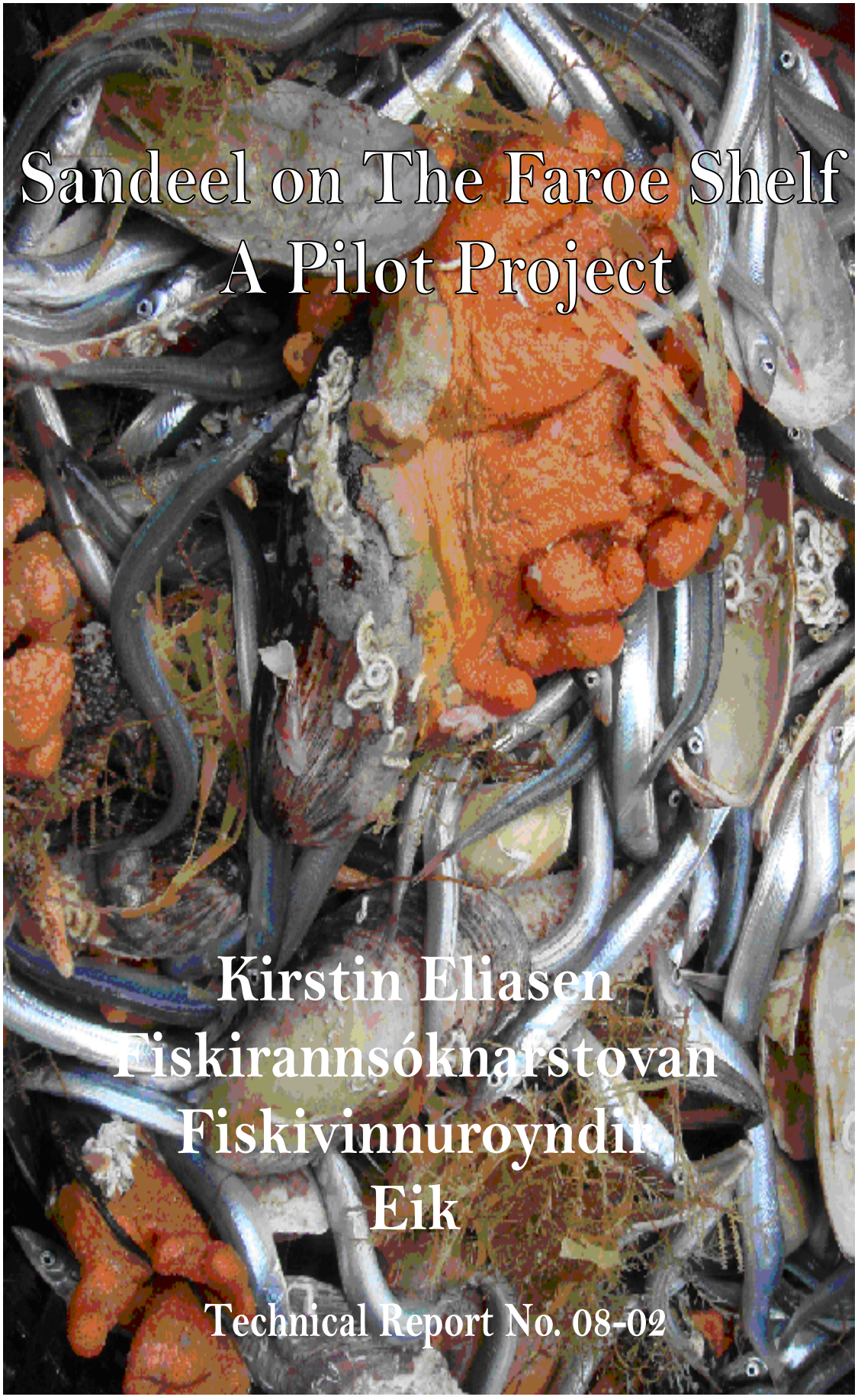

Sandeel on The Faroe Shelf
A Pilot Project

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Sandeel on the Faroe shelf

Introduction

Sandeel (*Ammodytes sp.*) is commonly known as a key species in several marine food webs in the North Atlantic (Furness and Tasker, 2000; Camphuysen, 2000; Furness, 2002; Poloczansalka et al., 2004). Sandeel forage on zooplankton (mainly copepods) (Macer, 1966; Reay, 1986), while being preyed upon by seabirds and larger fish, e.g. cod, haddock and saithe, and thus functions as an important link between higher and lower trophic levels (Frederiksen et al., 2006). Variations in sandeel density have been observed to affect the recruitment of several seabird and commercial fish stocks on the Faroe shelf. In spite of sparse information regarding Faroese sandeel, it has been possible to demonstrate this phenomenon in the relationship between cod growth, and the weight of sandeel in cod stomachs the previous year (Figure 1).

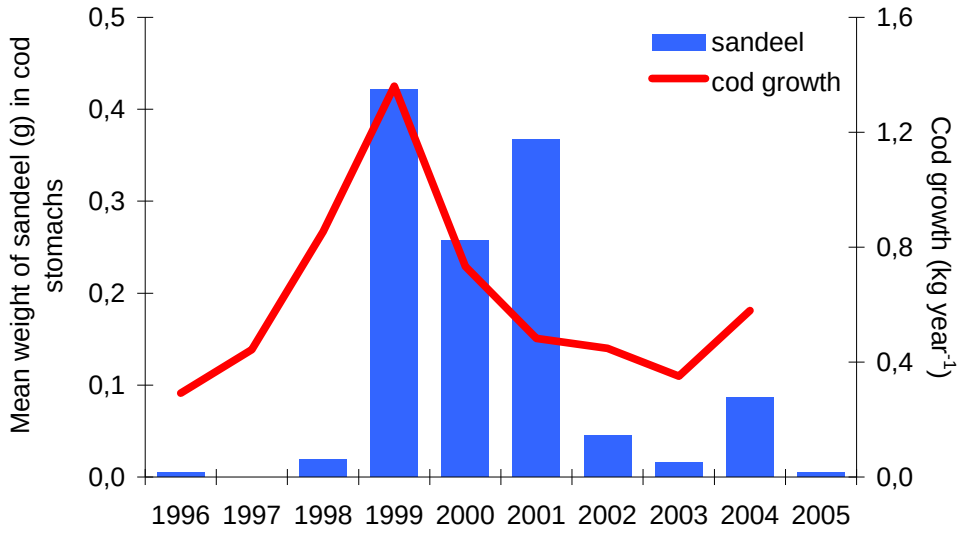

Figure 1. Mean weight of sandeel (g) in cod stomachs, and the cod growth following year (kg/year) on the Faroe shelf in the period 1996-2005.

The Faroe shelf is a relatively closed ecosystem with strong currents and an average water exchange rate of 2-3 months (Gaard and Hansen, 2000; Gaard, 2003). The water exchange rate is significantly related to the steepness of the front placed at a depth of approximately 110-130 m (Larsen et al., 2008). The primary production on the Faroe shelf has in periods been in strong correlation to the water exchange rate, and higher densities of large oceanic copepod species has been observed in years with high water exchange rates (Gaard and Hansen, 2000).

Compared to other common fish species in the Northeast Atlantic sandeel has a very distinctive behaviour. It spawns early, already in late December – early January, and has an early hatch of larvaes in late February – early March (Eliasen, 2005). As large juveniles the sandeel settles in sandy seabed substratum (Wright et al., 2000), and initiate a daily vertical migration into and out of the seabed - spending the night burrowed, and the light hours foraging for food. In autumn the daily migration ends, and the sandeel stays burrowed throughout the winter. The sandeel does not emerge from the seabed until approximately March, unless it is reproducing, and then it returns to the seabed immediately after spawning. The choice of settlement site is extremely specific, and the sandeel only accepts sandy sediments of particular particle size categories (Wright et al., 2000; Holland et al., 2005).

Prior studies

The information on sandeel on the Faroe shelf is very limited. The Faroese Fisheries Laboratory has for decades made 0-group surveys and demersal fish stock estimation surveys, but these investigations are designed for other fish species. Nonetheless, have these investigations contributed some information on sandeel densities and conditions in past years. The sandeel larvae index, based on the 0-group surveys, has shown to be of some value set in relation to other relevant factors. As a part of the demersal fish stock estimation surveys, stomach analysis of cod, haddock, and saithe have been performed, and because these fish species prey upon sandeel, the results can be used to infer the sandeel stock size the present year. In 2004 a study was made on the early life history of sandeel on the Faroe shelf. This study was mainly aimed at the larval/juvenile feeding behaviour and the food accessibility the current year. In 2004 another small sandeel survey was made, and some of the adult sandeel specimens collected then were used in present project.

Being a pilot project the methods used were new in this geographical area, but the goals where clear – to study the sandeel catchability and biology, and to locate suitable sandeel settlement sites.

Material and methods

The sandeel catchability was studied at two surveys, in April and June 2007 - trawling near the bottom at nine different sites with a fine meshed trawl. Due to practical complications, only the survey in April was successful. In the prospect of locating suitable sandeel settlement sites, sediment samples were collected by grab at 80 different locations placed randomly on the shelf.

Sandeel catchability

Sandeel has, until recently, been heavily fished in the North Sea, and the methods used there were studied to fit present circumstances. A trawl with a 5 mm cod end was towed near the bottom, at a speed of 3 knots, in approximately one hour, behind the research vessel Magnus Heinason. The choice of the trawl sites studied, were based on the thorough cod stomach analysis made by the Faroese Fisheries Laboratory (Figure 2).

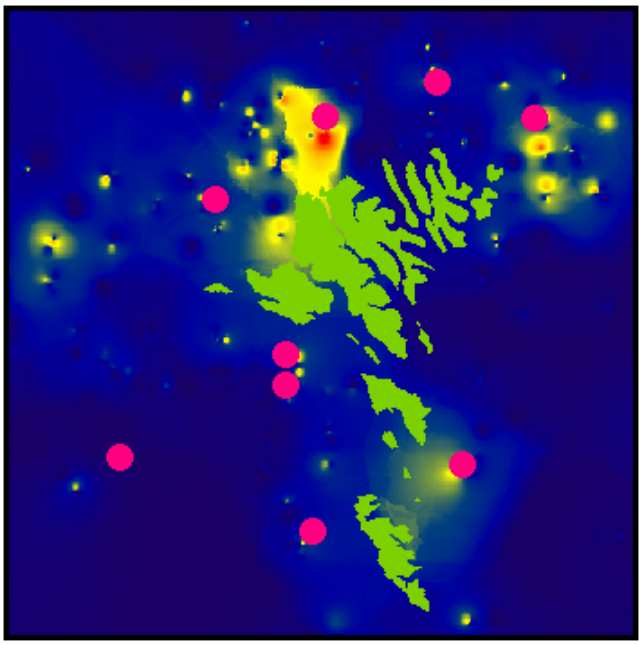

Figure 2. Thematic map of the frequency of sandeel in cod stomachs (1997-2006) and the location of the nine sites investigated (pink dots). (Yellow indicates high frequencies, while blue indicates low frequencies of sandeel in cod stomachs),

Biology

Several biological aspects were studied:

- Species composition
- Length and weight
- Age
- Sex and gonad maturity
- Stomach analysis
- Fat (lipid) content

Length was measured to nearest 0.1 cm (below), and weight to nearest 0.1 g. To exclude specimens from other families than *Ammodytidae*, external characteristics were examined (Muus and Nielsen, 1998), while both external characteristics, i.e. number of dorsal rays, and internal characteristics, i.e. number of vertebrae, were studied to identify the species (Reay, 1986). A short course in sandeel otolith reading was attended at the National Institute of Aquatic Resources in Denmark, and the determination of sex and gonad maturity was performed according to C. T. Macer (1966). Stomach content was counted and identified to species. Water from the *in situ* site was sampled, and examined by the same criteria's as the stomach content. Fat content was estimated according to a method developed by the Norwegian Fiskeridirektoratets Ernæringsinstitutt.

For comparison, some of the adult sandeel specimens collected in April 2004 were length-, weight-, and age estimated.

Suitable sites

By sieve the approximately 80 grab samples were discriminated into six different particle size categories, i.e. > 0 µm - 63 µm, > 63 µm – 250 µm, > 250 µm - 710 µm – 2 mm, and > 8 mm (Holland et al., 2005).

Results

Sandeel catchability

In April 2007 approximately one thousand sandeels, in concentrations ranging from 20-700 specimens per hawl, were collected from five out of the nine sites investigated (Figure 3). The remaining four sites did not contribute any sandeel.

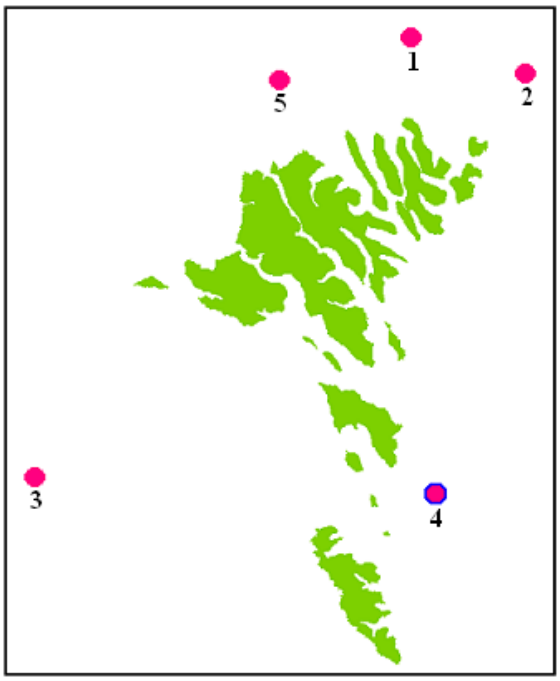

Figure 3. Trawl sites contributing sandeel in April 2007 (pink dots). The pink dot encircled is the site, which by far, contributed the most sandeel.

Biology

Species composition:

Almost 130 specimens were species identified, and all belonged to the family *Ammodytes* sp. The species *A. marinus* and *A. tobianus* have some overlapping characteristics, i.e. in the number of dorsal rays, and in the number of vertebras - it is thus not always possible to determine the species of a specimen. 81% of the specimens were for certain of the species *A. marinus*, while the remaining 19% belonged to the overlapping category (Figure 4). There seemed to be some geographic differences in the species characteristic composition, i.e. the sandeel gathered at sample site 2 and 3 were all for certain *A. marinus*, while the sandeel

collected at sample sites 1, 4, and 5 had a relatively equal quantity of specimens with the overlapping species characteristics (Figure 4).

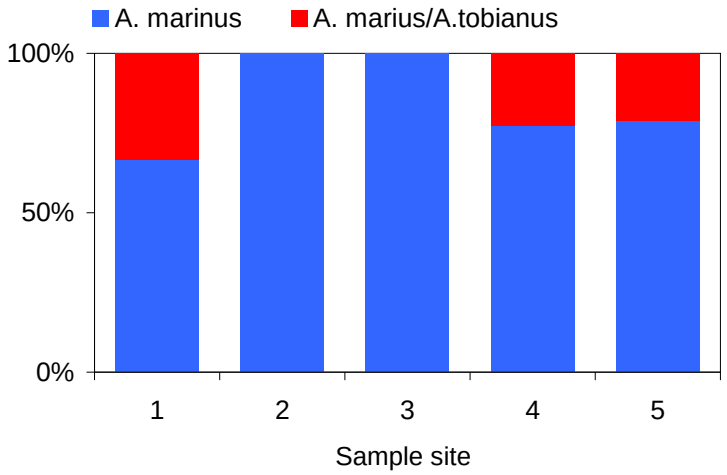

Figure 4. Species composition of the Faroese sandeel in April 2007 (n = 129).

Length and weight:

The sandeel length/weight-relationship in 2007 is shown in Figure 5. The largest specimen collected was 18.5 cm long and weighed 17.3 g, while the shortest was 8.4 cm long, and the lightest weighed 1.0 g. A tendency of enhanced weight as the specimens got longer was observed (Figure 5).

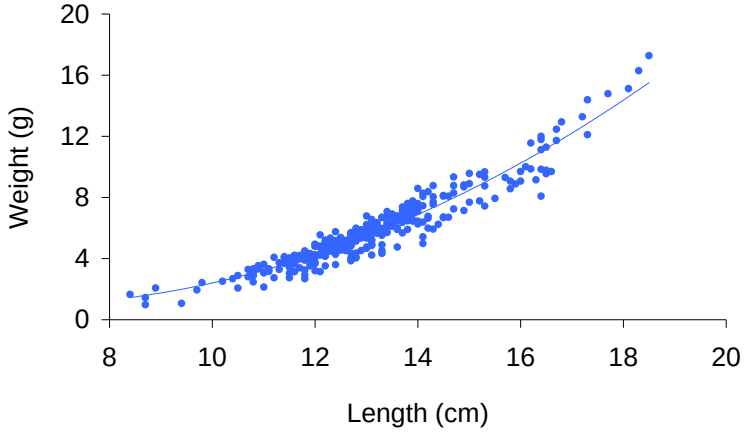

Figure 5. Sandeel length/weight relationship in 2007 (n = 727).

Sandeel collected in April 2007 had a slightly steeper growth curve than sandeel collected in April 2004 (Figure 6).

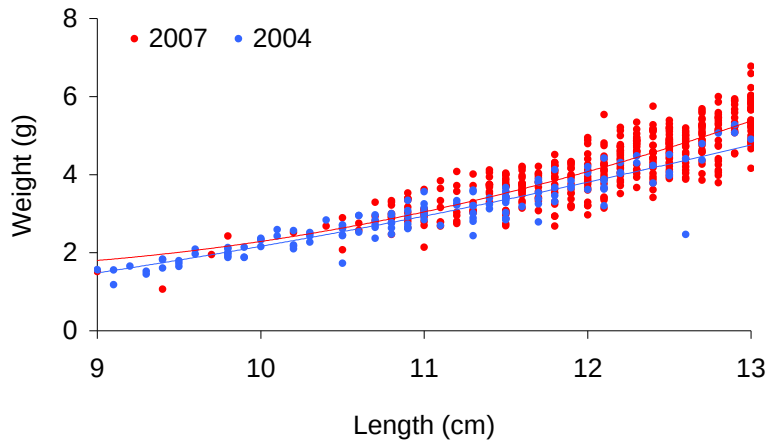

Figure 6. Length/weight-relationship of sandeel collected in April 2004 and April 2007
(n = 580).

It seemed as though the size composition separated the sites into two different groups (Figure 7). Sample site 2 and 3 had the largest specimens, both in length and weight, and were not significantly different from one another. While the specimens from sample sites 1, 4 and 5 were significantly similar in length and weight, but were in both instances smaller and different from the specimens at sample site 2 and 3. As Figure 6 indicated, sandeel from April 2004 were in a worse condition than sandeel from 2007 (Figure 7).

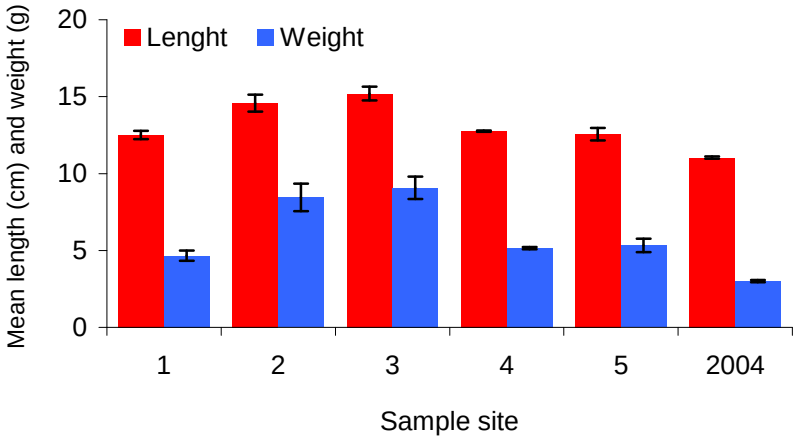

Figure 7. Mean sandeel length and weight at different sites in April 2007, and at a single site in April 2004.

Age composition:

The age of the Faroese sandeel ranged from 0 to 4 years in 2007 (Figure 8), and the total average age was 1.5 years (n=160). The female sandeel had a higher average age (1.94 years) than the males (1.78 years).

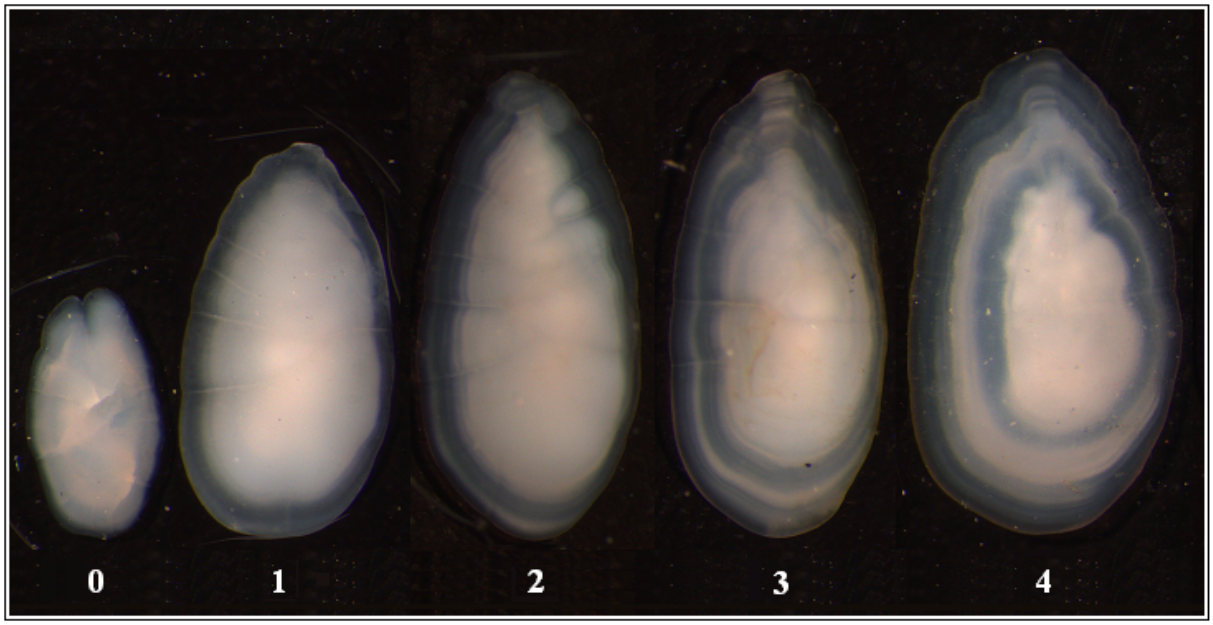

Figure 8. Sandeel otoliths at different age.
The number below each otolith represents the age in years.

Prey species such as sandeel typically have an age distribution, which reflects its prey function in the ecosystem. A heavy domination of juvenile and/or 1-year-old specimens is a typical characteristic of age distributions for severely preyed species. This was also the case in 2007 (Figure 9). Since present results origin from a survey compiled in April, the juvenile sandeel is still too small to be collected in the gear applied, and are thus not present.

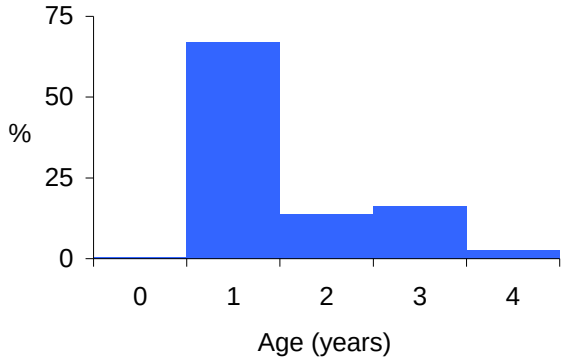

Figure 9. Age composition of the Faroese sandeel in April 2007.

The age composition at the sites differed. 1-year-old specimens dominated at site 1, 4, and 5, while 3-years-old specimens dominated at site 3 (Figure 10).

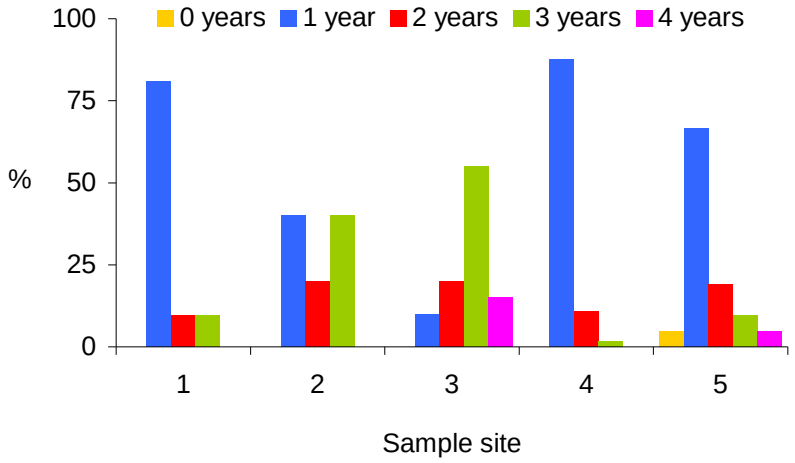

Figure 10. Age composition of sandeel at five different sites in April 2007.

The sandeel mean length and weight increased with age. The largest difference in length was of the 2 and 3-years-old, and in weight of the 3 and 4-years-old (Table 1).

Table 1. Mean sandeel length (cm) and weight (g) at different ages (years). Numbers in brackets indicate differences in length and weight from age to age.

Age (years)	Mean length (cm)	Mean weight (g)
1	12.63	4.93
2	13.9 (1.26)	7.14 (2.21)
3	15.35 (1.45)	9.15 (2.01)
4	16.75 (1.40)	12.48 (3.32)

Again the sites were compared, and the mean sandeel length at age differed greatly. At site 1 the sandeels of age 1, 2, and 3 were remarkably indifferent in length. At site 2 there was a great leap in length of the 1 and 2-years-old. The 1-year-old specimens at site 3 were pronouncedly smaller than at the other sites, but the remaining year classes did not differ and gradually increased in length. Site 4 had the largest 1-year-old specimens, and the length increased gradually with age. The 1 and 2-years-old

sandeels at site 5 had almost the same length, but afterwards the length increased gradually with age (Table 2).

Table 2. Mean sandeel length (cm) at different ages (years) at different sites on the Faroe shelf.

Age	Sampling site				
(years)	1	2	3	4	5
1	12,5	12,0	10,8	13,0	12,2
2	12,7	16,1	14,2	14,0	12,5
3	12,2	16,5	15,8	16,5	14,2
4			17,3		15,2

Sex and gonad maturity:

Because of the complications at the June survey (the trawl tore), only adult sandeel from April were available, and the gonad maturity stages detected also reflected this. All the sandeels, of both sexes, were in the maturity stages 1, 5, or 6 according to the C. T. Macer (1966) (Figure 11), which are the resting/virgin, spent, and recovering stages respectively.

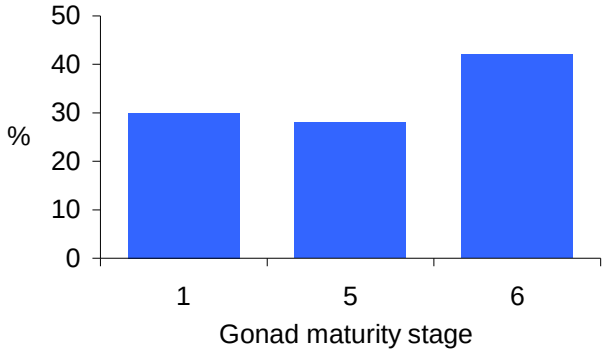

Figure 11. Gonad maturity stage composition on the Faroe shelf in April 2007.

The female/male ratio was 1:1.4. The size of the smallest detectable reproducing female was 11.2 cm and 4.1 g (Figure 12), and all females larger than 14.2 cm and 7.2 g had been reproducing the previous winter. The smallest detectable reproducing male was 11.5 cm long and weighed 4.0 g, and all males larger than 16.1 cm and 9.1 g had definitely reproduced the previous winter (Figure 13).

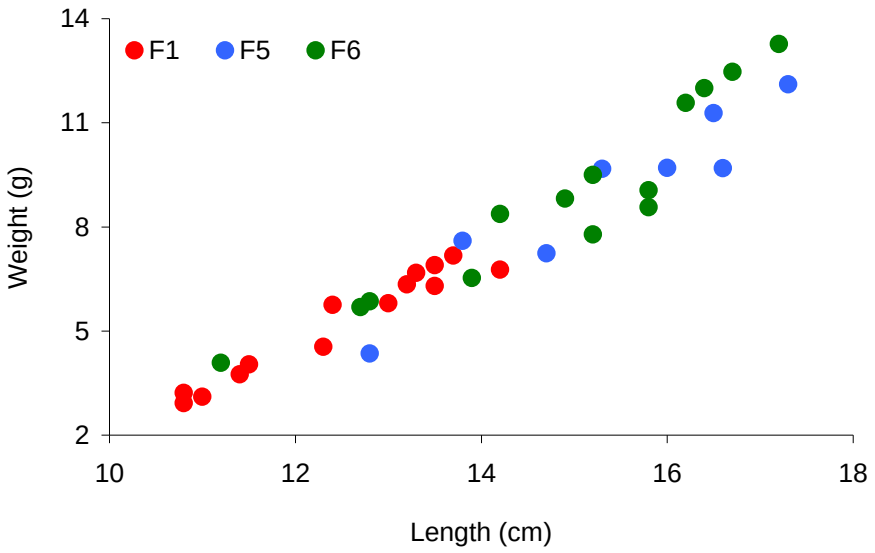

Figure 12. Female maturity stage composition in relation to size.
F1 = resting/virgin female, F5 = spent female, and F6 = recovering female (n = 36).

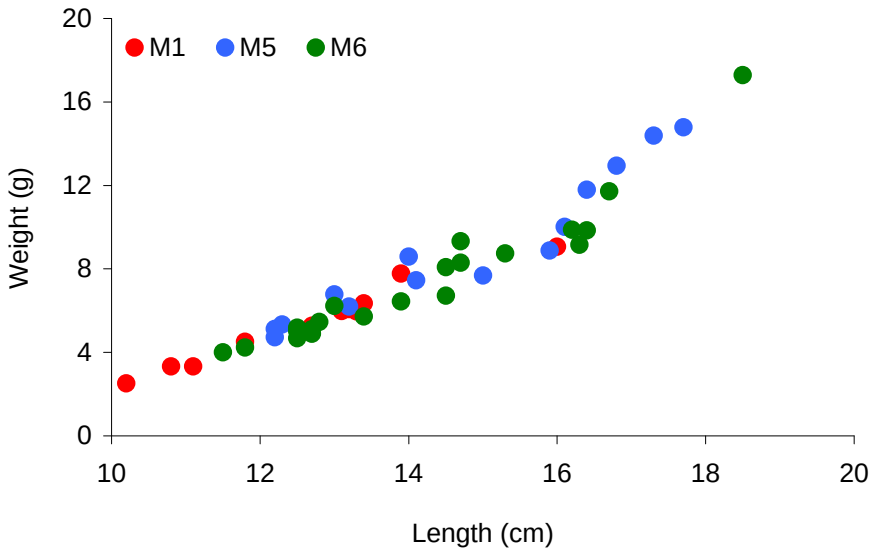

Figure 13. Male maturity stage composition in relation to size.
F1 = resting/virgin male, F5 = spent male, and F6 = recovering male (n = 51).

As could be expected, the sandeels in maturity stage 1 had the lowest average age (Figure 14). There was not observed any significant difference in age between females in the 5´th and 6´th maturity stage, while the difference between the males in these two maturity stage categories was pretty pronounced (Figure 14). Intrasexually the specimens in the 5´th maturity stage were of the same average age,

while the specimens in the other two maturity stage categories had a slightly different average age, with the females being older in both instances (Figure 14).

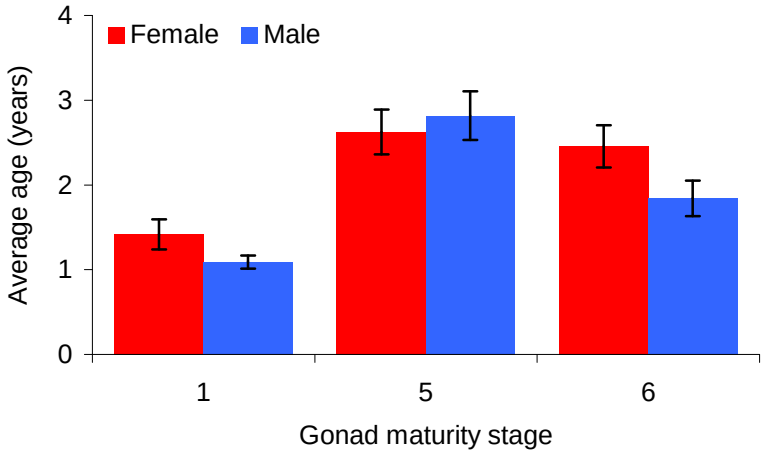

Figure 14. Average age (years) at different gonad maturity stages.

All sandeels older than three were mature, but until then, the males did have a larger proportion of reproducing specimens than the females (Table 3).

Table 3. Sexual difference in maturity at age.

	Female	**Male**
Age (years)	Mature (%)	Mature (%)
1	38	52
2	57	83
3	92	100
4	100	100

Regarding gonad maturity the grouping of sites was not as distinguishable as observed in some of the other features. Sample site 3 still had the highest value, and was perhaps significantly higher than sample sites 4 and 5, but more could not be concluded (Figure 15).

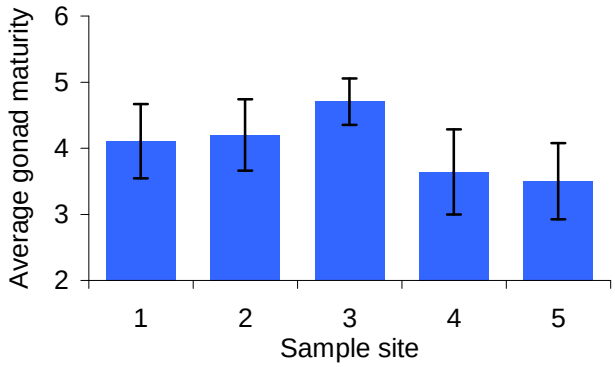

Figure 15. Average gonad maturity at different sites.

At the stock estimation survey on the Faroe Bank (21 -28 March 2007) 18 sandeels were collected from cod stomachs investigated. As on the Faroe shelf the 1´th and 6´th maturity stages were dominating, but no specimens in the 5´th stage was obtained, instead two females were in the developing (2´th) stage, and one male in the ripening (3´th) stage (Figure 16 and 17).

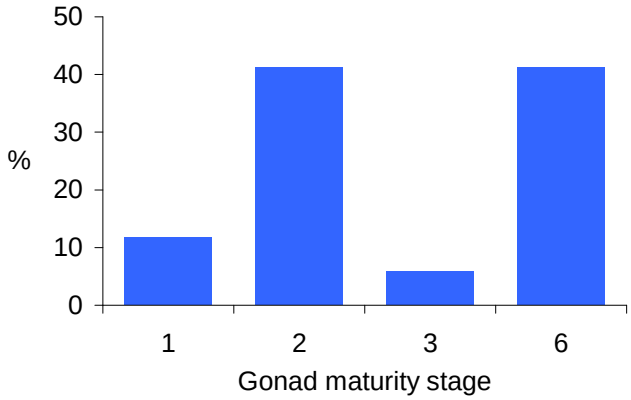

Figure 16. Gonad maturity stage composition in April 2007 on the Faroe Bank.

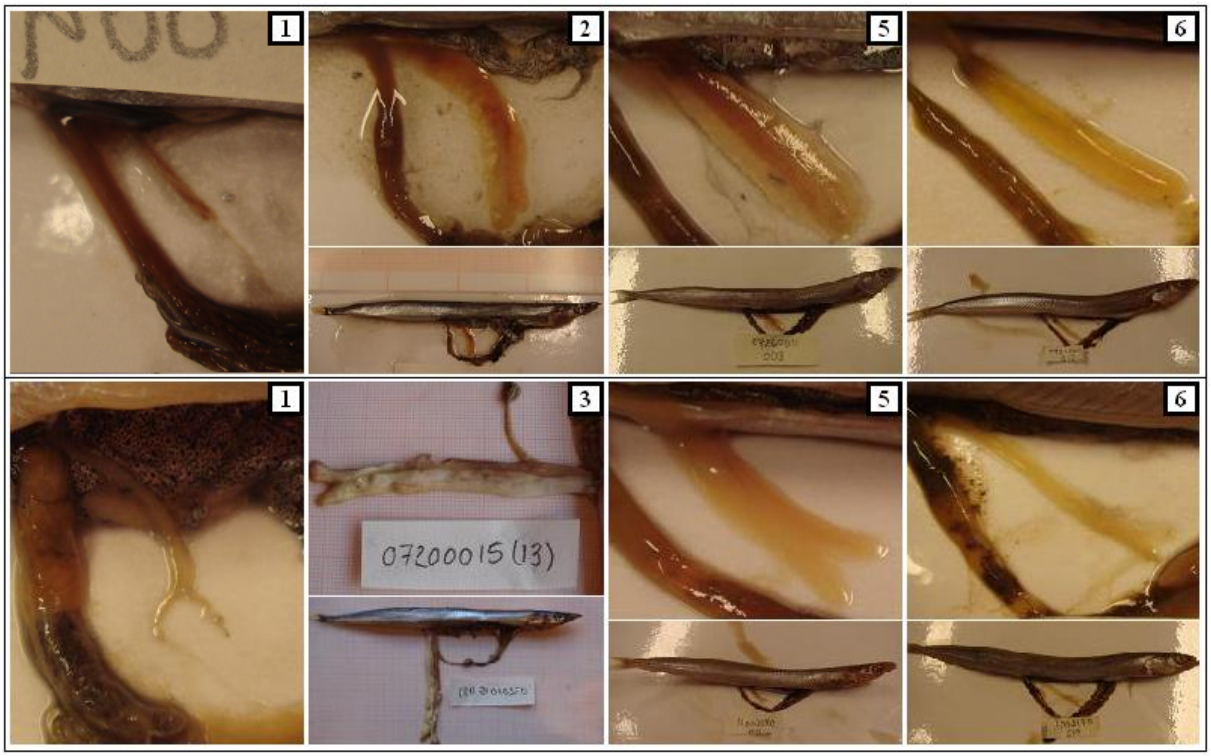

Figure 17. Gonad maturity stages of *Ammodytes marinus*.
Upper row = female, lower row = male.
Number in upper right corner of picture indicates the maturity stage.

All the sandeels studied (both from the Faroe shelf and the Faroe Bank) regarding sex and gonad majority, were species identified and qualified as possible *A. marinus*.

Stomach analysis:

Quite unexpectedly the stomach content and food item selection varied severely of sandeel collected at different sites on the Faroe shelf (Figure 18). Two of the sample sites, sample site 1 and 2, where located relatively close to each other, but the relative amount of different zooplankton species in the stomach, and thus also the selection, showed a clear difference. The stomachs of the sandeel collected at sample site 1 consisted of equally large portions of the zooplankton species *Calanus* sp., *Pseudocalanus* sp., and barnacle nauplii, while the stomach content at sample site 2 was dominated (>50%) by *Calanus* sp. The sandeel from the sample sites 1 and 2 also differed in selectivity, with the former having a strong selection for barnacle nauplii, while the latter had a relatively equal selection for *Pseudocalanus* sp. and barnacle nauplii, and a stronger tendency for *Calanus* sp. selection.

Sample site 3 and 4 both differed from the two previous mentioned sample sites, with sample site 3 being the most different from the other three sample sites. Of the four sample sites studied, sample site 3 had the largest concentration of *Calanus* sp. individuals, and the smallest concentration of *Pseudocalanus* sp. individuals in the environment. However the stomach content, and thus also the selectivity, reflected a totally different image, with a domination of *Pseudocalanus* sp. in the stomachs. Beside the category "other copepods and copepodnauplii", the food choice pattern at sample site 4 was relatively similar to the surrounding environment.

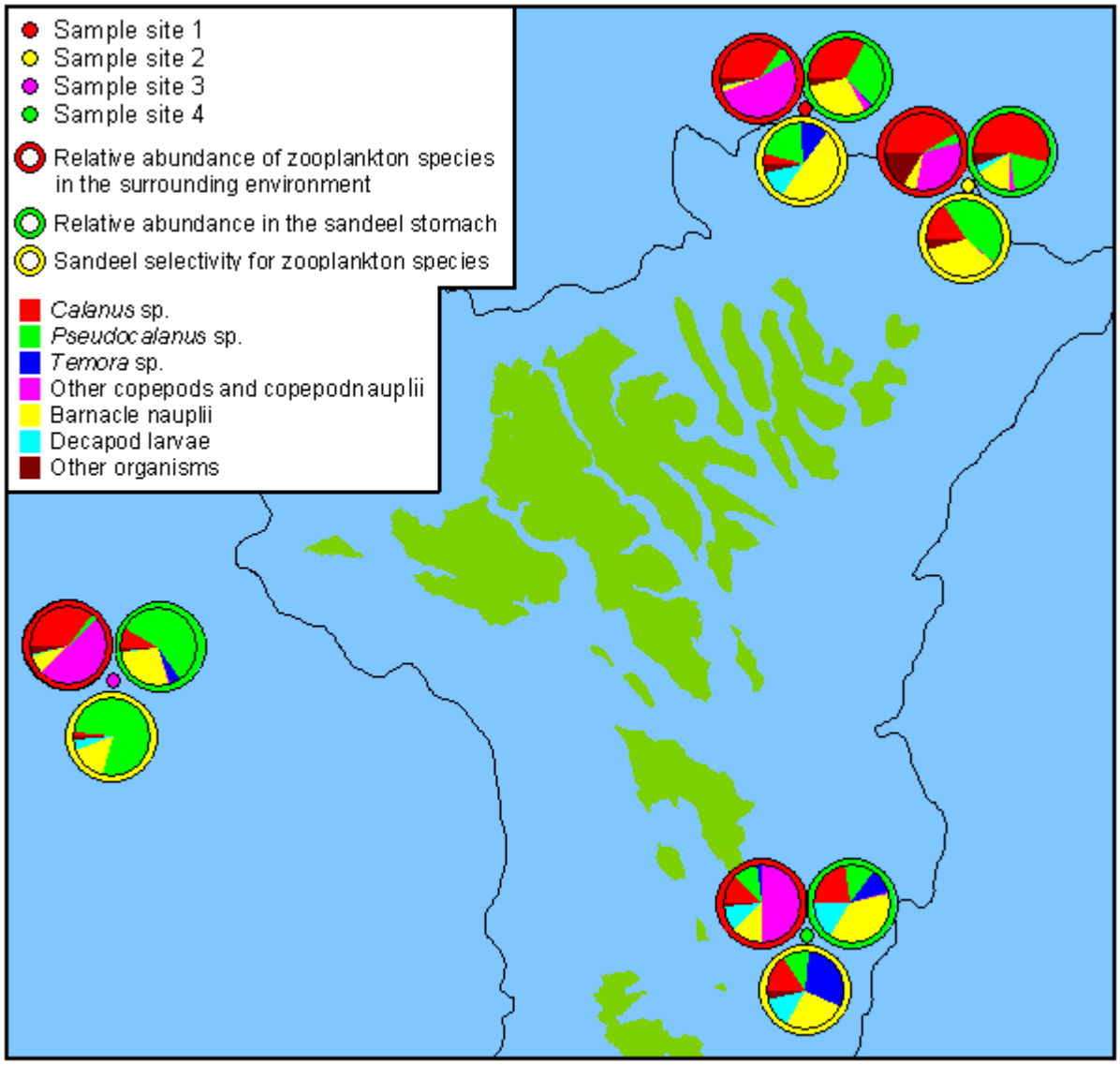

Figure 18. Comparison of the relative zooplankton species abundance in the environment (encircled in red), the relative abundance of zooplankton species in the sandeel stomach (encircled in green), and the sandeel selection of different

zooplankton species (encircled in yellow) at four different sites on the Faroe shelf in April 2007.

Fat (lipid) content:

It was not possible to detect any relation between the sandeel relative fat content and its length (Figure 19), nor weight (Figure 20), i.e. a shorter and lighter specimen could have a higher relative fat content than a longer and heavier specimen, and vice versa.

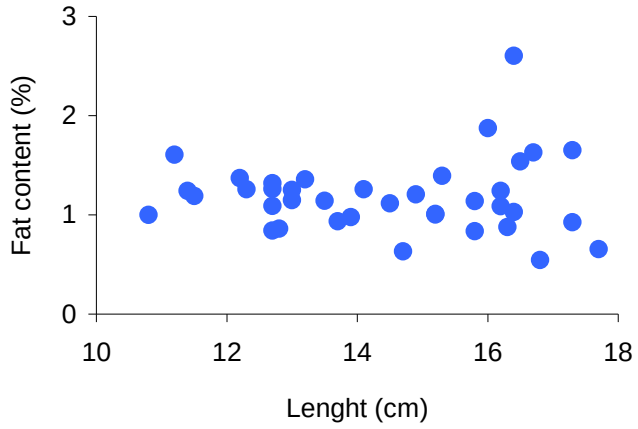

Figure 19. Relative fat content (%) and sandeel length (cm) relation (n = 38).

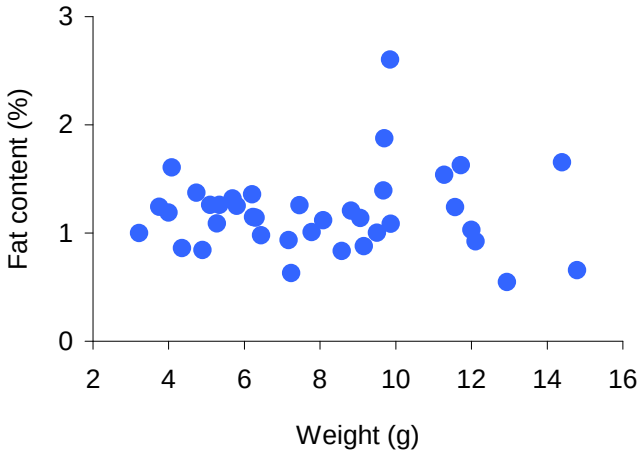

Figure 20. Relative fat content (%) and sandeel weight (g) relation (n = 38).

As in the length/weight-, and the age composition there was observed a difference in the relative fat content at sites (Figure 21). The most remarkable feature discovered in the relative fat content results, was from sample site 2, which was in the group of larger specimens regarding length and weight (Figure 7), but in the relative fat content aspect had a significant lower value than both sample site 3 and 5. Sample

site 3, on the other hand, appeared to have the highest relative fat content, although not significantly higher than sample site 1 and 5.

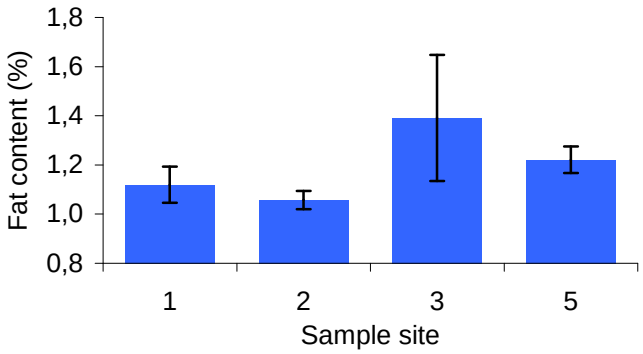

Figure 21. Relative fat content (%), and sample site relation (n = 38).

Regarding the sex, the males did show a slight intrageographical difference in the relative fat content, while the females did not (Figure 22).

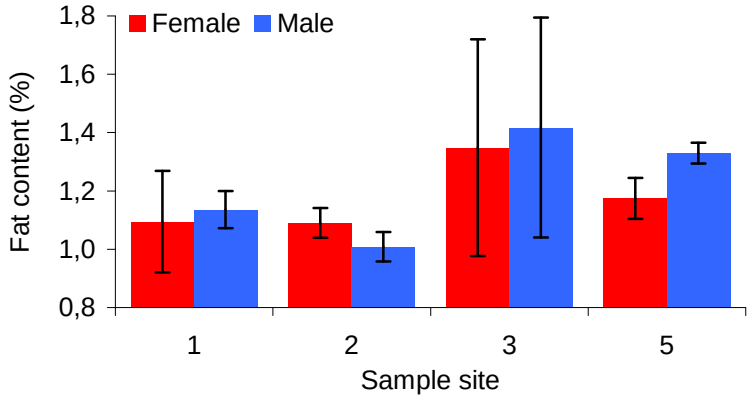

Figure 22. Relative fat content (%) in relation to sex and sample site (n = 38).

This phenomenon was not caused by differences in fat content at different maturity stage categories (Figure 23).

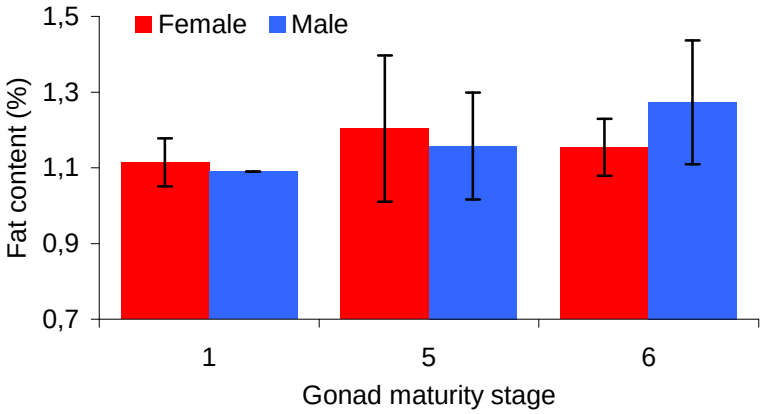

Figure 23. Relative fat content (%) in relation to sex and gonad maturity stage (n = 38).

Suitable sandeel sites

In the prospect of locating suitable sandeel sites the aim is to map the Faroe shelf seabed substratum. The map will separate the seabed into the percentile proportional content of six different particle size categories. Because the specific particle composition of the substratum can exclude or include the sediment as being suitable for sandeel settlement, this mapping can, and will, be used as guidance for further, and more accurate localisations of potential sandeel settlement sites.

All together 80 randomly placed sites were examined, but none of them qualified as suitable according to Holland et al. (2005). There are three main reasons for a site to be categorised as not suitable: too high coarse silt content (>2%), too low medium sand content (<55%), or too low coarse sand content (<15%). The sites differed in the degree of unsuitableness, with some only failing one category, while others failed two, or all three categories (Figure 24).

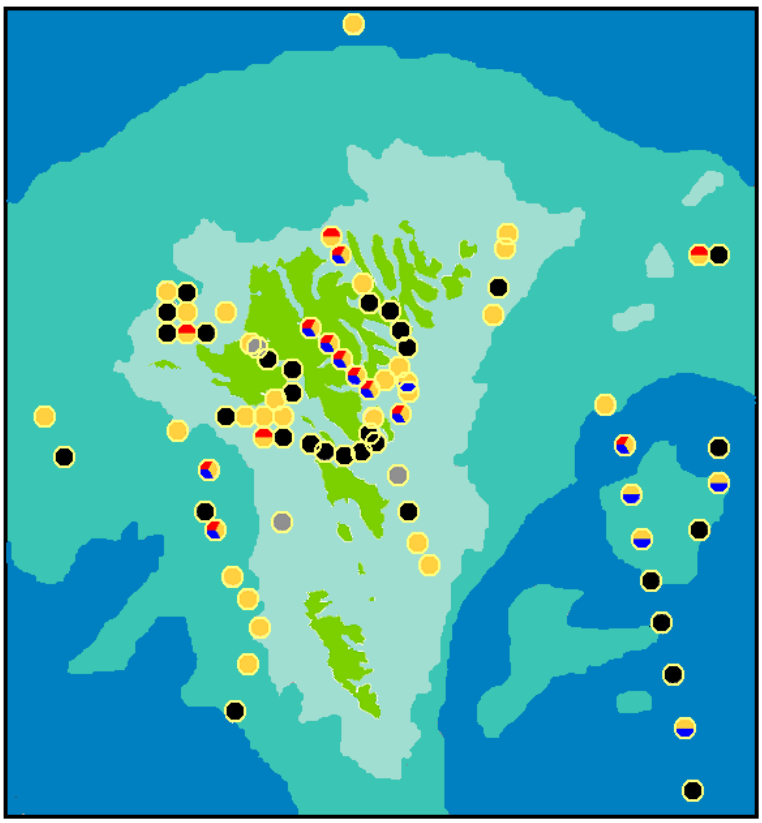

Figure 24. Map of the seabed sites examined.

Grouping according to Holland et al. (2005): Black = hard seabed, grey = large scallops, blue = too high coarse silt content (>2%), yellow = too low medium sand content (<55%), and red = too low coarse sand content (<15%).

Discussion

To determine potential sandeel sites, the method of studying cod stomachs seems to be pretty reliable. The trawl used in 2007 was not designed for sandeel, and thus not ideal. Later on, in April 2008, a trawl designed especially for the purpose was used at same sites, and the results were very convincing – sandeel was collected at all sites investigated, and in proportions above all expectations. The large variations in CPUE in 2007 are most likely a result of the sandeels daily migration pattern rather than an expression of the actual local stock size. Because the sandeel occupies two different habitats, stock size estimations should be done in periods when the total stock most likely only occupies one of the habitats, i.e. the seabed at night or in winter (Greenstreet et al., 2006).

Ammodytes marinus is the dominating sandeel species in the North Atlantic (Bergstad et al., 2001), and this was also the case on the Faroe shelf in 2007. Another sandeel species, *Ammodytes tobianus*, is also common in the North Atlantic, but no "certain" specimens were collected during present project. *A. tobianus* has a shallower depth preference (down to 50 m) than *A. marinus* (down to 150 m) (Mouritsen, 2007). Since the shallowest site examined had a depth of 72 m, the presence of *A. tobianus* on the Faroe shelf can not be excluded. In the larval phase the sandeel is planktivorous and homogeneously distributed on the Faroe shelf. However, no larval *A. tobianus* specimens were collected in a larval sandeel study compiled in 2004 (Eliasen, 2005). The quantity of *A. tobianus* on the Faroe shelf is thus most likely limited.

Many higher species favour sandeel as prey, and because of its hibernating trait, the sandeel has two separate goals to achieve during the active foraging period: 1. Excluding a maximum quantity of predators by increasing in length. 2. Storage enough fat to survive the following winter, and perhaps reproduce (Greenstreet et al., 2006). The larger sandeel specimens in 2007 had a relatively higher body weight than smaller specimens - most likely because the shorter specimens had their attention on avoiding predators, while the larger specimens focused on reproduction. Considering the maximum length of sandeels to be 25 cm, the sandeel collected in 2007 where small. Nonetheless, did they seem to be in a better condition than the sandeel collected in April 2004.

Apparently there was a grouping of sites in species characteristics, length, weight, and age, and it did not seem to be geographically dependent. Resent studies in the North Sea have indicated that sandeel forms sub-colonies of specimens of the same size, i.e. small specimens create foraging schools with other small specimens, and the other way around. It cannot be excluded that the observed grouping of sites really was a reflection of this phenomenon, rather than an actual difference of sites. Nonetheless did the grouping of sites diminish, as the data analysing extended.

The age composition of the Faroese sandeel stock in 2007 verified the assumption of sandeel being a heavily preyed species on the Faroe shelf. Sandeel is not a relatively long-lived fish species, its maximum age recorded is ten years (Bergstad et al., 2001), and the age structure of the Faroese sandeel community, with a heavy domination of young specimens, is a typical trait for exposed prey species (Kvist et al., 2001). However, the oldest specimen collected in this study was only 4 years old, which is young compared to other studies (Lewy et al., 2004).

The Faroese Fisheries Laboratory has continually compiled a annual sandeel juvenile index (Figure 25), but the survey collecting the background material for this index is designed for other fish species, and can thus be questionable. If the annual recruitment, natural mortality, and predation pressure on a fish stock is constant, i.e. the same every year, the stock would have most 1-year-old specimens, second most 2-years-old specimens, third most 3-years-old specimens, etc. The age composition in April 2007 did not unambiguous indicate this structure – the Faroese shelf had in 2007 a higher quantity of 3-years-old than 2-years-old sandeel (Figure 9). 3-years-old sandeel in 2007 are hatched in 2004, and, according to the index, 2004 was a considerably better juvenile sandeel year than 2005 (Figure 25), and can the sandeel juvenile index be utilized with more confidence in the future.

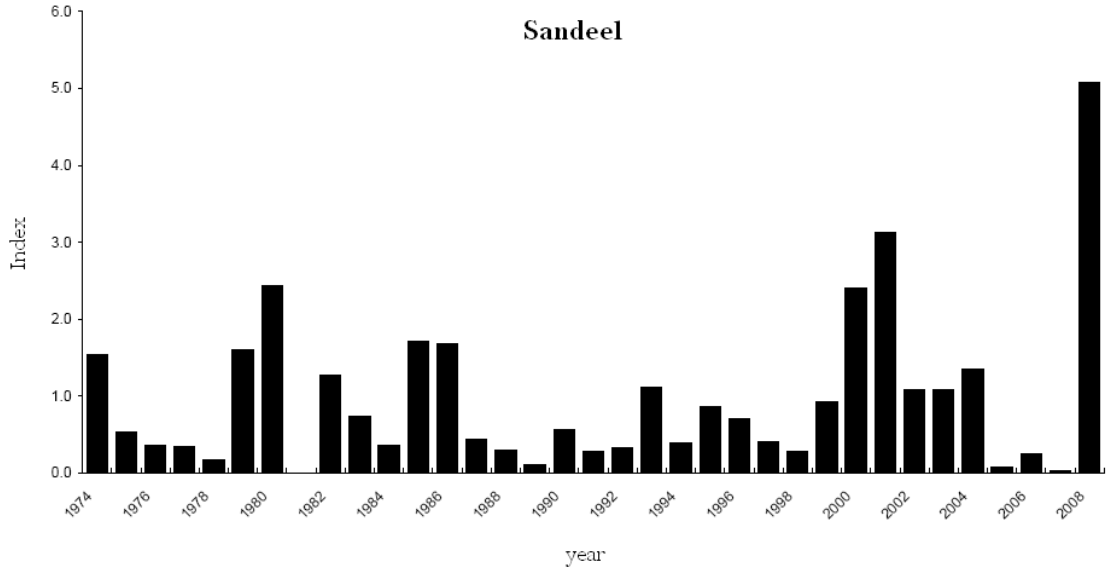

Figure 25. Index of Faroese sandeel juveniles in the period 1974 - 2008.

Length and weight of Faroese sandeels can to a limited extent be used as an estimation of age (Table 4), but kept must be in mind that the results are only based on specimens collected in April a single year.

Table 4. Age of Faroese sandeel in relation to its length (cm) and weight (g) in April 2007.

	Length (cm)	Weight (g)
At the most 1 years old	<14	<4.0
At least 2 years old	>15	>10.0
At least 3 years old	>16	-

The sex ratio, with a dominance of males (58%), is not unusual (Bergstad et al., 2002), but a relatively equal portion of both sexes is the most common (Bergstad et al., 2001). Since the Faroe shelf contributes such a distinctive environment, it is expected that the Faroese sandeel can vary in biological features compared to elsewhere. However, the male age-at-maturity pattern of the Faroese sandeel in 2007 was very similar to observations made at Fisher Bank in 1999 (Boulcott et al., 2007). Prior to present study there has not been observed any sexual difference in the maturity-at-age pattern of sandeel (Macer, 1966; Bergstad et al., 2002), and since current results are based on data collected in April, when the sandeel might be in the

1´th stage of maturity even though it has been spawning the previous winter, some females might wrongly have been detected as non-reproducers.

The Faroese sandeel community in April 2007 consisted of almost equally large portions (30%) of specimens in the 1´th and 5´th stage of maturity, while the remaining 40% were in the 6´th stage. This composition of gonad maturity stages is most similar to the March composition in the North Sea (Macer, 1966). In April almost no specimens are in the 5´th stage of maturity in the North Sea (Macer, 1966). Since the 6´th stage of maturity is followed by the 1´th stage of maturity, the Faroese sandeel development, and recovery, of gonads is seasonally later than of its co-specimens in the North Sea. A seasonally later spawning might cause a lag in the recovery of gonads in Faroese sandeel compared to sandeels in the North Sea. A larval study in 2004 revealed that the spawning of Faroese sandeel takes place around the commencement of a new year, while studies in the North Sea has shown eggs of *Ammodytes* species, most likely *A. marinus*, occurring in sand samples as early as the 5´th of December (Macer, 1966). Newly hatched sandeels also occur two to three weeks earlier in Shetland waters than on the Faroe shelf (Wright and Bailey, 1996).

As recorded beforehand, there is a strong correlation between length and weight, and the gonad maturity of sandeel (Bergstad et al., 2001). When the sandeel was younger than 4 years, the mean length and weight of the reproducing sandeels did in 2007 not immerse 13 cm and 6,2 g respectively (Table 5), and is this consistent with similar studies elsewhere (Bergstad et al., 2001).

Table 5. Mean length and weight of non-reproducing and reproducing 1-, 2-, and 3-years old Faroese sandeels.

	1-year-old		**2-year-olds**		**3-year-olds**	
	length (cm)	weight (g)	length (cm)	weight (g)	length (cm)	weight (g)
Non-reproducing	12,0	4,7	12,8	5,8	13,0	5,8
Reproducing	13,3	6,2	14,6	8,6	15,4	9,3

Nonetheless, it does seem as though the Faroese sandeel has a lower average age at 50% maturity compared to elsewhere (Table 2). In 2007 all the males and 92% of the females were mature by the age of three, while a similar study in the North Sea in

1996-97 resulted in an average age of 3.2 years at 50% maturity (Bergstad et al., 2001).

The results of the eighteen sandeel from the Faroe Bank examined were quite remarkable. The Faroe Bank sandeel were all "possible" *A. marinus*, yet did they have a completely different maturity stage composition. They were collected approximately three to four weeks earlier than the Faroe shelf sandeel, in late March, but the gonad maturity composition reminded mostly of the January composition in the North Sea, i.e. in the period when the majority of the North Sea sandeel is either ripe or running (Macer, 1966; Bergstad et al., 2001).

Overall was the stomach content of the Faroese sandeel similar to that of sandeel examined in the North Sea, but the occurrence of food species varied (Table 6). The results from the North Sea do not include seasonal variation, i.e. the values are the mean occurrence throughout a year, and can the difference thus be an expression of seasonal, rather than geographical, differences. However, there was observed a tendency of geographical differences in the choice of food species on the Faroe shelf alone.

Table 6. Proportion of sandeel stomachs in which different food item species occurred (%). Numbers in brackets indicate results from similar study made in the North Sea (Macer, 1966).

Sample site	Calanus sp.	Pseudocalanus sp.	Temora sp.	Barnacle nauplii	Decapod larvae	Polychaeta	Fish ova
1	100	100	10	100	20	10	50
2	67	100	11	78	33	67	22
3	100	100	100	100	100	50	0
4	100	100	100	100	100	0	40
Mean occurence	92 (23)	100 (27)	55 (64)	94 (31)	63 (24)	32 (46)	28 (15)

Breeding success of seabird is not solely dependent on the number of food items brought to the chick by the parents, but indeed also of the energy quality of the prey

species. Sandeel is usually considered to be a high quality prey species, but studies have shown that the quality of sandeels can vary annually (Wanless et al., 2005). Due to lack of equipment (a muffle furnace, 600°C), it was not possible to use the same method in determining the energy content as other scientist have used in similar studies. Since the energy content of sandeel is crucial to the predator, prior studies are most frequently compiled in periods when the predators are most vulnerable to limitations in food access and quality, e.g. in the breeding season of seabirds. The breeding period of seabirds is usually from June to August, and it has not been possible to obtain any comparable data on April sandeel fat content. The June-August sandeel fat content in the North Sea was in 2004 markedly lower than observed other years (Wanless et al., 2005), but still it was almost twice as high as the fat content observed on the Faroe shelf in April 2007 (Table 7). The difference in methods makes the comparability of the results questionable, but if they are comparable, the Faroese sandeel has to double its fat content in the next 2-4 months to reach the same level as of a low fat content year in the North Sea. Nonetheless, in the prospect of understanding the ecological influence sandeel has on higher trophic levels, it is highly relevant to include fat content measurements in future sandeel investigations on the Faroe shelf.

Table 7. Minimum, maximum, and average sandeel fat content (g cm^{-1}) on the Faroe shelf in April 2007, and in the North Sea in June-August 2004 (Wanless et al., 2005).

	Faroe shelf	North Sea	Difference
Min	0,003	0,005	0,002
Max	0,016	0,028	0,013
Average	0,006	0,015	0,008

Surprisingly did none of the sediment samples investigated result in findings of suitable seabed substratum according to Holland et al. 2005. However, sandeel was collected at site 4 even though it did not have the suitable settlement site characteristics. Containing only 27% medium sand, site 4 did fail to be categorized as a suitable settlement site. The Faroe shelf seabed is very heterogeneous, with the bottom topography and local currents determining the characteristics of the substratum. The Faroese sandeel might thus have adapted to other demands in sediment characteristics. If this adaptation to the Faroe shelf circumstances includes

a drop in the demand of medium sand to being at least 27%, instead of 55%, then 18% of the investigated sites could be categorized as suitable for sandeel settlement. However, this study is the first small step towards a larger and more comprehensive investigation of the Faroe shelf seabed, and more detailed information will be accessible in the future.

Concluding remarks

Since the quantity of research on the Faroese sandeel is almost negligible, all results are new information, but kept must be in mind that the results presented here are only a snap shot of the big picture – both annual and interannual variations are almost none existent. However, this project has revealed, not surprisingly, that research and subsequent results from elsewhere cannot unrestrained be transferred onto Faroese sandeels and circumstances. Future research of the Faroese sandeel is thus requisite in the prospect of understanding the Faroese marine ecosystem better.

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