

**Report of the**

**TMAP Salt Marsh Workshop  
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**Common Wadden Sea Secretariat  
Trilateral Monitoring and Assessment Group**

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## Preface

The workshop on monitoring of salt marshes has been performed in the framework of the Trilateral Monitoring and Assessment Program (TMAP) of the Trilateral Cooperation on the Protection of the Wadden Sea.

It has the task to develop a common salt marsh monitoring program based on the ongoing national monitoring programs according to the requirements of the trilateral Targets as described in the Wadden Sea Plan (WSP 1997).

Salt marsh monitoring experts from the Netherlands and Germany participated at the workshop which was chaired by Mr. Jan Bakker from the University of Groningen. Because of organizational difficulties, the participation of Danish experts was cancelled in short time before the workshop. However, they have been included in the preparation of the final workshop report and the follow-up activities.

The workshop was organized by the Trilateral Monitoring and Assessment Group (TMAG) together with the Common Wadden Sea Secretariat and kindly hosted by the Rijksinstituut voor Kust en Zee (RIKZ) in Haren (The Netherlands).

## 1. Introduction

### *Salt marshes: Ecology, utilization and management*

The Wadden Sea salt marshes are highly specialized halophytic ecosystems on alluvial sediments, within the upper reach of tidally fluctuating seawater. They consist of (semi-) natural pioneer-, grassland- and dwarf shrub-communities, including many invertebrate animal species, which are almost always found in a clear zoning. Salt marshes also provide resting, breeding, and feeding grounds for substantial numbers of birds (e.g. geese), many of them migratory. In addition, depending upon regional and national circumstances, salt marshes have a function in coastal protection and are used as meadows (grazing and mowing).

**Table 1:** Surface area (ha) of the different salt marsh types in the Wadden Sea (QSR 1999).

Salt marsh type	Denmark	Schleswig-Holstein	Niedersachsen	The Netherlands
1. Barrier-islands:				
a. barrier-connected	2,000	220	2820	3,060
b. green beaches	1,780	660	120	0
c. foreland	0	0	0	60
2. Mainland:				
a1. mainland marsh	3,770	6,620	4,990	4,380
a2. summerpolder	0	0	1,600	1,200
b. estuarine	800	410	500	730
3. Halligen	0	2,100	0	0

All Wadden Sea salt marshes develop in a close interaction of hydrodynamical processes with vegetation development, either natural or man-enhanced. Salt marshes can be found on the barrier islands, along the mainland coast, in the estuaries and on the halligen (Table 1).

On the barrier islands, three types of salt marsh can be distinguished, all of which are mainly natural. Barrier-connected salt marshes develop at the lee side of sand dune systems of the barrier islands. The morphology shows an intricate pattern of creeks, levees and basins. Various transitions between salt marsh, beach plain, dune slacks, and dry dunes occur and may show a relatively high species diversity. Green beaches develop on high and open beach plains. Many characteristics are shared with the above type. Foreland salt marshes develop in front of some island dikes. They are more clayish and richer in organic matter and the clay-containing layer is of a greater thickness than in barrier-connected salt marshes.

Along the mainland coast, two salt marsh types, mostly artificial, are found. The first type are salt marshes situated in front of the mainland coastal plain, normally bordered by sea dikes at the landward

side, are of the above described foreland type. The development has been stimulated by regulation of both key processes: enhancement of the drainage and reduction of wave/current energy. In Denmark and Germany, there are salt marshes along the mainland coastline which are not artificial or influenced by coastal protection measures (Måde/Tjæreborg-marsken, south of Esbjerg and from Kjelst to Skallingen; St. Peter-Ording). The estuarine type resembles the foreland type, but the vegetation and invertebrate fauna show a brackish gradient, perpendicular to the normal zoning.

Halligen are splendid, populated, salt marsh islands on dwelling mounds. They have been naturally accreted on surviving parts of marshes flooded in the past, and are highly exposed to wave energy. Halligen salt marshes resemble the mainland foreland type but have a more natural morphology.

Various human activities can have an impact on salt marshes. Through coastal protection activities almost all the area of foreland-type salt marshes along the mainland coast has an oversized creek system and a reduced morphological variation by maintaining the drainage channels and brushwood groynes. Grazing by domestic animals interferes with the natural development of salt marshes. It leads to a monotonous habitat structure and, in this way, to less attractive conditions for breeding birds. Low-rate grazing, on the other hand, can increase the diversity of plant and animal species on sites. Indirect disturbances by hunting activities will, at least, show effects on the distribution and behavior of breeding and roosting birds. The construction of parking and camping places, marinas, harbors, airports and other infrastructure causes surface-sealing. Other activities, e.g. camping, hiking, and kite flying cause disturbance in the salt marshes (QSR 1999).

It is the trilateral policy to increase the area of natural salt marshes and, in artificial salt marshes, to increase the natural morphology and dynamics, including natural drainage patterns, and to improve the natural vegetation structure, without reducing the present area. An increase of natural salt marsh area may also result from reducing human interference in existing salt marshes. The four most important, interrelated, factors relevant for natural dynamics and morphology in salt marshes are erosion, sea level rise, grazing and artificial drainage.

In order to assess the progress in implementation of the trilateral Targets, salt marshes are being monitored within the Trilateral Monitoring and Assessment Program (TMAP).

### ***Development of the TMAP***

The Trilateral Monitoring and Assessment Program (TMAP) is the common monitoring program for the Wadden Sea carried out by The Netherlands, Germany and Denmark in the framework of the Trilateral Wadden Sea Cooperation. It is coordinated by the Trilateral Monitoring and Assessment Group (TMAG) which was established in 1994 to implement the TMAP. The TMAG is also responsible for the coordination of ecological research, the development of a trilateral data handling and the preparation of assessment reports of the Wadden Sea ecosystem at regular intervals.

A basic concept of the TMAP has been elaborated by the Trilateral Monitoring Expert Group (TMEG) in the period 1992 – 1993 (TMEG 1993). In 1993, the concept was adopted by the Senior Officials and the program started with a sub-set of parameters based on the existing and not yet harmonized national monitoring programs in January 1994.

During 1995 – 1997, the TMAG developed common guidelines for TMAP parameters, a trilateral data management and a proposal on the implementation of the different parts of the TMAP. Based on the workshop results, the TMAG prepared an implementation plan for the whole TMAP. Priority parameter groups were defined and different implementation scenarios were developed taking into account technical and financial implications (TMAG 1997). The work was carried out with financial support of the LIFE program of the European Commission (DEMOWAD Project) (TMAG 1998). Based on the implementation plan by the TMAG, the Ministers decided at the State Conference in 1997 to implement a Common Package of parameters including the associated data management.

Several expert workshops were organized by the TMAG in 1995 and 1996 to yield the requirements for the modification of ongoing monitoring programs and to give recommendations for the implementation of the TMAP concerning the selection monitoring parameters, methods, frequencies, areas, statistics and quality assurance.

### ***Salt marsh monitoring in the TMAP***

In the TMAP Common Package, the monitoring of salt marshes is carried out for two purposes:

1. to get basic information about changes in salt marsh development due to changes in sea level rise, coastal protection and agricultural utilization
2. to assess the progress made in implementation of the trilateral Targets.

The monitoring is also carried out to assess the progress made in implementation of the trilateral Targets (Wadden Sea Plan, 1997). The following salt marsh Targets are valid for the cooperation area:

- Increased area of natural salt marshes,
- An increased natural morphology and dynamics, including natural drainage patterns of artificial salt marshes, under the condition that the present surface is not reduced;
- An improved natural vegetation structure of artificial salt marshes, including the pioneer zone.
- Favorable conditions for migrating and breeding birds.

One of the five expert workshops organized by the TMAG was the workshop "Salt Marshes/Geomorphology/Recreational Activities" in 1995. It gave recommendation concerning monitoring of general parameters (geomorphology, sediment characteristics, hydrology, flooding), salt marsh vegetation and fauna, salt marsh management/utilization, as well as recreational activities. (Marencic et al. 1996). This concerned species and process parameters, as well as, community parameters. The focus of the workshop was mainly to develop the monitoring strategy and the design of the program. Technical details could not be discussed and were postponed to a later stage.

Based on the expert recommendations, the TMAG prepared common guidelines for salt marsh monitoring as part of the TAMP common package entailing the following parameters:

- location and area of salt marshes (every 5 years, by remote sensing methods and GIS),
- vegetation types (common classification to be prepared) (every 5 years, by remote sensing methods and GIS)
- grazing (type and no. of animals per salt marsh site and/or defined sub-areas, from official statistics or other sources depending on the national situation, every year)

Additionally, information should be obtained concerning morphology and drainage of salt marshes.

## 2. Objectives of the Workshop

Salt marsh monitoring is carried out in all countries using different methods and classification schemes which has led, so far, to a heterogeneous data basis, which is not harmonized and difficult to compare on a trilateral basis.

A large amount of GIS data is available (except in Denmark), which is updated in regular intervals (5-10 years) to document changes of all salt marshes in the Wadden Sea Area. In most cases, these data allows a very detailed insight on salt marsh development and support management decisions on a regional scale. Additionally, more detailed investigations on project basis are carried out on selected salt marsh sites for specific management questions or for scientific purposes.

The TMAP aims to harmonize the existing national salt marsh monitoring programs on a higher, less detailed level by using a common trilateral classification scheme (compatible with EU requirements). The existing monitoring schemes may remain unchanged, only the interpretation of the data will be harmonized.

The workshop should define a common classification key derived from the requirements of the TMAP Common Package and the Targets and give recommendations on the refinement of the TMAP guidelines.

The workshop has the tasks:

1. To prepare an inventory of the major differences between the present salt marsh monitoring schemes in all three countries;
2. To develop a common key or classification scheme based on existing national keys and to define the extent of GIS utilization for the following TMAP parameters:
  - Location and area of salt marshes (definition of main salt marsh types, e.g. natural salt marshes, different types of artificial salt marshes).
  - Vegetation types (definition of common vegetation types (general categories) based on existing national keys; no more than 10 vegetation types should be used.)
  - Morphology of salt marshes (definition of main morphological characteristics of salt marshes, e.g. regarding drainage pattern).
  - Agricultural management or utilization of salt marshes (definition of categories, e.g. regarding stocking rate and grazing intensity).
3. To develop proposals for refinements of the TMAP guidelines to be carried out by the TMAG.

The definition of a common criteria with regard to drainage pattern and agricultural use or management of salt marshes is necessary to prepare a trilateral inventory and a subsequent evaluation according to the Wadden Sea Plan (projects 3.2.2 and 3.2.3).

### 3. Presentations

An overview about the national programs has been compiled in **Annex 3**.

*[text to be amended]*

#### ***The Netherlands***

Salt marsh monitoring is carried out in the framework of the MWTL Program of Rijkswaterstaat. All salt marshes at the mainland coast and the islands are monitored every 5 years by aerial surveys in June-July. Aerial photographs (scale 1:5,000 and 1:10,000) are interpreted and digitized in ArcInfo in autumn of the same year. Ground truth surveys are carried out in the second year in August-September and a vegetation classification is prepared and the basis of these surveys (Koppejan et al. 1999). In future, the application of other remote sensing systems will be tested, e.g. the use of airborne scanner (HYMAP) or satellites.

Regular field surveys have been carried out on the mainland salt marshes since the mid 1960s. The development of the salt marsh vegetation is monitored on several transects. Additionally, soil level changes is calculated by sedimentation erosion bar measurements. Based on the results, management scheme were developed with regard to grazing and drainage.

The classification salt marsh vegetation is carried out according the SALT 97 program. About 10 different landscape types and 50 different vegetation types are distinguished (De Jong et al. 1998).

#### ***Germany***

In Lower Saxony, mapping of terrestrial habitats in the National Park an the islands and mainland is carried out every 5-7 years. Aerial photographs (scale 1:10,000) were taken in 1991 and 1997 during July – August. The next survey is planned in 2002. Ground truth surveys are carried out one year after the flight. The interpreted photographs are digitized in ArcInfo. Vegetation classification is based on biotope types after Drachenfels (1994). A pilot project on the application of new remote sensing techniques using HRSC (airborne scanner) has been carried out in the Elbe estuary.

Regular field surveys have been carried out at selected salt marsh areas on several transects and permanent plots (see Annex 3) by NLÖ *[to be amended]*.

In Schleswig-Holstein, surveys of total area by remote sensing are carried out every 5 years. Data are available from 1989 and 1996. Aerial photographs (scale 1:5,000) are taken in July-August and preliminary interpreted in autumn. After ground truth surveys in the following year, vegetation maps are prepared and digitized in ArcInfo.

Field surveys are carried out in the framework of the "Vorlandmonitoring" at selected reference site at the mainland coast (Hofstede, L.A. & R. Schirmacher 1996, Stock & Kiehl 2000). Beside vegetation, hydrology, morphology and sediment characteristics are compiled (see Annex 3).

#### ***Denmark***

*[no representation at the workshop – information to be added later]*

***Conclusion on the current status of salt marsh monitoring***

Salt marsh monitoring has been carried out in all countries to a large extent to support management decisions with regard to grazing, drainage and coastal protection over the last twenty years. Additionally, a lot of knowledge has been gained during several research projects from universities e.g. concerning the effects of grazing.

In the last years, the application of aerial photographs and GIS in routine monitoring was a considerable progress in establishing a sound data basis. The aerial surveys are carried out in a comparable way in the Netherlands and in Germany concerning the frequency, time of surveys, remote sensing techniques and GIS software.

The overview about the current salt marsh monitoring also showed that the applied methods vary between the three countries. Different systems for classification of vegetation or biotope types are in use. This concerns also classification of management related parameters like grazing or drainage. As a consequence, the data cannot directly be compared and used for a trilateral assessment.

In order to develop a common monitoring strategy for the TMAP, the workshop identified the following main items and discussed them in detail:

1. Monitoring of location and area of salt marshes by remote sensing
2. Vegetation type classification
3. Morphology of salt marshes - drainage pattern
4. Agricultural management or utilization of salt marshes
5. Target specification: Vegetation structure of artificial salt marshes
6. Coordination with the bird monitoring program
7. Salt marsh field surveys

The workshop identified also several important topics for future monitoring and research (Chapter 5).

## 4. Development of a common monitoring strategy

The workshop discussed the existing salt marsh monitoring programs concerning the applied methods, the comparability of the results and the possibilities to harmonize the surveys. It gave recommendations for the refinement of the TMAP guidelines and identified follow-up activities in order to improve the existing salt marsh monitoring and assessment.

### 4.1 Monitoring of location and area of salt marshes by remote sensing

Remote sensing methods are the most effective techniques to monitor all salt marshes on a broader scale. Monitoring by aerial photographs in combination with ground truth surveys are appropriate to follow the development of salt marshes and are carried out in the Netherlands and Germany. Aerial photographs with a scale of 1:5,000 – 1:10,000 (CIR) can be regarded sufficient for monitoring of location and area of salt marshes and vegetation classification (see section 4.2). The surveys should be carried out in summer (preferably in July/August) about every 5 years. Ground truth surveys are necessary for the interpretation of aerial photographs and should be pursued on selected reference areas.

The workshop identified the interpretation of the photographs as one of the most important working step. Experiences from a Dutch project revealed that photo interpretation was very subjective. The obtained results depended on a high degree on the experiences and the background of the different interpreters.

Therefore, it is necessary to develop an appropriate interpretation scheme with a standardized method in order to ensure the quality of the results. The workshop recommended that intercalibration exercises should be carried on this topic with the aim to exchange knowledge and to assess the comparability of the different approaches in the three countries.

### 4.2 Vegetation type classification

Different classification systems are applied for salt marsh vegetation in each country:

1. Netherlands: SALT 97 classification (vegetation types)
2. Germany: Lower Saxony: Biotope types (mapping key of Lower Saxony);  
Schleswig-Holstein: Vegetations types (after Schaminée et al. 1998);
3. Denmark: *[to be added]*

Each of these classification systems entail a number of vegetation sub-types with different definition e.g. concerning species composition, dominant or characteristic species, or in the case of biotope types, also information about land use.

Very detailed classification systems which are necessary for regional management purposes, may not be necessary for a trilateral assessment. Therefore, the workshop proposed to aggregate these sub-types to a higher level e.g. of plant associations which would be still sufficient to meet the requirements of the TMAP and the Targets. This information can be derived from by aerial photographs with a scale of 1:5,000 – 1:10,000.

The workshop developed a draft classification system (Table 1) which should be tested and, if necessary, further modified. The workshop decided to discuss the result of the test at a second salt marsh workshop in 2001.

**Table 1:** Proposed vegetation classification for salt marshes in the Wadden Sea

Salt marsh zonation	Vegetation classification: Dominant species <sup>1)</sup>
Pioneer zone <sup>2)</sup>	1. <i>Salicornia</i> spp./ <i>Spartina anglica</i>
Low Marsh	2. <i>Puccinellia maritima</i> 3. <i>Halimione portulacoides</i>
Middle marsh	4. <i>Festuca rubra</i> 5. <i>Elymus athericus</i> 6. <i>Artemisia maritima</i> 7. <i>Juncus gerardi</i> 8. <i>Juncus maritimus</i> (islands) 9. ( <i>Agrostis stolonifera</i> ) 10. ( <i>Lolium perenne</i> )
Estuaries / Brackish areas	11. <i>Phragmites australis</i> 12. <i>Scirpus (Bolboschoenus) maritimus</i>

Explanatory notes:

1) In general, the percentage cover of dominant species is >25%. In some cases, the coverage may be lower.

2) The pioneer zone is determined by a low vegetation cover (e.g. 5% vegetation cover). Only few species of low marsh are present (e.g. < 5% coverage by *Puccinellia*).

#### 4.3 Morphology of salt marshes - drainage pattern

By maintaining the drainage channels and brushwood groynes along the mainland coast, almost all the area of foreland-type salt marshes has an oversized creek system and a reduced morphological variation. Reduction or cessation of systematic drainage has proven to be a good method to reach a more natural drainage pattern. It is the Dutch and German policy to reduce artificial drainage with the aim of achieving a more natural drainage system and a more differentiated vegetation in accordance with the trilateral Target (QSR 1999).

The workshop recommended to monitor three different types of drainage pattern:

1. no artificial drainage in the past (number of years to be specified; sometimes only estimation possible);
2. no artificial drainage on a regular basis (maintenance works only episodic);
3. ongoing drainage measures on a regular basis (e.g. every 2-5 years).

It has to be tested if the information can be derived from the vegetation maps or if also information from other sources is necessary which would require additional effort.

Moreover, it is recommended to compile information about coastal protection measures with a direct impact on the salt marshes, e.g. construction and maintenance of brushwood groynes, sod removal and clay extraction.

#### 4.4 Agricultural management or exploitation of salt marshes

One of the main impact on salt marsh vegetation is grazing by domestic animals. Heavy grazing by cattle or sheep may lead to a destruction of the top soil layer and a decrease of perennial vegetation. On the other hand, low-rate grazing can increase the diversity of plant and animal species (QSR 1999).

Information about the management or agricultural utilization by grazing is necessary to assess the salt marsh development with regard to the TMAP objectives and the trilateral Targets. The TMAP guidelines proposed to monitor the stocking rates (number of animals per ha) to assess the grazing pressure on salt marshes.

In the Netherlands, stocking rates of salt marsh sites is difficult to obtain and to quantify at sites which are owned by local farmers. In Germany, the stoking rates can be determined for most of the salt marsh sites.

General stocking rates give an average number of animals per ha salt marsh. The workshop stated that these figures alone are not sufficient to assess the impact of grazing on salt marsh vegetation.

Important additional information like duration of grazing, time of the year and types of animals are necessary to assess grazing intensity. This information is difficult to obtain because they can vary between years and depend also on the weather conditions. This affects the structure of the vegetation and especially the pattern locally heavily (short) grazed areas and hardly grazed (tall) patches and spatial arrangement.

The workshop concluded that stocking rates alone will give only limited information about possible impacts on salt marsh vegetation. Because grazing intensity is reflected by the vegetation structure, monitoring of grazing intensity should focus on these parameters instead of stocking rates.

Three types of can be distinguished concerning grazing intensity ~~which can be obtained by aerial photographs~~:

1. no grazing (areas without any management or utilization by grazing; year of grazing ceased)
2. extensive grazing (areas with grazing; diverse canopy heights, but not a uniform vegetation and short canopy as under c, but a mosaic of short and tall canopy).
3. intensive grazing (whole area with uniform vegetation and short canopy height)

#### **4.5 Target specification: vegetation structure of artificial salt marshes**

The trilateral Target aims at a more natural vegetation structure of artificial salt marshes. The workshop stated that it would be not possible to quantify or even to give description of such a natural situation in artificial salt marshes. Because the development to a more "natural vegetation structure" is a continuous and slow process depending on the geomorphology of the given area, it would not be possible to define an end situation as a reference value. For example, artificial salt marshes without drainage and grazing may show a uniform vegetation structure compared to a natural salt marsh because of the given geomorphological conditions.

The workshop agreed to the following specification of the Target "An improved natural vegetation structure of artificial salt marshes":

- The aim is a salt marsh vegetation diversity reflecting the geomorphological conditions of the habitat.

With regard to monitoring, the development of the vegetation has to be followed over several years and to be assessed if this process is governed mainly by the geomorphological conditions or other influences.

#### **4.6 Coordination with the bird monitoring programs**

Salt marshes are important habitats for migrating and breeding birds. Information about salt marsh vegetation, grazing intensity and drainage measures is necessary to assess the results of the bird monitoring and to decide on management measures for birds.

The current salt marsh monitoring gives an overview about the summer vegetation structure every 5-6 years. Only limited information is available about vegetation structure or canopy height on yearly basis or for specific times of the year, e.g. during breeding seasons or winter/spring seasons.

The workshop stated that the different programs in the TMAP like salt marsh and bird monitoring should be coordinated as much as possible to be able to use results for different purposes thus enhancing the efficiency and quality of the monitoring program.

The workshop recommended that the Joint Monitoring Groups for Breeding and Migratory Birds should indicate which type of information is needed from the salt marsh monitoring program (e.g. parameters, time of the year, spatial pattern of short and tall canopy) to be able to evaluate the trilateral Targets.

#### 4.7 Salt marsh field surveys

Salt marsh field surveys are carried out at several sites on annual basis (see table) in combination with large scale monitoring by remote sensing.

In the Netherlands, yearly measurements have been carried out since the early 1960s. Transects from the dike to the tidal flats with grid cells and permanent plots have been established at several sites at the mainland coast and on the islands. The aim is to get more detailed information about vegetation development and sedimentation characteristics in relation to different management regimes. Measurements of seasonal and yearly soil level changes are calculated from sediment-erosion-bar measurements.

In Schleswig-Holstein, 11 reference areas have been established on the mainland coast. These reference areas are not part of the TMAP. They are monitored in the framework of the "Vorland-Monitoringprogramm" (Hofstedte & Schirmacher 1996) every one to two years concerning hydrographical and morphological parameters, sediment characteristics, vegetation types, as well as, breeding and migrating birds.

In Lower Saxony, five salt marsh areas have been regularly monitored using transects or permanent plots. [*to be amended*]

The workshop stressed the need for detailed field surveys to be able to meet the objectives of the TMAP and the Targets, to support management decisions with regard to grazing or to assess the development of sedimentation rates in different types of salt marshes with regard to sea level rise.

The workshop recommended to include field surveys which are already carried out in the Netherlands and Germany into the TMAP common package. The different monitoring strategies should be evaluated with the aim to make the existing surveys better compatible.

**Table:** Overview of salt marsh sites where field surveys are carried out

The Netherlands	Niedersachsen	Schleswig-Holstein	Denmark
Texel	Leybucht	Hindenburgdamm	Skallingen
Terschelling	Münstersommerpolder	Osewolder Koog	Rømø-dam
Vlieland	Elisab.-Außengroden.	Sönke-Nissen-Koog Vorland	
Ameland	Jadebusen	Hamburger Hallig	Højer Forland
Schiermonnikoog	Wurster Küste	Pohnshalligkoog/Nordstrand	
Rottumerplaat		Nordfriedrichskoog Vorland	
Rottumeroog		Tümlauer Bucht	
Griend		Hedwigenkoog	
Noord-Friesl.- Buitendijks		Friedrichskoog Vorland	
Penzemerlannen		Dieksander Koog-Nord	
Groninger coast		Dieksander Koog-Süd	
Punt van Reide			
Dollard			

## 5. Future topics for monitoring and research

The ongoing salt marsh monitoring programs and the existing long-term studies are necessary to get a basic overview about the salt marsh development in the Wadden Sea. They should be continued and adapted to new scientific and technical developments, as well as, to new future topics.

The workshop identified the following topics which will get more importance in the future:

### ***b. Sea level rise***

Results of long-term monitoring in the Dutch Wadden Sea showed that sedimentation in salt marshes can compensate the present sea level rise and, in most cases, bottom subsidence e.g. on Ameland, caused by gas extraction (QSR 1999). On the other hand, sea level rise may lead to an erosion of tidal flats which would also have negative consequences on the salt marshes. Therefore, also interactions between both systems, tidal area and salt marshes, have to be assessed over a longer period.

The workshop recommended to establish leveling transects in salt marshes covering on a transect from the seawall to the outer tidal flats with focus on the salt marsh edges. The cooperation with coastal protection authorities should be enhanced and the available long-term data sets should be combined.

### ***b. Outbankment***

By outbankment of summer polders new semi-natural salt marshes could be created. In the Netherlands, a project will start in Friesland Buijtendijks in July 2001 which concerns an area of 135 ha. A five year monitoring program will accompany the measure. In Lower Saxony, a 150 ha large summer polder will be outbanked on the island of Langeoog in 2001. This site was embanked in 1936 and still has some typical salt marsh vegetation. A 10-years study has been set up to monitor the effects of the outbankment concerning morphology, sedimentation, vegetation and birds.

Other examples of outbankments can be found at the Humber estuary, the Wash, the Baltic coast of Schleswig-Holstein (beach barrier system, north of the river Schlei), the Leybucht (Hauener Hoog, 100 ha, outbanked in 1995) and the Greifswalder Bodden (Karredorfer Wiesen, 350 ha, 1995).

The workshop recommended to develop a common strategy for research and monitoring activities accompanying the outbankment projects based on the experiences from the Wadden Sea and other European sites.

### ***c. Changes in land use***

Land use changes in salt marshes e.g. cessation of grazing have effects over a long time period. Experiences from existing long-term studies show that vegetation is still changing after 10 – 20 years of non-grazing. To assess the long-term effects of different grazing regimes on the vegetation, it is necessary to continue the existing long-term studies. After the long-term grazing experiment in the Leybucht was stopped; the only areas left are the Sönke-Nissen Koog Vorland and Friedrichskoog Vorland in Schleswig-Holstein.

### ***d. Drainage***

Experiments on a local scale to study different drainage techniques and their effects on the salt marsh vegetation are necessary to integrate nature conservation and coastal protection strategies.

### ***e. Aging of salt marshes***

Because most of the mainland the salt marshes are fixed and no new pioneer zone can develop, most salt marshes may develop into mid salt marshes whereas pioneer zone and low salt marsh may disappear. Without management measures, the existing salt marshes may vanish within the next 30 years. Management strategies have to be developed to counteract this serious development. Possible management options could be stimulation of cyclic erosion at selected areas or creating young salt marshes by a applying integrated grazing and drainage measures. Another option could be a protection of salt marsh edges by sand walls instead of groynes. [*text to be checked / modified*]

The workshop concluded that aging of salt marshes is a serious threat for the future. It is recommended to gain more knowledge about different management options to counteract the aging of salt marshes.

### ***f. Estuarine gradients***

In the Netherlands, several projects to restore the estuarine gradients are planned. At the moment, Lauwersmeer has not been included.

In Lower Saxony, data about estuarine salt marshes are available from the Weser estuary [?]. Only limited information is available from other estuaries. [*to be amended*]

In Schleswig-Holstein, a long term study has been set up at the Beltringharder Koog concerning vegetation and birds. Other important parameters like benthos, fish or hydrology are not measured.

The workshop recommended to include also data from estuarine or brackish salt marshes into the TMAP. Moreover, potential areas for restoration measures should be monitored, e.g. Lauwersmeer, Breebaart polder (Dollart), Beltringharder Koog or Meldorfer Koog.

## 6. Recommendations and Follow up activities

### ***Second Salt Marsh Workshop in 2001***

The workshop identified several activities which should be carried out at a second salt marsh workshop in 2001 to be held on 14- 15 November 2001 in Ribe, Denmark:

1. Draft vegetation classification

The proposed classification should be tested and the results should be compared. If necessary, the classification should be refined.

2. Remote sensing techniques and aerial photographs

The experiences with different techniques should be exchanged and the application of new methods should be discussed. The interpretation of aerial photographs should be compared during an intercalibration exercise.

3. Salt marsh transect monitoring (field surveys)

The existing monitoring strategies should be compared and proposals to harmonize the strategies should be discussed. An intercalibration exercise should be carried out to evaluate the different monitoring strategies with the aim enhance the comparability of the existing surveys.

4. Assessment procedure

A common trilateral assessment procedure should be developed taking into account the requirements of the Targets.

5. Data handling

A harmonized data handling for salt marsh data (GIS and other data) should be developed in the framework of the TMAP.

### ***TMAP guidelines***

The workshop prepared a new version of the TMAP guidelines for monitoring of salt marshes which is attached as **Annex 4**.

The current TMAP common package endorsed in 1997, entails a large scale monitoring of salt marshes based on aerial photographs with a frequency of 5 – 6 years. Monitoring of transects or permanent plots have not been included although they are carried out in long-term programs at several salt marsh sites.

Monitoring of local development of vegetation or sedimentation on an annual basis is necessary to support management decisions and to assess the results of large scale monitoring by remote sensing.

The workshop recommended to include the ongoing field surveys in the TMAP. Because different monitoring strategies for field surveys are applied in each country, the results may not be compared directly. The workshop recommended to assess the different methods and to discuss possibilities to harmonize monitoring strategies to get comparable results.

### ***Information exchange***

Furthermore, the workshop agreed to enhance the information exchange concerning developments in salt marsh monitoring and management, projects and reports and to prepare an overview about available vegetation surveys in the Wadden Sea (areas, years, scales)

The workshop welcomed the offer of Mr. Jan Bakker to broaden the scope of the "Coastal ecology" workshops of the University of Groningen to management and monitoring aspects in order to increase the cooperation between scientists and managers.

The workshop regret that no participants from Denmark could attend the workshop and urged the Danish colleagues to participate in the follow up activities.

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[to be amended]

## **Annex 1 Terms of Reference**

### **TMAP Salt Marsh Expert Workshop Terms of Reference**

#### **1. Introduction**

Monitoring of salt marshes is part of the Common Package TMAP. It is carried out in all countries using different methods and classification schemes which has led, so far, to a heterogeneous data basis, which is not harmonized and not comparable.

The workshop has the aim to develop the necessary prerequisites to meet the TMAP objectives and to allow for a trilateral assessment.

In the TMAP, the monitoring of salt marshes (all island and mainland salt marshes) is carried out to assess changes in:

- Location and area of salt marshes (natural and artificial),
  - Vegetation types,
- due to climate changes, coastal protection measures and agricultural utilization.

The monitoring is also carried out to assess the progress made in implementation of the trilateral Targets (Leeuwarden Conference, 1994). The following Targets apply to salt marshes:

- Increased area of natural salt marshes,
- An increased natural morphology and dynamics, including natural drainage patterns of artificial salt marshes, under the condition that the present surface is not reduced;
- An improved natural vegetation structure of artificial salt marshes, including the pioneer zone.

#### **2. Tasks**

The workshop has the tasks:

1. To prepare an inventory the major differences between the present salt marsh monitoring schemes in all three countries;
2. To develop a common key or classification scheme based on existing national keys and to define the extend of GIS utilization for the following TMAP parameters:
  - Location and area of salt marshes (definition of main salt marsh types, e.g. natural salt marshes, different types of artificial salt marshes).
  - Vegetation types (definition of common vegetation types (general categories) based on existing national keys; no more than 10 vegetation types should be used.)
  - Morphology of salt marshes (definition of main morphological characteristics of salt marshes, e.g. regarding drainage pattern).
  - Agricultural management or utilization of salt marshes (definition of categories, e.g. regarding grazing intensity).
3. To develop proposals for refinements of the TMAP guidelines to be carried out by the TMAG.

#### **3. Participation**

The workshop will be attended by persons who are in charge of the national salt marsh in organizational and technical aspects. The TMAG will nominate participants of the workshop and appoint a chairman. The CWSS will be responsible for the secretarial work.

#### **4. Mandate**

The workshop will be held as a TMAP expert workshop under the responsibility of the TMAG to carry out the tasks given above. The workshop will report to the TMAG on the results.

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### Annex 3 Inventory Salt Marsh Monitoring

[to be amended]

	The Netherlands	Niedersachsen	Schleswig-Holstein	Denmark [to be amended]
1. General				
1.1 Institutes	Dick de Jong, RIKZ Middelburg, Kees Dijkema, Alterra, Texel, Leo Soldaat, Meetkundige Dienst Delft	Norbert Hecker, Jörn Bunje, Nationalparkverwaltung, Wilfried Heiber, Niedersächsisches Landesamt für Ökologie	Martin Stock, Jörn Kohlhus, Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer in cooperation with ALR (coastal protection)	National Environmental Research Institute, Kalø, Ribe and Sønderjyllands Amt, Kystinspektoratet
1.2 Title	Salt Marsh Monitoring (RWS MWTL program)	Mapping of mainland and island salt marshes in the National Park	Salt marsh monitoring	
1.3 Aim	Management of salt marshes with regard to vegetation, sedimentation and sea level rise.		Management of salt marshes with regard to vegetation, sedimentation and sea level rise.	
2. Aerial surveys		By NLPV		
2.1 Area and frequency	Total area, every 5 years, in June/July	Total area every, in 1991 and 1997 (planned: every 5 - 7 years), in July/August, next flight in 2002	Total area, every 5 years. (1989, 1996), in July/August	Selected areas, irregular surveys
2.3 Methods	Aerial photographs, scale 1:5,000 or 1:10,000, false color, 60% overlap, stereoscopic interpretation. Ground truth (verification one year after aerial survey)	Aerial photographs, scale 1:10,000, CIR, stereoscopic interpretation. Ground truth (interpretation key, 543 reference areas, verification one year after aerial survey).	Aerial photographs, scale 1:5,000 or 1:10,000, CIR, interpretation. Ground truth (verification one year after aerial survey)	
2.4 GIS	Digital vegetation maps, Calculation of changes in salt marsh area, vegetation-zones, vegetation types and species.	Analog maps digitized in ArcInfo.	ArcInfo, digital vegetation maps, calculation of changes in salt marsh area, vegetation zones, vegetation types and species.	
2.5 Classification	Vegetation types SALT 97 (about 50 different sub types and 10 landscape types).	Mapping key of Lower Saxony (Drachenfels 1994). Saltmarsh biotope types: Tidal flats with vegetation (Spartina flats, Salicornia flats), Lower salt marsh (2 sub-types), Upper salt marsh (6 sub-types).	Vegetation types and complexes (Schaminée et al. 1998), translation tables with 500 groups, vegetation zonation maps (8 groups).	
3. Field surveys		By NLÖ		

	<b>The Netherlands</b>	<b>Niedersachsen</b>	<b>Schleswig- Holstein</b>	<b>Denmark [to be amended]</b>
3.1 Area and frequency	Selected transects and sedimentation fields (since mid 1960s, every 5 years, last years annually).	Selected salt marsh areas with permanent plots (every 1 – 5 years), ground truth and aerial photographs	8 salt marsh reference sites (mainland), every year, transects and permanent plots.	Hojer foreland since 1981-83 (Uni Copenhagen), Sakallingen, start in 1965/70 (Uni Aarhus), irregular sampling.
3.2 Vegetation	Vegetation types (50 different types, SALT 97).	Vegetation types, (after Braun-Blanquet).	Basic info are vegetation units, translated into vegetation types, zonation, dominance, canopy height, biomass. Vegetation maps after Schaminée et al. 1998. Other parameters: birds, morphology, sediment characteristics, management measures.	Species coverage, permanent plots and transects.
3.3. Sedimentation	Sdimentation rates (sedimentation-erosion bars).	Height and sedimentation (several measurement points), by NLWK (coastal protection).	Sedimentation-erosion bars planned in 2001.	?
3.4 Leveling	Several transects [?]	Levelling: two transects (Norderney, Hilgenriederstel).	Leveling transects on reference areas.	?
<b>4 Data handling</b>	GIS, Database at RIKZ [?], geographical data in ArcInfo, others in Excel	GIS, database at NLPV, geographical dat in ArcInfo, others?	GIS, database at NPA, geographical data in ArcInfo, others in Excel, Oracle data base planned.	?
<b>5 Quality assurance</b>	Guidelines "Standaardvoorschrift Kweidekartierung" February 1999	[guidelines?]	No guidelines	?

## **Annex 4 Proposal Draft TMAP Guidelines Salt Marshes**

### **1. Salt Marshes**

#### **1.1 Objectives**

The monitoring of salt marshes (all island and mainland salt marshes) is carried out to document the development of salt marshes in the Wadden Sea in order to obtain sound basic information with regard to the TMAP Issues of Concern and the trilateral Targets.

##### *TMAP Issues of Concern*

Monitoring of salt marshes is carried out assess changes in

- location and the area of salt marshes (natural and artificial),
  - vegetation types
- due to climate changes, coastal protection measures, and agricultural utilization (e.g. grazing).

##### *Trilateral Target (Wadden Sea Plan 1997)*

The habitat type salt marshes includes all mainland and island salt marshes, including the pioneer zone. Also the brackish marshes in the estuaries are considered part of this habitat.

The following targets apply to salt marshes:

- an increased area of natural salt marshes;
- an increased natural morphology and dynamics, including natural drainage patterns of artificial salt marshes, under the condition that the present surface area is not reduced;
- an improved natural vegetation structure of artificial salt marshes, including the pioneer zone;
- favorable condition for migrating and breeding birds.

#### **1.3 Monitoring areas**

- whole Wadden Sea area
- selected areas for field surveys

#### **1.4 Total salt marsh area by remote sensing techniques**

##### **a. Frequency and time**

- every 5 years (a higher frequency may be appropriate for selected areas, e.g. because of changes in management)
- during summer: June-August

##### **b. Methods**

Aerial photographs (CIR) with a scale 1:5,000 - 1:10,000 should be obtained. Ground truth surveys are necessary for the interpretation of aerial photographs. The digitized photographs should be transferred to a Geographical Information System. Standard software should be used. [Geo-reference points, *to be included*]

Intercalibration exercises should be carried out to assess the comparability of different interpretation procedures.

##### **c. Parameters**

###### *Location and area*

Spatial extent of salt marshes (total area and vegetation types) should be calculated for sub-areas by GIS procedures

###### *Vegetation types*

Different classification systems are applied for salt marsh vegetation in each country. They entail a number of vegetation sub-types with different definition e.g. concerning species composition, dominant or characteristic species, or in the case of biotope types, also information about land use. These detailed classification systems are necessary for regional management. For trilateral purpose these sub-types have been aggregated to a higher level. A draft classification system (Table 1) has been developed which is currently in its test phase. GIS calculation should be carried out applying the common vegetation classification.

**Table 1:** Common vegetation classification for salt marshes in the Wadden Sea (draft version)

Salt marsh zonation	Vegetation classification: Dominant species <sup>1)</sup>
Pioneer zone <sup>2)</sup>	<ul style="list-style-type: none"> <li>• Salicornia spp./ Spartina anglica</li> </ul>
Low Marsh	<ul style="list-style-type: none"> <li>• Puccinellia maritima</li> <li>• Halimione portulacoides</li> </ul>
Middle marsh	<ul style="list-style-type: none"> <li>• Festuca rubra</li> <li>• Elymus athericus</li> <li>• Artemisia maritima</li> <li>• Juncus gerardi</li> <li>• Juncus maritimus (islands)</li> <li>• (Agrostis stolonifera)</li> <li>• (Lolium perenne)</li> </ul>
Estuaries / Brackish areas	<ul style="list-style-type: none"> <li>• Phragmites australis</li> <li>• Scirpus (Bolboschoenus) maritimus</li> </ul>

Explanatory notes:

1) In general, the percentage cover of dominant species is >25%. In some cases, the coverage may be lower.

2) The pioneer zone is determined by a low vegetation cover (e.g. 5% vegetation cover). Only few species of low marsh are present (e.g. < 5% coverage by Puccinellia).

#### *Vegetation structure of artificial salt marshes*

The trilateral Target aims at a more “natural vegetation structure” of artificial salt marshes. Because the vegetation structure in artificial salt marshes depends on the geomorphology of the given area, it is not possible to define an end situation as a reference value. For example, artificial salt marshes without drainage and grazing may show a uniform vegetation structure compared to a natural salt marsh because of the given geomorphological conditions.

With regard to monitoring, the development of the vegetation has to be followed over several years and to be assessed if this process is governed mainly by the geomorphological conditions or other influences.

#### *Grazing*

The effects of the management or agricultural utilization of salt marshes by grazing are reflected in the vegetation structure. Three types can be distinguished concerning grazing intensity [~~which can be obtained by aerial photographs~~]:

- no grazing (areas without any management or utilization by grazing; year of grazing ceased)
- extensive grazing (areas with grazing; diverse canopy heights, but not a uniform vegetation and short canopy as under c, but a mosaic of short and tall canopy).
- intensive grazing (whole area with uniform vegetation and short canopy height)

Additional information like stocking rates and types of animals should be also important to assess grazing intensity.

#### *Drainage system*

Three different types of drainage pattern of salt marshes should be distinguished:

- no artificial drainage in the past (number of years to be specified; sometimes only estimation possible);
- no artificial drainage on a regular basis (maintenance works only episodic);
- ongoing drainage measures on a regular basis (e.g. every 2-5 years).

It has to be tested if the information can be derived from the vegetation maps or if also information from other sources are necessary which would require additional effort.

It is recommended to compile information about coastal protection measures with a direct impact on the salt marshes, e.g. construction or maintenance of brushwood groynes, sod removal and clay extraction.

## 1.5 Field surveys

Salt marsh field surveys should be carried out at several sites on annual basis in combination with large scale monitoring by remote sensing. They are necessary to meet the objectives of the TMAP and the Targets, to support management decisions with regard to grazing or to assess the development of sedimentation rates in different types of salt marshes with regard to sea level rise.

The existing field surveys are carried out using different monitoring strategies. They should be harmonized with the aim to make the results of the different surveys comparable for a trilateral assessment.

### a. Frequency and time

- annual surveys in reference areas
- during summer

### b. Methods

Different methods are in use which have to be made comparable before they can be implemented in the TMAP

### c. Parameters

- Hydrology: mean high tide, mean low tide, inundation time and frequency,
- Morphology: height, salt marsh edge, topography,
- Sediment characteristics,
- Coastal protection measurement,
- Biological parameters: vegetation (types, zonation, dominance/diversity, canopy height and pattern therein, biomass), breeding and migrating birds

## 1.6 Quality assurance

A successful monitoring program is directly related to the collection and interpretation of relevant and reliable data. In addition to appropriate sampling and interpretation procedures, it is vital to establish a system of data quality assurance. This concerns accuracy and precision of sampling and analytical procedures, regular check of the applied methods and intercalibration exercises.

Presently, a common strategy to implement quality assurance procedures in salt marsh monitoring is not available. The EU funded BEQUALM project (parallel to QUASIMEME) mainly focuses on biological effects monitoring and on taxonomic aspects of benthos and plankton communities.

Specific QA activities for salt marsh monitoring should be carried out for the following items:

- intercalibration exercises concerning interpretation of aerial photographs,
- field surveys: comparability of different monitoring strategies, intercalibration exercises.

## 1.7 Reporting requirements

The monitoring data should be stored in datafiles at best as GIS covers or standard databases. The existing data storage should be harmonized as far as possible based on the existing systems. This means mainly the usage of databases and geographical information systems. This would make it easier to compile, to deliver and to assess the data on trilateral level.

The reporting should entail information on used methods and any other information relevant for an assessment of the data. The data can then be delivered to the TMAP data unit, to make it available for trilateral assessment.

The monitoring data of the data originators is mostly stored in GIS covers, databases or spread sheets. The information including the meta data has to be delivered to the national TMAP Data Units where it will be transferred into the trilateral harmonized TMAP database structure.

The monitoring results should be reported annually and made available via the TMAP data unit. Data delivery to the TMAP data unit has to be organized on the national level.

## **1.8 Monitoring authorities**

### **Denmark**

- Danmark Miljøundersøgelser (DMU, Kalø),
- Ribe Amt,
- Sønderjyllands Amt,

### **Germany**

- Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer, Tönning,
- Amt für ländliche Räume, Husum,
- Nationalparkverwaltung Niedersächsisches Wattenmeer, Wilhelmshaven,
- Niedersächsisches Landesamt für Ökologie, Forschungsstelle Küste,

### **The Netherlands**

- Rijksinstituut voor Kust en Zee (RIKZ),
- RWS Meetkundige Dienst Delft,
- Alterra, Texel,
- RWS Directie Noord Nederland.