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**COMPARISONS BETWEEN SIZE DISTRIBUTION IN SURVEYS AND
COMMERCIAL CATCHES – A USEFUL TOOL FOR MONITORING CHANGES IN
THE SIZE SELECTION IN THE FISHERIES?**

by

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Abstract

A method is proposed for using fish length distributions from standardized research surveys for estimating relative selection in the fisheries. The method is applied on data for North-east arctic cod in the 1990-ies. Survey-related selection for the Norwegian trawl fishery is compared between years and between data covering different seasons and geographical areas. Some uncertainties of the data are recognised and discussed. In spite of this there seem to be a fair consistency among the data sources, leading to the conclusion that the selection on length groups near the minimum catching size increased considerably in 1998 and has decreased in 1999 and 2000. Possible reasons for this development are indicated.

Introduction

In the literature comprehensive studies are available on how technical details of fishing gears influence the size selection. Such studies form the basis for a number of regulations regarding mesh size, sorting devices, gear dimensions and so on. The size selection for a fishery as a whole depends on a number of additional factors that are difficult to predict or measure. Such factors are (among many others); the spatial and seasonal mixing of different size groups of fish, the price difference between size groups, technological development, quota limitations, by-catch regulations and area closures. In addition the temptations to break the regulations may vary, for instance depending on absence/ presence of coast guard vessels. Such effects work on various time scales and geographical scales. Methods for monitoring changes in the size selection of the fishery at various scales are needed, both for evaluating the effects of the existing regulations and for improving the assessment and prediction of the stock situation.

Abundance estimation surveys are aimed at covering the whole stock. They are applying sampling gears that are well documented and standardized between vessels and between years. A change from one year to the next in the size distribution from a survey is expected to reflect some change in the true size distribution of the stock, even though the survey catchability may depend on the fish size. Size distributions from surveys could therefore work as a useful reference to get a kind of relative selection when analysing the size distribution in commercial

catches. In this paper data on North-east Arctic cod from demersal fish surveys in the Barents Sea and from the Norwegian trawl fishery have been used to compare survey-related selection between years and to compare survey-related selection at various time scales and geographical scales.

Material and methods

Table 1a gives survey estimates by length for cod in the Norwegian winter (February) bottom trawl survey, for the period 1993-2000. This survey started in 1981, and since 2000 it has been a joint Norwegian-Russian survey. In the late 80-ies and early 90-ies several changes in survey methodology was introduced. Therefore, only the years after 1992 are used here. Jakobsen *et al.* (1997) describe the survey and the changes in methodology. They also describe the functional relationship between fish size and effective fishing width of the trawl assumed in the swept area estimation procedure. For comparisons with other studies based on direct catch rates by length in the research trawl, an attempt was made to remove this length dependent function in the estimates, by applying a factor corresponding to the mid-point in each 5 cm length interval. Since these factors have been applied directly on the total survey estimate, it is an approximation compared to using raw data without length dependent fishing width. These factors and the results are shown in Table 1b.

Annual trawl catch, all areas

Total annual landings by length for the Norwegian trawl fleet are shown in Table 2 for the period 1993-2000. These data are as reported to the Arctic Fisheries Working Group (AFWG), where catch by length is used as input to the "fleksibest" model. When these data were calculated, the samples from catches and the samples from landings were treated equally. Over this period the amount of sampling of catches has increased relative to the amount of sampling of landings.

The ratio between annual catch by length and survey estimate by length can be considered as the relative fishing pressure by length for a given year. Since the fishery reflects the whole year, while the survey only covers one month, the growth of the fish confuses the direct interpretation of this ratio. The ratio by length can, however, be compared between years, if it is normalised for the annual overall fishing pressure. The ratio for the size groups having full selection could be a useful measure of overall fishing pressure. Here it is assumed that fish above 60cm have full selection. Relative selection RS_i for length group i is therefore calculated as

$$RS_i = (C_i/S_i) / (C_{>60}/S_{>60}) \quad (1)$$

Where C is catch in number and S is survey estimate in number.

First quarter catch, Western Barents Sea

Table 3 shows the catches of cod taken by Norwegian trawlers during the first quarter in the area north of 70° N and west of 30° E. These catches are distributed on length according to total number of cod measured by the Norwegian Coast Guard during inspections of Norwegian trawlers in the same area and quarter. Table 4 gives the abundance estimates in the winter

survey for the same area (Main Areas A,B,C and S, Jakobsen *et al.* 1997). The Table also includes values where length dependent fishing width is removed, as described above.

Relative selection is calculated by equation (1).

July-August, Bear Island-Region

Another source of information for calculating relative selection in commercial trawl relative to research vessel trawl is the data from the closed area monitoring surveys that are conducted by the Norwegian Directorate of Fisheries. The purpose of these surveys is to evaluate the needs for closing areas for fishing, in order to protect undersized fish. Here a typical commercial cod trawl with 55 mm sorting grid (Sort X) is used. Some of these surveys overlap in time with the Norwegian summer survey (Aglen 1999), where the standard research trawl is used. In July-August 1997 and 1999 there was a reasonable overlap between these two surveys at bottom depths between 100 and 300 m in ICES sub-Division IIb, south of 76°30' north. Table 5 shows the average catch rates (number of fish per n. mile towed) by length for the commercial trawl and the research trawl for those surveys in the overlapping areas.

Relative selection was calculated by equation (1) with the modification that the catch was replaced by the average catch rate for the commercial trawl, and the survey estimate was replaced by average catch rate for the research trawl (Table 5).

Mid August, small area (10 by 16 n.miles)

During the summer survey in 1995 two research vessels were inter-calibrating their research trawls within an approximately 10 times 16 n. mile area to the west of Bear Island (between 74°13' and 74°22' north and 16°50' and 17°50' east), while, during the same week, three commercial trawlers with observers onboard were working in the same area. Table 6 shows average catch rates by length for each vessel in that experiment.

Relative selection was calculated by equation (1) with the modification that the catch was replaced by the average catch rate for the commercial trawl, and the survey estimate was replaced by average catch rate for the research trawl (Table 6).

Results

Relative selection was calculated by equation (1) from the data presented in Tables 1-6. Figures 1 and 2 show survey-related selection by length group for the annual catch and Figure 5 shows survey-related selection for the first quarter catch in Western Barents Sea. The results were not sensitive to whether the survey estimates were based on length dependent or fixed fishing width. This is because the assumed length dependence is rather weak for the size groups with high selection in the commercial fishery, and the scaling factor (ratio for all fish above 60 cm, equation (1)) takes account of the systematic difference in assumed fishing width for large fish.

For the annual catch the between year variation in relative selection is largest for the largest fish (Figures 1 and 2). During the winter survey a large, but variable, proportion of the largest fish is

on spawning migration outside the survey area. This fish is available to the commercial trawlers both on its spawning migration and in the Barents Sea during other seasons. When considering only catches taken in the same area and season as the survey (Figure 5) it is seen that this tendency of increased year to year variation for the largest fish is less pronounced. In the size range 42.5 to 62.5 cm the between year variability is larger in the period 1997-2000 (Figure 2) than in the period 1993-1996 (Figure 1). The high variability in the last period is also confirmed in the first quarter catches in the Western area (Figure 5). Figures 3 and 6 show that the relative selection for the length groups 47.5 and 52.5 had a peak in 1998, remained fairly high in 1999 and return to the pre-98 level in 2000. A similar development is observed for the age groups 4 and 5 in the relative fishing mortality at age (Figure 4) taken from the last stock assessment (ICES 2001).

The survey related selection calculated from the closed area monitoring survey show large differences between July-August 1997 and July-August 1999 (Figure 7). Below 45 cm the 1997 monitoring survey show higher selection than any of the other cases considered here. These monitoring surveys may spend more effort in areas with concentrations of undersized fish and could be biased compared to an ordinary abundance estimation survey.

The data from the individual commercial trawlers represents few hauls, and it is seen that average catch rates differed largely between the vessels (Table 6), even though all the tows were taken within few days in a quite restricted area. In spite of this, the relative selections for the two vessels not using sorting grid are fairly similar, at least for fish lengths below 50 cm (Figure 8). For the length groups 42.5 – 57.5 cm the relative selection "curve" for the vessel using sorting grid is about 5 cm further to the right than the other two. The two research vessels were in this case towing in parallel (0.3 to 0.5 n.mile between the vessels) and they had a reasonable number of tows. Here it is seen that the average catch rates for these two vessels are quite close for all length groups above 22.5 cm (Table 6).

Discussion

The various data sources have different weaknesses. As mentioned the whole year catch includes catches from other seasons and areas than covered by the survey, and thus lead to some uncertainties relating to the largest fish which is poorly covered by the survey. In addition the growth of the fish confuses the interpretation of the results. These two factors are largely reduced when only considering the first quarter catch in the western area. Here the results are based on the Coast Guard inspections, which could be biased, because the Coast Guard may focus on areas where by-catches are high or there are concentrations of undersized fish. In addition, the amount of inspections has increased during recent years. This could indicate that the sampling strategy has changed over the same period.

The closed area monitoring surveys may be biased towards areas with concentrations of undersized fish. In addition, the data are taken in an area and a season where the cod is known to move around rather quickly. Therefore, some week time-lag between the closed area monitoring and the research vessel survey could involve considerable changes in fish size distribution.

The data on individual commercial trawlers in the small area represents very few catches for two of the vessels.

In spite of these weaknesses it seems that the results from the different data sources within the same year (Figure 9) are in most cases more similar than the results for the same data source compared between years. This indicates that in each of the data sets there are some signals of significant year-effects in the size selection in the Norwegian trawl fishery.

A systematic evaluation of all regulations, control measures, market developments and changes in the fleet would be required to try to explain the between year differences in selection indicated in this study. At this stage only some hypothesis may be raised. One interesting pattern is the development for the selection of the length groups 47.5 and 52.5 in recent years. It decreased from 1996 to 1997 and raised considerably in 1998, then decreasing again in 1999 and 2000. The decrease in 97 could be caused by more extensive use of sorting grids, since it was made mandatory from the beginning of the year. In 1997 and 1998 the total quota was high relative to the fishable stock and the quota was not reached. It seems that the fleet focused on the large fish until it became more profitable to fish in areas with smaller fish. A shift in that respect might have occurred during 1998. During 1998 the Norwegian Coast Guard inspections showed an increased proportion of small fish in the catches, especially in the Grey Zone during the autumn. In 1999 and 2000 large areas with undersized fish have been closed for most of the year. In addition the quotas have been reduced.

References

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- ICES 2001.** Report of the Arctic Fisheries Working Group. ICES CM 2001/ACFM:19.
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A. AGLLEN: Comparisons between size distribution in surveys and commercial catches. ...

Table 1. Estimated number of cod (millions) by 5 cm length group in the total winter survey. The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

a: Estimates based on length dependent fishing width (as in survey reports)

b: Estimates converted to 25 m fishing width independent of length. Factor is the factor by 5 cm group used for conversion.

Length (cm)	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60
a														
1993	208.5	175.9	60.0	90.0	109.2	65.1	40.1	59.1	62.6	30.7	12.5	7.6	4.8	61.3
1994	324.4	128.2	153.0	113.5	83.0	114.9	131.3	87.5	45.1	37.0	31.3	17.2	6.6	96.4
1995	315.4	212.8	97.7	84.9	114.3	103.4	98.3	113.8	97.6	51.7	25.2	17.3	10.1	111.8
1996	380.9	328.0	82.9	51.7	54.9	64.0	69.2	59.5	46.7	43.9	28.8	12.8	5.7	96.4
1997	604.4	367.3	141.0	109.9	50.1	31.5	34.9	37.6	34.8	23.8	15.3	10.0	6.1	58.2
1998	366.8	162.2	138.3	171.0	139.8	84.6	42.3	22.9	16.7	14.4	10.4	7.6	3.7	39.0
1999	245.7	96.0	116.7	79.7	78.2	67.4	50.8	29.0	13.4	6.7	5.0	4.1	3.2	21.2
2000	79.8	182.0	131.7	85.7	67.9	55.2	46.2	46.3	31.1	15.9	7.8	3.3	1.7	30.3
2001	41.3	46.1	54.8	97.4	111.3	80.1	59.9	46.0	28.7	19.3	12.7	6.5	3.5	43.9
b														
Factor	0.81	0.90	0.98	1.06	1.12	1.19	1.24	1.30	1.35	1.39	1.39	1.39	1.39	
1993	168.7	158.6	59.0	95.1	122.7	77.2	49.8	76.7	84.5	42.8	17.4	10.6	6.6	*85.5
1994	262.5	115.6	150.4	119.9	93.2	136.2	163.3	113.6	60.9	51.6	43.6	24.0	9.1	134.4
1995	255.3	191.9	96.0	89.7	128.4	122.6	122.2	147.8	131.7	72.1	35.1	24.2	14.1	155.9
1996	308.3	295.8	81.5	54.6	61.6	75.8	86.1	77.2	63.0	61.2	40.2	17.9	8.0	134.4
1997	489.2	331.3	138.6	116.0	56.3	37.3	43.3	48.8	46.9	33.2	21.3	13.9	8.4	81.2
1998	296.9	146.2	136.0	180.6	157.0	100.2	52.5	29.8	22.5	20.0	14.4	10.6	5.1	54.3
1999	198.8	86.6	114.7	84.1	87.9	79.9	63.2	37.6	18.1	9.3	6.9	5.7	4.4	29.6
2000	64.6	164.2	129.4	90.5	76.3	65.4	57.5	60.0	42.0	22.1	10.8	4.6	2.3	42.2
2001	33.4	41.6	53.9	102.9	125.1	95.0	74.5	59.6	38.8	26.8	17.7	9.1	4.9	61.2

Table 2. Annual catches of cod (millions) by 5 cm length groups in the Norwegian trawl fishery (all areas). The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

Length (cm)	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60
1993	0.0	0.0	0.0	0.1	0.4	1.4	1.9	2.9	4.8	5.4	3.6	2.2	1.4	16.9
1994	0.0	0.0	0.0	0.3	0.6	1.5	3.7	6.3	7.7	9.3	10.9	6.2	2.9	34.8
1995	0.0	0.0	0.0	0.0	0.1	0.5	1.9	6.1	13.3	14.0	9.7	6.1	3.6	36.1
1996	0.1	0.1	0.0	0.1	0.3	0.9	2.0	4.3	6.4	8.5	8.3	5.9	3.7	31.5
1997	0.0	0.0	0.0	0.2	0.6	1.0	1.8	3.4	6.0	8.2	9.1	7.8	5.2	36.9
1998	0.0	0.0	0.1	0.4	1.1	2.6	4.7	6.0	5.6	5.3	4.7	3.8	2.7	21.5
1999	0.0	0.0	0.1	0.3	0.7	2.0	4.4	7.5	7.7	5.4	3.6	2.6	2.0	16.3
2000	0.0	0.0	0.0	0.1	0.3	0.9	2.2	4.6	6.7	6.5	4.4	2.5	1.3	16.3

A. AGLN: Comparisons between size distribution in surveys and commercial catches. ...

Table 3. Catches of cod (millions) by length in the Norwegian trawl fishery in the first quarter in the Western Barents Sea. The length distributions are based on Coast Guard inspections. N is number of fish measured. The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

Length (cm)	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60	N
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.28	0.44	0.88	1.16	1.44	1.30	0.75	5.49	589
1998	0.00	0.00	0.00	0.00	0.04	0.20	0.50	0.68	0.64	0.77	0.80	1.09	0.86	0.47	3.81	1110
1999	0.00	0.00	0.00	0.00	0.01	0.03	0.23	0.60	0.93	1.01	0.80	0.68	0.57	0.43	3.00	6421
2000	0.00	0.00	0.00	0.00	0.01	0.04	0.15	0.43	1.28	2.03	3.00	2.14	0.89	0.32	6.61	22618

Table 4. Estimated number of cod (millions) by 5 cm length group in the Western Barents Sea in the winter survey. The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

a: Estimates based on length dependent fishing width (as in survey reports)

b: Estimates converted to 25 m fishing width independent of length. Factors by 5 cm group used for conversion are as specified in Table 1b.

Length (cm)	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60	N
a																
1997	297.54	6.42	3.27	1.24	1.17	0.73	0.82	1.14	1.42	1.69	1.43	1.06	0.73	0.43	3.91	13075
1998	470.66	6.75	3.48	3.93	5.70	5.44	4.03	2.11	1.16	0.96	0.91	0.71	0.57	0.25	2.74	19134
1999	39.82	2.99	1.22	1.25	1.44	2.60	3.11	2.71	1.68	0.84	0.47	0.39	0.32	0.27	1.67	8547
2000	30.54	2.18	3.83	3.15	2.26	2.65	2.63	2.75	3.24	2.17	1.11	0.57	0.24	0.12	2.21	10505
b																
1997	225.38	5.20	2.95	1.22	1.24	0.82	0.98	1.42	1.85	2.28	1.99	1.47	1.01	0.60	5.45	
1998	356.51	5.46	3.14	3.87	6.02	6.11	4.78	2.62	1.51	1.29	1.27	0.99	0.79	0.35	3.82	
1999	30.16	2.42	1.10	1.23	1.52	2.92	3.68	3.37	2.18	1.14	0.66	0.55	0.45	0.38	2.33	
2000	23.13	1.76	3.45	3.09	2.38	2.97	3.12	3.41	4.20	2.93	1.55	0.79	0.33	0.17	3.09	

Table 5. Average catch rates of cod (number per n. mile towed) in commercial trawl (CT) in the closed area monitoring surveys and in research trawl (RT) in the Norwegian summer survey. All data restricted to the southern part of ICES sub-Division IIb in July-August. The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

Length (cm)	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60	# of hauls
CT 1997	0.01	0.46	1.11	4.38	6.20	3.89	3.94	5.12	5.53	6.13	3.74	2.74	1.80	15.76	23
CT 1999	0.01	0.01	0.23	0.70	1.05	2.93	6.97	8.93	8.39	5.02	2.68	1.82	1.12	11.98	33
RT 1997	58.30	26.97	11.82	8.67	9.66	6.83	5.67	4.16	3.83	3.90	3.73	1.88	1.62	11.89	50
RT 1999	35.37	35.76	18.19	21.83	12.73	8.34	12.89	11.77	7.07	3.97	1.54	1.56	1.08	8.84	47

Table 6. Average catch rates of cod (number per n. mile) for individual vessels fishing in the same area in mid-August 1995. RT1 and RT2 are research vessels using research trawl. CT1, CT2 and CT3 are fishing vessels using commercial trawl. CT1 used 55mm sorting grid, the other two fished without sorting grid and their combined catch rates are shown (CT2+3). The length groups are labelled by the mid-point of the interval. >60 is the sum of all fish above 60 cm.

Length (cm)	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	>60	# of hauls
RT1	163.3	17.4	22.5	30.9	26.0	34.1	22.5	17.6	27.0	34.7	21.3	10.2	6.0	77.5	27
RT2	235.3	27.4	28.8	29.2	26.2	35.6	25.0	18.6	28.0	37.6	21.2	11.9	6.7	83.3	27
CT1	0.0	0.0	0.0	1.4	4.5	14.4	20.4	29.4	93.4	141.4	106.4	53.4	41.1	389.1	8
CT2	0.0	0.0	0.0	0.9	1.9	11.8	17.2	23.4	47.1	65.5	40.7	24.1	17.1	169.0	4
CT3	0.0	0.0	5.8	7.7	18.7	23.6	72.5	110.9	316.2	401.5	212.3	80.5	71.3	819.1	3
CT2+3	0.0	0.0	1.4	2.5	5.9	14.6	30.4	44.4	111.6	146.0	81.8	37.6	30.1	324.8	7

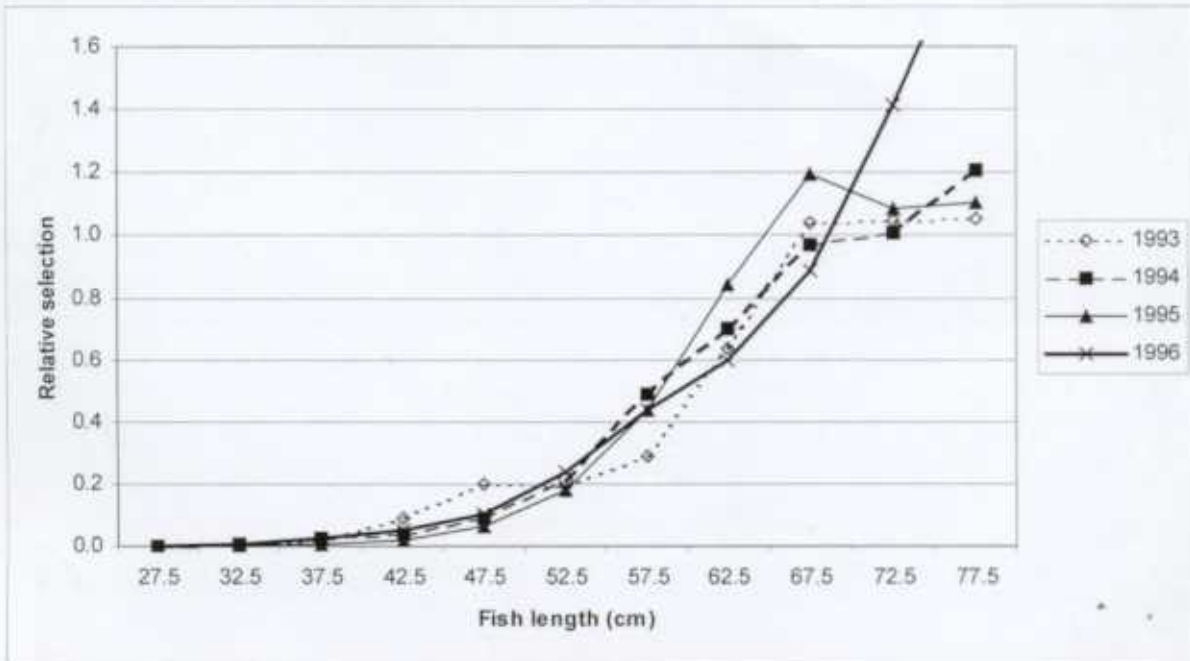


Figure 1. Survey-related selection by length groups for the annual landings by Norwegian trawlers in the years 1993-1996.

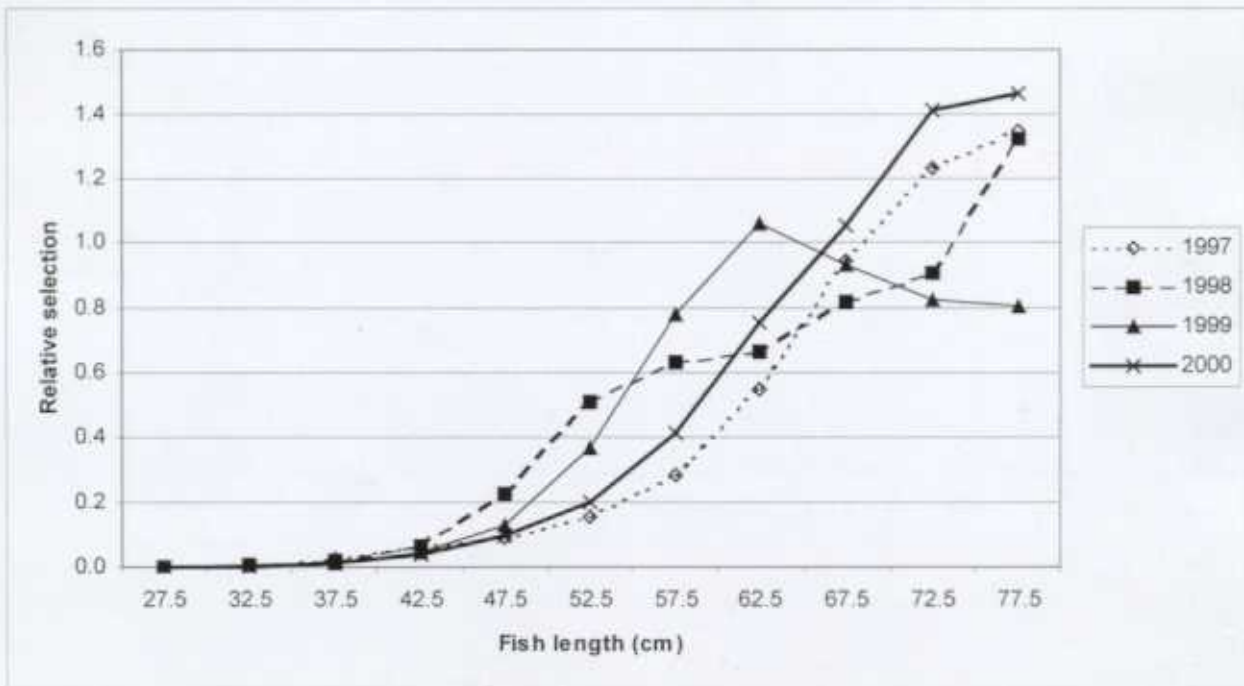


Figure 2. Survey-related selection by length groups for the annual landings by Norwegian trawlers in the years 1997-2000.

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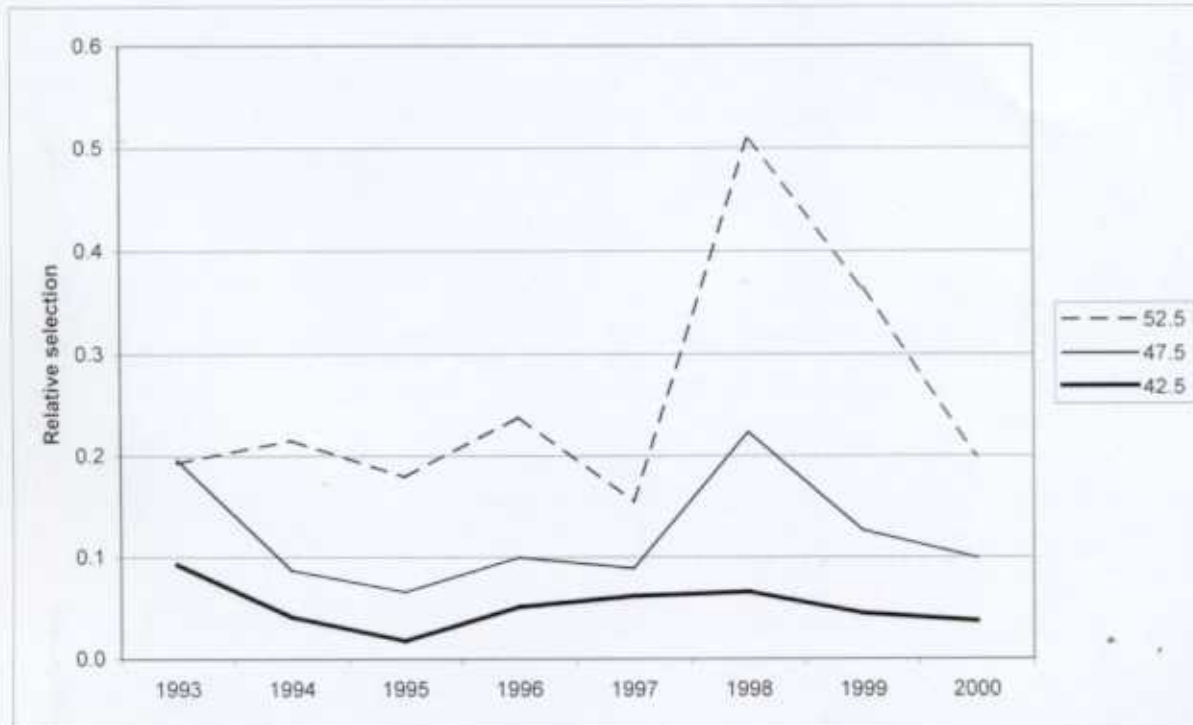


Figure 3. Survey-related selection by years for the length groups 42.5, 47.5 and 52.5 for annual landings by Norwegian trawlers in the years 1993-2000.

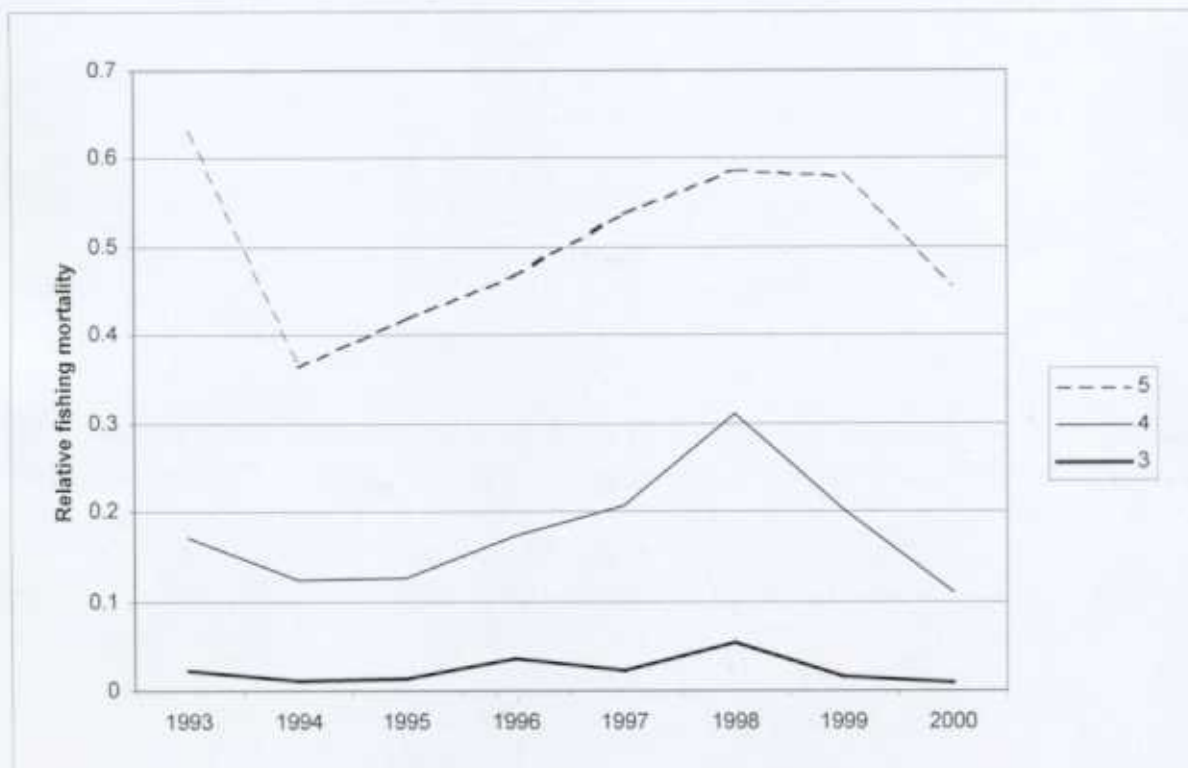


Figure 4. Relative fishing mortality (F) for age groups 3,4 and 5 (F relative to the average F for age groups 5 to 10) for the total fishery of North-east arctic cod, as calculated by the ICES Arctic fisheries Working Group (ICES C.M. 2001/ACFM:19).

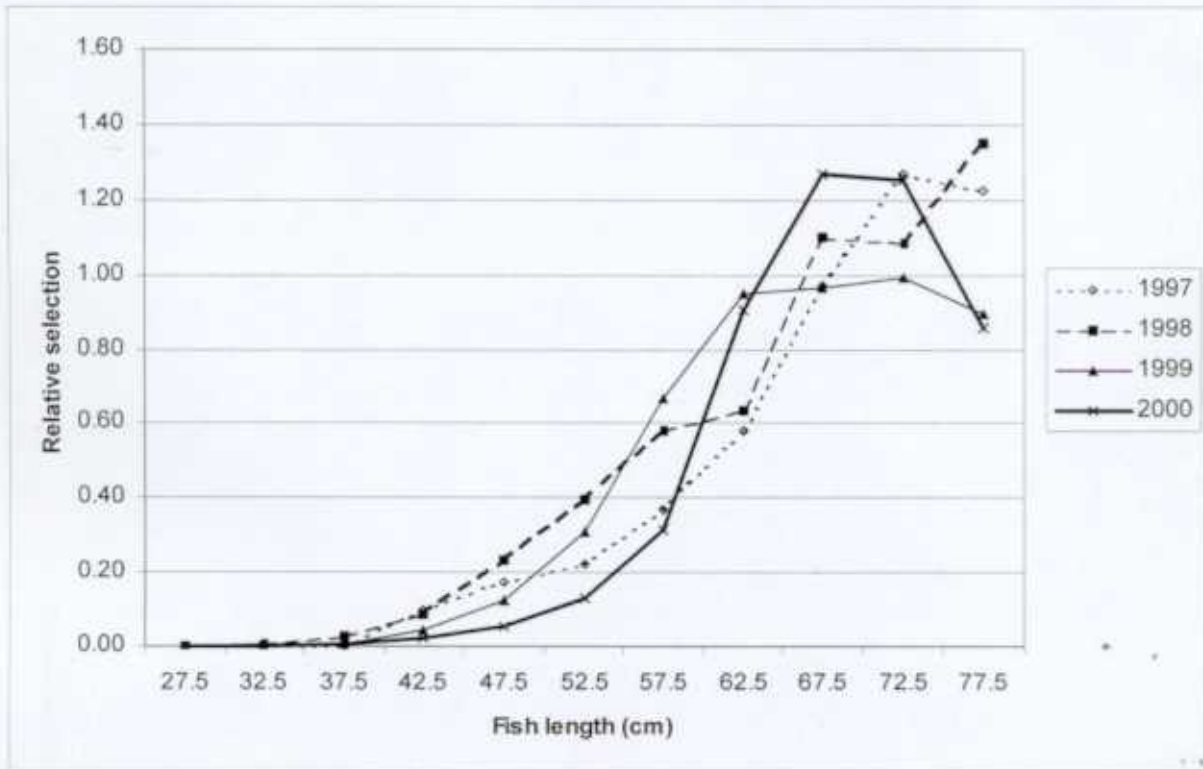


Figure 5. Survey-related selection by length groups for the landings by Norwegian trawlers in the Western Barents Sea during the first quarter.

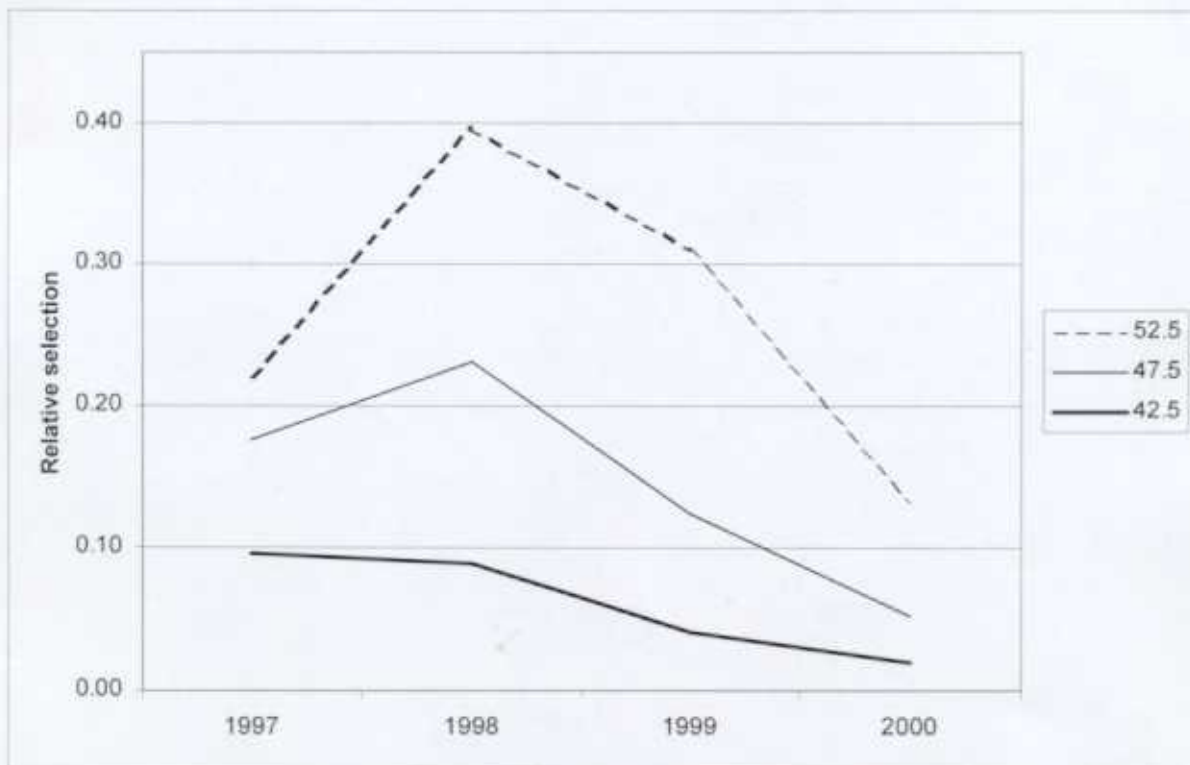


Figure 6. Survey-related selection by year for the length groups 52.5, 47.5 and 42.5 for the landings by Norwegian trawlers in the Western Barents Sea during the first quarter.

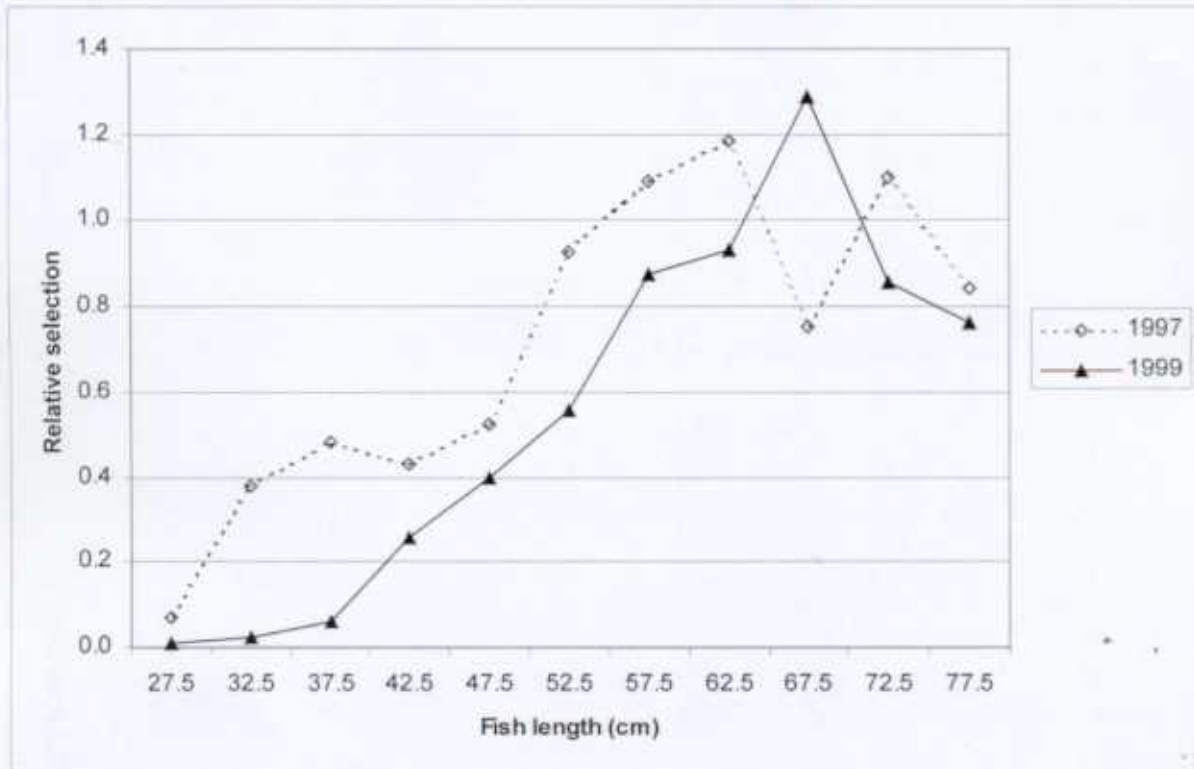


Figure 7. Selection for commercial trawl relative to research vessel trawl based on comparisons in southern part of ICES sub-Division IIb during July-August 1997 and 1999.

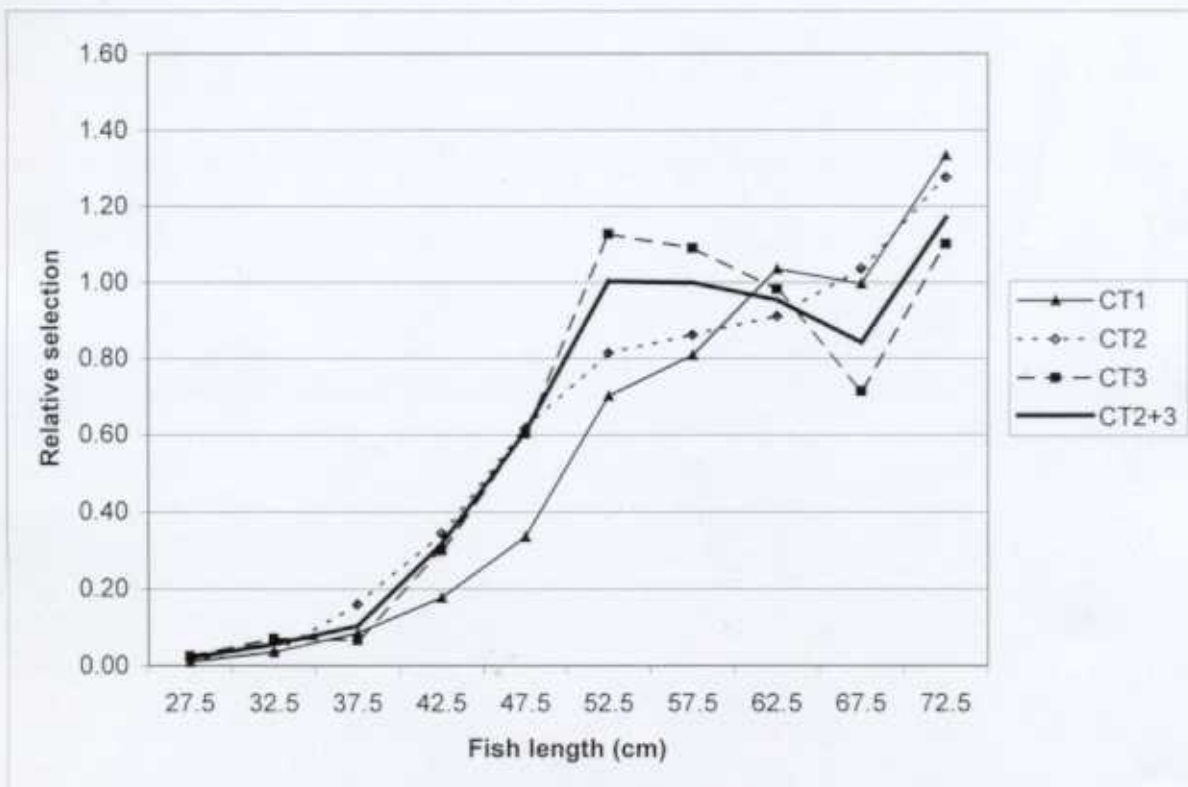


Figure 8. Selection for individual commercial trawlers (CT1, CT2 and CT3) relative to research vessel trawl. CT2 and CT3 fished without sorting grid and their combined results are shown (CT2+3). CT1 used 55 mm sorting grid. The vessels were fishing close to the research vessels during mid August 1995.

A. AGLN: Comparisons between size distribution in surveys and commercial catches. ...

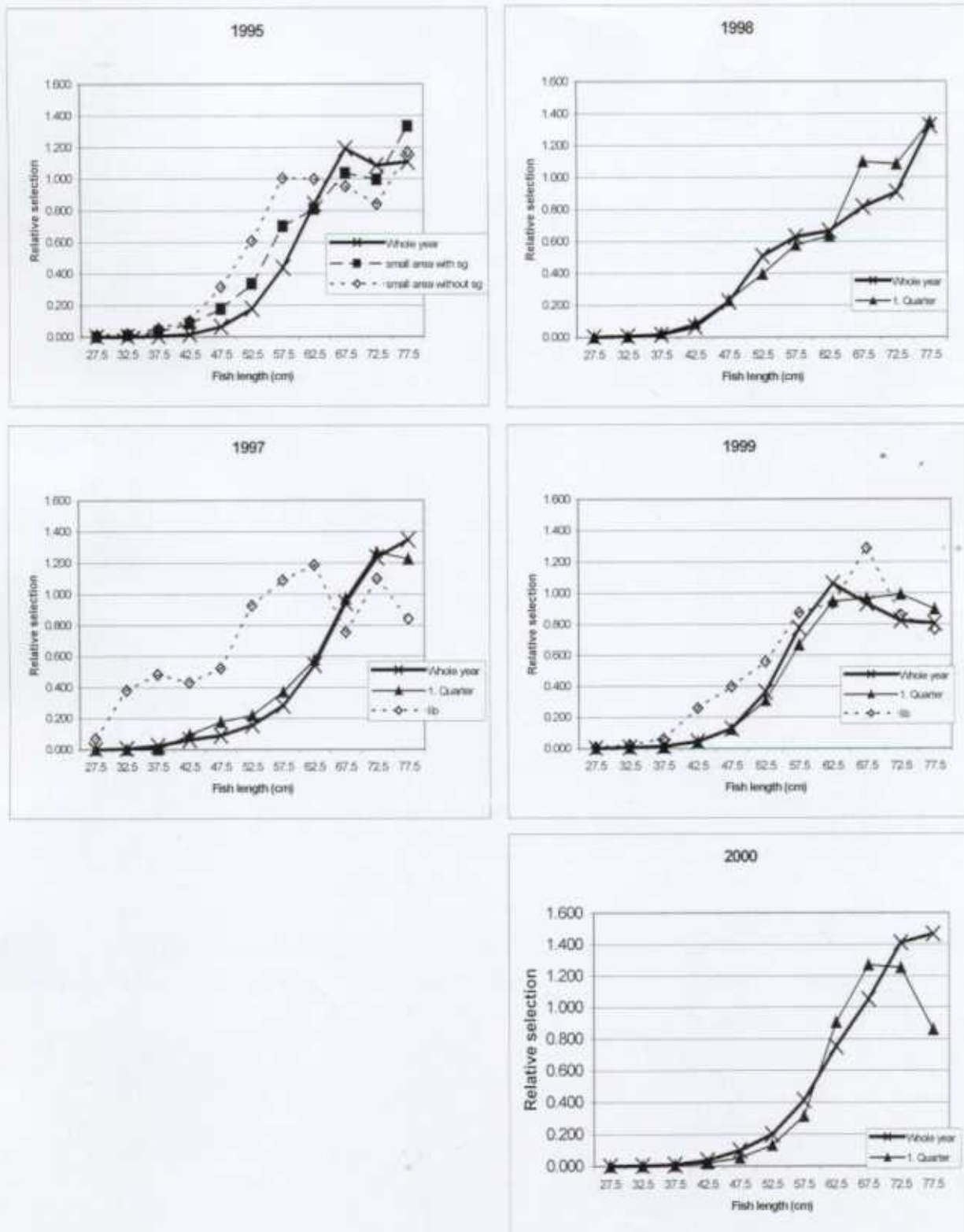


Figure 9. Comparisons of survey-related selections obtained from the various data sources within the same year. Ib represents the closed area monitoring surveys in southern part of ICES sub-division I Ib. sg means sorting grid.