

**PREDATION ON JUVENILE FLATFISH BY CORMORANTS
PHALACROCORAX CARBO IN THE DUTCH WADDEN SEA**

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PREDATION ON JUVENILE FLATFISH BY CORMORANTS
***PHALACROCORAX CARBO* IN THE DUTCH WADDEN SEA**

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Marine Ecology

SAMENVATTING

Sterfte van jonge platvis in het Nederlandse deel van de Waddenzee als gevolg van predatie door aalscholvers *Phalacrocorax carbo* werd bestudeerd door middel van analyse van braakballen en de reconstructie van vissoort en grootte aan de hand van de gevonden otolieten. Braakballen werden in de herfst verzameld op de slaapplekken van de belangrijkste kolonies. Aalscholvers arriveerden in mei en de aantallen in de Nederlandse Waddenzee namen vervolgens toe van 1600 in mei tot 5100 in augustus. Vervolgens namen de aantallen af tot 1400 in oktober. Vanaf november waren aalscholvers niet meer in groten getale aanwezig. Gemiddeld waren er ongeveer 3400 aalscholvers aanwezig van mei tot november. Totaal werden er 24 verschillende soorten vis gevonden in 198 geanalyseerde braakballen. In aantallen gemeten droeg platvis voor 73% bij. Schol werd het meest frequent gevonden (in 17.5% van de gevallen), gevolgd door schaar (12.1%), bot (8.5%) en tong (1.1%). De totale predatie door aalscholvers werd berekend door vermenigvuldiging van het gemiddeld aantal aanwezige aalscholvers met het aantal dagen dat zij in de Waddenzee aanwezig zijn (180) en met het gemiddeld aantal platvissen in de braakballen, onder de aanname dat per dag één braakbal per aalscholver gevormd wordt en dat iedere gegeten platvis in de braakbal wordt teruggevonden. In totaal werden ongeveer 28.5 miljoen jonge platvissen gegeten, waarbij van ongeveer 60% de soort achterhaald kon worden. Predatie door aalscholvers bleek grootte-selektief te zijn in alle vier de platvissoorten. Schol werd het meest gegeten (7.3 miljoen), gevolgd door schaar (5.3 miljoen), bot (3.1 miljoen) en tong (0.4 miljoen). In vergelijking tot schattingen van de totale hoeveelheid platvis aanwezig in de Nederlandse Waddenzee, leverde het lage dagelijkse mortaliteiten $M (d^{-1})$ op, variërend van respectievelijk 0.0013 voor schaar tot 0.00003 voor tong. Dit leidt tot de conclusie dat predatie door aalscholvers niet de belangrijkste mortaliteitsfactor is voor jonge platvis in de zomer in de Nederlandse Waddenzee.

SUMMARY

Predation by great cormorants *Phalacrocorax carbo* on juvenile flatfish in the Dutch Wadden Sea was studied. Predation pressure was estimated based on the analysis of regurgitated pellets and the reconstruction of fish species and size based on otoliths found. Pellets were collected in one main colony and in the main night roosts in autumn. Cormorants arrived in May and total numbers in the Dutch Wadden Sea increased from about 1600 in May to 5100 in August. Hereafter numbers decreased to about 1400 in October. From November onwards no significant numbers were found in the area. On average about 3400 cormorants were present between May and October. In total 24 different fish species were found in 198 pellets. In numbers flatfish amounted on average 73% of the fish found. Among the flatfish species, plaice was found most frequently (17.5%), followed by dab (12.1%), flounder (8.5) and sole (1.1%). Total predation pressure by cormorants was estimated by multiplying the mean number of cormorants with the time the cormorants were present in the Wadden Sea (180 days) and with the mean number of flatfish found in the pellets, under the assumption that each pellet contains the remains of the fish eaten during the previous 24 hours. In total about 28.5 millions of juvenile flatfish were consumed, of which about 60% could be identified to species level. Predation appeared to be size-selective in all flatfish species. Juvenile plaice was most heavily preyed upon, more than 7.3 millions were consumed. Also 5.3 million juvenile dab, 3.1 million flounder and about 0.4 million sole were consumed. A comparison with data from a flatfish survey in the area revealed that instantaneous mortality rates $M (d^{-1})$ were low and ranged from respectively 0.0013 for dab and 0.00003 for sole. This leads to the conclusion that cormorant predation is not an important source of mortality in flatfish in the Dutch Wadden Sea during the summer period.

1. INTRODUCTION

The Wadden Sea is an important nursery area for several North Sea flatfish species, such as plaice *Pleuronectes platessa*, flounder *Platichthys flesus* and sole *Solea solea* (ZIJLSTRA, 1972; DANKERS *et al.*, 1978; VAN BEEK *et al.*, 1989). All three flatfish species spawn in winter in the open North Sea or in the coastal zone. The developing pelagic larvae settle in the Wadden Sea in spring and the demersal juveniles stay and grow in the area during their first years of life. In autumn they migrate to deeper waters and in spring they return in the area. After a few years they become mature and leave the area to join the adult stock.

Several studies have been carried out in the Wadden Sea on the mortality of juvenile flatfish and their predators. Larval flatfish are preyed upon by coelenterates (VAN DER VEER, 1985), and just settled juveniles suffer from predation by crustaceans, shrimps *Crangon crangon* and crabs *Carcinus maenas* (VAN DER VEER, 1986; VAN DER VEER & BERGMAN, 1987). With increasing size, other predators, such as fish, birds and seals become dominant (MACER, 1967; EDWARDS & STEELE, 1968; VAN DER VEER, 1986). This sequence in type of predation appears to be a rather general pattern also operating in other coastal flatfish nurseries (PIHL, 1990; VAN DER VEER *et al.*, 1990; 1996; ELLIS & GIBSON, 1995).

Information on both plaice and flounder suggests that in these species year-class strength is determined already in the pelagic stages (VAN DER VEER, 1986; VAN DER VEER *et al.*, 1991). Mortality by shrimps and crabs appeared to be significant (VAN DER VEER, 1986; VAN DER VEER & BERGMAN, 1987; PIHL, 1990; VAN DER VEER *et al.*, 1990; 1991) but acting only in a regulating way, damping the interannual variability in year-class strength (VAN DER VEER, 1986; VAN DER VEER *et al.*, 1990, 1991; BEVERTON & ILES, 1992). BEVERTON & ILES (1992) reviewed all available information on mortality of juvenile flatfish in European waters and concluded that also in summer after the period of predation by crustaceans significant mortality among juvenile flatfish did occur. This suggests that the combined effect of predation by fish, seals and birds might be of importance in the Wadden Sea. ELLIS & GIBSON (1995) concluded that once flatfishes had attained a size of 45 mm, they had outgrown the fish

predators present in their area of study, Trallee bay, Scotland. Assuming a similar situation for the Wadden Sea, this means that predation by seals and/or birds must be significant during the summer period. No quantitative information is present about these sources of predation. This study aims to quantify one of these sources, i.e. the predation by an avian predator, the cormorant *Phalacrocorax carbo*, on juvenile flatfish in the Dutch Wadden Sea.

Two main types of cormorant predation on juvenile flatfish can be distinguished: the feeding of chicks by the parents with small 0-group flatfish and the catch of larger sized juveniles by adults and fledged juveniles for their own consumption. Previous research in Cornwall and in the Wadden Sea has shown that more than 40% of cormorant prey consisted of juvenile flatfish. (STEVEN, 1933; VAN DEN BERG 1993, VAN DAMME 1994a). Cormorants arrive in the Dutch Wadden Sea in April-May to build up energy reserves and they leave the area again in September-October. Regurgitated pellets were collected from a colony and roosts and prey species were identified from the morphology of the otoliths that were retained from these pellets. For each species, relationships between fish length and otolith size were used to reconstruct the original fish size from each otolith. Based on these estimates of the flatfish consumption of individual cormorants, together with information on the number of cormorants present during the season in the area, total predation on flatfish was calculated. These figures were compared with estimates of the total juvenile flatfish stock present in the area, to reveal:

- [1] the importance of this source of predation
- [2] to what extent this type of predation is size-selective.

2. MATERIAL AND METHODS

2.1. AREA OF STUDY

The Wadden Sea is a shallow coastal sea along the northern and western coast of the Netherlands, Germany and Denmark, separated from the North Sea by a row of barrier islands. It is connected with the North Sea by deep tidal channels. In the Dutch part of the area the rivers IJssel and Ems discharge into the Wadden Sea.

In the Dutch Wadden Sea several colonies and important night roosts for cormorants are

found. At a number of night roosts and at the colony De Hond pellets were collected (Fig. 1). De Schorren is a protected saltmarsh and nature reserve on the eastern side of the island Texel. Only during very high tides De Schorren are flooded. Cormorants gather on the mud flat in front of De Schorren during low tide, but they flee to De Schorren with the flood tide. De Schorren is also used by cormorants as a night roost. Similarly, the Kooihoekschor is a saltmarsh and nature reserve at the Balgzand and used by cormorants as a night roost and as a resting place during high tide. De Havendam is a loose barrier dam in front of the sluice and inlet of the harbour of Den Oever. There is little direct human disturbance, because it can only be reached by boat. Cormorants use the dam as a night roost. Griend is a bird sanctuary in the Wadden Sea southwest of the island Terschelling. Griend is uninhabited, except from May until August when two birdwatchers are living on the island. Cormorants use the high, sandy tidal flat on the eastern side of Griend as a night roost. De Boschplaat on the eastern part of the island Terschelling is a protected nature reserve, of which only a few parts are open for public. It is a salt marsh outside the dikes. The southern part of the marsh is used by cormorants as a night roost. De Hond is an artificial island on a mud flat in the Ems situated between two gullies and it contains a gaspit. The island can only be reached by boat during high tide and is visited once a month by servicemen.

2.2. DATA COLLECTION

Flatfish data were taken from a survey carried out in September 1987 in the Dutch Wadden Sea (see BERGMAN *et al.*, 1989). In each tidal basin a number of beam trawl samples was collected at the tidal flats, in the subtidal and in the deeper tidal at a period of 3 hours around high water. For the intertidal area a rubber dinghy was used with a 2 m beam trawl with a mesh size of 5 x 5 mm. In the subtidal and deep gullies fishing was done from RV 'Navicula' using a 3 m beamtrawl with a mesh size of 1 x 1 cm. The distance trawl was assessed with a meter wheel fitted to the frame (2m trawl) or with Decca (3m trawl). The catches were sorted out on board within a few hours, and of each catch flatfishes were measured to the nearest 0.5 cm total length class below. The numbers of flatfish caught were corrected for distance trawled and for net efficiency (DAPPER, 1975;

KUIPERS, 1975; BERGMAN *et al.*, 1989). For each tidal basin the mean density for the tidal flats and the subtidal was estimated and the total abundance was calculated.

The average number of cormorants present in the Wadden Sea was estimated based on counts on the roosts. Bird numbers were derived from (irregular) counts by volunteers that were forwarded to SOVON (Samenwerkende Organisaties Vogelonderzoek Nederland). In addition, each time pellets were collected, the number of cormorants present was counted. These two sources of information were combined to get an estimate of the number of cormorants present in the Dutch Wadden Sea.

Pellets of cormorants were collected in September 1992 in the colony De Hond in the Ems and in August 1993 on the other night roosts. Only complete and fresh pellets were taken and in this way approximately 30 pellets were collected at each location and they were stored at -20°C. For analysis the pellets were defrosted in 'hand' warm water. After this the mucous was dissolved in 1M NaOH. It was checked that NaOH did not dissolve otoliths. Otoliths and other identifiable remains (e.g. pharyngeal bones and scales) were collected and air-dried. Otoliths were identified using HÄRKÖNEN (1986) in combination with the NIOZ reference collection. Each otolith was measured using a projection microscope (40x) for small ones and vernier callipers for larger ones. The total length and width of the otolith was determined, except for damaged ones. Other fish remains were not measured, but they were used for identification.

2.3. STATISTICAL ANALYSIS

For each fish species, the otoliths were identified as a left or right otolith and subsequently if possible they were paired. Except if left or right otoliths were clearly larger they would be counted as one fish (MARTEIJN & DIRKSEN, 1991). Remaining otoliths which could not be identified as a left or right one were counted and divided by 2. The wear of the otoliths was visually determined and was divided in four classes, according to VAN DAMME (1994b): 0 no wear, 1 slightly worn, 2 heavy wear and 3 very heavy wear.

In each pellet and for each fish species the minimum numbers of fish eaten was calculated based on the number of pairs and the highest number of remaining left or right otoliths. For

each sampling location, the mean number of fish eaten per pellet was estimated. Fish size and weight was reconstructed based on the actual length or width of the individual otolith.

Flatfish predation was estimated for each sampling location based on [1] the estimate of the mean number of cormorants present; [2] the number of days the cormorants are present in the Wadden Sea; [3] the mean number of flatfish present in the pellets and [4] the assumption that each pellet contains the fish remains of the fish eaten during the previous 24 hours, in other words cormorants produce one pellet a day (DUFFY & LAURENSEN 1983; JOHNSTONE *et al.*, 1990; ZIJLSTRA & VAN EERDEN, 1995).

3. RESULTS

3.1. FLATFISH ABUNDANCE

In total 213 million juvenile flatfish were present in the Dutch Wadden Sea in autumn 1987 according to the survey data (Table 1). The most abundant species were plaice (87.6 million) and sole (82.5 million), followed by dab (34.8 million) and flounder (8.1 million). The abundance of the various flatfish differed with respect to tidal basin, tidal/subtidal and species.

Plaice was present in all tidal basins in relatively constant densities. Highest numbers could always be observed at the tidal flats. In total about 75% of all numbers could be found at the tidal flats. Dab showed a more variable pattern in abundance. In some tidal basins hardly any juvenile dab was found. Most individuals were present in the subtidal, and hardly any dab was caught at the tidal flats. Most numbers were found in the Vlie tidal basin. About 30% of all individuals was found at the tidal flats and 70% was caught in the subtidal. Sole was also found in all tidal basins in rather variable numbers. Most individuals were observed in the Friesche Zeegat and in the Ems-Dollard. In general, numbers found were highest in the subtidal. In total about 35% was caught at the tidal flats and 65% in the subtidal area. Juvenile flounder was present in almost all tidal basins, be it in rather variable numbers. In general numbers were highest at the tidal flats and in total 75% of all individuals were collected at the tidal flats.

The size-frequency distributions varied between the species (Fig. 2). For all species most individuals caught were 0-group flatfish.

Furthermore, low numbers of 1-group were found. The smallest sizes were found in dab, peak numbers were found at a size of 5 cm total length. In sole and flounder, the peak numbers had a size of about 7 cm, while in plaice the peak was at about 8 cm.

3.2. PELLET ANALYSIS

3.2.1. SPECIES COMPOSITION

In total 198 pellets were collected and examined, of which nine pellets did not contain fish remains (Table 2). Some otoliths could not be identified to species level, but could only be determined to family. In total otoliths of 24 different fish species were found

Five different types of otoliths belonged to fresh water species, three species can be found both in the fresh water and in the marine environment and the other 15 species were salt water species. Fresh water fish was observed in the pellets from Balgzand, Den Oever and De Hond, locations in close proximity of fresh water habitats. The pellets from Den Oever contained the highest proportion otoliths of fresh water fish, 42%, while at Balgzand and De Hond this proportion amounted to respectively 11 and 19%.

Of all species found, only a few were present in significant numbers. Flatfish were by far the most abundant fishes at each sampling location. Only Gobiidae (15.3%) and smelt (2.7%) accounted for more than 1% of the number of fishes found in the pellets. In numbers flatfish amounted on average 73% of the individuals found (Table 2). Some variability was observed between locations. The lowest proportions of flatfish were found at Den Oever (43%) and De Hond (46%). At the other areas the proportions of flatfish varied between 79 and 83%.

Among the flatfish species, plaice was found most frequently (17.5%), followed by dab (12.1%), flounder (8.5) and sole (1.1%) These species were found in all pellets with fish remains as were Gobiidae. The relative contribution of the various flatfish species differed between the locations. At Den Oever and De Hond, low proportions of plaice were found of 9%. In all locations the proportion of sole was low, less than 3%. The contribution of dab and flounder varied also considerably between respectively 4-18% and 4-16%. However, these figures might be biased by the relatively large proportion of flatfish otoliths that

could only be identified to family and not to species (10-39%).

3.2.2. NUMBER OF FLATFISH

The estimated mean number of flatfish per pellet differed between locations (Table 4). The largest mean number of flatfish was observed at Griend, about 136 flatfish per pellet, while at De Hond only 16 flatfish per pellet were found. In all areas, only low numbers of sole per pellet were found of less than about 2 individuals per pellet. Between locations there was a large variability in the number of plaice, flounder and dab. On average, plaice was most abundant (about 16 fish per pellet), followed by dab (11 fish per pellet) and flounder (about 8 individuals per pellet). Except for De Hond, at all locations a large number of otoliths could not be identified to species level.

3.2.3. FLATFISH SIZE

The sizes of the flatfish consumed were reconstructed based on fish length - otolith width relationships (Table 5). The size was reconstructed with a correction for otolith wear. Different percentages were tested until agreement existed between the smallest sizes reconstructed and those found in the field (Fig. 3) This resulted in a correction for wear of 15%.

Almost all individuals appeared to have been juvenile flatfish, mainly 0-group and I-group fish (Fig. 4). The largest reconstructed size of a flatfish amounted 32 cm. The majority of the flatfish were smaller than 15 cm total length. In plaice the reconstructed size of the individuals consumed showed that mainly 0-group plaice was taken. Also in dab mainly small individuals, less than 10 cm total length were found in the pellets. In sole a larger size range was observed and also larger individuals up to 30 cm were found. In flounder also mainly 0-group was consumed (up to about 12 cm) and to a lesser extent I-group. Unidentified flatfish were relatively small in reconstructed size with maximum numbers at a size range of 3 to 5 cm total length.

3.3. CORMORANT ABUNDANCE

Cormorants data were available for 12 locations, covering the main part of the population (Table 6). In all areas in the Dutch Wadden Sea, cormorants arrived in May. Total numbers in the Dutch Wadden Sea con-

tinuously increased from about 1600 in May to 5100 in August. Hereafter numbers decreased to about 1400 in October. From November onwards no significant numbers were found in the area. On average about 3400 cormorants were present between May and October.

Cormorants were most at Griend, Terschelling and Texel. In general, the patterns in abundance between the various locations was the same during the season. The main presence of cormorants in the Dutch Wadden Sea was from May to the end of October, i.e. 6 months or 180 days.

3.4. PREDATION PRESSURE ON FLATFISH

3.4.1. FLATFISH NUMBERS

The total predation pressure by cormorants on flatfish could be estimated by multiplying [1] the mean number of cormorants present (Table 7); [2] the number of days the cormorants are present in the Wadden Sea (180 days) and [3] the mean number of flatfish present in the pellets (Table 4), under the assumption that each pellet contains the remains of the fish eaten during the previous 24 hours.

In total about 28.5 millions of juvenile flatfish were consumed, of which about 60% could be identified to species level. Of these juvenile plaice were most heavily preyed upon, more than 7.3 million of individuals. Also a lot of juvenile dab (5.3 million) and flounder (3.1 million) were consumed. Only about 0.4 million of juvenile sole were eaten. The actual figures would be higher because of the large amount of unidentified juvenile flatfish otoliths in the pellets (12.4 million fish). Predation pressure on flatfish was lowest at De Hond in the eastern part of the Dutch Wadden Sea and at Den Oever in the western part. Most juvenile flatfish were consumed at Griend (16.0 million), followed by Schorren (5.2 million).

An estimate of the mortality induced by cormorant predation was calculated by comparing the amount of flatfish consumed by cormorants with the abundance estimates of the flatfish survey (Table 8), according to:

$$N_t = N_0 \cdot e^{-M^t}$$

in which N_t is the flatfish abundance in autumn; N_0 is the total abundance of both the estimate of the predation pressure and the numbers present in the field in autumn (N^t); t is period of cormorant predation in days and M is instantaneous mortality rate (d^{-1}). Total stage

mortality M_t varied between 0.237 for dab and 0.006 for juvenile sole. The instantaneous mortality rate M (d^{-1}) differed in a similar way between receptively 0.0013 for dab and 0.00003 for sole.

3.4.2. SIZE-SELECTIVITY

Size-selectivity of predation on juvenile flatfish by cormorants was examined by comparing the size-frequency distributions in the field (Fig. 2) with the reconstructed size-frequency of the flatfish from the pellets (Fig. 3).

For all four flatfish species a clear difference was observed between the size-frequency in the field and those reconstructed from the pellets (Table 9). For all four flatfish species it appeared that relatively more larger individuals were consumed (Fig. 3) than would be expected based on the size-frequency distributions in the field (Fig. 2).

4. DISCUSSION

4.1. SAMPLING STRATEGY

The sampling design of both the analysis of the predation by cormorants and of the flatfish survey might have introduced some sources of bias.

Pellets have only been collected in August and September. The calculated total amount of flatfish caught by cormorants during late summer is based on these pellets. However it might be possible that the diet of the cormorants shows seasonal variation, which might influence the estimate of the number of flatfishes consumed.

It is also possible that some otoliths have been completely digested by cormorants. Experimental data result in recovery rates of otoliths less than 100%. ZIJLSTRA & VAN EERDEN (1995) recovered only 52% of the otoliths ingested by cormorants in the pellets. JOHNSTONE *et al.* (1990) found a recovery rate of 72% for large cod *Gadus morhua* otoliths and a recovery rate of 22% for small sprat *Sprattus sprattus* otoliths. Empty pellets were also rather frequently observed, in 20% by ZIJLSTRA & VAN EERDEN (1995), while in this study only 5% of the pellets contained no fish remains. Therefore, the reconstructed predation pressure should be considered as an underestimation.

The absolute size of the prey consumed was based on the length or the width of the otoliths found. Comparing the length-frequency

distribution of the various flatfish species in the pellets with in the field, showed that the flatfishes found in the pellets were 1 to 3 cm smaller than the flatfishes caught in the field. Therefore, a correction for wear of the otoliths was introduced. Both ZIJLSTRA & VAN EERDEN (1995) and DUFFY & LAURENSEN (1983) found a wear of 25% for cormorants in captivity, but the pH of the stomach acid of cormorants in captivity is, because of stress, lower than normal (ZIJLSTRA & VAN EERDEN 1995). Assuming a wear of 15% was high enough to result in a good correspondence of the smallest individuals reconstructed from the otoliths and found in the field. However, unidentified flatfish were in general smaller. This might suggest a larger wear for these otoliths and also explain the difficulties with the identification.

Secondary consumption of fish might be another source of bias. BLACKWELL & SINCLAIR (1995) found evidence of secondary consumption of fish by double-crested cormorants, however in the case of flatfish predation in the Dutch Wadden Sea this is less likely. First, cannibalism of flatfish as observed in British waters (MACER, 1967; EDWARDS & STEELE, 1968) is not observed in the Dutch Wadden Sea (KUIPERS, 1977; de Vlas, 1979). Also the other potential predators, such as gadoids and lesser weever (see VAN DER VEER *et al.*, 1990) are hardly found as otoliths in the cormorant pellets in this study.

Counts of cormorants were not carried out regularly. The estimate in this study was made on data from several years, 1990 until 1994. Also counts have been carried out at more places than pellets were collected. Therefore, the numbers present will reflect only the order of magnitude.

The flatfish survey was carried out in autumn by means of a beam-trawl, a fishing gear that is optimal for flatfish sampling. However, the survey was restricted to areas where sampling was possible, omitting extremely silty stations. Since juvenile flounder is especially found in muddy areas, this might have resulted in an underestimation of the number of flounder.

4.2. PREDATION ON FLATFISH

In total 24 different fish species have been found in the pellets, among which four fresh water and one brackish water species: roach, rudd, smelt, ruffe and perch. Studies at colonies near fresh water lakes in the Netherlands

showed these fish species to be the most important in the diet of the cormorants in these areas (VOSLAMBER, 1988; DIRKSEN *et al.*, 1990; MARTEIJN & DIRKSEN, 1991; VELDKAMP, 1994). Cormorants are considered to be opportunistic feeders, which means that the diet composition is determined by the availability of the various fish species (MARTUCCI & CONSIGLIO, 1991). The data in this study do not show a clear species preference, but indicate that cormorants take whatever fish species is present. Almost all the salt water fish caught by the cormorants are benthic or demersal, but the fresh water fish caught are all pelagic. Most probably there are more benthic and demersal fish in the Wadden Sea than in Lake IJssel. In the Dutch Wadden Sea 65% of all the fish is benthic or demersal (HOVENKAMP & VAN DER VEER, 1993). Because of the tides it is probably also easier for cormorants to catch benthic fish in the Wadden Sea than in Lake IJssel.

Flatfish are the most important fish group in the cormorants diet in the Dutch Wadden Sea. Also STEVEN (1933), MILLS (1969) and RICHNER (1995) found the food of cormorants, in respectively England and Scotland, to be mainly flatfish: 40 to 85% of the diet. In the Dutch Wadden Sea the same percentages have been found, 41 to 83%. Even at De Hond and Den Oever where cormorants were able to catch freshwater fishes too, flatfish still outnumbered other fish species in the pellets. Plaice, followed by dab and flounder, is the most important flatfish species caught. Although the reconstructed size-frequency distributions of the individuals found in the pellets might be biased to some extent by the sampling strategy, all information suggests that the predation by cormorants might be size-selective, with a preference for relatively larger individuals.

In total cormorants appeared to catch roughly 28.5 millions of flatfish in the Dutch part of the Wadden Sea each year. Despite this substantial amount of flatfish, estimates suggest that this resulted in rather low instantaneous mortality rates of between 0.00003 d^{-1} for sole and flounder to 0.0007 d^{-1} for plaice and 0.0013 d^{-1} for dab. For juvenile plaice information is present about phase mortality and duration during early life (BEVERTON & ILES, 1992). For post-settlers they estimated a daily instantaneous mortality rate of 0.0049 d^{-1} between August and October. Assuming that all

cormorant predation would be restricted to 0-group only, this means that predation by cormorants would account for only a small fraction of total mortality. Considering the mortality rates for the other three flatfish species, dab, sole and flounder, the same will be true for these species. Therefore, other sources of predation must be responsible for the observed mortalities.

The conclusion that cormorant predation is not the main source of mortality in the Dutch Wadden Sea, supports the view of MILLS (1969). He concluded that cormorants can have a serious effect on flatfish stocks in enclosed sea lochs, but will have little effect on flatfish stocks in open waters.

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TABLE 1.

Mean density (n.1000 m⁻²) and absolute numbers of juvenile flatfish in the various tidal basins of the Dutch Wadden Sea at the tidal flats (T), in the subtidal (S) and combined (T+S).

a: plaice

Tidal basin	Mean density (n.1000 ⁻²)			Total abundance (* 10 ⁶)		
	T	S	T+S	T	S	T+S
Marsdiep	38.1	12.1	18.1	4.8	5.1	9.9
Eierlandse Gat	60.5	22.0	51.4	7.0	0.8	7.8
Vlie	38.4	50.7	43.9	12.5	13.4	25.9
Borndiep	39.5	32.1	37.7	8.0	2.0	10.0
Pinkegat	78.8	18.5	70.2	4.5	0.3	4.8
Friesche Zeegat	47.9	37.2	45.5	4.6	1.0	5.6
Eierlandsebalg	112.0	5.1	95.0	3.6	0.1	3.7
Lauwers	96.3	12.4	80.7	10.6	0.3	10.9
Schild						
Ems-Dollard	30.7	13.5	25.2	7.5	1.5	9.0
			Total	63.1	24.5	87.6

b: dab

Tidal basin	Mean density (n.1000 ⁻²)			Total abundance (* 10 ⁶)		
	T	S	T+S	T	S	T+S
Marsdiep	0.0	0.5	0.4	0.0	0.2	0.2
Eierlandse Gat	0.0	7.2	1.7	0.0	0.3	0.2
Vlie	0.0	91.2	40.9	0.0	24.0	24.0
Borndiep	0.7	12.8	3.6	0.2	0.8	1.0
Pinkegat	0.0	0.0	0.0	0.0	0.0	0.0
Friesche Zeegat	0.4	39.0	8.9	0.1	1.0	1.1
Eierlandsebalg	0.0	10.5	1.6	0.0	0.2	0.2
Lauwers	3.3	1.75	3.0	0.4	0.1	0.5
Schild						
Ems-Dollard	1.9	0.8	1.5	7.5	0.1	7.6
			Total	8.0	26.8	34.8

c: sole

Tidal basin	Mean density (n.1000 ⁻²)			Total abundance (* 10 ⁶)		
	T	S	T+S	T	S	T+S
Marsdiep	1.2	0.0	0.3	0.2	0.0	0.2
Eierlandse Gat	0.0	41.3	9.8	0.0	1.5	1.5
Vlie	1.1	2.5	1.7	0.3	0.7	1.0
Borndiep	17.5	27.8	20.0	3.5	1.7	5.3
Pinkegat	3.0	32.8	7.8	0.2	0.5	0.7
Friesche Zeegat	10.9	487.4	115.5	1.0	13.1	14.2
Eierlandsebalg	1.0	7.7	2.0	0.0	0.2	0.2
Lauwers	7.0	56.7	16.2	0.8	1.4	2.1
Schild						
Ems-Dollard	95.3	307.1	162.9	23.3	34.1	57.4
			Total	29.3	53.2	82.5

d: flounder

Tidal basin	Mean density (n.1000 ⁻²)			Total abundance (* 10 ⁶)		
	T	S	T+S	T	S	T+S
Marsdiep	0.6	0.0	0.1	0.1	0.0	0.1
Eierlandse Gat	2.0	0.0	1.5	0.2	0.0	0.2
Vlie	8.7	3.9	6.5	2.8	1.0	3.8
Borndiep	0.0	0.0	0.0	0.0	0.0	0.0
Pinkegat	0.7	0.0	0.6	0.0	0.0	0.0
Friesche Zeegat	1.2	0.8	1.1	0.1	0.0	0.1
Eierlandsebalg	0.0	2.7	0.4	0.0	0.1	0.1
Lauwers	0.9	0.0	0.7	0.1	0.0	0.1
Schild						
Ems-Dollard	10.7	8.6	10.1	2.6	1.0	3.6
			Total	6.0	2.1	8.1

TABLE 2.

Species composition and absolute numbers of fresh water (F) and salt water (S) fish eaten by cormorants in the Dutch Wadden Sea based on otolith recovered from pellets collected at the various roosts in August 1993 and at the Hond in September 1992. For more information see text

Order	Family	Latin name	Species name	F/S	Schorren	Balgzand	Den Oever	Griend	Bosch-plaat	Hond	Total
Pleuronectiformes	Pleuronectidae	<i>Pleuronectes platessa</i>	plaice	S	329	266	98	767	237	57	1754
		<i>Limanda limanda</i>	dab	S	223	91	38	579	179	100	1210
		<i>Platichthys flesus</i>	flounder	F/S	280	63	123	135	238	46	885
	Bothidae	<i>Scophthalmus rhombus</i>	brill	S					1		1
	Soleidae	<i>Solea solea</i>	sole	S	44	9	2	10	41	8	114
Perciformes	Percidae		unidentified	S	522	316	187	1294	554	60	2933
		<i>Gymnocephalus cernuus</i>	ruffe	F			8			25	33
		<i>Perca fluviatilis</i>	perch	F		67	401			19	487
	Carangidae	<i>Trachurus trachurus</i>	scad	S	1						1
	Zoarcidae	<i>Zoarces viviparus</i>	eelpout	S	1		3				4
	Pholididae	<i>Pholis gunnellus</i>	butterfish	S			14			10	24
	Ammoditydae		unidentified	S	2	1		23	6	7	39
	Callionymidae	<i>Callionymus lyra</i>	dragonet	S					38		38
	Gobiidae			F/S	370	52	11	549	271	96	1349
	Scombridae	<i>Scomber scombrus</i>	mackerel	S		5			2		7
	Salmoniformes	Osmeridae	<i>Osmerus eperlanus</i>	smelt	F/S			152	3		90
Scorpaeniformes	Triglidae			S		1			5		6
	Cottidae	<i>Myoxocephalus scorpius</i>	bull-rout	S	7	3	4			7	21
	Cyclopteridae	<i>Cyclopterus lumpus</i>	lumpsucker	S				1			1
Gadiformes	Gadidae	<i>Trisopterus</i> sp.		S	1		2				3
		<i>Merlangius merlangus</i>	whiting	S	3		1	1	2	1	8
		<i>Pollachius pollachius</i>	pollack	S		1					1
		<i>Alosa fallax</i>	twaite shad	S		7					7
Cypriniiformes	Cyprinidae	<i>Rutilus rutilus</i>	roach	F		10	7				17
		<i>Rutilus erythrophthalmus</i>	rudd	F		21					21
			unidentified	F		18	5		75		98
Total number of fish					1783	931	1056	3362	1649	526	9307
Number of species					10	14	14	8	10	11	22
Number of pellets					30	30	25	37	40	35	198
Empty pellets					1	2	0	1	?	5	9

TABLE 3.

Proportion (%) of different flatfish found in the pellets of the cormorants at the various locations in the Dutch Wadden Sea in Autumn. (-: < 1). Data from Table 2.

Latin name	Species name	Schorren	Balgzand	Den Oever	Griend	Bosch-plaat	Hond	Total
<i>Pleuronectes platessa</i>	plaice	18	28	9	23	15	9	17.5
<i>Limanda limanda</i>	dab	13	10	4	17	11	18	12.1
<i>Platichthys flesus</i>	flounder	16	7	12	4	15	8	8.5
<i>Scophthalmus rhombus</i>	brill					-		
<i>Solea solea</i>	sole	2	1	-	-	3	1	1.1
	unidentified	30	33	18	39	36	10	33.7
Total		79	79	43	83	80	46	72.9

TABLE 4.

Mean number of flatfish found in the pellets of the cormorants at the various locations in the Dutch Wadden Sea in Autumn. (-: < 1). Data from Table 1.

Latin name	Species name	Schorren	Balgzand	Den Oever	Griend	Bosch-plaat	Hond	Total
<i>Pleuronectes platessa</i>	plaice	18.3	15.3	6.4	35.5	10.7	3.4	15.6
<i>Limanda limanda</i>	dab	12.3	5.0	2.2	27.6	7.7	6.2	10.8
<i>Platichthys flesus</i>	flounder	15.4	3.4	7.1	4.9	11.3	2.7	7.6
<i>Scophthalmus rhombus</i>	brill					-		-
<i>Solea solea</i>	sole	2.3	0.5	0.2	0.4	2.0	0.5	1.0
	unidentified	35.1	21.7	14.8	67.5	28.7	2.8	30.1
Total per pellet		83.3	45.9	30.6	135.8	60.3	15.6	65.0

TABLE 5.

Linear regression relationships between total fish length (TL;cm) and otolith length (OL;mm) and otolith width (OW; mm) for the various flatfish species, according to $FL = a + b \cdot OL/OW$ (plaice, dab, flounder) and $\ln OL/OW$ (sole), together with number of observations and regression coefficient.

Latin name	Species name	OL/OW	a	b	n	r ²	Reference
<i>Pleuronectes platessa</i>	plaice	OL	-2.12	4.88	752	0.99	Huibers, 1995
		OW	-4.66	8.17	787	0.97	Huibers, 1995
<i>Limanda limanda</i>	dab	OL	-3.51	5.32	663	0.95	This study
		OW	-5.29	8.79	465	0.94	This study
<i>Platichthys flesus</i>	flounder	OL	-3.24	5.45	331	0.96	Huibers, 1995
		OW	-5.83	9.55	352	0.96	Huibers, 1995
<i>Solea solea</i>	sole	OL	-1.26	8.09		0.96	Härkönen, 1986

TABLE 6.

Mean monthly number of cormorants present at the various routs and resting areas in the Dutch Wadden Sea. Estimates are based on own observations during collection of the pellets and on data obtained from the SOVON database.

Location	May	June	July	August	September	October	Total per location	Mean number
Texel	400	400	500	600	800	300	3000	541
Vlieland	50	0	100	100	200	70	520	
Balgzand/Mokbaai	250	100	300	300	350	100	1400	547
Wieringen	230	50	200	400	500	100	1480	
Terschelling	100	1000	1000	1000	500	200	3800	805
Ameland	20	50	30	50	30	10	190	
Schiermonnikoog	20	20	40	60	50	10	200	
Engelsmanplaat	20	40	80	70	70	20	300	
Rottum	30	150	100	50	10	0	340	
Griend	250	1000	1700	2000	1500	500	6950	
De Hond	150	200	400	400	300	100	1550	1158
Coastline	100	200	150	100	150	50	750	
								383
Total	1620	3210	4600	5130	4460	1460		3413

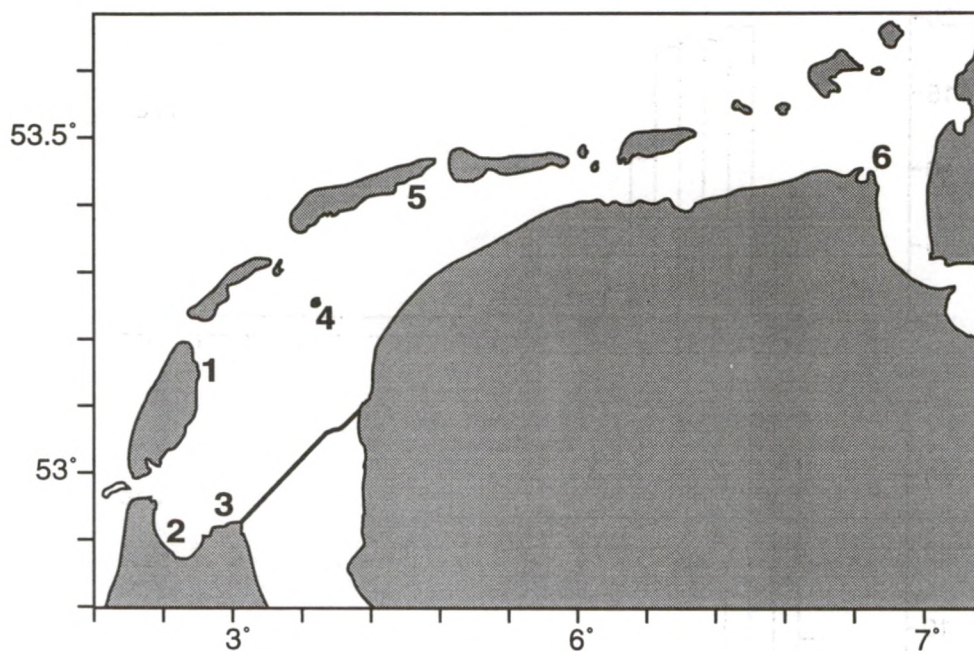


Fig. 1. Location of the main night roots (1-5) and colony (6) of cormorants in the Dutch Wadden Sea where pellets were collected. 1: Schorren; 2: Balgzand; 3: Den Oever; 4: Griend; 5: Boschplaat; 6: Hond. For more information see text.

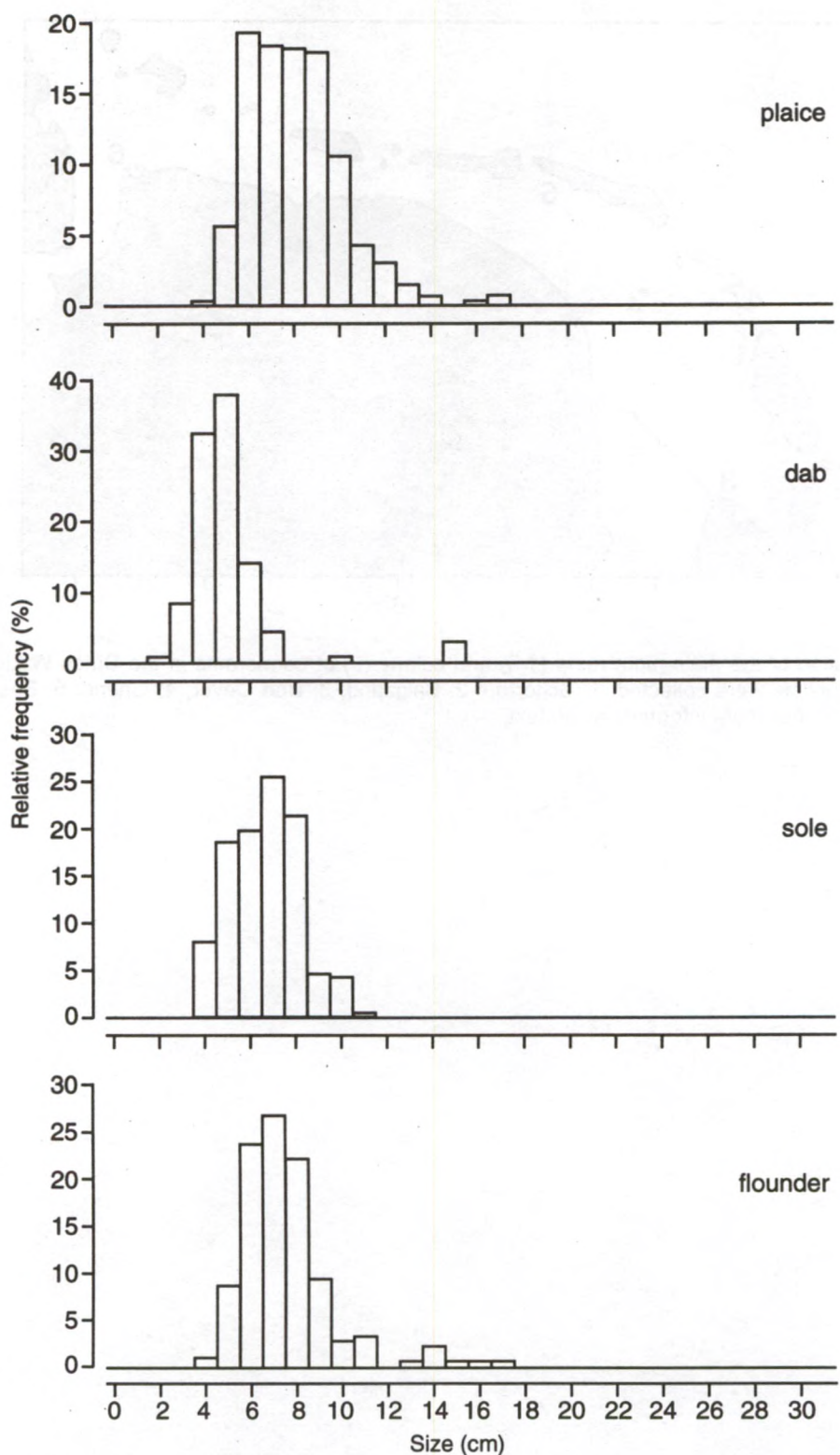


Fig. 2. Size frequency distributions (cm) of juvenile flatfish in the Dutch Wadden Sea in autumn 1987, based on survey data in the whole arwa. For more information see text.

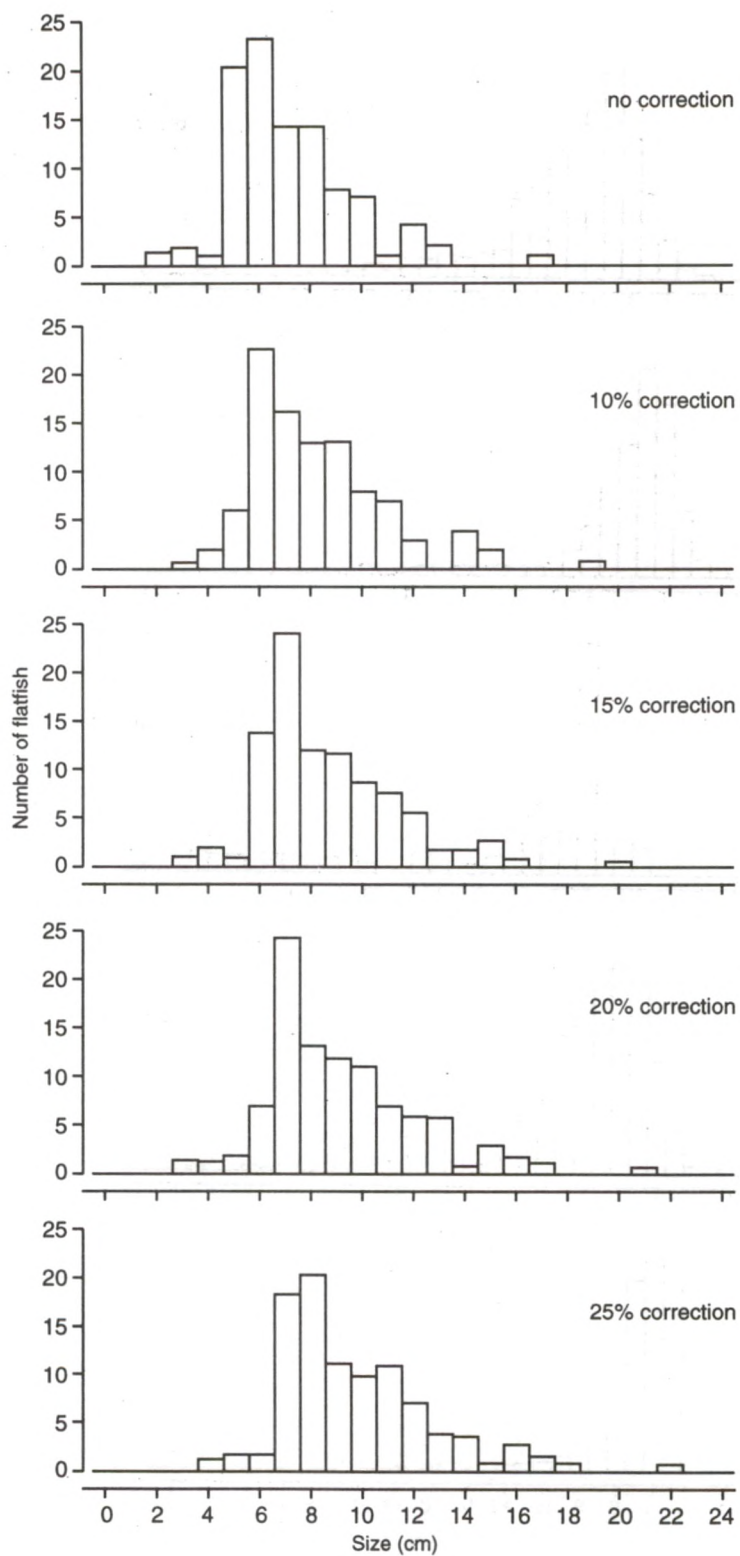


Fig. 3. Reconstructed size-frequency distribution of juvenile plaice from the pellets collected at Den Oever, after correction for wear with resp. 0, 10, 15, 20 and 25%.

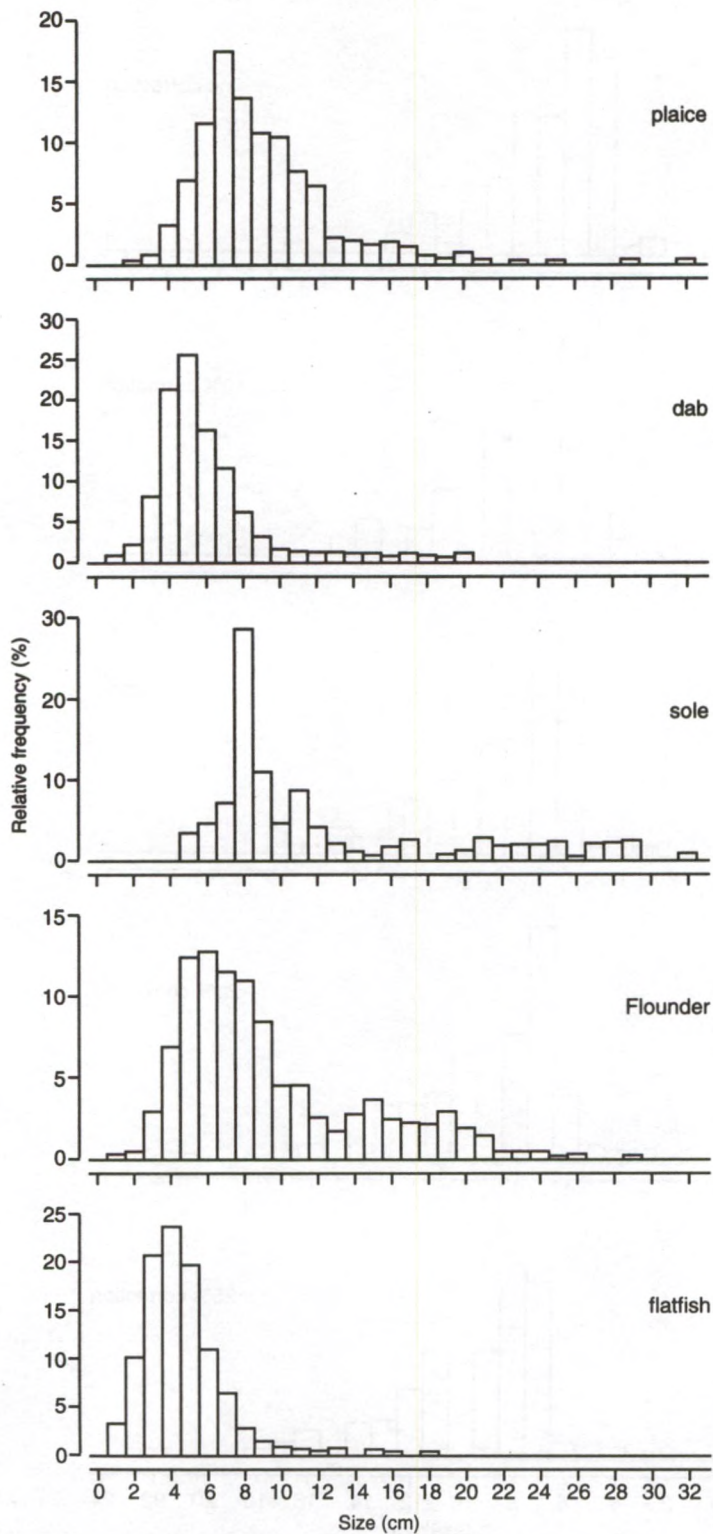


Fig. 4. Reconstructed size frequency distributions (cm) of consumed juvenile flatfish by cormorants in the Dutch Wadden Sea, based on the sizes of the otolith found in all pellets after correction for wear with 15%.

Appendix 1

Number of otoliths found of the various fish species in different pellets. PP = plaice; LL = dab; PF = flounder; SS = sole; UF = unidentified flatfish; GC = ruffe; PF = perch; TT = scad; ZV = eelpout; PG = butterfish; CL = dragonet; SS = mackerel; OE = smelt; MS = bull-rout; CL = lumpsucker; MM = whiting; PP = pollack; AF = twaite shad; RR = roach; RE = rudd; TR = Trisopterus spec; CY = Cyprinidae; TRI = Triglidae; GOB = Gobiidae; AMM= Ammoditydae. For latin names see Table 2.

Pellet No	Location	PP	LL	PF	SS	UF	GC	PF	TT	ZV	PG	CL	SS	OE	MS	CL	MM	PP	AF	RR	RE	TR	CY	TRI	AMM	GOB
1	Schorren																									
2	Schorren					3									6		2									
3	Schorren	5		8		1																				
4	Schorren	7		5		1																				
5	Schorren	6		6	1	10											2								2	
6	Schorren	4	5	2		30									6											
7	Schorren	6		2	2	2																				
8	Schorren	26	15	21		54																				1
9	Schorren	6	2	10	4	9																				20
10	Schorren	1		2		4																				
11	Schorren	5		3	3	2																2				
12	Schorren	13	7	9	6	29																				
13	Schorren	24	14	22	2	50																				1
14	Schorren	8	2	5	9	3																				
15	Schorren	4		3		1			2																	
16	Schorren	8	3	7	33	9																				
17	Schorren	98	65	66		146																				139
18	Schorren	104	97	59		118																				7
19	Schorren	3		3		5																				
20	Schorren	21	17	15	2	80											1									7
21	Schorren	11	9	8	2	21																				273
22	Schorren	27	6	29		45																				20
23	Schorren	15	6	12		31									2											
24	Schorren	29	19	29	1	16																				7
25	Schorren	6	2	1		34																				6
26	Schorren	75	78	102		173																				28
27	Schorren									2															2	
28	Schorren	19	9	18	1	129																				1
29	Schorren					9																				195
30	Schorren					3																				12
31	Balgzand	2				1							9					2								
32	Balgzand	2																		11						
33	Balgzand	7				11									2									2		
34	Balgzand	4																								
35	Balgzand																									
36	Balgzand																									
37	Balgzand	6																								
38	Balgzand	13				6																				17
39	Balgzand																			5						

Cont. Appendix 1

Pellet	Location																												
		No	PP	LL	PF	SS	UF	GC	PF	TT	ZV	PG	CL	SS	OE	MS	CL	MM	PP	AF	RR	RE	TR	CY	TRI	AMM	GOB		
20	Balgzand	40	68	22	1		40																				16		
	Balgzand	41	60	28	14		80									1											7		
	Balgzand	42	2		5		12																						
	Balgzand	43	8																	12			9						
	Balgzand	44	2				2																						
	Balgzand	45	5	1	1	1	13																				1		
	Balgzand	46	9		6		4																				11		
	Balgzand	47	9		2		52																			2	3		
	Balgzand	48	48	17	6		117																				27		
	Balgzand	49					4																						
	Balgzand	50	3	2			18																				2		
	Balgzand	51	53	24	5	8	36									2											2		
	Balgzand	52								29													36						
	Balgzand	53	47	24	19	2	55																						
	Balgzand	54	16	4	10		14																						
	Balgzand	55					1										22												
	Balgzand	56	13	7	4	2	30																						
	Balgzand	57	24	5	10		19			19															12		2		
	Balgzand	58	20	3	3		51																						
	Balgzand	59								50															21				
	Balgzand	60	7	2	9	2	42																						
	Den Oever	61			3			5																	2				
	Den Oever	62	1	1	2		50	6		2						4													
	Den Oever	63			2					516						24													
	Den Oever	64			2			1																					
	Den Oever	65	8	1	10		36									7													
	Den Oever	66	1		4		9						7											1			5		
	Den Oever	67	2		3		9									1	8										2		
	Den Oever	68			6		15																				4		
	Den Oever	69								14																			
	Den Oever	70	29	17	37	4	75						2																
	Den Oever	71	3		1		4					4																	
	Den Oever	72								6																			
	Den Oever	73								59						1													
	Den Oever	74								67			4			190													
	Den Oever	75	1		3		1			1															3				
Den Oever	76								1																				
Den Oever	77								7						4														
Den Oever	78	2	1	5		8																							
Den Oever	79	6	1	5		31						1			2														
Den Oever	80	53	13	44		54						2														2			
Den Oever	81			1		13			32			5														2			
Den Oever	82	35	13	24		39																				2			
Den Oever	83								69						64					10			1						
Den Oever	84	9	2	10		25																							

Cont. Appendix 1

	Pellet No	Location	Pellets																									
			PP	LL	PF	SS	UF	GC	PF	TT	ZV	PG	CL	SS	OE	MS	CL	MM	PP	AF	RR	RE	TR	CY	TRI	AMM	GOB	
21	85	Den Oever	11	5	15			2									2											
	86	Griend	20	48	12		43																		4	20		
	87	Griend	4	13		1	25																		7			
	88	Griend	5	9	1	1	43																		2			
	89	Griend																										
	90	Griend	23	31	6	1	41																		1			
	91	Griend	4		2		3																					
	92	Griend		2			4																		5			
	93	Griend	14	51	12	3	94																					
	94	Griend	2	8			4																			4		
	95	Griend	30	83	6		44																			5		
	96	Griend	15	12			9																			493		
	97	Griend	9	6	2		14																			4		
	98	Griend	12	10			55																		4			
	99	Griend	24	29	11		116										2									5		
	100	Griend	23	13	3		51																		11	3		
	101	Griend	15		2		10																					
	102	Griend	78	31	29		105										2								1	2		
	103	Griend	84	45	28	1	70																			2		
	104	Griend	44	45	6		128																		1	1		
	105	Griend	89	75	15		73								6													
106	Griend	16	4			67																						
107	Griend	2				8																			2			
108	Griend	1																										
109	Griend	23	7			71																						
110	Griend	7				3																		1	62			
111	Griend	106	45	3	4	105																			1			
112	Griend	58	37	2		8																			11			
113	Griend	126	99	8		210																			3			
114	Griend	77	28	8		57																						
115	Griend	126	95	7	3	207																			7			
116	Griend	42	24	3		102																			8			
117	Griend	34	19	1		170																		2	10			
118	Griend	3				2																						
119	Griend	13	8	2		36																			5			
120	Griend	32	19	3		121																			6			
121	Griend	62	38			177																			19			
122	Griend	47	55	6		133																			5			
123	Griend	7	3			20																			344			
124	Boschplaat 40 pellets	428	308	451	78	###						76	2				4							9	13	537		
164	De Hond																						27					
165	De Hond						36	3															5					
166	De Hond	4	5	1										10											90			
167	De Hond	2	3	7		15								11											1			

Cont. Appendix 1

[illegible]

Appendix 2

Length (mm) of the otoliths plaice in the various pellets, without correction for wear.

Pellet No	Location	?	0.0	0.5	1.0	Otolith length (mm)									
						1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
1	Schorren														
2	Schorren														
3	Schorren	1				1	2		1						
4	Schorren	1					1		1	2	2				
5	Schorren	2					1	3							
6	Schorren	1				2			1						
7	Schorren	1						1	3	1					
8	Schorren	4			1	12	4			4					
9	Schorren	1					4					1			
10	Schorren								1						
11	Schorren	1								2	2				
12	Schorren	4				3	5	1							
13	Schorren	2				4	14	3		1					
14	Schorren	3				1	3		1						
15	Schorren						1	1	2						
16	Schorren	1					2	1		3	1				
17	Schorren	9			6	56	24	2							
18	Schorren	7			11	60	23	3							
19	Schorren	1					1	1							
20	Schorren	4			7	10									
21	Schorren	3			1	5	2								
22	Schorren	6			3	12	5			1					
23	Schorren	2				10	3								
24	Schorren	4			1	8	10	1		3	1				
25	Schorren	3			1	1	1								
26	Schorren	9			6	44	13	3							
27	Schorren														
28	Schorren	3			2	10	3		1						
29	Schorren														
30	Schorren														
31	Balgzand	1					1								
32	Balgzand	1						1							
33	Balgzand	4				1	2								
34	Balgzand	2				1			1						
35	Balgzand														
36	Balgzand														
37	Balgzand					1	3								
38	Balgzand	5			1	3			2	2					
39	Balgzand														
40	Balgzand	3			2	47	9	5	2						
41	Balgzand	3				30	23	1	1	2					
42	Balgzand	1					1								
43	Balgzand				1	1	2	2		2					
44	Balgzand									1	1				
45	Balgzand	4					1								
46	Balgzand	3				1	2	1		1	1				
47	Balgzand				1	5	3								
48	Balgzand	2				28	17		1						
49	Balgzand														
50	Balgzand					3									
51	Balgzand	11				22	14	4	3						
52	Balgzand														
53	Balgzand	6				18	17	3	1	1					
54	Balgzand	6				4	2	2	2						
55	Balgzand														
56	Balgzand	8				4		1							
57	Balgzand	2			1	5	1	2	6	5		2			
58	Balgzand	5				10	2		3						
59	Balgzand														
60	Balgzand					7									

Cont. Appendix 2

Pellet No	Location	?	0.0	0.5	1.0	Otolith length (mm)									
						1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
61	Den Oever					1									
62	Den Oever														
63	Den Oever														
64	Den Oever														
65	Den Oever	8													
66	Den Oever	1													
67	Den Oever					2									
68	Den Oever														
69	Den Oever														
70	Den Oever	4				22	3								
71	Den Oever	1					2								
72	Den Oever														
73	Den Oever														
74	Den Oever														
75	Den Oever								1						
76	Den Oever														
77	Den Oever														
78	Den Oever	1							1						
79	Den Oever	2				2	2								
80	Den Oever	4				30	18	1							
81	Den Oever														
82	Den Oever	10			1	19	4								
83	Den Oever														
84	Den Oever	9				9	1								
85	Den Oever	1					10								
86	Griend				4	12	4								
87	Griend				1	2		1							
88	Griend				1	2	2								
89	Griend														
90	Griend				1	18	4								
91	Griend									4					
92	Griend														
93	Griend	1			2	2	3	3	3						
94	Griend					2									
95	Griend				5	21	4								
96	Griend				1	14									
97	Griend	1				1	1	1	1	2		2			
98	Griend				5	5		2							
99	Griend				14	9	1								
100	Griend	2				16	3	2							
101	Griend					2	10		2						
102	Griend	3		1	42	28	2			2					
103	Griend				43	33	2	2	1	1					
104	Griend	2			12	19	2	3	5						
105	Griend				18	51	15	2	2						
106	Griend	2			9	5									
107	Griend	1					1								
108	Griend				1										
109	Griend	4			6	10	3								
110	Griend	1				3	3								
111	Griend	2			12	70	10	3	6	1	2				
112	Griend				1	32	25								
113	Griend	2			78	33	8		1		2				
114	Griend	1			6	39	11	7	6	3			2		
115	Griend	12			13	65	35		1						
116	Griend	1			12	24	4								
117	Griend	3			10	17	2								
118	Griend	1				2									
119	Griend	4			4	4		1							
120	Griend	2			14	6	2	5	2						
121	Griend	5			9	27	17	4							
122	Griend	1			15	28	3								
123	Griend				3	4									
124	Boschplaat	83		1	90	144	73	13	7	8	3	5			

Cont. Appendix 2

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
164	Hond												
165	Hond												
166	Hond				2		1		1				
167	Hond	1			1								
168	Hond												
169	Hond												
170	Hond	5											
171	Hond												
172	Hond												
173	Hond												
174	Hond												
175	Hond				1	2	1						
176	Hond												
177	Hond												
178	Hond												
179	Hond												
180	Hond				8	8	4						
181	Hond												
182	Hond				1	7	8	3	1				
183	Hond												
184	Hond												
185	Hond						2						
186	Hond	7			1		2			1			
187	Hond					1	1	1					
188	Hond												
189	Hond												
190	Hond												
191	Hond												
192	Hond												
193	Hond				1								
194	Hond			1	14	15							

Appendix 3

Length (mm) of the otoliths of dab in the various pellets, without correction for wear.

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1	Schorren												
2	Schorren												
3	Schorren												
4	Schorren												
5	Schorren												
6	Schorren	1				4		1					
7	Schorren												
8	Schorren			7	7	1							
9	Schorren				1	1							
10	Schorren												
11	Schorren												
12	Schorren				2	3	2						
13	Schorren				2	11							
14	Schorren						2						
15	Schorren												
16	Schorren	2							1				
17	Schorren			19	45	1							
18	Schorren	1			45	50							
19	Schorren												
20	Schorren	4			8	5							
21	Schorren	1			6	2							
22	Schorren	1			4	1							
23	Schorren		1	1	4								
24	Schorren			3	13			1	1				
25	Schorren				2								
26	Schorren			44	29	1							
27	Schorren												
28	Schorren			5	3	1							
29	Schorren												
30	Schorren												
31	Balgzand												
32	Balgzand												
33	Balgzand												
34	Balgzand												
35	Balgzand												
36	Balgzand												
37	Balgzand												
38	Balgzand												
39	Balgzand												
40	Balgzand			10	12								
41	Balgzand			5	19	4							
42	Balgzand												
43	Balgzand												
44	Balgzand												
45	Balgzand			1									
46	Balgzand												
47	Balgzand												
48	Balgzand			1	13	3							
49	Balgzand												
50	Balgzand				2								
51	Balgzand			2	19	3							
52	Balgzand												
53	Balgzand			2	19	3							
54	Balgzand	1			1	2							
55	Balgzand												
56	Balgzand			4	3								
57	Balgzand			1	4								
58	Balgzand			3									
59	Balgzand												
60	Balgzand			2									

Cont. Appendix 3

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
61	Den Oever												
62	Den Oever			1									
63	Den Oever												
64	Den Oever												
65	Den Oever	1											
66	Den Oever												
67	Den Oever												
68	Den Oever												
69	Den Oever												
70	Den Oever			10	6								
71	Den Oever												
72	Den Oever												
73	Den Oever												
74	Den Oever												
75	Den Oever												
76	Den Oever												
77	Den Oever												
78	Den Oever			1									
79	Den Oever			1									
80	Den Oever			4	8	1							
81	Den Oever												
82	Den Oever			5	7								
83	Den Oever												
84	Den Oever				2								
85	Den Oever	2				2	1						
86	Griend				43	3	2						
87	Griend				10	3							
88	Griend			1	6	1	1						
89	Griend												
90	Griend												
91	Griend												
92	Griend				2								
93	Griend			4	44	3							
94	Griend			1	4	3							
95	Griend	1			53	26	1	1					
96	Griend				11	1							
97	Griend					4	1	1					
98	Griend				6	2		2					
99	Griend				23	6							
100	Griend				4	8	1						
101	Griend												
102	Griend				20	10	2						
103	Griend				35	9	1						
104	Griend			2	22	17			3				
105	Griend	1			51	20		2					
106	Griend				4								
107	Griend												
108	Griend												
109	Griend				5	2							
110	Griend												
111	Griend				23	22							
112	Griend				11	25	1						
113	Griend			2	90	6							
114	Griend			1	15	11	1						
115	Griend	1			54	33	3	2	2				
116	Griend				20	3							
117	Griend				19								
118	Griend												
119	Griend	2			4	3							
120	Griend				16	3							
121	Griend				26	11	1						
122	Griend				49	6							
123	Griend				3								
124	Boschplaat	7		2	79	82	15	10	7	6			

Pellet No	Location	Otolith length (mm)											Total
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	
164	Hond												1
165	Hond												1
166	Hond				5								5
167	Hond				2	1							3
168	Hond												1
169	Hond												1
170	Hond							3	6	5			14
171	Hond												1
172	Hond												1
173	Hond												1
174	Hond												1
175	Hond				8		4	1					13
176	Hond												1
177	Hond												1
178	Hond												1
179	Hond												1
180	Hond				50	19	1						70
181	Hond												1
182	Hond				4	3							7
183	Hond												1
184	Hond												1
185	Hond						2						2
186	Hond					1	1	2	3	5	1		13
187	Hond				1								1
188	Hond												1
189	Hond												1
190	Hond												1
191	Hond					1	1	2					4
192	Hond												1
193	Hond				6		2						8
194	Hond				36	10							46

Appendix 4

Length (mm) of the otoliths of flounder in the various pellets, without correction for wear.

Pellet No	Location	?	0.0	0.5	1.0	Otolith length (mm)									
						1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0		
1	Schorren														
2	Schorren														
3	Schorren	5					2		1						
4	Schorren	1					1	2	1						
5	Schorren	4				1		1							
6	Schorren	2													
7	Schorren	2													
8	Schorren	3				14	4								
9	Schorren	3					4		2	1					
10	Schorren							2							
11	Schorren	1								2					
12	Schorren	2				2	3		1	1					
13	Schorren					16	1		5						
14	Schorren	2							1	1	1				
15	Schorren	1						2							
16	Schorren	2							2	2	1				
17	Schorren		1	38	23	4									
18	Schorren	1		2	29	25	2								
19	Schorren	3													
20	Schorren	2				12	1								
21	Schorren	1			2	1	3	1							
22	Schorren	6			1	10	7			2	3				
23	Schorren	2				6	4								
24	Schorren	3			1	9	4		4	4	4				
25	Schorren		1												
26	Schorren	18		8	30	61	10								
27	Schorren														
28	Schorren	1			2	10	5								
29	Schorren														
30	Schorren														
31	Balgzand														
32	Balgzand														
33	Balgzand														
34	Balgzand														
35	Balgzand														
36	Balgzand														
37	Balgzand														
38	Balgzand														
39	Balgzand														
40	Balgzand					1									
41	Balgzand				7	3		2							
42	Balgzand	3					2								
43	Balgzand														
44	Balgzand														
45	Balgzand	1													
46	Balgzand							1	2	3					
47	Balgzand							2							
48	Balgzand		1	3			2								
49	Balgzand														
50	Balgzand														
51	Balgzand	2				2	1								
52	Balgzand														
53	Balgzand	4			2	6	6	1							
54	Balgzand	5						1		3	1				
55	Balgzand														
56	Balgzand	2			1	1									
57	Balgzand	3			1					6					
58	Balgzand						3								
59	Balgzand														
60	Balgzand		4	2			2								

Cont. Appendix 4

Pellet No	Location	?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	Count	Mean	St. Dev.	Max
61	Den Oever	2												2	0.0	0.0	0.0
62	Den Oever			1	1									2	0.5	0.0	1.0
63	Den Oever							2						2	2.5	0.0	2.5
64	Den Oever							1		1				2	3.0	0.0	3.5
65	Den Oever	5				1		2	1		1			5	2.0	0.8	3.0
66	Den Oever	4												4	0.0	0.0	0.0
67	Den Oever				3									3	0.5	0.0	1.0
68	Den Oever	5							1					5	3.0	0.0	3.5
69	Den Oever													0	0.0	0.0	0.0
70	Den Oever	7			5	18	2	1	2	1	1			29	1.5	1.0	3.0
71	Den Oever				1									1	1.0	0.0	1.0
72	Den Oever													0	0.0	0.0	0.0
73	Den Oever													0	0.0	0.0	0.0
74	Den Oever													0	0.0	0.0	0.0
75	Den Oever	1					1				1			2	2.0	0.0	2.5
76	Den Oever													0	0.0	0.0	0.0
77	Den Oever													0	0.0	0.0	0.0
78	Den Oever			2	2			1						5	1.0	0.0	2.0
79	Den Oever	2			2	1								5	0.5	0.0	1.0
80	Den Oever		1	33	4	3			3					41	0.5	1.0	3.0
81	Den Oever	1												1	0.0	0.0	0.0
82	Den Oever	5			5	11	1		1	1				9	1.0	0.8	2.0
83	Den Oever													0	0.0	0.0	0.0
84	Den Oever	6				4								6	1.0	0.0	1.0
85	Den Oever				2	8	2		1					13	1.0	0.8	2.0
86	Griend				5	5	2							12	1.0	0.8	2.0
87	Griend													0	0.0	0.0	0.0
88	Griend					1								1	1.0	0.0	1.0
89	Griend													0	0.0	0.0	0.0
90	Griend				1	18	4							23	1.0	1.0	3.0
91	Griend										1	1		2	4.0	0.0	4.5
92	Griend													0	0.0	0.0	0.0
93	Griend				1	7	2			1				10	1.0	0.8	2.0
94	Griend													0	0.0	0.0	0.0
95	Griend				6									6	0.5	0.0	1.0
96	Griend													0	0.0	0.0	0.0
97	Griend									1	1			2	3.5	0.0	4.0
98	Griend													0	0.0	0.0	0.0
99	Griend	2			3	6								11	1.0	0.8	2.0
100	Griend						1		1		1			3	2.0	0.0	2.5
101	Griend								1	1				2	3.0	0.0	3.5
102	Griend				18	11								29	1.0	1.0	3.0
103	Griend		1		17	7	1							19	0.5	0.8	1.5
104	Griend				1	1	4							6	1.0	0.0	1.5
105	Griend				10	5								15	0.5	0.8	1.5
106	Griend													0	0.0	0.0	0.0
107	Griend													0	0.0	0.0	0.0
108	Griend													0	0.0	0.0	0.0
109	Griend													0	0.0	0.0	0.0
110	Griend													0	0.0	0.0	0.0
111	Griend				2	1								3	0.5	0.0	1.0
112	Griend					2								2	1.0	0.0	1.0
113	Griend				7	1								8	0.5	0.0	1.0
114	Griend					4			2	2				4	2.5	0.0	3.0
115	Griend				3	3	1							7	1.0	0.8	2.0
116	Griend				2	1								3	0.5	0.0	1.0
117	Griend				1									1	0.5	0.0	1.0
118	Griend													0	0.0	0.0	0.0
119	Griend				2									2	0.5	0.0	1.0
120	Griend				3									3	0.5	0.0	1.0
121	Griend													0	0.0	0.0	0.0
122	Griend			1	5									6	0.5	0.8	1.5
123	Griend													0	0.0	0.0	0.0
124	Boschplaat	66			132	152	65	16	9	6				280	1.0	1.0	3.0

Cont. Appendix 4

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
164	Hond												
165	Hond												
166	Hond				1								
167	Hond	1				2	2		1	1			
168	Hond												
169	Hond												
170	Hond	4							1				
171	Hond				1	3							
172	Hond												
173	Hond												
174	Hond												
175	Hond												
176	Hond												
177	Hond												
178	Hond												
179	Hond												
180	Hond				1	1							
181	Hond				5	5	4						
182	Hond												
183	Hond												
184	Hond												
185	Hond												
186	Hond					1	4	6	6	7			
187	Hond				1								
188	Hond												
189	Hond												
190	Hond												
191	Hond												
192	Hond												
193	Hond	1											
194	Hond			1	10	1							

Appendix 5

Length (mm) of the otoliths of sole in the various pellets, without correction for wear.

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1	Schorren												
2	Schorren												
3	Schorren												
4	Schorren												
5	Schorren					1							
6	Schorren												
7	Schorren	2											
8	Schorren												
9	Schorren	1						2	1				
10	Schorren												
11	Schorren						1		2				
12	Schorren	3						1	2				
13	Schorren		1	1									
14	Schorren			3	4		2						
15	Schorren												
16	Schorren			8	12	7	4	2					
17	Schorren												
18	Schorren												
19	Schorren												
20	Schorren		2										
21	Schorren						2						
22	Schorren												
23	Schorren												
24	Schorren			1									
25	Schorren												
26	Schorren												
27	Schorren												
28	Schorren	1											
29	Schorren												
30	Schorren												
31	Balgzand												
32	Balgzand												
33	Balgzand												
34	Balgzand												
35	Balgzand												
36	Balgzand												
37	Balgzand												
38	Balgzand												
39	Balgzand												
40	Balgzand												
41	Balgzand												
42	Balgzand												
43	Balgzand												
44	Balgzand												
45	Balgzand							1					
46	Balgzand												
47	Balgzand												
48	Balgzand												
49	Balgzand												
50	Balgzand												
51	Balgzand		1	3			2	2					
52	Balgzand												
53	Balgzand			2									
54	Balgzand												
55	Balgzand												
56	Balgzand							2					
57	Balgzand												
58	Balgzand												
59	Balgzand												
60	Balgzand	2											

Cont. Appendix 5

Pellet No	Location	Otolith length (mm)												
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	
61	Den Oever													
62	Den Oever													
63	Den Oever													
64	Den Oever													
65	Den Oever													
66	Den Oever													
67	Den Oever													
68	Den Oever													
69	Den Oever													
70	Den Oever			4										
71	Den Oever													
72	Den Oever													
73	Den Oever													
74	Den Oever													
75	Den Oever													
76	Den Oever													
77	Den Oever													
78	Den Oever													
79	Den Oever													
80	Den Oever													
81	Den Oever													
82	Den Oever													
83	Den Oever													
84	Den Oever													
85	Den Oever													
86	Griend													
87	Griend				1									
88	Griend			1										
89	Griend													
90	Griend			1										
91	Griend													
92	Griend													
93	Griend			3										
94	Griend													
95	Griend													
96	Griend													
97	Griend													
98	Griend													
99	Griend													
100	Griend													
101	Griend													
102	Griend													
103	Griend				1									
104	Griend													
105	Griend													
106	Griend													
107	Griend													
108	Griend													
109	Griend													
110	Griend													
111	Griend							4						
112	Griend													
113	Griend													
114	Griend													
115	Griend	1		2										
116	Griend													
117	Griend													
118	Griend													
119	Griend													
120	Griend													
121	Griend													
122	Griend													
123	Griend													
124	Boschplaat	2		2	55	12	3		1		1			

Cont. Appendix 5

Pellet No	Location	Otolith length (mm)											
		?	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
164	Hond												
165	Hond												
166	Hond												
167	Hond												
168	Hond												
169	Hond												
170	Hond												
171	Hond												
172	Hond												
173	Hond												
174	Hond												
175	Hond												
176	Hond												
177	Hond												
178	Hond												
179	Hond												
180	Hond			1	6								
181	Hond												
182	Hond												
183	Hond												
184	Hond												
185	Hond												
186	Hond			1	1								
187	Hond												
188	Hond												
189	Hond												
190	Hond												
191	Hond												
192	Hond												
193	Hond			1									
194	Hond				4								

Appendix 6

Width (mm) of the otoliths of plaice in the various pellets, without correction for wear.

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
1	Schorren									
2	Schorren									
3	Schorren				1					
4	Schorren					1				
5	Schorren				1	1				
6	Schorren				1					
7	Schorren			1						
8	Schorren			4						
9	Schorren						1			
10	Schorren									
11	Schorren						1			
12	Schorren			3	1					
13	Schorren			2						
14	Schorren					2		1		
15	Schorren									
16	Schorren					1				
17	Schorren			3	5	1				
18	Schorren			7						
19	Schorren					1				
20	Schorren			2	2					
21	Schorren			3						
22	Schorren			3		2				
23	Schorren			2						
24	Schorren			4						
25	Schorren			1	2					
26	Schorren			4	4					
27	Schorren									
28	Schorren			2	1					
29	Schorren									
30	Schorren									
31	Balgzand				1					
32	Balgzand				1					
33	Balgzand			4						
34	Balgzand			1		1				
35	Balgzand									
36	Balgzand									
37	Balgzand				1	1				
38	Balgzand			1	2	2				
39	Balgzand									
40	Balgzand		1	2						
41	Balgzand			3						
42	Balgzand			1						
43	Balgzand									
44	Balgzand									
45	Balgzand				4					
46	Balgzand				3					
47	Balgzand									
48	Balgzand				1	1				
49	Balgzand									
50	Balgzand									
51	Balgzand			8	1	1				
52	Balgzand									
53	Balgzand			2	4					
54	Balgzand				3	2		1		
55	Balgzand									
56	Balgzand			1	6	1				
57	Balgzand				1	1				
58	Balgzand			3	2					
59	Balgzand									
60	Balgzand									

Cont. Appendix 6

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
61	Den Oever									
62	Den Oever									
63	Den Oever									
64	Den Oever									
65	Den Oever				2	4	2			
66	Den Oever				1					
67	Den Oever									
68	Den Oever									
69	Den Oever									
70	Den Oever		1		3					
71	Den Oever			1						
72	Den Oever									
73	Den Oever									
74	Den Oever									
75	Den Oever									
76	Den Oever									
77	Den Oever									
78	Den Oever					1				
79	Den Oever				1	1				
80	Den Oever			3	1					
81	Den Oever									
82	Den Oever		3	5	2					
83	Den Oever									
84	Den Oever				2	1				
85	Den Oever				1					
86	Griend									
87	Griend									
88	Griend									
89	Griend									
90	Griend									
91	Griend									
92	Griend									
93	Griend					1				
94	Griend									
95	Griend									
96	Griend									
97	Griend				1					
98	Griend									
99	Griend									
100	Griend			1	1					
101	Griend									
102	Griend		1	2						
103	Griend			2						
104	Griend									
105	Griend									
106	Griend		1	1						
107	Griend			1						
108	Griend									
109	Griend		1	1	2					
110	Griend			1						
111	Griend			1	1					
112	Griend									
113	Griend			1	1					
114	Griend				1					
115	Griend		1	10	1					
116	Griend			1						
117	Griend			2	1					
118	Griend			1						
119	Griend		1	2	1					
120	Griend			1	1					
121	Griend		1	2						
122	Griend			1						
123	Griend									
124	Boschplaat		12	42	23	4		1		

Cont. Appendix 6

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
164	Hond									
165	Hond									
166	Hond									
167	Hond			1						
168	Hond									
169	Hond									
170	Hond				2	3				
171	Hond									
172	Hond									
173	Hond									
174	Hond									
175	Hond									
176	Hond									
177	Hond									
178	Hond									
179	Hond									
180	Hond									
181	Hond									
182	Hond									
183	Hond									
184	Hond									
185	Hond									
186	Hond			4	3					
187	Hond									
188	Hond									
189	Hond									
190	Hond									
191	Hond									
192	Hond									
193	Hond									
194	Hond									

Appendix 7

Width (mm) of the otoliths of dab in the various pellets, without correction for wear.

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
1	Schorren									
2	Schorren									
3	Schorren									
4	Schorren									
5	Schorren									
6	Schorren									
7	Schorren									
8	Schorren									
9	Schorren									
10	Schorren									
11	Schorren									
12	Schorren									
13	Schorren			1						
14	Schorren									
15	Schorren									
16	Schorren					2				
17	Schorren									
18	Schorren			1						
19	Schorren									
20	Schorren		2	2						
21	Schorren			1						
22	Schorren			1						
23	Schorren									
24	Schorren									
25	Schorren									
26	Schorren									
27	Schorren									
28	Schorren									
29	Schorren									
30	Schorren									
31	Balgzand									
32	Balgzand									
33	Balgzand									
34	Balgzand									
35	Balgzand									
36	Balgzand									
37	Balgzand									
38	Balgzand									
39	Balgzand									
40	Balgzand									
41	Balgzand									
42	Balgzand									
43	Balgzand									
44	Balgzand									
45	Balgzand									
46	Balgzand									
47	Balgzand									
48	Balgzand									
49	Balgzand									
50	Balgzand									
51	Balgzand									
52	Balgzand									
53	Balgzand									
54	Balgzand			1						
55	Balgzand									
56	Balgzand									
57	Balgzand									
58	Balgzand									
59	Balgzand									
60	Balgzand									

Cont. Appendix 7

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
61	Den Oever									
62	Den Oever									
63	Den Oever									
64	Den Oever									
65	Den Oever			1						
66	Den Oever									
67	Den Oever									
68	Den Oever									
69	Den Oever									
70	Den Oever									
71	Den Oever									
72	Den Oever									
73	Den Oever									
74	Den Oever									
75	Den Oever									
76	Den Oever									
77	Den Oever									
78	Den Oever									
79	Den Oever									
80	Den Oever									
81	Den Oever									
82	Den Oever			1						
83	Den Oever									
84	Den Oever									
85	Den Oever			2						
86	Griend									
87	Griend									
88	Griend									
89	Griend									
90	Griend									
91	Griend									
92	Griend									
93	Griend									
94	Griend									
95	Griend					1				
96	Griend									
97	Griend									
98	Griend									
99	Griend									
100	Griend									
101	Griend									
102	Griend									
103	Griend									
104	Griend									
105	Griend			1						
106	Griend									
107	Griend									
108	Griend									
109	Griend									
110	Griend									
111	Griend									
112	Griend									
113	Griend									
114	Griend									
115	Griend				1					
116	Griend									
117	Griend									
118	Griend									
119	Griend			2						
120	Griend									
121	Griend									
122	Griend									
123	Griend									
124	Boschplaat			3	4					

Cont. Appendix 7

Pellet No	Location	Otolith width (mm)							
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5 4.0
164	Hond								
165	Hond								
166	Hond								
167	Hond								
168	Hond								
169	Hond								
170	Hond								
171	Hond								
172	Hond								
173	Hond								
174	Hond								
175	Hond								
176	Hond								
177	Hond								
178	Hond								
179	Hond								
180	Hond								
181	Hond								
182	Hond								
183	Hond								
184	Hond								
185	Hond								
186	Hond								
187	Hond								
188	Hond								
189	Hond								
190	Hond								
191	Hond								
192	Hond								
193	Hond								
194	Hond								

Appendix 8

Length (mm) of the otoliths of flounder in the various pellets, without correction for wear.

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
1	Schorren									
2	Schorren									
3	Schorren				2	3				
4	Schorren					1				
5	Schorren				2	2				
6	Schorren					2				
7	Schorren				2					
8	Schorren				1	1	1			
9	Schorren				1	2				
10	Schorren									
11	Schorren						1			
12	Schorren			2						
13	Schorren									
14	Schorren						2			
15	Schorren					1				
16	Schorren			1		1				
17	Schorren									
18	Schorren			1						
19	Schorren			1	2					
20	Schorren	1		1						
21	Schorren					1				
22	Schorren			3	1	2				
23	Schorren			2						
24	Schorren			1		2				
25	Schorren									
26	Schorren			14	3					
27	Schorren									
28	Schorren					1				
29	Schorren									
30	Schorren									
31	Balgzand									
32	Balgzand									
33	Balgzand									
34	Balgzand									
35	Balgzand									
36	Balgzand									
37	Balgzand									
38	Balgzand									
39	Balgzand									
40	Balgzand									
41	Balgzand			1	1					
42	Balgzand				3					
43	Balgzand									
44	Balgzand									
45	Balgzand				1					
46	Balgzand									
47	Balgzand									
48	Balgzand									
49	Balgzand									
50	Balgzand									
51	Balgzand			1	1					
52	Balgzand									
53	Balgzand			1	2	1				
54	Balgzand				1	2	1			
55	Balgzand									
56	Balgzand					2				
57	Balgzand				2	1				
58	Balgzand									
59	Balgzand									
60	Balgzand	1								

Cont. Appendix 8

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
61	Den Oever				2					
62	Den Oever									
63	Den Oever									
64	Den Oever									
65	Den Oever				2	3				
66	Den Oever				4					
67	Den Oever									
68	Den Oever					2	2	1		
69	Den Oever									
70	Den Oever			1	5	1				
71	Den Oever									
72	Den Oever									
73	Den Oever									
74	Den Oever									
75	Den Oever					1				
76	Den Oever									
77	Den Oever									
78	Den Oever									
79	Den Oever				2					
80	Den Oever									
81	Den Oever				1					
82	Den Oever		1	4						
83	Den Oever									
84	Den Oever				5	1				
85	Den Oever									
86	Griend									
87	Griend									
88	Griend									
89	Griend									
90	Griend									
91	Griend									
92	Griend									
93	Griend					1				
94	Griend									
95	Griend									
96	Griend									
97	Griend									
98	Griend									
99	Griend			1	1					
100	Griend									
101	Griend									
102	Griend									
103	Griend			1	1					
104	Griend									
105	Griend									
106	Griend									
107	Griend									
108	Griend									
109	Griend									
110	Griend									
111	Griend									
112	Griend									
113	Griend									
114	Griend									
115	Griend									
116	Griend									
117	Griend									
118	Griend									
119	Griend									
120	Griend									
121	Griend									
122	Griend									
123	Griend									
124	Boschplaat		8	34	19	3	2			

Cont. Appendix 8

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
164	Hond									
165	Hond									
166	Hond									
167	Hond					1				
168	Hond									
169	Hond									
170	Hond				2	2				
171	Hond									
172	Hond									
173	Hond									
174	Hond									
175	Hond									
176	Hond									
177	Hond									
178	Hond									
179	Hond									
180	Hond									
181	Hond									
182	Hond									
183	Hond									
184	Hond									
185	Hond									
186	Hond			2	1					
187	Hond									
188	Hond									
189	Hond									
190	Hond									
191	Hond									
192	Hond									
193	Hond			1						
194	Hond									

Appendix 9.

Length (mm) of the otoliths of sole in the various pellets, without correction for wear.

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
1	Schorren									
2	Schorren									
3	Schorren									
4	Schorren									
5	Schorren									
6	Schorren									
7	Schorren					2				
8	Schorren									
9	Schorren						1			
10	Schorren									
11	Schorren									
12	Schorren					3				
13	Schorren									
14	Schorren									
15	Schorren									
16	Schorren									
17	Schorren									
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29	Schorren									
30	Schorren									
31	Balgzand									
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55	Balgzand									
56	Balgzand									
57	Balgzand									
58	Balgzand									
59	Balgzand									
60	Balgzand					2				

Cont. Appendix 9

Pellet No	Location	Otolith width (mm)							
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5 4.0
61	Den Oever								
62	Den Oever								
63	Den Oever								
64	Den Oever								
65	Den Oever								
66	Den Oever								
67	Den Oever								
68	Den Oever								
69	Den Oever								
70	Den Oever								
71	Den Oever								
72	Den Oever								
73	Den Oever								
74	Den Oever								
75	Den Oever								
76	Den Oever								
77	Den Oever								
78	Den Oever								
79	Den Oever								
80	Den Oever								
81	Den Oever								
82	Den Oever								
83	Den Oever								
84	Den Oever								
85	Den Oever								
86	Griend								
87	Griend								
88	Griend								
89	Griend								
90	Griend								
91	Griend								
92	Griend								
93	Griend								
94	Griend								
95	Griend								
96	Griend								
97	Griend								
98	Griend								
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101	Griend								
102	Griend								
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105	Griend								
106	Griend								
107	Griend								
108	Griend								
109	Griend								
110	Griend								
111	Griend								
112	Griend								
113	Griend								
114	Griend								
115	Griend		1						
116	Griend								
117	Griend								
118	Griend								
119	Griend								
120	Griend								
121	Griend								
122	Griend								
123	Griend								
124	Boschplaat				2				

Pellet No	Location	Otolith width (mm)								
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
164	Hond									
165	Hond									
166	Hond									
167	Hond									
168	Hond									
169	Hond									
170	Hond									
171	Hond									
172	Hond									
173	Hond									
174	Hond									
175	Hond									
176	Hond									
177	Hond									
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180	Hond									
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183	Hond									
184	Hond									
185	Hond									
186	Hond									
187	Hond									
188	Hond									
189	Hond									
190	Hond									
191	Hond									
192	Hond									
193	Hond									
194	Hond									

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