

Joint Swedish and Danish survey for cod in the Kattegat November-December 2014

Marie Storr-Paulsen and Ole Jørgsen
DTU-Aqua, Charlottenlund Slot, DK 2920 Charlottenlund, Denmark
and
Katja Ringdahl and Johan Lövgren
Havsfiskelaboratoriet, Fiskeriverket, Box 4, 453 21, Lysekil, Sweden

Abstract

An annual survey targeting cod in Kattegat was initiated in 2008 and has been conducted for the 6th year in 2014 (In 2012 no survey was conducted). The survey is conducted every year in November-December by four commercial trawlers from Denmark and Sweden and the design and number of hauls (80) has been unchanged during the years. The catches of cod were generally very much increasing in 2014.

Introduction

Since 2003 the cod fishery in Kattegat has been restricted by steadily decreasing quotas due to low abundance of cod estimated from the cod assessment. ICES consider, however, the cod assessment in Kattegat uncertain due to the catch data quality and the analytic assessment has not been accepted by ACFM/ACOM in recent years. The assessment has shown a discrepancy between the reported landings and total removals from the stock and ICES assumed that the majority of the unallocated mortality was caused by discard, but other factors such as migration, non reported landings and re-allocation of catches also could be part of the problem. Therefore, the assessment has to be largely based on available fisheries independent survey information. The surveys conducted previously in the Kattegat area were however not well suited for estimation of total cod abundance mainly due to poor coverage and sampling intensity. This implies that also the relative abundance indices obtained from these surveys were relatively noisy, especially for older ages. In 2008 a joint Swedish – Danish survey series directly aimed at cod and with better coverage of the area was initiated.

The goal of the Kattegat cod survey is to provide fisheries independent data for estimating the abundance, biomass, recruitment index and distribution of cod. The results should be used to strengthen the scientific advice on the cod stock in Kattegat. Due to its considerably better coverage compared to hitherto available surveys, the joint Swedish and Danish Kattegat cod survey improves the knowledge of spatial distribution of cod by size/age-groups and provides valuable information for monitoring the effect of the closed area established in the Kattegat from January 1. 2009.

Restrictions

The four commercial trawlers participating in the survey conduct the survey without any restrictions in the vessels quota, days at sea regulation and with dispensation from all by-catch regulations.

Materials and Methods

Survey design

Survey area

The survey area is covering Kattegat area restricted northward by a line from Skagen to the Tistlarna lighthouse and south-eastward by a line between Gilleleje and Kullen and south-westward by a line between Gniben and Hassensør on Djursland. Further, the area is restricted by the 20 m depth contour line and the area is split in areas "North" and "South". However, the two fjords Laholmsbugten and Skældervigen are also included in the survey area despite that the depth is shallower than 20 meter

Survey method and stratification

The survey is designed as a stratified random bottom trawl survey. The survey area is stratified in three strata: a stratum with expected high density of cod, a stratum with medium density and a stratum with low density of cod based on information from the fishers. Each stratum is further subdivided in 5*5 nm squares (sections). The high density stratum has been allocated relatively more stations than the other strata (Fig 1). The survey has been conducted since 2008 with a gap in 2012 and only Swedish vessels participating in 2013.). In 2010 and 2011 there were a minor re-stratification to adopt the areas to the catch information collected during the former years. The survey strata was moderated slightly in 2013 to take into account the closed area very a separate strata has been placed.

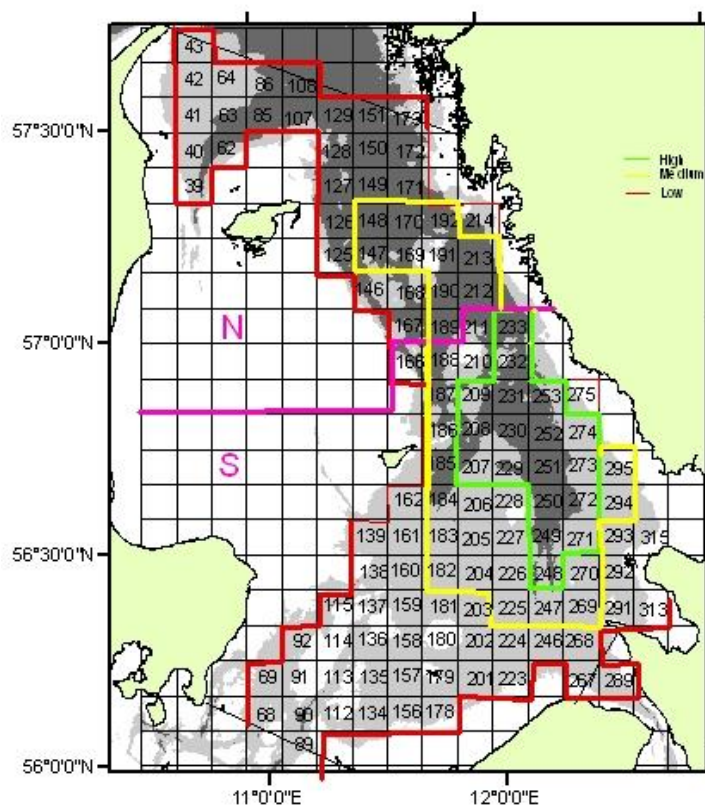


Fig 1. The re-stratified survey area with section numbers. **Green** High density of cod. **Yellow** Medium density. **Red** Low density. **N** and **S** Northern and southern area, respectively.

Station (tow) location

The survey is planned with in average 3.3 trawl hauls per day in 6 days for each of the 4 vessels, i.e. in total 80 trawl hauls. The hauls are allocated randomly to the 5*5 nm squares and each vessel will fish in 20 different squares. In the high and medium density strata several vessels are allowed to fish in the same square. In the low density stratum only one haul is allowed in each square. Furthermore the low density area is divided in a Southern, Northern, Eastern and Western area. The 2 Danish vessels fish in the Western low density area and the two Swedish vessel fish in the two Eastern areas.

Numbers of stations by vessel, stratum and area

Ship	High density	Medium density	Low density (South)	Low density (North)	Closed area	Total
Den ₁	6	5	7		2	20
Den ₂	6	5		7	2	20
Swe ₁	6	5	7		2	20
Swe ₂	6	5		7	2	20

Target species

The survey is directed against and designed for cod, but the catch of all species is, however, recorded.

Survey period

The survey took place during November 22 - December 10, 2011.

Vessels and Fishing gear

Vessels

The survey is conducted by four commercial chartered trawlers, two covering the northern and two the southern area, respectively. Two vessels are Swedish and the other two are Danish. The vessels have been appointed due to the similarity in engine power, length and applicability for scientific investigations.

DK-Vessel 1

DK-Vessel 1

Danish participant	1 (H 79 "TIK".)
Engine (KW):	309 kW
Tonnage (BRT):	42
Length (m):	17
Door type/size	
Owner	Poul Erik Hansen

DK-Vessel 2

Danish participant	2 (FN261- Stjerne)
Engine (KW):	220 kW
Tonnage (BRT):	20
Length (m):	17
Door type/size	
Owner	John Jerup

SW-Vessel 1

Swedish participant	1 (VG 37 – Ganler)
Engine (KW):	373 kW
Tonnage (BRT):	74
Length (m):	17.94
Door type/size	
Owner	Kjell Svahn

SW-Vessel 2

Swedish participant	2 (VG 104 – Tärnan)
Engine (KW):	272 kW
Tonnage (BRT):	68
Length (m):	15.73
Door type/size	
Owner	Börje Nilsson

Gear

The trawl is a commercial bottom trawl provided by the EC LOT 3 project.

Trawl (see Annex 1): A Swedish TV-trawl 112 ft 24-464 mounted with 13 8'' balls and 16 6'' balls.

Ground gear: Rock hopper type with 4 thumps rubber discs at 10 cm

Mesh size in cod end: 70 mm stretch mesh.

Otter boards: 64''-66" "Thyborøn"

Warp: 15 mm.

The trawls are checked continuously during the survey.

Fishing operation

Within each square the skipper decides on the best way to fish at the location (e.g. exact position and tow direction). Maximum 5 min of the total trawling time should be outside the allocated square. If the 5 minutes are exceeded the haul should be terminated.

Trawling was restricted to 15 min. before sunrise to 15 min. after sun set.

Trawl procedure:

Towing time: 60 min (towing time down to 20 min is accepted).

Towing speed: Between 2.7 kn. and 3.4 over the seabed, but speed should not vary within a station.

Hauls start: when the trawl is considered going stable on the bottom, roughly 5-7 min after wires are connected.

Haul end: when hauling back starts.

Trawled distance: is estimated from the plotter or by the mean of the towing speed recoded every 10 min. and the total towing time.

Sampling of catch

There were two technicians/scientists from DTU-Aqua (Danish vessels) or Fiskeriverket (Swedish vessels), on board each vessel who were responsible for processing the catch.

The catch was processed in accordance with BITS standard operating procedures for trawl surveys. After each haul the catch was sorted by species and weighed to nearest 0.1 kg and the number of specimens recorded. All fish species are measured as total length (TL) to 1.0 cm below. Norwegian lobster was measured in mm.

In total 910 otoliths were sampled for age determination.

Screening of data

All trawl data (position, wingspread, towing speed etc.) and catch and length frequency data on cod were screened for unrealistic figures before further estimations.

Data

Data are stored in a standard data base and could, if the survey continues, be uploaded to the ICES DATRAS system.

Estimation of stock indices

CPUE

CPUE is estimated as mean catch (kg or number at age) per hour.

Survey area

Hence no stations are deeper than 100 m, biomass and abundance is estimated for depths between 20 and 100 m (including the two shallow fjords Laholmsbugten and Skældervigen). The survey area is stratified in three density strata: HIGH, MEDIUM and LOW. The total survey area is 10204 km² (Table 1).

Table 1. Areas distributed on strata.

High density	Medium density	Low density	Closed area	All
21 squares	26 squares	65 squares	8 squares	120 squares
1800.8 km ²	2229.5 km ²	5573.8 km ²	686 km ²	10290 km ²

Biomass and abundance

Two different approaches were used in the biomass and abundance estimation. 1) A traditional Swept area calculation where mean catch km⁻² is multiplied with the stratum area and a 2) GRASP (General Regression model for spatial predictions).

1) Biomass and abundance estimates are obtained by applying the swept area method using the recorded towed distance and wing spread and the stratum area as weighting factor (Cohran, 1977). Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length} \times \text{Door spread}}{\text{Bridle length} + \text{Ground gear length}}$$

Door spread is estimated for the single hauls, using a warp divergence method (Anon. 2006) (Annex 1).

Swept area = (distance towed (nm) * 1.852) * (wing spread(m) / 1000)

The catchability coefficient is assumed to be 1.0.

All catches are standardized to 1 km² swept prior to further calculations.

Over all S.E. is estimated using the stratum area as weighting factor.

2) GRASP is a general method for making spatial predictions of a response variables using point surveys of the response variables and spatial coverage of predictor variables. We used GRASP to estimate the total fishable biomass of Kattegat cod using the swept area method based on survey data. GRAPS allows integrating data on bottom complexity, hydrographic variables, and all other kind of predictor variables that are spatially referenced and to use such models to produce predictions of biomass and abundance. GRASP models will produce estimates of stock size that are independent on catch based VPA kind of modeling and thus provide alternative stock estimates compared to traditional assessment models.

For obtaining absolute estimates of cod biomass, we included a length based logistic model of cod catchability as estimated by Haley and Myers (2001) derived from IBTS surveys for the summer/autumn period in the North Sea and Skagerrak. The 50th and the 5th percentiles of the estimated parameters of the catchability models (Haley and Myers (2001) were used to calculate the length specific catchability of cod. For comparison, a model where catchability coefficient is assumed to be 1.0 for all length classes was also used.

Results

All 80 planned stations were covered. Only results on cod are presented although information on a number of other species was collected.

Cod

Cod was caught at all 80 stations. The catches were, however, generally low (Annex 3) but with the highest catches in the high density area and lowest in the low density area.

The distribution of cod catches in numbers and weight is given in Fig 2.

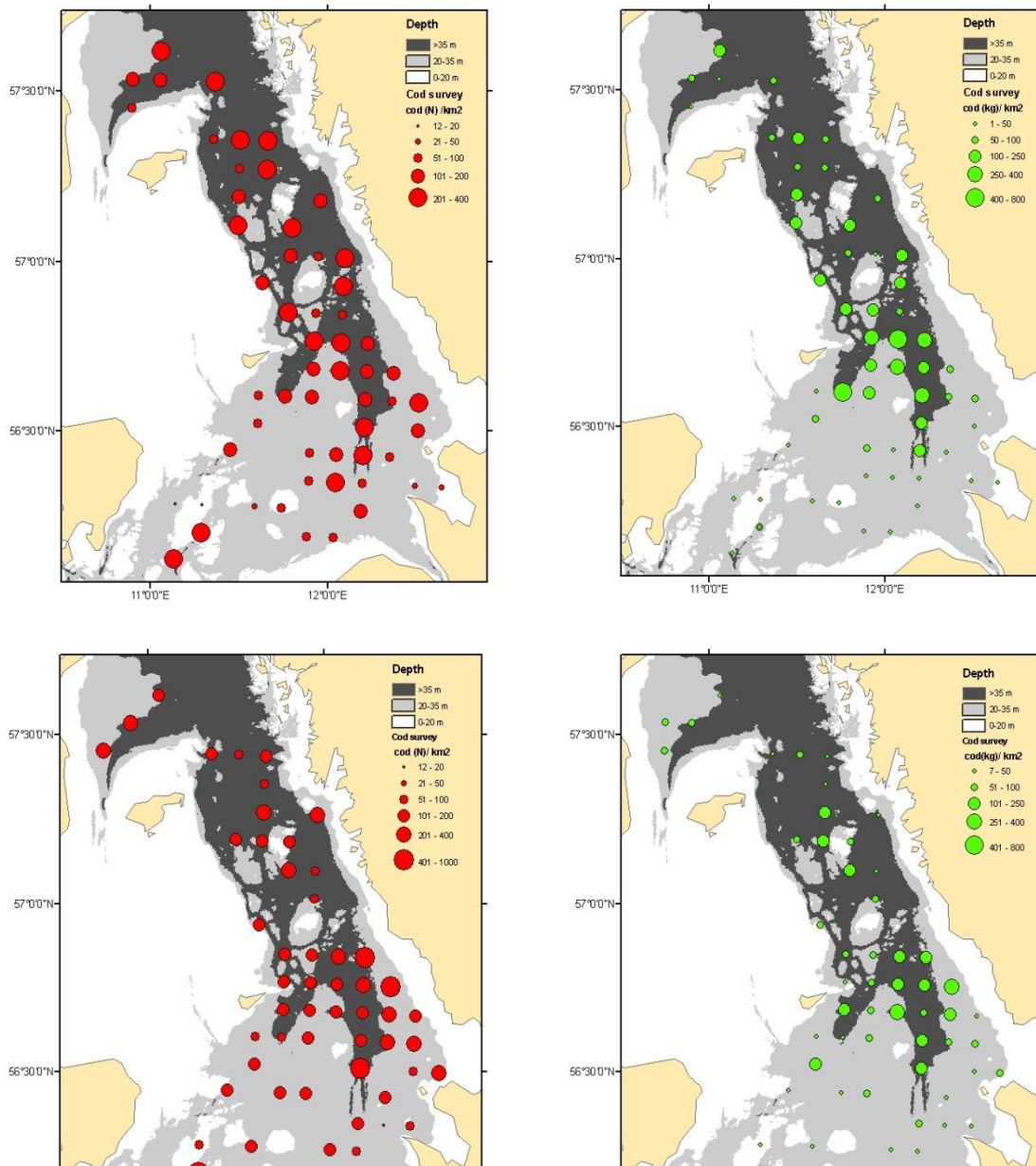
Biomass and abundance by method 1.

The trawlable biomass of cod was in 2011 estimated at 944.5 tons compared to 739.6 tons in 2010 (Table 2). The highest density (0.28 ton per km²) and biomass (434.6 tons) was found in the high density area (Table 3).

Table 2. Biomass (tons) and abundance of cod with S.E. together with weight and number km⁻² by year.

Year	Biomass	S.E	Wight km ⁻²	Abundance	S.E.	Number km ⁻²
2008	1008.4	125.9	0.0997	1.55*10 ⁶	0.12*10 ⁶	152.7
2009	776.3	86.8	0.0767	2.10*10 ⁶	0.30*10 ⁶	207.9
2010	739.6	101.9	0.0725	2.55*10 ⁶	0.12*10 ⁶	210.5
2011	944.5	126.1	0.0926	2.07*10 ⁶	0.20*10 ⁶	202.7

The trawlable abundance was in 2011 estimated at 2.07*10⁶ compared to an estimated at 2.55 mill. (Table 2) in 2010. The highest density was observed in the high density area, 350 specimens per km², while the largest abundance 0.94*10⁶ was found in the low density area (Table 4)



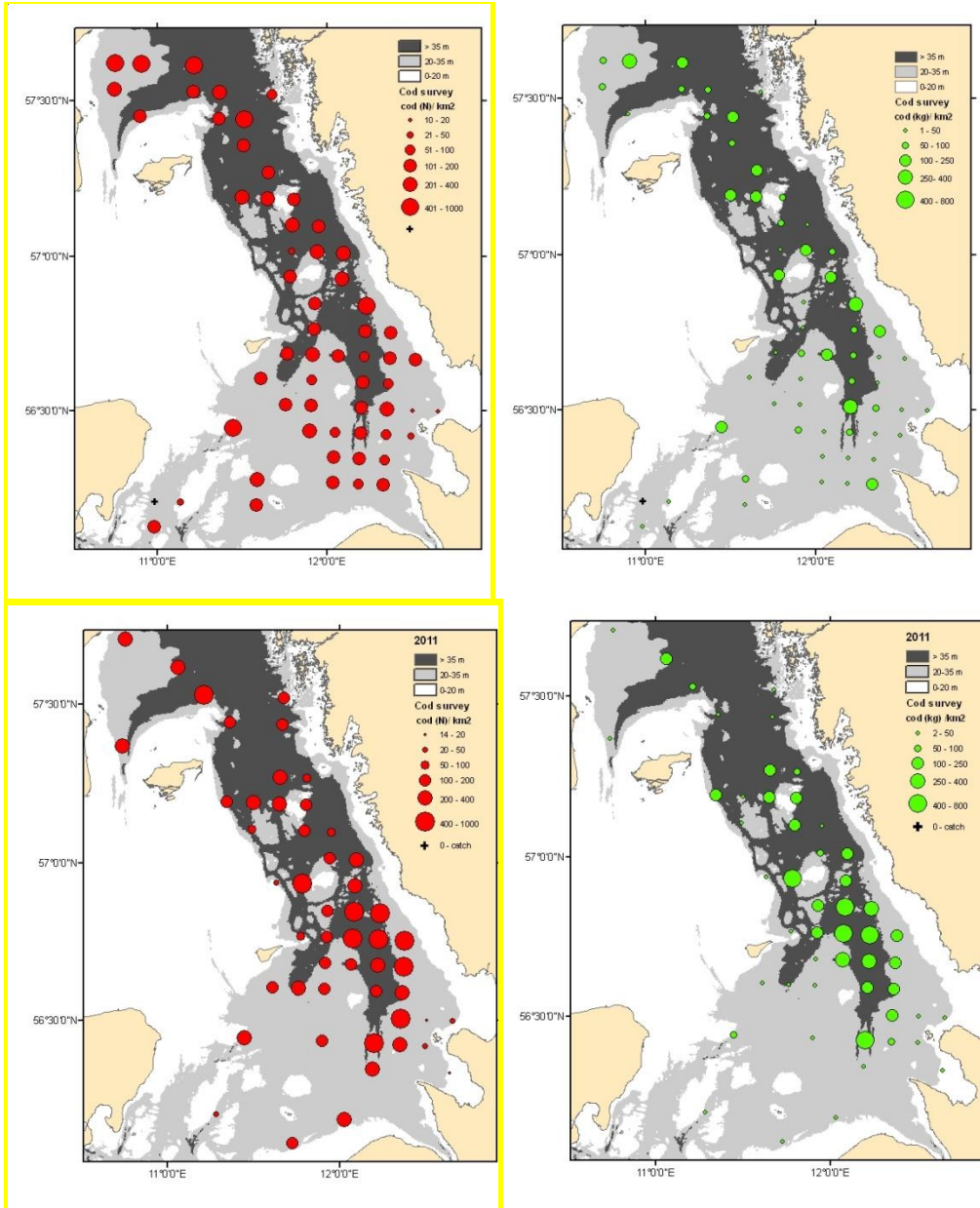


Figure 2. Abundance (left) and biomass (right) of cod per km² calculated as an average from all vessels per square. Upper panel 2008 mid panel 2009, lower panel 2010 and 2011

Table 3. Cod 2011. Total biomass (tons), area, number of hauls, mean biomass per km² (tons), and Standard Error by density strata (Div.).

1	1000	1000	1000	1000	1000
2	1000	1000	1000	1000	1000
3	1000	1000	1000	1000	1000
4	1000	1000	1000	1000	1000
5	1000	1000	1000	1000	1000
6	1000	1000	1000	1000	1000
7	1000	1000	1000	1000	1000
8	1000	1000	1000	1000	1000
9	1000	1000	1000	1000	1000
10	1000	1000	1000	1000	1000
11	1000	1000	1000	1000	1000
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13	1000	1000	1000	1000	1000
14	1000	1000	1000	1000	1000
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16	1000	1000	1000	1000	1000
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18	1000	1000	1000	1000	1000
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20	1000	1000	1000	1000	1000
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22	1000	1000	1000	1000	1000
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27	1000	1000	1000	1000	1000
28	1000	1000	1000	1000	1000
29	1000	1000	1000	1000	1000
30	1000	1000	1000	1000	1000
31	1000	1000	1000	1000	1000
32	1000	1000	1000	1000	1000
33	1000	1000	1000	1000	1000
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37	1000	1000	1000	1000	1000
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39	1000	1000	1000	1000	1000
40	1000	1000	1000	1000	1000
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42	1000	1000	1000	1000	1000
43	1000	1000	1000	1000	1000
44	1000	1000	1000	1000	1000
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95	1000	1000	1000	1000	1000
96	1000	1000	1000	1000	1000
97	1000	1000	1000	1000	1000
98	1000	1000	1000	1000	1000
99	1000	1000	1000	1000	1000
100	1000	1000	1000	1000	1000

Table 4. Cod 2011. Total abundance , area, number of hauls, mean abundance per km² and Standard Error distributed on by density strata (Div.).

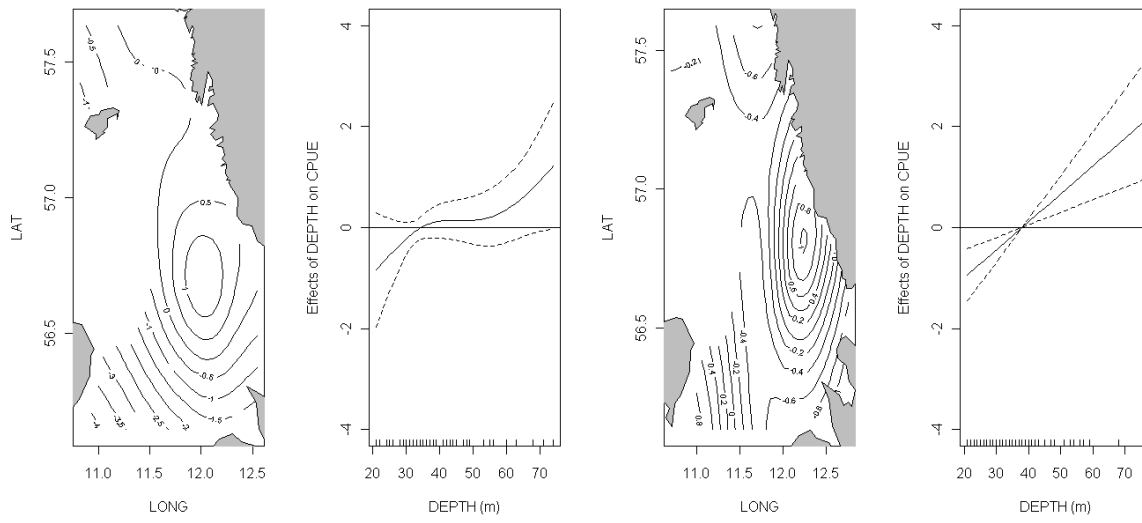
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98	1000	1000	1000	1000	1000
99	1000	1000	1000	1000	1000
100	1000	1000	1000	1000	1000

Biomass calculated with GRASP

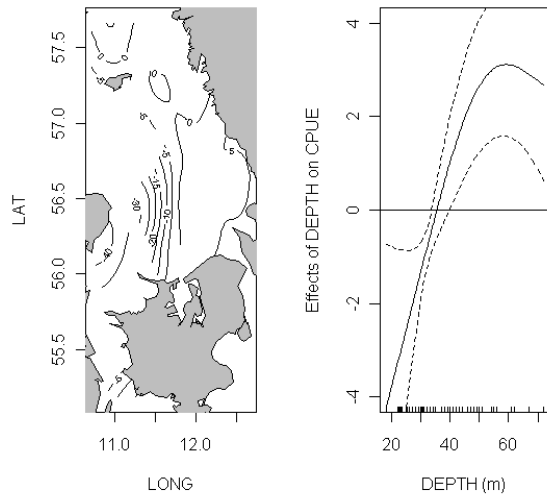
The final model, after backward stepwise selection based on significance included only the interaction between LAT:LONG and DEPTH as significant terms. The model was able to significantly reduce the total deviance explaining about 72% in 2010. Compared with 60% of the total deviance 2008 and 50% 2009 respectively. The plot of the LAT:LONG on CPUE showed the highest concentrations of cod larger than 39 cm are found in the central part of the Kattegat in all years (Figure 3 a,b,c), while depth has a positive effect on CPUE with the highest cod biomass located in area deeper than 40 meters both 2008 and 2009. For 2010 the depth has a positive effect already at 35 m (Figure 3 a,b,c). The spatial model predictions for the Kattegat area for cod larger than 39 cm are presented in Figure 4.

The trawlable cod biomass (cod >39 cm) ranged between 567 and 1125 tones with 50th percentiles and 5th percentile respectively. Assuming that the catchability (q) of the sweeps is 50% of catchability of the trawl (q=1). These estimates are lower than both 2008 and 2009. Were the trawlable cod biomass was estimated to be 1289 and 2454 tones 2008 and 947 and 1457 tones in 2009 50th percentiles and 5th percentile respectively.

A GRASP model for cod less than 39 cm was also produced on survey data for 2008 and 2009 using the same interactions(LAT:LONG and DEPTH) as in the model for cod larger than 39 cm. The model was able to significantly reduce the total deviance explaining about 63% o2010. Compared with 60 % 2008 and 55 % 2009. The highest concentrations of cod less than 39 cm was found in the central part of Kattegatt in 2009, whereas in 2010, it was more concentrated toward the north of Kattegatt.

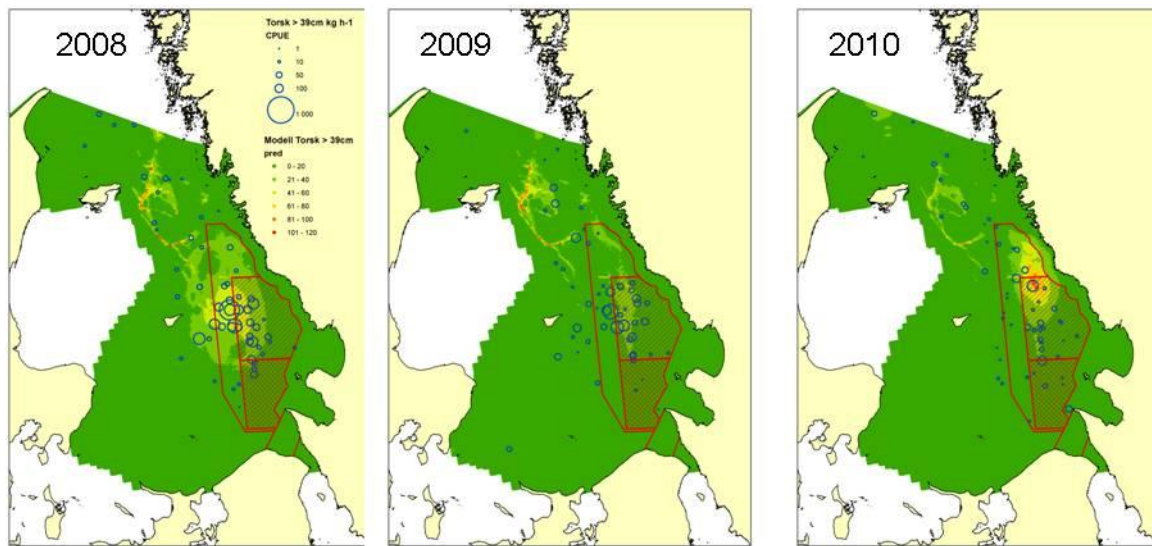


a) b)



c)

Figure 3 a and b. Plots of the predictor effects (LAT:LONG, depth) as estimated by the final GAM models on CPUE ($\text{kg}\cdot\text{h}^{-1}$) for Cod larger than 39 cm. a) 2008 , b) 2009 and c) 2010.



a)

b)

c)

Figure 4. Spatial distribution of CPUE in kg•h⁻¹ of cod in the Kattegat estimated for Cod >39 cm in a) 2008 ,b)2009 and c)2010. Colours indicate modeled results while bubbleplots show results from different hauls.

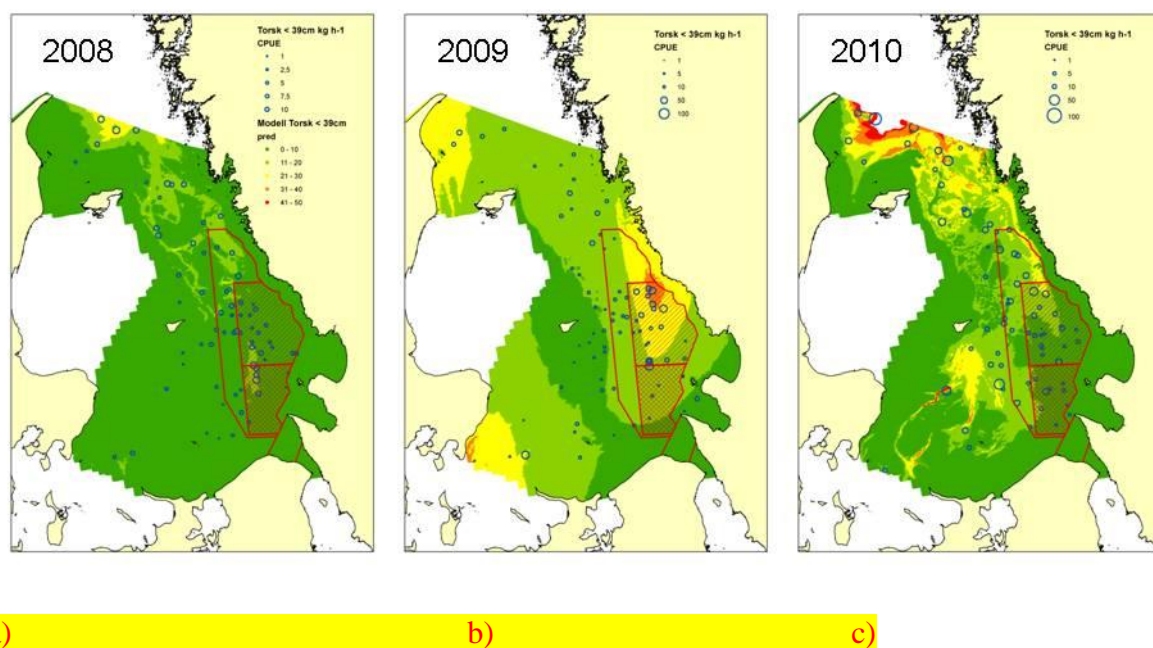


Figure 5. Spatial distribution of CPUE in $\text{kg}\cdot\text{h}^{-1}$ of cod in the Kattegat estimated for Cod <39 cm in a) 2008 b)2009 and c) 2010 . Colours indicate modeled results while bubbleplots show results from different hauls.

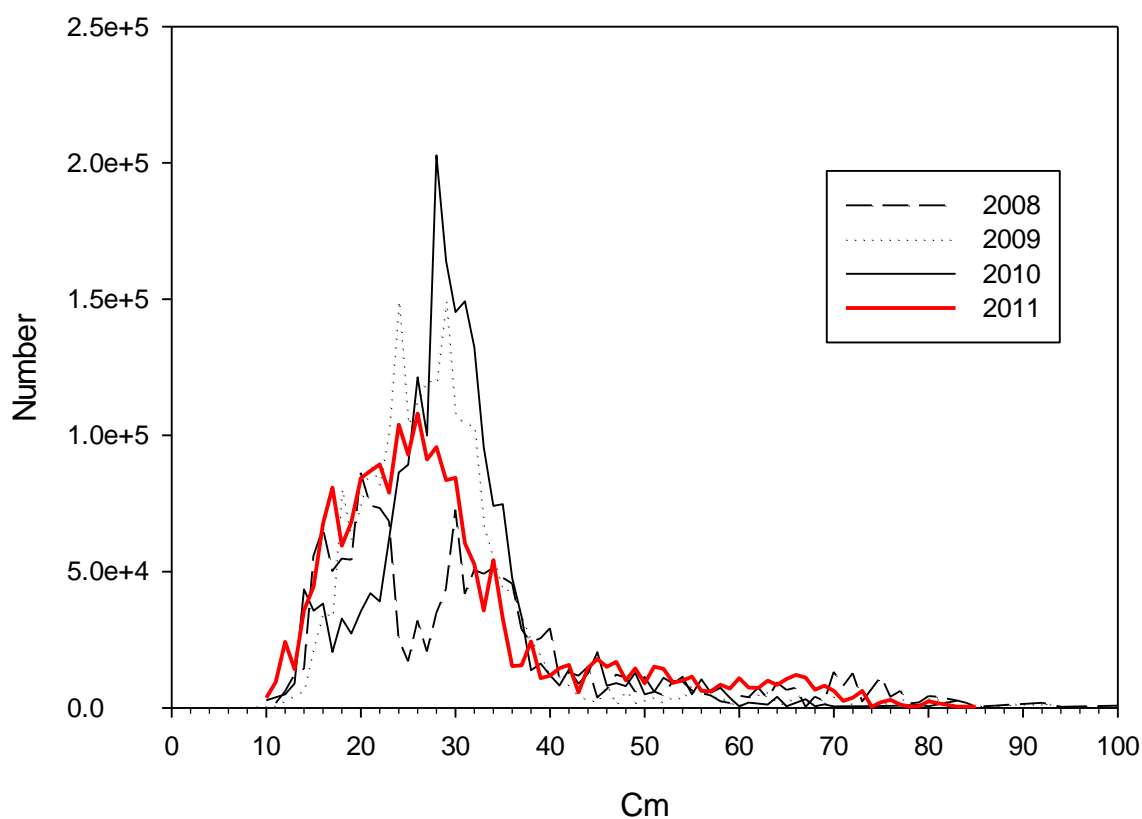


Fig. 6. Length distribution in total number of cod weighted by stratum area by year in the total survey area.

Length distribution

The length ranged from 10 to 85 cm. The overall length distribution (weighted by stratum area) showed modes at 24 and 26 cm together with a number of minor modes. The number of cod > 40 cm is still at a very low level (Fig 6).

Most small cod were found in the low density area, while there were few cod > 40 cm in any of the areas (Fig 7).

Age distribution

The overall age distribution (weighted by stratum area) showed a very clear dominance of age 1 and very few fish older than 2 years in all years (Fig 8). The increase in numbers between age 0 and age 1 year-class may be caused by trawl selectivity. Number by age and year is given in Table 5.

Table 5. Number at age of cod by year in the survey area.

Age	2008	2009	2010	2011
0	512281.9	260350.0	231616.5	430766.2
1	591938.0	1559905.6	1469566.3	1122208.1
2	249683.8	209152.7	420303.8	327129.5
3	94205.0	27316.6	20148.0	168436.4
4	59493.5	17424.3	4332.2	15637.4
5	28791.3	20352.0	2216.6	3919.3
6	6823.6	6838.6	269.0	0.0
7	1859.7	0.0	0.0	0.0
8	0.0	1147.1	0.0	0.0
9	1277.7	0.0	0.0	0.0

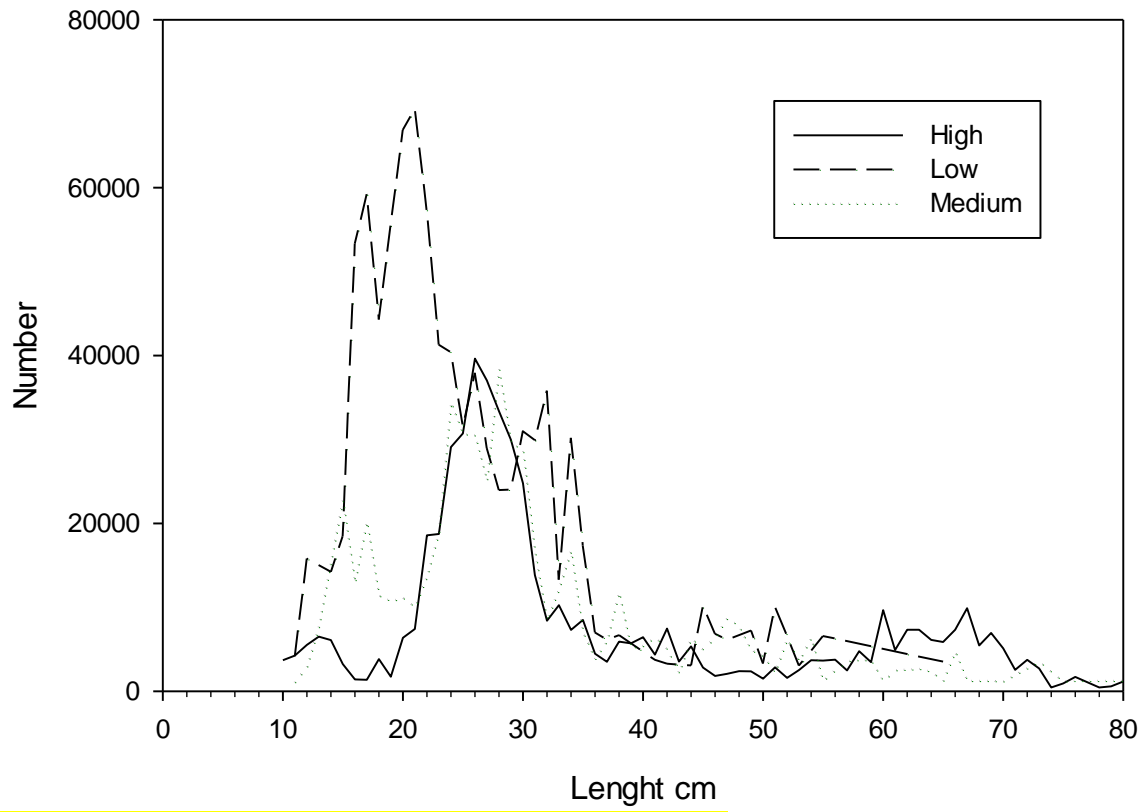


Fig. 7. Length distribution of cod in total number by stratum.

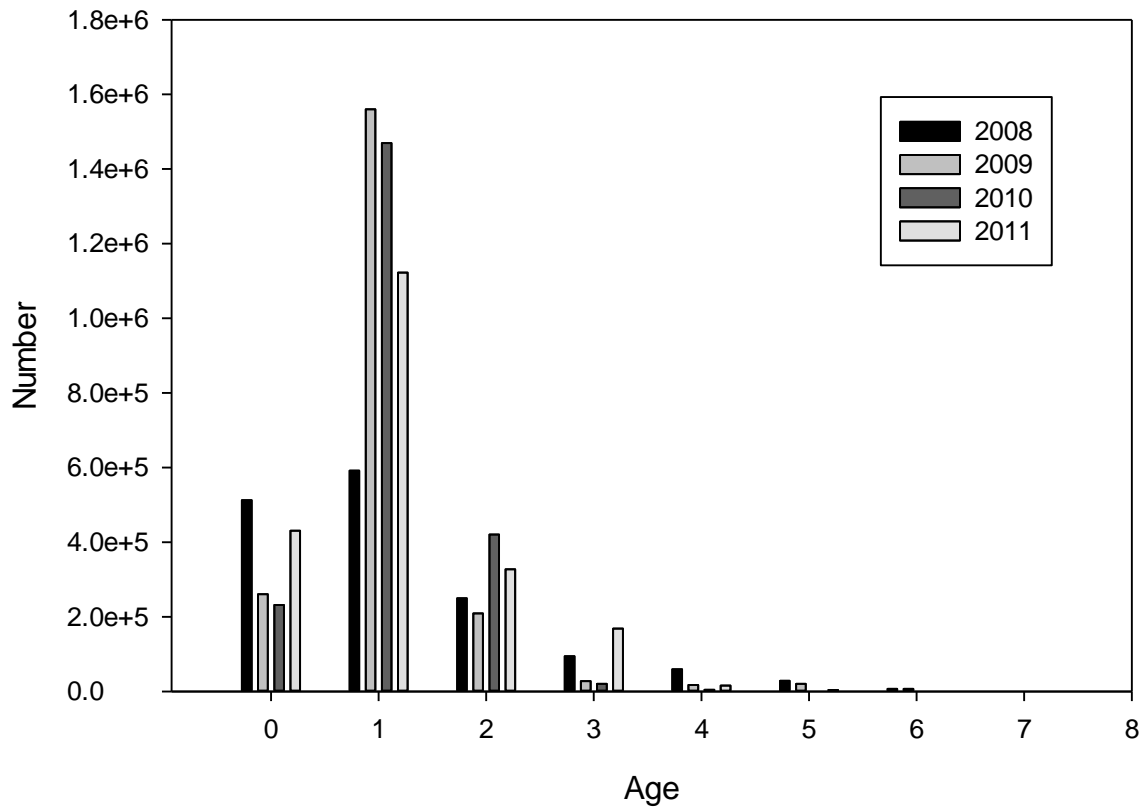


Fig 8. Over all age distribution (weighted by stratum area) of cod by year in total number in the survey area.

Most age 0 and age 1 were found in the low density area while most age 2+ were found in the high density area (Fig. 9).

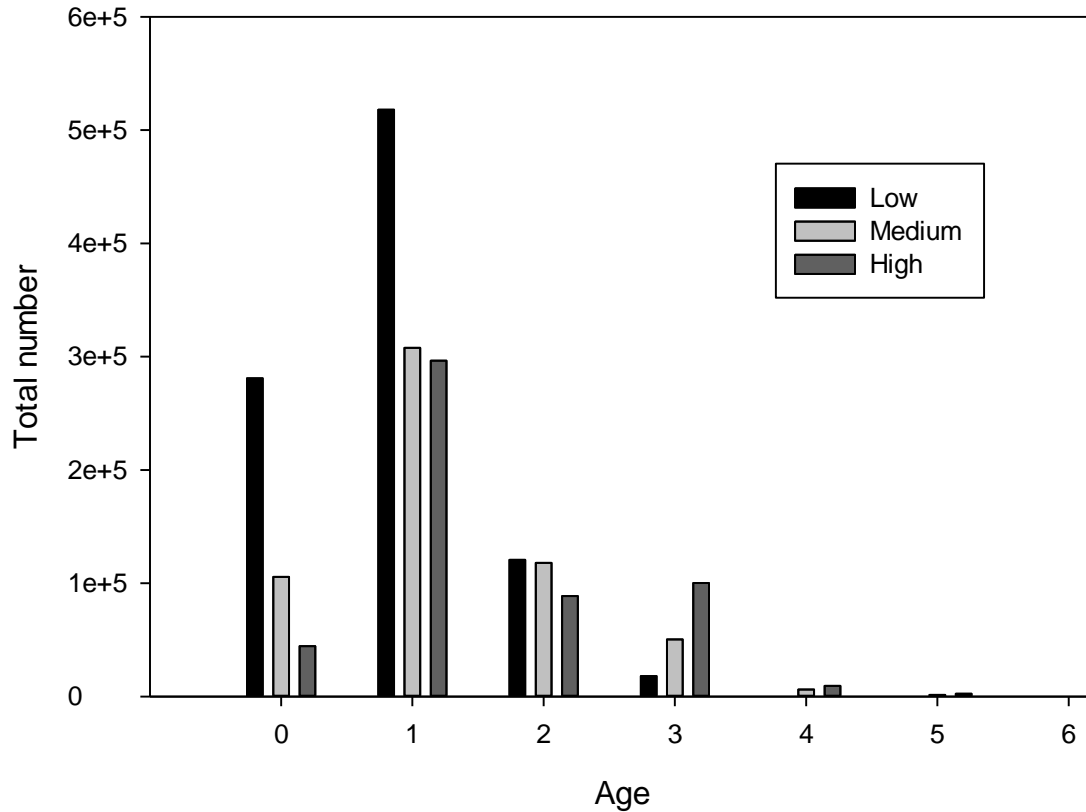


Fig. 9. Age distribution of cod in total number distributed on density areas.

CPUE

CPUE in both weight and number caught per hour was highest in the high density area (Table 6).

Table 6. CPUE of cod in number and kg per hour with SE distributed on density areas.

Division	Number	Weight	SE Number	SE Weight	n
High	30.5	23.9	2.9	3.2	36
Low	13.9	3.2	2.7	0.8	20
Medium	19.7	9.9	2.6	3.2	24
All	23.1	14.5	1.8	2.0	80

The overall CPUE in 2011 was 23.1 specimen and 14.5 kg compared to 16.1 specimens and 6.6 kg, respectively, in 2010 (Table 7).

Table 7. CPUE in weight (kg) and number by with S.E.

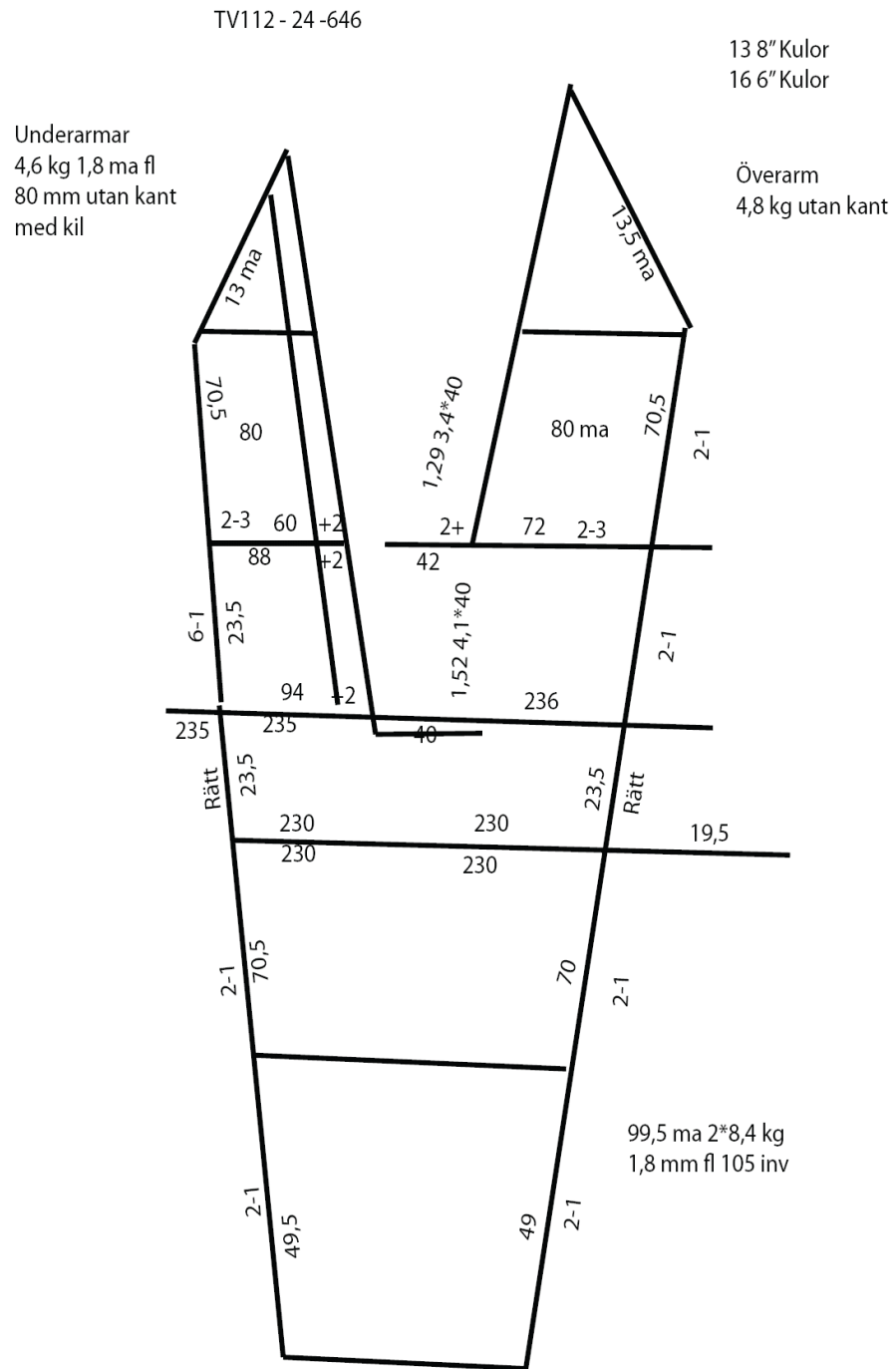
Year	CPUE weight	S.E.	CPUE number	S.E.
2008	14.1	2.6	14.2	0.99
2009	8.9	0.9	20.1	2.0
2010	6.6	0.8	16.1	1.7
2011	14.5	2.0	23.1	1.8

The overall CPUE in number by age and year is given in Table 8. In 2011 age 1 dominated the catches as in previous years, but there were relatively more age 3 cod in the catches compared to previous years

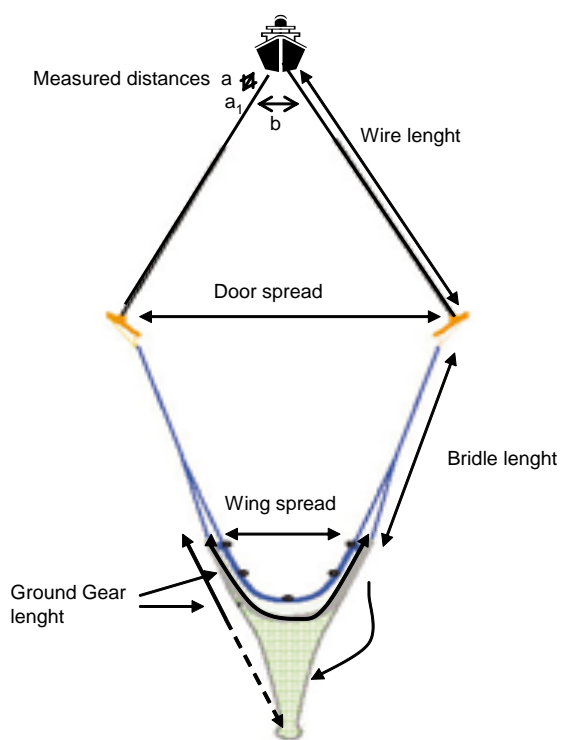
Table 8. CPUE (hour) of cod in number by year and age.

Age	0	1	2	3	4	5	6	7	8	9
2008	4.72	5.45	2.30	0.87	0.55	0.27	0.06	0.02	0.00	0.01
2009	1.42	15.57	2.12	0.32	0.24	0.27	0.01	0	0.01	0
2010	1.52	10.59	3.74	0.25	0.04	0.03	0.01	0	0	0
2011	3.25	12.60	3.87	3.03	0.29	0.07	0	0	0	0

Annex 1. TV112 trawl



Annex 2. Calculation of wing spread.



Calculations of door spread and wing spread

Assuming that the distance between the trawl doors and the wires form an equilateral triangle, the door spread have been calculated as

$$\text{Door spread} = \frac{\text{Wire length} \times \text{measured distance } b}{\text{measured distance } a}$$

For every haul, a length on the wire (distance a) and the length between the wires measured at a_1 (distance b) have been recorded.

Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length} \times \text{Door spread}}{\text{Bridle length} + \text{Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flume Tank, Hull, UK)

NOTE: Figure not according to scale

Annex 3. Haul by haul information. Swept area in km², catch weight of cod in kg

References

Anon. 2008. Course in Trawl Gear Technology”, May 2006, SeaFish Flume Tank, Hull, UK

Cochran, W. G. 1977: Sampling Techniques, Third edition, Wiley & Sons.