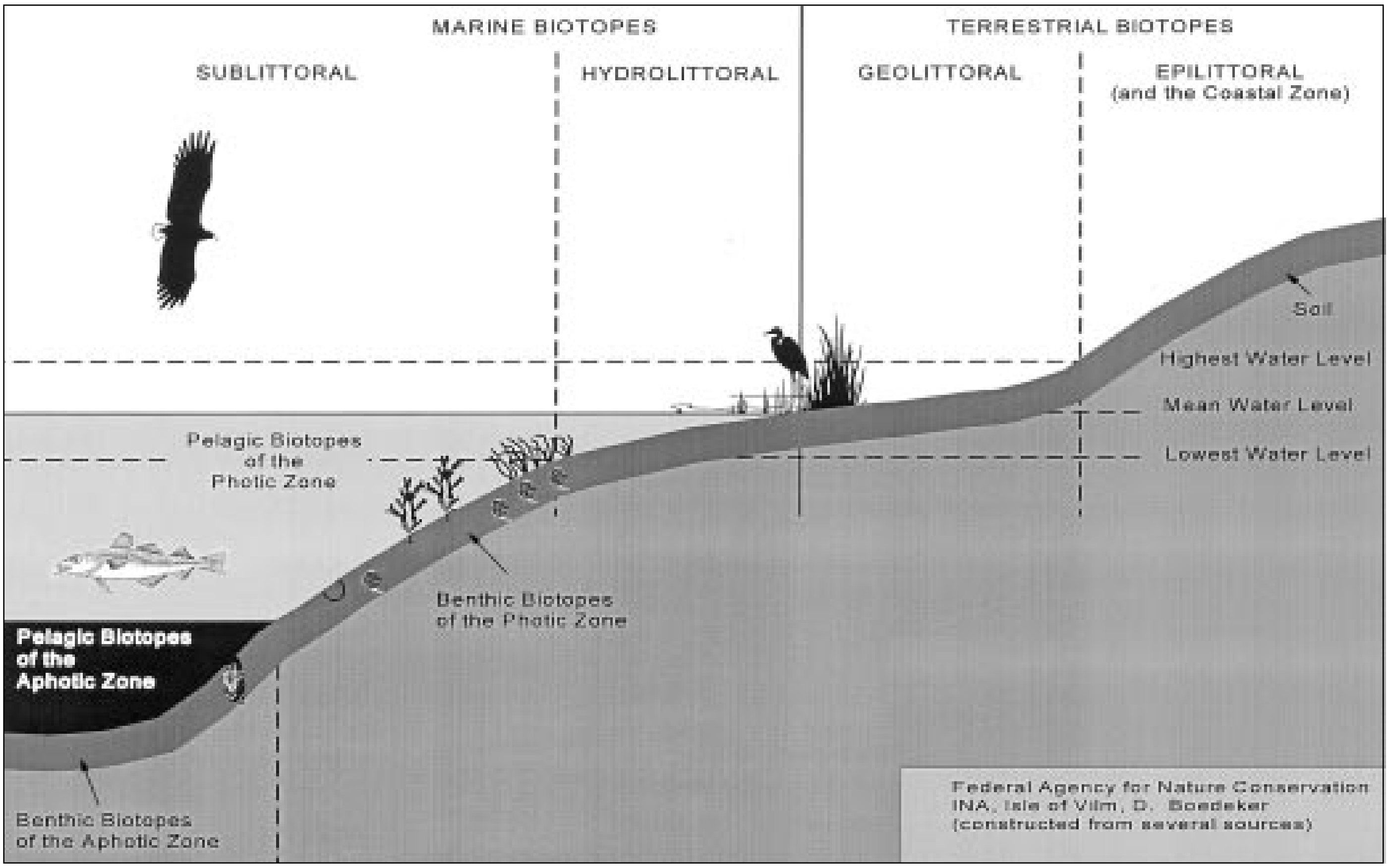

Figure 3: Zonation of marine and coastal biotopes of the Baltic Sea area

based on the degree of decline of area or on the degree of loss of ecological quality. The quality of the biotope refers to its biodiversity, to the presence of its typical fauna and flora, and its abiotic conditions, structure, interactions of species, etc.

4.1 Criteria system

The preparation of a Red List of biotopes requires the development of a coherent system of criteria (Table 1) that reflect precisely the degree of endangerment of a certain biotope. Such criteria should be suitable to describe qualitative and quantitative tendencies in the conditions of a particular biotope. In addition, it is essential to incorporate ecozoological aspects, particularly in the marine environment. It is adequate to use threat categories similar to those of several Red Data Books for animals and plants, for example, *Red Data Book of the Baltic Region* (Ingelög *et al.*, 1993) to describe the net loss of area of biotopes (quantitative tendencies). Nevertheless, negative trends for the quality of certain biotopes also represent a threat to biotopes, including creeping degradation with the effect of a devaluation of the ecological quality. Devaluation of a biotope means the loss of certain physical structures, typical structural subelements, species communities and characteristic animals and plants living in that biotope or biotope complex.

Thus, criteria must describe the consequences of interferences with abiotic parameters and pollution (Blab *et al.*, 1995). The criteria system applied here (Table 1), follows the proposals of Blab *et al.* (1995) that were also used for the *Red Lists of Biotopes, Flora and Fauna of the Trilateral Wadden Sea Area* (von Nordheim *et al.*, 1996b). In both publications two basic criteria of threat to biotopes were identified: ***Loss of Area*** (DE) and ***Loss of Quality*** (QU). The third criterion proposed by Blab *et al.*, (1995) and used for the Trilateral Red Data Book, *Regeneration Ability*, has not been applied for the present Red List for the Baltic Sea, the Belt Sea and the Kattegat, because the contributors to the book estimated that there were too many uncertainties and unanswered questions in this respect for the survey area.

For the Red List of biotope complexes only one criterion category ***"Loss of Quality"*** (QU) was assessed by the experts, because biotope complexes cover in most cases a much larger area than a single biotope and therefore they are mainly threatened rather by loss of quality than by loss of area *(Table 2)*.

4.2 Categories and ranks of threat

The categories of threats used in this Red Data Book together with an explanation of the ranking system are shown in Table 1.

Table 1: Criteria for threat assessments for biotope types

<table>
<tr><th colspan="3">CRITERIA SYSTEM FOR ASSESSING THE DEGREE TO WHICH A CERTAIN <u>BIOTOPE</u> IS UNDER THREAT WITHIN THE SURVEY AREA</th></tr>
<tr><th>CRITERION I
"loss of area"
Threatened by <u>direct</u> destruction
(DE)</th><th>CRITERION II
"loss of quality"
Threatened by <u>qualitative</u> changes
(QU)</th><th>OVERALL ASSESSMENT
(Σ)</th></tr>
<tr><td>0 - Completely destroyed
(total loss of area)
Biotope which was previously present in the survey area, but today can no longer be proven to exist.</td><td>0 - Completely destroyed
(completely changed)
Biotope whose quality is affected so severely that its typical or natural variants are completely destroyed.</td><td>0 - Completely destroyed</td></tr>
<tr><td>1 - Immediately threatened
(immediate danger of total loss of area)
Biotope of which only little portions in the former area of distribution still exist. If impacts continue and no protection or management measures are taken a complete destruction has to be expected.</td><td>1 - Immediately threatened
(immediate danger of becoming completely changed)
Biotope whose quality is negatively affected in the entire area so that typical or natural variants can only be found in one or very few subregions.</td><td>1 - Immediately threatened</td></tr>
<tr><td>2 - Heavily endangered
(heavy danger of severe loss of area)
Biotope that shows a heavy decline of area in almost the entire region or that is already extinct in several sub-regions.</td><td>2 - Heavily endangered
(heavy danger of becoming severely changed)
Biotope whose quality is negatively affected in a way that
- a decline of typical variants can be stated in almost the entire area or that
- typical variants already became extinct in several subregions.</td><td>2 - Heavily endangered</td></tr>
<tr><td>3 - Endangered
(danger of loss of area)
Biotope that shows a negative development of area extend over a broad range of the region or that is locally extinct at many sites.</td><td>3 - Endangered
(danger of becoming decisively changed)
Biotope whose quality is negatively affected in a way that
- a decline of typical variants in several subregions can be stated or
- typical variants already became locally extinct at numerous sites.</td><td>3 - Endangered</td></tr>
<tr><td colspan="3">P - Potentially endangered
This category does not represent a category of actual threat according to categories 1-3. Biotopes potentially threatened are those which have been always rare or which exist only in a small area but which might easily qualify for even the category "0" if their small area of distribution is affected by adverse impacts.</td></tr>
<tr><td colspan="3">* Presumably not endangered at present</td></tr>
<tr><td colspan="3">? No data available</td></tr>
<tr><td colspan="3">- Does not occur in the survey area</td></tr>
<tr><td colspan="3">X Classification not meaningful</td></tr>
</table>

Table 2: Criteria for threat assessments for biotope complexes

CRITERIA SYSTEM FOR ASSESSING THE DEGREE TO WHICH A CERTAIN BIOTOPE COMPLEX IS UNDER THREAT IN THE SURVEY AREA	
0	***- Completely destroyed*** ***(decisively changed)*** Biotope complexes whose quality* is affected so severely that all biotope types with their typical or natural variants are completely destroyed.
1	***- Immediately threatened (in immediate danger of becoming decisively changed)*** Biotope complexes whose quality* is negatively affected nearly in the whole area so that all biotope types with their typical or natural variants are only left in one or very few subregions.
2	***- Heavily endangered (heavily in danger of becoming decisively changed)*** Biotope complexes whose quality* is negatively affected in a way that - a decline of typical biotope types with their variants can be stated in almost the entire area or - typical biotope types already became extinct in several subregions.
3	***- Endangered (in danger of becoming decisively changed)*** Biotope complexes whose quality* is negatively affected in a way that - a decline of typical biotope types in several subregions can be stated or - typical biotope types already became locally extinct at numerous sites.
P - Potentially endangered This category does not represent a category of actual threat according to categories 1-3. Biotope Complexes potentially threatened are those which have been always rare or which exist only in a small area, but which might easily qualify for even the category "0" if their small area of distribution is affected by adverse impacts.	
**** Presumably not endangered at present***	
? No data available	
- Does not occur in the survey area	
X Classification not meaningful	

*Quality of a biotope complex refers to its biodiversity, to the presence of its typical fauna and flora, especially its typical biotope types and to its abiotic conditions, structur, interaction of the species, etc.

It reflects and ranks the alterations of certain biotope types, qualitative changes and development trends due to human impacts in a certain survey area within the past 10 to 100 or 150 years, as for most areas no reliable information seems to be available before this. Thus, the basis for comparisons is mostly the state and the structure of the coastal landscape before industri-alization and not the virgin state of nature (Blab *et al.*, 1995). For this assessment the experts of the HELCOM Project Group used information from maps, photographs, descriptions, scientific publications and consultations with local people. For threat assess-ments early scientific literature, mappings and mea-surements were compared with the most recent available data and information.

An ***Overall Assessment*** **(Σ),** of the degree to which certain biotopes are assumed to be threatened in the whole Baltic Sea area, was also evaluated by the experts of the HELCOM Project Group. Only in those cases where no agreement on the overall degree of threat could be reached, the arithmetic mean based on the different national assessments was used.

5. Human Impacts

Information about human impacts that cause an endangerment to certain biotopes or biotope complexes is urgently needed when planning specific protection measures for threatened biotopes or for the elaboration of integrated coastal zone management plans (ICZMPs). Thus, in the present *Red List of Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat* the actual or presumed human impacts (Table 3 and Figures 4 - 16) are indicated if such a statement based on the present state of knowledge seemed to be possible. For this purpose a list of hu-man impacts was compiled by the Project Group, similar to the list of threat factors in the *Red Lists of Biotopes, Flora and Fauna of the Trilateral Wadden Sea Area* (von Nordheim *et al.*, 1996b).

The human impacts are subdivided into two groups depending on whether the effect is an ***irreversible or reversible loss or change (C)*** of the biotope/biotope complex or a ***temporary disturbance (D)***. The second letter in the abbreviation code of a threat refers to the type of threat and an additional country-code is added (e.g., CH^{RUPE} for building activities in the St Petersburg Region of Russia), if this particular threat occurs only in one or few countries.

Figure 4:
Loss of coastal biotopes by intensive **agriculture and drainage (CA)** in combination with **coastal defence (CD)** (photo: H. Sterr)

Figure 5:
An extreme example of **coastal defence measures (CD)** and **touristic impacts (CG)** (photo: H. Sterr)

Figure 6:
Building activites for recreation purposes (CH); a large marina (photo: D. Boedeker)

Figure 7:
Water regulation (CW) in coastal lowlands (photo: C. Herrmann)

Figure 8:
Construction, dredging and dumping of dredged material (CB); dredging in a shipping channel (photo: D. Boedeker)

Figure 9:
Algae mats, as a consequence of **eutrophication (CE)** (photo: W. Fiedler)

Figure 10:
Tourism and recreational activities (CG, DR) along the coast (photo: D. Boedeker)

Figure 11:
Coastal amber **mining (CM)** (photo: D. Boedeker)

Figure 12:
Overfishing, bottom trawling, mariculture (CF); large fishing trawlers (photo: D. Boedeker)

Figure 13:
Construction (CB) in coastal areas; ship yards and harbours (photo: D. Boedeker)

Figure 14:
Prospecting (CM) and pollution (CP); an offshore oil-rig (photo: D. Boedeker)

Figure 15:
Pollution of air and water (CP); (photo: J. Kostet)

Figure 16:
Military activities (DY) (photo: D. Boedeker)

Table 3: Human impacts

HUMAN IMPACTS AND THEIR ABBREVIATIONS	
(C) Biotope loss or change (irreversible or reversible)	
CA -	Agriculture (intensive, changing, land reclamation, stop of traditional farming)
CB -	Construction, dredging, dumping of dredged material
CD -	Coastal defence, e.g., dyking, stabilization of sand
CE -	Eutrophication (fertilization, sewage, combustion)
CF -	Overfishing, bottom trawling, mariculture (fishfarming or mariculture is indicated with an additional F (CF^F)
CH -	Building activities for recreation purposes, e.g., summer houses, marinas
CG -	Wear (traffic, tourism)
CM -	Mineral extraction (prospecting, mining, dredging)
CP -	Pollution (non-eutrophication) of air, earth and water (pesticides, waste disposal, sewage, combustion, oil)
CT -	Forestry (deforestation, plantations, changes)
CW -	Water regulation (drainage, rerouting, extraction/desiccation, land reclamation)
CY -	Military activities (shooting, bombing, etc.)
(D) Biotope disturbance (temporary)	
DA -	Agriculture, forestry
DB -	Construction, dredging, dumping of dredged material, mineral extraction
DF -	Fishing, hunting
DY -	Military activities (shooting, bombing, etc.)
DR -	Recreational activities

6. Practical Implementation and Outlook

There are some limitations in the use of a red List of biotopes. In reality biotopes are not static but under continuous change as elements of a system in space and time resulting in problems for a classification. A continuous "creeping" degradation may change the character of a specific biotope to the extent that a whole set of quite different biotopes may develop from it step by step (Blab *et al.*, 1995). A revised edition of this book is planned to be published after some years and the editors would appreciate comments on the present version compiled by the experts of the HELCOM Project Group at any time. It might, for example, be necessary to add to the listed and evaluated biotopes and biotope complexes new types if future assessments and field data can not or only partly be classified as a biotope type or biotope complex of this Red List (Connor *et al.*, 1995b). For that reason the present (Red) Lists are structured in a way that they remain open for further additions or that the status of threat can be altered if the degree of endangerment of a specific biotope or biotope complex has changed.

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Evaluation of the Red List of Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and the Kattegat

Henning von Nordheim, Dieter Boedeker, Ralf Grunewald

The overall assessment of threat **(∑)** to the marine and coastal biotope complexes and biotopes of the Baltic Sea, the Belt Sea and the Kattegat presented in Tables 4 and 5 gives cause for concern (see description of procedure in the Introduction, 4.2): 83.4% of all biotopes of the survey area are rated by the experts as “heavily endangered” (15%) or “endangered” (68.4%) (Fig. 17). In this overall rating no discrimination has been made between threats by direct destruction or by qualitive change. Although no biotope or biotope complex is considered to be already “completely destroyed” or “immediately threatened” on an overall scale, this result clearly reflects the heavy adverse impacts that human activities have had and still have on the marine and coastal biodiversity and biotopes.

In the five main biotope groups especially biotopes of coastal lake ecosystems (42.9%), of pelagic waters (25%) and of terrestrial ecosystems (24%) are rated “heavily endangered”, whereas all (100%) of the three selected riverine areas, 88.7% of the benthic and 75% of the pelagic biotopes are rated “endangered” (Fig. 17).

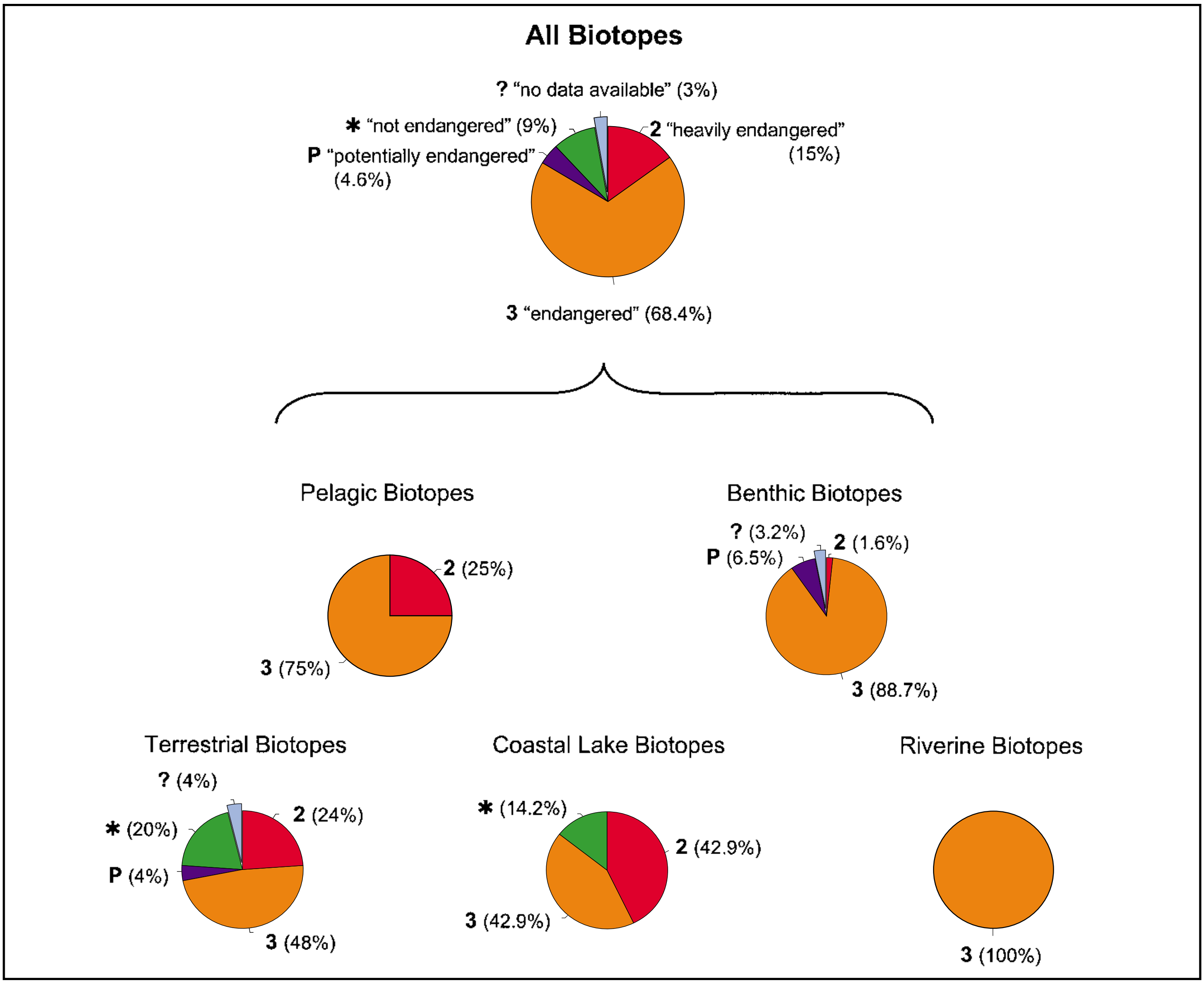


Figure 17:
Percentage of different threat categories for the biotopes of the Baltic Sea, the Belt Sea and the Kattegat

All of the 13 biotope complexes assessed by the experts are considered to be “heavily endangered” (1 biotope complex) or “endangered” (12 biotope complexes) in the Baltic Sea, the Belt Sea and the Kattegat due to losses of ecological quality (Table 4).

When assessing and compiling the Baltic-wide overall status of threat for a certain biotope or biotope complex the experts always tried to base this on thorough knowledge of the different biotopes and biotope complexes in the individual countries. Hence, due to lack of complete information, in the case of four biotopes it was not possible to present a Baltic-wide status of threat. This should be an incentive to focus further research on unknown or only poorly known biotopes of the Baltic.

Some clear indications of the main threats as well as reasons for the bad condition of numerous biotopes in the Baltic Sea, the Belt Sea and the Kattegat are given by the number of entries that the experts granted for each adverse human impact existing or expected in relation to specific biotopes. A grouping of them according to the five main biotope groups shows the total number of entries within each category, which is limited, of course, by the number of biotopes within a group (Fig. 18).

The present state of knowledge shown here, clearly indicates that all coastal and marine biotopes of the Helsinki Convention area are (still) threatened by different kinds of pollution of the air, earth and water (CP).

The marine and limnic waters are mostly affected by eutrophication (CE, Fig. 18). This is especially true for benthic biotopes, since eutrophication, among other effects, reduces the depth of the photic zone and consequently restricts the distribution of benthic vegetation (Fig. 9). It is, however, also a problem in the deep, aphotic areas below the halocline, wich are often subject to oxygen deficiency. Eutrophication leads to an increase in the input and decomposition of organic material (primarily phytoplankton) into these biotopes, causing a further decrease in oxygen levels which results in an enlargement of those areas which are unsuitable for fish and higher macrozoobenthic invertebrates to live in. Also different marine construction activities, dredging and dumping of dredged material (CB) and some fishery practices such as bottom trawling and mariculture (CF, DF) can have heavy but primarily local negative impacts on pelagic and especially benthic ecosystems and biotopes (Figs 8,12).

Some coastal terrestrial biotopes in the southern Baltic region are primarily affected by activities related to coastal defence measures (CD, Fig. 5). These activities often hinder or they even interrupt the complex interactions of coastal dynamics by preventing beaches as well as cliffs from being abraded, which results in an obstruction of sand supply for necessary beach nourishment elsewhere. Very often natural coastal biotope complexes have been altered and modified and especially the dunes are regularly planted with trees (sometimes exotic species) in order to fix the sand (CD and CT). In most Baltic regions

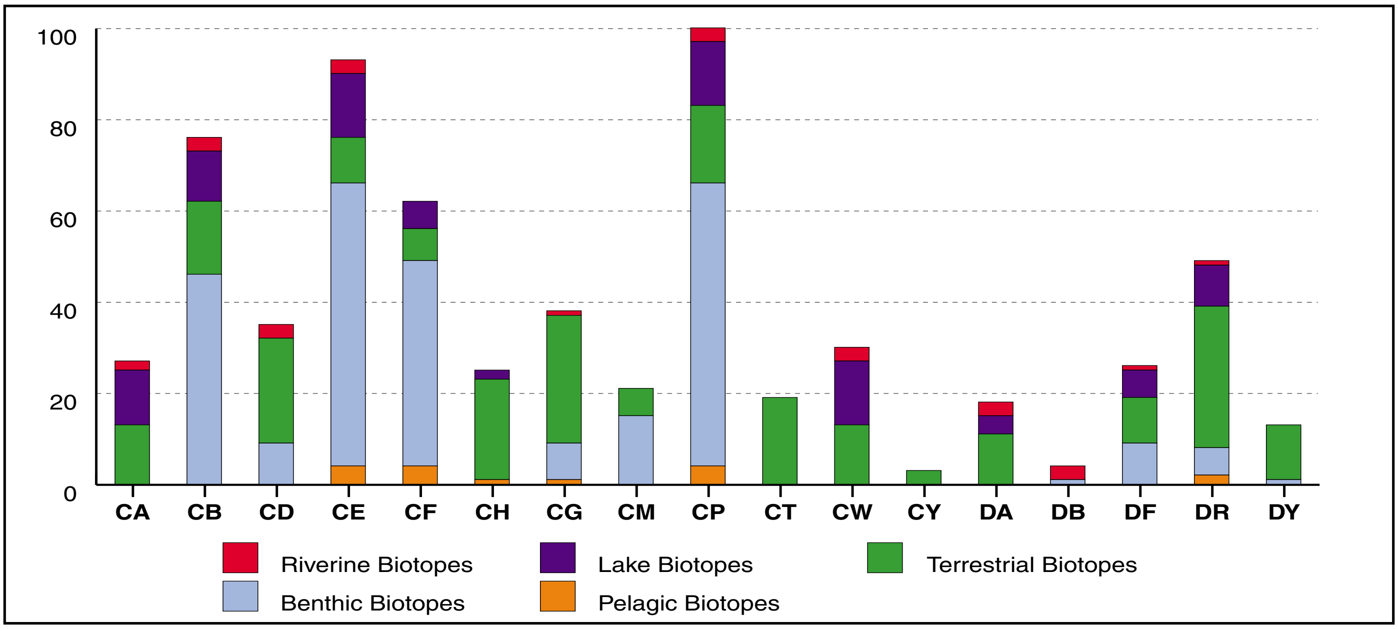


Figure 18:
Total number of entries of adverse human impacts in the Red List of Biotopes (for further explanation of abbreviations refer to Table 3)

particularly the building activities for recreational purposes such as large camping grounds, marinas, summer houses or hotel complexes at or near the beach (Figs 6,10), but also constructions of harbours, ship yards (Fig. 13) or factories (Fig. 15) cause problems (CB, CH, DB). These human impacts regularly result in permanent direct destruction or fragmentation of biotopes. Tourism and its necessary infrastructure also create a temporary disturbance on a much wider scale: more and more tourists frequent the coastal area and their activities often pose severe threats to fragile biotopes (CG and DR).

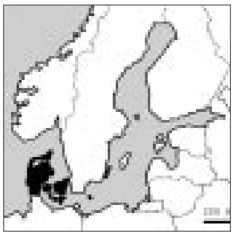
Agriculture (CA), if it is executed as intensive, industrialized farming, must also be mentioned as a complex of important human impacts (among other factors it is a very important diffuse source for eutrophication and pollution), particularly because in coastal areas it is often connected to water regulation measures (CW, drainage, regulation of rivers) that are carried out primarily to suit agricultural needs. Such measures pose a direct threat to many terrestrial coastal natural or seminatural biotopes (Figs 4,7).

It should be noted that the experts' records of adverse human impacts in a number of cases follow the precautionary approach (which is distinctly promoted by the 1992 Helsinki Convention), i.e. these records refer to actual as well as potential threats. The adverse human activities listed thus include activities which have taken or are taking place as well as activities that are anticipated for the future. Also, in some cases the question, if and to what extend a certain activity has a negative impact on biotopes and their biodiversity can not yet be satisfactorily answered or scientifically proven. Thus, in coming years much more emphasis has to be laid on investigating the impacts of human activities on biotope and ecosystem functions.

The Helsinki Commission (HELCOM), however, in the past years has agreed on a large number of recommendations and guidelines addressing several of the adverse human impacts mentioned above. This has led to certain continuous improvements of conditions, but in a number of cases slow or no implementation of the recommendations by the Contracting Parties contribute to the negative results of the assessment presented in the following chapters.

For this reason, apart from calling for enforced efforts of all Contracting Parties to the Convention to implement already existing recommendations and guidelines to improve the general environmental conditions for the biotopes in the Convention area, further steps concerning adverse human impacts that are not yet subject to HELCOM Recommendations should be taken. Further, to streamline the HELCOM efforts with existing European Commission activities and directives the presented new classification system is currently integrated due to HELCOM's EC-NATURE activities into the EUNIS system of the European Commission. Now it should be considered by HELCOM and those contracting countries who are also member states to the European Union, if the most threatened biotopes of the Helsinki Convention area can be taken up in the EC-Directive on the conservation of natural habitats and wild flora and fauna (Habitats Directive 92/43/EEC) at Annex I.

In addition, as a matter of urgency it should be thoroughly investigated if and by what means the most threatened biotopes of the category "heavily endangered" can be conserved and protected from direct losses, changes or disturbances and if possibly the development of a new HELCOM Recommendation for the conservation and protection of particularly threatened biotopes in the Convention area can be an appropriate measure to reach this aim.



INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF DENMARK

Ole Norden Andersen

1. General Introduction

The Danish contribution to this Red Data Book has come about by participation in only some of the meetings in the subgroup under EC-NATURE dealing with the Red List. National consultations have been conducted bi- or trilaterally between the national delegate, marine biologist Dr Ole Norden Andersen, and specialists on coastal dynamics (Dr Niels Nielsen), ecological botany (Dr Peter Vestergaard), limnic and terrestrial botany (Dr Claus Helweg Ovesen), marine botany (Dr Ruth Nielsen) and marine zoology (Dr Jørgen Nørrevang Jensen).

2. Geographic Description

Except for the waters around Bornholm and the coastal waters south of the Øresund and east of the Darss Sill, all the Danish waters are located in the outer Baltic Sea area. The inner Danish waters - inside Skagen - covering ca. 45,000 km^2 are 'HELCOM waters' of which ca. 1,500 km^2, 15,400 km^2 and 8,800 km^2 cover the Limfjord, Kattegat and the waters around Bornholm respectively.

3. Characterization of the Marine Environment

The Danish waters, with a mean depth of less than 25 m (55% less than 20 m) and a maximum depth of about 100 m, constitute a sill area between the Baltic Sea and the Skagerrak where depths of several hundred metres occur. Shallowest are the 8 m deep Drogden in the Øresund and the 17 m deep Darss Sill in the Femer Belt in the western-most Baltic Sea. This transitional zone between the Baltic Sea, with average surface to bottom salinities of less than 15‰, and the more saline North Sea, with average salinities of more than 30‰, is dominated by a surface current, initially 7-8‰, flowing from the Baltic Sea towards the Skagerrak and the North Sea and a baroclinic bottom current, initially 34‰, flowing the other way. Under favourable weather conditions, for example, long lasting westerly storms, the bottom current may reach and replenish the deep areas of the Baltic Sea with oxygen rich water. These two currents mix in a discontinuity layer or halocline, where and when turbulence is caused by wind, bottom roughness and narrow passages. The surface layer becomes shallower and more saline, as one moves north through the Kattegat.

This halocline is an important factor enhancing the productivity of the pelagial, but it also plays a major role in promoting oxygen deficiency below the halocline, especially under eutrophic and certain weather conditions. This may even take place in relatively shallow areas just below the halocline, which in the Kattegat can be no deeper than 10 m. Parts of the Kattegat have been under marine influence since 14,000 BP while large areas in the western part of the Kattegat were dry land until the beginning of the Holocene transgression. During the Holocene hydrographic conditions and sedimentation patterns changed several times. A major change is probably related to the opening of the Danish Straits.

The seabed sediments in the central and western part of Kattegat are dominated by sand, muddy sand and lag deposits consisting of clay/glacial till often with a thin cover of sand or mud (Nielsen *et al.*, 1992).

Like the Danish land area, the sea bottom has been shaped by the glacier and melt water activities under and following one or more ice ages. Therefore the sea bottom largely consists of more or less intact moraines with scattered residual stone reefs dotting vast stretches of sand among a multitude of sediment basins with silty to clay sediments and channels from old sunken rivers in an archipelago-like landscape. Only at Bornholm does crystalline bedrock occur. Limestone and chalk bedrock is found at and off Djursland, in the Øresund and at and off the Stevns and Møns cliffs. Many stone reefs occur as a series of islands of algal and epifauna communities located in a salinity gradient. Other characteristic features of the Danish waters are the many shallow and highly productive areas serving as foraging areas for sea birds and as nursery and foraging areas for fish.

4. Characterization of the Terrestrial Environment

The Danish land area is largely a moraine landscape formed by glacial and postglacial processes. Only on Bornholm and at cliffs on Djursland, Møn and Stevns does bedrock surface. The original very irregular coastline has in many places been simplified by the action of the sea, resulting in a coastline of mixed cliffs, lowlying shores, barrier coasts and sandy or gravelly spits enclosing lagoons or bordering on bays. Close to 65% of the land area is farmland, ca. 12% is forested, ca. 3.4% is meadow and humid grassland, ca. 2.1% are bogs, ca 1.9% are heath, ca. 1.3% are lakes, and ca. 0.6% are uncultivated dry meadows. The meadows are largely included in the farmland.

5. Threats

A main threat to coastal and marine biotopes is euthrophication, not being a direct threat to any species but promoting biotope change and great temporal variations. Concern is also focused on alien substances such as anti-fouling agents and other chemical pollutants causing imposex and other changes in molluscs and hampering the moulting processes in crustaceans.

6. Conservation

Inside a 100 m wide strip along the coastline it is forbidden to use set gill nets, within 3 nautical miles from the coastline it is forbidden to use most trawls and in the entire area it is forbidden to use beam trawls. Conservation orders can be adopted inside the entire marine area. Thirteen conservation order areas cover close to 380 km^2, 77 game reserves cover ca. 1,380 km^2 (2 of them, covering 13 km^2, are also conservation order areas), 21 Ramsar Areas cover 4,640 km^2, 47 EC-Bird Directive Areas (SPAs) cover 5,970 km^2, 50 proposed EC-Habitats Directive Areas (SACs) cover 5,800 km^2 and 19 proposed Baltic Sea Protected Areas (BSPAs) cover 2,300 km^2 of sea area. Additionally 4.3% of the land area is strictly protected. On land a coastal strip extending 300 m inland from the beginning of continuous land vegetation, is protected, and in a 3 km wide strip along the coast special consideration is given to nature when planning for construction and traffic. Furthermore dunes covering 3% of the land area are protected and it is prohibited to alter the state of natural lakes and certain streams, heaths, bogs, marshes, moors and the like, salt marshes, swamps and coastal meadows, and humid permanent grasslands and uncultivated dry meadows of a certain size individually or together. These biotopes cover ca. 10% of the land area.

Otherwise, biotope protection against undesirable effects of raw material extraction at sea seems to have been brought well in hand with the Raw Materials Act, Act No. 569 of June 30, 1997 issued by the Danish Ministry of Environment and Energy published by *The National Forest and Nature Agency, Denmark*. Mention can also be made to the Nature Protection Act, Act. No. 9 of January, 1992 similarly issued and published in 1993 by the same agency.

7. Further Reading

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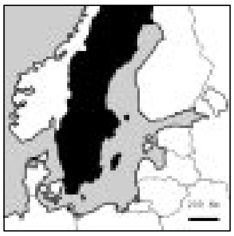

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF SWEDEN

Anders Johansson

1. General Introduction

The Swedish compilation was produced by the County Council of Kalmar with the assistance of the University of Kalmar. It should be emphasized that this compilation reflects the present knowledge of threats to marine and coastal biotopes along the Swedish coast. Hopefully more resources will be allocated to the documentation of marine and coastal biotopes and their geographic distribution. The *Red List of Biotopes and Biotope Complexes of the Baltic Sea, Belt Sea and Kattegat* ought to be revised within a couple of years as threats change and additional knowledge of the biotopes becomes available. Currently data on the geographic distribution of the listed marine biotopes is scarce and therefore, threat estimation is difficult.

2. Geographic Description

The Swedish waters in the Baltic Sea area consist of a wide range of marine biotopes with a very varied flora and fauna. The geographic distribution of organisms along the Swedish coast is restricted by the salinity gradient from the Kattegat to the Bothnian Bay. The large number of different biotopes is the result of the geographic diversity as well as variations in salinty, temperature, etc. (Fig. 2).

The characteristics of the different geographic regions are presented for each subregion of the Baltic Sea.

3. Characterization of the Marine and Coastal Environment

3.1 The Bothnian Bay
The Bothnian Bay is characterized by an archipelago in the north consisting of sand and gravel islands while the southern part is a moraine coast with exposed rocky and gravel shores. Several areas in the region are important as feeding, nursing and breeding areas for fish and birds. Land elevation is 9 mm/year. Salinity in the surface layers is 0-4‰ and marine species are present. The dominating coastal biotopes or complexes in the region are sandy beaches, gravel beaches, fladas, estuaries, large shallow bays and coastal plains. The soft bottom fauna communities are dominated by the species *Monoporeia affinis* and *Saduria entomon*.

3.2 The Quark
This region is subject to a rapid land elevation of 8-9 mm/year and is characterized by a vast shallow archipelago which is an important feeding and breeding area for fish and birds. Ringed seal (*Phoca vitulina botnica*) reside in the area. The region is the northern distribution border for several species such as cod and *Macoma balthica*. Typical marine and coastal biotopes are rocky shores and rocky bottoms, fladas and glo-lakes.

3.3 The Bothnian Sea
The northern part is a moraine and cliff coast with high, steeply sloping cliffs and deep waters. Fjord-like bays cut deep into the mainland and the region contains the only Swedish Baltic fjord (the Ångermanfjord) as well as the highest Swedish island (Mjältön, 236 m). The southern part resembles the northern but lacks the high and steep coastline. Islands and skerries occur in the north but are rare in the southern part of the region. Sandy beaches are rare, but not of minor importance. Most of the beaches consist of gravel and boulders. Land elevation is 8 mm/year. Salinity is 4-6‰ in the surface layers. Soft bottom biotopes dominate the deep waters, while sand bottom and rock bottom are the main (bottom) biotopes in shallow areas. The soft bottom communities are dominated by *Macoma balthica* and *Saduria entomon* although *Monoporeia affinis* is more common in the deeper parts. The northern part of the Bothnian Sea marks the border of the northern distribution of *Mytilus edulis* and *Fucus vesiculosus*. Endemic species occur in the northern part of the region as a result of the transformational zone between brackish waters and more limnic conditions.

3.4 The Archipelago Sea
The vast archipelago, with a land elevation of 4-5 mm/year, forms the border between the Gulf of Bothnia and the Baltic Proper. Thus, the organisms living here are a mixture of limnic and marine species, and many of them are living on the limit of their geographic distribution, e.g., *Zostera marina*. Many areas in the region are important as feeding, nursing and breeding areas for fish and birds. Seals, otter and harbour porpoise live in the region. The macroalgae on the rocky bottoms form zonation belts while *Mytilus edulis*

covers vegetation free rocky bottoms. Long narrow brackish fjord-like bays penetrate the mainland coast. Other typical biotopes or biotope complexes in the region are fladas and glo-lakes, rocky beaches and bottoms, islands and skerries.

3.5 The Baltic Proper
This part of the Swedish coast consists of a wide variety of marine biotopes that are ecologically important for the Baltic. Salinity in the surface layer is 6-8‰. The number of marine species declines along the salinity gradient from the Sound area to the northern part of the Baltic Proper. There are vast archipelagos in the north and south-east. Long fjord-like bays are common along the northern coast while moraine coasts appear in the southern part of Kalmarsund. Sandy beaches are common along the coasts of southern Sweden, occasionally interrupted by moraine beaches on the south coast. Limestone cliffs occur on the islands of Öland and Gotland. There are several areas in the region which are important as feeding, nursing and breeding grounds for fish, birds and seals. Two areas, the southern Kalmarsund and Måkläppen at the Falsterbo Peninsula, are the most important seal breeding grounds in the Swedish part of the Baltic Proper.

3.6 The Sound and the Kattegat
In this transition zone between the Baltic and the Skagerrak the number of marine organisms increases with the increasing influence of the more saline waters from the Skagerrak. Salinity in the surface layer is 8-10‰ in the southern Sound and 18-30‰ in the Kattegat. Sandy beaches and vast, ecologically important, shallow soft bottoms with a high productivity are common along the Swedish coast of the Sound. Hard rock cliffs exist in the northern part and moraine cliffs on Ven Island in the middle of the Sound. The Swedish Kattegat coastline is composed of sand and moraine beaches interrupted by hard rock cliffs. In the northern part of the Kattegat there is an archipelago extending into the Skagerrak. Typical biotopes are of soft bottoms, sandy beaches and rocky beaches. The soft bottom fauna of the region consists of a wide variety of communities. The salinity gradient has a strong influence on the species composition of these communities. The total number of species declines with decreasing salinity.

4. Threats and Human Impacts

The Swedish Environment Protection Agency has stated that the primary threats to the biological diversity of Sweden´s marine environment are euthrophication, toxic pollutants and exploitation of resources and sea areas. Some of the threats or impacts, such as euthrophication, are easier to estimate than others since the effects have been thoroughly studied. Other threats are directly governed by environmental laws and thus are of interest of authorities. It is, however, difficult to estimate the likely impact of threats or the degree they occur, e.g., dredging in areas with land elevation or the effects of a wide variety of pollutants.

5. Conservation

The establishment of marine reserves is an important part of long-term efforts to protect valuable marine areas in the Swedish part of the Baltic. This is an important aspect of Sweden's national commitment to international treaties and conventions. An area is termed a marine reserve if its marine assets are conserved under a protection order. This involves delimitation of the area, management regulations and continuous monitoring programmes. This may be achieved by an ordinance pursuant to the Nature Conservation Act, for example. Such ordinances may be supplemented with orders issued under laws and ordinances such as the National Resources Act, the Environment Protection Act, the Water Rights Act, the Continental Shelf Act, the Environment Impact Report Act, the Shipping Ordinance Act and others.

The county administrations bear the main responsibility for implementing protection of areas of natural value (with the exception of national parks). In 1997 the Swedish Environment Protection Agency gave priority to the protection of 16 areas in Sweden. Several of these areas are planned to be protected in the near future.

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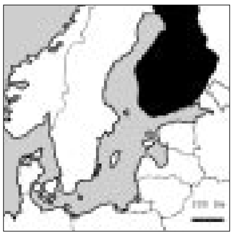

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF FINLAND

Annamaija Lehvo, Jan Ekebom & *Saara Bäck*

1. General Introduction

The estimate of human impacts and the evaluation of threats to the biotopes and biotope complexes was mainly based on literature and by taking into account the knowledge of many specialists. So, a lot of compromises have been made. Main contributors for Finland, in addition to the authors of this chapter, were Thomas Bonn and Heikki Toivonen.

2. Geographic Description

The shoreline length of the Finnish mainland is ca. 5,000 km. This would increase to almost 40,000 km if the fragmented archipelago was included. Finland has ca. 73,000 islands and 52,600 of these are small, less than one hectare in size (Fig. 2).

On the coast of Finland, as the earths crust rises, new land emerges from the sea. The rate of land uplift varies from 8 mm/year on the north-west coast of Finland to 4 mm/year on the south-west part. It is estimated that the increase in land area of Finland amounts to 700 km^2 a century as a result of land uplift.

The coastline consists mainly of bedrock, although the inner parts of the archipelagos and bays are sheltered enough for the deposition of fine material. Forty two percent of the coast is bedrock, with a similar percentage of moraine. Approximately 5% is sand and 10% is mud. Hard bottoms are usually found in more exposed outer archipelago areas where currents and wave action prevent particles from settling.

The coast of Finland can be divided into six coastal regions according to relief, shore density and shore types:

1) **Åland** is characterized by a high relief amplitude and an abundance of rocky shores (over 75%).
2) In the **south-west Archipelago** the zonal structure of the coast is evident. In the outer coastal zone nearly all the shores are rocky. The proportion of boulder clay shores is highest in the middle coastal zone. The proportion of clay and silt shores increases towards the mainland, reaching a maximum in the inner coastal zone. Of all the shores in the region, more than half are rocky, 30% are till and 11% clay and silt.
3) The boundary between the coastal regions of the **Bothnian Sea - Quark** and the south-west Archipelago is distinct. The most obvious difference is the abundance of till shores in the Bothnian Sea and the Quark, with over 80% of the shores being till and only 6% rocky.
4) The coastal region of the **Bothnian Bay** is conspicously different from the rest of the coast, because of its flatness, sparsity of islands and abundance of fine-grained soils and sand. Because of the fluctuations of the water level, the shore has been subject to wave action for a long time. Thus, despite the rapidity of uplift, littoral forces have a fairly long time to shape the shore and alter its sedimentary composition.
5) The coast of the **western Gulf of Finland** is also zonal and similar to the south-west Archipelago. It is, however, much narrower, as the land slopes more steeply than in south-west Finland.
6) On the coast of the **eastern Gulf of Finland**, the proportion of rocky shores is 27%, till shores 46% and gravel and sand shores 12%. Due to the slower land uplift littoral processes could shape the coast more intensively than elsewhere in Finland.

3. Characterization of the Marine Environment

When considering the marine water masses near the Finnish coast, the Baltic Sea can be divided into two major water bodies, the Gulf of Finland and the Gulf of Bothnia. The Gulf of Finland is a direct extension of the Baltic Proper and the combined effects of the large freshwater inflow in the eastern end and the water exchange with the Baltic Proper lead to strong salinity gradients. On a long-term, basin wide scale, the overall water circulation in the Gulf of Finland is anti-clockwise, resulting in a westward transport along the Finnish coast. Surface salinity varies from over 6‰ in the western parts to around 3‰ in the eastern regions of the Finnish part of the Gulf of Finland. Freshwater conditions are approached in the river mouths.

The Gulf of Bothnia (including the Bothnian Bay, Bothnian Sea, Åland Sea and Archipelago Sea) is a brackish water body with two major basins and two larger archipelago areas in the northern and south-eastern part. The northern and southern basin are separated by a shallow sill, the Northern Quark. A counter-clockwise rotation of long-term mean currents occurs in the basins and in the Gulf as a whole. Inflow of freshwater from numerous rivers and from precipitation causes the dominant estuarine character of the Bothnian Bay, when it mixes with saline water that enters from the Baltic Proper. Surface salinity is around 3.5‰ in the northern basin, approaching freshwater conditions in the river mouth areas. In the Bothnian Sea, the surface salinity increases to around 6.5‰. The Bothnian Bay freezes even in mild winters and the ice cover lasts on average 170 to 190 days (70 days in the Archipelago Sea).

The marine biotopes within the photic zone are generally split in this publication into two categories, those with or without vegetation. During the working process it became apparent that for the Finnish coast at least one more classification level of the marine biotopes should be developed, to include the names of main species. This is necessary to evaluate the threat factors. It is recommended that due to the paucity of relevent data, long term mapping of the vegetation would be needed to continue this classification work.

On rocky seabeds there are zones of algae communities. These hard bottoms provide the most suitable substrata for green, brown and red algae, while charophytes and phanerogams inhabit sediment bottoms in sheltered areas. A typical zonation of macroalgae is usually found with green algae dominating near the surface, brown algae in the shallow sublittoral, and red algae at the greatest depths.

On the hard bottoms of the hydrolittoral zone there is a typical annual cycle of biotopes. In spring when there is no ice cover, sessile diatoms cover the bare rocks. The diatoms are replaced by the filamentous *Pilayella littoralis* and followed by the green alga *Cladophora glomerata* dominated biotope during summer. The filamentous red alga *Ceramium gobii* and brown algae dominate during autumn and winter.

On the hard bottoms *Fucus vesiculosus* is the only large perennial seaweed that is widespread from the eastern part of the Gulf of Finland to the Quark. It has a wide vertical range, from depths of about 0.5 m down to 5-6 m. As such it can form the basic habitat for, e.g., the hard bottom macrofauna.

General deterioration of the *F. vesiculosus* community is of great concern, because it has a key role in the Baltic Sea ecosystems. In the sublittoral in south-west Finland, the perennial red algae *Furcellaria Phyllophora* or brown algae *Sphacelaria arctica* dominated biotopes are representative, while in eastern parts of the Gulf of Finland *Cladophora rupestris* replaces the red algae. In the Bothnian Bay the perennial alga *Cladophora aegagrophila* and the water moss *Fontinalis* spp. extend downwards from the lower limit of sea ice at two metres depth.

Sandy bottoms are characterized by the *Ruppia-Zannichellia* and the *Potamogetonaceae-Ranunculus* dominated biotopes. The *Zostera marina* community is widespread but threatened in the Baltic Sea. It forms scattered stands in the south-western archipelago and along the coast of the Gulf of Finland. Beds of *Zostera marina* grow on the clean unpolluted sandy bottoms normally down to depths of ca. 2-4 metres. On muddy bottoms along the Finnish coast a special low salinity biotope occurs dominated by *Ceratophyllum-Stratiotes-Lemna trisulca*.

The bottom vegetation in shallow bays can be dominated by charophyte meadows. Most charophyte species occurring in brackish water are rare and threatened. In areas dominated by charophytes, 2-4 charophyte species can co-occur. *Nitella* spp. and *Chara baltica* are found mainly on sheltered muddy bottoms. *Chara aspera* is common on shallow sandy bottoms, *Chara canescens* and *Tolypella nidifica* occur often with it.

Increasing occurrences of benthic drift macroalgae have been recorded on shallow soft bottoms. The mats can cause hypoxic or anoxic conditions with the development of hydrogen sulphide in the sediment. The natural littoral vegetation can be replaced and the bottom fauna can be affected by the algal mat covering the available substrata.

Fladas and glo-lakes are small, shallow and sheltered, clearly delimited water bodies, either still connected with the sea or cut off from it by land. They are common along Finnish coasts and archipelagos and also along other rising coasts around the Baltic Sea. The isolation process of such water bodies has resulted in a distinct morphological and botanical succession with many different phases visible. They are often characterized by a well developed reed zone and luxuriant submerged macrophyte vegetation. The species composition includes marine species, such as *Fucus vesiculosus,* as well as freshwater species like *Myriophyllum* spp. and *Potamogeton* spp. With increasing isolation and decreasing salinity species like *Chara tomentosa*, *Najas marina* and *Ruppia maritima* become more common.

4. Characterization of the Terrestrial Environment

The impact of the past ice-ages on the landscape and biotopes has shaped the terrestrial coastal biotopes in Finland. The underlying Precambrian rock was scraped bare in many places. Loose mineral substrata were transported by the glacial ice itself or by melting streams of glacial water. Heavy mineral particles or pieces settled quickly while fine clay particles were transported far and finally most of them settled to the bottom of the Baltic Sea basin. The results of these immense forces can be seen in the landscape today, especially in the coastal region.

The land, once pressed down under the thick layer of ice, still rises after being relieved of the heavy ice shield, creating new patches of land for plants and animals to colonize. At the Bothnian Sea the coast slopes very gently. The impact of the land uplift can be easily seen. Large shallow areas have successively become coastal meadows which in turn become invaded by bushes and trees. The use of coastal meadows as pastures has decreased dramatically and many coastal meadows have been invaded by reeds as a result.

Since almost half of the shores in Finland are rocky, islands and skerries are the most typical feature of the large archipelagos. The vegetation on rocky skerries is usually very sparse and often consists of lichens and mosaic-like pioneer vegetation. Such communities are very sensitive to trampling, just like the fragile plant communities of esker islands. Examples of such plant species are *Cakile maritima, Honckenya peploides and Salsola kali*. Esker islands, formed by glaciofluvial forces, occur infrequently along the entire coast of Finland.

5. Threats

In some archipelago areas in Finland, especially near cities, the shoreline is cut off from the hinterland by coastal development. One or more buildings per each 200 m strip of shoreline and within 100 m from the shoreline may occur. In areas with such a ‘closed’ shoreline biotopes and biotope complexes are often fragmented and the effects of human activity are evident almost everywhere. As much as 37.3% of Finland’s coastal shores constitute closed shorelines, when each 200 m strip of built shoreline is assessed, using a 1:20,000 scaled map. Since the 1940’s, houses, holiday cottages and saunas, built close to the shore, have become one of the major threats to phytobenthic biota. Building activity is a likely threat causing the fragmentation of biotopes. Also trampling of the shores is considered a serious threat to the terrestrial biotopes.

Eutrophication is considered to be the main threat to marine biotopes. In Finland, this includes, above all, the effects of agriculture. However, since it is too difficult to distinguish in a specific biotope between the effects of atmospheric eutrophication, nutrients emitted by agriculture into the river runoff and other sources, eutrophication as a general threat was not further subdivided. Aquaculture or fish farming (mariculture) is the second main problem occurring in the Archipelago Sea, off the south-west coast of Finland. In these areas fish farming is the second largest nutrient source after atmospheric deposition.

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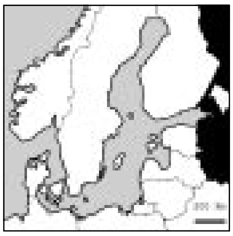


INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF THE RUSSIAN ST PETERSBURG REGION

Vladimir Pogrebov & Anton K. Chtchoukine

1. General Introduction

The coastal area of the Russian Federation in the Baltic consists of two parts:

1. The Kaliningrad region with two major lagoons bordering the Baltic Proper is characterized by biotopes with a greater Atlantic influence. Due to the high freshwater input from the Nemunas and Pregola rivers the waters within the Curonian Lagoon and the Vistula Lagoon only have a low salinity compared to the open waters of the Baltic Proper.
2. The eastern part of the Gulf of Finland is much more under the influence of the continental and boreal climate. The waters of the St Petersburg region are much more brackish (Fig. 19) compared with more saline western areas.

For obvious reasons it was decided to describe these two areas separately. The marine and coastal biotopes of the Russian St Petersburg region are dealt with in the following text, whereas the description of the marine and coastal environment of the Kaliningrad region can be found in a separate chapter.

2. Geographic Description

The Gulf of Finland is a relatively narrow bay which stretches from east to west over more than 400 km (Fig. 2). The entrance of the gulf is 75 km wide. In the widest part of the bay between the top of Vyborg Bay and the southern coast of Narva Bay it is more than 130 km. In the most eastern part, in the Neva Bay, the Gulf of Finland is only 15 km wide. The total area of the Gulf of Finland (without the islands) is about 30,000 km^2, approximately 7% of the Baltic Sea total area. The water volume of the Gulf of Finland is more than 1,000 km^3.

The preliminary subdivision of the eastern part of the Gulf of Finland into different landscape regions is based on a special geomorphologic and vegetation analysis. The region can be subdivided into 16 land- and seascape regions (L.r.; S.r.):

- North-Eastern Gulf of Finland landscape region (l.r.) - rapakivi granite bedrock coast
- Primorsk Eastern Gulf of Finland l.r. - granite and gneiss-granite bedrock coast
- Raivola Eastern Gulf of Finland l.r. - shingle (gravel and pebble beaches) coast
- Zelenogorsk Eastern Gulf of Finland l.r. - sand coast
- Neva Eastern Gulf of Finland l.r. - uplifted zones in combination with sand beaches and Neva River estuary and moraine lagoon Lahtinsky Razliv Lake
- Koporje Eastern Gulf of Finland l.r. - combination of sand and gravel beaches and marshes
- Sosnovyi Bor Eastern Gulf of Finland l.r. - technogenous zones in combination with sand beaches
- Luga Eastern Gulf of Finland l.r. - combination of sandy beaches, moraine coast and gravel zones
- Kurgalsky Eastern Gulf of Finland l.r. - combination of dunes and moraine islets and bars
- Narva Eastern Gulf of Finland l.r. - sandy coast
- Central Islands Eastern Gulf of Finland l.r. - moraine and sandy coast of islands
- Gogland Eastern Gulf of Finland l.r. - individual uplifted bedrocks (islands Gogland and Tuter)
- Neva Bay Eastern Gulf of Finland seascape region (s.r.) - shallow, very low salinity waters of Neva River Estuary
- North Marine & Vyborg Bay Eastern Gulf of Finland s.r. - brackish waters, a system of archipelagoes with fjard-like bays
- South Marine (Luga & Koporje Bay) s.r. - brackish waters of bays under high anthropogenic influence, especially nutrient load
- Central Marine s.r. - brackish open waters.

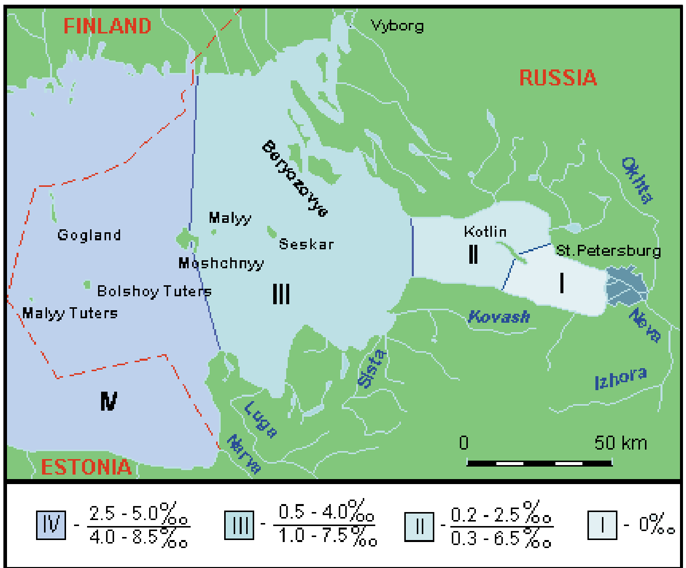
3. Characterization of the Marine Environment

The largest islands off the southern coast of the Gulf of Finland are Moshchnyy, Kotlin (where Kronstadt is located), Seskar, Malyy Tuters and Bolshoy Tuters. The largest islands off the northern coast of the Gulf form the Beryozovyy archipelago and Gogland Island.

The Gulf is rather shallow, averaging 40 to 60 m and gradually increasing from the top of the bay to its mouth. The shallowest area, the Neva Bay or Marquise Puddle, is located between the Neva River mouth and Kotlin Island. The average depth is about 3-5 m. The deepest part of the Gulf at 105 m is recorded near Gogland Island.

The tidal range in the Gulf of Finland is between 1 to 5 cm. Their ecological significance is negligible. Surge phenomena are certainly much more important and their amplitude ranges from 0.5 m to 1.5 m, but sometimes may reach 3-4 m. During the November flood of 1824, the water level in the Neva River was 3.75 m higher than the normal level. The lowest water level, recorded on Kotlin Island in November 1890, was 1.67 m lower than the normal level. Thus, the total variation of long-term water level fluctuations is nearly 5 m.

The regime of currents in the Gulf of Finland is governed by a combined effect of the river runoff and the variability of the wind over the Baltic Sea and the coast. The strongest currents are recorded at depths of less than 10 m. Their average values are 5-10 cm/s. Maximum values are recorded along the coasts during storms and reach 50-80 cm/s



Hydrological and hydrochemical regions of the eastern part of the Gulf of Finland (Ostov, 1971)

I - Fresh water shoal III - Brackish water area

II - Transition zone IV - Eastern deep-water area

Figure 19:
Hydrological and hydrochemical regions of the eastern part of the Gulf of Finland (Ostov, 1971)

The Neva River runoff is one of the main factors governing the hydrological and hydrochemical regime in the Gulf of Finland. The mean annual Neva River runoff is 80 km^3 or 2,500 m^3/s.

Due to the Neva River runoff, water salinity in the Russian part of the Gulf of Finland varies from 0‰ in the Neva Bay, to nearly 10‰ in the deepest part of the bay near Gogland Island. Fig. 19 shows sub-divisions of the Gulf of Finland according to the salinity. As shown, salinity increases from the east to the west.

Surface water of the Neva Bay is freshwater, whereas salinity of the surface water near the Gogland Island is about 3-5‰. Bottom water salinity near Gogland Island is about 7-8‰.

The soluble oxygen content in the Gulf of Finland normally ranges from 80-100% saturation, although in some deep-water areas of the Vyborg Bay it is sometimes less than 50% saturation.

In the Gulf of Finland there are many types of bottom sediments ranging from clay and silt to rocks.

The variety of habitats in the Gulf of Finland (and range of salinity) have resulted in differences in aquatic communities between eastern and western parts. There are freshwater (limnic) flora and fauna in the Neva Bay, brackish water communities in the middle part of the Gulf and almost marine communities at its western boundaries.

4. Characterization of the Terrestrial Environment

The terrestrial environment of the St Petersburg region may be devided into three zones: Apart from the eastern Gulf of Finland it is necessary to mention that the Russian (eastern) shoreline of the Gulf of Narva as well as several islands (Gogland, Tuter, etc.) are distinctively different regions. These three zones show some similarities as well as several differences, however in terms of the scope of this publication one should regard them as one large coastal unit with a total mainland shoreline of about 550 km.

The eastern part of the Gulf of Finland can be divided into the Baltic Sea, the Skandinavian Bedrock Shield and the East European Platform (or Russian Plain). The southern part is in the temperate zone whereas the north belongs to the boreal zone. This makes the whole region a transitional zone, not only between Arctic tundra and temporal steppe communities, but also between the east, dominated by the more continental west Siberia (boreal taiga) and the Ural mountains, and the west, characterized by the more oceanic central European communities (mixed broad-leaved forests). The high biodiversity indicates the structurally diverse composition of the different biotopes. Each main biogeographic element (arctic, boreal European, boreal Siberian, nemoral) of the flora of north and north-west Russia (between the city of Achangelsk and the Gulf of Finland) is represented by typical higher vascular plants. Atlantic, southern boreal and nemoral European floristic elements are more common to the west and on the shoreline. The meridian of floristic diversity is on the southern part of the St Petersburg region where over 750 species per square kilometre were recorded. The region is important for many species of migratory birds as it is part of the European-Arctic Migration Flyway. Three Ramsar sites are in the region and breeding conditions are suitable for northern species as well as for those with a more southern distribution. The number of nesting birds increases along a gradient from west to east, this, however, is believed not to depend on the changing habitat conditions, but rather to be an anthropogenic induced phenomenon.

Generally the relief of the areas belonging to the Scandinavian bedrock shield and the Russian Plain are of glacial and fluvio-glacial origin. However, exposed bedrock is typical along the northern coasts of the Gulf of Finland and some islands in its central part.

The recent geomorphologic changes took place during the postglacial period of the last 11,000 years. The most important is the land uplift in the territories of the Karelian Isthmus and the erosion caused by transgressive sea waters of the Littorina Sea. Unlike the southern part, where the Narova and Luga river valleys are of fluvio-glacial origin formed by lake sediments near the ice shield in combination with moraine parts, the actual shape of the coast in the north is not the result of erosive forces.

5. Threats

A large number of threatened species live, forage and reproduce in the Gulf of Finland. The most well known are Atlantic salmon and sturgeon (probably extinct); however, 10 other threatened fish species can be named.

The location of a large industrial centre such as St Petersburg at the head of the Gulf of Finland has resulted in a substantial impact on its ecosystems and biotopes. Major pollutants are trace metals and oil products. According to data by RINLAN (Russian State Research Institute for Nature Conservation of the Baltic and the North), the content of cadmium in the mud of some port areas in the Neva Bay is 40 times higher than the ‘normal’ level for the Baltic Sea. Concentrations of zinc, copper and oil products in such areas are generally much higher compared to ‘normal’ levels. The level of eutrophication is also high. The degree of contamination is highest in the following sites of the Gulf of Finland:

- the harbours of St Petersburg, Kronstadt and other ports
- the mouth areas of the Neva and Luga Rivers
- the northern part of Vyborg Bay.

Thermal pollution occurs in Koporskaya Bay from the Sosnovyy Bor nuclear electric power station.

6. Conservation and Outlook

Some areas of the Gulf of Finland are almost undisturbed, mainly due to special political conditions that existed until not long ago. Areas were managed for decades by the USSR Ministry of Defence, Navy and border-guards creating “reserves” (at least for part of the sites). These areas are also largely unstudied from the scientific viewpoint, since research was also restricted.

Comprehensive scientific work on the conservation of the different regions of the Gulf is far from being complete. The most important future work should include more thorough studies of the shallow (coastal) areas and the deep-water areas of the western Gulf of Finland (so far these areas are poorly studied from the biological point of view).

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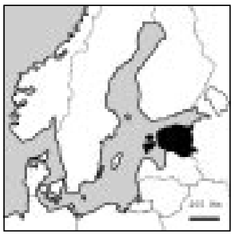

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF ESTONIA

Georg Martin, Anneli Palo & Kadri Möller

1. General Introduction

The first step on a national level was to distribute the preliminary list of coastal and marine biotopes of the Baltic Sea to the main experts of coastal geology, geomorphology and botany requesting their comments and additions. The preliminary assessment of threat was evaluated by six experts. The Red List was also distributed to the appropriate scientists, to nature conservationists of the local government and to representatives of the non-governmental organizations. The final Red List of Biotopes was then completed according to the results of the workshop “Estonian Red List of Coastal and Marine Biotopes” held in November 1996. Sixteen experts participated in the workshop and each biotope was discussed to evaluate the threats and their extent.

Main experts contributing to the compilation of the Estonian part of Red List of Baltic Biotopes were Juri Kask (Estonian Geological Survey), Kaarel Orviku (s/c “Merin”), Elle Puurmann (Läänemaa Centre for West Estonian Archipelago Biosphere Reserve) and Elle Roosaluste (Institute of Botany and Ecology, Tartu University). Financial support came from the Estonian Environmental Fund.

2. Geographic Description

Estonia is located in the north-eastern part of the Baltic Sea. It is bounded to the north by the Gulf of Finland, to the west by the Baltic Proper and to the south-west by the Gulf of Riga (Fig. 2). The area between the islands of the West Estonian Archipelago is called Väinameri (Belt Sea in Estonian) or West Estonian Archipelago Sea and forms an area of numerous narrow and shallow straights and bays. All four of these major Baltic Sea areas have characteristic physical, chemical and biological features.

3. Characterization of the Marine Environment

3.1 Gulf of Finland

The Estonian coastline of the Gulf of Finland extends from the mouth of the Gulf (where its waters join the Baltic Proper) to approximately the centre of the Gulf and ends at the mouth of the Narva River. The surface water salinity along this part of the Gulf is between 6.5-7.2‰ in the western part and 3-3.5‰ in the eastern part. The morphology of the coastline is very different from the opposite coast of the Gulf, a result of its different geological origin. The coastline is rather uniform, exposed, without major gulfs or archipelagos and has a comparatively steep coastal slope. The main environmental factors determining the development of coastal benthic biotopes are substrata, depth and salinity. Benthic vegetation is limited to depths of less than 15 m.

3.2 Gulf of Riga

This Gulf is quite isolated from the waters of the Baltic Proper and therefore has its own peculiarities regarding the nutrient and salinity regime. Due to the shallowness of the area the Gulf lacks a permanent halocline and the salinity ranges from 0.5-2.0‰ in coastal areas near bigger river discharges to 7.5-7.7‰ in deeper areas close to Irbe Sound connecting the Gulf to the waters of the Baltic Proper. A very important feature of the oceanographic regime of the Gulf is a relatively high nitrogen content (2-3 times higher than normal levels), and the whole area is supposed to be phosphorus limited. The bottom of the Gulf of Riga is very diverse in structure and origin. The prevailing seabed type is an accumulation bottom. The photic zone extends to depths of 15 m and the lowest limits of phytobenthos distribution were recorded at 11 m depth. The coastline of the Gulf is mostly open and exposed in the eastern part while a system of shallow, enclosed bays with soft accumulation bottoms occur in the northern part. The main environmental factors structuring the development of benthic vegetation in the area are depth and substratum type, while in areas close to major riverine discharges eutrophication seems to play a major role.

3.3 West Estonian Archipelago Sea

The inner sea of the West Estonian Archipelago has a surface area of approximately 2,000 km^2 and an average depth of about 5 m. The deepest place is the 22 m deep area located in the strait between Muhu Island and the Estonian mainland. Almost all the bottom is within the photic zone hence biological production in the area is huge. The hydrological regime is quite heterogeneous because of the weather driven movement of water masses from the Gulf of Finland, Gulf of Riga and Baltic Proper through this area. As the major environmental characteristics change rapidly and drastically, very specific environmental conditions for the development of benthic biotopes can occur.

3.4 The Baltic Proper

The westernmost coastline of the West Estonian Archipelago faces the waters of the Baltic Proper with its low nutrient levels and high water transparency. The bottom composition of this part of the Estonian coastal sea is characterized by a dominance of hard substrata in the shallow sublittoral which is usually in the photic zone. Benthic vegetation is recorded to a depth of 20 m in this region which is quite typical for the open Baltic Proper.

3.5 Coastal Marine Biotopes

The great diversity of ecological conditions in the marine areas surrounding Estonia allows the development of a large variety of biotopes. For each of the major water bodies off and around Estonia a certain complex of biotopes is dominant although in general a very wide range of biotopes is present in each particular region. In most cases depth and substratum are the most important ecological factors determining the development of different biotopes, but in some particular areas salinity and eutrophication levels also have a major influence.

3.6 Threats

The coastal sea of Estonia has generally quite natural conditions for the development of the marine biota. The potential threats are quite different for different sea areas depending on the geographical location, terrestrial influence and human activities. The human impact is mostly from fishing and shipping. The areas close to the bigger cities (Tallinn, Pärnu and Narva Bay) and bigger riverine discharges (Pärnu River, Kasari River, Narva River) are influenced by eutrophication, but this generally poses only a local threat - so far. Commercial exploitation of marine resources has the greatest influence on fish, without having a significant influence on the marine biotopes. An exception is the commercial exploitation of *Furcellaria lumbricalis-Coccotylus truncatus* communities in Kassari Bay in the West Estonian Archipelago Sea where the limited amount of the resource can be easily disturbed by overexploitation. At present the biggest potential threat for coastal sea biotopes is the continuous rise in the eutrophication level of the Baltic Sea which influences water transparency and sedimentation processes.

4. Characterization of the Terrestrial Environment

The length of the Estonian coastline is 3,794 km of which 1,242 km are on the mainland and 2,552 km are divided among the islands. The coastlines of the three biggest islands (Saaremaa, Hiiumaa, Muhu) form 50% of the islands total coastlines. These islands also form 93% of the islands total land area. Alltogether 1,521 islands have been counted in Estonia, of which 1,116 are islets with an area of less than 1 ha.

Estonia’s long and indented coastline makes it an important area for migratory birds along the East Atlantic Flyway. Estonia has many coastal wetlands, such as shallow bays and coastal meadows, and the continuous annual land rise of 2 mm creates many habitats suitable for waterfowls. Huge flocks of Barnacle geese forage in Estonia and poorly drained or other wet fields provide suitable resting sites for Bewick’s swan. Almost the entire north-west European population of this species rests in Estonia during spring migration. Estonian coasts also provide a relatively favourable habitat for grey seals.

4.1 Geology and Geomorphology

In Estonia, the crystalline basement is covered with Vendian, Cambrian, Ordovician, Silurian and Devonian sedimentary rocks. On the coast the following rocks crop out: in north Estonia Cambrian and Ordovician clays, sandstones and limestones; on west Estonian islands Silurian limestones and in south-west Estonia Devonian sandstones. There are only a few places in Estonia (in western Saaremaa) where gently sloping rocky shores are found. Mostly shores are covered with Quaternary sediments (sand, gravel, pebbles, boulders). Finer sediments accumulate to beach ridges, and boulders form pavement-like structures which protect the shore from storm damage. Sandy beaches are mostly gently sloping. Active dunes, not exceeding 2 m in height, only occur in a very few places.

The older sedimentary bedrock is exposed in places where glaciofluvial sediments are thin or where active abrasion takes place. Till and sandy beaches periodically can also be abrasive and in these cases till terraces and sandy beaches are formed and waves can occasionally destroy the old dunes. Such abrasive shores are, however, uncommon in Estonia and flat till and sandy beaches occur more often.

4.2 The Land Uplift

As the earths crust rises continuously (1-2 mm per year) many coastal formations are situated inland from the contemporary coastline. Large old dunes are covered with forest and are no longer influenced by the sea. There is a large number of shallow coastal lakes in Estonia and many of them have lost their connection to the sea relatively recently. Many shallow gulfs face the same future. Transitional mires and bogs have developed from former lagoons that are now located several kilometers from the coastal fens, but since they are separated from the sea by extensive forests and coastal plains they are not considered as coastal wetlands in the frame of this project.

Due to the continuous uplift of the earths crust older beach ridges move inland and at the same time new beach ridges are formed. These are slowly covered with vegetation. Such landforms are called alvars in Estonia (Fig. 89), and are characterized by ridges of limestone shingle with a typical xerophilous vegetation.

The broad-leaved forests on the talus slope of cliffs are other interesting coastal zone habitats. These inactive cliffs are interesting, because of their species-rich habitats, which are very rare in harsh climatic conditions. They are consequently protected.

The Estonian coastal sea is generally shallow and freezes to the bottom in winter carrying large boulders and other material that waves cannot otherwise move. When the ice melts in springtime, large transformations of the coast line can occur depending on the direction and strength of winds.

Waves may force ice inland, where blocks up to 10 metres high can destroy forest and soil. If the wind blows parallel to the coast, ice is carried far away from its place of origin and as it melts new sedimentary material (e.g., boulders) is deposited on sandy beaches.

4.3 Terrestrial Biotopes

The Estonian coast is naturally very diverse due to its geological diversity, the gradual uplift of the earths crust and transformations caused by ice. The coastal types usually occur as a mosaic reflecting the different sediments and formation prozesses. Traditional human forms of landuse like grazing and building add to this effect.

- Bars, spits, and beach ridges (Biotope codes 3.1 - 3.3)

As the earths crust continiuously rises, a shortage of sedimentary material occurs, subsequently spits and bars are not very large, mostly only a few hundred metres long, and rarely a few kilometres.

The coastline is a mosaic of different coast types which are often mixed, for example, sandy beaches with large boulders, limestone cliffs with sandy beaches or mixed gravel and limestone shingle beach ridges. The latter may be caused by coastal streams and longitudinal sediment transport with some material having been abraded from underwater beach ridges.

In Estonia sandy beach ridges can develop into primary dunes, but as the earths crust rises the shortage of further mobile sand prevents coastal dunes from being formed. Sand beaches are usually 30 m wide, but on steeper slopes the natural forest line is closer to the water. Pine forests grow on the beach ridges.

Various associations occur on stony beaches. On limestone shingle alvars develop. However, large alvars can only persist if managed by grazing, otherwise they become overgrown by junipers and later forest. As the earths crust rises new alvars are formed on the coastal front.

On flat shores where sediments are mixed (pebbles, sand, clay and silt), coastal meadows occur. Primary coastal meadows are common in Estonia, but considering the length of the coastline and the activity of sea which hinders human activity in this zone, they are not threatened. On upper coastal meadows traditional landuse - grazing - is needed, because, if land is left fallow, junipers appear on the more calcareous meadows and later the natural succession will lead to pine forest (more seldom with alders). In places with a high clay and moisture content, reeds or alders are more common. If a pebble shore is not used by man, it gets covered with forest. Storms often cause floodings in these forests, leaving strips of fallen trees as evidence. Ridges of seaweed are very common in Estonia.

- Dunes (3.4)

As mentioned before, coastal dunes and wet dune slacks are very low or small and do not develop beyond their primary stage. Consequently it is difficult to establish whether coastal heath forests have developed on dunes or beach ridges. Heaths and heath forests are, however, quite rare in Estonian coastal areas and also threatened.

- Rocky shores (3.5)

These are shores where sedimentary bedrock is exposed. They only occur in a few places on western

Saaremaa and other islands. The inclination of the limestone rock is such that no cliff is formed. Terraces, up to some tens of centimetres each, can be seen and the rocky shores are covered with alvars and alvar forests.

- Coastal cliffs and caves (3.6)
Cliffs exposed in Estonia are mostly limestone, less commonly sandstone, have interstitial clay layers and are between 1-60 m high. Lower cliffs occur on the outcroped areas of Silurian rocks on the west Estonian islands. The north Estonian coastline has high inactive banks with bank forests at its base for many dozens of kilometres. Caves or hollows eroded by waves occur here, although caves deeper than 2-3 metres do not exist along the Estonian coastline.

- Coastal meadows and wetlands (3.7)
Reed stands are very common in Estonia since the coastline is gently sloping and there are plenty of gulfs where sediment settles. The increasing eutrophication of the sea can even cause sandy beaches to overgrow with reeds. Rush stands are also quite common. Sedge communities most often occur on flooded areas not under the direct influence of the sea, although according to the Estonian classification they are considered as coastal meadows and wetlands.

Salt marshes are rare in Estonia as the already low salinity decreases even the closer to the coastline. Areas with a few typical salt marsh swards only occur on the western islands. The most well known is the Salinomme salt marsh, which is a very flat shore with reed stands, coastal meadows and salt marshes. Characteristic species are *Spergularia salina*, *Suaeda maritima* and *Salicornia europaea.*

On the lower coastal meadows the typical plant communities are: *Tripolio-Triglochinetum maritimi* and *Glauco-maritimae-Juncetum gerardii,* while on upper coastal meadows *Festucetum rubrae* and *Festucetum arundinaceae* communities are typical. Upper coastal meadows can overgrow with reeds, junipers and shrubs and later with forest, as grazing has been drastically reduced during recent years.

As the Estonian coast is very diverse, all vegetation units are entwined in various ways, and since alvars provide a form of grazing on relatively steep coasts they are also mentioned in this subdivision.

On flooded areas *Caricetum distichae* and other communities more characteristic for flood plains appear.

Data on coastal swamps (strictly following the thickness of the peat layer) were not usable but the existence of these small communities close to coastal lakes and headwater areas is very probable, and should be noted.

- Coastal lakes (4)
There are a lot of low gulfs that are temporarily connected to the sea or permanently by a narrow strait, coastal lakes which have lost contact to the sea and pools with different water conditions. Only very few of them are drained or used for fish breeding, and generally they are not used for recreation either. Their shores are used as pastures or for harvesting reed, but more often they are in their natural state and very important as bird nesting areas. No research about the trophic status of coastal lakes has been carried out.

- River mouth areas (5)
The only considerable river mouth with brackish water in Estonia is that of the river Kasari which flows into Matsalu Bay. Large reed stands, coastal meadows and floodplains expand on its delta. It has been a nature conservation area since 1957 and a Ramsar Convention area since 1975.

4.4 Threats
The factors endangering inland biotopes can generally be divided into two groups:
1) diminishing of traditional agriculture results in the overgrowing of coastal meadows, which are important for birds, with reed and junipers
2) increasing recreational activities (construction and tourism); this includes the construction of summer cottages and marinas, also uncontrolled small excavations or vehicles being driven over fragile vegetation and/or habitats.

Building activity is mostly controlable, whereas in areas of low population density it is very dfficult to prevent people from driving their cars onto beaches. According to the Act on the Protection of Marine and Freshwater Coasts, Shores and Banks of Estonia, building is forbidden within 200 m of the coast on islands and 100 m on the mainland. Only renovation of old buildings is allowed. Furthermore, the shoreline must be passable on foot (including private land) although certain temporal restrictions on passing are possible and permitted activities are limited.

Individuals are allowed to take raw building material for their own needs from their own property without permission unless it is a nature conservation area. Sometimes problems arise with people taking shingle and gravel from beach ridges. Often, therefore, the appearance of the coast is visually scarred as in some places large quarries had been opened. In a few cases the quarries have been flattened afterwards making renaturalisation possible. Smaller pits where only a few truckloads of raw material have been taken away, still exist however.

On many shores former Soviet coast guard buildings are still present and Estonia has not yet found resources to remove them. It is quite probable that they may become privatized, and problems will arise when owners want to rebuild them into summerhouses or other buildings related to tourism. This problem will need thorough consideration in each case to determine the best solution. In certain cases, this form of use can be quite reasonable, although old observation towers are in many cases in a state of decay and very dangerous.

Shores in many places have been spoilt by dumping. Border guards have left behind old machinery, glass etc., and tourists leave bottles, cans and other garbage.

Where access by car is possible people tend to throw their garbage over the edge of the cliff. Old shingle and gravel quarries are also used as illegal dumping grounds.

To conclude it can be said that the Estonian coast is more potentially than actually threatened. However this situation may change very quickly with an increase in private landownership, and damage to the coast is already significant close to cities and in some popular tourist areas.

5. Legal Protection of the Coastal Area

In April 1996 approximately 20% of the Estonian coastline was protected by different forms of protection (nature reserve, national park, landscape reserve). This is not the final figure, because this evaluation of existing protected areas and the process of creating new ones is still ongoing. Two acts regulate the management and protection of the coastal zone:

- The Act on the Protection of Natural Objects, which regulates the designation and manage-ment of protected areas
- The Act on the Protection of Marine and Fresh-water Coasts, Shores and Banks, which re-gulates economic activities (e.g. building) in the coastal area.

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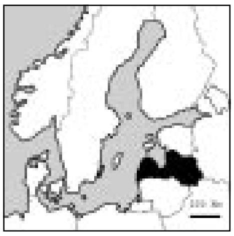

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF LATVIA

Ivars Kabucis & Ainars Aunins

1. General Introduction

The local Latvian working group was estabilished after the first meeting of the HELCOM Project Group. It was composed of G. Eberhards, Ainars Aunins, Ivars Kabucis, Eriks Karins, Brigita Laime, Otars Opermanis, Loreta Urtane, Andris Urtans.

Up to this project most of the research concerning coastal habitats had been focused on plant and animal distribution and less or no attention was paid to the occurrence and distribution of habitats. Investigations were not coordinated and were carried out separately. Scientists of different branches also used different habitat classification systems. The main task was to integrate the existing knowledge into the newly proposed system and to gather additional information on habitats for which the information was insufficient.

In the seventies, for example, only dune flora was investigated, while in the nineties phytosociological research was carried out without using any certain dune habitat classification. Independently the dynamics of the coastal relief have been monitored since the seventies. Biological research, however, was not closely related to geological investigations which resulted in more specific problems, for example, distinguishing between dunes and beach ridges in some areas. In several instances it was difficult to integrate all these classifications into the newly proposed one.

Research on marine biotopes was mostly focused on pollution and its impact on biomass and community structure. There was no information available on macrophyte vegetation covering the sea floor. The lack of published information in this field caused additional difficulties, because the occurence of some of the proposed habitats in Latvia was uncertain. The lack of habitat monitoring and case studies made it sometimes very hard to evaluate threat levels and the importance of certain threat factors.

2. Geographic Description

Latvia is located on the eastern shore of the Baltic Sea on the north-western edge of the East European Plain. The sea coast of Latvia extends over some 490 km, 182 km along the Baltic Sea and 308 km along the Gulf of Riga. The coast along the Baltic Sea is fairly linear with only two headlands (Ovisrags and Akmenrags) which slightly project into the sea (Fig. 2).

3. Marine and coastal waters

3.1 Introduction

The salinity of the Baltic Sea in the central parts off the Latvian coast is only 7‰ in the upper and 12‰ in deep layers. The salinity of the Gulf of Riga is unstable and linked to riverine freshwater and salt water inflows from the Baltic Sea. Compared to the Baltic Sea, the freshwater inflow per cubic metre in the Gulf of Riga is three times higher. The mean salinity in the Gulf of Riga is 5.8‰. In the central part salinity is fairly constant, oscillating close to the mean level. The salinity in the upper layer gradually decreases during the spring, due to the melting of snow and ice, reaching a minimum in May (about 5‰); nevertheless, salinity in the Daugava, Lielupe and Gauja river mouths may be as low as 2-3‰ (Pastors, 1994). These river mouths have sand islands and wide beaches which are ideal nesting sites for terns and oystercatchers.

The biodiversity of the flora and fauna of the Baltic Sea and the Gulf of Riga has developed as a result of the geophysical factors present and the geologial history of the Baltic Sea. Salinity is one of the key factors structuring the distribution of flora and fauna, and both marine and freshwater species are found. As the salinity of the Baltic Sea decreases from the south-west to the north-east, so does macrofaunal richness. Only 77 macrofauna species are found in the Latvian coastal waters of the Baltic Sea and in the Gulf of Riga (Kautsky, 1993). The large influx of freshwater into the Gulf of Riga due to river runoff, is reflected in the distribution of many typical freshwater plants and animals, especially along the Gulf coast.

There are 10 larger coastal lakes of which two are brackish (Liepaja Lake, Pape Lake) and the rest freshwater. Several of them were formerly considered to be mesotrophic (e.g., Engure Lake, Liepaja Lake), but due to pollution and eutrophication all of them are now eutrophic. Engure Lake, however, still shows some characteristics of a mesotrophic lake (*Chara*-dominated communities and lucid water).

Soluble oxygen concentrations are highest in the spring (10 mg/l in upper layers, 7-8 mg/l in bottom layers). In shallow waters and in upper layers, the oxygen concentration is about 8 mg/l, while oxygen depletion occurs in depths greater than 65-75 m, with high hydrogen sulphide concentrations common in depths greater than 150 m.

Changes in the water level in the Baltic Sea and the Gulf of Riga are largely due to wind induced inflows or outflows. In the Gulf of Riga, water levels have short-term fluctuations, along with a small tidal periodicity, causing irregular daily fluctuations with an amplitude of 10-13 cm.

During gales, westerlies and south-westerlies the water level in the Gulf can rise by 50-60 cm, and sometimes up to 100 cm. North-westerly winds drive water into the Gulf causing a rapid increase in the water level along the southern coast, and causing flooding in the Daugave, Lielupe and Gauja river mouths. The water level can decrease on the eastern side of the Gulf during easterly winds and can be as low as 90 cm below the mean water level of the Baltic Sea. The amplitude of the water level in the Gulf of Riga is 3,44 m, and along the Baltic Sea Coast slightly over 2 m.

3.2 The Gulf of Riga

The Gulf of Riga is divided from the Baltic Sea by the Kurzeme Peninsula and the Monzunda Archipelago Islands. Coastal waters are fairly shallow. About 50 m from the shore, depths are 20-30 m, except in Ventspils where depth of 71 m is achieved in the Piltene Depression.

The water in the Gulf of Riga originates from precipitation, river influx, and inflows from the Baltic Sea. The Daugava, Gauja and Lielupe rivers contribute 82% to the freshwater input to the Gulf.

Water exchange through the straights causes water circulation in the Gulf of Riga. There are two cyclic flows (40-60 km diameter), one around Ruhnu Island and the other in the south, along with smaller cyclic patterns (only few kilometers in size). The circular flows reach 5-8 cm/s and up to 15-25 cm/s during gales. The current direction varies with the depth, sometimes by even 180°. The current in the Baltic Sea flows parallel to the coast, depending on the wind direction, and can sometimes reach a velocity of 1 m/s (Pastors, 1994).

3.3 Pelagic biotopes

Along the Baltic Sea coast, the highest concentrations of bacterioplankton (mean 0,5-2 million cells/ml) occur near Ventspils and Liepaja, about 1-2 km off the shore. The highest microorganism counts were observed in surface waters, whereas at depths of 30-40 m the numbers are up to three times lower (Apine, 1982).

Along the Baltic Sea coast of Latvia, the biomass of phytoplankton is low and rarely reaches 1 mg/l, and fresh water bacillariophyta species are rare. However, at the mouth of the Venta river, phytoplankton biomass frequently exceeds 1mg/l. Here, freshwater species dominate in the summer whereas in the autumn, phytoplankton biomass rapidly decreases to 0,1 mg/l. In autumn, freshwater species are found to a depth of even 30 m (Rudzuroga, 1987).

Zooplankton biomass and number vary seasonally and spatially (horizontally and vertically) along the Baltic Sea coast of Latvia. This is especially evident from June to October when a few species quickly increase in number with increased temperatures in the upper layer and an increase in salinity due to marine inflows and reduced riverine input.

Maximum microorganism counts occur in the southern part of the Gulf at the mouths of the Daugava and Gauja rivers; minimum numbers occur in the Irbe Straight. In the southern part of the Gulf where a distinct thermocline occurs, the warmer surface water contains 2-3 times the number of microorganisms than the benthic zone. There the temperature gradient is less distinct and organic accumulation in the benthic layer has a greater impact on bacterial community structure (Apine, 1984).

In the Gulf of Riga, the most productive zooplankton communities occur in the surface layers near the mouths of large rivers (Daugave, Gauja and Lielupe). High numbers also occur at depths of 5-10 m and in a small zone in the western part at a depth of 10-20 m. Waters with higher salinities and without thermal stratification support higher zooplankton productivity.

3.4 Benthic biotopes

The coastal seabed of the Baltic Sea and the Gulf of Riga is made of sand and some organic sediments. The development of a thermocline causes oxygen depletion resulting in anoxic conditions in deeper areas. As a result, toxic sulphur compounds are produced, and only few organisms can survive.

The Baltic seabed is mostly sand, frequently with stones, pebbles and gravel. In deep areas with little water movement, sedimentation of organic material occurs and on slopes, where currents are faster, the sand erodes leaving clays.

Exposed Middle Devonian layers are found in the Gulf of Riga along the bedslope between Skulte and Tuja (sandstone) and between Ragaciems and Jaunkemeri (dolomite). In some areas of the Gulf (northern parts and south of Kolgasrags), muddy sand occurs. The entire central part of the Gulf of Riga deeper than 20 m is covered by organic sediments. The larger portion of the Gulf of Riga belongs to the Central Depression and has a fairly flat bottom with depths of up to 40 m. The deepest point is 67 m at the Mersrags Depression (Pastors, 1994).

The surface layer of the sediment is richly populated, although fewer organisms occur in deeper layers of organic sediments, mainly due to anaerobic conditions. The sandy clay sediments contain high concentrations of organic matter providing a more suitable environment for benthos. The richest microflora in the Gulf of Riga is found near river mouths, where the mixing of salt- and freshwater causes coagulation and sedimentation of organic material (Apine, 1982).

The highest zoobenthos numbers occur at 20-30 m depth and the lowest above 5 m depth. Erosion of sand close to the shore results in species-poor communities, although at depths greater than 5 m, *Macoma balthica, Nereis diversicolor, Prostoma obscurum* and *Tubifex costata* are found. A higher species diversity occurs at 10 m depths in fine sands with plant detritus.

The sediments at 20 m depth are humic sands with plant detritus. Increasing pollution loads into the sea during the last 30 years have decreased light penetration, and the maximun depth for macroalgae has shifted from 25 m to 10-15 m. The composition of macroalgae species changes with depth, with green algae inhabiting the closest shore zone, followed by brown algae and then red algae. Eleven taxa of red algae, nine species of brown algae, fifteen species of green algae, 3 species of charophytes and 13 species of phanerogams have been found in the Gulf of Riga (Kukk, 1996). Particularly in areas with industrial and municipal loads the species composition has changed during the last 30 to 35 years. The number of macrozoobenthos species decreased by 11. Alone four *Chara*-species disappeared and the green alga *Cladophora glomerata* and the red alga *Ceramium tenuicorne* have considerably increased (Kukk, 1996).

4. Terrestrial Biotopes

4.1 Introduction

The formation of the Piejuras (coastal) Plain, characterized by a plain with dune relief, occurred in association with the development of the Baltic Sea. Soils of the Piejuras (coastal) lowland are usually sandy (typical podzolic gleys).

The typical coastal topography of Latvia includes complexes of foredunes, white dunes, grey dunes and brown dunes. Foredune and white dune complexes occur along 230 km (45%) of the coast, interspersed with stretches of coastal meadows or narrow beaches bordered with forests or cliffs. Sandy beach is the dominant biotope occurring along a length of 240 km. Gravel and shingle beaches stretch over 150-180 km. Boulder beaches are much rarer occurring only along the coast between Mersrags and Engure and between Tuja and Ainazi. About 123 km of the coastline is subject to erosion, creating active cliffs with heights of about 6-15 m.

Beaches are generally between 10-80 m wide, although sometimes even up to 100 m. They also vary in form and inclination depending on the geomorphologic origin, which is also reflected in the associated vegetation. Along some stretches of the Baltic Sea and the Gulf of Riga beaches with typical littoral flora exist. Due to wind and water erosion, a closed plant cover cannot develop, and plants occur individually or in small groups. These sites are most popular for recreation, which has resulted in the complete loss of these communities in some areas (Riga, Jurmala and Liepaja).

4.2 Dune complexes

On white dunes, of about 5-6 m height and a length of a few kilometres, grasses are mixed with *Anthyllis maritima*. Some stretches of shore have systems of 2 or 3 white dunes running parallel to the coast exceeding lengths of 120 m. Wet dune slacks occuring in the dune systems are dominated mostly by mesophilic grassland communities. The white dune communities differ between the Baltic Sea and the Gulf of Riga, due to plant distribution patterns. Willows can nearly always be found on white dunes forming bands or groups from natural colonization or planting.

In grey dune communities, the moss and lichen and herb flora increases in dominance. Grey dunes are rare, as forests have often been planted adjacent to the white dunes. Since grey dunes are among the endangered biotopes in Latvia, forest plantations should not be extended any further into the dunes.

A unique coastal ecosystem has developed close to the Lithuanian border neighbouring the Nidas bog. In the area of contact between the bog, the beach and foredune, an interesting community is found on peat and sand where typical species of tall herbs grow jointly together with dune species.

4.3 Cliffs

About 123 km of the coastline is subject to erosion, creating cliffs of about 6-15 m in heigth. The only sandstone cliff is situated on the eastern coast of the Gulf of Riga and all others are moraine cliffs. Long stretches of coast with the highest moraine cliffs are found on the Baltic Sea coast. Where the erosion has halted or decreased, the cliffs are overgrown with plants typical of beach, foredune and adjacent ecosystems. Cliffs usually occur below forests or meadows. “Vertical zonation” is apparent, with dune and beach species found near the foot of the cliffs and meadow and forest plants near the top.

5. Threats

The ecosystems are particularly threatened by changes in water chemistry caused by pollutants and eutrophicants (chemical, organic or biological).

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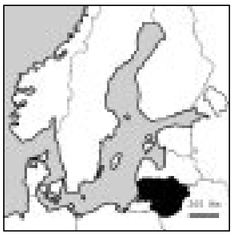

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF LITHUANIA

Sergej Olenin & Kristina Klovaitė

1. General Introduction

The Lithuanian zone of the Baltic Sea is situated in the south-eastern part of the Baltic Proper (Fig. 2). The shoreline, from the Russian (Kaliningrad) border on the Curonian Spit (Kursiu nerija) to the Latvian border on the mainland, is 94 km long.

The aquatic part comprises the Baltic Sea and the Curonian Lagoon (Kursiu marios), while the terrestrial part of the coastal zone includes the Curonian Spit and the mainland area. Further subdivision of both aquatic and terrestrial parts and their characterization is given below.

The work on a Red List is not complete and there is a need for it to be revised regularly. In Lithuania work is continuing on a detailed classification of the Curonian Lagoon benthic biotopes and hence these biotopes are not included into the present evaluation scheme.

2. Characterization of the Marine Environment

The offshore waters show the typical stratification pattern for the Baltic Proper with the upper layer (mean salinity 7-8‰) separated by a permanent halocline at 70-80 m depth from the more saline subhalocline water layer which is oxygen defficient.

In the coastal area major hydrological features are determined by the interaction between the south-eastern Baltic offshore waters and the runoff of the mostly freshwater Curonian Lagoon. Often the frontal zone between the sea and lagoon water is very narrow (20-40 m), and because of obvious differences in water colour and transparency, it may be easily visible. The mixed waters are of lower salinity and, depending on the hydrometeorological situation they may stretch several tens of kilometres, mostly in the northern direction (Zaromskis, 1994, Joksas, 1994, Olenina, 1997). The average temperature of the coastal waters has an annual range of 24 K , showing a typical boreal seasonal pattern (Asmontas, 1994). In July-August the summer thermocline is formed at the depth of 20-30 m, so almost all the coastal zone is influenced by the warm water above the thermocline. In winter, ice is a normal phenomenon along the shoreline; its width varies from 20-30 m to several hundred metres, with a thickness from 10-15 to 40-50 cm, depending on the severity of the winter.

The most windy months are October, November and December (on average 5-6 days the wind speed exceeds 15 m/s); wind speeds of 30 m/s occur once every 5 years (Birman *et al.*, 1985). The strongest and longest hurricanes affecting the Lithuanian coast occured during the latest two decades (the wind speed reached 50 m/s and waves heights of 7 m), and they caused severe damage to the whole coastal zone (Kirlys, 1990).

The permanent influence of winds, waves and water currents produces a hydrodynamically very active environment resulting in no oxygen deficiency and no oxygen based gradients in the distribution of bottom biota in the coastal area in contrast to the deeper offshore areas (Olenin, 1997).

Recently the numerical classification of the phytoplankton communities (Olenina,1997) revealed three major pelagic biotopes:

1) the area off the Curonian Lagoon outlet with dominant brackish water algae (*Skeletonema costatum,Chaetoceros wighamii*, *Gomphosphaeria pusilla*) and species also abundant in the oligohaline area of the lagoon itself (*Stephanodiscus hantzschii, Diatoma tenuis*);
2) the south-eastern Baltic coastal area beyond the direct influence of the lagoon's outflow with most abundant species *Skeletonema costatum, Chaetoceros wighamii* and *Peridiniella catenata* in spring and small flagellates in summer and autumn; and
3) the distant offshore area, which is characterized by clear dominance of marine species (*Peridiniella catenata, Protoperidinium brevipes, Gonyaulax verior*, *Prorocentrum balticum, Nodularia spumi-gena, Coscinodiscus granii*).

According to geomorphological and geological studies (e.g., Gudelis & Janukonis, 1977; Gudelis *et al.,* 1990; Pustelnikov, 1990; Zaromskis, 1982, 1992; Zilinskas, 1995 and others) the distribution of bottom sediments in the coastal zone is determined by the Curonian Lagoon alluvium (deposits) and abrasive-erosive processes. The slightly and moderately accumulative sites (e.g., Melnrage-Giruliai) alternate with intensively (Karkle moraine cliff) and moderately (Nemirseta-Palanga) erosive areas.

The mainland sub-marine coastal slope, extending from the shore down to 25-30 m, is characterized by the most diverse bottom types. Its uppermost part, 0-4(6) m, is covered by mobile quartz sand and along the mainland moraine bank (pebble-gravel deposits with large boulders) lies below this, extending down to 25-30 m. Patches of pebble-gravel deposits occur in sites down to 60 m, but in general, this type of bottom is common only on the coastal slope (Pustelnikov *et al.*, 1984). Here, the sandy and stony bottoms alternate on a small scale within tens - hundred metres, with patches of aleurite and mud in natural or man-made (e.g., the outer shippingchannel of Klaipeda harbour) depressions. All this makes the sea bottom very patchy in the coastal areas, and its bottom fauna is the most diverse.

Along the Curonian Spit the bottom sediments are much more homogenous, with sand prevailing throughout this area. In general, the character of sediments changes from the mixture of sand and gravel in the coastal area affected by waves to aleurites and pelitic muds in deeper areas (Pustelnikov *et al.,* 1984; Pustelnikov, 1990).

The principles of the benthic biotopes classification and their detailed descriptions are given in several recent publications (Olenin, 1994, 1997; Olenin *et al*., 1996). The biotopes show a distinguishable vertical zonation pattern, which is listed below.

1) An exposed sandy (on sites with gravel and pebbles) beach swashed by waves and flooded by water during storms with decomposing algae (mainly *Furcellaria lumbricalis*); no macrofauna is present except sparse specimen of the air breathing amphipod *Talorchestia deshayesii,* interstitial meiofauna occurs in the lower, wet section of the biotope;
2) Narrow depressions of 0.5-1.5 m depth made by bores along the sandy beach face in the uppermost part of the submarine slope; containing mats of floating, partly decomposing macroalgae (mostly filamentous greens with *Furcellaria* spp.) densely inhabited by the amphipods *Gammarus* spp. and *Bathyporeia* spp. in summer; in winter usually covered by ice;
3) Sands, movable by waves and currents, in water 1-5 m deep; inhabited by mobile burrowing amphipods (*Bathyporeia* and *Corophium* spp.), shrimps *(Crangon* spp.*)* and mysid shrimps *(Neomysis* spp. and *Mysis* spp.*),* the tube dwelling polychaete *Pygospio elegans* and infaunal “borrowers” (oligochaetes, polychaetes *Nereis diversicolor* and *Marenzelleria viridis),* and fish fry.
4) Shingle beds with small boulders, gravel and coarse sand between 1-5 m deep; an unstable substratum with a strong abrasive and erosive effect by wave action and moving substratum precludes the development of epifauna and macrophytes; barnacles *Balanus improvisus* (mostly the first year juveniles) are found on the underside of the more stable boulders.
5) Large boulders (1-4 m in diameter), lying on sandy or gravel bottoms at depths of 1-3 m; they are covered by the opportunistic (seasonal) filamentous green (*Cladophora* spp. and *Enteromorpha* spp.) and brown (*Pilaella* spp.) macroalgae with dense populations of amphipods *Gammarus* spp. and *Bathyporeia* spp.*;*
6) Stony bottoms (boulders and cobbles with a mixture of pebbles and gravel at the depth from 4-14 m with red algae *Furcellaria lumbricalis,* common mussel *Mytilus edulis,* Barnacle *Balanus improvisus,* bryozoan *Electra cru-stulenta*, and up to 50 other species of macro-fauna;
7) Stony bottoms at the depth from 5-30 m with dense aggregations of stationary epifaunal suspension feeders *Mytilus edulis* and *Balanus improvisus,* colonies of hydrozoan *Cordylophora caspia* and single specimens of the red algae *Ceramium rubrum* (occurs down to 20 m);
8) Sand and coarse aleurite bottoms at depths of 5-30 m with the bivalves *Macoma balthica* and *Mya arenaria,* polychaetes *Pygospio elegans* and *Nereis diversicolor* and the amphipod *Corophium volutator.*

2.1 Threats to the Marine Environment

The most serious negative changes during recent decades is the clear decline in the distribution of *Furcellaria* spp. in Lithuanian waters, most probably due to the synergetic effect of eutrophication and the increase in intensity of storm events (Olenin and Labanauskas 1994). It can also be assumed that there were formerly quite large populations of the marine eel grass *Zostera marina* on sandy bottoms and the brown alga *Fucus vesiculosus* on stony bottoms in the Lithuanian coastal zone. Scientific documentation on this is lacking, but from information obtained from local fishermen and inhabitants of the coastal zone it is quite obvious as huge amounts of both plants were cast ashore after each storm. The eel grass was used to fill in mattresses, while *Fucus* for fertilisation of soil. Now the density of both species is next to zero: still it is possible to find very scarce fresh specimens after storms, but no colonies of living plants were found on the bottom during the underwater investigation period in 1993-1997 by the Centre for System Analysis, Klaipeda University.

2.2 Conservation of the Marine Environment

Of the biotopes listed above, the stony bottoms with the red algae *F. lumbricalis* show the highest biodiversity at species level, and from this point of view, one may consider them to have the greatest conservation value. However, the whole coastal zone represents an indivisible functional unit, and the mosaic of biotopes (biotope diversity) is the main precondition for maintaining its rich and diverse living resources. For instance, the sandy bottom biotopes of the uppermost part of the underwater slope are important nursery areas for many fish species; stony bottoms are used as spawning grounds by Baltic herring; benthic macrofauna of both sandy and stony bottoms serve as a foraging source for marine species and freshwater fish migrating from the neighbouring Curonian Lagoon.

3. Characterization of the Curonian Lagoon

The Curonian Lagoon, the largest coastal lagoon in the Baltic Sea, is also a highly eutrophied water body (Povilanskas and Rascius, 1994). It is an enclosed shallow (mean depth 3.7 m) lagoon, connected to the Baltic Sea by the narrow (width 400-600 m) Klaipėda Straight. The southern and central parts of the lagoon are freshwater due to discharge from Nemunas (98% of total) and other rivers, while the northern part is oligohaline with irregular salinity fluctuations from 0 to 8‰. Water temperature shows a typical boreal pattern with highest values (23-25 °C) from July to August. From December to February the lagoon is usually covered by ice. During recent decades substancial anthropogenic changes occurred in the lagoon itself and its large drainage area. One of the most important and serious consequences is the ongoing eutrophication: the total phosphorous content has increased 3-4 times and total nitrogen five times from 1950s to 1990s (Zaromskis, 1996). Blue-green algae blooms are regular annual phenomena, which occur from the end of June until the beginning of November. Potentially toxic species *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* are most abundant during this period (Olenina, 1997).

Within the Lithuanian part of the lagoon three main pelagic biotopes can be distinguished:

1) the northern area, which is influenced by the sea; species of marine origin (such as *Katodinium rotundatum, Heterocapsa triquetra, Nodularia spumigena* among others) dominate here;
2) the central open area, characterized by the dominance of the diatoms *Stephanodiscus hantzschii, Diatoma tenuis, Asterionella formosa* in spring, blue-green algae *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* in summer, and blue-green algae (*A. flos-aquae*) with green algae *Planktonema lauterbornii, Scenedesmus opoliensis* in autumn;
3) the front area at the mouth of Nemunas river, where the dominance of diatoms is characteristic not only for spring, but during summer season as well.

The main water current in the Curonian Lagoon is the outflow of the Nemunas River. It continues north of the river mouth, while the southern part of the lagoon is left almost untouched. Here a large sedimentation zone exists. The main underwater habitat throughout the entire area is a soft bottom of silt and sand. Hard substrata, suitable for the attachment of large sessile animals, are of biogenic origin: primarily the abundant shell deposits of the zebra mussel *Dreissena polymorpha* either from living congregations or empty shells. It should be noted that *D. polymorpha* is an alien species to the lagoon and for the Baltic Sea. It appeared approximately two hundreds years ago, and now its dense communities cover about one quarter of the total lagoon area.

A detailed classification of the Curonian Lagoon benthic biotopes is under development and therefore these biotopes were not included into the present evaluation scheme. Preliminary three main benthic ecological zones can be identified:

1) muddy-sandy sedimentary bottoms with worms (Oligochaeta) and larvae of midges (Chironomidae) as dominating groups have a comparatively low species diversity (usually 3 to 5 species) in the freshwater central part of the lagoon;
2) bottoms covered by a dense community (mussel beds) of the filtrating mollusc *D. polymorpha* and comprising up to 50 other bottom macrofauna species - mostly in the central part of the lagoon affected by Nemunas;
3) mixed bottoms in the northern part influenced by sea and freshwater masses; industrial and municipal waste discharge from Klaipeda; dredging operations with different sediments: sand, gravel, moraine clay and mud; mixed and very diverse environmental conditions make it possible for both marine and freshwater species to exist there, in some cases the communities are comparatively diverse.

4. Characterization of the Terrestrial Environment

In general, open and flat landscapes are dominant in the Lithuanian coastal region. The northernmost area from the Latvian border to Klaipeda city is a plain of marine origin, comprised by several lythomorphogenetic stripes more or less parallel to the sea. There are sandy, up to 100 m wide, sea beaches, 7-15 m high dunes, mostly covered with grass or forests, sandy and swampy hinter-dune depressions and graded sea terrace plains attached to the loamy glacial ridge. The average elevation level is 6-10 m above the sea (WWF Report, 1994).

Some specific features may be found in this part of the Lithuanian coast: the River Sventoji with a twisted bed, is surrounded by cattle grazed meadows; the large maritime health resort of Palanga is intensively used for recreation; the former military area of Nemirseta; the moraine cliff of Karkle; and the Klaipeda suburb park-forest.

Klaipeda city is the largest urban area of the Lithuanian coast with 210,000 inhabitants, intensive industry and one of the biggest ports in the Baltic. It greatly influences the neighbouring natural and semi-natural areas.

The area from Klaipeda to the Nemunas River Delta, on the eastern shore of the Curonian Lagoon, is a flat coastal plain. The territory is crossed by the King William Canal, which is joined by several open drainage canals. Almost the entire coast of the lagoon is wetland with reed stands, mires and swamps (WWF Report, 1994). Halophyte species enduring brackish and saline conditions like sea rocket (*Cakile maritima*), prickly saltwort (*Salsola kali*), golden dock (*Rumex maritimus*), sea arrow-grass (*Triglochin maritima*) also occur here (Povilanskas & Rascius, 1994).

The Nemunas Delta is characterized by a mosaic of biotopes. The river with its numerous branches forms a vast delta area, comprising meadows, marshes, mires, lakes, inlets, large bogs and a few patches of forest. This area is flooded between 10 and 60 days per year, and the water covers from 220 to 400 km^2, including the Kaliningrad part of the delta (WWF Report, 1994). Most of the biotopes are significantly influenced by these floodings.

Agricultural land use in the Delta, with its fertile alluvial soils, is important for the local economy. The area has been subjected to a strong anthropogenic impact by the construction of polders and drainage canals as well as peat excavation, which have changed the hydrologic system of meadows (WWF Report, 1994).

The largest area of the Curonian Lagoon coastal zone is occupied by plant communities characterized by reed (*Phragmites australis*), bulrush (*Schoenoplectus lacustris*), yellow water-lily (*Nuphar lutea*), pondweeds (*Potamogeton perfoliatus*, *P. lucens*) and their associations (Povilanskas & Rascius, 1994).

The area is rich in fauna and flora, with several species listed in the Red Data Book of Lithuania. In total more than 430 vascular plants are found here. The East Atlantic Flyway stretches across the seashore and the Curonian Lagoon. Annually, 10-100 million migrating birds pass along the coast (Povilanskas & Rascius, 1994).

The Curonian Spit is a narrow (400-2,000 m) and long (99 km) sandy peninsula, 52 km belong to Lithuania. The landscape is characterized by the open migrating dunes and sandy areas supporting different types and varrying degrees of plant cover.

The natural forests had been cut in previous centuries and in order to protect the local villages from drifting sands the Spit has been forested with mountain pine and other coniferous trees. At present nearly 89% of the area is covered by semi-natural forests or plantations and the rest of the area comprises of different types of dunes and reed stands on the Curonian Lagoon shore.

4.1 Conservation of the Coastal Environment

There are three protected areas within the Lithuanian coastal zone: the national park *Kursiu Nerija* and regional parks *Pajuris* and Nemunas Delta. All of them are included in the proposed Baltic Sea Protected Areas (BSPA) of Lithuania. In spite of geographical closeness, the geomorphological, hydrological and biological characteristics of these three areas are quite different and represent different types of nature (see above).

The threats also vary from one biotope complex to another.The threats of crucial importance to the marine part are: ongoing eutrophication, increased frequency of storm events, disposal of dredged material and oil spills. For the aquatic part of the lagoon eutrophication (heavy algae blooms), invasion of alien species, discharge of waste waters, hydrotechnical constructions are noteworthy.

On land, in the Klaipeda-Palanga region and on the Curonian Spit, the most important threats are building activities, expansion of summer villages and pressure from tourism; for the Nemunas Delta the increase in intensity of agriculture and fishing, and the extension of the polder system is of importance.

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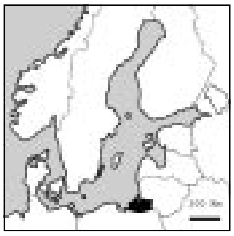

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF THE KALININGRAD REGION (RUSSIA)

Ralf Grunewald & *Michael Y. Durkin*

1. General Introduction

The coastal area of the Russian Federation in the Baltic consists of two parts:

1) The Kaliningrad region, with two major lagoons bordering the Baltic Proper, is characterized by biotopes with an increased Atlantic influence. Due to the high freshwater input from the Nemunas and Pregola rivers the waters of the Curonian Lagoon and the Vistula Lagoon have a low salinity compared to the open waters of the Baltic Proper.
2) The eastern part of the Gulf of Finland is much more under the influence of the continental and boreal climate. The waters of the St Petersburg region are more brackish compared with more saline western areas.

For obvious reasons it was decided to describe these two areas separately. The marine and coastal biotopes of the Kaliningrad region are dealt with in the following text, whereas the description of the marine and coastal environment of the Russian St Petersburg region can be found in a different chapter above.

2. Geographic Description

The marine and coastal areas of the Kaliningrad region are situated in the south-east of the Baltic Sea (see Fig. 2). The most important features of the area are the 49 km long, Russian part of the Curonian Spit (Kurshkaja Spit) with a total length of 99 km, the 83 km long Sambian Peninsula and the Vistula Spit (of which 25 km belong to Russia). This adds up to 157 km of marine coast within the Kaliningrad region (Litvin *et al.*, 1994).

3. Characterization of the Marine Environment

The marine environment of the Kaliningrad region can be divided into a more saline outer area belonging to the south-eastern part of the Baltic Proper and the two estuarine water bodies of the Vistula Lagoon and Curonian Lagoon.

3.1 Curonian Lagoon

With an influx of about 20 km^3 of freshwater per year, the Curonian Lagoon has a very low salinity; nevertheless, the narrow connection to the open Baltic in the northern lagoon allows the influx of more saline waters under special weather conditions. A division between a shallow northern part (Krantas), a fractured middle part (Vidmares) and a deeper part in the south (Budumas) is usually used to describe the lagoon. The Nemunas Delta is situated on the eastern shore of the Curonian Lagoon (see also national chapter of Lithuania) and is a major source of sediments. The mean depth of the lagoon is 3.7 m and the greatest depth is only 5.8 m. Freshwater macrophytes like *Nuphar lutea* (yellow water lily), *Potamogeton perfoliatus* (pondweed), *P. lucens* (shining pondweed), *Lemna gibba* (fat duckweed) and the endangered or rare *P. rutilus* (shetland pondweed) and *Nymphoides peltata* (fringed water lily) occur, as they tolerate the brackish water. The transitional hydrolittoral is largely covered with reed communities dominated by *Phragmites australis* (reed) or *Schoenoplectus lacustris* (bulrush).

The changing living conditions are reflected in the diverse benthic fauna which can be divided into three groups. The southern, more isolated areas are dominated by *Oligochaeta* (worms) and *Chironomidae* (midge larvae), the central areas, under the influence of the River Nemunas, are colonized by the alien mussel *Dreissena polymorpha* (zebra mussel), and the northern regions with changing water conditions (sea and freshwater) show a mixture between more marine and more limnic organisms.

Up to 50 different species of fish inhabit the lagoon some of which are of commercial importance. Large numbers of migrating birds use the lagoon as a major resting area along the East Atlantic Flyway. Several species of waterfowl also breed in the area (Povilanskas & Rascius, 1994).

3.2 Vistula Lagoon

The continuous growth of the adjacent Vistula Spit has almost cut off the lagoon from the open Baltic. Only the narrow straight in the north allows water to be exchanged between the brackish lagoon and the south-eastern Baltic Proper. The total water area is 838 km^2, the greatest depth 5.2 m and the average depth 2.6 m (Andrulewicz *et al.*, 1994).

The low salinity, between 1-4‰, leads to the dominance of freshwater species with only very few brackish water organisms living in the lagoon. The bottom is composed mainly of sandy or muddy substrata and supports various *Potamogeton* species to exist. In the hydrolittoral, plants such as *Phragmites australis* (reed), *Schoenoplectus lacustris* (bulrush), *Typha angustifolia* (cattail) and *Sagittaria sagittifolia* (arrowhead) grow (Andrulewicz *et al*., 1994).

3.3 Offshore marine environment

On the marine side, gently sloping accumulative terraces are found with *Macoma balthica* being a dominating organism. In between are small areas of sand, gravel and pebble with colonies of *Mytilus edulis* and *Balanus improvisus*. Further out – in deeper areas of about 18 to 29 m depth – ancient coasts, e.g., old dune complexes and relict cliffs submerged during the Littorina transgression, are found (Litvin *et al*, 1994).

4. Characterization of the Terrestrial Environment

4.1 Sambian Peninsula

The Sambian Peninsula is situated in the north-west of the Kaliningrad region and is formed from an elevated morainic plateau, with cliffs along the shoreline. These bluffs may reach heights of 55-60 m and are covered with a mosaic of forests (pine, hornbeam), meadows and other cultivated areas (Litvin *et al*., 1994).

4.2 Curonian Spit and Vistula Spit

Both spits represent a typical landscape feature of the southern Baltic. The Curonian Spit is the larger one with a width of 0.4 to 3.8 km and a length of 49 km (within Russia). It supports a mosaic of sandy ridges, foredunes and all other stages of succession typical for dunes. The dune complexes may reach heights of up to 68 m (Genys, 1994). On older dune complexes pine forests have been planted and wet dune slacks or alder stands also occur. This is also typical for the Vistula Spit, of which 25 km are within Russia.

5. Threats

Research has shown that the water catchment areas of the Pregola and Nemunas Rivers are two of the major sources of pollution for the Vistula and Curonian Lagoon respectively (Krasnov, 1993), and trans-boundary effects are very impotant. Huge quantities of suspended substances are discharged into the Pregola river mouth, with high concentrations of nitrogen compounds. The same is true for the Curonian Lagoon where eutrophication is caused by an annual input of up to 150,000 t of organic material. The main source of pollution in the river Nemunas has changed from factories which are situated in Russia and in Lithuania, to untreated municipal sewage. Several non-point sources also contribute substantially to the eutrophication of the Curonian Lagoon, and it has been estimated that airborne nitrogen compounds total about 20 kg/ha (Povilanskas & Rascius, 1994). Similar figures are given for the Vistula Lagoon by Andrulewicz *et al.* (1994). About 47,000 t of organic matter are released into the lagoon from Poland and Russia, primarily from factories and due to the poor standard of waste water treatment of the city of Kaliningrad.

Terrestrial biotopes have been altered over a long period. Tree planting, as a measure for stabilizing the migrating dunes, began in the 17th century (Genys, 1994). Historical records describe the devastation of the old natural or almost natural forests during the Seven Year War (1756-63). The mobile sand proved to be a major threat to farms and other settlements; thus, solutions were sought to stabilize the shifting dunes. The first successful attempts were probably made in 1811 (Genys, 1994) and stabilization was achieved by a combined effort of sand trapping fences, planting grasses and trees. Among the species used for planting were pines, birches and willows. *Pinus mugo* (mountain pine) and several other exotic trees were most commonly planted.

6. Conservation

The Kurshkaja Spit National Park is one of the most important conservation sites of the Kaliningrad region. It is located in the south of the Curonian Spit, reaching from the lagoon to the open sea. It was established in 1987 and covers about 70 km^2, of which 40% are protected as a strict nature reserve. Several other sites, such as botanical reserves, natural monuments, nature, zoological and landscape reserves are other forms of conservation which alltogether give 210 km^2 a protection status (Krasnov, 1993).

Since major ecosystems like the Vistula Lagoon and the Kurshkaja Lagoon are both divided between two countries (Poland and Russia, Lithuania and Russia) only a combined effort will secure the conservation or restoration of these large areas. In the years following the fall of communist power and the subsequent breakdown of a highly subsidized industry, a drop in pollution loads has brought some relief to the region. There is, however, still a need for further measures to be taken. Eutrophication has been identified as the major threat and hence, a better waste water treatment is among the most important future steps. During the last few years some improvements have been made by adding biological waste water treatment facilities to old installations and building completely new plants.

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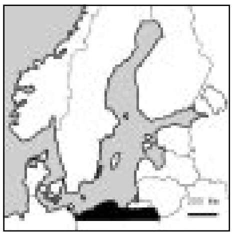

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF POLAND

Jacek Herbich & Jan Warzocha

1. Marine Biotopes (Jan Warzocha)

1.1 General Introduction

The evaluation of the marine biotopes of Poland is based mainly on available literature as well as unpublished long-term data and observations on temporal and spatial scales. Most of the historical data, especially from HELCOM monitoring, concern deep-water benthic and pelagic biotopes. Intensive studies have also been carried out in the Gulf of Gdansk and Pomeranian Bay. Less is known about shallow water biotopes in the open sea region. This is due to the relatively low intensity of research and wide range of natural and anthropogenic environmental factors affecting those biotopes. In order to supplement and verify historical data additional field research and observations were completed by the author in 1997 with attention focused on the benthic biotopes of the coastal region.

Main contributors for Poland were Maciej Wołowicz, Krzysztof Skóra, Eugeniusz Andrulewicz, Andrzej Redlarski and Marcin Węsławski. This work was coordinated and financially supported by the National Foundation for Environmental Protection in Warsaw and the Ministry of Environmental Protection, Natural Resources and Forestry.

1.2 Geographic Description

The Polish marine zone comprises the eastern and western part of the southern Baltic Proper and constitutes about 10% of the entire Baltic (see map on the inside cover). The following subregions occur within this zone:

1) the southern part of the Bornholm Deep (max. depth 90 m),
2) the Slupsk Furrow (90 m),
3) the western part of the Gdansk Deep (110 m),
4) the south-western part of the Gotland Deep (120 m),
5) the eastern part of the Pomeranian Bay and the western part of the Gulf of Gdansk.

A stable halocline occurs at a depth of 60 m in the Bornholm Deep, at 70 m in the Slupsk Furrow, and 80 m in the Gdansk Deep. The salinity of the isohaline layer is about 7‰, while below the halocline it varies between about 18‰ in the Bornholm Deep and 10‰ in the Gdansk Deep.

One can also distinguish three banks: the eastern part of the Oder Bank, Slupsk Bank, and the southern part of the Middle Bank. This zone is adjacent to two large lagoons, the Szczecin Lagoon in the west and the Vistula Lagoon in the east. A low sandy shore predominates. The predominance of sandy sediments, covering nearly the entire bottom of the coastal zone, and up to a depth of 70-80 m in the open waters, is a characteristic feature of bottom morphology. In this zone, both in the photic sublittoral and deeper sublittoral areas covered with gravel and sporadically with stones or boulders can be found.

The dynamic coastal zone is characterized by a strong process of sediment resuspension and transport. The bottom of the deep part of the zone is covered with muddy sediments, while the Slupsk Furrow is an erosion area with till and gravel in the outer parts and mud covered clay in the centre. The predominance of sandy sediments and the dynamic nature of the photic zone of the open sea do not favour the development of macrophyte vegetation.

1.3 Characterization of the Marine Environment

Sandy bottom biotopes are dominated by macrophyte vegetation only occur in the sheltered Puck Bay. Some small areas of stony bottom covered with macrophytes occur on the Slupsk Bank and in the Gulf of Gdansk.

The degree of naturalness and degradation of biotopes varies, with the greatest changes being observed below the halocline in the Gdansk and Bornholm Deep. Long-lasting periods of oxygen deficiency have caused the disappearance of almost all macroscopic life on the bottom and the impoverished plankton has limitated fish reproduction. Recent observations have shown that a similar process is taking place in the deepest part of the Slupsk Furrow.

Great changes have also been observed in the shallow water biotopes in the low salinity part of Puck Bay where the underwater meadows are reduced in size and have changed in structure. Nano or two species meadows have begun to prevail and a community with *Fucus vesiculosus* and *Furcellaria* spp. as dominant species, may no longer exist. A predomination of brown algae species *Pilayella litoralis* and *Ectocarpus siliculosus* as the only representatives of phytobenthos in some areas is a new phenomenom. Changes in macrophyte vegetation were followed by changes in structure of benthic and planktonic communities.

Such drastic changes have not been observed in the open waters above the halocline. Biotopes with a high degree of naturalness occur there, those from the bottom of the Slupsk Bank are an example. Good light conditions together with the rocky bottom in the Slupsk Bank favour the development of macrophytes and associated bottom fauna. In that region the following macrophytes were observed: *Fucus vesiculosus, Furcellaria lumbricalis, Delesseria sanguinea* and some others, which have probably disappeared in the Gulf of Gdansk.

1.4 Threats

The discharges of nutrients and pollutants, carried into the Polish coastal bays from the waters of the Vistula and Oder rivers are considered the greatest threats to biotopes in the Polish zone.

Alien species pose a potential threat which is difficult to foresee and evaluate. Recent studies have shown a very dynamic development of the polychaete *Marenzelleria viridis* which has been brought from America with ballast waters, and which has become a dominant species in waters close to river outlets. *Negobius melanostomus*, a fish brought from the Caspian Sea, is becoming more dominant in the Gulf of Gdansk.

1.5 Conservation

The European Red List of Threatened Animals and Plants includes the following species which are found in the Polish zone: harbour porpoise, ringed seal, sturgeon (extinct), and lavaret. Species conservation comprises all Baltic mammals, nearly all birds occurring permanently or periodically in the Polish zone, and the following fish: *Acipenser sturio, Alosa fallax, Alosa alosa, Pomatoschistus microps, Myoxocephalus quadricornis, Liparis liparis, Spinachia spinachia*.

The Baltic Sea Protected Areas (BSPA) now include the Wolinski National Park and some adjacent areas, and there are ongoing plans aimed at delimiting the areas at the Leba region, the Slupsk Bank, the Gulf of Gdansk and the Pomeranian Bay.

2. Terrrestrial Biotopes (Jacek Herbich)

2.1 General Introduction

The list of available literature concerning terrestrial biotopes consists of more than 230 references and they vary greatly in their content. Some of them deal with the whole nature of the most interesting and valuable parts of the coastal region, protected as national parks (Wolinski and Slowinski National Parks) and landscape parks (among others Hel Peninsula, Puck Bay and Vistula Sandbar). These papers include maps of the real vegetation. Most papers refer only to selected problems of the coastal region, e.g., differentiation of some plant communities. There are only a few papers dealing with specified types of vegetation along the whole coast, for instance dune pine forests or halophilous communities. Numerous sources such as geological maps, maps of habitats and treestands, maps of wetlands which include the whole investigated area, as well as local maps of real vegetation and aerial photos of some parts of the coast, have given only indirect information. On the basis of all available materials a draft map of distribution of biotopes at the scale of 1:100,000 was prepared. It was found that because of the intensity in human activity and the rapid changes caused by other factors, a great portion of the material used included historical data. As a result all the information collected in the draft map has been verified in the field before the final map of biotopes and the list of their threats and human impacts was completed. Main contributors to the terrestrial biotopes chapter were Maria Herbichowa, Zofia Lenartowicz, Leslaw Wołejko, Kazimierz Furmańczyk, Ryszard Markowski, Hanna Piotrowska, Paweł Sągin. This work was coordinated and financially supported by the National Foundation for Environmental Protection in Warsaw and the Ministry of Environmental Protection, Natural Resources and Forestry.

2.2 Geographic Description

The Polish coast is about 500 km long. The coastal habitats zone, which generally reflects the creating or destructive activities of the sea, varies in width and is dependent, among others, on the type of landscape. This zone is narrowest along the cliff dominated areas of the coast, where the sea abrades the dilluvial uplands. In such places this zone rarely exceeds a width of 20 - 30 metres. The broadest sections of this zone are located along the low-lying, marshy shores of bays and river mouths, where brackish waters can extend far inland. The farest influence of the sea is found at Szczecin, located approx. 60 km from the shore.

2.3 Characterization of the Terrestrial Environment

Two main types of the coast dominate in Poland - flat coast with a belt of dunes, which is ca 400 km long, and cliff coast which is ca 100 km long. At the foot of both there is an almost continuous strip of sandy beach. Pebble beaches occur only locally and periodically at the foot of cliffs after some storms when there is an onshore wind. Sand transported by currents and waves can cover pebbles temporarily until removed by storms.

The width of the beach usually is not greater than 10 - 50 metres. On the back of the seashore and highest parts of the beach, foredunes can develop. They form low, narrow and discontinuous belts and are mostly covered, initially by forms of *Elymo-Ammophiletum* and in one locality by *Agropyretum juncei*. Behind the foredunes there is a rampart of white (yellow) dune, overgrown by *Elymo-Ammophiletum*. As the transport of sand gradually stops the accumulation of humus increases and grey and brown dunes develop. The grey dunes are covered by *Helichryso-Jasionetum*, and brown dunes are usually overgrown by a special coastal pine forest *Empetro nigri-Pinetum* and more rarely by broad-leaved forests with oak, beech and birch, usually classified as *Betulo-Quercetum*. In some places of the grey dunes, mostly on the edges of pine forests and in clearings, dwarf shrub communities develop, mostly *Calluna vulgaris* and/or *Empetrum nigrum*. Slacks occur between dunes. Depending on hydrological conditions and the stages of vegetation succession dunes can be overgrown by various types of nonforest vegetation and forest plant communities on mineral, organic-mineral or organic soil. In some dune slacks a thin layer of peat has accumulated. On the Leba Bar in the Slowinski National Park (a Biosphere and Ramsar Reserve) there is an unique complex of mobile dunes and dune slacks.

Behind the dune zone a belt of mires (fens and bogs), wetlands on mineral substratum and coastal lakes occur. These lakes and wetlands were formerly sea bays which have been separated from the sea by sand bars. The lakes are shallow, connected with the sea and brackish (salinity of the water is 0.4‰ - 3‰) as the result of an influx of sea water during storms. The shores of these lakes are flat and usually swampy, overgrown mostly by *Phragmites australis* and swamp forests. Most of the mires are fens, but in few places there are raised bogs. The southern border of the coastal zone is dilluvial upland which adjoins this belt.

The cliff sections of the Polish coast are of Pleistocene origin and are built up mainly from moraine clay and more rarely from sand. The cliff biotope diversity depends on the intensity of abrasion: the intensively abraded cliffs are bare or covered only by initial herbal vegetation, slow abrasion enables the development of shrubs and forests. Dead cliffs are forested.

In a few places along the Polish coast, on the low-lying, peaty river banks and bay shores flooded by sea water, halophilous vegetation can be found. On meadows and pastures it is represented mainly by *Juncetum gerardii*. Tall herb communities (*Scirpetum maritimi* and *Soncho-Archangelicetum*) develop in wet depressions between halophilous meadows, in ditches and along river and lagoon banks.

2.4 Threats to the Coastal Environment

The degree of naturalness and degradation of biotopes varies strongly. Generally all biotopes are threatened by various forms of human activities. Dune biotopes are most threatened by various ways to stabilize the sand. On the foredunes and white dunes grasses are commonly planted, primarily *Ammophila arenaria*. As a result of such management, the rampart of white dunes is partly artificial. Moreover, on white dunes shrubs are very often planted - mainly *Salix daphnoides* and *Rosa rugosa*. Almost everywhere grey dunes are artificially afforested, mostly *Pinus sylvestris* is planted, but not long ago some alien species like *Pinus mugo, P. banksiana, P. nigra* and *P. strobus* were introduced. On large areas of brown dunes natural broad-leaves forests have been cut down and replaced by pine monocultures. To a great extent the dune slacks have been drained and afforested. The anthropogenic changes mentioned are accompanied by natural factors: intensified abrasion of dunes causes “dune cliffs” that border on a belt of planted forests. To protect dunes against abrasion on the most threatened sections of the coast an artificial bank of beach sand is heaped up and in some places strengthened with stones. Strong recreational pressure causes, among other things, the removal of organic beach ridges, and dunes are changed into parks with paths, lawns and planted trees. As a result on the prevailing part of the Polish coast, the natural zonation of dune biotopes and vegetation has disappeared.

Most of the mires and other types of wetlands located between dunes and Pleistocene uplands have been drained. Their natural nonforest and forest vegetation has almost completely disappeared and has been replaced by grasslands, fields and tree plantations. In numerous places, especially on raised bogs, peat has been exploited. Extensive use of wet meadows on the previous fen habitats has caused the development of economically worthless plant communities dominated by *Deschampsia caespitosa* and/ or *Juncus effusus*. In some places, where the use of wet meadows has been abandoned, secondary vegetation dominated by reeds has developed. Extremely threatened are halophilous meadows, caused by the general transformation of wetlands, and inappropriate and ineffective forms of protection. This has resulted in the disappearance of protected halophilous plant communities and species in two nature reserves.

Water in almost all coastal lakes is considerably polluted. One of the main factors is sewage fed directly into the lakes or from rivers. Not long ago sewage was mostly untreated, although now sewage treatment facilities are slowly being constructed. Additionally, water in rivers is loaded with fertilizers washed out from fields. Large parts of the rivers have artificial features: beds are regulated and straightened, and natural banks are changed into embankments. Oxbow lakes have almost disappeared and are now very rare.

Cliffs are less threatened in comparison to dunes and wetlands, and damage occurs only on coastal sections where towns, villages and some lighthouse walls at the foot of the cliff are constructed and sometimes additionally secured with boulders placed on beaches. On such cliff sections primary biotopes disappear and forests start to develop. In one case (the Rozewie Cape) the planting of trees to stabilize the cliff has been documented.

2.5 Conservation

The most valuable parts of the Polish coast are protected as two national parks, two landscape parks, several areas of protected landscape and several nature reserves. In the Slowinski National Park, complexes of mobile dunes, coastal lakes and adjacent mires are protected; this park is also Biosphere and Ramsar Reserve. The Wolinski National Park protects various forests on Pleistocene upland on Wolin Island, cliffs and a fragment of the Swina delta. The Coastal Landscape Park comprises of the Hel Peninsula, cliff, dune, marshy coast and Puck Bay. The Landscape Park of the Vistula Bar protects a part of the bar enclosing the Vistula Lagoon. All these parks adjoin the already established or planned sea protected areas, which are elements of the BSPA (Baltic Sea Protected Areas).

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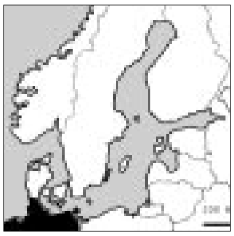

INTRODUCTION TO THE MARINE AND COASTAL ENVIRONMENT OF GERMANY

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1. General Introduction

In the HELCOM Project, Mr Boedeker from the Federal Agency for Nature Conservation (BfN) acted as the official contact person for Germany. The BfN organized one national expert seminar during August 1996 to compile the German part of the Red List. The experts based their work on the German Red List of Biotopes that covers all of Germany and also contains Baltic marine and coastal biotopes (Riecken *et al.*, 1994). After that meeting the contact person consulted the contributors about each meeting of the HELCOM Project Group.

Main contributors to the Red Data Book:
Jürgen Gemperlein, (contact person Schleswig-Holstein), Christof Herrmann, (contact person Mecklenburg-Vorpommern), and the following further experts: Fritz Gosselck, Helmut Kühne, Reinhard Lampe, Henning von Nordheim, Uwe Riecken, Hilmar Schnick, Joachim Voss.

2. Geographic Description

The length of the German coastline of the Baltic Sea is about 2,300 km (including the coasts of all bays and lagoons), of which approximately 1,700 km belong to the Federal State of Mecklenburg-Vorpommern and 600 km to the State of Schleswig-Holstein. The fjord like bay *"Flensburger Förde"* forms the border between Schleswig-Holstein and Denmark in the north-west, and the Oder Lagoon is the border between Mecklenburg-Vorpommern and Poland in the east.

3. Characterization of the Marine Environment

The German part of the Baltic Sea belongs to two different geographic regions: The Kiel- and Mecklenburg Bay in the west are parts of the Kattegat/Belt Sea area, whereas the Prerow Bay, Arkona Basin and Pomeranian Bay in the east belong to the Baltic Proper. The regions are separated by the Darss Sill (Fig. 2). Both bodies of water are very shallow; only a few areas are deeper than 25 m (e.g., the Arkona Basin with a maximum depth of 53 m).

The surface water of the Kiel Bay (northern Belt Sea) has a mean salinity of 15 to 25‰ (PSU), the Mecklenburg Bay (southern Belt Sea) 11-13‰, and that of the Prerow Bay, Pomeranian Bay, and Arkona Basin (Baltic Proper) 6-10‰. The more saline bottom water has 18 to 25‰ in the Kiel Bay, 14 to 18‰ in the Mecklenburg Bay and 11-13‰ in the Arkona Basin (Landesamt für Natur und Umwelt des Landes Schleswig-Holstein, 1998; Hupfer, 1984; Umweltminister des Landes Mecklenburg-Vorpommern, 1994; Matthäus, 1995).

Boulder clay is a typical and widely spread glacial mixed sediment of the south-western Baltic Sea with grain sizes from clay to big stones and a large amount of marl. It has the character of a hard bottom, because it is bound together by calcium carbonate. Under conditions of erosion, boulder clay is also a basic material for new sedimentation processes. In that case, its material - made up of various grain sizes - is taken up by currents, transported, sorted, and re-deposited at varying distances from the erosion area, depending on grain size and transport energy. Once the finer material is eroded, only stony and larger fragments of the boulder clay remain on the sea bottom. This "residual sediment" is found along almost the entire coast. The sand is redeposited mainly along the coasts and in larger offshore areas of the Kiel- and Pomeranian Bay. Sandy bottoms also occur between Mecklenburg Bay and Arkona Sea. In deeper basins, fjord like bays, and channels, silt and mud deposits dominate (Köster & Lemke, 1995).

The photic zone may extend down to 20 m and even more, for example, at the Walkyrien Ground and Kadet Trench. However, there are also areas where even on stones at a depth of 2-3 m no vegetation can be found, since light transparency is very much reduced due to eutrophication or riverine inflow, as is the case in the Oder outflow area of the Pomeranian Bay (Meyer, 1997).

The Darss Sill forms a natural border for the distribution of many marine euryhaline species like the bivalve *Corbula gibba* and the polychaets *Terebellides stroemi* and *Pectinaria koreni*. Therefore, beyond the Darss Sill, the number of species is much lower than in the Belt Sea. According to recent (1993-1996) macrozoobenthic records, the number of species in the Mecklenburg Bay was 106, whereas beyond the Darss Sill only 68 species have been found (Gosselck *et al.*, 1996).

Another typical feature is the fluctuation of species number and distribution. Several species cannot reproduce under the brackish water conditions of the Belt Sea and the Baltic Proper, but can settle these regions if larvae or juveniles are transported from the Kattegat by inflowing currents. Such species may disappear during long stagnation periods and return with the next stronger water inflow. Examples are the echinoderm *Ophiura albida*, the bivalve *Abra alba,* and the crustacean *Phoxocephalus holbölli* (Gosselck *et al.*, 1996).

Besides the salinity, sediment character and oxygen availability are the main factors determining the composition of the marine benthic communities. The most important benthic communities of the German part of the Baltic Sea can be described as follows (Gosselck, 1996):

Shallow stone and boulder grounds 0-10 (20) m: These areas are rich in macrophytes, epizooic organisms, and small and juvenile fishes. A dominant species growing on the stones and boulders is the common mussel (*Mytilus edulis*). Typical algae are *Cladophora* spp. and *Enteromorpha* spp. in the shallow zone, whereas *Fucus vesiculosus* may reach down to 10 m, and red algae like *Phyllophora, Ceramium, Polysiphonia, Delesseria sanguinea, Furcellaria fastigiata* etc. even up to a depth of 20...24 m. Remarkable *Laminaria saccharina* occurences have been found down to 16...22 m depth at Walkyrien Ground, on the slopes of the Kadet Trench and around northern Rügen (*"Jasmund*", *"Wittow*"). A unique feature is the dense occurrence of *Chorda tomentosa* on stone fields of the Adler Ground (Meyer, 1997; Gosselck, 1998).

Sand and fine sand, 0-10 m: Up to a depth of 8 m the sand areas can be settled by eel grass (*Zostera marina*). For example, eel grass meadows are a typical feature of the shallow waters at Orth Bay/Fehmarn, off the coast between Travemünde and Klützhöved, in the outer Wismar Bight/north of the Island Poel, and north of Zingst Peninsula. But in many cases sandy bottoms lack or have only poor eel grass coverage. The common mussel (*Mytilus edulis*) may form extensive banks, which serve as a secondary hard substrate for red algae. Abundant animal species of sandy bottoms which are not covered by eel grass or common mussel (*Mytilus edulis*) banks are the bivalves *Mya arenaria*, *Macoma balthica*, and, east of the Darss Sill, also *Cerastoderma lamarcki*. The polychaets *Arenicola marina* (only west of Hiddensee Island), *Pygospio elegans*, *Heteromastus filiformis,* and *Scoloplos armiger,* as well as the crustaceans *Bathyporeia pilosa* and *Crangon crangon* are also typical representatives of the community.

Fine sand with increasing silt content, ***10-15 m:*** Macrophytes are scarce, although brown and red algae can be found in some areas. In some regions, common mussels and drifting brown and red algae may cover the bottom. Characteristic species are the molluscs *Mya arenaria*, *Macoma balthica*, *Cerastoderma lamarcki*, *Hydrobia ulvae*, the polychaets *Scoloplos armiger*, *Heteromastus filiformis, Terbellides stroemi,* and *Pygospio elegans*. West of the Darss Sill, the higher salinity of this zone allows marine species like the starfish *Asterias rubens* and the polychaets *Nephtys* spp., *Travisia forbesii,* and *Pectinaria koreni* to exist.

Silty sand and silt, 15-20 m: In the Belt Sea, this zone forms the last ecological niche for a marine fauna, which previously had also settled deeper areas, but nearly became extinct there due to oxygen deficiency. The high salinity and low temperature of the zone between 15 and 20 m still provides appropriate conditions for communities of long-lived bivalves such as *Arctica islandica* and *Astarte* spp. In recent years, the abundance of the common mussel has increased considerably, displacing formerly dominant species such as *Mysella bidentata*, *Macoma balthica,* and *Scoloplos armiger*. Upwelling of oxygen-deficient deep water occasionally may kill the benthic fauna, with the exception of *Arctica islandica* and the *Astarte* species, which can survive oxygen deficiency for a certain time.

Oxygen-deficient silt zone below 20 m: The former community of long-lived bivalves like *Arctica islandica* and *Astarte* spp. nearly died off in the 1960s due to oxygen deficiency. In a few areas, such as the north-western Mecklenburg Bay, *Arctica islandica* and a number of other typical species still occur in considerable abundance. However, since the 1960s, oxygen deficiency is a regular phenomenon during summer stagnation. After the mixing of the entire body of water in autumn, the bottom becomes settled by larvae and immigrants from neighbouring areas. Typical species of this opportunistic short-term community are *Halycryptus spinulosus*, *Capitella capitata*, *Polydora ciliata*, *Diastylis rathkei*, *Harmothoe sarsi,* and various juvenile mussels.

Oxygen-rich silt zone below 20 m: In the German part of the Baltic Sea, there are only a few of these areas such as the Kadet Trench and the northern Lübeck Bay. The biocoenosis is characterized by a high diversity of marine species. The crustacean

Diastylis rathkei and the bivalves *Macoma balthica* and *Mytilus edulis* are dominant. In the Kadet Trench, the red algae *Delesseria sanguinea* has been found up to a depth of 24 m, and *Laminaria saccharina* up to 18 m (Gosselck, 1998).

Lagoons and fjord like bays: Long and narrow fjord like bays (*"Förden*") are a characteristic feature of the north-western part of the German Belt Sea (Schleswig-Holstein), whereas shallow lagoons (*"Bodden", "Haffs*") are typical for the eastern part of Mecklenburg-Vorpommern.

The hydrographic conditions in the deep fjord like bays (*"Förden*") are mainly influenced by the meteorologically-dictated water exchange with the Baltic Sea and the regionally different freshwater inflow. The *"Kieler Förde*" and *"Eckernförder Bucht*" with their wide and open mouths are strongly influenced by the hydrographic conditions of the adjacent sea, whereas the narrow *"Schlei*" and *"Flensburger Förde*" show a reduced water exchange. The latter are heavily polluted with nutrients from diffuse sources and suffer from eutrophication problems. The *"Schlei*" is the most nutrient-enriched fjord like bay of Schleswig-Holstein; it has been intensively polluted for almost 5 decades (Landesamt für Wasserhaushalt und Küsten, 1978).

In the inner *"Schlei*", year-round intensive blooms of the blue-green algae *Microcystis aeruginosa* dominate the primary production and lead to anaerobic mud formation virtually everywhere. A hundred years ago, the bottom of the shallow *"Schlei*" was covered with an abundant submersed vegetation. Today, this has nearly vanished, and the species diversity of the macrozoobenthos is reduced. Some species are now more abundant, such as the bivalve *Mya arenaria,* the polychaets *Alkmaria romijni, Streblospio shrubsoli, Nereis* spp., and *Marenzelleria viridis,* as well as midge larvae (Chironomidae) (Pahnke, 1976).

In the eastern part of the *"Schlei*", near Schleimünde, the situation is much closer to the natural conditions. A variety of plants like *Zostera marina, Z. noltii, Potamogeton pectinatus,* and *Chorda filum,* mussel beds *(Mytilus edulis)*, and a considerable number of other zoobenthic animals are found. Of great importance for migrating birds is a wind-generated wadden area with a dense population of snails (*Hydrobia* spp.), crustaceans (*Corophium volutator)* and polychaets (*Nereis diversicolor)* (CRM, 1997a).

The other fjord like bays of the western Baltic Sea are much deeper (down to 30 m) than the *"Schlei*", and in summer, a seasonal pycnocline inhibits the vertical mixing of water. Especially in the deep parts of the *"Flensburger Förde*", deficiency of oxygen is observed every year. The oxygen depletion occasionally leads to hydrogen sulphide formation (H_2S). As a consequence, bottom animal and fish kills occur. Therefore, species number and composition of macrozoobenthos is partly reduced to some resistent species. Dominant species are the polychaets *Polydora ciliata, Capitella capitata, Heteromastus filiformis,* and *Anaitides maculata,* the bivalves *Corbula gibba, Abra alba,* and *Mysella bidentata,* the crustaceans *Diastylis rathkei* and *Corophium volutator,* nematodes, and oligochaetes (Bluhm, 1990). Species composition is much more diverse in shallow sediments above the thermo- and halocline, e.g., in the outer "*Flensburger Förde*" at the designated Baltic Sea Protected Area "*Geltinger Birk/Kalkgrund*". During the last years, 176 species have been found, including such endangered species (according to the Red Lists of the German Baltic Sea, Merck & v. Nordheim, 1996) like *Astarte montagui, Macoma calcarea, Scrobicularia plana, Euchone papillosa,* and Scalibregma inflatum (CRM, 1997b).

Due to the elevated organic production, deterioration of light climate (decrease of *Secchi* depth) might be responsible for the observed changes in depth distribution of submersed plants. In the *"Flensburger Förde*", some of the 50 observed species of bottom vegetation live today only in shallower areas (Sund, 1991).

The *"Bodden*" are a characteristic feature of the eastern part of the German Baltic Sea. In the western part, only the *"Wismar-Bucht*" (Wismar Bight) and the *"Dassower See*" have the characters of a *"Bodden*". *"Bodden*" are shallow waters which are clearly separated from the Baltic Sea by surrounding land and/or submarine sills. Water exchange with the sea is therefore impaired. Depending on the degree of separation and the amount of freshwater inflow, the *"Bodden*" differ with respect to salinity ranging from nearly freshwater conditions (inner Oder Lagoon) to more than 10‰ (Wismar Bight). Some *"Bodden*" have a typical estuarine character showing a distinct salinity gradient (Darss-Zingst Lagoon Chain, estuary of the river Warnow, Oder Lagoon). Strong eutrophication effects are typical for lagoons with very low water exchange and/or high freshwater inflow (*"Kleiner Jasmunder Bodden*", Oder Lagoon). A higher proportion of freshwater species and low numbers of marine species are typical for most of the lagoons. Charophytes and vascular plants like *Potamogeton* spp., *Ruppia maritima, R. cirrhosa,* and *Zannichellia palustris* may dominate, if light transparency is sufficient. *Zostera marina* and *Zostera noltii* may occur in lagoons with higher salinity (Wismar Bight, Greifswald Lagoon). The depth of the photic zone differs depending on eutrophication impacts and water exchange. It varies between <0.5 m and 3-4 m (HELCOM, 1996; Lampe, 1997).

For the Oder Lagoon, the dominance of two alien species - the bivalve *Dreissena polymorpha* and the polychaet *Marenzelleria viridis* - is obvious.

A characteristic habitat of some lagoons are wind-generated "wadden" areas. These silty sand flats are exposed at lower water levels. They are important resting and feeding sites for breeding and migrating waders. The largest wind-generated "wadden" areas are around the sandy spits of Hiddensee Island (*"Gellen*", *"Bessin*"), at the south coast of the Greifswald Lagoon (*"Wampener Riff*", *"Struck*") and around the bird island *"Langenwerder*" in the outer Wismar Bight.

4. Characterization of the Coastal Environment

The landscape of the German shoreline is characterized by moraine cliffs, Holocene accumulation areas, and coastal wetlands. In the north-eastern part of the Island Rügen, the famous chalk cliffs (softrock) are a special landmark.

Cliffs:
Cliffs form a rather large proportion of the borderline between land and sea. In Schleswig-Holstein, they extend over 90 km, 35 km of which are eroding. On the outer coast of Mecklenburg-Vorpommern, 128 km of a total of 354 km is cliff coast, 74 km being heavily influenced by erosion. Except for the chalk cliffs of Jasmund (about 8 km), the cliffs are abraded moraines from the last ice age. Coastal abrasion is rather strong in many regions; the average loss amounts 22 m/century in Schleswig-Holstein and 34 m in Mecklenburg-Vorpommern. In the most exposed areas, it may even reach values of up to 210 m/century ("*Rosenort*" near Rostock) (Ministerium für Bau, Landesentwicklung und Umwelt Mecklenburg-Vorpommern, 1997).

The coasts of the fjord like bays of Schleswig-Holstein and the lagoons of Mecklenburg-Vorpommern are also characterized by an alternation of low-lying coasts and cliffs. However, since the abrasive forces are weaker, the backward movement of the cliffs is slower. In some places, cliffs which have not been exposed to abrasion processes for a long time have become inactive and thus covered with trees.

Biotope complexes of accumulation areas:
The material abraded from the cliffs is transported along the coast and accumulates in sheltered areas, where it forms sand bars, spits, and ridges. From the accumulated material, wind blows up dunes, and waves and ice form beach ridges. Depressions behind such sandy barriers become filled with sea and precipitation water - brackish water lagoons, and in further succession, wet dune slacks, swamps, and mires evolve. At an early stage, the dunes are settled by pioneer vegetation (foredunes, white dunes), which may eventually develop to a climax forest vegetation (brown dunes).

Such dune areas can be found connecting Pleistocene moraine cores, where Holocene accumulation processes have formed natural land bridges. An example is the narrow Holocene land bridge *"Schaabe*" on Rügen Island between the Pleistocene cores *"Jasmund*" and *"Wittow*". The same process is not yet complete for the spits of the Island Hiddensee (*"Gellen*", *"Bessin*"). However, these spits cannot connect with the neighbouring land as long as the shipping channels are kept open by dredging operations.

The largest accumulation area of the German Baltic coast is the Darss-Zingst Peninsula with the spit *"Darsser Ort*" as the most active accumulation site. Here, one can find all typical biotopes, such as sandy spits without vegetation, brackish water lagoons with reed stands, all dune formations from foredunes to brown dunes covered with pine forests, as well as dune slacks with swampy alder and oak forests.

In Schleswig-Holstein, the only dune complex covered with (almost) natural forest is the nature reserve *"Bewaldete Düne bei Noer*" (wooded dune at Noer, Fig. 74).

The brackish water lakes *"Kleiner und Großer Binnensee*" (Schleswig-Holstein) are typical examples of how coastal lakes are separated from the sea by growing and expanding sand bars (HELCOM, 1996; Klug *et al.*, 1988). On the coast of Mecklenburg-Vorpommern, the *"Riedensee*", *"Conventer See*" and *"Heiligensee*" are similar examples of coastal lakes.

Salt marshes and other coastal wetlands:
Salt marshes are a characteristic feature especially of the Vorpommern lagoon coasts. In the western part of the German Baltic Sea and on the outer coast, they are less common. They developed on Holocene and

Pleistocene sand flats or ground moraines in the flood range of the Baltic Sea at a height between the mean water line and 70 cm above it. Above this height, the influence of salt water is not strong enough for the development of typical salt plant communities (Krisch, 1990). Depressions within the salt marshes which are flooded for most of the year become covered with an annual vegetation of *Spergularia maritima*, *S. salina* and *Salicornia europaea* when they dry out during summer.

In contrast to the North Sea, the large salt marshes of the southern Baltic are seminatural habitats. Cattle grazing is an essential factor for their existence. If grazing is stopped, reed stands quickly develop.

Typical for most of the salt marshes are thin peat layers. Older peat layers consist of deposited reed remains, whereas, as a result of grazing, the upper layer consists of a distinct salt meadow peat. Organic and mineral sedimentation have alternated with the sea level fluctuations since the end of the Littorina transgression 5,700 years ago, so that in many cases the soil profile shows an alternation of organic layers with mineral sediment accumulations. Peat layers are normally thin. Only in a few cases do they reach a thickness of 1 m or more, e.g., in the Oder Lagoon area.

Formerly, salt meadows were quite extensive on the coast of Mecklenburg-Vorpommern. But in the middle of the last century, dyking and drainage was started, first with small summer dykes, later with high winter dykes, excluding every influence of salt water. During the 1960s and 1970s of this century, nearly all of the remaining larger coastal meadows became subject to amelioration efforts. The final situation was that only about 15% of originally 43,404 ha had been left to the influence of coastral floods. Most of these areas are of small size - areas for which amelioration efforts did not seem to be profitable. Of the remaining 6,600 ha of undyked floodplains, today about 3,700 ha are managed as salt meadows, i.e., they are grazed by cattle. The rest has been abandoned and reeds have developed. In recent years, efforts have been started to restore salt meadows and other coastal floodplains. Some projects have already been realized (Holz *et al.*, 1996; Herrmann & Holz, 1997).

On the Baltic Sea coast of Schleswig-Holstein, salt meadows are naturally less widely distributed than in eastern Mecklenburg-Vorpommern. However, the history has been about the same. In addition to a loss of area, there is also a loss of quality, which becomes evident, for example, by the decrease of typical salt meadow communities (e.g. *Junco-Caricetum extensae*, *Blysmetum rufi*) (Dierssen, 1988). Larger areas of salt meadows in Schleswig-Holstein still exist on the coast between the south-west of the island Fehmarn and Heiligenhafen, around the *“Neustädter Binnenwasser*” and around coastal lakes at *“Hohwachter Bucht*”, *“Geltinger Birk*” and *“Schlei*”.

A different type of coastal wetlands are the meadows in the Peene mouth area (Mecklenburg-Vorpommern) - several thousand hectares of fen with very well-developed peat layers. This area also includes a raised bog which has grown up on the fen. The salt influence is very weak here due to the low salinity of the Oder Lagoon and the freshwater inflow of the river Peene. About 1,500 ha of fen has been kept without drainage and, for decades, without use. Today it is covered with reeds and swamp shrubbery (willows etc.). However, most of the fen was dyked and drained during the past decades. As a result of peat degradation, the soil surface sunk down by up to 1 m. Under current conditions, the agricultural management of these areas is far from being economically profitable. After a dyke break in 1995, an area of nearly 1,800 ha has converted into a swampy, shallow water plain with small mud and grass islands, which are used by gulls, terns, ducks and grebes as breeding sites.

5. Threats

Major threats for the marine biotopes are eutrophication and other forms of pollution (especially oil pollution). Sand and gravel extraction and dumping of dredged material may also impair marine life in the areas concerned. The impact of fisheries is mainly the killing of sea ducks and marine mammals as unwanted by-catch, especially of set-net fishery. Since bottom trawl fishery is prohibited by law in the coastal waters up to 3 nautical miles from the base line, the most sensitive benthic communities can be considered as protected from this kind of disturbance. The construction of offshore wind parks might become a future impact, especially to migrating, resting and wintering sea birds, but also to benthic biotopes which could be affected by loss of area and alteration of sediment dynamics. The effects of electromagnetic fields of submarine power cables are still poorly understood and need further investigation.

Resting and feeding birds can become disturbed by leisure activities, such as wind surfing and boating.

The coastal biotopes are threatened to varying degrees. Cliffs actually do not seem to be threatened; however, some stretches have been consolidated by stone walls in the past so that they have changed their character and lost their function as sediment suppliers. The large dune areas are mostly situated within protected areas (national parks and nature reserves). In some locations, impact results from tourist facilities (e.g., campgrounds) or disturbances of sediment dynamics (e.g., by coastal defence systems, harbours, and maintenance of shipping channels). Dunes in the vicinity of sea resorts and sandy beaches are negatively impacted by recreational activities. In addition, coastal defence measures such as beach nourishment and construction of coastal defence dunes affect such habitats in some areas.

Most coastal wetlands are heavily disturbed by continuing drainage and intensive agricultural use. Salt meadows are threatened by abandonment or inappropriate grazing regimes. The bird fauna of these areas is highly endangered by the increase of predator density during the last years, especially of foxes as a consequence of rabies vaccination.

6. Conservation

Some large and numerous smaller marine and coastal areas are protected as national parks or nature reserves. The largest one is the national park *“Vorpommersche Boddenlandschaft*“ which covers an area of 80,500 ha, including 68,700 ha of water. Other large protected areas are the national park *“Jasmund*“ (3,000 ha) and the nature reserves *“Mönchgut*“ (2,340 ha), *“Halbinsel Wustrow*“ (1,940 ha) *“Peenemünder Haken, Struck und Ruden*“ (1,870 ha), *“Insel Koos, Kooser See und Wampener Riff*“ (1,560 ha), *“Altwarper Binnendünen, Neuwarper See und Riether Werder*“ (1,460 ha) *“Anklamer Stadtbruch*“ (1,200 ha), *“Tetzitzer See mit Halbinsel Liddow und Banzelvitzer Bergen*“ (1,088 ha) in Mecklenburg-Vorpommern, while the largest marine and coastal nature reserves of Schleswig-Holstein are *“Dassower See und Inseln Buchhorst und Graswerder (Plönswerder)*“ (800 ha) and “*Geltinger Birk*“ (773 ha). Further agglomerations of nature reserves in Schleswig-Holstein are on the Fehmarn Island (*“Grüner Brink*”, *“Wallnau*”, *“Krummsteert-Sulsdorfer Wiek*” (a total of 730 ha) and in the Hohwacht Bay region with the protected areas *“Sehlendorfer Binnensee*”, *“Kleiner Binnensee und angrenzende Salzwiesen*”, *“Kronswarder*” (a total of 490 ha). Including 11 further existing coastal nature reserves, about 10% of the Schleswig-Holstein Baltic Sea coast is currently protected. Twenty-seven further areas covering another 12% of the coastline have been recommended for designation as nature reserves by the nature conservation authorities (Landesamt für Natur und Umwelt des Landes Schleswig-Holstein, 1981, 1993,1989, 1998).

A number of areas are also designated as EC Bird Directive Areas, among them the lagoons Wismar Bight (19,900 ha) and Greifswald Lagoon (85,000 ha) in Mecklenburg-Vorpommern. These areas are also subject to the provisions of the EC Habitats Directive.

In Schleswig-Holstein, all coastal nature reserves have been proposed for designation as “NATURA 2000” areas according to the EC Habitats Directive. Currently, large areas of the coast (especially in the regions of *“Flensburger Förde*”, *“Schlei*”, *“Kieler Förde*”, *“Hohwachter Bucht*”, Fehmarn Island) as well as numerous shallow waters areas along the entire coast are being assessed with respect to their suitability for becoming “NATURA 2000” areas and Baltic Sea Protected Areas (BSPA) according to HELCOM Recommendation 15/5 (Ministerium für Umwelt, Natur und Forsten, 1997).

The German Federal Nature Conservation Act in Article 20c contains a list of generally protected biotopes. The different Federal States (*“Länder”*) have the obligation to implement this legal biotope protection by their own legislation. They are also entitled to enlarge the federal list by adding further biotope types.

Thus, the most important legally protected coastal biotopes and biotope complexes by state law in Schleswig-Holstein and in Mecklenburg-Vorpommern are:

1) marine stone and boulder grounds (code no. 2.2.2)
3) cliffs (3.6),
4) reed stands (3.7.1),
5) coastal meadows and salt marshes (3.7.2),
6) (brackish) coastal lakes (4.1.1.).

Furthermore, in Mecklenburg-Vorpommern lagoons (*“Bodden*” and *“Haffs*”, Complex G) are protected by law. In addition both states protect their coastal strip. Article 11 of the State Nature Conservation Act of Schleswig-Holstein is the legal instrument to protect the coastal strip for recreational purposes and against water pollution up to 100 m landwards from the mean water line. In Mecklenburg-Vorpommern, the protected coastal strip reaches 200 m land and seaward from the mean water line (Article 19 of the State Nature Conservation Act, 1998). Within this strip, particularly building activities are highly restricted. Under certain circumstances, both state nature conservation acts entitle the nature conservation authorities to grant exceptions from these regulations (Nordberg, 1994).

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DESCRIPTION OF MARINE AND COASTAL BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

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1. Introduction

Biotope complexes are larger units of coastal landscape, like major geomorphological formations, or large areas influenced by a specific physiographic feature.

When compiling the HELCOM Red List of Biotopes it became apparent that it does not include biotope complexes. Thus the Red List of Biotope Complexes is a complement to the Red List of Biotopes.

In compliance with the precautionary principle, this list includes biotope complexes that are threatened or rare in some areas of the Baltic Sea, although they may be common and less threatened in other areas. This fact should be kept in mind when applying this list for the selection of future areas to be protected.

This list of biotope complexes is not intended to be complete and therefore should be updated when necessary.

2. Biotope Complexes:

A) Rocky coasts

A rocky coast (Fig. 20) is a long coastal stretch (> 1.0 km, usually > 10 km) where bedrock is the dominant feature consisting of a complex of different biotopes. Rocky coasts include cliffs as well as gently sloping rocky shores. They may consist of sedimentary bedrock, for example, limestone, chalk or crystalline bedrock, such as granite.

Remarks:
Rocky coasts are common along the northern coast of the Gulf of Finland, the coasts of the Bothnian Sea, and in most parts of the Swedish coast. In these areas rocky coasts are not as rare as in other parts of the Baltic Sea area, especially in the southern Baltic.

Examples of rocky coasts:

Denmark:	Northern coast of Bornholm (crystalline bedrock, granite), cliffs of Stevns (limestone) and Møen (chalk)
Sweden:	Areas dominated by gently sloping bedrock shores on the Swedish east coast
Finland:	Most parts of the outer archipelago areas in the Gulf of Finland and the Archipelago Sea; ca. 42% of the Finnish coast consists of bedrock (Granö *et al.*,1995)
Russia/St Pe.:	Gogland, western part of the Vyborg Bay, western part of Beryzovye Islands
Estonia:	Vilsandi
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	Chalk coast of Jasmund Peninsula (Rügen Island).

Cliffs (subtype of rocky coasts)
Cliffs (Fig. 21) are vertical rock walls marked by unbroken steepness, either made of material that has a surface resistant to abrasion (non-active cliffs) or material that has a surface which frequently erodes. This is usually caused by waves, currents, ice or temperature changes.

Examples of cliff coasts:

Denmark:	The bedrock cliffs of the north coast of Bornholm, Møns Klint (chalk cliffs), Stevns Klint (lime-stone cliffs)
Sweden:	Kullaberg, Hovs hallar, NW-Öland, west coast of Gotland
Finland:	Bedrock cliffs of Bothanian Bay
Russia/St Pe.:	None
Estonia:	(limestone cliffs) the cape of Pakri, Ninase and Panga (Saaremaa Island), Väike-Pakri, Osmussaar, Püssina, inactive cliff of Üügu (Muhu Island), Islet of Kessu; sand-stone cliffs of Meriküla, Rannamõisa, Türisalu

Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	Chalk cliff of Jasmund Peninsula (Rügen Island).

B) Sandy coasts

Sandy coasts (Fig. 22) are areas where sand is the dominant substratum along a long stretch of the shoreline (> 1.0 km, usually > 10 km) and hence a landscape formed by a complex of different sandy biotopes such as dunes and sandy beach ridges. Sandy coasts are mainly formed on accumulation sites of coastal sediment transport, but they may also occur where Pleistocene outwash plains meet the coast.

Dunes are hills or ridges of sand piled up by the wind. They are of various shape depending on (among others) the amount of sand, direction and transport ability of the wind, humidity of the sand, and vegetation. Dunes or large dune fields can shift, when they are without stabilising vegetation (shifting/ migrating dunes).

Beach ridges are formed by the forces of waves or ice. Unlike dunes they may contain also larger grain size fractions like shingles, pebbles and boulders.

Remarks:

Sandy coasts are distinguished here from moraine coasts by being more consistently formed out of sand particles.

Examples of sandy coasts:

Denmark:	Common (as such or in association with dune complexes)
Sweden:	Ootska Sandön, coast of Scania
Finland:	Hanko Peninsula, Dragsfjärd (Ölmos), Porvoo (Vessö)...
Russia/St Pe.:	Narva Bay, northern coast of the Gulf of Finland transition zone
Estonia:	Pärnu bay, Narva bay
Latvia:	Most of the Latvian coast of the Gulf of Riga and of the Baltic Sea
Lithuania:	Most of the Lithuanian coast
Russia/Kalin.:	Curonian Spit, Vistula Spit
Poland:	Major part of the Polish coast (80%)
Germany:	Darss-Zingst Peninsula, Schaabe (Rügen Island), SW-coast of Hiddensee, Schleimünde.

Examples of dunes:

Denmark:	Anholt, northern coast of Zealand and Læsø, along the east coast of Vendsyssel north of the Limfjord, along part of the south and west coast of Bornholm and the east coast of Falster
Sweden:	Gotska sandön, Skåne (east coast and the south-eastern art), southern Halland
Finland:	Vattaja, Cape Tauvo, Yyteri (near Pori), Hailuoto, Kalajoki, Hanko peninsula
Russia/St Pe.:	Coastline near Zelenogorsk and eastwards of Primorsk, Koporskaya Bay, Luzhskkaya Bay
Estonia:	Eastern and south-eastern coast of the Ruhnu Island, peninsulas of Kõpu and Tahkuna (Hiiumaa Island)
Latvia:	Most of the Latvian coast of the Gulf of Riga and of the Baltic Sea
Lithuania:	From Klaipeda to the Latvian border, except the coast at Karkle
Russia/Kalin.:	Curonian Spit
Poland:	Major parts of the Polish coast, moving dunes in Slowinski National Park in the central part of the Polish coast, near Leba
Germany:	Hohe Düne (Darss), NW-coast of Usedom Island, Schaabe (Rügen Island).

C) Moraine coasts

Moraine coasts (Fig. 23) occur as cliffs, as well as gently sloping and low-lying shores. There is a great variety of grain size compositions (boulder clay) ranging from big stones to clay, sometimes very well sorted, sometimes not sorted at all. In sheltered parts shores with (salt) marsh vegetation and fine sediment can be found alongside inactive cliffs. In exposed areas below the active cliffs beaches of fine material (fine sediment, sand, gravel etc.) are often missing since any accumulation of debris is swept away by waves and currents and only coarse components make up the beach. The near-shore sea bottoms at moraine coasts are usually a mixture of stone, gravel, sand, clay, gyttja etc.

Examples of moraine coasts and moraine cliffs:

Denmark:	Common in all coastal areas, moraine cliffs are most numerous along the northern coast of Zealand (Sjælland) and on the eastern coast of Jutland, often at the entrance of a fjord
Sweden:	The mainland side of southern Kalmarsund, Kåseberga, on the Swedish coast of the Bothnian Bay

Finland: Common in all coastal areas (about 40% of the Finnish coast consists of moraines), most numerous on the west coast
Russia/St Pe.: Southern part of the Gulf of Finland transition zone, mouth areas of Sista and Voronka rivers
Estonia: (moraine cliff or moraine bluff) certain places on the coasts of West-Estonia and Saaremaa Island, capes of Juminda and Pärispea (Lahemaa National Park), Mõntu
Latvia: Jurkalne, Akmensrags-Ziemupe, Mazirbe-Kolka
Lithuania: Karkle moraine cliff (very small and consequently not classified as a biotope complex)
Russia/Kalin.: Sambian Peninsula
Poland: 20 % of the Polish coast. The highest and the best known moraine cliffs are on Wolin Island and Cape Rozewie
Germany: Predominant along most of the coast of Schleswig-Holstein and of Mecklenburg.

D) Flat coasts subject to intensive land upheaval
Areas where the annual primary land upheaval exceeds 7 mm (actual total land uplift) and where the succession of biotopes along the land upheaval gradient from marine to terrestrial environments can be seen (Fig. 89); on flat shores these successions often result in a distinct zoning of various biotopes under continuous change. The past, present and future of these different stages of succession is reflected in the neighbouring biotopes. The successions may include several biotopes ranging from sublittoral aquatic vegetation via reedbeds and coastal meadows to shrubberies, primary forests or coastal wetlands. Rocky habitats with pioneer communities and coastal brackish and freshwater bodies are typical for many land upheaval areas.

Remarks:
Land uplift areas are usually large complexes which may include some of the other landscape types such as river outlets. Land upheaval areas are characteristic of the Finnish coast of the Bothnian Bay, but also occur to a lesser extent at the Swedish coast of the Bothnian Bay. The value of low-lying land upheaval coasts for nature conservation is increasingly diminished by anthropogenic activities.

Examples of land upheaval (land uplift) areas:
Denmark: None
Sweden: The Swedish coast of the Bothnian Bay
Finland: The Finnish coast of the Bothnian Bay
Russia/St Pe.: None (here land upheavel does not exceed 2 mm/a)
Estonia: Alvars (here land upheavel does not exceed 2 mm/a)
Latvia: None
Lithuania: None
Russia/Kalin.: None
Poland: None
Germany: None.

E) Fjords
A fjord is a long - often narrow - sea inlet which is usually separated from the open sea by a submerged sill. A fjord originates from glacial erosion. No minimum depth is defined for fjords, but depth can range from shallow areas to more than 1000 m in depth. The deposition of particulate substrata is most intense at the head of the fjords associated with major rivers. River discharge, if taking place, usually results in a stratification of different density waters.

Remarks:
Fjords with steep mountain sides are very rare in the Baltic Sea. The fjords in the Baltic consist usually of soft mud, although other substrates may also occur. The definition given here is based on that from Davidson *et al*. (1991).

Examples of fjords:
Denmark: None (no true fjords)
Sweden: Nynäsviken, Norrtäljeviken, Tjärö, Verkeväcksviken, Gamlebyviken, Syrsan, Valdemarsviken, Slätbaken
Finland: Pojoviken Bay
Russia/St Pe.: None
Estonia: None
Latvia: None
Lithuania: None
Russia/Kalin.: None
Poland: None
Germany: None.

F) Fjards/fjord like bays, including "Förden"
Fjards/fjord like bays are shallow, structurally complex and often narrow sea inlets typical of glaciated lowland coasts with an open and irregular coastline. Fjards usually lack a main channel and the characteristic sill of most fjords. The form often reflects the underlying morphology, and although ice-scoured rock basins and bars are characteristic features, fjards are nevertheless relatively shallow, often with numerous islands.

Remarks:
Fjards are common features in archipelago areas (Sweden and Finland use the local term fjärd). This definition is based on that given for fjards by Davidson *et al*. (1991). “Förden” are often tube-like elongated bays consisting of glacial debris (Fig. 24). They originate as channels of postglacial melted ice streams, or terminal basins of glacial erosion and are very common in Denmark and Schleswig-Holstein (Germany).

Examples of fjards/fjord like bays:

Denmark:	Roskilde Fjord, Isefjord, Mariager Fjord, Randers Fjord, Horsens Fjord, Vejle Fjord, Kolding Fjord, Æbeltoft Vig
Sweden:	Villinge, Norröra-Söderöra, Utö, Torhamn-area, Tokö-Lövö, Svensksundsviken, Gillsviken
Finland:	A common type in all archipelago areas: Stor-Pernåviken, Lill-Pernåviken, Lappdalsfjärden,...
Russia/St Pe.:	Vyborg Bay
Estonia:	None
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	Schlei, Kieler Förde, Flensburger Förde.

G) Lagoons, including “Bodden”, barrier lagoons and “Fladas”

The term lagoon includes bays that are more or less separated from the sea by surrounding land, but still with permanent connection and water exchange with the sea. Lagoons are commonly shallow, often with a varying salinity. The size range is undefined, but large coastal lagoons may have a surface area of several square kilometres and small lagoons a surface area of only a few hectares. In the Baltic Sea several specific types of lagoons (Bodden, barrier lagoons and Fladas) exist:

Bodden
Bodden are lagoon-like internal waters of the Pleistocene formed coast and were flooded during the Littorina transgression. They are more or less separated from the adjacent Baltic Sea by moraines, Holocene spits and/or sills (submerged moraines).

Bodden are usually shallow with sandy or muddy bottoms, often with stones and occasionally with deeper areas (holes). Depending on the degree of separation from the Baltic Sea the water bodies of these shallow waters often have large salinity fluctuations, which cause different benthic vegetation zones with, for example, *Potamogeton pectinatus, Zostera marina* and algae as well as the fauna (e.g., marine and freshwater fish species). The “Bodden-landschaft” is a typical coastal landscape (Fig. 25 and aerial photo: Fig. 31) of the easternmost German coast (including Rügen Island) and the Polish Szczecin Lagoon area.

Remarks:
One can distinguish between an estuarian type of Bodden with strong freshwater inflow and a distinct salinity gradient towards the Baltic Sea (“Saaler Bodden”, Oder Lagoon) and a none-estuarian type where the salinity is equal to the adjacent Baltic Sea because of a strong water exchange and low freshwater inflow (“Greifswalder Bodden”). The estuarian type is more susceptible to pollution and eutrophication.

Barrier lagoons
These lagoons represent a succession stage of a barrier coast where coastal bars evolve into spits and finally enclose coastal lakes. Their greatest depth usually does not exceed a metre.

Fladas
Fladas or flads (Fig. 26) are small, shallow, clearly delimited brackish water bodies which are still connected to the sea. The bottom of flads is usually covered with submerged macrophyte vegetation. Common on land upheaval (land uplift) coasts of the Baltic, flads are part of a succession process: juvenile flad - flad - gloflad - glo. A detailed description of flads, and other morphological types in the succession, is given by Munsterhjelm (1987, 1996)

Remarks:
Flads are a common landscape type in most archipelago areas in Finland and Sweden.

Examples of lagoons (excluding Bodden and Fladas):

Denmark:	In Køge Bugt and Sejerø Bugt (barrier lagoons)
Sweden:	Faglarö (S. Fladen), Hölö (Norsfladen), Runmarö (Östersjöfladen) Jungfruskär, Salthamn, Lyckefjärd, Flaggfladen, Bovik
Finland:	Modermagan (Pernå)
Russia/St Pe.:	Curonian Lagoon, Vistula Lagoon
Estonia:	Käina Bay, Harilaid, Saunja Bay
Latvia:	Liepaja Lake, Pape Lake
Lithuania:	Curonian Lagoon

Russia/Kalin.:	Curonian Lagoon and Vistula Lagoon
Poland:	Vistula Lagoon, some coastal lakes, e.g., Leba lake
Germany:	none.

Examples of Bodden:

Denmark:	Basnæs Nor, Holsteinborg Nor, Karrebæck Fjord, Dybsø Fjord, Præstø Fjord
Sweden:	None
Finland:	None
Russia/St Pe.:	None
Estonia	None
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	Szczecin Lagoon (or Oder Lagoon)
Germany:	Saaler Bodden, Oderhaff (in English: Oder Lagoon), Greifswalder Bodden (in English: Greifswald Lagoon).

Examples of Fladas:

Denmark:	None
Sweden:	Utålskedjan
Finland:	Fladas occur in relatively small numbers in most archipelago areas on the coasts of Finland.
Russia/St Pe.:	Fladas of the Beryozouye Islands
Estonia:	None
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	None.

H) Large spits of sand and/or gravel separating a lagoon from the sea

Large spits (Fig. 27) are one of the most exciting features of dynamic coastal processes in the nearshore zone. They originate from sand and gravel that is transported along the shore, before it is deposited when the transport energy becomes weaker. A spit grows from an ongoing sand/gravel supply. It is attached to land at one end and separated from the mainland by a strait/sound/narrow/sill at the other end. A lagoon or bay separates the spit from the mainland while the spit separates the bay from the open sea. Dune evolution is possible when sand supply is sufficient.

Examples of large spits separating a lagoon from the Sea:

Denmark:	Dragene, Albuen, Hyllekrog, Rødsand and Præstø (partly enclosed bays or fjards)
Sweden:	None
Finland:	Several small sites on the Ostrobothnian coast
Russia/St Pe.:	None
Estonia:	gravel spit Küdemaa (Saaremaa Island)
Latvia:	None
Lithuania:	Curonian spit
Russia/Kalin.:	Western part of Curonian Spit, Vistula Spit
Poland:	Hel peninsula, Vistula Spit, Leba sand bar
Germany:	Zingst Peninsula, Gellen, Bock, Bessin.

I) Riverine areas under backwater influence by the sea

A riverine area (under backwater influence by the sea) is an area above the river estuary (mouth, outlet) where sea water periodically or occasionally penetrates the land along a flat, swampy river valley (Fig. 29). Depending on local conditions, species of freshwater or salty habitats may occur, with halophytic species and whole communities being typical.

Examples of riverine areas

Denmark:	Mariager Fjord and many small stream outlets
Sweden:	None
Finland:	None
Russia/St Pe.:	Luga, Rosson, Narva
Estonia:	Kasari river (Matsalu Bay)
Latvia:	Daugava, Lielupe
Lithuania:	Sventoji
Russia/Kalin.:	Pregola river
Poland:	Dziwna, Reda, Rega
Germany:	Ryck, Peene, Mühlenau, Warnow.

J) Estuaries and river mouth areas

Baltic Estuaries are, for example, lagoons, bay like river mouth areas, deltas or parts of archipelago areas (Fig. 30) where freshwater meets the brackish water of the sea. Due to wind induced backwater effects of the whole water body of the Baltic Sea (Seiches) that cause irregular tidal effects, this zone is determined by a moving mixed water body with high input of organic matter.

Remarks:

The vegetation in estuaries (river mouth areas) can be very rich/diverse, consisting of reeds, sedges and submerged plants.

Examples of estuaries and river mouth areas:

Denmark:	Gudenåen-Randers Fjord, Horsens Fjord, Vejle Fjord, Kolding Fjord
Sweden:	Bräkneån, Hagbyån, Virån, Loftaån
Finland:	Porvoonjoki river mouth area, Kymijoki river mouth area, Merikarviandoki Aurajoki river mouth area
Russia/St Pe.:	Neva estuary
Estonia:	None
Latvia:	Daugava, Lielupe
Lithuania:	Nemunas delta
Russia/Kalin.:	Nemunas delta
Poland:	Oder Lagoon, Vistula Lagoon, some coastal lakes
Germany:	Oder Lagoon, Warnow estuary, Peene mouth area.

K) Archipelagos

An island group consisting of numerous islands, islets and skerries of various sizes and substratum types (Fig. 28); usually close to a mainland and usually zoned on grounds of land mass, exposition and vegetation. A succession of biotopes from marine to terrestrial environments is visible on almost every island, and a succession from exposed marine or terrestrial biotopes to more sheltered biotopes, often closer to the mainland, is visible on a larger scale. No size range has been defined for archipelagos but archipelagos usually extend over a large area and may comprise many of the types of biotope complexes such as bays and coastal dune complexes.

Remarks:

Archipelagos are a typical coastal feature of the northern Baltic Sea. Large archipelagos can be found at the Finnish and Swedish coasts. The Archipelago Sea along with Åland embraces the largest concentration of islands in the world. The boundaries of a archipelago can be very difficult to define. The number and size of archipelagos not disturbed by anthropogenic impact is decreasing.

Examples of archipelagos:

Denmark:	The islands encompassing the Belt Sea east of the peninsula of Jutland, Ertholmene
Sweden:	Luleå archipelago, Stockholm archipelago, Gryts Archipelago, Blekinge Archipelago, Misterhults Archipelago, Tjusts archipelago,...
Finland:	Vasa Archipelago, Oura Archipelago, Ekenäs Archipelago, Pellinge Archipelago
Russia/St Pe.:	Vyborg Bay archipelago, Beryozovye Islands
Estonia:	West Estonian archipelago
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	None.

L) Solitary islands

A solitary island (Fig. 31) is not part of an archipelago and often occurs with plant and animal species that are not found, or are extremely rare, on the adjacent mainland. If necessary, further differentiation based on geology is possible.

Examples of solitary islands:

Denmark:	Anholt, Laesø, Bornholm
Sweden:	Holmön, Blå Jungfrun
Finland:	Hailuoto,
Russia/St Pe.:	Gogland, Malyy Tuters and Bolshoy Tuters islands, Moshchnyys Seskar
Estonia:	Ruhnu, Osmussaar
Latvia:	None
Lithuania:	None
Russia/Kalin.:	None
Poland:	None
Germany:	Greifswalder Oie, Isle of Vilm, Hiddensee, Poel.

M) Esker islands

Esker islands consist mainly of sand, gravel and boulder clay with scattered stones of variable size. These islands with sandy, rocky and shingle beach vegetation as well as sublittoral vegetation host a unique mosaic of different kinds of vegetation communities.

Examples of esker islands:

Denmark:	Nørrerev in Roskilde Fjord
Sweden	Haparanda Sandskär, Sandön, St Järknön, Trotten, Saltor
Finland:	Pitkäviiri (Gulf of Finland), Gåsören (Gulf of Finland), Jurmo (The Archipelago Sea)
Russia/St Pe.:	Malyy Island, islands in Kotlin Island Archipelago, Virgin Islands
Estonia:	None
Latvia:	None
Lithuania	None
Russia/Kalin.:	None
Poland:	None
Germany:	None.

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Figure 20:
Rocky coasts (A), Finland (photo: J. Kostet)

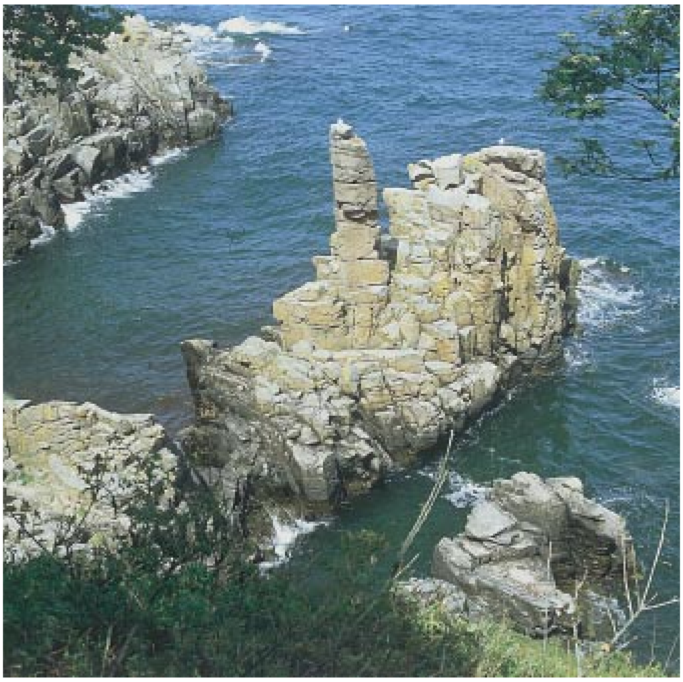

Figure 21:
Rocky coasts, (A), (subtype cliffs), Bornholm, Denmark (photo: C. Herrmann)

Figure 22:
Sandy coasts (B), Curonian Spit, Lithuania (photo: C. Herrmann)

Figure 23:
Moraine coasts (C), Isle of Vilm, Germany (photo: D. Boedeker)

Figure 24:
Fjards/Fjord like Bays (F), (Förden) Satelite image of Kiel Bight with the fjord like bays: Schlei, Eckernförde Bay and Kiel Bay from north to south, Germany (photo: Deutsches Fernerkundungszentrum DFD des DLR)

Figure 25:
Lagoons including Bodden, barrier lagoons and Fladas (G), (Bodden), National Park Vorpommersche Boddenlandschaft, Germany (photo: H. D. Knapp)

Figure 26:
Lagoons including bodden, barrier lagoons and Fladas (G), (Fladas), Björkviksflada, Ekenäs Archipelago, south coast of Finland (photo: J. Ekebom)

Figure 27:
Large spits of sand and/or gravel separating a lagoon from the sea (H), Vistula Spit, Poland (photo: H. D. Knapp)

Figure 28:
Archipelago (K), Brännskär, Tvärminne Archipelago, south-west coast of Finland (photo: J. Ekebom)

Figure 29:
Riverine areas under backwater influence of the sea (I), Mühlenau streamlet, Germany (photo: H. Sterr)

Figure 30:
Estuaries and river mouth areas (J), Großer Wotig in the Peene Stream, Germany (photo: R. Abraham)

Figure 31: **Solitary island (M)**, Isle of Vilm, Germany (photo: J. Klaus)

DESCRIPTION OF MARINE AND COASTAL BIOTOPES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

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The waters of the Baltic Sea can be divided into an outer Baltic Sea area composed of the Kattegat, Øresund, Belt Sea, and the Baltic Sea west of the Darss Sill and an inner Baltic Sea area composed of the Baltic Sea Proper east of the Darss Sill, the Gulf of Riga, the Gulf of Finland, the Archipelago Sea, the Bothnian Sea, and the Bothnian Bay (see Figs 1, 2).

The Baltic Sea is a gigant estuarine system where mean salinities drop from near oceanic conditions with more than 30 ‰ in the west to near limnic conditions in the innermost eastern and northern parts. At the Darss Sill salinities are on average 8-10 ‰. Another characteristic estuarine feature of the water body is the permanent halocline between an upper less saline and a lower more saline water mass. The depth of the halocline rises from 60-80 m in the northern Baltic Proper to 20-30 m in the southernmost part where the inner and outer areas meet and further to 10-20 m in the northern Kattegat. Also many narrow fjords and fjards are estuarine, generally with a drop in mean salinity and an increasingly shallow brackish surface layer from the mouth to the head. Archipelago areas are quite typical for the northern Baltic Sea. Furthermore, the number of marine species of plants and animals decreases drastically from the Kattegat to the inner parts of the Baltic Sea. In the innermost parts of the Gulf of Bothnia and the Gulf of Finland freshwater species predominate.

Definitions (see Fig. 3):
The littoral zone is the transitional area between land and sea. It includes the sea bottom, the shore and the terrestrial part of the coast that is influenced by marine processes even by spray.

- The **sublittoral** is below the littoral and always covered by water.
- The **hydrolittoral** is the part of the littoral zone which is below the mean water line.
- The **geolittoral** is the terrestrial part of the Baltic shore that is flooded episodically.
- The **epilittoral** is the terrestrial part of the Baltic coast above the high water line, but still influenced sporadically by marine processes, even episodically by spraywater.
- Level bottoms are horizontal or sloping more or less flat or gently undulating bottoms.
- Reefs are ridges of solid rock or accumulations of coarse mineral substrata protruding above the level bottoms and found entirely below or extending partly above the surface of the water.
- (Sand)banks are large undersea elevations of various shape rising from the sea bottom.
- (Sand)bars are submerged ridges which are built up by currents and/or waves in coastal waters. Sometimes systems of sandbars develop parallel to the coast.

1. PELAGIC MARINE BIOTOPES

The pelagial is inhabited by plankton, e.g., bacteria, unicellular microalgae and zooplankton, meroplanktonic larvae of benthic animals, fish eggs and fish larvae, holoplanktonic crustaceans and jellyfish, and nekton including fish and marine mammals.

1.1 Offshore (deep) waters

These are biotopes of the water body of the open Baltic Sea area deeper than 15-25 m and largely without interaction between wave orbits and the sea bottom (depending on fetch length). Primary production is, to a great extent affected by stratification and wind induced mixing of the water column.

1.1.1 Above the halocline (Fig. 32)

Includes most or all of the productive layer in a well mixed or stratified water mass.

1.1.2 Below the halocline

Below the productive layer - except in parts of the outer Baltic Sea area.The oxygen content of the water generally decreases with increasing depth. Inorganic phosphorus accumulates in anaerobic deep waters of the Baltic Proper and in some basins in the outer Baltic Sea area. The salinity and oxygen level of the upper parts of the deep layer is of great importance for the survival of planktonic organisms. Cod eggs, for example, are spawned above the halocline and, only if the salinity is 10 ‰ or higher, are prevented from sinking to depths below the halocline where oxygen levels are too low for them to survive.

1.2 Coastal (shallow) waters

Biotopes of the water body of the coastal areas of the Baltic Sea area with depths down to 15-25 m, usually with interaction between wave orbits and the sea bottom (depending on fetch length); (Fig. 33). Visibility, which is limited by particulate matter from land, fresh water outlets and the sea floor (by resuspension) as well as by eutrophication induced phytoplankton growth can restrict the depth of the photic zone to 1-2 m or even less. Eutrophication has increasingly been the reason for mass blooming of planktonic algae, as well as oxygen deficiency.

1.2.1 Outer

May extend to some nautical miles from the coast, sometimes beyond coastal channels and basins and above sublittoral offshore banks and bars. Outer coastal shallow waters include, for example, the outermost part of archipelago areas.

1.2.2 Inner

More or less sheltered or enclosed brackish or estuarine water bodies (where freshwater meets seawater) like lagoons, fjards, fjord-like bays and river mouths.

2. BENTHIC MARINE BIOTOPES

The distribution of the benthic flora and fauna reflects the physical, chemical and biological properties of the water column, including the degree of water coverage and the light regime, and oxygen availability as well as the type of bottom and to some degree, the history of the Baltic Sea area.

Hard substrata like crystalline bedrock, boulders, stones, gravel and also mussel beds are a prerequisite for the occurrence of macro-algae and sessile macro-epifauna, while ”soft” bottoms like sand, silt, soft clay and mud house cormophytes, infauna and interstitial meso-organisms. There is a more or less distinct depth zonation of macro algae. The distribution of infaunal communities also largely correlates with depth and substratum, modified by salinity.

2.1 Rocky bottoms

Bottoms consisting of hard or soft bedrock or bedrock-like substrata. Irrespective of light, depth, salinity, temperature and biological factors, the most important natural environmental factors determining species abundance are exposure to waves, currents and scouring by ice. On hard bedrock macrophytic algae are the main biotope-forming organisms along with *Mytilus* spp. The *Fucus vesiculosus* biotope plays a key role on hard bottoms in the Baltic Sea sublittoral zone.

2.1.1 Soft rock

Sedimentary soft bedrock bottoms such as chalk or boulder clay/marl, further subdivided into:

2.1.1.1 Aphotic zone
2.1.1.2 Sublittoral photic zone (Fig. 34)
2.1.1.2.1 Level bottoms with little or no macrophyte vegetation
2.1.1.2.2 Level bottoms dominated by macrophyte vegetation
2.1.1.2.3 Reefs (Fig. 35)
2.1.1.3 Hydrolittoral (Fig. 36)
2.1.1.3.1 Level bottoms with little or no macrophyte vegetation
2.1.1.3.2 Level bottoms dominated by macrophyte vegetation
2.1.1.3.3 Reefs

2.1.2 Solid rock (bedrock)

Crystalline bedrock bottoms like granite and gneiss and sedimentary bedrock like sandstone and lime-stone, further subdivided into.

2.1.2.1 Aphotic zone
2.1.2.2 Sublittoral photic zone (Fig. 37)
2.1.2.2.1 Level bottoms with little or no macrophyte vegetation
2.1.2.2.2 Level bottoms dominated by macrophyte vegetation
2.1.2.2.3 Reefs
2.1.2.3 Hydrolittoral (Fig. 38)
2.1.2.3.1 Level bottoms with little or no macrophyte vegetation
2.1.2.3.2 Level bottoms dominated by macrophyte vegetation
2.1.2.3.3 Reefs

2.2 Stony bottoms

Biotopes of sea bottoms predominantly covered by big stones or boulders (>100 mm). Vegetation and sessile fauna is similar to that of the rocky bottoms. Since no rocky bottoms occur in the south-western part of the Baltic Sea and in the outer Baltic Sea area, except along most of the Swedish coast and a few places in Denmark (such as Bornholm), such stones and boulders constitute the main substrata for hard bottom flora and fauna in those areas. Biotopes are further subdivided into:

2.2.1 Aphotic zone
2.2.2 Sublittoral photic zone
2.2.2.1 Level bottoms with little or no macrophyte vegetation (Fig. 39)
2.2.2.2 Level bottoms dominated by macrophyte vegetation (Fig. 40)
2.2.2.3 Reefs (Fig. 41)
2.2.3 Hydrolittoral (Fig. 42)
2.2.3.1 Level bottoms with little or no macrophyte vegetation

2.2.3.2 Level bottoms dominated by macrophyte vegetation
2.2.3.3 Reefs

2.3 Hard clay bottoms

Compact sediments with a mean grain size of <0.002 mm and with the character of a hard bottom (Fig. 43), further subdivided into:
2.3.1 Aphotic zone
2.3.2 Sublittoral photic zone
2.3.2.1 Bottoms with little or no macrophyte vegetation
2.3.3 Hydrolittoral
2.3.3.1 Bottoms with little or no macrophyte vegetation

2.4 Gravel bottoms

Sea bottoms consisting entirely of gravel and pebbles (mean grain size 2 mm - <100 mm). Pleistocene banks and shorelines consisting of gravel and pebbles are swept bare by currents or are revealed when gullies cut through old sediments. Relatively few organisms can inhabit the interstitial spaces or use this sediment as a substratum. Some fish species require such hard substrata for depositing their eggs. Biotopes are further subdivided into:
2.4.1 Aphotic zone
2.4.2 Sublittoral photic zone
2.4.2.1 Level bottoms with little or no macrophyte vegetation
2.4.2.2 Level bottoms dominated by macrophyte vegetation (Fig. 44)
2.4.2.3 Banks with or without macrophyte vegetation
2.4.3 Hydrolittoral (Fig. 45)
2.4.3.1 Level bottoms with little or no macrophyte vegetation
2.4.3.2 Level bottoms dominated by macrophyte vegetation
2.4.3.3 Banks with or without macrophyte vegetation

2.5 Sandy bottoms

Sea bottoms consisting largely of sand (mean grain size 0.06 mm - <2.0 mm). The epi- and infaunal communities or species like *Crangon crangon, Mya arenaria* are typical in the entire Baltic Sea area and *Venus gallina* in the outer Baltic Sea area. In shallow areas *Zostera marina, Chara aspera* and *Potamogeton pectinatus* may occur. Biotopes are further subdivided into:
2.5.1 Aphotic zone (Fig. 46)
2.5.2 Sublittoral photic zone
2.5.2.1 Level bottoms with little or no macrophyte vegetation (Fig. 47)
2.5.2.2 Level bottoms dominated by macrophyte vegetation (Fig. 48)
2.5.2.3 Bars
2.5.2.4 Banks with or without macrophyte vegetation
2.5.3 Hydrolittoral
2.5.3.1 Level bottoms with little or no macrophyte vegetation (Fig. 49)
2.5.3.2 Level bottoms dominated by macrophyte vegetation (Fig. 50)
2.5.3.3 Bars
2.5.3.4 Banks with or without macrophyte vegetation (Fig. 51)

2.6 Shell gravel bottoms

Sea bottoms consisting largely of mollusc shells or small shell fragments, often in large patches of sediment. Due to the large variety of interstitial space, inhabited by many species of often very specialized fauna, for example, *Amphioxus* spp. (Fig. 52). Biotopes are further subdivided into:
2.6.1 Aphotic zone
2.6.2 Sublittoral photic zone

2.7 Muddy bottoms

Bottoms consisting largely of silt, mud or soft clay (mean grain size <0.06mm). This biotope is inhabited by the *Amphiura* and *Haploops* communities in the Kattegat, *Syndosmya* in the Belt Sea area and communities with *Macoma baltika, Pontoporeia femorata, Scoloplos armiger* in the Baltic Proper. Because of anoxic conditions most of the subhalocline areas in the Baltic Proper and in parts of the Belt Sea are without macrofauna. In the northern Baltic Sea species such as *Macoma baltika, Monoporeia affinis* and *Nereis diversicolor* are common. In shallow areas with low salinity, for example, inner archipelago areas, freshwater species, such as insect larvae and freshwater plants like reeds and rushes are common. Biotopes are further subdivided into:
2.7.1 Aphotic zone (Fig. 53)
2.7.2 Sublittoral photic zone
2.7.2.1 With little or no macrophyte vegetation
2.7.2.2 Dominated by macrophyte vegetation (Fig. 54)
2.7.3 Hydrolittoral
2.7.3.1 With little or no macrophyte vegetation
2.7.3.2 Dominated by macrophyte vegetation (Fig. 55)

2.8 Mixed sediment bottoms

Bottoms with a mixture of several substrata such as stones, gravel, sand, mud and clay, occurring, for example, in moraine areas, creating a mosaic of hard and soft bottom communities which creates the possibility for comparatively high total species diversity to exist. Biotopes are further subdivided into:

2.8.1 Aphotic zone
2.8.2 Sublittoral photic zone
2.8.2.1 With little or no macrophyte vegetation (Fig. 56)
2.8.2.2 Dominated by macrophyte vegetation
2.8.3 Hydrolittoral (Fig. 57)
2.8.3.1 With little or no macrophyte vegetation
2.8.3.2 Dominated by macrophyte vegetation

2.9 Mussel beds

The Common mussel (*Mytilus edulis*) occurs throughout most of the Baltic Sea Area, the horse mussel (*Modiolus modiolus*) in the Kattegat and the zebra mussel (*Dreissena polymorpha*) in the coastal lagoons. All of them form dense colonies and often create multi-layered beds on hard or soft substrata. They themselves act as substratum for other animals and algae. Biotopes are further subdivided into:

2.9.1 Aphotic zone
2.9.2 Sublittoral photic zone (Fig. 58)
2.9.2.1 With little or no macrophyte vegetation
2.9.2.2 Dominated by macrophyte vegetation
2.9.3 Hydrolittoral
2.9.3.1 With little or no macrophyte vegetation
2.9.3.2 Dominated by macrophyte vegetation

2.10 Bubbling reefs

Submarine landscapes of carbonate-cemented (high-magnesium calcite, dolomite or aragonite) sandstones supporting a diverse ecosystem at methane seeps. They are a result of microbial methane oxidation in the sediment. Due to erosion of the surrounded unconsolidated sediment they are exposed as structures up to 100 m^2, consisting of pavements, complex formations of overlying slab-type layers and pillars up to heights of 4 m. The formations are interspersed With gas vents that intermittently release gas, primarily methane, at up to 25 litres per hour. Found only in sandy areas in the northern Kattegat. Biotopes are further subdivided into:

2.10.1 Aphotic zone
2.10.2 Sublittoral photic zone (Fig. 59)
2.10.2.1 With little or no macrophyte vegetation
2.10.2.2 Dominated by macrophyte vegetation

2.11 Peat bottoms

Subfossile substrata laid bare by currents or protruding in gullies, always without macrophytes.

2.11.1 Sublittoral (Fig. 60)
2.11.2 Hydrolittoral

3. TERRESTRIAL BIOTOPES

Geolittoral and epilittoral coastal zones of the Baltic Sea and typical coastal biotopes, like dunes, cliffs and wetlands formed by marine processes.

3.1 Spits/bars

Strips of sand, gravel, pebble and/or shingle along the shore or across the entrance of small bays formed by morphodynamic processes. These biotopes of the geolittoral and epilottoral zone may be connected with the mainland. In most cases they have little vegetation and due to this are an important breeding place for waders and terns and a roosting site for other coastal birds and waterfowl (Figs 61, 62).

3.2 Beaches

Beaches are almost flat and in most cases exposed to the open sea with no or little vegetation. Further differentiation is made by substratum type.

3.2.1 Sandy beaches

Sandy shores that are influenced by wave and wind action, salt and sand drift. The lower parts are usually free of vegetation, often with drift lines or accumulations of dead algae along the shore. In the upper parts primary dunes with characteristic vegetation (*Agropyron junceiformis*) may occur (Fig. 63). Special examples of plants growing on sandy beaches in the northern Baltic Sea are *Honckenya peploides, Empetrum nigrum* and *Leymus arenarius.*

3.2.2 Gravel and shingle beaches

Clean pebble (shingle) and gravel shores (grain size from 2 to 200 mm, Fig. 64)

3.2.3 Boulder beaches

Mixed sediment shores dominated by boulders and boulder clay or marl, usually at moraine coasts with stone blocks larger than 200 mm (Fig. 65).

3.3 Beach ridges

Beach ridges are of various mixtures of sand, gravel, pebbles, boulders and plant material of the geolittoral and epilittoral. They can be formed by many coastal dynamic processes, like waves, ice pressure and fluctuating water levels during storms. At erosive coasts where fossile peat layers are abraded, ridges of peat may occur. Coastal plains can have systems of ridges running parallel to the coast. The older ridges can become covered with bushes and trees. Further differentiation is made by substratum type and vegetation.

3.3.1 Sandy beach ridges
3.3.1.1 With no or low vegetation (Fig. 66)
3.3.1.2 Dominated by shrubs or trees (Fig. 67)

3.3.2 Beach ridges consisting of gravel pebbles and/or boulders
3.3.2.1 With no or low vegetation (Fig. 68)
3.3.2.2 Dominated by shrubs or trees
3.3.3 Beach ridges consisting of algal or other plant material
Often influenced by dynamic processes that cause complete abrasion as well as reaccumulation at other locations (mostly consisting of dead *Fucus vesiculosus* and *Zostera marina*).

3.4 Coastal dunes

Hills of various height and shape formed by windblown sand along sandy beaches. Depending on the degree of exposure and succession either free of vegetation or more or less covered with *Ammophila arenaria, Leymus arenarius, Calluna vulgaris, Empetrum nigrum* and/or other grasses, dwarf shrubs, bushes or forests. Further subdivided into:
3.4.1 Foredunes (Fig. 69)
Beginning of dune succession; low sand formations on the upper beach strongly influenced by wind and sea water; normally colonised by fragments of typical primary dune vegetation, for example, *Agropyron junceiformis, Honckenya peploides.*
3.4.2 White dunes (Fig. 70)
Higher dunes, beginning development of freshwater lentils; windblown sand is permanently accumulated; gradually increasing colonisation by marram grass (*Ammophila arenaria), Leymus arenarius, Carex arenaria*.
3.4.2.1 White dunes s.str.
3.4.2.2 Green dunes
Intermediate stage between the white and grey dune stage with only low ongoing sand accumulation; *Leymus arenarius* and marram grass (*Ammophila arenaria*) consistently growing on the sand.
3.4.3 Grey dunes (Fig. 71)
Dunes of considerable height but no further sand accumulation; some are enriched with humus colonized by lichens, mosses and/or poor grassland (for example *Corynephorus canescens, Jasione montana ssp. litoralis, Viola tricolor ssp. maritima*). On grey dunes in the northern Baltic Sea there are also lichens *Cetraria islandica* and *Cladonia arbuscula* which are common.
Further subdivided into:
3.4.4 Brown dunes with dwarf shrubs (Fig. 72)
Sheltered dunes with a shallow fragile soil layer. Either short growing heather, *Salix repens* and crowberries *(Empetrum nigrum*) or the common heather or ling (*Calluna vulgaris*) colonising the dune, in some areas preserved by extensive sheep grazing.
3.4.5 Brown dunes with dune shrubbery
Sheltered dunes with, e.g., sand consolidation, enrichment of humus and with shrubberies of *Hippophae rhamnoides, Juniperus communis* or *Rosa pimpinellifolia*; (shrubberies of non autochthonous species for example *Rosa rugosa* are not included).
3.4.6 Brown dunes covered with trees
3.4.6.1 Covered with natural or almost natural coniferous forest (Fig. 73), for example, pines *(Pinus silvestris)*
3.4.6.2 Covered with natural or almost natural deciduous forest (beech, birch, oak, Fig. 74)
3.4.7 Wet dune slacks (Fig. 75)
Depressions formed, for example, as a result of deflation or coastal erosion within the dune belt of the coast. Due to groundwater contact covered with swamp or fen vegetation, that varies with the salinity and the amount of lime in the soil. Further subdivided into:
3.4.7.1 Wet dune stacks incl. coastal fens with low vegetation
3.4.7.2 Wet dune stacks incl. coastal fens dominated by shrubs or trees
3.4.8 Migrating dunes (Fig. 76, also Fig. 22)
Mostly clean dunes moving due to strong airborne sand drift in the prevailing wind direction

3.5 Gently sloping rocky shores

Long coastal stretches (plains) sloping gently into the water, consisting of compact solid rocks. Further division is made by rock types and vegetation:
3.5.1 Limestone
3.5.1.1 With no or low vegetation (Fig. 77)
3.5.1.2 Dominated by shrubs or trees
3.5.2 Sandstone
3.5.2.1 With no or low vegetation
3.5.2.2 Dominated by shrubs or trees
3.5.3 Crystalline bedrock (Fig. 78, see also Fig. 20)
3.5.3.1 Without vegetation
3.5.3.2 With low vegetation
3.5.3.3 Dominated by shrubs or trees

3.6 Coastal cliffs and caves

Cliffs are steep slopes and bluffs resulting from marine abrasion processes. Near the shoreline, cliffs are under periodic or episodic retreat due to, for example, waves, currents, ice, wind or groundwater and weather processes. In most cases as a result of changing from abrasion to accumulation active parts of cliffs can become inactive and vice versa. Inactive cliffs are not under retreat but their slopes are often covered with shrubs and trees. Further differentiation is made by rock types and vegetation:
3.6.1 Limestone (Fig. 79)
3.6.1.1 With no or low vegetation

3.6.1.2 Dominated by shrubs or trees
3.6.2 Sandstone
3.6.2.1 With no or low vegetation
3.6.2.2 Dominated by shrubs or trees
3.6.3 Chalk (Fig. 80)
3.6.3.1 With no or low vegetation
3.6.3.2 Dominated by shrubs or trees
3.6.4 Crystalline bedrock (Fig. 81, see also Fig. 21)
3.6.4.1 With no or low vegetation
3.6.4.2 Dominated by shrubs or trees
3.6.5 Moraine cliffs (Fig. 23)
Moraine cliffs consist mostly of a mixture of marl, clay, sand and stones (boulder clay), sometimes the material is pure sand, marl or hard clay. Further subdivided into:
3.6.5.1 With no or low vegetation (Fig. 82)
3.6.5.2 Dominated by shrubs or trees (Fig. 83)
3.6.6 Caves
Coastal caves are excavations in cliffs, usually larger than about 1 m^3 caused by waves or ice pressure, and with no or low daylight.

3.7 Coastal wetlands and meadows

Different biotopes of the geolittoral and the epilittoral at flat or gently sloping sedimentary shorelines or on already developed soil layers of different types of rock, always covered with vegetation. Usually these biotopes are geologically young, swampy or paludal (sometimes temporarily influenced by brackish water), peated or on inorganic grounds. At sheltered bays or inlets of shallow coastal waters even the geolittoral can be covered by trees. Further subdivided into:
3.7.1 Reed, rush and sedge stands
Geolittoral, in most cases with *Phragmites australis, Bolboschoenus maritimus* partly *Scirpus* spp. and tall *Carex* spp.
3.7.1.1 Natural stands (Fig. 84)
Natural stands that are not in use or modified by man.
3.7.1.2 Harvested stands (Fig. 85)
Almost natural stands that are harvested at specific intervals.
3.7.2 Meadows / pastures
3.7.2.1 Salt pioneer swards (Fig. 86)
Halophilous pioneer swards are the lowest part of saltmarshes occurring on episodical flooded mudflats and covered with annual pioneer formation, for example, *Salicornia europaea, Suaeda maritima, Halimione pedunculata*.
3.7.2.2 Lower meadows (Fig. 87)
Typical marshes occurring on more or less wet and episodical flooded coastal areas with meadows of, for example, *Puccinellia distans, Agrostis stolonifera* and *Juncus gerardii.*
3.7.2.3 Upper meadows (Fig. 88)
Elevated areas of marshes that are flooded only during extreme weather conditions with *Festuca rubra* dominating.
3.7.2.4 Dry meadows (incl. “Alvars”) (Fig. 89)
Mostly semi-natural meadows as part of a complex of dry coastal meadows. Alvars occur on limestone covered only by a thin soil layer, sometimes reaching far inland, in this case lacking marine influence.
3.7.2.5 Tall herb stands (Fig. 90)
Tall herb stands situated landward of the episodical flooded zone.
3.7.3 Swamps
Swamps include different biotopes on coastal wetland sites with vegetation on inorganic soils flooded by fresh or brackish water throughout most of the vegetation period. Further subdivided into:
3.7.3.1 With low vegetation
Swamps with herbaceous vegetation.
3.7.3.2 Dominated by shrubs or trees (Fig. 91)
Coastal wet forests and bushes consisting of „fen-wood“ biotopes of the geolittoral and paludal forests of the epilittoral (willow, ash, alder), sometimes reaching far inland, in this case lacking marine influence.
3.7.4 Bogs (Fig. 92)
Bogs consist of different biotopes at coastal wetland sites with oligotrophic rain-fed vegetation on thick peat layers (formed mostly from *Sphagnum* spp.). Bogs may develop on coastal floodplains, forming a part of a biotope mosaic of caostal wetlands in areas of humid climate conditions. Water is supplied only by precipitation.
3.7.5 Coastal fens (Fig. 93)
Biotopes at coastal wetland sites with eu- meso- and meso-oligotrophic vegetation on peat layers (formed mainly from sedges and brown moss species) developing under the impact of ground and flood water. Further subdivided into:
3.7.5.1 Calcareous (“rich” fens)
Fens developed under influence of ground water, rich in calcium carbonate.
3.7.5.2 Acid (“poor” fens)
Neutral and acid fens dominated by sedges, grasses, and soils with low content or lack of calcium carbonate.

4. COASTAL LAKES, POOLS and “GLO-LAKES”

4.1 Coastal lakes

Lakes, separated from the sea by beach ridges, large spits or rocks with varying amount of vegetation. Location and shape may be changed by flooding. With growing beach ridges and spits such lakes can become totally separated from seawater inflow and will develop to brackish and, later on, to freshwater lakes. Sometimes temporarily chemically stratified (meromictic). Characterized by freshwater plant communities, including some marine elements (Fig. 94). Further subdivision is made by salinity, trophic status and morphological genesis:

4.1.1 Brackish

Coastal lakes with brackish water usually with submerged macrophytes and reed stands. Morphological genesis different from Glo-lakes.

4.1.1.1 Eutrophic
4.1.1.2 Mesotrophic
4.1.2 Freshwater

Coastal lakes with freshwater usually with submerged macrophytes and reed stands.

4.1.2.1 Eutrophic
4.1.2.2 Mesotrophic
4.1.2.3 Oligotrophic
4.1.3 Glo-lakes

Glo-lakes are small, shallow, clearly delimited brackish water bodies that have been cut off from the sea. Glo-lakes always have a previous geomorphological genesis as “Fladas”. The bottoms of Glo-lakes are usually covered with submerged macrophyte vegetation but freshwater species are more common than in fladas. Common at land upheaval coasts of the Baltic. Examples of typical submerged macrophytes are *Najas marina, Myriophyllum verticillatum, Utricularia vulgaris* and *Drepanocladus* spp.

4.1.3.1 Eutrophic
4.1.3.2 Mesotrophic

4.2 Permanent pools (incl. rock pools etc.)

A small waterbody, usually sheltered or very sheltered with infrequent or no input of water from the adjacent sea. The varying salinity depends on the degree of marine influence and rainfall.

4.2.1 Brackish pools (Fig. 95)
4.2.1.1 Eutrophic
4.2.1.2 Mesotrophic
4.2.1.3 Oligotrophic
4.2.2 Freshwater pools
4.2.2.1 Eutrophic
4.2.2.2 Mesotrophic

4.3 Temporary pools (including rock pool etc.)

Pools, occasionally drying out, usually sheltered or very sheltered with infrequent or no input of water from the adjacent sea. The varying salinity depends on the degree of marine influence and rainfall (Fig. 96).

4.3.1 Brackish pools
4.3.2 Freshwater pools

5. SELECTED BIOTOPES OF RIVERINE AND RIVER MOUTH AREAS

The lowest part of rivers and riverside areas influenced by backwater effects of the sea. Characterized by freshwater communities, including some marine elements.

5.1 River beds

The benthic zone of a river always covered with water (Fig. 97).

5.2 River banks

River banks are the river sides reaching from the river bed to the river shore (Fig. 97).

5.3 Oxbow lakes

Lakes and ponds cut off from the main parts of the rivers.

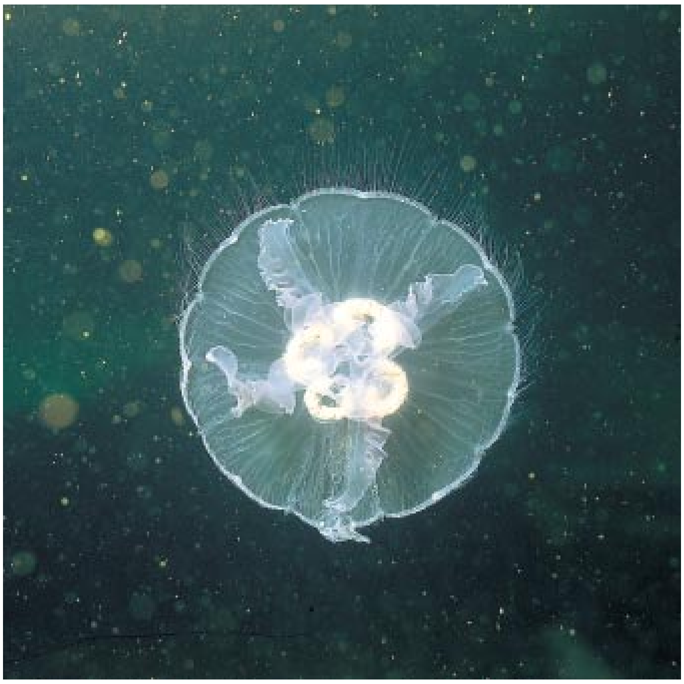

Figure 32:
Offshore (deep) waters above the halcline (1.1.1), with common jellyfish (photo: P. Hübner & J.C. Krause)

Figure 33:
Coastal (shallow) waters (1.2), Ruden Island, Germany (photo: R. Abraham)

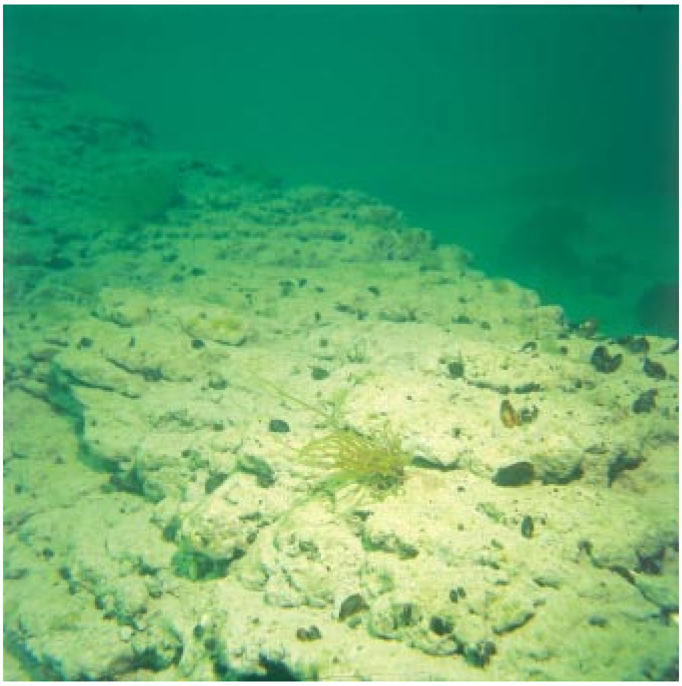

Figure 34:
Soft rock bottoms (boulder clay/marl) **of the photic zone (2.1.1.2)**, Germany (photo: W. Fiedler)

Figure 35:
Soft rock reef (2.1.1.2.3) with colonies of *Mytilus edulis* and red algeas, chalk reef off Rügen Island, Germany (photo: P. Hübner & J.C. Krause)

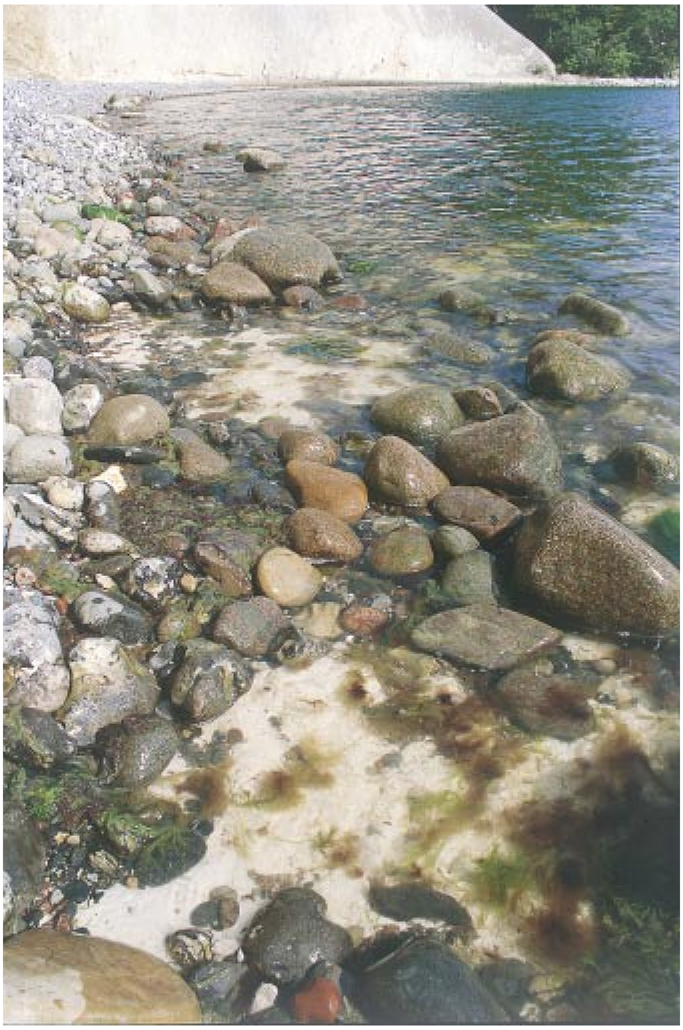

Figure 36:
Hydrolittoral soft rock bottoms (chalk) (2.1.1.3) mixed with boulders, Jasmund National Park, Germany (photo: R. Grunewald)

Figure 37:
Sublittoral solid rock bottom (crystalline bedrock) dominated by macrophyte vegetation (2.1.2.2) partly covered by *Fucus vesiculosus*, Bornholm Island, Denmark
(photo: P. Hübner & J.C. Krause)

Figure 38:
Hydrolittorial solid rock bottoms without macrophyte vegetation (2.1.2.3) - example of Ordovician limestone shore, Öland Island, Sweden
(photo: D. Boedeker)

Figure 39:
Sublittorial level stony bottoms of the photic zone with little or no macrophyte vegetation (2.2.2.1), with flatfish and common mussel *(Mytilus edulis)*, Poland (photo: W. Paczynski)

Figure 40:
Sublittoral level stony bottoms (2.2.2.2) dominated by macrophyte vegetation *(Fucus vesiculosus*), waters around Bornholm, Denmark (photo: P. Hübner & J.C. Krause)

Figure 41:
Sublittorial stony reefs of the photic zone (2.2.2.3) small *Laminaria sacharina*, red algae and red cyanobacteria waters off Rügen Island, Germany (photo: P. Hübner & J.C. Krause)

Figure 42:
Hydrolittoral stony bottoms (2.2.3), West Estonia (photo: C. Herrmann)

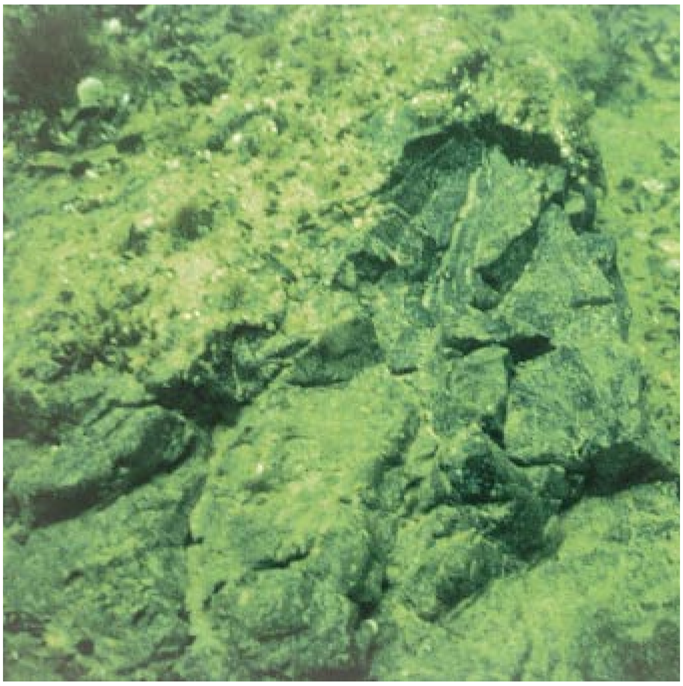

Figure 43:
Hard clay bottoms (2.3), Gulf of Gdansk, Poland (photo: W. Paczynski)

Figure 44:
Sublittorial level gravel bottoms dominated by macrophyte vegetation (2.4.2.2), Saaremaa Island, Estonia (photo: G. Marin)

Figure 45:
Hydrolittoral gravel bottom (2.4.3), aerial view from the edge of chalk cliffs, Rügen Island, Germany (photo: R. Grunewald)

Figure 46:
Sandy bottoms of the aphotic zone (2.5.1), Poland (photo: W. Paczynski)

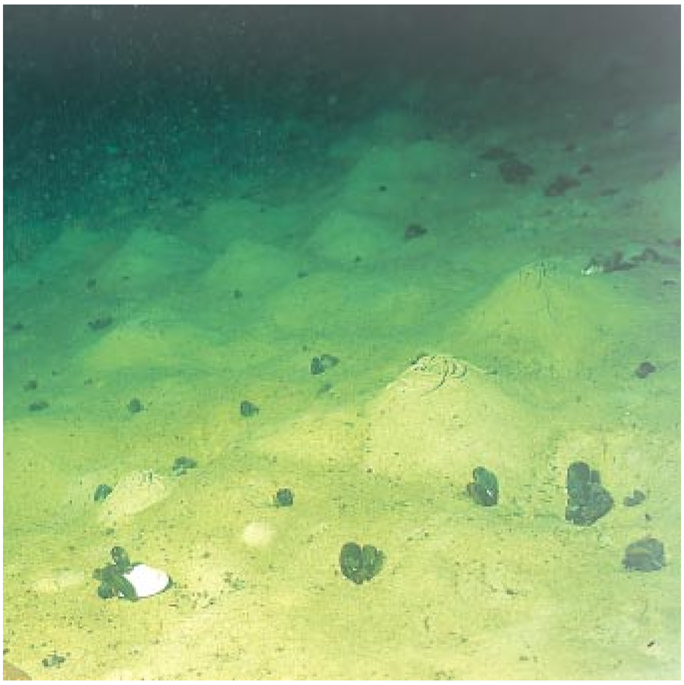

Figure 47:
Sublittorial level sandy bottoms with little or no macrophyte vegetation (2.5.2.1) with burrows of *Arenicola marina*, Germany
(photo: P. Hübner & J.C. Krause)

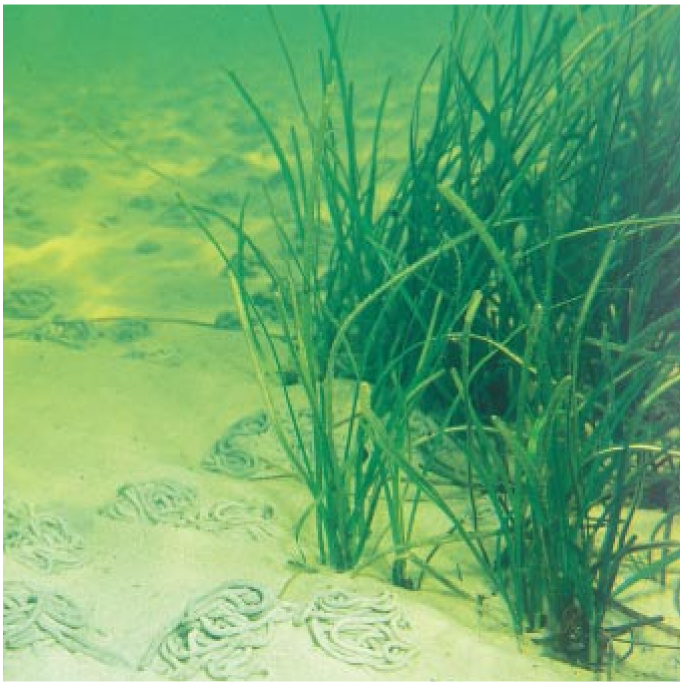

Figure 48:
Sublittorial sandy bottoms dominated by macrophyte vegetation (2.5.2.2) *Zostera marina* on the right and without macrophyte vegetation on the left with *Arenicola marina*, Germany
(photo: W. Fiedler)

Figure 49:
Hydrolittoral level sandy bottoms with little or no macrophyte vegetation (2.5.3.1) and **sand bars (2.5.3.3)**, in the lower hydrolittoral, Germany
(photo: A. Krismann)

Figure 50:
Hydrolittoral level sandy bottoms dominated by macrophyte vegetation (2.5.3.2) (*Enteromorpha* spp.), Germany (photo: W. Fiedler)

Figure 51:
Hydrolittoral sandbanks (2.5.3.4) (wind induced flats, “wadden areas”), Wampener Riff, Greifswald Lagoon Germany (photo: C. Herrmann)

Figure 52:
Shell gravel bottoms (2.6), shells of the common mussel *(Mytilus edulis)*, Germany
(photo: P. Hübner & J.C. Krause)

Figure 53:
Muddy bottoms of the aphotic zone (2.7.1), with brittle stars (primarily *Ophiura albida*) and sea pen *(Virgularia mirabilis)*, sea cucumber *(Psolus phantapus)*, Denmark (photo: O. N. Andersen)

Figure 54:
Sublittoral muddy bottoms of the photic zone (2.7.2.2), with *Zostera nana* Germany
(photo: W. Fiedler)

Figure 55:
Hydrolittoral muddy bottom (2.7.3.2), mixed with fine sand, covered with charophytes, Greifswald Lagoon, Germany (photo: R. Grunewald)

Figure 56:
Mixed sediment bottoms of the photic zone (2.8.2.1), boulders covered with barnacles and *Mytilus edulis* Germany
(photo: P. Hübner & J.C. Krause)

Figure 57:
Hydrolittoral mixed sediment bottoms (2.8.3), Naissar Island, Estonia (photo: G. Martin)

Figure 58:
Sublittoral mussel beds of the photic zone (2.9.2), with common starfish *(Asterias rubens)* feeding on common mussel *(Mytilus edulis)* and red cyanobacteria, Germany
(photo: P. Hübner & J.C. Krause)

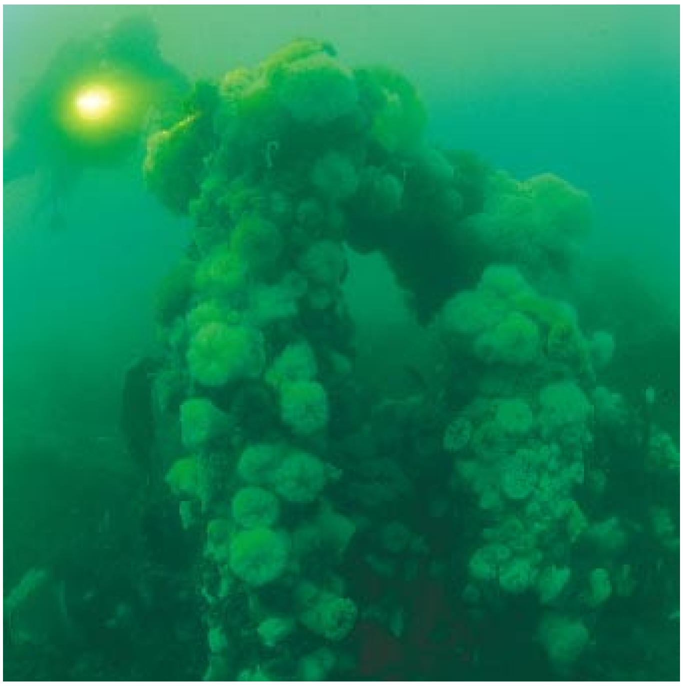

Figure 59:
Bubbling Reefs of the photic zone (2.10), northern Kattegatt, Denmark (photo: D. Kaasby)

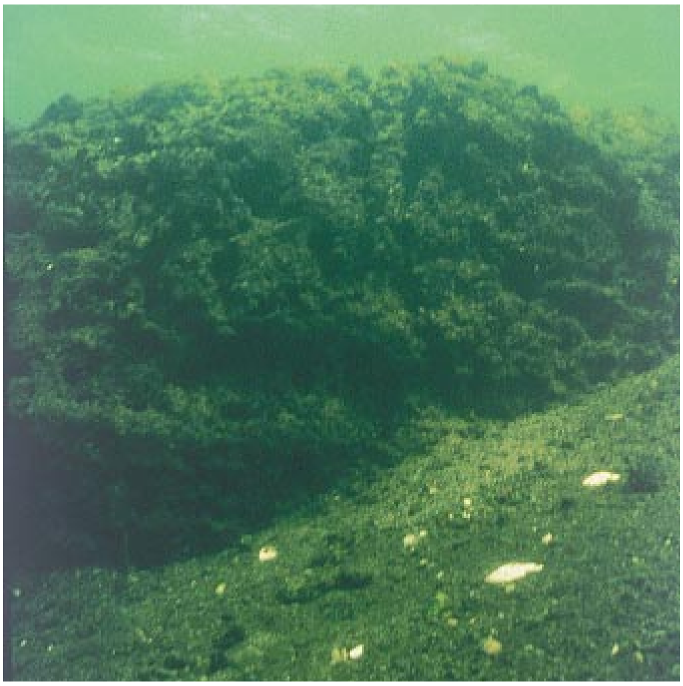

Figure 60:
Sublittoral peat bottoms (2.11.1), Puck Lagoon, Poland (photo: E. Andrulewicz)

Figure 61:
Sandy spit (3.1), Puck Bay, Poland (photo: E. Andrulewicz)

Figure 62:
Gravel spit (3.1), Långörn, Finland (photo: J. Kostet)

Figure 63:
Sandy beaches (3.2.1), Slowinski National Park, Poland (photo: J. Herbich)

Figure 64:
Gravel and shingle beaches (3.2.2), Öland Island, Sweden (photo: D. Boedeker)

Figure 65:
Boulder beach (3.2.3), Rügen Island, Germany (photo: R. Grunewald)

Figure 66:
Sandy beach ridge with no or low vegetation (3.3.1.1), Greifswald Lagoon, Germany (photo: C. Herrmann)

Figure 67:
(old) **Sandy beach ridges dominated by shrubs and trees (3.3.1.2)**, Isle of Vilm, Germany (photo: C. Herrmann)

Figure 68:
Gravel beach ridge with low vegetation (3.3.2.1), Vormsi Island, Estonia (photo: I. Klein)

Figure 69:
Foredune (3.4.1), primary dune vegetation, National Park Vorpommersche Boddenlandschaft, Germany (photo: H. D. Knapp)

Figure 70:
White dune (3.4.2), Leba, Poland (photo: H. D. Knapp)

Figure 71:
Grey dune (3.4.3), central coast, Poland (photo: J. Herbich)

Figure 72:
Brown dunes with dwarf shrubs (3.4.4.1), Germany (photo: H. D. Knapp)

Figure 73:
Brown dune covered with natural or almost natural coniferous forest (3.4.5.1), Hel Peninsula, Poland (photo: J. Herbich)

Figure 74:
(small) **Brown dune covered with natural or almost natural deciduous forest (3.4.5.2)**, Noer, Germany (photo: D. Boedeker)

Figure 75:
Wet dune slack (3.4.6), with different forms of vegetation, Slowinski National Park, Poland (photo: J. Herbich)

Figure 76:
Migrating dune (3.4.7) (moving into swamp 3.7.3.1), Slowinski National Park, Poland (photo: J. Herbich)

Figure 77:
Gently sloping limestone shores (3.5.1.1), Öland Island, Sweden (photo: H. D. Knapp)

Figure: 78:
Gently sloping crystalline bedrock shores (3.5.3), near Nyköping, Sweden (photo: C. Herrmann)

Figure 79: **Coastal limestone cliff (3.6.1)**, Panga, Estonia (photo: A. Palo)

Figure 80. **Coastal (chalk) cliff (3.6.3)**, Jasmund National Park, Rügen Island, Germany (photo: R. Grunewald)

Figure 81: **Coastal crystalline bedrock cliff (3.6.4)**, Bornholm Island, Denmark (photo: R. Grunewald)

Figure 82: (aktive) **Moraine cliff with no or low vegetation (3.6.5.1)**, Rügen Island, Germany (photo: C. Herrmann)

Figure 83:
Moraine cliff dominated by shrubs and trees (3.6.5.2), Isle of Vilm, Germany
(photo: R. Grunewald)

Figure 84:
Natural or almost natural reed, rush and sedge stands (3.7.1.1), Rügen Island, Germany
(photo: C. Herrmann)

Figure: 85:
Harvested reed stands (3.7.1.2), Rügen Island, Germany (photo: R. Grunewald)

Figure 86:
Salt pioneer sward (3.7.2.1), Vormsi island, Estonia (photo: I. Klein)

Figure 87:
Lower meadow (3.7.2.2), temporarily flooded, Germany (photo: R. Abraham)

Figure 88:
Upper meadow (3.7.2.3), lower meadows are flooded, Greifswald Lagoon, Germany (photo: C. Herrmann)

Figure 89:
Dry meadow (Alvar) (3.7.2.4), also a fine example for a flat coast subject to land upheaval (biotope complex D), Estonia (photo: A. Palo)

Figure 90:
Tall herb stands (3.7.2.5), Poland (photo: J. Herbich)

Figure 91:
Swamps dominated by shrubs and trees (3.7.3.2), Latvia (photo: D. Boedeker)

Figure 92:
Coastal bog (3.7.4), Lithuania (photo: C. Herrmann)

Figure 93:
Coastal fen (3.7.5), Lithuania (photo: D. Boedeker)

Figure 94:
Coastal lake (4.1), with strong coastal defence measures, Germany (photo: H. Sterr)

Figure 95:
Example of a permant brackish pool (4.2.1) (rock pool), Sweden (photo: C. Herrmann)

Figure 96:
Example of a temporary pool (4.3), Curonian Spit, Lithuania (photo: C. Herrmann)

Figure 97:
River beds (5.2) and **River banks (5.1)**, central coast, Poland (photo: J. Herbich)

RED LIST OF MARINE AND COASTAL BIOTOPES AND BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

1. Introduction

The following lists present the overall assessment of the degree to which a certain biotope or biotope complex is under threat in the Baltic Sea area. The different biotopes and biotope complexes are arranged in groups according to their current status of endangerment. This allows a quick way to look up the biotopes or biotope complexes of any threat category whereas the following tables (Table 4 and Table 5) can be used to look up special biotopes, but also provide detailed information on biotopes and biotope complexes on a national level.

2. Red List of Biotope Complexes of the Baltic Sea Area

Category "2" Heavily endangered:

Biotope Complex:	Code:
Lagoons including Bodden and Fladas	G

Category "3" Endangered:

Biotope Complex:	Code:
Rocky coast	A
Sandy coast	B
Moraine coast	C
Flat coast subject to intensive land upheaval	D
Fjords	E
Fjards/fjord like bays	F
Large spits of sand and/or gravel separating a lagoon from the sea	H
Riverine areas under backwater influence by the sea	I
Estuaries and river mouth areas	J
Archipelagos	K
Solitary islands	L
Esker islands	M

3. Red List of Biotopes of the Baltic Sea Area

Category "2" Heavily endangered:

Biotope:	Code:
Offshore (deep) waters below the halocline	1.1.2
Sublittoral level sandy bottoms dominated by macrophyte vegetation	2.5.2.2
Grey dunes	3.4.3
Brown dunes with dwarf shrubs	3.4.4
Brown dunes with dune shrubbery	3.4.5
Natural or almost natural coniferous forest on dunes	3.4.6.1
Natural or almost natural deciduous forest on dunes (beech, birch forest)	3.4.6.2
Wet dune slacks, including coastal fens with low vegetation	3.4.7.1
Salt pioneer swards	3.7.2.1
Lower meadows	3.7.2.2
Upper meadows	3.7.2.3
Tall herb stands	3.7.2.5
Coastal bogs	3.7.4
Calcareous fens ("rich" fens)	3.7.5.1
Eutrophic brackish coastal lakes	4.1.1.1
Mesotrophic brackish coastal lakes	4.1.1.2
Mesotrophic freshwater coastal lakes	4.1.2.2
Oligotrophic freshwater coastal lakes	4.1.2.3
Permanent eutrophic freshwater pools (incl. rock pools etc.)	4.2.2.1
Permanent mesotrophic freshwater pools (incl. rock pools etc.)	4.2.2.2

Category "3" Endangered:

Biotope:	Code:
Offshore (deep) waters above the halocline	1.1.1
Outer coastal (shallow) waters	1.2.1
Inner coastal (shallow) waters	1.2.2
Soft rock bottoms of the aphotic zone	2.1.1.1
Sublittoral level soft rock bottoms with little or no macrophyte vegetation of the photic zone	2.1.1.2.1
Sublittoral level soft rock bottoms dominated by macrophyte vegetation	2.1.1.2.2
Sublittoral soft rock reefs of the photic zone with little or no macrophyte vegetation	2.1.1.2.3
Hydrolittoral level soft rock bottoms with little or no macrophyte vegetation	2.1.1.3.1
Hydrolittoral level soft rock bottoms dominated by macrophyte vegetation	2.1.1.3.2
Hydrolittoral soft rock reefs with or without macrophyte vegetation	2.1.1.3.3
Solid rock bottoms of the aphotic zone	2.1.2.1

Sublittoral level solid rock bottoms with little or no macrophyte vegetation of the photic zone	2.1.2.2.1
Sublittoral level solid rock bottoms dominated by macrophyte vegetation	2.1.2.2.2
Sublittoral solid rock reefs of the photic zone with or without macrophyte vegetation	2.1.2.2.3
Hydrolittoral level solid rock bottoms with little or no macrophyte vegetation	2.1.2.3.1
Hydrolittoral level solid rock bottoms dominated by macrophyte vegetation	2.1.2.3.2
Hydrolittoral solid rock reefs with or without macrophyte vegetation	2.1.2.3.3
Stony bottoms of the aphotic zone	2.2.1
Sublittoral level stony bottoms with little or no macrophyte vegetation of the photic zone	2.2.2.1
Sublittoral level stony bottoms dominated by macrophyte vegetation	2.2.2.2
Sublittoral stony reefs of the photic zone with or without macrophyte vegetation	2.2.2.3
Hydrolittoral level stony bottoms with little or no macrophyte vegetation	2.2.3.1
Hydrolittoral level stony bottoms dominated by macrophyte vegetation	2.2.3.2
Stony reefs of the hydrolittoral with or without macrophyte vegetation	2.2.3.3
Hard clay bottoms of the aphotic zone	2.3.1
Sublittoral hard clay bottoms with little or no macrophyte vegetation of the photic zone	2.3.2.1
Hydrolittoral hard clay bottoms with little or no macrophyte vegetation	2.3.3.1
Gravel bottoms of the aphotic zone	2.4.1
Sublittoral level gravel bottoms with little or no macrophyte vegetation of the photic zone	2.4.2.1
Sublittoral level gravel bottoms dominated by macrophyte vegetation	2.4.2.2
Sublittoral gravel banks of the photic zone with or without macrophyte vegetation	2.4.2.3
Hydrolittoral level gravel bottoms with little or no macrophyte vegetation	2.4.3.1
Hydrolittoral level gravel bottoms dominated by macrophyte vegetation	2.4.3.2
Hydrolittoral gravel banks with or without macrophyte vegetation	2.4.3.3
Sandy bottoms of the aphotic zone	2.5.1
Sublittoral level sandy bottoms with little or no macrophyte vegetation of the photic zone	2.5.2.1
Sand bars of the sublittoral photic zone	2.5.2.3
Sand banks of the sublittoral photic zone with or without macrophyte vegetation	2.5.2.4
Hydrolittoral level sandy bottoms with little or no macrophyte vegetation	2.5.3.1
Hydrolittoral level sandy bottoms dominated by macrophyte vegetation	2.5.3.2
Hydrolittoral sand bars	2.5.3.3
Hydrolittoral sand banks with or without macrophyte vegetation	2.5.3.4
Muddy bottoms of the aphotic zone	2.7.1
Sublittoral muddy bottoms with little or no macrophyte vegetation of the photic zone	2.7.2.1
Sublittoral muddy bottoms dominated by macrophyte vegetation	2.7.2.2
Hydrolittoral muddy bottoms with little or no macrophyte vegetation	2.7.3.1
Hydrolittoral muddy bottoms dominated by macrophyte vegetation	2.7.3.2
Mixed sediments of the aphotic zone	2.8.1
Sublittoral mixed sediments with little or no macrophyte vegetation of the photic zone	2.8.2.1
Sublittoral mixed sediments dominated by macrophyte vegetation	2.8.2.2
Hydrolittoral mixed sediments with little or no macrophyte vegetation	2.8.3.1
Hydrolittoral mixed sediments dominated by macrophyte vegetation	2.8.3.2
Mussel beds of the aphotic zone	2.9.1
Sublittoral mussel beds with little or no macrophyte vegetation of the photic zone	2.9.2.1
Sublittoral mussel beds covered with macrophyte vegetation	2.9.2.2
Hydrolittoral mussel beds with little or no macrophyte vegetation	2.9.3.1
Hydrolittoral mussel beds covered with macrophyte vegetation	2.9.3.2
Sublittoral peat bottoms	2.11.1
Spits/bars	3.1
Sandy beaches	3.2.1
Gravel and shingle beaches	3.2.2
Boulder beaches	3.2.3
Sandy beach ridges with no or low vegetation	3.3.1.1
Sandy beach ridges dominated by shrubs or trees	3.3.1.2
Beach ridges consisting of gravel, pebbles and/or boulders with no or low vegetation	3.3.2.1
Beach ridges consisting of gravel, pebbles and/or boulders dominated by shrubs or trees	3.3.2.2
Beach ridges consisting of algal or other plant material	3.3.3
Fore dunes	3.4.1
White dunes s.str.	3.4.2.1
Green dunes	3.4.2.2
Wet dune slacks, including coastal fens dominated by shrubs or trees	3.4.7.2
Gently sloping limestone shores with no or low vegetation	3.5.1.1

Gently sloping limestone shores dominated by shrubs or trees	3.5.1.2
Gently sloping crystalline bedrock shores with no vegetation	3.5.3.1
Gently sloping crystalline bedrock shores dominated by shrubs or trees	3.5.3.3
Moraine cliffs with no or low vegetation	3.6.5.1
Natural reed, rush and sedge stands	3.7.1.1
Harvested reed, rush and sedge stands	3.7.1.2
Dry meadows (incl., alvars)	3.7.2.4
Swamps with low vegetation	3.7.3.1
Swamps dominated by shrubs or trees (natural or almost natural wet forests)	3.7.3.2
Acid fens (“poor” fens)	3.7.5.2
Eutrophic freshwater coastal lakes	4.1.2.1
Eutrophic glo-lakes	4.1.3.1
Mesotrophic glo-lakes	4.1.3.2
Permanent eutrophic brackish pools (incl. rock pools etc.)	4.2.1.1
Permanent mesotrophic brackish pools (incl. rock pools etc.)	4.2.1.2
Permanent oligotrophic brackish pools (incl. rock pools etc.)	4.2.1.3
River beds	5.1
River banks	5.2
Oxbow lakes	5.3

Category “P” Potentially endangered:

Biotope:	Code:
Bubbling reefs of the aphotic zone	2.10.1
Sublittoral bubbling reefs with little or no macrophyte vegetation of the photic zone	2.10.2.1
Sublittoral bubbling reefs dominated by macrophyte vegetation of the photic zone	2.10.2.2
Hydrolittoral peat bottoms	2.11.2
Migrating dunes	3.4.8
Sandstone cliffs with no or low vegetation	3.6.2.1

Category “*” Presumably not endangered at present:

Biotope:	Code:
Gently sloping crystalline bedrock shores with low vegetation	3.5.3.2
Limestone cliffs with no or low vegetation	3.6.1.1
Limestone cliffs dominated by shrubs or trees	3.6.1.2
Sandstone cliffs dominated by shrubs or trees	3.6.2.2
Chalk cliffs with no or low vegetation	3.6.3.1
Chalk cliffs dominated by shrubs or trees	3.6.3.2
Crystalline bedrock cliffs with no or low vegetation	3.6.4.1
Crystalline bedrock cliffs dominated by shrubs or trees	3.6.4.2
Moraine cliffs dominated by shrubs or trees	3.6.5.2
Caves	3.6.6
Temporary brackish pools (rock pools etc.)	4.3.1
Temporary freshwater pools (rock pools etc.)	4.3.2

Category “?” No data available:

Biotope:	Code:
Shell gravel bottoms of the aphotic zone	2.6.1
Sublittoral shell gravel bottoms of the photic zone	2.6.2
Gently sloping sandstone shores with no or low vegetation	3.5.2.1
Gently sloping sandstone shores dominated by shrubs or trees	3.5.2.2

Table 4: RED LIST AND THREAT EVALUATION OF MARINE AND COASTAL BIOTOPE COMPLEXES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

(for abreviations, please, refer to the introductory chapter)

Code	Biotope complexes	Σ	DK	SWE	FIN	RU^{Pe}	EST	LAT	LIT	RU^{Ka}	POL	GER
A	Rocky coasts	3	*	3	3	3	3	-	-	-	-	p
B	Sandy coasts	3	*	3	2	2	3	*	3	2-3	2-3	2-3
C	Moraine coasts	3	*	3	3	3	*	*	-	3	3	3
D	Flat coasts subject to intensive land upheaval	3	-	3	3	-	-	-	-	-	-	-
E	Fjords	3	-	3	3	-	-	-	-	-	-	-
F	Fjards/fjord like bays	3	3	3	3	3	-	-	-	-	-	2
G	Lagoons including Bodden, barrier lagoons, and Fladas	2	3	3	2	*	3	2	2	2-3	2	2
H	Large spits of sand and/or gravel separating a lagoon from the sea	3	p	-	2	-	*	-	3	2-3	3	2
I	Riverine areas under backwater influence by the sea	3	3	-	-	2	3	2	*	2-3	2-3	2-3
J	Estuaries and river mouth areas	3	3	3	3	2	-	2	3	2-3	2	2
K	Archipelagos	3	*	3	3	p	3	-	-	-	-	-
L	Solitary islands	3	p	3	2	3	3	-	-	-	-	3
M	Esker islands	3	p	3	2	*	-	-	-	-	-	-

Table 5: RED LIST AND THREAT EVALUATION OF MARINE AND COASTAL BIOTOPES OF THE BALTIC SEA, BELT SEA AND KATTEGAT

(for abbreviations, please, refer to the introductory chapter, Table 3)

Code	Biotope type	Σ	DK		SWE		FIN		RU[Pe]		EST		LAT		LIT		RU[Ka]		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
1	**PELAGIC MARINE BIOTOPES**																						
1.1	Offshore (deep) waters																						
1.1.1	Offshore (deep) waters above the halocline	3	*	3	*	3	*	3	*	3	*	3	*	3	*	3	*	3	*	3	*	3	CE,CF,CP
1.1.2	Offshore (deep) waters below the halocline	2	*	3	*	2	*	2	*	2	*	3	*	2	*	2	?	?	*	2	*	2	CE,CF,CP
1.2	Coastal (shallow) waters																						
1.2.1	Outer coastal (shallow) waters	3	*	3	*	3	*	3	*	3	*	*	*	3	*	3	2-3	2-3	*	3	*	3	CE,CF,CP, DR
1.2.2	Inner coastal (shallow) waters	3	*	3	*	3	*	2	*	2	3	3	3	3	*	2	2-3	2-3	*	3	*	2-3	CE,CF,CG, CH[GER],CP, DR
2	**BENTHIC MARINE BIOTOPES**																						
2.1	Rocky bottoms																						
2.1.1	Soft rock bottoms																						
2.1.1.1	Soft rock bottoms of the aphotic zone	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	*	?	CB[SWE],CE, CP
2.1.1.2	Sublittoral photic zone																						
2.1.1.2.1	Sublittoral level soft rock bottoms with little or no macrophyte vegetation of the photic zone	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	*	P	CB[SWE],CE, CP

Code	Biotope type	Σ	DK		SWE		FIN		RU Pe		EST		LAT		LIT		RU Ka		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.1.1.2.2	Sublittoral level soft rock bottoms dominated by macrophyte vegetation	3	*	3	3	3	?	?	-	-	-	-	-	-	-	-	?	?	-	-	*	2	CB^{SWE},CE, CP
2.1.1.2.3	Sublittoral soft rock reefs of the photic zone with little or no macrophyte vegetation	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	*	2	CB^{SWE},CE, CP
2.1.1.3	Hydrolittoral																						
2.1.1.3.1	Hydrolittoral level soft rock bottoms with little or no macrophyte vegetation	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CB^{SWE},CE, CP
2.1.1.3.2	Hydrolittoral level soft rock bottoms dominated by macrophyte vegetation	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CB^{SWE},CE, CP
2.1.1.3.3	Hydrolittoral soft rock reefs with or without macrophyte vegetation	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CB^{SWE},CE, CP
2.1.2	Solid rock bottoms (bedrock)																						
2.1.2.1	Solid rock bottoms of the aphotic zone	3	*	3	3	3	3	3	*	*	3	3	3	3	-	-	-	-	-	-	-	-	CE,CF^{F},CP
2.1.2.2	Sublittoral photic zone																						
2.1.2.2.1	Sublittoral level solid rock bottoms with little or no macrophyte vegetation of the photic zone	3	*	3	*	*	3	3	*	*	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{F},CP
2.1.2.2.2	Sublittoral level solid rock bottoms dominated by macrophyte vegetation	3	*	3	3	2	3	2	*	*	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{Fin},CP
2.1.2.2.3	Sublittoral solid rock reefs of the photic zone with or without macrophyte vegetation	3	*	3	3	3	3	3	*	*	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{F},CP

Code	Biotope type	Σ	DK		SWE		FIN		RU^Pe		EST		LAT		LIT		RU^Ka		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.1.2.3	Hydrolittoral																						
2.1.2.3.1	Hydrolittoral level solid rock bottoms with little or no macrophyte vegetation	3	*	3	*	3	*	3	P	3	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^F,CP, DR
2.1.2.3.2	Hydrolittoral level solid rock bottoms dominated by macrophyte vegetation	3	*	3	3	2	*	3	P	3	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^F,CP, DR
2.1.2.3.3	Hydrolittoral solid rock reefs with or without macrophyte vegetation	3	*	3	*	3	*	3	*	*	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^F,CP, DY
2.2	Stony bottoms																						
2.2.1	Stony bottoms of the aphotic zone	3	P	3	3	3	3	3	P	3	*	*	*	3	*	3	?	3	*	3	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2	Sublittoral photic zone																						
2.2.2.1	Sublittoral level stony bottoms with little or no macrophyte vegetation of the photic zone	3	P	3	*	3	3	3	P	3	X	X	3	3	3	2	2-3	2-3	P	2	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2.2	Sublittoral level stony bottoms dominated by macrophyte vegetation	3	P	3	3	3	3	3	P	3	3	3	P	3	3	2	?	?	P	2	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2.3	Sublittoral stony reefs of the photic zone with or without macrophyte vegetation	3	P	3	*	3	3	3	P	3	*	3	*	3	-	-	?	?	-	-	2	2	CB,CE,CF, CM^{DK},CP
2.2.3	Hydrolittoral																						
2.2.3.1	Hydrolittoral level stony bottoms with little or no macrophyte vegetation	3	*	3	*	3	*	3	P	3	X	X	*	3	*	3	2-3	2-3	*	3	*	3	CB^{FIN},CD^{GER}, CE,CF^F,CP
2.2.3.2	Hydrolittoral level stony bottoms dominated by macrophyte vegetation	3	*	3	3	3	*	3	P	3	3	3	*	3	*	3	2-3	2-3	-	-	*	2	CB,CD^{GER}, CE^{FIN},CF^F, CP

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.1.2.3	Hydrolittoral																						
2.1.2.3.1	Hydrolittoral level solid rock bottoms with little or no macrophyte vegetation	3	*	3	*	3	*	3	P	3	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{F},CP, DR
2.1.2.3.2	Hydrolittoral level solid rock bottoms dominated by macrophyte vegetation	3	*	3	3	2	*	3	P	3	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{F},CP, DR
2.1.2.3.3	Hydrolittoral solid rock reefs with or without macrophyte vegetation	3	*	3	*	3	*	3	*	*	3	3	-	-	-	-	-	-	-	-	-	-	CE,CF^{F},CP, DY
2.2	Stony bottoms																						
2.2.1	Stony bottoms of the aphotic zone	3	P	3	3	3	3	3	P	3	*	*	*	3	*	3	?	3	*	3	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2	Sublittoral photic zone																						
2.2.2.1	Sublittoral level stony bottoms with little or no macrophyte vegetation of the photic zone	3	P	3	*	3	3	3	P	3	X	X	3	3	3	2	2-3	2-3	P	2	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2.2	Sublittoral level stony bottoms dominated by macrophyte vegetation	3	P	3	3	3	3	3	P	3	3	3	P	3	3	2	?	?	P	2	*	2-3	CB,CE,CF, CM^{DK},CP
2.2.2.3	Sublittoral stony reefs of the photic zone with or without macrophyte vegetation	3	P	3	*	3	3	3	P	3	*	3	*	3	-	-	?	?	-	-	2	2	CB,CE,CF, CM^{DK},CP
2.2.3	Hydrolittoral																						
2.2.3.1	Hydrolittoral level stony bottoms with little or no macrophyte vegetation	3	*	3	*	3	*	3	P	3	X	X	*	3	*	3	2-3	2-3	*	3	*	3	CB^{FIN},CD^{GER}, CE,CF^{F},CP
2.2.3.2	Hydrolittoral level stony bottoms dominated by macrophyte vegetation	3	*	3	3	3	*	3	P	3	3	3	*	3	*	3	2-3	2-3	-	-	*	2	CB,CD^{GER}, CE^{FIN},CF^{F}, CP

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.4.3	Hydrolittoral																						
2.4.3.1	Hydrolittoral level gravel bottoms with little or no macrophyte vegetation	3	*	3	P	3	*	3	3	3	3	3	3	3	*	3	2-3	2-3	*	3	*	3	CB^{SWE},CD, CE,CF^{F},CP, DF
2.4.3.2	Hydrolittoral level gravel bottoms dominated by macrophyte vegetation	3	*	3	P	3	*	3	3	3	3	3	3	3	*	3	2-3	2-3	-	-	*	3	CB^{SWE},CD, CE,CF^{F},CP, DF
2.4.3.3	Hydrolittoral gravel banks with or without macrophyte vegetation	3	*	3	P	3	3	3	-	-	3	3	-	-	-	-	?	?	-	-	*	3	CB^{SWE},CE, CF^{F},CP,CM, DF
2.5	Sandy bottoms																						
2.5.1	Sandy bottoms of the aphotic zone	3	*	3	2	3	3	3	3	3	*	*	*	3	P	3	2-3	2-3	*	3	*	3	CB,CE,CF, CM,CP
2.5.2	Sublittoral photic zone																						
2.5.2.1	Sublittoral level sandy bottoms with little or no macrophyte vegetation of the photic zone	3	*	3	P	3	2	2	3	2	3	3	*	3	3	3	2-3	2-3	*	3	*	3	CB,CE,CF, CM,CP
2.5.2.2	Sublittoral level sandy bottoms dominated by macrophyte vegetation	2	*	3	3	3	2	2	-	-	3	3	2	2	2	1	2-3	2-3	2	1	3	3	CB,CE,CF, CM,CP
2.5.2.3	Sand bars of the sublittoral photic zone	3	*	3	3	3	3	3	3	3	3	3	*	3	3	3	2-3	2-3	P	3	*	3	CB,CE,CF, CM,CP
2.5.2.4	Sand banks of the sublittoral photic zone with or without macrophyte vegetation	3	*	3	3	3	3	3	?	?	3	3	-	-	-	-	2-3	2-3	3	3	-	-	CB,CE,CF, CM,CP
2.5.3	Hydrolittoral																						
2.5.3.1	Hydrolittoral level sandy bottoms with little or no macrophyte vegetation	3	*	3	P	3	3	3	3	3	3	3	3	3	3	3	2-3	2-3	3	3	*	3	CB,CD,CE, CF^{F},CG, CM^{RUKA},CP, DF

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.5.3.2	Hydrolittoral level sandy bottoms dominated by macrophyte vegetation	3	*	3	P	3	3	3	3	3	3	3	3	2	-	-	2-3	2-3	3	3	3	3	CB,CD^{GER}, CE,CF^{F},CG, CP,DF
2.5.3.3	Hydrolittoral sand bars	3	*	3	P	3	3	3	P	3	3	3	3	3	-	-	2-3	2-3	P	3	P	3	CB,CD,CE, CF^{F},CG,CP, DF
2.5.3.4	Hydrolittoral sand banks with or without macrophyte vegetation	3	*	3	P	3	3	3	P	3	3	3	-	-	-	-	2-3	2-3	2	3	-	-	CB,CD,CE, CF^{F}CG,CP, DF
2.6	Shell gravel bottoms																						
2.6.1	Shell gravel bottoms of the aphotic zone	?	*	3	?	?	-	-	-	-	-	-	-	-	?	?	2-3	2-3	?	?	-	-	CE,CP
2.6.2	Sublittoral shell gravel bottoms of the photic zone	?	*	3	?	?	-	-	-	-	-	-	-	-	?	?	2-3	2-3	?	?	?	?	CE,CP
2.7	Muddy bottoms																						
2.7.1	Muddy bottoms of the aphotic zone	3	*	3	2	2	*	3	3	3	*	*	*	*	*	3	?	?	*	2	*	2	CB^{SWE},CE, CF^{F},CP
2.7.2	Sublittoral photic zone																						
2.7.2.1	Sublittoral muddy bottoms with little or no macrophyte vegetation of the photic zone	3	*	3	2	2	*	3	3	3	*	*	*	3	*	*	2-3	2-3	*	2	*	3	CB^{SWE},CE, CF^{F},CG,CP
2.7.2.2	Sublittoral muddy bottoms dominated by macrophyte vegetation	3	*	3	2	2	*	3	3	3	-	-	*	3	-	-	2-3	2-3	?	?	3	3	CB^{SWE},CE, CF^{F},CG,CP
2.7.3	Hydrolittoral																						
2.7.3.1	Hydrolittoral muddy bottoms with little or no macrophyte vegetation	3	*	3	3	3	*	3	3	3	3	3	*	3	-	-	2-3	2-3	-	-	3	2	CB^{SWE},CE, CF^{F},CP

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.7.3.2	Hydrolittoral muddy bottoms dominated by macrophyte vegetation	3	*	3	3	3	*	3	3	3	3	3	-	-	-	-	2-3	2-3	3	3	3	2-3	CB^{SWE},CE, CF^{F},CP
2.8	Mixed sediment bottoms																						
2.8.1	Mixed sediments of the aphotic zone	3	*	3	3	3	*	3	P	*	*	*	3	3	*	3	2-3	2-3	*	3	*	2	CB,CE,CF, CP
2.8.2	Sublittoral photic zone																						
2.8.2.1	Sublittoral mixed sediments with little or no macrophyte vegetation of the photic zone	3	*	3	3	3	*	3	P	3	*	*	3	3	*	3	2-3	2-3	*	2	*	3	CB,CE,CF, CG,CP
2.8.2.2	Sublittoral mixed sediments dominated by macrophyte vegetation	3	*	3	2	2	*	3	P	3	?	?	3	3	3	2	2-3	2-3	2	2	*	3	CB,CE,CF, CG,CP
2.8.3	Hydrolittoral																						
2.8.3.1	Hydrolittoral mixed sediments with little or no macrophyte vegetation	3	*	3	3	3	*	3	3	3	*	*	3	3	*	3	2-3	2-3	3	3	*	3	CB^{SWE},CE, CF^{F},CP,DF, DR
2.8.3.2	Hydrolittoral mixed sediments dominated by macrophyte vegetation	3	*	3	2	2	*	3	3	3	*	*	-	-	*	2	2-3	2-3	3	2	2	2	CB^{SWE},CE, CF^{F},CP,DF, DR
2.9	Mussel beds																						
2.9.1	Mussel beds of the aphotic zone	3	*	3	3	3	-	-	-	-	-	-	-	-	?	?	?	?	-	-	-	-	CB^{SWE},CE,C P
2.9.2	Sublittoral mussel beds of the photic zone																						
2.9.2.1	Sublittoral mussel beds with little or no macrophyte vegetation of the photic zone	3	*	3	3	3	-	-	-	-	-	-	-	-	?	?	?	?	*	3	P	2	CB^{SWE},CE, CF,CP
2.9.2.2	Sublittoral mussel beds covered with macrophyte vegetation	3	*	3	3	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	P	2	CB^{SWE},CE, CF,CP

Code	Biotope type	Σ	DK		SWE		FIN		RU[Pe]		EST		LAT		LIT		RU[Ka]		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
2.9.3	Hydrolittoral																						
2.9.3.1	Hydrolittoral mussel beds with little or no macrophyte vegetation	3	*	3	?	?	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CB[SWE],CE, CP
2.9.3.2	Hydrolittoral mussel beds covered with macrophyte vegetation	3	*	3	?	?	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CB[SWE],CE, CP
2.10	Bubbling reefs																						
2.10.1	Bubbling reefs of the aphotic zone	P	P	3	?	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CE,CF,CP
2.10.2	Sublittoral photic zone																						
2.10.2.1	Sublittoral bubbling reefs with little or no macrophyte vegetation of the photic zone	P	2	3	?	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CE,CF,CP, DR
2.10.2.2	Sublittoral bubbling reefs dominated by macrophyte vegetation of the photic zone	P	P	3	?	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	CE,CF,CP, DR
2.11	Peat bottoms																						
2.11.1	Sublittoral peat bottoms	3	*	3	*	*	?	?	-	-	-	-	-	-	-	-	?	?	P	3	P	*	CB,CE, CD[GER],CP
2.11.2	Hydrolittoral peat bottoms	P	-	-	?	?	?	?	-	-	-	-	-	-	-	-	?	?	P	3	P	*	CE,CP
3	**TERRESTRIAL BIOTOPES**																						
3.1	Spits/bars	3	*	3	p	3	2	2	-	-	3	3	P	3	-	-	2-3	2-3	P	2-3	P	2-3	CB,CD,CG, CP,DF,DR

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.2	Beaches																						
3.2.1	Sandy beaches	3	*	*	3	3	3	2	2	2	3	3	*	3	*	3	2-3	2-3	*	3	*	3	CD,CE^{RUPE}, CG,CH^{RUPE}, CP,CT,DF, DR
3.2.2	Gravel and shingle beaches	3	*	*	*	3	3	3	3	3	P	*	*	3	-	-	3	3	*	P	*	3	CD,CG, CH^{RUPE},CP, CT,DF,DR
3.2.3	Boulder beaches	3	*	*	*	3	*	3	3	3	P	*	*	3	-	-	3	3	P	P	*	3	CD,CG,CP, CT,DF,DR
3.3	Beach ridges																						
3.3.1	Sandy beach ridges																						
3.3.1.1	Sandy beach ridges with no or low vegetation	3	*	*	P	3	2	2	?	?	3	3	3	3	*	3	2	2	*	*	2	2	CB,CD, CF^{LAT},CG, CH,CP,DR, DY^{SWE}
3.3.1.2	Sandy beach ridges dominated by shrubs or trees	3	*	*	P	3	2	2	?	?	3	3	3	2	*	3	2-3	2-3	P	P	2	2	CB,CG,CH, CT^{POL},DR, DY^{SWE}
3.3.2	Beach ridges consisting of gravel, pebbles and/or boulders																						
3.3.2.1	Beach ridges consisting of gravel, pebbles and/or boulders with no or low vegetation	3	*	*	P	*	3	3	?	?	3	3	3	3	-	-	3	3	-	-	2-3	2-3	CB,CF^{LAT}, CG,CH,CM, DR,DY^{SWE}
3.3.2.2	Beach ridges consisting of gravel, pebbles and/or boulders dominated by shrubs or trees	3	*	*	P	*	3	3	?	?	3	3	3	2	-	-	3	3	-	-	2	2	CB,CG,CH, CT,DR, DY^{SWE}
3.3.3	Beach ridges consisting of algal or other plant material	3	*	*	*	3	*	*	*	*	*	*	*	*	*	*	3	3	P	3	-	-	CD,CP,DR

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.4	Coastal dunes																						
3.4.1	Foredunes	3	*	*	*	3	3	2	*	*	3	3	P	3	P	3	0	0	3	3	2-3	2-3	CB,CD,CG, CY^{EST},DR
3.4.2	White dunes																						
3.4.2.1	White dunes s.str.	3	*	*	P	3	2	2	?	?	3	3	P	3	3	2-3	2	2	2	2	2	2	CB^{RUPE},CD, CG,CH^{RUPE}, CT^{RUPE}, CY^{EST}, DA^{RUPE}, DF^{LAT}, DR^{RUPE}, DY^{SWE}
3.4.2.2	Green dunes	3	*	3	P	3	?	?	3	3	-	-	P	3	P	3	3	3	2	2	-	-	CB^{RUPE}, CD,CG, CH^{RUPE}, CT^{RUPE}, DA^{RUPE}, DR^{RUPE}, DY^{SWE}
3.4.3	Grey dunes	2	*	3	3	3	2	2	2	2	3	3	3	2	P	3	2-3	2-3	2	2	2	2	CB^{RUPE}, CD,CG, CH,CT, DA^{RUPE}, DR^{RUPE}, DY^{SWE}
3.4.4	Brown dunes with dwarf shrubs	2	P	3	3	3	1	2	2	2	3	3	P	3	P	3	2-3	2-3	2	2	2	2	CB^{RUPE}, CD,CG, CH,CT, DA^{RUPE}, DR^{RUPE}, DY^{SWE}
3.4.5	Brown dunes with dune shrubbery	2	P	3	3	3	1	2	2	2	3	3	*	*	-	-	3	3	P	P	2	2	CB^{RUPE}, CD,CG, CH,CT, DA^{RUPE}, DR^{RUPE}, DY^{SWE}

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.4.6	Brown dunes covered with trees																						
3.4.6.1	Natural or almost natural coniferous forest on dunes	2	-	-	2	2	2	2	2	2	3	3	3	2	P	3	?	3	*	3	2	2	CB^{RUPE}, CG,CH,CT, DA^{RUPE}, DR,DY^{LAT}
3.4.6.2	Natural or almost natural deciduous forest on dunes (beech, oak, birch forest)	2	*	*	2	2	2	2	-	-	3	3	P	3	P	3	?	3	2	2	2	2-3	CG^{FIN},CH, CT,DR, DY^{SWE}
3.4.7	Wet dune slacks																						
3.4.7.1	Wet dune slacks, incl. coastal fens with low vegetation	2	*	*	3	3	2	2	?	?	*	*	*	3	-	-	3	3	2	3	2	2	CG,CH,CT, CW
3.4.7.2	Wet dune slacks, incl. coastal fens dominated by shrubs or trees	3	*	*	3	3	2	2	?	?	*	*	*	3	-	-	3	3	3	3	3	3	CG,CH,CT, CW
3.4.8	Migrating dunes	P	*	*	P	*	-	-	-	-	-	-	-	-	P	3	2-3	2-3	P	P	1	3	CD,CT,DR
3.5	Gently sloping rocky shores																						
3.5.1	Limestone shores																						
3.5.1.1	Gently sloping limestone shores with no or low vegetation	3	-	-	P	3	-	-	-	-	*	*	-	-	-	-	-	-	-	-	-	-	CA
3.5.1.2	Gently sloping limestone shores dominated by shrubs or trees	3	-	-	P	3	-	-	-	-	*	*	-	-	-	-	-	-	-	-	-	-	0
3.5.2	Sandstone shores																						
3.5.2.1	Gently sloping sandstone shores with no or low vegetation	?	*	*	?	?	-	-	-	-	P	P	-	-	-	-	?	?	-	-	-	-	DR
3.5.2.2	Gently sloping sandstone shores dominated by shrubs or trees	?	*	*	?	?	-	-	-	-	P	P	-	-	-	-	?	?	-	-	-	-	DR

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.5.3	Crystalline bedrock shores																						
3.5.3.1	Gently sloping crystalline bedrock shores with no vegetation	3	*	*	*	3	3	*	3	3	-	-	-	-	-	-	-	-	-	-	-	-	CH, DR^{RUPE}
3.5.3.2	Gently sloping crystalline bedrock shores with low vegetation	*	*	*	*	*	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	CG,CH, DR^{RUPE}
3.5.3.3	Gently sloping crystalline bedrock shores dominated by shrubs or trees	3	*	*	*	3	3	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	CG,CH,CT, DA^{RUPE}, DR^{RUPE}
3.6	Coastal cliffs and caves																						
3.6.1	Limestone cliffs																						
3.6.1.1	Limestone cliffs with no or low vegetation	*	*	*	*	*	-	-	-	-	*	3	-	-	-	-	-	-	-	-	-	-	CB^{EST}, CE^{EST}, CM^{EST}, CP^{EST}
3.6.1.2	Limestone cliffs dominated by shrubs or trees	*	*	*	*	*	-	-	-	-	*	3	-	-	-	-	-	-	-	-	-	-	CA,CB^{EST}, CE^{EST}, CM^{EST}, CP^{EST}
3.6.2	Sandstone cliffs																						
3.6.2.1	Sandstone cliffs with no or low vegetation	P	*	*	-	-	-	-	-	-	*	P	P	3	-	-	-	-	-	-	-	-	CG
3.6.2.2	Sandstone cliffs dominated by shrubs or trees	*	*	*	-	-	-	-	-	-	*	P	-	-	-	-	-	-	-	-	-	-	CG
3.6.3	Chalk cliffs																						
3.6.3.1	Chalk cliffs with no or low vegetation	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	-
3.6.3.2	Chalk cliffs dominated by shrubs or trees	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	-

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.6.4	Crystalline bedrock cliffs																						
3.6.4.1	Crystalline bedrock cliffs with no or low vegetation	*	*	*	P	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-
3.6.4.2	Crystalline bedrock cliffs dominated by shrubs or trees	*	*	*	P	*	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	CG, DR^{RUPE}
3.6.5	Moraine cliffs																						
3.6.5.1	Moraine cliffs with no or low vegetation	3	*	*	?	?	-	-	-	-	*	*	*	3	3	3	2-3	2-3	*	*	3	3	CD,DR
3.6.5.2	Moraine cliffs dominated by shrubs or trees	*	*	*	?	?	-	-	-	-	*	*	-	-	-	-	3	3	P	*	3	3	CD,DR
3.6.6	Caves	*	*	*	*	*	-	-	-	-	*	*	-	-	-	-	?	?	-	-	-	-	0
3.7	Coastal wetlands and meadows																						
3.7.1	Reed, rush and sedge stands																						
3.7.1.1	Natural reed, rush and sedge stands	3	-	-	*	*	3	3	2	2	*	*	*	3	2-3	2	?	?	P	P	3	3	CA,CB^{RUPE}, CD,CE, CF^{RUPE},CG, CH^{RUPE},CP, CW,DA^{RUPE} DF^{RUPE},DR
3.7.1.2	Harvested reed, rush and sedge stands	3	-	-	-	-	P	P	?	?	3	3	-	-	2-3	3	?	?	P	P	3	3	CA,CD,CE, CP,CW,DR
3.7.2	Meadows/pastures																						
3.7.2.1	Salt pioneer swards	2	*	*	P	3	2	1	-	-	*	*	3	3	-	-	?	?	0	0	2	3	CA,CE,CG, CP,CW
3.7.2.2	Lower meadows	2	*	*	P	3	3	2	2	2	*	*	1	1	P	3	?	3	1	1	2	2	CA,CD, CF^{RUPE},CG, CP^{RUPE},CW DF^{RUPE}, DR^{RUPE}

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
3.7.2.3	Upper meadows	2	*	*	P	3	3	2	2	2	2	2	2	1	P	3	?	?	1	1	2	2	CA,CD, CF^{RUPE}, CG,CH, CP^{RUPE},CW DF^{RUPE}, DR^{RUPE}
3.7.2.4	Dry meadows (incl. alvars)	3	*	*	P	3	-	-	3	3	3	2	-	-	-	-	-	-	-	-	-	-	CA,CH^{EST}, CM^{EST}, CY^{RUPE}, DY^{RUPE}
3.7.2.5	Tall herb stands	2	*	*	*	*	*	*	1	1	2	2	1	1	P	3	?	?	2	2	3	3	CA,CB^{RUPE}, CD,CG,CH, CP,DA^{RUPE} DR^{RUPE},CW
3.7.3	Swamps																						
3.7.3.1	Swamps with low vegetation	3	*	*	P	3	2	2	3	3	*	*	P	3	P	3	3	3	3	2	?	?	CA,CD^{RUPE}, CE^{RUPE}, CF^{RUPE},CP, CW,DF^{RUPE}
3.7.3.2	Swamps dominated by shrubs or trees (natural or almost natural wet forests)	3	*	*	P	3	2	2	2	2	*	*	P	3	P	3	3	3	3	3	P	3	CD^{RUPE}, CE^{RUPE}, CF^{RUPE},CP, CT,CW, DA^{RUPE}, DF^{RUPE}
3.7.4	Coastal bogs	2	*	3	3	3	2	2	?	?	-	-	2	1	P	3	3	3	1	1	P	2	CA^{GER},CE, CD^{GER},CM, CT,CW
3.7.5	Coastal fens																						
3.7.5.1	Calcareous fens ("rich" fens)	2	P	2	P	3	2	2	-	-	3	3	2	2	-	-	?	?	-	-	X	X	CA,CP,CW
3.7.5.2	Acid fens ("poor" fens)	3	*	*	P	3	3	3	3	3	*	*	3	3	P	3	?	?	2	2	X	X	CA,CE, CM^{RUPE}, CT^{RUPE},CW DA^{RUPE}

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
4	**COASTAL LAKES, POOLS and "GLO-LAKES"**																						
4.1	Coastal lakes																						
4.1.1	Brackish coastal lakes																						
4.1.1.1	Eutrophic brackish coastal lakes	2	*	*	?	?	3	2	-	-	*	*	2	1	-	-	?	?	*	3	3	2	CA,CB, CE,CF,CP, CW,DR,DF
4.1.1.2	Mesotrophic brackish coastal lakes	2	*	*	*	3	3	2	-	-	?	?	0	0	-	-	?	?	-	-	-	-	CA,CB, CE,CF,CP, CW,DR,DF
4.1.2	Freshwater coastal lakes																						
4.1.2.1	Eutrophic freshwater coastal lakes	3	*	*	*	*	3	2	3	3	*	*	2	1	-	-	3	3	-	-	*	*	CA,CB, CE,CF^{RUPE}, CH^{RUPE},CP, CW,DA^{RUPE} DF^{RUPE},DR
4.1.2.2	Mesotrophic freshwater coastal lakes	2	*	*	*	*	3	2	2	2	?	?	0	0	P	3	?	?	-	-	-	-	CA,CB, CE,CF^{RUPE}, CH^{RUPE},CP, CW,DA^{RUPE} DF^{RUPE},DR
4.1.2.3	Oligotrophic freshwater coastal lakes	2	P	2	*	*	2	1	?	?	-	-	-	-	-	-	?	?	-	-	-	-	CA,CB,CE, CP,CW,DR
4.1.3	Glo-lakes																						
4.1.3.1	Eutrophic glo-lakes	3	-	-	P	3	3	2	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CA,CB,CE, CP,CW,DR
4.1.3.2	Mesotrophic glo-lakes	3	-	-	P	3	3	2	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CA,CB,CE, CP,CW,DR

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
4.2	Permanent pools (incl. rock pools etc.)																						
4.2.1	Permanent brackish pools																						
4.2.1.1	Permanent eutrophic brackish pools (incl. rock pools etc.)	3	-	-	*	*	3	2	-	-	*	*	3	2	-	-	?	?	-	-	-	-	CA,CB^{LAT}, CE,CP,CW
4.2.1.2	Permanent mesotrophic brackish pools (incl. rock pools etc.)	3	-	-	*	*	3	2	-	-	?	?	-	-	-	-	?	?	-	-	-	-	CA,CB^{LAT}, CE,CP, CW
4.2.1.3	Permanent oligotrophic brackish pools (incl. rock pools etc.)	3	-	-	*	3	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	CE,CW, CA,CP^{FIN}
4.2.2	Permanent freshwater pools																						
4.2.2.1	Permanent eutrophic freshwater pools (incl. rock pools etc.)	2	-	-	?	?	3	2	3	3	*	*	-	-	-	-	?	?	-	-	-	-	CA,CB^{RUPE}, CE,CF^{RUPE}, CP,CW, DA^{RUPE}, DF^{RUPE}
4.2.2.2	Permanent mesotrophic freshwater pools (incl. rock pools etc.)	2	-	-	?	?	2	2	2	2	?	?	-	-	-	-	?	?	-	-	-	-	CA, CB^{RUPE}, CE,CF^{RUPE}, CP,CW, DA^{RUPE}, DF^{RUPE}
4.3	Temporary pools (incl. rock pools etc.)																						
4.3.1	Temporary brackish pools (rock pools etc.)	*	*	*	*	*	*	*	3	3	*	*	*	3	-	-	?	?	-	-	-	-	CE^{RUPE}, CP^{RUPE}, CW^{RUPE}, DR
4.3.2	Temporary freshwater pools (rock pools etc.)	*	*	*	*	*	*	*	3	3	*	*	*	3	-	-	?	?	-	-	*	*	CE^{RUPE}, CP^{RUPE}, CW^{RUPE}, DR

Code	Biotope type	Σ	DK		SWE		FIN		RU^{Pe}		EST		LAT		LIT		RU^{Ka}		POL		GER		Major human impacts
			DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	DE	QU	
5	**Selected biotopes of RIVERINE and RIVER MOUTH AREAS**																						
5.1	River beds	3	*	3	3	3	*	3	P	2	3	3	P	2	P	3	?	?	*	2-3	?	?	CB,CD, CE,CF^{RUPE}, CG^{RUPE}, CP,CW, DA^{RUPE}, DB^{RUPE}
5.2	River banks	3	*	*	3	3	*	3	3	2	3	3	P	3	*	*	?	?	2	1	-	-	CA^{RUPE}, CB,CD^{POL}, CE,CP, CW^{RUPE}, DA^{RUPE}, DB^{RUPE}, DF^{RUPE}, DR^{RUPE}
5.3	Oxbow lakes	3	*	3	3	3	3	3	3	3	3	3	P	3	*	*	?	?	1	1	-	-	CA,CB,CD CE,CP,CW DA^{RUPE}, DB^{RUPE}

BALTIC SEA ENVIRONMENT PROCEEDINGS

No. 1 JOINT ACTIVITIES OF THE BALTIC SEA STATES WITHIN THE FRAMEWORK OF THE CONVENTION ON THE PROTECTION OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA 1974-1978 (1979)*

No. 2 REPORT OF THE INTERIM COMMISSION (IC) TO THE BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION (1981)*

No. 3 ACTIVITIES OF THE COMMISSION 1980
- Report on the activities of the Baltic Marine Environment Protection Commission during 1980
- HELCOM Recommendations passed during 1980 (1981)*

No. 4 BALTIC MARINE ENVIRONMENT BIBLIOGRAPHY 1970-1979 (1981)*

No. 5A ASSESSMENT OF THE EFFECTS OF POLLUTION ON THE NATURAL RESOURCES OF THE BALTIC SEA, 1980 PART A-1: OVERALL CONCLUSIONS (1981)*

No. 5B ASSESSMENT OF THE EFFECTS OF POLLUTION ON THE NATURAL RESOURCES OF THE BALTIC SEA, 1980
PART A-1: OVERALL CONCLUSIONS
PART A-2: SUMMARY OF RESULTS
PART B: SCIENTIFIC MATERIAL (1981)

No. 6 WORKSHOP ON THE ANALYSIS OF HYDROCARBONS IN SEAWATER
Institut für Meereskunde an der Universität Kiel, Department of Marine Chemistry, March 23 - April 3, 1981 (1982)

No. 7 ACTIVITIES OF THE COMMISSION 1981
- Report of the activities of the Baltic Marine Environment Protection Commission during 1981 including the Third Meeting of the Commission held in Helsinki 16-19 February 1982
- HELCOM Recommendations passed during 1981 and 1982 (1982)

No. 8 ACTIVITIES OF THE COMMISSION 1982
- Report of the activities of the Baltic Marine Environment Protection Commission during 1982 including the Fourth Meeting of the Commission held in Helsinki 1-3 February 1983
- HELCOM Recommendations passed during 1982 and 1983 (1983)

No. 9 SECOND BIOLOGICAL INTERCALIBRATION WORKSHOP
Marine Pollution Laboratory and Marine Division of the National Agency of Environmental Protection, Denmark, August 17-20, 1982, Rønne, Denmark (1983)

No. 10 TEN YEARS AFTER THE SIGNING OF THE HELSINKI CONVENTION
National Statements by the Contracting Parties on the Achievements in Implementing the Goals of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (1984)

No. 11 STUDIES ON SHIP CASUALTIES IN THE BALTIC SEA 1979-1981
Helsinki University of Technology, Ship Hydrodynamics Laboratory, Otaniemi, Finland
P. Tuovinen, V. Kostilainen and A. Hämäläinen (1984)

No. 12 GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE SECOND STAGE (1984)*

No. 13 ACTIVITIES OF THE COMMISSION 1983
- Report of the activities of the Baltic Marine Environment Protection Commission during 1983 including the Fifth Meeting of the Commission held in Helsinki 13-16 March 1984
- HELCOM Recommendations passed during 1983 and 1984 (1984)

No. 14 SEMINAR ON REVIEW OF PROGRESS MADE IN WATER PROTECTION MEASURES
17-21 October 1983, Espoo, Finland (1985)

*) out of print

No. 15 ACTIVITIES OF THE COMMISSION 1984
- Report of the activities of the Baltic Marine Environment Protection Commission during 1984 including the Sixth Meeting of the Commission held in Helsinki 12-15 March 1985
- HELCOM Recommendations passed during 1984 and 1985 (1985)

No. 16 WATER BALANCE OF THE BALTIC SEA
A Regional Cooperation Project of the Baltic Sea States;
International Summary Report (1986)

No. 17A FIRST PERIODIC ASSESSMENT OF THE STATE OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA, 1980-1985; GENERAL CONCLUSIONS (1986)

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