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Oskarshamn site investigation

The abundance of nightly pelagic fish in the Baltic Sea outside Simpevarp nuclear power station

Olof Enderlein, National Board of Fisheries

June 2005

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Keywords: Pelagic fish, Biomass, Hydroacoustic.

Abstract

This investigation is a step in the process of finding a suitable area for deep repository of spent nuclear fuel in the community of Oskarshamn.

The coast of the Baltic Sea outside Simpevarp nuclear power station has during 2004 been investigated at three occasions by hydroacoustics to estimate the amount of nightly pelagic fish. Eight transects were used at each occasion. One night was also spent pelagic-trawling in this area to get an idea of the fish-species the hydroacoustics had counted. The 15th of June the densities along the transects varied from 470 to 4,524 fish per ha, the 16th to 17th of June from 613 to 1,342 fish per ha and the of August 31 to the of September 1 from 1,824 to 5,591 fish per ha. The estimated biomass for these three occasions was 49.6 ± 18.2 kg/ha, 20.9 ± 5.7 kg/ha and 56.8 ± 20.0 kg/ha respectively.

The most numerous fish species in the trawl the 15th to 16th of June was sprat (*Sprattus sprattus L.*). Other species caught were herring (*Clupea harengus* L.), stickleback (*Gasterosterus aculeatus* L.), dab (*Platichthys flesus* L.) and a few individuals of the family *Cottidae.*

Sammanfattning

Inom projektet för undersökningar av lämplig lokal för slutförvaring av kärnbränsle i Oskarshamns kommun har en uppskattning av mängden nattlig pelagisk fisk i havsområdet utanför kärnkraftsverk vid Simpevarp gjorts. Mängden fisk har uppskattats nattetid längs åtta sträckor vid tre tillfällen 2004. En natt genomfördes dessutom pelagisk trålning för att få en uppfattning om vilka fiskarter som räknades via hydroacustik.

Natten den 15 juni 2004 varierade tätheten av fisk från 470 till 4 524 fiskar/ha längs de åtta sträckorna. Den 16–17 juni hade mängderna drastiskt minskat till 613 till 1 342 fiskar/ha. I skiftet augusti–september (31/8–1/9) varierade mängden fisk från 1 824 till 5 591 fiskar/ha. Den uppskattade pelagiska fiskbiomassan inom det undersökta området var 49,6 ± 18,2, 20,9 ± 5,7 och 56,8 ± 20,0 kg/ha för var och en av de tre nätterna.

Den vanligaste fiskarten i trålen (15–16 juni) var skarpsill (*Sprattus sprattus L.*). Andra arter som fångades var strömming (*Clupea harengus L.*), storspigg (*Gasterosterus aculeatus L.*), skubbskädda (*Platichthys flesus L.*) och simpa (familjen *Cottidae*).

Contents

1 Introduction

A site investigation is an important step in the process of siting a deep repository for spent nuclear fuel. SKB is responsible for the investigations in the Simpevarp area, Oskarshamns municipality. The investigation is divided into a number of discipline specific programs. This discipline-specific program for stock assessment of fish aimed at an estimate of the nightly pelagic fish-stock was performed in the Baltic Sea outside the Simpevarp nuclear power station (Figure 1-1).

The program was conducted by means of hydro-acoustics along eight transects at three different occasions, two in June 2004 and one in August–September 2004. That resulted in three estimates of the number of fish per surface area and their size distribution. To get an indication of what species were counted one night was spent pelagic trawling.

The activity was performed according to Activity plan SKB AP PO 400-04-048. This report describes the methods used and the results obtained from the surveys (20040615, 20040616, 20040617, 20040831 and 20040901) in the Baltic Sea outside the Simpevarp nuclear power station.

The original results from the activity are stored in the SICADA data base and are traceable by the activity plan number (AP PS 400-04-048).

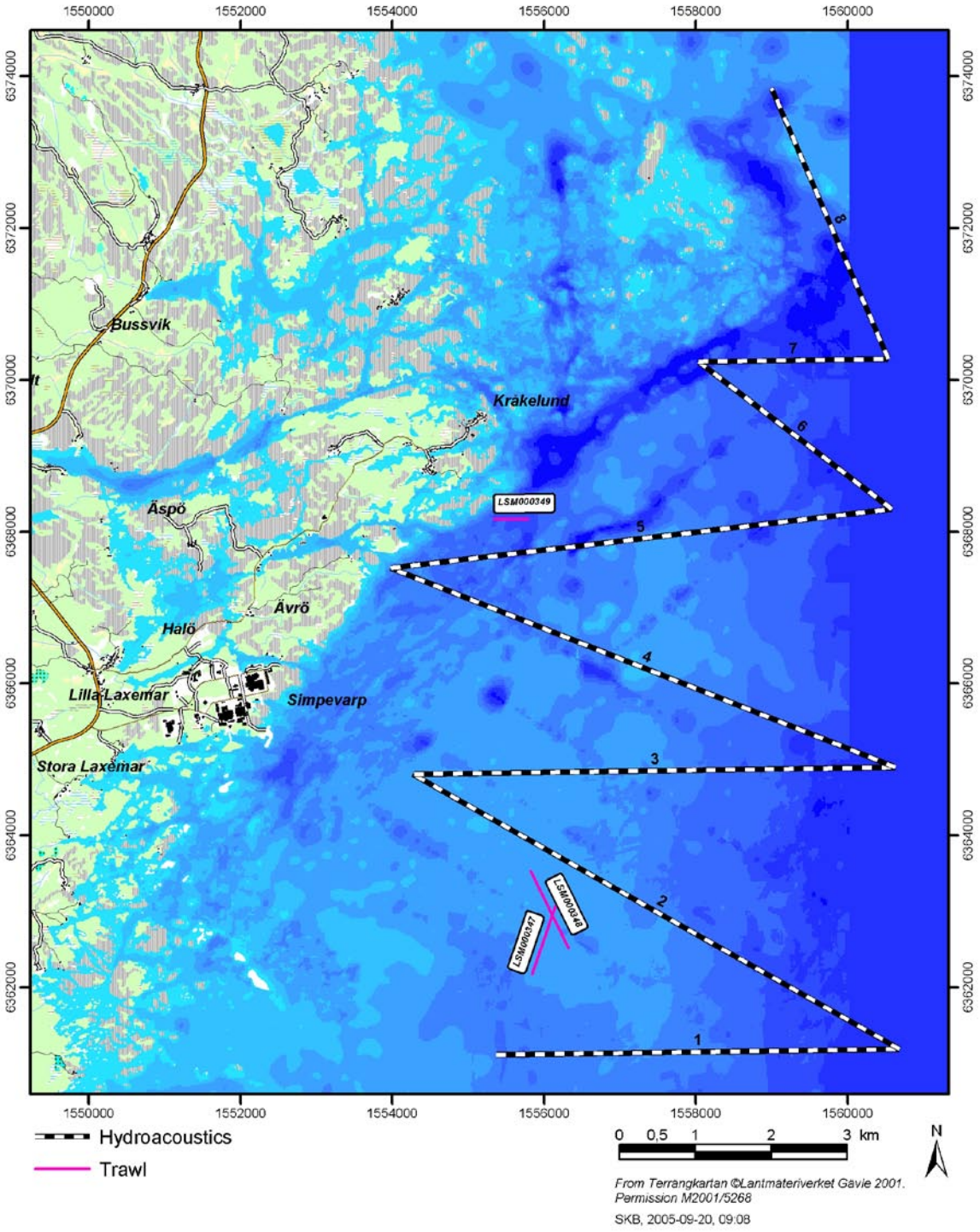

Figure 1-1. *The area of the Baltic sea outside Simpevarp, were hydro-acoustic investigation (black and white transects) and trawling (red transects) was performed during 2004.*

2 Objective and scope

The general objective of the activity was to gather information about the fish population, fish biomass and species composition in the Baltic Sea outside Simpevarp.

3 Equipment

3.1 Description of equipment

The R/W Ancylus from the National Board of Fisheries was used as a platform for both the trawling and hydro-acoustics.

3.1.1 Pelagic trawling

The pelagic trawling was done with a pelagic herring-trawl 364/40 with a mesh-size of 5 mm knot to knot in the cod-end. The positioning of the trawl in the water was done by ropes of different length between the two otter-boards and two buoys at the surface. The rope-length used was 5 m, 2 m and 5 m for the respective trawl-hauls. The actual depth of the float- and lead line of the trawl with different rope-length has previous been determined by a dept-sensor. In this case with the rope-length used the depth of the float-line – lead-line were 9–14 m, 6–11 m and 9–14 m. The trawl-speed was 2 knots and the time trawled 10 min. Start and stop positions as well as the actual distance is found in Appendix 1, Table 1.

3.1.2 Hydro-acoustics

For the hydro-acoustic part of the survey a Simrad EY 500 transceiver was used connected to a 70 kHz single beam transducer and a personal computer. The operating program was of version 5.31. The transducer was mounted at the bottom of the R/W Ancylus. The post processing program used to analyse the in the field recorded data was EP 500 version 5.3.

The vertical resolution used for the analysis was in 2 m steps except the first (5–6 m). The back stepping from the bottom was 0.5 m.

The equipment was calibrated against a copper sphere.

3.1.3 Estimation fish biomass

Statistical analyses of the primary data were performed with the software, STATISTICA 7.0

To achieve an estimate of the variance of the biomass within the investigated area the geostatistical software by /Petigas and Prampart, 1993/ was used.

4 Execution

4.1 The Simpevarp area

The Simpevarp area (Oskarshamn community) is situated 30 km north of Oskarshamn. The investigation area is located east of the nuclear power plant in the Baltic Sea, see Figure 1-1.

The area is an open shallow part of the Baltic Sea exposed to winds from southwest, east and northeast. The depth rarely exceeds 36 m and the bottom topography is highly variable.

The first survey was conducted the 14th of June to 17th of June 2004. In the first and the third night hydro-acoustics was conducted along transects given in Figure 1-1. The second night (15–16 June) three trawl-hauls as well as hydro-acoustics when trawling were done along transects shown in Figure 1-1.

Both trawling and hydro-acoustics were conducted during dark hours. This is because the fish has left the bottom and the schools are dissolved during the dark hours. When this is the case the equipment on board the boat can count each individual fish. The latitude and longitude when starting, turning respective stopping is given in Appendix1, Table 1.

4.2 Execution of field work

4.2.1 Pelagic trawling

The catch from each trawl-haul was sorted for species. The total catch of each species was weighted in g. If the number of one species was low (< 100 individuals) all were measured by length (total length) in mm. In case of higher numbers (here sprat *Sprattus sprattus* L.) three sub-samples of 100 individuals each were taken and measured for total weight and 100 fish for individual length.

4.2.2 Hydro-acoustics

The hydro-acoustics was run along 8 transects each one of the three night surveyed (15/6, 16–17/6 and 31/8–1/9 2004). The location as latitude and longitude in the beginning and the end of each transect is given in Figure 1-1.

The speed used was 6 knots. Hydro-acoustics used for estimation of fish-stocks is well described by /MacLennan and Simmonds, 1992/.

4.3 Data handling/post processing

The hydroacoustic data collected in the field was stored on jaz-drives. These data were compressed and scrutinised in the laboratory for disturbances. These could be either poor bottom or faulty echoes. The poor or missing bottom was substituted by a new bottom and faulty echoes deleted before the data could be analysed for fish per ha. In these data very few corrections had to be done. In the actual analyse for fish per ha it happened that the program gave a warning of “Low single fish resolution” resulting in very high number of fish per ha for a particular depth inter-wall. In such a case the result was substituted by the data from the closest depth inter-wall. Even this type of corrections that had to be done was few and related to the first depth inter-wall.

4.4 Nonconformities

No nonconformities. Even the weather was decent.

5 Results

All the basic data are found in Table 1–3, in Appendix 1.

5.1 Pelagic trawling

The trawl hauls had to be kept short (0.36–0.37 nm), as it was difficult to find areas with sufficient depth for pelagic trawling. Two depth-intervals were used, 6–11 m (second haul) and 9–14 m (first and third haul). The catch was fairly similar in the three hauls. Three species sprat, herring (*Clupea harengus* L.) and stickleback (*Gasterosteus aculeatus* L.) was common in all hauls. Additional species were dab (*Platichthys flesus* L.) with two fishes in the second haul and one fish of the family Cottidae in each one of hauls one and three. The length distribution of the fish from the three hauls (Figure 5-1, 5-2, 5-3) showed stickleback to be 4–6 cm, sprat 8–18 cm with the majority of 9–10 cm, herring 9–20 cm and the two dabs were the largest with 23 and 24 cm total length.

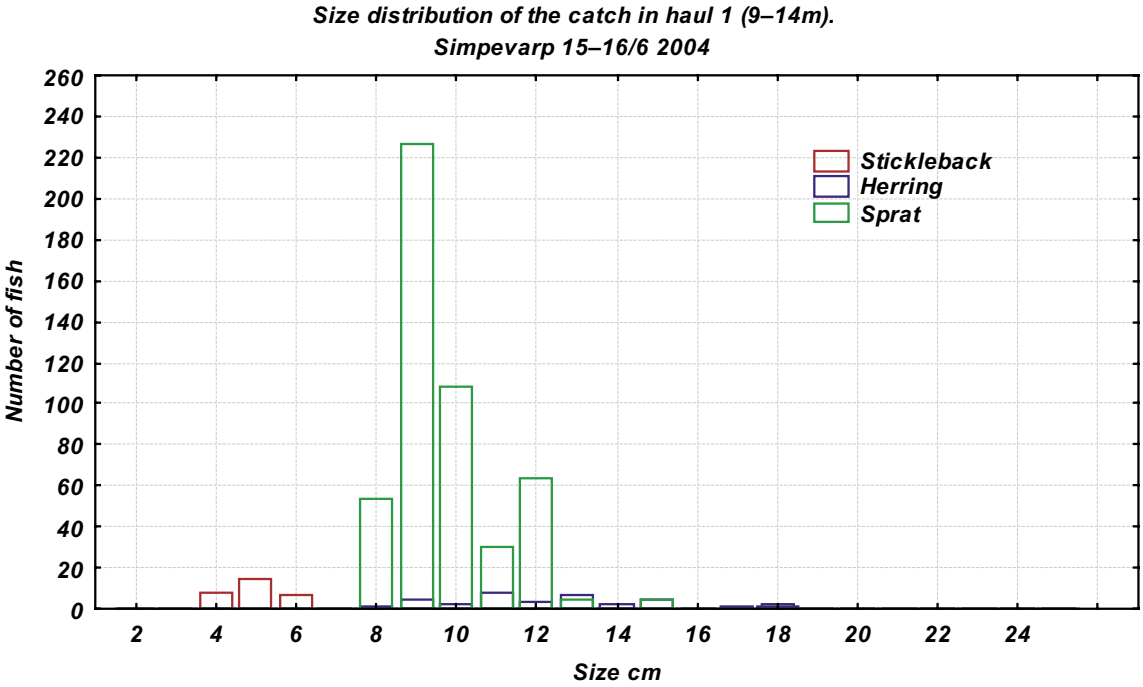

Figure 5-1. *The size distribution of the fish caught in the first trawl-haul.*

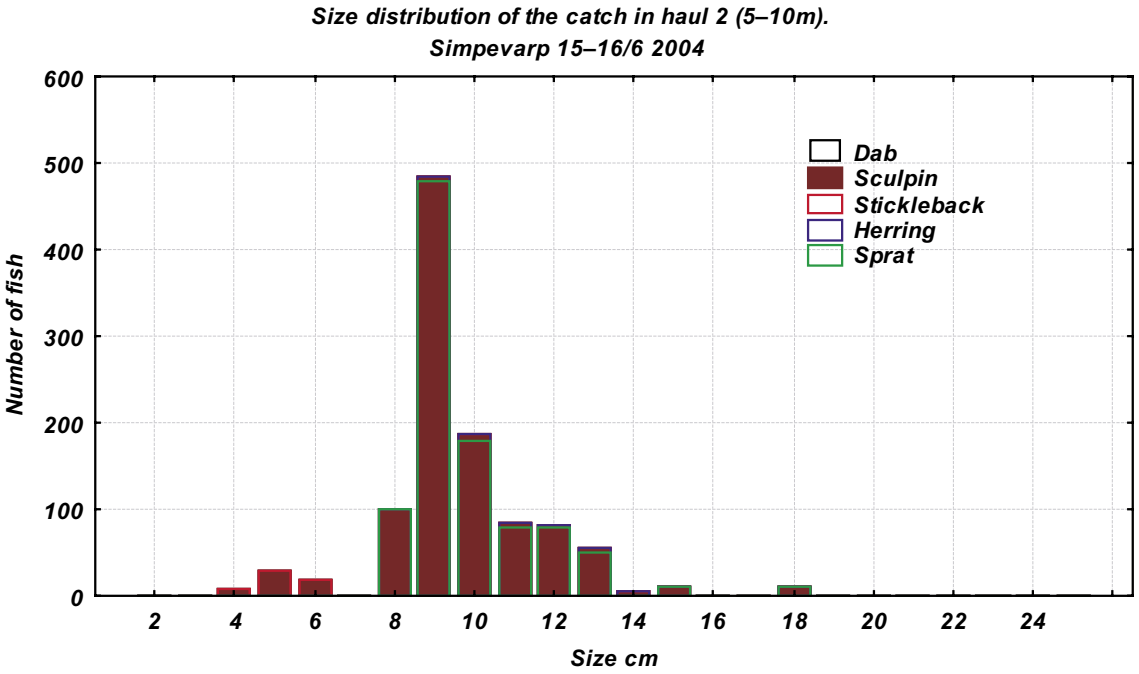

Figure 5-2. *The size distribution of the fish caught in the second trawl-haul.*

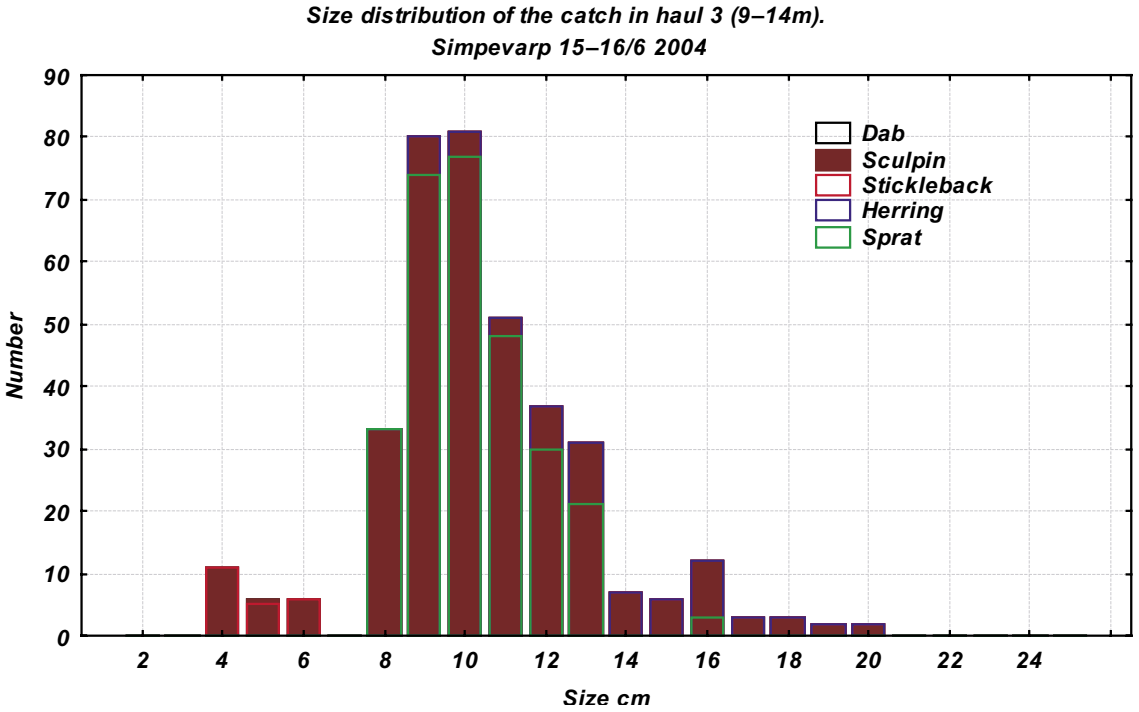

Figure 5-3. *The size distribution of the fish caught in the third trawl-haul.*

The samples taken were only measured for individual length and total sample-weight. These data have been used to construct a length-weight relationship Figure. 5-4.

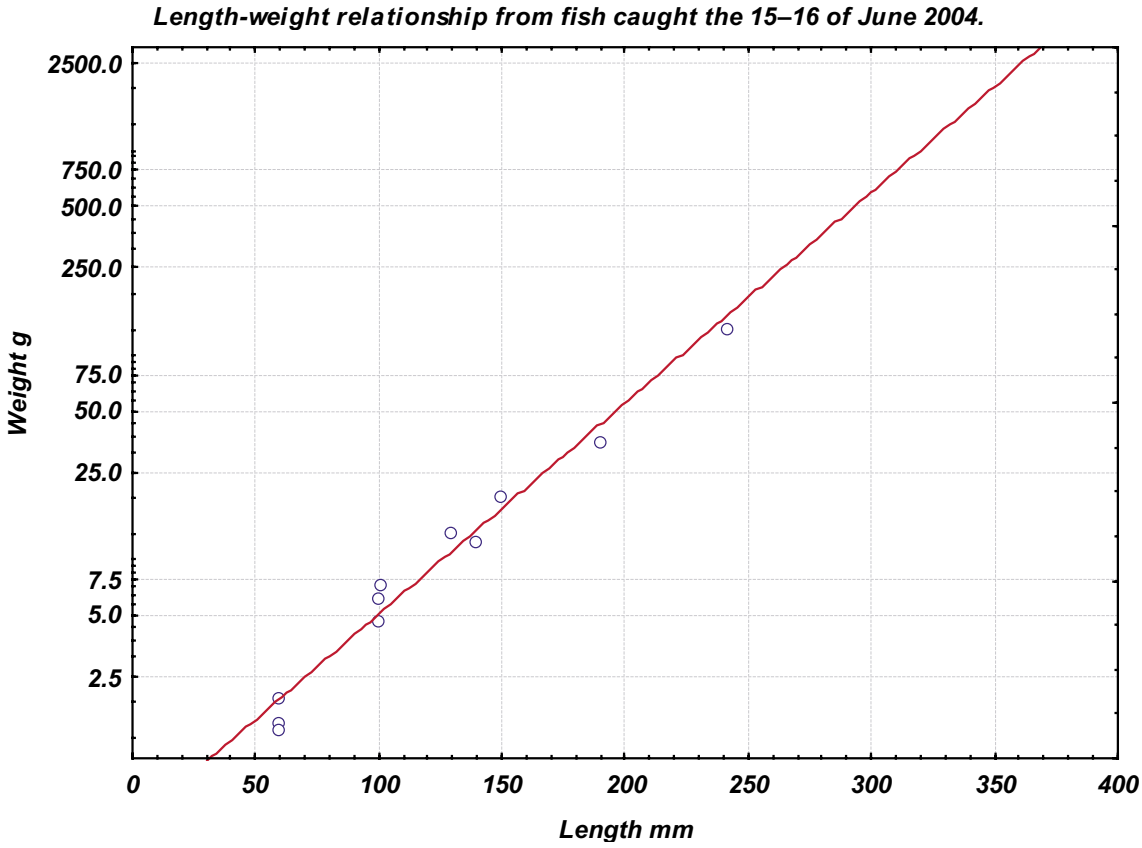

Figure 5-4. *The length-weight relationship of fish caught in the trawl.*

5.2 Hydro-acoustics

Hydro-acoustics was done along the same eight transects at each one of the three occasions (15/6, 16–17/6 and 31/8–1/9 2004).

The analyse of the recorded hydro-acoustic data was done in 2 m vertical steps, except for the first 5–6 m, for each transect. These results are here referred to as "cell-results". The cell-results have then been summed up vertically for each transect and expressed as number per ha in twelve different groups of target strength expressed in dB (Appendix 1, Table 2). To give a picture of the vertical distribution of fish within the investigated area the "cell-results" for all transects have been summed up "horizontally". The distribution is fairly even over the depth in June and a strong concentration of fish at 10–12 m in August–September (Figure 5-5). This is not too surprising, as the water in June should be less stratified than in August–September. Unfortunately only one temperature-profile was taken (June) (Figure 5-6) and then only down to 14 m.

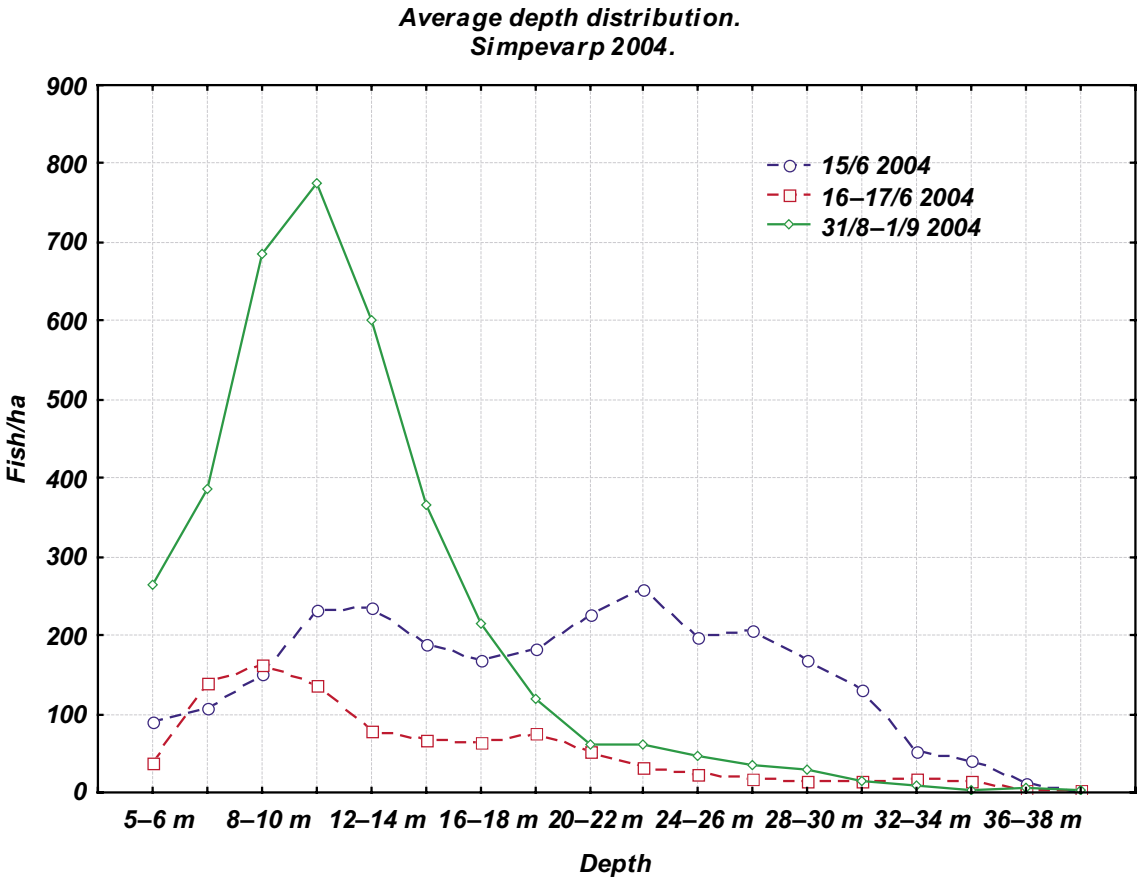

Figure 5-5. *The depth distribution of fish in the investigated area at the three occasions.*

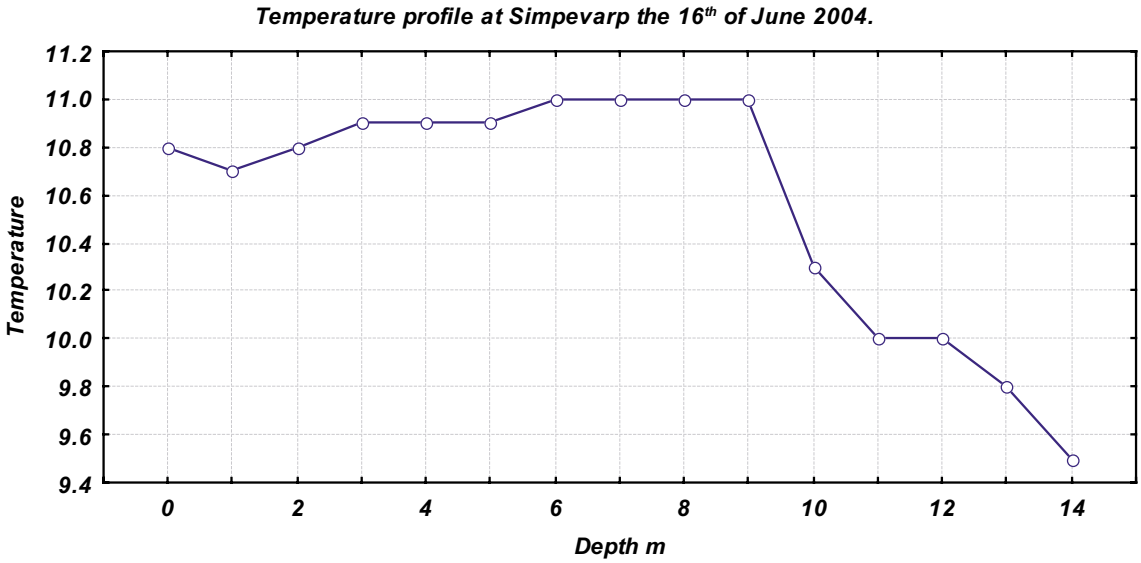

Figure 5-6. *The temperature profile outside the Simpevarp nuclear power station.*

5.3 Estimation of the biomass of fish

In this case two ways to estimate the biomass has been considered. Either to convert the total Sa values or uses the TS (target strength) distribution (see Appendix 1, Table 2). The total Sa value is area back-scattering coefficient expressed in m^2/ha for all echoes i.e. an index of the biomass. Using the trawl-results and the total Sa values from each trawl-haul a regression can be achieved between kg caught and total Sa values within the trawled depth. In this investigation the intention was to do so but with only three trawl-hauls this way was rejected in favour of using the TS distribution.

The first step was to construct a correlation between the length-distribution of the fish caught (Figure 5-1, 5-2 and 5-3) in the trawl and the TS distribution from the same volume trawled (Appendix 1, Table 2). The correlation found can be described by:

$$TS = 20\log L - 68$$

where:

TS = target-strength in dB.

L = total fish-length in cm.

The correlation is in good agreement with what was found by /Lindem and Sandlund 1984/.

In the next step the corresponding length within each TS class has been given a weight from the length-weight correlation in Figure 5-4, and a mean biomass for each one of the three night surveyed was calculated. The result is showed in Table 5-1.

When a single beam transducer is used the EP 500 program uses an indirect statistical method /Craigs and Forbes, 1969/ to calculate the in-situ Target Strength (TS). If targets (i. e. in this case individual fishes) are too close the program cannot separate the single echoes from each other and one or more echoes will be lumped and counted as one bigger fish. This problem is clearly visible in table 2, Appendix 1, where the number of fish larger than –41 dB is far too high. In the estimation of the fish-biomass only data of echoes smaller than –38 dB are used. The result will be a certain underestimation of the fish-biomass. The resulting estimated fish-biomass for each transect is shown in Figure 5-7. Estimates of the variance of the mean biomass from the three nights surveyed, within the investigated area (based on mean values from each transect) are shown in Tabell 5-1 and Figure 5-8.

Tabell 5-1. Estimate of the biomass of pelagic fish in the investigated area.

Date	Mean (kg/ha)	Variance σ^2	95% konfidence. limit
20040615	49.6	698.5	± 18.2
20040616-20040617	20.9	690.4	± 5.7
20040831-20040901	56.8	831.2	± 20.0

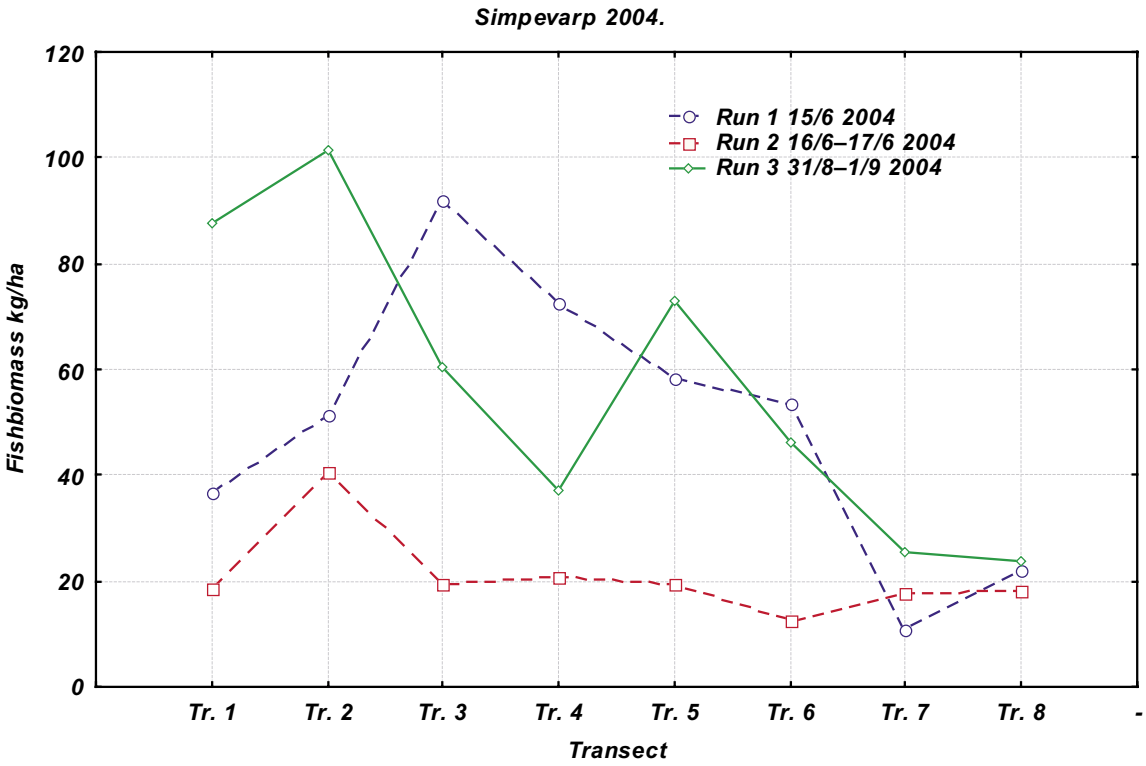

Figure 5-7. *The estimated fish-biomass along each transect for each one of the three occasions.*

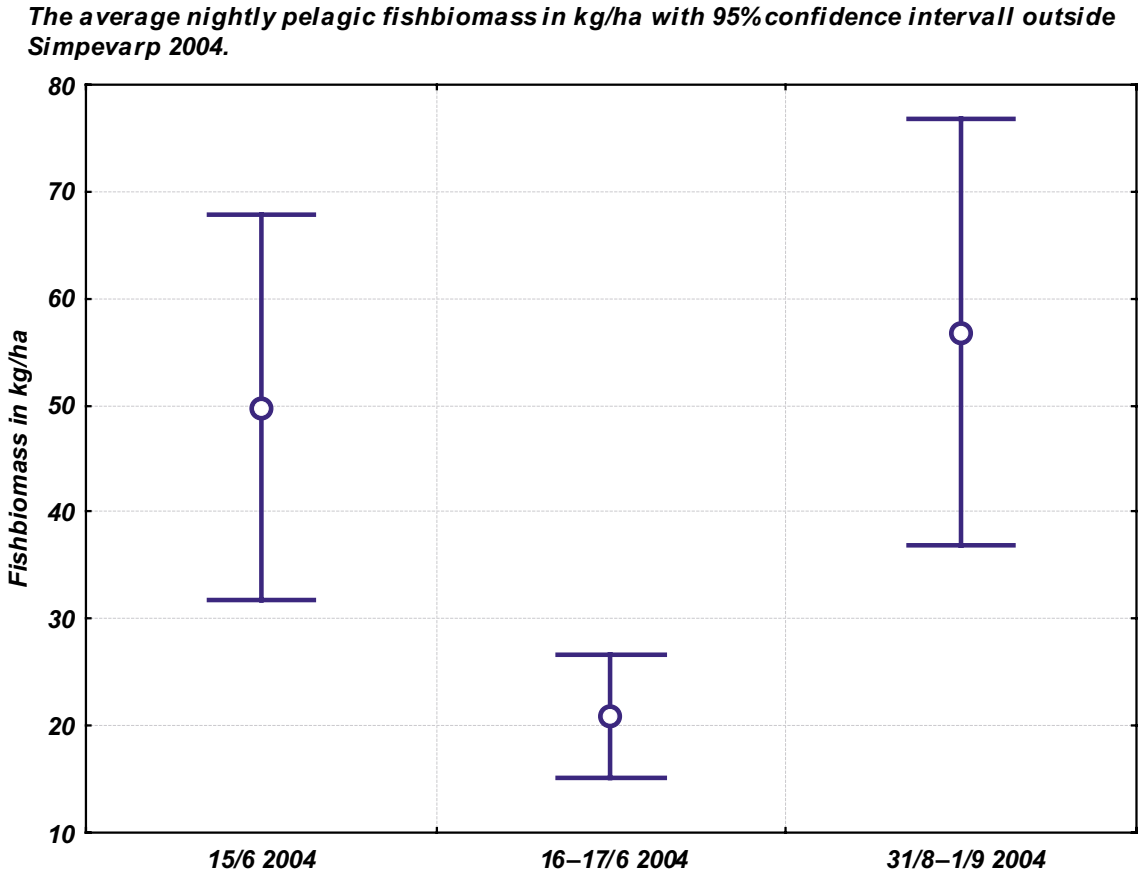

Figure 5-8. *The nightly pelagic fish-biomass in kg/ha with 95% confidence interval at each one of the three occasions.*

6 Summary and discussions

The amount of fish given both as number per ha and as an estimate of the biomass is only valid for the nightly pelagic fish. But as can be seen from the pelagic trawl-catches even species that normally is considered as bottom-bound, here dad and species belonging to the family *Cottidae*, can bee found in the pelagic during the night. But the proportion of the entire “bottom-bound” population that has been counted by the equipment is impossible to tell.

It should also bee remembered that both the numbers per ha and the biomass of the nightly pelagic fish stock is an underestimation. This is due to that the equipment requires a certain vertical distance between fish for them to be counted as individual fish.

Although this costal area is shallow and open and thus wind-exposed it is a bit surprising that the fish population can be significantly lower only two nights later.

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Appendix 1

Tables of results

Table 1. Transects for hydroacoutics and trawling.

Date (no.)	Start-time	Air temp.	Surface temp.	Winddir.	Windspeed (m/s)	Start Latitud	Longitud	Stop Latitud	Longitud	Direction (degrees)	Time (min)	Speed (knots)	Length (nm)
Hydro-acoustics													
20040615 (1)	0.1	14	10	W	12	572180	164292	572380	164230	90	29	6	3.2
20040615 (2)	0.39	13.5	10	W	10	572180	164850	572380	164230	301	41	6	3.9
20040615 (3)	1.2	13.3	11	W	10	572380	164229	572380	164850	90	34	6	3.33
20040615 (4)	1.54	12.9	10	W	10	572380	164850	572570	164240	300	38	6	3.8
20040615 (5)	2.32	13.2	9	W	10	572570	164240	572570	164850	90	32	6	3.3
20040615 (6)	3.04	12.7	10	W	8	572570	164850	572715	164620	320	22	6	1.9
20040615 (7)	3.26	12.7	10	W	8	572714	164619	572714	164850	90	12	6	1.24
20040615 (8)	3.38	12.7	10	W	8	572714	164850	572870	164720	337	17	6	1.7
Hydro-acoustics													
20040616 (1)		12.3	10	W	5	572180	164292	572380	164230	90	30	6	3
20040616 (2)		12.3	10	W	5	572180	164850	572380	164230	301	40	6	3.4
20040616 (3)	22.43	12.3	10	W	5	572380	164229	572380	164850	90	34	6	3.3
20040616 (4)	23.17	11.7	10	W	5	572380	164850	572570	164240	300	38	6	3.8
20040616 (5)	23.55	11.9	11	W	5	572570	164240	572570	164850	90	33	6	3.3
20040617 (6)	0.28	11.9	10	W	5	572570	164850	572715	164620	320	21	6	1.9
20040617 (7)	0.49	12.1	11	W	5	572715	164619	572714	164850	90	11	6	1.2
20040617 (8)	1	12.2	10	W	5	572714	164850	572870	164720	337	19	6	1.7
Hydro-acoustics													
20040831 (1)	22.17	14.8	16	SE	8	572180	164292	572179	164850	90	30	6	3.2
20040831 (2)	22.47	14.7	17	SE	8	572179	164850	572380	164230	301	40	6	3.9
20040831 (3)	23.27	14.4	15	SE	7	572380	164230	572379	164850	90	34	6	3.33
20040901 (4)	0.01	14.8	16	SE	7	572379	164850	572570	164240	301	38	6	3.8
20040901 (5)	0.39	14.5	14	SE	6	572570	164240	572570	164850	90	35	6	3.3
20040901 (6)	1.14	14.9	16	SE	6	572570	164850	572714	164619	320	19	6	1.9
20040901 (7)	1.33	14.9	13	SE	6	572714	164619	572714	164849	90	14	6	1.24
20040901 (8)	1.42	14.9	14	SE	6	572714	164849	572869	164725	337	17	6	1.7
Trawaling													
20040615	23.17	12.2	10	W	6	572283	164380	572254	164401	158	10	2	0.36
20040616	0.17	11.2	10	W	6	572298	164361	572265	164390	158	10	2	0.37
20040616	1.44	10.6	11	W	5	572568	164296	572568	164363	90	10	2	0.36

Table 2. Number of individuals/ha in twelwe different groups of Target Strength (TS), the calculated total amount of fish individuals/ha and the back scattering coefficient Sa (m^2/ha) i.e. an index of the biomass.

Date (no)/ TS (dB)	–56	–53	–50	–47	–44	–41	–38	–35	–32	–29	–26	–23	Tot. (fish/ha)	Sa (m^2/ha)
Hydro-acoustics														
20040615 (1)			1,247	1,068	313	73	27	8	6	1	1		2,744	1.44
20040615 (2)			1,437	1,558	416	116	29	14	3	2			3,575	1.38
20040615 (3)			1,057	2,235	855	276	90	8	2	1			4,524	2.53
20040615 (4)			904	1,802	735	196	62	5	5		2		3,711	1.62
20040615 (5)			838	1,005	550	195	71	22	8	1	1	1	2,692	1.4
20040615 (6)			1,082	952	367	203	102	29	10				2,745	2.1
20040615 (7)			69	158	113	37	70	17	2	4			470	0.82
20040615 (8)			234	132	71	130	55	20	18	10	2	1	673	1.41
Hydro-acoustics														
20040616 (1)			246	127	144	84	50	18	14	1	2		686	1.09
20040616 (2)			208	349	191	227	69	11	5	8		1	1,069	1.01
20040616 (3)			171	169	128	96	34	10	3	2			613	0.72
20040616 (4)			257	207	255	64	25	12	1				821	0.64
20040616 (5)			367	245	162	70	31	5	3	1	2	3	889	0.81
20040617 (6)			488	340	129	19	12	5	1	1		1	996	0.63
20040617 (7)			716	390	154	40	28	12	2				1,342	0.98
20040617 (8)			546	417	126	56	21	4	2	2	2	1	1,177	0.93
Hydro-acoustics														
20040831 (1)	1,047	817	723	995	685	361	53	6	4	2	1		4,694	3.12
20040831 (2)	1,307	829	610	742	739	473	97	5	6	2	1		4,811	2.66
20040831 (3)	1,506	737	601	659	490	231	72	9		1		2	4,308	2.53
20040901 (4)	1,798	2,054	386	1,092	170	86	5						5,591	1.44
20040901 (5)	438	652	590	955	534	306	85	10	1		2		3,573	2.98
20040901 (6)	301	666	511	592	362	176	35	8		1		1	2,653	1.88
20040901 (7)	271	389	517	522	220	67	21	2					2,009	1.15
20040901 (8)	369	362	369	396	250	61	12	3	1		1		1,824	1.16
Trawling	**Trawldepth (m)**													
20040615	Trål 1 (9–14 m)		79	56	67	50	25	43	7	4			331	0.61
20040616	Trål 2 (6–11 m)		171	15	22		16						224	0.57
20040616	Trål 3 (9–14 m)		57	89	23	27	21	5	4				226	0.5

Table 3. Number and weight of fish species in the trawl catches.

Trawling	Trawl-depth (m)	Sprat number	weight	Herring number	weight	Stickle-back number	weight	Cottidae number	weight	Dab number	weight
20040615	Trål 1 (9–14 m)	493	3,010	35	450	30	60	1	36		
20040616	Trål 2 (6–11 m)	989	4,648	30	350	58	86			2	254
20040616	Trål 3 (9–14 m)	285	2,040	62	1,190	22	30	1	0.5		