FURTHER OBSERVATION ON THE DAILY CHANGE IN AMOUNT OF CATCHES OF PLANKTON ANIMALS IN VERTICAL HAULS*

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The previous observations (Motoda & Anraku, 1954) made near western entrance to the Tsugaru Strait in October, 1953, have shown that the total number of plankton animals occurring in the layers of 150-0 m, 300-0 m and 450-0 m are different in daytime from at night as expressed by the ratios 100 : 140, 100 : 141 and 100 : 126 respectively. More extensive data being required for determining the depth from which the catches by vertical hauls would yield the same amount quite irrespective of the time of day, the herein described observation was undertaken along the same line as the previous studies.

The locality of the present sampling was the offing to the eastward of Cape Esan, south coast of Hokkaido, exactly 41° 45′N, 141° 39.8′E, but the ship was shifted about around this position by one and half miles at the most during her drift for sampling. The vertical hauls from 150 m, 300 m, 450 m and 600 m depth to the surface, each repeated once, were made both in daytime (8 : 40 a. m.–11 : 08 a. m.) and at night (10 : 45 p. m.–1 : 20 a. m.) on 17th and 18th, May, 1954. The velocity of the haul was held as constant as possible at 100 cm per second. The angle of wire carrying the net sometimes attained to about 30 degrees against vertical line, but in most cases it was less than this and often the wire was suspended perfectly vertical. The wire, however, having been let out without adjustment for obtaining accurately the desired depth, the sampling depth presented here only means the length of the wire itself.

The net employed was 45 cm in mouth diameter, approximately 165 cm in length, of which the body was constructed of Japanese grit gauze No. 56, having 0.3–0.32 mm of approximate mesh aperture. The net was provided with a flow meter held rigidly at the centre of the mouth ring to register the amount of water filtered. Before the sampling, calibration of flow meter was performed by vertical hauls for 150–0 m with the flow meter kept at the centre of the ring from which the body of net was previously removed. By three experiments the revolutions were counted as 1177 in the mean, so that, when the flow meter is

Table 1. Vertical gradient of temperature and chlorinity

Depth (m)	T (°C)	Cl ‰*
0	9.90	18.79
10	10.23	18.69
25	9.36	18.74
50	9.29	18.76
75	9.61	18.74
100	8.48	18.99
150	6.49	18.76
200	3.80	18.69
300	2.53	18.73
400	2.75	18.74
600	2.99	18.85

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attached on the net, 100 revolutions would correspond to 2.03 cubic metres of water presumably filtered by the net.

The gradient of temperature increased to some extent at the depth between 150 and 200 metres, though the chlorinity was kept nearly uniform through whole vertical range observed (table 1). The plankton samples consisted of a large bulk of copepods, euphausiids, mysids, amphipods, chaetognaths and hydromedusae, the remainder being a small number of ostracods, pteropods, appendicularians and polychaetes. Full data are given in table 2. It was indicated that the number of small calanids, such as *Paracalanus* and *Clausocalanus*, fluctuated irregularly and widely in repeated hauls (line 8 in table 2).

Table 2. Individual number of each plankton group found in each sample

Sampling time	Daytime								Night							
Depth (m)	150~0		300~0		450~0		600~0		150~0		300~0		450~0		600~0	
No. of sampling	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Calanus plumchrus	200	225	360	305	522	480	1700	1630	200	260	256	240	400	380	1920	1985
C. cristatus	0	2	22	33	34	37	46	48	3	1	23	16	24	34	76	56
Eucalanus spp.	1	2	21	35	200	208	440	548	0	0	64	56	328	280	480	444
Metridia lucens	350	342	1600	880	1600	1490	2180	2400	840	520	560	1180	1040	1920	3680	2600
Small calanids	11520	10880	12480	4480	3650	1980	11840	9600	14720	20480	8640	11840	8320	8160	10200	5160
Euphausiacea	12	23	78	57	78	87	108	80	76	109	25	62	62	71	76	47
Themisto sp.	11	8	53	27	20	29	51	33	31	17	33	23	40	42	48	32
Conchoecia sp.	0	0	32	32	40	120	195	224	0	1	16	64	130	128	128	130
Sagitta spp.	35	49	211	172	228	251	329	383	58	63	120	160	221	165	340	316
Hydromedusae	34	71	109	121	69	109	178	108	41	36	44	55	78	81	65	76
Limacina sp.	4	12	44	8	8	62	16	128	16	40	4	16	64	12	32	32
Oikopleura spp.	4	4	4	12	4	5	1	2	0	1	16	4	0	8	4	0
Polychaetes	0	0	0	0	0	2	15	5	0	0	1	1	1	3	6	12

Table 3. Total number of plankton animals excluding small calanids, *Paracalanus* and *Clausocalanus*, found in various hauls

Sampling layer (m)	Amount of water in column for 45 cm-net (m^3)	Sampling time	No. of sampling	Reading of flow meter	Amount of water filtered by the net (m^3)	Total number of plankton animals excluding small calanids					
						Number of animals actually collected	Number of animals in water column corresponding to the sampling layer	Mean for repeated samplings	Mean for day and night	Ratio of number in daytime to at night	Percentage for day-night mean
150~0	23.9	Daytime	1	870	17.7	651	879	927	1482	100	63
			2	890	18.1	738	974				
		Night	3	870	17.7	1445	1951	2036		220	137
			4	860	17.5	1548	2121				
300~0	47.8	Daytime	5	1690	34.3	2534	4282	3495	3036	100	115
			6	1774	36.0	1682	2708				
		Night	7	1685	34.2	1172	1981	2577		74	85
			8	1686	34.2	1877	3172				
450~0	71.7	Daytime	9	2510	51.0	2803	3952	3921	2824	100	103
			10	2620	53.2	2881	3889				
		Night	11	2515	51.1	2368	3315	3726		95	97
			12	2620	53.2	3064	4136				
600~0	95.6	Daytime	13	3550	72.1	4259	5664	6856	7327	100	94
			14	3279	66.6	5589	8048				
		Night	15	3830	77.8	6855	8431	7797		114	106
			16	3780	76.7	5730	7162				

This irregularity of occurrence was possibly due to inhomogenous distribution of these small calanid copepods within a small area of the sea. They might be concentrated here and there for some certain unknown reason. Therefore, to estimate the regular daily change of catches of general plankton animals, the number of plankton animals excluding the above small copepods was taken into consideration (table 3).

Table 3 indicates that the catch by haul from 150 m depth at night is more than double the catch in daytime, but the difference in catches between day and night is reduced when the haul is made from 300 m depth or below. The percentage standard deviation of haul to haul variation in vertical haul from 150m depth with 45 cm-net was calculated in an experiment about 18.6 % (about 70% and 141% of 95% fiducial limits) (Motoda & Anraku, unpublished). Applying this, the variation in catches by day and night in the present observation is significantly different only for the 150–0 m haul. The later experiments gave data on haul to haul variation (percentage standard deviation) of catches by vertical haul from about 150 m depth with such net as used in the present sampling from which was calculated a value of about 13% (about 78% and 128% of 95% fiducial limits). If the above results is applied to the present collections there occur in the 150–0 m haul significant difference in variability of catches between day and night. However, in the third series of operations carried on under the identical conditions the haul to haul variation was as large as 48%; then the 95% fiducial limits were roughly 45% and 202%, so that one count could not be considered significantly different from another one unless it was less than one-half or more than two times that value. If the last value of percentage standard deviation is applied to the present catches they are not significantly different as between day and night even in the 0-150 m layer.

King and Hida (1954) made an observation on the variability in zooplankton abundance in Hawaiian waters, obtaining an obvious day-night difference among the 200 m oblique hauls. They advocated that the collections at any time of the day would be corrected by the curve of the sine function obtained from diurnal change in catches of above levels.

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