Survey report

International Acoustic Herring Survey

Norwegian Sea

R/V "G.O. Sars", 1/5-1/6, 1997

Survey number 1997007

Institute of Marine Research, Bergen, Norway

Introduction

The reported survey forms part of a co-ordinated effort organised under the auspices of ICES to undertake an international acoustic herring survey in the Norwegian Sea in May 1997. The main aim of the survey was to obtain an acoustic estimate of the Norwegian spring spawning herring stock. The survey was planned under "The ICES planning group on Surveys on Pelagic Fish in the Norwegian Sea (PGSPEN)" which met in Bergen in February 1997 (anon. 1997).

A total of four vessels, from Iceland, The Faroes, EU (Swedish vessel) and Norway participated and carried out a co-ordinated survey effort, including a large scale coverage of the herring stock and ad-hoc mini-surveys in areas of high herring densities. The four vessels carried out a substantial number of survey-days which allowed for a relatively dense coverage of the entire area of distribution of the adult herring and a large proportion of the adolescent herring. Sampling of plankton and hydrography was included as a central part of the survey programme.

The present report gives an account of the survey carried out by the R/V "G.O. Sars" of the Institute of Marine Reasearch (IMR), Bergen, Norway, and presents a preliminary estimate of the herring stock in the areas covered by this vessel. The data collected by all the participating vessels will be brought together during a meeting to take place in Reykjavik 20-23 August 1997 with the aim to produce an official estimate of the herring stock.

Participants

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Methods

Acoustic registrations

Acoustic recordings were made by a 38 kHz Simrad EK500. Postprocessing and allocation of area backscattering strengths, Sa, to species or groups of species was done with a Bergen Echo Integrator (BEI).The following characteristics applied for the echo-sounder:

TRANSDUCER DEPTH	7.5m
ABSORBSION COEF	10db
TIME VARIED GAIN	20 log R

PULSE LENGTH	MEDIUM
BANDWITH	WIDE
MAX POWER	2000W
2 WAY-BEAM ANGLE	21.0db
Sv TRANSDUCER GAIN	27.2db
Ts TRANSDUCER GAIN	27.1db
ANGLE SENSIVITY	21.9
3db BEAMWITH	7.1deg
ALONGSHIP OFFSET	-0.08deg
ATHW OFFSET	0.05deg
PING INTERVAL	0.0
SOUND VELOCITY	1470m/s

Trawl sampling

Pelagic trawling was carried out using a "Åkra pelagic trawl" with a vertical opening varying from 25 to 35 meters depending on the mode of trawling and trawling depth. When hauled in the surface the trawl was fitted with two buoys on each of the fore ends of the wings which allowed sampling from the very surface and down to about 25 m. A buoy was also fixed to the middle of the head-line to secure that the headline skimmed the surface from bellow. When hauled in the surface wirelengths of 250 m were used. When hauled at deep registrations, a Scanmar depth sensor and a Simrad trawl eye was fitted to the trawl.

Surface or deep trawl hauls of 30 minutes duration were in general performed in pre-set positions with approx. 60 nm spacing along the survey track (Fig.1). In addition opportunistic hauls were performed on registrations of herring or blue whiting both close to the surface and in the deep. These hauls lasted from a few minutes up to approx. 1 hour to obtain satisfactory sample sizes.

Along a section at 61°15' north, from 0° to 2° east, 7 surface hauls were made to verify that that postsmolt salmon had not yet reached the high velocity surface current running northwards along the western edge of the Vøring-plateau.

Fish sample analysis

Random samples of up to 100 specimens of herring and blue whiting were taken from the trawl catches. The samples were worked up according to the standard procedures of IMR, with the exception that scales or otoliths were only taken from 50 individuals for age determination. Stomach samples were collected from 30 individuals in each sample.

In salmon the total and fork lengths were measured, scales samples taken and the fish frozen whole for later analysis.

Acoustic estimate

The acoustic registrations were allocated to 4 major groups: herring, blue-whiting, mesopelagic fish and plankton, based on the characteristics of the echo registrations and the

composition of the trawl catches made in the corresponding area and depth. In areas where herring and blue whiting appeared in mixed registrations, herring was allocated a somewhat higher percentage of the total Sa value than indicated from the trawl catch composition. This was done due to a presumed higher catchability of the blue whiting.

The length dependent density coefficient: $C_f = 1.23*106*L^{-2.0}$ was used for conversion of Sa values into age stratified estimates of biomass of herring by statistical square. The computations were done using the standard IMR programme Mengd2.

CTD

The CTD probe was lowered to 1000 meters or to just above the bottom in shallower areas in a total of 84 stations (Fig. 2). In one station on the Gimsøy section it was lowered to 1600 m.

Nutrient samples and chlorophyll-a

The CTD probe was equipped with a Rosette water bottle sampler with 12 5-l water bottles. Samples for nutrient salts were mostly taken from 1000, 700, 500, 400, 300, 200, 150, 100, 50, 30, 20 and 10m, and chlorophyll-a samples from the upper 100m and from surface water. During the Gimsøy transect the maximum depth was changed to 1500m. Water samples were obtained from 70 out of the 84 CTD-stations. They will be analysed at the Institute of Marine Research after the survey. Stations with water samples are shown in table 1.

Zooplankton sampling

The main gear used for zooplankton sampling was a 1 m^2 MOCNESS plankton trawl with 8 nets with 180 µm mesh. The nets were opened and closed at selected depths to provide vertical profiles of the plankton distributions. The MOCNESS was towed at about 2 knots while hauling slowly from the lowest sampling depth to the surface. On most stations standard depths were 500-400, 400-300, 300-200, 200-100, 100-50, 50-25 and 25-0m. The total number of MOCNESS stations was 55 (Fig. 3), and only during four stations the weather prevented use of the gear. As a backup gear a WP2-net was used in 200-0m. It was also the standard net for sampling on the 10 stations on the Gimsøy transect. Total number of WP2-hauls was 13 (Fig. 3). The zooplankton sampling is summed up in table 1.

All zooplankton samples were divided to make subsamples for preserving in formaline and for biomass measurements. The biomass part was sieved through a 2000µm, a 1000µm and a 180µm nylon mesh to make three sizes of plankton. Krill, shrimps and fishes were sorted out from the >2000µm plankton, and all the categories were dried on pre-weighed aluminium dishes for about 24 hours at 70_C. Weighing of the samples and calculation of the dry weights in mg m^{-3} (MOCNESS) or g m^{-2} (WP2) will be done at the Institute of Marine Research. All zooplankton relevant data were loaded into the Helix database during the cruise.

Lumpsucker tagging

All lumpsuckers (*Cyclopterus lumpus*) caught were transferred live to a an aquarium for tagging and release. The fish were tagged with Hall-Print PDA/ PDT tags in the back, just bellow the dorsal fin. A total of 312 individuals were tagged and released throughout the surveyed area.

Results and discussion

Herring distribution.

Herring was observed throughout most of the surveyed area, and the 0-line could be drawn in most areas except in the SW-part towards the Faroes and in the NE parts towards the Barents Sea (Fig. 4). Combined with the registrations made by the Icelandic and Faroese vessel, which covered the area west of 0°, this means that the entire adult stock was covered during the survey.

From no registrations of herring close to the Norwegian coast, the density of herring increased westwards from about 90 nm off the coast. The largest concentrations were observed between 65° north and 68° north, and from 5° east to 4° west. The western boundary was at about 6° west, while the northern boundary was not found. Probably the concentrations of adolescent herring in the northernmost area continued into the Barents Sea. As compared to the distribution observed in 1996, it appears that the westernmost registrations of herring were somewhat more eastern in 1997. This may be due to the somewhat lower temperatures observed in the eastern parts of the East-Icelandic current. However, the amount of herring situated close to these colder water masses had increased significantly as compared to last year and the mean distribution of biomass had moved westward from last year.

In general the mean length increased westwards (Fig 5, Table 2), which is in accordance with the observations made earlier years. There was also a tendency of younger herring in the NE-areas (Fig. 5), which reflects the westward migration of adolescent herring out of the Barents Sea.

Herring abundance

Based on the acoustic registrations, the scrutinised acoustic integrator values (Fig. 6) and the analysed fish samples, a preliminary age structured estimate of the herring in the surveyed area was run (Table 3). In squares not covered by the «G.O.Sars», Sa values were interpolated from the nearest squares (Fig. 7). A simple algorithm, weighting the four nearest neighbouring squares by 2, while the next second nearest four got a weight of 1, was applied. It should be strongly stressed that the presented estimate is based solely on the data collected onboard G.O.Sars and that the official estimate based on the data of all four vessels may significantly differ from the one presented below.

Table 3. Condensed age stratified herring abundance estimate. Biom=Biomass in thousand tonnes, N=Number in millions, L=Mean total length in cm, W=Mean weight in grams.

Age	3	4	5	6	7	8	9	10	11	12	13	14
Biom	140	496	3403	2866	626	482	57	23	86	134	19	810
N	1169	3599	18867	13546	2473	1771	178	77	288	415	60	2472
L (cm)	25.3	26.7	30.0	31.8	33.8	34.8	36.2	36.4	36.5	37.2	36.5	37.4
W (g)	120	138	180	212	253	272	317	302	299	322	311	328

The total estimate of stock biomass is 9.141 million tonnes, and the stock in number is 44.915 billion individuals within the surveyed area (Appendix A).

Evaluation of the acoustic estimate.

Except for a storm during the first night, the weather conditions were favourable for acoustic registrations throughout the survey.

The obtained number of herring samples available was regarded satisfactory in most areas, taking into account a relatively continuos gradient in size and age composition on an east-west axis and in general small differences in these parameters between neighbouring samples. However, in the south-eastern part of the surveyed area, most of the obtained samples were small and could preferentially have been larger.

The quality of the obtained scale samples is not satisfactory and may effect the quality of the estimate. Effort should therefore be put into the development of a device which could secure less scale-loss in the trawl-samples.

In some areas herring and blue whiting appeared in mixed concentrations making the scrutinising process difficult. This area stretched as a band in north-south direction about in the middle of the surveyed area. Apart from this area, the herring appeared either above the blue whiting, like in east, or, like in the westernmost areas, alone.

Blue whiting distribution

Blue-whiting was distributed over large parts of the surveyed area (Fig. 8, 9). The blue whiting was more easterly distributed than the herring and did not protrude into the cold western areas. The strong 1995 and 1996 yearclasses constituted most of the blue-whiting biomass, reflecting that the adults were out of this area on their southern spawning migration.

Temperatures

The temperatures (°C), represented by isolines, in 0, 20, 50, 100, 200, 300 and 500 meters are given in figure 10 to 16.

Species composition and biomass of plankton

Calanus finmarchicus (Copepoda) was the dominant species throughout the area. It was abundant in the upper 200 m, and the youngest copepodite stages and nauplii were found closest to the surface together with *Pseudocalanus* sp., *Microcalanus* sp. and *Oithona* sp.. *Metridia longa* was also abundant and associated with *C. finmarchicus*, but the peak of abundance was a little deeper. *C. hyperboreus* generally had a deep distribution, coming closer to the surface in the cold water in west. *Euchaeta* was found in the deepest layer around 400-500m. The chaetognaths belonged to the lower part of the water column, together with the medusa *Aglantha digitale*. Amphipods up to about 10mm length were also common in the samples. Krill were almost always present at lower and intermediate depth. Individuals longer than 15mm were identified from the biomass samples, showing *Meganyctiphanes norvegicus* being the most numerous species and *Thysanoessa inermis* ranking as number two. T. longicaudata was also common (less than 15mm). Shrimps (*Sergestes*, *Phasiphaea*) and fish (*Benthosema*) were found regularly in the deepest samples. Larvae of cod were identified from the surface samples on station 303.

Herring and plankton

The chlorophyll samples and samples for zooplankton biomass have not been analysed. However, a preliminary study of the chlorophyll-filters and MOCNESS-profile samples give an impression of the present status with regard to biological development in the investigated area.

To the east a phytoplankton bloom and developing of a new generation of *Calanus finmarchicus* was observed; young copepodite stages dominated the biomasses in the uppermost 50 meters. At greater depths the samples were occasionally dominated by skeleton remains of the developing copepod stock. Closer to the front between warm Atlantic watermasses and the colder East-Iceland Current the *Calanus* spawning was at its very beginning, the new generation had not grown beyond the naupliar stages, and the biomasses were relatively low in the surface layers.
Below 300 meter the zooplankton was dominated by arrow worms, *Calanus hyperboreus, Euchaeta norvegica* and amphipods. Since the biomass analyses take place at a later stage it is uncertain to what extent the present biomasses were as high as those observed in April.

Close to the surface west of the cold water front at certain locations high biomasses of the overwintering *Calanus finmarchicus* and *C. hyperboreus* were observed. In this area the new production had not , or just recently begun.

In the most dense herring concentrations just east of the front the feeding activity seemed to be low, as almost empty herring stomachs were observed regularly. This may be caused by relatively poor feeding conditions in this area where the herring has spent the time since April. Further to the east the herring fed upon the *C. finmarchicus* generation of the year, in view of the stomach fullness this seemed to be a suitable food resource. The herring in the westernmost area was feeding upon the rich supply of adult *Calanus* in the upper 50 meters, from the rich stomach content this area was the best area for feeding in May.

In the weeks to come we expect that the area west of the front will be gradually more available for the herring to feed in due to the stabilisation of water masses through the development of a thermocline, followed by the phytoplankton bloom and the raising of the overwintering *Calanus* to the surface to spawn. It is therefore expected that at least the oldest part of the herring stock will gradually find their food supply further west as the area of phytoplankton bloom and *Calanus* spawning moves westward.

Whale observations

All whales observed from the bridge were noted, to be reported to the IMR Marine Mammals Section. The observations include Fin-whale, Minke-whale, Sperm-whale, Killer-whales, Bottlenosed-whale and Dolphins. Despite a continuos watch on the bridge and favourable weather conditions, relatively few whales were observed during the survey. From earlier whale counting surveys conducted by the IMR it is known that the surveyed area is rich in several whale species, and the low number of observations is mainly due to the fact that no dedicated effort was carried out to observe whales.

Migratory birds

A series of migratory birds were observed resting onboard the ship during the survey. At least three of these died during their stay onboard, one of them killed and eaten on the port trawl-winch by a hawk.

Report production

This report was produced by an entousiastic team including all participants listed at page 2. Thank's to all of you, and to the captains and their crews, for an enjoyfull month at sea and a job well done !

Tromsø 1/6, 1997

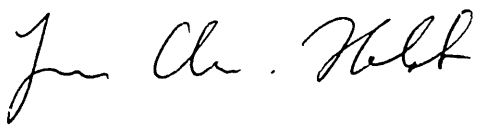

Table 1. Listing of CTD-stations, water bottles and plankton net hauls.

CTD St.no.	Latitude	Longitude	E=1 W=-1	Gimsøy transect	Nutr.salt Chl.ph.	WP2-net depth (m)	MOCNESS depth (m)
228	6215	445	1		x		
229	6215	235	1		x	200-0	
230	6215	25	1		x	200-0	
231	6215	130	-1		x		400-0m
232	6215	300	-1		x		200-0m
233	6315	300	-1		x		200-0m
234	6315	102	-1		x		200-0m
235	6315	110	1		x		200-0m
236	6315	314	1		x		200-0m
237	6315	527	1		x		200-0m
238	6415	700	1		x		200-0m
239	6415	500	1		x		200-0m
240	6414	215	1		x		200-0m
241	6415	0	1		x	200-0	
242	6415	219	-1		x		200-0m
243	6415	435	-1		x		500-0m
244	6515	435	-1		x		200-0m
245	6517	215	-1		x		200-0m
246	6515	12	-1		x		200-0m
247	6515	230	1		x		500-0m
248	6515	452	1		x		200-0m
249	6515	830	1		x		200-0m
250	6615	830	1		x		200-0m
251	6615	608	1		x		500-0m
252	6615	340	1		x		500-0m
253	6615	112	1		x		500-0m
254	6615	110	-1		x		500-0m
255	6615	338	-1		x		500-0m
256	6616	419	-1				
257	6615	610	-1		x		500-0m
258	6645	610	-1		x	200-0	
259	6645	340	-1		x		500-0m
260	6645	102	-1		x		500-0m
261	6645	30	-1		x		500-0m
262	6715	30	-1		x		500-0m
263	6715	305	-1		x		500-0m
264	6715	530	-1				
265	6815	530	-1		x		500-0m
266	6815	300	-1		x		
267	6815	30	-1		x		500-0m
268	6915	30	-1		x		
269	6915	148	-1		x		500-0m
270	7015	148	-1				
271	7015	130	1		x		500-0m
272	6915	130	1				

Table 1. Continued.

273	6815	130	1		x		500-0m
274	6715	136	1		x		500-0m
275	6715	410	1		x		500-0m
276	6715	645	1		x		500-0m
277	6715	920	1		x		357-0m
278	6715	1030	1		x		190-0m
279	6615	1030	1				
280	6627	1102	1		x		
281	6703	1214	1		x		277-0m
282	6733	1312	1				
283	6732	1344	1				
284	6740	1130	1				
285	6758	1130	1				
286	6815	1130	1		x		103-0m
287	6815	836	1		x		500-0m
288	6815	540	1		x		500-0m
289	6815	240	1		x		500-0m
290	6915	135	1		x		500-0m
291	6915	406	1		x		500-0m
292	6915	640	1		x		500-0m
293	6915	920	1		x		500-0m
294	6946	742	1		x		500-0m
295	6951	935	1	x	x		
296	6942	1016	1	x	x	200-0	500-0m
297	6929	1057	1	x	x	200-0	
298	6914	1137	1	x	x	200-0	
299	6902	1217	1	x	x	200-0	500-0m
300	6851	1248	1	x	x	200-0	
301	6844	1310	1	x	x	110-0	
302	6835	1335	1	x	x	115-0	
303	6831	1347	1	x	x	130-0	141-0m
304	6826	1401	1	x	x	164-0	
305	6945	1310	1				
306	6945	1455	1		x		500-0m
307	6945	1630	1				
308	7015	1730	1		x		203-0m
309	7015	1533	1				
310	7015	1320	1				
311	7015	1130	1		x		500-0m
312	7045	1130	1				
313	7115	1130	1				
314	7115	1430	1		x		
315	7115	1710	1				
316	7115	1930	1		x		193-0m
Total							
87				10	73	13	57

Table 2. Length distribution with mean weights and lengths of herring and blue whiting.

DATE	970502		970503		970503		970504		970504		970504		970504		970504		970505		970506		970506		970506		970506		970507		[illegible]		[illegible]		970508		970508		970508		970508		970508		970508	
ST.NO.	166		169		169		170		170		171		172		173		175		176		176		178		178		180		181		182		183		184		185		185		186		
SPECIES	BLUE WH		BLUE WH		HERRING		BLUE WH		HERRING		HERRING		BLUE WH		BLUE WH		HERRING		BLUE WH		HERRING		HERRING		BLUE WH		HERRING		HERRING		HERRING		HERRING		HERRING		BLUE WH		HERRING		
cm	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)
14.0													1	13																														
14.5																																											
15.0							1	19																																		
15.5							1	21					1	19											1	19																		
16.0							6	24					4	21											1	21																		
16.5	1	23	1	25			9	27					7	23					2	23					1	25																	
17.0	2	26	2	26			12	25					8	25											2	27																	
17.5	2	28	1	28			12	27					8	27					2	27					1	31																	
18.0	5	30	9	30			17	31					19	30					1	30					7	33																	
18.5	6	32	8	32			10	35					11	33					4	33					8	36																	
19.0	5	35	11	35			12	36					11	45					7	39					15	38																	
19.5	3	38	19	40			4	40					10	39	1	35			9	41					8	42																	
20.0	1	39	18	41			5	39					8	43					4	43					11	43																	
20.5			9	45			3	47					3	47					2	45					5	48																	
21.0	4	48	5	46									2	51					3	46					6	49													1	46			
21.5	2	59	6	52			2	49					2	52					5	54					5	53													1	52			
22.0	8	61	3	60									1	54					3	62					11	62													1	56			
22.5	9	61	4	62									1	57					15	64					3	67																	
23.0	13	67	1	63			1	69					1	61					5	71					7	71													2	67			
23.5	14	75	2	70									2	79					13	71					2	75													2	76			
24.0	12	78	1	75			2	69											15	77					3	80																	
24.5	5	87					1	78											4	80					2	84													2	80			
25.0	1	91					2	87											1	86																			1	94			
25.5	1	101																	3	92					1	92																	
26.0	3	102																	1	98																							
26.5	1	103																	1	103																							
27.0	2	108			1	136																							1	136		1	138									
27.5																																											
28.0					1	158																																			5	143
28.5					1	149			1	165											1	145							1	159											7	153
29.0					7	160			3	169											3	160							3	161			2	161							7	163
29.5					10	166			2	170											2	182					1	162	5	165			3	156	1	161					16	165
30.0					12	176			1	166	2	185									2	170					5	170	10	173			5	172	1	182					9	172
30.5					17	182			1	184	2	200									2	183					4	181	10	179			6	180	3	186					18	180
31.0					16	199											1	180			2	195	1	200			8	208	9	186			4	187	1	192					12	186
31.5					12	199			1	193							1	179			1	194					15	193	5	198			9	191	7	196	1	184			8	200
32.0					6	212			1	219																	18	203	3	206			6	200	2	215	1	206			4	200
32.5					4	234					1	230					1	239									15	217	9	217	1	219	1	210			1	217			3	216
33.0					1	243			1	207															1	227	8	230	3	238					2	228					5	231
33.5					4	241																					6	234	6	246			2	227							3	233
34.0																	1	240									3	251	5	248			1	228								
34.5																	1	277											3	248			1	259								
35.0					1	267																					2	288			1	281	1	273							
35.5																											3	273	4	278							1	249			2	280
36.0																											1	297							1	275						
36.5																											2	337	4	303												
37.0																											3	315	2	322												
37.5																											2	355	8	325			1	311							1	341
38.0																											1	360	4	339												
38.5																											3	361	1	345												
39.0																																										
39.5																													4	332							1	315				
40.0																																										
SUM	100		100		93		100		11		5		100		1		5		100		13		2		100		100		100		2		43		18		5		10		100	
MEAN W		62.6		41.7		190.1		34.1		180.1		200.0		35.3		35.0		223.0		60.4		175.3		213.5		48.8		226.7		231.3		250.0		192.3		201.4		234.2		69.4		183.9
MEAN L	22.1		19.9		30.7		18.4		30.1		30.7		18.6		19.5		32.7		22.0		29.9		31.8		20.3		32.3		32.5		33.3		30.8		31.1		33.7		22.7		30.1	

Table 2. Continued.

970508		970509		970509		970509		970509		970509		970509		970510		970511		970511		970512		970512		970512		970512		970513		970514		970514		970514		970518		970518		970518		970518	
186		187		187		188		189		190		191		194		197		198		199		199		200		201		205		206		207		208		219		221		222		223	
BLUE WH		HERRING		BLUE WH		BLUE WH		BLUE WH		HERRING		HERRING		HERRING		HERRING		BLUE WH		BLUE WH		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING		BLUE WH		HERRING		HERRING		HERRING	
n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)
						1	15											1	14																								
				1	19			2	16																																
				1	21			5	17									2	20																	2	20						
								7	19									6	22																	3	22						
								4	22									13	24																	7	24						
								12	25									14	25																	8	26						
				2	27			6	28									7	27																	10	29						
2	31			2	30			7	30									7	30	1	31													4	31						
6	35			7	31			6	31									17	38															7	35						
4	40			5	38			6	35									12	40															5	38						
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2	45			4	47			5	44									2	45															1	50						
5	55			10	48			1	48									2	48																						
5	52			8	52			3	53																																
10	56			10	59			6	57					1	73			2	55	2	63																				
13	66			10	61			5	62					2	78					1	63																				
16	69			8	69			2	65											1	75																				
15	70			9	70			3	70					1	85			1	64	1	77																				
9	77			3	77			9	75					5	98					1	81																				
4	84			4	81			1	80					3	104					1	88																				
1	87			2	77			3	86					1	99					1	96																				
								1	94					1	118	1	112			1	92																				
												1	126			1	123																								
										2	121	1	134	1	135	1	139																								
								1	116	2	130			2	132	1	141																								
										2	137	2	148	1	148	2	144																					1	141				
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		1	154							12	153	6	164	2	171	4	159							2	154													2	160	1	162	1	152
		3	160							21	159	15	170			15	166					1	176	2	170			1	154			1	167	1	160			5	170	4	168		
		5	165							23	166	9	183	3	188	16	174					5	182	2	172			1	176	1	172							4	172	4	180	1	175
		2	174							11	174	28	183	1	199	13	180					3	187	4	186	1	170	3	170	2	183	3	185	1	189			11	180	3	190		
		3	176							8	179	14	191	2	205	9	190					5	189	3	192	2	177	2	190	3	190	2	199	1	193			9	191	5	195	2	191
		4	180							9	186	10	203			12	194					3	190	5	199	3	190	4	191	3	193	2	192	4	186			5	202	4	193	4	196
		1	216							1	200	2	212			7	207					3	202	4	236	3	237	10	195	6	202	3	214	7	199			20	205	6	206	3	213
		1	205							2	207	2	216			1	209					3	211	10	214	5	211	10	206	8	219	3	223	2	199			7	210	2	216	4	214
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										2	200					2	236							5	231	2	230	7	224	11	233	1	262	4	240			3	227	3	237	4	246
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																2	250					1	264	7	258	1	261	4	254	7	256							3	251			2	258
																1	285							8	279	3	255	9	262	5	264							4	265	3	269	1	285
																						1	280	3	281	2	286	3	280	1	279			4	266			3	273	1	295	3	276
																1	307							6	295	1	312	1	297	3	281			5	284			1	274				
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																								7	313	1	310	7	292	6	316			7	301			1	322	3	331	2	317
																								7	326	2	330	4	303	6	323	1	359	10	301			1	325	2	318	1	329
																								5	345	2	343	5	337	5	329			6	323			5	324	2	338	1	321
																								1	349	2	340	3	346	4	336			7	318							1	343
																								1	368			3	358	2	350							1	368			1	359
																										1	350																
100		20		100		1		100		100		100		27		100		100		10		30		100		39		100		100		20		66		50		100		50		50	
	60.8		173.8		52.9		15.0		42.7		165.9		184.8		138.3		184.2		32.7		72.9		205.5		261.5		253.5		242.4		256.5		219.2		268.1		29.9		217.1		222.2		245.3
22.1		30.1		21.2		14.5		19.6		29.5		30.0		26.5		30.1		18.1		23.0		31.2		33.8		33.8		33.7		34.0		31.7		35.0		17.6		32.0		31.9		33.3	

Table 2. Continued.

970519		970519		970519		970519		970519		970519		970519		970520		970520		970521		970521		970524		970524		970524		970525		970525		970526		970526		970526		970526		970527		970527	
224		225		226		227		227		228		229		231		234		236		237		246		247		248		249		251		252		253		254		255		256		257	
HERRING		HERRING		HERRING		HERRING		BLUE WH		HERRING		HERRING		HERRING		BLUE WH		HERRING		HERRING		BLUE WH		HERRING		BLUE WH		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING	
n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)
								1	15																																				
																1	18									1	20																		
								1	20																																				
								1	19													1	20				2	23																
								3	25							8	25										6	26																
								5	27							10	27					1	22				14	28																
								7	30							2	30										11	29																
								9	32							1	32										10	37																
								5	33							1	33										4	36														2	49	
								6	37																		2	41															
								2	42																																	1	55	
								5	44																											1	58					3	61	
								2	48																																	3	65	
																						1	58																			4	71	
																								1	68																	12	78	
																						1	54													2	86					5	84	
								1	60													1	66	1	89															1	83	8	89	
								1	73													6	68	3	95															1	93	9	105	
																						3	73	3	99																	5	99	
								1	81													5	79	5	105															2	114	5	103	
																						4	79	3	113											2	113			1	103	6	118	
																						1	84	9	118											3	115			4	121	4	126	
										1	121													2	122											2	126			2	126	10	128	
										1	130	1	132											4	129											3	130					5	133	
										3	130													9	136			1	137			1	137			5	138			5	146	3	144	
										2	145											1	110	6	144			2	150							8	145			4	142	1	150	
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				1	157					5	156	6	157	1	163									5	162			3	164			1	170	2	171	7	160			3	160			
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		3	171	1	164	1	173			10	170	13	172															9	173	1	182	4	183	6	187	7	171	4	173	3	175			
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1	250									5	241																	1	242	7	246	5	251	3	241	1	229	8	242	5	248	2	226	
1	251									2	247	1	241																	5	247	7	248	1	255			2	260	9	253	1	263	
				1	260					1	239			1	279													1	265			3	274					4	265	4	258	1	231	
1	274																													3	276	2	306	1	286			2	291	2	256			
																				1	308									4	288	3	293							1	273			
																																					1	309			1	303	
1	315																																					1	306					
																																						2	279	1	336			
										1	337													1	333							1	358										
																		1	378																			1	318					
8		14		50		10		50		100		100		7		23		4		2		28		72		50		100		86		100		100		100		100		100		100	
	239.9		181.1		193.9		193.1		35.3		188.2		176.7		221.0		26.7		243.8		286.0		80.2		139.6		30.6		192.0		220.7		230.2		208.1		166.3		215.2		201.1		116.5
33.1		29.9		30.7		30.6		18.4		30.1		29.5		30.7		16.9		32.5		34.3		23.9		26.5		17.4		30.2		31.8		31.5		30.6		28.0		30.9		30.0		23.9	

Table 2. Continued.

970527		970529		970529		970529		970529		970530		970530		970530		970531		970531	
258		262		264		267		268		269		271		272		274		276	
HERRING		HERRING		HERRING		BLUE WH		HERRING		HERRING		HERRING		HERRING		HERRING		HERRING	
n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)	n	w(g)
						3	17												
						9	18												
						13	20												
						16	22												
						17	24												
						5	27												
						5	30												
						8	30												
						1	35												
						1	37												
						2	42												
																1	55		
						2	47												
						4	50												
						3	57			1	61								
2	97					4	58	2	94	1	110								
2	106					4	61	4	108							1	101		
						2	66	9	110	1	116								
6	116							3	105							1	112		
2	120	1	85	1	84			9	124	4	126								
8	130							8	125	2	137	1	124			2	111		
6	135							7	135	3	132								
5	141					1	70	5	143	2	139					2	128	1	119
6	153							5	154	6	154					1	141	9	133
5	166							8	153	3	168					2	160	8	145
11	164							6	179	8	174			2	156	2	140	3	146
6	171							8	182	7	187	1	178					3	151
7	182							8	175	14	189			2	174	2	190	2	175
12	191							9	201	14	200	8	196	2	189	5	193		
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6	198							1	220	8	214	19	206	7	190	8	211		
3	212							1	216	3	218	6	210	11	203	9	222		
3	238							2	233	4	240	15	221	6	204	7	227		
1	269									4	237	8	227	12	220	1	228		
										1	286	13	242	13	229	5	243		
												6	248	8	248	4	244		
												4	256	15	251	2	268		
												5	260	5	265				
										1	251	1	263	5	274				
												4	302	3	269				
														1	282				
												1	326	1	300				
												1	343						
												1	330						
												1	393						
														1	363				
100		1		1		100		100		100		100		100		60		26	
	165.3		85.0		84.0		30.6		153.8		187.9		229.9		227.5		201.7		143.0
27.4		24.5		24.5		18.0		26.5		28.4		31.3		31.8		29.6		27.1	

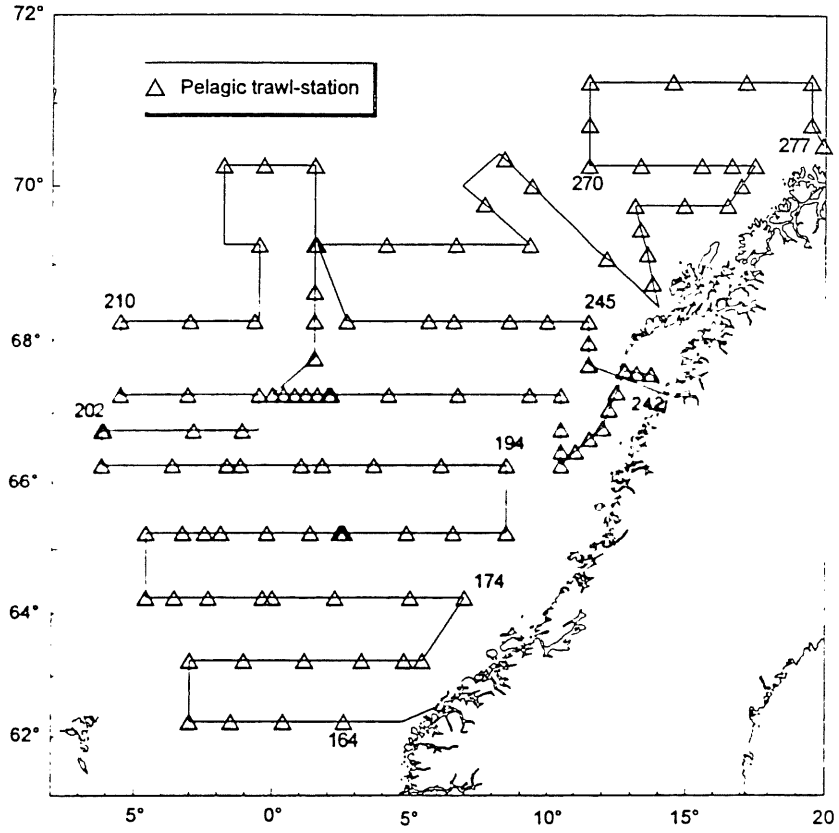

Figure 1. Survey transects and pelagic trawl stations of «G.O.Sars» during 1/5-1/6, 1997.

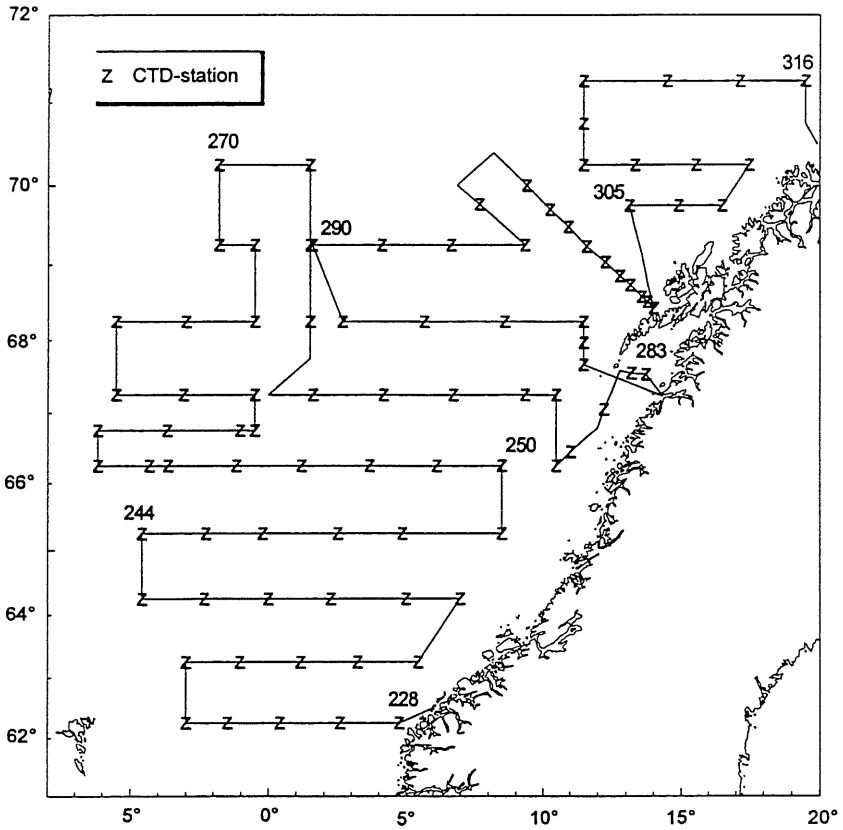

Figure 2. CTD-stations taken during the period 1/5-1/6, 1997.

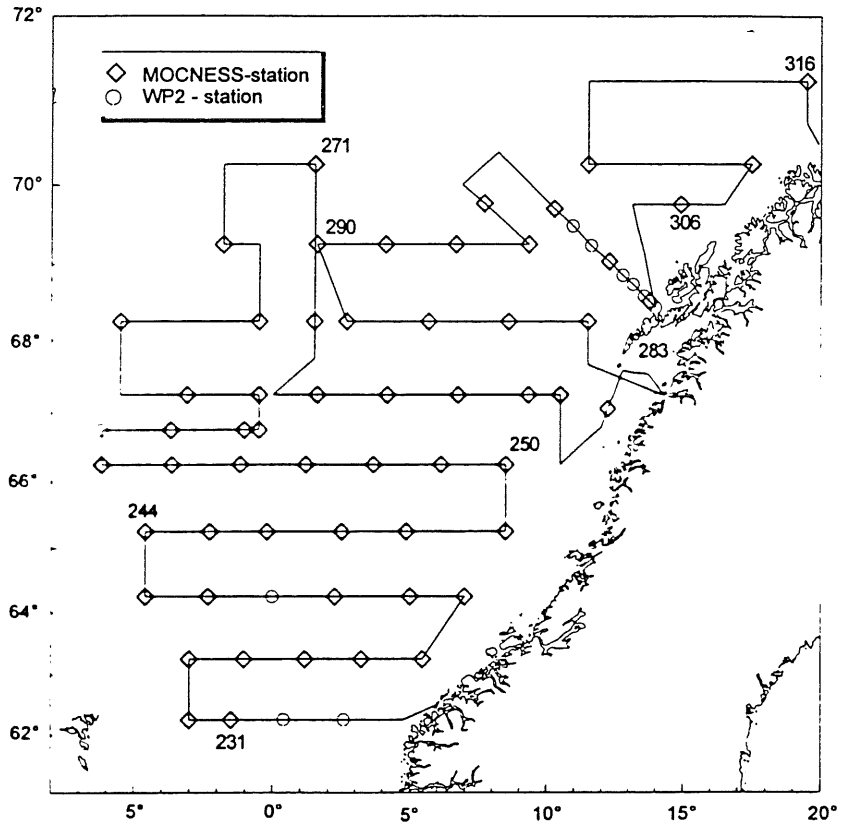

Figure 3. Mocness and WP2 hauls taken during the period 1/5-1/6, 1997.

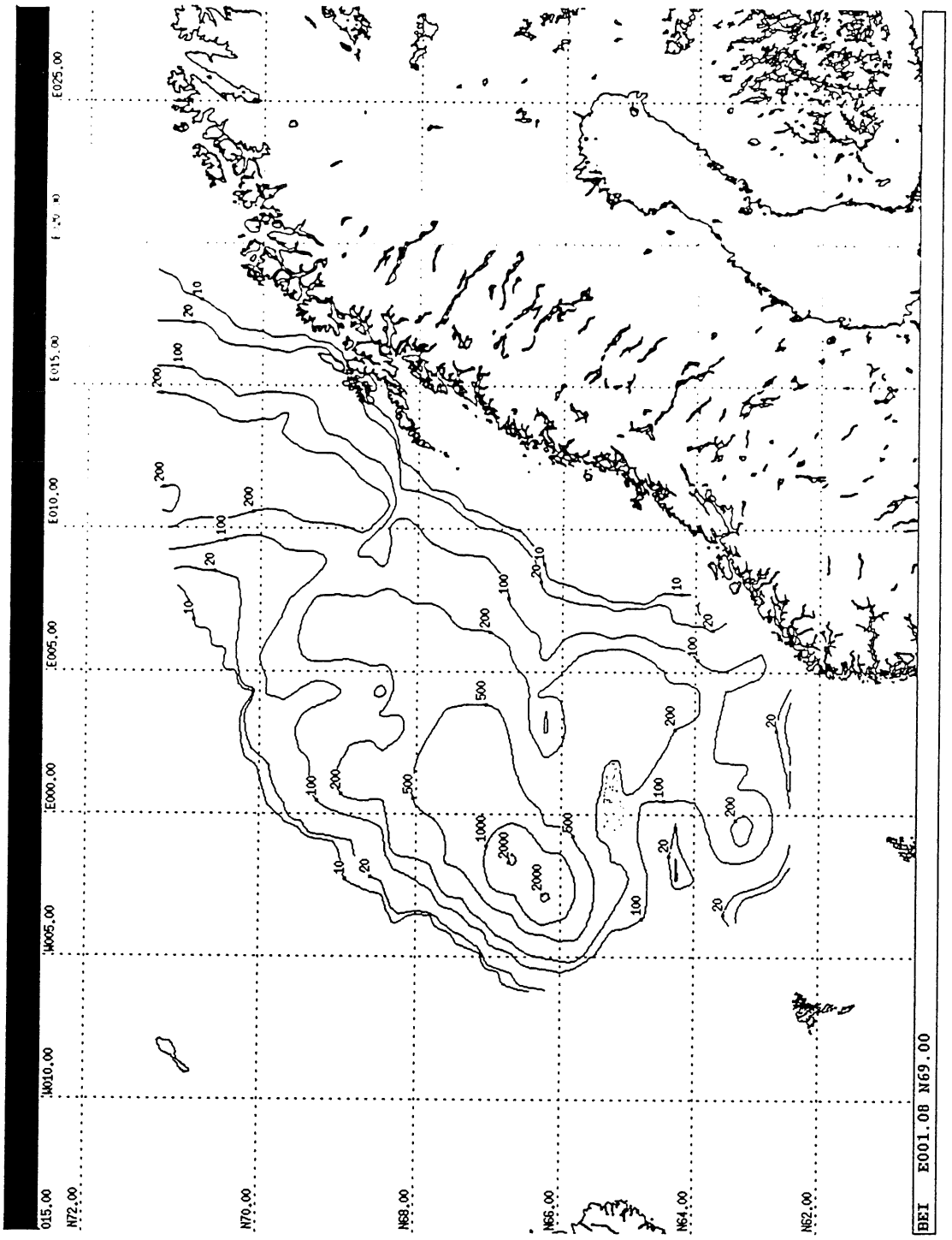

Figure 4. Relative distribution of herring represented by isolines of smoothed Sa values.

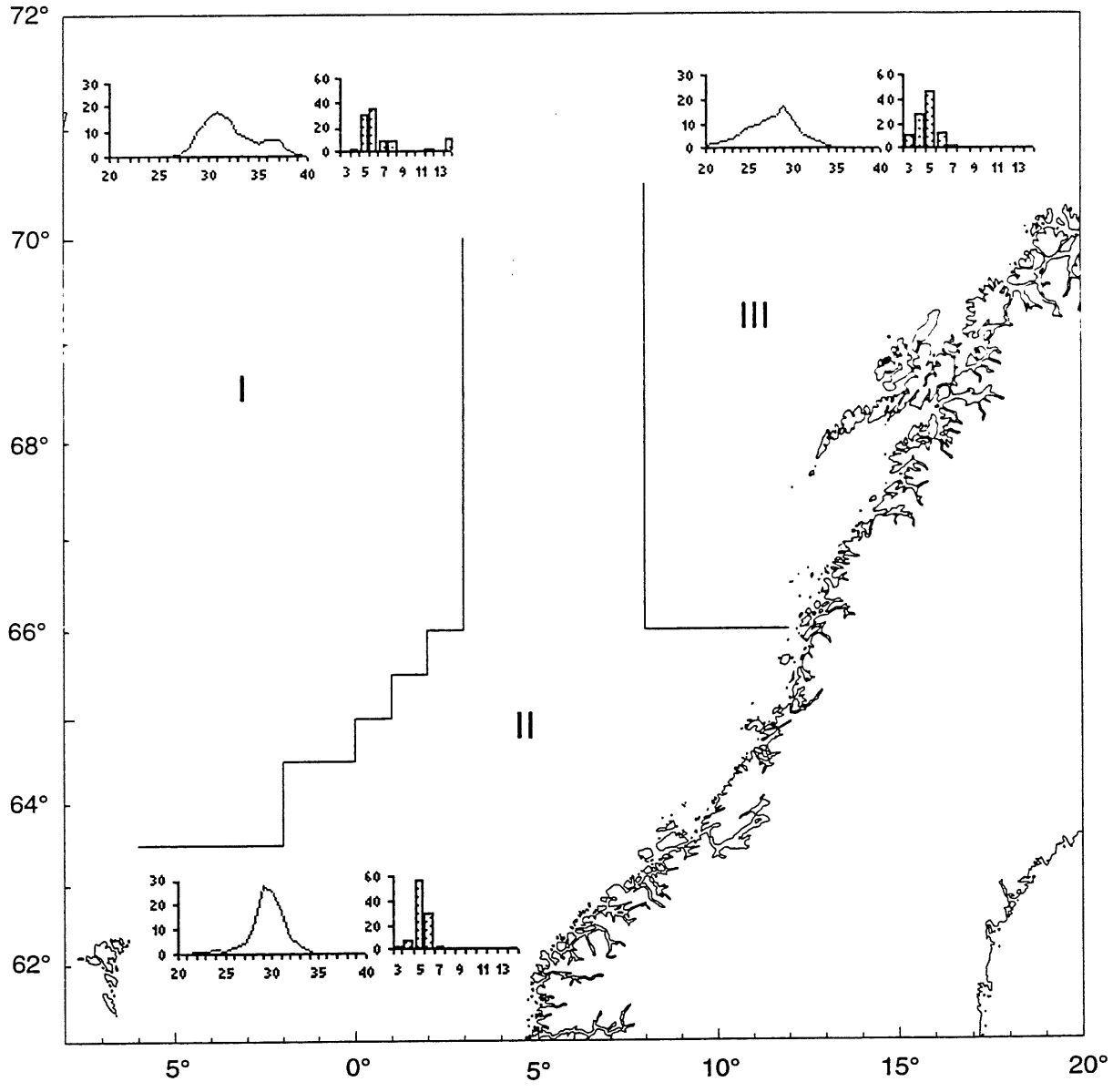

Figure 5. Length and age distribution by area of herring.

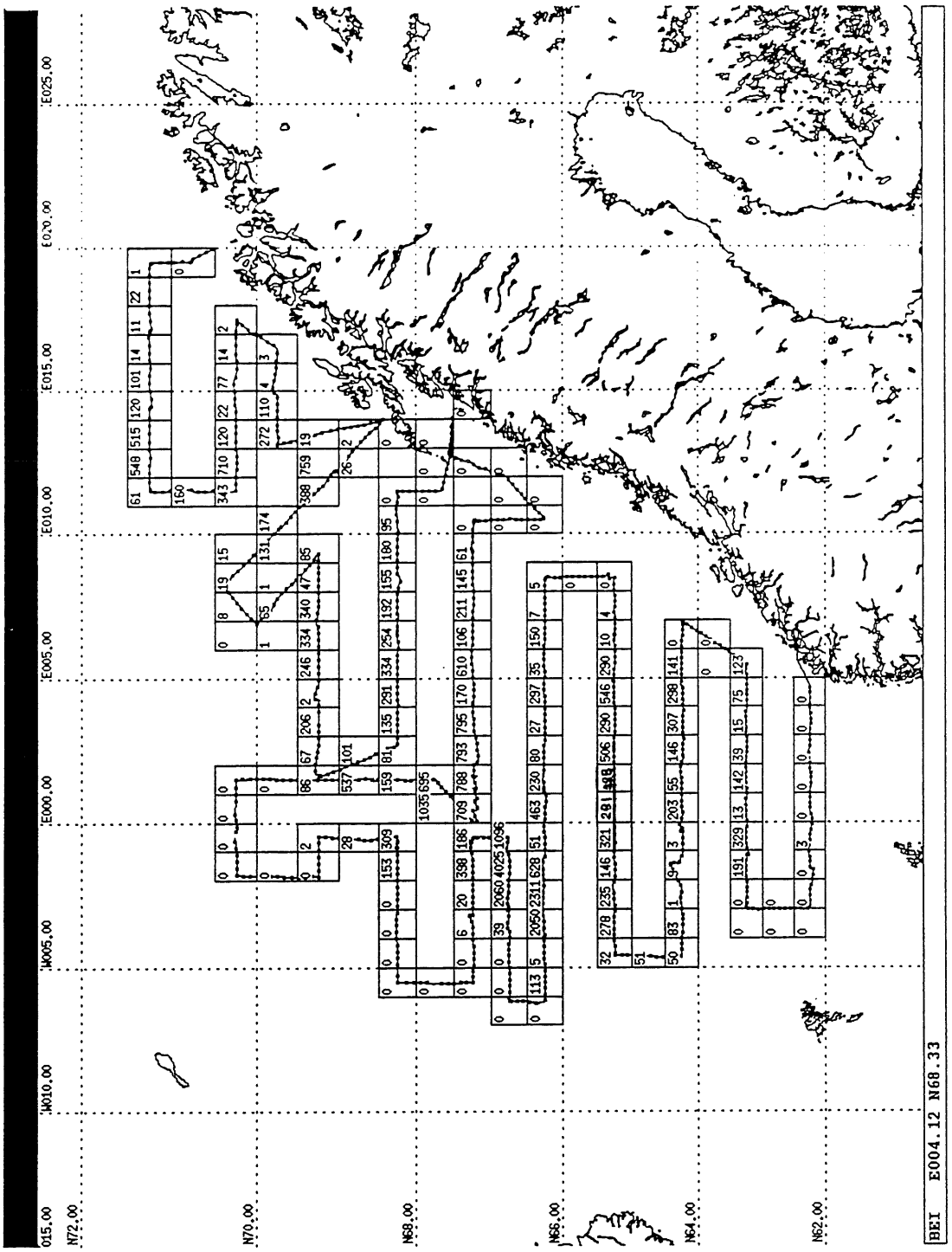

Figure 6. Mean Sa values allocated to herring by statistical square.

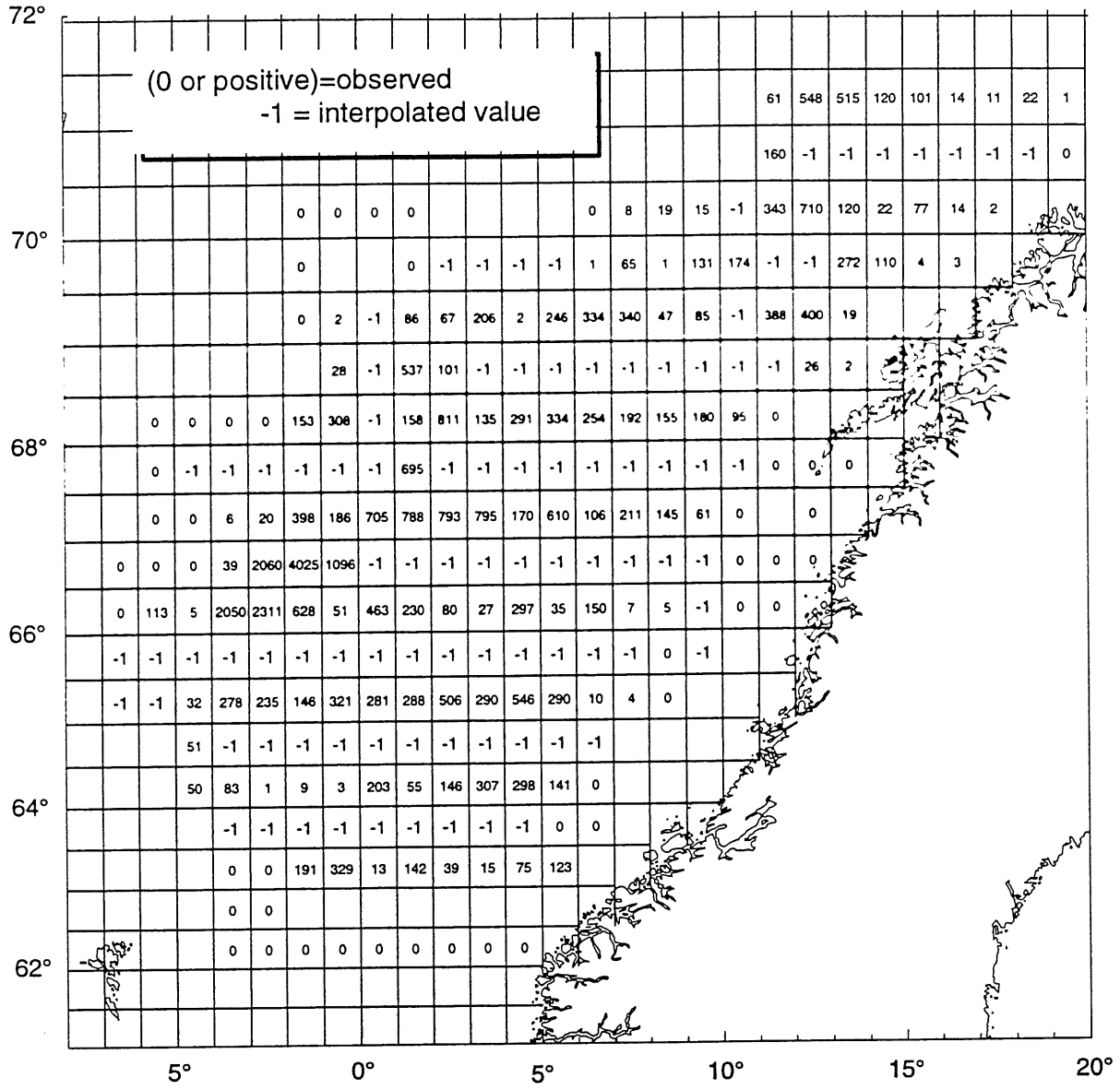

Figure 7. Squares of observed and interpolated values as used in the presented herring estimate.

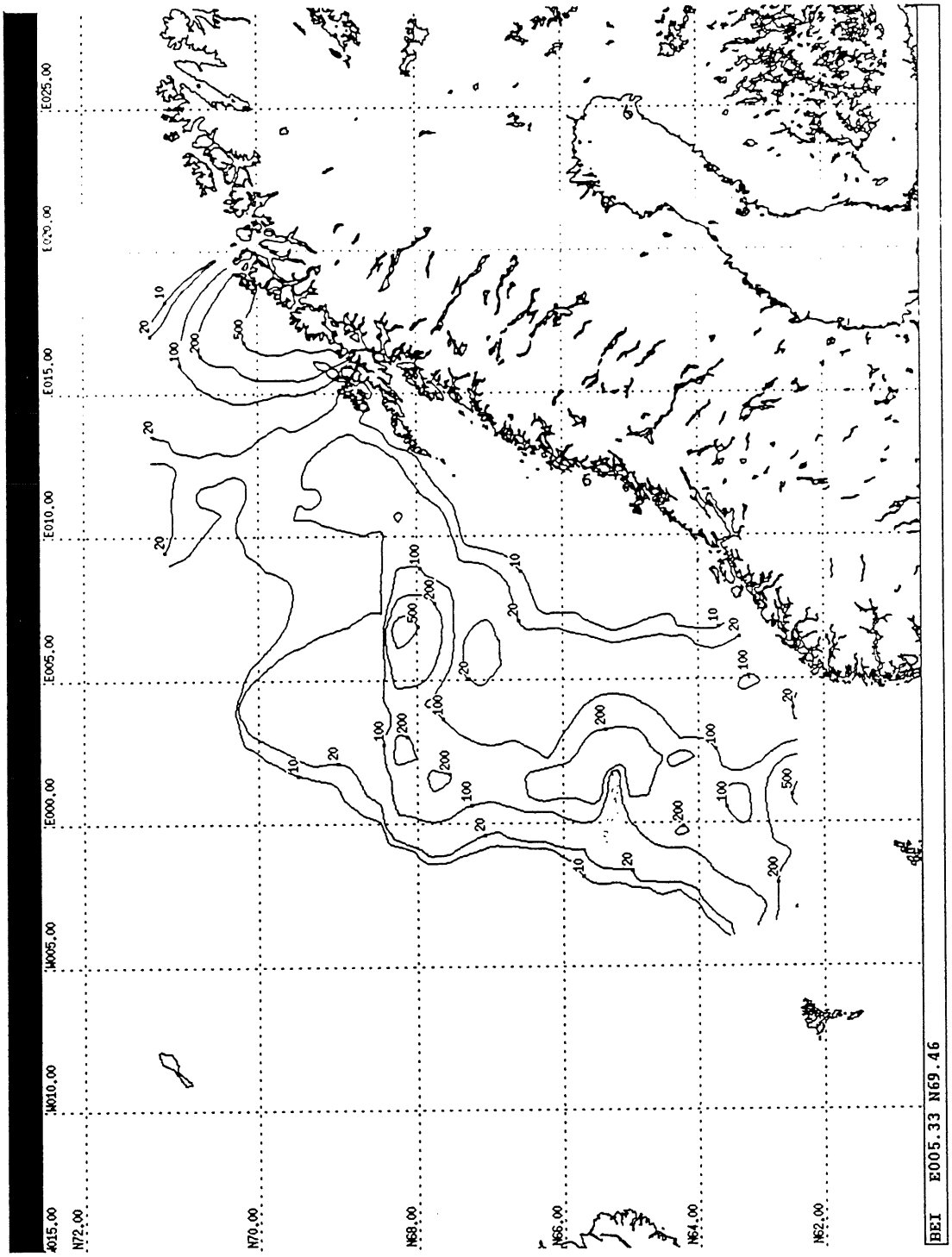

Figure 8. Relative distribution of blue whiting represented by isolines of smoothed Sa values.

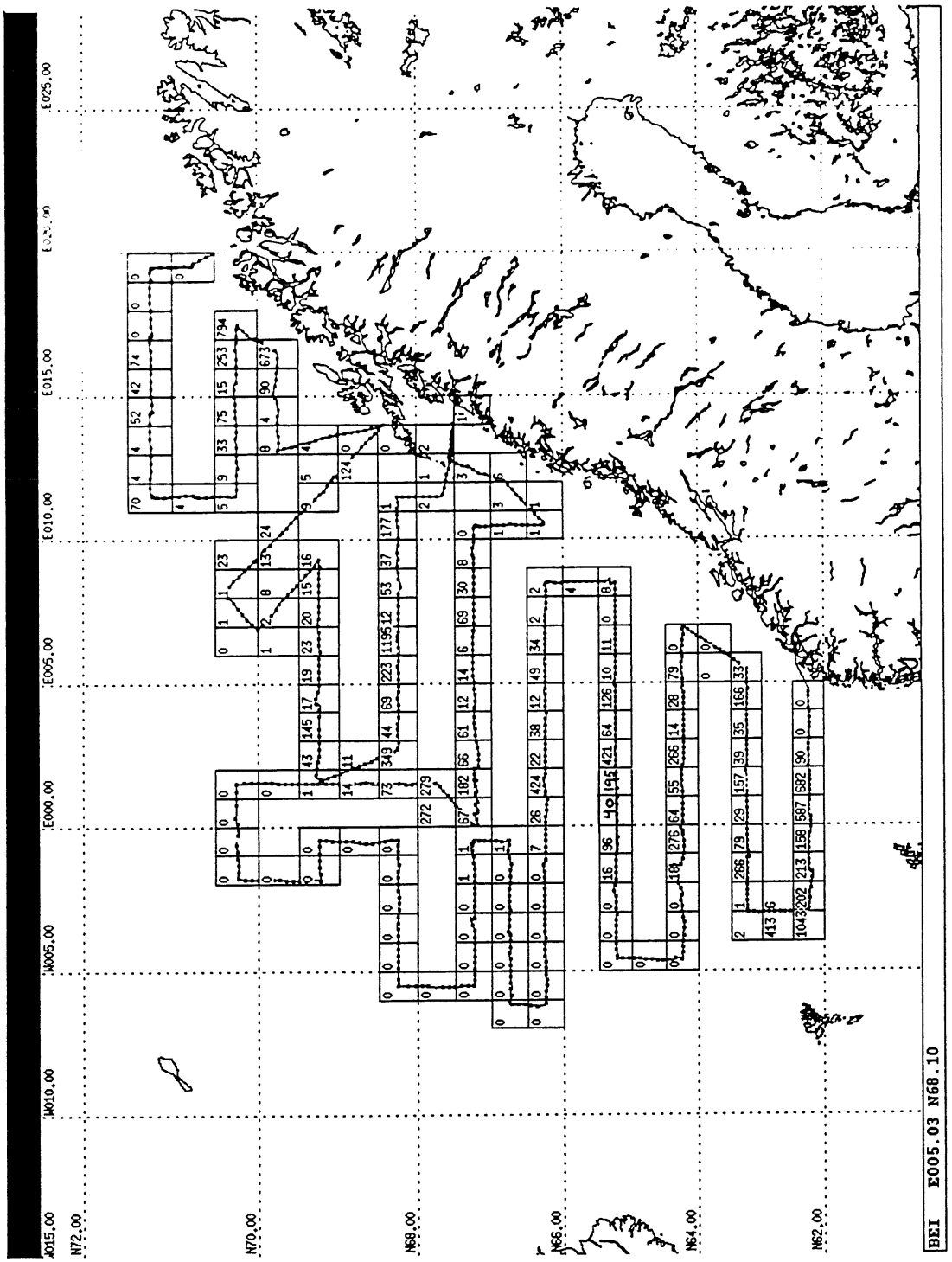

Figure 9. Mean Sa values allocated to blue whiting by statistical square.

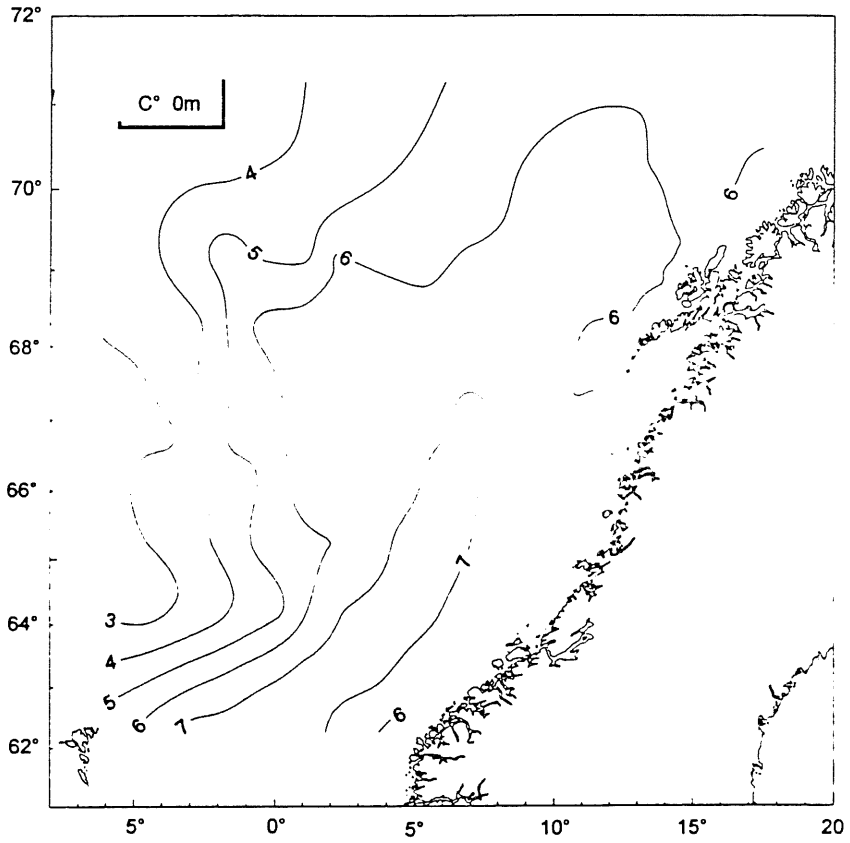

Figure 10. Temperatures at the surface during 1/5-1/6, 1997.

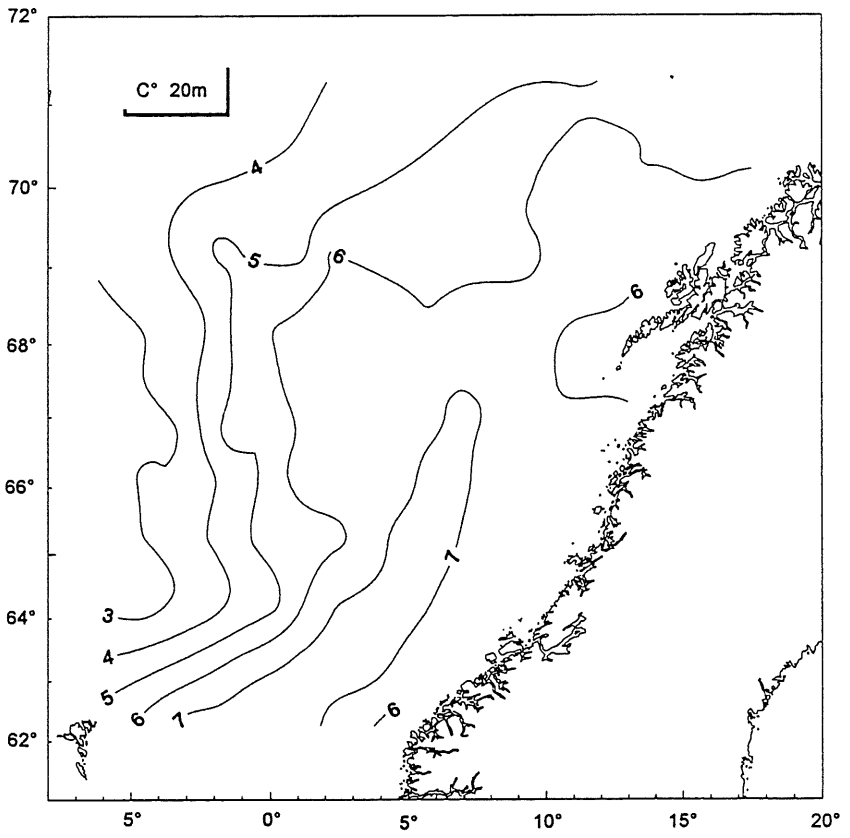

Figure 11. Temperatures at 20 m during 1/5-1/6, 1997.

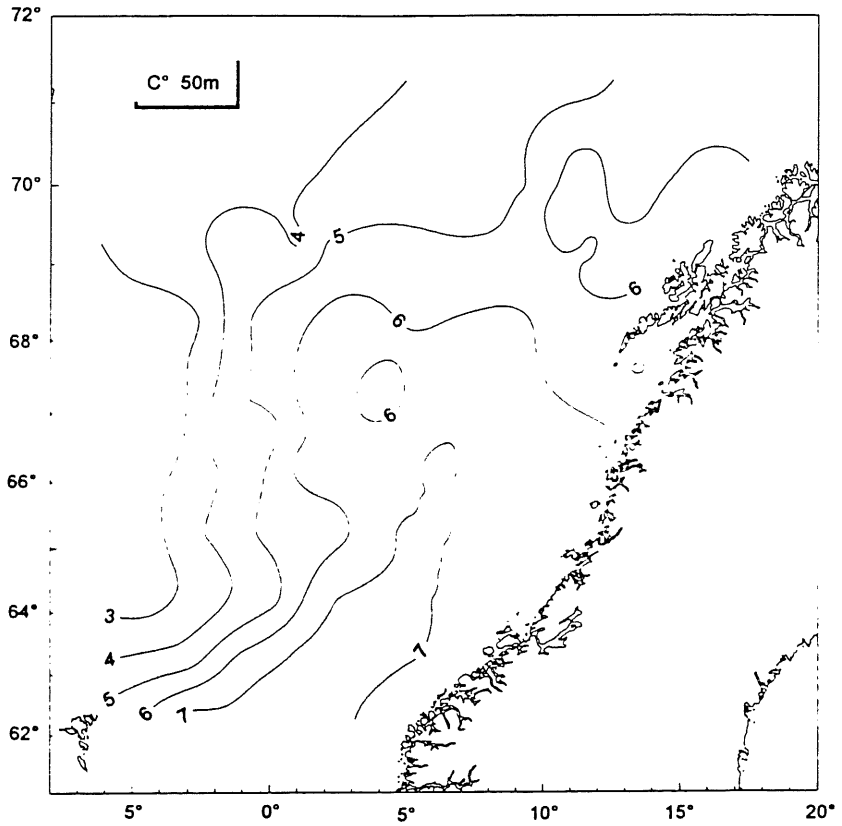

Figure 12. Temperatures at 50 m during 1/5-1/6, 1997.

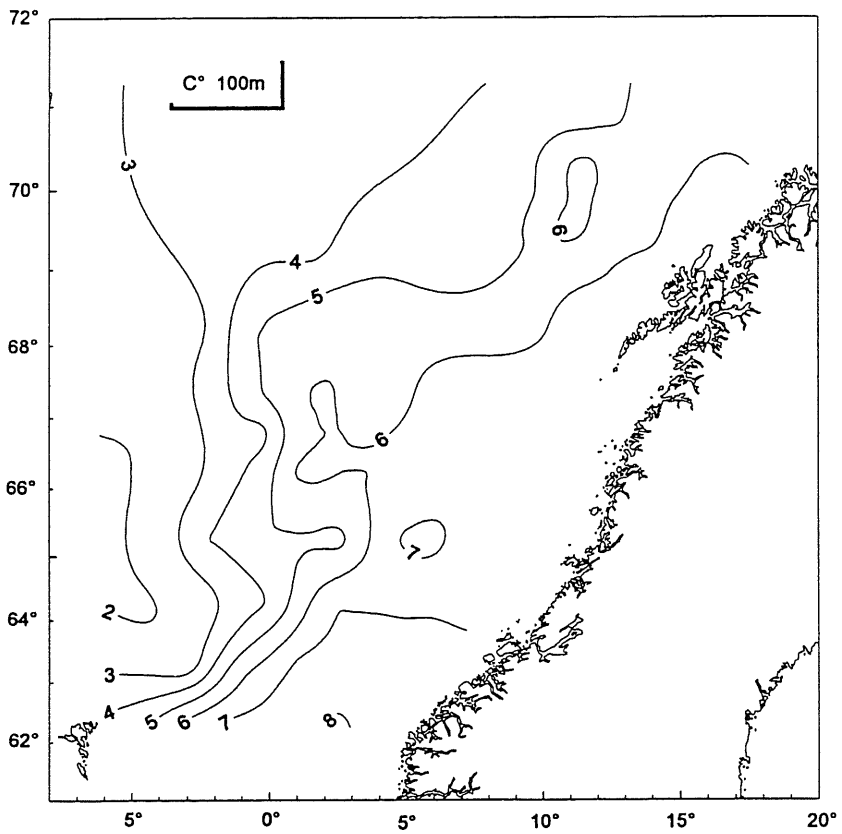

Figure 13. Temperatures at 100 m during 1/5-1/6, 1997.

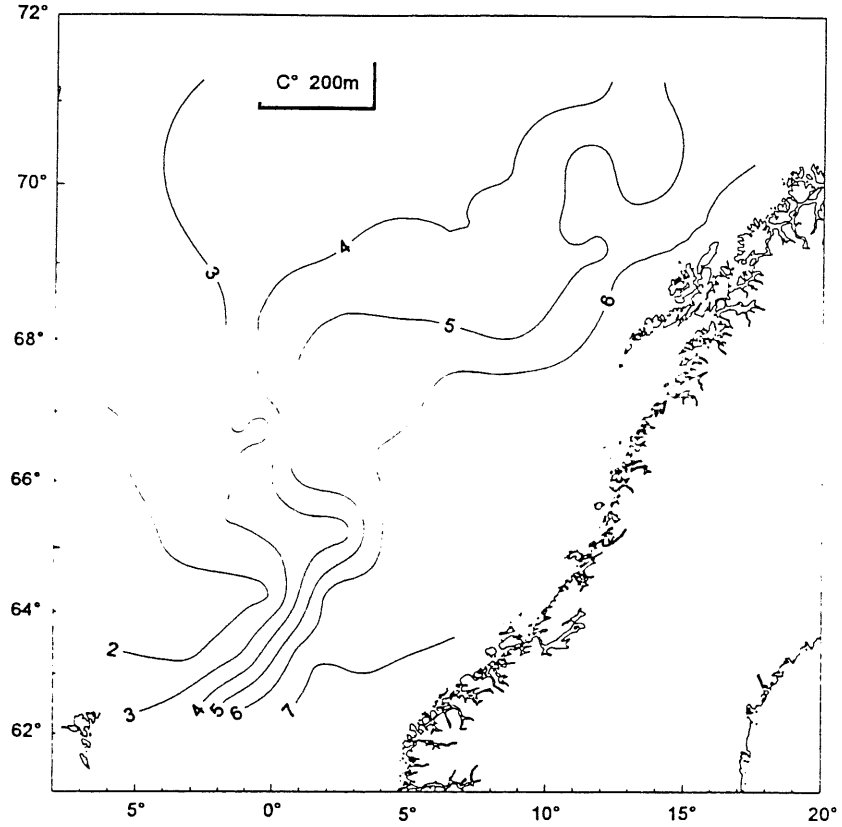

Figure 14. Temperatures at 200 m during 1/5-1/6, 1997.

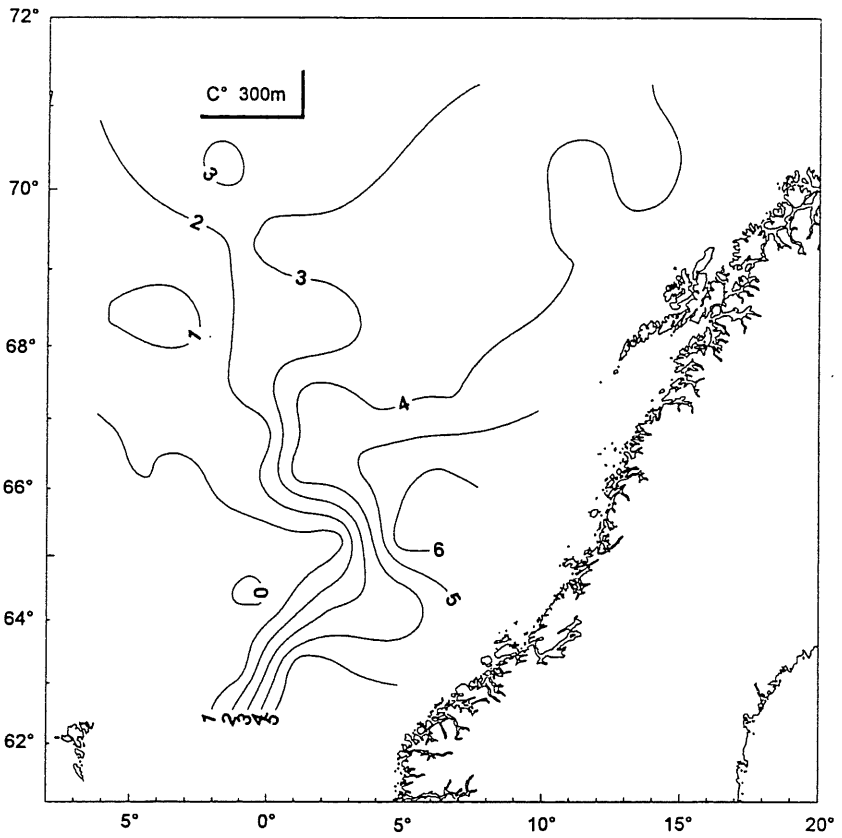

Figure 15. Temperatures at 300 m during 1/5-1/6, 1997.

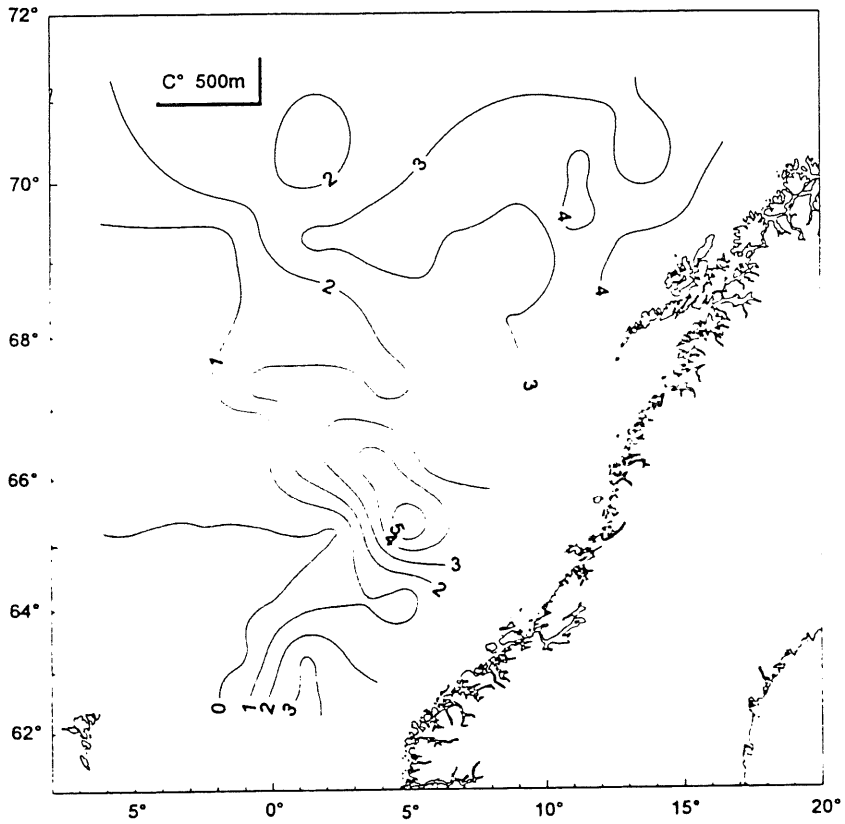

Figure 16. Temperatures at 500 m during 1/5-1/6, 1997.

Mengd2 Ver 0692 Mengdeberegninger SILD Side 195
Antall i omr. : N x 10 Exp-6 Middel-lengde : Cm Vekt i omr. : Tonn x 10 Exp-3
Gj.vekt : Gram Kondisjon : 1000 x Vekt/ Lengde Exp+3 Dato : 31/ 5-1997
6 -2.00
Omrtde : Alle C : 1.230 * 10 * L

Lengde	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Tot	Vekt	Gj.v
18.0-18.9			9													9	.4	50.0
19.0-19.9			31													31	1.8	57.7
20.0-20.9			23	14												37	2.5	66.7
21.0-21.9			16	108												124	9.9	79.5
22.0-22.9			60	159												219	19.5	89.1
23.0-23.9			157	110												267	26.4	98.9
24.0-24.9			331	215	35											581	64.6	111.2
25.0-25.9			129	414	180											723	91.6	126.8
26.0-26.9			89	794	130											1013	137.6	135.9
27.0-27.9			87	866	637											1590	238.2	149.8
28.0-28.9			172	602	2362	180										3316	542.2	163.5
29.0-29.9			65	232	6657	840										7794	1351.0	173.3
30.0-30.9				64	5747	2341	74									8226	1550.3	188.5
31.0-31.9				21	2621	4439	53									7134	1458.0	204.4
32.0-32.9					403	3608	462	134								4607	1030.8	223.7
33.0-33.9					82	1709	790	126								2707	658.8	243.4
34.0-34.9					13	324	700	823			53					1913	505.0	264.0
35.0-35.9						91	296	491	46	41	41			89		1095	309.4	282.6
36.0-36.9						14	58	197	132		121	191	60	629		1402	438.7	312.9
37.0-37.9							40			36		172		1276		1524	501.0	328.7
38.0-38.9											73	35		391		499	169.5	339.7
39.0-39.9												17		87		104	34.5	332.1
Antall:	0	0	1169	3599	18867	13546	2473	1771	178	77	288	415	60	2472	0	44915		
Gj.lgd:	.00	.00	25.32	26.69	29.91	31.79	33.84	34.78	36.24	36.44	36.50	37.21	36.50	37.40	.00	31.07		
Vekt:	.0	.0	139.9	496.2	3403.2	2866.3	626.4	481.9	56.5	23.2	86.0	133.5	18.7	809.8	.0	9141.7		
Gj.vkt:	.0	.0	119.7	137.9	180.4	211.6	253.3	272.1	317.3	301.6	298.7	321.7	311.0	327.6	.0	203.5		
Kond.:	.0	.0	7.2	7.2	6.7	6.6	6.5	6.5	6.7	6.2	6.2	6.3	6.4	6.3	.0	6.7		

Appendix B

Acoustic intercalibration between R/V "Argos" and R/V "G.O.Sars", Norwegian Sea, 4-5 May, 1997

Introduction

An intercalibration between the R/V "Argos" and the R/V "G.O.Sars" was carried out on the 4-5 May 1997 in the area between E004°38' and E002 °16' along the latitude of N64°15'. Data were collected from 9 pelagic channels, covering the depth-range from 15 metres below surface to 500 metres below surface. No bottom channels were added. The main aim of the exercise was to compare the performance of the acoustic systems of the two participating vessels, and thereby elucidate possible ship effects on the abundance estimate.

Methods

The ships were sailing side by side, with a distance of 0.2 nautical miles between them. The course was 270°, the speed 10 knots, and the sailed distance was 60 nautical miles. Both vessels used their own log to measure the sailed distance and to reset their echo integrating system. Absolute area back scattering coefficients by nautical mile, Sa, were exchanged on radio after the intercalibration.

Registrations and conditions

The echo recordings consisted mainly of schools and patches of herring near the surface, but also plankton were record, especially between 300 and 400 meters. The weather conditions during the calibration were fairly good, with a windspeed of approximately 16-20 knots from north-east, and some swell. The settings of the echo sounder systems were in principle the same as during the survey. Details are shown in appendix A.

Analysis and results

In figure 1 the collected integrator-data from all pelagic channels have been summarised for both vessels and presented by mile. A close study of the graphs reveals that the "G.O.Sars" have more miles of high values, and also a higher mean integrator value. The

higher number of high values indicate that "G.O.Sars" detected more schools than "Argos", perhaps due to a difference in ship avoidance effect on herring between the two vessels. To further study the difference in mean level between the vessels, all miles with large values were filtered out. The remaining mile values were plotted and a linear regression fitted to the data (Fig. 2). As shown in the diagram the observed area density for "Argos" was only 0.2565 times that of "G.O.Sars". This difference can hardly be explained by ship avoidance alone, and the conclusion must be that one or both of the two ships systems is not performing satisfactory and that both systems should be put under further investigation.

Conclusions

Based on the results of the intercalibration it was decided to carry out an absolute calibration of the "G.O.Sars" acoustic system in order to reveal eventual system errors which could have caused the deficiencies observed in performance between "Argos" and "G.O.Sars". Such a calibration was carried out in Mistfjord the 22 May, showing normal values for the system. Further investigations onboard the "Argos" revealed, according to the survey leader, that one of the echo-sounder quadrants were out of function during the intercalibration, thus explaining the observed deficiencies. A closer look into the relative performance of the two systems could be carried out during the Reykjavik meeting in August by comparing the observed mean values by vessel in neighbouring squares.

EK-500 SETTINGS

	G.O.SARS	ARGOS
TRANSDUCER DEPTH	7.5m	4.0m
ABSORBSION COEF	10db	10db
PULSE LENGTH	MEDIUM	MEDIUM
BANDWITH	WIDE	WIDE
MAX POWER	2000W	2000W
2 WAY-BEAM ANGLE	21.0db	-20.6db
Sv TRANSDUCER GAIN	27.2db	26.5db
Ts TRANSDUCER GAIN	27.1db	26.5db
ANGLE SENSIVITY	21.9	21.9
3db BEAMWITH	7.1deg	7.1deg
ALONGSHIP OFFSET	-0.08deg	0
ATHW OFFSET	0.05deg	0
PING INTERVAL	0.0	0.0
SOUND VELOCITY	1470m/s	1500m/s
DISTANCE INTERVAL	1 n.m	1 n.m

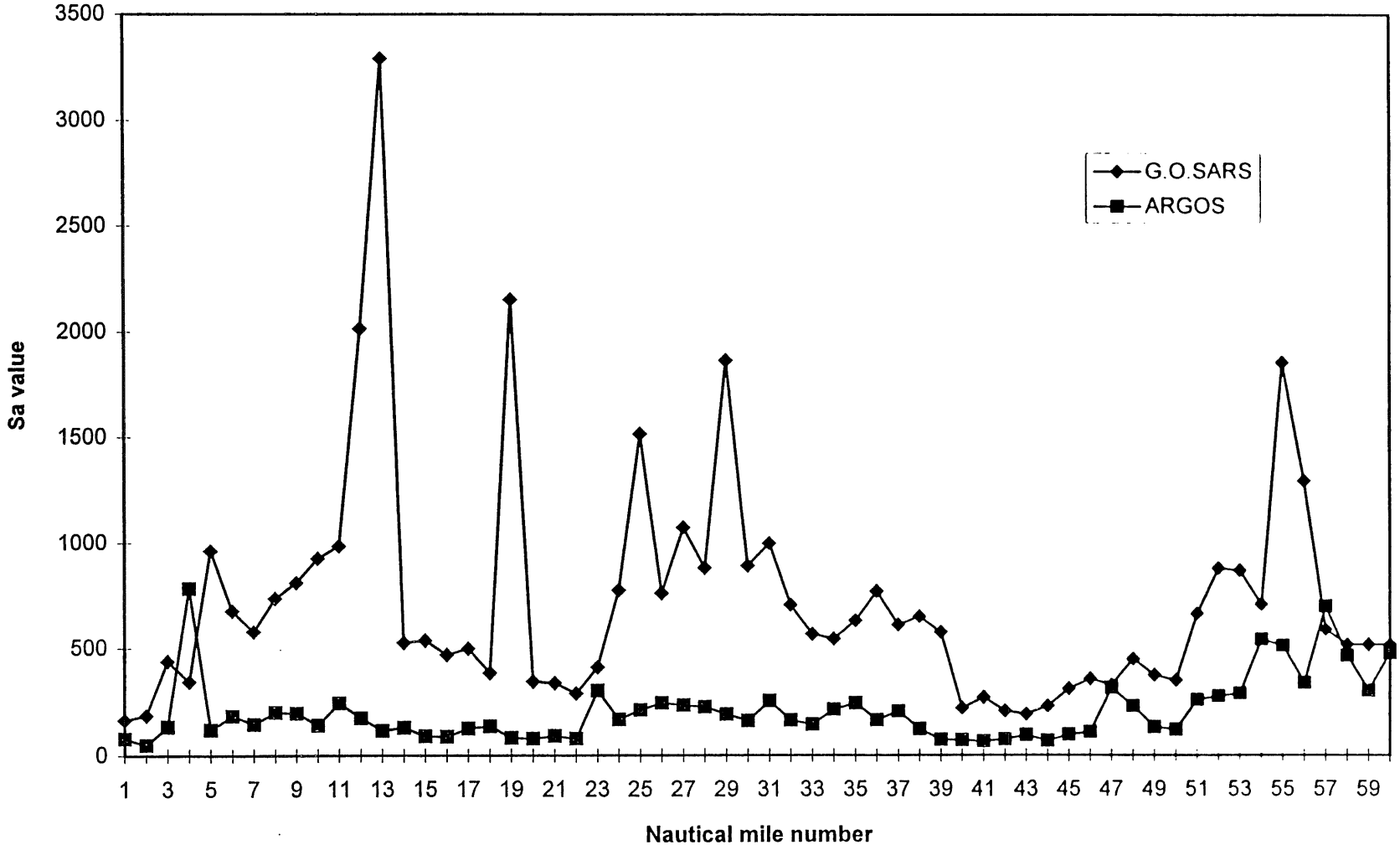
Intercalibration between R/V "Argos" and R/V "G.O.Sars"
Sa value by n.mile
Sa value
3500
3000
2500
2000
1500
1000
500
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
Nautical mile number
G.O.SARS
ARGOS

Figure 1.

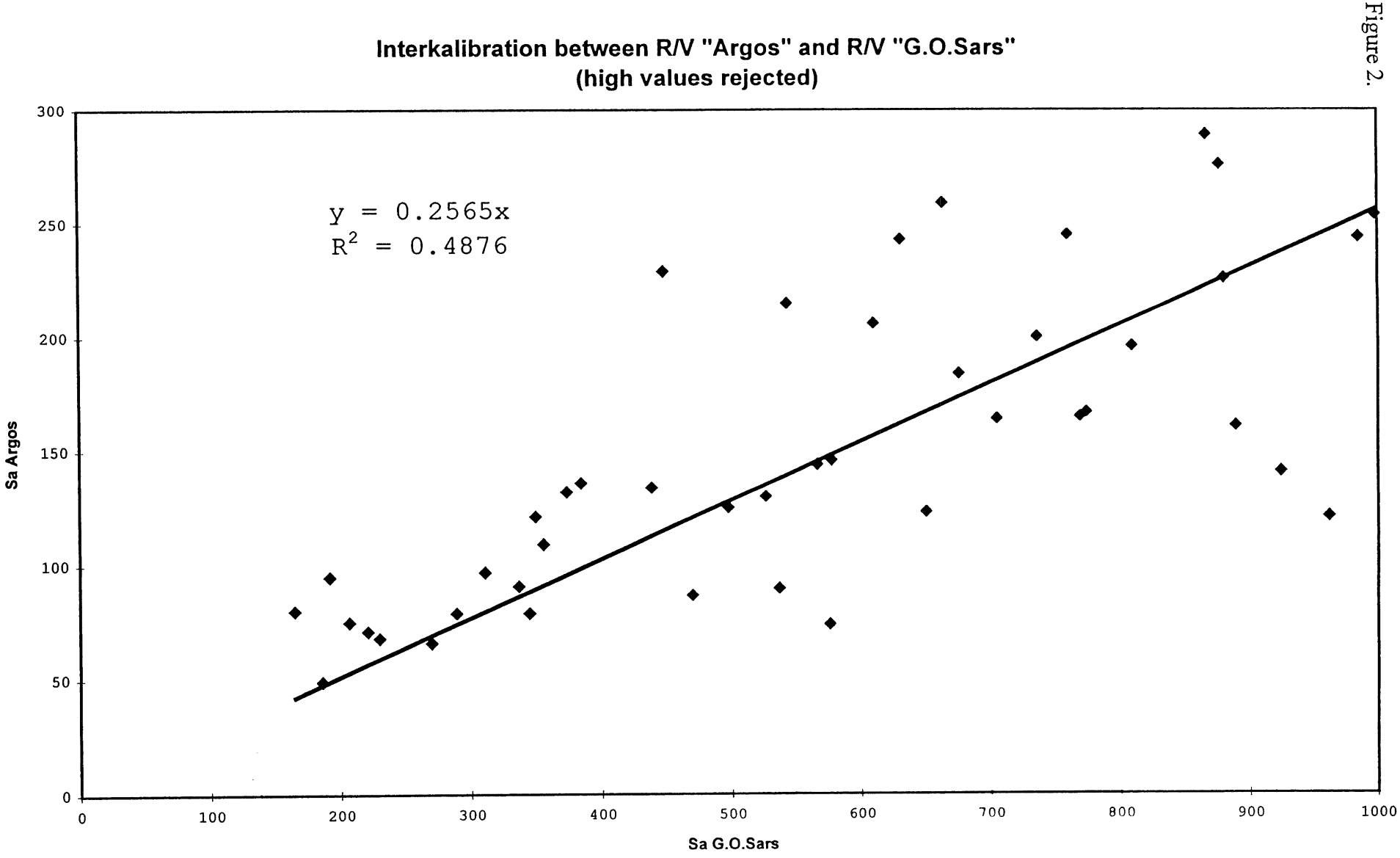
Interkalibration between R/V "Argos" and R/V "G.O.Sars"
(high values rejected)
y = 0.2565x
R2 = 0.4876
Sa Argos
Sa G.O.Sars
0
50
100
150
200
250
300
0
100
200
300
400
500
600
700
800
900
1000

Figure 2.