Minutes of the meeting in the CHARM vegetation group

3rd and 4th September 2002

Participants

Christoffer Boström, Åbo Academy University (AAU), Finland
Ari Ruuskanen, Finnish Environment Institute (FEI), Finland
Kaire Torn, Estonian Marine Institute (EMI), Estonia
Georg Martin, Estonian Marine Institute (EMI), Estonia
Dorte Krause-Jensen, National Environmental Research Institute (NERI), Denmark

3rd September

Which data are available and how comparable are they?
Dorte presented our compilation of meta data and gave an overview of the available data in CHARM (based on deliverable 3).

Presentation of data and ideas on vegetation indicators and analyses
We presented and discussed ideas on possible vegetation indicators/quality elements and how to analyse these indicators. Short summaries of the presentations are shown below:

Macroalgae in Finland by Ari Ruuskanen
The Finnnish metadata consists of approximately 600 records concerning macro algae. The lower growth limit of *Fucus vesiculosus* belt is mentioned in over 200 records during 1990s. Thus, vertical growth limit of *Fucus* belt could be one useful parameter to use.

The geographical distribution of *Fucus vesiculosus* along the coast of Finland extends from the Quark in the Gulf of Bothnia to the eastern parts of the Gulf of Finland. In general, a continuous *Fucus vesiculosus* belt lies between 0.5-3 metres in the inner archipelago, and between 0.7-9 metres in the outer archipelago. The lower and upper limits and the optimum growth depth of the continuous belt becomes gradually deeper from sheltered to exposed shores and from the east towards the west in the Gulf of Finland. The deepest *Fucus* individuals of the shore occur approximately one metre deeper than lower individuals of continuous belt.

It is assumed that light probably regulates the lower growth limit, as there is a clear correlation between the growth depth and the compensation point of photosynthesis. Thus, the lower growth limit of *Fucus* belt can be used as an indicator of long term changes in water quality in terms of light penetration. However, all 200 records are not useful. A problem is how to define the lower growth limit of *Fucus*. In some records the lower growth limit is considered as the deepest limit of continuous belt (i.e., that part of belt in which individuals are near each others and are mature etc.), but in some records a lower limit is considered as the deepest individual of the shore. Thus, one possibility is to analyse the lower limit of continuous belt and the lower limit of individuals separately, because different environmental factors may regulate them.

However, wave exposure and ice cover are factors which affect strongly *Fucus* belt in local scale, and which should be taken into consideration when comparing and analysing long term changes in vertical growth range of *Fucus* belt.

It is shown that both lower limit of continuous belt and individuals are regulated by shore exposure in local scale. The more exposed shore the deeper growth limit. An usual way to determine shore exposure is to use cartographic methoods, such as Effective fetch, in which a shore is given a numerical value to represent wave exposure of the shore. However, a numerical exposure value taken at the shore probably does not represent the true *in situ* conditions on the bottom. A shore may be classified as sheltered if it is located close to the main land, in the archipelago, and is protected by islands even if the shore faces the main wind direction. A shore may also be classified as sheltered on the partially exposed side of an island in the outermost archipelago. These two shore types can have the same calculated exposure index, however; the water motion, turbidity and sedimentation can be totally different on the bottom and have a different effect on *Fucus vesiculosus* morphology and belt formation.

The upper growth limit of the belt seems to be determined by ice, as the upper growth limit of the belt is the lowest limit of the ice cover. During a severe winter, the pack ice may clear the bottom and the *Fucus* belt as well, easily down to 5 metres in the outer archipelago. However, this may not happen every year. Some years pack ice is lacking, and the upper growth limit of *F. vesiculosus* belt may reach up to 0.7 m. In the inner archipelago, where pack ice does not exist and the ice cover is solid, the lowest limit of the ice cover is about 0.5 m. Consequently, the upper growth limit is more predictable and stable in the inner archipelago than in the outer part of the archipelago. The upper growth limit can be considered to be unpredictable due to effect of ice in the outer archipelago, but, in contrast, the lower growth limit of the belt can be expected to be more stable, thus reflecting long-term changes in the environment.

Macroalgae along the Estonian coast by Georg Martin
Estonian phytobenthos data presented for CHARM metadata base consists of different datasets originating from different historical periods. Regular phytobenthos monitoring is running since 1995 in Estonia and consists of annual observations and quantitative sampling in 6 coastal areas. From period before that data from different single investigations is available. Historical data (before 1995) is mostly qualitative data (species lists in given observation site) with seldom information of total wet weight of the sample and total coverage estimations. In many cases this data is not digitised and exact locations of findings is also impossible to determine due to loss of original maps. While currently running phytobenthos monitoring programme was designed according to HELCOM guidelines and is therefore well comparable with data from other Baltic areas. Together with data originating from several research and monitoring programmes carried out during recent decade this dataset can be used on the Baltic Sea scale as well as for local modelling purposes to complete the tasks of WP3.

Proposed WFD classification system of Estonian coastal sea areas includes following phytobenthos indicators:

- Max. depth penetration of phytobenhos
- Max. depth penetration of Fucus vesiculosus belt
- Max. depth penetration of Fucus vesiculosus plants
- Quantitative proportion of annual and perennial species in the area.

This system is going to be tested in three coastal areas with different environmental conditions during the current field season and first results are expected by the end of the year.

Benthic vegetation in Latvia by Anda Ikauniece (presented by Dorte)
Anda gave an overview of the Latvian vegetation data and provided the following preliminary ideas on use of the macroalgal data from the Gulf of Riga:

- As the IAE macroalgal data represent only one year it could be useful to link them with data from 1995, obtained during Gulf of Riga Project, as the sampling areas have been the same;
- IAE data could be sufficient for local small-scale analysis relating distribution and abundance of vegetation to the environmental factors as the physico-chemical data coverage is quite good. However, not all information according to the metadata template exists (is never collected). Thus other local factors should be included – e.g. current speed or DOM;
- Historic comparisons are problematic, although using data set from 1995 (environmental information is available at IAE) the community changes could be shown at Saulkrasti, as the improvement was stated during 1999 survey;

- The general feeling is that in southern GoR case the depth distribution of algal belts together with presence and biomass of *Fucus* and *Furcellaria* could be the indicators.

German data in the context of basic aims of WP3 by Sigrid Sagert (Sigrid had to cancel her participation in last minute, but she sent her presentation by E-mail)
Sigrid presented the German monitoring programme for macrophytes: sites, methods, availability of physicochemical data and an overview of the macrophyte data.

"Eelgrass in Scandinavia – local and regional patterns" by Christoffer Boström
Remote sensing of eelgrass and the WFD
During the implementation of the European Water Framework Directive, indicator species, which can be used for the ecological classification of coastal waters, are needed. Eelgrass, *Zostera marina* has a wide distribution in Scandinavia. However, significant eutrophication related changes in benthic vegetation have been recorded throughout the Baltic Sea during the past 10 years, and recent investigations point at 50% areal reductions of *Zostera* meadows along the Swedish west coast since the 1980's (Baden et al. in prep.). In order to assess the (1) present status, (2) obtain quantitatively reliable data on the distribution (within and among-site), and (3) monitor these red-listed marine biotopes, there is a need of developing and testing new methods – a necessary first step towards cost-effective management of these systems. Our project aims at testing aerial photography of large areas in order to monitor spatio-temporal changes in *Zostera* meadows.

Currently the first distribution maps of marine vegetated landscapes ("seascapes") have been obtained by digital aerial photography and processed using digital image analysis and GIS-technology. A pilot study showed, that in a shallow (1-3 m) model area encompassing about 7000 m2, both patch mortality in terms of detachment of above-ground biomass by wind-disturbance and patch expansion in terms of clonal growth were significant between two successive years (2001-2002). Such rapid natural dynamics implicate that changes in bed structure (area cover, patch size, number of patches and patch shape) and loss of shallow water eelgrass beds are controlled by physical processes (wind and waves). Consequently, effects of eutrophication (reduced water transparency) on eelgrass beds can not be discriminated from natural dynamics, but the method is suitable for characterization of broad-scale patterns, and may be used succesfully for the typology of coastal areas. An important task is to investigate and test these techniques over broader spatial scale, e.g. in Denmark and Sweden, where good historical records of eelgrass exist. From a methodological point of view, digital aerial photography, combined with GIS analysis, is a very fast and accurate tool for future monitoring of seagrass meadows in the Baltic Sea. The limitations include high water turbidity (Secchi limit 5-6 m) and strong (>6 m/s) winds.

Faunal biodiversity: *Fucus vesiculosus* belts and *Zostera marina* meadows
Zostera is the one of the most abundant macrophytes on exposed sandy bottoms in Finland. Discrete patches or continuous beds stabilize bare substrates, and provide niches for several animal groups, which otherwise could not exist in this environment. It is clear that *Zostera* is an important structuring species maintaining high faunal diversity in Finnish coastal waters. The difference in substrate requirements of *Zostera* between brackish and marine waters is reflected in the composition of the associated faunal assemblages, and may have long-term consequences for the survival of *Zostera* populations. Despite the narrow niche (exposed sandy bottoms in the outer Archipelago areas) occupied by *Zostera* in Finland, the meadows support a generalized invertebrate fauna. For example, the *Zostera* leaf canopy has several species in common with the *Fucus vesiculosus* belt (Kautsky and van der Maarel 1990, pers. obs.).

Fucus is the dominating macrophyte in the rocky archipelagos of the northern Baltic Sea, and hosts on average 10-15 faunal dominants (Haage 1975, 1976, Fagerholm 1978), a similar number as the *Zostera* leaf canopy, but lacks several of the infaunal taxa (bivalves, burrowing amphipods, polychaetes and oligochaetes) found among the *Zostera* rhizomes. The three-dimensional structure of *Zostera* beds, exemplified by a rich sediment infauna, contributes significantly to total biodiversity and abundance, making *Zostera* meadows almost twice as rich in species as the

Fucus ecosystem. Considering this pattern across larger spatial scales, the relative importance of *Zostera* for coastal biodiversity in the low saline areas of the Baltic Sea is higher than in fully marine waters (Swedish west coast), since most of the macrofaunal taxa living in the northern Baltic Sea are found in the *Zostera* system, while in fully marine waters only a fraction of the total marine animal diversity is represented in *Zostera* beds. Notably, the leaf fauna of eelgrass beds along the whole salinity gradient from Finland to the Swedish west coast is equally diverse (Baden and Boström 2001).

Extended abstract from BOSTRÖM, C., BONSDORFF, E., KANGAS, P. & NORKKO, A. 2002. Long-term changes in a brackish water *Zostera marina* community indicate effects of eutrophication. *Estuarine Coastal Shelf Science,* in press.
In June 1993, a seagrass locality (Tvärminne, SW Finland) thoroughly studied in 1968 – 71 was revisited in order to detect possible long-term changes in both vegetation structure (distribution, density, biomass) and benthic infauna (species composition, abundance, biomass, distribution and diversity patterns). The study shows that the shoot density had increased in sparse (<20 shoots $\cdot$ m^{-2}) *Z. marina*, while dense (>150 shoots $\cdot$ m^{-2}) *Z. marina* patches showed similar biomass values (20 g AFDW$\cdot$ m^{-2}) as in the 1970's. In contrast to the vegetation, where little apparent change could be recorded, the total abundance and biomass of zoobenthos has increased significantly between 1968-71 and 1993 in the dense *Z. marina* patches. These changes are mainly attributed to significant increases of the bivalve *Macoma balthica* L., mudsnails *Hydrobia* spp. and oligochaetes. In sparse *Z. marina* diversity in terms of number of taxa exhibited minor changes over time, whereas in dense *Z. marina* patches the mean number of taxa has increased from 16 to 20. This study represents a rare example of long-term persistence of seagrass communities in an area where the negative effects of nutrient enrichment are evident in virtually all other macrophyte ecosystems, e.g. the Fucus belts. The faunal changes in the *Z. marina* community indicate increased food availability, which is associated with positive effects of coastal eutrophication. As seagrass responses to slowly increasing nutrient enrichment are not gradual (Duarte 1995), it was concluded, that eventhough stable over the past 25 yrs, the *Z. marina* communities in the northern Baltic Sea have reached a critical stage where continued eutrophication will most likely involve reduction of seagrass biomass and loss of valuable faunal habitats, and thus possible loss of overall biodiversity. Hence, faunal changes in seagrass meadows reflect changes in the eutrophication related changes in the marine environment, and should be considered during classification of the state of coastal waters.

The depth limit of eelgrass by Dorte Krause-Jensen
Abstract: Krause-Jensen, D., Greve, T.M., Nielsen, K. The European Water Framework Directive in practice: eelgrass as a quality element. For submission to Ambio
We aimed to test the implementation of the European Water Framework Directive (WFD) in practice using the depth limit of eelgrass as example. A large historic data material from 1900 provided a unique opportunity to characterise "reference conditions" that reflect an "undisturbed" ecosystem. Actual depth limits were obtained from the National Danish Monitoring Programme. Data represented a wide range of Danish coastal water bodies but were grouped into 10 water body types based on differences in salinity and depth as required by the WFD. The ecological status of a given water body was then defined according to the degree of deviation of actual depth limits from reference levels defined for that water body type. We found that reference conditions varied markedly within a given type of water body and that the use of type-specific reference conditions therefore implied a serious risk of misinterpretation of ecological status. Site-specific reference conditions seem to be a robust alternative that may be considered for the implementation of the WFD.

Eelgrass abundance versus depth by Dorte Krause-Jensen
Extended abstract: Krause-Jensen, D., Pedersen, M.F. & Jensen, C. Regulation of eelgrass *Zostera marina* cover in Danish coastal waters. Estuaries. accepted
A large data set, collected under the national Danish monitoring programme, was used to evaluate the importance of photon flux density (PFD), relative wave exposure (REI), littoral slope and salinity in regulating eelgrass cover at different depth intervals in Danish coastal waters.

Average eelgrass cover exhibited a bell-shaped pattern with depth, reflecting that different factors regulate eelgrass cover at shallow- and deep-water sites. The multiple logistic regression analysis was used to identify regulating factors and determine their role in relation to eelgrass cover at different depth intervals. PFD, REI and salinity were main factors affecting eelgrass cover while littoral slope had no significant effect. Eelgrass cover increased with increasing PFD at water depths of more than 2 m, while cover was inversely related to REI in shallow water. This pattern favoured eelgrass cover at intermediate depths where levels of PFD and REI were moderate. Salinity had a minor, but significant, effect on eelgrass cover that is most likely related to the varying costs of osmoregulation with changing salinity. The analysis provided a useful conceptual framework for understanding the factors that regulate eelgrass abundance with depth. Although the regression model was statistically significant and included the factors generally considered most important in regulating eelgrass cover, its explanatory power was low, especially in shallow water. The largest discrepancies between predicted and observed values of cover appeared in cases where no eelgrass occurred despite sufficient light and moderate levels of exposure (almost 50% of all observations). These discrepancies suggest that population losses due stochastic phenomena, such as extreme wind events, play an important regulating role that is not adequately described by average exposure levels. A more thorough knowledge on the importance of such loss processes and the time scales involved in recovery of seagrass populations after severe disturbance are necessary if we are to understand the regulation of seagrass distribution in shallow coastal areas more fully.

In relation to the Water Framework Directive, shallow water eelgrass populations do not seem to be a useful quality element because they are largely dominated by physical forces. By contrast, the deep eelgrass populations respond more directly to changing water quality and are likely to be useful quality elements.

Questions/inputs from Sergej Olenin

- Should we include data from such nearly freshwater environments as the Curonian Lagoon? E.g. German boddens in their most diluted parts may look very similar. Species composition will be dominated by freshwater species.

  Comments: Unfortunately we had no representatives from Germany who could inform us about whether the German freshwater-brackish areas are included.

- Can we use episodic underwater video survey data?

  Comments: The video surveys are useful if they are quantifiable, so that they provide information on the cover of given species/groups at specific depths, and possible of the depth limit of the vegetation.

Discussion and selection of possible vegetation quality elements

We discussed requirements for a good quality element and arrived at the following:

A good quality element must:

- respond predictably to changes in water quality
- show unidirectional response to changes in water quality (e.g. no parabolic response)
- be possible to define reference conditions for
- be robust with low natural variability
- be well defined

A good quality element should preferably be:

- important for the ecosystem
- easy to measure
- cheap

Based on the presentations of data and ideas we made a list of possible quality elements and grouped them into quality elements for macroalgae (Table 5), angiosperms (Table 6) and associated fauna (Table 7). We evaluated the advantages and disadvantages of each of them according to the requirements of a good indicator. We gave each quality element a score that reflected our expectation to the element on a scale from 1 (good) to 5 (bad).

In the end, we selected those of the possible quality elements that we want to analyse further through CHARM (Table 8). The depth distribution of the vegetation is one of the major elements that we decided to analyse in detail. It encompasses several quality elements that are relevant for both angiosperms and macroalgae (see Figure 1).

We also organised a working group for each of the quality elements to be analysed in CHARM. The working groups should analyse their quality element relative to the demands of each deliverable.

Those who did not participate in the meeting are of course welcome to join the working groups and to propose supplementary analyses. Please let me know which working groups you would like to join.

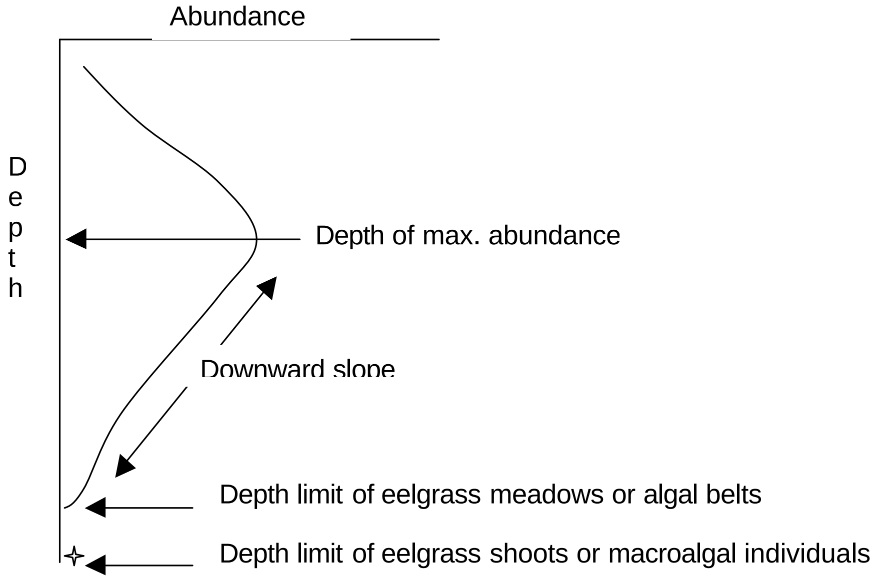

Figure: Explanation of terms used in Table 5, 6 and 8 to describe depth distribution of macrophytes

Table 5. Possible quality elements on macroalgae, their advantages, disadvantages and score (1: good; 5: bad)

POSSIBLE QUALITY ELEMENTS - MACROALGAE	ADVANTAGES	DISADVANTAGES	SCOR 1-5
Depth distribution			
• Depth limit of perennial individuals of:	Regulated by light (& substrate)	Substrate may limit the distribution (need to be recorded)	1
- *Fucus vesiculosus*	Possible to define ref. conditions	Current may limit distribution in some areas	
- *Furcellaria lumbricalis*	Well defined	Cover of filamentous algae may complicate investigation	
- Total algal community	Easy to record/cheap	In some areas depth limits of algae>max diving depth (25m)	
		Grazing may remove sporelings	
		Shading by ice may affect depth limit	
• Depth limit of continuous belts of *Fucus vesiculosus*	Partly regulated by light	Substrate may limit distribution (need to be recorded)	1
	Possible to define reference conditions	Current may limit the distribution in some areas	
	Well defined	Cover of filamentous algae may complicate investigation	
	Easy to record/cheap	Requires Fucus belts	
		Limit of belt must be well-defined	
		Shading by ice may affect depth limit	
• Depth of max. abundance of:	Objective if measured as biomass	By biomass: laborous; By coverage: diffuse/subjective	3
- *Fucus vesiculosus*	Partly light regulated	Depends partly on exposure	
- *Furcellaria lumbricalis*		Reference level hard to define	
- Total algal community			
• Downward slope of abundance of:	Partly light regulated	Needs much work, but possibly doesn't give much more info than depth limits	3
- *Fucus vesiculosus*		Reference level hard to define	
- *Furcellaria lumbricalis*			
- Total algal community			
Species composition			
• Species number of macroalgae	A measure of biodiversity	Not robust	4
	Importance for ecosystem	Requires expert knowledge	
	Much historical information	Unpredictable response to water quality	
• Annual/perennial	May work also in shallow areas	Needs much work: abundance of all species	*2*
	Predictable response to water quality	Reference level hard to define	
	Implication for ecosystems		
	Mentioned in WFD		
• Abundance of drift algae	Related to water quality	Relates to exposure	*3*
	Importance for ecosystem & socioeconomy	Needs frequent sampling	
• Sensitive species - e.g. Charophytes	Related to water quality	Area specific	
		Difficult to quantify in WDF	*1*

Table 5. Possible quality elements on angiosperms, their advantages, disadvantages and score (1: good; 5: bad)

POSSIBLE QUALITY ELEMENTS - ANGIOSPERMS	ADVANTAGES	DISADVANTAGES	SCORE 1-5
Depth distribution			
• Depth limit of eelgrass shoots	Regulated by light Possible to define ref. conditions Well defined Easy to record/cheap	Substrate quality may play a role Current/exposure limits distribution in some areas Filamentous algae may cover eelgrass and make it hard to see	1
• Depth limit of eelgrass meadows	Regulated by light Possible to define reference conditions Easy to record/cheap	Substrate quality may play a role Current/exposure limits distribution in some areas Filamentous algae may cover eelgrass and make it hard to see Works only in areas with eelgrass meadows Limit of meadows need to be well-defined	1
• Depth of max eelgrass abundance	Objective if measured as biomass Partly light regulated	By biomass: laborous; By coverage: diffuse/subjective Depends also on exposure	3
• Downward slope of eelgrass abundance	Partly light regulated	Needs much work (does not give more info than depth limit)	3
Species composition			
• Species number		No direct relation to water quality	
• Filamentous algae/eelgrass	May work also in shallow areas Predictable response to water quality Implication for ecosystems Mentioned in WFD	Filamentous algae are dynamic and need frequent sampling Reference level hard to define	
Area cover of eelgrass	Importance for ecosystem Easy to measure in sandy areas - air photo	Dynamics in shallow water is largely physically controlled - unpredictable High natural variability Ref. con. hard to define	4 - but OK for typology

Table 7. Possible quality elements on fauna associated to either eelgrass or Fucus communities, their advantages, disadvantages and score (1: good; 5: bad)

POSSIBLE QUALITY ELEMENTS - ASSOCIATED FAUNA	ADVANTAGES	DISADVANTAGES	SCORE 1-5
• Species number, functional groups, sensitive species	Predictable response to water quality Sensitive	Ref. con. may be hard to define Requires expert knowledge As laborious as sediment fauna samples	2

Table 8. Selected quality elements, the habitats they refer to and the working groups 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 parenthesis 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

4th September

Planning of work for the coming year

We planned the work to be done for deliverable 15 which needs to be ready by next summer. For details please see the revised detailed workplan for WP3.