

**Final report**

***Northern North Sea  
Saithe (and Cod)***

***“A self sampling project”***

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Skipper and crew of MFV “Farnella”**



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## Executive Summary

The Northern North Sea Saithe (and Cod) FSP was established in response to an industry- and science-perceived absence of realistic data on the 2004 and 2005 year classes of saithe and the 2005 and 2006 year classes of cod. The 2005 and 2004 year classes of saithe (4 and 5 year olds) are of particular interest because they were predicted to contribute significantly to projected landings in 2008 and subsequently to contribute to the spawning-stock biomass of the species in 2009.

This study uses data collected at haul level by fishermen aboard the commercial fishing vessel MFV “Farnella” over a two-year period. Throughout, fishing was widespread in the northern North Sea, but for the most part was focused on ICES Division IVa. The skipper and crew were trained in sampling techniques prior to collecting the data, and all information sent ashore was checked regularly. Observer-accompanied trips were also carried out to ensure a high standard of data quality.

Between May 2007 and March 2009 (the study period) MFV “Farnella” embarked on **51** commercial fishing trips in the northern North Sea (ICES IVa), hauled **1154** times, and caught 3.3 million saithe (*Pollachius virens*) and 51 000 Atlantic cod (*Gadus morhua*). Of the fish caught, the crew measured most of the cod (48 772) and 26 518 saithe (**75 290** in total).

For the study period at least, saithe appear to have had three strong year-classes in the fishery; the 2002 (7 year olds), 2004 (5 year olds) and 2005 (4 year olds) year classes. These combined constituted two-thirds of the estimated 3.3 million saithe caught by the vessel during the study period. The hypothesis behind this study is that the 2005 and 2004 year classes could contribute significantly to predicted saithe landings in 2008 and thence contribute to the spawning stock in 2009. This is supported by this study. Indeed the 2005 and 2004 year classes of saithe contributed to >50% of the fish landed by “Farnella”.

On average, cod catches were small throughout and remained a small part of the vessel’s landings (<2%). Suggestions that the 2005 year class of cod may be stronger than previous years are, however, well substantiated in our data. Of the cod caught during the study period, ~30 000 (60%) were aged 4 years (2005 year class). The 2004 year class (5 year olds) were not as abundant (13% of the catch). Moreover, cod older than the 2004 year class were rarely taken.

Discarding of both species was low. The percentage of cod caught and subsequently discarded throughout the study period was <1% by weight and number. Of the saithe caught, <0.01% (by weight and number) is estimated to be discarded. Additionally, low discard rates were also recorded by the observer who accompanied three of the trips.

The “Farnella” provided accurate catch data for every haul for the whole two years, along with measuring >75 000 fish. The data enabled us to plot the fine-scale distributions of cod and saithe in the North Sea, to show which year classes were influential and how they moved in and out of the fishery. Previously, such information has been costly to gather; the project demonstrated that high resolution data on fisheries can be collected by fishermen. Moreover, and most importantly, this is a clear example of how fishermen and scientists can work together for prolonged periods of time to achieve a common goal, in this case of providing information underpinning sustainable fisheries – a true Fisheries Science Partnership.

## 1. Introduction

The Fisheries Science Partnership (FSP) was established in 2003 to build relationships between fishermen and scientists, and to involve fishers in the co-commissioning of science. Since 2003 more than 40 projects have been completed, tackling a broad range of fisheries operational issues. Project reports already completed are available on the FSP page of the Cefas website ([www.cefas.co.uk](http://www.cefas.co.uk)). The FSP is funded by the UK Department for Environment, Food and Rural Affairs (Defra).

The primary aims of the Fisheries Science Partnership are to:-

- (a) provide information from commercial fishing catches on key stocks to supplement the data sources traditionally used in ICES assessments;
- (b) investigate concerns raised by fishermen on scientific assessments or on stocks not currently assessed;
- (c) investigate innovative scientific methods and or more selective/environmentally friendly fishing methods; and,
- (d) support the work of Regional Advisory Councils.

Industry proposals for FSP projects have typically been developed at a port/regional level, refined and agreed with Cefas, and approved by the FSP Steering Group. Charter vessels are selected through an open tendering procedure, and are given dispensations from the relevant quota and effort controls and to fish in non-UK waters if appropriate.

The Northern North Sea Saithe (and Cod) FSP programme has been able to provide over two years monthly data on the catch composition of saithe and cod. It was established in response to an industry- and science-perceived absence of realistic data on the 2004 and 2005 year classes of saithe and to some extent too of the 2005 and 2006 year classes of cod. The 2005 and 2004 year classes of saithe (4 and 5 year olds in 2009) are of particular interest because they were predicted to contribute significantly to projected landings in 2008 and subsequently to contribute to the spawning-stock biomass of the species in 2009. There is also a lack of reliable information about year-class strength before the 2003 year class (ICES 2007). Similarly, the 2005 year class of North Sea cod was thought by some to be stronger than the previous few years of weak recruitment. In addition to data on the 2005 cod year class, information on the 2006 year class and the general abundance of cod of all ages can provide useful supplementary information and insight into changes in cod distributions throughout the year.

The project used data collected at a haul level collected by the fishermen aboard the commercial fishing vessel MFV "Farnella" over a two-year period. "Farnella" operates in the northern North Sea and targets saithe. The skipper and crew are trained in sampling techniques prior to collecting the data. It is hoped that the broad coverage (all trips, all hauls for 24 months) will compensate for the less-reliable assessment method of standardisation of sampling.

## Objectives

1. To describe the distribution and abundance of saithe and cod, in particular the 2004 and 2005 year classes of saithe and the 2005 and 2006 year classes of cod.
2. To enable scientists to use data collected by the fishing industry for scientific purposes.



**A haul of saithe coming aboard MFV "Farnella" in May 2007**

## 2. Material and methods

### 2.1 The fishing vessel and area fished

The study was conducted between May 2007 and March 2009 (herein referred to as the study period) on board the commercial fishing vessel MFV “Farnella” (length overall, 40.2 m; GRT 667; main engine, 1880 kW). “Farnella” uses a trawl typical of the northern North Sea saithe fishery (headline height 4 m, door spread 110–115 m codend mesh >110 mm, tow speed 4 knots). Throughout, fishing took place in the northern North Sea, but for the most part focused on ICES Division IVa (Fig. 1).

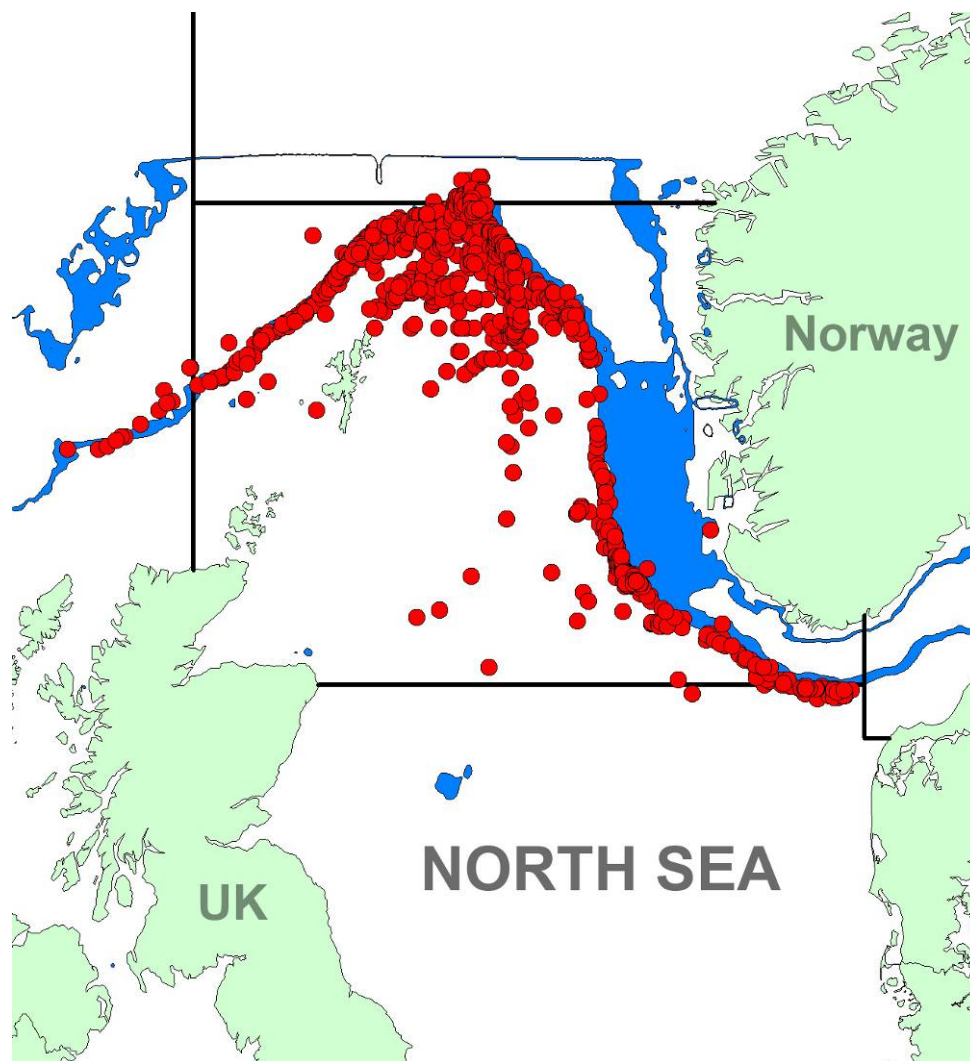


Fig.1. Map of the North Sea showing MFV “Farnella” haul locations throughout the study period (red). The 200 m bathycline is shown in blue.

## **2.2 Data collection**

### **2.2.1 Self sampling**

#### *2.2.1.1 Estimating fish numbers and weights*

The skipper and crew were asked to provide estimates of the weight and number of retained and discarded cod and saithe of each size grade for every haul. At the end of each haul, fishroom staff provided the wheelhouse a tally recording the number of baskets per grade of cod and saithe caught. Baskets were estimated at 45 kg, and the numbers of fish in each basket were assessed regularly (to take into account the seasonal and spatial variations of fish condition).

#### *2.2.1.2 Biotic and abiotic measurements*

All cod were caught in every haul were measured, and a minimum of 100 saithe per size grade were measured per trip. When necessary (large hauls), saithe numbers were raised to haul level as a proportion of the total catch, using volume-based raising factors. All fish were measured to the nearest centimetre below (total length). Environmental conditions (sea state, wind strength/direction) and physical conditions (depth, position, haul-duration and gear properties) were recorded along with the biological data.

### **2.2.2 Observer sampling**

Three observer trips were conducted throughout the study period. The first observer trip, in May 2007, was used to train the skipper and crew of the “Farnella” in sampling methods (Annex 1.1). The second and third observer trips were used to maintain the standards applied from the start (there was skipper and crew turnover) and particularly to ensure that the self-sampling was of a very high standard. These second two observer trips were carried out in the first quarters of 2008 and 2009 (Annexes 1.2 and 1.3). Information collected from the trained observers was used to validate the data provided by the vessel and to provide a more detailed overview of the fishery with respect to bycatch and discards.

### **2.2.3 Fish age determination**

A total of 29 000 fish otoliths was removed at sea by observers and from fish landed to fish markets. Of these, 15 500 were from cod and 13 500 from saithe. All otoliths were extracted from fish that had been caught in ICES area IVa between April 2007 and March 2009 (the study period covered by this report). Otoliths were mounted, sectioned, stained, read, and re-read for quality control purposes, according to the protocols of Cefas and Marine Scotland - Marine Laboratory.

## **2.3 Data analysis**

### **2.3.1 Data handling**

Trip, haul, length, catch and age data were entered onto a MS access database. All data entered were cross-checked against the paperwork and quality-controlled for inaccuracies. Data were handled using SPSS V17 statistical software, charts were produced using Sigmaplot V10.0, and maps were created in MapInfo V7.8.

### **2.3.2 Converting fish length into fish ages**

Age-at-length data collected from the 15 500 cod and 13 500 saithe that were aged were used. Data were collected throughout the year to take into account length

variations of a growing age class. At a given length in any quarter, fish age will vary. For example, in quarter 3 of 2007, 49 cod of the 70-cm length class were aged as between one and four years old (Table 1), so when one 70-cm cod was observed and measured in quarter 3, it was aged proportionally to what was observed in the population (Table 2, Fish 1). Each fish length has a different combination of proportions at a given age (Table 2, Fish 2). If more than one fish was observed at a given length, then the number at length was multiplied by the proportion at age (Table 2, Fish 3) to give the estimated numbers at a given age.

Age-length keys (ALKs) applied to this analysis are area- (ICES IVa), species- (cod or saithe) and season-specific (quarters 1, 2, 3 and 4). Sex is not taken into account. When a fish length could not be matched with a length that had been aged in a particular quarter, then seasonality was removed and an aggregated ALK for the whole year was used. This occurred in <2% of the >75 000 fish measured.

Table 1  
Fish of equal length have varying ages

| Species      | Year | Quarter | Length (cm) | Age | Number    | Proportion |
|--------------|------|---------|-------------|-----|-----------|------------|
| COD          | 2007 | 3       | 70          | 1   | 1         | 0.02       |
| COD          | 2007 | 3       | 70          | 2   | 29        | 0.59       |
| COD          | 2007 | 3       | 70          | 3   | 18        | 0.37       |
| COD          | 2007 | 3       | 70          | 4   | 1         | 0.02       |
| <b>Total</b> |      |         |             |     | <b>49</b> | <b>1</b>   |

Table 2  
Fish of different lengths have different age proportions

| Fish No | Year | Quarter | Species | Length(cm) | N at length | category | Age | Number at age |
|---------|------|---------|---------|------------|-------------|----------|-----|---------------|
| 1       | 2007 | 3       | COD     | 70         | 1           | 2        | 1   | <b>0.02</b>   |
| 1       | 2007 | 3       | COD     | 70         | 1           | 2        | 2   | <b>0.59</b>   |
| 1       | 2007 | 3       | COD     | 70         | 1           | 2        | 3   | <b>0.37</b>   |
| 1       | 2007 | 3       | COD     | 70         | 1           | 2        | 4   | <b>0.02</b>   |
| 2       | 2007 | 3       | COD     | <b>45</b>  | 1           | 5        | 1   | <b>0.00</b>   |
| 2       | 2007 | 3       | COD     | <b>45</b>  | 1           | 5        | 2   | <b>0.91</b>   |
| 2       | 2007 | 3       | COD     | <b>45</b>  | 1           | 5        | 3   | <b>0.09</b>   |
| 2       | 2007 | 3       | COD     | <b>45</b>  | 1           | 5        | 4   | <b>0.00</b>   |
| 3       | 2007 | 3       | COD     | 70         | <b>10</b>   | 3        | 1   | <b>0.20</b>   |
| 3       | 2007 | 3       | COD     | 70         | <b>10</b>   | 3        | 2   | <b>5.90</b>   |
| 3       | 2007 | 3       | COD     | 70         | <b>10</b>   | 3        | 3   | <b>3.70</b>   |
| 3       | 2007 | 3       | COD     | 70         | <b>10</b>   | 3        | 4   | <b>0.20</b>   |

### 2.3.3 Generating an age-category key

Haul data are presented in numbers of fish caught by category. In order to make use of this information and to evaluate the numbers-at-age of fish caught at a particular haul location, we need to understand the age spread of a particular category. Fishermen were asked to record the category of the fish measured. With each measurement we can assess the age of the fish, so an area, species and season

age-category key can be generated. For example, in quarter 3 of 2007, an estimated 1 990 category 4 cod were caught. These were aged between 2 and 6 years old (Table 3), so when a category 4 fish was caught (now disregarding length information) we applied the same method as an ALK and aged it proportionally using an age category key (ACK). For example, If 1000 category 4 cod were caught in a particular haul, we would estimate 533 to be age 2 (1000 x 0.533), 398 to be age 3 (1000 x 0.398), 66 to be age 4, etc

Table 3  
Enumerating the numbers of fish of different ages at each grade

| Species      | Year | Quarter | category | Age | Number      | Proportion |
|--------------|------|---------|----------|-----|-------------|------------|
| COD          | 2007 | 3       | 4        | 2   | 1060.65     | 0.533      |
| COD          | 2007 | 3       | 4        | 3   | 791.95      | 0.398      |
| COD          | 2007 | 3       | 4        | 4   | 131.11      | 0.066      |
| COD          | 2007 | 3       | 4        | 5   | 3.54        | 0.002      |
| COD          | 2007 | 3       | 4        | 6   | 2.74        | 0.001      |
| <b>Total</b> |      |         |          |     | <b>1990</b> | <b>1</b>   |

#### 2.3.4 Calculating catch per unit effort

The total numbers of fish caught each month (by species) were divided by the total haul duration to determine the numbers of fish caught per hour, or the catch per unit effort (CPUE). This unit allowed the catch data to be standardised and used for comparative analysis.

## 3. Results

### 3.1 Numbers and weights

Between May 2007 and March 2009 (the study period) MFV “Farnella” undertook 51 commercial fishing trips in the northern North Sea (ICES IVa), hauled **1154** times, and caught 3.3 million saithe (*Pollachius virens*) and 51 000 Atlantic cod (*Gadus morhua*). Trips ranged in length between 3 and 12 days, and tows were between 0.5 and 8 h duration (mean 5.1 h). Of the fish caught, the crew measured all cod caught (48 772) and 26 518 saithe (**75 290** in total). In all, 3 974 t of fish were caught, 98% (3 852 t) being saithe and 122 t being cod. Table 5 shows the numbers of fish caught of each age class during the study period. Number of hours fished in a particular year are also shown.

Table 4  
Summary of retained and discarded catch weights and numbers for Atlantic cod and saithe caught during the study period.

| Species      | Retained         |                  | Discarded   |            |
|--------------|------------------|------------------|-------------|------------|
|              | Weight (kg)      | Number           | Weight (kg) | Number     |
| Saithe       | 3 852 011        | 3 294 591        | 22          | 37         |
| Atlantic cod | 122 089          | 51 045           | 117         | 187        |
| <b>Total</b> | <b>3 974 100</b> | <b>3 345 636</b> | <b>139</b>  | <b>224</b> |

Table 5  
Summary of the numbers of fish caught (cod and saithe) at each age class.

| Year class           | 2007          |                | 2008          |                  | 2009         |                |
|----------------------|---------------|----------------|---------------|------------------|--------------|----------------|
|                      | Cod           | Saithe         | Cod           | Saithe           | Cod          | Saithe         |
| 2008                 | 0             | 0              | 0             | 0                | 4            | 0              |
| 2007                 | 0             | 0              | 125           | 307              | 684          | 14,102         |
| 2006                 | 175           | 0              | 3,792         | 86,247           | 2,788        | 147,777        |
| 2005                 | 9,264         | 49,410         | 21,181        | 485,625          | 1,220        | 185,056        |
| 2004                 | 3,294         | 240,018        | 3,220         | 551,479          | 422          | 117,013        |
| 2003                 | 1,749         | 170,057        | 1,464         | 145,394          | 145          | 82,251         |
| 2002                 | 379           | 360,889        | 308           | 316,974          | 86           | 30,100         |
| 2001                 | 178           | 58,879         | 186           | 62,579           | 63           | 20,531         |
| 2000                 | 82            | 34,829         | 90            | 47,688           | 31           | 10,257         |
| 1999                 | 82            | 12,392         | 82            | 26,639           | 3            | 3,528          |
| 1998                 | 18            | 4,266          | 4             | 10,995           | 1            | 1,008          |
| 1997                 | 3             | 731            | 3             | 2,005            | 1            | 451            |
| 1996                 | 1             | 357            | 0             | 1,066            | 0            | 130            |
| 1995                 | 4             | 148            | 0             | 125              | 0            | 82             |
| 1994                 | 0             | 85             | 0             | 132              | 0            | 79             |
| 1993                 | 0             | 90             | 0             | 57               | 0            | 25             |
| 1992                 | 0             | 45             | 0             | 26               | 0            | 95             |
| 1991                 | 0             | 10             | 0             | 5                | 0            | 0              |
| 1990                 | 0             | 450            | 0             | 0                | 0            | 0              |
| 1989                 | 0             | 0              | 0             | 0                | 0            | 0              |
| 1988                 | 0             | 0              | 0             | 0                | 0            | 0              |
| <b>Total</b>         | <b>15,229</b> | <b>932,654</b> | <b>30,454</b> | <b>1,737,344</b> | <b>5,446</b> | <b>612,485</b> |
| <b>Hours fishing</b> | <b>321</b>    |                | <b>623</b>    |                  | <b>190</b>   |                |

### 3.2 Saithe (Coley)

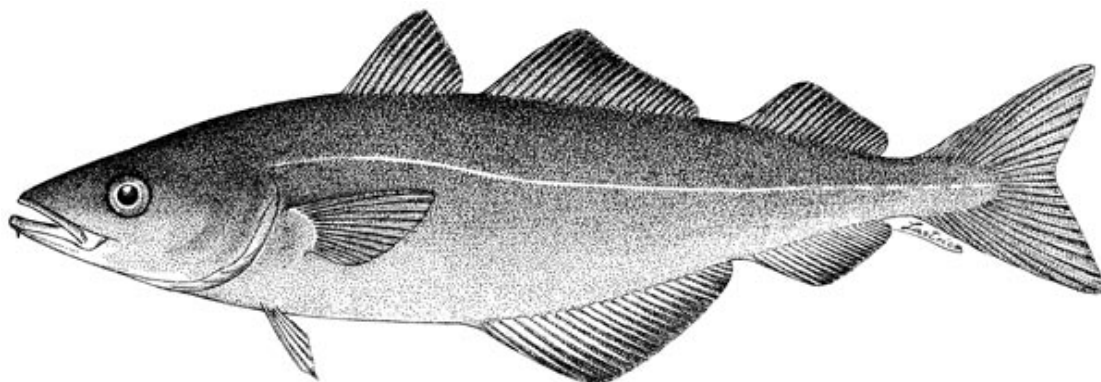


Illustration by Daniel M.Cohen Tadashi Inada Tomio Iwamoto Nadia Scialabba 1990. FAO Fisheries Synopsis. 125, Vol.10. Rome, FAO. 1990. 442 pp.

#### 3.2.1 Temporal catch patterns

The numbers of saithe caught in a given month varied considerably throughout the study period. Excluding July (limited sampling) and August 2007 (no sampling), the number of saithe caught per month ranged from 26 000 (June 2007) to 300 000

(March 2008) (Fig. 2). Catch rates of saithe also varied considerably, with averages of 200 fish per hour caught in Nov 2008 and 1700 fish per hour in Jan 2009 (Fig. 2)

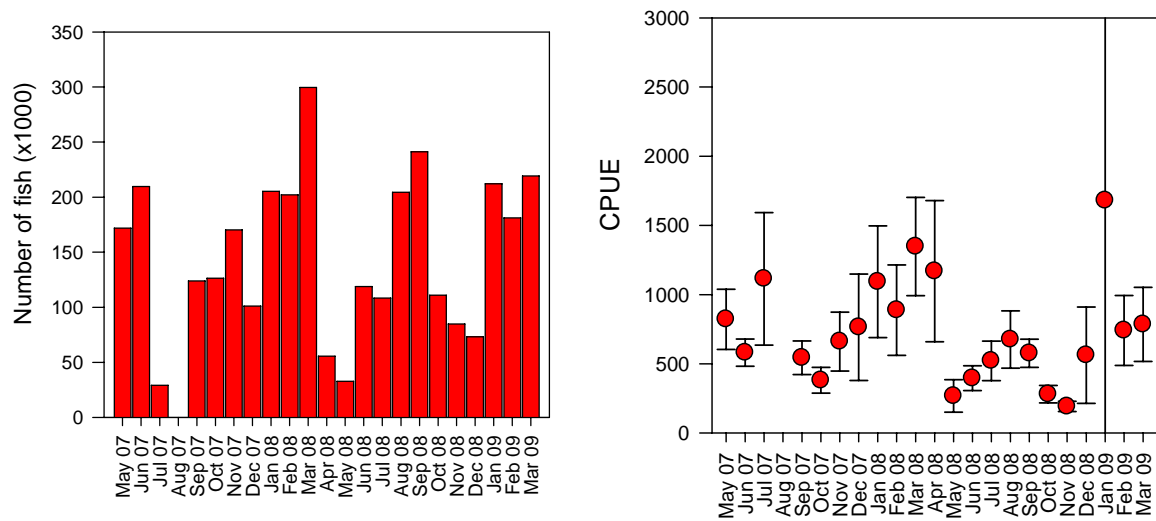


Fig. 2. Numbers and CPUE of saithe caught per month.  
Error bars show  $\pm$ standard errors

### 3.2.2 Year class catch patterns

Three strong year classes of saithe appear in the catch composition of “Farnella”. The 2005, 2006 and 2002 year classes together constituted more than 75% of the saithe caught during the study period (Fig. 3). Catch rates (numbers of fish caught per hour) were also highest for these three year classes.

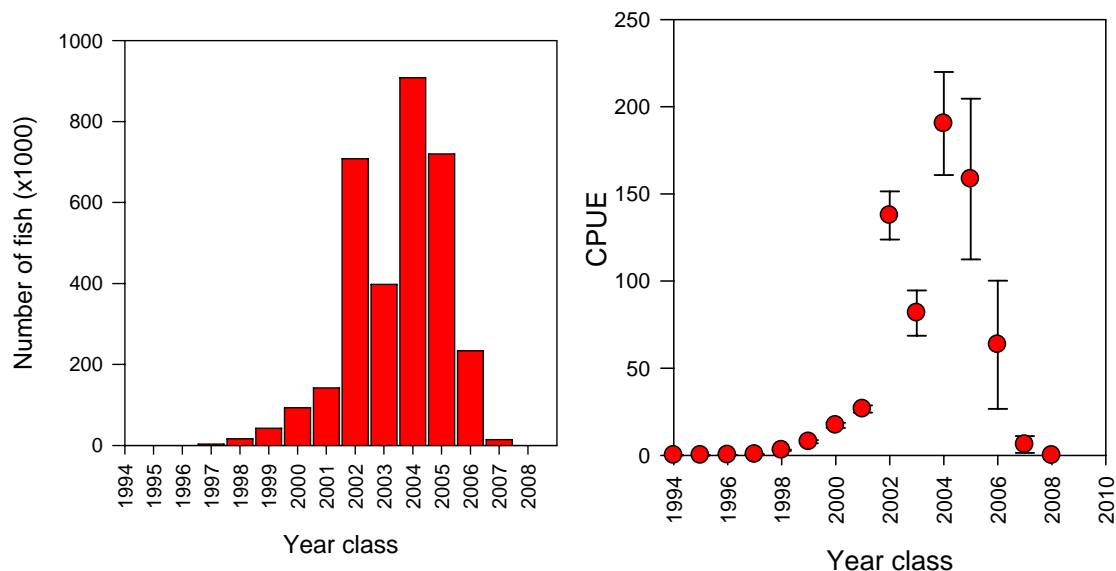


Fig. 3. Numbers and CPUE of saithe by year class.  
Error bars show  $\pm$ standard errors

### 3.2.3 Spatial catch patterns

#### 2005 year class

The 2005 year class of saithe constituted 8% of the catch of saithe during 2007 (i.e. when they were 2-year-old fish – Table 5), and as 3-year-olds in 2008, 30% of the saithe caught (Figures 4, 6 and Table 5). In general, saithe were caught in higher numbers and at greater catch rates in winter (Figs 2 and 4).

[Click on image to view animation](#)

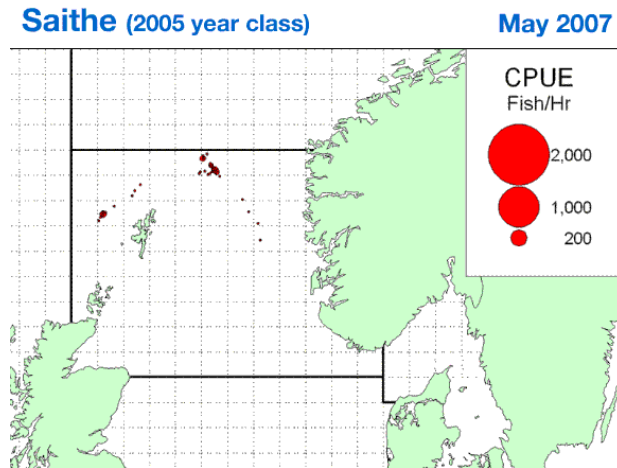


Fig.4. Saithe (2005 year- class) spatial catch patterns.

#### 2004 year class

The 2004 year class of saithe constituted 26% of the saithe caught in 2007 (as 3-year-olds), 32% in 2008 (as 4-year-olds) and 19% of the saithe caught in 2009 (as 5-year-olds). This decline throughout the study period can be seen in Figures 5 and 6.

[Click on image to view animation](#)

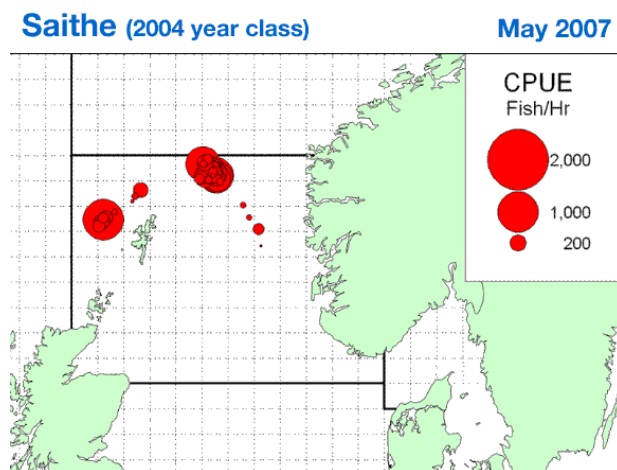


Fig.5. Saithe (2004 year- class) spatial catch patterns.

## Saithe catch rates

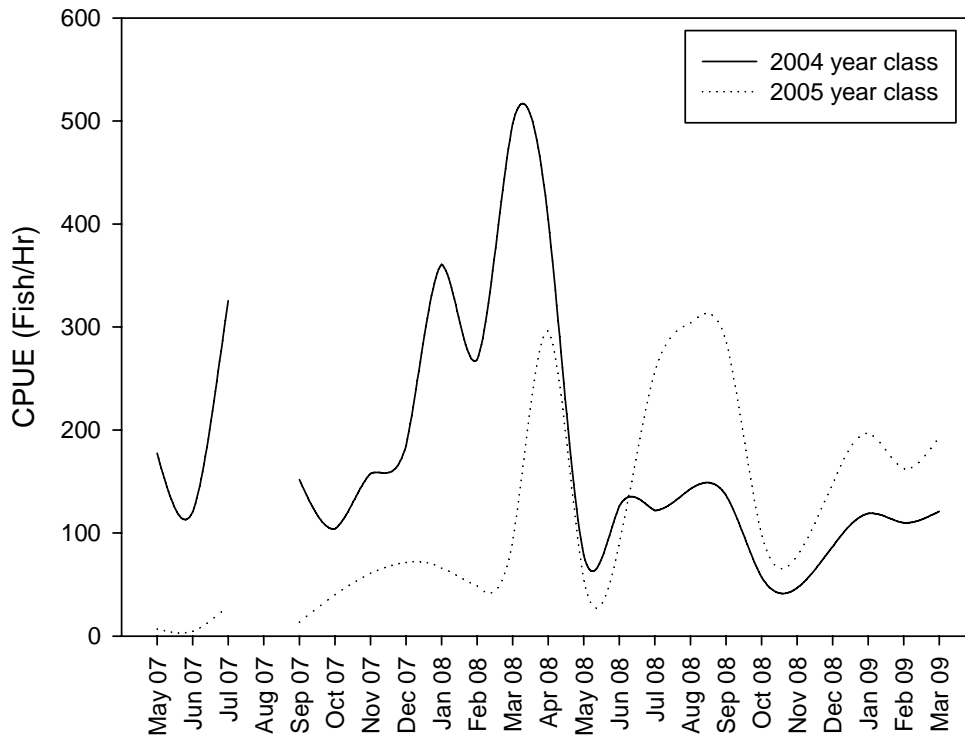


Fig. 6. Average catch rates of the 2005 and 2004 year classes of saithe.

### Other year classes

The 2002 year class was a dominant year class in 2007 (as 5-year-olds), but as the study continued the proportion of fish of this age class caught declined. In 2009, the same year class (as 7-year-olds) made up just 5% of the saithe caught. The spatial distribution of the 2003, 2002 and 2001 year classes combined are displayed in Figure 7. These fish were caught throughout the study period, but catch rates fell during summer (Figs 2 and 7).

[Click on image to view animation](#)

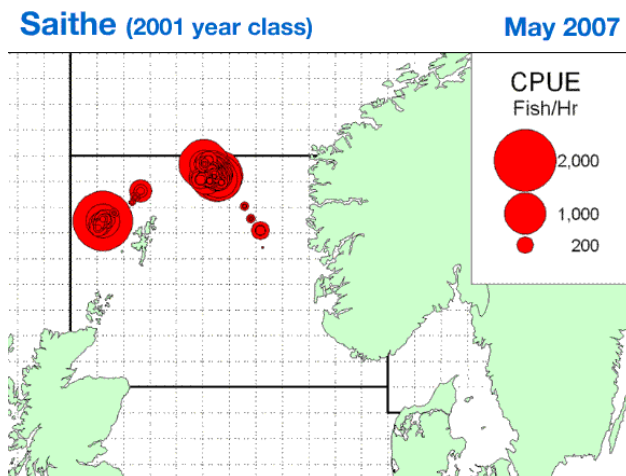


Fig.7. Saithe (2001-2003 year- class) spatial catch patterns.

Of the saithe caught during the study period, 95% (3.1 million) were younger than the 2000 year class. Catch rates of large old saithe were highest in January and February when “Farnella” was fishing off the Shetland Isles. The distribution of the 2000+ year classes is shown in Figure 8.

Click on image to view animation

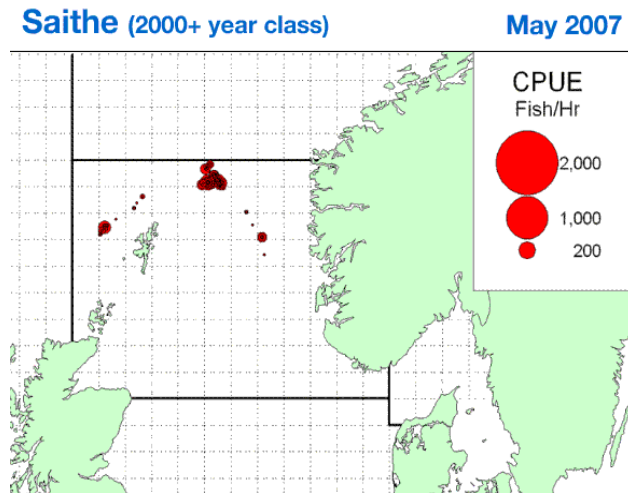


Fig.8. Saithe (2000+ year- class) spatial catch patterns.

### 3.2.4 Size categories

Saithe were caught and graded into four size categories for sale at the market. The few that were unsuitable for the market were discarded. The length and age distributions of each size category are shown in Figure 9. There is an overlap between the lengths and ages of saithe marketed in a particular size category.

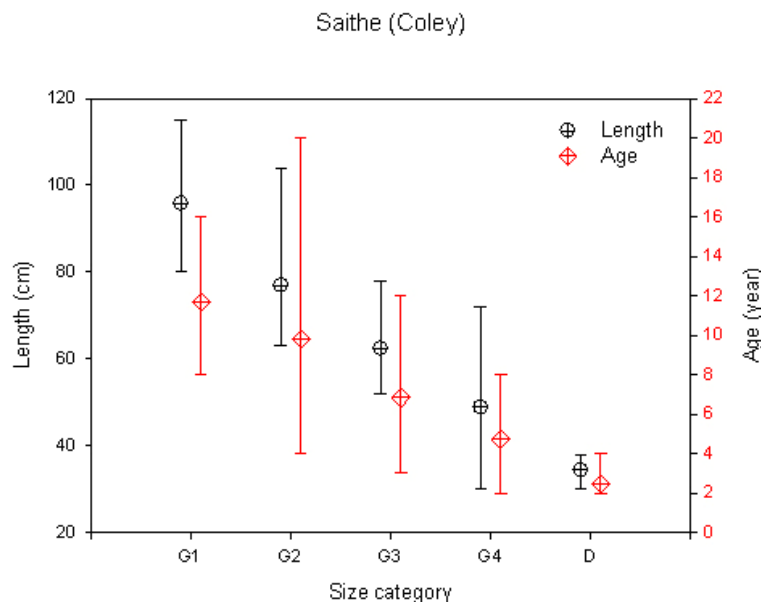


Fig. 9. Length (black) and age (red) of saithe found within various size categories. The whiskers show the range (minimum and maximum), and circles and diamonds the mean values. (G1=grade 1, G2 = grade 2, G3 = grade 3, G4 = grade 4, D = discarded saithe).

### 3.2.5 Saithe growth

Using the age-at-length data for saithe (13 500 fish aged) we can see how fish of different age grow over time. The 2006 year class of fish were first aged in the third quarter of 2007 (Fig. 10), and that age class grew from 12 cm to 35 cm in just 6 months. Growth rates slow considerably when saithe reach 40 cm long; in one year a saithe grows ~11 cm from 40 cm length (Fig. 10).

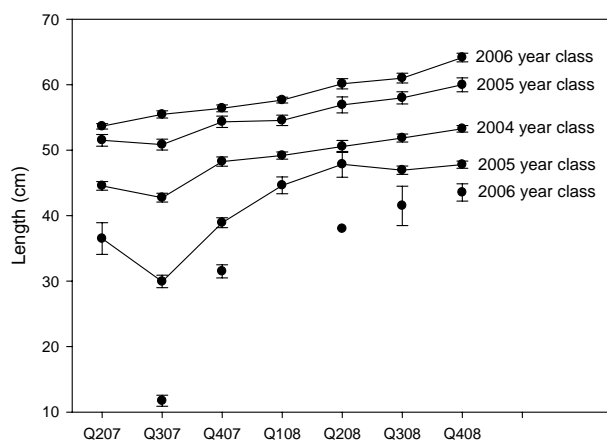


Fig.10. Fish length by year class and quarter for northern North Sea saithe.

Error bars show  $\pm 2$  standard errors

Q207 = quarter 2, 2007, Q307 = quarter 3, 2007, Q407 = quarter 4, 2007, Q108 = quarter 1 2008, Q208 = quarter 2 2008, Q308 = quarter 3 2008, Q408 = quarter 4 2008.

### 3.3 Cod

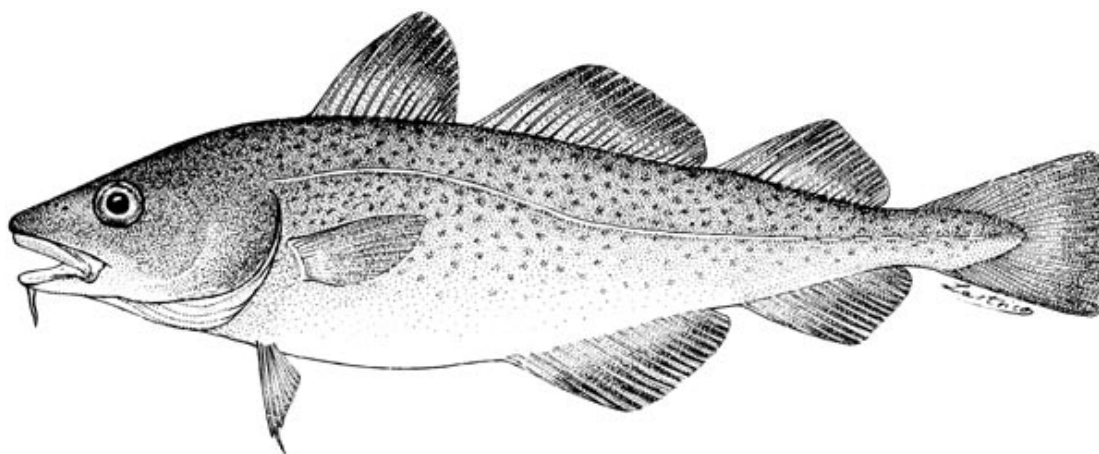


Illustration by Daniel M.Cohen Tadashi Inada Tomio Iwamoto Nadia Scialabba 1990. FAO Fisheries Synopsis, 125, Vol.10. Rome, FAO. 1990. 442 pp.

#### 3.3.1 Temporal catch patterns

The number of cod caught per month varied considerably throughout the period of study. Excluding July (very limited sampling) and August 2007 (no sampling), the number of cod caught per month ranged from 100 in May 2008 to 8200 in November

2008 (Fig. 11). Catch rates of cod were consistently low throughout the study period, but highest in September 2008 (20 fish per hour) and lowest in November 2008 (0.5 fish per hour). In general, catch rates of cod were highest in summer and declined in winter (Fig. 11). It is during this latter period when saithe catch rates in the fishery increase (Fig. 2).

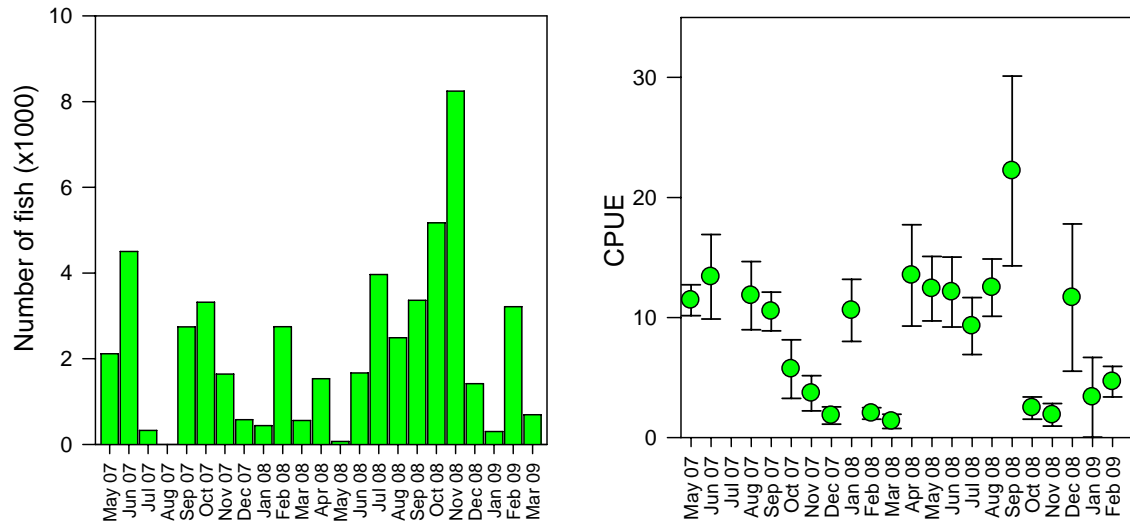


Fig.11. Numbers and CPUE of cod caught per month. Error bars show  $\pm$ standard errors

### 3.3.2 Year class catch patterns

One relatively strong year class of cod appeared in the catch composition of “Farnella”; 60% of all the cod caught over the 23-month study sampling period were of the 2005 year class (Figs 12, 14, and Table 5).

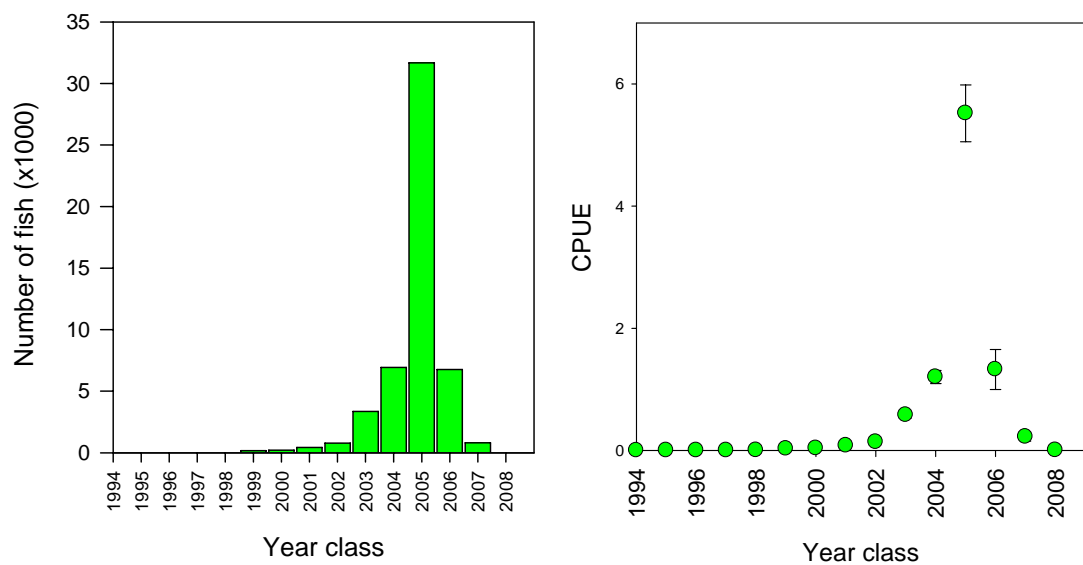


Fig.12. Numbers and CPUE of cod by year class Error bars show  $\pm$ standard errors

### 3.3.3 Spatial catch patterns

#### 2006 year class

Catches of the 2006 year class were low throughout the study period. In 2007 the 2006 year class constituted <1% of the cod caught, 10% in 2008 and 50% in 2009. Actual numbers caught, however, were low (Fig. 13, Table 5) Catches of the 2006 year class of cod are shown in Figure 13.

[Click on image to view animation](#)

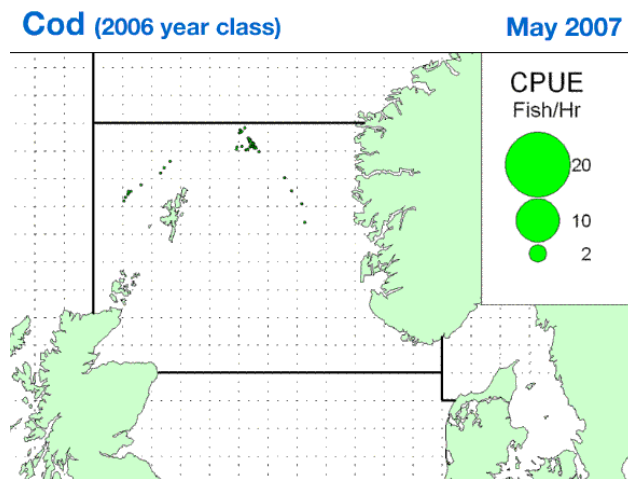


Fig.13. Cod (2006 year class) spatial catch patterns.

#### 2005 year class

The 2005 year class represented 61%, 69% and 22% of the 2007, 2008 and 2009 year classes, respectively, in the catches (see Table 5). In all, 52 000 cod were caught during the study, 30 000 (60%) of the 2005 year class (Fig. 12). In general, catches of cod decline during winter and increase during summer (Figs 11, 14). Spatial distributions of the 2005 year class of cod caught by “Farnella” are shown in Figure 14.

[Click on image to view animation](#)

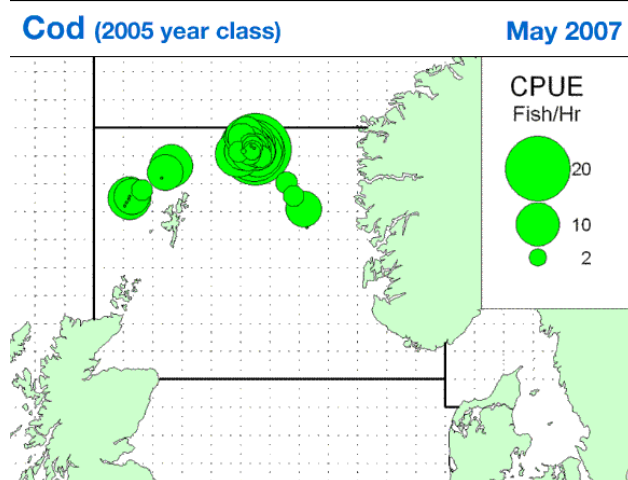


Fig.14. Cod (2005 year class) spatial catch patterns.

### Cod catch rates

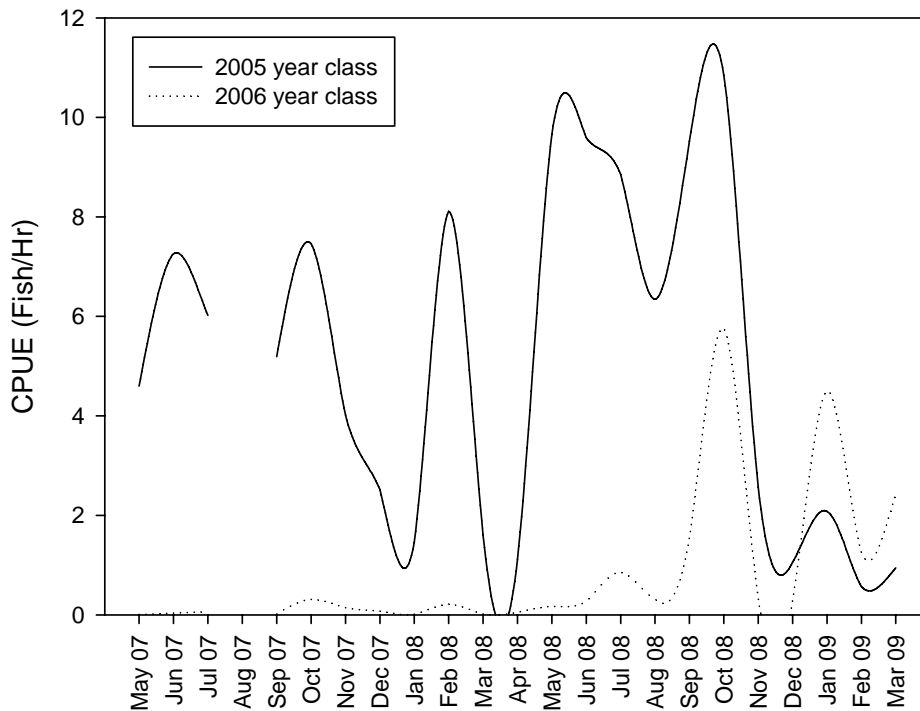


Fig. 15. Average catch rates of 2006 and 2005 year classes of cod.

#### Other year classes

The 2004 year class of cod represented a high proportion of the cod caught in 2007 and 2008 (Fig. 16, Table 5). In 2009 these fish (at 5 years old) made up <10% of the cod caught. “Farnella” only fished for the project for three months in 2009 but in that time, a new emerging year class, the 2006 year class, was coming through, with 50% of all cod caught coming from that year class. The distributions of the 2004 and 2006 year classes are shown in Figure 16.

Click on images to view animation

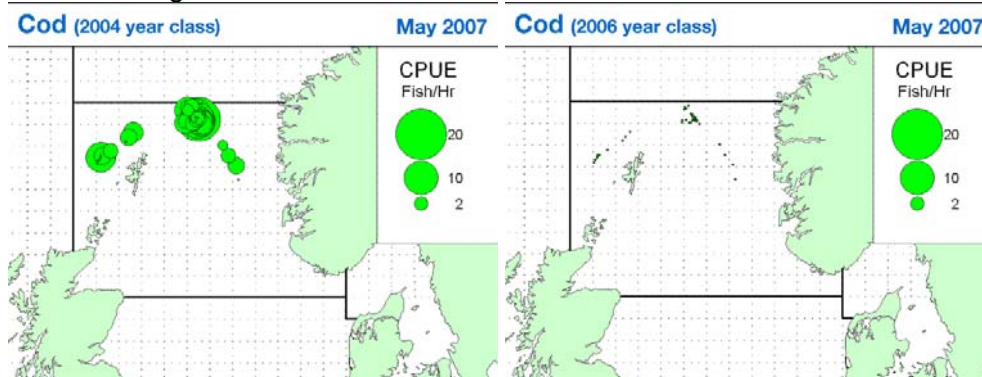


Fig.16. Cod (2006 year class) and (2004 yearclass) spatial catch patterns.

Other year classes of cod were few in number, fish older than the 2004 year class constituting <10% of the total number of cod caught during the project (Fig. 17).

Click on images to view animation

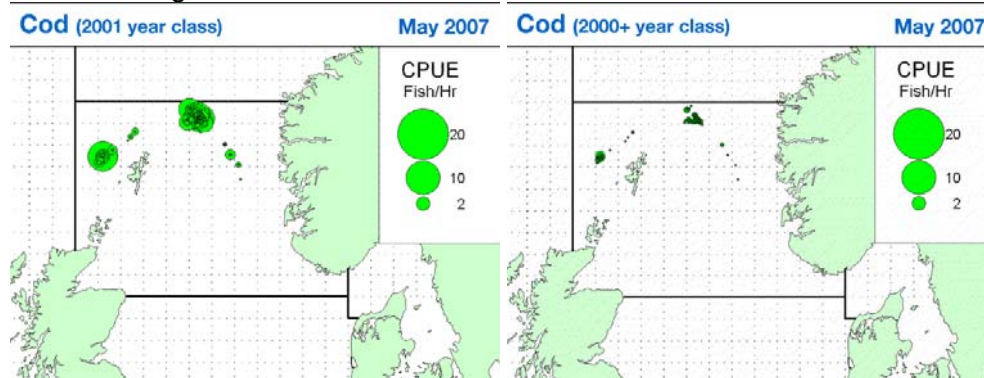


Fig.17. Cod (2001-2003 year classes) and (2000+ year-class) spatial catch patterns.

### 3.3.4 Size categories

Cod were caught and either discarded or graded into five size categories. The length and age distributions of each size category are shown in Figure 18. There is clear overlap between size categories with respect to fish length and age, much more so for cod than for saithe (Fig. 9).

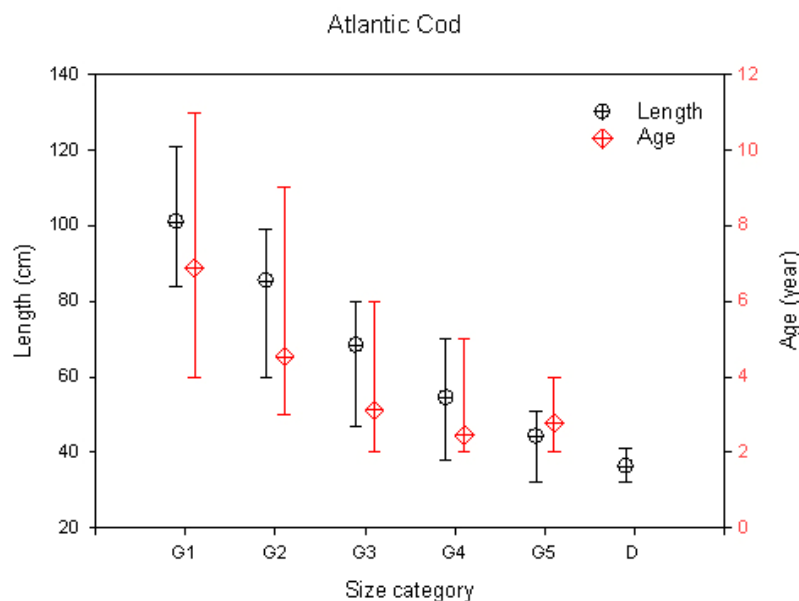


Fig. 18. Length (black) and ages (red) of cod found within various size categories. Whiskers show the range (minimum and maximum) and circles and diamonds the mean values (G1=grade 1, G2 = grade 2, G3 = grade 3, G4 = grade 4, G5 = grade 5, D = discarded cod).

### 3.3.5 Cod growth

The 2007 year class of cod were the youngest (1 year old) to enter the commercial fishery, but the 2005 year class still dominated the catch (Figs 12, 14). In the second quarter of 2007, cod of the 2005 year class had an average length of 46 cm and grew a further 12 cm to 58 cm in the following 12 months.

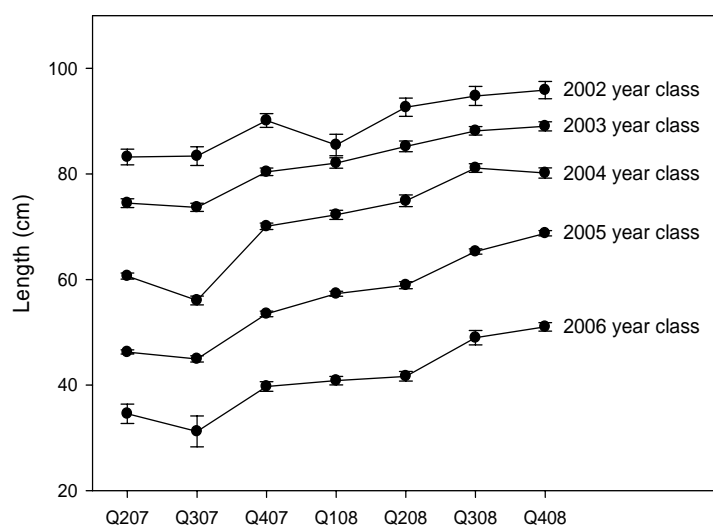


Fig.19. Fish length by year class and quarter for northern North Sea cod

Error bars show  $\pm 2$  standard errors

Q207 = quarter 2, 2007, Q307 = quarter 3, 2007, Q407 = quarter 4, 2007, Q108 = quarter 1 2008, Q208 = quarter 2 2008, Q308 = quarter 3 2008, Q408 = quarter 4 2008

### 3.4 Discards and bycatch

#### 3.4.1 Self-sampling data

Discarding of both species was low. In the 1135 hauls where cod were caught, 187 fish (117kg) were recorded as discarded (Table 4). The percentage of cod caught and subsequently discarded throughout the study period was <1% by weight and number. Of the saithe caught, less than 0.01% (by weight and number) was estimated to be discarded.

#### 3.4.2 Observer data

From the observer data, it is clear that discards of saithe and cod were definitely <1%, an impressive avoidance record of discards by the fishery. The data presented in Table 6 show the numbers of fish retained and discarded from one observer trip conducted in February 2009. Landings data were taken from the fishing activities database (FAD) for trips that MFV "Farnella" undertook while servicing this project. The FAD data (and observer data) both show that saithe landings dominated (>90%) the records (Fig. 20).

Table 6  
Species encountered on one observed trip (Annex 1.3).

| COMMON NAME              | LATIN NAME                   | RETAINED      | DISCARDED    | %DISCARDED |
|--------------------------|------------------------------|---------------|--------------|------------|
| <b>SAITHE</b>            | <b>POLLACHIUS VIRENS</b>     | 59,152        | 386          | 0.6        |
| COMMON LING              | MOLVA MOLVA                  | 2,516         | 1            | 0.1        |
| HADDOCK                  | MELANOGRAMMUS AEGLEFINUS     | 1,314         | 15           | 1.1        |
| REDFISHES                | SEBASTES SPP                 | 350           | 339          | 49.2       |
| EUROPEAN HAKE            | MERLUCCIIUS MERLUCCIIUS      | 19            | 421          | 95.7       |
| GREY GURNARD             | EUTRIGLA GURNARDUS           | 0             | 392          | 100.0      |
| RABBIT FISH(RAT-TAIL)    | CHIMAERA MONSTROSA           | 0             | 358          | 100.0      |
| (EUROPEAN) MACKEREL      | SCOMBER SCOMBRUS             | 0             | 279          | 100.0      |
| SQUID                    | OMMASTREPHIDAE               | 0             | 221          | 100.0      |
| <b>COD</b>               | <b>GADUS MORHUA</b>          | 169           | 1            | 0.8        |
| ANGLERFISH (MONK)        | LOPHIUS PISCATORIUS          | 130           | 1            | 1.0        |
| WHITING                  | MERLANGIUS MERLANGUS         | 126           | 3            | 2.1        |
| MEGRIM                   | LEPIDORHOMBUS WHIFFIAGONIS   | 51            | 54           | 51.3       |
| TUSK                     | BROSME BROSME                | 82            | 3            | 3.2        |
| CUCKOO RAY               | RAJA NAEVUS                  | 0             | 77           | 100.0      |
| WITCH                    | GLYPTOCEPHALUS CYNOGLOSSUS   | 0             | 76           | 100.0      |
| ARGENTINES               | ARGENTINIDAE                 | 0             | 54           | 100.0      |
| NORTHERN SQUID           | LOLIGO FORBESI               | 0             | 50           | 100.0      |
| GREATER FORKBEARD        | PHYCIS BLENNOIDES            | 0             | 49           | 100.0      |
| ROUND SKATE              | RAJA FYLLAE                  | 0             | 36           | 100.0      |
| STARRY RAY               | RAJA RADIATA                 | 0             | 31           | 100.0      |
| NORWAY POUT              | TRISOPTERUS ESMARKI          | 0             | 31           | 100.0      |
| CATFISHES                | ANARHICHAS SPP               | 28            | 0            | 0.0        |
| BLUE WHITING             | MICROMESISTIUS POUTASSOU     | 0             | 27           | 100.0      |
| AMERICAN PLAICE (LR DAB) | HIPPOGLOSSOIDES PLATESSOIDES | 0             | 26           | 100.0      |
| HERRING                  | CLUPEA HARENGUS              | 0             | 14           | 100.0      |
| NORWAY LOBSTER           | NEPHROPS NORVEGICUS          | 0             | 11           | 100.0      |
| RED GURNARD              | ASPITRIGLA CUCULUS           | 0             | 5            | 100.0      |
| LEMON SOLE               | MICROSTOMUS KITT             | 5             | 0            | 0.0        |
| BLACKMOUTHED DOGFISH     | GALEUS MELASTOMUS            | 0             | 5            | 100.0      |
| HALIBUT                  | HIPPOGLOSSUS HIPPOGLOSSUS    | 5             | 0            | 0.0        |
| BLUE LING                | MOLVA DYPTELYGIA             | 4             | 0            | 0.0        |
| POLLACK                  | POLLACHIUS POLLACHIUS        | 3             | 0            | 0.0        |
| WHITE-ANGLERFISH         | LOPHIUS BUDEGASSA            | 3             | 0            | 0.0        |
| COMMON DRAGONET          | CALLIONYMUS LYRA             | 0             | 1            | 100.0      |
| ROSE FISH                | SEBASTES MENTELLA            | 1             | 0            | 0.0        |
| DAB                      | LIMANDA LIMANDA              | 0             | 1            | 100.0      |
| LONG-NOSE SKATE          | RAJA OXYRINCHUS              | 0             | 1            | 100.0      |
| <b>TOTAL</b>             |                              | <b>63,958</b> | <b>2,970</b> | <b>4.4</b> |

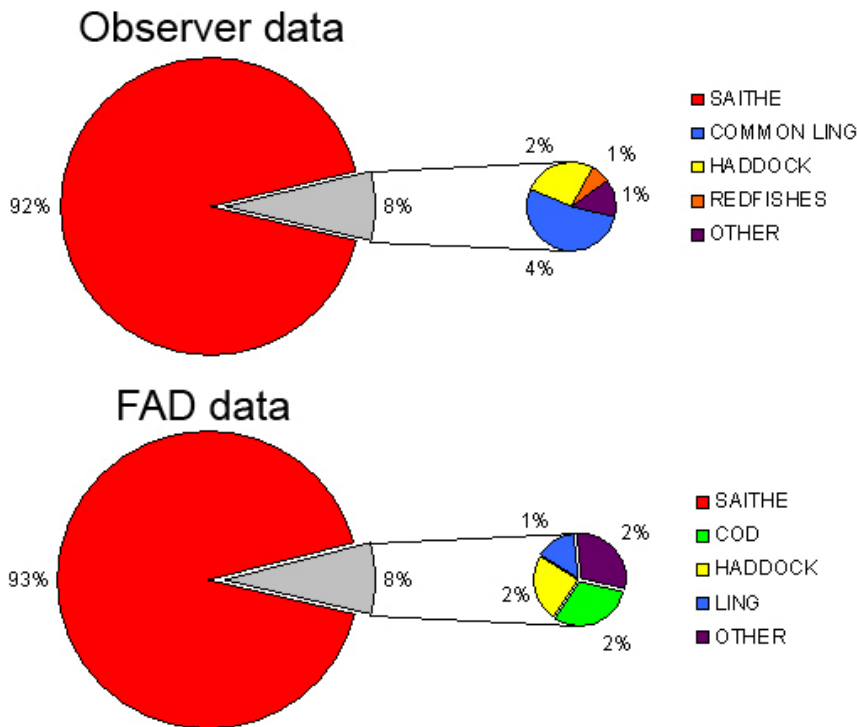


Fig. 20. Catch composition comparisons between observer data and that from the fishing activities database.

#### 4. Discussion

The northern North Sea saithe fishery is an example of a single-species fishery. Although the vessel was requested to collect catch data on cod and saithe only, observers who accompanied the trips reported low bycatch (Figure 20) and their observation data supported the low discard value calculated overall for the study (0.01% by number, Tables 4, 6). Discard rates in this fishery are indeed very low when compared with those of demersal otter trawlers fishing in other parts of the North Sea (Enever *et al.* 2008) and furthermore, are some of the lowest recorded in the world (Kelleher 2005).

Both cod and saithe are widespread in their distribution throughout the North Sea. However, the data show that at certain times of the year and in certain areas of the northern North Sea, the catch rates of both species vary. For saithe, catch rates are generally better in winter (November – March) than in summer (May – September), by a factor of three (Fig. 2). During winter, it is thought that the better catch rates are attributable to large spawning aggregations being present on the fishing grounds. Moreover, this pattern of seasonal abundance is opposite that of cod (Fig. 11) and could suggest some behavioural interaction between the two species. A saithe–cod relationship in which large catches of saithe cause low catches of cod and *vice versa* was also documented by Cotter *et al.* (2004).

For the study period at least, saithe appear to have had three strong year classes in the fishery; the 2002 (7 year olds in 2009), 2004 (5 year olds) and 2005 (4 year olds) year classes. These combined made up two-thirds of the estimated 3.3 million saithe caught by the “Farnella” during the study period. The hypothesis behind this study is

that the 2005 and 2004 year classes could contribute significantly to predicted saithe landings in 2008 and thence contribute to the spawning stock in 2009. This hypothesis is supported by the results of this study. Indeed the 2005 and 2004 year classes of saithe contributed to more than half the fish landed by “Farnella” (Table 5, Fig. 3).

On average, cod catches were small throughout the 23 months of the project, and remained a small portion of the vessel’s landings (Tables 4, 5). Suggestions that the 2005 year class of cod may be stronger than previous years are well substantiated by the data presented here (Figs 10, 12), though there are no records for earlier years (at least for years when recruitment was good) with which to compare the cod catches made during this project. Of the ~52 000 cod caught during the study period, ~30 000 (60%) were aged 4 in 2009 (the 2005 year class) fish. The 2004 year class (5 year olds) were not as abundant (13% of the catch). Moreover, cod older than the 2004 year class are now scarce in the catches (Figs 10, 13).

The Farnella for the two years of the project provided accurate catch data for every haul. Alongside this effort, they measured more than 75 000 fish, an impressive number in anyone’s book. These data have allowed us to plot the fine-scale distributions of cod and saithe in the northern North Sea and to answer some of the important questions surrounding the biology and management of two key commercial species in the North Sea. We have shown, for instance, which year classes are dominant for the two species targeted, and how these year classes move in and out of the fishery. Previously, this information has been expensive to gather, but this project has demonstrated that fisheries data of high resolution can be collected by suitably trained fishermen, as long as regular quality control is applied, to preclude the effects of data-quality loss with time. Furthermore, and most importantly, this is a clear example of how fishermen and scientists can work together for prolonged periods of time to achieve a common goal – in this case a true Fisheries Science Partnership.

### **Acknowledgements**

Thanks go to Skippers John Musgrave and Charles Waddy, Mate Alan Netherton, 1<sup>st</sup> Engineer Tomislav Bukolic, Chef Steve (Rimmer) Rimmington, 2<sup>nd</sup> Engineer Janis Pencis, and deckhands Kevin Moore, Sean O’Keith, Joe Regan, Lee Utting, Lee Norrie and Carl Burstle. Particular recognition should go to Boatswain Roy Feve for his excellent and professional approach to the sampling effort and data recording throughout this programme.

***A massive thank you to the skipper and crew of the FV Farnella***



I also thank Marine Scotland – Marine Laboratory, Aberdeen, for providing us with most of the cod and saithe age data that allowed us to analyse the catch in the way we felt most appropriate. Thanks are also due to Cefas colleagues Andrew Payne, Randolph Velterop, Oliver Wade, Allan Reese, Christine Smith, Mary Brown, Mark Etherton, Matthew Oxborrow and Donald Malone for various support in bringing this massive database to useful fruition.

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## Annex

### 1.1 OBSERVER TRIP 1

**Cruise Report Narrative :** FV Farnella (H135)

**Skipper:** John Musgrave

**Observers:** 1. Randolph Velterop (CEFAS) 6th –17th June 2007

**Gear:** Demersal groundfish gear with 110mm codend mesh

**Duration:** Self-sampling will be carried out on commercial trips undertaken over a 12 month period (March 07 – March 08) with a minimum of 200 sea days. Two \*10 day observer trips will take place in quarter 2 and quarter 4.

**Area:** ICES sub-area IVa

**Aims:** To describe the fine scale distribution and abundance in time and space of saithe and cod, including specific information on the 2004 and 2005 year classes of saithe and 2005 and 2006 year classes of cod.

FARNELLA sailed from Scarbster harbour at 23:00 UTC on Wednesday 6<sup>th</sup> June 2007 and steamed to the north past the west side of Shetlands to grounds known as North Flugga, shooting at 14:05 Hrs on Thursday 7<sup>th</sup> June.

After completing 7 hauls in Flugga Farnella towed towards the Magnus Oil Field shooting at 14:30 on Saturday 9<sup>th</sup> June. A large object was snagged at 19:30. Slipping the warps seemed to remove the object; though hauling at 20:30 revealed this was not the case as a 6ft crane hook had ripped the headline and top of the net. Fishing continued in Magnus, Tampen, Flugga and Submarine with average hauls of fish (50-100 baskets per haul).

On Wednesday after steaming for 2 hours fishing commenced near the Heather Oil Field. Two tows were completed with again poor fishing before cod ends were changed from 110mm to 120mm and the Farnella steamed towards the Gulfaks Oil Field in the Norwegian sector to complete 2 further tows. The remaining tows were carried out near Udshire Hole, Klondyke and Coral Bank, before finally hauling at 00:30 on Sunday 17<sup>th</sup> June and steaming to Hanstholm in Denmark where the catch was landed.

This was the longest commercial trip Farnella has undertaken this year, and reflected the average Saithe fishing for this time of year. Fishing is generally considered to be poor during the summer period as Saithe are constantly moving chasing feed.

Of the 34 hauls carried out during the trip 32 were sampled with the collection of 825 otoliths (402 saithe, 423 cod).

I would like to acknowledge the efforts of the skipper and crew of the Farnella and thank them for their hospitality and ongoing help during the survey.

(Seen in draft by skipper)  
Randolph Velterop 17/6/07

## 1.2 OBSERVER TRIP 2

**Cruise Report Narrative :** FV Farnella (H135)

**Skipper:** Charlie Waddy

**Observers:** 1. Oliver Wade (CEFAS) 24th February –2nd March 2008

The Farnella sailed from Hanstolm in northern Denmark at 17:00 on Sunday the 24<sup>th</sup> February in a SW 8 Gale. She steamed north for over 24 hours to the Alwyn oil fields, known as the 'twin towers', to grounds traditionally associated with plentiful catches of small Saithe. The first haul was shot away at 20:30 on the 25<sup>th</sup> February.

Two hauls were shot here and then the Farnella steamed further north to the grounds around the Magnus rig where there is a good mixed fishery and the first larger fish were seen.

On Thursday the 27<sup>th</sup> February the Farnella was to be found to the Northeast of the Shetlands fishing an area known as the 'tampen finger', again with plentiful catches of grade 3 and grade 4 Saithe. That evening the Farnella steamed back south to the area around the Magnus rig again to try and find some larger fish.

The ship and crew had a long, rough steam home on Saturday the 1<sup>st</sup> March, sheltering from the storm in the lee of the Shetland and Orkney Islands and landed in Scrabster at 3:00 am on Sunday the 2<sup>nd</sup> March.

### 1.3 OBSERVER TRIP 3

**Cruise Report Narrative :** FV Farnella (H135)

**Skipper:** John Musgrave

**Observers:** 1. Jon Ashworth (CEFAS) 01<sup>th</sup> February –09<sup>th</sup> February 2009 March 2008

02-03/02/09

Farnella shot in the vicinity of the Gullsfak gas field at 17:30 hauling 6hrs later for a disappointing 17 baskets of small Saithe. Skipper Musgrave then shot on a deeper contour for slightly better results but still not good enough, two more shots were made in beautiful calm conditions before the decision was made to steam NW into the UK sector, whilst waiting for clearance to exit the Norwegian sector and enter the UK sector skipper Musgrave shot haul 5 on the 180m contour in order to keep the boat fishing. Insufficient fish here meant that the skipper got the gear aboard again and continued into the UK sector to an area known as Tampen a spit of shoal ground where news of good fishing had been received from several boats.

04-05/02/09

Haul 6 in the area known as Tampen was disappointing, however, subsequent shots in the same area proved slightly more promising, average hauls through the day were around 70-80 baskets. Fish was spread out and quite difficult to pin down, approximately 9 other boats were fishing in the area, from Poland, France, Germany, UK and Norway (the Norwegians were not allowed to fish north of the 62 degree line unlike the other vessels, this seemed to be the area where Saithe was most abundant).

Haul 8 on the 5<sup>th</sup> produced 118 baskets for 6hrs and haul 9 nearer 235 baskets of Saithe for 4hrs. The general run of fish in haul 8 was quite small (mainly category 4), however this improved on haul number 9 where the majority of fish were category 3 this is the most desirable size as it generally makes best money at market. Haul 10 and 11 produced 92 and 88 baskets of Saithe respectively, haul 11 shot in approximately 400meters produced the highest rate of general discards observed so far although the great majority of species were of no marketable value such as Rabbitfish (*Chimera monstrosa*) and Starry ray (*Raja radiata*).

06/02/09

By the morning of the 6<sup>th</sup> many of the trawlers had dispersed and skipper Musgrave was close to steaming elsewhere, however, towards the end of haul 13 encouraging marks were noticed on the sounder and the trawl was shot back for another go, fishing remained steady with haul 14 producing 85 baskets so without any firm information about how other boats were doing skipper Musgrave shot back. Haul 15 came fast after only 1.5 hours and was not sampled, haul 16 was shot back but retrieved after only 1.75 hours as information received suggested good fishing around Pinguin oil field.

07/02/09

Skipper Musgrave steamed to the area and shot haul 17 with a wing end tickler of 3/8" chain. Haul 17 produced 110 baskets of mainly category 3 and 4 Saithe. Haul 18 produced 91 baskets but haul 19 and 20 produced 286 baskets and 223 baskets respectively, catching approximately 25% of the trip so far in less than 8 hours. Vessels around the Farnella, some much larger, were only managing 100 to 120 basket hauls and skipper Musgrave believed that his success was down to the use of the tickler chain as the marks he was seeing were very tight to the seabed. This was supported as night fell and the fish rose from the seabed as the next haul produced 105 baskets of mainly category 4 Saithe.08/02/09

The Farnella steamed South for approximately 1 hour as skipper Musgrave waited for confirmation on where the Farnella should land, haul 22 was shot in the vicinity of Strathspey well heads for a much more mixed catch of fish, some of the largest Saithe for the trip were encountered here and the largest haul of Cod (46 fish). The next haul was the last and skipper Musgrave continued to tow in Southerly direction towards the Alwyn oil field, the

tickler chain parted this haul and the result was a disappointing bag of less than 30 baskets, mainly Haddock.

The Farnella was underway by 13:30 to land the fish at Peterhead on Monday for sale in France on Tuesday. Skipper Musgrave was happy with the trip considering it to be both successful in terms of fish caught and efficient in terms of fuel and gear.