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Occurrence and food consumption of the common eider, *Somateria mollissima*, in the Wadden Sea of Schleswig-Holstein*

Georg Nehls

Staatliche Vogelschutzwarte, Biologiezentrum; Olshausenstraße 40–60, D-2300 Kiel, Federal Republic of Germany

ABSTRACT: The number of eider in the Wadden Sea of Schleswig-Holstein was counted by aerial surveys during 1986 and 1987. The highest number occurred during migration in October 1987 with 151 000 ducks, the lowest number during the breeding time in May 1987 with 6000 ducks. About 100 000–120 000 eiders moult in July/August in the Wadden Sea of Schleswig-Holstein, but only 30 000–40 000 stay over winter. The average number was 62 000 ducks. Eider have increased in number since the seventies, when the average population size was estimated to be only 23 000. The increase referred mainly to moulting and migrating eider, whereas numbers in winter remained constant. There are substantial changes in the spatial distribution over the year. In most areas sites used during moult, migration and winter can be clearly separated, although so far no obvious differences in the morphology of these areas could be found. The annual food consumption was calculated to be 3.1×10^6 kg AFDW or 1.3 g AFDW $\times$ m^{-2} $\times$ $year^{-1}$, which is about 5 % of the average biomass of macrozoobenthos. The increase in the number of eider has led to a significant increase in total food consumption of carnivorous birds, which was estimated at 7.1×10^6 kg AFDW $\times$ $year^{-1}$ in the seventies and now reaches 9.0×10^6 kg AFDW $\times$ $year^{-1}$, of which the eider takes 34 %. The reasons for and consequences of the increase of the eider are discussed in context with the eutrophication of the North Sea and possible competition with shellfishery.

INTRODUCTION

The eider is the only seaduck occurring in substantial numbers in the inner parts of the Wadden Sea. Birds originating from the Baltic Sea use this area for moulting, wintering and a few also for breeding (Swennen, 1983). A long lasting increase in the breeding population of the Baltic was followed by growing numbers in the Wadden Sea since the 1970s (Nehls et al., 1988). In 1986 a research program was started in the National Parks of Schleswig-Holstein and Niedersachsen to study the number of eider, their spatial distribution and changes over the year, as well as their food and feeding habits. This paper reports on the results from Schleswig-Holstein.

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MATERIAL AND METHODS

From September 26th 1986 to October 18th 1987, 12 aerial surveys, covering the Wadden Sea of Schleswig-Holstein, were conducted to map the numbers and distribution of eider in the area. Flights were carried out during low tide, starting at the mouth of the river Elbe and ending at the island of Sylt. The counts were performed with 3 observers using a twin engine Cessna 337. The results of the counts were improved and checked by slides made during the flight. For details and flight route see Nehls et al. (1988).

Aerial surveys have been used for many years to count eider in the Wadden Sea (Drenckhahn et al., 1971; Joensen, 1973, 1974; Swennen, 1976), so that statements concerning changes in numbers and distribution refer mainly to results that were attained by using the same method.

RESULTS

Numbers and distribution

The results of 12 aerial surveys, carried out in 1986 and 1987, are shown in Figure 1. It appears that very high numbers of eider occur during moult in July and August. After moulting, the numbers decline, but in October the autumn migration leads to a marked increase again. The number of wintering eider is much lower, and during early summer only a small fraction stays in the Wadden Sea. The function of the Wadden Sea of

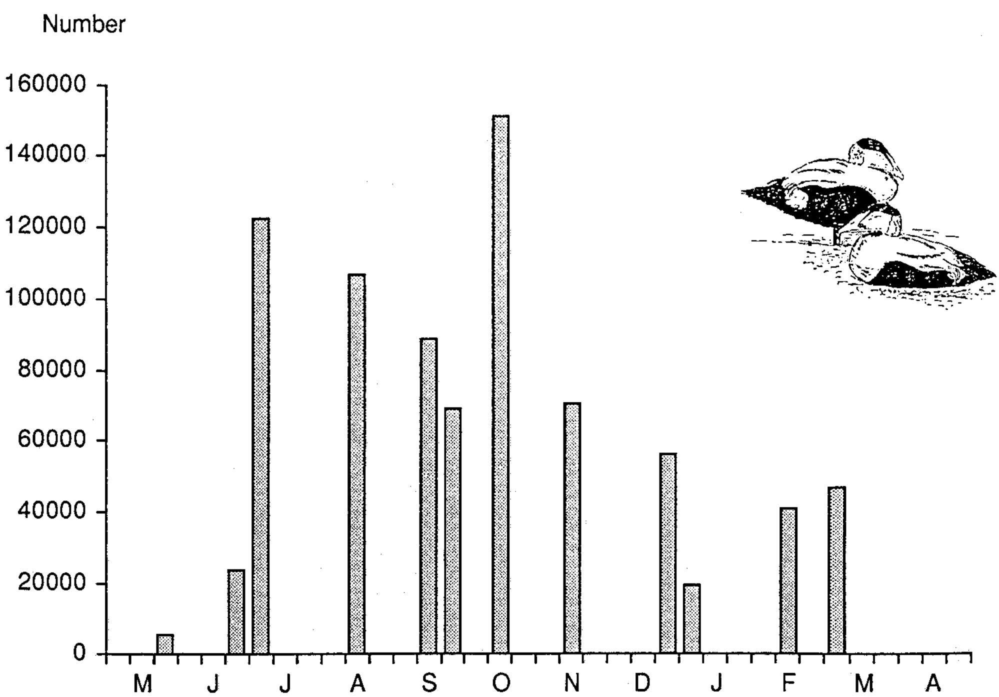

Fig. 1. Results of 12 aerial surveys carried out in the Wadden Sea of Schleswig-Holstein

Schleswig-Holstein in the annual cycle of the eider is therefore quite different from the Danish and the Dutch part, where highest numbers occur during winter (Laursen, 1987; Swennen, 1976).

The number of eider moulting in the Wadden Sea of Schleswig-Holstein has increased considerably since the seventies. Although numbers of moulters have tripled in this period, wintering numbers remained constant (Nehls et al., 1988). The change in numbers refers mainly to the long lasting increase of the breeding population in the Baltic Sea, which is caused by an increase in salinity and the eutrophication (Stjernberg, 1982; Nehls et al., 1988) but to a certain extent also to a change in the moulting areas of the Danish breeding population (Franzmann, 1983), which is however too small to explain all of it.

The eider uses all areas of the Wadden Sea of Schleswig-Holstein, but in the course of the year substantial changes in the spatial distribution occur. These allow a distinction between moulting and wintering areas (Fig. 2). The eiders are constantly on the move through the Wadden Sea and some parts may be visited for only a few weeks of the year. The summer situation is seriously affected by recreational activities like boating, and high moulting concentrations are not to be found near inhabited islands or busy ship-routes (Nehls & Thiel, 1988). So far, no obvious differences in the morphological or hydrological structure of these areas could be found to explain these movements.

The increase of the eider showed regional differences. Strong increases were reported from the island of Trischen or the area of the Nordfriesische Außensände, whereas the numbers north of the Hindenburgdamm have remained constant for at least 20 years (Nehls et al., 1988). In Niedersachsen new sites have been colonized during the last 15 years (Nehls et al., 1988). In the Dutch and Danish parts of the Wadden Sea no changes in numbers could be found in that time (Swennen et al., 1989).

Food and consumption

Eider feed on marine invertebrates, mainly molluscs, throughout the year. In the Wadden Sea the mussel, *Mytilus edulis*, and the cockle, *Cerastoderma edule*, are the most important food items. Shorecrabs, *Carcinus maenas*, Baltic tellins, *Macoma balthica*, clams, *Mya arenaria*, periwinkles, *Littorina littorea*, and seastars, *Asterias rubens*, are only of minor importance. In the Dutch Wadden Sea mussels and cockles each take a share of 40 % in the eider's food (Swennen, 1976). In Schleswig-Holstein preliminary investigations, analysing about 7000 faeces in 1987 and 1988 (Nehls, unpubl. data), showed that cockles contribute about 75 % to the food of the eider during summer, when numbers are highest. For the wintertime no data are available so far. Eider use various feeding techniques which allow feeding on tidal and subtidal areas. In the Wadden Sea feeding takes place mainly during rising or ebbing tide. At low tide, eider rest on exposed sandflats or on the water. Cockles are mainly taken from tidal flats by trampling, which leaves small craters of about 50 cm in diameter and 20 cm deep. These are easily visible from the plane. The eider can however take cockles by diving as they do regularly in the Baltic Sea (Madsen, 1954; Kirchhoff, 1979). Mussels are taken by diving at high tide, when eider aggregate in large flocks over the mussel beds, both on subtidal and intertidal areas (Swennen, pers. comm.; Ketzenberg, pers. comm.).

Total consumption by eider in the Wadden Sea of Schleswig-Holstein was calculated

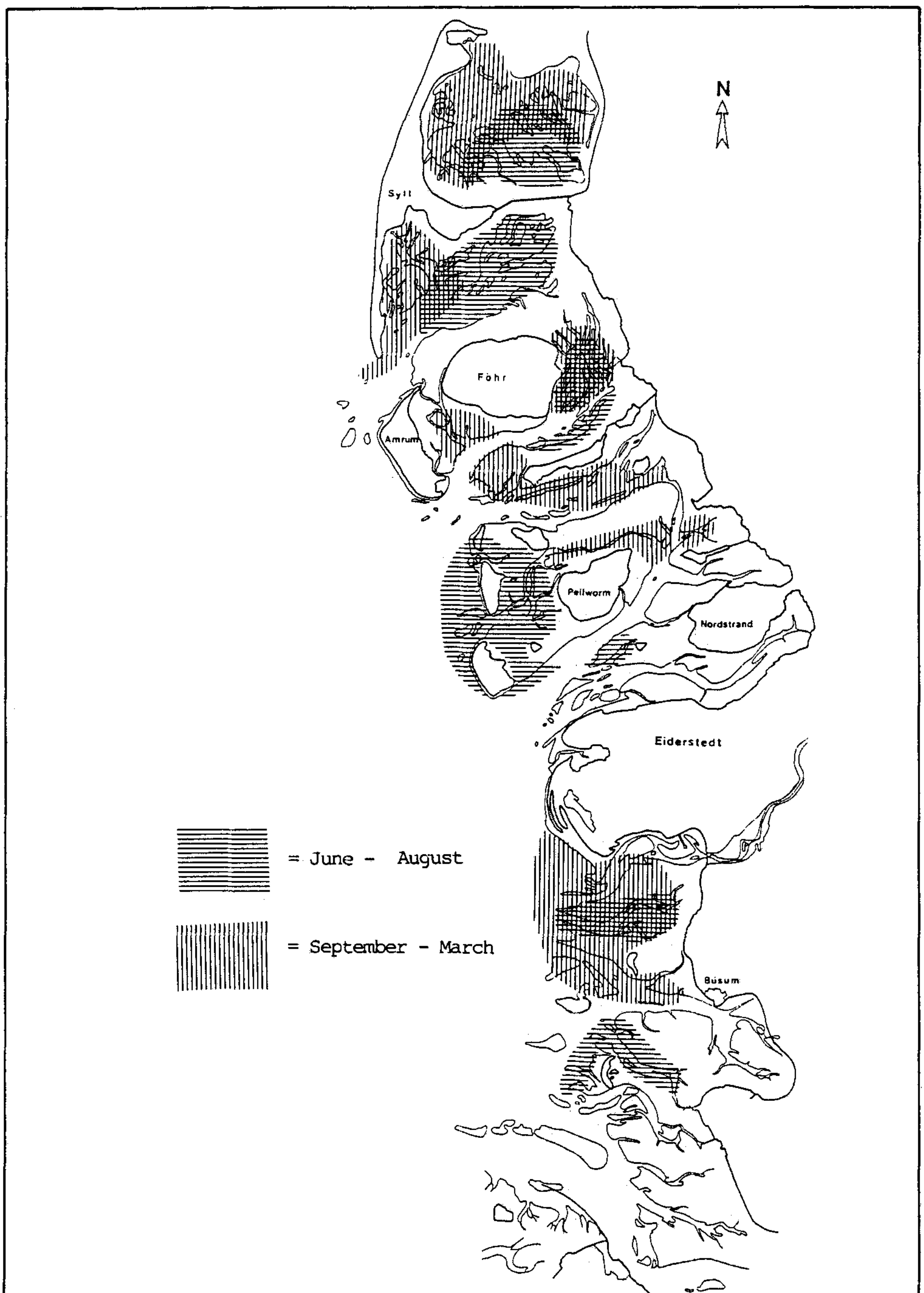

Fig. 2. Distribution of moulting and wintering eider in the Wadden Sea of Schleswig-Holstein; areas where more than 5000 eiders were counted are hatched

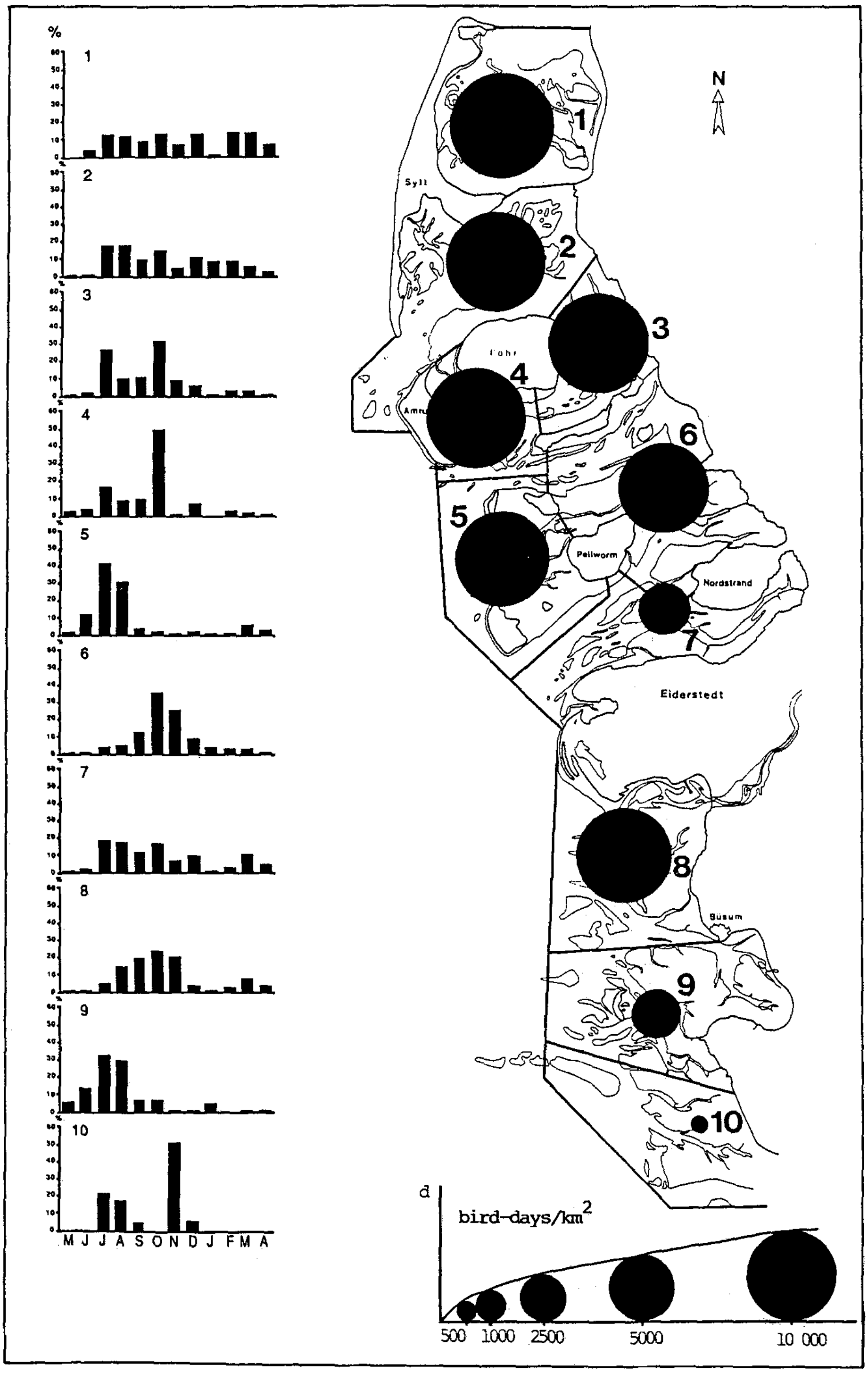

Fig. 3. Regional phenology and bird days km^{-2} $year^{-1}$ in the Wadden Sea of Schleswig-Holstein

by using the data given by Swennen (1976), who estimated the daily demand of an eider to be 138 g AFDW (ashfree dry weight) equal to 2.5 kg molluscs (wet weight, including shells). The total average number of eider in the Wadden Sea was calculated at 62 000, which was multiplied by 365 days and the daily demand, giving a total annual demand of:

$$62\,000 \times 365 \times 138 \text{ g AFDW} = 3.1 \times 10^6 \text{ kg AFDW}$$
$$\text{or } 62\,000 \times 365 \times 2.5 \text{ kg} = 56\,575 \text{ t molluscs}$$

Related to the area of the Wadden Sea of Schleswig-Holstein this leads to a consumption of 1.3 g AFDW $\times$ m^{-2} $\times$ year^{-1}, which is about 5 % of the biomass of the macrozoobenthos as found by Reise (pers. comm.) in the Nordstrander Bay or by Beukema (1983) on tidal flats of the Dutch Wadden Sea. For their main food species, cockles and mussels, the proportion taken by eider is higher, reaching 12.5 % of the total biomass. Since mussels reach a much higher biomass in the subtidal areas (de Wilde & Beukema, 1984), the proportion taken by eider there is lower.

Consumption by the eider in the Wadden Sea of Schleswig-Holstein has tripled since the seventies, when Drenckhahn (in Busche, 1980) calculated the annual demand to be 1.2×10^6 kg AFDW. The total consumption by carnivorous birds was then estimated to be 7.2×10^6 kg AFDW, of which the eider took 17 %. With increased eider numbers the total consumption by carnivorous birds now amounts to 9.1×10^6 kg AFDW or 3.82 g AFDW $\times$ m^{-2}, of which the eider takes a share of 34 %. Since some other important bird species of the Wadden Sea like the shelduck or the gulls have increased as well (Rüger et al., 1986; Vauk & Prüter, 1987), the total consumption may reach 5 g AFDW $\times$ m^{-2} $\times$ year^{-1}. Consumption by the eider in Schleswig-Holstein has only recently reached the level reported from the Netherlands for the seventies (Swennen, 1976).

To discover whether the changing spatial distribution leads to a different pattern in predation pressure, the Wadden Sea of Schleswig-Holstein was divided into 10 sections, where the consumption by eider was calculated separately. Figure 3 shows the phenology of the eider and the average numbers per area for each section, representing the consumption. The annual consumption in the different sections varies from 0.37 to 1.95 g AFDW $\times$ m^{-2} $\times$ year^{-1}, but the figures for sections that are important for eider are surprisingly similar, although they have clearly different functions in the annual cycle of the eider in the Wadden Sea.

DISCUSSION

The strong increase of the eider in the Wadden Sea of Schleswig-Holstein, the regular changes in their spatial distribution, and the conspicuous similarities in the annual consumption in the different sections of the Wadden Sea of Schleswig-Holstein, as well as in the other parts of the Wadden Sea, leads to questions about the function of the eider in this ecosystem. Two questions are of special interest:

(1) How was it possible that the most important avian predator colonized many areas of the Wadden Sea just recently?

(2) What is the limiting factor for the numbers of eider in the Wadden Sea?

Regarding Question (1): The reasons for the increase of the eider are found in the hydrological changes and the eutrophication of the Baltic Sea. In the Wadden Sea no such drastic changes, like mussels or cockles spreading into new areas, were reported that could explain the increase. So it seems likely that the eider, as Swennen (1976) suggested, found unexploited food resources in the Wadden Sea. Although mussels and cockles are a preferred prey of many other animals, this seems to be possible. On the tidal flats about ten different bird species (Smit & Wolff, 1983) as well as crabs, shrimps, flatfish and even polychaetes (Reise, 1985) prey on the various age classes of cockles, but only oystercatcher and eider feed on cockles larger than 2 cm. Since oystercatchers preferably feed on rather high mudflats close to their roosts (Zwarts, 1983), there seems to be little interference with the eider, which can easily take advantage of this situation and move into new places without competing with other predators. In the Königshafen of Sylt where only few eiders occur, Reise (1985) found almost no predation and, therefore, reduced mortality in cockles larger than 3 cm.

Regarding Question (2): In several parts of the study area the number of eider did not increase, inspite of the fact that more and more eider from the Baltic appeared in the Wadden Sea. The annual consumption in these areas is rather similar, so it could be that the population of eider has reached the maximum density that these areas can support. This seems to be reasonable, since other studies (Pehrsson, 1973, 1978, 1984) have shown the available food to be a main factor regulating the number of eider. However, the consumption by eider in relation to the available food resources in the Wadden Sea (12.5 % of cockles and mussels) is much lower than reported from other areas. In the Ythan estuary, eider consume 39 % of the annual mussel production which is 20 % of all zoobenthos production (Milne & Dunnet, 1972). In the St. Lawrence estuary, Canada, eiders take during summer 10–30 % of their preferred prey, a *Littorina* species (Cantin et al., 1974).

Furthermore, there has been a major increase in the biomass of the zoobenthos in the Wadden Sea, at least in parts of the areas where eiders occur but did not increase (Beukema & Cadée, 1986) even though there should be better feeding conditions today. The biggest problem for birds feeding on cockles or mussels in the Wadden Sea is the occurrence of marked fluctuations in these molluscs, due to severe losses in cold winters (Beukema, 1979; Dörjes, 1980; Heiber, 1985). The cockle population of tidal areas may be totally exterminated when ice covers the flats. After a cold winter it lasts until late August, when eiders can feed on the new age class again, which means that both wintering and moulting eiders are affected by high cockle mortality in cold winters. As cold winters occur regularly, the number of eider in the Wadden Sea is probably limited by the surviving amount of food, which also explains the low level of consumption in the relation to the average biomass of their prey. In the Wadden Sea, no changes in numbers that could be related to fluctuations in the abundance of cockles or mussels have been found so far, although eider counts have been made for more than 20 years.

This all means that eiders have probably got little benefit from the eutrophication of the Wadden Sea and the following increase of macrozoobenthos biomass. It has mainly improved the feeding conditions of good years and has not resulted in constantly and predictably larger food resources, because the winter mortality of their food is still the same.

The relation between eider and shellfishery is not clear in this case. Nehls et al. (1988) showed that the number of eider does not depend on mussel cultures. On the other hand, eiders do not seem to be negatively affected by mussel fishery although it reduces the standing stock of mussels considerably in autumn. One explanation is the preference for small mussels of 2–3 cm on the part of the eider (Kirchhoff, 1979; Milne & Dunnet, 1972), whereas harvested mussels are usually larger than 5 cm. The situation is quite different for the cockle, since harvested cockles of 3 cm in size are within the range preferred by eider. Competition between eider and fishermen will, at least in the present situation, only occur in years with low cockle or mussel populations. But since both the eider population and the shellfishery are still expanding in the Wadden Sea, further research is necessary to monitor the population of the eider and to study its feeding ecology and its relation to the fishery.

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