Wintering diving duck populations in the Öresund, southern Sweden, in relation to available food resources

L. Nilsson
Department of Animal Ecology, University of Lund, Ecology Building, S-223 62 Lund, Sweden.
Email: leif.nilsson@zooekol.lu.se

Intensive surveys of staging and wintering diving ducks in the Öresund area, southern Sweden, were undertaken during the winters 1995/96, 1996/97 and 1997/98 as a part of the Environmental Impact Assessment (EIA) related to the establishment of a Fixed Link (bridge–tunnel–artificial island) between Sweden and Denmark. Monitoring of the benthic fauna made it possible to compare the calculated food requirements of the diving duck populations with their food resources. Overall, the diving ducks (mainly Tufted Duck *Aythya fuligula,* Scaup *Aythya marila* and Goldeneye *Bucephala clangula*) consumed between 2.6% and 4.6 % of the standing crop of suitable food organisms. It is, however, probable that higher proportions of the prey are consumed in the shallowest areas compared to areas with deeper water. A prolonged period of ice cover during one of the study years made a large proportion of the feeding areas unavailable, but the main mussel beds were still free of ice because of strong currents so this had only limited impact on the food availability for the ducks.

Aythya marila, Aythya fuligula, Bucephala clangula, Somateria mollissima**, staging and wintering numbers, exploitation of food resources**

The southern part of the Öresund between Sweden and Denmark has long been known as an internationally important staging and wintering area for a number of different waterfowl species (Nilsson 1972, 1975, 1996) Part of the area (Falsterbo – Foteviken) is listed among the Swedish Ramsar sites, as the Danish island of Saltholm. Moreover, a number of other sites in the Öresund also fulfil the criteria for internationally important wintering sites for waterfowl, even if they have not been designated as internationally important areas under the Ramsar Convention.

Due to the importance of the area for a number of bird species, intensive studies of staging and wintering waterfowl on both the Swedish and Danish sides of the Öresund were included in an Environmental Impact Assessment (EIA) study for the Fixed Link between Sweden and Denmark, which was constructed during the latter part of the 1990s and completed in the summer of 2000 (Öresundskonsortiet 1995, 1998). This link, which is 16 km long, consists of a combined railroad and motorway connection from Lernacken, on the Swedish side of the Öresund, to Kastrup, in Denmark, including a 1,092-m-long high bridge, 6,700 m of connecting bridges, an artificial island and a 3,500-m submerged tunnel.

One of the conditions imposed on the construction of the Fixed Link was that it should not obstruct the water currents in and out of the Baltic Sea, which are of vital importance for this area. Thus, large-scale compensatory dredging was undertaken in addition to the dredging for the construction of the bridge and tunnel. As disturbance from the building operations and the risk of sediment spill from the dredging could potentially have a negative effect on marine life in the area, including on staging and wintering waterfowl, extensive studies of the benthic fauna and waterfowl were undertaken as a part of the control programme following the EIA. Thus, the intensive studies made in connection with the construction of the Fixed Link provided an excellent data set for a study of the diving duck populations in the area in relation to their food resources, an aspect which had been studied in a slightly different area in the Öresund 30 years earlier (Nilsson 1969, 1970, 1972, 1980). The earlier work formed part of a larger study on the non-breeding ecology of diving ducks in the region.

This paper will relate the occurrence of benthivorous diving ducks in the study area during the non-breeding season to their food supply. More detailed reports on the waterfowl work are to be found in the technical reports from the project, in which the possible effects of the construction work on the bird fauna were evaluated in detail (see Nilsson 1998, 1999).

Study areas

The general area for the impact assessment study related to the Fixed Link was from Falsterbo in the south to Barsebäck (cf. Nilsson 1996, 1998), but more intensive studies were undertaken closer to the construction site and to the south of it (**Figure 1**). According to the EIA (Öresundskonsortiet 1995, 1998), the possible impact zone extends to and includes the Malmö harbour area, but the area between Lernacken (the end of the bridge, on the Swedish coast) and Malmö has very little natural waterfowl habitat, although parts are used as daytime roosts for Tufted Ducks *Aythya fuligula*.

Lernacken, in the north of the study area, is an area of artificial hills along the shoreline created from deposits of calciferous material. Further south, Klagshamn is an artificial peninsula made of similar material from an excavation that now forms a pond used as a daytime roost by the waterfowl. Originally, there were grazing meadows along the shore in the area between Lernacken and Foteviken.

The area of water between Lernacken and Foteviken is in general very shallow, large parts having a depth of less than 3 m (**Figure 1**) and extensive areas having a depth of less than 1 m. The inner parts are muddy with patches of tassel pondweed *Ruppia* sp., whereas extensive *Zostera* sp. meadows on a sandy substrate are found further out (SEMAC 1997b). Extensive areas, especially at Lernacken and close to the bridge have a moraine bottom with boulders and rich mussel beds that include a rich fauna of other benthic animals (VKI/Toxicon 1994).

Due to the currents in the Öresund, the waters off Lernacken are among the last areas to freeze during hard winters, the area of open water sometimes extending south to the Klagshamn peninsula, whereas the rest of the southern part of the Swedish Öresund coast is completely iced over. Moreover, just south of Lernacken the current keeps even shallow water free of ice during cold periods.

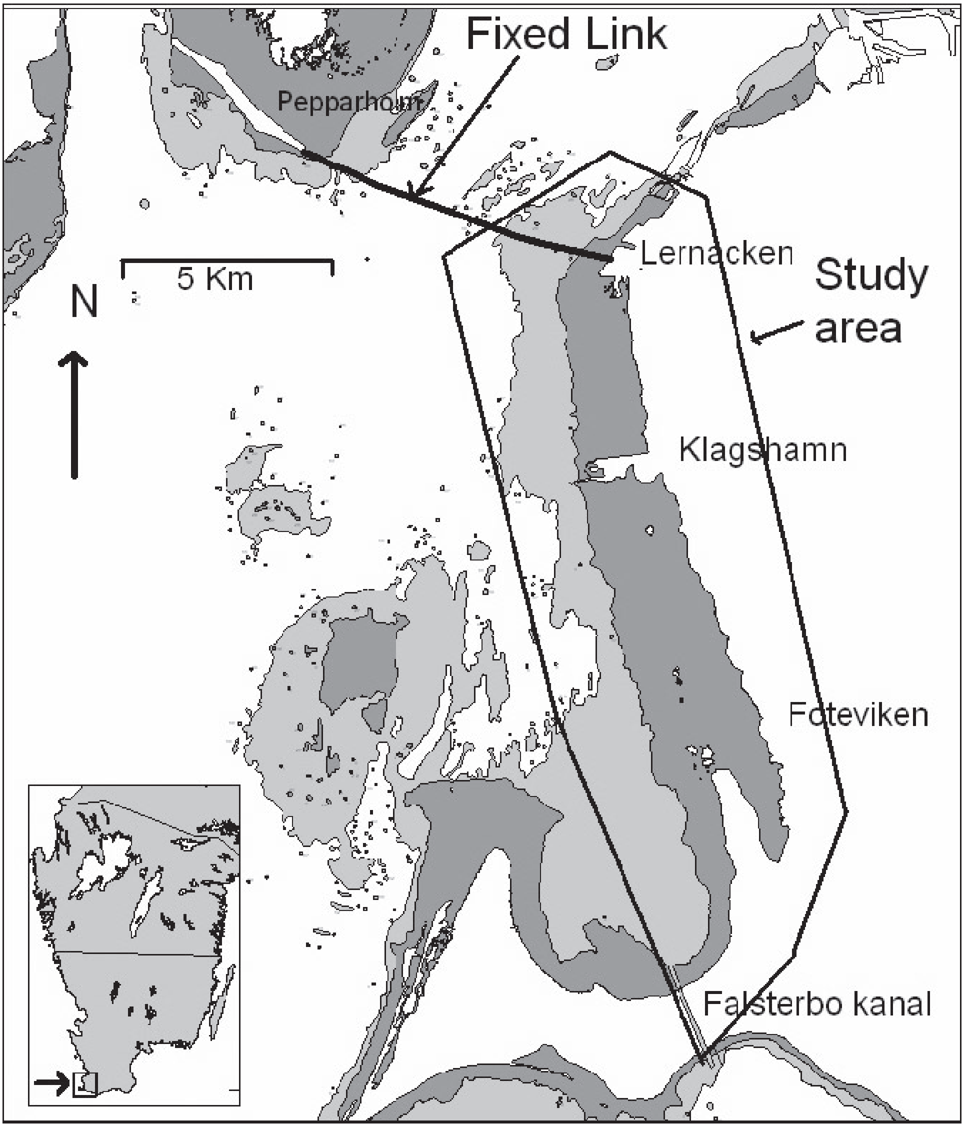
Methods

Waterfowl counts

The utilisation of the area by feeding waterfowl was based on the calculation of bird-days for the different species in different areas. In 1995/96 and 1996/97 counts were undertaken each week in the entire area between Barsebäck and Falsterbo (Nilsson 1996, 1998), of which the present study area (**Figure 1**) forms a part. Counts of all species were also performed each week during August–March 1997/98 in the main study area (Nilsson 1999).

The counts were undertaken from the shore either through telescopes from fixed observation points situated such that all the sectors could be covered, or by the observer walking along the shore line. Telescopes with 20–50x magnification were regularly used. Counts were undertaken only during good weather conditions. From aerial surveys and boat counts it is known that the diving ducks in the Öresund are feeding in areas where they can be counted accurately from the shore. The Tufted Duck is active at night, feeding at sea (Nilsson 1970), making feeding flights in the evening from roosts at ponds and protected areas within the study area; from radar observations (M. Green, unpublished data), it is known that they feed within the study area. For a thorough description and discussion of census methods see Nilsson (1975, 1976).

Figure 1. Map of the study area in the Öresund, for a general position in southern Sweden, see inserted map. Areas with a water depth of 0–3 and 3–6 m marked with dark and light grey, respectively.



Estimation of food consumption of different species

For the present study, estimates of food consumption for the different species were based on the literature. Standard Metabolic Rate (SMR) was calculated according to Lasiewski & Dawson (1967), while daily energy consumption was estimated to 3 x SMR according to Nilsson & Nilsson (1976). In a study of the Tufted Duck, Laughlin (1973) used 2.5 x SMR, but the factor 3 x SMR has been used here, as the study was undertaken in a more demanding winter situation.

In the calculation of the energy demands during the winter seasons here, 1,370 kJ/24 h has been used for the smaller diving ducks and 2,160 kJ/24 h for Eider *Somateria mollissima*. According to Ankar & Elmgren (1976, see further discussion in Nilsson 1980) this compares to a mean daily consumption of 1,420 g fresh weight of Blue Mussels *Mytilus edulis* for the smaller species and 2,260 g for the Eider.

Specific studies in marine areas of the smaller diving duck species important in this study are lacking, but Nehls (1995) has made an intensive study of the feeding ecology of the Eider with special reference to its utilisation of Blue Mussels as a food source. For the winter he estimated the daily energy consumption to be 3,000 kJ/24 h, whereas the corresponding value for the summer was 2,100 kJ/24 h. Based on extensive activity-budget studies, the energy requirements were set at 4.3 x BMR, which is a very high value (cf. also Nehls 1989, 1991). 3,000 kJ/24 h corresponds to a consumption of 3,100 g wet weight of Blue Mussels/24 h. Swennen (1976) in the Netherlands estimated the consumption of Blue Mussels to be 2,500 g/24 h, whereas Guillemette *et al*. (1992, 1996) gave a consumption of 2,000 g/24h. For growing Eider ducklings at an age of 50 days, Cantin *et al*. (1974) estimated the energy consumption to be 1,900 kJ/24 h.

For the smaller diving ducks, some studies and experiments have been undertaken in relation to their utilisation of the freshwater bivalve Zebra Mussel *Dreissena polymorpha* both in Europe and in North America (e.g. Hamilton *et al.* 1994; Pedroli 1981; Suter 1982a, 1982b). For Tufted Duck, Pedroli (1981) estimated a daily food consumption of about 1,000 g fresh weight. For the related Ring-necked Duck *Aythya collaris*, the energy requirements were estimated to be 550–700 kJ/24 h (Jeske & Percival 1995).

Suter (1982b) studied diving ducks and their consumption of *Dreissena* on the Lake of Constance and found a daily consumption rate in winter of 760–930 g fresh weight for Tufted Duck, whereas the rate for Pochard *Aythya ferina* was 875–1,050 g. Goldeneye *Bucephala clangula* had a more varied diet in Suter's study area, feeding partly on *Trichoptera,* and had an estimated energy consumption of 1,140–1,420 kJ/24 h for the larger males and 850–1,050 kJ/24 h for the females. In another study, Galhoff (1987) estimated the energy consumption of wintering Pochards in Switzerland and found a marked variation around a mean of about 840 kJ/24 h. De Leeuw (1997) estimated the Daily Energy Expenditure for a Tufted Duck of 600 g to be 1,080 kJ/24 h in the winter, feeding on *Dreissena.* A quite marked variation in the energy requirements are to be expected for a diving bird as there is a marked variation in the amount of energy used to bring up food from different depths, in addition to the variation due to temperature conditions (De Leeuw 1997).

Results

Numbers and occurrence

The dominant diving duck in the area during the winter was the Tufted Duck, which reached a peak count of more than 7,000 individuals in 1995/96 and 1997/98 and 9,000 individuals in 1996/97 (**Figure 2**). The majority of Tufted Ducks arrived in the area from October, although smaller numbers were present earlier, and left mainly in March and April. The totals counted were markedly higher during the two colder winters of 1995/96 and 1996/97 than in the mild winter of 1997/98. There was a quite marked variation in the number of Tufted Ducks during the winter, related mainly to the ice conditions, which depending on the circumstances could lead to marked concentrations in the area or to an almost complete abandonment. The two peaks in the mild winter of 1997/98 were related to short cold spells.

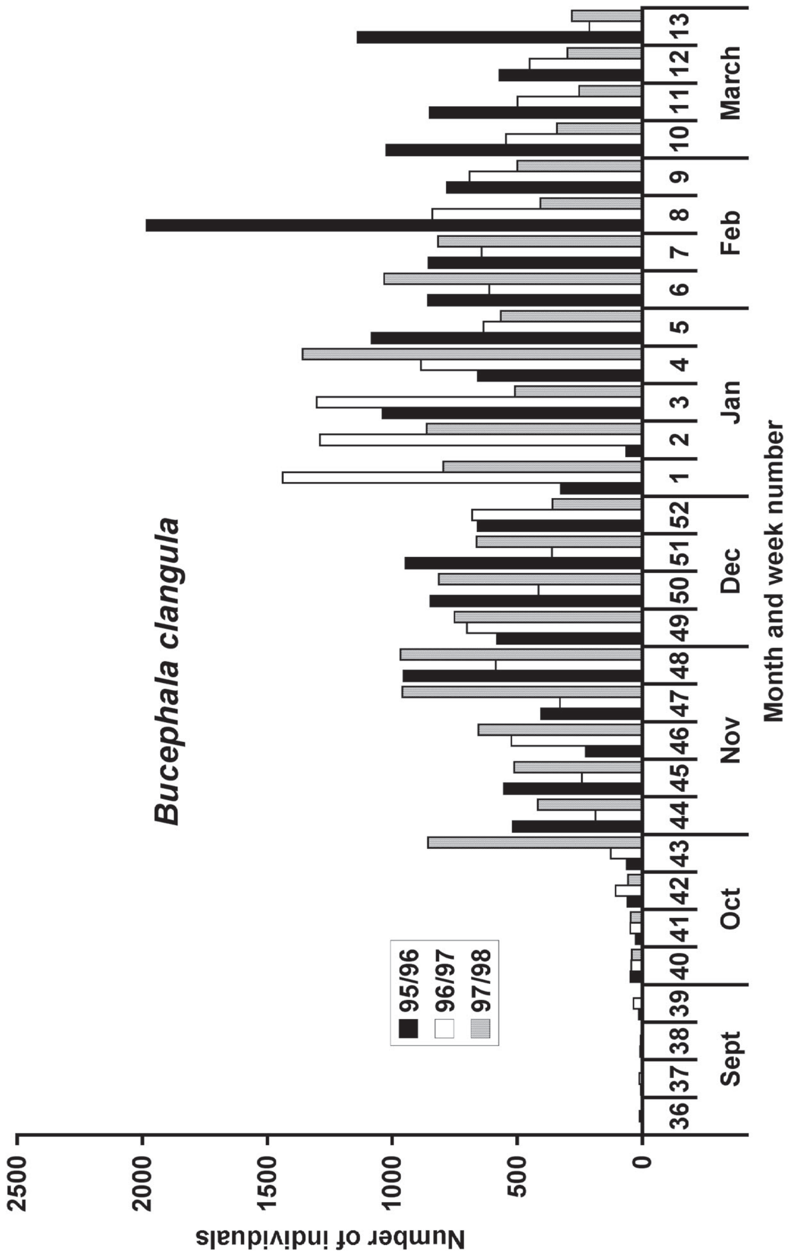
During the autumn and during ice-free periods in the winter, Tufted Ducks were concentrated on a coastal pond at Klagshamn and the Falsterbo Canal that offered sheltered roosts during the day from which they made feeding flights to the sea during the night (Nilsson 1972). In icy periods the Tufted Ducks were mostly found close to the ice-edge in the area between Klagshamn and Lernacken.

The flocks of Tufted Ducks regularly included varying numbers of Scaup *Aythya marila,* the Scaup normally arriving somewhat later than the Tufted Ducks. The Scaup used the same roosts as the Tufted Ducks and had the same pattern of feeding flights to the sea. In 1995/96 between 200 and 400 Scaup were regularly counted during the winter period, with peaks of up to 900–1000, but in the other winters normally fewer than 100 Scaup were found, with occasional counts of up to 200 individuals.

The Goldeneye is a common winter guest in the study area. During the summer, small groups and single individuals were seen mainly in the Foteviken area. In October, the autumn migration started and there was a steady increase in numbers, which peaked in December, with counts between 700 and 1,000 individuals being most frequent. Some peaks with appreciably higher counts were noted during the periods of prolonged ice cover. The flocks left the area in March–April.

In contrast to Tufted Duck and Scaup, the Goldeneye is active diurnally and was found feeding throughout the study area (Nilsson 1972). The Eider is mainly a summer visitor to the area, also being seen in large numbers during spring and autumn migration, whereas the numbers seen in winter are low. The appearance of the Eider on this part of the Swedish coast is very much influenced by the large breeding colony at Saltholm, the Swedish coast forming important nursery areas for the young

Figure 2. Total number of Scaup, Tufted Ducks, Goldeneye and Eiders per 10-day period in the study area, between Lernacken and Foteviken, southern Sweden, during September–March 1995/96–1997/98.



hatched at Saltholm, some remaining in Swedish waters during the early part of the autumn. Occasional high counts in March are related to the intensive Eider migration through the Öresund in spring.

Food requirements

Based on an overall daily energy requirement of 1,370 kJ for the small diving ducks and 2,160 kJ for the Eider (see methods), the total food requirements during the period September–March were estimated to be between 1,290 x 10^6 kJ and 734 x 10^6 kJ for the three seasons (**Table 1**). If the diving ducks use the entire depth-range to 6 m (normal diving range, cf. Nilsson 1972), this compares to an exploitation rate of 17.5 to 30.8 kJ/m^2 of bottom area.

In 1995/96 and 1996/97 there were periods of prolonged ice cover when large parts of the feeding areas were unavailable to the ducks (**Table 2**). Most mussel beds were still available to the diving ducks, whereas the availability of the other benthic fauna was much reduced. Calculated for the total area to a depth of 6 m, the rate of consumption during the period of prolonged ice cover only increased to 37.2 kJ/m^2 in 1995/96, whereas the period of prolonged ice cover in 1996/97 was shorter, the consumption rate for the ice-free areas

Table 1. Calculation of food requirements for the diving ducks in the Foteviken–Lernacken area, southern Sweden, September–March 1995/96–1997/98.

	1995/96	**1996/97**	**1997/98**
Number of bird days			
Scaup *Aythya marila*	37,989	9,569	9,506
Tufted Duck *Aythya fuligula*	728,406	480,522	397,649
Goldeneye *Bucephala clangula*	119,994	101,248	105,924
Subtotal small diving ducks	886,389	591,339	513,079
Eider *Somateria mollissima*	35,238	27,083	14,623
TOTAL	**921,627**	**618,422**	**527,702**
Total food requirements (kJ * 10^6)			
Small diving ducks (1,370 kJ/24h)	1,214	810	703
Eider *Somateria mollissima* (2,160 kJ/24h)	76	58	32
TOTAL	**1,290**	**868**	**735**
Food requirements (kJ/m^2)			
Calculated for different depths			
0–3 m (2,440 ha)	53	36	30
0–6 m (4,190 ha)	31	21	18
Food consumption in % of total resources (28,200 *10^6 kJ (for calculation see **Table 3**)	**4.6**	**3.1**	**2.6**

during this period being only 7.6 kJ/m^2 or a fraction of the rate calculated for the entire winter.

Exploitation of food resources

The benthic monitoring programme for the Fixed Link Project provides background data that make it possible to make a rough calculation of the standing crop of available food resources in the area (VKI/Toxicon 1994, 1995, 1996a, 1996b). For the benthic fauna other than mussels, this study uses 500 kJ/m^2 in the calculations, based on means for the inner parts of the surveyed areas; for the areas 3–6 m deep, it uses 200 kJ/m^2, being a realistic estimate based on the biomass values for the outer stations in the profiles between Lernacken and Klagshamn.

In some areas large food resources in the form of mussel beds are available in addition to the other benthic fauna (SEMAC JV 1997a, 1998; VKI/Toxicon 1996c). The occurrence of mussel beds is, however, very patchy, and even in the areas with mussel beds the coverage shows much variation. Within the study area the major mussel beds are found in the areas close to Lernacken, where biomasses of between 1 kg/m^2 and 3 kg/m^2 wet weight of mussels were regularly found at several stations during a survey in February/March 1992. The total estimated standing crop of Blue Mussels, using a calculated mean density of 1.9 kg/m^2, amounts to about 10,000 tonnes for the areas (550 ha) closest to Lernacken with a depth of between 3 m and 6 m. Stations further south between Lernacken and Klagshamn had lower mussel biomasses, ranging from 58–318 g/m^2. For the other areas with mussels, a value of 200 g/m^2 or 195 kJ/m^2 are used.

The overall standing crop of food animals in the area between Foteviken and Lernacken to a depth of 6 m can accordingly be estimated to amount to 28,000 x 10^6 kJ for the depth interval 0–6 m when the entire area is free of ice, the food resources being significantly reduced during the period of prolonged ice cover, especially for the non-mussel food (**Table 3**). This is, however, a very rough estimate that does not take into account the fact that some of the mussels may be too big for the smaller species etc. Without taking these restrictions into consideration, it was calculated that the total food consumption of the diving duck populations in the area amounted to between 2.6% and 4.6% (**Table 1**) of the standing crop.

In 1995/96 and 1996/97 there were icy periods when large parts of the feeding areas and thus non-mussel benthic fauna were unavailable to the ducks (**Table 2**), although most mussel beds were still available. Nevertheless, consumption by diving ducks in 1995/96 amounted to only 4.2% of the calculated standing crop for the ice-free areas (**Tables 2 and 3**). The effect of the ice was less marked in 1996/97 as the period of prolonged ice cover was much shorter. The effect was much more marked for the other fauna, for which only about 25% or less was available compared with years in which there was no ice cover.

Table 2. Calculation of food requirements for the diving ducks in the Foteviken – Lernacken area, southern Sweden, during periods of prolonged ice cover in 1995/96 and 1996/97.

Ice-period	1995/96 21 Dec – 31 Mar	1996/97 15 Dec – 10 Feb
Number of bird days		
Scaup *Aythya marila*	27,800	3,790
Tufted Duck *Aythya fuligula*	352,500	67,700
Goldeneye *Bucephala clangula*	77,600	50,400
Subtotal small diving ducks	475,900	121,890
Eider *Somateria mollissima*	9,700	40
TOTAL	**485,600**	**121,930**
Total food requirements (kJ * 10^6)		
Small diving ducks (1,370 kJ/24h)	627	159
Eider *Somateria mollissima* (2160 kJ/24h)	21	0
TOTAL	**648**	**159**
Available ice-free ha)		
Depth 0–3 m	490	570
Depth 0–6 m	1,250	1,530
Food requirements (kJ/m^2)		
Calculated for different depths		
0–3 m	132	28
0–6 m	37	8
Total food resources (kJ * 10^6) in ice-free areas	**15,040**	**15,760**
Food consumption in % of total resources in ice-free areas	**4.2**	**1.0**

Table 3. Calculation of available food resources for diving ducks feeding on benthic fauna within the depth interval 0–6 m in the area between Lernacken and Foteviken, southern Sweden. For references to biomass values, see text.

	Available feeding areas (ha)			**Calculated food resources kJ*10^6**		
	Open water	Periods of prolonged ice cover		Open water	Periods of prolonged ice cover	
		95/96	96/97		95/96	96/97
Blue Mussel *Mytilus edulis*						
High density area (1,900 g = 1,840 kJ/m^2)	550	550	550	10,100	10,100	10,100
Low density area (200 g = 195 kJ/m^2)	1,250	750	750	2,440	1,460	1,460
Subtotal				12,540	11,560	11,560
Other benthic fauna						
Depth area 0–3 m	2,440	490	570	12,200	980	1,140
Depth area 3–6 m	1,740	1,250	1,530	3,480	2,500	3,060
Subtotal				15,680	3,480	4,200
OVERALL TOTAL				**28,220**	**15,040**	**15,760**

Discussion

The studies made during 1995/96–1997/98 presented here as well as earlier studies (Nilsson 1969, 1972) in the Öresund showed that the available food resources were sufficient for much larger numbers of diving ducks than present in the area, even during periods of prolonged ice cover such as in 1995/96 and 1996/97 (Nilsson 1969, 1972, 1980). The overall exploitation rate by the diving ducks in the area was in the order of 2.6–4.6% of the calculated standing crop, slightly lower than a rough calculation presented for the entire Baltic by Nilsson (1980).

Different parts of the area may, however, be more or less exploited by feeding diving ducks, as was apparent from the distribution of such species in the area, but as the Tufted Ducks, which are nocturnal feeders, dominated among the diving ducks, it was not possible to differentiate between different areas.

In an earlier study in the Öresund, in the Bjärred area to the north of the present study area, it was calculated that diving ducks consumed about 26% of the benthic food resources in the shallowest waters (Nilsson 1969, 1972, recalculated in Nilsson 1980). For some preferred food items such as *Hydrobia* sp. and *Cardium*, the rate of exploitation was much higher (Nilsson 1969, 1972, 1980). The bottom fauna of the Bjärred area is similar to the bottom fauna of the shallowest parts of the present study area, but the Bjärred area did not have the same extensive mussel beds as the areas off Lernacken. It is probable that the diving ducks use a higher proportion of the available food in inner parts of the present study area compared to areas further out at sea.

The present calculations are approximate, nevertheless they give an indication of the relationship between the exploitation of the overall food resources and the occurrence of diving ducks. In this respect it must be noted that even if productivity is lower during the winter compared to the summer there is some productivity during the early autumn that influences the availability of food for diving ducks. On the other hand, some of the mussels are too big to be suitable as food for the smaller diving ducks or are uneconomical as prey for different reasons (De Leeuw & Van Eerden 1992). In the calculations here 6 m has been used as a limit for the diving depth, but some species can use feeding areas with greater depth, thus increasing the available feeding areas appreciably. However, diving to greater depths is more costly and the daily energy requirements will increase.

Studies relating diving duck food consumption to available food resources are few (cf. Nilsson 1969, 1972, 1980). Böhme (1993) found that the diving duck community of Wohlenberger Wiek (Wismarbucht, Germany) consumed less than 1% of the standing crop of food animals. Leipe (1985) studied relations between mainly Long-tailed Ducks *Clangula hyemalis* and Scaup and marine food resources in Greifswalder Bodden, also on the Baltic coast of Germany, and also reached the conclusion that the diving duck populations had only a negligible impact on the available food resources there. Recently Žydelis (2002) studied the wintering waterfowl communities off the Lithuanian coast of the Baltic. For Long-tailed Duck feeding over mainly hard bottoms, the estimated food consumption amounted to only 1–2 % of the standing crop, but the studies indicate that Velvet Scoter *Melanitta fusca* could have a considerable impact on the soft-bottom communities in this part of the Baltic.

In contrast to the coastal studies, the diving ducks (together with Coot *Fulica atra*) have sometimes been found to deplete inland food resources, e.g. available *Dreissena* beds in the Lake of Constance (Suter 1982a, b).

During cold winters, large parts of the shallow areas in the study area are covered with ice for extensive periods, and the feeding areas for the diving ducks are markedly reduced. The major mussel beds in the present study area are, however, situated in somewhat deeper water, so during periods of moderate ice cover such as those experienced during the present study the diving ducks have sufficient food resources available. Even so, the diving ducks can be food-stressed during colder periods. In the Tufted Duck, which is an inferior diver compared to the Goldeneye (Nilsson 1972), this can be seen in a change from feeding only at night to feeding also during the day (Nilsson 1970) as was noticed during the periods of prolonged ice cover in 1995/96 and 1996/97 (L. Nilsson, unpublished data).

Normally, there are sufficient ice-free areas for the diving ducks in the Öresund even during the hardest winters with prolonged ice cover, especially as the current moves the ice and the birds can find some ice-free areas. Since waterfowl counts started in the area there have, however, been some hard winters when the ice conditions forced the diving ducks to leave the area, and in the very cold winters of 1963 and 1970 there was some mortality among the wintering diving ducks, especially Tufted Ducks (L. Nilsson, unpublished data; c.f. also Boyd 1964 for Britain).

Acknowledgements

The study was undertaken as a part of the Control Programme for the Fixed Link between Sweden and Denmark, under a contract between Öresunds Konsortiet and the University of Lund. Most of the fieldwork was undertaken by Martin Green, Martin Granbom and Lars Råberg.

References

Ankar, S. & Elmgren, R. 1976. *The Benthic Macro- and Meiofauna of the Askö-Landsort Area (Northern Baltic Proper). A Stratified Random Sampling Survey,* Contributions from the Askö Laboratory, No 11. University of Stockholm, Sweden.

Boyd, H. 1964. Wildfowl and other waterfowl found dead in England and Wales in January–March 1963. *Wildfowl Trust Annual Report* 15: 20-23.

Böhme, D. 1993. Zur Nahrungsökologie überwinternder Tauchenten in der Wohlenberger Wiek/Wismarbucht. *Beiträge zur Vogelkunde* 39: 257-284.

Cantin, M., Bedard, J. & Milne, H. 1974. The food and feeding of Common Eiders in the St. Lawrence estuary in summer. *Canadian Journal of Zoology* 52: 319-334.

De Leeuw, J.J. 1997. Demanding divers. Ecological energetics of food exploitation by diving ducks. *Van Zee tot Land* 61. Ministerie van Verkeer en Waterstaat Directoraat-Generaal Rijkswaterstaat. Directie Ijsselmeergebied. Lelystad, The Netherlands.

De Leeuw, J.J. & van Eerden, M.R. 1992. Size selection in diving Tufted Ducks *Aythya fuligula* explained by differential handling of small and large mussels *Dreissena polymorpha. Ardea* 80: 353-362.

Galhoff, H. 1987. Untersuchungen zum Energiebedarf und zur Nahrungsnutzung auf einem Stausee überwinternder Tafelenten (*Aythya ferina* L.). *Ökologie der Vögel* 9: 71-84.

Guillemette, M., Ydenberg, R.C. & Himmelman, J.H. 1992. The role of energy intake in prey and habitat selection of Common Eiders *Somateria mollissima* in winter: a risk-sensitive interpretation. *Journal of Animal Ecology* 61: 599-610.

Guillemette, M., Reed, A. & Himmelman, J.H. 1996. Availability and consumption of food by Common Eiders wintering in the Gulf of St. Lawrence: evidence of prey depletion. *Canadian Journal of Zoology* 74: 32-38.

Hamilton, D.J., Ankney, C.D. & Bailey, R.C. 1994. Predation of Zebra Mussels by diving ducks: an exclosure study. *Ecology* 75: 521-531.

Jeske, C.W. & Percival, H.F. 1995. Time and energy budgets of wintering Ring-necked Ducks *Aythya collaris* in Florida, USA. *Wildfowl* 46: 109-118.

Lasiewski, R.C. & Dawson, W.R. 1967. A re-examination of the relation between standard metabolic rate and body weight in birds. *Condor* 69:13-23.

Laughlin, K.F. 1973. Bioenergetics of Tufted Duck *Aythya fuligula* at Loch Leven, Kinross. *Proceedings Royal Society Edinburgh* 74: 383-389.

Leipe, T. 1985. Zur Nahrungsökologie der Eisente *Clangula hyemalis* im Greifswalder Bodden (unter Berücksichtigung einiger anderer nordischer Tauchenten-arten). *Beiträge zur Vogelkunde* 31: 121-140.

Nehls, G. 1989. Occurrence and food consumption of the Common Eider, *Somateria mollissima*, in the Wadden Sea of Schleswig-Holstein. *Helgoländer Meeresuntersuchungen* 43: 385-393.

Nehls, G. 1991. Bestand, Jahresrythmus und Nahrungsökologie der Eiderente *Somateria mollissima,* L. 1758, in Schleswig-Holsteinischen Wattenmeer. *Corax* 14(3): 1-66.

Nehls, G. 1995. Strategien der Ernährung und ihre Bedeutung für Energihaushalt und Ökologie der Eiderente *Somateria mollissima. Berichte, Forschungs und Technologiezentrum Westküste der Universität Kiel* No 10. University of Kiel, Germany.

Nilsson, L. 1969. Food consumption of diving ducks at the coast of south Sweden in relation to food resources. *Oikos* 20: 128-135.

Nilsson, L. 1970. Food seeking activity of south Swedish diving ducks in the non-breeding season. *Oikos* 21: 145-154.

Nilsson, L. 1972. Habitat selection, food choice and feeding habits of diving ducks in coastal waters of South Sweden during the non-breeding season. *Ornis Scandinavica* 3: 55-78.

Nilsson, L. 1975. Midwinter distribution and numbers of Swedish Anatidae. *Ornis Scandinavica* 6: 83-107.

Nilsson, L. 1976. Monthly counts as a measure of population changes in some species of Anatidae in south Sweden. *Ornis Scandinavica* 7: 193-205.

Nilsson, L. 1980. Wintering diving duck populations and available food resources in the Baltic. *Wildfowl* 31: 131-143.

Nilsson, L. 1996. *Resting and Wintering Waterfowl along the Swedish Coast of the Öresund, 1962–1995,* Unpublished Report to Öresundskonsortiet. Ecological Institute, University of Lund, Sweden.

Nilsson, L. 1998. *Monitoring of Resting and Wintering Waterfowl along the Swedish Coast of Southern Öresund, July 1996 – June 1997 in Relation to the Fixed Link across the Öresund,* Unpublished Report to Öresundskonsortiet. Ecological Institute, University of Lund, Sweden.

Nilsson, L. 1999. *Monitoring of Resting and Wintering Waterfowl along the Swedish Coast of Southern Öresund, July 1997 – March 1998 in Relation to the Fixed Link across the Öresund,* Unpublished report to Öresundskonsortiet. Ecological Institute, University of Lund.

Nilsson, S.G. & Nilsson, I.N. 1976. Numbers, food consumption and fish predation by birds in Lake Möckeln, southern Sweden. *Ornis Scandinavica*. 7: 61-70.

Öresundskonsortiet 1995. *The Öresund Link. Supplementary Assessment of the Impacts on the Marine Environment of the Öresund Link.* Öresundskonsortiet, Copenhagen, Denmark.

Öresundskonsortiet 1998. *Assessment of the Impacts on the Marine Environment of the Öresund Link.* Öresundskonsortiet, Copenhagen, Denmark.

Pedroli, J.C. 1981. Les relations entre la moule zébrée *Dreissena polymorpha* et les oiseaux aquatiques. Dissertation, University of Neuchâtel, Switzerland.

SEMAC JV 1997a. *The Authorities' Control and Monitoring Programme for the Fixed Link across Öresund. Common Mussels,* Status Report 1996. Unpublished report to Öresundskonsortiet.

SEMAC JV 1997b. *The Authorities' Control and Monitoring Programme for the Fixed Link across Öresund. Benthic Vegetation,* Status Report 1996. Unpublished report to Öresundskonsortiet.

SEMAC JV 1998. *The Authorities' Control and Monitoring Programme for the Fixed Link across Öresund. Common Mussels,* Status Report 1997. Unpublished report to Öresundskonsortiet..

Suter, W. 1982a. Vergleichende Nahrungsökologie von überwinternden Tauchenten (*Bucephala, Aythya*) und Blässhuhn *Fulica atra* am Untersee-Ende/Hochrhein (Bodensee). *Ornithologische Beobachter*. 79: 225-254.

Suter, W. 1982b. Der Einfluss von Wasservögeln auf Populationen der Wandermuschel (*Dreissena polymorpha* Pall.) am Untersee/Hochrein (Bodensee). *Schweizer Zeitschrift für Hydrobiologie.* 44: 149-161.

Swennen, C. 1976. Populatie-struktur en voedsel van de Eidereend *Somateria mollissima* in de Nederlandse Waddenzee. *Ardea* 64: 311-371.

VKI/Toxicon 1994. *Baseline Survey on the Macrozoobenthos in Shallow Water at Amager and Saltholm and from Lundåkrabugten to Falsterbo,* Document No 94/148/0E.

VKI/Toxicon 1995. Supplementary Baseline Studies on Benthic Fauna in Öresund. Shallow Waters, Document No 95/114/1E.

VKI/Toxicon 1996a. *Baseline Survey of the Macrozoobenthos in Shallow Water around Saltholm and along the Danish and Swedish Shores in 1995,* Document No. 96/115/2E.
VKI/Toxicon 1996b. *Monitoring of Macrozoobenthos in Shallow Water during the Spring of 1996,* Document No. 96/121/1E.
VKI/Toxicon 1996c. *Biomass, Coverage and Size Distribution of Common Mussel, 1995*, Document No 96/118/1E.
Žydelis, R. 2002. *Habitat Selection of Waterbirds Wintering in the Lithuanian Coastal Zone of the Baltic Sea.* Doctoral dissertation, Institute of Ecology, Vilnius, Lithuania.