RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2076
(D.c.9)

ICNAF Res. Doc. 68/88

ANNUAL MEETING - JUNE 1968

U.S.A. - U.S.S.R. JOINT WORK ON ZOOPLANKTON SAMPLING METHODS

by

J.A. Posgay, R.R. Marak, and R.C. Hennemuth

Bureau of Commercial Fisheries, Biological Laboratory
Woods Hole, Massachusetts

INTRODUCTION

The fishery research vessel Albatros of the Atlantic Research Institute of Marine Fisheries and Oceanography, Kaliningrad, USSR, visited Woods Hole, Massachusetts from 14 September to 2 November 1967. While there the USSR scientists aboard the ship discussed the sampling problems involved in the ICNAF-Georges Bank Survey with USA scientists at the Bureau of Commercial Fisheries Biological Laboratory. These discussions led to a joint cruise with Albatross IV of the USA to evaluate two new samplers developed by BCF, Woods Hole, and to measure the variability of estimates of zooplankton abundance. After the cruise, the two groups worked together sorting some of the samples to standardize the processing methods.

The samples collected were divided in half so that each group had a complete set from both vessels. It was intended that both sets of samples would be processed and that we would then prepare a joint paper giving the results obtained by the two vessels and the two groups of sorters. This, unfortunately, has not been possible because of the great amount of time required to sort the samples. This document reports the results of analyzing the set of samples processed by the U.S.A. The joint paper will appear at a later date.

The samplers used consist of a pair of tubes yoked together in such a manner that when fastened to the towing wire they are free to swivel in both the horizontal and vertical planes. Used with an efficient depressor so that the lower end of the wire is almost vertical, the mouths of the sampler enter undisturbed water. The smaller sampler, the BCF Bongo (.03), has a pair of 20.3 cm I.D. tubes while the larger sampler, the BCF Bongo (.3), has a pair of 61 cm tubes. The nets used were cylinder-cones of .505 mm nylon gauze with a filtering area to mouth area ratio of 15:1 in the small samplers and 8:1 in the large sampler. A more complete description of the samplers is given in another Document of this meeting.

All tows were 20-minute 10-step oblique hauls from 50 meters to the surface. The time at depth during each tow was recorded with a mechanical time-depth recorder. The amount of water filtered was measured with mechanical flowmeters. The gear used on both ships was identical, supplied by the USA, and great care was used to insure that towing methods were also identical. After the cruise, the collection was divided into two sets by random selection between the port and starboard nets of the samplers. Previous investigation had shown extremely high correlation (>.95) between the two nets of the bongo samplers.

SAMPLING DESIGN

EXPERIMENT 1 - Survey with .03 m^2 samplers

This experiment was designed to measure the within and between ship variability of estimates of abundance. Each ship occupied 12 randomly pre-selected stations within a 20km X 20km area. Tows were made at 5 knots (155 m/min) using only the small samplers.

EXPERIMENT 2 - Effects of mouth area, speed of tow, and vessel

The ships worked around a floating buoy attached to a parachute drogue 25 meters down. Each ship made 8 daytime tows and 8 nighttime tows. Both the small and the large samplers were towed simultaneously. Both ships set their gear simultaneously and towed on the same course at either 3 or 6 knots (93 and 185 m/min) according to a preselected random sequence. The ships were never more than 200 meters apart when setting out.

EXPERIMENT 3 - Survey with .3 m^2 samplers

This was a repeat of Experiment 1 in the same area but made 48 hours later using the large samplers.

Preliminary sorting of a few of the samples showed that there were only very small numbers of fish eggs and larvae in the collections but that euphausiids and arrow worms (Sagitta sp.) were quite abundant. It was agreed, therefore, that the processing of the collections would consist of the following:

1. Measuring displacement volume of total sample.
2. Subsampling as required.
3. Picking out, identifying (when possible), counting, and measuring of all fish eggs, fish larvae, arrow worms, and euphausiids.
4. Recording results on tally sheets.
5. Sending copies of all tally sheets to the other Laboratory.

PARTICIPANTS

ALBATROSS IV (USA)

USA

Julius A. Posgay
James M. Crossen
Henry W. Jensen
Ann McTiernan
Kenneth W. Sherman

USSR

Valentin A. Bryantsev
Eduard L. Afnagel
Olga I. Krylova
Florentsa T. Matusko (interpreter)

ALBATROS (USSR)

USSR

Arkadi S. Noskov
Nikolai A. Korochanskiy
Valentin I. Vinogradov
Vladimir P. Volkov

USA

Robert R. Marak
Eugene Maltzeff (interpreter)
James J. McGuire
Thomas L. Morris

RESULTS

Experiment 2

We will consider Experiment 2 first since it measures differences between ships and between the large and the small samplers. These are needed before we can interpret the result of Experiments 1 and 3. The results of Experiment 2 are shown in Table 1. They are given as the mean catch of fish eggs, fish larvae, euphausiids, and Sagitta arranged by vessel, speed of tow, time of day, and mouth area of the sampler. Each value represents the mean of four tows except in two cases where a sample was lost.

Examination of the pairs of values showing the between ship comparisons reveals only five cases where one ship caught more than twice as much as the other. Three of these are in the fish larvae column; two cases where the USSR vessel caught more and one where the USA vessel caught more. Since the mean catch of larvae per cubic meter for all tows combined is .035 for the USA vessel and .032 for the USSR vessel, these individual differences are probably not important. The other two large differences between ships occur under Sagitta; the catches of the small sampler at 6 knots both day and night. In the between gear comparisons only two cases occur in which one sampler caught more than twice as much as the other. These are the catches of Sagitta by the USSR vessel at 6 knots both day and night. These differences and some of the other smaller ones are examined below using both parametric and nonparametric tests of significance. Figure 1 is a plot of the catches made by the large sampler against the catches of the small sampler.

Table 2 shows the same data as Table 1 but with the catches pooled so that all 3 knot tows can be compared with all 6 knot tows, all day tows with all night tows, and all small sampler tows with all large sampler tows. An asterisk between a pair of mean values shows that the non-parametric Mann-Whitney U test gave a significant difference at the .05 level, and 0 shows that the test showed no significant difference. Unmarked pairs were not tested because of the small difference between them. The large day-night difference between the catches of euphausiids was expected since most of these animals migrate down below the sampling depth during the day.

The data have also been transformed by taking the natural logarithm of the catch per cubic meter plus one to improve the normality of the distribution. Table 3 shows the result of the analysis of variance on the transformed data. The effect of speed is significant for eggs, and Sagitta taken by the USSR vessel but only for Sagitta taken by the USA vessel. In all these cases the slower speed took the larger catches. The effect of mouth area is significant only for Sagitta taken by the USSR vessel. The interaction of speed and mouth area was not significant in any case. The mean catches and coefficients of variation are similar between vessels with the possible exception of euphausiids where the USSR vessel caught more at night than the USA vessel.

The big difference between vessels and, for the USSR vessel, between samplers occured in the catches of Sagitta. Table 4, which lists all catches of Sagitta in Experiment 2, shows what happened to cause these differences. For some reason the small sampler on the USSR vessel was very inefficient at 6 knots compared with any sampler, towed at either speed by either vessel. We have been unable to account for this difference. The time-depth records show no difference in the tow profiles; the flowmeter records show no difference in water passage through the sampler. The catches of other organisms taken in the same tows do not show the difference so it cannot be malfunction of the gear.

In the three way analysis of variance, considering the factors as speed mouth area, and vessel, significant 3-way interactions were observed for the catches of fish eggs and euphausiids (Table 5). The speed effect was significant for both mouth areas on the USSR vessel. On the USA vessel, however, the interaction of speed and mouth area show a curious reversal; the small sampler caught significantly more at the lower speed while the larger sampler caught significantly more at the higher speed.

Experiment 1

Before selecting the station locations in both Experiment 1 and 3, the sampling area was divided into four quadrats; three stations were then selected in each quadrat for each vessel. Both vessels began their sampling program at about the same time in the morning and finished up about the same time a few hours after dark. Thus, while there was no attempt to synchronize the sampling, each vessel occupied its three stations in the first quadrat approximately during the same time period and then proceeded to the next quadrat.

Table 6 shows the catches, of the four organisms that were sorted out, taken during each tow by each vessel. The mean catches between vessels for the entire sampling area are quite similar. The Mann-Whitney test showed no significant difference between vessels at the .05 level for any of the organisms. The difference between the catches of eggs just missed being significant.

Experiment 3

Table 7 shows the results of Experiment 3. The difference between the mean catches of the two vessels are quite small except for larvae. The Mann-Whitney test showed that the difference in the catches of larvae was just significant at the .05 level. The most interesting thing about these results is the great increase in abundance of all four organisms in the sampling area since it had been sampled 48 hours earlier during Experiment 1.

The abundance of eggs and larvae was twenty times greater; euphausiids and Sagitta ten times. Both vessels show it and, as demonstrated in the discussion of Experiment 2, it was not the result of using the larger samplers during Experiment 3. A large, real change in the abundance of the animals had occured between the two sampling periods.

Analysis of variance - Experiments 1 and 3

The data of Tables 6 and 7 were transformed by taking the natural logarithim of the catch per cubic meter plus one. Table 8 shows the mean and variance for each vessel and each organism by quadrats and for the entire sampling area for Experiment 1. Table 9 shows the same statistics for Experiment 3. Table 10 gives the values for the F-test in the analysis of variance. As expected, all organisms show significant differences at the .01 level between experiments. The differences between quadrats within experiments were also highly significant for eggs, larvae, and euphausiids but not significant for Sagitta. The differences between vessels within quadrats were highly significant for eggs and larvae, significant for euphausiids, but not significant for Sagitta.

CONCLUSIONS

1. There is no difference in the catches of the large and the small samplers. In a large scale survey, however, the large sampler might be preferred because it filters more water for the same amount of ship time and provides more individuals for length-frequency and life history studies.

2. Towing at 6 knots does not give better samples than towing at 3 knots. Further analysis of the collections, particularly the species composition and size composition may modify this conclusion.

3. The observed differences between vessels needs further investigation; perhaps with three vessels.

4. The observed differences in the estimates of abundance over rather small differences in time and space need further analysis and investigation to determine what density of sampling would be necessary to achieve acceptable levels of precision for the calculation of mortality rates of fish larvae.

Table 1. Mean catches of fish eggs, fish larvae, euphausiids, and Sagitta per cubic meter of water filtered for each combination of vessel, speed, gear, and time of day. Experiment 2

Organism	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
Vessel	USA	USSR	USA	USSR	USA	USSR	USA	USSR
			3 Knots - Day					
Gear								
.03	.426	.615	.011	.026	.734	.825	3.767	2.822
.3	.304	.558	.020	.041	1.014	1.487	3.857	4.156
			3 Knots - Night					
.03	.307	.432	.053	.065	16.139	26.833	4.521	4.334
.3	.314	.537	.054	.040	14.262	28.354	6.122	5.496
			6 Knots - Day					
.03	.264	.325	.017	.011	.869	.595	2.838	1.047
.3	.372	.251	.025	.022	.655	1.030	2.527	2.836
			6 Knots - Night					
.03	.352	.306	.061	.026	13.279	9.145	3.154	.930
.3	.350	.290	.039	.024	12.617	10.207	3.494	2.106

Table 2. Summary of the results of Experiment 2. The values are mean catch per cubic meter of water filtered.

Organism	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
Vessel	USA	USSR	USA	USSR	USA	USSR	USA	USSR
Factor								
3 Knots	.338	*.536	.034	.043	8.[illegible]37 0	14.375	4.566	4.202
		*		0		0	*	*
6 Knots	.334	.293	.036	.021	6.855	5.244	3.003 *	1.730
Day	.342	.437	.018	.025	.818	.984	3.247	2.715
			*					
Night	.331	.391	.052	.039	14.074	18.634	4.323	3.216
.03	.337	.420	.036	.032	7.755	9.350	3.570 *	2.283
								*
.3	.335	.409	.034	.032	7.137	10.270	4.000	3.648

Table 3. Analysis of variance of Experiment 2. The values are the result of dividing the catch made at the higher level of the factor by the catch at the lower level. An asterisk marks those effects that are significant at the .05 level; two asterisks at the .01 level.

Organism	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
Vessel	USA	USSR	USA	USSR	USA	USSR	USA	USSR
Effects								
Speed	.97	.84**	1.00	.98	.94	.56	.79*	51**
M. Area	.99	.99	1.00	1.00	1.09	1.18	.97	.9[illegible]
S-M. A.	1.03	.97	1.00	1.00	1.05	1.00	.98	1.17
Mean	.294	.340	.028	.031	1.221	1.736	1.470	1.282
Variance	.0115	.0059	.0004	.0004	.1126	.1278	.0396	.0534
Coeff. Var.	.36	.23	.71	.64	.27	.21	.14	.18

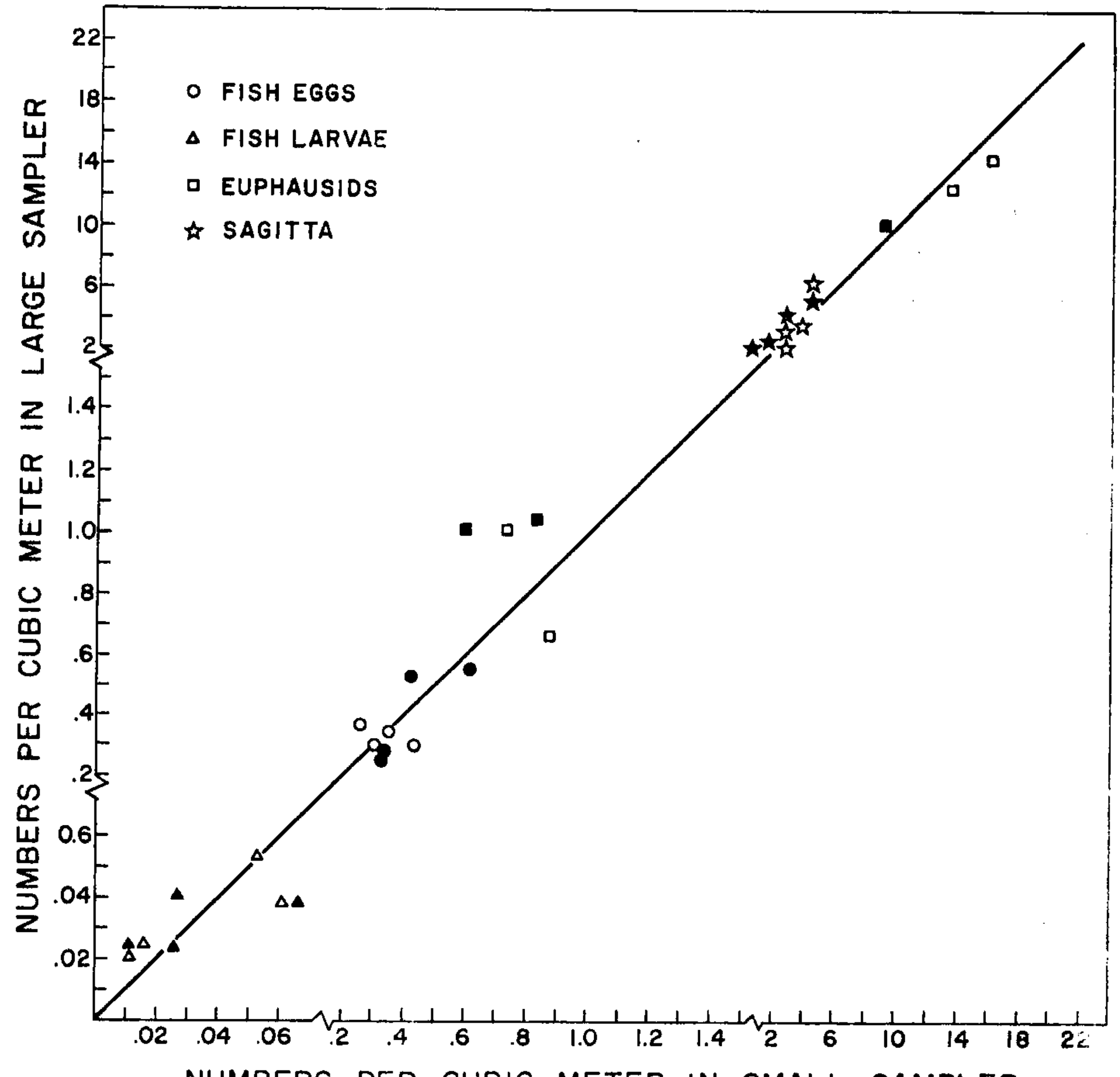

Figure 1. Scatter diagram of the data of Table 1. The open symbols are for the USA vessel; closed for the USSR vessel. The regression equation is Y = .2404 + 1.0067 X with a correlation coefficient of .992.

Table 4. Numbers of Sagitta taken per cubic meter of water filtered for each tow of both vessels in Experiment 2.

VESSEL	USA	USA	USSR	USSR	USA	USA	USSR	USSR
Speed	3 Knots				6 Knots			
Gear	.03	.3	.03	.3	.03	.3	.03	.3
Time	Day				Day			
	2.276	2.364	2.786	3.854	3.736	2.192	1.958	3.431
	3.030	3.068	2.929	3.674	1.816	2.647	.875	2.233
	5.045	4.140	2.262	4.490	2.346	1.762	.451	2.584
	4.719	5.845	3.311	4.607	3.453	3.507	.906	3.095
Mean	3.767	3.857	2.822	4.156	2.838	2.527	1.047	2.836
Time	Night				Night			
	4.250	4.893	4.769	8.489	4.227	4.838	.703	2.513
	2.886	3.548	2.876	3.586	2.386	2.563	.581	1.376
	2.999	3.797	4.251	4.471	2.607	---	1.308	2.252
	7.951	12.252	5.441	5.438	2.848	3.082	1.129	2.284
Mean	4.521	6.122	4.334	5.496	3.154	3.494	.930	2.106

Table 5. Analysis of variance of Experiment 2. Main effects and interactions between speed, mouth area, and vessel on catches of fish eggs and euphausiids.

		FISH EGGS			
Sampler		USA		USSR	
		3 Knots	6 Knots	3 Knots	6 Knots
	.03	.334*	.239	.435*	.294
	.3	.201	.332*	.482*	.244
Mean		.268	.286	.459*	.269
		EUPHAUSIIDS			
		3 Knots	6 Knots	3 Knots	6 Knots
	.03	1.856*	1.388	1.913*	1.615
	.3	1.534	1.913*	2.241*	1.409
Mean		1.695	1.650	2.077*	1.512

Table 6. Catches of fish eggs, fish larvae, euphausiids, and Sagitta by both vessels in Experiment 2. Values are numbers caught per cubic meter filtered. The dashes represent a lost sample.

ITEM	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
Vessel	USA	USSR	USA	USSR	USA	USSR	USA	USSR
Tow No.								
101	.056	1.166	.019	.168	.271	8.698	4.460	3.791
102	.198	1.422	.063	.095	3.982	7.350	8.523	7[illegible]08
103	.241	.558	.028	.063	.472	.663	4.342	4.044
104	.273	----	.028	----	.085	----	2.508	----
105	.066	.210	.086	.020	.209	.130	3.865	1.050
106	.082	1.327	.036	.063	.800	.116	3.427	3.949
107	1.786	.632	.028	.042	.655	.095	3.123	1.327
108	.371	,070	.010	.010	.381	.280	3.513	9.870
109	.135	.170	.009	.000	.541	.066	2.126	6.412
110	.140	.305	.009	.095	1.113	6.044	2.235	4.486
111	.170	.505	.028	.000	12.334	10.562	5.479	3.549
112	.616	.798	.098	.023	3.679	7.284	1.518	3.271
Mean	.345	.647	.037	.053	2.044	3.753	3.760	4.478

Table 7. Catches of fish eggs, fish larvae, euphausiids, and Sagitta by both vessels in Experiment 3. Values are numbers caught per cubic meter filtered. The dashes represent a lost sample.

ITEM	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
Vessel	USA	USSR	USA	USSR	USA	USSR	USA	USSR
Tow No.								
301	11.576	4.800	.314	.090	6.759	2.860	42.811	17.260
302	5.926	12.131	.195	7.771	5.213	78.427	45.050	46.416
303	3.621	10.109	.113	.400	2.791	4.717	70.951	40.614
304	1.745	.698	.182	.060	3.018	2.179	69.429	17.795
305	.857	3.430	.054	.180	.527	2.722	12.279	25.390
306	1.907	9.266	.183	.253	----	3.380	-----	30.169
307	.144	9.098	.099	.253	2.820	6.076	26.282	37.761
308	2.348	12.805	.110	1.106	2.999	50.207	25.777	45.953
309	1.778	2.560	.167	1.000	4.111	78.080	9.704	37.200
310	10.380	2.359	1.027	.348	92.587	8.803	59.142	63.822
311	12.686	24.598	1.036	5.781	156.486	36.897	64.367	47.490
312	57.664	16.899	1.099	1.792	124.446	101.882	13.551	36.425
Mean	9.219	9.063	.382	1.586	36.523	31.353	39.940	37.191

Table 2. Means and variances of the transformed data by quadrat and for the entire sampling area for each vessel and each organism. Experiment 1.

	FISH EGGS		FISH LARVAE		EUPHAUSIIDS		SAGITTA	
	Mean	Var.	Mean	Var.	Mean	Var.	Mean	Var.
Quad 1								
USA	.150	.0072	.036	.0005	.744	.5623	1.876	.107[illegible]
USSR	.693	.0511	.103	.0023	1.634	.9561	1.775	.101[illegible]
Quad 2								
USA	.128	.0097	.049	.0009	.286	.0710	1.4[illegible]	.028[illegible]
USSR	.518	.2138	.041	.0009	.116	.0001	1.153	.388[illegible]
Quad 3								
USA	.489	.2240	.015	.0001	.419	.0685	1.354	.036[illegible]
USSR	.238	.0495	.017	.0005	.134	.0098	1.745	.64[illegible]
Quad 4								
USA	.256	.0378	.044	.0020	1.627	.8540	1.322	.239[illegible]
USSR	.421	.0258	.038	.0022	2.171	.0638	1.556	.017[illegible]
Total								
USA	.256	.0507	.036	.0006	.769	.2719	1.4[illegible]	.074[illegible]
USSR	.468	.0466	.050	.0011	1.014	.2059	1.559	.191[illegible]

Table 9. Means and variances of the transformed data by quadrat and for the entire sampling area for each vessel and for each organism. Experiment 3.

	Fish Eggs		Fish Larvae		Euphausiids		Sagitta	
	Mean	Var.	Mean	Var.	Mean	Var.	Mean	Var.
Quad 1								
USA	1.999	.2537	.186	.0069	1.736	.1344	3.962	.0746
USSR	2.247	.1863	.865	1.2964	2.490	2.7039	3.497	.2677
Quad 2								
USA	.899	.0595	.129	.0044	.907	.4682	3.420	1.3918
USSR	1.449	.8106	.150	.0071	1.316	.0257	3.215	.0664
Quad 3								
USA	.788	.3290	.118	.0010	1.453	.0245	2.988	.2[illegible]60
USSR	2.069	.5035	.554	.0819	3.421	1.6554	3.716	.0133
Quad 4								
USA	3.040	.8070	.720	.0003	4.810	.0681	3.651	.7129
USSR	2.446	1.1754	1.080	.6549	3.517	1.3921	3.892	.0752
Total								
USA	1.682	.2635	.288	.0023	2.227	.0922	3.505	.3539
USSR	2.053	.4865	.662	.3710	2.686	1.0504	3.580	.0768

Table 10. F test values for the analysis of variance of Experiments 1 and 3. A single asterisk denotes significance at the .05 level; a double asterisk at the .01 level.

Item	Fish Eggs	Fish Larvae	Euphausiids	Sagitta
Source				
Between Experiments	9.62**	54.05**	50.29**	195.46**
Between Quadrats	5.42**	5.07**	10.76**	1.28
Between Vessels within Quadrats	21.95**	9.98**	2.39*	.88