BERNET CATCH

Network on the implementation of
EU Water Framework Directive
in the Baltic Sea Catchment

BERNET CATCH Regional Report:

Odense Fjord, Water Management Plan

Provisional Management Plan pursuant to the EU Water Framework Directive

January 2006

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Introduction

This Water Management Plan "*Odense Fjord, Water Management Plan, Provisional Management Plan pursuant to the Water Framework Directive*", is a part of the BERNET CATCH project.

BERNET is a network co-operation between seven regions from seven countries around the Baltic Sea. BERNET CATCH focuses on the integrated management of catchments and the regional implementation of the EU Water Framework Directive (WFD). Through the activities in BERNET CATCH, the partners wish to prepare the regional implementation of the WFD, and evaluate the different regional solutions to the implementation of the WFD. In BERNET CATCH every partner has to make a provisional Water Management Plan for a pilot river basin.

The basis of this management plan is a result of the following activities/products:

- Article 5 reporting (Odense Pilot River Basin - Provisional Article 5 Report pursuant to the water framework directive, Fyn County November 2003)
- Reporting on program of measures (coastal waters, lakes, watercourses, groundwater's, and nature (wetlands)) including economy of measures
- Monitoring program according to WFD
- Involvement of public stakeholders

This management plan is mainly focussing Odense Fjord, and do not fully present an integrated Water Management Plan including all waters (watercourses, coastal waters, lakes, ground waters and wetlands) in the pilot river basin. The BERNET resources and timetables do not fit the making of a fully management plan in details including all waters and all relevant pressures within the pilot river basin.

A fully management plan of "Odense Pilot River Basin" will be elaborated in connection with the LIFE-founded project "Odense PRB-AgriPom-Agricultural Programme of Measures", which ends summer 2007.

The program of measures is a central part of a management plan. Such programs tell what to do to assure "good ecological quality" in every part of the aquatic environment in the river basin by 2015. I.e. how to reduce outlets of nutrients from point sources and diffuse sources.

The aim of the Water Framework Directive is to assure good ecological quality in all parts of the aquatic environment by 2015. This aim has to be fulfilled through the making and implementation of Water Management Plans.

The program of measures presented in this management plan is only focusing on the management of eutrophication problems related Odense Fjord, and includes thus programs of measures regarding outlets of sewage from households and industries, and outlets from agricultural activities. Specific measures related lakes, groundwaters, rivers and wetlands are not included yet.

The making of programmes of measures is an iterative process illustrated in figure 1.1, involving stakeholders and political decisions.

The programme of measures related Odense Fjord is one of many programmes of measures for all the waters within Odense Pilot River basin. These waters enter all together the Odense Pilot River Basin Water Management Plan. Programmes of measures regarding rivers, lakes and groundwater within Odense Pilot River Basin are also included in this reporting. These programs of measures are at the moment made individually for each type of water, and the programs are not balanced against each other. Some of the measures targeted Odense Fjord, will also enhance the protection of groundwater's, lakes and rivers. Vice versa there will be measures targeted the protection off rivers, lakes and groundwater's, which affect the protection of Odense Fjord. Therefore the final Odense Pilot River Basin Water Management Plan has to harmonize the different programmes of measures targeted the different waters to ensure that you get value for money.

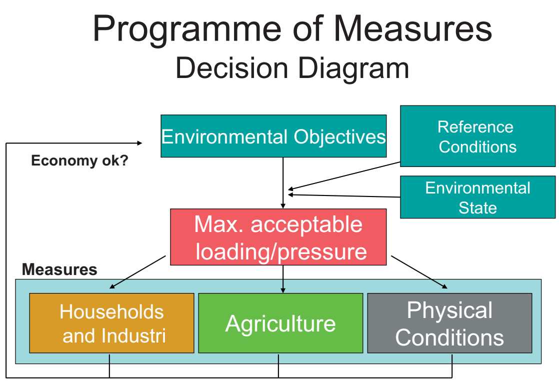
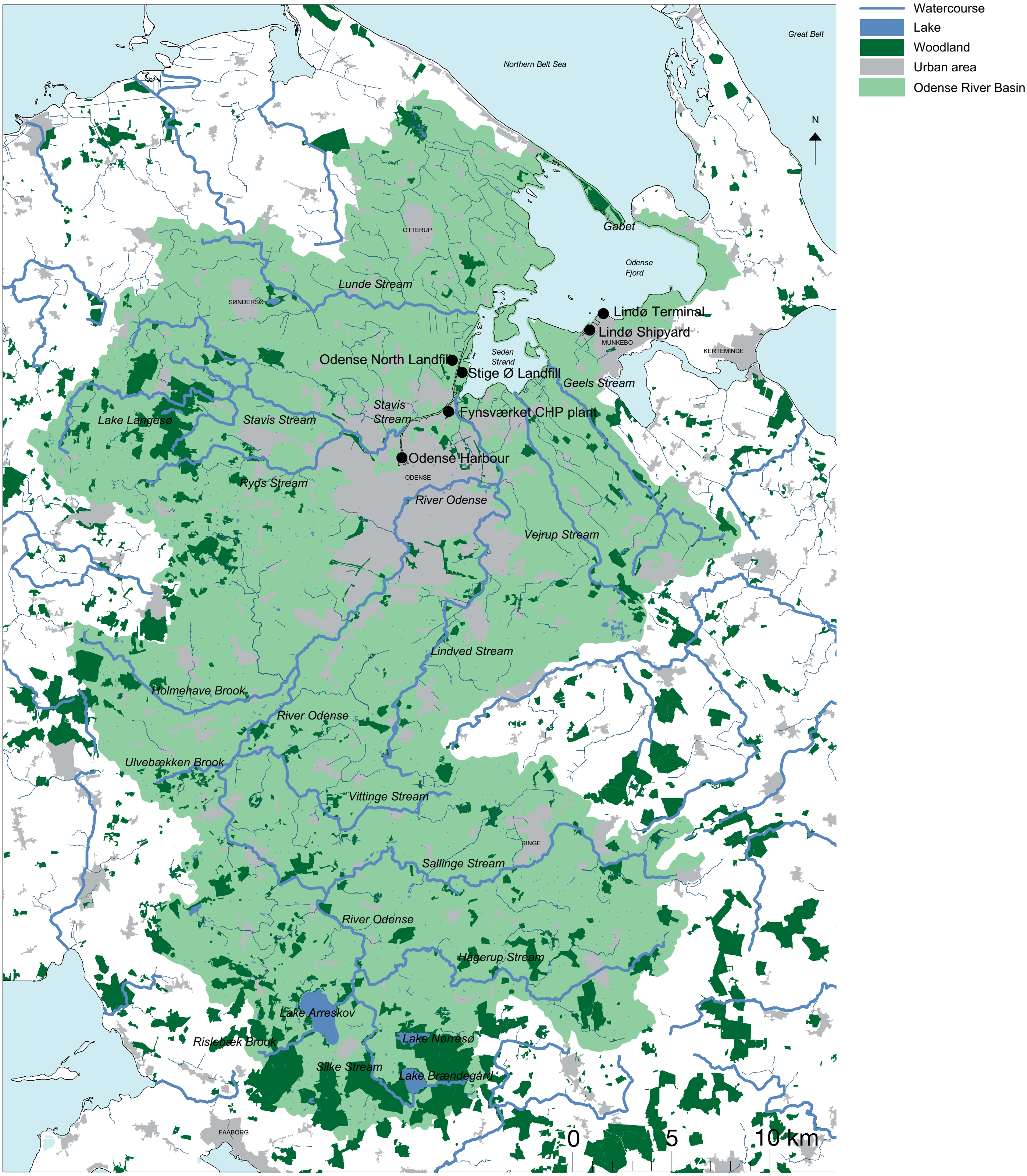


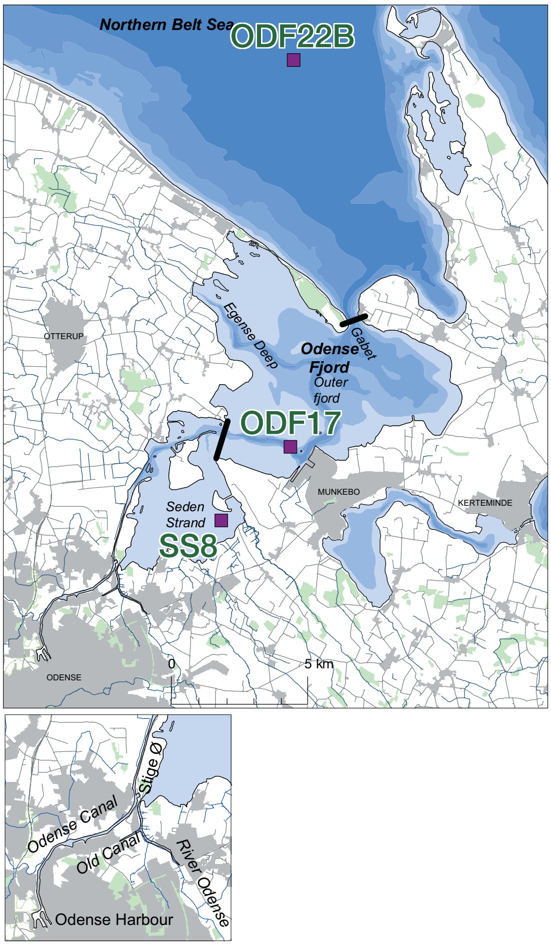
Figure 1.1
Making programmes of measures – Decision diagram.


Watercourse
Lake
Woodland
Urban area
Odense River Basin
N
Great Belt
Northern Belt Sea
Gabet
Odense Fjord
OTTERUP
Lunde Stream
SØNDERSØ
Lindø Terminal
Lindø Shipyard
MUNKEBO
KERTEMINDE
Seden Strand
Odense North Landfill
Stige Ø Landfill
Geels Stream
Stavis Stream
Lake Langesø
Fynsværket CHP plant
Odense Harbour
ODENSE
Ryds Stream
River Odense
Vejrup Stream
Lindved Stream
Holmehave Brook
River Odense
Ulvebækken Brook
Vittinge Stream
RINGE
Sallinge Stream
River Odense
Hågerup Stream
Lake Arreskov
Lake Nørresø
Lake Brændegård
Silke Stream
FAABORG
0
5
10 km

1. Description of the geographical area

1.1. Odense Fjord

Odense Fjord is a shallow (mean depth 2.25 m), mesohaline estuary located in the northern part of Funen. The area under water is 65 km^2. The fjord can be subdivided into a small inner fjord called Seden Strand with a mean depth of 0.8 m, and an outer fjord with a mean depth of 2.7 m (figure 1.1a).



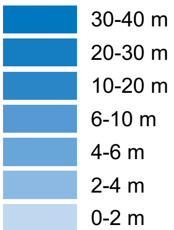
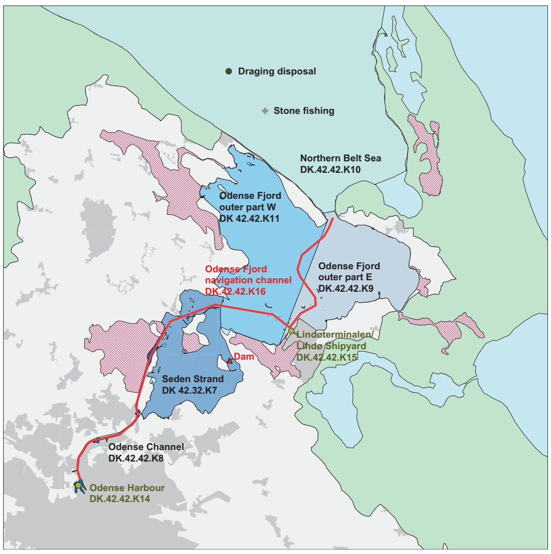


Figure 1.1a
Map of Odense Fjord indicating the boundaries of the inner fjord (Seden Strand) and outer fjord. The three monitoring stations, SS8 in Seden Strand, ODF17 in the outer part of the fjord and ODF22B in the boundary zone outside the fjord are indicated.



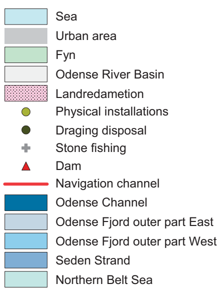


Figure 1.1b
Water bodies in Odense Fjord, numbered according to the Article 5- analysis of Water District 42, Fyn County (Fyns Amt 2004) .

Fjord types	No. of water bodies		
	Natura 2000 protected	Not protected	Total
Inner fjord (SS)	1	0	1
Outer fjord (ODF)	1	1	2
Heavily modified water bodies			17
Total no. of water bodies			20

Table 1.1a
Total No. of water bodies in Odense Fjord.

Heavily modified water bodies in Odense Fjord	
Harbours	2
Navigation routes, fairways and channels	2
Dykes, dams and boardwalks/bridges	1
Drained former fjord areas	12
Total	**17**

Table 1.1b
Heavily modified water bodies in Odense Fjord.

By far the largest source of freshwater input to the fjord is the river Odense, which feeds into the inner part of Seden Strand. Water exchange between the fjord and the open marine water (Northern Belt Sea) takes place via the mouth of the fjord called Gabet. Using a hydrodynamic model (MIKE 3) it has been calculated that the residence time for river Odense water in the fjord is low, around 17 days (annual mean) for the fjord as a whole and nine days for Seden Strand (DHI, 2000).

Ecoregions, typology and water body designation

Odense Fjord belongs to ecoregion 4, the North Sea, pursuant to the Water Framework Directive but to the Baltic Sea (Baltic bioregion) pursuant to the Habitats Directive.

At the national level Odense Fjord is subdivided into two types and thus water bodies – the inner fjord called Seden Strand and the outer fjord called Odense Fjord, outer part.

A water body must consist of a single type of water body, and can only be designated to a single ecological status class. According to the EU Guidance Document "Identification of water bodies", protected areas have also to be taken into account, and in cases where only parts of a water body are designated as protected areas, subdivision into several water bodies can be considered. Heavily modified water bodies, including drained areas, are also delineated as separate water bodies. According to these criteria, Odense Fjord is subdivided into three major water bodies and 17 heavily modified water bodies, in total 20 water bodies (table 1.1a-b and figure 1.1a).

1.2 Running waters and lakes

There are 316 stream water bodies totalling 1,115 km in length within the Odense Pilot River Basin (OPRB) (fig.1.2a). Three stream types are recognized on the basis of size-related parameters (catchment size, length from source, stream width, and stream order). Their catchment size, total length and the number of designated water bodies are as follows:

Stream types	Catchment size (km^2)	Total stream length (km)	Number of Water bodies
Type 1	<10	661.6	225
Type 2	10-100	216.4	45
Type 3	>100	52.7	11

There are 2,620 lakes and ponds larger than 0.01 ha within the OPRB. With one exception, only those larger than 5 ha are considered here. Former, now drained lakes are also considered as water bodies (fig. 1.2b).

Among 11 national lake types (defined only for lakes >5 ha), only three occur with certainty within the OPRB. Their characteristics and the number of designated water bodies (i.e. lakes) are as follows:

Lake types	Lake type characteristics				No. of lakes/water bodies
	Alkalinity	Colour	Salinity	Depth	
9	High	Low	Low	Low	11
10	High	Low	Low	Deep	1
11	High	Low	High	Low	1?
6	Low	High	Low	Deep	1

1.3 Groundwater

36 ground water bodies are designated in the Odense Fjord Pilot River Basin covering an area of 722 km^2 which is 61 % of the total area (fig. 1.3).

Almost all ground water bodies are located in aquifers consisting of sand.

29 ground water bodies are in contact with surface waters – typically streams and lakes. This could influence on the environmental status of the surface water. 26 water bodies have contact all year round while 3 ground water bodies only have contact to the surface water during the winter.

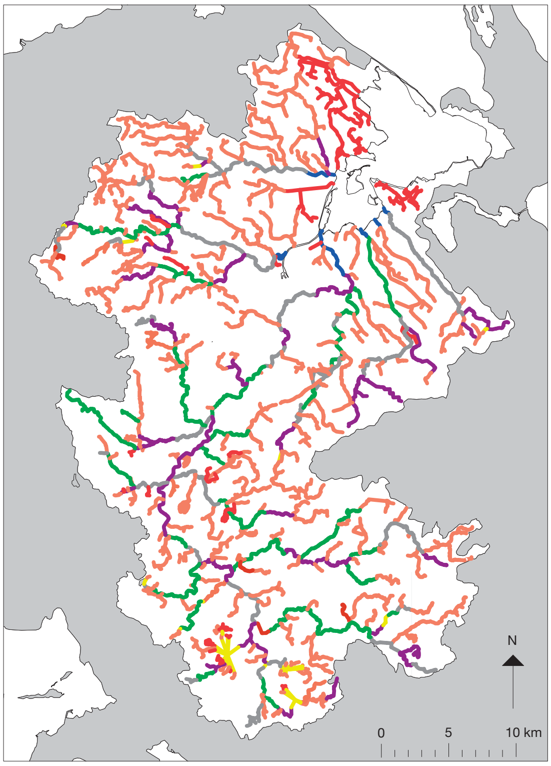


Figure 1.2a
Stream water bodies in the OPRB.
Water Bodies

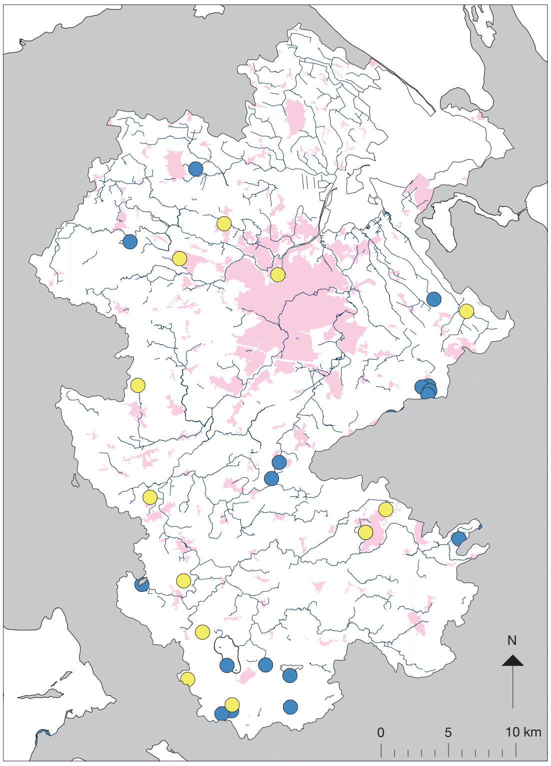


Figure 1.2b
Lake water bodies in the OPRB.
Lake
Former lake (drained land)
Watercourse
Urban area

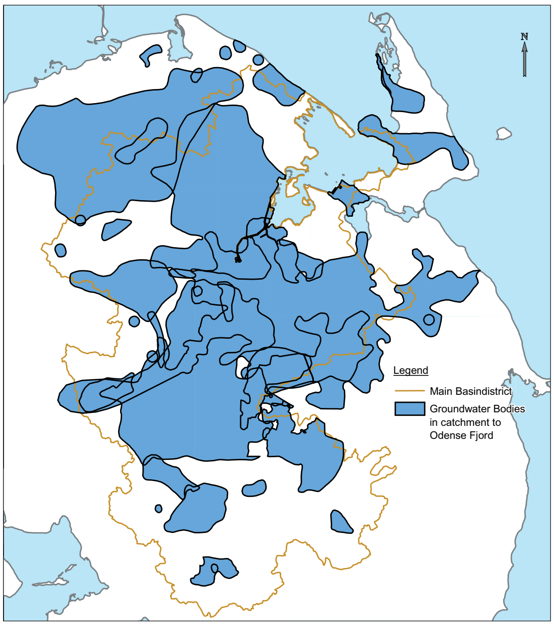


Figure 1.3
Designation of ground-water bodies in the OPRB.

Agriculture

The dominant crops grown in Odense River Basin are winter- and spring cereals accounting for around 2/3 of the total area with crop production, (table 1.4a). Live stock density (LU/ha) is around 1 LU/ha for the total catchment with pigs accounting for around 60% of the total LU's, (figure 1.4d).

Application of nitrogen and phosphorus to the grown field in the catchment is about 11.400 tonnes of nitrogen and 1.900 tonnes of phosphorus, (table 1.4a). Thus, the mean annual area specific application rates for the farmed land only (69.000 ha) have been around 165 kg N/ha and 28 kg P/ha. Manure accounts for around 73% of the applied phosphorus and around 40% of the applied nitrogen. The live stock production (meat, milk and eggs) has increased by around 40% in the periode 1985-2003.

1.4 The catchment

Odense River Basin encompasses an area of approx. 1060 km². Key figures characterising the catchment are listed in Table 1.4a.

Topography, landscape and soil types

The topography of the catchment (figure 1.4a) shows almost no points reaching heights above 100m's, (compared to Danish zero). This lowland catchment - in this respect - being very much alike the general topographic characteristics of eastern Denmark. The most common landscape feature is moraine plains covered by moraine clay. Clay soil types are slightly dominant and encompass approx. 51% of the total are, while the sandy soil types cover approx. 49%.

Land use, population and waste water

Just as elsewhere in Denmark, land use in Odense River Basin is dominated by agricultural exploitation, (table 1.4a and figure 1.4.b). Thus, farmland accounts for around 64% of the land use in the catchment. Of the remainder, approx. 13% is accounted for by urban areas and around 11% is woodland. Finally, inland fresh waters and natural countryside covers around 11%.

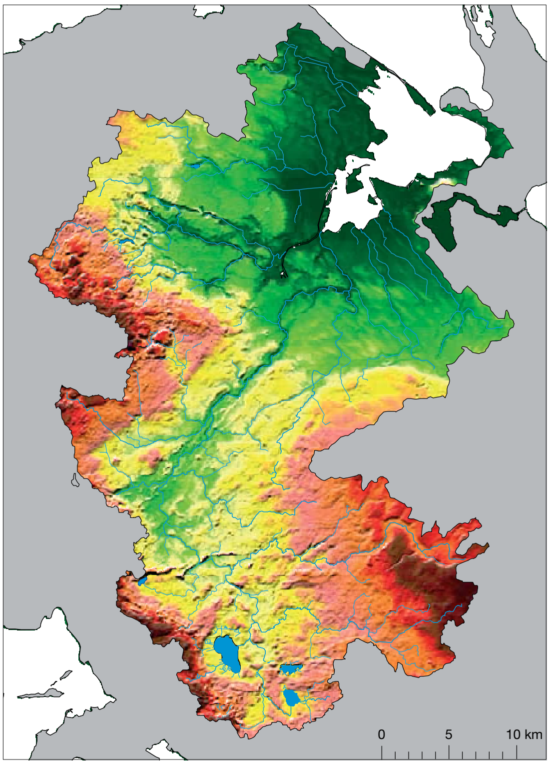
The population of Odense River Basin numbers around 240.000 inhabitants corresponding to 226 inh./km². 90% of the sewage produced by the inhabitants is discharged to municipal sewage treatment plants, the remaining part (10%) being produced outside the town areas. As an overall mean for the catchment around 244 tonnes of nitrogen and 22 tonnes of total phosphorus is discharged with sewage water, (table 1.4a).

Table 1.4
Key characteristics for the catchment to Odense Fjord.

Key characteristica for the catchment	
Catchment area km²	1058
Population	
Total (thousands)	240
Density (inh./km²)	226
Landuse (%)	
Urban areas	13
Cultivated land	64
Woodland	11
Inland waters and natural countryside (mires, meadows etc.)	11
Crop distribution, % of farmed area ***	
Winter cereals	45
Seed crops	8
Pulses	2
Grass/green fodder	10
Permanent grass	4
Root crops	5
Market gardens	3
Spring cereals	23
Nitrogen application (tonnes N) (agriculture*)	
Manure	5000
Art. fertiliser	6400
Total	11400
Phosphorus application (tonnes P) (agriculture*)	
Manure	1370
Art. fertiliser	530
Total	1900
Sewage outlets **	
Total Nitrogen (tonnes N)	244
Total Phosporus (tonnes P)	22
Climate ****	
Precipitation, mm	825
Discharge, mm	305
Temperature, °C	8.4

* Mean for 1999-2002.
** Mean 1999/2000-2003/04.
*** Mean 2003.
**** Mean 1990-2000

Topography



Land Use

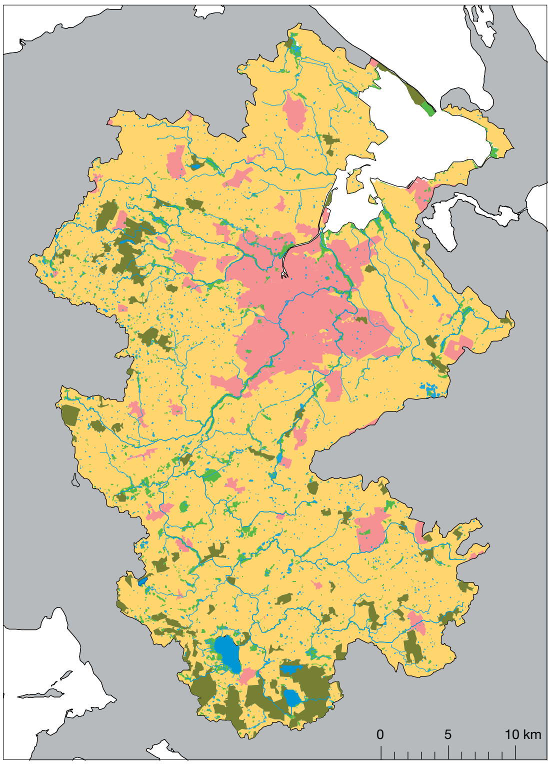


Figure 1.4a (left) Topography of Odense River Basin.

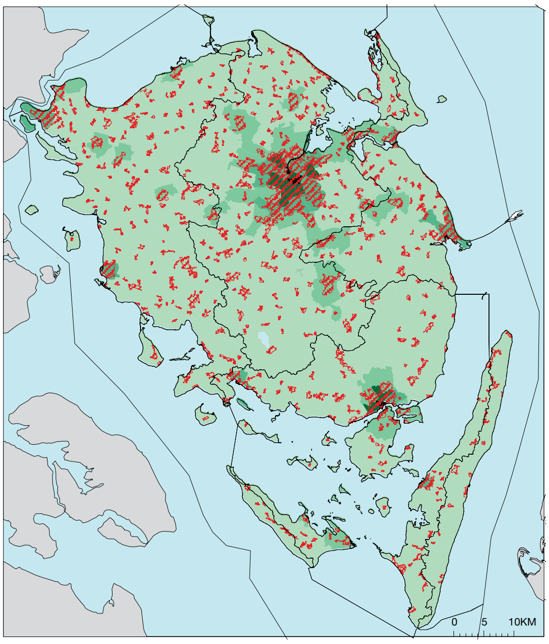
Height above Danish Zero Level

- 0-10 m
- 10-20 m
- 20-30 m
- 30-40 m
- 40-50 m
- 50-60 m
- 60-70 m
- 70-80 m
- 80-90 m
- 90-100 m
- 100-110 m
- Over 110 m
- Watercourse

Figure 1.4b (right) Land Use in Odense River Basin.

- Urban areas
- Cultivated land
- Woodland
- Inland waters (lakes, watercourses)
- Natural contryside (mires, meadows, etc.)

Population density



Livestock density

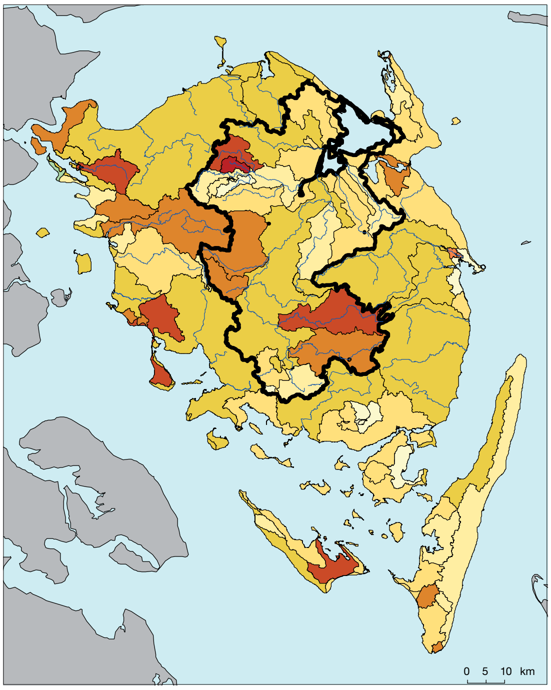


Figure 1.4c (left) Population density. Odense River Basin is indicated.

Population density
inhabitants/km²

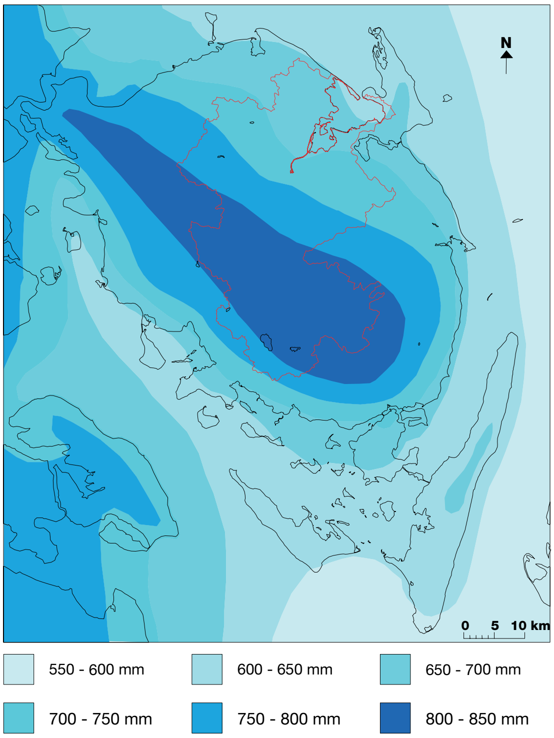
0	til	150
150	til	500
500	til	1.500
1.500	til	3.500
>3.500		

Urban area

Figure 1.4d (right) Livestock density in Odense River Basin 2002 in relation to the area of farmed land in the sub-catchments.

- 1.4 and above
- 1.2-1.4
- 1-1.2
- 0.8-1
- 0.6-0.8
- 0.4-0.6
- 0-0.4
- no information

Figure 1.4e
Average annual precipitation (1961-1990). Odense River Basin is indicated.



Precipitation, fresh water discharge, temperature

Precipitation over the Odense River Basin is at its highest in the southern part of the catchment, (figure 1.4e) and significantly lesser over the northern, near coastal land areas. For the period 1990-2000 mean precipitation was around 825 mm/y leading to the discharge of 305 mm/y freshwater from the catchment as an overall annual mean for the same period. Mean annual air temperature is around 8°C.


Photo: Jan Kofod Winther

2. Pressures and risk analysis

2.1 Pressures

The water bodies in the catchment area draining to Odense Fjord and the fjord itself are impacted in different ways by natural (background) and antropogenic pressures. Some of the most important antropogenic pressures are illustrated in figure 2.1a.

Nutrients as phosphorus and nitrogen are discharged to surface waters and towards the ground waters with sewage from different sewage water sources and from farmed land. Hence, nutrient loading of most surface water bodies (streams, ponds, lakes, fjord) in the catchment are well above the natural 'background' loadings causing eutrophication of these water bodies. Hazardous substances (pesticides, heavy metals etc.) are discharged from point sources and/or diffuse sources. Emissions to atmosphere from farms, industry and the transport sector are either deposited in the catchment or exported. Some of the total deposition (i.e. of ammonia) is imported from sources outside the catchment. The hydrological cycle itself is impacted by water abstraction, drainage of farmed land, canalisations of streams, stream maintenance (i.e. weed cutting).

The pressures and the effect of these on environmental quality will vary across the catchment area and depend on the character and vulnerability of the different water bodies (streams. lakes, fjord etc.). The major pressures in the catchment have been quantified and to a wide degree geographically distributed, (GIS). Some of the most important of these pressures are illustrated and commented below.

Eutrophication of surface waters

In general almost all the surface waters in the catchment are eutropic due to the pollution with nutrients (nitrogen, phosphorus) discharged with sewage or lost from the farmed land. The degree of eutrophication will vary between the different specific water bodies. As an – typically – example the eutrophication is illustrated for the Odense fjord, (figure 2.1b). As a mean for the period 1999/2000-2003/2004 around 44 % of the total phosporus loading to the fjord was due to sewage outlets, 25 % was due to loss from farmed land, thus leaving 31% to the natural reference ("background") loading. Reference loading is estimated assuming a 'reference' concentration of 0.05 mg P/l in the total discharge to the fjord. The corresponding figures for the total Nitrogen loading to the Odense Fjord are: Sewage (13 %), agriculture (69 %) and reference loading (18%). The latter figure estimated by assuming a 'reference' concentration of 1 mg N/l in the total land based discharge. The diffuse nitrogen pollution in the sub-catchments varies according to variations in farming intensity and application of artificial fertiliser and manure to the fields. Some of the variation in the diffuse nitrogen load is illustrated in figure 2.1e.

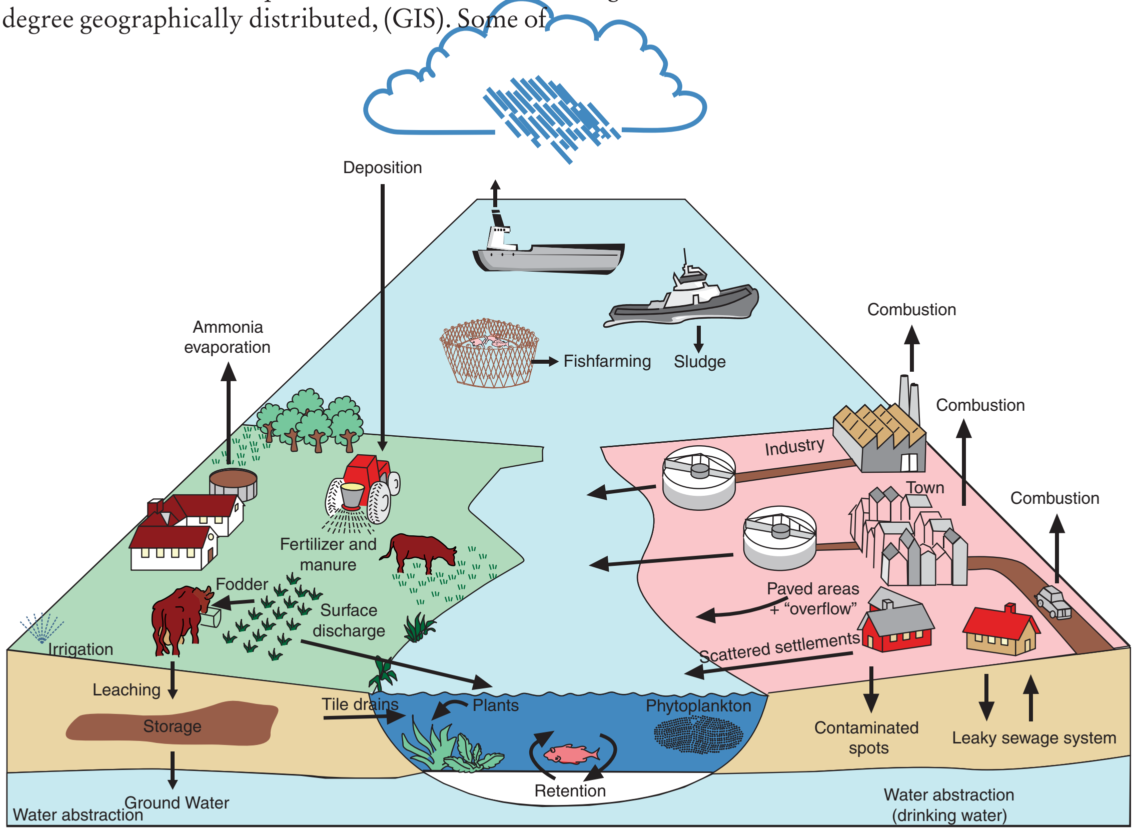


Figure 2.1a
Draft of important pressures of the environment.

Agriculture Pressure
Nitrogen

Significant key-indicators

1. Fertilizer use
   - High fertilizer use in catchments imply risk of high leaching
2. Animal density
   - High animal density implies risk of low nutrient utilization and therefore high leaching and high ammonia evaporation
3. Retention capacity
   - A high retention capacity in catchments can help to remove nitrogen when it is leached from the soil to the water bodies

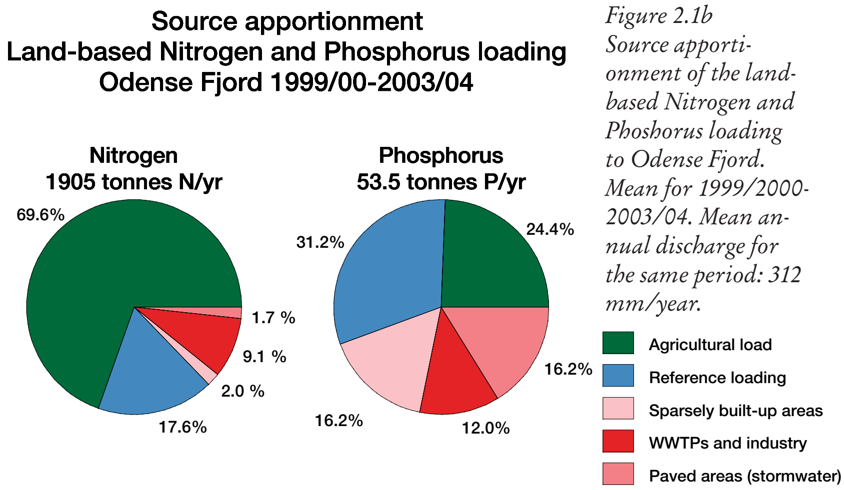


Figure 2.1b
Source apportionment of the land-based Nitrogen and Phoshorus loading to Odense Fjord. Mean for 1999/2000-2003/04. Mean annual discharge for the same period: 312 mm/year.

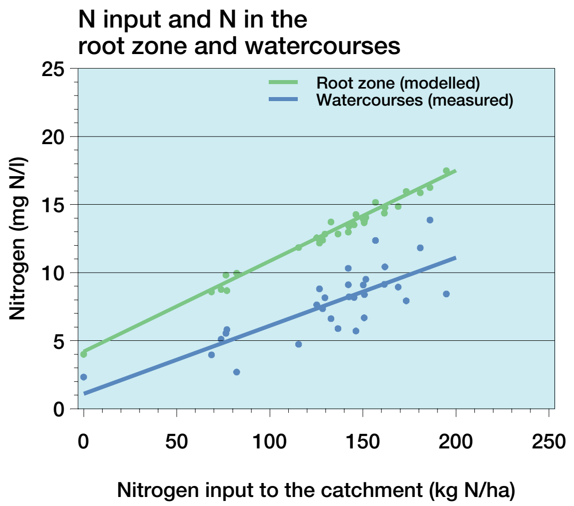


Figure 2.1c
Nitrogen concentration in water courses and root zone water (1m b.g.s.) on Fyn as a function of nitrogen input to the individual catchments (mean values: 1990-2000).
The root zone concentrations are modelled using a simple leaching model. The water course concentrations are measured.

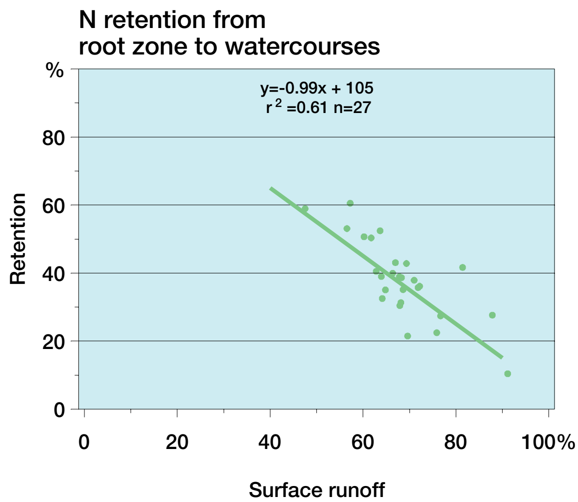


Figure 2.1d
Nitrogen retention during transport from the root zone to water courses as a function of the relative share of rapid runoff to the water courses.

The impact of the land based loading on the nutrient concentrations in the fjord is clearly seen in figure 2.2 showing for the period 1985-2004 the co-variation in the nutrient loading and the nitrogen and phosphorus content of the surface waters in the fjord. Phosphorus loading has been hugely reduced by around 75% during the last 20 years due to improved sewage treatment. A lesser reduction (around 35%) is seen in the nitrogen loading. This latter reduction caused by a combined effect of improved sewage treatment (around 10-15%-points) and a reduction in diffuse pollution from farmed land, (around 20-25%-points).

Some overall indicators of the pressure from agriculture are listed in the Box. Further more the relations between nitrogen concentrations in root zone (modelled) and streams (measured) in 27 catchments in Fyn County and the total amount of nitrogen applied with manure and artificial fertiliser in these catchments are shown in figure 2.1c. Although this relation is rather significant the impact of agriculture on water quality in streams (nitrogen) also depends on catchment specific hydrological characteristics. If the degree of surface run off (tile drains etc.) is relatively low, a significant higher proportion of leached nitrogen from the root zone of the grown fields is retained in such catchment compared to the lower retention in catchments where discharge in streams primarily consists of surface near run off, (figure 2.1d).

Nitrogen deposition from the atmosphere

Atmospheric nitrogen deposition is significantly increased compared to 'pristine' deposition due to the emissions and subsequently deposition of nitrogen (NH_x, NO_x) from antropogenic sources. Actual mean figure for the deposition over land areas is around 20 kg N/ha (wet- and dry deposition). For the near coastal marine waters the annual deposition is around 12 kg N/ha (Figure 2.1.f). The nitrogen deposition shows the highest figures in areas with high farming intensity due to deposition of locally emitted ammonia from the farms in these areas. However, for the total catchment a significant part (60-70%) of the depo-

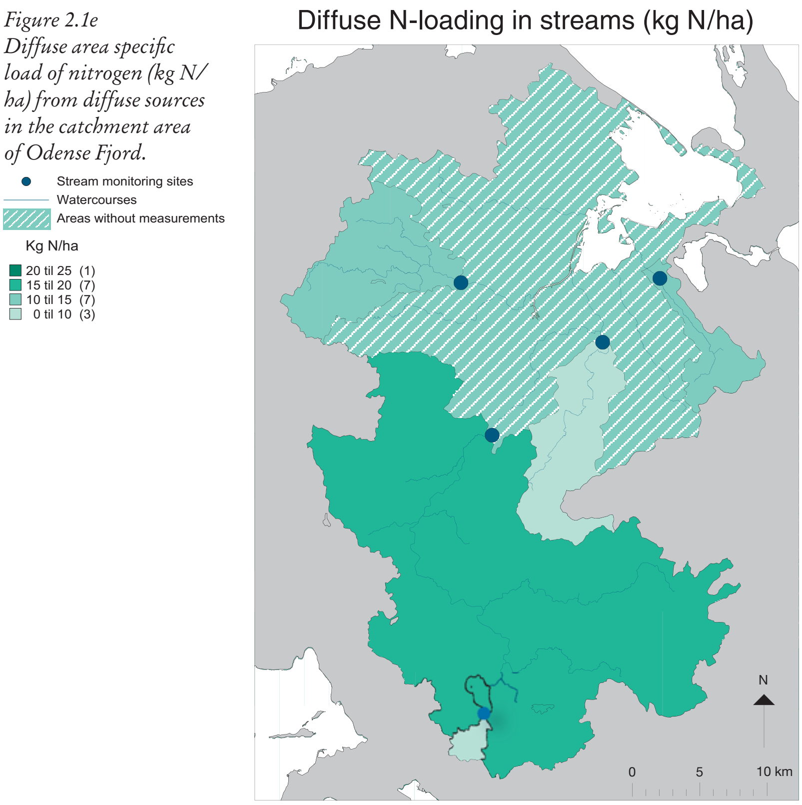
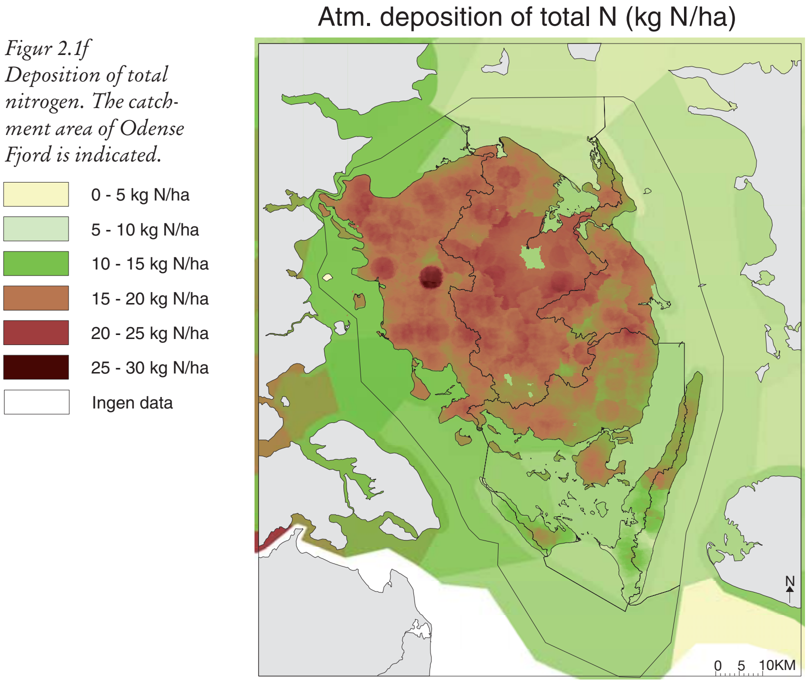


Figure 2.1e
Diffuse area specific load of nitrogen (kg N/ha) from diffuse sources in the catchment area of Odense Fjord.



Figur 2.1f
Deposition of total nitrogen. The catchment area of Odense Fjord is indicated.

sition is imported from emission sources outside the catchment. This deposition contributes to the general eutrophication of the environment.

Impact on groundwaters

The pressures on ground water quantity and quality is due to water abstraction and the actual or potentially future leaching of water enriched in hazardous matters (i.e. pesticides) or nutrients as nitrate. Leachings of nitrates is related to intensity and type of farming activity. However, for most aquifers high capacities of denitrification in the soils overlaying these aquifers effectively reduce most of the leached nitrate. The assessment of the pressures actually or potentially threatening the quality of the ground waters has been an ongoing activity for many years. As an example the distribution of specific contaminated sites is shown in figure 2.1.g.

Physical impact

The fjord

The most important physical impacts on the Odense Fjord are caused by harbours, navigation channels and land reclamation (see figure 1.2). Odense Harbour, Lindø Shipyard and Lindø Terminal are installations of considerable size that have entailed major physical changes to the fjord's natural coastline. In addition, a number of minor harbours and quays are situated in the fjord. Navigation channels have been excavated in connection with the harbours, and these have to be dredged every few years. This dredging work periodically places marked physical pressure on the fjord, especially in the form of large amounts of resuspended sediment that reduces the transparency of the water column and causes sedimentation on the seabed.

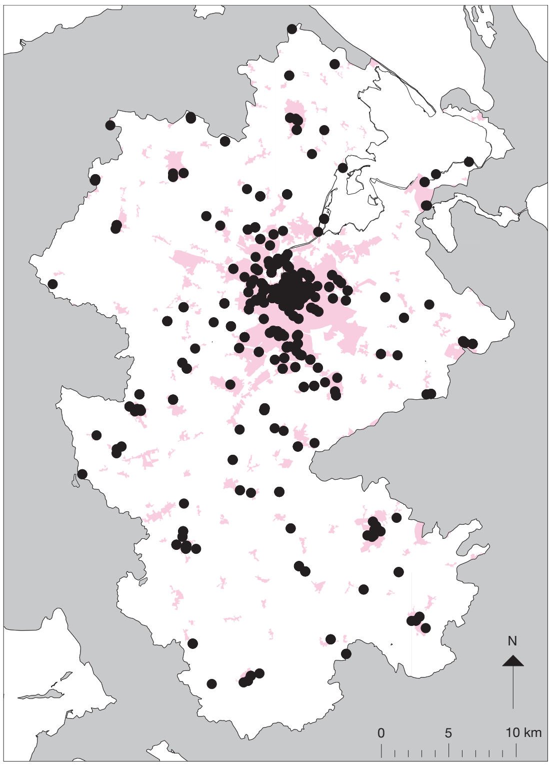
The catchment

During the years a significantly number of watercourses, lakes, ponds and wetlands within the catchment has experienced significant physical changes. In the Odense Fjord, approximately 20% of the former water covered area has disappeared due to land reclamation (fig. 1.2 and 2.1h). The development in the number and quality of the wetlands illustrates the general trend. Thus, 72% of meadows, fens and mires have disappeared since 1890 (Fig. 2.1h), whereas 34%, 22% and 12% of the remaining wetlands are impacted by drainage, filling-up and excavation, respectively. About 66% of the present-day watercourses are significantly modified due to piping, straightening and deepening. Additionally, there are numerous obstructions that prevent spawning migration of trout, and physical management (including weed cutting) still significantly reduce the biological diversity of macrophytes in most streams. Although probably 75% of small shallow lakes and ponds have disappeared during the last 100 years, the remaining larger lakes are only slightly physically impacted. Furthermore, besides the obvious significance of these changes for the quality and quantity of the aquatic environment an important effect of these changes has been considerably reduced the capacity of the fjord and catchment to retain nitrogen and phosphorus.

Photo: Søren Larsen

*Sea lettuce (*Ulva lactuca*) dominated the vegetation of the inner fjord (Seden Strand) in the 1980-90'ies.*

Contaminated sites



Meadows and bogs, 1890 and 1992

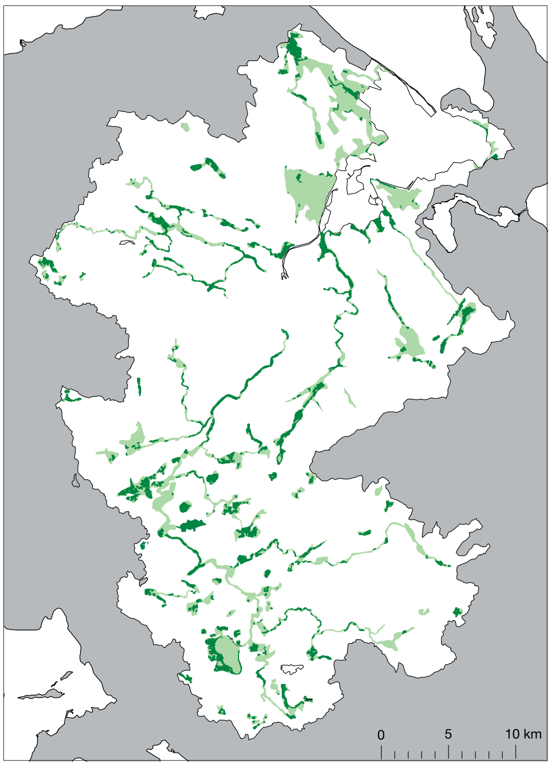


Figure 2.1.g (left) Distribution of contaminated sites.

● Contaminated sites

Urban area

Figure 2.1.h (right) Distribution of meadows and bogs in the catchment area, 1890 and 1990.

Distribution in

1890

1992

*Widgeon grass (*Ruppia maritima*) has returned to the inner fjord in the late 1990'ies, but is still affected by filamentous algae.*

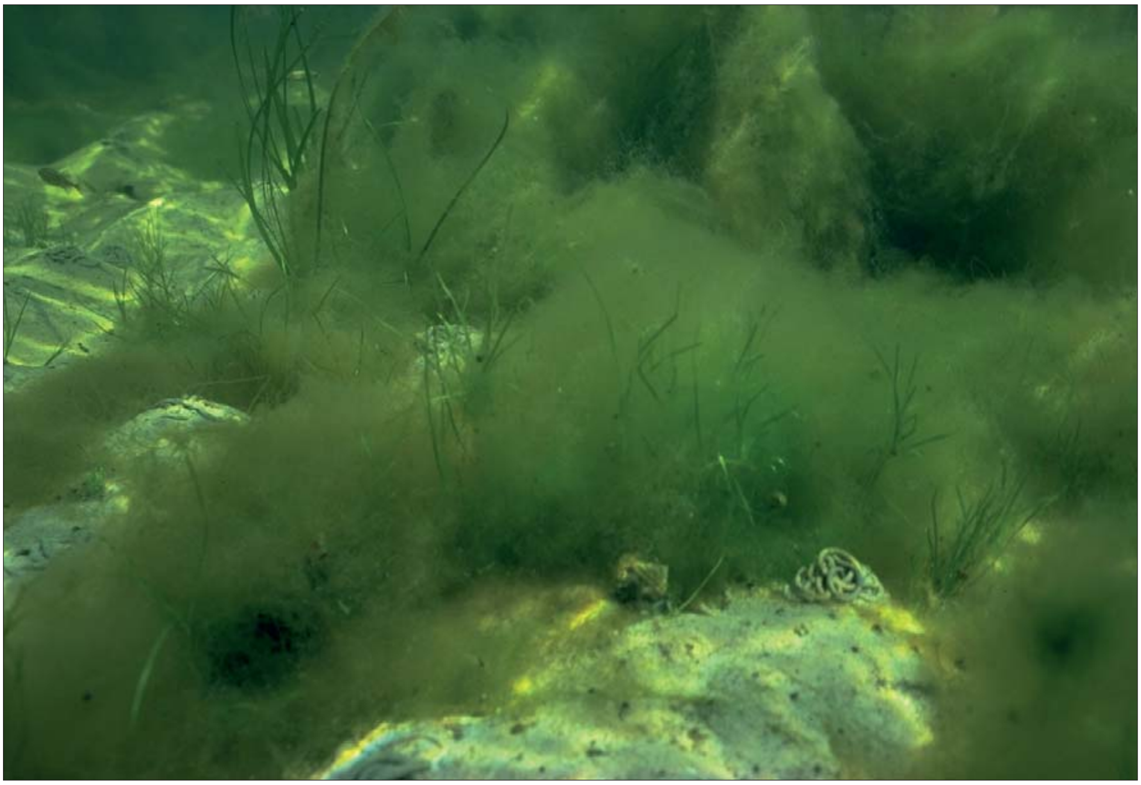


Photo: Nanna Rask

2.2 Risk analysis, the fjord

The risk analysis for coastal waters, is first of all based on the aims stipulated in the Regional Plan for Fyn County. It must be stressed that this procedure, that do not follow the guidelines of The Water Framework Directive, is decided by the national authorities. However, in case of the Regional Plan for Fyn County, the aims largely conform with "good ecological quality" according to the Water Framework Directive. The quality objective for most of the fjord is "fish waters for angling and/or spawning and nursery grounds for fish"(general/basic quality objectives), which corresponds to the WFD "good ecological quality". The remainder of the Odense Fjord has been designated as "a reference area for scientific studies" (stringent quality objectives). It is at present a matter of discussion in Denmark, whether this stringent objective will be fulfilled by WFD "good ecological quality". No part of the fjord has been designated with "eased" aims that may be equivalent to moderate or even poorer ecological quality. The first step of the risk analysis is to estimate the present status of the water bodies. Secondly, the status is extrapolated to the 2015 situation taking into account (a) expected developments in all relevant pressures, and (b) already planned and decided programmes of measures (related to these pressures) that are not directly associated with the WFD.

The present status of Odense Fjord

The present ecological status of the Odense Fjord is described by nutrient levels and by eutrophication effects as well as impact of hazardous substances on animals and plants.

Due to the reduction in nutrient inputs, the nitrogen concentration in the water in the inner part of Odense Fjord (Seden Strand, station SS8) has decreased from approx. 2.5 mg N/l to approx. 1.8 mg N/l), while the phosphorus concentration has decreased from approx. 0.6 mg P/l to approx. 0.1 mg P/l (figure 2.2.).

Trend in source-apportioned annual nitrogen and phosphorus loading from land-based sources together with the annual mean concentration in the surface water at station ODF17 in the outer part of Odense Fjord.

The nitrogen concentration in the fjord is closely related to nitrogen input. In years when freshwater runoff is high, the nitrogen concentration in the fjord water is thus greater than in years when freshwater runoff is low, as for example in 1996–97 (figure 2.2).

As a result of the reduction in nutrient loading of the fjord, the former mass occurrences of sea lettuce (*Ulav lactuca)* have diminished, and the rooted macrophyte vegetation has gained ground in the inner fjord. Widgeon grass (*Ruppia maritima)* and eelgrass (*Zostera marina)* have thus recolonized different parts of the inner fjord,

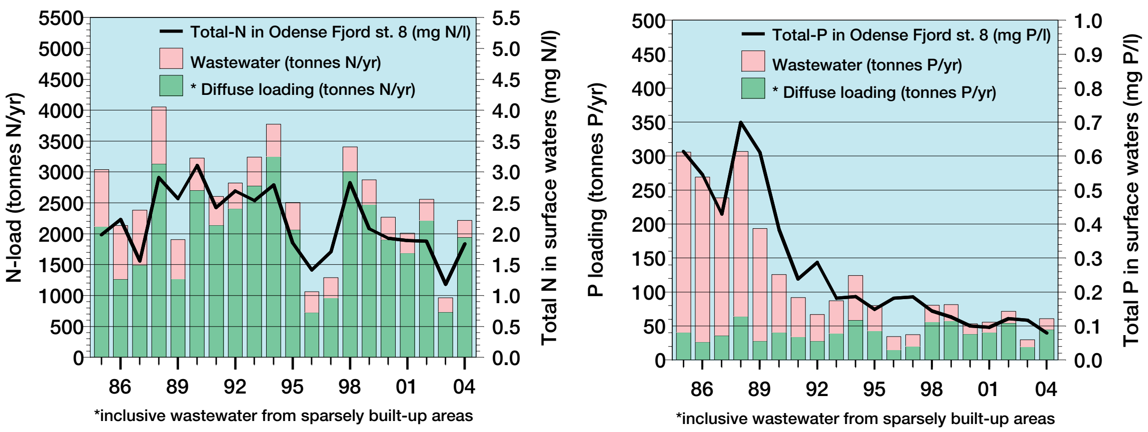


Figure 2.2
Trend in source-apportioned annual nitrogen and phosphorus loading from land-based sources together with the annual mean concentration in the surface water at station SS8 in the inner part of Odense Fjord (Seden Strand).

and a more diverse macroalgal community has established in the outer fjord, including a large proportion of the slowly growing brown algae bladder wrack (*Fucus vesiculosus)* and serrated wrack (*Fucus serratus)*. Nutrient loading is still so high, however, that for long periods of the growth season the inner fjord is still dominated by rapidly growing ephemeral macroalgae, especially sea lettuce and filamentous algae, e.g. *Ectocarpus siliculosus* and *Cladophora sp.*

The benthic invertebrate fauna of the fjord is diverse, but is dominated by eutrophication-dependent filter-feeding species of polychaetes and molluscs. The benthic filterfeeders are exerting pronounced control over the phytoplankton biomass, which is normally quite low despite of the high nutrient level in the fjord. Mass occurrences of phytoplankton are however occasionally observed.

The fjord is also impacted by hazardous substances. The TBT, PAHs and PCB concentrations in sediments in parts of the fjord exceed the international criteria for ecotoxicological effects. The fauna is severely affected, and effects on the vegetation cannot be excluded. The content of TBT and certain PAHs and PCBs (polychlorinated biphenyls) in common mussels is so high that the limit values recommended in international conventions are exceeded. The Danish Veterinary and Foods Administration advices against consuming mussels from Odense Fjord and has prohibited commercial mussel fishery in the fjord. The TBT content in the fjord sediment is also so high as to cause sexual and reproductive changes in the common periwinkle (*Littorina littorea*).

Contaminant-induced biological effects have also been observed in eelpout, *Zoarces viviparous*. Thus, specimens with elevated levels of deformed larvae and an increased production of detoxication enzymes in the liver were found. In clams, *Mya arenaria*, the sex ratio were significantly altered and in common mussels, *Mytilus edulis*, the cell organelles were affected. Although TBT has the potential to induce such effects, attention has also been paid to other substances like organochlorines, pesticides, PAHs and heavy metals.

In general, the fjord still exhibits a high level of eutrophication and considerable effects of hazardous substances, although some improvement have been obtained in the fjord after reduction of the external load. The existing environmental objectives are thus not fulfilled in any part of the fjord, and have not been fulfilled since the 1970ies, where monitoring and water quality assessment was started.

Risk analysis

When assessing the risk of not fulfilling the environmental objectives by 2015, the expected future impact of nutrients is a main subject. Analyses show an expected reduction to Odense Fjord of nitrogen run off by ca. 20% (400 tonnes), and of phosphorus by 5% in 2015, compared to the 1999-2003 mean. To the coastal waters around Fyn, the reduction will be approx. 17% for nitrogen and 5% for phosphorus.

Due to low precipitation in 1996-97 and again in 2003, nutrient run-off was considerably lower during these years than it is expected to be in 2015. In none of these years, the environmental objectives were fulfilled, neither in the Odense Fjord, nor in the coastal waters in general. Furthermore, combined dynamic and empirical modelling conducted in Odense Fjord points at a needed minimum reduction of nitrogen load of at least 50% (1000 tonnes or more) to the fjord in order to obtain “good ecological quality”, parallel to the Region Plan general objective.

The impact of hazardous substances is also expected to be too high in 2015 to allow compliance with the general objective.

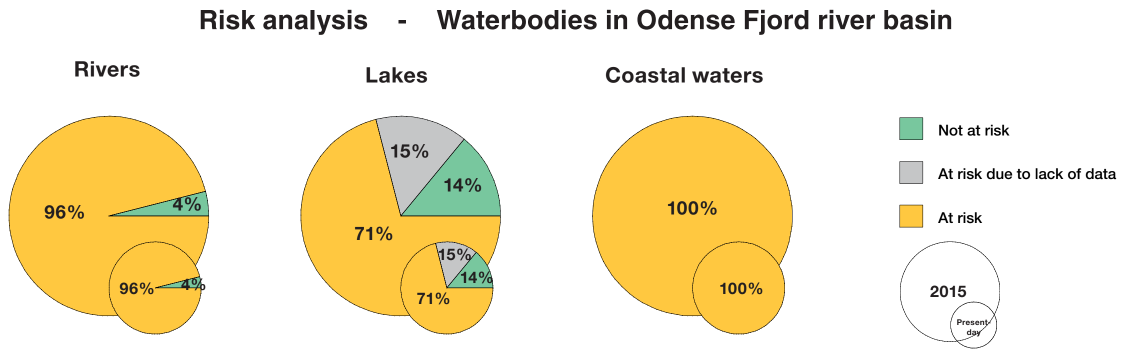


Figure 2.3. Summary of the "Baseline 2015" risk assessment for surface waters in Odense Fjord river basin. The expected situation in 2015 for rivers, lakes and coastal waters is shown together with the present ecological status for comparison. Areas with no data are also at risk, acc. to the definitions in the WFD.

Thus, the whole Odense Fjord is at risk of not fulfilling the environmental objectives in 2015.

In parallel, the coastal waters around Fyn are all judged to be at risk of not fulfilling the objectives by 2015, due to impact of nutrients, hazardous substances, and in case of some smaller coves, also due to physical regulation of the water exchange with the surrounding open waters.

The quality and status of some small coastal water bodies is not known due to lack of recent monitoring data. These water bodies are automatically regarded as being at risk.

The result of the risk analysis is that all of the water bodies in the coastal waters are at risk by 2015.

2.3 Risk analysis, running waters and lakes

The risk analysis for running waters and lakes, like that for the coastal waters, is first of all based on the aims stipulated in the Regional Plan for Fyn County. It must be stressed that this procedure, that do not follow the guidelines of The Water Framework Directive, is decided by the national authorities. However in case of the Regional Plan for Fyn County, the aims largely conform with "good ecological quality" according to the Water Framework Directive, although the Regional Plan for some water bodies operates with "eased" aims that may be equivalent to moderate or even poorer ecological quality. The first step of the risk analysis is to estimate the present status of the water bodies. Secondly, the status is extrapolated to the 2015 situation taking into account (a) expected developments in all relevant pressures, and (b) already planned and decided programmes of measures (related to these pressures) that are not directly associated with the WFD.

Regarding the running waters the ecological quality is described using macroinvertebrates (Danish Stream Fauna Index) and physical criteria (Danish Physical Index). If certain values of these indices are not fulfilled, then the regional aims are not met and the water bodies may be at risk. Further, the regional aims are not met if physical obstacles prevent "free" migration of macroinvertebrates and fish within the running water systems. The quality is also not satisfactory if hazardous substances have negative effect on the organisms. Only pressures like sewage discharges from scattered homes are expected to be reduced due to already planned programmes of measures.

The quality and status of a great number of running water bodies (about 29 % based on stream length) is not known due to lack of available monitoring data. The water bodies are automatically regarded as being at risk.

The result of the risk analysis is that 96 % of the water bodies in running waters (calculated based on stream length) are at risk by 2015. The reasons are primarily poor physical properties and in some cases poor water quality. The poor physical condition is primarily due to the intensive cultivation of river valleys, where rivers have often been regulated by straightening and canalisation. Moreover, the river valleys are frequently drained and the rivers maintained in an environmentally unsound manner (weed clearance, dredging, etc.). These actions and activities severely affect the hydromorphological conditions in the rivers. The poor water quality is mostly caused by sewage outlets from scattered houses and storm water outlets, but also discharges of hazardous substances are sometimes significant.

The ecological quality of lakes is described using water quality criteria like summer-mean concentration of total phosphorus, total nitrogen, chlorophyll-a, and mean Secchi depth. Also the presence and abundance of submerse aquatic plants and the fish community structure is taken into consideration.

The risk analysis shows that 12 out of 14 larger lakes are at risk of not complying with the regional aims by 2015. The main reason is too high discharges of nutrients from farmed areas, although poorly treated sewage from scattered homes may be a problem is some cases. Further, some lakes may suffer form internal nutrient loads. Although the risk analysis was not carried out for a large number of small lakes, available data indicate that these are as much at risk as the larger lakes, and that they suffer mainly from the same pressures (feeding introduced ducks for hunting purposes may, however, also be a serious problem in small lakes).

2.4 Risk analysis, groundwater

There are 31 groundwater bodies in Odense River Basin for which data are available for assessing their status.

Eighteen of the groundwater bodies are affected by one or more hazardous substances, 16 of them to such an extent that their status much be considered to be poor. In addition, one of the groundwater bodies with poor status is also so contaminated by nitrate as to preclude compliance with both the 25 mg/l and 50 mg/l environmental objectives for nitrate.

Five of the 18 affected groundwater bodies are affected by nitrate, but as mentioned above the environmental objective is only exceeded in 1 case.

Thirteen groundwater bodies are unaffected.

The status of 16 groundwater bodies is poor and that of 15 groundwater bodies is good (see the figure). Application of the EU criterion for nitrate (50 mg/l) will not change the number of groundwater bodies having good status.

Nitrate contamination derives from diffuse sources – in this case agriculture, while contamination with hazardous substances is presumed to derive predominantly from point sources. To some extent this also applies to contamination with pesticides.

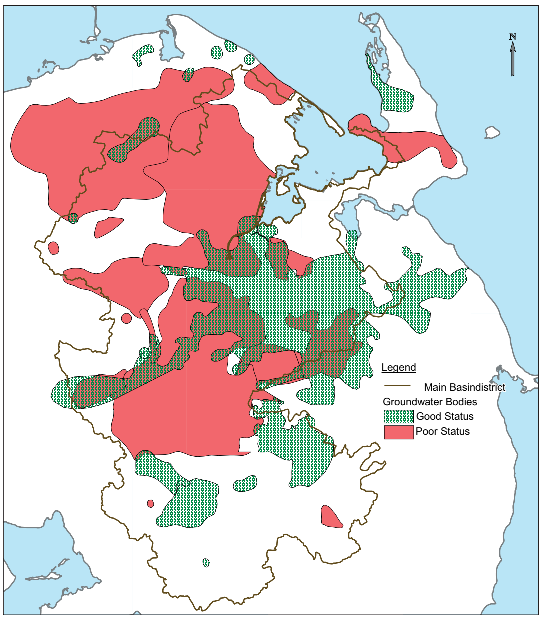


Figure 2.4
Status of the groundwater bodies in Odense River Basin.

3. Protected areas

Article 6 and Annex IV of the Water Framework Directive stipulate that the register of protected areas shall include:

- Areas designated for the abstraction of water intended for human consumption under Article 7.
- Areas designated for the protection of economically significant aquatic species (Directives 78/659/EEC and 79/923/EEC).
- Bodies of water designated as recreational waters, including areas designated as bathing waters under the Bathing Water Directive (76/160/EEC).
- Nutrient-sensitive areas, including areas designated as vulnerable zones under the Nitrates Directive (91/676/EEC) and areas designated as sensitive areas under the Urban Waste Water Directive (91/271/EEC).
- Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC).

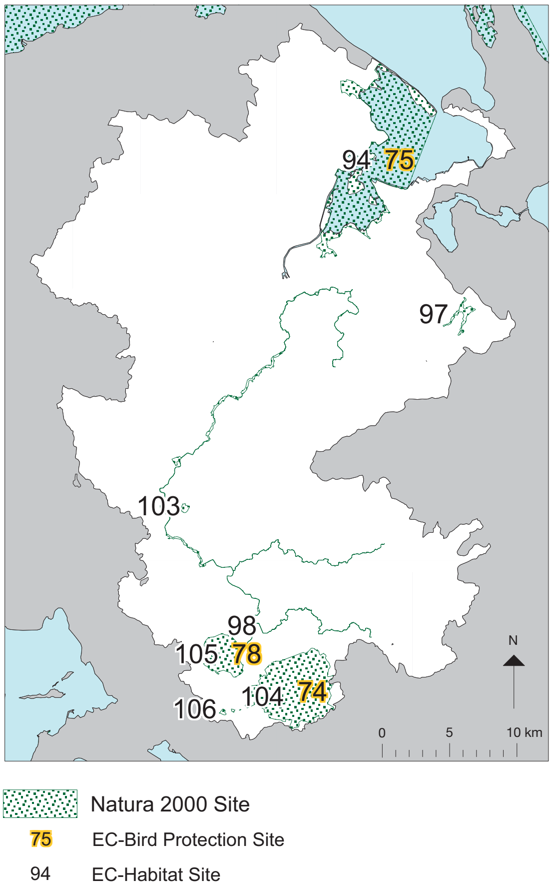


Figure 3.1
Natura 2000-areas in the OPRB. See appendix 3.1 and 3.2 for name of the areas and for species and habitat types designated for each area.

3.1 Surface waters and wetlands

Natura 2000

Due to the natural qualities of Odense Fjord, the western and southern parts of the fjord have been designated as international protected areas (Natura 2000) pursuant to the Habitats Directive and the Birds Directive. The main parts of the river Odense Å, the Arreskov lake and the Nørresø and Brændegaard lakes and the associated wetlands are also designated as Natura 2000 areas (figure 3.1).

Shellfish waters

The Shellfish Waters Directive will be fully implemented through the Environmental Objectives Act, and designation of protected areas will be fulfilled in the coming years. The Danish Veterinary and Foods Administration, however, advices against consuming mussels from Odense Fjord and has prohibited commercial mussel fishery in the fjord because of high levels of hazardous substances.

Bathing areas

No bathing areas have been designated in Odense Fjord.

Nutrient-sensitive areas

The Nitrates Directive and the Urban Waste Water Directive have been implemented in Denmark. The whole of the country, and thus the whole OPRB-area, including the fjord, rivers, lakes and wetlands, has been designated as a nutrient-sensitive area, and hence are also encompassed by the measures generally implemented in Denmark pursuant to Action Plans on the Aquatic Environment I, II and III to meet the requirements of the directives, cf. also Danish Environmental Protection Agency Statutory Order No. 501 of 21 June 1999.

International conventions

One of the purposes of the Water Framework Directive is to contribute to "achieving the objectives of relevant international agreements". The coastal waters of Fyn are encompassed by the Helsinki Convention (HELCOM). The OSPAR Convention covers the northeast Atlantic and the inner Danish marine waters up to and including the southern Kattegat, and thus encompasses areas very close to the coastal waters of Fyn.

3.2 Groundwater

33 aquifers/groundwater bodies of the total of 34 WBs in the OPRB have been designated as protected areas acc. to the WFD-criteria: aquifers/groundwater bodies from which more than 3.650 m2 is abstracted per year (27 WBs), and those bodies intended for such use (6 WBs), (figure 3.2)

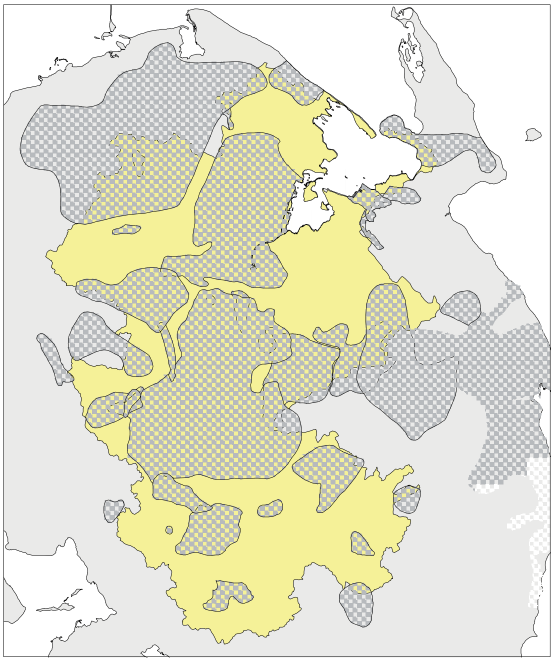


Figure 3.2
Location of protected aquifers/groundwater bodies in and near the OPRB.

4. Provisional environmental objectives

According to the Water Framework Directive, classification of ecological status has to be based on type-specific reference conditions and normative definitions of status. Status is described using the biological quality elements macrophytes, phytoplankton and benthic invertebrate fauna together with supporting physico-chemical quality elements such as Secchi depth, nutrient concentrations, oxygen content, concentration of hazardous substances, etc. For freshwater systems, fish fauna is also included. In the reference conditions the biological quality elements have to exhibit the same values as "high ecological status", where no, or only very minor, anthropogenic deviation from the natural conditions can be tolerated. The status classes "high" and "good" ecological status are established relative to the reference condition. As a rule, all surface water bodies must exhibit "good ecological status" and all groundwater bodies "good quality" no later than 2015. In the WFD Article 5, it is prescribed that a risk analysis must be carried out in 2004, in order to judge whether the surface and ground waters will fulfil the objectives in 2015 or not. This risk analysis should be based on the reference conditions and subsequent classifications mentioned above.

In Denmark, however, the national authorities decided, in August 2005, that the risk analysis should be based on the existing objectives stipulated in the Regional Planning, cf. ch. 2. These existing objectives are largely comparable to the operational, quantitative objectives developed below in chapters 4.1-4-3.

4.1 The fjord

The quality objectives in the Regional Plan serve as the basis for establishing environmental objectives pursuant to the Water Framework Directive and Environmental Objectives Act. The quality objectives in Fyn County's Regional Plan for 2001–2013 stipulate that the northwestern part of the fjord should fulfil the high objective "reference area for scientific studies". The quality objective set for the remainder of the fjord is "fish waters for angling and/or fishery" and, where the natural conditions permit, "spawning and/or nursery grounds for fish". As outlined in figure 3.1, two-thirds of the fjord is internationally protected as a Natura 2000 site, due to the Habitats and Bird Protection Directives.

In order to ensure adequate protection of the natural worth of the Natura 2000 sites, i.e. attainment of favourable conservation status for species and habitat types for which the site was designated, these areas have at minimum to fulfil "good ecological quality". It is not yet known whether attainment of favourable conservation status will entail other requirements than those that otherwise have to be met in order to attain "good ecological quality".

Based on modelling and historical data, a set of reference values for important biological and chemical quality elements have been developed for the fjord. In this case, reference values are site-specific (not type-specific). In order to comply with at least good ecological quality, provisional operational objectives for 'good' and 'high' ecological status of the fjord are suggested (Table 4.1). Thus, criteria for good and high ecological and chemical quality are set at a permitted 15% and 25% deviation from reference conditions, respectively.

For both macroalgal biomass and eelgrass depth distribution, a correlation can be established between biological state of the fjord and nitrogen loading of the fjord (Fig. 4.1). According to these relations, the nitrogen input to the fjord must not exceed appr. 1000 tN/yr, if "good ecological status" shall be obtained.

If higher status is required, due to e.g. Nature 2000 protection, further reductions are needed.

Due to the effects of the sediment phosphorus pool in the fjord and the present conditions for limitation of algal growth in which nitrogen is still the primary limiting nutrient for most of the year, no clear relationship can be established from the model between phosphorus concentration and macroalgal growth. Experimental studies of sea lettuce (*Ulva lactuca*) growth in Seden Strand, however, underscore that both nitrogen and phosphorus input to the fjord continue to be important for algal growth, and that limitation of algal growth is least pronounced closest to the mouth of the river Odense Å, which comprises the main source of nutrient input to the fjord.

The reduction in nutrient loading of the fjord required to ensure the fjord's ecological and chemical status will thus entail at least a halving of the present nitrogen load and a considerable reduction in the phosphorus load under normal

Table 4.1
Threshold values describing reference conditions and 'good' and 'moderate' ecological and chemical status in the two water bodies in Odense Fjord. The threshold values for good ecological and high ecological status are defined as 25% and 15% deviation, respectively, from reference conditions except for macroalgal (sea lettuce) biomass (see note). The threshold values for TN and Secchi depth are calculated from 15% and 25% deviations of historical (reference) eelgrass depths and used in the empirical eelgrass depth-TN (logarithmic) and eelgrass depth-Secchi depth (linear) relations of Nielsen et al. (2002). Values for TP are based on 15% and 25% deviations from reference conditions in the 'Natural state scenario'-runs of the dynamic MIKE 3-model.

Treshold values for good and high ecological status

	Eelgrass depth limit (m)		Sea lettuce gC/m²	Secchi depth (m)		TN (µg/l)		TP (µg/l)	
	SS	ODF	SS	SS	ODF	SS	ODF	SS	ODF
Reference values	>4	>6	<10	-	>7,3	<666	>374	<30	<10
High status	>3,4	>5,1	12,5 [1)]	-	6,1	794	464	34,5	11,5
Good status	>3	>4,5	15 [1)]	-	5,3	976	548	37,5	12,5

1) High and good ecological status defined as 25% and 50% deviation, respectively, from reference condition.

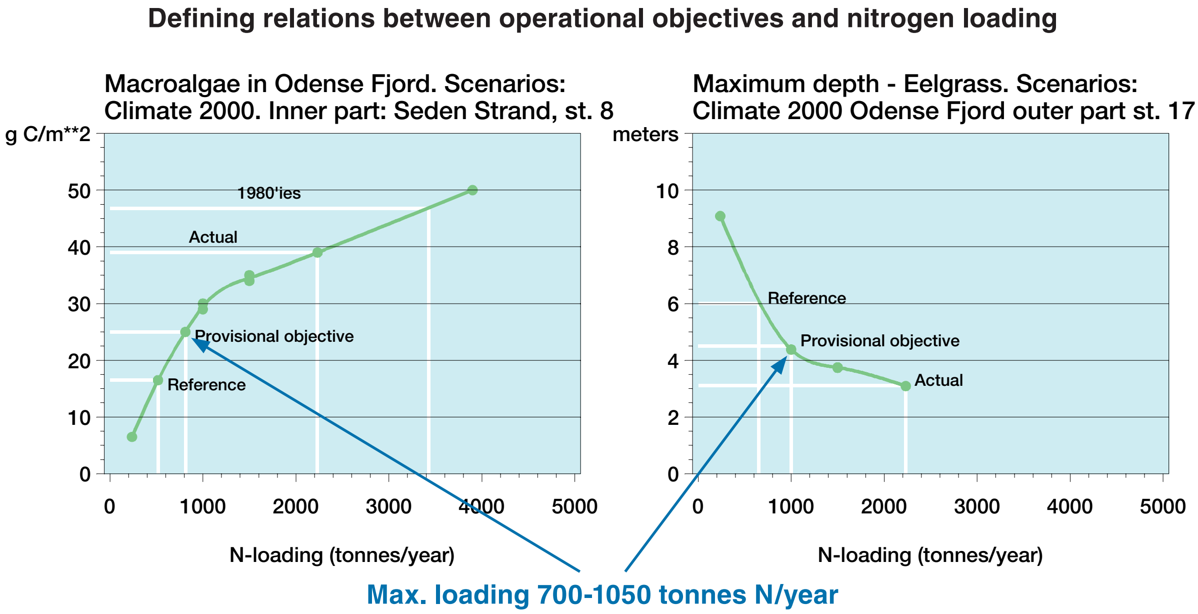


Figure 4.1
Relations between nitrogen loading and biological variables, based on empirical and dynamic modelling. The reference load is estimated from dynamic and empirical modelling and historical data.

Quality criteria	Stream types 1-3	Lake type 9 (and 6)	Lake type 10
Danish Physical Index	≥ 0.60 (25)		
Danish Stream Fauna Index	≥5		
Total-P (µg/l)		≤ 50	≤ 25

climatic conditions. It will not be possible to attain these reduction targets with the current and already planned measures under the Action Plans on the Aquatic environment I, II and III and the planned measures to reduce discharges from sparsely built-up areas.

4.2 Running waters and lakes

In order to comply with at least good ecological quality the following provisional operational objectives for running waters and lakes are proposed:

4.3 Groundwater

The environmental objectives specified below apply to groundwater bodies, i.e. the objectives have to be fulfilled by the distinct volume of groundwater within an aquifer and hence do not apply to all groundwater.

Objectives are set for both “good chemical status” and “good quantitative status”. If status is not good, it is considered poor.

Good chemical status

In order for the status to be considered good, the groundwater must fulfil the following standards:

- Nitrate – 25 mg/l for groundwater bodies used for abstraction of drinking water * and 50 mg/l for other groundwater bodies
- Pesticides – nothing in groundwater bodies used for abstraction of drinking water* and <0.1µg/l for other groundwater bodies
- Hazardous substances* – nothing present (below the limit of detection)
- Conductivity – <100 mS/m*.

* These objectives are set by Fyn County and are to some extent specified in the Regional Plan.

As regards nitrate and pesticides, the Water Framework Directive and forthcoming Groundwater Directive stipulate quality standards of 50 mg/l and 0.1 µg/l, respectively. These standards have not been finally implemented in Denmark.

In addition, the chemical composition of the groundwater body must not be such that the concentration of contaminants results in:

- Failure of associated surface water bodies to achieve their environmental objective
- Diminution in the status of such water bodies
- Significant damage to terrestrial ecosystems which depend directly on the groundwater body.

Good quantitative status

- Groundwater abstraction must not exceed the long-term groundwater recharge
- The level of groundwater must not be so affected by anthropogenic activity as to result in:
- The failure of associated surface water bodies to achieve their environmental objectives
- Diminution in the status of such water bodies
- Significant damage to terrestrial ecosystems which depend directly on the groundwater body.

5. Programme of measures

5.1 Introduction

The program of measures is made on the basis of the objectives presented in the previous chapter. There is so far only elaborated a program of measures for Odense Fjord. The detailed program of measures related every water body within the Odense Pilot River Basin is in preparation.

The different measures can mainly be related the following pressure types:

- Diffuse pressures (water- and airborne)
- Point source pressures (i.e. sewage outlets)
- Physical pressures (i.e. drainage and river maintenance)

The measures identified related to each type of waters is presented in table 5.1. A plus indicates that this measures is identified as priority measure related that specific type of water body. The measures includes measures on sewage outlets from households and industry and measures reducing diffuse loads of pollutant substances from agriculture including waterborne as well as airborne pollutants. Also measures to minimize impacts from physical pressures are important, including measures to re-meandering the regulated watercourses, measures to regain free passage for migrating fish through the watercourses and measures to regain the retention capacity (nutrients etc.) in river beds (reconstruction of wetlands).

In the final water management plan, the different program of measures related each of the water types should be optimised against each other to ensure that you get value for money. That means it should be taken into account that a specific measure can affect the quality of more than one type of water body. Par example some of the measures targeted Odense Fjord will also enhance the protection of lakes, groundwater and watercourses (This optimization has not been fully implemented yet!).

Potential measures to fulfil the WFD objectives in Odense Fjord river basin						
Pressures and measures to reduce them	**Target pressure or aim of measure**	**Affected water bodies/habitats**				
		Coastal waters	Lakes	Rivers	Ground-water	Terrestrial natural habitats
Diffuse pressures – agriculture						
Improved utilization of nutrients in manure o Improved utilization of animal fodder o Storage requirements (min. 12 months capacity) o Requirements as to manure application systems and max. amount of manure applied.	N and P loads	+	+		+	(+)
Improved utilization of nutrients in manure o Reduced ammonia volatilization (livestock housing, manure storage and application)	N load (airborne)	(+)	+		(+)	+
Enclosed storage facilities for manure and silage, including facilities to eliminate ammonia volatilization and odour pollution	N, P and BOD loads	+	+	+	+	+
Reduced livestock production/density	N and P loads	+	+		+	+
Catch crops: Optimized and increased use	N load	+	+		+	
Spring ploughing instead of autumn ploughing	N load	+	+		+	
Set-aside for: o Wetlands, natural habitats and permanent grassland in river valleys o New natural habitats, forests and permanent grassland	N and P loads Sediment load Improved/natural hydromorph. structure Restore natural habitats	+ +	+ +	+ +	+	+ +
Fertilization requirements (N, P): o Reduced N and P fertilization quotas	N and P loads	+	+		+	
Fertilization demands (P): o Phosphorus balance at field level o Reduced P fertilization quota in soils with high P content	P load	+	+			
Cultivation restrictions on potentially erosive areas	P and sediment loads	+	+	+		
Buffer zones (uncultivated) alongside surface waters (rivers, lakes, etc.)	P and sediment loads	+	+	+		
Reduced or regulated drainage	Hydrology, N and P loads	+	+			+
Diffuse pressures – forestry						
o Leaving vegetation in the felling area o Planting as soon as possible o Leaving buffer strips alongside rivers o Increasing the amount of deciduous trees	Sediment, N and P loads,	+	+	+		+
Point-source pressures						
Wastewater treatment facilities o Sparsely built-up areas – improved wastewater treatment o Municipal treatment plants – improved wastewater treatment o Stormwater outfalls – basins o Renewal/renovation of sewerage systems	N, P and BOD loads Hazardous substance load Pathogenic bacteria and virus load	+ + +	+ + +	+ + +	+	
o Former waste disposal sites – measures to reduce leaching	N, P and BOD loads Hazardous substance load	+ +	+ +	++ ++	++ ++	
Reducing physical pressures						
Reintroducing and protecting migratory fish o Removal of obstructions for fish migration o Restrictions on angling and fishery and at potential spawning grounds, etc.	Improved/natural hydromorphological structure Reintroduction of migratory fish	+	+	+		
Re-establishment of natural rivers and river valleys o Re-meandering of regulated rivers and reopening of culverted streams o Restoration of gravel and stones in river beds o Cessation or minimization of river maintenance o Extensification of cultivation	Improved/natural hydromorphological structure N and P loads Sediment load	+	+	++		++
Cessation/reduction of groundwater and surface water abstraction	Improved/natural hydromorphological structure			+	+	+
Others						
Biomanipulation of lakes	Increased water transparency and greater plant and animal diversity		+			
Removal of contaminated sediments and soils	P load, hazardous substance load	+	+	(+)	+	
Reducing emissions to the atmosphere from traffic, industries and livestock	N load,	+	+			+

Table 5.1
Identified measures related the different water types within the Odense Pilot River Basin. The main effect of the measure is indicated.

5.2 Coastal waters

The input of nutrients to the fjord needs to be reduced considerably if good ecological status is to be attained (see previous chapter). There is thus a need for measures to at least halve the nitrogen input to the fjord. Phosphorus input also has to be reduced considerably compared with present inputs. Such a reduction in nutrient inputs to Odense Fjord primarily necessitates reducing loading from agriculture (nitrogen and phosphorus), but loading from point sources (especially phosphorus) also needs to be reduced. Moreover, measures need to be taken to reduce inputs of hazardous substances to the fjord.

Riverine inputs of nitrogen and phosphorus to the fjord from the catchment currently amount to 2,100–2.400 tonnes nitrogen and 60 tonnes phosphorus. A further approx. 100 tonnes nitrogen and 0.7 tonnes phosphorus are input to the fjord annually via the atmosphere. As is also apparent from the above, inputs of nutrients to the fjord from towns, industry and agriculture have decreased over the past 20 years as a result of measures pursuant to wastewater and regional planning in the county and the Action Plans on the Aquatic Environment (table 5.2).

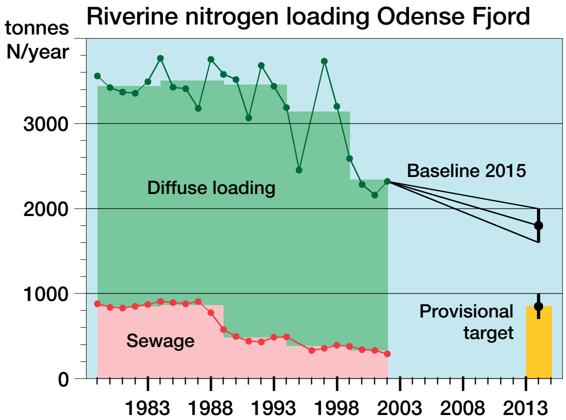


Figure 5.1 Landbased Nitrogen loading 1980-2003 of Odense Fjord and forecasts for the development in this loading for the coming years, using different scenarios for the forecast, (table 4.2 and table 4.3). Preliminary target load ensuring good ecological quality of the fjord by 2016 has been estimated to around 700-1000 tonnes N/year (climate 2000).

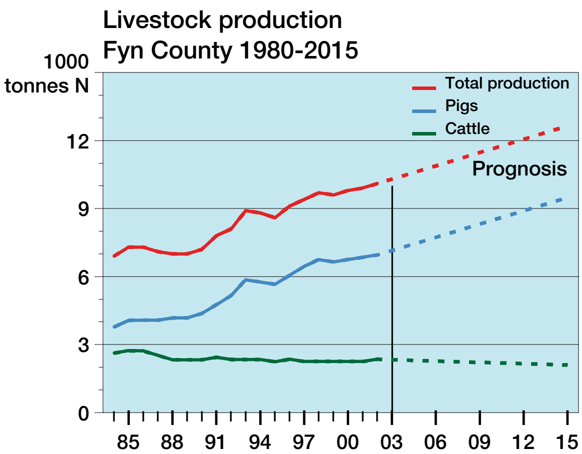


Figure 5.2 Development of the livestock production in Fyn County (1000 tonnes N) estimated as produced products (milk, meat, eggs and hides). Source: Danedi 2004. The prognosis is based on (Dansk Landbrug (2004) and (Kyllingsbæk (2004)).

A program of measures to reduce the annual riverine runoff of nutrients to Odense Fjord by up to 1,000–1,200 tonnes of nitrogen and 6–? tonnes of phosphorus are presented below. The program is chosen among different alternatives as the most cost effective of measures encompass both measures directed at point sources and measures directed at diffuse sources (primarily agriculture).

The dimensioning of this program is taken into account that some already planned/decided activities will have an effect on nutrient runoff to the fjord. Thus the program of measures imply a calculated effect of the most recently implemented/adopted programmes of measures within the river basin and the effect of expected increased activities (agriculture etc) until 2015 (table 5.3).

Preconditions - "Baseline 2015"

When determining the need for further measures and their costs, it is necessary to base this on the pressure to which the fjord will be subject once all the adopted/planned activities have taken effect – the so-called "baseline 2015". The present pressure on the fjord thus has to be corrected for the effect of such measures/activities (see table 5.3 and figure 5.1). The financial costs of the measures can also be affected by changed future activities, for example, if livestock production is allowed to increase, thereby "commandeering" part of the cheapest means of reducing the environmental impact of the expanded agricultural production and thereby indirectly increasing the costs of reducing the environmental pressure from existing agricultural production. If supplementary environmental measures are not implemented in connection with expansion of livestock production, nutrient loss (waterborne and airborne) to the surroundings will be enhanced. Without supplementary environmental measures the total nitrogen loss to the surroundings will thus typically be increased by 25–45 kg N for each additional livestock unit produced. Just under half of the increased loss takes place via leaching, of which approx. 40% reaches the fjord. In comparison, just less than 1 kg nitrogen is discharged with wastewater per year for each person in the fjord catchment.

The effect of the most recently implemented/adopted programmes of measures (the Regional Plan, Action Plan on the Aquatic Environment III: 2005–2015) will first become detectable in the watercourses during the coming decade. Thus Action Plan on the Aquatic Environment III is expected to reduce nitrogen input to the fjord by a further 400 tonnes N/yr, and

Riverine inputs of nitrogen and phosphorus to Odense Fjord						
Year	Nitrogen			Phosphorus		
	Tonnes N/yr	Kg N/ha/yr	mg N/l	Tonnes P/yr	Kg P/ha/yr	mg P/l
1980's	3500	33	9,6	295	2,8	0,82
Actual loading *1	2100-2400	17-20	5,8-6,7	64	0,6	0,18
"Baseline 2015" - prognosis	1700-2000	16-19	4,7-5,6	60	0,5	0,16
"Target load" 2015	700-1050	6,6-10,0	1,9-2,9	?		
Required load reduction compared to "Baseline 2015"	650-1300			?		

*1: loading 1999-2004.

Table 5.2
Riverine inputs of nitrogen and phosphorus to the fjord All data are normalized climat in 2000, corresponding a freshwater loading to the fjord on 360 . 10^6 m3/yr. "Baseline 2015" means the loading once all the adopted/ planned activities have taken effect. "Target load" means the maximum loading of the fjord commensurate with "good ecological status.

improved wastewater treatment in the catchment will reduce loading by a further 30 tonnes N/yr. Based on the measurements made in the watercourses over the past five years there seems to be no great residual effect of Action Plan on the Aquatic Environment II, as was also concluded in connection with its final evaluation and the preparatory work on Action Plan on the Aquatic Environment III.

The authorizations to expand livestock production issued in recent years in the fjord catchment can in themselves entail an increase in loading of the fjord as it has been accepted that the expansion can increase the total nitrogen input to the fjord by up to 100 tonnes N/yr. The calculations take into account the environmental effect of current changes in production systems, etc. In the period 2000–2004, the authorities thus authorized a 20% increase in livestock production in the catchment of Odense Fjord. The actual increase in production resulting from the issuance of these authorizations will not become apparent until after a few years. Data from Statistics Denmark show that livestock production on Funen has been steadily increasing since the mid 1980s corresponding to a 40% increase in production (milk, meat, eggs and hides) in the period 1985–2003 or an average of 2% per year. Over the period 2000–2003, production in the county has increased by 1.7% annually (figure 5.2). The statistical evidence thus indicates that the issuance of authorizations to expand production actually leads to an increase in livestock production in the county.

Looking to the future, Danish Agriculture estimates that livestock production in the county will increase further up to 2015 (Danish Agriculture, 2004). Thus production of slaughter pigs is expected to increase by 39%, the sow stock and

The effect of the most recently implemented/adopted programmes of measures and The effect of expected increased activities (agriculture etc) Prognosis 2005-2015		
Measure/activity	Expected effect on loading to Odense Fjord 2005-2015	
	Tonnes nitrogen/yr	Tonnes phosphorus/yr
NAPAE II, resilience	0?	-
NAPAE III	- 400	?
Reduced sewage outlets (planned)	- 30	- 4
Increased animal production up to +20% (approved 2000-2004)	+ (0-100)	+? *2
Further increase in animal production 2005-2015 Prognosis: +26% *3	0 *1	+? *1

*1: Presuming that authorisations of increased production is given on condition that measures are taken to prevent increased loading.
*2 A continued excess application of phosphorus to fields will slowly enhance the loss of phosphorus from fields, but it is very uncertain to calculate the exact values.
*3: Based on Dansk Landbrug (2004) and Kyllingsbæk (2004).

Table 5.3
The table shows the effect of the most recently implemented/ adopted programmes of measures and the effect of expected increased activities (agriculture etc) in the period 2005-2015.
NAPAE: National Action Plan for the Aquatic Environment.

poultry production are expected to increase, and the dairy cattle and breeding cattle stocks are expected to decrease. Overall, this corresponds to a further 26% increase in livestock production (milk, meat, eggs and hides) in the county (Kyllingsbæk, 2004) or a growth rate for the next decade that is slightly greater (15%) than seen in the preceding decades.

It can thus be concluded that the present loading of the fjord can be expected to be reduced by the net figure of an additional 300–400 tonnes N/yr as a result of the initiated and planned activities that can be expected to affect the input of nitrogen to the fjord during the period 2005–2015 (table 5.2, 5.3 and figure 5.1).

Agriculture - measures

In connection with the preparation of Action Plan on the Aquatic Environment III the Ministry of the Environment and the Ministry of Foods, Agriculture and Fisheries have thoroughly elucidated the possibilities for regulating the total loss of nutrients from agriculture, both airborne (ammonia) and waterborne (nitrogen and phosphorus). A broad array of measures to reduce the loss has been analysed, including the effect and economics of the use of the individual measures. With the participation of Fyn County and others, the Odense Fjord River Basin has been included as an example. Thus scenarios have been drawn up for measures in the agricultural area that reduce nutrient loading of Odense Fjord – including both effect calculations and cost calculations (www.vmp3.dk). This comprehensive material serves as the background for the present presentation of cost effective easures to reduce the nutrient losses from agricultural production in the Odense Fjord River Basin.

Categories and types of measure

The various types of measure are summarized in five categories in Fact Box 2. How these various measures other than the economic instruments can be cost effectively applied in the Odense River Basin is briefly described below.

Nitrogen – measures

A number of scenarios have been established for Odense Fjord that each describe how various doses of measures can be used to achieve a given nitrogen reduction target.

When dosing the various measures in the various scenarios, it was taken into account that not all the measures can be applied to an equally great area. For example, there is an upper limit for how much farmland can be converted to denitrifying wetlands.

The most cost effective scenario that reduce the annual nitrogen input to the fjord by 1,000–1,200 tonnes N/yr is shown in table 5.4 This agricultural program of measures corresponding to a load reduction of the order needed to reduce nitrogen loading of the fjord to a target load commensurate with "good ecological status".

The analyses show that it is possible to implement environmental measures in agriculture that will reduce nitrogen loading of Odense Fjord by 1,000–1,200 tonnes N/yr. It is possible to reduce loading of the fjord by this amount without reducing livestock production in the catchment, but crop production will have to be reduced, because the cultivated area might be reduced by at least 7,5% depending on which combination of measures is selected.

In general, establishment of wetlands and reduced fertilization norms are the most effective measures if large reductions in loading are to be achieved. Catch crops are also effective and have a substantial effect.

The total budgeted costs for the three analysed scenarios range from DKK 30 million to 84 million per year. If account is taken of the programmes of measures for the other water bodies and ecosystems in Odense Pilot River Basin (watercourses, lakes, groundwater, and terrestrial ecosystems) it could transpire that another

Table 5.4
The most cost-effective measures reducing the load to the fjord by 1100 tonnes per year. Based on MEM, 2003a (extract).

Agricultural measures - Nitrogen Effect and economy						
Measure	Area involved Hectare (percent of agricultural area)	Cost 1.000.000 DKK/yr	Reduced Nitrogen leaching		Reduced Nitrogen loading Odense Fjord (50% retention)	
				Cost effectiveness		Cost effectiveness
			tonnes N	DKK/kg N	tonnes N	DKK/kg N
Better utilization of animal fodder	70.000 (100%)	0	45	0	23	0
10% higher utilization of animal manure	70.000 (100%)	2,4	142	17	71	34
Catch-crops: Optimized utilization of existing catch-crops on areas with manure	3.200(4,6 %)	0	38	0	19	0
Catch-crops: Increased use	5.000(7,1%)	1,3	185	7	93	14
Wetlands in river valleys –Set aside for wetlands	5.400(7,7%)	15,7	540	29	540	29
Reduced N-fertilizer quota (20%)	70.000 (100%)	9,0	603	15	301	30
Total cost		28,9 (3,8 mio € /yr)				
Total reduction - leaching, loading			1553		1099	
Cost effectiveness - average (DKK/kg N removed)						26 (3,5 € /kg N)

combination of measures could be the most cost-effective. In comparison the present cost sewage treatment within the Odense Fjord river basin is about 380 million DKK per year and the cost of existing measures related agriculture is about 7 million DKK per year.

Generally speaking, the analysed agricultural measures can be divided into two categories as far as concerns cost-effectiveness determined from an overall assessment of their reduction in nitrogen loading of Odense Fjord. Two measures – targeting of the current catch crops to those fields that receive manure and improved fodder utilization – are assessed as being cost-neutral. Thereafter the set-aside of arable land in river valleys is considered to be the most cost-effective measure followed by a further reduction in the nitrogen norm. Afforestation, subsidies for agri-environmental measures (voluntary measures, EU subsidized), reduced livestock herds and conversion to organic farming are the least cost-effective measures regarding reduced Nitrogen load. Authorizations for increasing livestock production can therefore prove to be expensive for society if it subsequently proves necessary to buy back all or part of the production rights in order to ensure compliance with the environmental objectives. Organic farming can be an alternative if prevention of pesticide losses is a priority i.e. areas where groundwater tables are poor protected by the soils.

Moreover, if authorizations for increased livestock production in Odense River Basin continue to be issued, the above-mentioned costs will increase due to the "commandeering" of part of the cheapest means of reducing the environmental impact of the expanded agricultural production and thereby indirectly increasing the costs of reducing the environmental pressure from existing agricultural production.

Box 2
Measures reducing agricultural losses of nutrients organised in categories/types

Technological types
- **Improvement of manure and slurry**
  - **biogas**
  - **separation techniques**
- **Limitation of ammonia evaporation**
  - **application of acid to slurry**
  - **improvement of stables**

Fertiliser related types
- **Standards for utilization and maximum use of manure and slurry**
- **Reduced fertilizer quota**

Land use related types
- **Demand of utilization of catch crops**
- **Set a side areas**
  - **reduced application of fertilizer**
  - **catch crops**
  - **selection of agricultural areas for wet lands, forests and riparian areas free of cultivation**
- **Cultivation without ploughing**

Measures effecting both the water environment as well as the terrestrial environment
- **Stop rotation cultivation along river valleys**
- **Stop cultivation along riparian areas**
- **Reduction of ammonia emission**
- **Organic farming**

Economical measures
- **Fees on fertilizers, quotas**
- **Subsidies to environmental improvements – CAP (voluntarily)**
  - **reduced application of fertilizer catch crops selection of agricultural ar-eas for wet lands, forests and riparian areas free of cultivation**

Photo: Bjarne Andresen

Phosphorus – measures

The nessesary specific measures to limit the agricultural phosphorus losses and ensuring good ecological status of Odense Fjord and the lakes within the catchment of Odense Fjord are listed in Box 3.The measures are specifically directed at meeting the following four sub-objectives related a reduction of agricultural phosphorus loads,:

1. The excess application of phosphorus to fields should cease in order to prevent future enhanced loss of phosphorus from cultivated land.
2. The amount of phosphorus applied to fields with high phosphorus content in soils should be reduced in order to reduce phosphorus loss from these areas.
3. The input of phosphorus to surface waters via erosion should be reduced and minimized.
4. Reestablishment of wetlands in river valleys to retain both nitrogen and phosphorus that leaches from cultivated land.

The Danish Action Plan on the Aquatic Environment III may make a considerable contribution to attainment of sub-objective 3 (erosion-limiting measures), although this is uncertain as the agreement has not yet been finally implemented. Sub-objectives 1 and 2 will not be fulfilled, however. Action Plan on the Aquatic Environment III aims to halve the excess application of phosphorus to fields compared with inputs in 2001 (see figure 5.3). Thus the Action Plan does not eliminate excess application of phosphorus to fields, and in the long term, phosphorus loss from fields in which excessive phosphorus is applied will thus be enhanced. Neither does the Action Plan focus on cultivated land with high phosphorus content in soils (and potentially high phosphorus loss) as a result of many years of massive over fertilization with phosphorus.

Box 3
Measures to limit phosphorus loss in Odense Pilot River Basin:

1. **Requirement for phosphorus balance at field level (all fields in catchment)**
   - **To be achieved through such means as improved distribution of manure**
     (Phosphorus balance: Phosphorus applied as manure and artificial fertilizer = phosphorus removed in the crop as an average over five years)
2. **Requirement for reduced phosphorus fertilization on land with a high plant available phosphorus content in soil**
   - **If Olsen-P >4: P input is max 75% of that removed in the crop**
     (Olsen-P: Plant available phosphorus in soil)
3. **Identification/charting of potentially erosive areas**
4. **Cultivation restrictions on potentially erosive areas**
   - **Permanent grass**
   - **Reduced soil preparation, etc.**
5. **Establishment of wetlands in river valleys to retain nutrients (see also the proposed measures for nitrogen).**

Effects and cost of the phosphorus measures is seen in table 5.5 (Calculations have not yet been performed of the effects and costs of all the measures for reducing phosphorus loss).

The requirement for phosphorus balance at field level will entail increased transport costs for manure to ensure better distribution of the phosphorus content of manure. These increased costs will be counterbalanced by cost savings for the purchase of commercial phosphorus fertilizer, however. The preparatory work for Action Plan on the Aquatic Environment III thus concluded that as regards Fyn County/Odense River Basin, the "additional costs associated with improved distribution of manure will be limited". However, the costs will increase if livestock production is increased, not least in a situation where the amount of phosphorus in manure is presently close to corresponding to the phosphorus requirement for crop production. The authorization of further increases in livestock production will therefore increase the costs of solving the phosphorus problems associated with the existing livestock production.

Table 5.5
Measures to limit phosphorus losses – effects and costs.

Agriculture – Measures to limit phosphorus loss Effects and costs

Measures	Effect – reduced loading to Odense Fjord Tonnes P/yr	Total Costs Mio. DKK
Phosphorus balance at field level (all fields)	No increased P-loss	0
Reduced phosphorus ferlilization on soils with high plant available phosphorus content	?	?
Identification/charting of potentially erosive areas	-	?
Cultivation restrictions on potentially erosive areas	-?	?
Establishment of wetlands in river valleys (N –measure cf. table 5.4)	- 5	See table 5.4

?: Calculation of the costs or effect has not been done yet.

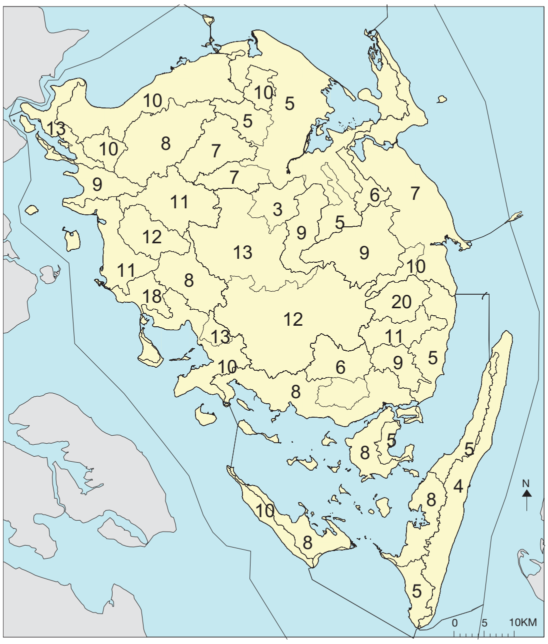


Figure 5.3
The excess application of phosphorus to fields (kg P/hectare) on annual basis (2001) calculated as average values representing the agricultural area within sub-catchments to Odense Fjord. MEM, 2003a.

Point source measures
Wastewater containing nitrogen and phosphorus is discharged to Odense Fjord from wastewater treatment plants, from stormwater outfalls from separate and combined sewerage systems, from sparsely built-up areas and from enterprises. Since the late 1980s, the total wastewater discharges of nitrogen and phosphorus to the fjord from these four types of point source have decreased by 84% (Nitrogen) and 98% (Phosphorus). The decrease is largely attributable to improved treatment at the wastewater treatment plants.

Further measures are planned/approved, especially regarding outlets from scattered settlements, storm water outlets and outlets from enterprises and waste disposal sites. These measures are targeted as well improvement of the ecological status of watercourses, lakes and Odense Fjord.

The high standards of existing municipal wastewater treatment plants within the catchment of Odense Pilot River Basin make it generally difficult and expensive to make further improvements, but improvements are necessary especially regarding outlets of hazardous substances, phosphorus, and pathogenic bacteria and viruses.

Tables 4.3 show the nutrient discharges and costs associated with the implementation of the programme of measures directed at point sources for the current situation (2005), upon implementation of the measures already planned ("Baseline 2015"), and measures upon implementation of WFD (Measures upon implementation of WFD are still under preparation!).

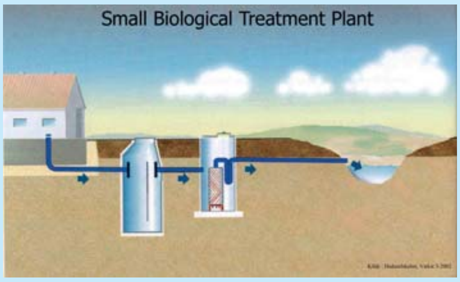
5.3 Running waters
(In preparation)

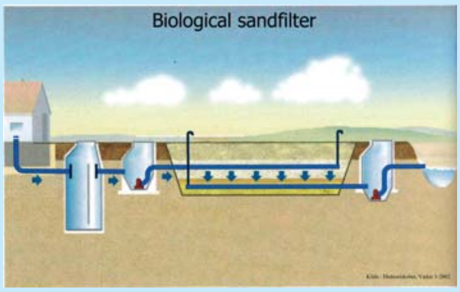
5.4 Groundwater
(In preparation)

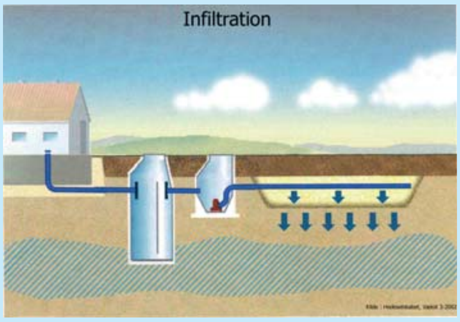
5.5 Lakes
(In preparation)

5.6 Wetlands
(In preparation)

Box1
Scattered settlements
Types of measures







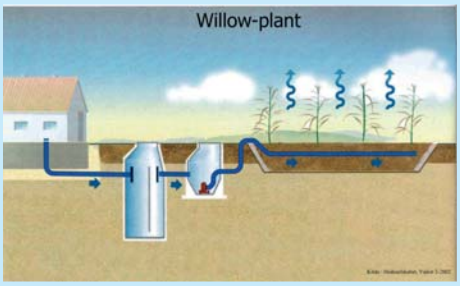


Photo: Stig Eggert Pedersen

Costs of improved sewage treatment:
Typically 60.000 DKK or 8.000 €
per household/settlement

Table 5.6
Point source measures.
Effect and economy.

Point source measures Effect and economy				
Status 2005 – Already implemented measures		Loading 2000-2005 (% reduction compared 1980's) N tonnes/yr	 P tonnes/yr	TOTAL COST mio. DKK operational costs construction costs
Treatment plants	Enhanced phosphorus and nitrogen removal	167 (84%)	6,2 (98%)	375/yr (oper.+ const.) *1
Storm water outlets	Basins	27	7,6	? (operational) ? (construction)
Scattered settlements	Improved treatment (organic matter + phosphorus) on aprox. 300 settlements	37	8,4	0,66/yr (operational) 18 (construction)
Enterprises + waste disposal site	Power plant enterprise pay for compensate enhanced municipal sewage treatment Percolate collecting system	164	1,5	92 (construction) 3,5-5/yr (operational)
Total – "Status 2005 - Already implemented measures"		395	24	> 380 mio DKK/yr (operational + construction) > 110 mio DKK (construction)
Measures already planned – "Baseline 2015"		Baseline loading 2015 / Reduction of loading compared 2000-2005 N tonnes/yr	 P tonnes/yr	TOTAL COST mio. DKK operational costs construction costs
Treatment plants	Renovation of treatment facilities Close outdated smaller treatment plants	165 / 2	5,8 / 0,4	? (operational) ? (construction)
Storm water outlets	Basins – combined sewer systems Mechanical and chemical treatment facilities	25 / 0	5,1 / 0	0
Scattered settlements	Improved treatment (org. matter + P) on further aprox. 4000 settlements. Phosphorus removal on half of it.	29 / 8	6,4 / 2	270 (construction) 10/yr (operational)
Enterprises + waste disposal site	Reshaping of rivermouth (Odense river) because of outlet of cooling water from power plant	32/20	0,25/0,15	15 (construction)
Total – "Measures already planned - Baseline 2015"		255 / 30	18 / 3	>285 mio DKK (construction) >10 mio DKK/yr (operational)
Measures WFD (Scenario)		Loading 2015/ Reduction of loading compared baseline 2015 N tonnes/yr	 P tonnes/yr	TOTAL COST mio. DKK operational costs construction costs
reatment plants	UV+Ozon treatment facilities Enhanced phosphorus removal	<165 / ?	<5,8 / ?	85-100 (construction) 14/yr (operation)
Storm water outlets	Basins – combined sewer systems Mechanical and chem. treatment facilities	<25 / ?	<5,1 / ?	500 (construction) ? (operation)
Scattered settlements	Improved treatment (org. matter + P) on further approximately 1275 settlements.	25 / 9	3,6 / 2,8	100 (construction) 3,7/yr (operation)
Enterprises + waste disp. site	No further measures	32 / 0	0,25 / 0	-
Total – "Measures WFD"		<247 / >9	<14 / >2,8	685-700 mio DKK (constr.) >17,7?mio DKK (operation)

?: It is for the time being not possible to calculate the costs or the loading.

6. Monitoring programme

Monitoring is an essential part of a Water Management Plan, and has the primary purpose to evaluate the effect of the measures taken to improve the ecological quality in those water bodies, that do not comply with good ecological quality. A secondary purpose is to adjust these measures or to put new ones into force. This kind of monitoring is termed *operational monitoring* in the Water Framework Directive. *Investigative monitoring* may be used as a supplement if the reasons for insufficient ecological quality are not known. *Surveillance monitoring* is carried out in those water bodies that have good ecological quality according to provisional or current quality criteria. Within the OPRB, some or all water bodies in coastal waters, streams and lakes as well as groundwater are already included in the National Monitoring Programme for the Aquatic Environment and the Terrestrial Nature (NOVANA).

The elements in a proposed programme for operational monitoring within the OPRB, including coastal water, watercourses, lakes, and groundwater, and also including the most important pressures, are presented briefly in Tab. 6.1.

In order to integrate the results of the monitoring of pressures and the ecological status in the water bodies, modelling tools are under development for lakes in general, and for the Odense Fjord in particular.

Modelling tools will also be important when dealing with the huge amount of small water bodies, which will have to be treated in a representative way, as it is not possible to monitor all the individual water bodies.

Monitoring types according to WFD

Operational monitoring

- **Where "Good Ecological Status" is not achieved but the reasons of insufficient ecological quality are known**

Investigative monitoring

- **Where reasons of insufficient ecological quality are not known**
- **Supporting the operational monitoring**

Surveillance monitoring

- **Where "Good Ecological Status" is achieved**
- **Check if the Water Bodies maintain "Good ecological status"**

6.1 Coastal waters

In the coastal part of the OPRB, Odense Fjord, 3 major water bodies and 17 heavily modified water bodies (see ch. 1, figure 1.2) have been defined.

As good ecological status (GES) has not been attained for any parts of Odense Fjord (see ch. 4), only the operational and investigative monitoring are relevant. So far it is considered that only the operational monitoring is needed for the moment, as the reasons for not fulfilling GES are well known.

Due to its high status in NOVANA as a nationally representative, intensively studied fjord with high-frequency measurements of many variables, parts of the monitoring program in Odense Fjord, especially the eutrophication-related monitoring, is somewhat above what is recommended in the WFD. Generally, the frequencies recommended in the WFD are considered to be too low for e.g. an improvement of ecological status to be well-documented. The program shown in tab. 6.1 is aimed at maintaining the fjord as an intensively studied area, e.g. due to the importance of continuity and maintaining a high quality in the existing, invaluable long time series, development of modelling tools etc. In terms of monitoring of hazardous substances, current NOVANA monitoring is generally less intensive than the WFD recommendations, and should accordingly be upgraded; this is especially true for Odense Fjord, where the pressure from certain hazardous substances on biota is severe (see chap. 2).

The transposition of the Shellfish Waters Directive is not yet fully completed in Denmark, and the monitoring required according to this directive therefore cannot be described in detail, but will probably need some more focus on hygienic monitoring. For Natura 2000 sites, specific monitoring programmes to follow the achievement of good preservation status for species as well as habitats selected according to these directives will be necessary. Such programmes are still under development on a national level.

6.2 Running waters

Due to resource constraints it is unrealistic to monitor all 316 stream water bodies within the OPRB. Thus, it is necessary – and permissible – to monitor a representative subset of water bodies.

Surveillance monitoring is performed at all 15 stream water bodies having good ecological quality, however. The choice of parameters and frequencies are in accordance with WFD recom-

Odense Pilot River Basin – Operational Monitoring Program							
Aquatic media	Biology		Hydromorphology		Physico-chemical		Monitoring Pressures
	Quality elements	Frequency /interval	Quality elements	Frequency /interval	Quality elements	Frequency/ interval	
Water-courses	Macrophytes	1 / 2	Hydrological regime	Continuously	Organic matter nutrients	4 / 2	River maintenance Erosion of banks & riparian zones Wastewater, Nutrient loss from agriculture
	Macrozoobenthos	1 / 2	River continuity	1 / 1	Other pollutants	4 / on demand	
	FIsh	1 / 2	Morphology	1 / 2	Priority pollutants	4 / on demand	
Lakes (large)	Phytoplankton	7 / 2	Hydrology	12 / 2	Temperature, oxygen, salinity, alkalinity	7 or 12 / 2	Wastewater, Nutrient loss from agriculture hunting and fishery
	Macrophytes	1 / 2	Morphology	1 / on demand	Nutrients	12 / 2	
	Macrozoobenthos	1 / 2	-	-	Other pollutants	6 / on demand	
	Fish	1 / 1	-	-	Priority pollutants	6 / on demand	
Ponds	Phytoplankton	6 (1) / 1	-	-	Temperature, oxygen, salinity, alkalinity	6 (1) / 1	Wastewater, nutrient loss from agriculture hunting and fishery
	Macrophytes	1 / 1	-	-	Nutrients	6 (1) / 1	
Costal waters	Phytoplankton	26-52/ 6	-	-	Temperature, oxygen, salinity	26-52 / 6	Wastewater, Nutrient loss from agriculture Industrial emissions Navigation and up-keeping of shipping lanes
	Macrophytes	2 / 3	-	-	Nutrients	26-52 / 6	
	Macrozoobenthos	1 / 3	-	-	Other pollutants	2-4 /3	
	-	-	-	-	Priority pollutants	3-7 /3	
Ground-water	-				Nutrients Inorganic substances Other pollutants	90 / 6	Nutrient loss from agriculture, Use of pesticides, Industrial emissions

Table 6.1
Overview of a proposed programme for operational monitoring in coastal waters, watercourses, lakes/ponds, and groundwater within the OPRB. Fre-quency describes the number of sampling during a monitoring year, interval describes the number of years that monitoring is carried out within a 6-years pe-riod. "Monitoring Pressures" describes pressures needed to be regularly monitored, because of their linkage to the implementation of the WFD objectives.

mendations except that phytoplankton and phytobenthos are not included. Two water bodies are already included in the National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments (NOVANA), although only one of them fulfils the demands of the present programme.

Operational monitoring is optional for 301 stream water bodies with either insufficient or unknown ecological status. Only 72 of these water bodies will be included in the future monitoring programme, however, of which 40 are stream type 1, 22 are stream type 2 and 10 are stream type 3. Due to the relatively large size of the water bodies, at least 108 monitoring sites are required to ensure proper representation of ecological quality. Twenty of these are included in NOVANA. The number of parameters will be somewhat reduced compared to the WFD recommendations (excluding phytoplankton, phytobenthos, temperature, oxygen, salinity and alkalinity).

No investigative monitoring is planned.

6.3 Lakes

Surveillance monitoring is only performed at two of the 14 lakes larger than 5 ha within the OPRB (one of which is included in NOVANA). The proposed programme is generally in agreement with WFD recommendations except that (1) phytobenthos is not included and (2) the lakes are monitored at longer intervals (every third year instead of every year) but far more frequently during each monitoring year.

Operational monitoring is optional for at least 12 "large" lakes with inadequate ecological status, but should also include a representative subset of the 2,600 smaller lakes and ponds for which the ecological status is practically unknown. Six "large" lakes and 25 small lakes/ponds are included in NOVANA. The programme for "large" lakes resembles that for surveillance monitoring except that the sampling frequency is increased significantly for nutrients and phytoplankton (tab. 6.2). For smaller lakes and ponds, a reduced programme (in accordance with NOVANA) is suggested.

In addition to the monitoring of ecological status, nutrient inputs from the various sources must also be monitored. This will only be carried out at a subset of representative lakes (including "near-reference" lakes) in order to establish empirical models linking catchment land use and nutrient load, supplemented by similar empirical models linking nutrient load and in-lake nutrient concentrations derived from the present monitoring programme. By inputting knowledge of land use these models can be used to predict the nutrient load in the remaining lakes and to assess the quality of the non-monitored lakes.

No investigative monitoring is planned.

6.4 Pressures on surface waters

Although the WFD predominantly focuses on monitoring quality elements in the water bodies that may be indicative for specific pressures, monitoring of the pressures themselves (nutrient loads, hazardous substance levels and loads, physical factors) is certainly important in order to link between pressures and impact. This is especially important in operational monitoring. In the absence of pressure monitoring, it may be impossible to link pressures properly with their effects in the associated water bodies, and thus to be able to adjust plans for obtaining good ecological quality. But monitoring possible pressures - or at least "background" levels of these pressures (e.g. run-off of nitrogen from catchments) - is even important in surveillance monitoring. Thus, such monitoring may be able to detect the reasons for future negative changes in the water bodies that at present have good ecological quality because these negative changes would otherwise be unexplained. And monitoring the "back ground" levels of pressures at water bodies with good or even high ecological quality is important in comparison with monitoring levels of pressures that induce moderate and worse ecological quality in other water bodies.

For simple resource reasons the monitoring of pressures may be limited to a representative subset of water bodies. In the case of nutrient loads, the data obtained may then be used to establish empiric models linking catchment land use and nutrient load. For lakes (and certain coastal water bodies) these models may be supplemented by similar empiric models linking nutrient load and water body nutrient concentrations, derived from the present monitoring programme. With an input of knowledge of point sources (including wastewater discharges from scattered homes, stormwater systems) and land use, these models may be used to predict the nutrient load in the rest of the coastal water bodies and lakes, and additionally to assess the quality of those water bodies that are not monitored at all.

Whereas the current, well-functioning monitoring program concerning the pressures arising from nutrient loads should be continued and further improved, as outlined above, it will be a challenge to generate a monitoring programme for input quantities and sources of hazardous substances, for which knowledge are relatively scarce. Once established, such a programme may replace some of the concentration monitoring of hazardous substances in the water phases and sediments of the water bodies, whereas it is important to maintain the monitoring of biota, both in the form of concentrations in biota (due to the accumulation effect) and harmful effects on biota.

Finally, various physical pressures may need specific monitoring programs. This may hold for factors like e.g. river maintenance and erosion of banks and riparian zones in watercourses and the upkeeping of shipping routes and extent of navigation in coastal zones; this type of monitoring may also be important in order to assess the heavily modified water bodies.

6.5 Groundwater

For evaluation of the chemical status, surveillance and operational monitoring could be carried out in 31 out of 36 water bodies by using the existing monitoring system on the water wells in the area (table 6.1). There are 616 water wells in the Odense Fjord area all suited for the purpose (table 6.1). Additionally, it could be relevant to establish a few new boreholes for monitoring and to adjust the existing monitoring programme.

Investigative monitoring is carried out in connection with investigation, remediation and surveillance of polluted sites.

Surveillance of the quantitative status primarily is carried through monitoring of the water table and extraction of water on the waterworks. Additionally there is a surveillance of the groundwater table in selected areas included in a regional monitoring programme.

7. Public Participation

Introduction to Public Participation

Public Participation is an important part of the implementation of the Water Framework Directive. The Directive is, however, loosely defined regarding specific demands on public participation.

In order to implement a Water Plan successfully it is highly necessary to get acceptance of the plan, the suggested environmental objectives, and the measures needed to reach the objectives in order to achieve good ecological status in the region in question.

This calls for identification of all stakeholders, and their participation early on in the process.

7.1 Who was involved and when?

As described in the previous chapters of the present Water Management Plan the major steps in creating this plan have been the preparation of two reports, the Basic Description and the Programme of Measures.

These reports have been elaborated by the administration of the Water Authority, and they have been thoroughly discussed with stakeholders present in the catchment of Odense Fjord. An overview of stakeholders can be seen in table 7.1.

The stakeholders' organizations were invited to a series of meetings prepared by the Water Authority. These meetings were part of a larger plan for involving the public in the different steps of creating a Water Plan. The participation plan can be seen in table 7.2.

The plan for public participation holds the following elements:

- Involvement of stakeholder groups through:
  - National Scientific Board
  - Regional Political Board
  - Technica Advisory Board
- Special theme in Regional Plan 2005*
- Creation of homepage
- Ad hoc meetings
- Press coverage
- Information folder

* The Regional Plan is a comprehensive plan in Denmark describing a 12 year period. The plan is revised every four years, and it is binding to the municipalities involved.

In spring 2003 two advisory boards were created: the National Scientific Board and the Regional Political Board. The two groups were created to ensure both a high professional quality of the reports and to ensure that local/regional political level was in agreement with the decisions taken on basis of the Basic Description and the Programme of Measures. Both groups consisted of members from stakeholders' organizations

To facilitate the comprehensive work a Technical Advisory Board was created in spring 2004 to ensure that details of the work (the reports) were thoroughly discussed in a forum of professionals. Also this group consisted of members from stakeholders' organizations.

As seen above the preparations of the Water Plan was made a special theme in the legally obligatory Regional Plan 2005. Ad hoc meetings and creation of an Information folder as part of the public participation plan was not fulfilled, whilst Press coverage and a Homepage was covered www.odenseprb.fyns-amt.dk as well as a stakeholder analysis. The purpos of the analysis was to ensure participation of all relevant stakeholders, and not forget anyone.

Except from the missing folder and ad hoc meetings the plan was followed although with some delay time wise.

7.2 What comments have the Water Authority received?

The public participation process in OPR has benefited from the effort of the three advisory boards. The Technical Advisory Board especially has delivered substantial comments to the reports. This work group has offered time and resources in giving a series of comments to the two main reports (Basic Description and Programme of Measures).

The comments from all three advisory boards can be divided into the following categories:

1 **Technical comments**
2 **Comments in relation to definition of environmental goals and reference condition**
3 **Political comments**
4 **Comments to the process as such**

The contents of the different categories can be summarized into the following:

Technical comments

- Clarification of facts
- Concrete suggestions to improve characterisation
- Identification of lacking tools in carrying out the Basic Description
- Suggestions concerning: how to define modified water bodies
- Demands for economic calculations regarding Programme of Measures

Comments in relation to definition of environmental goals and reference condition

- Input to definition of goals
- Tools for assessment of present condition, and definition of goals
- Scientific support to definition of goals
- Support to: how far back should we assess reference conditions
- Suggestions to definitions to reference conditions and further application
- Necessary coordination to different EU directives

Political comments

- Strong criticism of environmental goals; some wanted them stronger, some weaker
- Demand of immediate economical assessments
- Demand of non-publication of the Basic Description
- Views on costs of implementation of a future Water Plan
- Backing possibilities to technological solutions regarding agricultural emissions

Comments to the process as such

- Attention to level of ambition
- Attention to the necessary teamwork between involved parties
- Criticism of the work form in the first period of collaboration
- Praise of the work form in the later period of collaboration
- Demand of suggestions on how to make measures/goals operational

What type of action has been taken regarding the comments?

The Water Authority has managed the comments in different ways. In relation to **technical comments**, actual necessary alterations have been incorporated in the Basic Description and Programme of Measures. An overview of all comments can be seen in minutes from the meetings.

Comments to definition of reference condition and environmental goals have been managed in three different ways. Concrete answers have been given to questions on methods. Furthermore, suggestions to which elements should enter the assessment of definition of environmental goals and reference conditions have been or will be considered. Data basis and announcements from the national level will also influence these elements. Finally, comments on coordination to other EU-directives have led to internal discussions in the county administration and within other authorities.

Some of the more **political comments** have caused the county council politicians to respond directly to these comments.

In relation to **comments to the process as such**, these comments have drawn attention to the work process and the way cooperation is performed between stakeholders and between stakeholders and the authority. During the discussions of the Basic Description it became obvious that the process as such needed a great deal of mutual information and time for the necessary dialogue between stakeholders. During the discussions of the Programme of Measures the stakeholders' groups obtained a higher information level about each other, and the process was smoother although still time consuming.

Presently (August 2005) comments from all relevant stakeholders regarding Programme of Measures have been presented to the Water Authority, and especially the positive comments on the latest meetings should be emphasized. It was remarked that the Water Authority had done a serious and well managed job in collecting all the many different comments and opinions, and treated these comment with the greatest respect although fundamental disagreements continue to exist between stakeholders.

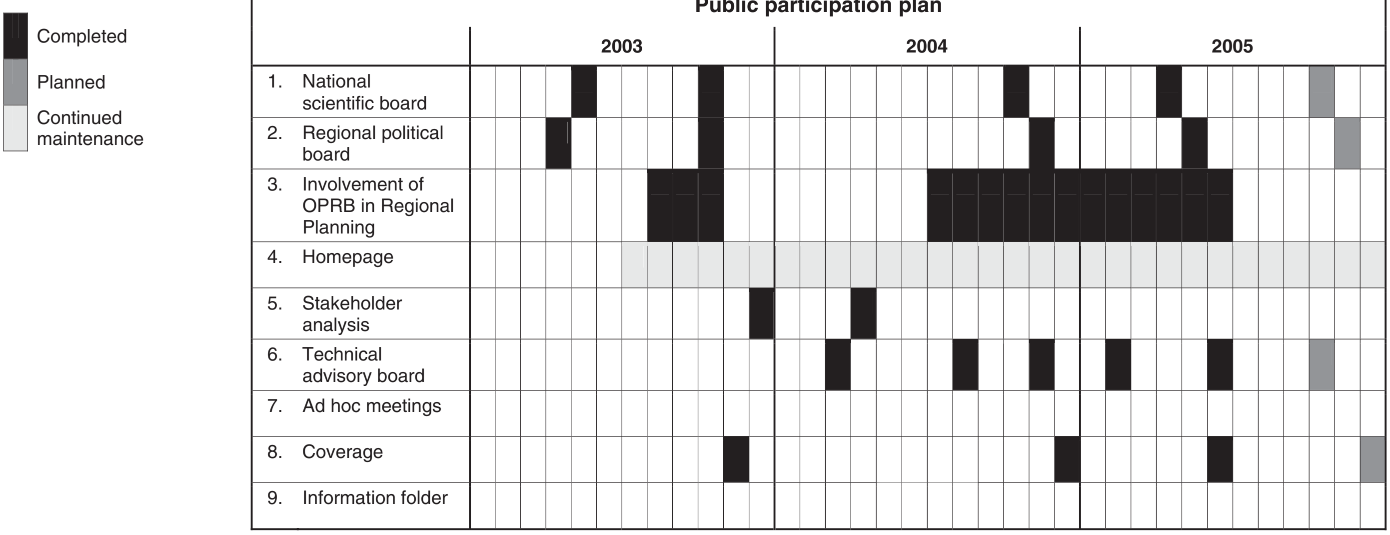
The Water Authority would have wished that some stakeholders' groups had been more active during the meetings. This wish goes for more than one group. Municipalities that will have a key role to play when the implementation of the Water Plan is carried out have contributed less than hoped for. On the other hand other groups, for example Farmers' Organizations, have contributed very much to discussions of the two reports.

The Water Authority sees these different levels of participation as an expression of different level of means and resources to put into such a work. It reflects the economical and political strength of these stakeholder groups.

Table 7.1

Stakeholders				
Level of repre-sentatives	Core Actors	Other Authorities	Business interests, research, etc.	NGOs, associations
Local & regional	Fyn County	Municipalities	Local industries, agro-industrial companies	Anglers Association
			Representatives of private consultants	Association of Hunters
			3 associations of Farmers called: Association of Family Farmers Fyn Associations of Farmers Fyn Association of big landowners	
			Fyn Tourist Board	
			Odense & Fyn Waterworks	
National	Danish Forest & Nature Agency		Confederation of Danish Industries	Danish Ornithologists' Association
	Danish EPA		Danish Waterworks	Danish Society for Conservation of Nature
	Ministry of Environment	Danish Regions (Counties' Assoc.)	Danish Professional Gardeners	Danish Forestry Extension
	Ministry of Food, Ag-riculture & Fisheries	Danish Food Econom-ics Research Institute	Universities & Research institutes	Danish Outdoor Council

Table 7.2



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Annex 9.1

Basis for the selection of the EU habitat sites in Odense River Basin (habitats and species)

* indicates priority habitat types

No. 94 Odense Fjord

1110 Sandbanks which are slightly covered by sea water all the time
1140 Mudflats and sandflats not covered by seawater at low tide
1160 Large shallow inlets and bays
1310 *Salicornia* and other annuals colonizing mud and sand
1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
4010 Northern Atlantic wet heaths with *Erica tetralix*
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
7220 *Petrifying springs with tufa formation (*Cratoneurion*)
7230 Alkaline fens

No. 97 The mires Urup Dam, Brabæk Mose, Birkende Mose and Illemose

1903 Fen orchid *Liparis loeselii*
3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
7210 *Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
7230 Alkaline fens
91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)

No. 98 River Odense with River Hågerup, River Sallinge and River Lindved

1016 Desmoulin's whorl snail *Vertigo moulinsiana*
1032 Common river mussel *Unio crassus*
1096 Brook lamprey *Lampetra planeri*
1149 Spined loach *Cobitis taenia*
3260 Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
7220 *Petrifying springs with tufa formation (*Cratoneurion*)
7230 Alkaline fens
91E0 *Alluvial forests with *Alnus glutinosa* and **Fraxinus excelsior** (*Alno-Padion, Alnion incanae, Salicion albae*)

No. 103 Storelung

7120 Degraded raised bogs still capable of natural regeneration
91D0 *Bog woodland

No. 104 Forests and lakes south of Brahetrolleborg

1016 Desmoulin's whorl snail *Vertigo moulinsiana*
1166 Great crested newt *Triturus cristatus*
3150 Natural eutrophic lakes with *Magnopotamion or Hydrocharition* - type vegetation
3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
7110 *Active raised bogs
7230 Alkaline fens
91D0 *Bog woodland
91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

No. 105 Lake Arreskov

1016 Desmoulin's whorl snail *Vertigo moulinsiana*
3150 Natural eutrophic lakes with *Magnopotamion or Hydrocharition* – type vegetation
3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
7230 Alkaline fens
91D0 *Bog woodland
91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

No. 106 Lake Store Øresø, Lake Sortesø and Lake Iglesø

3150 Natural eutrophic lakes with *Magnopotamion or Hydrocharition* – type vegetation
3260 Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
7140 Transition mires and quaking bogs
7150 Depressions on peat substrates of the *Rhynchosporion*
7230 Alkaline fens

Annex 9.2

EC Bird Protection sites in the Odense River Basin

No. 74 Lake Brændegård, Lake Nørresø and forests around Brahetrolleborg
Cormorant *Phalacrocorax carbo*
Grey lag goose *Anser anser*
Common pochard *Aythya ferina*
Tufted duck *Aythya fuligula*

No. 75 Odense Fjord
Arctic tern *Sterna paradisea*
Sandwich tern *Sterna sandvicensis*
Marsh harrier *Circus aeruginosis*
Avocet *Recurvirostra avosetta*
Mute swan *Cygnus olor*
Whooper swan *Cygnus Cygnus*
Red-breasted merganser *Mergus serrator*
Goosander *Mergus merganser*
Coot *Fulica atra*

No. 78 Lake Arreskov
Marsh harrier *Circus aeruginosis*
Common tern *Sterna hirundo*
Grey lag goose *Anser anser*
Common pochard *Aythya ferina*