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An Evaluation of the IMR Summer Bottom Trawl Survey in the Barents Sea

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Summary

A committee was formed to evaluate the Institute of Marine Research summer survey in the Barents Sea, which has been conducted annually since 1995. The primary focus of the committee was the survey's importance for the assessment of Northeast Arctic cod, with a secondary focus on its other present or potential uses. It was found that the summer and winter survey indices of cod abundance were consistent, *i.e.* indicated similar trends in cod abundance, and that for the same amount of effort, the winter survey in the Barents Sea would generate estimates of cod abundance that were much more precise than those from the summer survey. It is concluded that the summer survey does not provide significantly more information for the assessment of cod than the winter survey and the Lofoten acoustic survey of spawning biomass. Thus the summer survey should be continued only if other uses justify its high cost.

Introduction

A summer (July through September) combined bottom trawl and acoustic survey of demersal fish in the Barents Sea and West Spitsbergen region was begun in 1995 (Aglen, 1999). The northern part of the survey is nearly identical to the region covered by the

Svalbard annual survey, which was conducted in summer from 1981 though 1994. The primary focus of the summer survey is to cover the areal distribution of Northeast Arctic cod, though, additional data from surveys farther north in 1996 and 1997 indicate that the summer survey as presently designed may not completely cover the cod stock. A secondary goal of these surveys is to provide information on redfish, haddock, Greenland halibut, *etc.* and to gather data on the state of the ecosystem necessary to measure long- and short-term environmental trends.

It was decided when the summer survey was started in 1995 that the survey would be evaluated after it had been in existence for five years. A committee was formed in spring, 2000, whose charge was to determine, given the cost of the summer survey, if it provided significantly more and unique information than already provided by the winter bottom trawl survey and whether any crucial information on other species would be lost by having only one annual survey in winter or summer. In particular, whether the summer survey provides significantly more information for the assessment of Northeast Arctic cod than is already generated by the winter survey and the Lofoten spring acoustic survey of the cod spawning stock.

A statistical comparison of the summer and winter surveys

The summer survey series is relatively short, especially so since for two (1997 and 1998) of the five years, the Russian Zone was not covered. Therefore, it was not possible to evaluate definitively the effectiveness of the summer surveys over time. Furthermore, since the true stock sizes are not known, the accuracy of the indices (*i.e.*, measure how well they followed trends in actual abundance) could not be determined. Thus the precision of the cod and haddock indices for summer and winter was evaluated, and, given the shortness of the summer series, a rough comparison was made of the estimated trends generated by the two series.

Areal distribution of cod and haddock

In Figure 1 are plots of the spatial distribution of cod for the winter and summer surveys for the years 1995 through 1999. The major difference between these two surveys is that the summer survey appears to have a fairly well defined eastern and northern boundary (except for the years when the Russian Zone was not covered) compared with the winter survey, that is there is generally zero or low catches at the edge of the summer survey. In contrast, the winter survey has relatively large catches at its boundary, which indicates that the cod stock may not be completely covered by the winter survey in the north and east (unless the ice border is an effective barrier for cod) and in the west (*e.g.*, part of the spawning stock has migrated out of the survey area). Cod is caught throughout the areas covered by both surveys though the summer survey has a much higher proportion of zero catches.

The spatial distribution of haddock (Figure 2) is concentrated in the southern part of the survey regions during summer and winter. Both surveys appear to have well-defined boundaries for haddock.

Precision of density estimates

In Table 1 are estimates of the precision of the average catch of cod per tow (log scale) for the summer and winter surveys. The standard deviation of the catch per tow distribution was estimated for two length classes (cod length less than or equal to 22 cm and greater than 22 cm) and for the total catch per tow. The estimated standard deviations were generally much higher in summer than in winter (Table 1), which implies that cod are more patchily distributed in summer than in winter. Thus if both survey indices are proportional to abundance, then for the same amount of effort, the winter survey will generate a more precise index than the summer survey. For example, the average estimated standard deviation (*s.d.*) for total catch equals 1.36 for the winter survey and 2.02 for the summer survey. Therefore, more than twice [$(2.02/1.36)^2$] as many stations would have to be sampled in summer than is winter to obtain estimates of equal precision. The estimated variance of the catch per tow distribution of cod in 5 cm length intervals is also considerably more variable in summer than in winter (*e.g.,* compare Appendix 1 in Aglen, 1999 with Table 6.4 in Korsbrekke *et al.*).

The distribution of cod catches in summer is also more variable than in winter in the subarea defined by latitude < 74^o and longitude > 20^o and < 40^o (Figure 1, Table 2). The probable reasons that the winter survey is more precise than the summer survey are that cod are concentrated in a smaller area and are more uniformly distributed in winter than in summer. It should be kept in mind that this is only a comparison of the precision of the two surveys, not a comparison of their relative accuracy.

The haddock density estimates, given the same amount of effort (*i.e.* equal sample sizes), are approximately as precise (in terms of the coefficient of variation) in summer as in winter (Table 3). The *s.d.* in the entire survey area is larger, on average, in winter than in summer, but this is mainly caused by the high proportion of zeros in summer. The standard deviations are approximately equal in the reduced area (Table 4), which contains many fewer zero values and a much higher average density.

For both cod and haddock there are stronger diurnal changes in catch in winter than in summer (Table 5). These changes increase the sampling variance but if the ratio of day to night catches is relatively stable from year to year, this factor should not cause a significant bias.

Estimates of length-frequency distributions

In Figures 3 and 4 are the estimates of the length distributions for cod and haddock, respectively. Given the variability of the estimated length histograms, they show a fairly consistent pattern of relatively high mortality from winter to summer for the smaller fish, as would be expected. The variability of the estimates is relatively high compared with the number of fish measured since the effective sample size (the number of fish that would need to be sampled to obtain the same precision if the fish could be sampled at random) for estimating length distributions is a small percentage of the number of fish measured. For example, during the 1995 winter survey, 47,286 cod were measured, but the effective sample size was 313 fish or 0.66% of the total number of cod that were sampled (Table 6). The average effective sample size for the summer and winter surveys was 0.86% of the total number of fish measured.

When fish caught together are more similar than fish in the entire population, than the effective sample size for estimating a particular population characteristic is usually much lower than the number of fished sampled. For example, the effective sample size for survey estimates of average stomach contents of Northeast Arctic cod is considerably lower than the number of stomachs collected since fish caught together tend to have similar stomach contents (Bogstad *et al.*, 1995).

The effective sample sizes for the length distribution of haddock were also relatively small (Table 7). The consequences of a low effective sample size can be seen clearly in the 1996 surveys for haddock. The effective sample sizes were 69 for the winter survey and 51 fish for the summer survey (Table 7). Both histograms for 1996 are bimodal (Figure 4), but the winter survey indicates that there was a larger proportion of large fish in winter than in summer. This is most likely caused by sampling variability.

The small effective sample sizes for both surveys mean that many more fish than necessary are measured during both surveys. Reducing the number of fish measured will not, of course, increase the effective sample size, but by measuring fewer fish, the precision of the estimates will not be significantly reduced and samplers will have more time to make other biological measurements. One way to increase the effective sample size for these surveys, which would increase the precision of length distribution estimates, without increasing survey cost is to reduce tow duration from 30 minutes to, for example, 15 minutes and use the time saved to sample at more stations.

Comparison of summer and winter survey estimates of cod abundance

Both surveys indicate similar trends in the abundance of cod during the period 1995 through 1999. For example, in Figure 5 are plots of the abundance indices for cod ages 1 through 9 from Mehl (1999, Table 6.7) for the winter surveys, and Aglen (2000, first table, adjusted total) for the summer surveys. Taking into account sampling variability, possible differences in catchability, and natural fishing mortality from winter until the following summer, the two surveys appear to be quite consistent. The tendency for getting higher indices in summer for ages 7 and older fish is most likely because parts of the spawning stock have started their annual journey to Lofoten before the winter survey begins and therefore are outside the survey area.

The summer and winter survey indices are consistent with each other, and both surveys provide accurate estimates of subsequent stock abundance estimates made by the Arctic Fisheries Working Group. For example, plots of the ICES VPA estimates of the number of ages 7+ Northeast Arctic cod in January (ICES, 2000) versus; (a), the summer survey index of the number of 6+ cod the previous September and (b), the winter survey index of the abundance of ages 7+ cod in February, are shown in Figure 6. It is apparent that both surveys have produced estimates of the number of 7+ cod that are comparable to those generated by the latest ICES (2000) assessment and, hence, are considerably more reliable than those produced by the annual assessments (Kosbrekke *et al.*, 2000).

Need for the summer survey in the assessment of cod

The summer survey is one of several inputs available for the assessment of the cod stock. Other data sources include; commercial catch statistics, the winter survey and the Lofoten acoustic survey of the spawning stock. To date, the summer survey has not been used in the cod assessments (*e.g.,* XSA tuning). However, based on the 1999 summer survey, the weight-at-ages used in the stock prognosis were adjusted downwards by 10-15%, just before the TAC was set, enabling the ACFM in November to give more precise advise. The Svalbard part of the summer survey has been conducted since 1981 and data since 1983 are currently used in the cod assessments.

Korsbrekke *et al.* (2000) have shown that the winter bottom trawl survey and the Lofoten acoustic survey of spawning biomass provide a basis (independent of recent commercial catch statistics) for assessing the cod stock that appears to be more accurate than the annual ICES assessments. When the summer time series is sufficiently long, this survey also has the potential of providing an accurate survey-based assessment of the cod stock. The Northeast Artic cod stock is by far Norway's most important commercial species and it thus may be prudent, if, for example, problems occurred in conducting the winter survey caused by bad weather, *etc.*, to have the summer survey as an alternate data source for assessing the stock.

Other applications of the summer survey

There are other current and potential uses for the data from the summer surveys. These include:

- Stomach samples from cod are needed in February and August to estimate what and how much prey cod consumed. These consumption estimates are used in the assessments of cod, haddock and capelin.
- The summer surveys provide information on the geographical distribution and migration of cod that could be an important input for modeling the predation of cod on capelin.
- Of potential interest is the spatial overlap of cod, seals and whales for estimating the consumption of cod by marine mammals. Several whale species are not in the Barents Sea in winter, *e.g.* minke whales, and seals have a different spatial distribution in summer than in winter.
- Projects have recently been implemented to improve the assessment of haddock and the summer survey may prove to be an important source of information for increasing the accuracy of the haddock assessments.
- The Svalbard survey is required for the proper evaluation of the *Sebastes mentella* stock. In addition, the entire summer survey is the only survey that covers completely the immature redfish.
- The Svalbard survey is necessary for assessing the Greenland halibut stock.
- Since the summer survey has been in existence for only five years and is, therefore, not yet important as a time series, it would be useful to embed experiments within this survey that may lead to improvements in overall survey methodology. For example, it is evident that we presently tow too long at each

station and reducing tow duration and using the time saved to sample at more stations would increase the precision and efficiency of all our surveys. By taking tows of varying durations during the summer survey, the most efficient tow duration could be determined and the results applied to our other surveys.

The cost of the summer survey

The summer survey uses approximately 60 ship-days and 250 man-days (scientific staff,. does not include crew days) to cover the entire area. To survey only the Svalbard sub-region, would take 20 ship-days and 80 man-days. Additional costs are; ship expenses, overtime pay, shore leave, *etc.*

There is also an indirect cost associated with the summer surveys. These surveys are fairly routine and the time spent by highly trained scientists and technicians on these cruises could, perhaps, be better utilized back at the laboratory refining and interpreting the vast amount of available data from other sources. It is not clear whether the IMR needs more data to improve our assessments or the present personnel needs more time to improve the assessments based on current and historical data.

Conclusions

Abundance indices from the summer surveys are consistent with the winter survey indices and support the conclusion made by Korsbrekke *et al.* (2000) that survey data alone provide more timely estimates of stock development than the annual ICES assessments.

The summer survey is not an important additional source of information for the assessment of Northeast Arctic cod. The winter survey and the Lofoten acoustic survey of the spawning stock provide a sufficient basis for assessing cod, and so the likely role of the summer survey is to be an ‘insurance policy’ in case something went wrong during the winter survey.

The variance of the catch per tow of cod during the summer survey is more than twice the catch variance of the winter survey. Thus it would take double the effort in summer to obtain density estimates that are as precise as the winter estimates. Hence it appears that it is more efficient to conduct a cod survey in winter than in summer.

It is not clear, given the high cost of the summer survey, if the other uses and potential uses of the survey, which were listed above, are sufficient to justify continuing the summer survey as it is today. Some of the data and information generated by the summer survey are important (stomach content data, stock distribution relative to climatic conditions and stock overlap) and should be collected in the future. These data could be collected more economically by continuing to survey the Svalbard region, which has been surveyed since 1981, and coordinating sampling effort with the other surveys that are conducted during late summer and early autumn in the region. To accomplish these goals, a Svalbard survey would need approximately 20 ship days compared with 60 for the complete summer survey. Although this sampling strategy would generate the data required for the assessment of Northeast Arctic cod, it is unknown if it would be sufficient to fulfill all other needs.

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Committee

The members of the Evaluation Committee were: Asgeir Aglen; Olav Rune Godø; Vidar Hjellvik, who analyzed the summer and winter survey data; Sigbjørn Mehl; Odd Nakken; and Michael Pennington.

Table 1. The number of stations, *N*; the average number of cod per tow-hr (log scale) for three length groups (≤ 22 cm, ≥ 23 cm and total number caught), $\bar{y}$; and the estimates of the standard deviation, $\hat{\sigma}$, for each length group for the winter survey (a) and the summer survey (b).

(a) Winter

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	298	5.66	1.94	3.83	2.59	6.45	1.37
96	315	6.04	1.69	4.12	2.14	6.53	1.31
97	178	4.92	2.09	4.55	1.28	5.80	1.35
98	200	4.87	1.87	4.68	1.47	5.79	1.36
99	224	3.82	1.87	4.44	1.53	5.16	1.42
	Avg.	5.06	1.89	4.32	1.80	5.95	1.36

(b) Summer

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	357	3.58	2.23	3.87	2.10	4.78	2.01
96	348	4.79	1.99	4.06	2.08	5.51	1.79
97	281	4.11	2.23	3.66	2.15	4.90	2.02
98	238	3.81	2.53	3.82	2.25	4.80	2.35
99	230	3.36	2.11	4.26	2.04	4.84	1.95
	Avg.	3.93	2.22	3.94	2.12	4.97	2.02

Table 2. The number of stations, N; the average number of cod per tow-hr (log scale) for three length groups (≤ 22 cm, ≥ 23 cm and total number caught), $\bar{y}$; and the estimates of the standard deviation, $\hat{\sigma}$, for each length group for the winter survey (a) and the summer survey (b) in the subarea (lat. < 74°, 20° < Lon. < 40°).

(a) Winter

Year	N	$\bar{y}_{\le 22cm}$	$\hat{\sigma}_{\le 22cm}$	$\bar{y}_{\ge 23cm}$	$\hat{\sigma}_{\ge 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	172	5.51	1.59	5.23	1.74	6.57	0.85
96	215	6.13	1.47	4.87	1.45	6.63	1.14
97	133	5.49	1.52	4.70	1.23	6.08	1.18
98	144	5.23	1.37	4.89	1.14	5.96	1.06
99	182	4.07	1.77	4.43	1.59	5.25	1.43
	Avg.	5.27	1.54	4.82	1.43	6.10	1.13

(b) Summer

Year	N	$\bar{y}_{\le 22cm}$	$\hat{\sigma}_{\le 22cm}$	$\bar{y}_{\ge 23cm}$	$\hat{\sigma}_{\ge 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	117	4.41	1.57	4.30	1.52	5.28	1.36
96	134	5.87	1.34	4.70	1.46	6.26	1.28
97	128	4.53	2.15	4.06	1.89	5.18	1.98
98	101	4.96	2.05	4.27	2.03	5.44	2.11
99	93	4.36	1.45	4.89	1.39	5.48	1.25
	Avg.	4.83	1.71	4.44	1.66	5.53	1.59

Table 3. The number of stations, N; the average number of haddock per tow-hr (log scale) for three length groups (≤ 22 cm, ≥ 23 cm and total number caught), $\bar{y}$; and the estimates of the standard deviation, $\hat{\sigma}$, for each length group for the winter survey (a) and the summer survey (b).

(a) Winter

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	298	3.09	2.69	2.50	2.71	3.58	2.98
96	315	2.59	2.32	2.74	2.68	3.44	2.71
97	178	3.36	2.64	2.68	2.44	3.76	2.73
98	200	2.26	2.15	2.38	2.19	2.96	2.37
99	224	3.60	2.49	2.09	2.02	3.86	2.50
	Avg.	2.98	2.46	2.48	2.41	3.52	2.66

(b) Summer

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	357	1.45	2.23	2.00	2.25	2.42	2.54
96	348	0.80	1.59	1.53	2.10	1.71	2.21
97	281	1.26	2.03	1.01	1.73	1.52	2.22
98	238	0.95	1.78	0.86	1.65	1.28	2.00
99	230	1.11	2.10	0.71	1.43	1.24	2.21
	Avg.	1.11	1.95	1.22	1.83	1.63	2.24

Table 4. The number of stations, N; the average number of haddock per tow-hr (log scale) for three length groups (≤ 22 cm, ≥ 23 cm and total number caught), $\bar{y}$; and the estimates of the standard deviation, $\hat{\sigma}$, for each length group for the winter survey (a) and the summer survey (b) in the subarea (lat. < 74°, 20° < Lon. < 40°).

(a) Winter

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	172	4.43	2.30	3.92	2.53	5.12	2.47
96	215	3.21	2.30	3.50	2.56	4.24	2.52
97	133	3.88	2.56	3.03	2.47	4.25	2.68
98	144	2.71	2.23	2.88	2.19	3.46	2.40
99	182	3.73	2.48	2.28	2.02	3.97	2.52
	Avg.	3.59	2.37	3.12	2.35	4.21	2.52

(b) Summer

Year	N	$\bar{y}_{\leq 22cm}$	$\hat{\sigma}_{\leq 22cm}$	$\bar{y}_{\geq 23cm}$	$\hat{\sigma}_{\geq 23cm}$	$\bar{y}_{total}$	$\hat{\sigma}_{total}$
95	117	3.28	2.64	3.22	2.23	4.02	2.63
96	134	1.56	2.05	2.21	2.29	2.46	2.47
97	128	2.31	2.41	1.86	2.02	2.68	2.53
98	101	2.03	2.23	1.72	2.12	2.52	2.39
99	93	2.72	2.56	1.71	1.82	3.00	2.60
	Avg.	2.38	2.38	2.14	2.10	2.94	2.52

Table 5. Estimates of day/night differences (*D,* log scale) in the average survey catch of cod for the three length classes. A zero estimate would indicate no day/night difference.

Year	Winter			Summer		
	$D_{\leq 22cm}$	$D_{\geq 23cm}$	D_{total}	$D_{\leq 22cm}$	$D_{\geq 23cm}$	D_{total}
95	0.36	0.39	0.24	0.23	-0.28	0.00
96	0.95	0.58	0.62	-0.09	-0.44	-0.25
97	1.86	0.53	1.40	-0.73	-0.29	-0.56
98	1.59	0.60	1.13	-0.88	-0.47	-0.90
99	1.31	0.45	0.79	0.03	0.11	0.14

Table 6. Estimated effective sample size, n_{eff}, of the survey estimate of the length distribution of cod. N is the number of stations at which cod were caught, n is the total number of cod caught, m is the number measured, $\hat{R}$ is the estimate of mean length and var($\hat{R}$) is its variance. In the last column is the effective sample size expressed as a percentage of the number measured. Panel (a), winter and (b) summer.

(a) Winter

Year	N	n	m	$\hat{R}$ (cm)	var($\hat{R}$)	n_{eff}	$(n_{eff}/m)\times100\%$
95	295	175006	47286	19.76	0.72	313	0.66
96	314	209114	44021	17.98	0.30	511	1.10
97	177	71418	25689	19.04	2.10	119	0.46
98	197	60746	32536	22.14	0.68	394	1.21
99	223	50192	21760	24.60	1.89	107	0.49
	Avg.	113295	34258			289	0.78%

(b) Summer

Year	N	n	m	$\hat{R}$ (cm)	var($\hat{R}$)	n_{eff}	$(n_{eff}/m)\times100\%$
95	329	66643	46161	31.18	1.36	252	0.55
96	341	115834	45286	24.35	0.56	478	1.05
97	266	72093	26947	23.12	0.78	266	0.99
98	218	72360	23461	25.08	1.06	184	0.78
99	217	46593	23253	30.78	0.91	211	0.91
	Avg.	74705	33022			278	0.86%

Table 7. . Estimated effective sample size, n_{eff}, of the survey estimate of the length distribution of haddock. N is the number of stations at which haddock were caught, n is the total number of haddock caught, m is the number measured, $\hat{R}$ is the estimate of mean length and var($\hat{R}$) is its variance. In the last column is the effective sample size expressed as a percentage of the number measured. Panel (a), winter and (b) summer.

(a) Winter

Year	N	n	m	$\hat{R}$ (cm)	var($\hat{R}$)	n_{eff}	$(n_{eff}/m)\times 100\%$
95	199	66009	22938	25.01	1.03	168	0.73
96	235	54892	25525	32.01	2.88	69	0.27
97	140	37441	13273	21.98	0.81	185	1.39
98	144	12704	9620	23.90	0.95	169	1.76
99	182	41612	12152	13.35	0.35	188	1.55
	Avg.	42532	16702			155	0.71%

(b) Summer

Year	N	n	m	$\hat{R}$ (cm)	var($\hat{R}$)	n_{eff}	$(n_{eff}/m)\times 100\%$
95	208	25771	15763	26.95	0.95	147	0.93
96	163	14139	7338	31.09	3.65	51	0.70
97	114	13560	4314	23.07	1.72	56	1.29
98	89	7432	2699	21.33	0.34	170	6.30
99	140	11922	5489	20.11	0.36	197	3.59
	Avg.	14565	7536			124	2.56%

Note: Figures 1 –5 are a product of 'cut and paste.' If you would like copies, please write me (michael@imr.no).

Figure 1. Spatial dis[illegible] trawl catches of cod from 1995-1999 in the entire survey [illegible]ed by (lat. < 74^o, 20^o < Lon. < 40^o).

Figure 1 (cont.).

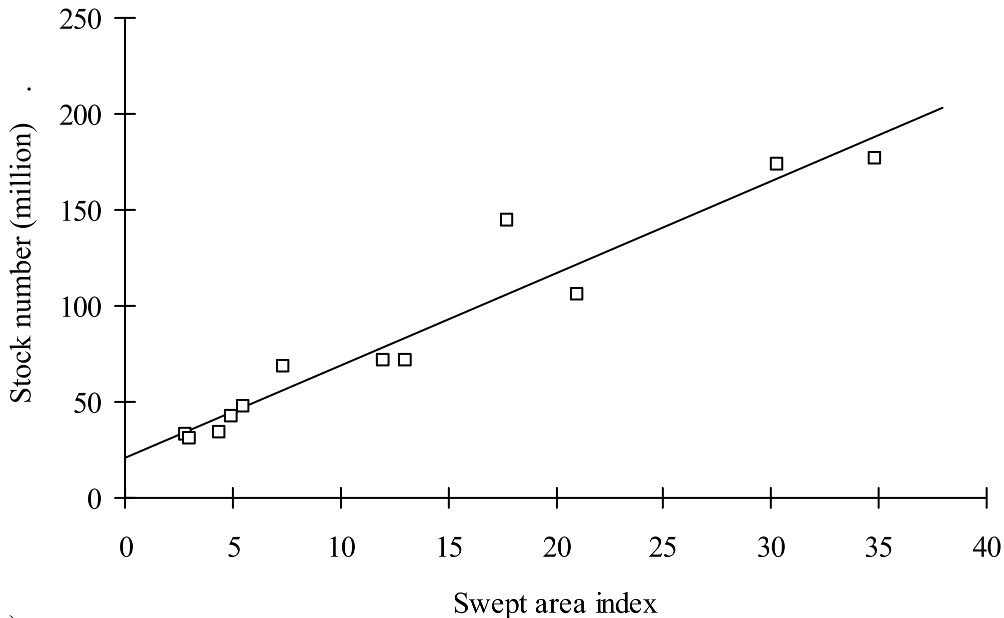
Figure 2. Spatial distribution of the winter bottom trawl catches of haddock from 1995-1999 in the entire survey area and in the sub-area defined by (lat. < 74^o, 20^o < Lon. < 40^o).

Figure 2 (cont.).

Figure 3. Estimated length frequency of cod for the years 1995 through 1999 generated by the winter and summer surveys.

Figure 4. Estimated length frequency of haddock for the years 1995 through 1999 generated by the winter and summer surveys.

Figure 5. Estimates of the relative abundance of cod versus age from the winter and summer surveys for the years 1995 through 1999 (top panel). In the bottom panel each year class is followed from winter, 1995, to summer, 1999. For example, the 1993 year class first appears at age 2 in winter 1995 and the final observation is at age 6 in summer 1999.



(b)

Figure 6. VPA estimates of the number of ages 7+ cod (ICES, 2000) versus the summer survey index of ages 6+ cod for 1995–1999 (a), and versus the winter trawl survey abundance index for ages 7+ cod for 1981-1992. The straight lines are the estimated regression lines. Since the winter survey series is sufficiently long, only converged values of the VPA estimates are compared with the survey index (see Korsbrekke *et al.*, 2000).