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6. Studies on the Biotic and Inorganic Factors of Environment for *Nautilus*

by

Akihiko SHINOMIYA[1], Uday RAJ[2] and Johnson SEETO[2]

Introduction

During the field operation for the ecological studies on the habitat of *Nautilus* late in August and in September, 1983, the trapping experiments on *Nautilus* were practiced 21 times at the 13 stations off Suva (Fig. 1, A) and the six stations off Pacific Harbour (Fig. 1, B). The oceanographic and physiographic surveys in these areas were carried out during the same period of time (HAYASAKA, *et al.*, 1985).

The traps used for the experiments were the type "TR-A" (HAYASAKA *et al.*, 1984) of three different sizes, large (2 m × 1 m × 1.2 m), medium (1.2 m × 1 m × 0.8 m) and small (1 m × 0.8 m × 0.8 m). They are made of iron frame covered with 15-mm wire-netting used for the deep sea fishing by the IMR* staff. As the bait for trapping *Nautilus*, whole bodies of a few frozen sardine

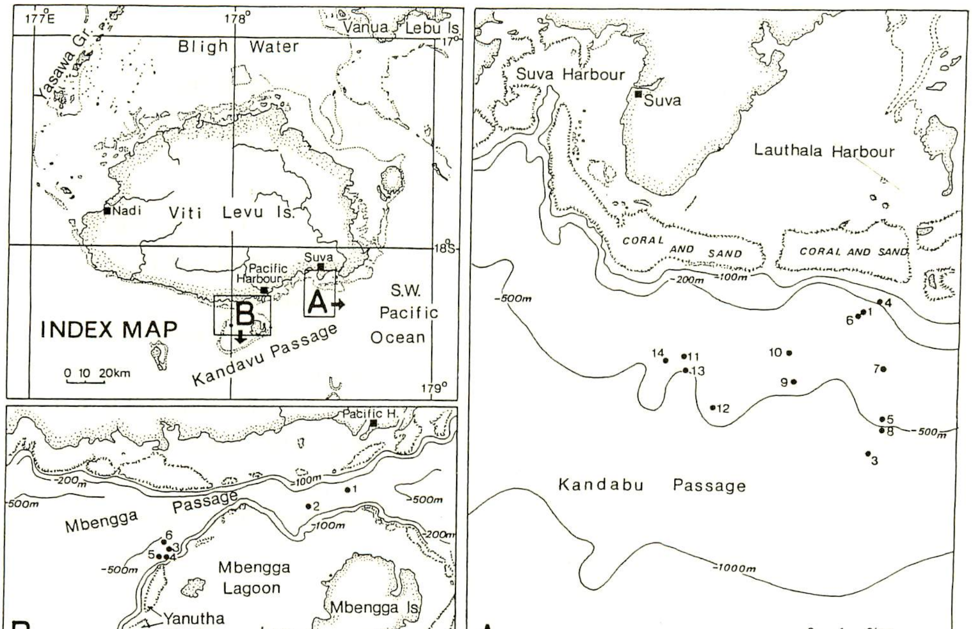

Fig. 1. Maps of the Suva (A) and Pacific Harbour (B) areas, Viti Levu Island, showing the sampling stations of *Nautilus pompilius*.

1) Laboratory of Marine Biology, Faculty of Fisheries, Kagoshima University, Kagoshima 890, Japan.
2) Institute of Marine Resources, the University of the South Pacific, Suva, Fiji.
*) Abbreviation for the Institute of Marine Resources, the University of the South Pacific.

or small tuna were suspended inside of each trap. Five to seven traps of various sizes connected to a buoy were settled on the sea bottom. Each set of traps was settled in daytime and drawn up next morning. The positions and depths of trapping stations were determined precisely by the rader and the echo-sounder on the research ship "Aphareus" owned by IMR.

By trapping, fishes and crustaceans (shrimps and crabs) were collected with or without *Nautilus* (Table 1 and 2). Here the writers wish to describe fishes and shrimps collected and to discuss the relations between *Nautilus,* shrimps and the oceanographic environmental factors in the present area.

Remarks on the Fauna Associated with *Nautilus*

Fishes (Plate 25)

The fishes trapped were classified into 10 families, 12 genera and 14 species (Table 1). Among them, seven species such as *Squalus japonicus, Conger japonicus, Etelis carbunculus, Lutjanus malabaricus, Pristipomoides argyrogrammicus, Epinephelus morrhua* and *Setarches guentheri* have been known to live in the Japanese waters and regarded to be the species with a wide distribution in the Pacific. The number of individuals of each species was rather small except for the species belonging to the genus *Pristipomoides.* There seemed to be no correlation in catch between *Nautilus* and any species of fish.

Crustaceans (Plates 26, 27)

The crustaceans, namely shrimps and crabs captured by trapping were classified into nine families, 13 genera and 19 species (Table 2). Among them 9 species being the half of them, such as *Aristaeus virilis, Penaeopsis eduardoi, Parapenaeus fissurus, Heterocarpus ensifer, H. gibbosus, H. sibogae, Plesionika martia, Calappa pustulosa* and *Charybdis miles* have been known to live in the Japanese waters and regarded to be the species having the vast distribution in the Pacific. In Table 3, the results of oceanographic observations at 21 trapping stations, ten of which were estimated from the data at the neighboring stations (for details *see* HAYASAKA *et al.*, 1985), and the catch of *Nautilus* and 12 species of shrimp in each station are shown.

Through the many years experience of trapping, the scientists at IMR have had an impression that there is a close relation of coexistence between *Nautilus* and shrimps in the present area. This was also felt strongly during 1983 field works and is understandable from Table 3. In other words, the existence of shrimps may be regarded as one of the biotic factors of the environment for *Nautilus*.

Fortunately, through the underwater still camera works performed by a member of the present project team (HATTORI, *et al.* 1985), a rather young *Nautilus* clinging to several shrimps gathering around the bait was clearly photographed. It can be seen in the picture that *Nautilus* opens its tentacles as if it were to catch the shrimps. This is a valuable evidence not only for coexistence of *Nautilus* and shrimps but also for feeding habit of *Nautilus*. Based on the results of analysis on esophagus and stomach contents (SAISHO and TANABE, 1985) and of the rearing experiment in the laboratory aquarium (KAKINUMA and TSUKAHARA, 1985), it was confirmed that nautili have been feeding on some kind of crustacea in nature. Therefore, nautili possibly chased some kind

Table 1. List and catch records of fishes collected by trapping for *Nautilus*.

Scientific name	Station (Number of specimens: Total length in cm)					Total
Scyliorhinidae						
1. Cephaloscyllium isabella Bonneterre	SV 9 (2: 60- 97)	SV11-1(1: 85)	SV13 (2: --)	PH 3 (1: 95)		6
Squalidae						
2. Squalus japonicus Ishikawa	SV14 (1: 57)					1
Congridae						
3. Conger japonicus Bleeker	SV 7 (1: 34)	SV14 (2: --)				3
4. Conger verreauxi Kaup	SV10 (1: 109)	SV11-2(2: 129-137)				3
Muraenesocidae						
5. Muraenesox bagio (Hamilton et Buchanan)	SV 1 (2: 88-103)	SV 4 (1: 88)				3
Moridae						
6. Physiculus sp.	SV 7 (2: 16- 20)	PH 4 (1: 30)	PH 6 (1: 31)			4
Anomalopidae						
7. Anomalops sp.	PH 3 (1: 4)					1
Lutjanidae						
8. Etelis carbunculus Cuvier	SV11-1(2: 59- 70)	SV11-2(1: 93)	SV13 (1: 59)	PH 2 (1: 69)	PH 5 (1: 63)	6
9. Lutjanus malabaricus (Bloch et Schneider)	SV 4 (1: 44)					1
10. Pristipomoides argyrogrammicus (Valenciennes)	SV 1 (12: 16- 23)	SV13 (1: 23)				13
Serranidae						
11. Epinephelus magniscuttis Costel, Fourmanoir et Gueze	SV 1 (1: 58)					1
12. Epinephelus morrhua (Valenciennes)	PH 2 (1: 56)					1
Ophidiidae						
13. Neobythites macrops Günther	SV 5 (1: 22)	SV13 (1: 24)				2
Scorpaenidae						
14. Setarches guentheri Johnson	PH 5 (1: 18)					1

Table 2. List and catch records of crustaceans (shrimps and crabs) collected by trapping for *Nautilus*.

Scientific name	Station and number of specimens (total weight)																					Total
	SV 1 no. g.	SV 3 no. g.	SV 4 no. g.	SV 5 no. g.	SV 6 no. g.	SV 7 no. g.	SV 8 no. g.	SV 9 no. g.	SV 10 no. g.	SV11-1 no. g.	SV11-2 no. g.	SV12-1 no. g.	SV12-2 no. g.	SV 13 no. g.	SV 14 no. g.	PH 1 no. g.	PH 2 no. g.	PH 3 no. g.	PH 4 no. g.	PH 5 no. g.	PH 6 no. g.	
Aristeidae																						
1. Aristaeus virilis (Bate)		2(32)		2(30)			6(-)				2(50)	1(16)										13
Penaeidae																						
2. Penaeopsis eduardoi Pérez-Farfante								1(6)		2(24)												3
3. Parapenaeus fissurus (Bate)					1(9)											2(14)						3
Oplophoridae																						
4. Acanthephyra armata A. Milne Edwards		1(30)					1(-)															2
Pandalidae																						
5. Heterocarpus ensifer A. Milne Edwards						13(78)			11(64)							27(116)	24(39)	2(8)	22(100)			99
6. Heterocarpus gibbosus Bate				14(131)			14(157)	56(877)		3(26)	27(444)	19(354)	81(1281)	1(26)	1(18)			22(294)		36(469)	10(157)	284
7. Heterocarpus laevigatus Bate		10(286)					12(300)	14(422)														36
8. Heterocarpus sibogae De Man		68(580)		217(1150)		32(338)	77(800)	59(585)	22(247)	116(1193)	262(2279)	157(1181)	290(2560)	264(2227)	216(1962)			321(2678)	46(458)	443(3205)	291(2547)	2881
9. Plesionika ensis A. Milne Edwards		1(-)					1(6)			7(31)		1(4)				9(52)			1(8)	7(50)	2(22)	29
10. Plesionika longirostris (Borradaile)			2(14)		31(245)	16(131)	1(10)		57(359)	1(10)						98(618)	69(281)		44(314)		26(210)	345
11. Plesionika martia (A. Milne Edwards)		5(33)			1(12)				1(6)									1(8)				8
12. Parapandalus serratifrons Borradaile			14(38)		7(75)	1(10)			2(8)	1(4)				6(23)	4(11)		5(12)		12(37)			52
Nephropidae																						
13. Nephropid lobster											1(30)										1(17)	2
Calappidae																						
14. Calappa pustulosa Alcock			1(-)																			1
Geryonidae																						
15. Geryon quiquedens Smith																		1(1560)				1
16. Geryonid crab						1(50)			1(22)												1(-)	3
Portunidae																						
17. Charybdis miles De Haan			3(100)																			3
18. Charybdis sp.					1(7)																	1
Xanthidae																						
19. Xanthid crab	1(-)		2(-)		2(86)											5(237)						10

Table 3. Source data of oceanographic conditions and number of shrimps collected with *Nautilus*. DEPTH: water depth, WTEMP: water temperature, SALIN: salinity, DO: dissolved oxygen, HSIB: *Heterocarpus sibogae*, HENS: *H. ensifer*, HGIB: *H. gibbosus*, HLAEV: *H. laevigatus*, PMAR: *Plesionika martia*, PENS: *P. ensis*, PLONG: *P. longirostris*, AVIRI: *Aristaeus virilis*, PSERRA: *Parapandalus serratifrons*, PFISS: *Parapenaeus fissurus*, PEDUA: *Penaeopsis eduardoi*, AARMA: *Acanthephyra armata*, NAUTI: *Nautilus pompilius*.

Station	Date	DEPTH fm (m)	WTEMP	SALIN	DO	HSIB	HENS	HGIB	HLAEV	PMAR	PENS	PLONG	AVIRI	PSERRA	PFISS	PEDUA	AARMA	NAUTI
SV 1	Aug. 30	150(275)	19.0	33.90	6.25	0	0	0	0	0	0	0	0	0	0	0	0	4
SV 3	Aug. 30	350(640)	7.4	31.60	6.40	68	0	0	10	5	1	0	2	0	0	0	1	0
SV 4	Aug. 30	100(180)	22.5	34.15	6.50	0	0	0	0	0	0	2	0	14	0	0	0	0
SV 5	Aug. 30	250(460)	10.2	33.34	6.05	217	0	14	0	0	0	0	2	0	0	0	0	7
SV 6	Sep. 1	130(240)	20.5	33.98	6.30	0	0	0	0	1	0	31	0	7	1	0	0	1
SV 7	Sep. 1	200(365)	14.5	33.74	5.85	32	13	0	0	0	0	16	0	1	0	0	0	1
SV 8	Sep. 1	300(550)	8.1	32.70	6.65	77	0	14	12	0	1	1	6	0	0	0	1	2
SV 9	Sep. 2	250(460)	10.2	33.34	6.05	59	0	56	14	0	0	0	0	0	0	1	0	8
SV10	Sep. 2	180(330)	16.4	33.82	6.10	22	11	0	0	1	0	57	0	2	0	0	0	6
SV11-1	Sep. 2	230(420)	11.8	33.53	5.75	116	0	3	0	0	7	1	0	1	0	2	0	10
SV11-2	Sep. 27	230(420)	11.8	33.53	5.75	262	0	27	0	0	0	0	2	0	0	0	0	17
SV12-1	Sep. 9	250(460)	10.2	33.34	6.05	157	0	19	0	0	1	0	1	0	0	0	0	7
SV12-2	Sep. 27	250(460)	10.2	33.34	6.05	290	0	81	0	0	0	0	0	0	0	0	0	14
SV13	Sep. 9	230(420)	11.8	33.53	5.75	264	0	1	0	0	0	0	0	6	0	0	0	19
SV14	Sep. 9	210(385)	13.4	33.67	5.85	216	0	1	0	0	0	0	0	4	0	0	0	5
PH 1	Sep. 20	180(330)	16.4	33.82	6.10	0	27	0	0	0	9	98	0	0	2	0	0	2
PH 2	Sep. 20	140(255)	19.8	33.93	6.25	0	24	0	0	0	0	69	0	5	0	0	0	1
PH 3	Sep. 21	250(460)	10.2	33.34	6.05	321	2	22	0	1	0	0	0	0	0	0	0	14
PH 4	Sep. 21	210(385)	13.4	33.67	5.85	46	22	0	0	0	1	44	0	12	0	0	0	16
PH 5	Sep. 22	230(420)	11.8	33.53	5.75	443	0	36	0	0	7	0	0	0	0	0	0	10
PH 6	Sep. 22	255(465)	9.6	33.23	6.20	291	0	10	0	0	2	26	0	0	0	0	0	19
Mean		217.857	13.295	33.478	6.074	137.190	4.714	13.524	1.714	0.381	1.381	16.429	0.691	2.476	0.143	0.143	0.095	7.762
S.D.		56.454	4.166	0.524	0.251	131.053	8.773	20.964	4.244	1.090	2.645	27.413	1.396	4.043	0.467	0.467	0.294	6.339
Total number of animals						2881	99	284	36	8	29	345	13	52	3	3	2	163

of shrimps as their food, resulting in their sympatric distribution.

On the occasion of trapping *Nautilus* carried out in the Philippines, shrimps captured together with *Nautilus* were very few (HAYASAKA *et al.*, 1982) because of the wide openings of traps (30-mm mesh) through which shrimps could easily escape. This was also endorsed by the observation that the contemporaneous catch by the traps with 10-mm mesh gave several specimens of shrimps (*Parapandalus* sp.) together with *Nautilus*.

Such being the case, the writers tried to analyze statistically the correlation between the catch of *Nautilus*, of shrimps and the oceanographic environmental factors in the present area.

Correlation Analysis between the Catch of *Nautilus* and the Oceanographic and Biotic Factors.

Based on the data obtained through the 1983 field work, the writers performed the statistical analysis on the correlations of the number of captured *Nautilus* to the four oceanographic factors, water depth, water temperature, dissolved oxygen (DO) and salinity (HAYASAKA *et al.*, 1985), and to the number of captured shrimps (12 species) at each station. The data analysis between the number of captured *Nautilus* and the environmental factors mentioned above were performed according to the single correlation and multiple regression techniques using a small type computer (NEC PC-9801).

Simple correlation analysis

Correlation analysis was practiced between *Nautilus* and the 16 factors including the four oceanographic factors and the biotic factors represented by the catch of 12 species of shrimps. In Table 4, the simple correlations based on the combination of these two variables are shown.

The following 9 combinations showed very high correlations, namely, depht of water vs. water temperature, depth of water vs. salinity, water temperature vs. salinity, salinity vs. *P. martia*, salinity vs. *A. armata*, *H. ensifer* vs. *P. longirostris*, *H. laevigatus* vs. *A. armata*, *P. longirostris* vs. *P. fissurus*, and *A. virilis* vs. *A. armata*.

The correlations of DO (-0.58) and water temperature (-0.46) were rather high in the number of captured *Nautilus*, but low in the water depth (0.29). On the other hand, *H. sibogae* (0.69) had the highest correlation (Fig. 2), while *H. gibbosus* (0.36) and *A. armata* (-0.35) had lower.

From these facts it was strongly suggested that the coexistance of *Nautilus* and *H. sibogae* might be very common in the present areas.

Multiple regression analysis

The multiple regression equation obtained from a stepwise procedure was:

$$Y = -0.771X_1 - 8.086X_2 - 26.758X_3 - 10.339X_4 + 1241.880 \qquad (1)$$
$$(R = 0.8056,\ R^2 = 0.6490)$$

where, Y is the number of captured *Nautilus*, X_1 the water depth, X_2 the water temperature, X_3 the DO value, R the multiple regression coefficent and R^2 the determining coefficient. The correspondence of the actual and estimated values of the number of captured *Nautilus* based on the Eq. (1) was not good ($R^2 = 0.6490$). The value of R^2 indicated that the estimated values could

Table 4. Single correlations of 17 variables, as shown in Table 3.

	DEPTH	WTEMP	SALIN	DO	HSIB	HENS	HGIB	HLAEV	PMAR	PENS	PLONG	AVIRI	PSERRA	PFISS	PEDUA	AARMA	NAUTI
DEPTH	1	-.96833	-.90443	-.04933	0.44661	-.35073	0.34195	0.54795	0.43887	0.04532	-.42372	0.53025	-.58181	-.29572	0.10202	0.61575	0.29731
WTEMP		1	0.77432	0.20367	-.57525	0.37245	-.43839	-.44336	-.23343	-.06249	0.45571	-.45212	0.59498	0.32862	-.14909	-.43184	-.45859
SALIN			1	-.25926	-.19432	0.32368	-.15648	-.64333	-.72399	0.02471	0.35386	-.56827	0.44038	0.23131	-.00640	-.82233	-.00749
DO				1	-.48951	-.05746	-.15531	0.43997	0.32364	-.24316	0.09817	0.46061	0.11318	0.11327	-.27301	0.58320	-.58005
HSIB					1	-.46677	0.49836	-.21479	-.13818	0.11874	-.47428	-.01834	-.35428	-.32053	-.09390	-.16015	0.68815
HENS						1	-.33526	-.21705	-.12307	0.26323	0.88677	-.23821	0.23342	0.46368	-.16453	-.17434	-.19817
HGIB							1	0.24894	-.17961	-.05684	-.36365	0.01495	-.38781	-.19752	0.10432	-.10096	0.36107
HLAEV								1	0.37348	-.11755	-.23715	0.56011	-.24739	-.12367	0.21299	0.70983	-.25387
PMAR									1	-.09987	-.06921	0.15790	-.11680	-.01338	-.10701	0.63071	-.28321
PENS										1	0.33462	-.11540	-.23514	0.53464	0.38031	-.04672	-.01163
PLONG											1	-.25820	0.16960	0.66165	-.17605	-.18852	-.22303
AVIRI												1	-.27151	-.13573	-.13573	0.78550	-.18239
PSERRA													1	0.01082	-.13705	-.19872	0.07919
PFISS														1	-.09375	-.09934	-.29442
PEDUA															1	-.09934	0.07590
AARMA																1	-.34610
NAUTI																	1

Remarks

confidence level of correlation coefficient (r)

0.434=r at P=0.05, N=21

0.549=r at P=0.01, N=21

__________ : r is significant at 99% confidence level

---------- : r is significant at 95% confidence level but not significant at 99% level

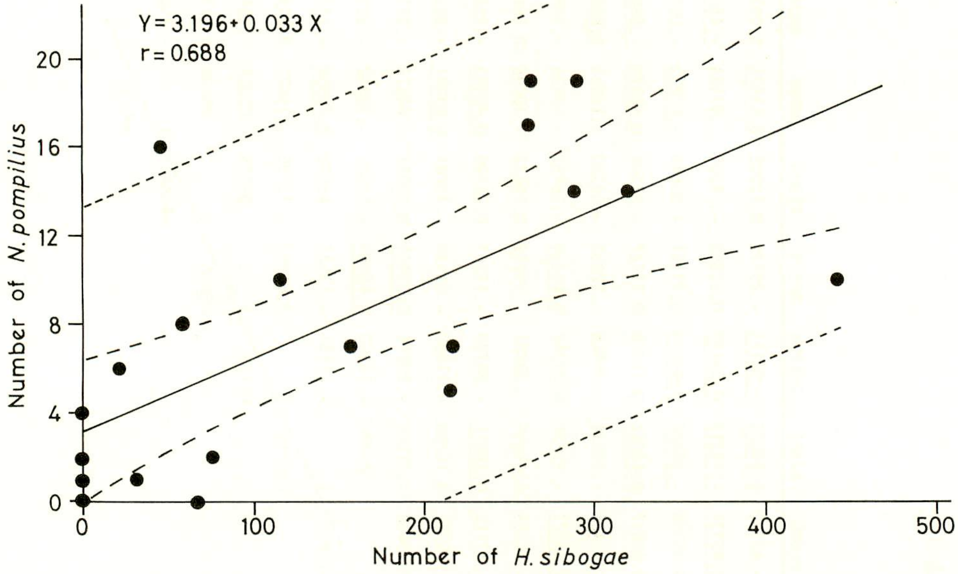

Fig. 2. Double scatter diagram showing the relationship between the numbers of *N. pompilius* and *H. sibogae* collected. The 95 % confidence interval of estimated values expressed by the line (— — — —) and that of actual values by the line (-----).

account for 64.9 % of the flucations of the actually observed values.

The multiple regression analysis was practiced with the biotic factors related to the number of captured shrimps as the explaining variables. The result was:

$$Y = 0.053X_1 + 0.092X_2 - 0.011X_3 + 0.013X_4 - 0.511X_5 - 1.122X_6 + 0.079X_7 + 0.095X_8 + 0.251X_9 + 0.849X_{10} + 6.272X_{11} + 0.157X_{12} - 1.084 \quad (2)$$
$$(R = 0.8152,\ R^2 = 0.6646)$$

where, Y is the same as in the Eq. (1) and X_1 to X_{12} the number of captured shrimps (12 species). The determining coefficent R^2 was 0.6646, and this value was not much different from the one in Eq. (1).

Further, the authors tried to make the multiple regression analysis based on the combination of the environmental factors, oceanographic and biotic. Through the six kinds of the multiple regression analysis on the 12 biotic factors and two of four oceanographic factors, it was made clear that the following combination gives the highest determining coefficient:

$$Y = -1.108X_1 - 0.922X_2 + 0.023X_3 - 0.194X_4 - 0.001X_5 - 0.279X_6 - 1.327X_7 - 0.661X_8 + 0.128X_9 - 0.600X_{10} + 0.543X_{11} - 0.265X_{12} + 2.701X_{13} - 2.960X_{14} + 49.935 \quad (3)$$
$$(R = 0.8738,\ R^2 = 0.7635)$$

Where, Y is the number of captured *Nautilus*, X_1 the temperature, X_2 the salinity and X_3 to X_{14} the number of captured shrimps (12 species). The determining coefficient ($R^2 = 0.7635$) in this case was higher than those of Eqs. (1) and (2); 76 % of the fluctuation of the number of *Nautilus* captured could be explained from Eq. (3).

The multiple regression analysis on the 14 factors, 4 oceanographic and 10 of 12 biotic factors was as follows:

$$Y = -0.247X_1 - 3.082X_2 - 12.796X_3 - 10.385X_4 + 0.010X_5 - 0.386X_6 + 0.024X_7 - 0.216X_8 - 1.530X_9 - 0.379X_{10} + 0.183X_{11} + 0.513X_{12} - 1.727X_{13} - 1.854X_{14} + 591.831 \quad (4)$$

$$(R = 0.8773,\ R^2 = 0.7697)$$

where, Y is the number of captured *Nautilus*, X_1 the depth, X_2 the temperature, X_3 the salinity, X_4 the DO and X_5 to X_{14} the number of shrimps belonging to 10 species excluding *A. virilis* and *P. eduardoi*. The value of the determining coefficient ($R^2 = 0.7697$) was slightly higher than that of Eq. (3); 77 % of the fluctuation of the number of *Nautilus* captured could be explained from Eq. (4).

Similarly in Eq. (4), where the 4 oceanographic and 10 biotic factors were combined, there were 66 sets of calculations according to how to select 10 of 12 biotic factors. To check the difference between the values of determining coefficients resulting from the different combinations of shrimp species, the multiple regression analysis was made on the 10 species except for the two of the lowest single correlation coefficients with the number of *Nautilus* captured and the 4 oceanographic factors. It was also done the 10 species other than the two which had the highest single correlation coefficients and the four oceanographic factors. These analyses showed that the difference in determining coefficient between the above two cases undertaken was as small as 0.006. This suggests that even in other cases on the combinations of factors mentioned above the determining coefficients must be little different from those obtained from Eq. (4).

As the results of the multiple regression analyses, it was made clear that the combination of the oceanographic factors and the biotic ones represented by the number of shrimps captured about 80 % of the fluctuation of the number of *Nautilus* captured could be explained. However, the determining coefficients might not be influenced by any particular factors of the oceanographic and biotic, but the fluctuation of the number of captured *Nautilus* must be explained by some collective function of the environmental factors.

The unexplainable 20 % on the fluctuation of the number of *Nautilus* seemed to have a relation to some other factors such as the sediments, current, and topography of the bottom, or the biotic factors other than shrimps.

Concluding Remarks

The close correlation between captures of *Nautilus* and shrimps was clarified through the present study. However, further investigation should be made on the predatory relationship between the two types of animals and their detailed modes of occurrence in the natural habitat, as well as on the unexplained fluctuation of the number of captured *Nautilus* related to some other environmental factors.

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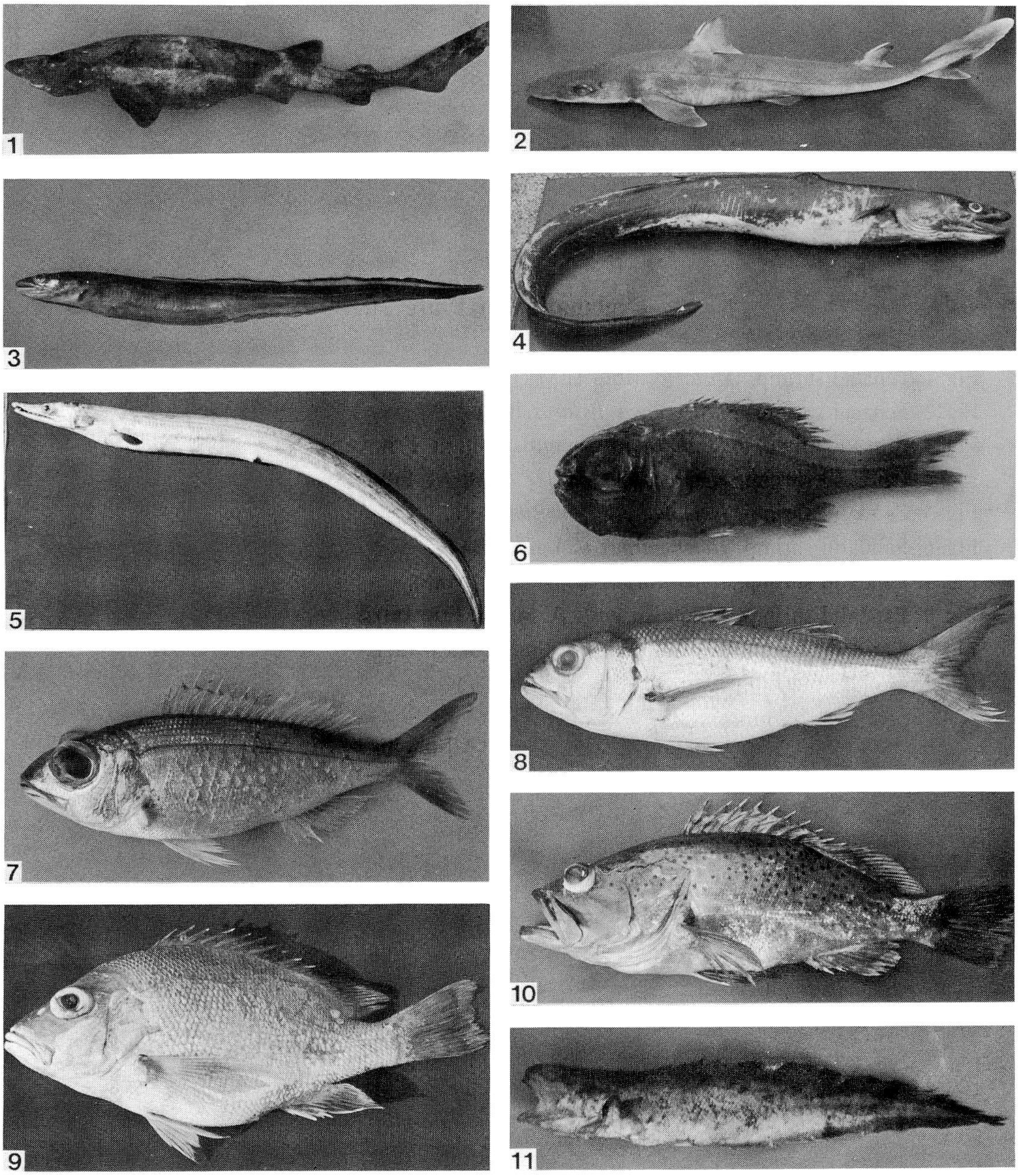
Plates 25-27

Explanation of Plate 25

(Total lengths are in parentheses.)

Fig. 1. Cat shark, *Cephaloscyllium isabella* BONNETERRE (95 cm).
Fig. 2. Dogfish shark, *Squalus japonicus* ISHIKAWA (57 cm).
Fig. 3. Conger eel, *Conger japonicus* BLEEKER (34 cm).
Fig. 4. Conger eel, *Conger verreauxi* KAUP (137 cm).
Fig. 5. Pike eel, *Muraenesox bagio* (HAMILTON et BUCHANAN) (88 cm)
Fig. 6. Lanterneye fish, *Anomalops* sp.
Fig. 7. Snapper, *Pristipomoides argyrogrammicus* (VALENCIENNES) (23 cm).
Fig. 8. Snapper, *Etelis carbunculus* CUVIER (63 cm).
Fig. 9. Snapper, *Lutjanus malabaricus* (BLOCH et SCHNEIDER) (44 cm).
Fig. 10. Grouper, *Epinephelus magniscuttis* COSTEL, FOURMANOIR et GUEZE (58 cm).
Fig. 11. Cusk-eel, *Neobythites macrops* GÜNTHER (24 cm).

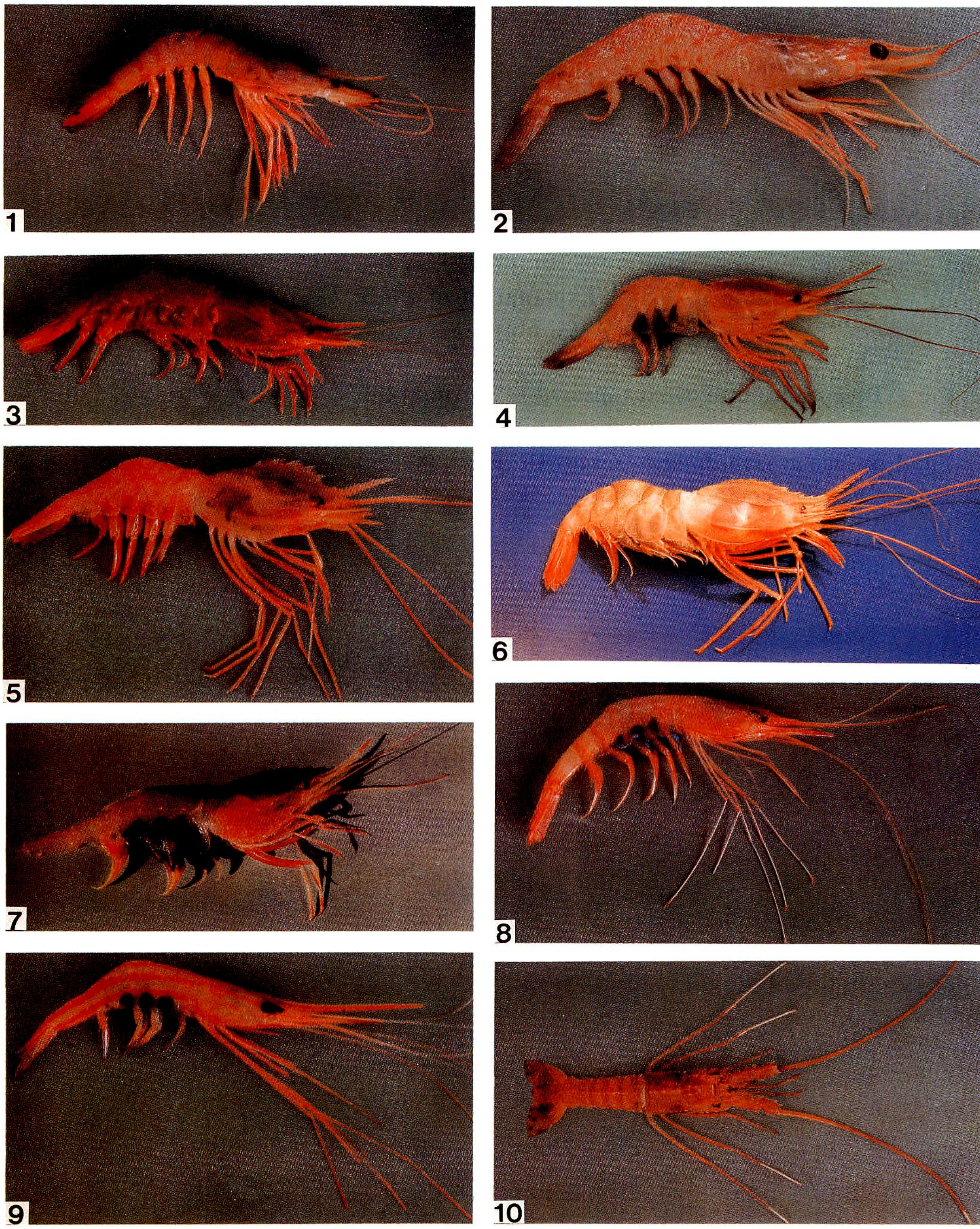
(All photos by Mr. SARAN SINGH)



Explanation of Plate 26

Fig. 1. Penaeid shrimp, *Aristaeus virilis* (BATE).
Fig. 2. Penaeid shrimp, *Parapenaeus fissurus* BATE.
Fig. 3. Peaked shrimp, *Acanthephyra armata* A. MILNE EDWARDS.
Fig. 4. Pandalid shrimp, *Heterocarpus ensifer* A. MILNE EDWARDS.
Fig. 5. Pandalid shrimp, *Heterocarpus gibbosus* BATE.
Fig. 6. Pandalid shrimp, *Heterocarpus laevigatus* BATE.
Fig. 7. Pandalid shrimp, *Heterocarpus sibogae* DE MAN.
Fig. 8. Pandalid shrimp, *Plesionika ensis* A. MILNE EDWARDS.
Fig. 9. Carid shrimp, *Parapandalus serratifrons* BORRADAILE.
Fig. 10. Nephropid lobster.

(All photos by Mr. SARAN SINGH)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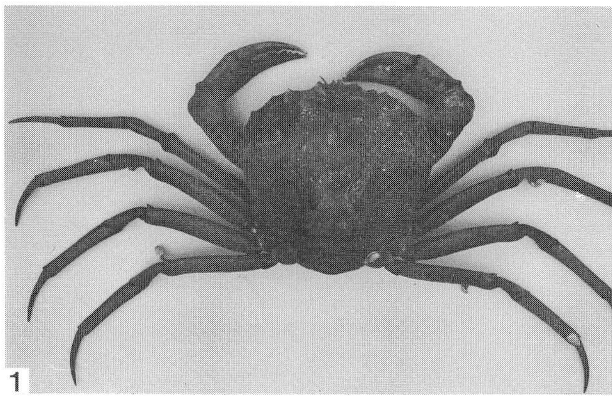
Explanation of Plate 27

(Carapace lengths are in parentheses.)

Fig. 1. Deep-sea red crab, *Geryon quiquedens* SMITH (17 cm).
Fig. 2. Geryonid crab.
Fig. 3. Swimming crab, *Charybdis miles* DE HAAN (8.5 cm).
Fig. 4. Swimming crab, *Charybdis* sp.
Fig. 5. Xanthid crab.

(All photos by Mr. SARAN SINGH)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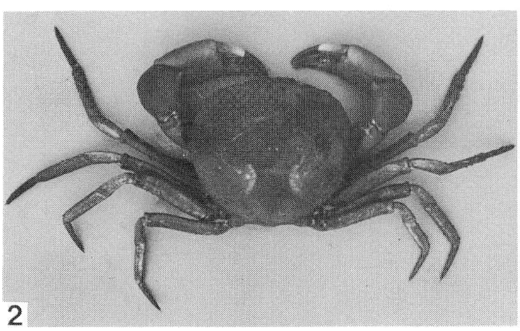
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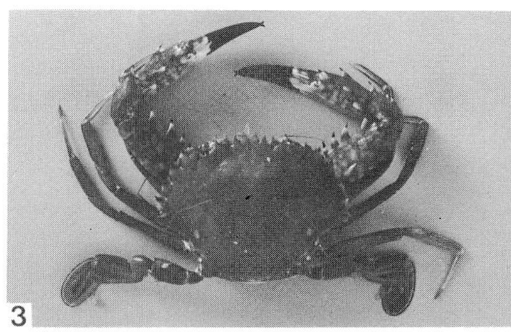
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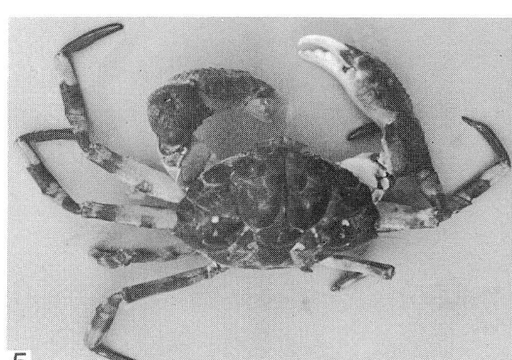
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