LEARNER'S GUIDE NO. 10

Hatching new scientists across the borders

THEORY AND EXERCISES
FOR TEACHERS

The Baltic Sea Project

This book was produced within the Baltic Sea Project
- a part of the UNESCO Associated Schools Project.

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Editor and editorial team:
Brian Dall Schyth, Søren Levring, Birgitte Bjørn Petersen
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BY KERSTI SÕGEL
GENERAL COORDINATOR
OF THE BALTIC SEA PROJECT

FOREWORD

Every one of us has their special relationship with the Baltic Sea - moments that will last. The Baltic Sea Project has itself lasted for 25 years. I believe that thanks to the Project, tens of thousands of people have memories to cherish. The Baltic Sea Project is a unique and active network of schools that works with education in the field of sustainable development from the scientific point of view both on the local and regional scale. Sustainable does not mean the same as being at a standstill. Clever solutions that help to produce more with fewer resources are an exciting challenge to us all.

The United Nations Decade of Education for Sustainable Development led by UNESCO ends in 2014 - summaries will be made of the changes that have taken place. During this time we have gained much more knowledge about the condition of our planet and various possible future strategies have become clearer. The expression ‘sustainable development’ belongs to our daily vocabulary. However, does it affect our behaviour and values? Many decisions are made on a political level but it is important that communities participate, and everyone should take responsibility. Planning your daily activities reasonably helps to protect the Baltic Sea. Cooperation, the pillar on which the Baltic Sea Project stands, is also the key in planning sustainable development. All the countries around the Baltic Sea depend upon each other. Broadening one’s mind helps to give meaning to one’s activities and find solutions to the problem of how to protect the environment while the human population of the world is continually increasing. We are connected to other ecosystems and we are a part of the whole world.

This book is meant as a handbook for new BSP teachers. It will give an overview of the main methods that teachers and students have used to study the Baltic Sea in this project. The subjects covered include the most important methods of observing and studying, while their background is also explained. The condition of the Baltic Sea has improved but we need greater changes. Agriculture and heavy traffic are still serious problems. Changes do not always happen as fast as we would want, but on the other hand, everybody has to start somewhere. We need to work together to be successful.

I would like to thank all the people who contributed to writing this book and I would like to express my appreciation to the editor Mr. Brian Dall Schyth, Denmark, and his hard work for preparing BSP Learner's Guide No. 10 but particularly I give thanks to the Danish national coordinator Mr. Søren Levring, who developed the idea for this book and led it to success.

We have already achieved a lot, but we can ensure with our activities, that we can give a better place to live for those who come after us.

Content

BSP camp in Meri-Pori, Finland, 26.-31. May 2013

BY SØREN LEVRING

To be a Baltic Sea Teacher 01.

A handbook

This is a handbook for teachers enrolled in the Baltic Sea Project (BSP). The intention of the book is to explain relevant theories and practices to be used in teaching under the BSP programmes which will be mentioned briefly below. Currently, more than 200 schools from all nine countries around the Baltic Sea are involved in these programmes. Most practices referred to have been worked out and tested by teachers and students in national and international camps or training courses which are an important part of the activities of BSP.

THE FOLLOWING DEFINES WORK DONE BY TEACHERS IN THE BSP:

- English is used as a common working language, even when participant have only minor skills
- Exercises are either done directly in nature or are carried out as laboratory exercises with relevance to the nature in or around the Baltic Sea area

High priority learning-goals are:

- Democratic responsibility
- Theories about the environment and the Baltic Sea, which are the common interests for the joining countries
- Intercultural awareness which is taught through teamwork with colleagues in the other BSP countries

BSP PROGRAMMES

A BSP-teacher is working within the following programmes:

Water quality in the Baltic Sea
The condition of the sea is primarily determined by investigating the living organisms (biotic factors) in the water and in the sediment although abiotic factors such as salinity, pH and concentration of selected nutrients are also included.

Rivers
The condition of the sea is determined by investigating biotic and abiotic factors in the freshwater.

BSP Coast Watch
BSP Coast Watch is a programme to study animals, plants and aspects of human impacts on the seashore. The programme is suitable for all ages of students.

Air Quality
Estimation of air quality by the use of bio-indicators. Fir-trees and lichens are used for this purpose.
Phenological studies
As an example students study the first signs of spring.

Bird Ecology

1. Long-term monitoring of the abundance of breeding birds at selected localities
2. A count of waterbirds washed ashore and
3. A count of midwinter waterbirds.

Figure 1.1
Investigations in The Rivers Programme

Figure 1.2
Fossilized jellyfish to be found at Bornholm. BSP teachers and students together at camp

Figure 1.3
Bird Ecology

Figure 1.4
Hatching new scientist across the border. Teachers and students from Poland and Denmark

Figure 1.5
Final Conference in Vilnius 2009. Students from Egå Secondary School Denmark


1.3


1.1


1.4


1.2

1.5

Environmental History
Studies of the history of our environments - Environment has a history!

Environmental measurements
Common environmental research done in the whole BSP area.

For every programme there is a programme coordinator. Names of these can be found on the homepage of BSP (www.b-s-p.org/home/programmes/).

For science education it is possible to share results from Rivers, Water quality, Coast Watch etc. using a new app developed under the BSP project and which will be mentioned in this book. It will be possible for students to use this app from mobile phones and similar devices.

Result gained under specific programmes can be sent to the programme coordinator or can be published directly on the website and/or in the BSP-newsletter. In Denmark publication of results is also possible in the annual ASP-report.

There are several printed learners guides available on varying subjects of relevance to the programmes. A list of these as well as electronic versions (as pdf-files) can be found at the website: www.b-s-p.org.

SCIENCE AND SUSTAINABILITY

In the Baltic Sea Project teachers are working across national borders to increase awareness of sustainability and to hatch new scientist amongst students.

This must be done in cooperation between all levels in the educational system to inspire students and to show them the possibilities for future engagement and work. Current evidence points to the importance of working together across educational sectors like secondary schools and universities.

NETWORKING

BSP-schools must have an active international profile and the board and leadership at the school must be ready to support the work and especially be aware of the UNESCO values.

UNESCO strives to build networks among nations that enable this kind of solidarity, by:

- Mobilizing for education: so that every child, boy or girl, has access to quality education as a fundamental human right and as a prerequisite for human development.

- Building intercultural understanding: through protection of heritage and support for cultural diversity. UNESCO created the idea of World Heritage to protect sites of outstanding universal value.

- Pursuing scientific cooperation: such as early warning systems for tsunamis or trans-boundary water management agreements, to strengthen ties between nations and societies.

- Protecting freedom of expression: an essential condition for democracy, development and human dignity.

(ref. UNESCO homepage http://en.unesco.org/about-us/introducing-unesco)

CULTURAL CROSS-BORDER UNDERSTANDING AND CAPABILITY TO ACT BETWEEN CULTURES ARE NECESSARY IN THE GLOBAL COMMUNITY

The direct contact between teachers and students across borders is important. Besides visits where people meet physically the organization of direct contact is today largely via internet connections using different platforms such as social media for presentation of data and activities recorded in video, pictures, sound or text taking advantage of the large amount of software freely available on the internet. The EU website www.etwinning.eu also gives a good platform for cooperation in a safe digital environment.

For students as well as teachers the visits with collaborating partners at friendship BSP-schools is an experience for life. These visits give the students a possibility to meet eye-to-eye and gives them a sense of being part of an environment where they can work together at the same topic or subject. The personal experience for students is broadened by living in private homes of host families during such visits. Participations in international student camps, the Nordplus Junior programme or Erasmus programme through EU funding are other possibilities for which the national coordinator should be consulted for more information. The national coordinator can also provide help with finding partner schools.

THE ORGANISATION OF THE NETWORK FOR BALTIC SEA PROJECT

BSP is organized with one national coordinator in each country steered by a general coordinator. The national coordinators meet every year to develop new events and materials. In this respect they also act as the steering group. As BSP is a programme within the UNESCO Associated School Programme (ASP) this board is directly connected to the national UNESCO-commissions and the UNESCO Paris www.unesco.org and United Nations.

The general coordination is managed for 3 year periods by one selected member country. The general coordinator has different tasks:

- to organize meetings for the national coordinators
- to take care of the website www.b-s-sp.org
- to launch the BSP-Newsletter twice a year.
- to organize international student camps
- to find possibilities for training courses focusing on the work described within the BSP programmes
- general coordination to organize camps with participants from all the BSP countries

The national coordinators are able to give more information about these activities and the possibilities to take part in such actions.

First of all, every member of this network must be dedicated to the development of the skills of their students and must as such be ready to take a part in this.

BY PER WERGE

How BSP was born 02.

A tool for better environmental treatment of The Baltic Sea and for breaking up The Cold War

The main reason for creating the school network BSP around The Baltic Sea in the late 1980es was the still growing problem of pollution both in the sea and in its surrounding catchment area together with the political and thus civil lack of access to influence upon the situation. The "adult world" had so far shown its inability to protect the common natural waters and its life forms. In 1974 seven Baltic coastal states had signed The Helsinki Convention which entered into force on the 3rd May 1980. The HELCOM Commission was subsequently established for monitoring and running the necessary negotiations regarding the pollution of The Baltic Sea (more info on www.helcom.fi).

Due to the existence of the "Iron Curtain" such negotiations did generally not result in common efforts for improvement of the environment. "The Iron Curtain" 1947-1989 was a kind of ideological, political, economic and communicative after-war barrier between the East- and West European countries and it blocked for most cross-boundary prevention against pollution as well as for serious discussions about the environmental situation.

The general lack of democracy was of course opposed by the people of the Baltic countries. Their reluctance to accept the governmental lack of responsibility for the environment was shown when, in the late 1980es, the populations of the three Baltic Soviet Republics, made an impressive political happening reflecting the sudden prohibition for going bathing in the polluted sea by making a long hand-in-hand line of people from Tallinn in Estonia passing Riga in Latvia to Vilnius in Lithuania.

The initiators of The Baltic Sea Project (some of them Finnish members of the Helsinki Commission) regarded the children, the young and future generations, as the only possible non-compromised part of the population able to build up a new awareness and behaviour for the common marine environment.

The establishment of the school network BSP was not the only organisation that occurred in 1989-90 as people's unassuming reaction to the miserable development of the marine environment. Parallel to the BSP an "adult" organization was established - the Non-Governmental Organization (NGO), CCB Coalition Clean Baltic with main address in Uppsala, Sweden, based on the already existing nature protection organizations in all the countries. CCB has used "legal" lobbyism to gain a positive influence on the later governmental and international treatment and planning within EU for the marine environment. Further details can be found on the CCBs website www.ccb.se.

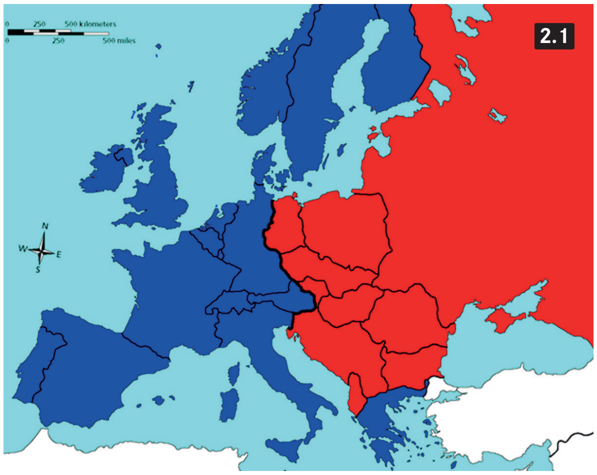
Since the end of The Cold War in 1989 more countries from the Baltic region have been included within The

European Union. The Helsinki Convention has been modernized by year 2000, and EU has now a wide political programme for the environment, including that of The Baltic Sea.

Research done as field work or lab work has a well estimated value, and is necessary for schooling of future researchers committed to the problems of environmental concern. In accordance with the extra motivation and schooling, which the students get within BSP, this may add a bit of Baltic Identity, which is necessary when working for a better environment in the region.

Figure 2.1
Map of the "Iron Curtain"

Figure 2.2
The iron curtain divided effectively Europe in two separate worlds



BY PER WERGE

03. How the Baltic Sea region was born

Geophysical changes of the coasts of The Baltic Sea

The landscapes and the coasts of the Baltic Sea region look very different from North to South and from East to West, and had there not been a common sea we would perhaps not even speak of a region. It is the water, including the water cycle and secondly to this the coasts, which define the Baltic Sea Region. In this chapter the coasts will be in focus.

It is reasonable, and perhaps necessary, to start out by taking an overall look at the geological basis for the coasts and landscapes. In most parts of the Baltic Sea region this basis is not visible, because it is found underground as bedrock formed during early geological periods, the oldest being more than 2,8 billion years old, meaning that it is older than half of the Earth's existence. What is mostly visible in the landscapes are younger formations. These are either glacial erosion materials from mountains after they were raised or up folded by immense tectonic forces or they are sediments carried by rivers or water currents in the sea.

As it would be a huge task to explain the formation of all the coasts in the Baltic Sea region, the following will be only a sketch, a model which can help to distinguish the structure and conditions of the most common coastal environments in the region.

BASIC TRAITS OF THE FORMING OF THE LANDSCAPES

The geological structure of Northern Europe (also mapped in LG4 p.72) the underground of the Baltic Sea area is composed of four main subsoil shields or tables:

1. The Fenno-scandinavian Shield (Sweden-Finland), 1-2.8 billion years old, consisting of mainly very old crystalline bedrock, granites and other materials from the Precambrian Period.

2. The Caledonian Folding underneath Norway, Denmark and Northern Germany, 400 Mio. Years old, is from the Palaeozoic period.

3. Hercynian bedrock between the Harz and the Alps, 300 Mio. years old, dated back to the end of Palaeozoic times, i.e. Carbon and Perm.

4. The East European Table – basically sea bottom of chalk and other marine sediments like sandstone and in some places shale from the Mesozoic and Palaeozoic periods, among them the Triassic, Jurassic and Cretaceous Periods, 500-65 Mio. years old.

FIGURE 3.1

The crystalline bedrock is visible in or near the surface in Sweden and Finland, with the highest stretch "Kølen" (the keel) along the watershed between Sweden and Norway. But apart from the northern granitic rock the surface of the eastern and southern Baltic basin consist of soft materials. Both rocks in the north and the sediments in the east and south were later again scrubbed, formed and replaced by the movements of glaciers during several ice ages in the Quaternary Period - the past 2 million years. Of the around 10-12 cold periods, the latest two of them, the Saale and Weichsel Ages, produced most of the present glacial landforms. Especially the last period, Weichsel 110.000-10.000 years ago, changed and reshaped the former glacial landscape into the topography of today.

FIGURE 3.2

At its thickest point the ice cap of Scandinavia reached 3.8 km and its remarkable weight depressed the land by nearly 300 meter in the Bothnian Bay, 150 m in a circle connecting the areas where Oslo, Stockholm and Tampere are today and 50 m in a circle from present-day Murmansk to Tallinn, Kristiansstad and Frederikshavn. This is the reason why the northern part of the Baltic region is still raising after the ice age, when the ice melted away, and why conversely the southern part sinks year by year, movements which are called the isostatic movements.

Abrasion began when warmer conditions returned and the ice began to melt again. Strong erosion took place near to the ice margin, where the ice was thinner and less plastic and melt water helped the movement over the bed. The erosion created three important types of glacial landscapes: First, the u-shaped valleys and rounded cirques found in the rocky mountains. Secondly, the valley landscape formed near the ice margin, eroded and reshaped in the floor of older sediments and moraines as broad valleys and fjords across the Baltic coasts. In some places sediments of chalk and limestone have been caught and raised in a vertical position by the ice - as the cliffs of the islands Rügen and Møn in the southern part of The Baltic Sea. A third type of glacial landscape is composed of hills of materials brought by the ice and deposited along the former ice-channel as lateral moraines and as terminal moraines where the glaciers finally stopped moving due to melting.

Most deposition was made during the melting (ablation) periods. The outwash plains, in common with moraine plains and hills now fill the lower parts of the Baltic drainage basin, where most people live and the rivers run.

HOW THE BALTIC SEA WAS BORN

It is this landscape which today hosts The Baltic Sea. Nature simply made it by filling the lower areas with water melted from the ice and with water, derived from the raised ocean levels due to the melting ice caps. During the periglacial and postglacial ages that followed the Weichsel Age the Baltic basin hosted huge lakes or a sea open to the ocean.

FIGURE 3.3

By 8000 BC the Baltic Ice Lake was found here and by 7500-7000 BC the Yoldia Sea, around 6500 BC the Ancylus Lake and 5000-2000 BC the Littorina Sea. All were made of the melted water coming from the Nordic glaciers, and now filling the lowland which was still depressed by the weight of the remaining ice.
During the last 12.000 years the land that had been ice covered recovered its isostatic equilibrium slowly in a series of rise-events of a few metres each. Each rise was followed by periods of new sea and wave cuttings of hills, creating new cliffs and coastal plains behind new coastlines. These cliffs and plains and former shores are now located on elevated land often far from the coast.

The land to the south of The Baltic Sea has, in contrast to the northern parts, been sinking as a result of the tipping of the greater tectonic European plate along an axis from Skagen in Denmark over Skåne in Sweden and Riga Bay in Latvia to St. Petersburg in Russia. In the area south of this line future coastal and coast near landscape transformations might occur connected to the sinking land and the expected global rise in sea level.

FIGURE 3.4

COAST TYPES

To simplify things Danish geographers basically operate with two main geomorphological types of coast: Steep and flat (ref: The Great Danish Encyclopedia). This typology is of course too simple to describe the very different coasts around the Baltic Sea, and accordingly each country seems to have their own way of describing such coasts. Here we will use a German categorization made by Reinhard Lampe (see below). First, though, a short explanation of what creates the two main coast forms realized in the simplified Danish typology:

STEEP COAST or cliff coast occurs when waves erode cohesive materials, compressed sediments or hard rock. Steep Coast's profile consists of a cliff possibly with a wave eroded cavity (groove). If there is a seashore, it is made up of coarse material (gravel, stones and blocks), and the collapsed parts that are more or less formed by the waves. The water-covered part of the profile is usually a plane wave eroded surface, frequently covered with a stone pavement, possibly with large blocks which can not be moved by waves. Fine grain particles from the cliffs are carried away by waves and currents. Steep coasts of hard crystalline rocks can be stable for millennia, while the moraine coasts profile changes in spurts at specific severe storms and during high water.

FLAT SHORES or beach ridge coasts are formed in loose deposits, where the original geological profile is flat, or where sediment supply is great. Significant form elements are:
marine foreland with or without beach ridges or dunes, seashore and beach level with one or more sandbanks. Coast cross section changes character depending on wave conditions. During storms shore eroded material will extend outwardly and sandbanks will built up. During periods of calm weather sand is transported towards the shore, and the shore becomes wider. The loose sediment thus acts as a buffer against the waves of energy, and the profile is evolving toward a form that is in equilibrium with the wave action, the so-called equilibrium profile.

TIDE AND WAVE INFLUENCE: Some classifications are based on the tide and on the occurrence of different wave types and the wave energy. In The Baltic Sea the tide is limited to almost no tide, though rows of North Atlantic deep cyclones (type of cyclone families) in the enclosed Baltic body of water can create flooding by a standing wave, a seiche, with a wavelength of several hundred kilometers. This lapping may stow the water until 4 m above Zero (water level) in the Neva Bay by St. Petersburg or on the return at the south-western most coasts of The Baltic Sea.
The waves create so-called wave generated shores, mainly variations in sandbanks and formation of sand barriers. At present climatic based changes in the wind directions seem to be occurring in the Baltic Sea Area (in winter and spring from North East instead of East-South East, and during summer from South West instead of West) and may be connected to changing atmospheric air pressures. Such changes affect both steep and flat coasts, until a new balance (equilibrium) between abrasion (wear out) and accumulation is reached.
A raised sea level due to climatic changes will accelerate these processes. Cliffs will be attacked harder by waves causing lots of debris to be transported to sea, producing new sand and gravel beaches in neighbor bays - see the coast typology and map of Lampe.

TABLE 3.1 AND FIGURE 3.5

Figure 3.1
The geological structure of Northern Europe
(Map from Learners Guide no. 4 p. 72)

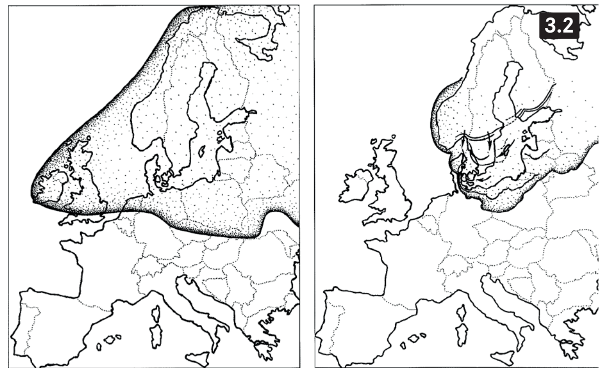
Figure 3.2
The ice cap during Saale/Weichsel periods and the receding stages during the last period
(Map from LG4 p. 73)

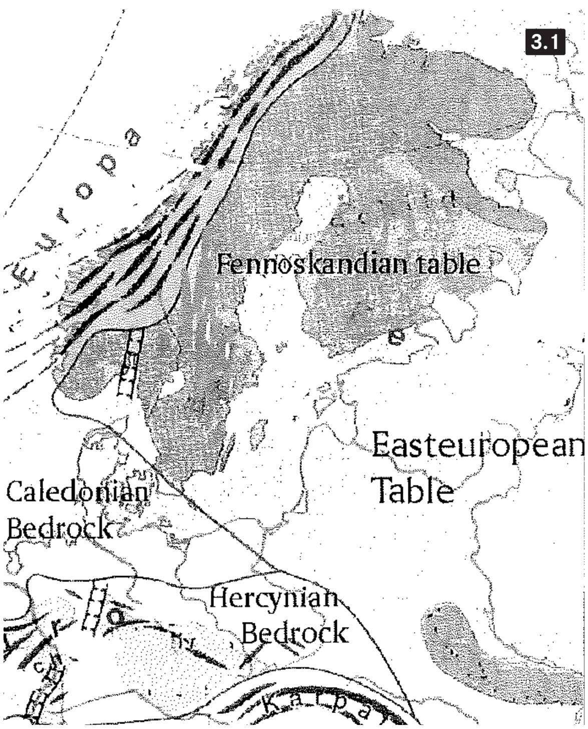
Figure 3.3
The different ocean levels since the ice age
(Map from LG1 "Working for better Water Quality in the Baltic Sea", p. 31)

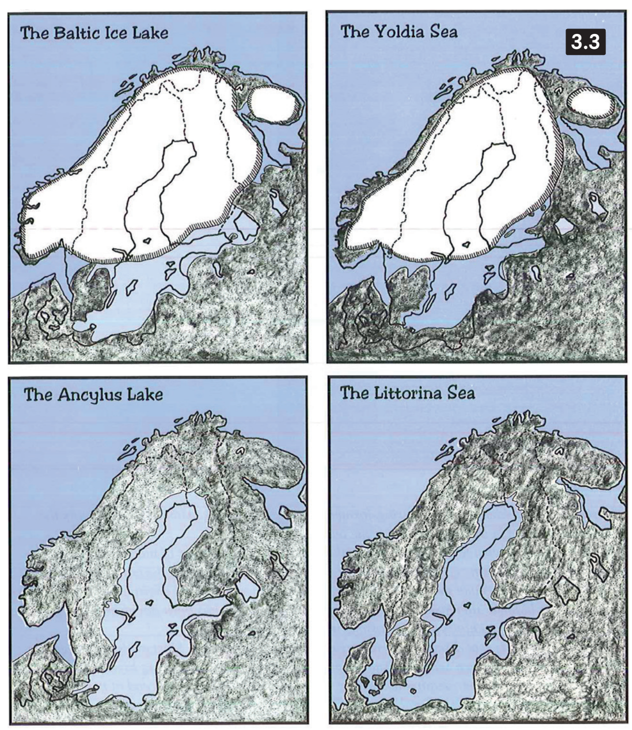
Figure 3.4
The isostatic movements in the Baltic Sea Area in mm/year

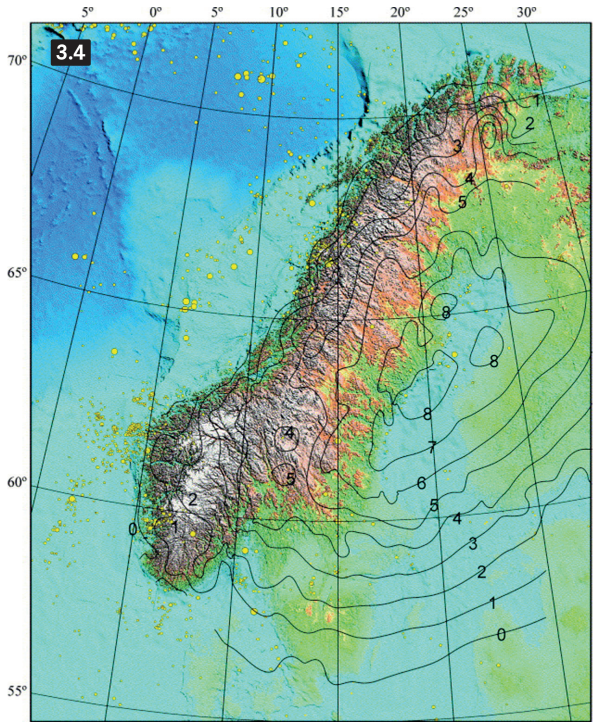
Figure 3.5
Reinhard Lampes map of coastal forms found around the Baltic Sea

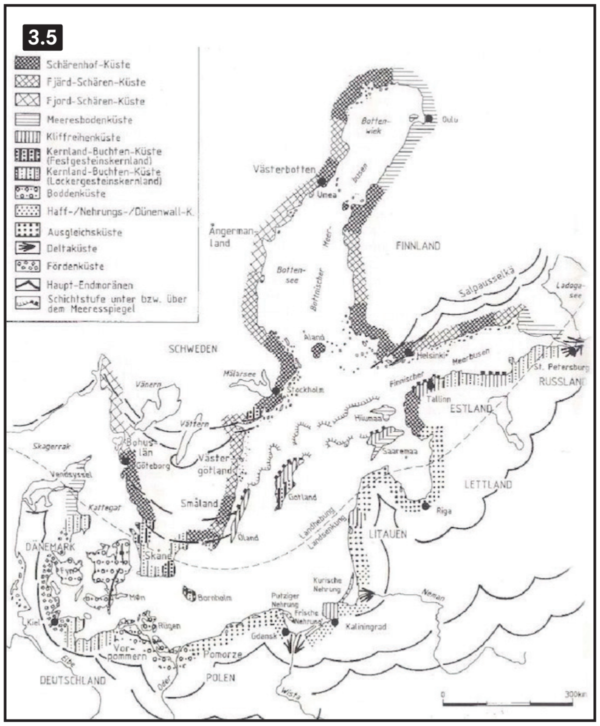
Figure 3.6
A simplified version of Reinhard Lampe's typology seen in figure 3.5. This may be handier to use in comparison with his schedule (Table 3.1)











Küstenformen an Nord- und Ostsee

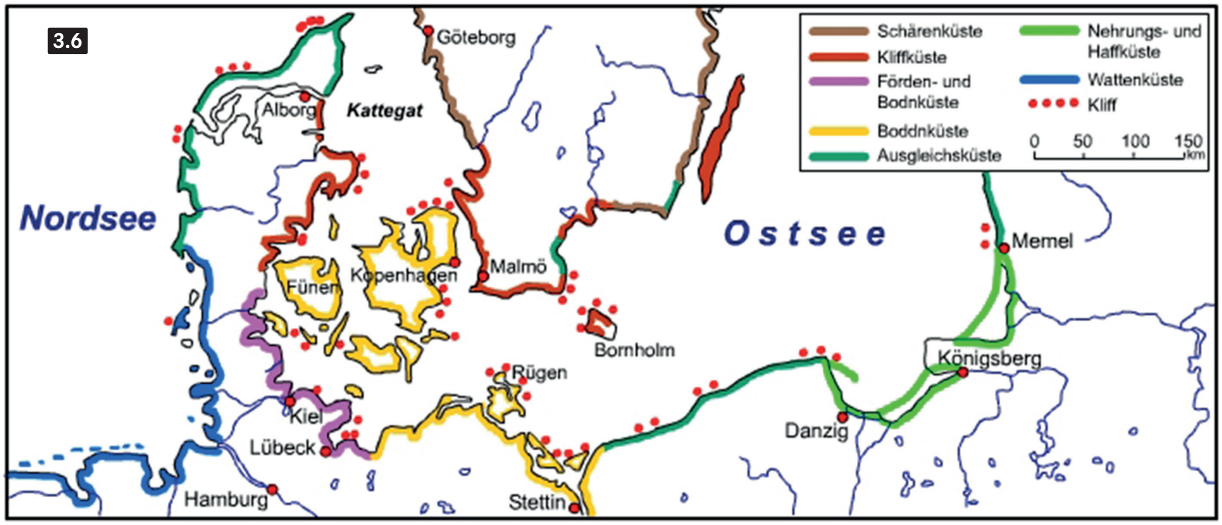


Table 3.1
Reinhard Lampes Coast typologi which counts 12 coastal types*

Coast type	Recent relief building	Isostatic movement	Material
Archipelago (Skärgård)	Nearly no forming	+/++	Crystalline or moraine
Fjärd-Archipelago	Nearly no forming	+/++	Crystalline rock
Fjord-Archipelago	Nearly no forming	+/++	Moraine
Seabed (Meeresboden)	Low intense abrasion or accumulation	+/++	Sand and stones and moraine
Cliff	From none to stark abrasion	-/+	Hard rock or moraine
Mainland 1 (Kernland)	Low accumulation in bays	-/+	Rock at mainland, sand or gravel at bay
Mainland 2 (Kernland)	Low to strong abrasion at mainland; Accumulation at bay	-/+	Moraine at mainland; sand and gravel at bay
Bodden	Like above, by inland coasts often phytogenetic growth	-/+	Like above, by inland coasts also bog
Haff and dunes (Lagoons and barriers)	Highly accumulating, by wind too, and phytogenetic growth	-/0	Sand, by inland coasts also bog
Compensational (Ausgleichsküste)	Abrasion shifting with accumulation forming sand barriers	-/+	Moraine, sand
Delta coasts	Marine-fluvial-wind accumulation, delta-lakes	-/+	Clay, silt, sand, bog
Förden (long narrow inlets)	Abrasion and accumulation	-	Moraine, sand,

(from Oda Störmer, Leibnitz Institute for Baltic Sea Research, Warnemünde, 2010)

*Coastal forms (Küstenformen). The terms of the signatures are similar to Lampes: Shären = archipelago (skerries); Kliff = Cliff; Förden = fjords; Bodden = bays; Ausgleichküste = Compensational; Nehrung and Haff = Barriers and lagoons; Watten = wade (at tidewater); Kliff = Cliff.

BY JAAN PÄRN

Rivers 04.

The rivers of the Baltic Sea area and suggestions for their investigation

INTRODUCTION

More than 250 rivers bring 440 km^3 of water to the Baltic Sea (2% of the sea's **volume**) a year. The average river **discharge** (or runoff) into the sea is 14,000 m^3/s. This may vary +/− 4000 m^3/s.

The streams feed from precipitation – rain and snow. The Baltic Sea **catchment** (the drainage area which the rivers collect their water from) covers 1.75 million km^2. This makes up 15% of Europe's territory and is home for 10% of Europeans. It includes territories from 14 countries including Sweden (25%), Russia (19%), Poland (18%), and Finland (17.4%). Three countries – Estonia, Latvia, and Lithuania – are completely within the catchment area.

FIGURE 4.1

The precipitation that falls upon the Baltic Sea catchment area is average in European terms (600–1500 mm/year). However, the **evapotranspiration** (the loss of water to the atmosphere through plants and soil) is only 30–70% because of the cool climate.

The Baltic Sea catchment is a former **glacial basin** – a huge depression made by a mass of ice (for further discussions on the development of this basin see chapter 4 of this book). The movement of the glacier can be traced in the basin's elongated shape.

The catchment boundaries are well defined – the Scandinavian mountains to the northwest, the Maanselkä and Vetrenny Poyas ridges to the northeast, the west Russian and Belarusian heights to the east, the Beskid, Carpathian, and Sudeten mountains and the German terminal moraines to the south. The catchment area is narrow and the rivers are short compared to the ones found elsewhere in the world.
The catchment area spans some 20° of geographical latitude, and climate types range from Sub-arctic (cold) and alpine (mountain) to maritime (sea). The catchment area can be divided roughly into a southern temperate (neither very hot nor very cold) and a northern boreal part.

The southern part is characterised by cultivated land. The water from this part runs to the Baltic proper, the Gulf of Riga and the Gulf of Finland. The northern boreal part is characterised by coniferous (pine and spruce) forests and peat. Tundra dominates the sub-arctic far north of the Baltic Sea catchment. The water from the northern parts flows to the Gulf of Bothnia and the Gulf of Finland.

Land use has changed during the last centuries. The number of people living in the Baltic Sea area has increased. Industrialisation and growing cities have changed the landscape, and much of the forest has been converted to farmland. Forest still dominates in the northern parts.

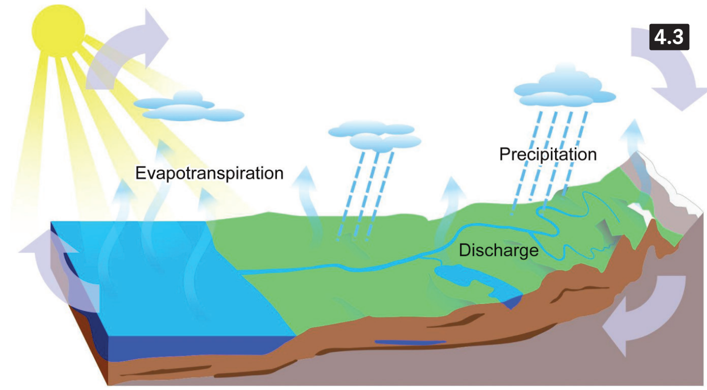
Figure 4.1.
The Baltic Sea catchment area with the seven largest rivers shown

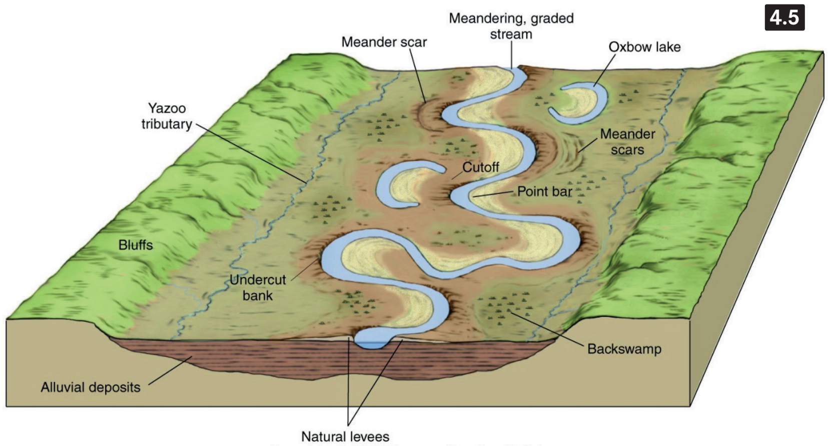
Figure 4. 2.
Land cover in the Baltic Sea catchment area. Data from the Global Land Cover Facility

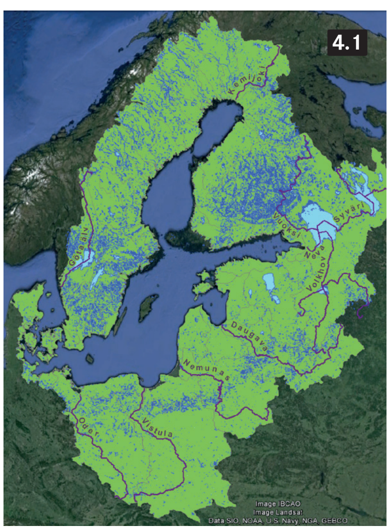
Figure 4.3.
Water cycle. Credit: Benutzer: Joooo

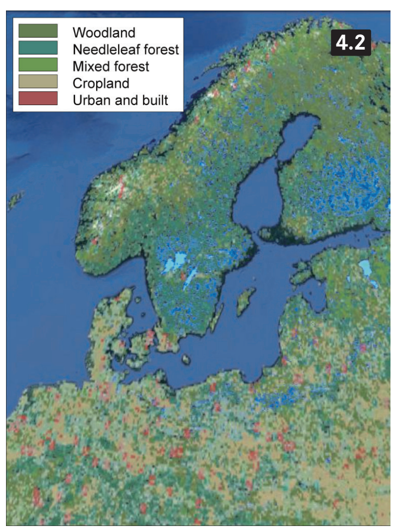
Figure 4.4.
Precipitation in millimetres [mm] in the Baltic Sea catchment area during year 1997 (Credit: Rubel & Hantel, Met. Atmos. Phys. 2001)

Figure 4.5.
Floodplain landforms









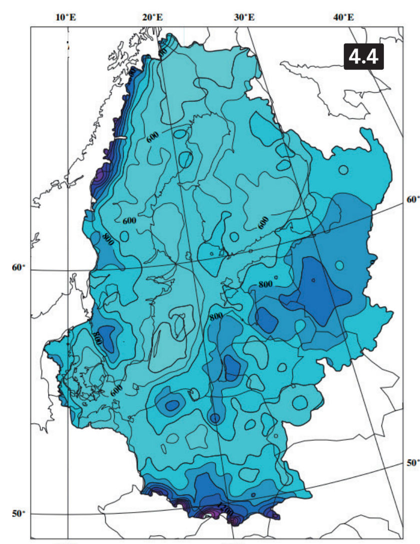


FIGURE 4.2

Approximately half of the total Baltic catchment consists of forest, most of the remainder being agricultural land.

Table 4.1
The ten largest rivers of the Baltic Sea catchment (Gailiušis et al., Baltica, 2011)

RIVER	CATCHMENT AREA [KM²]	MEAN DIS-CHARGE [M³/S*YEAR]
NEVA	281,000	2460
VISTULA	194,400	1065
DAUGAVA	87,900	659
NEMUNAS	98,200	632
GÖTA ÄLV	50,100	574
ODER	118,900	573
KEMIJOKI	51,400	562
ÅNGERMAN	31,900	489
LULE	25,200	486
INDALSÄLVEN	26,700	443

The Neva is the largest Baltic sub-catchment with 2460 m^3/s as its average discharge feeding from 281,000 km^2 of land. Other major rivers are the Vistula, the Daugava, and the Neman. The ten largest rivers are given in Table 4.1. These account for 59% of the total discharge. The next ten catchments have a total area of 251,000 km^2, with eight of these in Sweden and two in Finland.

HOW RIVERS FORM

The **water cycle** is the continuous movement of water to, on, and off the catchment (Figure 4.3). Water moves from one **reservoir** to another, mainly from the atmosphere to the land, from the land to the sea and from the land to the atmosphere. The corresponding **fluxes** (flows) are: precipitation, discharge, and evapotranspiration. In the processes, water may go through three phases: liquid, solid (snow, ice), and gas (vapour). The properties of the area all regulate the fluxes and determine how the cycle works: climate, **relief** (differences in height), soil, **vegetation** (plant cover), human activities.

FIGURE 4.3

PRECIPITATION

The westerly winds bring humid and mild air and most of the precipitation (despite the wind shelter which is provided by the Scandinavian mountains). The precipitation shows both a distinct **annual cycle** and a large regional variation. Precipitation is highest during July and August, and lowest from February to April. The southern part has a maritime climate and receives more rainfall.

FIGURE 4.4

The length of the **snow cover** season varies regionally within wide limits – from several days on average in southern Sweden to eight months in the land north of 65° latitude. Maximum snow depths in southern Sweden are below 20cm while it normally exceeds 80cm north of 65° latitude. The record snow depth of 327cm was observed in Kopparåsen in the Swedish fjells on 28. February 1926.

DISCHARGE

Rainfall or the melting of snow causes a surplus of water, for which there are basically two possible paths of escape. First, it may flow over the land to lower levels. As the water travels, the dispersed flow gets collected into streams, which eventually lead the discharge to the sea. This flow is called **surface discharge**. Secondly, surplus water may move slowly through the soil, traveling downward under the force of gravity to become part of the underlying **ground water**. Following underground paths, this water may emerge to become surface water.

Rainfall and snowmelt create water surplus at a delay called **residence time**. This is the average time a water particle spends in the specific reservoir before it continues its flow in the water cycle. Much more water is in storage for long periods than is actually moving through the cycle. The most important **terrestrial** (land-based) ”storehouses” for water are lakes, wetlands, and groundwater reservoirs. The residence time in rivers is a few days.

The length of the residence time depends on a few factors. The most important of these is the size of the catchment area. The larger the catchment area the longer the residence time between peak rainfall and peak discharge and the more gradual is the rate of decline of discharge after the peak.

We define a **stream** as a long, narrow body of flowing water occupying a trench-like hollow, or a **channel**, and moving to lower levels under the force of gravity. Streams form a **drainage** system. It consists of a branched network of stream channels, as well as the sloping ground surfaces that contribute **overland flow** to those channels. The entire system is bounded by a **watershed**, outlining typically a more or less pear-shaped catchment. The slopes and channels are adjusted to dispose of the discharge as efficiently as possible.

Each stream receives discharge from a small area of land surrounding the channel. This area may be regarded as a unit cell of the system. The entire land within the outer watershed constitutes the catchment. As an example, the Neva river system consists of the Vuoksi, Syväri and Volkhov rivers (figure 4.1).

EVAPOTRANSPIRATION

Evapotranspiration is powered by solar energy. Excessive evapotranspiration results in loss of **soil moisture**, water-**level drawdown**, and plant **water deficiency**. Droughts do not usually cause major damage in the Baltic Sea catchment area although reduced flow and low soil moisture may sometimes be harmful to the agriculture. The risk of this is highest in the warmest part of the catchment in Poland and Germany.

HUMAN IMPACT

Fresh running water in the form of streams and rivers is a vital resource. Our heavily industrialised societies require enormous supplies of fresh water. Urban dwellers consume water in their homes at rates of 150–400 l/person*day. Enormous quantities of water are used for cooling in electric power plants. In view of the increasing water demands, we can predict that it will be hard to achieve the needed supplies of pure fresh water in the future.

Human activities which alter the water cycle include: agriculture, industry, alteration of the chemical composition of the atmosphere, construction of dams, **deforestation** (removal of forest) and **afforestation** (planting forest), removal of groundwater from wells and rivers, urbanisation. Alarmingly, the available resource of pure fresh water is decreasing while demands are rising.
A significant portion of the rainfall in forested watersheds is absorbed into soils, is then stored as ground water, and is slowly discharged to streams. An urban surface is impervious, meaning it does not allow water to absorb nor go through. This is why an increase in impervious surface reduces residence time, especially during a **storm**.

Water pollution with **nitrogen** and **phosphorus** also increases as the population grows, agriculture intensifies and urbanisation advances over broader areas. Chemical pollution by direct disposal into streams is a well-known problem in the public. Nowadays in the Baltic Sea catchment areas, factories and populated areas have **waste treatment plants** but sometimes these do not function properly.

Agriculture and residence areas are important sources of **nitrogen** and **phosphorus**. Excessive concentrations of nitrogen in the water are highly toxic to humans. When these nutrients reach the lakes or the Baltic Sea, **algae** can, given the right amount of sun light, grow excessively and eventually deplete oxygen in the water. This may kill fish and other types of **aquatic animals**. Such processes where waters are supplied with an excess of organic nutrients especially nitrogen and phosphorus is called **eutrophication**. A particular form of pollution is caused by **acid mine water**, which contaminates the river with **sulphuric acid.**

HOW A RIVER FORMS OUR LANDSCAPE

A stream performs the geologic activities of **erosion**, **transportation**, and **deposition**. Consequently, the river can make two kinds of **land forms**: erosional and depositional. Where a stream erodes away rock, it forms a valley. **Ravine** and **canyon** are special types of valleys. Between the valleys ridges and hills remain. The **sediment** that is removed from the parental mass are transported by the water and deposited downstream, forming **fans** and **floodplains**.

FLOOD

Snowmelt peaks in the spring, leading to peak flow and, in some cases, a **flood** (overflow of water beyond normal limits, especially over what is normally dry land).

By far the most devastating floods in the area have been recorded in the Odra river catchment in 1997 with estimated damages of 6 billion Euro) and in the Vistula catchment in 2001 (3 billion Euro). The wettest year ever recorded in the Baltic Sea catchment was 1924 with a mean annual discharge of 18,167 m^3/s while 1976 was the driest with only 10,553 m^3. Records from the 19th century show that maximum discharges were even higher in the 19th century.

The national weather service of every country in the Baltic Sea catchment provides a **flood-warning service**. In order to do that, it designates a critical level above which **overbank flooding** may be expected.

FLOODPLAIN

A floodplain is a thick accumulation of alluvial (riverine) deposits. A floodplain is normally bounded on either side by banks. A steep bank is called a bluff, and an extremely steep bank is a cliff. These form at the outside bends of streams. Opposite to them on the inside bends sand and gravel point bars accumulate. The sand and gravel form natural levees next to the river channel. Behind these, streamwater gets trapped and forms a backswamp.

FIGURE 4.5

It is dominated by the **meandering** (winding) stream channel itself, plus **oxbow lakes** (abandoned reaches of former channels). Meanders develop narrow necks, which are cut off, shortening the river course and leaving oxbows abandoned. In a matter of decades, the oxbow is converted into a **meander scar** and later a swamp but when we dig a hole in it, we can still see its identity.

HOW A RIVER FORMS OUR LIFE

A healthy catchment keeps recycling clean fresh water. Swamps, bogs and other wetlands can be regarded as the 'livers' of our landscape as they process polluted water and make it cleaner. Plants and animals need clean water because the river is the only suitable environment for many of them. Farms need clean water for their crops and animals. Businesses and industries need a lot of water. As an example, it takes 1700 liters to water the cotton grown for a pair of Levi´s jeans and 60,000 liters of cooling water to make the steel in a Volkswagen Passat.
Pollution of the catchment area also increases the risk of losing geographical spots for popular recreative activities like swimming, boating and fishing. It is a privilege to live in a healthy catchment and people are willing to pay for it. Therefore property close to a clean river is very valuable.

How to investigate a river

The first thing we should do is to choose a well-accessible spot by the stream. Ideally, it should be a bridge or another kind of pass over the water where we can observe both banks and **gauge the stream discharge** (measure its flow).

STREAM GAUGING

The most important measure of stream flow is discharge, Q, defined as the **volume** (amount) of water passing through a **cross section** (Figure 5.6) in a unit of time. Discharge Q is stated in cubic meters per second [m^3/s]. Q may be obtained by taking the mean velocity V and multiplying it by the cross-sectional area, A. This relationship is stated by the important equation, $Q = A*V$.

FIGURE 4.6

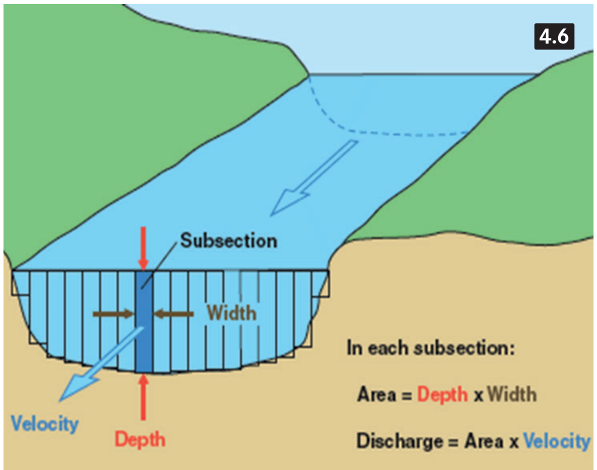
We realise that water flows faster in a channel of steep **gradient** because gravity has more effect on a steep

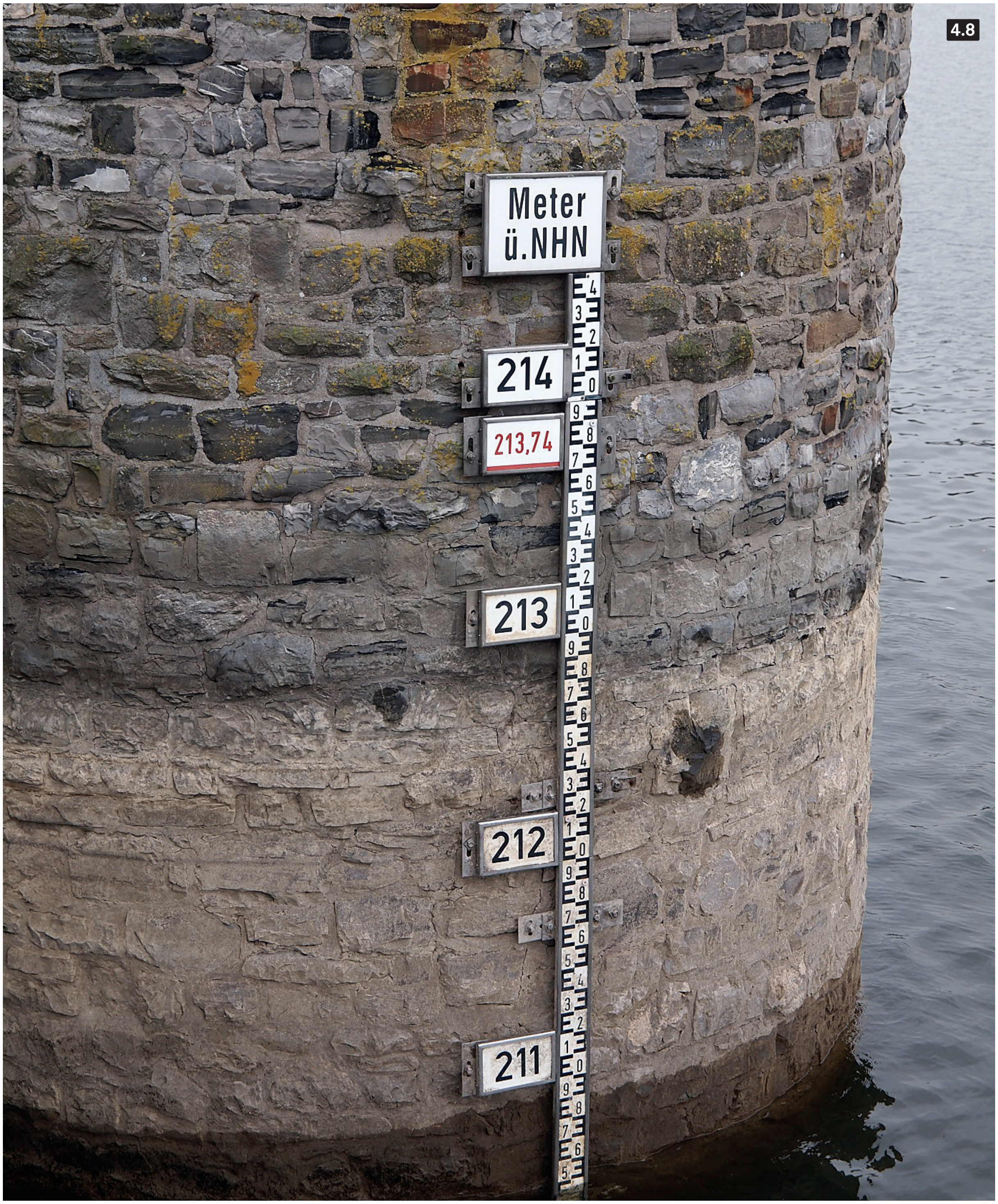
Figure 4.6.
Stream discharge is measured by determining the discharge in each part of a channel cross section and summing the discharges. Credit: USGS Water Science School

Figure 4.7.
Year 10 Kaikorai Valley students using a tape measure and a survey pole to determine the cross sectional area of their local stream in New Zealand. Credit: Kaikorai Valley College

Figure 4.8.
Staff gauge at Möhnesee, Germany. Credit: User Arnoldius

Figure 4.9.
U. S. Fish and Wildlife Service workshop using rubber ducks to measure stream velocity. Credit: Gary Peeples

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slope. V increases quickly where a stream passes from a deep pool of low gradient to a steep one. Also, as A decreases V must increase when discharge Q remains the same according to the formula above.

In order to gauge a stream, we need a couple of measuring devices. First of all, we need to find the width of our cross section. In order to do that, we should pull a tape measure across our stream.

FIGURE 4.7

A bridge often serves as a convenient means of crossing over the stream; otherwise, a small boat or tall rubber boots are used. Next, we need to gauge the bottom of our cross section. In order to do that, we need a device for measuring the **stream stage** (height of water surface). The simplest of these is a **survey pole** with a rigid meter rule attached to it. After having surveyed the bottom of our cross section, we may install a **staff gauge**, which is just a graduated vertical **scale** attached to a post or bridge pier.

FIGURE 4.8

This must be read directly by an observer whenever the stage is recorded. An automatic-recording gauge is even more useful.

After we have determined the cross-sectional area, we must measure the velocity. This requires a **current meter**. The device is put into the stream at intervals of no more than one meter, so velocity can be read at several points evenly distributed along the cross section. As a standard, at heights of >50cm, velocity should be read at two depths – at 20% and 80% of the water depth at the point. One reading at the 60% depth will suffice at water depths <50cm. We should always record each of the depth readings as we take it. We should never rely solely on our memory while recording.
After we have read the data, we can calculate the discharge for each subsection, Qp in the following way: Qp = depth * width * average velocity. The total Q of the cross section is calculated as the sum of of all Qp.
In case we do not have a current meter, we can mark a 10 m stream-bank stretch and throw a solid floating object into the water at the upstream, mark, and use a stopper watch to measure the time it takes for the object to move 10 m. To get the stream velocity in m/sec, divide distance with time and preferably average over severel measurements.

FIGURE 4.9

Similarly to the current meter procedure, the interval space between subsequent measurements should be less than 1 m. The result acquired by this method is actually an overestimation as it only reflects the velocity at the surface while closer to the bottom, **friction** reduces the velocity.

RELEVANT FACTORS REGARDING THE WATER QUALITY

Temperature is the most common physical characteristic of water quality. It affects the oxygen level, **photosynthesis** of aquatic plants and life conditions for aquatic animals, and the sensitivity of these organisms to pollution and disease.
Colour and **transparency** are visual measures of water **impurity**. A change of colour in the water may be the first indication of a water quality problem. However, it is hard to tell, for example, nitrate pollution from the colour. Yellowish water may have an excessive concentration of iron. Dark brown water indicates the water is coming from a **peatland** and is usually not polluted.

SMELL is another quick physical indicator of water impurity. Really bad smell may indicate that the river contains waste water.

WATER CHEMISTRY involves a long list of compounds we can measure. Special equipment is needed for each chemical test. The most common chemical characteristics are:

DISSOLVED oxygen – a necessary element for all aerobic forms of life. As dissolved oxygen leves drop below 5 mg/l, aquatic life is put under stress. The lower the concentration, the greater the stress. Oxygen levels below 2 mg/l can result in fish kills and deaths of other life forms.

pH – the reverse measure of the **acidity**. Most fish cannot live below pH 4, which means high acidity. The best level for the growth of algae and other aquatic plants is 7.5–8.5.

NITRATE – an important nutrient for plants. High Nitrate levels can cause algal blooms in the spring followed by oxygen depletion during summer.

PHOSPHATE – another important nutrient for plants.

CATCHMENT STUDY

In the previous paragraphs we realised that the quality of a stream is determined by it's catchment area. Therefore, to really understand our river we need to approximately determine its watershed. In order to do that, we need a **topographic map** for the area.

As soon as we have delimited the area the water originates from, we can start to investigate the properties of the land that influence the flowing water (geology, relief, climate, soil, vegetation, land use and point sources). The easiest way to do that is to find maps and other sources (web pages books, reports) about the area.

The main questions are:
What sort of land is our catchment made of?

What do we see when we dig a hole in the ground? Lose ground (like gravel or sand) is porous (has lots of tiny gaps that water can easily sink into), so water will go through the land surface and form ground water. Tightly packed ground, like clay, does not permit water to move through it, so water will stay on top or flow away.

Is our catchment steep or flat?

Steep land makes water run-off in rushing streams, flat land allows water to collect into lakes and swamps.

What vegetation covers our catchment?

Forests and swamps are natural water storages while water runs freely and gets polluted in the agricultural and populated areas.

How do people use the land in our catchment?

Arable fields and residence areas are **sources** of phosphate and nitrate. Forests and swamps are sources of organic carbon but they eliminate phosphate and nitrate from the discharge.

HOW TO WORK FOR A CLEAN RIVER

Knowledge of the water cycle and related processes enables us to evaluate our total water resource, to plan for its management, and to protect it from pollution.

We need to leave enough swamps and bogs and other natural areas in each catchment in order to recycle clean fresh water. Sometimes it is tricky to balance the direct needs of people with the needs of the river but if we do it right, there should still be space for less tolerant plants and animals and for getting our supplies of clean water.

The process of coordinating protection, management and development of water and land within a catchment is called a **River Basin Management Plan**. Many other sorts of public plans shape our catchment. In every municipality there has to be a **master plan**, which outlines the functional areas: for residential area, services, refreshment, agriculture, forestry etc. Some municipalities have a special environmental plan. We can visit our municipal planning office and find out whether a plan is being developed that may affect our river. If so, we have the right and opportunity to **participate** in the planning process. Participation is the process of sharing decisions which affect our lives and the life of our community. This means we first figure out what the impact of the planned activities may be. In order to do that, we may ask the planners to come to our school to explain the new plan. We can also observe the prepared decisions from the local news channels. If we have an idea on how the planned activity could be altered to the benefit of our river, we can suggest it to the planning office and expect the officers to consider the idea. It is easier to communicate with the planner if we have an organised group of children who discuss an idea and pass it on to the planner in coordination.

Several techniques can be proposed to enhance river health. Among these are:

Installation of **buffer strips**

River maintenance

River restoration

A buffer strip is an area of land maintained in permanent vegetation that helps to control river water quality. Most buffer strips deal with water originating from agricultural areas. Buffer strips trap sediment and enhance purification with regard to nitrate and phosphate.
River maintenance typically involves removal of man-made rubbish and debris that has accumulated in the channel, for example shopping trolleys, tyres, litter, and household rubbish.

River restoration is an opportunity to bring a river that was artificially straightened back to its natural condition. This may involve restoring meanders, supporting river banks, changing water levels and flows, creating floodplain wetlands, and providing public access.

BY PETER UHL PEDERSEN

Water Quality 05.

The Baltic Sea. The Ocean of salt and brackish water

The Baltic Sea is a small inland sea of 412 590 km^2, in fact the world's youngest inland sea. This means that the Baltic Sea can be regarded as the World's largest and most developed estuary. The current situation with regard to salinity has only existed for 3,000 years, but today the Baltic Sea is the world's largest brackish water area.

The south western part of the Baltic Sea has a salinity of 10-12 ‰. In the far north of the Gulf of Bothnia it falls to 3 ‰. This decrease is due to the passage of large amounts of fresh water into the Baltic Sea. As fresh water is lighter than salt water, fresh water and salt water only slowly get mixed. This is due to the formation of a halocline in large parts of the Baltic Sea. This layer also prevents oxygen from passing from the surface water to the bottom water and bottom water's lack of oxygen is one of the most serious problems of the Baltic Sea water quality.

FIGURE 5.1

The average water depth is about 54 meters. The Baltic Sea is surrounded by coasts and the catchment area has a population between 70 and 85 million people that throughout time have used the Baltic Sea as a sewer. This has obviously been very crucial to the Baltic ecosystem. If you compare the amount of fertilizer that is applied to the Baltic Sea with the amount that is fed to a field of barley, then the barley field gets around 100kg/ha per year while The Baltic Sea gets around 65 kg/ha. It's a tremendous amount of nutrients for sea algae to convert. Algae grow large during their primary growth period in spring. Then they sink to the bottom and decompose with high oxygen consumption as a result. This gives the well-known oxygen depletion.

There has probably always been a lack of oxygen in the deeper parts of the Baltic Sea, but today the depleted areas are larger than just thousand years ago. The higher amount of algae in the bloom could be seen as an advantage to the food chain and in this way also for the fish, but unfortunately, the negative effects have been more pronounced. This is because the amount of bottom animals, which are also an important part of the Baltic Sea food web, have been reduced due to oxygen depletion with lower catches of fish as a result.

BALTIC SEA AS AN ECOSYSTEM

Life, the plants and animals in the Baltic Sea, is constantly changing. The Baltic is a young ecosystem with many places of low biodiversity. Ecosystems generally become more and more complex. The greatest biodiversity is found in the oldest ecosystems, like Oceans and the ancient rainforests. Areas with low biodiversity are more likely to be colonized by new species, because the different niches are not occupied in advance. Generally, the animals in the Baltic Sea are smaller than the animals in the nearby waters, because they use more energy when they live under non-optimal salt concentration. This applies to both freshwater species and strict marine species. It is believed that especially the water balance and energy balance are problematic.

CHANGES OF LIFE CONDITIONS

The flora and fauna of the Baltic Sea are constantly added with new species that find a useful niche in places where they can breed and occupy larger areas. Evolution will naturally through time - and often surprisingly quickly - develop new species adapted to the Baltic Sea. We have not seen endemic species in the Baltic Sea yet.

An example of immigrant animals includes the bristle worm species *Marenzelleria viridis* and *M. wireni.* These species that have migrated from North America's east coast are interesting since in addition to their high tolerance towards large fluctuations in salinity they are also tolerant towards high concentrations of hydrogen sulphide, found in increasing concentrations in the more and more polluted Baltic Sea.

An old but interesting example of an immigrant animal is *Balanus improvisus.* These barnacles originate probably from the west coast of South America. They came to the Baltic Sea in the end of the nineteenth century. This barnacle is the only one that can tolerate the brackish waters of the Baltic Sea and it has now colonized the whole area.

A further example is eel swim bladder worm: *Anguillicola crassus,* which is a parasitic nematode. It invaded our waters between 1985 and 1990. It has strayed from Japanese eels and has lived as a parasite for millions of years. Since the European eel has evolutionarily speaking not yet adapted fully to this roundworm, an infection will involve the destruction of the swim bladder. The worm is live-bearing. The larvae are absorbed by water fleas which might, via a small fish be eaten by the European eel.

Fucus evanescens is an example of an adventive brown alga. It was probably introduced from the North Atlantic and like many of the other introduced species - probably via shipping. It came to our area a little before 1950 and is expected in some places to outperform the seaweed Bladder wrack *Fucus vesiculosus.*
Another example would be the brown alga *Sargassum multicum.* This species has not yet invaded the western parts of the Baltic Sea. But since it can survive at a salinity of 6-7 ‰, it is expected to invade large parts. Here it will most certainly cause great problems for the navigation of ships due to attachment to ships' propellers as well as to their water intakes.

RELICTS

Although the Baltic Sea has only existed for a relatively short time, it has already seen species coming and going. Many organisms have arrived under colder conditions than the present - disappearing again when the temperature rose. This has made the ecological balance vulnerable. In ancient ecosystems, when an organism dies out, there will always be another kind of species to fulfil its place. As the Baltic is so impoverished of species it cannot take place here. Some of the organisms from the cold period are still present. Those are relicts from the ice age. Baltic Crayfish *Saduria entoman* is an example.

THE HARBOR PORPOISE

A very small population of the harbour porpoise *Phocoena phocoena* exists in the Baltic Sea near Bornholm. Previously there was a large population. Now there are very few animals left probably due to human impact caused by factors such as fishermens bycatches and pollution with DDT, PCBs and other toxic compounds.

POLLUTION FROM AGRICULTURE AND INDUSTRY

Water quality in the Baltic Sea is influenced largely by the people in the catchment area. One can roughly divide the impact of man in this way: 1. Impact due to fertilizers and 2. Impact due to hazardous substances.

The invention of the toilet and sewage systems gave a much higher impact on the marine environment than had been seen before, when the manure was spread on the fields. The appearance of effective fertilizers in agriculture meant larger quantities of plant nutrients in the soil and from there leaching out to our water reservoirs. Waste water treatment plants could not remove these high amounts of nutrients. The farmers of the Baltic countries though have not spent much artificial fertilizer until now. But after these countries have joined the EU, it is expected that an increase in the efficiency of the agricultural sector will lead to an increased leaching of fertilizers into the water. Pollution from pesticides used by farmers is also expected.

Many toxic substances are coming from freshwater outlets and from airborne pollution. This comes from industry and ships in the Baltic Sea area. Some of the worst are organic substances containing chlorine, bromine or fluoride atoms. These substances can be transported easily by air. You will therefore often find them far away from the place where they were produced.

CLIMATE CHANGE

The effects of climate change will probably be the biggest challenge for people in the 21st century. In particular, the Baltic Sea is under threat due to the massive influence of the many people living in the catchment area and partly because of the low biodiversity. The water will get warmer. The sea water will become more acid due to the increase of carbon dioxide in the atmosphere. Creatures like molluscs having calcarous shells will therefore have difficulties in forming these. Fish eggs will have difficulties surviving. The salinity will decrease. Algae growth will become stronger. The thermo- and halocline will be developed further, with the result that the concentration of oxygen below the thermo- and halocline will get even weaker.
As the water gets warmer the organisms that are adapted to the present colder situation have a tendency to migrate to the north. As the Baltic is closed at the northern area, animals will not be able to move and therefore will probably become extinct. The empty ecological niches in the Baltic Sea will only slowly be filled out through migrating species from the south. At the same time unwanted invasive species will be introduced in ballast water or as fouling on ships. The absense of key species in the existing ecosystem will have potential dramatic effects. The fishery must adjust to major changes. Perhaps the cod fishery will be replaced by fishing for mullet. We have not seen it yet, but we must be aware that it could happen. The raised water levels and the fact that the returning storms that has so far ravaged every 100 years apart from now on will be expected every 10-15 years from now, with erosion and flooding as consequences. This will have a huge economic impact in an area like the Baltic Sea.

Figure 5.1
Model showing the salt migration in the Baltic Sea.
Camp Kappeln 2013

Figure 5.2
The boat from IOW're ready to go to collect water samples.
Camp Kappeln 2013

Figure 5.3
Students collecting samples of invertebrates.
Camp Pori 2013

Figure 5.4
Wateranalysis.
Camp Pori 2013

BY SIMO KORPELA AND ANJA HOKAJÄRVI

Environmental Measurements 06.

A BSP-programme that integrates studies in Biology, Chemistry and Physics

This programme is the youngest of the BSP programmes, although some of the included studies had already been developed for international co-operation between schools when the Baltic Sea Project was launched. Many BSP schools have participated in these projects for years. To carry out our research, we are allowed to use industrial laboratories, which is also why the number of participating schools has to be limited.

INTRODUCTION

The condition of the environment can be studied chemically or physically. Depending on the performance of the measuring equipment, the results can be very accurate or crude. But mere number sequences does not give reason to science. Combined with biological knowledge and long-term follow-up studies it does. This is what can be achieved in environmental studies.

Some things are easy to study, like for example temperature but others, like studying sulfur concentrations in pine needle samples, is quite impossible at school. When one studies nutrient contents in water samples one of the ”problems” for the equipment is the low concentration of nutrients in the samples. In that respect, sea water in open water areas is quite challenging to study.

Studies on water organisms and animals gives valuable information on the condition of water systems. Due to the size of the Baltic Sea, conducting comparative research is difficult; for example temperature and salt content vary greatly between different parts of the Sea. But locally they provide fabulous material for learning and teaching.

Our aim in the environmental studies programme is to carry out analyses in the same way everywhere. These analyses give comparative information on the condition of the environment in different locations.

The question here is: should schools concentrate on studies they can carry out themselves from the beginning to the end? Provided one settles with local study results the answer should be yes. Nevertheless, the aim of the Baltic Sea Programme is to get the big picture, which is why work has to be divided: biologists provide the samples which then are studied using methods from physics and chemistry.

However, the number of samples in the programme must be limited, which is why BSP encourages all schools to contact their local environmental offices and industrial and research laboratories to see if there's a chance for co-operation, which in our experience often is possible. Projects with different partners give invaluable experience to the students. We would be most pleased to co-operate, give advice and receive information on your studies.

PROGRAMME DETAILS

Common environmental research projects in the BSP area which are currently running are the Pine Needle

Project, Chemical Water Analysis Project and the Moss Bag study.

The teachers of environmental studies in Meri-Pori Upper Secondary have organized the research. The 2nd year students studying environmental science courses participate in all parts of the projects: posting instructions and sample bottles and bags, handling samples, following the measurements in laboratories, writing the reports with the help of teachers.

Participating schools: students can take samples, draw maps, pack and mail samples, and take part in the international BSP Project. When samples are taken and after the report is received, it is easy to discuss the results and the importance of research - how we can save our environment for future generations! Everyone can make an impact by taking small steps forward!

Table 6.1
Sulphur content measured in Pine needles
by the x-ray fluorescence method mentioned in the text

PINE NEEDLE PROJECT	
YEAR	S (PPM)
1995	1129
1996	1224
1997	1123
1998	1215
1999	1310
2000	1223
2001	1257
2002	1197
2003	1074
2004	1072
2005	1105
2006	1034
2007	1095
2008	949
2009	989
2010	1137
2011	1153
2012	1201
2013	1184

Pine needle Project (17 schools in 10 countries):
The schools get instructions and plastic bags and bottles for samples in November. The sampling time (two-year-old needles of Scots pine Pinus sylvestris) will be at the beginning of January.

The state of the wax layer upon the needles will be examined by scanning electron microscope pictures. The sulphur content will be measured by the X-ray fluorescence method. For these studies, we get help from the industrial laboratories of Sachtleben Pigments and Outotec.

Each year the participants in the Pine Needle Project get a report that includes the measurement results of all participating schools.
We have now results from twenty years doing these studies.

CHEMICAL WATER ANALYSIS PROJECT

Total nitrogen [Ntot] and total phosphorus [Ptot] have been measured in different parts of the Baltic Sea by 12 schools in 7 countries. The schools get instructions and bottles in the middle of October and the sampling time is at the beginning of November. The recommended way to do the sea water sampling would be taking one sample from the coastal waters and another from the open sea area. We have also got river and lake samples (from bank or shore) from the Baltic Sea drainage basin, too. To get the open area sample we would suggest for instance asking help from some fishermen or maybe even more easily from harbour pilots. The samples are measured by the Finnish Institute of Marine Research. The schools will get the results report in order to compare and to make their own conclusions. We have now results on this study from nine years.

Moss bag study (5 schools in 3 countries)
The aim is to study lead and cadmium concentrations in the air by using moss. When it rains, the moss absorbs water along with air impurities. These impurities can subsequently be measured in the moss. For the

past 20 years the measuring area in Finland has been in the surroundings of industrial plants in Harjavalta and Pori. We have also measured some foreign samples which our friendship schools have sent us. The measurements are done with the help of Sachtleben Pigments.

Figures on the following page
Students of Meri-Pori Upper Secondary are collecting samples in Pori area

Figure 6.1
Hanging moss bags

Figure 6.2
Pine needle sampling with long branch saw

Figure 6.3
Finding two year old pine needles

Figure 6.4
Collecting moss

Figure 6.5
Taking water sample on the shore of the Baltic Sea

Figure 6.6
Enjoying the beauty of nature in autumn-like forest


6.1


6.2


6.3


6.4


6.5


6.6

BY BO PERSSON

Environmental history 07.

What teaching of environmental history should include

There are several ways of teaching environmental history why this text cannot claim to be neither comprehensive nor complete. But despite this, there are significant aspects which an environmental history teaching should contain. To avoid or miss these probably means that the teaching becomes less adequate. It is these aspects which this text aspires to highlight.

Not too long ago the teaching of history mostly had a one-sided emphasis on the past without making the important connection between then and now. The teaching of environmental history early on chose a different starting point - but beginning with contemporary environmental problems quickly made the need for a historical perspective clear. With the help of the past, present problems could be explained. With the help of history, we simply understand more.

Environmental history teaching should include the student's immediate environment referring to the water, air, soil, etc. surrounding the student so that teaching becomes concrete. It is through field visits, tests, etc. in the local environment, that problems and issues are made obvious. This means that earlier references will be of less importance. Therefore, I believe that environmental history teaching according to this view is also democratic.

Environmental history teaching also means that students are working with conflicts. Studying different perceptions on the use of land, water and air in past and present, serves to clarify different attitudes towards our common nature and suggests how the impact on the environment could affect the future of people involved. Based on this, it is hoped that students perceive the time dimensions of then, now and the future.

Environmental history teaching also uses a timeline as a methodological tool. One way to exploit a timeline in the history of an environmental problem is to divide the timeline at specific point into different intervals. As an example, thinking in intervals can be used to show how long it took between the introductions of a specific substance until it was identified as a problem. Another interval can show how long it took for people to react and respond to the problem and so on. Using the timeline, it is thus possible to extend and develop students' knowledge of environmental issues.

In environmental history teaching local environmental problems are also linked to regional, national and international contexts. What is happening in the student's local environment should also be viewed in a larger context.
Environmental problems are in a way always local. But together with other local problems they develop into problems for the larger surroundings. Environmental history teaching hopes to reach an understanding in the students that they are themselves history.

In News Letter No.1 (26) 2005 and Learners ' Guide No.6, you will find more to read about the environmental history teaching.

Figure 7.1
Emajôgi River Estonia. Culture landscape disappear
in one generation. International teacher training course

BY S. BABITCH, E. MAIOROVA, Y. SHABALINA AND K. VARAKINA

Impact of the Changing human activity 08.

– on the Baltic coastal zones

Throughout history varying populations have preferred to settle in immediate areas near coastlines. For this reason the main part of economic activity has been and is still focused on coasts. During different historical periods it has been determined by diverse factors: development of natural resources, fishery, recreational activity, tourism, etc. But the most important factor was the opportunity to use the sea for trade. In ancient history and in the Middle Ages the European seas were the least dangerous, and in many cases the only trade route.

The second important factor is energy, without which implementation of economic activity is impossible. That is why we have decided to examine the influence of the economic activity on coasts from the position of two major industries: the power industry and the shipbuilding industry. The northern economic area of the North Sea and Baltic Sea was chosen as the region of research.

During various periods in European history diverse types of utilized energy dominated:

- Wind energy (windmills and sail) and water energy (watermills)
- Wood (fuel, in metal industry)
- Coal
- Oil
- Alternative resources (hydroelectric power stations, wind parks)
- Natural gas (will potentially become the most important energy resource for transport).

Transition from wooden shipbuilding to the production of ships made of metal has strongly affected coast economy. The transition happened at the same time as there was a change from a sailing fleet to a steamship fleet. Corresponding changes occurred also in shipbuilding, and therefore, they affected the environment of coasts as well as marine aquatic areas and the air.

The concentration of major capacities of windmills at that time (since 12th century) is explained by dominant winds of western turbulence. At the same period the most powerful watermills were placed in estuaries of rivers in the coastal zone.

FIGURE 8.1

Other needed resources (for textile, food, timber industries, etc.) were delivered by sea or by the big rivers (for instance, pine wood from Schwarzwald). All this was a powerful incentive to development shipbuilding which in turn stimulated growth of diverse industries like the textile industry (production of sails and ropes) and metal working (anchors, nails, etc.).

FIGURE 8.2

As a result, economic activity was concentrated in the

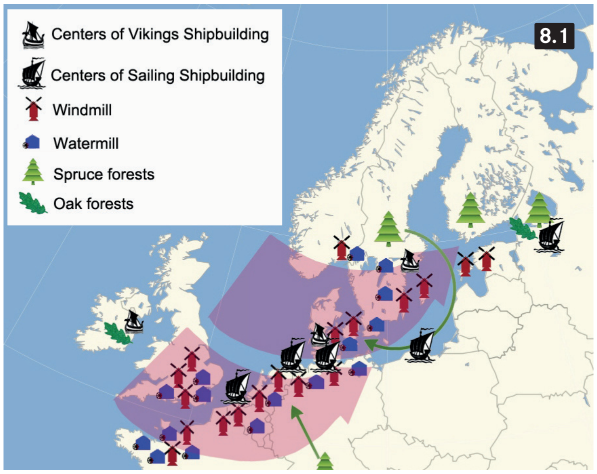
Figure 8.1
Dominant energy resources – wind and water energy
(10th – 18th centuries)

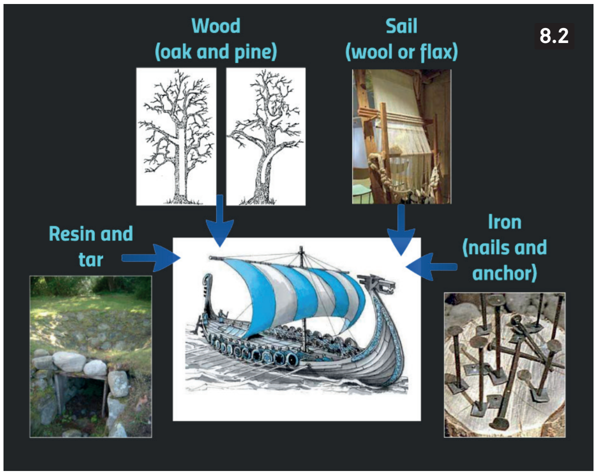
Figure 8.2.
The role of shipbuilding in the activation of different economical spheres from the coastal zone during the Vikings period

Figure 8.3
Park “Sestroretsk oaks”. Funded by the Russian national library before 1917

Figure 8.4
Lindulovskaya grove

Figure 8.5
Landscape of Stockholm with windmills





coastal zone, which resulted in the growth of cities and the appearance of typical ecological problems in urban areas: communal drains, elimination and pollution of territories, destruction of coastline, which is connected with extraction of sand, etc. beside this, it is necessary to add forest devastation (for example, forest devastation in Denmark, Schleswig, etc.). Transition to conifers (pine, larch) stopped destruction of coastal forests and has formed sustainable trade routes from the East (Sweden, Finland, Baltics, Russia) to the West for a long time. It, in its turn, stimulated development of shipbuilding in Sweden, Poland and Russia. We can mark some positive moments of this process. Oak groves (Sestroretsk; Figure 8.3) and pine groves (Lindulovskaya grove; Figure 8.4), which were artificially planted in the period of the beginning of shipbuilding in Saint-Petersburg (time of Peter the Great), have been saved up to the present time. Nowadays they are protected areas and popular recreational zones.

FIGURE 8.3 AND 8.4

At the same period of time the most important energy resource was wood, which was used for heating and for iron production based on marsh ore. The key region of iron production was Småland, thanks to its supplies of marsh ore and wood, which was grinded by windmills and was processed to charcoal. Hanseatic merchants exported iron to the Southern coast of the Baltics and further to Europe.

FIGURE 8.5

Thus economy, oriented towards this type of activity, was established in coastal areas of the Baltics. Active production of charcoal caused forest devastation of the number of coastal areas near Baltic and Northern seas, especially in England.
This is why the English were foremost interested in the search of a new energy resource. And they found it – coke. The epoch of coke and, alongside with that steel, railways, metallic and steam shipbuilding, came. This resulted in a fundamental change in the economic pattern of the coasts. Absence of big supplies of coke in the region of the Baltic Sea dictated big coke deliveries to the region from England, and later from Germany. Coal harbors appeared in practically all coastal cities (Stockholm, Saint-Petersburg, etc.). They influenced the difficult ecological conditions at the coasts for a long time (actually till the second half of 20th century).

FIGURE 8.6

Metallurgy also became a coastal industry: Saint-Petersburg, Liepāja, Stockholm, Göteborg, Gdańsk. Factories of ferrous metal industry polluted air and water with dust, sulfur dioxide gas, manganese compounds as well as small quantities of arsenic, phosphor, antimony and lead.

Starting from the 2nd half of 20th century oil became the dominant energy resource. Main oil transportations in the region of the Baltic and Northern seas were performed by sea. It resulted in the construction of receiving terminals, capacities for oil storage. Later on oil refining became one of the leading coastal industries of European economy.
Increasing sizes of ships carrying oil and other resources required construction of new supportive paths. It has resulted in and keeps on defining the destruction of coastline near large port complexes (Copenhagen, Klaipeda, Saint-Petersburg, etc.).

FIGURE 8.7 AND 8.8

After the energy crisis in the 1970s prices on energy products increased and oil extraction from the continental shelves became economically advantageous. In the North Sea oil extraction was expanded and an under- and overwater infrastructure was formed. At present oil is being extracted in the Baltic coastal aquatic areas of Russia and Poland. There are also such perspectives in the aquatic zones of Latvia and Lithuania. All this has resulted in extreme ecological conditions for the aquatic areas and the coasts of these seas. Besides this, the heat power industry, using coal and oil, is the main contaminant of the atmosphere.

FIGURE 8.9 AND 8.10

Since the 1990s the use of wind power in coastal areas in the region located in a zone of western wind distur-

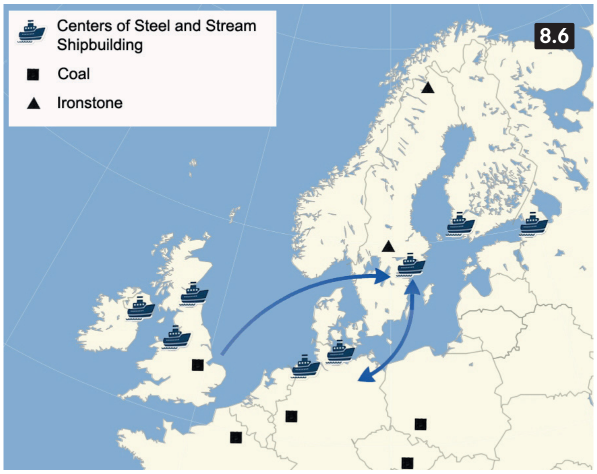
Figure 8.6
Steel and stream shipbuilding in 20th century

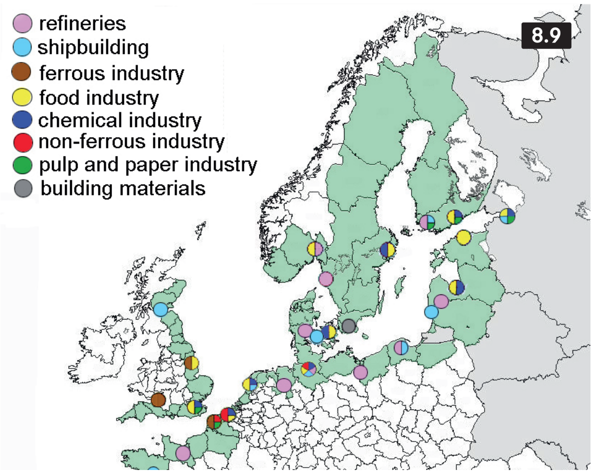
Figure 8.7
Eroded foredunes at Lemmeoja, Estonia (Photo: Sten Suuroja)

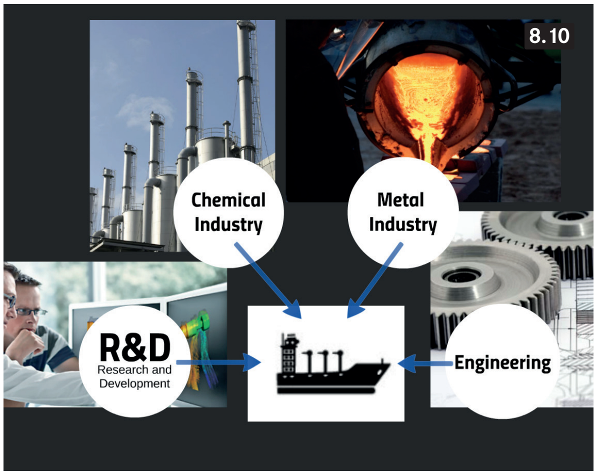
Figure 8.8
Erosion of coastal line as a result of economical activity

Figure 8.9
Map of the most problematic current activities for the coastal zone

Figure 8.10
The role of shipbuilding in the activation of different economical spheres in the coastal zone in modern times







bance has become more active. It created a new direction for mechanical engineering namely the production of the equipment for wind power stations. An important role in the development of this type of energy was played by the International treaty in Kyoto, which has limited emissions of the chemical compounds polluting the atmosphere (Carbon dioxide ($C0_2$), Methane (CH_4), Nitrous oxide (N_20), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6)).

FIGURE 8.11

Unfortunately, the economy crisis of 2008-09s has created problems of competitiveness for this type of energy. But European civilization has found a new energy resource once again - natural gas. Usage of this resource for heat power industry, metallurgy and for transport significantly decreases the emissions of contaminants into the atmosphere.

In 2015 new rules, restricting emissions of sulfur oxides to the atmosphere will take action. Implementation of restraining zones of SOx emissions will economically stimulate different companies to use Liquefied Natural Gas (LNG) as fuel. The region of the Baltic and Northern seas is considered as experimental. Later extension of these rules will cover all aquatic areas of Europe, which is going to stimulate extension of LNG all over Europe.

FIGURE 8.12

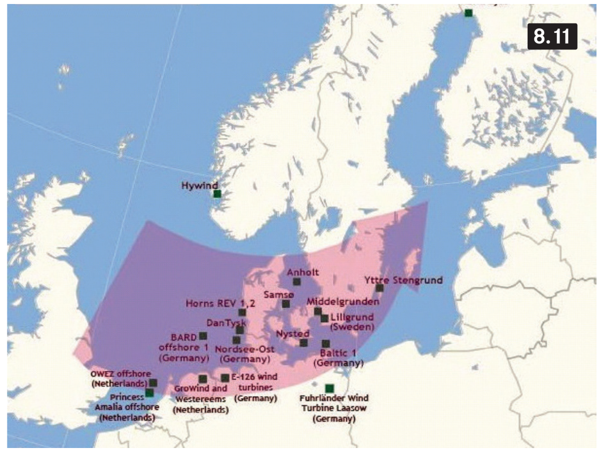
Accordingly, marine transport of LNG is being implemented in the whole region. By 2020 this network will be spread to other regions of Europe and will include transport by automobiles.

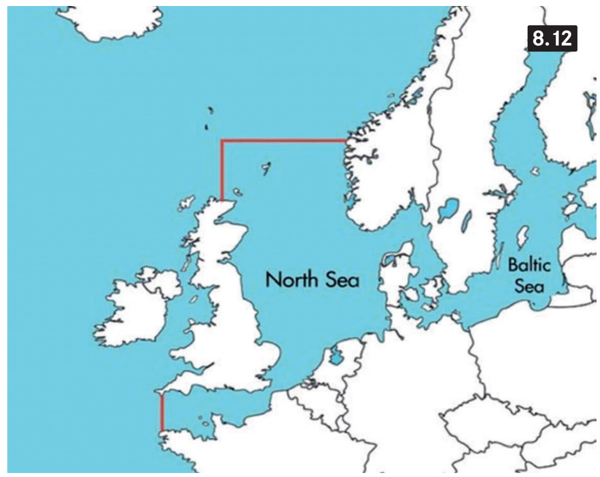
FIGURE 8.13

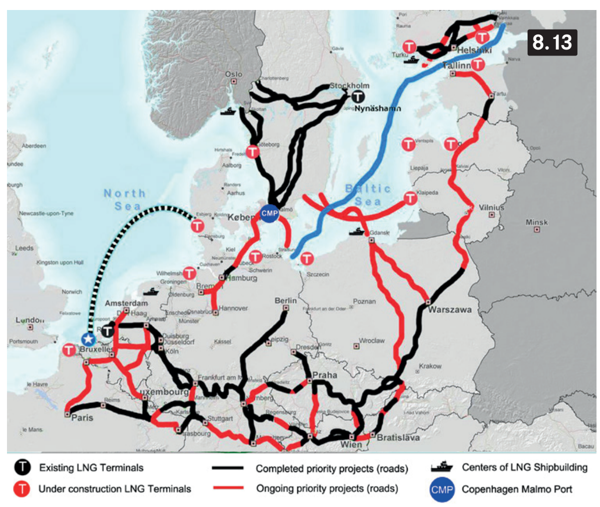
Figure 8.11
A map of modern alternative resources (wind energy).
Red arrow shows western wind disturbance

Figure 8.12
Restraining zone of SOx emissions by 2015

Figure 8.13
Map of modern and planning transport infrastructure (dominant energy resource – Liquefied Natural Gas (LNG)







BY PATRYCJA WOJTKOWIAK

Alien Species in the Baltic Sea 09.

Biological invasions are nowadays one of the greatest threats to the world's nature. The huge scale of the problem is due to this being one of the least predictable and most dynamic natural processes, caused by the developing civilisation. At the same time biological invasions are the least studied and recognized threats to biodiversity

Biological invasions are one of the most complicated problems with respect to nature conservation. First of all it is difficult to determine which species should be considered as foreign and which should be considered native. One additional complication is the great variety in terminology. People use alternative names for the same thing - such as introduced, invasive, non-native, exotic, naturalized, allochthonous and often such words are used inconsistently.

An attempt to solve this situation was made in 2002 during the Convention on Biological Diversity. The definition which was prepared on the Convention says that: Alien species are these which were introduced from outside the area of its natural occurrence due to human activities. The definition includes both adult individuals and stages like eggs, larvae, seeds and parts of individuals like tubers and propagules.

The main criteria for distinguishing species into native and foreign are whether their occurrence is the result of natural processes or a result of human activity. Native species are those who naturally occurred in the area in historic times. The transfer of a non-native species to the area by man is called an **introduction**.

Human activity like sailing, flying, riding brings species from continent to continent and from sea to sea. In this way evolutionarily established phyto- and zoogeographical boundaries starts to crack.

My area – The Gulf of Gdańsk is not the only one which has become a victim of invasions. But this process refers also to many others. Now, there are at least more than 100 species which should not be here. The features of the Baltic Sea make it very attractive for new organisms. The sea is in the moderate zone and can adopt hundreds of organisms from similar seas, from both hemispheres of the Earth. The wide range of salinity (2-25 PSU) is another positive condition for those organisms living in river estuaries as such prefer or even need salinities in this range. Also they must live in temperature ranges from 1-20 ºC.

People are often surprised when they realize the kind of organisms living close to them. Those who are big, visible to the naked eye enjoy a big interest. Those which are small, microscopic – planktonic, are invisible without a microscope at hand, but can often be more dangerous.
For example crabs. We have three common species in our waters. Two of these are foreign. One is living in

the neighbouring waters of the Danish straits and in the North Sea. This is the shore crab *Carcinus maenas*.

Bigger than this is a new stranger from the Japanese Sea – the Chinese mitten crab (*Eriocheir sinensis*). It treats the Baltic like an estuary, and comes to our seas from more saline waters. In its homeland it lives in the rivers. Here in Poland the mitten crab is searching for the same conditions by "walking" into the rivers that flow to the Baltic. *E. sinensis* can be considered a pest because it cuts fishing nets and destroys river defences. When making its burrows in the shore, it effectively weakens the flood dikes, allowing water to penetrate where it should not. Another crab is the very small Mud crab *Rhithropanopeus harrisii* which comes from North American waters. It has been living here for more than hundred years, but is not causing any environmental damages.

FIGURE 9.1

Another crustacean species, also originally from North America – the barnacle *Balanus improvises* with its white shells can also be considered problematic. The fact that this species is living on the animal carapace of other animals is not such a big problem. A problem is that *B. improvisus* cover stones lying on the bottom which is dangerous for swimmers, because they can injure their feet. Barnacles can cut human skin whereby pathogens such as bacteria can penetrate into the wound. It may result in severe infections. Barnacles also cover underwater parts of objects submerged in the water for example boats. In one square meter there can be up to four thousand or even more barnacles. Because of this high rate of growth, underwater surfaces get rough and thereby the friction between boat and water become higher. When this happen boat engines must work harder whereby they use more fuel. From the chimneys of ships and motorboats additional pollutants are emitted. It gets to the atmosphere and it is polluting the environment. The boat owners are also forced to clean the boats from covering organisms which is also very expensive. Sometimes boat owners are painting the underwater parts of ships and boats with special anti-fouling paints. This is expensive, effective to some extent – but also a toxic solution. The toxicants within the paint get dissolved in the water where they do harm to organisms like fishes which are also caught and eaten by humans. But also organisms like seals or harbour porpoises that feed exclusively on fishes get sick.

FIGURE 9.2

Transport by boats and ships are today the normal means for marine organisms. Ships carry huge tanks of ballast water which are transported from ports around the world to other destination ports. Those organisms which are able to survive the journey in the ballast water under less comfortable conditions like darkness, a deficit of oxygen, sometimes with pollutants, are released when the ballast tanks are emptied. In this way Round goby (*N. melanostomus*) came to Gdynia by a ship entering the local shipyard.

This species experienced a favourable situation for survival in the polish waters. In the Gulf of Gdańsk it had no real predators like big fishes, marine mammals just as there was no big fishery thanks to eutrophication. Also rich in the favourite food of the goby this was a real paradise for this fish. Stones, which are close to shores, became a place of refuge and spawning. Today we have millions of these gobies here. They are everywhere. In fact, there are not enough stones for them here, so they stick their eggs for example to old tires, pieces of wood and plastic bags. *N. melanostomus* is dangerous for native fishes like perches, flounders and eels because its diet is similar to theirs. There is also another problem for the fishermen because round gobies are so numerous in their harvest from fishing nets. Therefore they lose working time cleaning nets from this fish. *N. melanostomus* is currently migrating up the Vistula river. From the other side in the Black and Azov Seas two other species of gobies (*N. fluviatilis* and *N. gymnotrachelus*) are colonizing the Baltic Sea.

FIGURE 9.3

Nowadays, where we are all participating in the process of mixing our global biodiversity, it seems that invasions are not single incidents made throughout the development of human civilization, but rather a still growing problem enlarged by the newer stages in the evolution of our civilization. Foreign species seem to enhance the species composition of the Baltic Sea, but their occurrence has no positive economic importance. Through participation in BSP you can try to investigate causes and consequences of the invasion of new organisms institutionally and decide on your personal attitude towards these problems. Some of these species we can eat. Maybe it is worth trying?

Figure 9.1
The shore crab, C. maenas

Fig. 9.2
Barnacles on a ship anchor

Figure 9.3
Barnacles on the propeller on a boat

BY PETER UHL PEDERSEN

Coast Watch 10.

- a programme in the Baltic Sea Project

COASTWATCH is one of the oldest programmes in our portfolio even existing before the Baltic Sea Project was invented. The first international coordinator of the COASTWATCH programme under the Baltic Sea Project was Reet Kristian from Estonia. She was also the coordinator of the programme before it entered into the Baltic Sea Project.

The programme allows schools and their students to work with environmental education in coastal areas through the use of a special designed questionnaire intended for use during field surveys.
Many problems are dealt with in this questionnaire. Besides questions to the environmental status such as influences from the hinterland, questions about nature protection of the coastal zone and animal and plant life in the shallow water. Litter and waste problems are also considered. Water quality of inflows are analysed as well. All these different investigations can motivate and be used for further tests and investigations on all cognitive levels.

Because of the concept and the COASTWATCH history going so many years back it has naturally been a model and inspiration for many related activities and projects such as the Western Mediterranean Sea Project, the Caribbean Sea Project and the Danish supported "Sandwatch" mostly carried out of nations in the Pacific area. Recently, there has been an interest from Japan to make a similar project.

SELECTED SUGGESTIONS WHICH HAVE BEEN GIVEN TO THE COASTWATCH PROGRAMME / QUESTIONNAIRE BY USERS.
The list below is by no means exhaustive of all the comment received by end-users on this programme, but rather is a selection of suggestions which highlight some major pedagogical concerns in the teaching of environmental subjects to young students. In some cases the suggestions have been reformulated to fit into this text.

Concerning student motivation:
The students have to feel that their effort is part of an international investigation. Therefore you have to be very accurate and legible.

Student results should be taken serious. Therefore, it is also very important to give feedback on this kind of survey.

You can address relevant environmental key problems through discussions with the students based on the investigation carried out. As an example you can ask: What does the hinterland look like (farms, city, city dump etc.) and what influence does the type of hinterland have on the ecological state of the coast? In some countries there are legislations on what you can do close to a coast. There can be a law against summer cottage areas close to the coast. And we have also seen power plants and dumps so close to the coast that percolate can seap out to the coast and pollute this very intensely. Each country has laws to protect the marine environment from these influences. The students can try to find these laws and compare these with their findings doing the COASTWATCH session. You can also discuss which impact water from roofs and roads have on the environment close to the coast. Nitrate pollutes shallow waters on many sites in the Baltic Sea. The farmers pay a lot of money for nitrate to fertilize their fields. And later the society has to pay a lot of money to destroy nitrate in the wastewater from the fields! Is there a limit for nitrate from outlets in your country? Try to find the content of nitrate in your drinking water. Is it allowed to send this water out into nature? Discuss what would happen if we treated our forests the same way as we treat our marine environment! Here it is important to follow the news in the newspapers or contact people living close to the survey unit on the actual coast.

There is one question (E5) in the Coast Watch questionnaire which addresses the attitude of the student to the task he/she has been undertaking. It is interesting that many teams use this place to write about further studies and tests.

Concerning the usability of the gained knowledge - a student motivating factor

If you find inflows with smell and odd colours you can take samples and photos and contact the local authorities and ask why this water is not cleaned in waste-water-cleaning-plant before send out in nature. Often it is possible to get local maps on the sewage system. Here is it possible to see if the waste-water is let out without cleaning.

You can ask the technical management of the local community if they have some ideas about cleaning this water for oil waste.

You could also visit a local waste-water-treatment-plant. On this visit you could ask in what way this plant works and who is paying for the cleaning.

If a sandy desert would suddenly cover all the surface where we live, we would do something about it. But when dead seabed is spreading close to outlets in our shallow marine water. What do we do with this knowledge?

Many communities with tourist industry clean coasts many times each summer to make the coasts more attractive. But the natural inhabitants on coast do also deserve a clean beach. And also coasts with minor tourist interests could deserve cleaning. This is a good activity for students. You can use plastic bags to collect the waste. After collecting you can try to divide the waste into fractions: Coming from tourists – coming from ships. Or plastic – not plastic. Reusable not reusable. You could also try to find out from where or which country the waste is coming. If you send the waste back to “the producer” you could help to prevent more waste to come. You could make a little exhibition in a harbour to make sailors or sailing tourist feel responsible for the littering of the coast. When you participate in these activities juridically you follow the MARPOL convention as many countries have signed – and all the countries around the Baltic Sea. Apart from many other regulations you have in annex 5 section 5: Disposal at sea of the following are prohibited: 1. All subjects made of plastic, e.g. synthetic ropes, synthetic fishing gear, plastic waste bags and 2. All other waste e.g. paper products, rags, metal, bottles, pottery, and packing materials. All harbours are obligated to have facilities to receive waste from the ships. Do “your” harbour have this?

Concerning the scientific value of the programme:

Whereas it is accepted to send in results from all over the year, many observations and measurements are related to the time of the year. If you make chemical analyses you will see that Nitrate level is higher in the winter (due to washout from agriculture soil being more substantial in winter) than in the summer at the same spot. The reason is that algae use almost all available nitrates in the summer. And in the late summer you can observe mats of algae on the coasts. The recommendation is to make the survey between 12th to 25th of September.

Other relevant exercises to explore the problems further:

Some places in the Baltic Sea area you can find inflows with no water in the summer. Discuss the consequences and ecology for the environment.

Questions concerning the physical state of the coast can give motivation for a talk about the creation and the dynamic changes of the coastline. Discuss what significance the coastline direction to the main wind can have for the ability of the coast to tell about the state of the sea.

Try to find out the amount of organic matter in the mud by glowing the soil in a crucible. Compare the mass before and after. Or you can make a sediment analysis by adding the mud dissolved in water to an Imhoff glass and wait for some days before analysing.

The question C4 (in the questionnaire) is about nutrients in the sea. If there are too many nutrients you can see a lot of foam on the sea. You can discuss what happen when this foam appear. What consequences does this foam have for the environment? Is it possible to get rid of the foam? The foam comes from small plankton algae. Some of them lives in colonies kept together by a jelly. When this colony of algae dies and break down, the waves and the surf will whip this protein mass. Some places and sometimes you will see some very thick mats of foam. In marine environment on shallow water and often in fiords you will see concentrations of nutrients more than 20 times of what is normal in the environment. If some warm weather with sun occurs in a fortnight then you see the algae. So little time is needed to make so many generations of algae. The problem does not disappear because the algae die. Then they will just break down and be reused as nutrients in new generations of algae. The nutrients can be used and reused many times.

Selected other relevant commentaries:
A substantial part of the pollution in the Baltic Sea comes from inflows from the hinterland. The water inflows from land contain all substances from man-made activity. Working with pollution of the coast it is natural or necessary also to look at the conditions of inflow. You can roughly divide the influence from the inflows into 3 groups: supply of waste from household, supply of waste from industries and supply from diffuse sources (in some parts mainly from agriculture.)

If there are a lot of silt and mud on your coast unit it is most likely a coast where there is deposit. This is often seen in fiords with very calm water. Unfortunately heavy metals are easily attached to the fine grain material. Therefore a drill-test can give a historical view on the content of heavy metal in the sea or if you cannot make such a test rely on measurements by the local administration. From a city of 100.000 people there will be an expected outlet of 10 to 20 kg of Hg via the cleaned household waste water. But also the harbour bottom is a source as well as industrial plants.

In several places the ell-grass (*Zostera marina*) is being disturbed by the fishermen's tools. Partly it is spoiled by eutrophication and too many algae in the polluted water. The light can't reach the ell-grass. The ell-grass is most important as a hiding spot for the small fish larva. These problems are often seen in fiords. It is difficult for us to detect the exact amount of nutrients in the water. Therefore there is the question on "Extensive cover or thick mats" (C25 in the questionnaire). It is also possible to make investigations of algae growth in the classroom.

Besides that it is often very disgusting to take a bath in water with many algae there are other consequences to the sea. The many dead algae use up the oxygen in the water. This oxygen should have been used for other living organism: fish and the animals eaten by the fishes. Those who can swim away disappear. Those who can't: die! The decaying algae transform the sand bottom into mud bottom. This makes the coast less attractive for tourists. And such fish as plaice requires clean sand bottom. Gradually the plaice disappear to be replaced by less expensive species of flounder. These of cause affect the fishery. The changes in the algae species will change the food chain in the sea over time. In the future we will see less fish and more jellyfish as the top predator!

Our mess with nutrients in the shallow water change the overall ecological system. Changes which will mean that big areas of the sea will die. Nobody knows how much the sea can absorb of this kind of pollution before we have reached "the point of no return".

What shall you do if you find a living sea bird with oil on the feathers? The most natural is to try to save the bird by cleaning the feathers. This is very difficult.

Most of the birds have also got oil inside the body and will die no matter what you do. If you have cleaned the feathers carefully and you just missed a little spot – the bird will die anyway. You have just made the suffering longer. Normally our saving actions have no effect on the population of the species involved. Therefore – although it is very unpleasant – the most humane you can do is kill the bird fast.

Figure 10.1
The national coordiantors doing coast-watch at the coastline in Latvia

Figure 10.2
Different species of craps found at the Danish annual BSP-meeting 2012. Limfjorden in Denmark

The general littering on the coast is not the worst kind of pollution. Animals and plants will often survive the big quantities coming from outlets and mostly from ships passing by. But the litter is very visible. There are not many investigations of the size of the litter problem on coasts. One investigation found 103 gram litter pr. square meter. Another investigation found 775 kg pr. kilometre coastline – 2 weeks after a public cleaning of the coast. 5 – 10% came from tourists. Most of the rest came from the ships. A calculation showed that each passenger on a ship produce 2kg solid waste every day. A substantial amount comes from the cargo. The waste can float around for a long time. Plastic can almost not break down. Glass can also stay long time on the coast. The animals can get entangled in plastic net. Sometimes birds can be seen using plastic nets used for vegetables to make nests. The risk exists that the small chicks may get strangled when the get these nets around their neck. Some municipalities in Denmark are very strict in their cleaning of the coast. During a recent epidemic disease among seals it was difficult to explain why there were so big differences in the number of seals washed ashore at different coasts. The reason was that some municipalities, with high tourist population, went out each morning to collect dead seals and bury them. When this number of seals was counted as well – the numbers was not different anymore.

BY BRIAN DALL SCHYTH AND BIRGITTE BJØRN PETERSEN

General methodology used for investigating the waters of the Baltic Sea area

11.

Highlights from the previous Learners Guides

Reading through the previous nine Learners Guides one will find that they contain a wealth of methods. Although, they are all written by deeply skilled professionals in both science and the art of teaching, thereby securing both their usability and efficiency, one can easily get confused by the large amount of material at hand. Furthermore, many of the methods are spread throughout chapters in these volumes in between chapters on other subjects. It is also important to be aware that not all methods are equally usable in all the Baltic countries something which is partly due to differences in the facilities presented to teachers and student and partly due to differences in the methodological curricula in different countries. For the Learners Guide 10 it was therefore a deeply felt wish from not only the editorial group, but also from several BSP participants, that we did a small survey and presentation of the most relevant methods previously presented in the BSP Learners Guide series. Not only would this be a great help to new teachers in the BSP, but this would also sum up some of the most important methodologies used in the programmes joining the BSP together.

This list and the examples herein should, due to the reasons given above, by no means be considered exhaustive of what can be found in the previous guides. Rather we have aimed at selecting methods usable at a broad range of schools in the Baltic Sea area and such as to be representative of the methodologies used when investigating biotic and abiotic factors in our common waters. Basic are the protocols found in the appendixes of the Learners Guide no. 1 on “Water Quality” which deals mainly with the Baltic marine environment and no. 4 on “Rivers”. These protocols based on the identifications lists of flora and fauna given in the same learners guides are of special concern in BSP and as a natural consequence of this we have focused on the mentioned guides and their methods. The resulting list with comments and links below can be read and used as a guide to find good basic methods to use as a new BSP-teacher, methods which can be used for reporting in data for registration using the mentioned protocol sheets. This reporting has the aim of collecting all data gained in the BSP work for giving a broader picture of the situation in the Baltic Sea, not at least concerning aspects of biodiversity and pollution. The protocols are currently being developed as apps for faster registration. Included in the list below are also places to find the theoretical background for the suggested methods. In this way it becomes a list of: “where to start, how to investigate, and how to use the report and registration protocols.”

For selecting the right methods and chapters we are deeply indebted for the help we have received from primary school teacher Mr. Thomas Holm Petersen and high school teacher and former general coordinator of the Baltic Sea Project Mrs. Birthe Zimmermann. We apologize to the reader for any methods, whom she or he may consider good, but which have been omitted in the list. The responsibility is taken by the authors alone.

METHODS

In the Learner's Guide No1: Water Quality Assessment 1992 and Learner's Guide No 4: Working for better rivers in the Baltic Region 2000 there are relevant information for investigating flora, fauna and water quality as indicators for the status of the biotope in question. All Learners Guide publications can be found and printed for free at http://www.b-s-p.org/home/guides/. Page numbers in the list below refer to those in the specific guide.

METHODS AND THEORY BEHIND METHODS FROM "THE BALTIC SEA – LEARNER'S GUIDE NO. 1 – WATER QUALITY":

Chapter 6	**Common plants and animals**
Page 66	Introduction to coastal investigations – a combination of flora, fauna and local physic conditions.
Page 67-84	Description of the coastal flora and fauna of the registration protocol presented in the guide on page 192-195 (An App on this protocol is currently being developed,)
Page 85-89	Description of some common primarily coastal biotopes

Chapter 10	**Water and sediment tests**
Page 116	Introduction regarding tests and the protocol
Page 117-119	Instruction on how to use the registration protocol (p. 192-195)
Page 120-125	Manual for water and sediment tests - practical conditions regarding investigations
Page 126-127	Measuring salinity (Mohr titration)
Page 128	Measuring temperature and visibility
Page 129-131	Sampling water and growth experiments
Page 132-134	Sediment sampling
Page 134-139	Measuring organic matter and oxygen (Winkler titration)
Page 140-142	General about flora investigation

The BSP Water Quality Registration Protocol

Page 192-195	The BSP registration Protocol (for "marine" water quality) – Is being converted into an App.

METHODS AND THEORY BEHIND METHODS FROM "THE BALTIC SEA – LEARNER'S GUIDE NO. 4 – RIVERS"

Chapter 7	**Introduction to Baltic Rivers**
Page 60-69	River types in the Baltic

Chapter 13	**Rivers and organisms adapted to rivers**
Page 122-149	The flora and fauna in rivers

Chapter 14	**Methods used for estimating the water** quality in Rivers
Page 150-158	Physical and chemical tests
Page 159-160	Investigation of the aquatic vegetation
Page 161	Flora identification table
Page 162	Fauna identification table
Page 163-174	Water quality by index methods

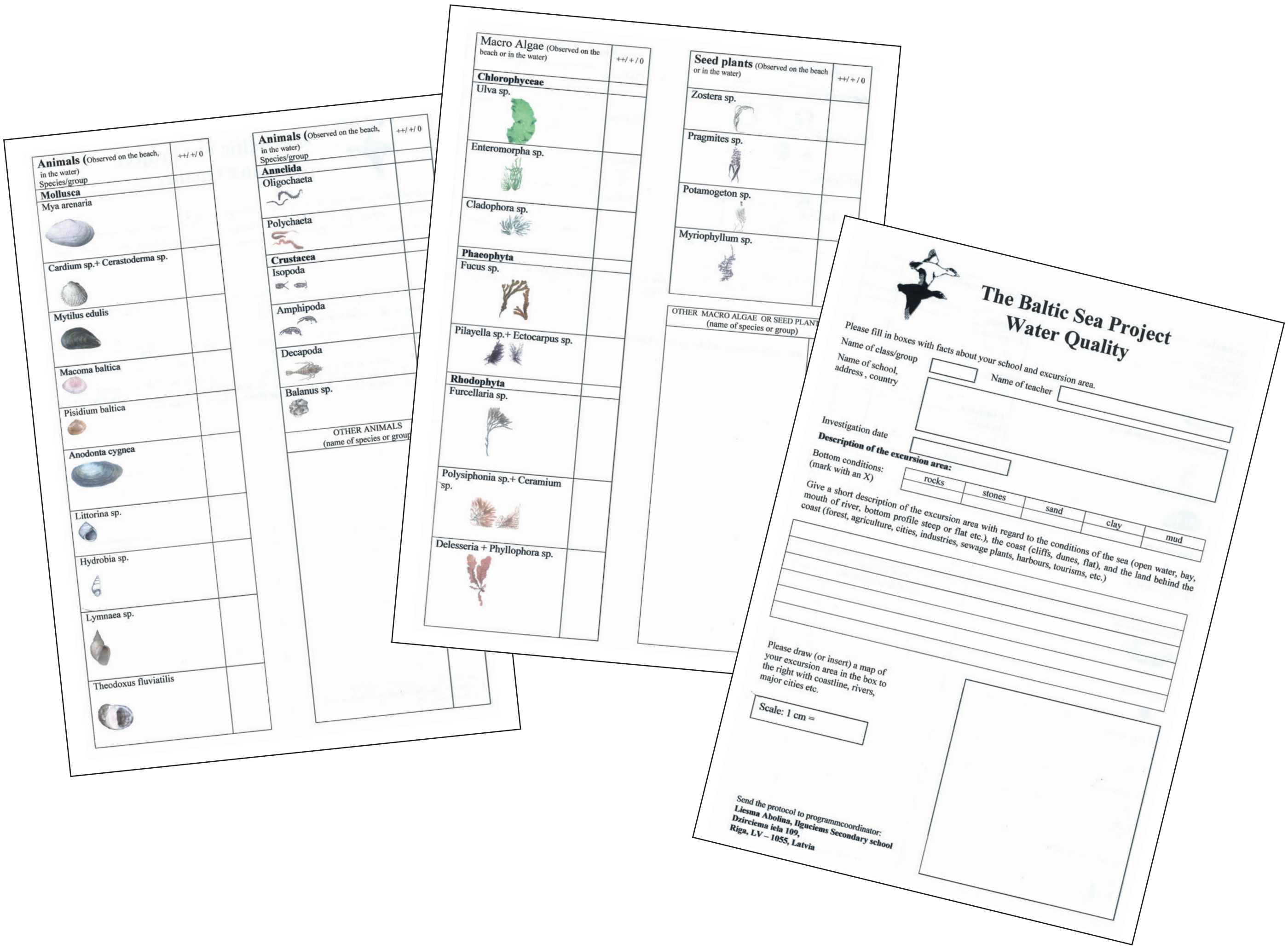
Appendix about methods

Page 191-193	Manual - an explained version of the River Registration Protocol (Appendix page 199-202)
Page 194	Collection methods
Page 195-198	Instructions - further instructions on how to use the protocol
Page 196	Pollution class estimation

Appendix: Protocol of river investigation

Page 199-202	The BSP registration Protocol of river investigation – is to be converted to an app.

Figure 11.1
Exampels of identification tables and the BSP registration protocol for water quality (Learner's Guide no. 1)



BSP camp in Meri-Pori, Finland, 26.-31. May 2013

BY MAREK PETERSON

12. Digital versions of the BSP programmes

BSP programmes on your laptop and smart phone

Advanced opportunities in a digital world has resulted in better data management through novel ways of inserting, collecting and analyzing different types of data. Whereas paper versions of the BSP programmes have been used by students and teachers for more than 20 years now, current development procedures are focusing on digitalization of the programmes and is now moving towards easier data manipulation and information sharing between students, teachers and coordinators.

ADVANTAGES OF DIGITAL BSP PROGRAMMES:

- The number of PCs, mobile phones or tablets being owned is growing constantly and such devices are becoming a natural part of our personal lifes and even of our way of working. Therefore end users are expected to be familiar with their own PC or mobile device for such purposes as the ones intended under the BSP programmes.

- Digital versions can be used with mobile phone or tablet while doing research in the field. Here it can help in the collection of more precise data due to the use of GPS coordinates and the use of multimedia (recording of movies, images, sound, etc). The collected information can be instantly uploaded or shared with teachers or other users before arriving back to the class room.

- Results gained through easy-to-use interfaces can basically be displayed momentarily and can be seen by other users in real time. Collected data can be shared and used inside the application administrative web page by coordinators, teachers and children (according to given permission).

- Data can be displayed or grouped by schools, countries, survey types, map views etc. Graphical diagrams produced inside the app or raw data can be exported in and out of the system.

- Secondary analysis of previously collected and analyzed data sets is possible.

- Digital data sharing makes the exchange of data with scientific research centers and universities easier.

SUPPORTED PLATFORMS (PLANNED):

- Microsoft Windows (XP or greater), Linux, Mac OS X computers:
  - Firefox
  - Safari
  - Chrome
  - Opera
  - Internet Explorer 8.0+
- Android OS, Apple iOS, Windows Phone:
  - native web browsers

The general web application is estimated to be ready witnin weeks of the publication of this book. While waiting for the finalization of the standalone native mobile applications for Android OS and Apple iOS the web version will work on all smartphones and tablets with screen size at least 320px width.

TECHNOLOGIES BEING USED ON THE USER INTERFACE / CLIENT SIDE:

- GPS - Global Positioning System on mobile devices (phones, tablets).

- OpenLayers map engine with various open source map layers for manual drawing of specific areas: point, line or polygon.

- Device specific multimedia options: image and video capture, sound recording.

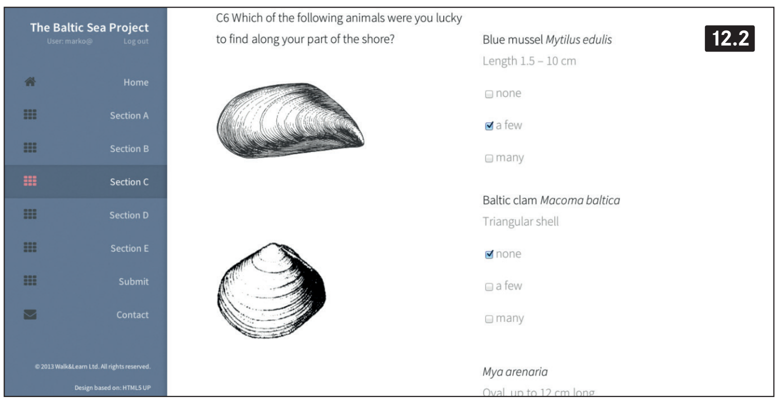
- LAN, WiFi or cellular data for internet connection depending on the device. While being preloaded, the data form can be used and filled in offline. Although the digital map may not have full offline support for web based version. This is solved in native application for Android and Apple mobile devices.

The application can use GPS signal for positioning user locations. All observations can have GPS tags and later it will be easy to see all observations made by other students on one map. GPS user positioning is not mandatory, but can give better value or quality towards future data analyzes.

ON THIS LINK THE FLOW WHEN USING AN APPLICATION CAN BE SEEN:

https://www.fluidui.com/editor/live/preview/p_6lG64W05kZhiMbh8qGp95W5lg1dZBeel.1384420650898

Screenshots from a desktop version of the coast monitoring programme Coast Watch (see chapter 10)



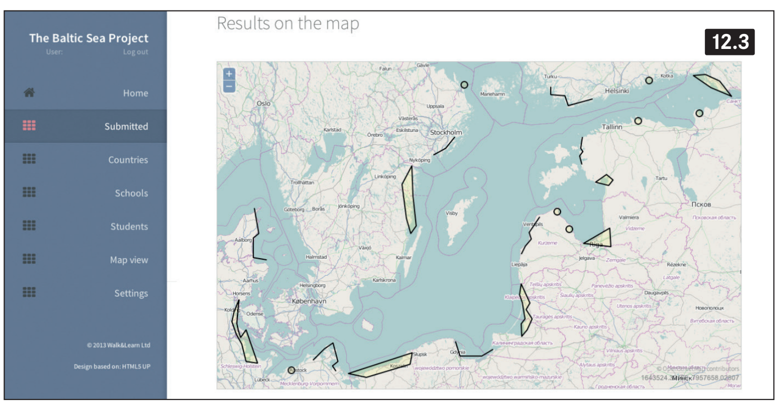
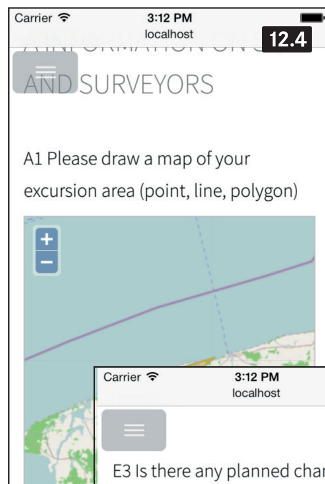


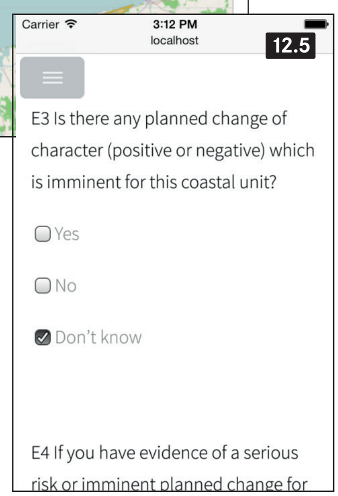
Figure 12.1
Administrator view

Figure 12.2
View for registration of species and number of species

Figure 12.3
Mapview for seeing results on different stretches of the coast line

Figure 12.4 + 12.5
Screenshots from a mobile version of the Coast Watch programme





Poland, September 2008

BY SVEN HILLE, IOW

13. The South Baltic WebLab*

The South Baltic WebLab aims at attracting school students for marine science

Under the leadership of the Leibniz-Institute for Baltic Sea Research Warnemünde six marine research institutions from five European countries have jointly run the project called „South Baltic WebLab“ from 2010 to 2013. The project was set up to generate interest in marine professions among teenagers.

The project consisted of four components, of which the virtual laboratory is the most important feature. The virtual laboratory contains five eLearning modules which cover state-of–the-art research topics in Baltic Sea research. The most complex module deals with the long term history of the Baltic Sea. How to make best use of this offer in classroom situations is described in the “teacher´s guide”, which will be presented in this chapter.

The other project components included an interactive internet platform where scientists shared their every-day scientific life via blogs, a database informing about internships and job opportunities, and yearly science camps which allowed young people to experience marine sciences in real life. During these marine science camps, school students from the whole South Baltic Region worked together and carried out scientific research on their own.

The guide presented here is intended to accompany the eLearning module entitled “History of the Baltic Sea” which is accessible via the website http://southbalticweblab.eu/modules.html . The module presents scientific concepts used to explore geologic and oceanographic changes that took place in the Baltic Sea area during the past 15 000 years. In the module students will experience how they – as marine scientists – extract some geological facts from the Baltic Sea itself. After working with this module the students should have gained a better understanding of how the Baltic Sea developed and they should have a better idea of how scientists work. Hopefully it will also raise their interest in marine sciences.

TABLE 13.1

Part-financed by the European Union (European Regional Development Fund)

*The project “The South Baltic WebLab“ is partly financed for three years by the European Union (European Regional Development Fund), in specific the “South Baltic Cross-Border Co-operation Programme 2007-2013”.

Table 13.1

TABULARIZED TEACHERS´ GUIDE

Time /Part	Contents	Work mode	Material
1./2. 90 min.			
Introduction 15 min	Start with the video: The sunken forest T: Why are there pine trees in the Baltic Sea? **S**: - It was not a sea but land in the past - Sea level must have changed **T**: We want to deal with the history of the Baltic Sea in the next lessons. Why do you think it is important to know something about its history? **S**: Because we only can find out what will happen in the future / consequences of climate change if we understand how and why things changed in the past. **Question:** **How can we / scientists find out about what happened in the past?** **Hypotheses regarding:** - Sediments - DNA - Old bottom water - Bedrock	Class	Video in Module; Headphones
Intro part of module 20 min	- Episodes from the history - Geological history – some background facts - How sediments are built up and how you take sediment samples	Individually	Module (Introduction)
10 min	Preparation for the three labs All the students should know what's going on in the three labs (Table on labs on the the blackboard)		Blackboard / Whiteboard Table on labs
Working in labs 45 min	All students start with an introduction in the Sediment lab. Then the students encounter three doors and split up to work in three different labs: - Sediment lab - Palaeontology lab - Dating lab Preparation of the presentations (taking notes, their results on their protocol)	Group Work	Three labs in the Module; Worksheet Protocol (in English only)
3./4. 90 min			
Presentations (30 min.)	While students are listening, they should note down important facts (conclusions or techniques) + add results for protocol.		Worksheet Protocol (in English only)
5 min.	Further preparation for the quiz: Module: What can you learn from the data	Class (teacher presents slides)	Module (three slides)
Quiz 15 min.	Students do the quiz individually	Individually	
Discussion 10 min	Discussion results (quiz). Pose questions about what we did not learn. Do we know: • why the (Baltic Ice) Lake turned into a sea 11 600 years ago? Where did the salt water enter and why? • why water level dropped so much that pine trees could grow in what is now the Hanö Bay? • why the pine forest was drowned again? • why the Baltic is a brackish sea today?		
History as we know it today (15 min)	The History of the Baltic Sea (Module). Ask students to note down important characteristics and processes		
Future (ideas) 15 min.	Class discusses possible future changes (caused by land uplift) with help of simulations	Class (S+T)	Module part: Simulating the future

TO GET ACCESS TO THE FULL VERSION OF THE GUIDE AS PDF AND ADDITIONAL WORKSHEETS PLEASE FOLLOW THIS LINK HTTP://WWW.B-S-P.ORG/UPLOAD/GUIDES/

* Part-financed by the European Union (European Regional Development Fund)
** Compiled by Pia Romare, Lund University, Sweden and Hilke Heinks, Bismarckschule, Hannover, Germany.

Figure 13.1
Students and teachers trying the South Baltic WebLab

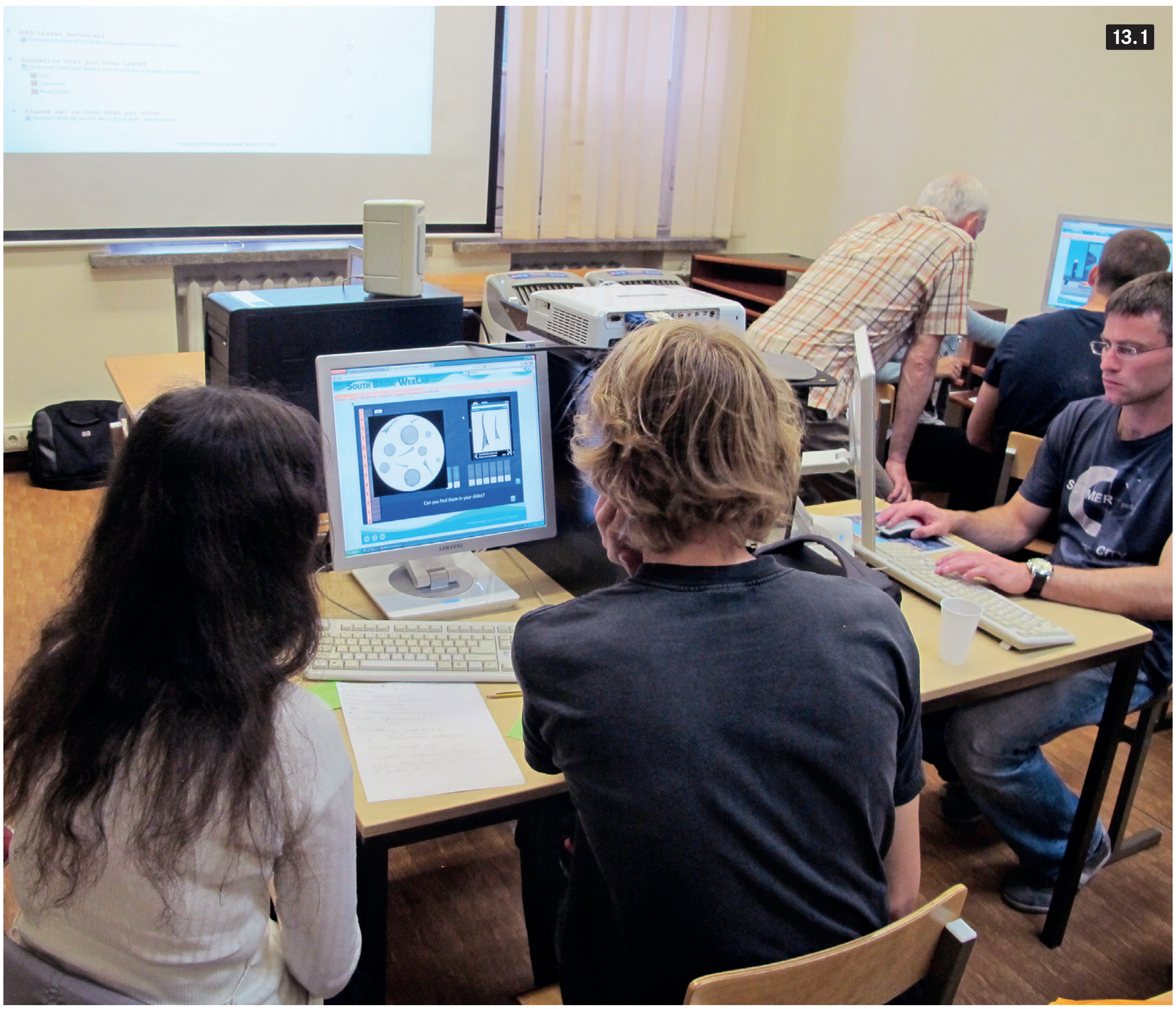


Figure 13.2
Screen shot from the South Baltic WebLab - An example of a student activity in the virtual reality WebLab. Gamification is used for easier learning and as a motivation factor. Here a scene from the Sediment lab: Opening the core, where a sediment core is to be analysed by the student playing the game

BY BIRGITTE B PETERSEN

14. Baltic Sea Project science camps

Students meet scientists

The prejudices amongst students concerning the work of scientists are probably well known to all. Scientists stowed away, far from the real world, investigating matters, never to be known outside a narrow group of colleagues. Well, this might feed cartoonists in the making of stereotypic jokes, but of course this could not be more wrong. Scientists are working with the real world and their method of observing things, getting hands-on experiences, and being in direct dialogue with colleagues is a fine way to break down pre assumptions.

The strong need for young students to open their eyes for the possibilities in the world of science is essential to the future development of society. The need for meeting the challenges related to climate change, for creating solutions aiming at a more sustainable consumption of natural recourses, and for developing innovational engineering in a global context, are the tasks for today and for tomorrow.

While these are just a few of the present and future problems, faced by scientists and students, education itself is the way for achieving the knowledge to address such problems. But before this starts, young students must choose amongst many options, and there is a tendency that students today prefer professions involving modern media and public exposure. By meeting real persons and trying out real scientist work, young students can find inspiration and add real life experience to the reasoning behind their choices regarding further education.

When school work makes students think of future possibilities, and their own role as acting citizens, it is always an important outcome. One student - Augustinas from Lithuania - attending a BSP science camp reflected on this:

To sum it up, the BSP-camp in Kappeln was an amazing experience. I could do something I will probably never try in the future, but I have no regrets. I don't think the information I gathered during the lessons will help me in my profession, as I'm not into ecology that much, but it certainly brought my attention to the Baltic Sea and makes me think about the damage our industry is causing to it.

How can these important and inspiring meetings between scientists and students become a part of the general education system? In the school network of the Baltic Sea Project science camps is one example of a solution. Science camps, especially summer camps have a long European tradition and have been carried out for many years, but the need for attendance of "real" scientists – on a high university educational level – is a renewing way of widening this tradition, thereby making the camps attractive for more students.

One example of a BSP-science camp is the annual camp in Meri-Pori, Finland, where methods and sampling of environmental data is taking place at a high educational level. Other examples are the BSP climate change science camp in Mols in Denmark in 2011, and the BSP science

Figure 14.1
Studentcamp Pori 2013. Pine needles analysis

Figure 14.2
Studentcamp Kapplen 2013. Birdwatch

Figure 14.3
EU Climate Commissioner Connie Hedegaard with the students at the camp in Mols, Denmark

Figure 14.4
A slide presented by Tony Fox, Department of Bioscience, University of Aarhus, Kalø, Denmark in a lecture at the camp at Mols, Denmark, 2011. His lifelong investigation made a big impression on the students

14.2


14.3


14.1

14.4

camp in Kappeln in Germany 2013. Examples from the last mentioned camps can serve as inspiration to further cooperation between schools and science institutions.

As a camp attending student
– Mikkel from Denmark - expressed it:
It was exciting to learn how diverse the way of life in the Baltic Sea actually is. The salinity varies throughout the sea, and it was interesting to see how different kind of animals and plants adapt to the changing environment. I got the opportunity to talk with some of the speakers, and it was great actual to talk to someone, who works with the Baltic Sea for a living. They study the Baltic Sea every day, and I learned a lot about how they work, and what they do. I hope that I can use that in my future.

THE BSP-SCIENCE CAMPS IN MOLS AND KAPPELN

Science camps have been known for many years, but have found a new approach, which is useful as a tool in the work of inspiring students to gain interest in science matters, and eventually consider a career as engineer or in working with natural science.

Bringing “real” scientists in direct dialogue with young students is a new strategy, and often leaves a strong impression on both sides. When students experience scientists, who are dedicated to their field of study it reveals to students a kind of honesty, which surpasses all the You Tube-videos and other learning materials in the world. It is a very strong matter to meet people, who search for answers and persist doing this, driven by curiosity and a deep knowledge of their subject. The following statements from students can serve as a few examples of this influence between students and scientists.

Mr. Andrew John Wright Ph.D. Department of Arctic Environment, University of Aarhus, Denmark presented a lecture: "Marine mammals and underwater noise in a changing ocean".

On the camp in Mols a young british biologist Andrew Wright told that he had chosen to work in Denmark, for a number of reasons.
Besides presenting his research regarding the recording of underwater sounds from mammals, he told the students of the choices he had had to make as a scientist.

In Denmark, the geography makes it easy to access open water from most places. This often means good conditions for underwater sound recordings and better possibilities to do field work and to collect usable data. Andrew Wright demonstrated examples of his recordings and the students were very impressed by his work. His investigations showed a possible link between naval activity and increased entanglement of harbor porpoises in fishing nets. The noise from naval vessels could be a contributing factor, possibly by diverting the attention of the porpoises away from the nets. These findings opens up for a better understanding of the basic biology of the harbour porpoise, and focuses on the ways that human activity affect these protected animals - a result of human activity unknown to the students prior to this talk.

In Kappeln, from Institute of Oceanology of the Polish Academy of Sciences (IO PAN), Sopot in Poland, biologist Ms. Kamilla Sfugier had chosen to let students meet the phenomenons themselves: how the size of mussels depends on the salt concentration of the water they inhabit, how osmosis has a direct influence on organic matter and how phytoplankton uses different strategies for growth. After the lecture and workshops, students from Nykoebing in Denmark, wrote:

First of all, we would like to thank BSP for a great science camp. It has been a fantastic experience, where we learned a lot of biology in many different ways. We - Camilla, Henna and Josefine - would like to highlight a workshop that all of us managed to get on our program. This was a hands-on workshop and the teacher was Kamilla Sfugier. At the workshop we learned a lot and we agreed that it was a most interesting lesson we had.

A summary of their experiences:
Phytoplankton compositions and different Baltic Sea living conditions
The part about phytoplankton, was separated into two parts: one where Kamilla taught us about the background information and one where we created a “phytoplankton model”. This model showed us in practice the different adoptions used to slow the sinking of plankton.

Kamilla told us that the plankton must avoid sinking because it needs sunlight for photosynthesis. Therefore,

Figure 14.5
Students with watersamples at Camp Kappeln. Laboratories at Klaus Harms Secundary School. Instructor from Institute of Oceanology, Sopot Poland

Figure 14.6
Eelgrass and invertebrates in the sample

Figure 14.7
Ole Mark from The Danish Institute of Water Hydrology (DHI) shows result of sea level rise caused by climate change. Camp Mols 2011

the plankton needs to be in a zone called “the photic zone” which is in the top 100 meters of the ocean, where the light of the sun reaches down. Our job was to create a type of plankton that did neither sink to the bottom nor flow on top of the water. Our teacher lined up different materials that we could use. For example: paperclips, modeling wax, potatoes, cord, spoons, erasers and tape. At the end of the lesson, one model from each group was tested in a tank full of salt water. It was a very funny learning experiment. It was not easy to “rebuilt” natures finest constructions.

SIZES OF MUSSELS AND DIFFERENT LIVING CONDITIONS IN THE BALTIC SEA

Then followed a presentation about the unique environment of the Baltic Sea and the reason for the low biodiversity, which is primarily due to the huge variation in salinity found here. This variation creates a stressful environment for many organisms as the salinity of the surrounding environment is very important for the survival of the organisms.
Salt exists in water as sodium ion and chloride ion. Charged ions like sodium ions and chloride ions are unable to pass through most biological membranes. The salinity gradient across such membranes can therefore only be regulated through active pumping of ions or passive transport of water called osmosis. It is dificult for marine species to regulate the content of water in their cells. It is this type of stress which is manifested in the limited body sizes of mussels.

Osmosis regulation in Marine Organisms

We made a model experiment with potatoes, where we examined what happened to a piece of potato in a hypo-, a hyper- and an isotonic solution.

We used three beakers with three different types of water.

1. One beaker filled with de-ionized water - the hypotonic solution.
2. One beaker filled with tap water - the isotonic solution.
3. One beaker filled with tap water and two teaspoons of salt - the hypertonic solution.

We checked the weight of each potato before the experiment, and then waited approximately 20-30 minutes to complete the experiment. Once time was up, we took the potatoes out of the beakers and checked the new weight. We recorded the data:

1. The beaker with the potato of the hypotonic solution had gained weight.
2. Nothing had happened with the isotonic solution, the weight of the potato was the same as in the beginning.
3. The potato with the hypertonic solution had lost weight.

The explanation comes from the fact that ions of sodium and chloride cannot pass the membranes of the potato. But water can, and this is why, the potato in beaker no. 1 gained weight: water had passed into the potato by osmosis. The ionic balance between the potato and the tap water in beaker no. 2 gave no reason for a change in the weight of the potato as the water was approximately isotonic to the potato. For the potato in beaker no. 3, water has passed out of the potato, and accordingly it had lost weight.
By this simple “hands on” experiment the theory of salinity stress – the osmosis regulation - was made visible to show how the marine living conditions in the Baltic Sea can be stressful.

A GIRL STUDENT FROM KLAUS HARMS SCHULE IN KAPPELN STATED:

The researchers tried to make their presentations easy to understand and they succeeded. I could understand them very easily. The presentation and the experiment about the salinity in the Baltic Sea from Dr. Sven Hille was the most interesting presentation for me. The growth of micro eco-system in the Schlei was a very interesting workshop too. It was amazing to see how many different species live in the Schlei and how many of them we found under the microscope. It was very interesting how many micro organisms grew in a short time on a simple plate the researchers had put in the water of the Schlei some weeks before the camp started.
One of the highlights of this project was the trip on the Schlei on a boat from the IOW Rostock Warnemünde. During this trip we experienced how the theoretical things, we learned in the workshops e.g. like measuring the Secchie depth or measuring the surface or bottom salinity in the Baltic Sea can be used in practice.

Secchie depth is a rather simple way of measuring the transparency of the water in question. Measurements are made on the site by lowering a special prepared disk down in the water, recording the depth where the disk is no longer visible from above. A small Secchie depth means that the water contains many planktonic organisms as well as much organic and inorganic matter. A larger depth means the opposite.

HOW TO GET SCIENTISTS INVOLVED IN STUDENT SCIENCE CAMPS?

Once a camp is planned and the science focus is settled, organizers can contact universities and other institutions of interest. Sometimes it is just a matter of coordinating calendars. Scientists are busy! If they have time, most are more than eager to share their latest work, and in BSP we have the most positive experience from the dialogues with scientists. Some even have obligations to present their results outside the universities, and this can be one way in which both parties can gain from this cooperation.

OUT OF SCHOOL ACTIVITIES

Finally out-of-school-activities should be mentioned, because these serve as strongly inspiring informal ways of learning. The list of existing school services offered by Universities and a varied number of Educational Science Centers, aiming to make science adventurous and interactive, can serve as inspiration to further search for local options.

Examples of universities offering science lectures and special school services

- IOW-Warnemünde, Leibniz Institute for Baltic Sea Research, Rostock:
  www.io-warnemuende.de/
  learn-about-the-sea.html

- National centers for research in science education (Denmark):
  nvhus.dk/house-of-natural-sciences.aspx
  nts-centeret.dk/eu/

- University of Copenhagen
  www.skoletjenesten.dk/Grundskolen/
  Naturvidenskab/LIFE

Most universities have this kind of school offer programmes.

Science centers with an educational, interactive profile

Denmark: www.universe.dk
Estonia: www.ahhaa.ee
Finland: www.heureka.fi
Germany: www.phaenomenta.com
Latvia: www.zinoo.lv
Lithuania: www.muziejus.lt
Poland: www.experyment.gdynia.pl
Sweden: www.vetenskapenshus.se
Russia: www.sciencecenterofpinellas.org/eic/

Only **one example** from each of the 9 BSP countries, recorded in 2014, is mentioned here – a lot more can be found on the web page: **www.ecsite.eu/members/directory**. Search for the country of interest in order to find a list of the science park network "**ECSITE** ".
Still, many more educational science parks can be found, which are not members of this network. The list, pages and links is furthermore constant developing, so do not exclude yourself from the newest options. Use local BSP contacts – they will know more.

BY LYDIA NICOLLET

15. From awareness-raising to engagement

The example of the European Project “Let’s Take Care of the Planet”

Learning is great and learning with a critical and scientific approach even better - but sometimes not enough to change behaviors and reach transformative action. This explains partly the reciprocal motivation and interest of the Baltic Sea Project (BSP) and the Let’s Take Care of the Planet (LTCP) project to work together: LTCP has been learning from the BSP’s scientific approach, and BSP has been learning from the LTCP’s engaging approach.
LTCP is a European project on Education for Sustainable Development (ESD) towards a young public, born in 2009, carried out in Europe by the French NGO Monde Pluriel. It invites the youth to enquire, debate and engage themselves in social and environmental issues and actions. Since 2012, the BSP network has been participating in LTCP with the participation of schools from five BSP countries. Both projects have a common interest in the sharing of school networks and in providing the youth with a complex approach of ESD issues with geographical diversity and both a local and global vision.

1: A FOCUS ON THE LTCP PROJECT

General framework

The European Project Let’s Take Care of the Planet proposes to exchange experiences and realities between the youth in different regions of Europe, to let them participate actively in debates on social and environmental issues and to select and implement concrete local actions.

The LTCP project was born out of the initiative of the Brazilian Ministry of Education, which organised the first **International Conference of Children and Youth,** in June 2010 in Brazil, with 47 participating countries, on the themes of “responsibility and environment”. One of the productions in Brazil was the writing of an International Youth Charter of Responsibilities, which became a reference document widely used as a medium to debate and give visibility to the youth voice.

The European Let’s Take Care of the Planet project is part of the continuity of this process. Two years after the International Conference, a European Conference was organised in Brussels in May 2012. It brought together youth delegates from 15 European countries and was the culmination of the ESD projects carried out by young people locally.

The two main objectives are to encourage intercultural dialogue between young people on SD issues, allowing to better understand their complexity and to enhance the capacity of our youth for action and commitment in order to move towards sustainable societies. It prepares them to debate socially important issues in such a way that they can take a stance in an enlightened way and implement considered actions.

SHARING NETWORKS TOWARDS A “GLOCAL” APPROACH

In May 2012, about 20 schools from the Baltic Sea Project participated in LTCP. Young delegates from

Denmark, Poland, Russia, Lithuania and Sweden were elected to participate and represent their country at the first European Youth Conference in Brussels, at the Committee of the Regions. The issues treated by the students from the Baltic region, by integrating this international project, could be shared with young people from other regions of Europe, and in the same way, the issues existing in other regions were discussed with the young people living near the Baltic, starting from each students local reality.

During all these stages going from the local to the global and coming back to the local, the young participants not only embrace diversity and interculturality, but they also realise how society is a web of life, requiring equilibrium, and feel stronger realizing that there is a whole community of engaged young people.

2: FROM LEARNING TO TRANSFORMING

Transformative action requires a real consciousness not only of the issues but also of the capacity of each individual to be active in the change. Beyond awareness-raising and scientific experimentation, a big challenge with the young people is to involve them in their schools and community as active citizen, to make them feel concerned about the issues so that they commit themselves into actions for concrete change towards sustainable societies. This is the main purpose of the LTCP project.

METHODOLOGY TOWARDS ENGAGEMENT

LTCP proposes a method to develop activities with young people trying to involve them in concrete actions, led by their conscience and motivation. Here are the main steps to reach this objective:

- **Inciting the youth to have a critical mind and form their own opinion** on society and environmental issues is a key stage to reach transformative behaviors. It requires both learning with a scientific approach (enquiring, making diagnosis, scientific experimentation), having a transversal approach to understand the complexity of the issues (exchanging with professionals from the scientific, political, business sectors) and experimenting a democratic participation (debating, electing delegates).

- **Debating on priorities**
  Through the debate, the youth will reach a consensus on the responsibilities they feel ready to assume. This moment is essential in the process since it enables the young people to move from the role of learner to instigator. Before launching the debate, the youth first have to identify one or more issues to be put into debate and prioritized. Each participant is invited to express their own view and argue based on knowledge and personal experience. The notion of responsibility with the youth is essential here (see part 3 below:
  “Introducing the notion of responsibility"), considering two prerequisites: feeling responsible does not mean feeling “guilty about” and the level of responsibility is proportional to one’s knowledge and power. Several approaches to facilitate the debate are possible. If no consensus naturally emerges, the facilitator must list the various proposals and can organize a vote to select them.

- **What actions can I take to face this priority?**
  The selected priorities then become the youth responsibilities, which must be issues they fell concerned about as actors for a change. The participants then propose actions they will implement, with their knowledge and at their level of power, responding to these responsibilities in concrete terms. To be sure these actions can be implemented, they should be able to answer these questions: where, how and when will we implement the action? To formulate and select the actions, the world Café (http://www.theworldcafe.com/) is an excellent facilitation method.

- **Following the implementation of actions**
  The students by participating in LTCP projects should follow the development from the start to the launching of the action and its implementation at the local level, assuming collectively and individually the responsibility they selected. To reach this objective it is necessary to have in each school a motivated team of teachers and staff involved in the project.

- **Passing on the torch to allow for further project development**
  The students will at the end of the school-year change

classes or leave the school but the projects and the actions must have a continuity to have a stronger impact. So before the end of the year, the students could plan a moment to pass on the torch to younger students. The creation of clubs concerning the environment in the school is also a good solution to give continuity to the school projects.

- **Evaluation**
  Evaluation is an important stage in the project: to assess the project quality, impact on the youth, understanding of the main issues and concepts, quality of exchanges. Hence the importance of maintaining contacts with the students for several years if possible.

ENGAGEMENT BY CONCRETE ACTION: ILLUSTRATIONS

After Learning, understanding, feeling concerned about it is now time for engagement, meaning commitment into concrete action. Here are some examples of what have been or can be implemented within the project.

LTCP translated into actions since 2009: the example of the Basque Country, Spain

Since 2009, the project has enabled the implementation of a large number of actions at different levels:
In middle schools and high schools: young people have created gardens, reintroduced native plants into green spaces, organised waste sorting, fitted pressure reduction valves on taps, reduced paper consumption, organised actions to raise the awareness of their families and schoolmates, created protocols for the welcoming of migrants and protocols for communication to address situations of conflict in community life.
At the local level (municipality), the young people have organized river and forest clean up sessions, they have launched campaigns for sustainable mobility, for the promotion of local consumption and of fair trade, they have held clothes collections for disadvantaged people, they have launched barter markets for development NGOs, and they collaborated with retirement homes and NGOs. They also presented their engagements to the local authorities.
At the regional level, several schools have organised a "school Agenda 21" day in other institutions to raise awareness; many young people have visited natural parks and discovered their local and regional culture. They presented the Charter of Responsibilities to young people, the European Open Letter (co-written by LTCP delegates in 2010 and 2012), and their own commitments and proposals to the regional and local authorities. Finally, these texts have become reference documents useful for distribution and debate.

COMMUNICATIVE ACTIONS AND FIELD ACTIONS

Two types of action can be distinguished, both being important for change: communication actions (posters, video, articles, collective documents, diffusion in the schools, families, local communities, social media, debate with elected representatives) and practical actions in the field, at local level (transforming each one's local reality beyond individual eco-gesture). Ideally, the young participants should not limit their activities to communication action, but also implement practical action on the issue, expecting a concrete result.

Examples of field actions

Reducing energy consumption to limit Climate change

Imagine a group working on climate change issues at the level of their community (home, school, city, region). The group, after making research and identifying the problems related to this topic in its school and its community, observes that reducing energy consumption is an answer to the problem of CO2 emission. And that, among the possibilities of energy reduction, there is no real existing policy to reduce energy consumption in their school. The group then defines one responsibility and related actions.
Responsibility: Committing ourselves to daily reduction of the school energy consumption, individually and collectively.
Actions:
- Completing an energy diagnosis of the school in collaboration with a specialized organization
- Setting up the corresponding corrective measures, i.e.: eco-citizens rules at the school (paper sorting, reduction of light, heating, electricity consumption in general), reflection on the origin of the lunch food proposed at school, improvement of the access conditions of the

bicycles and public transportation to the school, etc.
How: meetings with the head of school, its bursar and the local authorities (especially for the transportation question), contacting an organization specialized in energy diagnosis, awareness-raising campaigns in the school and community (papers, polls, surveys, exhibitions), etc.
Where: In the school with a link to the local community.
Source: Step by Step guide, 2009, LTCP International Conference Brazil

Example of a responsibility and actions on food
Imagine now a group working on the food issue. After enquiring and identifying the problems related to this topic in its school and its community, the group notes that more sustainable food management involves action on production, distribution, consumption and waste management (food and packaging waste). Not being able to take action directly on production and distribution, the students decide to take on the responsibility of contributing to improving the operation of the canteen of the school at their level. They will express this responsibility in this way: individually and collectively committing ourselves to contributing to establishing a sustainable management of the canteen in the school. They decide to implement several actions along these lines:
- Challenging the board of administration and the administrator on the choice of products distributed in the canteen (origin, environmental and social quality and packaging).
- Considering with the canteen staff the amount of waste generated and whether this is due to the organization of the service, to the quality of the food, to the behavior of the students, etc.
- Raising the awareness of their schoolmates about wastage and the sorting of waste.

Source: Step by Step guide, 2011, LTCP European Conference, Belgium

Let's plant trees in our village against deforestation (Bazaleti public school, Kharagauli, Georgia)
Pedagogical objectives: gaining awareness of the impact of deforestation at local level (lack of water in particular). Learning why, when, where and how to plant and take care of trees. Reducing consequences of deforestation.
Description of the action: A class participated in workshops on the issues of deforestation in order to identify the problems and the solutions to be provided. They collectively decided to plant trees in response to the issue of deforestation. The students spoke to the mayor of the village who supplied the plants.
Results: The trees were planted in the surroundings of the school, a debate between the young citizens and the local elected representatives took place, bringing collaboration.
Source: Step by Step guide, 2011, LTCP European Conference, Belgium

Let's save the world by producing Black Gold (Fen Bilimleri High School – Istanbul, Turkey)
Objectives of the action: To reduce the city's carbon emissions and waste management related costs by recycling organic waste and to raise awareness about the recycling of organic waste using composts.
Who: Environment club in conjunction with the teachers, the Ministry of Education, the municipality, the residents, the families and other educational institutions.
Description of the action: Cooperation with two municipalities, one of 450,000 residents and the other of 40,000 residents, the Şişli Science Center, 10 schools and two NGOs. Collection and recycling of organic waste from canteens in the gardens of educational institutions. Installation, distribution and management of a vermicomposter in the schools.
Source: Step by Step guide, 2011, LTCP European Conference, Belgium

EXAMPLES OF COMMUNICATIVE ACTIONS

- **Putting the youth voice into words and giving view to their engagement**
  The participants can write a reference document: this excellent collective exercise will result in an official text aiming at communicating and giving a voice to the opinion of the youth to the public. It can establish commitments and question the addressees. Participants can write a **manifesto, an open letter, a call for co-responsibility or a charter of responsibilities.**
  The workshop can include a session of brainstorming on the objectives, the structure of the document,

its use and the target audience. Groups of participants can then work on different parts of the text. The young people can present the responsibilities and actions they are engaged in. As an example, the Open Letter to Decision Makers drafted during the European Conference in May 2012, is available here: http://confint-europe.net/?navlang=en. The youth flash-mob played at the European Parliament Square in Brussels, one of the means of distributing the Open Letter, can be seen here: http://www.youtube.com/watch?v=w72E-i-Tgxw. This document was remitted to European elected representatives, a very strong moment for the young participants, who really felt engaged citizen with a message to say. The youth, once back in their city, remitted the document to their local representatives, the open letter then became a pretext for a debate between the younger generations and the politicians.

- **Creating and distributing educommunication tools**
  The participants can shape their messages in different ways in order to communicate it. They can create posters by drawing, painting, use of photos, writing, etc. even produce a radio or television program. They can write and edit articles on a blog or other related media. These tools can be distributed in an event, an exhibition in the school and/or the city. They can also be shared with other participant schools from Europe via an internet exchange platform.

- **Dialogue with the elected representatives**
  Dialogue between youth and locally (or regionally) elected representatives allows for the exchange between different instigators of the territory and for the confrontation of different points of view. This opens the school to the surrounding society towards a co-construction involving various actors (youth, teachers, schools technicians, local authorities). With such dialogues, the students can learn about the local policies, promote their voice and engagement, and even find support. The meetings may take place either in the school or at the headquarters of the concerned local authority.
  The contents of the exchanges may be: presentation by the elected person of the SD policy in the territory, presentation by the students of their project, and the relevant action if already selected, discussions on a diagnosis of the problem, proposals of actions (relevance, feasibility, competences required, collaboration) and a follow up and evaluation of the actions (second session). Such dialogues will be useful only if the invited elected representatives are open to a real dialogue with the young people, meaning that it is not only done as a part of a communication strategy.

3: INTRODUCING THE NOTION OF RESPONSIBILITY: A PEDAGOGICAL CHALLENGE

After considering the Let's Take Care of the Planet method and presenting examples of actions that illustrate the young people's engagement, let us analyze a key concept in the project approach: responsibility.

The difference between responsibility and action

A responsibility consists in raising awareness on a problem or an issue that may arise on a general commitment, a principle one believes in, an individual or collective decision. An action is more concrete, more specific. It answers the question "how will I implement these responsibilities?" Responsibilities and actions should be proportional to the level of power and knowledge of the young people: they should be easily implemented by them.

From awareness to responsibility

If everyone is part of the web of life, everything that we do is important to maintain the global equilibrium. Since we live related to the environment and other people, the responsibilities also become collective. The great challenge for each group will be to assume responsibilities that enhance both the environment and the quality of life in the local community.

But the first challenge to accept the necessity of one's own responsibility is t**o gain awareness of the interdependence** between what I do and the actual living conditions of other human beings (in a nearby or far-off environment), of the impact of my actions on the other side of the planet (concept of space) or on future generations (concept of time).

This reflection must take into account that, although all people have an equal entitlement to human rights, their

responsibility will be proportionate to each one's level of knowledge and power and on his membership of a wider group: the more power and knowledge we have, the more responsibilities we have in return. Everyone must in this way assume their responsibilities in relation to the environment and to other human beings.

And as mentioned in the International Charter of Human Responsibilities «Every human being has the capacity to assume responsibilities. **Each person also has the possibility of linking up with others to forge a collective strength**, which has more influence". (see: http://www.charter-human-responsibilities.net)

However, it is not enough to democratically debate the problems and evoke responsibilities, **we must also think about collectively constructing transformative actions**. This also implies that we assume the direct and indirect consequences of our actions coming from these responsibilities. If waste treatment is a problem in a local community, the inhabitants, along with the local authorities, must set up actions responding to their responsibilities, in order to limit the pollution due to the waste – reducing the quantity of waste or implementing waste sorting. With these opportunities to think and act, we will create new forms of being, living and interacting with a respect for diversity of nature and humanity.

Responsibility, the hidden face of law:
Can we imagine a collective life only based on rights? In a school, but also at the level of the society and the entire planet, do I only have rights? I have the right to move by car, to swim in clean rivers. But who has the duty to guarantee all this? The State and only the State, but this implies the duty to respect rules to life in the society? And myself, do I not have responsibilities here? At the level of a small community, a society and even of the whole planet, **right can exist only if there is at the same time responsibility**. Our responsibility can no longer be confined to a responsibility to our family, our neighborhood or our city. It concerns the whole planet.

Responsibility is based on ethics
One must first of all understand the difference between ethics and moral. In french (mother tongue of the author) moral, which means custom in Latin, is a regulation. It only says what I should do or should not do: you shall not kill, you shall not steal and you shall not put your chewing gum under your table. If you break the rules, you'll be punished. Ethics (from Greek meaning *character*) is something else. It is about our way to agree with, to rely on principles we deeply believe in to guide our choices. If I feel responsible for the protection of the water, I will be attentive about my own behavior, but no one is there to tell me that I have the right to use a given quantity of water per day. It is up to me, in all conscience, to make these decisions. So while moral calls on the fear of being punished, ethics calls on the awareness each of us has about what is desirable to do or not to do. It is up to us to make the choices. Ethics is much more demanding than morality.

Responsibility, interdependence, freedom and power
The idea of responsibility is inseparable from three other ideas: that of **interdependence**, freedom and power. Interdependence: everything that lives on the Earth is part of a great whole. My responsibility is not limited to my classmates, to the people of my city or even the inhabitants of my country. Once I can see interdependence between what I do and the concrete conditions of life at the other end of the Earth, the nature of my responsibility changes. As for space, it extends to the whole planet. As for time, it takes into account the consequences of my actions on future generations and on the Earth's finite resources. The more interdependent we are the more responsibility. If by my daily behavior, I change the climate in 50 years, I assume my responsibilities towards future generations and the planet. From there the beautiful words from the 1992 Earth Summit:

"We do not own the Earth, we borrow it from our children".

We need to take responsibility for the impact of our actions on the other side of the planet or on future generations. Thus, responsibility and interdependence are intimately related. The same goes for **responsibility and freedom**. If I had no freedom, if the adults, the institutions, the State, told me in detail what I have to do at every moment of my life, then I would have no responsibility. If the consequences of my actions were bad, then the adults, institutions and States would only have themselves to blame. Therefore I have responsibility only because I have freedom.

Lastly, r**esponsibility is inseparable from power**: If what I was doing had impact on nobody, then my responsibility would be microscopic. But if, on the contrary, I am the Mayor of my city, I am head of State, if I run a company, if I am a scholar, then what I do, what I decide will have consequences for millions of people. Each of us has responsibilities, but these are proportional to my level of knowledge and power. The more power I have, the more responsibility I have in return. Arguments like these can be found in the online Ethic and Responsibility network (http://www.ethica-respons.net/) and the text « Et si on Parlait de responsabilité » (Let's talk about responsibility) at http://www.charter-human-responsibilities.net/spip.php?article2136&lang=en) by Pierre Calame, 2010.

Acquiring both scientific knowledge of the reality and of the complexity of the challenges for sustainability, awareness about one's own capacity for action, and ability to make choices based on values, will altogether bring a young person to feel as an active citizen and to be motivated to commit himself or herself for a collective construction of sustainable societies. This is the main purpose of the Let's Take Care of the Planet approach. The notion of responsibility - a key notion today, has its rightful place at the core of the LTCP project as a means of inciting young people to think about their own role in today's big social and environmental challenges.

Figure 15.1
Website of Monde Pluriel. Meeting for coordinators of “Let,s take care of the Planet” Lyon 2013

Figure 15.2
Working with common statements in the workshop. Camp Mols 2011


SOLIDARITY
Create social connections between people of all ages in local and international communities
Web debates for solving problems and communities


Festival of Europe
Feest van Europa
Europäisches Fest
Altiero Spinelli
LET'S
TAKE
CARE OF THE
PLANET

LIST OF CONTRIBUTORS TO LEARNER´S GUIDE NO. 10

Kersti Sögel
Tartu Environmental Center, Estonia, BSP coordinator at the time of writing (the coordinator role has from January 1st 2014 been taken over by Gedy Siimenson, Estonia);
E-mail: kersti.sogel@teec.ee.

Søren Levring
Sønderborg Skolen, BSP coordinator in Denmark and coordinator on LG10;
E-mail: levring@post7.tele.dk

Per Werge
Nykøbing Katedralskole, Denmark;
E-mail: per.werge@gmail.com

Jaan Pärn
Dept. Geography, University of Tartu, Estonia;
E-mail: jaan.parn@ut.ee

Peter Uhl Pedersen
BSP Coast Watch programme coordinator;
E-mail: peter.uhl.pedersen@skolekom.dk

Simo Korpela & Anja Hokajärvi
(Environmental Measurements programme coordinator)
Meri-Pori upper secondary school, Finland;
E-mail: ahokajarvi@gmail.com

Bo Persson
Environmental History programme coordinator, Ekbackeskolan, Sweden;
E-mail: bo.persson@mah.se

Babitch, E. Maiorova, Y.,Shabalina, K., Varakina
Saint Petersburg State Economical University, Russia;
E-mail: stanislavbabitch@mail.ru

Patrycja Wojtkowiak
Liceum X, Gdynia, Poland;
E-mail: patrycjawojtkowiak@o2.pl

Brian Dall Schyth
Editor on LG10, Aarhus Statsgymnasium, Denmark;
E-mail: sc@aasg.dk

Birgitte Bjørn Petersen
Co-editor on LG10; House of Science, Sønderborg;
E-mail: bbbp@mail.dk

Marek Peterson
Walk&Learn;
E-mail: marek.peterson@gmail.com

Sven Hille
Leibniz Institute for Baltic Sea Research Warnemünde;
E-mail: Sven.hille@io-warnemuende.de

Lydia Nicollet
Let's Take Care of the Planet coordinator, Monde Pluriel NGO, France;
E-mail: lydia@infocom21.net

Birgitte Lynch
English grammar corrections to the text; Consulent at VUC Sønderborg;
E-mail: pupsen_1@hotmail.com

Peter Ochsner
General corrections to the text; Egå gymnasium, Denmark;
E-mail: po@egaa-gym.dk

CREDITS – PHOTOS AND DRAWINGS

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Figure 4.5.
Floodplain landforms.
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Figure 4.6.
Stream discharge is measured by determining the discharge in each part of a channel cross section and summing the discharges. Credit: USGS Water Science School.
Source: http://ga.water.usgs.gov/edu/streamflow2.html

Figure 4.7.
Year 10 Kaikorai Valley students using a tape measure and a survey pole to determine the cross sectional area of their local stream in New Zealand. Credit: Kaikorai Valley College.
Source: http://commons.wikimedia.org/wiki/File:Year_10_Kaikorai_Valley_College_students_measuring_the_cross_sectional_area_of_a_transect_across_the_stream_to_determine,_with_velocity_data,_the_flow_rate..JPG. Licensed under Creative Commons Attribution-Share Alike 3.0 Unported http://creativecommons.org/licenses/by-sa/3.0/deed.en

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Staff pole at Möhnesee, Germany. Credit: User Arnoldius.
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U. S. Fish and Wildlife Service workshop using rubber ducks to measure stream velocity. Credit: Gary Peeples, USFWS, www.fws.gov/asheville/.
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Figure 8.4
Lindulovskaya grove
Source: http://terijoki.spb.ru/g2/main.php?g2_itemId=19520

Figure 8.5
Landscape of Stockholm with windmills.
Source: http://sv.wikipedia.org/wiki/Stockholms_v%C3%A4derkvarnar

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Source: http://www.astra-project.org/06_winterstorm_study.html

Figure 8.8.
Erosion of coastal line as a result of economical activity.
Source: http://writtenintherocks.wordpress.com/2012/08/

Figure 8.12
Restraining zone of SOx emissions by 2015.
Source:http://www.seabreezes.co.im/index.php?option=com_content&view=article&id=784:ferries-to-be-hit&catid=27:maritime-log&Itemid=48