WORK PACKAGE 3

Key indicators and response in relation to typology for macrophytes

Detailed workplan

OBJECTIVES

The objectives of WP3 are:

- to determine the factors that regulate macrophyte communities and their temporal stability at local and regional scale
- to determine long-term changes in macrophyte communities in the Baltic Sea area
- to define macrophyte indicators that adequately describe the state of coastal ecosystems
- to define reference conditions for macrophyte communities, i.e. the status of vegetation under 'pristine' conditions, in different areas of the Baltic Sea.

DELIVERABLES

- (No. 3) Quality controlled data sets for macrophytes.
- (No. 15) Small-scale vegetation models.
- (No. 20 & 32) Reference conditions for benthic vegetation. Draft (No. 20) and final version (No. 32).
- (No. 21) Draft of scientific paper relating phytoplankton and macrovegetation to typology (WP 1-3).
- (No. 25) Large-scale vegetation models.
- (No. 26) Draft of 2 scientific papers relating biological indicators and water quality to physical gradients (lead by WP1).
- (No. 29) Draft of 2 scientific papers relating biological indicators and water quality to physical gradients with emphasis on reference conditions (lead by WP1).
- (No. 30) Definition of vegetation indicators.
- (No. 31) Verified typology for vegetation (i.e. identification of the status of vegetation indicators in different type areas).
- (No. 34) Monitoring recommendations for vegetation in the Baltic coastal zone.

HYPOTHESES

We hypothesise that:

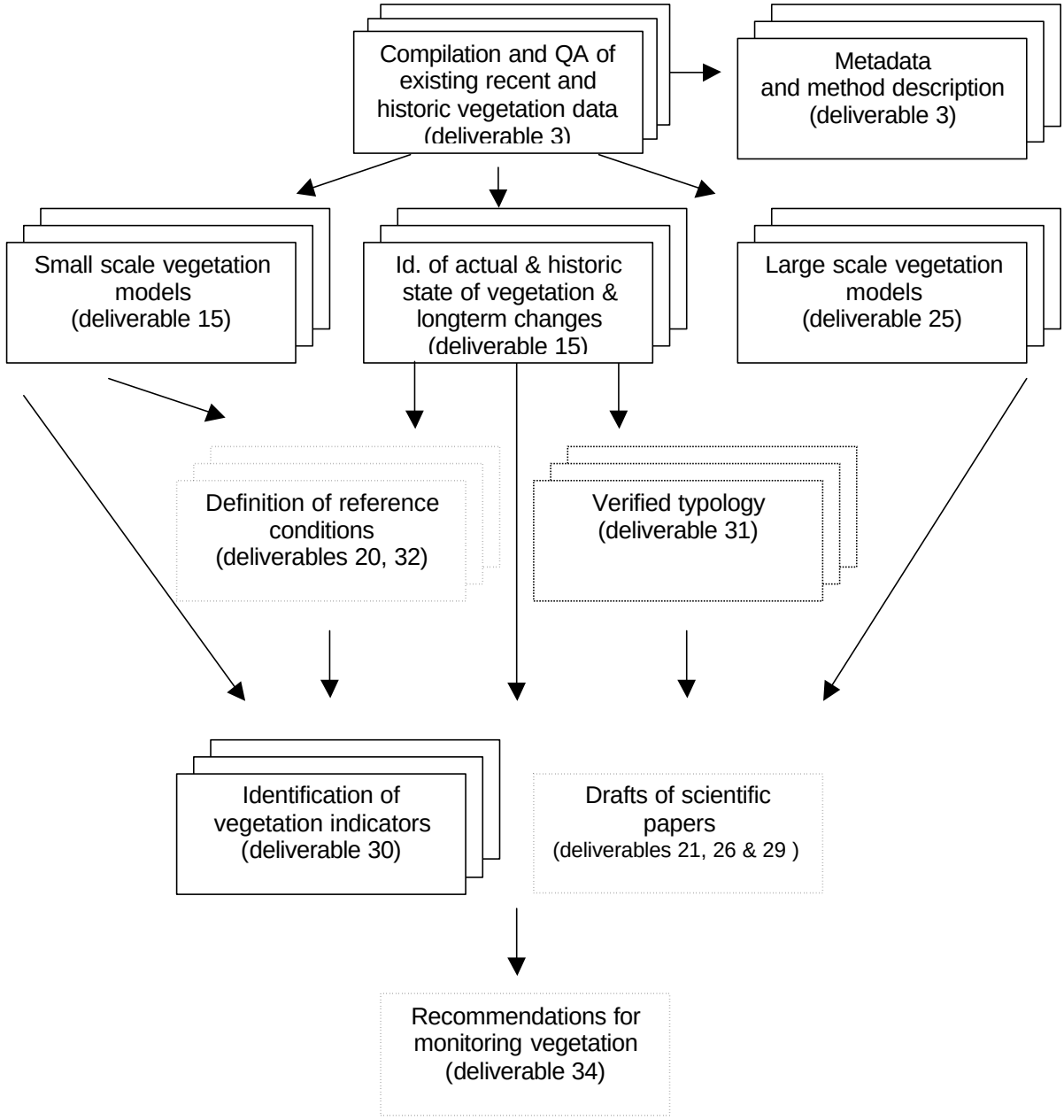
- Water quality, temperature, salinity, insolation, exposure, icecover and geomorphology (substratum, coastal slope) are important regulators of the distribution and abundance of macrophytes.
- The relative importance of the various regulating factors changes with the scale of study. Thus, insolation, temperature, ice-cover and salinity change across large spatial scales and are likely to regulate large-scale patterns of distribution and abundance of macrophytes across the Baltic distribution range. At the local scale, exposure, substratum and coastal

slope change from site to site, and are likely to play an important regulating role together with secondary gradients in water clarity, nutrient concentrations and salinity.

- Short- and long-term changes in distribution and abundance differ among macrophyte species due to differences in susceptibility to changing water quality and differences in colonisation capacity.
- Robust key indicators of vegetation can characterise the ecological state of coastal waters.
- Reference conditions for selected key parameters can be identified based on historical records and/or models relating the key parameters to anthropogenic pressure.

WORKPLAN

We have organised the work as illustrated by the flow diagram below.



Flow diagram of work plan and deliverables for work package 3. More boxes behind each other illustrate that parallel analyses are made by several partners. Dashed lines indicate that the deliverables are part of a larger deliverable.

DETAILED DESCRIPTION OF DELIVERABLES

All CHARM partners are responsible for data compilation, quality assurance and establishment of metadata (Del. 3)– even the partners not actually engaged in WP3. All partners engaged in WP3 are further responsible for the tasks connected with the vegetation in their respective area, i.e. small-scale data analyses, definition of reference conditions, identification of vegetation indicators and definition of typology (Del. 15, 20, 30-32, 34). In addition, some partners are responsible for large-scale analyses of vegetation data (Del. 25) and contributions to drafts of scientific papers (Del. 21, 26 & 29, Table 1). The participating and responsible persons from each institution are indicated in Table 2:

Each partner sends completed inputs to NERI, who is then responsible for compiling the inputs and finalising all deliverables within this work package.

Table 1. Responsibility of each partner in the various deliverables.

	NERI (1)	FEI (2)	AAU (3)	CORPI (5)	IOW (6)	EMI (7)	IAE (8)	SUSE (9)	MIR (10)	EMAUG (11)
person-months per partner:	24	11	8	3		9	4		4	15
Deliverable 3										
- Data compilation	X	X	X	X	X	X	X	X	X	X
- Quality assurrance	X	X	X	X	X	X	X	X	X	X
- Metadata	X	X	X	X	X	X	X	X	X	X
- Evaluation of comparability	X									
Deliverable 15										
- Small scale veg. models	X	X	X	X		X	X			X
- Actual and historic state	X	X	X	X		X	X			X
Deliverable 20										
- Reference conditions	X	X	X	X		X	X			X
Deliverable 21										
- Draft of paper	X	X	X			X				X
Deliverable 25										
- Large-scale models	X	X	X			X				X
Deliverable 26										
- Draft of paper	X	X	X			X				X
Deliverable 29										
- Draft of paper	X	X	X			X				X
Deliverable 30										
- Id. of indicators	X	X	X	X		X	X			X
Deliverable 31										
- Verified typology	X	X	X	X		X	X			X
Deliverable 32										
- Verified reference con.	X	X	X	X		X	X			X
Deliverable 34										
- Recommendations	X	X	X	X		X	X			X

The deadlines of deliverables are indicated in Table 3. The *internal deadline* is the deadline for the partners to send input to the WP-responsible (Dorte Krause-Jensen), *PL-deadline* is the deadline for the WP-responsible to send the deliverable to the project leader (Trine Christiansen) and the *EU deadline* is the deadline for the project leader to send the deliverable to EU.

Table 2. Persons from each institution participating and/or responsible for work in WP3.

Institution	Person	Participant	Responsible
NERI	Dorte Krause-Jensen	X	X
	Kurt Nielsen	X	
FEI	Saara Bäck	X	X
	Ari Ruuskanen	X	X
AAU	Erik Bonsdorff	X	X
CORPI	Sergei Olenin	X	X
	Darius Daunys	X	
IOW	Gerald Schernewski	X	X
EMI	Georg Martin	X	
	Kaire Torn	X	X
IAE	Andris Andrusaitis	X	X
SUSE	Sif Johansson	X	X
MIR	Jan Warzocha	X	X
EMAUG	Hendrik Schubert	X	X
	Sigrid Sagert	X	

Table3. Deadline for deliverables

	Internal deadline	PL-deadline	EU-deadline
Deliverable 3	15. Apr-02	15. May-02	01. June-02
- Datacompilation & QA			
- Metadata			
Deliverable 15	01. July-03	15. July-03	01. Aug-03
- Small scale veg. models			
- Actual and historic state			
Deliverable 20	01. Nov-03	15. Nov-03	01. Dec-03
- Reference conditions			
Deliverable 21	01. Nov-03	15. Nov-03	01. Dec-03
- Draft of paper			
Deliverable 25	01. May-04	15. May-04	01. June-04
- Large-scale veg. models			
Deliverable 26	01. May-04	15. May-04	01. June-04
- Draft of paper			
Deliverable 29	01. Nov-04	15. Nov-04	01. Dec-04
- Draft of paper			
Deliverable 30	01. Nov-04	15. Nov-04	01. Dec-04
- Id. of veg. indicators			
Deliverable 31	01. Nov-04	15. Nov-04	01. Dec-04
- Verified typology			
Deliverable 32	01. Nov-04	15. Nov-04	01. Dec-04
- Verified reference con.			
Deliverable 34	01. Nov-04	15. Nov-04	01. Dec-04
- Recommendations			

A detailed description of each deliverable follows below:

Deliverable 3: "Quality controlled data sets for macrophytes"
Nature of deliverable: The deliverable is a short report (Da) with a summary of main findings, methods and data. The report will contain the metadata and information on methods and quality assurance supplied by each partner. The level of comparability of data will be summarised by the task manager.

The deliverable contains the following tasks:

- *Compilation of data and construction of metadata:* Each partner compiles recent and historic data on macrophytes and coupled physico-chemical parameters from local areas of the Baltic Sea.

  The relevant vegetation parameters and physico-chemical parameters are defined in the 'data-compilation template' (see excel-file: template.xls) and in the metadata-template (Appendix 1).

  For small-and large scale vegetation analyses it is important that vegetation data and physico-chemical data are linked at the finest possible scale, i.e. preferably at station-level. As a consequence, if physico-chemical conditions are measured near the vegetation station, the station id. for the physico-chemical data should be indicated. For each dataset it should also be indicated which area (like estuary or embayment) the dataset belongs to (see Appendix 1 and the excel-file: template.xls).

  Each partner makes the local vegetation data and coupled physico-chemical data be available electronically. The compiled data should be organised in spread sheets using columns as defined by the 'data-compilation template' (excel-file: template.xls).

  All compiled data should be matched by a metadata description using the metadata template (Appendix 1). Preferably all compiled data should be available electronically, but if some material is available only in printed form, this material should still be included in the metadata description with the notification that the data are available only on print.

- *Quality assurrance:* Each partner takes the following steps in quality assurrance of local vegetation data:
  - Ensures that the nomenclature of macroalgal species follows Nielsen et al. (1995)[1].The nomenclature of marine angiosperms should also follow specified guidelines. For seagrasses, the latest taxonomic guide is by Kuo & Den Hartog (2001)[2].
  - Ensures that the selected data are of acceptable quality for local analyses. Thus, metadata sheets and worksheets with compiled data should be made only for data of acceptable quality.
  - Checks whether documentation and intercalibration of the methods exist

- *Metadata:* Each partner produces metadata, i.e. overview of the quality assured data regarding species, sites, sampling periods, frequency, vegetation parameters, chemical parameters and physical parameters as specified by the enclosed template (Appendix 1). The metadata allow an easy overview of the parameters available for analyses at local and regional scales.

  The metadata should be followed by a short description of sampling methods/ experimental methods used in the compiled data set and by information on the level quality assurance.

  Also, available information on local vegetation indicators already in use is most welcome. Such information can inspire the further analyses.

[1] Nielsen, R., Christiansen, Aa., Mathiesen, L. & Mathiesen, H. (1995) "Distributional index of the benthic macroalgae of the Baltic Sea area". Acta Botanica Fennica 155:1-51.

[2] Kuo, J. & Den Hartog, C. (2001) "Seagrass taxonomy and Identification key". Chapter 2 in Short, F.T. & Coles, R.G. (Eds.). Global Seagrass Research Methods. Elsevier.

- *Evaluation of comparability:* Based on the metadata, the workpackage responsible evaluates which vegetation parameters and physico-chemical parameters are available to allow a series of comparable small-scale analyses and which data sets allow large scale analyses. The evaluation includes:
  - Taxonomic level of comparability e.g. species / genus/ functional groups
  - Comparability of vegetation parameters: e.g. presence/ absence, cover, biomass
  - Comparability of physico-chemical parameter
  - Temporal and spatial scale of comparability

  The success of WP3 depends on the quality and comparability of existing data. Macrophyte data are likely to be most comparable at the local scale while differences in methods, intensity, scale and extension of sampling may cause difficulties in performing comparative studies with historical data and large scale data analyses. In large-scale analyses and in comparisons with historic data, it might therefore be necessary to use a lower level of detail, e.g. compare relative importance of functional groups and common, well-documented key species instead of doing comparisons at species level.

  Another crucial point can be to obtain reliable relationships between macrophyte characteristics and environmental factors. These analyses require that there are available physico-chemical data representing the stations where vegetation surveys are performed. While recent data often include these aspects, early studies rarely do. We may therefore need to use indirect data (e.g. increase in use of fertilizers during the last 50 years) to suggest the cause of long-term changes.

  The evaluation leads to a priority list of parameters to analyse at small and large scales (Deliverables 15 and 25). Based on the considerations above, it is likely that there may be 2 types of comparable data sets:
  - Detailed datasets from few areas (for local data analysis).
  - Coarse data sets from many areas (for regional data analysis or for evaluating long term changes).

Deliverable 15: "Small-scale vegetation models"
Nature of deliverable: The deliverable is a method development (Me). NERI compiles the report based on completed inputs from each working group (see Table 4) on methods, results and discussion regarding historic versus present state of the vegetation and small-scale models.

Aim
- Identify present and historic state of the vegetation and evaluate longterm changes
- Establish models that explain and predict changes in the vegetation based on changes in physicochemnical factors. The models should focus on individual areas of the Baltic Sea (i.e. small spatial scale).

All analyses should be based on selected quality elements on vegetation (Table 4). The work on each parameter is done in working groups that each have a responsible person (Table 4).

Identification of present and historical state of the vegetation and evaluation of longterm changes

Task 1. Selection of potential quality elements for vegetation

This task was completed during the meeting in the vegetation group 3rd-4th September 2002 (see minutes of meeting). The selected quality elements are shown in Table 4.

Table 4. Selected quality elements, the habitats they refer to and the working group taking care of the work to be done. The term "depth distribution" includes: "the depth limit of the deepest individuals", "the depth of maximum abundance"; in addition for Fucus "the depth limit of the continuous Fucus belt" and for eelgrass "the depth limit of meadows". The quality elements in paranthesis are of secondary priority. The responsible person within each working group is underlined.

Quality element	Habitats	Working group
Depth distribution of *Fucus vesiculosus*	Hard substrates	Kaire, Ari, Georg, Dorte
Depth distribution of total algal community	Hard substrates	Kaire, Ari, Georg, Dorte
Depth distribution of *Furcellaria lumbricalis*	Hard substrates	Georg
Depth distribution of *Zostera marina*	Soft/sandy substrates	Dorte, Christoffer
Annual/perennial macroalgae	Hard/soft substrates	Georg
(Filamentous algae/*Zostera marina)*	Soft/sandy substrates	Dorte, Christoffer
Sensitive species e.g. Charophytes	Sheltered bays with soft bottom	Kaire, Georg
Area cover and bed structure of *Zostera marina* as input to typology (and as possible quality element in protected areas)	Protected areas	Dorte, Christoffer
Associated fauna -eelgrass	Soft/sandy substrates	Christoffer

Task 2. Generate templates for compilation of data on each vegetation parameter and associated physico-chemical factors.
The working group for each parameter decides on the content and structure of the template. In order to make the analyses more comparable and minimise the work spent on compilation, the templates for the various quality elements should be as parallel as possible:

General comments for all templates:

- Information on areas should include
  - Name of district (e.g. "Arkona Sea - South", "Gulf of Finland")
    We can use the division of the sea into 22 districts as agreed in the WG no. 21 (see Nielsen, R. Kristiansen Aa, Mathiesen, L & Mathiesen, H. 1995. Distributional index of the benthic macroalgae of the Baltic Sea area. Acta Botanica Fennica 155: 1-51.)
    - Name of water body (e.g. "Mecklenburger Bucht", "Tvärminne Archipelago")
    - Site id.
    - Information on water body types should be added later on when the typology workpackage has generated this information
- Information on physicochemistry
  - Water chemistry data as summer means
  - Exposure (when needed). Based on fetch in various directions. Details are still to be identified.

Comments on templates for specific quality elements:

- *Depth distribution of Fucus vesiculosus, total algal community, Furcellaria lumbricalis*: These templates should all follow the same structure. The templates for depth distribution of *Fucus vesiculosus*, the total algal community and *Zostera marina* have already been generated, sent to all partners to be completed and in many cases the completed templates have been returned. A template on depth distribution of *Furcellaria lumbricalis* need to be generated following the same structure.
- *Ratio between annual and perennial macroalgae*: A template need to be generated.

- *Ratio between filamentous macroalgae and Zostera marina:* No general template on these data will be generated. This quality element may be tested on Danish data that contain some information on cover of *Zostera marina* and filamentous algae from the same sites.
- *Sensitive species, e.g. Charophytes:* There already is an international group working on Charophyte data from the Baltic Sea. This group has almost finalised their work and will present the results in a book (draft available in late 2002). We learn from these results before we initiate a possible further compilation of Baltic Charophyte data.
- *Area cover and bed structure of Zostera marina:* the vegetation metadata (deliverable 3) show that data on area distribution of *Zostera marina* exist only from Finland and Denmark and in one reference (Labanauskas 2000) from Lithuania. Some of the data have already been compiled and analysed (Boström et al. in press). There is no need for a specific template.
- *Associated fauna:* Finland has large data sets already available for these analysis. Christoffer checks whether is possible to obtain more data from other countries and evaluates whether it's necessary to generate a template.

Timing:

- Send drafts of the remaining templates ("Ratio between annual and perennial macroalgae", "Depth distribution of Furcellaria", "Associated fauna?") to Dorte by October 1st 2002.
- Dorte coordinates the templates in agreement with the groups and sends the request for all data by November 1st 2002
- All partners send completed templates with compiled data to Dorte by January 1st 2003

Task 2. Identify present - and historic state (when info is available) of the quality elements.
Based on the compiled data, present and historic levels of each of the possible quality elements is identified. The results can be presented as illustrated in Figure 1 and 2.

Task 3: Evaluation of long-term changes in vegetation
Long-term changes in each vegetation quality element is evaluated based on comparisons of historic versus present state of the quality elements.

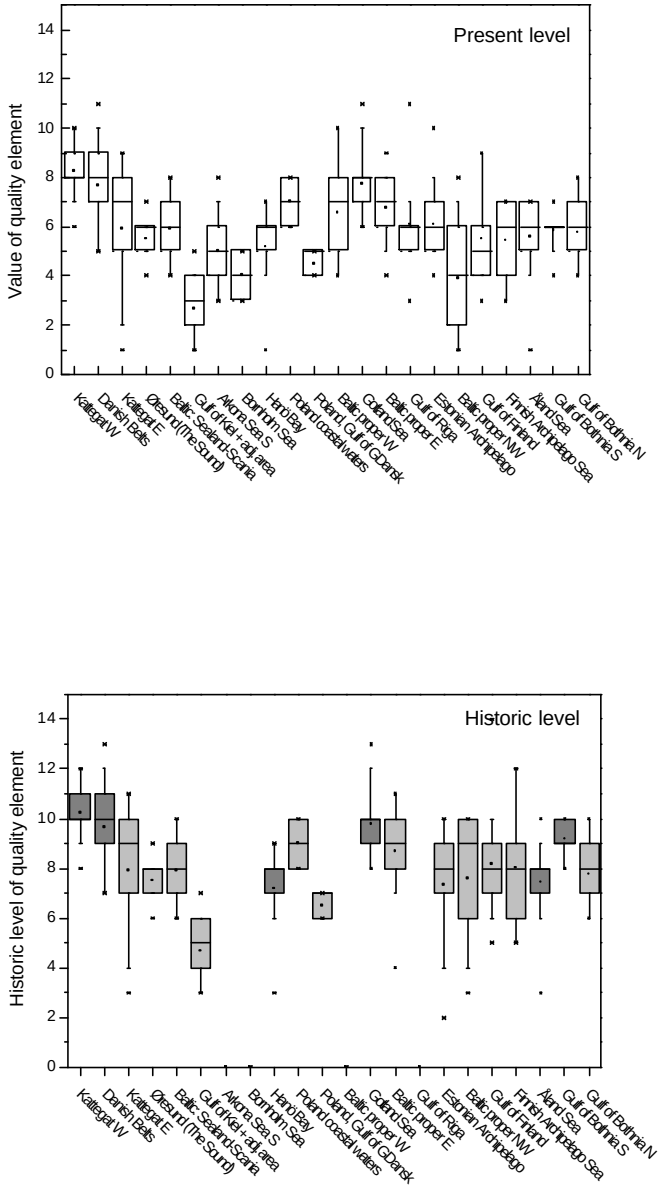


Figure 1. Present (1900-2002, upper panel) and historic levels (1900: dark gray; 1940-60: medium gray, 1960-70: pale grey, lower panel) of quality element X. Circles represent mean values of the quality element, lines represent medians, boxes represent 25-75% percentiles, and whiskers represent 10-90% percentiles of the variation among observations within a given district. Each quality element will vary considerably within a given district - the illustration serves to show possible spatial and temporal gradients in the quality elements.

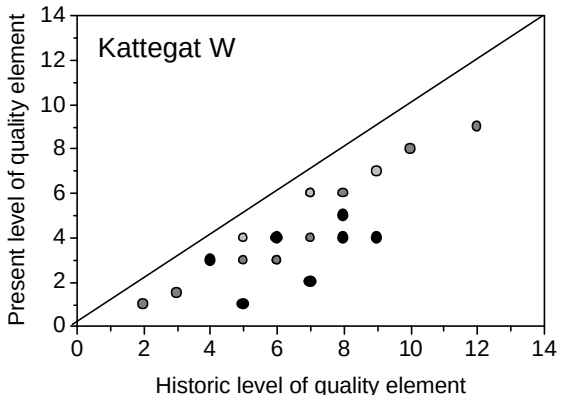


Figure 2. Present versus historic levels of quality elements in various districts of the Baltic Sea. Historic data are from 1900 (black circles), 1940-60 (dark grey circles) or 1960-1970 (pale grey circles).

Small scale vegetation models
The ultimate goal of both small and large-scale vegetation analyses is to identify relations between quality elements and anthropogenic impact. The models should explain and predict changes in the distribution and abundance of vegetation in relation to changes in water quality and geomorphology. The models should preferably allow us to separate between "natural" and "anthropogenic" impacts on vegetation.

Each working group considers the available data and selects areas with appropriate data for small-scale (local) analyses. Each working group also decides on the best analysis models for the data. The groups should take into account that small-scale analyses performed for different local areas should be as comparable as possible.

Ideas for analyses:

- Initially, each quality element could be related to each physico-chemical parameter by simple correlation/regression analysis in order to get a rough estimate of the main regulating factors.
- The multiple regression analysis could be carried out. Multiple regression analysis is well suited for analysis of deterministic, homogenous relationships.
- Ecological patterns, however, often deviate from deterministic relationships and rather show boundary or treshold relationships. To identify such various types of relationships among a response parameter and different regulation factors a flexible analysis is needed. Regression trees can provide this flexibility. These combine treshold, boundary and continous relationships in a hierarchical form (see Duarte 1991).

Duarte, C.M. 1991. Variance and the description of nature. Chapter 15, p 301-318 in Cole, J., Lovett, G & Findlay, S. (Eds.) Comparative analyses of ecosystems - patterns, mechanisms and theories. Springer Verlag, New York.

Deliverable 20 and 32: "Reference conditions for benthic vegetation".
- Draft (No. 20) and final version (No. 32).

Nature of deliverable: The deliverable is a short report (Re) integrating acquired knowledge. NERI compiles the report based on completed inputs from each partner on methods, results and discussion regarding reference conditions for benthic vegetation.

It is a prerequisite for the analyses, that WP1 provides input on typology, i.e. proposes which type areas to use.

Reference conditions should initially be defined for each type area based on results of deliverable 15: historical records and/or hindcasting based on small-scale models relating the key parameters to anthropogenic pressure. When using the hind-casting technique we should be aware that spatial gradients in vegetation indicators in relation to anthropogenic pressure do not necessarily imply similar temporal trends in relation to anthropogenic pressure.

The final version (No 32) may be adjusted based on the results of large-scale vegetation models (deliverable 25).

Deliverable 21: "Draft of scientific paper relating phytoplankton and macrophytes to typology"

The paper involves contributions from Workpackages 1 (Typology), 2 (Phytoplankton) and 3 (Macrophytes).

Deliverable 25: "Large-scale vegetation models"
Nature of deliverable: The deliverable is a method development (Me). NERI compiles the report based on completed inputs from FEI, AAU, EMI, and EMAUG on methods, results and discussion regarding large-scale vegetation models.

As for the small-scale analyses, the ultimate goal of the large-scale analyses is to identify relations between vegetation parameters and anthropogenic impact.

The large-scale analyses should focus on the parameters of high priority defined in deliverable 3 and should also build on the information obtained in small-scale analyses.

Small scale-analyses may, for example show that the relation between a given vegetation parameter and a given anthropogenic parameter differs among local areas. Large-scale analyses might then identify whether such a difference can be attributed to large-scale differences in e.g. salinity among the local areas.

Such broad scale relations should include initial correlations and regressions between the selected vegetation parameters and relevant physico-chemical parameters. Further analyses depend on the actual data.

Deliverable 26: "Draft of 2 scientific papers relating biological indicators and water quality parameters to physical gradients"

The work is lead by WP1 (typology). We need to contribute with information on macrophytes.

Deliverable 29: "Draft of 2 scientific papers relating biological indicators and water quality parameters to physical gradients with emphasis on reference conditions"

The work is lead by WP1 (typology). We need to contribute with information on macrophytes.

Deliverable 30: "Definition of vegetation indicators".
Nature of deliverable: The deliverable is a method development (Me). NERI compiles the report based on completed inputs from each partner.

Based on results of small and large-scale analyses, all WP3-partners define appropriate macrophyte indicators of the state of coastal ecosystems. An indicator is appropriate if it relates to anthropogenic impact in a predictable way and if reference conditions are well-established.

Deliverable 31: "Verified typology for vegetation"
(Input for typology work package)

Nature of deliverable: The deliverable is a short report (Re) integrating acquired knowledge. The information on benthic vegetation makes part of the over-all deliverable on typology.

We should evaluate whether the typology identified in WP1 makes sense with respect to macrophyte data.

Deliverable 34: "Monitoring recommendations for vegetation in the Baltic coastal zone"
Nature of deliverable: The deliverable is a short report (Re) integrating acquired knowledge. The information on benthic vegetation makes part of the over-all deliverable on monitoring recommendations.

NERI writes the report based on inputs on the following topics from each partner:

- Relevant physico-chemical parameters to include in a monitoring programme in order to evaluate changes in the vegetation
- Methods, frequency and time of sampling for the suggested indicators. The frequency of measurements should be related to the time scales of expected changes in the vegetation in relation to changes in water chemistry. References to available tests of methods and evaluations of sampling error are relevant in this context.

Appendix 1

METADATA

Where	*Data set*
Marine area Estuary, coastal area No. of sites/depth gradients Latitude and longitude of depth gradients	
When	
Sampling years (19XX-XX) Sampling months Frequency (obs. per year)	
Angiosperms (e.g. Zostera)	
Species	
Colonisation depths	
Max. col. depth of meadows Max. col. depth of isolated shoots Depth of max abundance	
Abundance at specific depths along gradients	
Investigated depths Biomass, below ground Biomass, above ground Shoot density Cover	
Area distribution	
km^2 seagrass cover	
Macroalgae	
Level of identification (species/genus/functional group) Define the functional groups *Colonisation depths* Max. col. depth of individual species Max. col. depth of deepest occurring macroalgae Depth of max macroalgal abundance *Abundance at specific depths along gradients* Investigated depths Biomass Cover **Key algal species** Species (Fucus vesiculosus/Charophyceans) *Colonisation depths* Max. col. depth of key species Depth of max key species abundance *Abundance at specific depths along gradients* Investigated depths Biomass Cover	

Physico-chemical data	
Id. of coupled water chemistry st. Salinity Inorganic nitrogen Total nitrogen Inorganic phosphorus Total phosphorus	
Exposure Slope of coast line Secchi-depth K_t (m^{-1}) Proportion of hard substratum Proportion of soft substratum	
Duration of icecover other factors other factors	
Reference:	
Data type: rawdata/aggregated data	
Data availability: electronically/printed	
Comments:	

Methods used in the compiled dataset:

Level of quality assurance: