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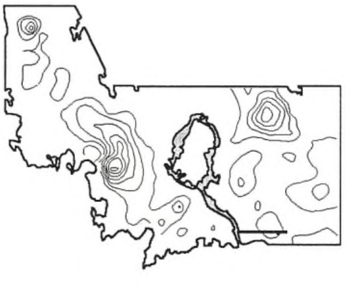

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Distribution and abundance of young pelagic fish, monitored by hydroacoustics in two coastal areas in the SW Bothnian Sea.

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Abstract

The distribution of young pelagic fish in autumn was studied by hydroacoustic techniques in two coastal areas in the SW Bothnian Sea, one exposed to cooling water from a nuclear power plant and the second a reference area free from local disturbance. Generally, herring young-of-the-year dominated among pelagic fish and often constituted over 80% of the total numbers of fish counted. Young herring were concentrated to certain parts of the studied archipelagos, predominantly to the more shallow waters and to the outer parts of the small inlets commonly occurring in these coastal areas. When comparing the results of subsequent visits in the different study areas, it was evident that the estimated densities often varied markedly between days, although the distribution patterns did not change. This was interpreted as an effect of migrations in and out of waters too shallow to be monitored by echosounder techniques. In September young herring evidently still depends upon an access to sheltered and very shallow habitats. Abundances of herring fry were higher in the cooling water exposed area compared to the reference, supporting earlier observations on positive temperature effects on fish recruitment at this nuclear power plant.

Introduction

Hydroacoustics has a long history in fisheries and fish research, and is considered to be a cost-efficient method for pelagic fish abundance estimates (Johannesson & Mitson 1983, Hansson 1993). Modern hydroacoustic techniques are increasingly used also to establish vertical as well as horizontal distribution patterns (Jurvelius 1991, Enderlein & Appelberg 1992, Eckmann 1994).

In the Gulf of Bothnia, the pelagic fish community is dominated by herring (*Clupea harengus*), three-spined stickleback (*Gasterosteus aculeatus*), and in the northern Bothnian Bay also vendace (*Coregonus albula*). These species migrate to the coastal bays and archipelagos for spawning, and their larvae and fry stay in these areas during their first months. Herring larvae are traditionally monitored by trawling in more open coastal waters (Parmanne & Sjöblom 1987). Recent studies have, however, revealed the large importance of even very sheltered areas as larval habitats. In the Finnish Archipelago Sea, larval abundances were highest in areas shallower than 5—6 m, and the importance of a closed morphometry was evident (Karås & Urho 1994).

After metamorphosis, the herring fry start migrating towards open waters. At this stage, the size of the fish makes sampling difficult, and there is often a lack of information on their distribution. Hydroacoustics may, however, provide a possibility to receive additional data, as the modern techniques allow a separation of targets also in the size range including young herring fry.

Fish recruitment and fish behaviour have been studied since the 1970's in the effluent area at the Forsmark nuclear power plant in the SW Bothnian Sea (Sandström 1990). These studies have been concentrated to the stationary warmwater fish community, but considerable interest has also been devoted to herring. Larval trawlings, fry samplings and gill net fishings have been done on a regular basis, with additional studies on the migratory habits by large scale taggings. Herring is attracted to the heated area in spring, and spawning starts earlier than in natural waters (Svedäng & Karås 1993). After hatching, larvae have been observed in high abundances in the shallow and sheltered archipelago during the summer.

In 1989, a Gulf of Bothnia coastal fish project was decided, and field samplings began in 1990. The main objectives of this project were to document the coastal fish communities in different parts of the Gulf of Bothnia and to study the recruitment biology of common species. The field samplings were concentrated to demersal fish, as they dominate among the resident coastal species. One of the selected study areas was situated east of the island Gräsö, separating the Forsmark area from the Åland Sea. As the Gräsö archipelago is of considerable size and includes quite large and deep bays, a study of pelagic fish was planned as a complement to the demersal fish investigations.

Hydroacoustic surveys were made during autumn in the Gräsö archipelago and in the areas surrounding the cooling water discharge from the Forsmark nuclear power plant. The primary objective was to increase the understanding of herring fry behaviour allowing more precise recruitment area descriptions, but the study was also made to document effects from cooling water release on the distribution of pelagic fry.

Study areas

Cooling water from the Forsmark nuclear power plant is discharged to the bay Öregrundsgrepen at the outer part of an archipelago (Fig. 1). The effluent flow is about 130 m^3/s at full operation and the water is heated about 10°C when passing the plant. Maximal exposure to heated water is in winter, as the three reactors are sequentially coasted down in summer for technical overhauls.

The study was made in the quite shallow waters surrounding the cooling water discharge (Fig. 1). Maximum depth is about 18 m and the northern and western parts are sheltered from winds blowing from the sea. Three subareas were selected representing different exposure to the effluents and to the open sea. The first is situated west of the Biotest basin. Maximum depth is 10 m, and the total area surveyed was 726 ha. The second survey area is found north-west of the Biotest basin, also with water depths below 10 m. About 770 ha were covered by the surveys. Considerable parts of these two subareas were shallower than 3 m, and thus could not be accurately studied by hydroacoustics. The third subarea is situated east of the Biotest basin and is more exposed to the open sea. Maximum water depth is 18 m. The area covered was 1 075 ha. Total area covered by the acoustic surveys at Forsmark was 2 600 ha.

The Gräsö archipelago is a natural area free from significant local environmental impact, well representing the coastal systems in the southern Bothnian Sea. Two subareas were surveyed (Fig. 2), the first close to the

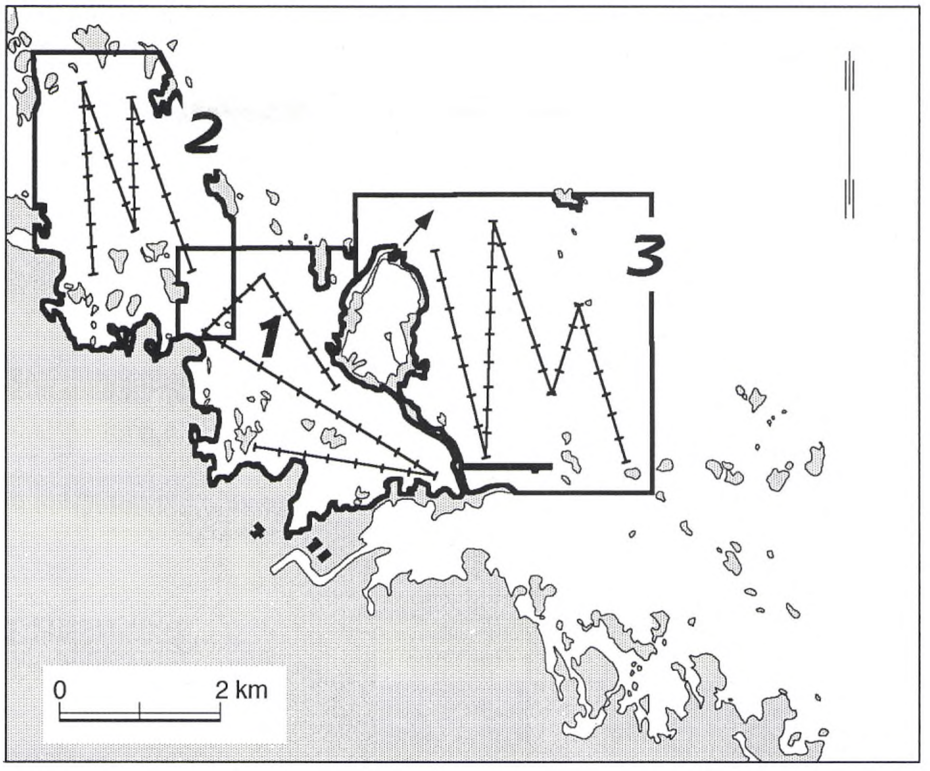


Figure 1*. Map showing the study area at Forsmark with subarea delimitations and segmented transects. Arrow indicates cooling water discharge.*

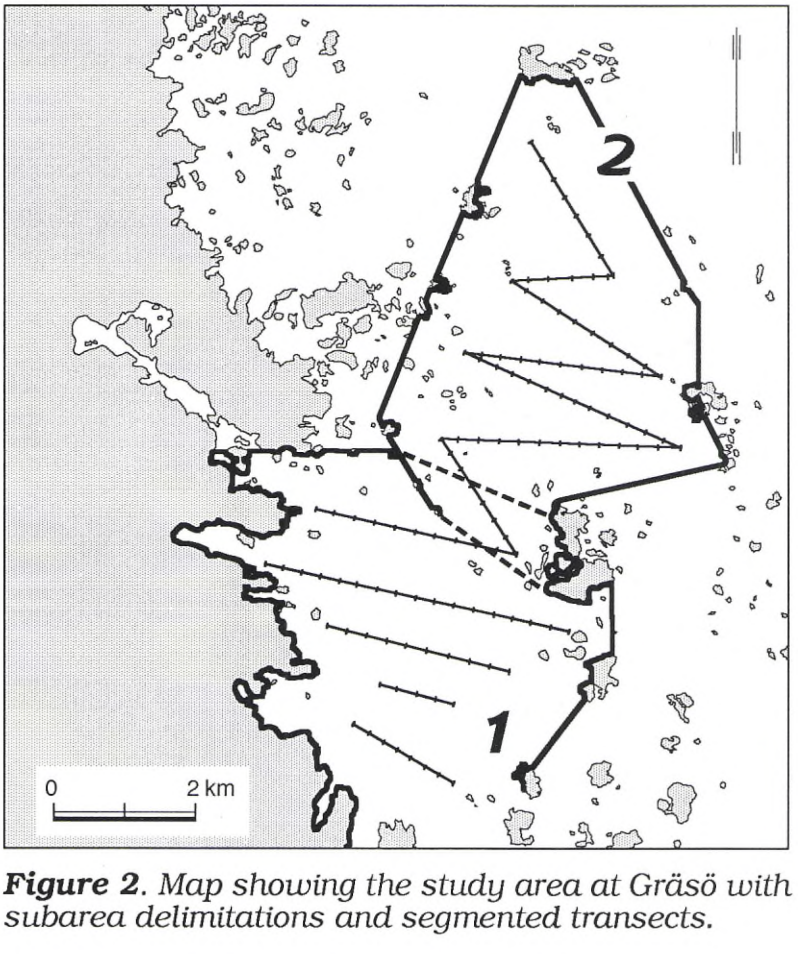


Figure 2*. Map showing the study area at Gräsö with subarea delimitations and segmented transects.*

mainland and the second in the middle part of the archipelago. Compared to at Forsmark, the studied bays are deeper (up to 30 m), but they are as well sheltered from the open sea with wide shallow margins that could not be included in the acoustic surveys. The areas covered were 1 930 ha and 1880 ha, respectively.

Material and methods

Hydroacoustics

The study was made during the period September 13 to 25, 1992.The acoustic data were collected with a SIMRAD EY 200 P portable scientific echosounder. Before the survey this system was calibrated using a standard copper sphere. The echo signals were recorded on magnetic tape (SONY HF-ES90) in a SONY TC-D5M stereo cassette recorder. Test signals were recorded on each side of the cassette tape to allow an accurate data processing. The ceramic transducer (type 70-24-FP) was mounted on a steel tube which was fixed to the side of the boat at a depth of 1 meter below the surface. All acoustic data were recorded both on magnetic tape and echogram paper. During the echo-survey the boat speed was about 6 knots.

The analysis was made with a hydroacoustic data acquisition system (HADAS) using a counting method based on an algorithm proposed by Craig & Forbes (1969) and IBM PC AT. The great advantage of this method is its ability to work with conventional transducers and echosounders. The drawback is that it needs a large acoustic basis for the computing, and that it assumes the fish to be uniformly distributed within the sampled volume. If the fish have an uneven depth distribution within the depth layer there will be an underestimation of the area density (fish/ha). This happens because the system calculates the mean volume density of fish within each depth layer, and this density is then projected into a surface area determined by the lobe diameter within this layer (Jurvelius 1991).

All acoustic data were analyzed in one depth layer starting with 1 meter from the transducer and finishing at the bottom. The received fish target strengths (TS) ranged from –56 dB to –38 dB. TS values were used to estimate fish length (L) by the formula: $TS = 20 \log L - 67$. To roughly discriminate young-of-the-year fish from others, the TS recordings were split into three sizegroups (I: –56 dB to –49 dB, II: –48 dB to –41 dB and III: –40 dB to – 38 dB), approximately corresponding to fish lengths of 4 — 8 cm, 9 — 20 cm and > 20 cm, respectively. All single fish echoes greater than –38 dB were truncated and shifted into the –40 to –38 dB size group. Fish density per hectare and fish lengths were estimated from signals with TS > –56 dB. Signals weaker than –56 dB were considered to be a noise or fish smaller than 4 cm, and were not further considered in the analysis.

The hydroacoustic surveys were made along stationary transects covering the most typical zones (Fig. 1, 2) of the subareas. Each transect was divided into segments of about 225 pings (Table 1). Two echo-surveys were made in each subarea during both day and night. The number of pings per segment in the separate transects fluctuated only little between surveys (Table 1), confirming that the accuracy in the division of transects into segments by the number of pings was satisfactory.

Table 1. Number of pings per segment (p/s) in the different subareas.

			p/s in transects no						
Subarea	Date	Time	I	II	III	IV	V	VI	VII
1	09—13	Day	227	229	171	214			
		Night	231	229	192	225			
	09—15	Day	226	220	171	216			
		Night	219	227	188	211			
2	09—13	Day	254	195	250	222			
		Night	239	188	241	210			
	09—15	Day	246	185	228	206			
		Night	249	193	238	208			
3	09—13	Day	272	203	258	213	234		
		Night	273	225	304	212	237		
	09—15	Day	227	220	266	235	232		
		Night	266	218	276	213	237		
4	09—21	Day	204	218	254	217	239		
		Night	216	207	216	211	223		
	09—23	Day	217	206	243	220	246		
		Night	212	215	210	221	220		
5	09—21	Day	216	256	209	227	217	229	242
	09—22	Night	221	243	180	237	240	178	215
	09—23	Day	204	240	204	244	212	208	212
	09—24	Night	226	238	204	214	204	257	236

The data acquisition system used is computer based. If data about scattering properties of individual fish is obtained, and the computer system is able to analyze the echo energy of individual scatterers, estimates of fish density and fish size can be obtained. The acoustic data, however, have to be matched with biology by catching samples from the surveyed fish using trawls, gill nets or other techniques.

Test fishing

A 4 mm mesh-size trawl was used to determine the fish species composition (in subareas 2 and 3 at Forsmark and at Gräsö), besides test fishings with three 3 m high and 35 m long gill-nets, consisting of 7 m panels with mesh-sizes 17, 21, 27, 35 and 50 mm. One additional 3 m high and 35 m long gill-net with mesh-size 12 mm was set in the eastern area at Gräsö, at the depth of 15—20 m. Gill-nets were set before sunset and lifted in the morning. All trawlings were made at night, shortly after the hydroacoustic surveys. Due to trawl selectivity and trawling speed, fish of bigger size groups — which were detected during the hydroacoustic surveys — were not caught.

Individual length and weight were measured on all fish, except in the small, 2—8 cm, herring where weights were determined from whole catch estimates.

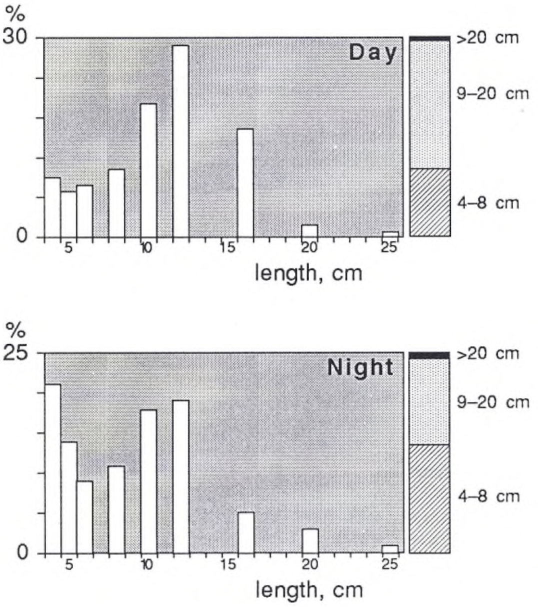


Figure 3a. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 13 in subarea 1 at Forsmark.*

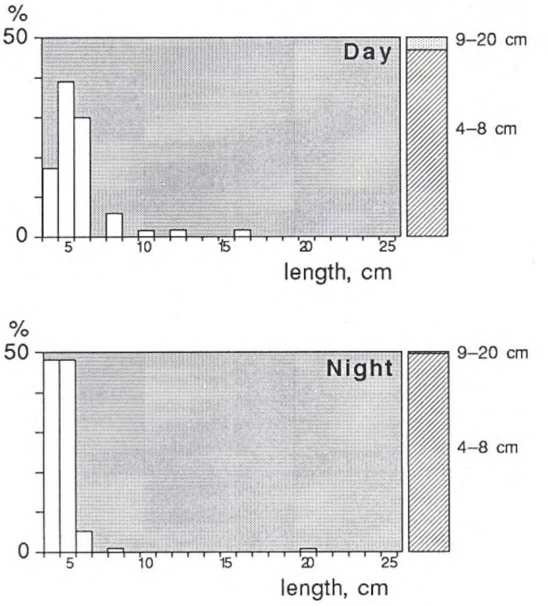


Figure 3b. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 15 in subarea 1 at Forsmark.*

Results

Forsmark

Hydroacoustic observations, Subarea 1

On September 13, fish within the size range 4—25 cm were detected in subarea 1, though the major part consisted of 4—16 cm individuals (Fig. 3a). The estimates of small fish (4—8 cm) differed between night and day cruises. In day-time they made up 33%, but their share increased to 55% at night.

The main day-time location of pelagic fish was seen in the S and SW parts of this subarea, close to the shore, where concentrations reached 20 000 fish/ha. The small-sized, 4—8 cm, fish also were concentrated to this area and their maximum density reached 2 400 fish/ha. At night the distribution centers of pelagic fish slightly changed to NW, and the maximum density was 18 000 fish/ha. The maximum abundance (7 000 fish/ha) of 4—8 cm length fish was found in the NW part, close to the shore (Fig. 4).

The acoustic surveys on September 15 were carried out in similar meteorological conditions as two days before. Some differences could, however, be seen in the results. At this survey, the smaller fish (4—8 cm) dominated both at day-time and night-time cruises (94% and 99%, respectively; Fig. 3b). The distributions were similar between cruises, except for the location of small fish, which were more evenly spread all over the territory on September 15 with a maximum concentration of 19 000 fish/ha in the southern part. At night there were detected three high density areas, mainly consisting of small fish, reaching up to 15 000 fish/ha (Fig. 5).

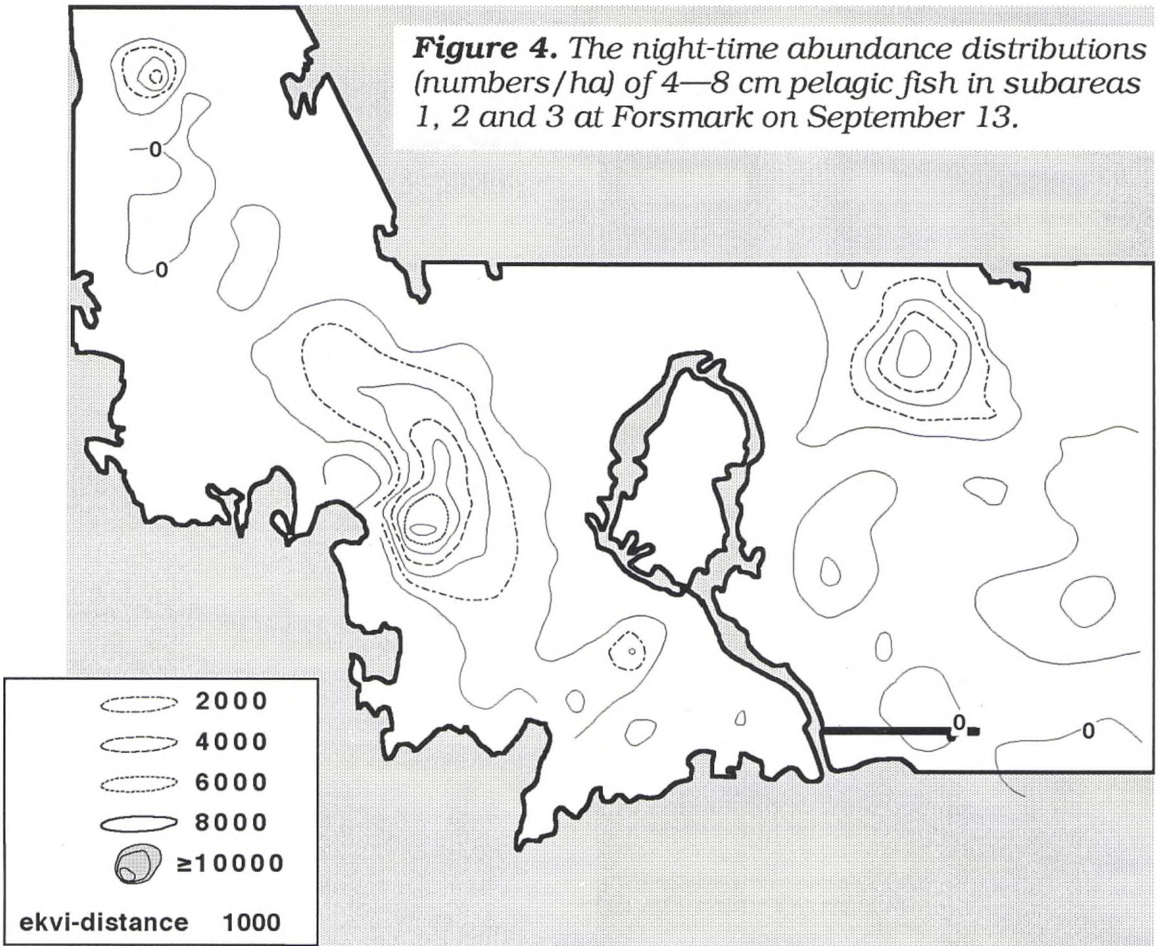


Figure 4. *The night-time abundance distributions (numbers/ha) of 4—8 cm pelagic fish in subareas 1, 2 and 3 at Forsmark on September 13.*

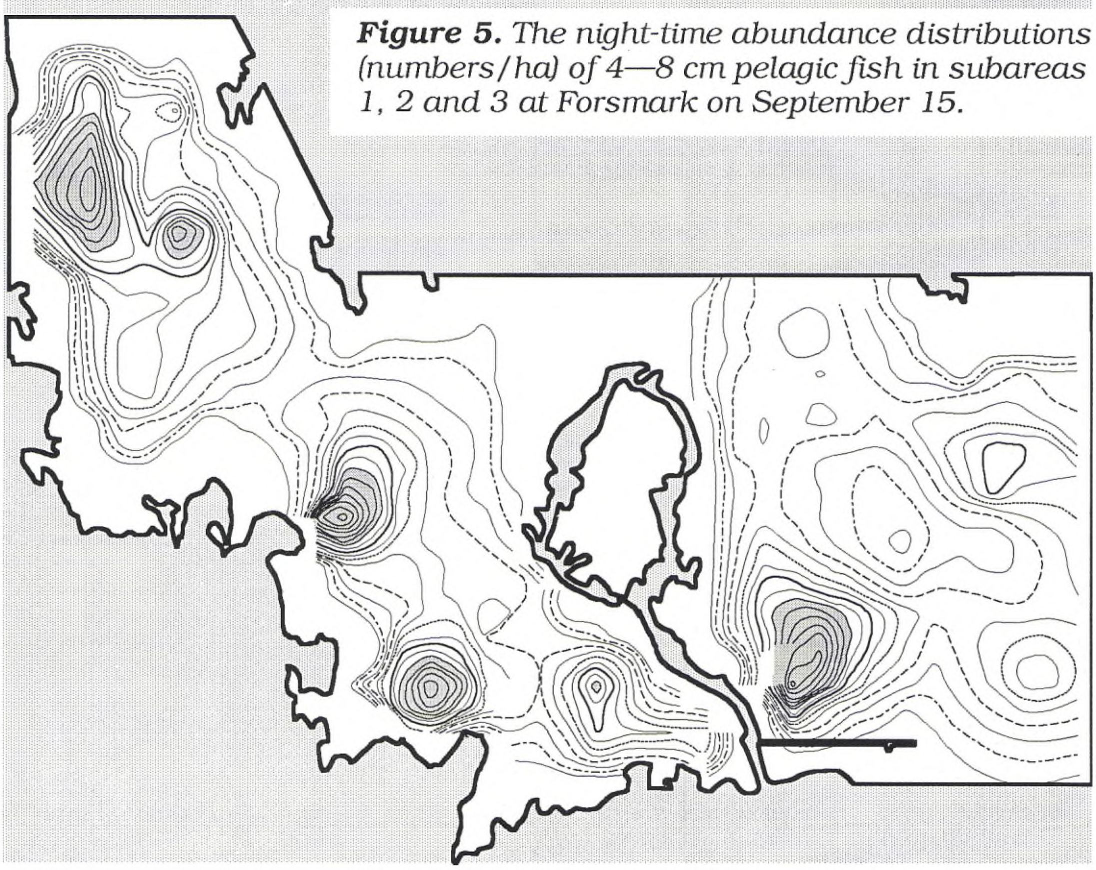


Figure 5. *The night-time abundance distributions (numbers/ha) of 4—8 cm pelagic fish in subareas 1, 2 and 3 at Forsmark on September 15.*

Subarea 2

In subarea 2 the size range at day-time as well as night-time surveys on September 13 was 4—25 cm, but the major part consisted of 4—16 cm fish (Fig. 6). The lenght group 4—8 cm covered 78% and 54%, respectively, of the total number of fish recorded. At day time fish were located mainly to the NW part of this subarea with maximum concentrations reaching up to 109 000 fish/ha. Small fish contributed strongly to this pattern with maximum abundance of 89 000 fish/ha in the size group 4—8 cm. At night the fish spread all over the area more or less uniformly. The abundance of 4—8 cm fish decreased sharply (about 30 times) and no stronger aggregations could be seen (Fig. 4).

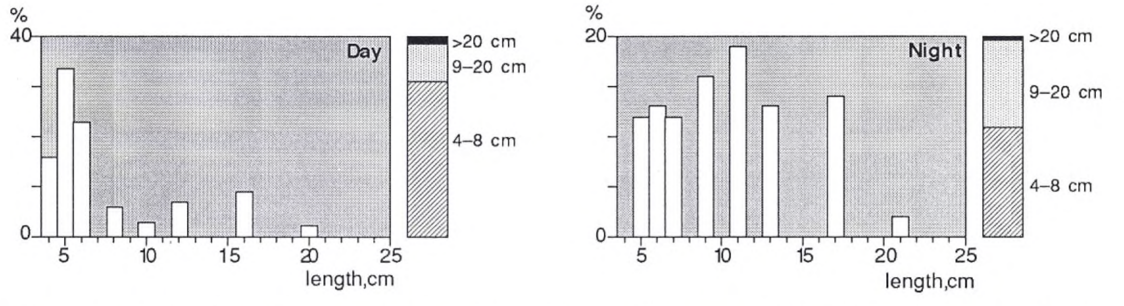


Figure 6. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 13 in subarea 2 at Forsmark.*

When repeating the echo survey in the second subarea after two days (September 15), there were not seen any marked changes in fish length distribution during the day-time survey, and the major part of detected fish were found in the length group 4—8 cm (93% of the total numbers). During night-time cruises, small fish dominated strongly, and the share of 4—8 cm fish increased from 54% to 99% since September 13. However, contrary to the data received September 13, there were no clear differences in length distributions or total fish abundances between day and night during this later study.

The distribution of small fish was more even in this subarea than in the other studied Forsmark subareas (Fig. 5), a pattern that remained from the September 13 survey. Although there were great differences in the abundance estimates between days, the positions of maximum concentrations coincided with those detected on September 13.

Subarea 3

The general patterns seen in the more sheltered subareas could also be detected in the open waters east of the Biotest basin, i.e. small fish dominated at day-time as well as at night-time. On September 13 the 4—8 cm fish constituted 78% and 54% of the total numbers counted, respectively (Fig. 7). Maximum young and adult fish abundances reaching 34 000 fish/ha (28 000 fish/ha in the length group 4—8 cm) were detected in the SSW part of the subarea, close to the shore. At night the fish were more evenly dispersed in all parts of the subarea and only one aggregation could be seen E of the cooling water discharge (Fig. 4).

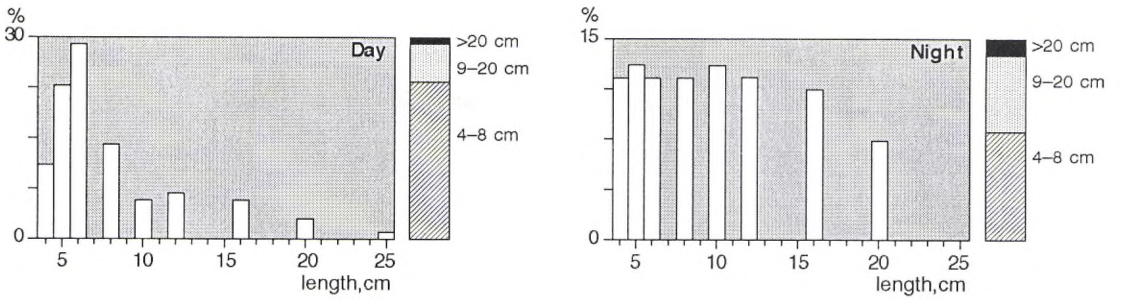


Figure 7. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 13 in subarea 3 at Forsmark.*

The day-time echo-survey on September 15 showed a strong decrease of fish abundance —almost three times— in all length groups since the previous cruise. At night much more fish of all length groups could be detected — up to 10 000 fish/ha. Both at day and night surveys the major part of recorded fish consisted of 4—8 cm individuals (93% and 73%, respectively. The distribution of small-sized fish differed from the situation on September 13, and the major aggregations now were found in the SW parts of the subarea, close to more shallow water (Fig. 5). Maximum concentrations up to 16 000 fish/ha were found.

Species identifications

Trawlings made during the night on September 14 in subareas 2 and 3 showed that the dominating fish species should be herring, ranging from 2 to 7 cm in lenght, as this was the only species observed in the catches. The major part (85 and 74%, respectively) consisted of 5—6 cm individuals (Fig. 8).

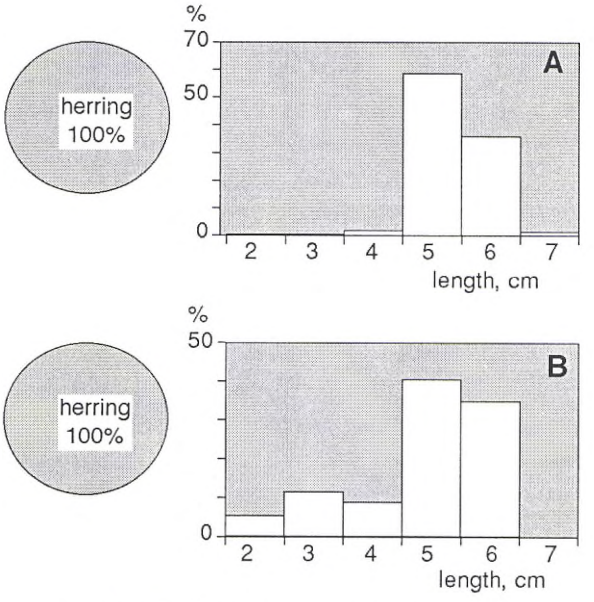


Figure 8. *Species compositions and length distributions of fish caught in night-time trawlings in subareas 2 (A) and 3 (B) at Forsmark.*

General comparisons

Summarizing the data collected by echo surveys carried out in the three subareas at Forsmark, it was evident that the major part of pelagic fish consisted of herring in the size range 4—8 cm; up to 93% at day-time and 99% at night-time surveys. Fish exceeding 20 cm in length were quite rare in the pelagic zone. The densest concentrations of pelagic fish (109 000 fish/ha in subarea 2), predominantly in the smallest length group 4—8 cm, were found in shallow water close to the small inlets and islands. Abundances were highèst in subarea 2, and no easily distinguished reactions could be seen in relation to the cooling water discharge. When comparing the different surveys, a general decrease in abundance with time was seen.

Gräsö

Hydroacoustic observations

The analysis of data collected on September 21 showed that at day-time in the pelagic areas of the Gräsö archipelago the stocks mainly consisted of small fish (Fig. 9, 10). For example, 4—8 cm fish contributed with 77 and 79%, respectively, in the two subareas. At night the share of small fish decreased, and fish of ca 25 cm length were especially abundant.

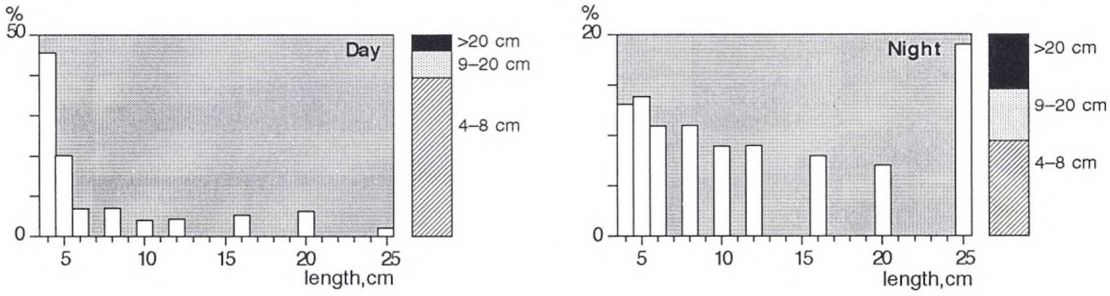


Figure 9. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 21 in subarea 1 at Gräsö.*

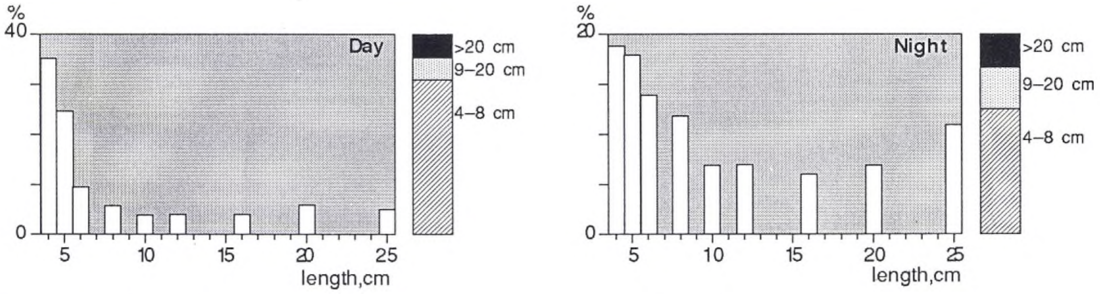


Figure 10. *The length distribution of pelagic fish recorded during the hydroacoustic day- and night-time surveys on September 21 in subarea 2 at Gräsö.*

Compared to the Forsmark area, abundances were generally lower. At Gräsö, day-time recordings reached 1 600 fish/ha and 2 400 fish/ha in the two subareas, and at night-time 8 000 and 9 000 fish/ha, respectively. The analysis of pelagic fish distribution in the SW subarea showed that at day-time the largest fish aggregations, consisting mainly of small-sized fish, were located to the W parts, close to the Gräsö inlets. Maximum concentration in this region reached up to 10 000 fish/ha of which 4—8 cm fish contributed with 9 400 fish/ha. At night pelagic fish were more dispersed, but the main concentrations had not moved from their previous positions (Fig. 11). Maximum abundances reached 14 000 fish/ha, and fish of the size group 4—8 cm 8 800 fish/ha. In the NE subarea maximum concentrations (8 900 fish/ha) consisting mainly of small fish (7 600 fish/ha) were found during the day in the eastern and central parts of the area. During the night the fish were more dispersed but aggregations were seen with up to 14 000 fish/ha, with fish of 4—8 cm in abundances up to 9 000 fish/ha (Fig. 11).

Figure 11. *The night-time abundance distributions (numbers/ha) of 4—8 cm pelagic fish in subareas 1 and 2 at Gräsö on September 21 and 22.*

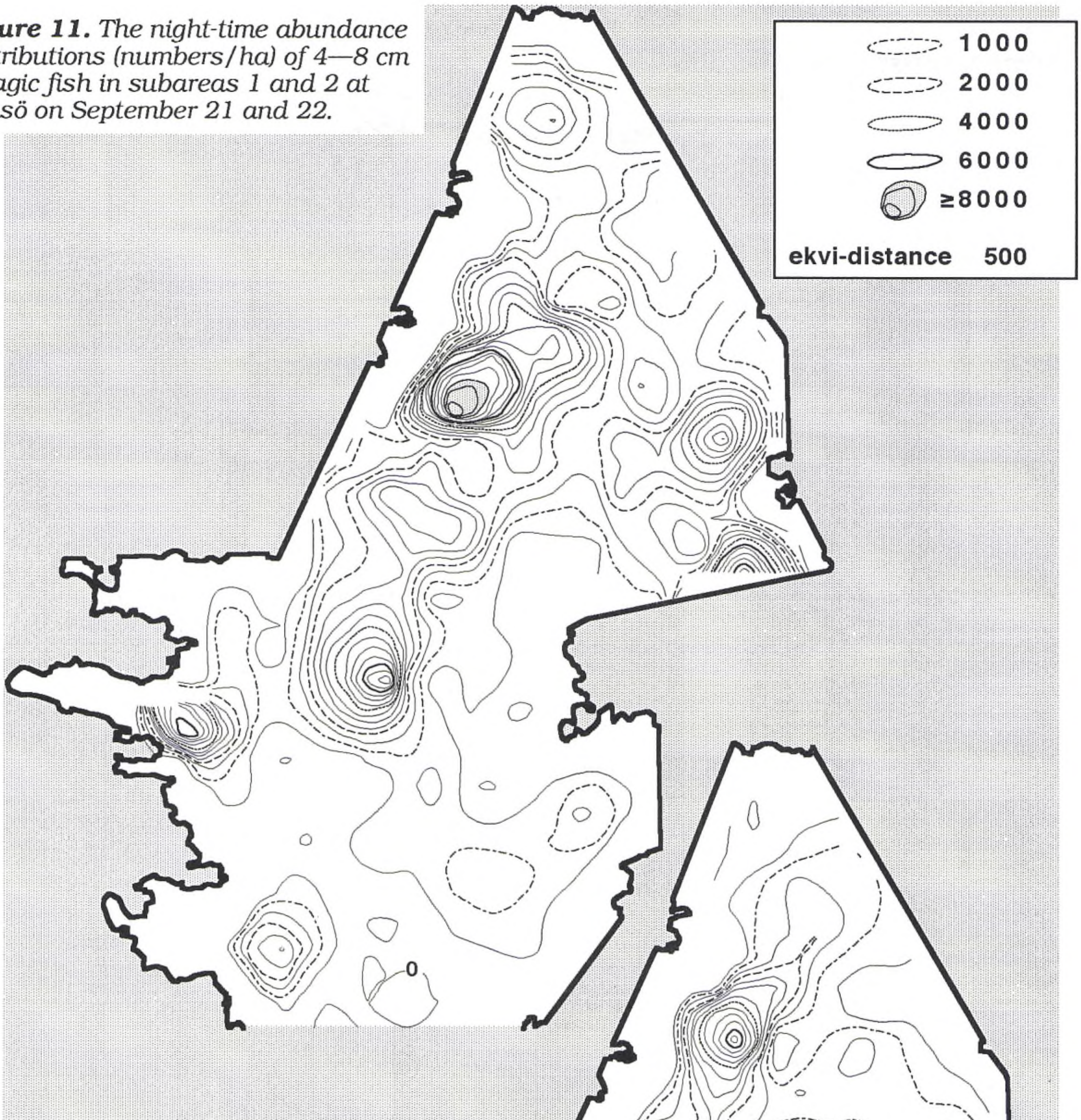
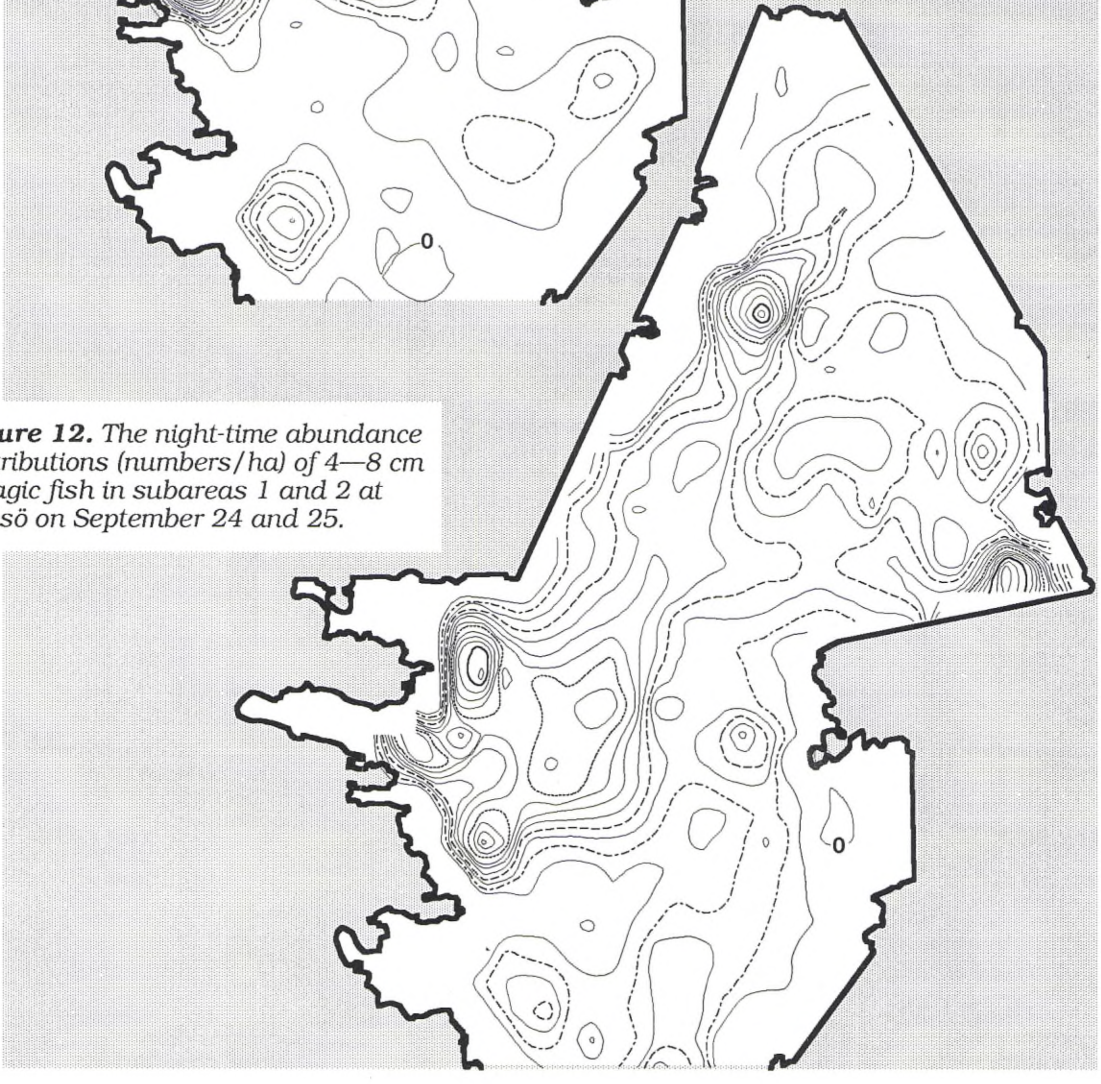


Figure 12. *The night-time abundance distributions (numbers/ha) of 4—8 cm pelagic fish in subareas 1 and 2 at Gräsö on September 24 and 25.*



When the study was repeated on September 23 and 25, the fish length structure did not deviate much from the previous visit. The total amount of fish recorded both at day and night surveys, however, had increased 1.5 to 2 times. The distribution of pelagic fish in the SW subarea had not changed much, although they were somewhat more scattered (Fig. 11, 12). Still, the main part consisted of small-sized individuals during day-time cruises. The maximum abundance reached 38 000 fish/ha, with 37 000 fish/ha in the length group 4—8 cm. At night the bigger fish were mainly located to the NW and E parts of the subarea where their abundance reached 21 000 fish/ha (6 500/ha of 4—8 cm fish; Fig. 12). In the NE subarea the major aggregations consisted mainly of small (4—8 cm) fish which at day-time were located to the central part in maximum abundances of 20 000/ha. At night the fish were dispersed almost evenly over the area (maximum abundance 12 000 fish/ha) and the only evident aggregations were seen in 4—8 cm fish with maximum abundances of 6 500 fish/ha (Fig. 12).

Species identifications
Trawling on September 21 in the western subarea (1) at Gräsö showed that herring dominated both in the 6 and 10 m depth layers, with up to 94% of the total catches (Fig. 13). Other fish species made insignificant contributions. The length of the caught herring varied from 3 to 17 cm, but the major part consisted of 3—7 cm individuals. The subareas at Gräsö differed in fish species composition and relative abundance. In trawl catches (September 24) in subarea 2 at the depth of 10 m, herring only made up 43% of the total catch and the rest was shared about equally between smelt and sand goby (Fig. 14). The herring length distribution also differed between subareas — the main part consisted of bigger individuals in subarea 2. The results of trawling at the bottom — about 20 m depth — showed a higher relative abundance of herring (up to 69%) with smelt and sand goby contributing with 13 and 19%, respectively. The length distribution of caught herring was similar to at 10 m depth (Fig. 14).

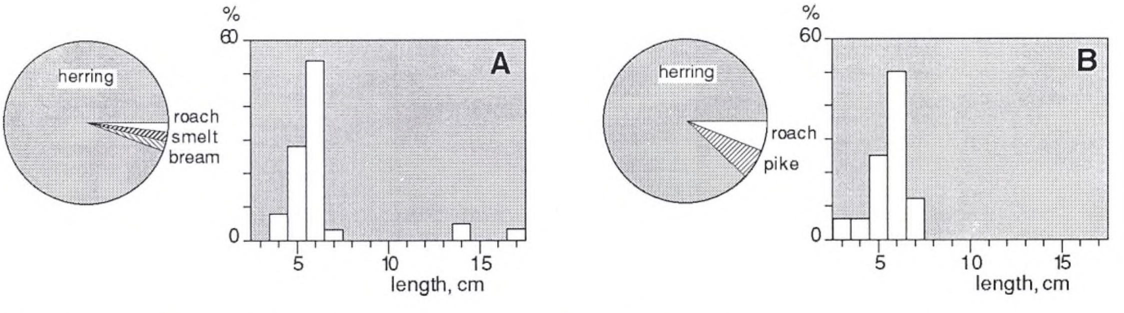


Figure 13. *Species composition and length distributions of herring caught in night-time pelagic trawlings at 10 m (A) and 6 m (B) depths in subarea 1 at Gräsö on September 21.*

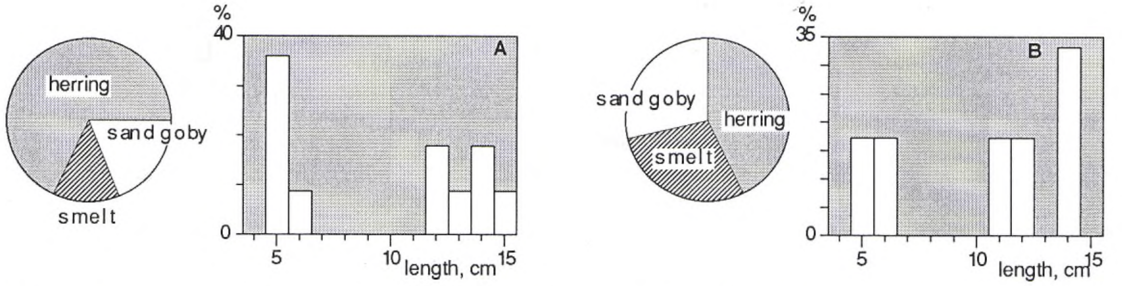


Figure 14. *Species composition and length distributions of herring caught in night-time pelagic trawlings at the bottom (A) and at a depth of 10 m (B) in subarea 2 at Gräsö.*

The gill net catches on September 24 in subarea 1 at Gräsö showed a much more varied species composition (Fig. 15). Nine species were caught (herring, perch, ruffe, roach, smelt, pike perch, silver bream, four-horned sculpin and eelpout), but the major part consisted of perch (63%). The share of herring was less than 4% and its length distribution varied from 15 to 21 cm. In the total gill-net catches length distribution of all caught fish varied from 7 to 37 cm, but the main part consisted of 8—22 cm individuals (Fig. 15).

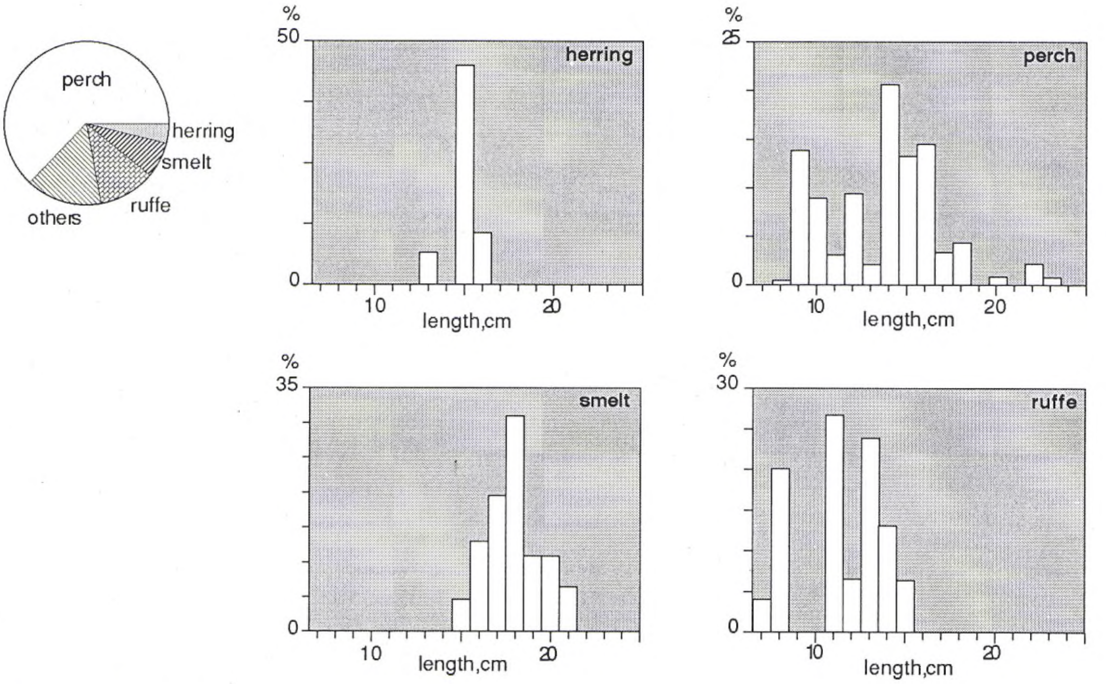


Figure 15. *Species compositions and length distributions of perch, ruffe and smelt caught in gill-nets at Gräsö.*

General comparisons

Generally, herring was the most common pelagic fish at Gräsö as well as in Forsmark. At Gräsö, however, there was a larger contribution of other species, mainly smelt, in the trawl and gill-net catches. The hydroacoustic studies demonstrated that fish of the smallest size-group dominated and constituted up to 62% of the total amounts during night cruises, while at

Table 2. *Abundance ($N \cdot ha^{-1} \cdot 10^{-3}$) of pelagic fish in different lenght groups in day and night hydroacoustic surveys at Forsmark (Fm) and Gräsö (Gö), September 13—25, 1992.*

		Day-time cruises							Night-time cruises						
Sub-		>20 cm		20—9 cm		8—4 cm		Total	>20 cm		20—9 cm		8—4 cm		Total
area	Date	N/ha	%	N/ha	%	N/ha	%	N/ha	N/ha	%	N/ha	%	N/ha	%	N/ha
Fm1	09—13	0.7	9.0	6.8	89.0	0.1	2.0	7.7	3.0	25.3	7.1	60.2	1.7	14.5	11.8
	09—15	0.4	5.0	0.6	6.8	7.5	88.2	8.5	0.1	0.8	0.1	1.2	6.2	98.0	6.3
Fm2	09—13	1.7	5.5	5.9	19.1	23.3	75.4	30.9	1.4	9.8	12.5	85.2	0.7	5.0	14.7
	09—15	1.2	13.9	0.8	9.3	6.7	76.8	8.7	1.9	21.2	0.1	1.6	6.8	72.2	8.9
Fm3	09—13	3.7	6.5	2.0	16.5	9.3	77.0	15.0	2.8	35.9	3.8	48.7	1.2	15.4	7.9
	09—15	2.2	11.7	0.1	3.9	3.0	84.4	5.3	0.9	9.3	3.5	34.8	5.6	55.9	10.1
Gö1	09—21	0.2	10.4	0.0	4.4	1.4	85.2	1.6	2.4	63.8	0.2	5.6	1.1	30.6	3.7
	09—23	0.3	6.3	0.2	4.2	4.4	89.5	4.9							
	09—25								5.6	70.6	0.4	4.7	2.0	27.7	7.9
Gö2	09—21	0.3	14.1	0.0	3.0	2.0	82.9	2.4							
	09—22								2.0	41.9	0.3	6.6	2.5	51.5	4.8
	09—23	0.2	4.1	0.3	7.4	3.3	88.5	3.7							
	09—24								2.1	40.7	1.2	24.0	1.8	35.3	5.2

day-time they reached 85%. These fishes should mainly be young-of-the-year herring. At the beginning of the study pelagic fish abundances, mainly 4—8 cm fish, were highest in the NE subarea (Fig. 11). After some days the abundance center had moved somewhat southwards, closer to the SW subarea; fish of the smallest sizegroup still dominating (Fig. 12).

Calculation of the total numbers of pelagic fish

The total numbers of pelagic fish in the subareas at Forsmark decreased by more than 50% from the first to the second visit in day-time as well as night-time surveys, except during day-time in subarea 1 (Table 2). Estimated total numbers per ha varied between 5 300 and 30 900 in day-time and between 6 300 and 14 700 during the night cruises.

At Gräsö, the estimated abundances increased with time in subarea 1, but in subarea 2 there was an increase in day-time and a decrease in night-time surveys (Table 2). Estimated total numbers per ha varied between 1 600 and 4 900 in day-time and between 3 700 and 10 900 in night-time surveys.

An attempt was made to determine the biomass of young-of-the-year (4—8 cm) herring, based on hydroacoustic data and weight measurements on fish captured in the test fishings. The mean weight of 4—8 cm length herring was 1.13 g. At day-time the highest biomass was determined in subareas 2 and 3 at Forsmark (20.4 t and 11.3 t, respectively). High biomasses were also detected in subarea 2 at Gräsö during the night surveys (18.7 t).

Discussion

The small-sized pelagic fish, mainly herring, generally were concentrated to definite parts of the studied coastal areas. High densities were often found in very shallow water close to the shore or in the vicinity of the small islands abundantly occurring in these waters. This distribution pattern was most pronounced in day-time. During the night the fish were more dispersed, forming looser aggregations. Night-time data consequently were preferred for our comparisons as the dispersed behavior allows a more accurate estimate of target number and fish size. It should be noted that water and air temperature during the research period varied very little, and there were not seen any correlations between fish distributions and such meteorologic variables as wind direction and strength, cloudiness etc.

Most pelagic fish belonged to the smallest size groups distinguished, and according to the test-fishing young-of-the-year herring dominated. Abundances of small fish were high in all study areas, but when the two areas were compared, young herring were more abundant at Forsmark. Although we could not demonstrate any strong behaviour in relation to the cooling water discharge, the concentrated spawing observed in the effluent area may have resulted in the generally high fry abundances noted in all parts of this archipelago (Svedäng & Karås 1993).

The pelagic fish community consequently was strongly dominated by young herring. Only in one subarea at Gräsö other species and older herring contributed significantly to the number of counted fish. Sand goby, smelt, roach and perch were observed in the trawl catches but not the three-spined stickleback which is generally common in the Baltic. Evidently, this species is only sparsely occurring in this part of the Bothnian Sea, an observation that is supported by the numeruos young fish studies made especially at Forsmark (Karås 1993).

The tendency for young herring to aggregate in small and shallow bays and close to the shore has been demonstrated in other studies (Karås 1993, Karås & Urho 1994) and the results confirmed previous observations at Forsmark using other techniques (Karås 1993). A considerable part of the Baltic herring stocks spawn in archipelagoes, e.g. the Archipelago Sea, where fishing is very important during the spring spawning period, and an access to shallow and sheltered areas for early life development seems necessary. This behaviour, however, makes a monitoring of young-of-the-year abundances difficult. Using acoustics, our results show that the fish may "disappear" from a study area very quickly. This difference between sampling occasions should most likely be an effect of diurnal and perhaps also other movements between very shallow water where they can not be counted by hydroacoustics and deeper areas where they may be reached by this method. Although accurate abundance comparisons thus can not be made, the results at Forsmark and Gräsö agree reasonably well with previous hydroacoustics data from the western coast of the Baltic proper (Hansson 1993). If a documentation of the distribution patterns is the primary objective, as in this study, hydroacoustics is a cost efficient method even if it is not possible to estimate total abundances. Often there was a good agreement between surveys in the distribution patterns, although the mean abundances differed very much.

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