6.4 *Coastal lagoons* (1150)

6.4.1 Identification of sub-features, pressure factors and potential indicators

Coastal lagoons are areas with more or less brackish water, which are complete or partly cut off from the open sea by sandbanks, pebbles or rocks. The completely cut off lagoons are called *beach lakes* in Denmark. The salinity can vary greatly depending on precipitation, evaporation, and input of water from the sea outside during storms, winter flooding or spring tides. *Coastal lagoons* can be with or without vegetation. Compared to other marine habitats, the species diversity is low. The species present are often especially suited to cope with large variations in salinity.

Coastal lagoons are often shallow, with a low water volume and with poor water exchange. Even low inputs of plant nutrients can have marked effects on flora and fauna. Different inputs of fresh water or saltwater due to, *e.g.* variations in precipitation or topography can have marked effects not only on the natural quality but also on the area of the habitat. Since salinity – especially in the *beach lakes* – is influenced by precipitation, human induced climate change (global warming) can become an important pressure factor in future.

The habitat *coastal lagoons* can be split up into the two sub-features:

- *Coastal lagoons with regular water exchange*
- *Beach lakes*

Anthropogenic pressure factors and possible indicators for the two types of *coastal lagoons (1150)* are shown in *Table 6.4.1*. Indicators and pressure factors are probably the same for both types of *lagoons*.

6.4.2 Available data

Of the 42 Natura 2000 sites, which have been designated solely or partly on the basis of the occurrence of the habitat *coastal lagoons,* data have been gathered in 17 (*Table 6.4.2*). From most of the sites data time series are less then 5 years long, but some longer time series do exist (*Figure 6.4.1*). Most of the time series on *benthic fauna* are 2-5 years long. Longer time series exist from Lillebælt and Sejerø Bugt. Data time series on *water quality* are mostly 2-10 years long, but 15 datasets cover more than 10 years. Data from only 1 year exist from the Wadden Sea. Data on *phyto*- and *zooplankton* are relatively few and most of them are from Nissum Fjord and Ringkøbing Fjord (*Table 6.4.2*).

6.4.3 Conclusions and recommendations

A large part of the available data on *coastal lagoons* is stored electronically. It will, therefore, be relatively easy to get them analysed. On the basis of an analysis, it should be assessed whether surveys should be arranged to obtain more data. The data and the locations of sampling stations seem to be satisfactory for an analysis of indicators for *coastal vegetation* and *benthic fauna*. Data concerning indicators in relation to hazardous substances are lacking. New data should, therefore, be gathered prior to the setting of conservation objectives for *coastal lagoons* in relation to hazardous substances.

Table 6.4.1 Proposals for potential indicators for assessing conservation status of the habitat *coastal lagoons (1150)* listed according to possible anthropogenic pressure factors, the unit of measurement, the method suggested to develop the indicators and thresholds and remarks.

Pressure factors	**Indicator**	**Unit of measurement**	**Method for developing indicators and threshold values**	**Comments**
Changes in runoff or in topography	Area	km²	By measuring area, *e.g.* on new or old aerial photos	Depends on precipitation and evaporation
Eutrophication	Depth distribution	M	Echo sounding	
	Vegetation coverage	Coverage %	Empirical modelling	Salinity dependent
	Species diversity of algae (including Characeans)	Number of species, various indexes, similarity	Empirical modelling	Salinity dependent
	Species diversity of phanerogams	Number of species, various indexes, similarity	Empirical modelling	Salinity dependent
	Species diversity of benthic fauna	Number of species, various indexes, similarity	Empirical modelling	Salinity dependent
Climate change (global warming)	Species composition	Similarity		
Environmentally hazardous substances	Concentrations in biota and sediment	Concentration		
	Reproductive disorders in Viviparous blenny (lysosomal stability) – general effect indicator	Activity/frequency	Activity/frequency levels compared to reference area	No data from monitoring in Denmark. Possible future use
	Specific effect indicator for PAH-like substances (EROD)	Activity/frequency	Activity/frequency levels compared to reference area	
	Imposex and intersex in snails (specific effect indicator for TBT)	Indexes for imposex and intersex		
	Species composition	Similarity		
Human induced variations in salinity	Species diversity of algae and phanerogams	Indexes for macro-algae and phanerogams	New and old data	Precipitation/evaporation
	Species diversity of fauna	Indexes for fauna		

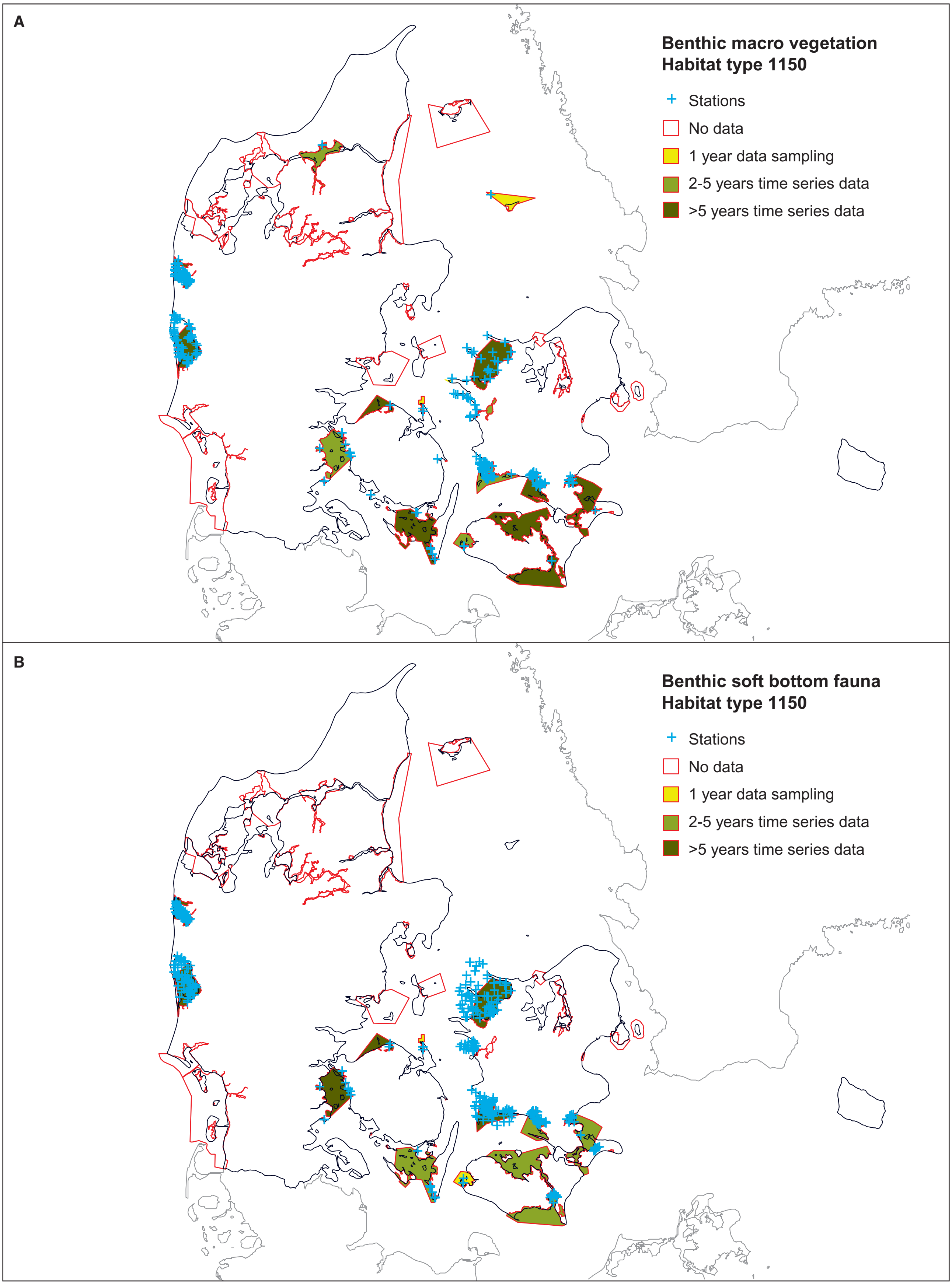


Figure 6.4.1 Natura 2000 sites designated solely or partly due to the presence of the habitat *coastal lagoons (1150)* (areas bordered with red). The maps show where *coastal vegetation* and *benthic fauna* respectively have been sampled inside the habitat (as blue crosses). The colour of a site indicates the length of the longest time series from a sampling station at the site.

Table 6.4.2 The Natura 2000 sites with the habitat coastal lagoons (1150) with the Danish SAC number and the number of sampling stations for each parameter shown. Also the number of sites with sampling stations, and the number of stations sampled per parameter, according to information from the counties, are shown.

Natura 2000 sites	Danish SAC no.	Vege-tation	Benthic fauna	Phyto-plank-ton	Zoo-plank-ton	Water quality	CTD
Coastal meadows on Læsø and the sea to the South	9						
Holtemmen, Højsande, and Nordmarken	10						
Ålborg Bugt, Randers Fjord, and Mariager Fjord	14						
Nibe Bredning, Halkær Ådal, and Sønderup Ådal	15	1		1		1	1
Løgstør Bredning, Vejlerne, and Bulbjerg	16						
Kielstrup Sø	22						
Agger Tange	28						
Dråby Vig, Nissum Bredning, Skibsted Fjord, and Agerø	29						
Lovns Bredning, Hjarbæk Fjord, and Skals Ådal	30						
Kås Hoved	31						
Helgenæs South	47						
Stavns Fjord, Samsø Østerflak, and Nordby Hede	51						
Horsens Fjord, the sea to the East, and Endelave	52						
Venø and Venø Sund	55						
Nissum Fjord	58	13	52	3	3	3	
Ringkøbing Fjord and Nymindestrømmen	62	18	43	12	1	4	
The Wadden Sea	78						
Fyns Hoved, Lillegrund and Lillestrand	91						
Æbelø, the sea to the South, and Nærå	92	1				3	3
Lillebælt	96	9	9	4		12	10
Østerø Sø	99					1	1
Bøjden Nor	107	1				1	1
Avernakø	109					2	2
Sydfynske Øhav	111	5	4	1		12	10
Roskilde Fjord	120						
Saltholm and surrounding sea	126						
Vestamager and the sea to the South	127						
Ølsemagle Strand and Staunings Ø	130						
The sea and coasts between Hundested and Rørvig	134	1					
Sejerø Bugt and Saltbæk Vig	135	13	3	2		3	3
Åmose, Tissø, Halleby Å, and Flasken	138						
Skælskør Fjord and the sea and coasts between Agersø and Glænø	143	29	49	7		8	8
The sea and coasts between Præstø Fjord and Grønsund	147	7	21	1		4	
The sea and coasts between Karrebæk Fjord and Knudshoved Odde	148	28	26			20	
Smålandsfarvandet north of Lolland, Guldborg Sund, Bøtø Nor and Hyllekrog-Rødsand Østerø Sø)	152	1	13			5	
Nakskov Fjord	158	1	2			2	
Mågerodde and Karby Odde	177						
Stege Nor	179					1	
Busemarke Mose and Råby Sø	192						
Risum Enge	221						
Kalø woods and Kalø Vig	230						
Thurø Rev	242						
Number of sites sampled per parameter		14	10	8	4	16	9
Number of stations per parameter		128	222	31	7	82	39

6.5 *Large shallow inlets and bays* (1160)

6.5.1 Identification of sub-features, pressure factors and potential indicators

The habitat *large shallow inlets and bays,* occurs in designated Natura 2000 sites from the North Sea to the Baltic Sea. The biological elements of this Annex 1 habitat can, therefore, be exposed to salinities from ca. 34‰ to 8 - 10‰ depending on location. The definition of this habitat allows for such large variation in biological composition that other Annex 1 habitats can be found inside the habitat. Thus, the bottom types can vary from stony or hard sandy bottom to soft muddy bottom. Exposure to wind and fresh water run-off can also vary. Together with the previously described large differences in salinity from site to site, this can lead to very different animal communities and plant cover in this habitat. The major anthropogenic pressure factors are eutrophication, fishing with towed bottom gears, extraction of sand, and hazardous substances such as antifouling paint from ships. Introduced invasive non-endemic species may impact on the quality of nature. Human induced climate change (global warming) may also turn out to be a pressure factor in future.

This Annex 1 habitat can, from a biological viewpoint, with benefit be subdivided into sub-features on the basis of, *e.g.* water depth, bottom type, and water retention time. Tidal activity and exposure to waves and currents are also relevant. It will be impossible to get an overall view of a thorough subdivision and several of the pressure factors and indicators will be repeated. So, although the combinations of pressure factors and indicators will vary among the different biologically segregated sub-features, the Annex 1 habitat is retained for the moment in *Table 6.5.1*.

6.5.2 Available data

Of the 38 Natura 2000 sites, which have been designated solely or partly on the basis of the occurrence of the habitat *large shallow inlets and bays,* data have been gathered in 23 (*Table 6.5.2*). The sites are shown on the maps in *Figure 6.5.1,* which gives an impression of the length of the longest data time series on *coastal vegetation* and *benthic fauna* from a station inside each site, and shows the location of sampling stations in the *habitat* both inside and outside Natura 2000 sites.

In Natura 2000 sites 176 (The sea around Nordre Rønner) and 112 (Hesselø), the counties have identified habitats of *large shallow inlets and bays,* on which the designations of the sites were not based.

As indicated in *Table 6.5.2*, great heterogeneity exists between the sites as to number of sampling stations and the necessary accompanying data on, *e.g.* water quality and CTD. Accompanying pelagic data and data on benthic fauna exists for 15 sites only, and on coastal vegetation for 14 sites. The lengths of time series for all parameters differ both at and between stations and sites. The significance of this for the assessment conservation objectives will depend on the heterogeneity in the strength of the pressure factors among sites and among years, and also on a possible segregation of the Annex 1 habitat into sub-fea-

Table 6.5.2 Proposals for potential indicators for assessing conservation status of the habitat *large shallow inlets and bays (1160)* listed according to possible anthropogenic pressure factors, the unit of measurement, the method suggested to develop the indicators and thresholds and remarks.

Pressure factors	Indicator	Unit of measurement	Method for developing indicators and threshold values	Comments
Extraction of sand, fishing with bottom towed gears	Macro fauna density, biomass per area, and species composition	Nos. m^{-2}, g m^{-2}	Empirical modelling	Data on *benthic fauna* can be problematic due to sampling problems
	Vegetation present		Old maps	
Eutrophication, non-endemic species	Macro-fauna density and biomass per area	Nos. m^{-2}, g m^{-2}	Empirical modelling	
	Vegetation coverage and depth distribution	%, m^2, m	Old maps and empirical modelling	
	Species diversity	Number of species, various indexes, similarity	Empirical modelling	
Climate change (global warming)	Species composition	Similarity		
Environmentally hazardous substances	Concentrations in biota and sediment	Concentration		
	Reproductive disorders in Viviparous blenny (lysosomal stability) – general effect indicator	Activity/frequency	Activity/frequency levels compared to reference area	No data from monitoring in Denmark. Possible future use
	Specific effect s for PAH-like substances (EROD)	Activity/frequency	Activity/frequency levels compared to reference area	
	Imposex and intersex in snails (specific effect indicator for TBT)	Indexes for imposex and intersex		
	Species composition	Similarity		

tures. All data listed in *Table 6.5.2* is stored electronically, but very few, mostly less than 20% of most of the parameters, are found in MADS. If the data are to be dealt with at the National Environmental Research Institute, the remainder has, therefore, to be transferred to the national database.

6.5.3 Conclusions and recommendations

Since data exist from a large number of sites, there is a great potential for empirical modelling or some other way of producing qualified proposals for thresholds. But the habitat *large shallow inlets and bays* include very different biological communities. The large number of Natura 2000 sites in which the habitat occurs is not necessarily very representative of the total number of sub-features present on the sites. At present it is not possible to assess whether data are sufficient to set conservation objectives.

It is recommended to divide the habitat *large shallow inlets and bays* into sub-features, which are defined to a greater extent than the habitat on the basis of biologically relevant parameters.

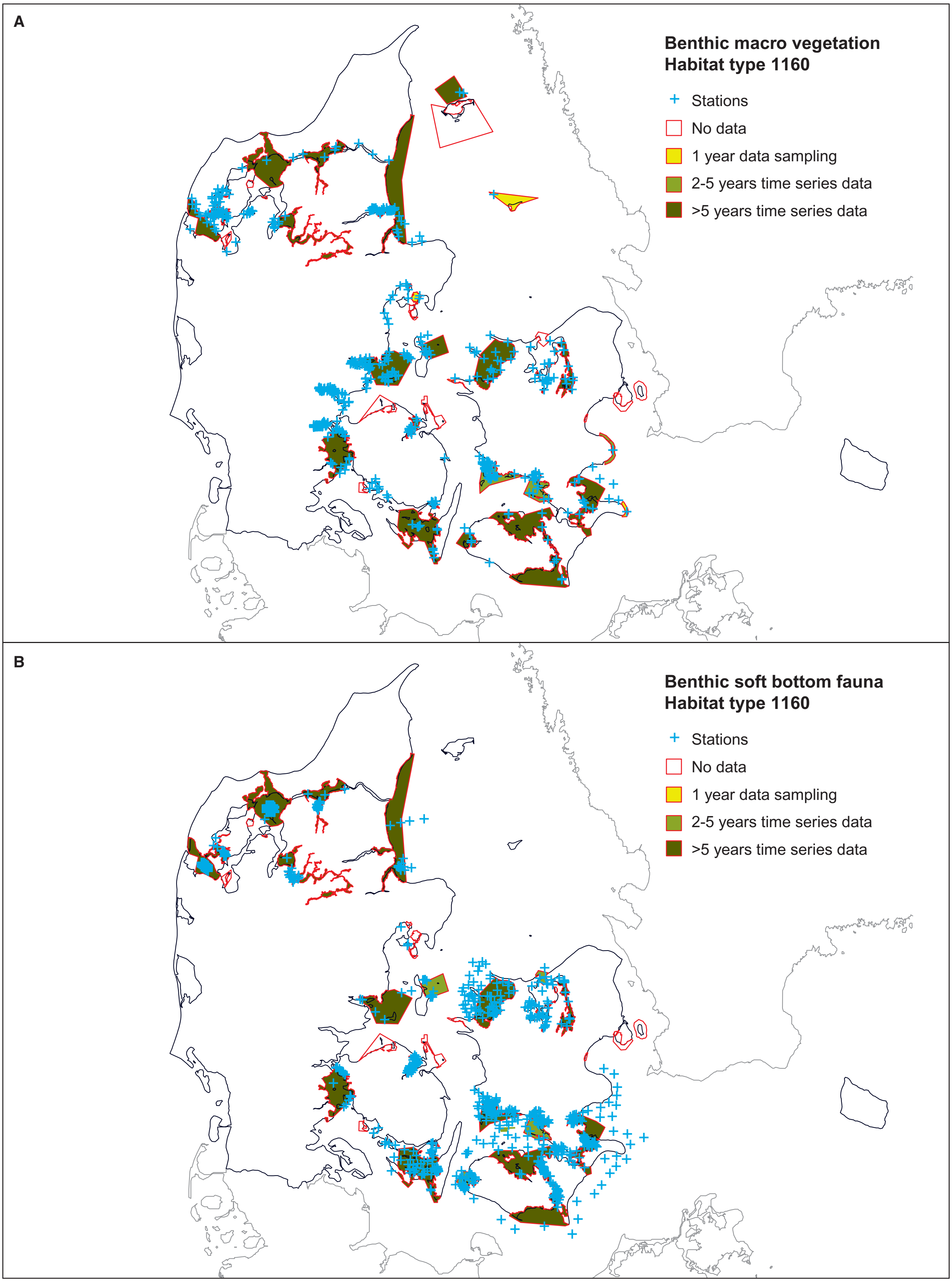


Figure 6.5.1 Natura 2000 sites designated solely or partly due to the presence of the habitat *large shallow inlets and bays (1160)* (areas bordered with red). The maps show where *coastal vegetation* and *benthic fauna* respectively have been sampled inside the habitat (as blue crosses). The colour of a site indicates the length of the longest time series from a sampling station at the site.

Table 6.5.2 The Natura 2000 sites with the habitat *large shallow inlets and bays (1160)* with the Danish SAC number and the number of sampling stations for each parameter shown. Also the number of sites with sampling stations, and the number of stations sampled per parameter, according to information from the counties, are shown.

Natura 2000 sites	Danish SAC no.	Vege-tation	Benthic fauna	Phyto-plank-ton	Zoo-plank-ton	Water quality	CTD
Ålborg Bugt, Randers Fjord, and Mariager Fjord	14	48	19	2		6	7
Nibe Bredning, Halkær Ådal, and Sønderup Ådal	15	3	22	2	1	4	4
Løgstør, Bredning, Vejlerne and Bulbjerg	16	1	47	1	1	1	7
Agger Tange	28	41	71	1	1	1	1
Dråby Vig, Nissum Bredning Skibsted Fjord, and Agerø	29						
Lovns bredning, Nibe Bredning, Halkær Ådal, and Sønderup Ådal	30	3	26			4	5
Helgenæs South	47						
Stavns Fjord, Samsø Østerflak, and Nordby Hede	51	9	9				
Horsens Fjord, the sea to the West, and Endelave	52	38	6	2		3	2
Venø and Venø Sund	55					1	6
Fyns Hoved, Lillegrund, and Lillestrand	91						
Æbelø, the sea to the South, and Nærå	92						
The sea between Romsø and Hindsholm plus Romsø	93						
Odense Fjord	94	12	43	2		6	5
Lillebælt	96	22	18	1		14	5
Maden on Helnæs and the sea to the West	108						
Sydfynske Øhav	111	12	62	2		18	12
Roskilde Fjord	120	9	55	5	1	17	
Saltholm and surrounding sea	126						
Vestamager and the sea to the South	127						
Ølsemagle Strand and Staunings Ø	130						
Jægerspris Skydeterræn	133	1					
The sea and coasts between Hundested and Rørvig	134	1	2				
Sejrø Bugt and Saltbæk Vig	135	13	3	2		3	3
Udby Vig	136	1	1				
Skælskør Fjord and the sea and coasts between Agersø and Glænø	143	29	49	8		8	8
The sea and coasts between Præstø Fjord and Grønsund	147	13	99	1		7	
The sea and coasts between Karrebæk Fjord and Knudshoved Odde	148	19	74			2	
Smålandsfarvandet north of Lolland, Guldborg Sund, Bøtø Nor and Hyllekrog-Rødsand	152	9	86				
Nakskov Fjord	158	4	23			5	
Mågerodde and Karby Odde	177						
Mols Bjerge with coastal waters	186	2					
Røsnæs and Røsnæs Rev	195						
Risum Enge	221						
Kalø woods and Kalø Vig	230	2					
Thurø Rev	242						
Kyndby Kyst	245	1	1				
Egernæs with islets, Ordrup Skov	247						
Number of sites sampled per parameter		23	20	12	4	16	12
Number of stations per parameter		293	716	28	4	100	65

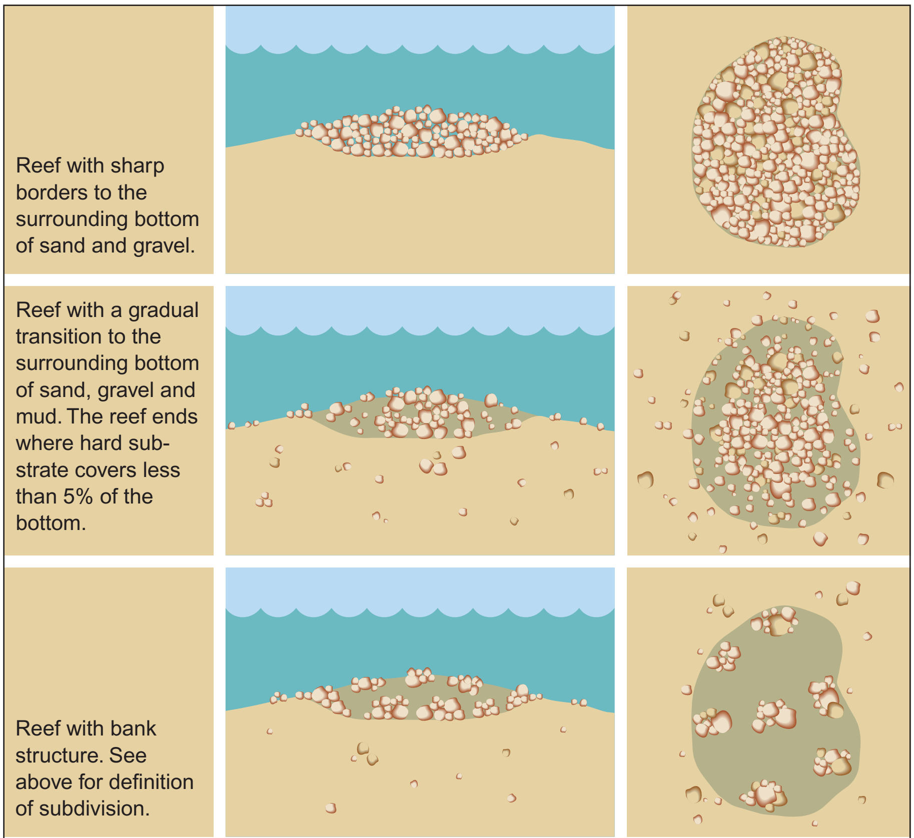
6.6 *Reefs* (1170)

6.6.1 Identification of sub-features, pressure factors and potential indicators

The habitat *reefs* occurs in proposed Natura 2000 sites from the North Sea to the Baltic Sea. The biological elements of these *reefs* can, therefore, be exposed to salinities from ca. 34‰ to 8 - 10‰ depending on location. Major parts of most of the known *reefs* consist of stable boulders and gravel. Unstable substrates consisting of gravel and pebbles are found on most *reefs* and dominate a few. Several *reefs* are dominated by biogenic material such as horse mussel banks, at depths below 15-18 m. The minimum water depth over the *reefs* and their vertical extent vary greatly from site to site. The light reaching the reefs is strongly influenced by the actual water depth and light is the major controlling factor for the benthic algae vegetation.

The definition of *reefs* in the Interpretation Manual of the Habitats Directive cannot be used to segregate *reefs* from other bottom types. For this reason a reef definition from *Dahl et al.* (2003) has been chosen, which is not based on "grain size" but on the *reefs'* function as habitats for plants and animals adapted to live on hard substrates *(Box 3)*.

Box 3 Definition of reefs and sketch of different reef types and their borders to other types of seabed habitats. The left column shows a vertical cut and the right column shows the reef seen from above.



A reef is an area rising from the surrounding sea floor. The hard substrate made by pebbles, gravel, boulders, cliffs or biogenic concretions have to cover at least 5% of the sea bottom and the size of this area must be at least 10 m². If the reef is subdivided into smaller banks, i.e. composed of separated aggregations of hard substrate, the border of the reef is limited by a line around all subsection which each meet the requirements of 10 m² size and 5% cover of hard substrate. If the reef is sharply or gradually changing into a sandy or gravel dominated seabed, the border of the reef is defined by the cover of 5% hard substrate.

Hard substrate is defined as:
Geological or biogenic material on the sea bottom with more than 10% of the surface covered by characteristic hard-substrate fauna and flora at least once a year.

A broader definition, which includes stony seabed's like those found along coastal cliffs (*habitat* 1230 of the Habitats Directive), could be chosen. Such an interpretation would enlarge the area with *reefs* in Danish waters, which would provide more biological data for assessing conservation status.

At present it must be concluded that the geomorphologic description of the proposed *reefs* areas is inadequate as regards to both sediment composition and vertical and horizontal distribution.

Existing knowledge provides a basis for dividing the *reefs* into the following 6 sub-features:

1. *Deep water stable reefs with structuralising algae (Figure 3.1B)*
2. *Deep water stable reefs with structuralising fauna (Figure 3.1C)*
3. *Shallow water stable reefs with structuralising algae (Figure 3.1A)*
4. *Shallow water table reefs dominated by Mytilus edulis* (*Figure 6.6.1A)*
5. *Shallow water unstable reefs (Figure 6.6.1B)*
6. *Deep water biogenic reefs (Figure 3.1D)*

Figure 6.6.1A Reef location on shallow water (Roskilde Fjord). *Photo Jens Larsen*

Figure 6.6.1B Reef location on shallow water with unstable substrate (Mejl Flak). *Photo Karsten Dahl*

The present major anthropogenic pressure factors for *reefs* are eutrophication, fishing with towed bottom gears and hazardous substances such as antifouling paints from ships. Stone fishing and extraction of gravel from thin surface layers are historic impacts. Few stones are fished on reefs today and stone fishing is prohibited on Natura 2000 sites. The effects of historic extraction of stones have a marked permanent effect on some *reefs* Introduced invasive non-endemic species may impact negatively on the quality of nature. Human induced climate change (global warming) and physical disturbance from, *e.g.* high-speed ferries or other vessels may turn out to be pressure factors in future.

Pressure factors are listed in *Table 6.6.1*, which also indicates, which of the 6 sub-features listed above they are relevant for.

6.6.2 Available data

Of the 51 Natura 2000 sites, which have been designated solely or partly on the basis of the occurrence of the habitat *reefs*, data have been gathered in 37 (*Table 6.6.2*). Data on *reef vegetation* exists from 52 sampling stations in 36 of these sites, whereas data on *reef fauna* exists from 20 sampling stations on 19 sites only.

Figure 6.6.2 gives an idea of the length of the data time series for *reef vegetation* and *reef fauna* from the Natura 2000 sites, which have been designated solely or in part on the basis of the habitat *reefs*. All sampling stations for *reef vegetation* inside and outside the sites are indicated on the map *Figure 6.6.2A*. The latter have been included in order to assess whether data from stations close to the sites should be included in the further work.

Sites from which data series are more than 5 years long are regarded as being reasonably well described with respect to variations in salinities, inputs of plant nutrients, etc. between years.

A number of *reefs* outside the Natura 2000 sites have been investigated. Some counties have studied the vegetation on *reefs* inside Natura 2000 sites, which were not designated due to the presence of the habitat *reefs*. Whether these *reefs* were originally missed, or the counties use other definitions of *reefs* than the Danish Forest and Nature Agency, perhaps including stony coastal areas is not clear.

Data on *phytoplankton*, *zooplankton*, *water quality* and *CTD* are very few from the Natura 2000 sites, which have been proposed solely or partly on the basis of *reefs.* The lack of pelagic data from the sites is not considered serious, since most of the *reefs* are located offshore. The fact that the open inner Danish waters move constantly allows us to use all available data, including data from outside the Natura 2000 sites.

Data on all parameters, except the *reef fauna*, has been gathered according to VMP/NOVA guidelines. Guidelines for the sampling of *reef fauna* have not yet been prepared. Information on percentage or degree of coverage by large organisms, which are easily recognised have been collected since the beginning of the 1990s, following the same procedures as for *reef vegetation*. These data exist from all sites. Their quality is variable, however, due to differences in the divers' knowledge of the species. The species in samples from many of the sampling stations have been determined in the laboratory.

Table 6.6.1 Proposals for potential indicators for assessing conservation status of the habitat *reefs (1170)* listed according to possible anthropogenic pressure factors, the unit of measurement, the method suggested to develop the indicators and thresholds and remarks.

Pressure factors	Indicator	Unit of measurement	Method for developing indicators and threshold values	Comments
Extraction of stones and gravel (possibly trawling)	Area	km²	Surveying or old data	
Eutrophication, stone fishing, fishing, climate change (global warming), non-endemic species	Total coverage of macro-algae	Coverage %	Empirical modelling	Applicable for *sub-features*: 1 and 6. Probably not very typology dependent
	Coverage of specific structuralising species of fauna	Coverage %		Applicable for *sub-features*: 2 and 6. Can be reduced if algae proliferate. Typology dependent
	Coverage of specific species of algae	Coverage %	Empirical modelling	Applicable for *sub-feature*: 3. Depth and typology dependent
	Species diversity of algae	Indexes for macro algae		Applicable for *sub-features*: 1, 3, and 5. Depth and typology dependent
	Species diversity of fauna	Indexes for fauna	Empirical modelling	Applicable for *sub-features*: 1, 2, 3, and 6
Climate change (global warming), eutrophication, fishing	Rare species of algae and fauna	Present/not present	New and old data	Applicable for all *sub-features*. Depth and typology dependent
Environmentally hazardous substances	Concentrations in biota and sediment	Concentration		Applicable for all *sub-features*:
	Reproductive disorder in Viviparous blenny (lysosomal stability) – general effect indicator	Activity/frequency	Activity/frequency compared to reference area	Applicable for *s*: 3, (4?), and (5?). No data from monitoring in Denmark. Possible future use
	Specific effect indicators for PAH-like substances (EROD)	Activity/frequency	Activity/frequency compared to reference area	Applicable for all *sub-features*
	Imposex and intersex in snails (specific effect indicator for TBT)	Indexes for imposex and intersex		Applicable for *sub-feature*: 1, 2, and (3)
	Species composition	Similarity		

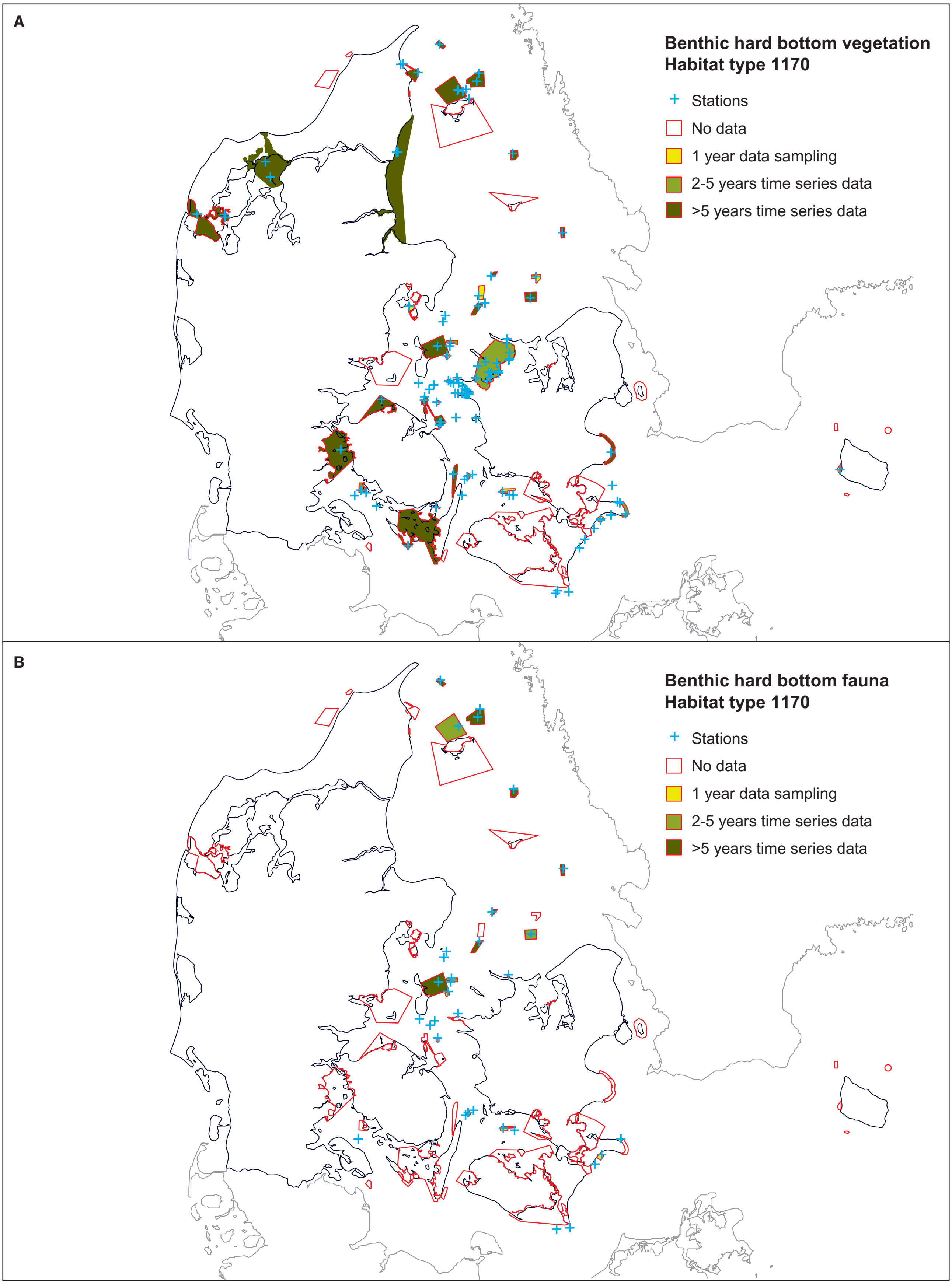


Figure 6.6.2 Natura 2000 sites designated solely or partly due to the presence of the habitat *reefs (1170)* (areas bordered with red). The maps show where *coastal vegetation* and *benthic fauna* respectively have been sampled inside the *habitat* (as blue crosses). The colour of a site indicates the length of the longest time series from a sampling station at the site.

Table 6.6.2 The Natura 2000 sites with the habitat *reefs (1170)* with the Danish SAC number and the number of sampling stations for each parameter shown. Also the number sites with sampling stations, and the number of stations sampled per parameter, according to information from the counties, are shown.

Natura 2000 sites	**Danish SAC no.**	**Vege-tation**	**Benthic fauna**	**Phyto-plank-ton**	**Zoo-plank-ton**	**Water quality**	**CTD**
Hirsholmene, the sea to the West, and the mouth of Ellinge Å	4	2				3	6
Coastal meadows on Læsø and the sea to the South	9						
Agger Tange	28	5					
Anholt and the sea to the North	42						
Helgenæs South	47	1					
Stavns Fjord, Samsø Østerflak and Nordby Hede	51	1	1				
Horsens Fjord, the sea to the East, and Endelave	52						
Fyns Hoved, Lillegrund and Lillestrand	91	2					
Æbelø, the sea to the South, and Nærå	92	2					
The sea between Romsø and Hindsholm plus Romsø	93	3					
Lillebælt	96	1					
Vresen	100	1					
Maden on Helnæs and the sea to the West	108	1					
Reefs south-east of Langeland	110						
Sydfynske Øhav	111	1					
Hesselø and surrounding reefs	112	1	1				
Saltholm and surrounding sea	126						
The sea and coasts between Præstø Fjord and Grønsund	147	1					
The sea and coasts between Karrebæk Fjord and Knudshoved Odde	148	1					
Kirkegrund	149	1	1				
Smålandsfarvandet north of Lolland, Guldborg Sund, Bøtø Nor and Hyllekrog-Rødsand	152						
Nakskov Fjord	158						
Kims Ryg	165	1	1				
Herthas Flak	166	1	1				
Lysegrund	167	1	1				
Læsø Trindel	168	2	2				
Store Middelgrund	169	1	1			1	
Briseis Flak	170	1	1				
Schultz's Grund	171	1	1	1	1	1	1
Ryggen	172	1	1			1	1
Bredegrund	173						
Hatterbarn	174	1	1				
Broen	175	2	1				
The sea around Nordre Rønner	176	3				1	
Mols Bjerge with coastal waters	186						
Røsnæs and the reef to the West	195	3	1			2	
Lønstrup Rødgrund	202						
Knudegrund	203			1		1	
Hastens Grund	204	1	1				
Munkegrunde	205	1	1				
Stevns Rev	206	1					
Klinteskov Kalkgrund	207	1					
Bøchers Grund	208	2	1				
Davids Banke	209						
Ertholmene	210						
Hvideodde Rev	211	1				1	
Bakkebræt and Bakkegrund	212						
Kalø woods and Kalø Vig	230						
Thurø Rev	242	1					
Ebbelykkerev	243	1	1				
Kyndby Kyst	245	1	1				
Number of sites sampled per parameter		36	19	2	1	8	3
Number of stations per parameter		52	20	2	1	11	8

Most of the data on *reef vegetation* is stored electronically in MADS. A private consultant has some of the data on *reef fauna* stored electronically, whereas most of the data from the 9 *reefs,* which are monitored in Kattegat is found on hand written forms only.

Long data time series on *reef vegetation* exist from many of the *reefs*. In each of 21 Natura 2000 sites there is at least one sampling station from which a data time series more than 5 years long exists. Data time series more than 10 years long exist from 10 sites. Most of the data were gathered in May-July, and some in August-October. The sampling depths are very different on the different *reefs.*

Old data on vegetation from *reefs* in Kattegat and the Belt Sea, gathered in the period 1880-1930 are not suitable as reference material for developing indicators and thresholds. This is because the algae were gathered by dredging, yielding qualitative data and unreliable depth estimates.

Among the 20 sampling stations for *reef fauna*, actual data time series exist only from the 9 *reefs*, which are monitored in Kattegat and from one *reef* in Samsø Belt.

Data on imposex effects on conchs as a result of TBT load from antifouling paints on ships exist from 3 *reefs* in Natura 2000 sites.

6.6.3 Conclusions and recommendations

Several good data series on *reef vegetation* exist from Kattegat and the Belt Sea, whereas data from the North Sea and the Baltic Sea are sparse. Provisional analyses of data from Kattegat (*Dahl et al.* in *Henriksen 2001*) indicate that an adequate platform exists for setting site-specific conservation objectives for the total vegetation cover at some *reef* localities. It is assessed that good data exists for further analysis in relation to the proposed indicators for *reef vegetation*.

So far, a limited number of analyses of data on *reef fauna* have been performed. The quality of the data should be evaluated thoroughly, and what is known about the effect of natural factors and anthropogenic pressure factors on the *reef fauna* should be made clear.

6.7 *Submarine structures made by leaking gases* (1180)

6.7.1 Identification of sub-features, pressure factors and potential indicators

These submarine structures are also called ″bubbling reefs″. They consist of sand grains and some times also some shell material cemented together with lime. The geomorphologic description of the habitat is poor. The structures can be more or less level with the surrounding sea bottom or they can be pillar-like raising several meters up from the surrounding seafloor (*Figure 6.7.1A-C*). They occur primarily in the inner Danish waters, *e.g.* in some of the proposed Natura 2000 sites in northern Kattegat. Some have also been found in the North Sea and around Great Britain (*e.g.* the Irish Sea).

It might be possible to distinguish between two sub-features as follows:

1. *Structures dominated by structuring algae communities in shallow water*
2. *Structures dominated by structuring faunal communities in deep water*

Figure 6.7.1A Submarine structure made by leaking gasses in Northern Kattegat. *Photo Dan Kaasby*

The major anthropogenic pressure factor for this habitat is eutrophication. Fishing with towed bottom gears and extraction of sand and gravel may also impact on the habitat. Hazardous substances and introduced non-endemic species may also have a negative effect on the habitat. Human induced climate change (global warming) and physical disturbance, *e.g.* from high-speed ferries or other vessels may also prove to be pressure factors in future.

Table 6.7.1 Proposals for potential indicators for assessing conservation status of the habitat *submarine structures made by leaking gases (1180)* listed according to possible anthropogenic pressure factors, the unit of measurement, the method suggested to develop the indicators and thresholds and remarks.

Pressure factors	**Indicator**	**Unit of measurement**	**Method for developing indicators and threshold values**	**Comments**
Stone fishing, gravel dredging, and possibly trawling	Area	km^2	Surveys or old data	
Eutrophication, fishing, climate change (global warming), non-endemic species	Coverage by specific indicator species of algae	%	By empirical modelling	Applicable for sub-feature 1. Depth and typology dependent
	Coverage by specific structuralizing species of fauna	%		Applicable for *sub-feature* 2. Can be reduced when algae proliferate
	Species diversity of algae	Indexes for macro-algae	By empirical modelling	Applicable for *sub-feature* 1. Depth and typology dependent
	Species diversity of fauna	Indexes for fauna	By empirical modelling	Applicable for *sub-feature* 2
Climate change (global warming), eutrophication, fishing	Rare species of plants and animals	Present/not present	New and old data	Applicable for both *sub-features*
Environmentally hazardous substances	Concentrations in biota and sediment	Concentration		Applicable for both *sub-features*
	Reproductive disorders in Viviparous blenny (lysosomal stability) – general effect indicator	Activity/frequency	Activity/frequency levels compared to a reference area	Possibly applicable for *sub-feature* 1
	Specific effect indicators for PAH-like substances (EROD)	Activity/frequency	Activity/frequency levels compared to a reference area	Applicable for both sub-features
	Imposex and intersex in snails (specific effect indicator for TBT)	Indexes for imposex and intersex		Applicable for both *sub-features*
	Species composition	Similarity		

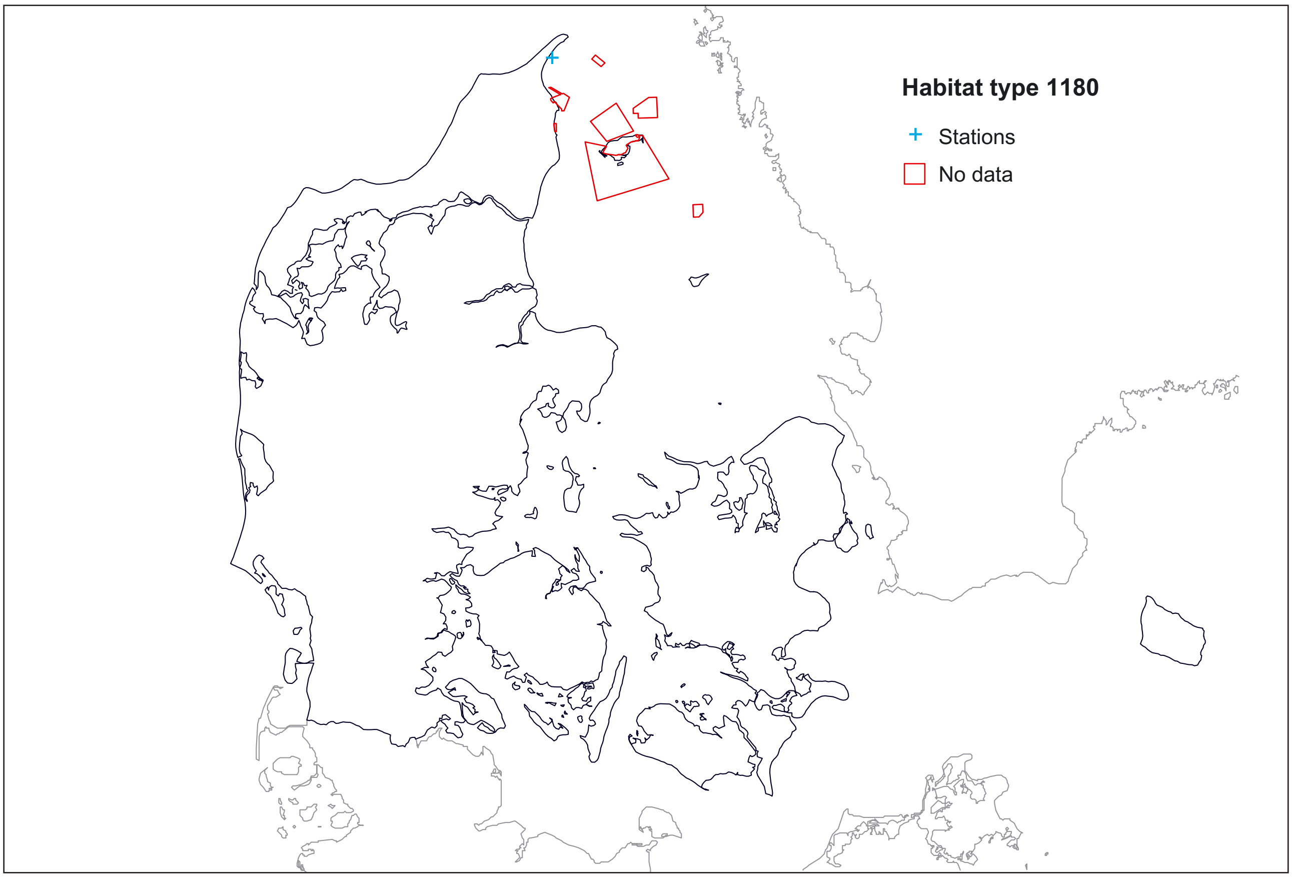


Figure 6.7.2 Natura 2000 sites designated solely or partly due to the presence of the habitat *submarine structures made by leaking gases (1180)* (areas bordered with red). The maps show where *coastal vegetation* and *benthic fauna* respectively have been sampled inside the *habitat* (as blue crosses). The colour of a site indicates the length of the longest time series from a sampling station at the site.

Table 6.7.2 The Natura 2000 sites with the habitat *submarine structures made by leaking gases (1180)* with the Danish SAC number and the number of sampling stations for each parameter shown. Also the number of sites with sampling stations, and the number of stations sampled per parameter, according to information from the counties, are shown.

Natura 2000 sites	Danish SAC no.	Vege-tation	Benthic fauna	Phyto-plankton	Water quality	CTD
Hirsholmene, the sea to the West, and the mouth of Ellinge Å	4				3	6
Coastal meadows on Læsø and the sea to the South	9					
Kims Ryg	165					
Herthas Flak	166					
Læsø Trindel	168					
The sea around Nordre Rønner	176				1	
Number of sites sampled per parameter		0	0	0	2	1
Number of stations per parameter		0	0	0	4	6

6.7.2 Available data

Figure 6.7.2 and *Table 6.7.2* show that biological monitoring and mapping data from the 6 Natura 2000 sites, which have been designated solely or partly on the basis of the habitat *submarine structures made by leaking gases* are lacking entirely.

The existing knowledge of the macroalgae and macrofauna of the habitat originates almost entirely from descriptions made by sport divers having attempted to locate and map the structures. But the chemical composition of the structure, the leaking gases and the micro-fauna of the structures have been studied scientifically. Data on *phytoplankton*, *zooplankton*, *water quality*, and *CTD* exists from two of the Natura 2000 sites. The lack of pelagial data from the sites is not considered serious, since most of the structures are located offshore. The fact that the open inner Danish waters move constantly allows us to use all available data, including data from outside the Natura 2000 sites.

Figure 6.7.1B Submarine structure made by leaking gasses in Northern Kattegat. *Photo Dan Kaasby*

6.7.3 Conclusions and recommendations

The total lack of systematically gathered data on this habitat constitutes a major problem. It is not clear at the moment whether the substrate of the "bubbling reefs" is comparable to stones from the nearby reefs as a substrate for macrophyte and animal communities. Therefore, it cannot be immediately determined whether the conservation objectives for reefs are directly applicable to submarine structures made by leaking gases.

Figure 6.7.1C Submarine structure made by leaking gasses in Northern Kattegat. *Photo Dan Kaasby*

6.8 *Submerged or partly submerged sea caves* (8330)

In Denmark, this *habitat* is found at Natura 2000 site 160, Hammeren and Slotslyngen at the island of Bornholm only.

A relatively long cave with shallow water in about 2/3 of the length of the cave was inspected in 2001. Only a single snail and a few strands of green algae were found in the water. Since the cave opens to the west, the exposure to waves is probably too great for other flora and fauna to persist there. The cave is regularly visited by leisure crafts and commercial tourist vessels, which sail into the cave.

According to biologist Henrik Jespersen from the county of Bornholm, several additional submerged caves are found in the area.

7 Guidelines for documentation of indicators

Guidelines for documenting a system of nature quality assessment using indicators made according to the Habitats Directive should be attuned to corresponding guidelines made according to the Water Framework Directive.

In order to ensure the greatest degree of objectivity and transparency in the way conservation status is assessed– specifically in defining the borderline between favourable and non-favourable conservation status – it is important to investigate and validate each indicator and its connection to anthropogenic and natural pressure factors.

This should be done by generally accepted and standardised procedures. Indicators and threshold values should basically be prepared and documented for the Annex 1 habitats.

Depending on the dependency of the indicator on salinity or other natural factors, the indicators are (i) general, (ii) type specific or (iii) site specific. The documentation requirements should be the same for all.

Documentation should generally comply with the 14 items listed in *Table 7.1*. The accompanying text is based on results from a project on criteria for conservation objectives and their documentation, initiated and financed by the Danish Environmental Protection Agency (*Pedersen et al. 2002*).

The documentation should be presented in a form similar to the data sheet for environmentally hazardous substances used in the NOVA programme. A draft is presented in *Pedersen et al. (2002)*. In this way a large and complex set of data can be presented clearly.

This project will not propose conservation objectives, indicators or threshold values, nor will it document any. Future work should include examples of indicators with data sheets. A data sheet "model" will, hereby, gradually be developed. During this process, a procedure for updating the data sheets and for developing supplementary indicators should be laid down.

Table 7.1 Draft data sheet for indicators and threshold values for a marine Annex 1 habitat based on *Pedersen et al. (2002)*. The data sheet should only contain the main information elements. Supplementary information should be in an annex.

Data sheet no. XXX	
1. Execution and approval	As part of the documentation of each indicator and threshold value quality assurance and quality control shall indicate: (i) Who has prepared the indicator and threshold value and (ii) Who has checked and approved the indicator and threshold value.

Version	Prepared by:	Checked by:	Approved by:	Date:

	Contact person:
	Performing institution:
	Approving institution:
2. SAC	State name and number of the SAC, *e.g.*: • Sydfynske Øhav (111)
3. *Habitat*	State the Annex 1 habitat in the SAC above, to which the indicator and threshold value applies, *e.g.*: • *Mudflats and sandflats not covered by seawater at low tide*
4. Quality element	State the quality element (indicator/parameter), *e.g.*: • Other aquatic vegetation (*sensu* the Water Framework Directive) • Depth limit for eelgrass • Unit of measurement: m (meter)
5. Reference state	Describe the value and variation of the quality parameter (indicator/parameter) for the Annex 1 habitat under reference conditions. Long description and the like should be in an annex.
6. Conservation objective and numeric divisions	State whether it is a general, type specific or location specific conservation objective. State the minimum (or maximum) for the indicator, i.e. the threshold value of the indicator representing a state of conservation of the Annex 1 habitat between favourable and unfavourable. Indicate the connection between the conservation objective, which has been set for the Annex 1 habitat and this threshold value of the indicator (Attaining this value is the criterion for having met the conservation objective), *e.g.*: • The conservation objective for reef 'XX' is favourable conservation status or good ecological quality. This implies, *e.g.* that the coverage % for erect perennial macro-algae at depth yy m is at least zz. • The conservation objective of sandbank ZZ is favourable conservation status or good ecological quality. This implies, *e.g.* that the oxygen concentration in the bottom water must not be less that 4 mg O_2 l^{-1}. As a minimum, the relationship between the conservation objective and the definitions of favourable and non-favourable conservation status in the Habitats Directive is described. If there is coincidence with indicators used under the Water Framework Directive, then the relationship between the conservation objective and the definitions *high, good* and *moderate ecological quality* of the Water Framework Directive is described. A table should show the numerical variation of the indicator values, divided into 2-5 classes. Classes I-V correspond to high ecological quality, good ecological quality, moderate ecological quality, poor ecological quality and bad ecological quality respectively. Classes I and II correspond to favourable conservation status. Classes III, IV, and V correspond to unfavourable conservation status. Classes IV and V are irrelevant in relation to the conservation objective and could be omitted. The values in the example below are random.

	I	II	III	IV	V
Conservation objective	>7		<7		
Class interval	12->10	10->7	7->5	5->2.5	2.5-0
Normalization	1->0.9	0.9->0.7	0.7->0.5	0.5->0.2	0.2->0

7. Data	Give a description with a table of the data used for developing the conservation objective. Describe variations in the data concerning each indicator for the habitat or type of locality (typology or type area) in question as standard deviation, minimum, maximum, median, mean, and quartile. Make a graph showing the variations and the borderline between favourable and unfavourable conservation status and perhaps also between high, good and moderate ecological quality. Longer presentations etc. should be in an annex.
8. Causality	Describe the natural and anthropogenic factors acting on the indicator, *e.g.*: • The concentration of oxygen in the bottom water depends on meteorological conditions and the rate of input of organic matter – ultimately of plant nutrients. Oxygen deficiency (< 2 mg O_2 l^{-1}) occurs only in calm periods when the water column becomes stratified and the exchange of oxygen with the atmosphere is at a minimum. During such circumstances the rate at which the oxygen concentration in the bottom water is reduced depends on (i) temperature, (ii) the biomass of respiring organisms, and (iii) the amount of readily decomposable organic matter at or near the sediment surface, the latter being largely dependent on the sedimentation of organic matter (*e.g.* phytoplankton) during the previous 10 months. • The species diversity of the benthic faunal community in fjord X depends on climatic conditions, physical disturbances due to fishing with bottom dredges and the input (by *e.g.* sedimentation) of organic matter. Cold winters with extensive ice cover reduce diversity in the following season considerably due to the extermination of species such as XX, YY. These species will normally re-establish themselves in the fjord in the course of a year. Fishing with dredges reduces the diversity of by selectively reducing stocks of species ZZ and AA. The input of organic matter influences the benthic faunal community in two ways: (i) in the long term filtrating organisms get the advantage (although the diversity does not change), and (ii) in the short term the number of days with oxygen deficiency increase, and “bottom death” occurs more often. Longer presentations etc. should be in an annex.
9. Subdividing Annex 1 habitats (Types)	If the conservation objective is general or habitat specific, then the variation between the different areas within the habitat in question must be described. This is irrelevant for site-specific conservation objectives. Longer presentations etc. should be in an annex.
10. Interpretation and weighting	Describe how the indicator values vary with the pressure factors and if they have to be weighted according to other pressure factors. Longer presentations etc. should be in an annex.
11. Monitoring	Describe to what extent the conservation objective indicators are part of existing or of future monitoring programmes. The manner in which the indicator is linked to the monitoring, which must be performed pursuant to the Habitats Directive and the Water Framework Directive should be described, including a proposal of how and at what frequency samples should be retrieved in order to make an assessment of whether the conservation objective has been met possible.
12. Scenarios	Describe scenarios of how the indicators react to changes in natural and anthropogenic pressure factors – preferably as implicit functions or models. Longer presentations etc. should be in an annex.
13. Special circumstances	Ad hoc or by reference to an annex.
14. References	To existing documentation such as: • Scientific literature • Technical reports, including guidelines from *HELCOM, OSPAR, ICES,* etc. • Monitoring reports, and • Common practice in other countries, including any EU guidelines, etc.

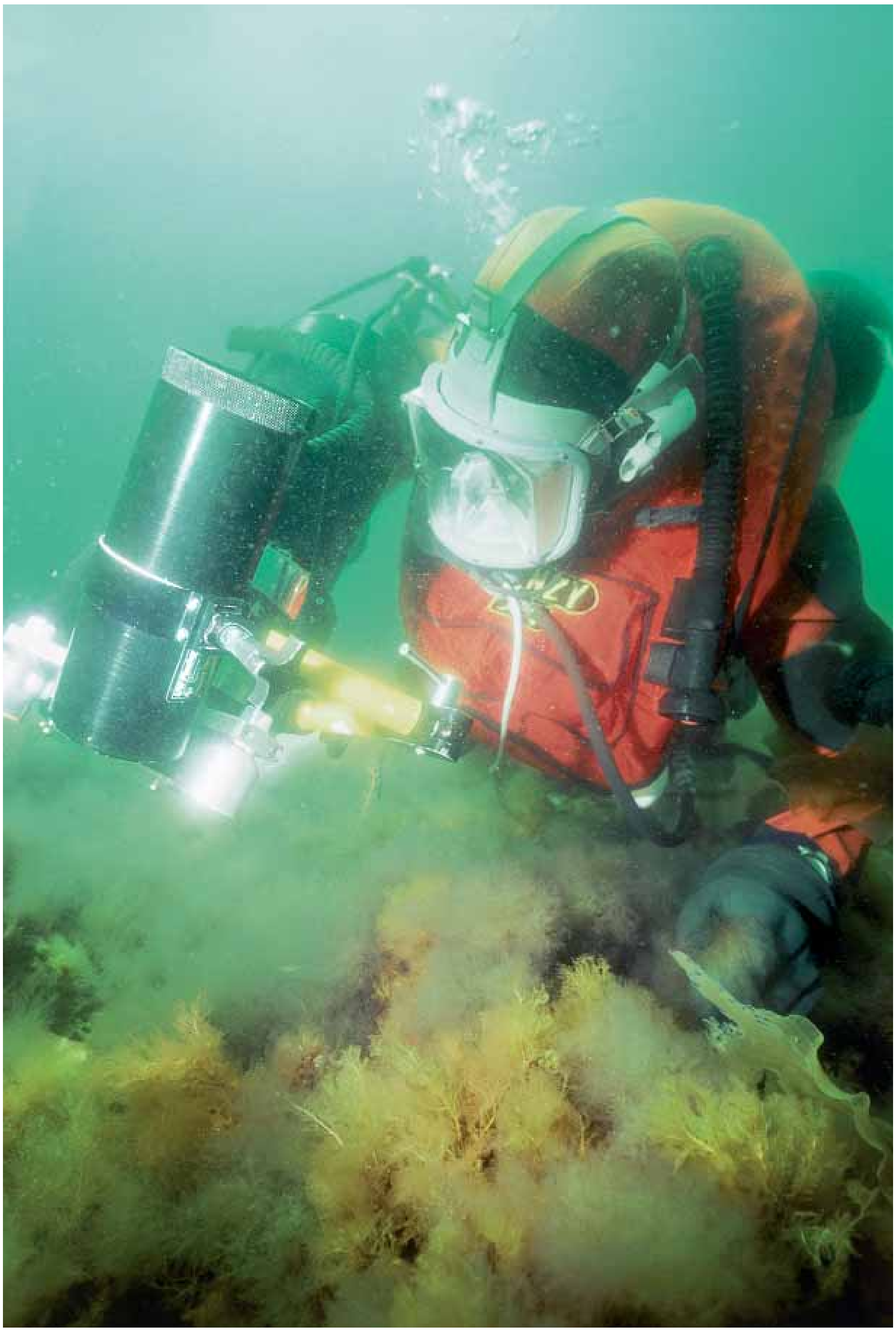


Figure 7.1 Monitoring of stone reef vegetation using scilled taxonomic divers. Observations are visible and discussed online with scilled taxonomic researchers on deck and recorded for documentation.
Photo Steffen Lundsteen

8 Discussion and conclusions

8.1 Concept for assessing conservation status of marine Annex 1 habitats

Eight of the marine habitats listed in the Habitats Directive's Annex 1 occur in Danish waters. These habitats, 213 separate sites in total, are the reason or part of the reasons for designating the marine parts of the Danish Natura 2000 network.

Marine Natura 2000 sites where Annex 1 habitats are the reason or part of the reason for the designation cover 10,584 km^2 or 74.7% of the total area covered by the Danish Natura 2000 network.

The report discusses the weaknesses of the definitions of the marine Annex 1 habitats. These habitats are defined primarily on the basis of geomorphology and not biology, as opposed to the majority of the terrestrial Annex 1 habitats. Most (perhaps all) of the marine Annex 1 habitats encompass different biological communities, which could/should be defined or at least treated as separate habitats, each with their own specific conservation objective. As a solution to this problem, it is proposed to divide the marine Annex 1 habitats into biologically based sub-features.

The biological content of a habitat is governed by a large number of natural factors such as depth, illumination, salinity, distance to nutrient sources, bottom type, and exposure to wind and currents. Consequently with the current knowledge, it can be difficult, if not impossible, to identify meaningful and universally applicable biological indicators for the evaluation of the conservation status of the Annex 1 habitats. The choice of indicators and thresholds may, therefore, be applicable in certain types or even be site-specific.

The existence of the marine habitats is not based on the presence of man, but their quality is.

The latest environmental assessment of Danish marine areas state that the quality in general is unacceptable. A reduction of pressures from many of the anthropogenic pressure factors will have a positive effect on the structure and functioning of the Annex 1 habitats. Also in this respect are the marine Annex 1 habitats different from the terrestrial ones, which often must be nursed to persist. Other pressure factors exist, such as the introduction of invasive non-indigenous species, which may result in irreversible negative impacts or former times stone fishery for harbour jetties which need restoration projects on reefs locations if habitat quality has to be regained.

The development of a quality assessment system for marine Annex 1 habitats conservation status should, ideally, be based on knowledge of the distribution extent, structure, and functioning of the Annex 1 habitat and of the biological composition in the absence of known anthropogenic pressure factors. However, we face the problem that description of impact of pressure factors in scientific and other types of literature is a rather new thing. The task – and the challenge – is to choose the levels of human impacts which can be accepted, if a favourable state of conservation is to be attained, being well aware of the fact, that one can only, to a certain degree, look back on the historic development in human impacts on nature.

The development of a system for assessing conservation status for the marine Annex 1 habitats must take the following central aspects into account:

- The marine Annex 1 habitats should be divided into biologically meaningful units (sub-features) in accordance with *JNCC*'s proposal for Great Britain.
- Knowledge of the distribution of the marine Annex 1 habitats and of their contents of biological based well-defined habitats is in general very poor and considerable effort is needed to gather such knowledge. Until this has been done, the first step is to develop an assessment system for Annex 1 habitats and/or habitat sub-features based on indicators and thresholds that reflect the general quality of the site rather than specific communities of fauna and flora.
- Most marine habitats have a depth dimension, which is central to the vegetation due to light extinction. The system of conservation objectives must take this important factor into account, perhaps by typological segregation.
- Marked structuralising natural physical and chemical gradients through the inner Danish waters strongly influence biology. Typological segregation or site-specific indicators and/or thresholds are, therefore, relevant.
- The biological systems in marine waters are generally very dynamic. Knowledge of natural variations in controlling factors is essential for the development of an assessment system for conservation status.
- Reference conditions describing a favourable state of conservation for habitats or habitat sub-features can not be based on existing environmental conditions. This makes the task of developing a biologically based conservation classification system very resource demanding.

The important first step in developing a biological based system for assessing habitat conservation status is to achieve knowledge about the chosen indicators responses to changes in important pressure factors.

The chosen indicators must all together be able to describe the status of structure, function and biological composition of the habitat or sub-feature in question and they shall function as tool to evaluate management of Natura 2000 areas in the future.

Knowledge about the relationships between indicators and pressure factors will be established using old and existing new data combined with empirical or dynamical modelling where it is possible.

When the relationships between pressure factors and indicators is satisfactory described a tools exists for the relevant authorities to set targets to be fulfilled if the habitat or its sub-features are to be assessed as having a favourable conservation status.

If there is no sufficient data, for scientific based thresholds, temporarily thresholds can be set based on judgement by experts, until proper data is available.

The ecological objectives of the EU Water Framework Directive are based on different concept. This directive state that the objectives (or status) have to be defined based on knowledge of reference conditions. The reference condition is defined as pristine conditions with no or very minor human impacts. Despite of this difference between the two directives, it is very important to ensure the highest level of harmonisation between them.

8.2 Potential attributes and presents of data for further analyses

The most important anthropogenic pressure factors have been identified for 7 of the 8 habitats present in Danish waters. Potential indicators have been identified and suggestions for methods to define their thresholds have been formulated.

The data evaluation indicates that a great amount of valuable data exists from Danish marine areas. However, dealing with specific habitat sites, this assessment also show that at present none or only sporadic data exists from many sites, making a judging of conservation status impossible in those cases.

The habitat *sandbanks which are slightly covered by seawater all the time* have few sites with good data on benthic as well as water quality variables and some other sites with rather sporadic data. The best dataset on coastal vegetation and benthic fauna can probably be used for empirical modelling, especially if accompanying data from adjacent areas are available. Subdividing the habitat into 3 sub-features will, however, reduce the amount of usable data, especially for benthic fauna. There is also some concern regarding the method used to sample benthic fauna on sandy bottom that might affect the quality of data.

It is recommended to analyse the existing data, especially data on *coastal vegetation* since all these data are presumed to be from areas of the same sub-feature "non exposed sandbanks in shallow water".

For the habitat *estuaries*, biological and physical-chemical data exist from Randers Fjord only, but it may also be possible to use data from Ringkøbing Fjord in the analyses. Changes in area covered by the habitat can be evaluated by use of existing aerial photos. For the habitat *mudflats and sandflats not covered by seawater at low tide,* biological and physical-chemical data exist from a few areas only. The exceptionally large amounts of data from the Wadden Sea should be sufficient for further analyses of this specific site.

The habitat *coastal lagoons* include several sites from which biological and physical-chemical data are sufficient for further analyses.

For the habitat *large shallow bays and inlets,* data from a large number of areas are potentially suited for developing empirical models or otherwise for delivering qualified proposals for indicators. Since the biological content of this habitat can very considerably due to natural structuring factors, the large number of sites with this habitat may represent several sub-features. Therefore, further analyses are needed in order to decide whether data are sufficient to set conservation objectives.

For the habitat *reefs,* good data time series exist for Kattegat and the Belt Sea. For the North Sea and the Baltic Sea, data are sparse. Provisional analyses of the reef vegetation data from Kattegat (*Dahl et al.* in *Henriksen 2001*) indicate that there is a good basis for setting site-specific conservation objectives for the total vegetation cover. There are sufficient data for further analyses in relation to the proposed indicators for *reef vegetation*. Data on *reef fauna* is poorly analysed. The quality of fauna data needs to be evaluated thoroughly and the relationship between fauna and anthropogenic pressure factors should be analysed.

There are no biological data at all from regional or national surveys of the habitat *submarine structures made by leaking gases*.

An inspection of the habitat *submerged or partially submerged sea caves,* located in one Natura 2000 site revealed almost no biological elements in one partly submerged cave. The reason for this is assessed to be the physical environment. Other submerged caves in the same site were not inspected.

The Danish regional and national environmental monitoring and mapping data have largely been collected according to standardised procedures since the 1980s. A large portion of the data is stored electronically. In spite of this, the process of attaining an overview of these data in connection with this project has been very time consuming, since the data were found in many different types of databases. Comprehensive analyses of data from the various Annex 1 habitats will entail some work gathering the data prior to analysing them.

The report also gives a proposal for guidelines for documenting the conservation objectives, to be described at a later stage of the process of developing a quality assessment tool for marine habitats.

Acknowledgement
Thanks to Nanna Rask for providing us with the excellent picture illustrating eutrophication effect.

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National Environmental Research Institute
Ministry of the Environment

ISBN 87-7772-800-9
ISSN 0905-815X

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