NOT TO BE CITED WITHOUT PRIOR
REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N1273

NAFO SCR Doc. 87/05

SCIENTIFIC COUNCIL MEETING - JANUARY 1987

Problems with Bottom Photography as a Method for Estimating Biomass of Shrimp (*Pandalus borealis*) off West Greenland

by

Dan M. Carlsson and Per Kanneworff

Grønlands Fiskeri - og Miljøundersøglser
Tagensvej 135, DK-2200 København N., Denmark

INTRODUCTION.

In the period 1977-85 regular sampling of data on shrimp abundance has been carried out in part of NAFO SA1 by means of bottom photography equipment. The different problems involved in the sampling method are reviewed and discussed, and the biomass estimates obtained are evaluated in connection with CPUE-indices from part of the commercial fishery and number and size distribution in biological samples from the photographic sampling sites.

THE PHOTOGRAPHIC METHOD.

Throughout the period of assessment of the Greenland shrimp stocks catch and effort data together with analyses of biological samples have been used to examine the distribution and state of the stocks. This assessement method is still the basis for scientific advice on management of the Greenland stocks, but in 1975 a new sampling method based on bottom photography was introduced in West Greenland to obtain further data on the density of shrimp (Kanneworff, 1978a; 1979a). The expected advantages of this method over sampling methods based on trawling gear were:

1. A fairly quick method for obtaining density indices from the large areas of shrimp distribution.
2. A more direct observation method without mesh selection problems offering density estimates in absolute terms.
3. Sampling could also be carried out in areas with rough bottom unfit for trawling.
4. Detection of smaller shrimp than those retained by trawling gear, offering possibility of an early information on changes in recruitment.

Some disadvantages and limiting factors in the use of this technique were also anticipated or experienced later:

1. Although a detection of smaller individuals than retained by the trawl would be possible, this sampling had also a minimum detectable size depending on the optical system and the type of film used.
2. The sampling would be very sensitive to suspended bottom material. This has proven to be a problem at certain sampling sites. A more or less reduced visibility close to the bottom

increases the minimum detectable size of the shrimp to an unknown level and causes severe troubles in estimating the numbers and mean weights in the affected size groups.

3. Working with a short exposure distance from the bottom sampling would be sensitive to the movements of the ship. Thus, working with a fairly small vessel (167 GRT), the sampling was limited to good weather conditions (i.e. winds below 10 m/sec and only light swell).

4. It was not possible to determine optimal sample size (i.e. number of photographs per station) during the sampling operation. Both shrimp density and distributional pattern, as well as eventual problems connected with par. 2 and 3 above, were unknown until after development and reading of the films.

5. Photographic sampling with this technique would only detect shrimp actually situated on the bottom. If a larger proportion of the stock was swimming above the bottom, it would require knowledge about diurnal and annual vertical migrations, so that suitable correction factors could be applied. Sampling in the free water masses was not regarded as a possible way of getting information on the size of the stock, partly because of the immense volumes of water from which a reasonable amount of samples should be taken, and partly because the sampled volume would not be sufficiently well defined.

6. For an optimal sampling procedure the degree of patchiness of the shrimp on the bottom should be known beforehand, so that a suitable sampling unit (i.e. exposure distance) and a sufficient number of photographs per sampling site could be chosen.

7. It proved to be impossible to determine precisely the limits between the established size groups. This was due to the following:

a. A different enlargement in different part of the photographs, because technical reasons made it necessary to work with a minor camera tilt angle (10 degrees from vertical), and

b. A measurement of the shrimp on the reading screen which could be correlated with e.g. the carapace length in biological sample could only be carried out very roughly.

8. The reading of the films involved some interpretaion problems. Thus a fairly long period of training for the different readers proved to be necessary to avoid personal bias.

9. Working with finer instruments from a smaller vessel in offshore areas very often leads to functional problems. Even though this equipment was built very robust some malfunctions due to rough handling were encountered from time to time. As it has not always been possible to detect certain technical failures during the sampling procedure or even during the cruise, many sites have showed to be very poorly sampled when the films were developed and read after the cruise.

HISTORICAL VIEW.

In 1976 a stratified trawl survey was carried out in the west Greenland area by the Greenland Fisheries and Environment Research Institute (Horsted, 1978), and a fishable biomass for the area surveyed was estimated on basis of the ´swept area´ method be to about 55000 tons. During the first two years of offshore photographic sampling the measured densities of shrimp and the calculated biomasses per unit area were used directly as stratum indices in the same stratum system as used in the trawl survey, in order to compare the two methods (Kanneworff, 1978b; 1979b). Having obtained a better knowledge of the region during the first years of operation, most of the strata used in the trawl survey were found to be too large to be treated as unit areas with uniform conditions for the shrimp population. Therefore a new stratification system was introduced in 1979 (Carlsson & Kanneworff, 1979), and this has been used as basis for all the photographic sampling since then.

The sampling scheme covered the areas between 66°00′N and 69°30′N in water depths from 100 to 600 meters (parts of Div. 0A, 1A, 1B and 1D), totalling 56406 square kilometers. The planned station grid for the surveys has been the same throughout the years, but the success of sampling has varied much from year to year with an almost complete coverage in the last three years only (Fig. 1).

The biomass estimates obtained by means of photography (Kanneworff, 1979b) were much higher than the estimate for the fishable biomass from the trawl survey, and the increasing trend in the years 1977-79 (Fig. 2) was in contrast to the rather steep decrease in CPUE-indices for the same area and period (Anon., 1980). Some doubt was therefore raised, whether the photographic figures could be used directly as density indices for the different strata.

Following an earlier attempt to use a simple mathematical model based on analysis of variance (Kanneworff, 1978a), a multiplicative shrimp distribution model was introduced (Jørgensen & Kanneworff, 1980). By means of this model biomass indices for the strata as measured by the photographic sampling were analysed for their dependency on a series of variables. When for each of the years in which this model was in use (Kanneworff, 1981; 1983; 1984; 1985; 1986), an optimal combination of variables had been determined, and estimates of those variables were found, a calculation of total biomass for all strata within the region surveyed (66°00′ - 69°30′ N in depths between 100 and 600 m) was carried out.

After a series of years with good coverage of the planned station grid a examination of the year to year variation in shrimp density could be carried out including a major part of the sampling sites (Kanneworff, 1986). This study showed that the five size groups had clearly different distribution patterns, so that analyses of the variations in density necessarily had to be carried out separately for the groups. However, analysis runs with separate groups did not increase the goodness of fit for the models tested, and it was thus concluded, that other measures should be taken to refine this type of models for describing shrimp density variations.

A comparison of CPUE-indices from part of the commercial shrimp fishery (Carlsson, 1987) with the photographic biomass estimates from all the different models used through the years is given in Fig. 2. Apart from the 1985-model none of the models exhibit an acceptable correlation with the CPUE-figures, but all of them reflect the main trends in the CPUE, however with some distortion.

The apparent good correlation of the figures from the 1985-model was discussed by Kanneworff (1986). This model was not regarded as reliable, exhibiting too low correlation coefficients.

FURTHER ANALYSES.

During the photographic surveys trawling was performed at all stations with suitable bottom conditions with the purpose to collect biological samples of shrimp and compare the distribution in these with the distribution in the photographic material. The CPUE figures from the research vessel were not used, as they were not considered reliable due to the size of the research vessel and variations in crew. The relative compositions and the estimated mean individual weights from the two sampling methods have been compared and discussed by Kanneworff (1981; 1983). This comparison was based on a size grouping of only three, which was in use at that time, and some discrepancies from the expected pattern were noted. A larger amount of small shrimp in the photographic samples is to be expected, as well as a lower average individual weight, but the material showed no real consistency.

When comparing the distribution of size groups in the photographic and the trawl material for the period 1981-85 (Table 1), it is evident that in far the most stations there is a tendency to relatively larger animals in trawl samples. At the same time the information that there has been a development in commercial fishing gears towards trawls with higher opening (from 5-10 m in the beginning of the fishery up to 20 m in the newest models) resulting in higher catch rates (Carlsson, 1987) might explain the obvious low comparability between the two sets of data (Figs. 3-8).

CONCLUSION.

Comparison of the biomass estimates and information on abundance of different size groups obtained by means of bottom photography with data on CPUE from the commercial fishery and size distributions from biological samples has shown a poor agreement between the photographic data and data from the other sources. Sampling by this method will thus be discontinued until further analysis, including a.o. a study of diurnal migration of the shrimp, might show that suitable correction factors could be applied to the photographic data.

REFERENCES

Anon., 1980. Report of Scientific Council. Special Meeting, November 1979. NAFO Scientific Council Reports 1979-1980, Part C:21-33.

Carlsson, D.M., 1986. Data on the shrimp fishery in NAFO Subarea 1 in 1984 and 1985. NAFO SCR Doc. 86/10.

Carlsson, D. M. & P. Kanneworff, 1987. The shrimp fishery in NAFO Subarea 1 in 1985 and 1986. NAFO SCR Doc. 87/8, Serial No. N1267.

Carlsson, D.M. & P. Kanneworff, 1979. Areas of basic strata in West Greenland, ICNAF/NAFO Subarea 1. ICNAF Res.Doc. 79/XI/11.

Horsted, S.A., 1978. A trawl survey of the offshore shrimp grounds in ICNAF Division 1B and an estimate of the shrimp biomass. ICNAF Sel.Pap. No. 4:23-30.

Jørgensen, A.G. & P. Kanneworff, 1980. Biomass of shrimp (Pandalus borealis) in NAFO Subarea 1 in 1977-80 estimated by means of bottom photography. NAFO SCR Doc. 80/XI/169.

Kanneworff, P., 1978a. Estimated density of shrimp, Pandalus borealis, in Greenland waters and calculation of biomass on the offshore grounds based on bottom photography. ICNAF Sel.Pap. No. 4: 61-65.

Kanneworff, P., 1978b. Density of shrimp (Pandalus borealis) in 1978 in ICNAF Subarea 1 based on bottom photography. ICNAF Res.Doc. 78/XI/89.

Kanneworff, P., 1979a. Density of shrimp (Pandalus borealis) in Greenland waters observed by means of Photography. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 175: 134-138.

Kanneworff, P., 1979b. Stock biomass 1979 of shrimp (Pandalus borealis) in NAFO Subarea 1 estimated by means of bottom photography. NAFO SCR Doc. 79/XI/9.

Kanneworff, P., 1981. Biomass of shrimp (Pandalus borealis) in NAFO SUBAREA 1 in 1977-81 estimated by means of bottom photography. NAFO SCR Doc. 81/XI/155.

Kanneworff, P., 1983. Biomass of shrimp (Pandalus borealis) in NAFO Subarea 1 in 1977-82 estimated by means of bottom photography. NAFO SCR Doc. 83/I/1.

Kanneworff, P., 1984. Biomass of shrimp (Pandalus borealis) in NAFO SA1 in 1978-83 estimated by means of bottom photography. NAFO SCR Doc. 84/I/6.

Kanneworff, P., 1985. Biomass of shrimp (Pandalus borealis) in NAFO Subarea 1 in 1981-84, estimated by means of bottom photography. NAFO SCR Doc. 85/I/8.

Kanneworff, P., 1986. Biomass of shrimp (Pandalus borealis) in NAFO SA1 in 1981-85 estimated by means of bottom photography. NAFO SCR Doc. 86/I/3.

Table 1. Distribution of shrimp in samples from photographic and trawl samples in the period 1981-85. The relative numbers given are permille of the largest size group.

YEAR	STNO	GEAR	RELATIVE NUMBERS IN GR1	GR2	GR3	GR4	GR5	AV. WGT
1983	6019	PHOTO	690	651	1000	1000	380	6.0
		TRAWL	96	157	448	657	1000	8.6
1981	9020	PHOTO	810	1000	291	51	0	3.8
		TRAWL	219	644	1000	572	566	6.7
1981	6021	PHOTO	52	86	1000	621	138	6.8
		TRAWL	7	46	536	1000	907	8.8
1981	6023	PHOTO	161	627	1000	233	10	5.2
		TRAWL	912	840	1000	366	458	5.4
1981	6024	PHOTO	920	1000	387	167	42	4.1
		TRAWL	977	688	734	590	1000	6.4
1981	6026	PHOTO	73	346	458	1000	257	7.2
		TRAWL	28	34	68	267	1000	10.3
1981	6027	PHOTO	1000	863	301	92	13	3.8
		TRAWL	636	409	1000	480	160	5.3
1981	6028	PHOTO	981	1000	494	474	94	4.7
		TRAWL	227	414	1000	912	503	6.9
1981	6029	PHOTO	17	325	1000	658	145	6.6
		TRAWL	48	686	1000	651	681	7.1
1981	6030	PHOTO	0	0	49	1000	37	8.3
		TRAWL	0	0	56	213	1000	11.1
1981	6033	PHOTO	1000	81	248	177	9	3.9
		TRAWL	36	120	518	1000	426	7.9
1981	6034	PHOTO	615	582	1000	763	78	5.5
		TRAWL	152	843	764	1000	555	6.8
1981	6037	PHOTO	488	1000	768	138	5	4.5
		TRAWL	1000	525	866	300	67	4.6
1982	6216	PHOTO	1000	377	421	156	0	4.0
		TRAWL	384	1000	472	194	199	5.0
1982	6218	PHOTO	16	327	1000	599	145	6.5
		TRAWL	87	603	1000	614	707	7.2
1982	6219	PHOTO	1000	678	311	54	6	3.7
		TRAWL	971	1000	364	193	175	4.4
1982	6222	PHOTO	28	159	1000	347	40	6.2
		TRAWL	86	268	1000	677	601	7.4
1982	6223	PHOTO	31	97	1000	841	198	7.1
		TRAWL	41	99	595	898	1000	8.6
1982	6224	PHOTO	173	125	1000	744	286	6.9
		TRAWL	28	148	844	1000	484	7.7
1982	6225	PHOTO	723	990	1000	723	123	5.3
		TRAWL	102	307	1000	903	676	7.5
1982	6227	PHOTO	258	174	1000	545	30	6.0
		TRAWL	52	116	480	653	1000	8.8
1982	6228	PHOTO	983	699	1000	305	10	4.6
		TRAWL	14	89	575	678	1000	8.8
1982	6229	PHOTO	1000	991	769	236	37	4.4
		TRAWL	109	184	1000	897	753	7.7
1982	6232	PHOTO	303	655	1000	99	21	4.9
		TRAWL	76	1000	344	134	56	4.9
1982	6234	PHOTO	36	332	1000	528	36	6.2
		TRAWL	5	172	951	951	1000	8.2
1982	6235	PHOTO	97	149	667	1000	179	7.2
		TRAWL	4	53	259	490	1000	9.5
1982	6236	PHOTO	685	957	1000	351	39	4.9
		TRAWL	117	599	1000	687	196	6.2
1982	6237	PHOTO	1000	553	488	75	5	3.9
		TRAWL	74	526	1000	634	314	6.6
1983	6428	PHOTO	0	73	1000	809	73	6.9
		TRAWL	30	67	1000	940	1000	8.4
1983	6429	PHOTO	106	622	1000	324	27	5.5
		TRAWL	271	751	1000	334	82	5.3
1983	6430	PHOTO	592	1000	327	47	0	4.0
		TRAWL	435	858	1000	543	105	5.3
1983	6435	PHOTO	34	288	1000	202	14	5.7
		TRAWL	77	333	1000	208	62	5.7
1983	6437	PHOTO	0	0	1000	250	0	6.5
		TRAWL	0	0	609	565	1000	9.1
1983	6438	PHOTO	500	0	1000	0	0	4.7
		TRAWL	0	132	1000	105	26	5.8
1983	6440	PHOTO	500	1000	500	222	83	4.7
		TRAWL	1000	706	579	421	278	5.1
1983	6442	PHOTO	229	1000	310	35	1	4.2
		TRAWL	622	1000	625	248	54	4.5
1983	6443	PHOTO	530	1000	312	27	0	4.0
		TRAWL	1000	127	52	29	14	2.6
1983	6444	PHOTO	85	893	1000	141	17	5.0
		TRAWL	89	473	1000	274	232	6.1
1983	6445	PHOTO	380	815	1000	482	47	5.3
		TRAWL	246	241	1000	716	478	7.0
1983	6446	PHOTO	228	1000	596	88	18	4.6
		TRAWL	554	737	1000	389	26	4.9
1983	6454	PHOTO	764	651	1000	193	23	4.6
		TRAWL	215	456	1000	762	370	6.6
1983	6455	PHOTO	32	138	1000	351	53	6.3
		TRAWL	8	148	1000	727	489	7.6
1983	6457	PHOTO	154	769	1000	368	38	5.4
		TRAWL	240	275	1000	927	815	7.6
1983	6458	PHOTO	543	879	1000	246	45	4.9
		TRAWL	265	94	767	1000	951	8.0
1983	6459	PHOTO	379	348	1000	466	0	5.5
		TRAWL	16	16	32	582	1000	10.1
1983	6460	PHOTO	748	110	1000	577	18	5.4
		TRAWL	0	19	315	478	1000	9.9
1983	6462	PHOTO	0	57	1000	395	57	6.5
		TRAWL	0	62	391	573	1000	9.3
1984	6713	PHOTO	0	512	1000	488	43	6.0
		TRAWL	93	394	1000	653	220	6.5
1984	6714	PHOTO	0	0	1000	333	0	6.8
		TRAWL	250	400	1000	350	150	5.8
1984	6716	PHOTO	0	0	1000	0	0	5.7
		TRAWL	0	100	1000	167	0	5.8
1984	6719	PHOTO	1000	311	71	6	3	3.0
		TRAWL	1000	941	450	265	118	4.4
1984	6720	PHOTO	179	1000	935	117	24	4.8
		TRAWL	270	1000	902	202	54	5.0
1984	6721	PHOTO	1000	981	370	53	34	3.8
		TRAWL	644	970	1000	211	157	4.9
1984	6722	PHOTO	85	236	1000	425	85	6.2
		TRAWL	31	361	1000	840	490	7.3
1984	6723	PHOTO	175	100	1000	100	100	5.6
		TRAWL	340	745	1000	426	189	6.2
1984	6724	PHOTO	87	378	1000	186	11	5.5
		TRAWL	75	251	1000	381	63	6.1
1984	6725	PHOTO	6	209	1000	173	6	5.8
		TRAWL	193	530	1000	598	152	6.1
1984	6726	PHOTO	0	279	1000	58	0	5.5
		TRAWL	221	972	1000	406	110	5.4
1984	6728	PHOTO	227	448	1000	364	20	5.5
		TRAWL	327	571	1000	816	293	6.2
1984	6729	PHOTO	718	1000	684	260	12	4.5
		TRAWL	87	283	1000	673	276	6.8
1984	6733	PHOTO	495	287	1000	396	69	5.4
		TRAWL	13	179	576	748	1000	8.8
1984	6734	PHOTO	17	131	1000	623	114	6.8
		TRAWL	5	37	384	1000	674	8.7
1984	6737	PHOTO	1000	108	203	159	9	3.8
		TRAWL	16	65	350	508	1000	9.5
1984	6738	PHOTO	1000	327	328	62	0	3.7
		TRAWL	117	458	1000	400	135	6.0
1984	6740	PHOTO	631	1000	863	35	0	4.3
		TRAWL	970	940	1000	251	40	4.4
1984	6749	PHOTO	495	1000	131	0	0	3.8
		TRAWL	1000	594	436	54	3	3.7
1985	1	PHOTO	13	244	1000	179	6	5.7
		TRAWL	88	396	1000	858	175	6.6
1985	5	PHOTO	0	73	1000	683	110	6.9
		TRAWL	3	55	1000	618	249	7.1
1985	7	PHOTO	0	1000	0	0	0	4.3
		TRAWL	949	1000	620	139	165	4.6
1985	8	PHOTO	1000	236	218	31	0	3.4
		TRAWL	63	470	1000	727	352	6.8
1985	9	PHOTO	29	29	1000	514	51	6.7
		TRAWL	11	52	736	1000	271	7.6
1985	10	PHOTO	0	213	1000	449	125	6.5
		TRAWL	0	9	568	1000	967	9.3
1985	12	PHOTO	17	486	1000	348	17	5.7
		TRAWL	0	112	878	822	1000	8.7
1985	13	PHOTO	399	1000	925	424	32	5.1
		TRAWL	111	284	839	1000	379	7.2
1985	14	PHOTO	1000	565	707	136	13	4.2
		TRAWL	3	74	853	1000	274	7.6
1985	19	PHOTO	32	561	1000	145	10	5.3
		TRAWL	8	155	1000	530	364	7.3
1985	21	PHOTO	0	121	1000	220	11	6.0
		TRAWL	0	69	720	799	1000	8.7
1985	23	PHOTO	619	1000	489	51	3	4.1
		TRAWL	23	412	1000	347	125	6.1

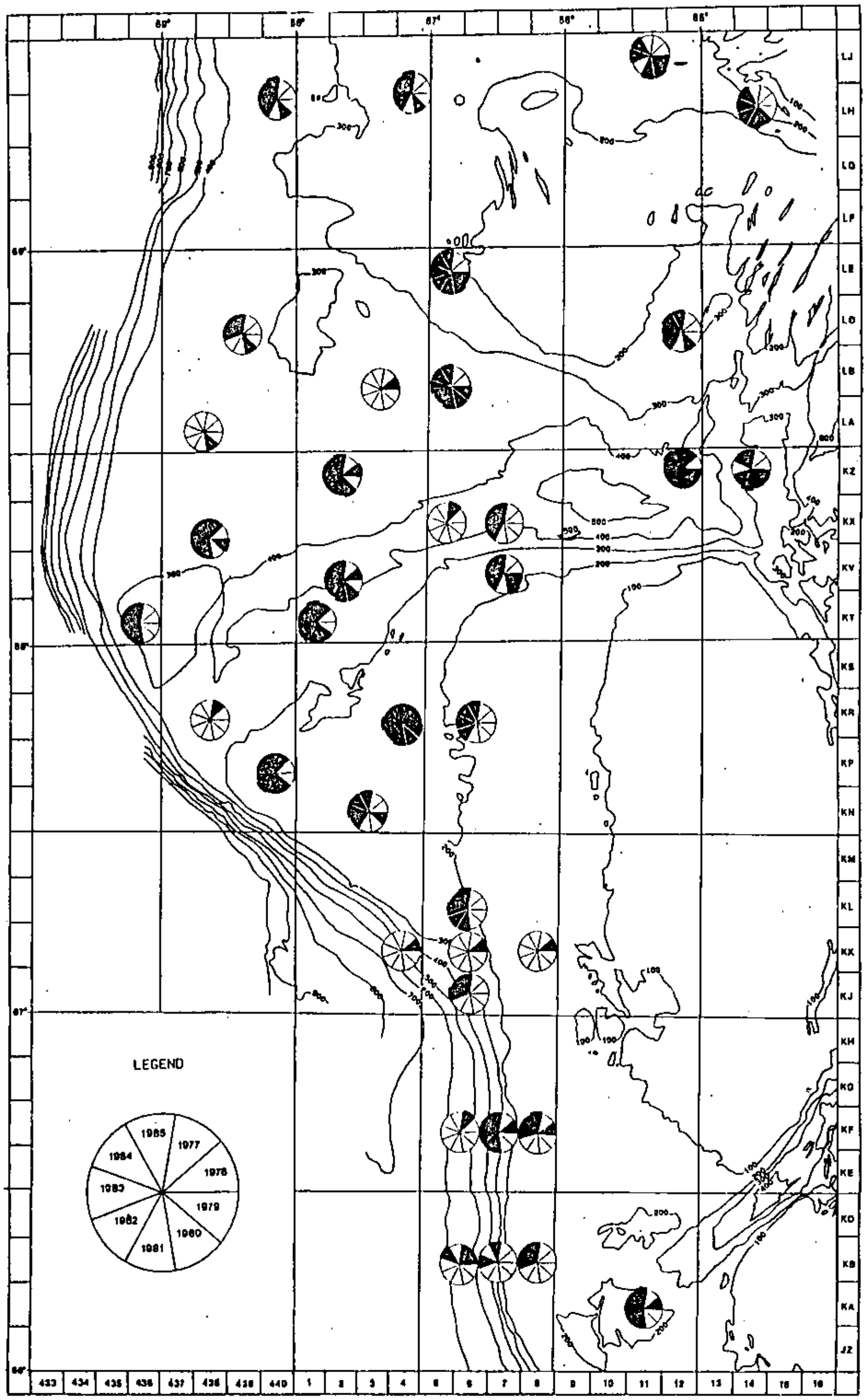

Fig. 1. Map of sampling stations in 1977-85. The shaded areas in the circles denote years in which sampling has been carried out, and the "exploded" parts of the circles show years in which small shrimp (groups one and two) have been dominating.

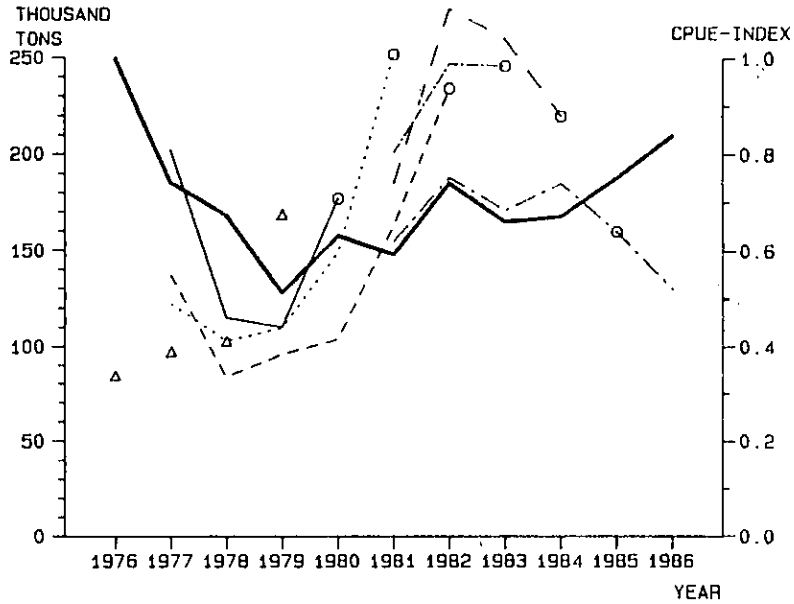

Fig. 2. Photographic biomass estimates from models used through the years 1977-85 and from a stratified trawl survey in 1976 compared with CPUE-indices from part of the commercial shrimp fishery. Triangles are results from the trawl survey and from photographic surveys based on the trawl survey stratification. Circles show the basic years for the different photographic models, which are shown by the thin curves. The thick curve gives the CPUE-indices.

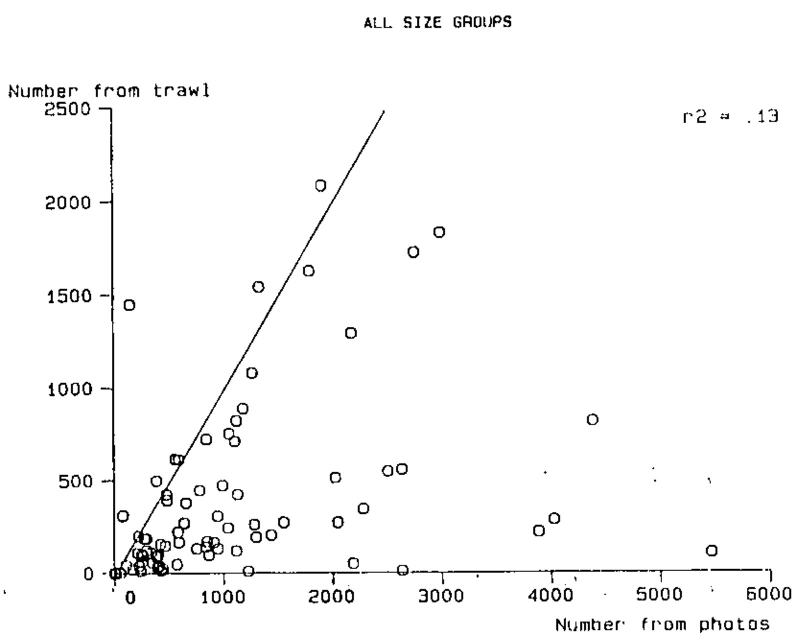

Fig. 3. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. All size groups. The straight curve indicates the 1:1 ratio between the two datasets.

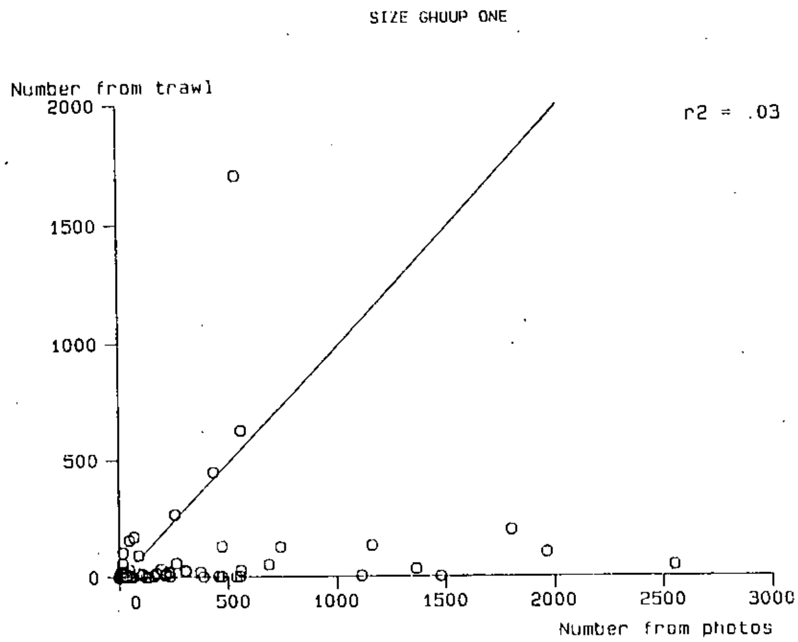

Fig. 4. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. Size group one. The straight curve indicates the 1:1 ratio between the two datasets.

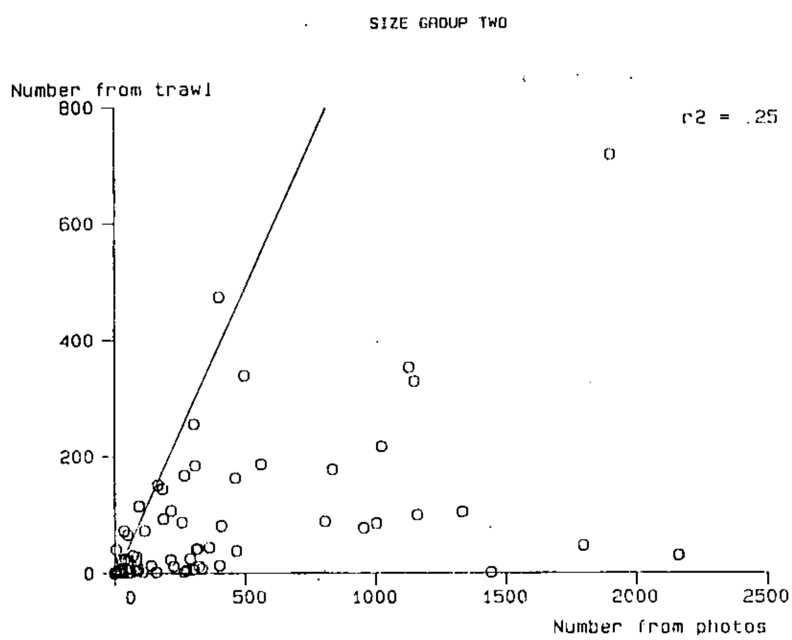

Fig. 5. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. Size group two. The straight curve indicates the 1:1 ratio between the two datasets.

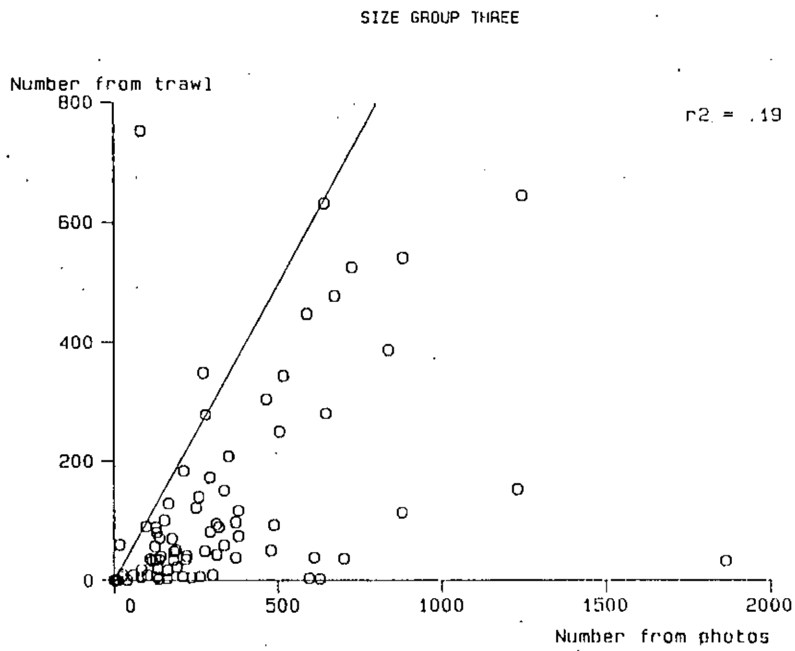

Fig. 6. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. Size group three. The straight curve indicates the 1:1 ratio between the two datasets.

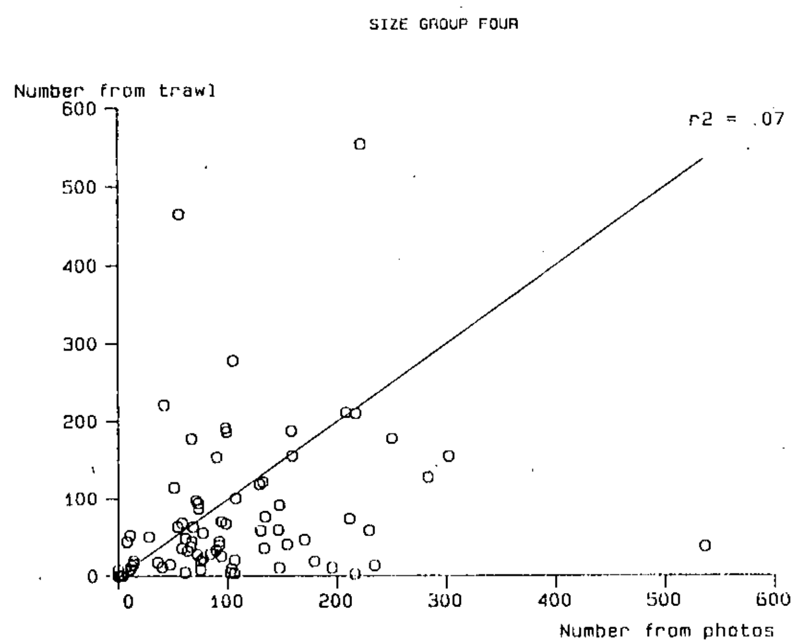

Fig. 7. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. Size group four. The straight curve indicates the 1:1 ratio between the two datasets.

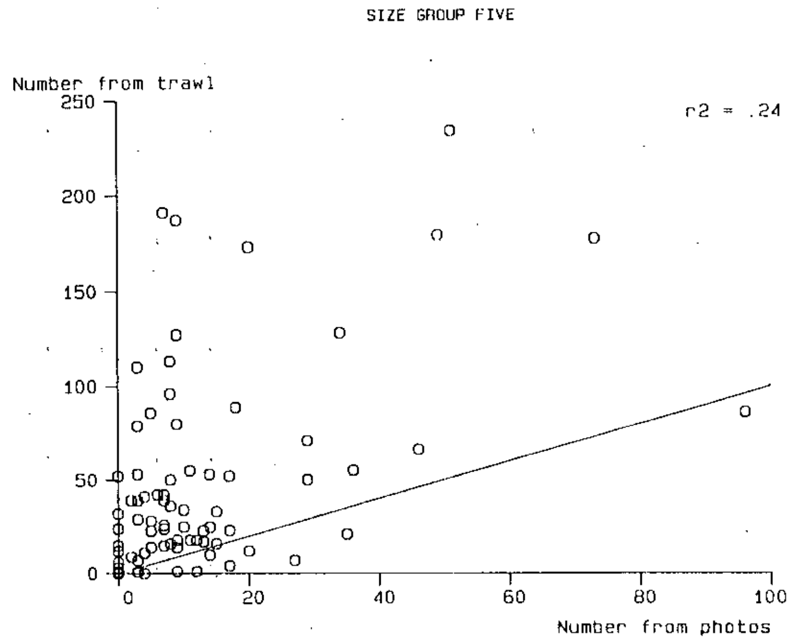

Fig. 8. Shrimp number per 1000 squaremeters in trawlsamples versus photosamples 1981-85. Size group five. The straight curve indicates the 1:1 ratio between the two datasets.