

**Danish Ministry of the Environment and Energy, Danish Ministry of  
Transport,  
Swedish Control and Steering Group for the Öresund Fixed Link**

**FINAL REPORT ON THE ENVIRONMENT AND  
THE ÖRESUND FIXED LINK'S COAST-TO-COAST INSTALLATION  
11<sup>th</sup> SEMI-ANNUAL REPORT  
July-December 2000**

# Colophon

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## List of contents

<b>0.</b>	<b>FOREWORD</b> .....	<b>4</b>
<b>1.</b>	<b>SUMMARY</b> .....	<b>5</b>
<b>2.</b>	<b>INTRODUCTION</b> .....	<b>6</b>
<b>3.</b>	<b>CONSTRUCTION WORK IN ÖRESUND</b> .....	<b>7</b>
3.1	ACCEPTANCE OF DREDGED QUANTITIES AND SPILLAGE ACCOUNTS.....	7
3.2	ACCEPTANCE OF MARGIN OF ERROR ON SPILLAGE PERCENTAGE .....	8
3.3	ACCEPTANCE OF ZERO-SOLUTION ON THE SWEDISH SIDE .....	8
<b>4.</b>	<b>ASSESSMENT OF THE FULFILMENT OF THE CRITERIA FOR ENVIRONMENTAL IMPACT IN ÖRESUND</b> .....	<b>9</b>
4.1	SEDIMENT SPREAD AND SEDIMENTATION .....	9
4.2	WATER QUALITY.....	9
4.3	BENTHIC VEGETATION.....	10
4.4	COMMON MUSSELS.....	11
4.5	BENTHIC FAUNA OTHER THAN COMMON MUSSELS .....	13
4.6	FISH .....	13
4.7	BIRDS .....	14
4.8	SHORE AND COAST .....	18
<b>5.</b>	<b>MONITORING THE LERNACKEN INSTALLATION CHANNEL</b> .....	<b>20</b>
<b>6.</b>	<b>COMPLETION ACTIVITIES</b> .....	<b>21</b>
<b>7.</b>	<b>REFERENCES</b> .....	<b>21</b>

## 0. Foreword

The explanatory notes to the Danish Construction Bill to build a fixed link over the Öresund state that every six months the Danish Government shall submit a progress report to the Danish Parliamentary Environment and Planning Committee on the environmental consequences of the construction work on the coast-to-coast section. On the Swedish side, the National Environment Protection Agency and the County Administrative Board of Skåne (Scania) are to keep the Swedish Government informed on the implementation of the project and the control and monitoring of the construction work, through the Control and Steering Group for the Öresund Fixed Link (KSÖ).

The previous semi-annual reports present the environmental management frameworks and the individual parts of the control and monitoring programme, together with a description of the results from autumn 1995 to winter 2000.

In this report, the Danish and Swedish supervisory authorities pronounce their final assessment of the fulfilment of the environmental criteria established for the construction work. The 9<sup>th</sup> and 10<sup>th</sup> semi-annual reports contained the preliminary assessments on the fulfilment of these criteria. Thus, these three reports contain the final collective assessments. These reports, which have been produced by the relevant Danish and Swedish environmental authorities, with the assistance of the Danish Ministry of Transport, are based on reports produced by Øresundsbro Konsortiet and consultants associated with the various aspects of the authorities' control and monitoring programme.

This semi-annual report is published in a joint Danish/Swedish version, with a separate version in English.

# 1. Summary

The Öresund Fixed Link was inaugurated and came into operation on 1<sup>st</sup> July 2000. Prior to this, the Danish Minister of Transport noted on 27<sup>th</sup> June 2000 in a letter to Øresundsbro Konsortiet, that an unchanged through-flow of water in Öresund and unchanged salt and oxygen supplies into the Baltic Sea ( the zero solution) had been assured following the completion of the Öresund Fixed Link. On the Swedish side on 3<sup>rd</sup> April 2001, the Environment Court at Växjö Assizes pronounced that Öresundsbro Konsortiet had fulfilled the criterion for the zero-solution in accordance with the Swedish definition. The criterion for the zero-solution was thus approved by the authorities in both countries.

On 27<sup>th</sup> November 2000, the Danish and Swedish supervisory authorities accepted Øresundsbro Konsortiet's final accounts for dredged quantities and spillage, as well as the margin of error for the calculations of the spillage percentage. The Environment Court further confirmed in its ruling of 3<sup>rd</sup> April 2001, that the Swedish criteria for the dredged quantities had been fulfilled. Consequently, the authorities have noted that all the dredging-technical criteria have been fulfilled.

During 2000, benthic vegetation, common mussels, eider, greylag geese and mute swans were carefully surveyed, as well as the coastal morphology in the construction zone. These surveys have shown that the fixed link and the construction operations have not adversely affected environmental conditions, nor have the environmental criteria been exceeded. These results point in the same direction as Øresundsbro Konsortiet's preliminary forecast of criteria fulfilment in May 2000.

In this concluding semi-annual report, the supervisory authorities thus note that all biological environmental criteria have been met.

The criterion for coastal morphology can not be given a final decision, as it applies over the whole of the link's projected lifespan of 100 years. Results and model estimates, however, show that so far, coastal morphological conditions have not given cause for further measures to be taken. Developments in the area between Saltholm and Peberholm will continue to be followed up by means of a special programme. The contents of this programme will be prepared by Øresundsbro Konsortiet, in consultation with the County of Copenhagen, which is the supervisory authority for this body of water.

To sum up, the supervisory authorities on both the Danish and Swedish sides have concurred with Øresundsbro Konsortiet's documentation on the fulfilment of those criteria applicable to the construction work on the coast to coast section of the Öresund Fixed Link.

During autumn 2000, the contractors have carried out final adjustments to one of the banks of the Lernacken access channel. Out of consideration to anglers, approximately 150 boulders have been laid out in the shallow waters. Øresundsbro Konsortiet has also cleared up items along the bridge alignment, and has carried out final checks and measurements. No visible changes to the seabed were found.

The big Baltic Sea Science Congress will take place in Stockholm from 25-29<sup>th</sup> November 2001. During mini-symposia, the authorities and consultants will present the main results, together with the latest findings on the registration and modelling of the biological impacts of extensive marine construction works such as the fixed link over Öresund. Researchers and administrators from the whole of the Baltic region are expected to attend the congress.

## 2. Introduction

With this 11<sup>th</sup> semi-annual report on the environment and the fixed link across Öresund, the Danish and Swedish supervisory authorities hereby present their final report on the environmental impact of construction work on the coast to coast section of the link.

The agreement between the Governments of Denmark and Sweden of 23<sup>rd</sup> March 1991 states that the final design of the Öresund Link shall be carried out with regard to what is ecologically motivated, technically possible and economically feasible, so as to prevent damage to the environment /ref. 13/. In accordance with the above, the Danish and Swedish authorities established quality objectives for the construction impacts on the environment in the Baltic Sea and Öresund, as well as on land, together with a control and monitoring programme.

For the coast to coast construction, the Danish and Swedish authorities determined that the Öresund Link must not be allowed to have any impact on the environment of the Baltic Sea, the so-called "zero solution". A zero-solution means that the Öresund Link must not alter the flow of water through Öresund, nor the supply of oxygen and salt into the Baltic.

In order to protect the animal and plant life of Öresund so far as was possible during the construction of the fixed link, Öresundsbro Konsortiet were charged with ensuring that the maximum, average spillage from the dredging operations in Öresund did not exceed 5 %. When planning the dredging operations, attention had to be paid to such sensitive seasonal factors as the growth period of eelgrass, the migration of herring through Öresund and the foraging of birds in the shallows around Saltholm.

Environmental protection has been specified in the criteria for the incidental environmental impact on water quality, benthic animal and plant communities, fish migration, bird populations and coastal morphology.

During the course of construction of the fixed link across Öresund, the co-operation between the authorities on the Danish and Swedish sides has been most successful. The Danish side was represented by the Danish Environmental Protection Agency, the National Forest and Nature Agency, the Ministry of Transport, the Ministry of Food, Agriculture and Fisheries, Dragør municipality, the County of Copenhagen, Copenhagen municipality, the Counties of Frederiksborg and of Roskilde, and Tårnby municipality. The Swedish side was represented by the Board of Fisheries, the Shipping and Navigation Administration, the County Administrative Board of Skåne, the City of Malmö, the Swedish Environment Protection Agency and the Swedish Geotechnical Institute. To these should be added the eleven members of the International Advisory Expert Panel. In addition, Copenhagen airport has participated with regard to the birds on Saltholm. Furthermore, there has been good and close co-operation between the authorities and the building contractors.

The work's progress and the results of the control and monitoring programmes have been continually presented in the semi-annual reports. These reports document the continual adaptations to the project, so that the impacts of the construction work, to the greatest extent possible, could be directed towards conforming to the forecasts contained in the environmental impact assessments.

From the point of view of the authorities, it was extremely positive that, from the start, Øresundsbro Konsortiet introduced an environmental management system.

An essential feature of Øresundsbro Konsortiet's environmental policy has been a clearly defined environmental strategy. This is based on so-called feedback principles in combination with detailed planning of the construction work, especially the dredging and reclamation operations. A combination of monitoring and model estimates has made it possible to follow the development of the impact on the environment and thus also, as required, to be able to adapt the construction work with the aim of meeting the environmental objectives.

By the end of 1998, the major part of the dredging work had been completed. It was thus possible in the 8<sup>th</sup> semi-annual report on the first six months of 1999, to include a special chapter on the calculation of sediment spillage and the associated margin of error /ref. 1/. The 9<sup>th</sup> and 10<sup>th</sup> semi-annual reports, for the second half of 1999 and the first half of 2000 respectively, covered the zero solution in special chapters /ref. 2, 3/. On the Danish side, the Minister of Transport noted on 27<sup>th</sup> June 2000, following consultation with the Minister of Environment and Energy, that, following the completion of the Öresund fixed link, the unaltered flow of water in Öresund and the supply of oxygen and salt into the Baltic Sea were assured.

In the 10<sup>th</sup> semi-annual report, the environmental authorities stated that the criteria for water quality, that is to say heavy metals and environmentally hazardous substances, sewage, nutrients and oxygen were fulfilled. Moreover, no exceeding of the criteria for mammals i.e. seals, foxes, cats and rats had been noted. Finally, the criterion for bathing water was judged to have been fulfilled.

This, the final semi-annual report presents the final assessments of the fulfilment of criteria. These concluding assessments are based on the results of all control and monitoring activity during the years 1993-2000.

### **3. Construction work in Öresund**

The Öresund Link became operational on 1<sup>st</sup> July 2000. During the second half of 2000, the contractors carried out a series of adjustments and work still outstanding, primarily on the mechanical and electronic systems. Furthermore, Sundlink carried out a final adjustment to one of the banks on the inner section of Lernacken access channel. Approximately 150 large boulders have been laid out in the shallows at Lernacken, for the benefit of anglers. After which a diving inspection and a completion measurement of the channel were carried out.

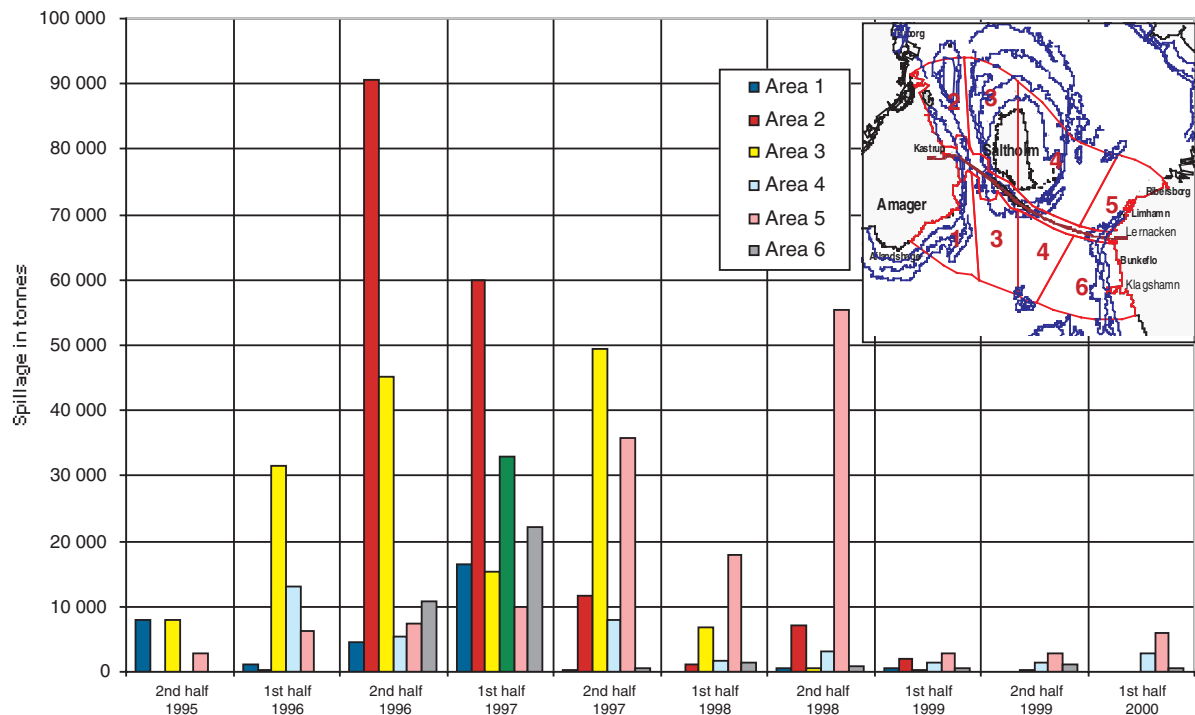
The clearing up of misplaced objects along the bridge alignment (200 m on either side) was carried out. Approximately 350 objects were found, mostly tyres, cabling and such like.

In addition, Øresundsbro Konsortiet carried out a completion measurement of the seabed along the alignment within a zone 200 m either side of the bridge. Apart from the protective islands around the pylons and the adjacent bridge pillars, the remains of the test island and the Lernacken access channel, no visible alterations have been noted on the seabed.

#### **3.1 Acceptance of dredged quantities and spillage accounts**

On 27<sup>th</sup> June 2000, Øresundsbro Konsortiet presented the final accounts for the dredged quantities and sediment spillage to the Danish and Swedish authorities /ref. 4/. The final account for the spillage for the remaining spillage-generating operations during the first half of 2000 was sent by the Øresundsbro Konsortiet to the authorities at the end of October 2000 /ref. 5/ (figure 1).

The Swedish Geotechnical Institute, together with the National Forest and Nature Agency, have on the basis of this, in a letter dated 27<sup>th</sup> November 2000, informed Øresundsbro Konsortiet that all requirements and criteria contained in the ruling of the Swedish Water Rights Court of 13<sup>th</sup> July 1995, and in the National Forest and Nature Agency's permit for extracting material from the seabed of 12<sup>th</sup> October 1995, have been fulfilled. On the basis of this, the Environment Court, on 3<sup>rd</sup> April 2001, decreed that the criterion for dredged quantities had been fulfilled.



**Figure 1.** Sediment spillage in areas 1-6 (see map in inset), every six months during the construction period, from and including 2<sup>nd</sup> half of 1995 up to 1<sup>st</sup> half of 2000. (Source: Øresundsbro Konsortiet, 2001)

### 3.2 Acceptance of margin of error on spillage percentage

On 27<sup>th</sup> June 2000, Øresundsbro Konsortiet sent an account of the spillage percentage margin of error for the dredging operations to the authorities /ref. 6/. In addition to this, Øresundsbro Konsortiet has produced a sub-account of the error on spillage from minor sources /ref. 7/.

The Swedish Geotechnical Institute, together with the National Forest and Nature Agency, in a letter of 27<sup>th</sup> November 2000, informed Øresundsbro Konsortiet that the Danish and Swedish authorities' criteria for the measurement accuracy of the spillage percentage had been met by a good margin (see further, special chapter in 8<sup>th</sup> semi-annual report) /ref. 1/.

### 3.3 Acceptance of zero-solution on the Swedish side

As mentioned in the 10<sup>th</sup> semi-annual report /ref. 3/, the Danish Minister of Transport noted in his letter of 27<sup>th</sup> June 2000 to Øresundsbro Konsortiet, that the Danish criterion for the zero solution had been fulfilled.

On the Swedish side, it is the Environment Court at Växjö Assizes which decides whether the zero solution has been fulfilled. On 28<sup>th</sup> August 2000, the Environment Court circulated Øresundsbro Konsortiet's documentation to the relevant Swedish authorities for comment, and via announcements in the press, the interested public was also given the opportunity to comment. On 3<sup>rd</sup> April 2001, the Environment Court issued its ruling in which it was confirmed that Øresundsbro Konsortiet had fulfilled the criterion of a zero solution in accordance with the Water Rights' Court definition, as well as the requirement for permitted quantities of dredged material.



## 4. Assessment of the fulfilment of the criteria for environmental impact in Öresund

In accordance with the Danish authorities' criteria /ref. 8/ and the criteria laid down in the Water Rights' Court ruling of July 1995 /ref. 9/, an overall control and monitoring programme was drawn up. This programme has during the construction period provided the basis for an assessment of the situation in the Öresund's environmental conditions, as well as providing the basis for planning and monitoring the possible impact of the construction activities. Following the completion of the construction work, the programme will show whether the impacts subside as expected.

Øresundsbro Konsortiet has, in connection with the individual dredging operations, carried out a feedback programme, with frequent monitoring of the marine environment around the dredging area. With the completion of the major dredging operations, the programme has been used to demonstrate to what extent the authorities' criteria have been met. The feedback programme includes surveys of sediment, eelgrass and common mussels, as well as the continual model estimates of these parameters.

The authorities' general programme has had the aim of providing complementary, independent monitoring of the environmental situation in the outer impact zone along the alignment of the Öresund fixed link, as well as in the monitoring area outside the zone of impact. The authorities' programme has embraced water quality, benthic vegetation, benthic fauna, fish, birds, coastal morphology and bathing water.

Both Øresundsbro Konsortiet's feedback monitoring and the authorities' monitoring programme have been continually adapted to the scope of the construction work, both spatially and in time. The most important dredging operations were completed by the end of 1998, and the extent of the feedback programme has, from 1999, been reduced both in time and space compared with previously /ref. 1/. Following a reduction in scope of the authorities' monitoring programme during 1999 /ref. 2/, surveys were reintroduced in 2000 of benthic vegetation, benthic fauna, common mussels, birds and coastal morphology.

The 10<sup>th</sup> semi-annual report presented a preliminary assessment of the fulfilment of the biological criteria /ref. 3/.

### 4.1 Sediment spread and sedimentation

*Dispersal, rebedding and deposition of sediment as a result of seabed operations, reclamation and erosion, as well as changed hydrographic conditions, can be accepted to such an extent as does not hinder compliance with the criteria laid down for the other aspects of the environment and nature /ref. 8/.*

During the first half of 2000, a geochemical validation was carried out of the model-estimated quantity of sedimented spillage at 31 stations in Öresund. This validation showed a reasonable agreement between the estimated and the measured quantities of sedimented spillage in the main sedimentation areas. In other areas which are characterised by an active re-mixture in the sediment of benthic animals, validation has not been possible.

### 4.2 Water quality

So far as water quality is concerned, environmental criteria have been established for heavy metals and environmentally hazardous substances, in respect of waste water, nutrients and oxygen.

The 10<sup>th</sup> semi-annual report gives an account of the environmental criteria, together with the results of the surveys /ref. 3/. In summing up, the Danish and Swedish supervisory authorities note that all the criteria for water quality have been met.

### 4.3 Benthic vegetation

*In the inner impact zone silting over or removal of vegetation can be accepted. In addition, a local decrease in the distribution depth of benthic vegetation can be accepted in the vicinity of the artificial peninsula and the artificial island. However, removal of vegetation must not lead to erosion that spreads outside the inner impact zone /ref. 8/.*

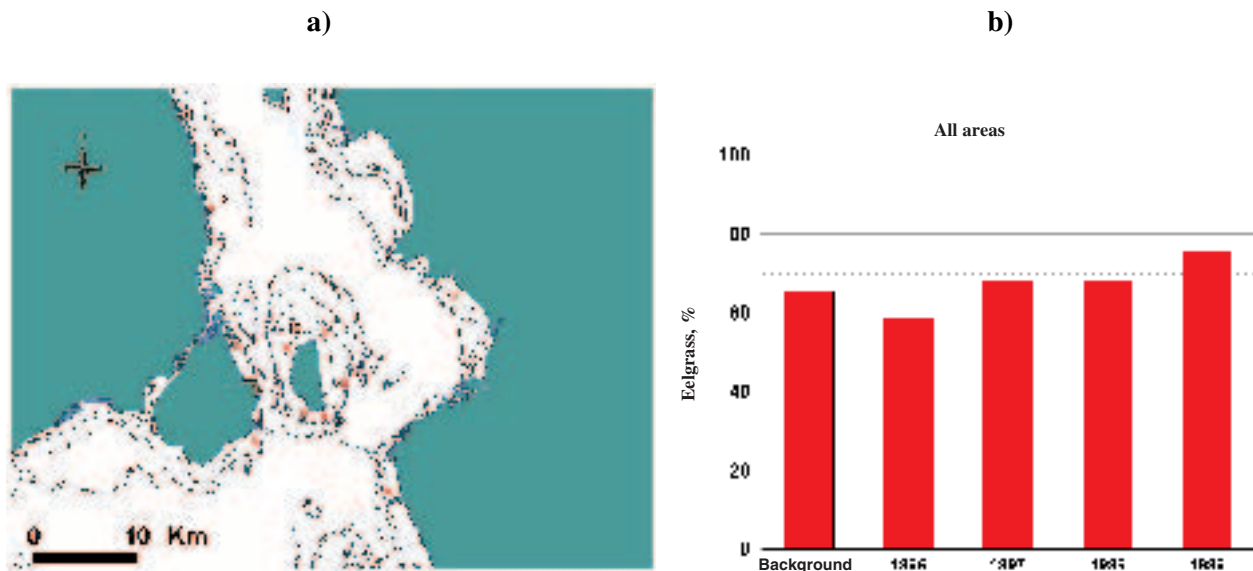
*In the outer impact zone temporary changes in the species composition, distribution and biomass of benthic vegetation as a consequence of shading and silting over can be accepted for at most 2 years for depths less than 5 m and for at most 5 years for depths greater than 5 m following completion of the seabed work /ref. 8/.*

*The changes must not amount to more than 25 % of the total distribution and biomass of the three important plant communities: eelgrass (*Zostera*), tasselweed (*Ruppia maritima*) and macroalgae /ref. 8/.*

*The biomass of eelgrass inside each area outside the work zones must never in any of the years through the effect of dredging be reduced with more than 25 % compared with normal conditions /ref. 9/.*

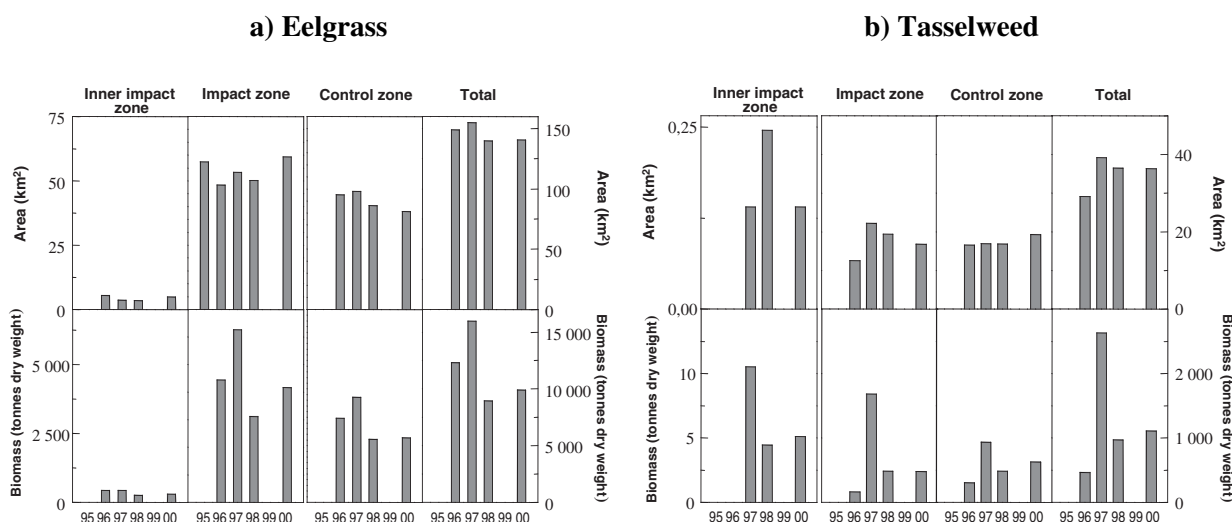
In September 2000, Øresundsbro Konsortiet carried out final surveys of the biomass and distribution of eelgrass. Results from the area west of Saltholm, where the eelgrass in deeper waters had previously indicated impact from the dredging operations in compensation dredging area CD#3-2, now showed that it had fully recovered /ref. 10/.

Furthermore, Øresundsbro Konsortiet has carried out a survey of eelgrass distribution in 10 selected fields (figur 2a). These surveys have been carried out with the help of aerial photography during the period 1996 to 2000. Results show that it is not possible to discern any decrease in the distribution of eelgrass during this period (figur 2b).



**Figure 2.** Positioning of the 10 sampling fields for testing eelgrass distribution (a), and average degree of coverage in percentage of the baseline surveys (100 %), plus 1996-1999 as an average of the 10 fields (b). (Source: Øresundsbro Konsortiet, 2001 /ref. 10/)

During the period 1993 to 2000, no statistically significant difference had been registered in vegetation growth in the monitoring and impact zone as a whole (figures 3a and 3b). On the other hand, changes had occurred in both the eelgrass and tasselweed communities in such a way that the vegetation's degree of coverage, biomass and shoot density during 2000 were highest nearest the bridge. The causes of this are not certain, but may be stress impact from the sediment spillage from the dredging work /ref. 11/.



**Figure 3.** *Eelgrass (a) and tasselweed (b) areas of distribution and total biomass in different areas of Öresund during the period 1996-1998 och 2000. Please note that different scales have been used in the two sub-diagrams. (Source: SEMAC, 2001 /ref 11/)*

To summarise, the results from the authorities' and Øresundsbro Konsortiet's monitoring during 2000 show that sediment spillage in connection with the construction work has not had a negative impact on the eelgrass and tasselweed communities in Öresund. Accordingly, the environmental criteria have been met.

#### 4.4 Common mussels

*In the inner impact zone a reduction in the biomass and distribution of common mussels can be accepted /ref. 8/.*

*In the outer impact zone the total area of common mussel banks with coverage exceeding 40 % must not be reduced by more than 25 % (relative to determined baseline levels) as a result of the construction work /ref. 8/.*

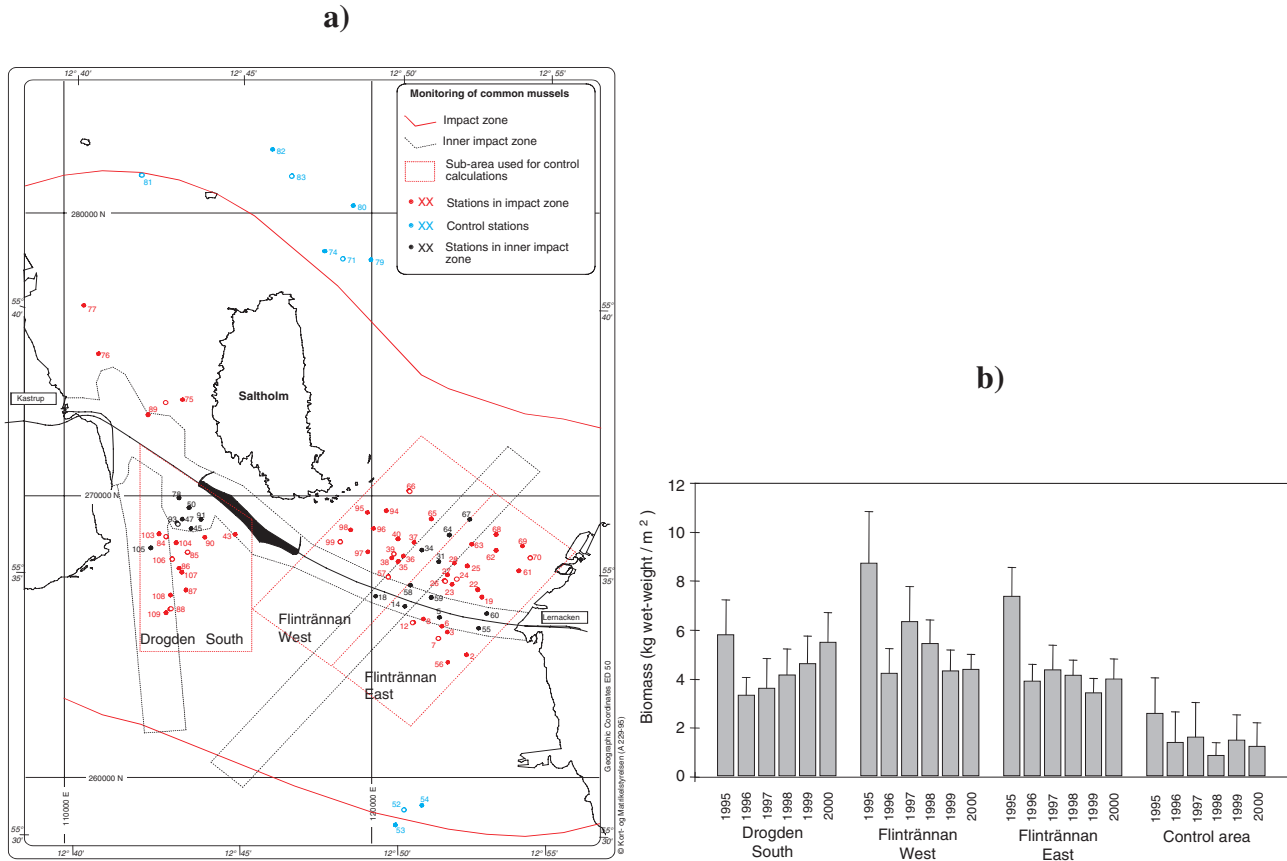
*The average biomass of common mussels in the outer impact zone must not be reduced by more than 25 % (relative to determined baseline levels) as a result of the construction work /ref. 8/.*

*In the outer impact zone the total area and biomass of common mussel must not deviate from the baseline levels for more than 2 years following completion of the construction work /ref. 8/.*

*The biomass of the mussels inside each area outside the work zones must never in any of the years through the effect of dredging be reduced with more than 25 % compared with normal conditions /ref. 9/.*

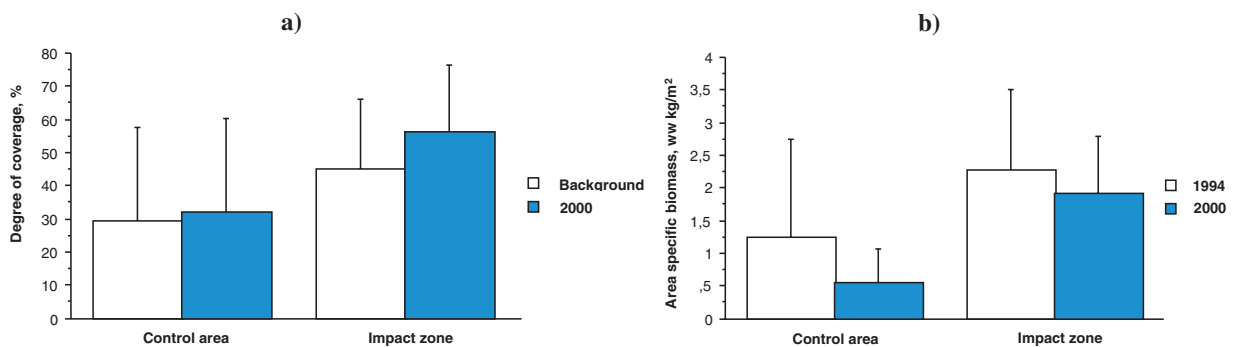
During the latter half of 2000, Øresundsbro Konsortiet undertook photo-screening surveys of common mussels in August and November. No signs of sedimentation were observed on the mussel beds, and, apart from the directly dredged areas in Drogden Fairway, the photo-screening revealed no sign of impacting from the dredging operations /ref. 12/.

In September and October 2000, Øresundsbro Konsortiet carried out the final collection of common mussels from the stations indicated in figure 4a. Degree of coverage, biomass and size distribution have been compared with the corresponding baseline surveys for 1995 /ref. 12/.



**Figure 4.** Position of sampling stations (a) in the outer impact zones Drodden South, Flintrännen West and East, plus development of the area-specific biomass (b) as wet-weight incl. shell. Confidence interval 95 % is given. (Source: Øresundsbro Konsortiet, 2001 /ref. 12/)

Compared with the baseline surveys, the biomass of common mussels has been reduced at most of the stations (figure 4b). However, the average reduction is greater in the control zone than in the three outer impact zones in Flintrännen and in Drodden. Within the outer impact zones, the proportion of stations with a degree of coverage higher than 40 % is almost unchanged compared with the conditions in 1995. These results are supported by those from the authorities' control and monitoring programme (figures 5a and b).



**Figure 5.** Mean and 95 % confidence interval for degree of coverage (a) and biomass (b) in wet-weight of shell- and soft-parts of common mussels in the control and outer impact zones during 1994 (baseline) and 2000. (Source: SEMAC, 2001 /ref. 14/)

To sum up, the activities associated with the construction of the fixed link have not had any significantly negative impact on the common mussel population, when compared with the baseline values for 1994, in respect of degree of coverage and biomass, and with the baseline values for 1995 in respect of heavy metal contents.

Accordingly, the supervisory authorities are of the opinion that the environmental criteria set up for common mussels have been met. The reductions registered in the outer impact zone are not significant, as the non-impacted control zone has experienced a greater reduction than the outer impact zone.

## 4.5 Benthic fauna other than common mussels

*In the inner impact zone reduced benthic invertebrate biomass and species number can be accepted /ref. 8/.*

*In the outer impact zone the benthic invertebrate biomass at water depths less than and greater than 6 m must not be reduced by more than 25 % and 50 %, respectively, (relative to determined baseline levels) as a result of the construction work /ref. 8/.*

*In the outer impact zone, species composition must only be changed (relative to determined baseline levels) for at most two years following completion of the construction work /ref. 8/.*

The development of the total individual density, biomass and number of species has been markedly different in Öresund compared with the conditions in Kattegat. In both places, animal life has declined compared with the baseline year of 1995, proportionately more, however, in Kattegat /ref. 15/. A thorough statistical analysis shows that the relatively small decline in Öresund's animal life can probably be linked to seabed deposition of spillage from the dredging work.

Species composition did not reveal any increased variation as a result of construction work, as the changes over time were much smaller than the differences between stations during the same year. Moreover, the species composition in 2000 appears to be the same as for the baseline year of 1995 /ref. 15/.

In conclusion, the results from the authorities' monitoring of the period 1996-2000 show that the sediment spillage associated with the construction work has not caused any negative impact on the soft-seabed fauna in Öresund. Consequently, the established environmental criteria have been met.

## 4.6 Fish

### **Herring migration**

Both the Danish and the Swedish authorities have laid down criteria regarding the migration of herring and other fish species through Öresund:

*The situation must not arise that sediment plumes simultaneously prevent the passage of herrings through both the Drogden Channel and Flinte Channel when moving south to their spawning grounds in the Baltic Sea, and when moving north to their foraging grounds in the Skagerrak and Kattegat /ref. 8/.*

*In the Drogden and at the Limhamn threshold the dredging operations must not be executed in such a way that the migration of the Rügen herring is significantly affected /ref. 9/.*

The migration of other species of fish has been safeguarded by the formulation of the following criterion:

*This criterion (for migrating herring) together with the criteria for the other aspects of nature and the environment also ensure the migration of eel, garfish, mackerel and lumpfish /ref. 8/*

In the period 1 March-31 October the work has to be executed in such a way that plumes of suspended sediment do not obstruct the passage of migrating fish and eel simultaneously through the Drogden and across the Limhamn threshold /ref. 9/.

Several migrating fish species use Öresund as a migration route between Kattegat/Skagerrak and the Baltic Sea Proper. The commercially important Rügen herring use Öresund as their wintering grounds as well as a migration route. The mature herring migrate in the autumn from their nursery grounds in Kattegat/Skagerrak and into Öresund in order to winter there. In early spring, they continue their migration south towards Rügen in order to spawn. After spawning, they migrate back to Kattegat/Skagerrak. Of the migrant species, herring are regarded as the most sensitive, and it is believed that, by safeguarding herring migration, the migration possibilities of other species are also safeguarded /ref. 22/.

The survey results are shown in the 10th semi-annual report /ref. 3/ and the authorities are of the opinion that the criteria for herring migration, and thus for other migrating fish, have been met.

### **Elvers, flatfish fry and cod**

*In the inner impact zone deterioration or destruction of potential fish spawning and nursery grounds can be accepted /ref. 8/.*

*In the outer impact zone deterioration of spawning and nursery conditions can be accepted for up to two years from completion of the seabed work. In the remainder of the Öresund the fish spawning and nursery grounds must not be affected /ref. 8/.*

On the basis of the results from both Øresundsbro Konsortiet's feedback monitoring (eelgrass and common mussels), and the supervisory authorities' programme for benthic vegetation and benthic fauna, the supervisory authorities consider that the criteria for elvers, flatfish fry and cod have been met.

In the Water Rights Court's ruling of 1995 /ref. 9/, the Board of Fisheries was given the responsibility of surveying elver migration into the Baltic Sea Proper, flatfish recruitment, sediment impact on pelagic eggs and fry, avoidance reactions by adult fish, effect of noise disturbance, vibrations and light on fish migration and monitoring of fishing, including recreational fishing. Parts of these surveys will continue until 2003, and the final assessment of these will only be made when the surveys are completed and reported.

## **4.7 Birds**

On the Danish side, special criteria were established for birds, whereas on the Swedish side, there were no special criteria for birds. The supervisory authorities and Øresundsbro Konsortiet nevertheless agreed to undertake surveys of migrating and staging seabirds and waders, breeding waders and wintering seabirds along the Swedish coasts because of their high population mobility in the Öresund region.

### **Birds on Saltholm**

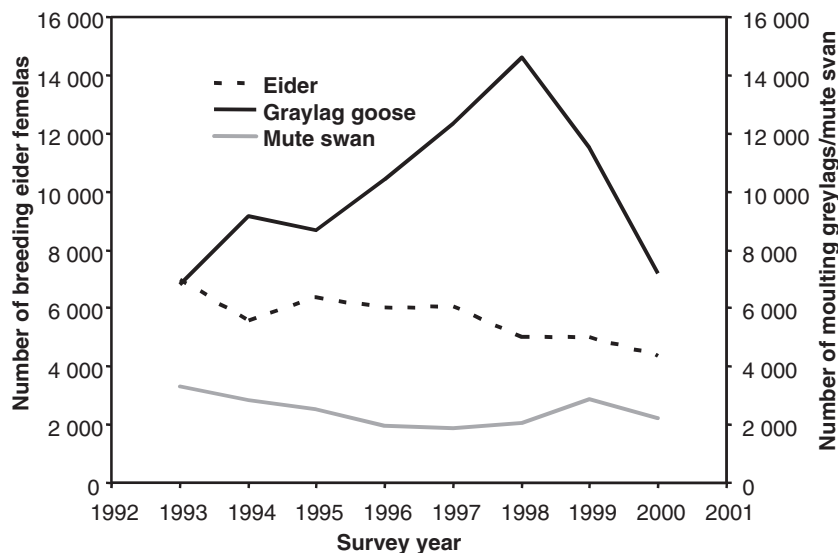
*A 15 % reduction can be accepted in the eider duck population on Saltholm /ref. 8/.*

*No later than five years after the completion of the seabed work the number of breeding eider pairs, determined as the number of nests, must be at least 90 % of the number of breeding eider pairs determined during the baseline studies /ref. 8/.*

*In the case of greylag geese and mute swans, the risk of a permanent reduction in the population of moulting birds at Saltholm can be accepted /ref. 8/.*

*The population of other breeding aquatic birds on Saltholm must not be significantly reduced /ref. 8/.*

When planning the surveying programme, the breeding population of eider and the populations of moulting greylag geese and mute swan on Saltholm were considered to be especially sensitive to the impact of construction work in the form of disturbance or food limitation (common mussels, eelgrass and tasselweed) /ref. 16/. By monitoring these three bird populations, their food resources and their reaction to disturbance, it was believed information would also be obtained on the possible impact on other bird species considered less sensitive at the population level. In this way, it has been possible to monitor the potential effects of the establishment of a fixed link on the bird life in general on Saltholm /ref. 17/.

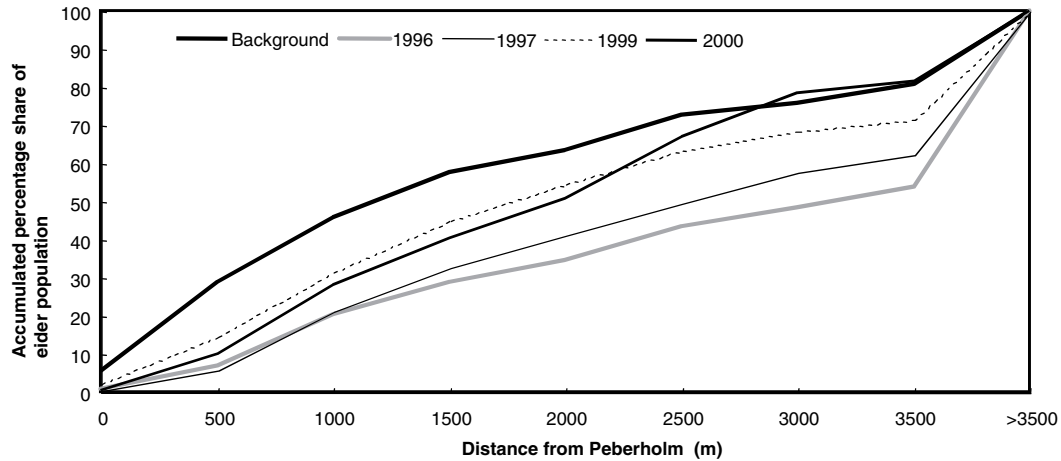


**Figure 6.** Population growth of breeding eider, plus moulting greylag geese and mute swan on Saltholm during the period 1993-2000. (Source: Danish National Environmental Research Institute, 2001)

The number of breeding female **eider** gradually declined by ca. 38 % from 1993 to 2000 /ref. 18/ (figure 6). The acceptance-level environment criterion established by the authorities has, therefore, formally been exceeded, as it was decided that, for the Saltholm eider population, a reduction of up to 15 % could be accepted as a result of construction work. By the latest, five years after the completion of construction work, the number of nests must be at least 90 % of the level observed before construction work began.

A more careful study of the results, however, shows that there is no connection between the negative trend in the eider population on Saltholm and the construction work /ref. 2, 3/. The monitoring programme thus revealed no impact from the construction work compared with the general changes in the eider population.

Eider behaviour was influenced by a marked redistribution away from the area around Peberholm (figure 7). During 1999 and 2000, this redistribution was less pronounced as the eider began to return to the area around Peberholm, probably due to reduced activities in the construction work.



**Figure 7.** Eider distribution around Saltholm, registered by aerial counts during baseline surveys, and 1996-1997 and 1999-2000. (Source: Danish National Environmental Research Institute, 2001)

During the 1990s, Saltholm developed into one of the greylag goose's most important moulting grounds in Europe. During the baseline surveys, between 7 000 and 9 000 greylag geese moulted on Saltholm, and during the first three years of construction, numbers rose from 10 500 to 14 500. Thereafter, the population halved in only two years, so that in 2000 numbers were back to the baseline survey level (figure 6). The increase in the goose population on Saltholm from 1993 to 1998 both reflects the general growth in population in northern Europe and the fact that Europe's most important moulting grounds in Holland lost some of their importance. A relocation of the greylag goose's moulting grounds in northern Europe has taken place during the period 1998-2000 /ref. 19/.

Greylag geese are extremely sensitive to human disturbance during their period of moult, during which they are unable to fly for 3-4 weeks. However, construction work disturbance has not had any measurably negative impact on the size of the population. The few occasions when construction work has brought about temporary interruptions in the greylag geese's normal activities, or local relocations, has not resulted in any changes in overall greylag goose distribution over the survey period 1993-2000.

Both nationally and regionally, the shallow waters around Saltholm constitute an important moulting ground for **mute swan**, with upto 3 300 recorded individuals in 1993. The marked decline in population recorded during the baseline surveys (1993-1995) continued during the first year of the construction period, when the population fell to below 2 000 individuals (figure 6). The population remained at this level until 1999, when it rose to 2 800, and then fell to 2 200 in 2000 /ref. 20/.

In the swans' foraging grounds, it has not been possible to find any changes in the swans' preferred sources of food - eelgrass and other marine vegetation - as a result of sediment spillage from the construction work. The moulting mute swans showed the same tendency to relocate as did the eider, by utilising the area around Peberholm to a lesser extent during the first three years of construction (1996-1998), compared with previous years.

The surveys of eider, greylag goose and mute swan, which are considered to be the most sensitive species in response to the construction work, showed no effects as a consequence of changes in food sources, or from significant disturbance from construction work. Routine monitoring of the coast of Saltholm by the local authorities showed that other potentially sensitive species such as oystercatcher, avocet, ringed plover, redshank, arctic tern and little tern have all shown a stable or increasing population growth over a 12 year period (1988-1999). It can, therefore be concluded that the criterion for the group of other breeding birds has not been exceeded /ref. 22/.



For **autumn-migrating seabirds**, the surveys show that, during the construction work, no significant decline has occurred in the total number of observations (bird days) for those species using Saltholm as a staging post during the period 1996-1998. Thus, the criterion for acceptable impact has not been exceeded /ref. 21/.

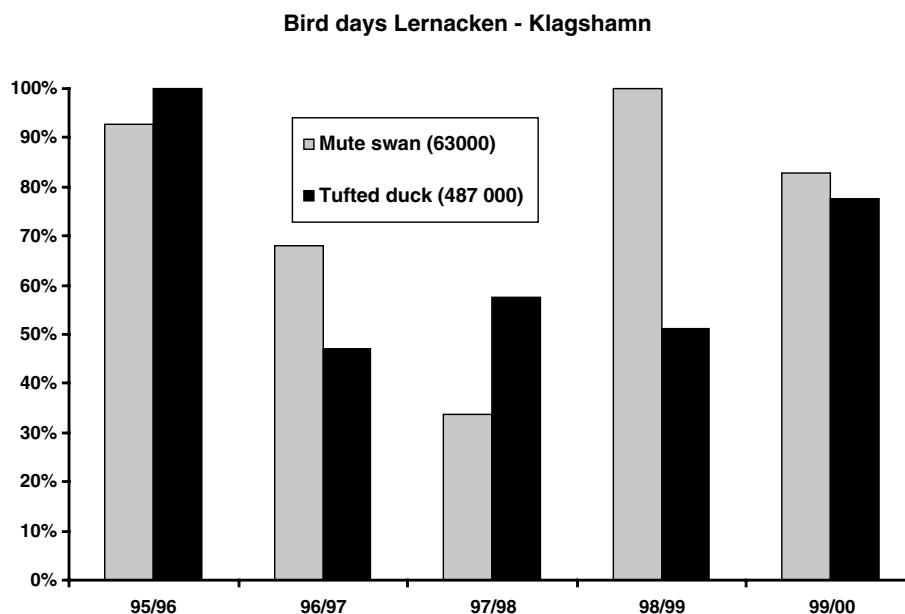
It can thus be stated that the environmental objectives set up by the Danish authorities for the impact on the birdlife of Saltholm have not been exceeded. Saltholm thus continues to carry a thriving bird population, which is of both national and international importance.

### Staging and wintering seabirds along the Swedish coast

The Swedish Öresund coast, like large parts of the Danish, especially around Saltholm, provides important staging and wintering grounds for large numbers of duck species and other wetland-dependent birds, especially waders. It has also long been known that, during cold winters, the area near the bridgehead provides a haven for the greater portion of wintering seabirds in southern Öresund, as this is the last area to freeze up.

When the project was planned, it was believed that bird occurrence could theoretically be affected in the area, either by direct disturbance from the construction work or by affecting food availability. Disturbance impact was judged to be limited to the area nearest Lernacken. In mild winters, relatively few seabirds are in the vicinity, whilst during cold winters large numbers are concentrated here. Furthermore, the mussel beds off Lernacken are exploited by considerable flocks of tufted duck, which, during the day, lie up in the ponds along the coast, including Klagshamn lake.

The inventories for 1995/96, as for 1996/97, comprised weekly counts of all resting seabirds in the area between Barsebäck and Falsterbo. The area between Lernacken and Foteviken was regarded as a potential impact zone, whilst Lomma bay and Falsterbo peninsula constituted reference areas. During 1997/98, the counts were restricted to the area between Barsebäck and Foteviken. In 1998/99 and 1999/2000, the counts were confined to the two key species, tufted duck and mute swan (figure 8).



**Figure 8.** Number of bird days for mute swan and tufted duck in the area between Lernacken and Klagshamn, 1995/1996 – 1999/2000. 100 % represents the maximum number of bird days during the survey period. (Source: Leif Nilsson /ref. 23/)

During 1998/99, there were no major works in the water. The number of swan days increased markedly, and was back to a normal level already by 1998/99, whereas the number of tufted duck days

was still low during 1998/99. Both species had returned to a normal level during 1999/2000. In total, the number of bird days for this season was somewhat lower than in 1995/96 for both species, but this was to be expected, as, compared with 1999/2000, 1995/96 was a mild winter /ref. 23/.

To summarise, the Danish and Swedish supervisory authorities note that work with the bridge caused temporary disturbance to the birdlife in connection with the ice period of 1996/97, which had been foreseen. The completed studies also showed that the birdlife quickly returned to normal, even in the inner impact zone, when construction work ceased.

### **Greylag goose**

In connection with the monitoring of greylag goose on Saltholm, it has been important to arrive at an estimate of Skåne's (Scania) greylag goose population, as this population, to a certain extent, utilises Saltholm as a moulting ground.

The surveys in southwestern Skåne have entailed the capture and ringing of greylag geese families in a lake district for a period each year. During the spring, the breeding population was surveyed, at the same time as the areas were checked for returning ringed geese. The greylag geese breeding results in the area were established. The greylag geese' dispersal for moulting, as well as their return, were kept under observation.

From 1994 to 2000, the greylag goose population increased from 530 to 770 pairs. During this period, the number of potential moulters from the study population in Skåne amounted to between ca. 1 500 and 3 000, with a significant variation between the years, depending on variable young production and survival during the winter. From 1992 upto and including 1999, there was a significant correlation between the number of greylag geese in the September inventories in Skåne (increasing) and the number of moulters on Saltholm, but these later fell.

In 1993, on Saltholm moulting areas 11% of the previously ringed Scanian juveniles that yet have not bred were observed. This proportion increased to between 25 and 30 % during 1997, only to decrease to ca. 15 % during 2000. Of the ringed one to two yearolds seen in Skåne during the spring, between 5 och 10 % moulted during the first years on Saltholm. The proportion increased to, at its peak, over 25 % in 1997, afterwhic it fell, amounting to less than 10 % in 2000. During the first years, a change was noted from moulting in Flevoland in the Netherlands to moulting on Saltholm, but in later years, when the number of moulters on Saltholm declined, moulting greylag geese from southwest Skåne have been recorded at other moulting localities in Sweden, such as Lake Hornborga and Tåkern /ref. 23/.

## **4.8 Shore and coast**

*The coastline outside the inner impact zone must not be changed significantly, and it shall be stable after the completion of the link. Sanding-up and major changes in the character of the seabed between the artificial island and Saltholm must not lead to the formation of a land bridge between the two. With regard to other coasts, only insignificant changes in the seabed and coastal conditions in the direction of more vegetated coast will be accepted /ref. 8/.*

Surveys of coastal morphological conditions have, in recent years, been concentrated on the area between Saltholm and Peberholm. This was because it is expected that the impact of the fixed link will be primarily on benthic conditions in this area.

The surveys in 2000 registered the hitherto largest expanse of fine-particle sediment between Saltholm and Peberholm. They showed that the chalk content in the sedimentet is falling, and that sediment spill spreads slowly /ref. 24/.

Sediment deposition is occurring in the southeast sector of Peberholm (figures 9, 10). The recurrent profile measurements for the period 1997-2000 show there has been a nett accumulation of material of

more than 3 cm per annum. A simple extrapolation of this rate of sedimentation demonstrates that a new island could form in this area in the space of a hundred years. However, the sedimentation is not of such proportions that there are grounds to believe that a land bridge would form, connecting Peberholm with Saltholm /ref. 24/.

At the southeast corner of Saltholm (at Svaneklapperne) (figure 9), an accumulation of benthic material has been recorded. A new feature is that, off Svaneklapperne, a new erosion zone has been recorded, caused by the construction of the Öresund Link. The sediment transportation conditions for this area cause material to be transported along Svaneklapperne in a northeasterly direction. The existing sand layer in the area is judged to be thin every where, and thus the sand deposit modest. Therefore, erosion is expected to cease when the sand has eroded away, exposing the chalk /ref. 25/.

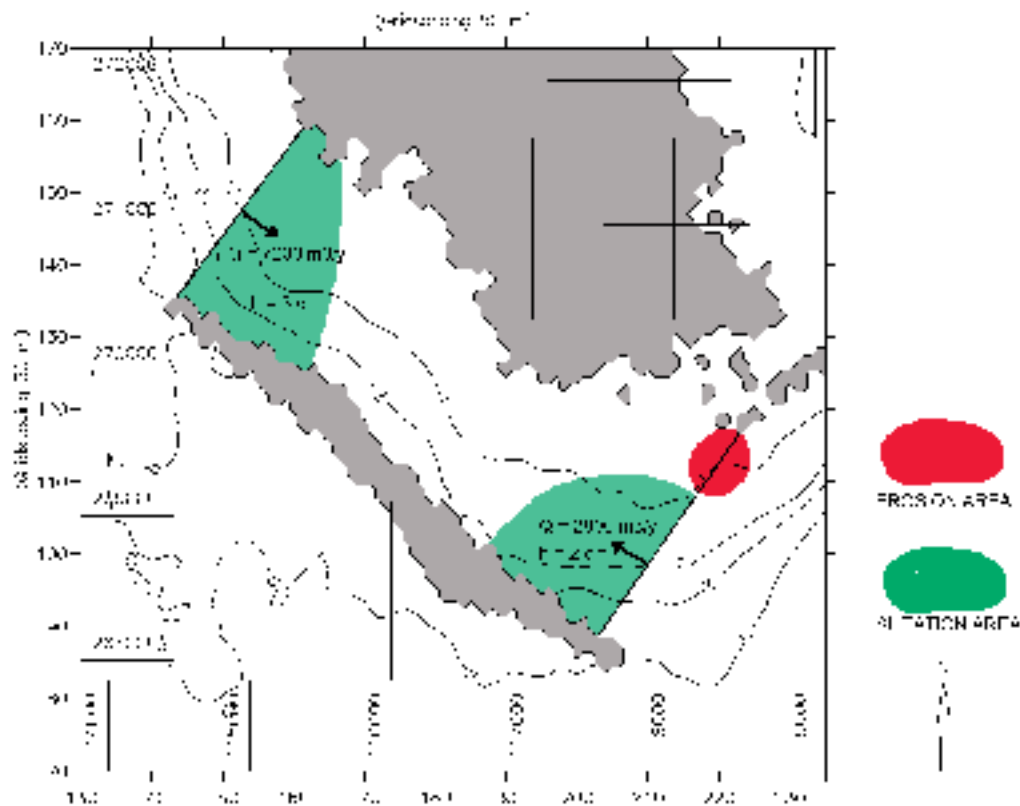


**Figure 9.** View of Peberholm with Svaneklapperne in the background to the north. (Source: Øresundsbro konsortiet, 2001)

The surveys in 2000 have also included a detailed mapping of the coast of Saltholm, as the basis for a classification of the coast's dynamic stability-conditions /ref. 2/. Analysis shows that the coasts in general are extremely robust, not only regarding changes in the natural, dynamic parameters, but also in respect of possible impacts caused by the fixed link. This probably depends on the chalk shelf on which Saltholm is situated, and which protects its coasts against changes in the waves and currents. As these surveys have only been in operation for five years, it is not possible to exclude a long-term impact on the coasts in the area.

To sum up, it is the understanding of the authorities that, throughout the whole survey period, no changes in the conditions of the coasts or seabed have been recorded which are in conflict with the environmental criteria.

Future developments in the area between Saltholm and Peberholm will be followed up in a special survey programme. This will be drawn up by Øresundsbro Konsortiet, in consultation with the County of Copenhagen, which is the supervisory authority in this sector of Öresund.



**Figure 10.** Annual sediment supply,  $Q$ , in the straits between Saltholm and Peberholm, and associated main sedimentation zone (green) with an average sedimentation,  $h$ , for a 5-year period. The main erosion zone (red) is also shown. (Source: Øresundsbro Konsortiet, 2001)

## 5. Monitoring the Lernacken installation channel

The purpose of this survey is to determine the extent to which the channel functions as a sediment trap for organic and inorganic material from surrounding areas, as well as the extent of the impact of any sedimentation on the benthic fauna.

The survey is being carried out in accordance with the Swedish Environment Court's ruling of 21<sup>st</sup> January 2000, instructing Øresundsbro Konsortiet to undertake annual surveys in the channel during the period 2000-2003. Thereafter, the decision will be taken as to whether the refilling of the channel is necessary /ref. 26/.

Results from the surveys for 2000 show that the benthic fauna in the channel does not to any essential degree deviate from the surrounding areas. The programme is also judged to be able to point to effects of possible oxygen shortages in the channel /ref. 27/.

In the innermost reaches of the channel, patches have been recorded on the seabed which are probably caused by the presence of hydro-sulphuric bacteria. This is possibly connected with the decomposition of filamentous algae farthest in the channel.

## 6. Completion activities

The experience gained and new methods for the control and steering of construction work in Öresund will be presented at seminars in Stockholm in November, 2001. The seminars are arranged by the Danish and Swedish supervisory authorities, in consultation with Øresundsbro Konsortiet and their consultants. The seminars are to be held within the framework of the Baltic Sea Science Congress, from 25<sup>th</sup> to 29<sup>th</sup> November 2001, in accordance with the recommendation from the final meeting of the International Advisory Expert Panel.

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