Joint Swedish and Danish survey for cod in the Kattegat December 2008

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Abstract

During December 2 -15 2008 a survey targeting cod in Kattegat was conducted by four commercial trawlers from Denmark and Sweden. In total 80 trawl hauls were made. The catches were generally low and the total swept area biomass and abundance was estimated as 1008 tons and 1.5 mill individuals, respectively. Few cod were above 40 cm and age 2 and the catches were dominated by fish age 0 and 1. The CPUE was 14.2 individuals and 14.1 kg per hour, respectively.

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 at present in the Kattegat area are 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 indeces obtained from the available surveys are relatively noisy, especially for older ages. The assessment of the cod stock in Kattegat would therefore, without doubt, benefit significantly from a survey directly aimed at cod and with better coverage of the area.

The 5 August 2006 a tender was submitted by Swedish Board of Fisheries, Institute of Marine Research (IMR-SE) in response to the open call for tenders, Reference No FISH/2006/15 Studies and Pilot projects for carrying out the common fisheries policy, Lot No 3: “Evaluation of the pilot effort regime in Kattegat” from Directorate-General for Fisheries and Maritime Affairs.

First phase of the project was successfully carried out in 2007 and led to the establishment of a baseline of economical, biological and fishery patterns based on historical data from Swedish and Danish fisheries. Sweden and Denmark are the only two countries fishing in the area apart from a small fishery for sole by Germany.

A series of cooperative discussions and studies, involving both scientists and fishers have been taking place in order to implement the final phase of the project.

Both Swedish and Danish scientists and the fishermen's organisations agrees that the poor survey quality hampers the assessment of the cod stock in Kattegat and an expert group consisting of people from the fishers organisations and scientists has designed a survey that should provide detailed information about the distribution and abundance of the cod stock in Kattegat. The initiative has been taken by the LOT 3 project group and was originally a strictly Swedish project. However, the involvement of Denmark has been considered as an improvement of the project and the survey has been designed in all details in agreement between fishers and scientists from both countries.

Goal

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 1 January 2009.

Restrictions

The 4 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 og 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.

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 and Northern area.

Numbers of stations by vessel, stratum and area

Ship	High density	Medium density	Low density (South)	Low density (North)	Total
Den_1	6	8	6		20
Den_2	6	8		6	20
Swe_1	6	8	6		20
Swe_2	6	8		6	20

Target species
The survey is directed to demersale species in Kattegat, but designed for cod. The catch of all species is, however, recorded and the survey results are also made available for the assessment of sole, plaice and Nephrops.

Survey period
The survey took place during December 2 - December 15 2008.

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

Danish participant	1 (H210 – Søren Kanne)
Engine (KW):	368 kW
Tonnage (BRT):	69.2
Length (m):	20.7
Owner	Flemming Christensen

DK-Vessel 2

Danish participant	2 (FN370- Susanne H)
Engine (KW):	220 kW
Tonnage (BRT):	52.6
Length (m):	18.4
Owner	Hans Jørgen Hansen

SW-Vessel 1

Swedish participant	1 (GG 1195 – Otseco)
Engine (KW):	175 kW
Tonnage (BRT):	28
Length (m):	15.34
Owner	Peter Bihl

SW-Vessel 2

Swedish participant	2 (VG 47 – Yvonne II)
Engine (KW):	294 kW
Tonnage (BRT):	88
Length (m):	21.18
Owner	Johnny Nilsson

Gear
The trawl is a commercial bottom trawl provided by the 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 Fiskerivärket (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 682 cod otoliths were sampled for age determination.

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

Data
Data are stored in a standard data base and could will, 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.

Biomass and abundance
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 10119 km^2 (Table 1).

Table 1. Areas distributed on strata.

High density	Medium density	Low density	All
10 squares	44 squares	64 squares	118 squares
857.5 km^2	3773 km^2	5488 km^2	10119 km^2

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:

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

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 km^2 swept prior to further calculations.

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

Results

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

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 are given as abundance Fig. 1a and biomass 1b

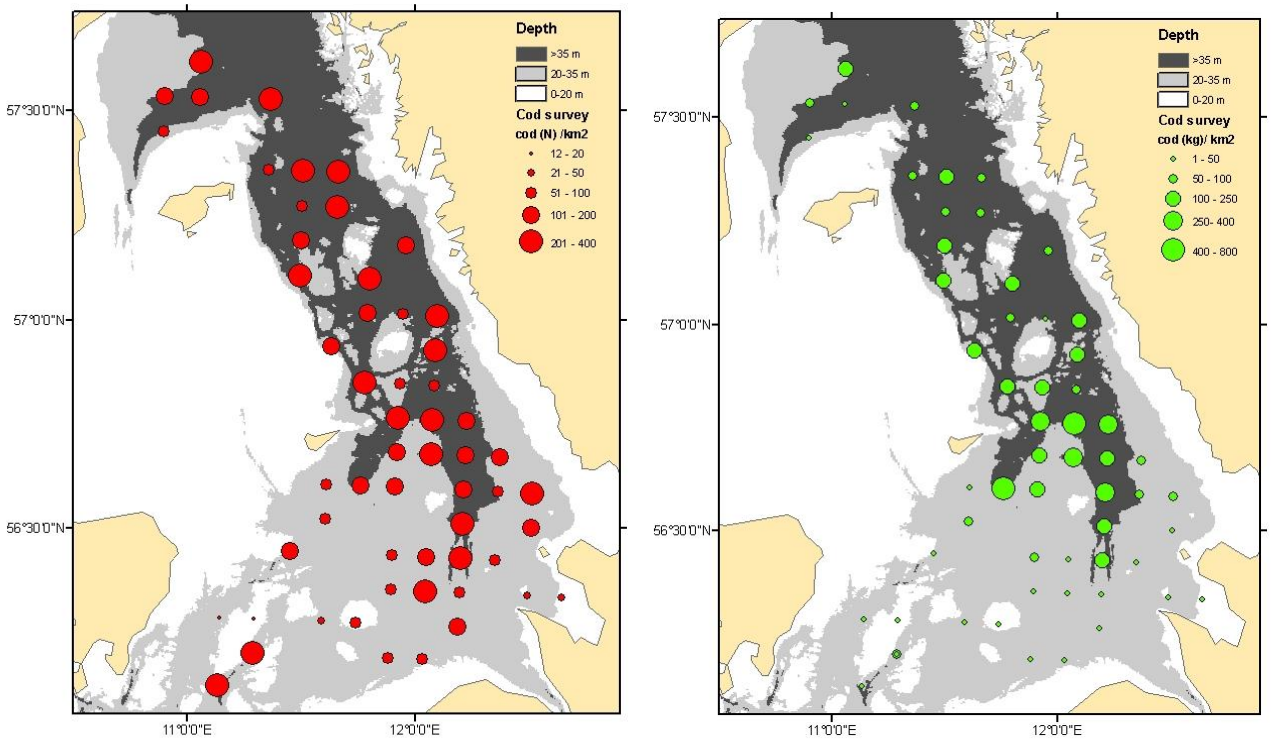


Figure 1ab. Abundance and biomass of cod per km2 calculated as an average from all vessels per square.

Biomass and abundance

The trawlable biomass of cod was estimated at 1008.4 tons (S.E. 125.9) (Table 2). The highest density was found in the High Density Area (0.32 ton per km^2), while the highest biomass was found in Medium Density Area (473.2 tons).

The trawlable abundance was estimated at 1545587.3 (S.E. 123176.1) specimens with the highest density in the High Density Area, 182.9 specimens per km^2 , while the largest abundance, 771799.2, was found in the Low Density Area (Table 3).

Table 2. Cod 2008. Area, number of hauls, mean biomass per km^2 (tons), biomass (tons) and Standard Error distributed on Density Strata (Div.).

Table 3. Cod 2008. Area, number of hauls, mean abundance per km^2, abundance and Standard Error distributed on Density Strata (Div.).

Length distribution

The length ranged from 11 to 106 cm. The overall length distribution (weighted by stratum area) showed two broad modes at 13-23 cm and 26-40 cm, respectively, and few fish larger than 40 cm (Fig 2).

Most small cod were found in the Low density area, while the largest cod were found in the High density area (Fig 3).

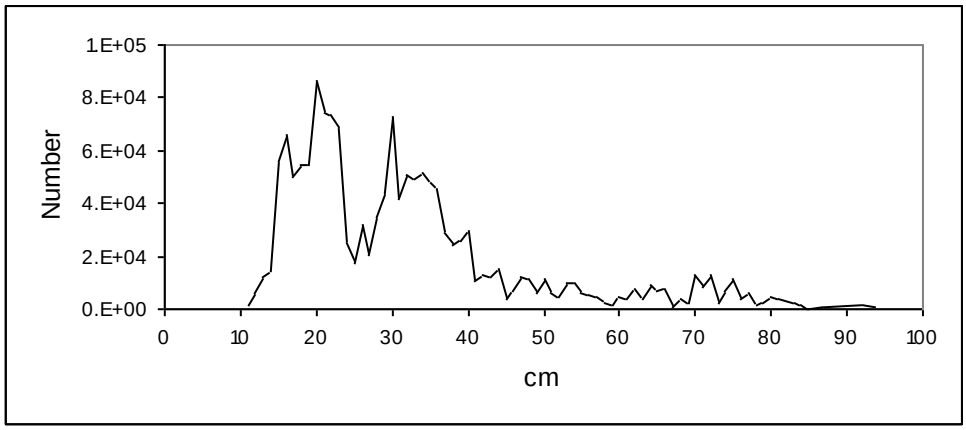


Fig. 2. Length distribution in number of cod in the total survey area.

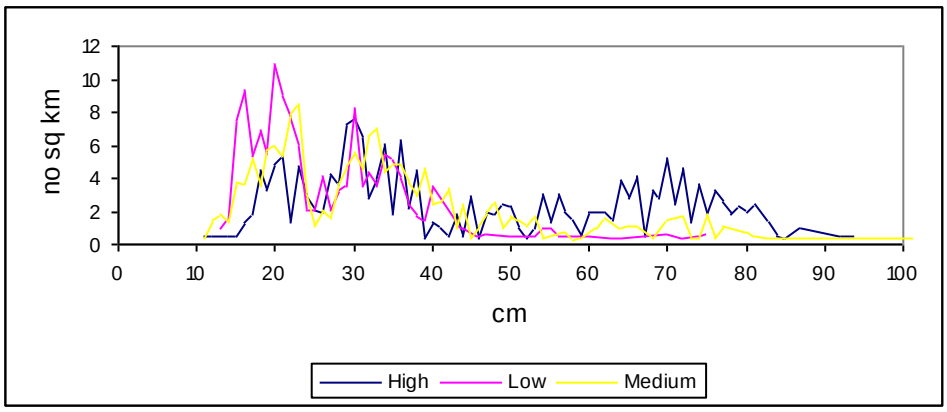


Fig. 3. Length distribution of cod in number per km^2 in the three strata.

Age distribution

The over all age distribution (weighted by stratum area) showed a clear dominance of ages 0 and 1 and very few fish older than 2 years (Fig 4). The catch of the 2007 year is higher than 2008 year class. Whether this is real or caused by trawl selectivity is not known. Number by age and mean weight at age is given in Table 4.

Table 4. Number at age of Cod in the survey area, mean weight and mean length at age with SE, respectively and number of observations.

age	Number	Weight	SE	Length	SE	n
0	512281.9	0.071	0.003	19.0	0.3	173
1	591938.0	0.294	0.013	29.1	0.5	199
2	249683.8	0.881	0.046	42.3	0.7	122
3	94205.0	2.313	0.111	59.2	1.0	83
4	59493.5	3.666	0.142	69.0	1.0	60
5	28791.3	4.895	0.221	77.7	1.1	32
6	6823.6	5.246	0.465	79.0	2.1	10
7	1859.7	6.875	0.775	88.0	4.0	2
8	0.0					
9	1277.7	12.8	.	106	.	1

Most age 0 and age 1 cod were found in the Low density area, while most old cod were found in the High density area (Fig 5).

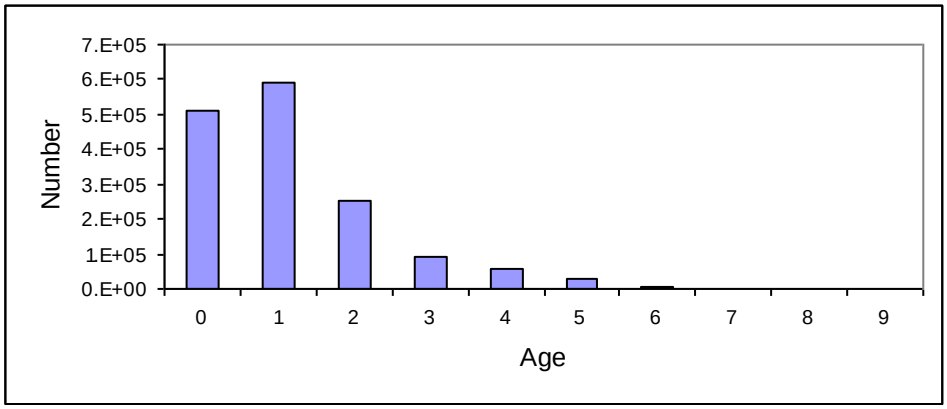


Fig 4. Over all age distribution (weighted by stratum area) of cod in total number in the survey area.

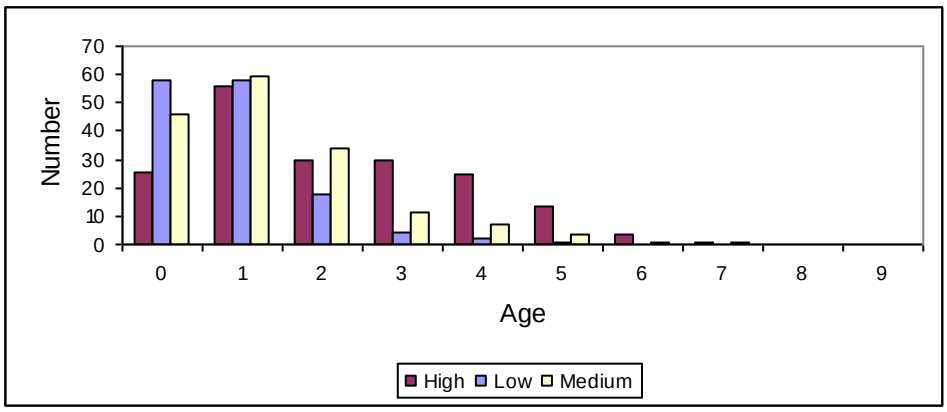


Fig. 5. Age distribution of cod in number per km^2 distributed on density areas.

CPUE.

CPUE in number per hour was fairly even in the three density areas, however with the largest number in the High density area and lowest in the Low density area, but differences were not statistically different (95%. Level). The mean CPUE in weight was highest in the High density area, 28. kg/hr and lowest in the Low density area (4.0 kg/hr). The difference in catch rates were statistically significant (95% level) between the High and Low density area and the Medium and Low density area, respectively (Table 5)

Table 5. CPUE of cod in number and kg per hour with SE distributed on density areas.

Division	Number	Weight	SE Number	SE Weight	n
High	16.3	28.3	2.0	7.3	24
Low	11.4	4.0	1.7	1.0	24
Medium	14.8	11.1	1.4	2.0	32
All	14.2	14.1	0.99	2.6	80

The over all CPUE was 14.2 specimens and 14.1 kg per hour, respectively (Table 5). The over all CPUE in number by age is given in Table 6.

Table 6. CPUE of cod in number by age per hour.

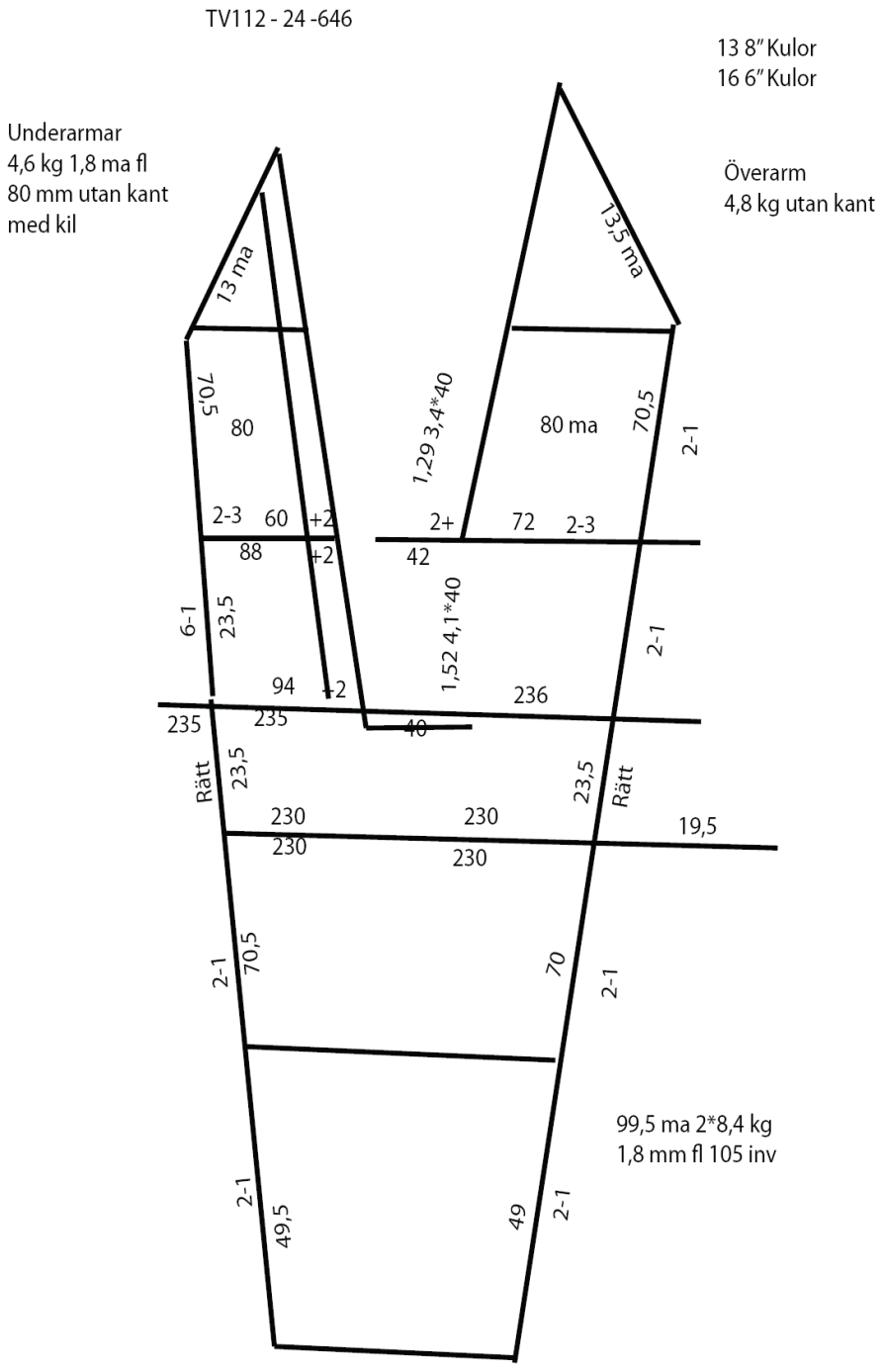
Age	0	1	2	3	4	5	6	7	8	9
CPUE all	4.72	5.45	2.30	0.87	0.55	0.27	0.06	0.02	0.00	0.01

The CPUE in kg varied quit a lot between vessels (10.8 – 18.0 kg per hour). The high CPUE was, however, mainly caused by one large catch on 181 kg, and the SE on the CPUE is high (SE 9.0). There is hence no statistical significant difference between the CPUE by the different vessels.

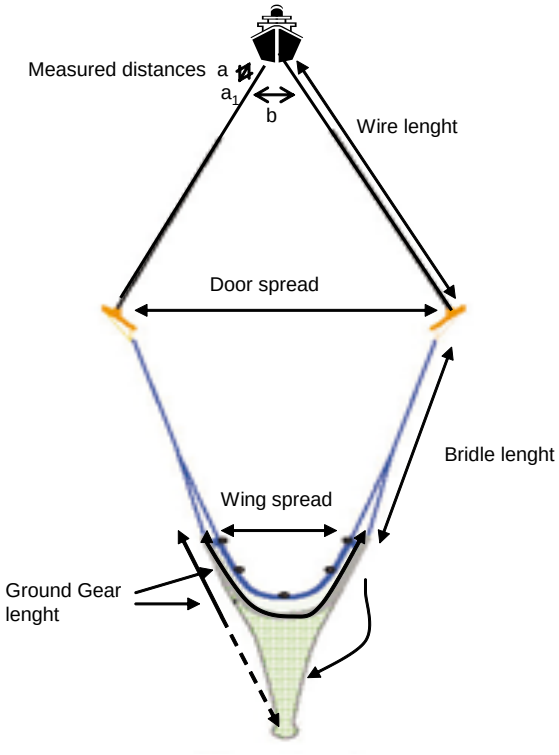
Table 7. CPUE of cod in number and weight with S.E. by vessel.

Vessel	Number	Weight	SE Number	SE Weight	n
FN370	16.3	15.7	1.6	3.3	20
H210	13.9	10.8	1.7	3.0	20
SDUO	13.2	12.0	1.9	2.6	20
SFEC	13.5	18.0	2.6	9.0	20

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

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

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:

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

(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. Time in min. Swept area in km^2 catch weight of cod in kg.

Division	Section	Haul	Vessel	Tow time	Sweptarea	Number	Weight
HIGH	208	41	FN370	60	0.0932	23	35.1
HIGH	209	21	H210	60	0.0935	12	18.6
HIGH	209	42	FN370	62	0.0984	7	10.6
HIGH	230	6	SFEC	60	0.0892	50	181.2
HIGH	230	10	SDUO	60	0.0799	10	13.8
HIGH	230	22	H210	60	0.0995	23	56.2
HIGH	230	43	FN370	60	0.0942	14	39.2
HIGH	231	9	SDUO	58	0.0799	7	6.6
HIGH	231	23	H210	51	0.0803	8	8.2
HIGH	249	9	SFEC	60	0.0892	29	14.9
HIGH	249	24	H210	60	0.1035	25	14.9
HIGH	249	44	FN370	60	0.0694	24	27.2
HIGH	250	3	SFEC	60	0.0844	15	43.5
HIGH	250	13	SDUO	61	0.0799	9	5.5
HIGH	250	25	H210	60	0.0906	20	29.5
HIGH	251	2	SFEC	60	0.0814	15	26.5
HIGH	251	14	SDUO	61	0.0770	9	9.1
HIGH	251	45	FN370	61	0.0969	16	23.5
HIGH	252	1	SFEC	60	0.0792	11	14.4
HIGH	252	11	SDUO	60	0.0808	12	17.5
HIGH	252	46	FN370	60	0.0932	25	52.9
HIGH	272	8	SFEC	60	0.0892	8	6.1
HIGH	272	12	SDUO	42	0.0861	9	12.5
HIGH	272	26	H210	60	0.0995	5	5.2
LOW	62	55	FN370	58	0.0661	5	1.2
LOW	63	56	FN370	60	0.0673	8	5.0
LOW	85	57	FN370	66	0.0730	11	3.4
LOW	86	5	SDUO	60	0.0763	20	9.0
LOW	90	35	H210	60	0.0777	20	1.6
LOW	92	36	H210	60	0.0803	1	0.1
LOW	107	6	SDUO	60	0.0814	23	7.5
LOW	113	37	H210	30	0.0375	9	0.5
LOW	114	39	H210	45	0.0583	1	0.1
LOW	127	4	SDUO	58	0.0713	7	7.0
LOW	129	7	SDUO	60	0.0906	24	8.0
LOW	138	38	H210	50	0.0740	13	1.3
LOW	149	58	FN370	60	0.1036	31	22.1
LOW	158	40	H210	50	0.0690	3	0.1
LOW	161	15	SFEC	60	0.0892	5	5.7
LOW	162	16	SFEC	60	0.0892	5	0.9
LOW	170	1	SDUO	60	0.0592	16	3.2
LOW	171	59	FN370	60	0.0870	18	7.0
LOW	201	19	SFEC	60	0.0923	6	0.3
LOW	213	2	SDUO	60	0.0812	9	5.5
LOW	213	60	FN370	60	0.0911	16	5.5
LOW	223	20	SFEC	60	0.0594	4	0.6
LOW	291	12	SFEC	60	0.0831	3	0.1
LOW	313	11	SFEC	40	0.0923	3	0.2
MEDIUM	146	27	H210	60	0.1077	25	12.0
MEDIUM	147	28	H210	55	0.0883	17	12.0
MEDIUM	148	3	SDUO	60	0.0848	8	5.0

MEDIUM	166	47	FN370	60	0.0942	16	10.8
MEDIUM	180	29	H210	60	0.0803	6	0.6
MEDIUM	184	15	SDUO	61	0.0814	11	33.0
MEDIUM	187	48	FN370	60	0.0963	21	19.2
MEDIUM	189	30	H210	60	0.0965	13	9.5
MEDIUM	190	49	FN370	60	0.0963	26	17.6
MEDIUM	203	18	SFEC	60	0.0954	7	0.7
MEDIUM	204	50	FN370	62	0.0867	7	4.5
MEDIUM	206	14	SFEC	56	0.0861	12	11.8
MEDIUM	207	16	SDUO	60	0.0574	6	14.5
MEDIUM	207	31	H210	60	0.0945	15	22.8
MEDIUM	211	8	SDUO	60	0.0829	5	1.7
MEDIUM	225	17	SFEC	60	0.0923	19	3.0
MEDIUM	226	20	SDUO	63	0.0560	5	1.5
MEDIUM	226	32	H210	60	0.0965	13	5.2
MEDIUM	229	7	SFEC	60	0.0923	19	23.2
MEDIUM	229	17	SDUO	60	0.0814	25	49.0
MEDIUM	229	51	FN370	60	0.0932	17	25.0
MEDIUM	232	5	SFEC	60	0.0861	29	11.7
MEDIUM	233	4	SFEC	60	0.0861	19	13.9
MEDIUM	246	52	FN370	60	0.0839	15	2.8
MEDIUM	247	13	SFEC	60	0.0892	1	0.1
MEDIUM	247	19	SDUO	61	0.0817	8	2.5
MEDIUM	248	18	SDUO	43	0.0814	27	16.0
MEDIUM	270	10	SFEC	60	0.0923	8	0.2
MEDIUM	273	33	H210	60	0.0965	14	7.1
MEDIUM	293	53	FN370	56	0.0754	10	0.7
MEDIUM	294	34	H210	60	0.0874	20	7.7
MEDIUM	294	54	FN370	60	0.0859	17	2.0

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.