Record of Trapping Experiment

Trapping experiment was the main body of the field work providing the data fundamental for all the studies planned in the present project. The details of trapping carried out in the Suva and the Pacific Harbour areas during the period from August 30 to September 27, 1983 are described in this section.

Locations and Methods

Trapping experiments were made in the waters off Suva Harbour (Kandavu Passage) and off Pacific Harbour (Mbengga Passage), Viti Levu Island. As shown in Fig. 5, the trapping stations are all situated outside of barrier reefs. The submarine topography near the trapping stations in each area is characterized by an abruptly dropping scarp off Suva and by a narrow submarine channel off Pacific Harbour.

Bottom animals including *Nautilus* were captured in three kinds of single or double entry traps, namely, 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) traps (see Pl. 2, figs. 2-3). They were deviced by the staff of the Institute of Marine Resources of the University of the South Pacific. Whole bodies of frozen sardine ("Salala" in Fijian language) or small tuna were used as bait. They were suspended from the top of each trap before putting in the water. The baited traps were settled on the bottom as a set of five to seven (two large, two or three medium, and one or two small traps) in a line and attached to a surface

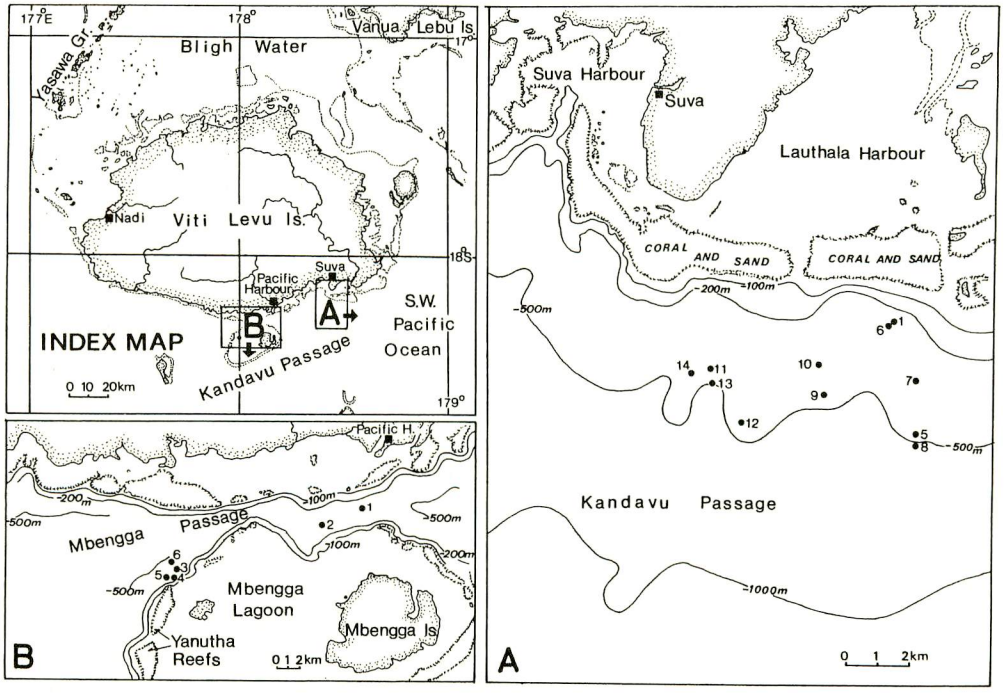


Fig. 5. Maps of the Suva and the Pacific Harbour areas, Viti Levu Island, Fiji, showing the sampling locations of *Nautilus pompilius*.

buoy with a floating line (Fig. 6). In addition, two dredge samplers were connected with two marginal traps to collect samples for grain-size analysis of bottom substrates and study on foraminifera. They were settled on the bottom in the daytime, and drawn up in the next morning. Trapping locations and their depths were determined accurately by a radar and an echo-sounder on the "Aphareus".

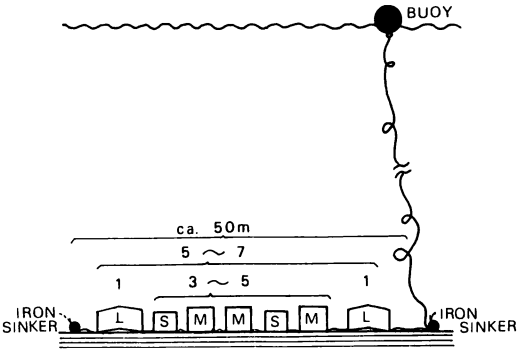


Fig. 6. Style of lining for trapping experiments.

Basic Data of *Nautilus* Captured

As shown in the catch records (Tables 1-2), our trapping experiments have been carried out at various depths between 180-640 m in the Suva and Pacific Harbour areas. As a result, 163 individuals of *Nautilus pompilius* were captured. In the study areas living *Nautilus* occur rather abundantly in depths between 360-470 m but the number of animals captured is not large in depths shallower than 300 m and deeper than 470 m. Furthermore, no *Nautilus* was sampled from Stations SV-4 (180 m) and SV-3 (640 m). According to the catch record in the Suva area during July-August, 1976 by WARD *et al.* (1977), no living *Nautilus* were found from the waters deeper than 550 m and shallower than 75 m. Our data match well with those of WARD *et al.* (1977), especially on the deepest capture.

Following capture, each nautilus was labeled, weighed, sexed and measured. Determination of sexes was based on the presence of primary reproductive organs such as testis and ovary. Several accessory organs (e. g. spadix in mature males and nidamental gland in females; HAYASAKA *et al.*, 1982, p. 100) were also used for sex identification. Maximum shell diameter and apertural whorl breadth and height were measured for each specimen with an aid of a slide caliper (0.05 mm accuracy). Except for the specimen PH-4-11, every live animal was weighed by means of a dial scale (5 g accuracy) at IMR. Basic biological data of the specimens captured are summarized in Tables 3 and 4. Among them, 58 individuals from the Suva area and 11 ones from the Pacific Harbour area had kept alive in glass water tanks in an air conditioning room at IMR for several days to observe their behaviours in captivity, and thereafter, they were tagged and released at a point near SV-7 for a long-term growth analysis under natural conditions. Among the remaining 104 specimens twelve living ones (SV-8-1, 8-2, 11-20, 12-11, 12-18, 13-15, PH-3-5, 3-11, 3-12, 3-14, 6-10 and 6-12) were transported to Kagoshima by air for further detailed

Table 1. Catch record and depth distribution of *Nautilus pompilius* from off Suva Harbour, Viti Levu island, the Fiji Islands during August to September, 1983 (Stations are arranged in order of depth).

Station no.	Depth (m)	Date	Number of traps	Number of *Nautilus*	Number of animals per trap
SV- 4	180	Aug. 30-31	6	0	0
SV- 6	240	Aug. 31-Sep. 1	6	1	0.17
SV- 1	275	Aug. 29-30	7	4	0.57
SV-10	330	Sep. 1-2	5	6	1.20
SV- 7	365	Aug. 31-Sep. 1	5	1	0.20
SV-14	385	Sep. 8-9	5	5	1.00
SV-11	420	Sep. 1-2	5	10	2.00
		Sep. 26-27	5	17	3.40
SV-13	420	Sep. 8-9	5	19	3.80
SV- 5	460	Aug. 30-31	5	7	1.40
SV- 9	460	Sep. 1-2	5	8	1.60
SV-12	460	Sep. 8-9	5	7	1.40
		Sep. 26-27	5	14	2.80
SV- 8	550	Aug. 31-Sep. 1	5	2	0.40
SV- 3	640	Aug. 29-30	7	0	0

Table 2. Catch record and depth distribution of *Nautilus pompilius* from off Pacific Harbour, Viti Levu island, the Fiji Islands in September, 1983 (Stations are arranged in order of depth).

Station no.	Depth (m)	Date	Number of traps	Number of *Nautilus*	Number of animals per trap
PH-2	255	Sep. 19-20	6	1	0.17
PH-1	330	Sep. 19-20	5	2	0.40
PH-4	385	Sep. 20-21	5	16	3.20
PH-5	420	Sep. 21-22	5	10	2.00
PH-3	460	Sep. 20-21	6	14	2.33
PH-6	465	Sep. 21-22	5	19	3.80

Table 3. Biological data of *Nautilus pompilius* captured from off Suva Harbour, Viti Levu island, the Fiji Islands (August-September, 1983).

Specimen	Sex	Weight (g)			Shell size (mm)			Form ratios			Associated animals
		Total	Tissue	Shell	D	B	H	B/D	H/D	B/H	
SV- 1- 1*	M	480	---	---	138.8	69.7	89.5	.502	.645	.779	
SV- 1- 2*	M	490	---	---	138.5	69.8	89.5	.504	.646	.800	15 fishes
SV- 1- 3*	M	600	---	---	152.4	71.0	101.0	.466	.663	.703	3 crabs
SV- 1- 4*	M	540	---	---	146.4	72.7	97.7	.497	.667	.744	
SV- 5- 1*	M	310	---	---	118.2	63.2	75.5	.535	.639	.837	
SV- 5- 2*	M	450	---	---	134.5	71.1	90.0	.529	.669	.790	
SV- 5- 3	F	400	276	112	131.6	65.4	87.4	.497	.664	.748	1 fish
SV- 5- 4	M	610	---	---	137.9	75.6	96.7	.548	.701	.782	216 shrimps
SV- 5- 5*	M	450	---	---	131.1	70.1	87.0	.535	.664	.806	
SV- 5- 6*	M	590	---	---	153.8	75.8	98.8	.493	.642	.767	
SV- 5- 7	M	210	149	61	104.5	54.6	67.3	.522	.644	.811	
SV- 6- 1	M	545	408	137	150.0	75.1	101.3	.501	.675	.741	5 fishes 39 shrimps 3 crabs
SV- 7- 1	M	495	366	129	134.8	69.8	86.7	.518	.643	.805	3 fishes 62 shrimps 1 crab
SV- 8- 1	F	540	---	---	147.1	70.6	98.1	.480	.667	.720	112 shrimps
SV- 8- 2	F	480	---	---	143.6	65.8	91.7	.458	.639	.718	
SV- 9- 1*	M	650	---	---	153.5	79.3	101.4	.517	.661	.782	
SV- 9- 2*	F	610	---	---	148.5	75.9	96.3	.511	.648	.788	
SV- 9- 3*	M	560	---	---	146.8	73.2	97.2	.499	.662	.753	
SV- 9- 4*	F	470	---	---	137.4	67.5	89.4	.491	.651	.755	2 fishes
SV- 9- 5*	M	610	---	---	154.0	75.1	100.6	.488	.653	.747	130 shrimps
SV- 9- 6*	M	430	---	---	142.5	68.7	92.3	.482	.648	.744	
SV- 9- 7*	M	560	---	---	148.2	77.0	97.9	.520	.661	.787	
SV- 9- 8*	M	580	---	---	151.6	73.2	101.0	.483	.666	.725	
SV-10- 1*	M	580	---	---	147.6	71.6	93.7	.485	.635	.764	
SV-10- 2*	M	580	---	---	147.6	72.6	96.3	.492	.652	.754	1 fish
SV-10- 3*	F	370	---	---	122.5	66.5	80.0	.543	.653	.831	93 shrimps
SV-10- 4*	M	270	---	---	111.9	60.5	73.8	.541	.660	.820	1 crab
SV-10- 5*	M	420	---	---	128.3	69.8	81.9	.544	.638	.852	
SV-10- 6	?	170	125	45	96.8	51.5	63.1	.532	.652	.816	
SV-11- 1*	F	380	---	---	136.0	64.5	87.4	.474	.643	.738	
SV-11- 2*	M	480	---	---	142.3	74.7	92.4	.525	.649	.808	
SV-11- 3*	M	550	---	---	140.6	73.7	88.1	.524	.627	.837	
SV-11- 4*	M	500	---	---	140.3	72.0	91.8	.513	.654	.784	
SV-11- 5*	M	510	---	---	142.1	70.7	89.2	.498	.628	.793	
SV-11- 6*	M	460	---	---	138.5	73.4	90.4	.530	.653	.812	
SV-11- 7*	M	290	---	---	114.2	63.5	72.2	.556	.632	.880	
SV-11- 8*		450	---	---	136.4	68.9	87.0	.505	.638	.792	
SV-11- 9*	M	520	---	---	149.0	72.5	96.3	.487	.646	.753	
SV-11-10*	M	590	---	---	143.9	69.9	93.7	.486	.651	.746	
SV-11-11*	M	400	---	---	134.7	68.8	88.6	.511	.658	.777	
SV-11-12*	M	540	---	---	143.1	74.7	94.2	.522	.658	.793	
SV-11-13*	M	500	---	---	141.6	71.0	94.7	.501	.669	.750	
SV-11-14*	M	380	---	---	125.2	68.9	84.8	.550	.677	.813	8 fishes
SV-11-15*	M	460	---	---	136.1	68.6	91.4	.504	.672	.751	435 shrimps
SV-11-16*	M	275	---	---	116.5	59.5	72.5	.511	.622	.821	
SV-11-17*	M	560	---	---	144.5	70.8	95.1	.490	.658	.744	

Table 3. Continued.

Specimen	Sex	Weight (g)			Shell size (mm)			Form ratios			Associated animals
		Total	Tissue	Shell	D	B	H	B/D	H/D	B/H	
SV-11-18*	M	210	---	---	103.5	56.0	66.9	.541	.646	.837	
SV-11-19*	M	400	---	---	111.3	58.1	72.4	.522	.650	.802	
SV-11-20	F	400	---	---	125.5	69.1	88.6	.551	.706	.780	
SV-11-21*	M	520	---	---	147.8	71.0	98.2	.480	.664	.723	
SV-11-22	F	490	---	---	140.6	69.6	91.1	.495	.648	.764	
SV-11-23*	M	330	---	---	111.6	65.1	80.8	.583	.724	.806	
SV-11-25*	M	460	---	---	135.6	72.5	90.5	.535	.667	.801	
SV-11-26*	M	575	---	---	143.7	75.1	95.6	.523	.665	.786	
SV-11-27	M	625	---	---	151.6	76.7	102.7	.506	.677	.747	
SV-11-28*	M	420	---	---	128.4	69.2	86.1	.539	.671	.804	
SV-12- 1	F	430	313	117	135.6	64.2	82.2	.476	.606	.781	
SV-12- 2	M	470	357	113	141.4	68.0	92.0	.481	.651	.739	
SV-12- 3	F	280	197	83	118.4	63.0	77.1	.532	.651	.817	
SV-12- 4	M	570	425	145	148.1	75.0	94.1	.506	.635	.797	
SV-12- 5	M	510	387	123	143.7	69.7	91.0	.485	.633	.766	
SV-12- 6	M	490	373	117	136.8	75.8	88.8	.554	.649	.854	
SV-12- 7	F	260	176	84	114.1	62.1	74.1	.544	.649	.838	
SV-12- 8*	M	260	---	---	110.8	57.8	74.2	.522	.670	.779	
SV-12- 9*	M	550	---	---	143.7	70.4	94.4	.490	.657	.746	
SV-12-10*	M	425	---	---	130.7	71.5	88.6	.547	.678	.807	549 shrimps
SV-12-11	F	650	---	---	154.3	76.4	102.9	.483	.667	.742	
SV-12-12*	M	555	---	---	142.2	71.5	96.8	.503	.681	.739	
SV-12-13*	M	490	---	---	138.0	71.2	92.1	.516	.667	.773	
SV-12-14*	M	295	---	---	120.2	63.7	78.7	.530	.655	.809	
SV-12-15*	M	325	---	---	118.5	66.2	82.3	.559	.695	.804	
SV-12-16*	M	330	---	---	120.6	65.2	79.8	.541	.662	.817	
SV-12-17	M	445	---	---	139.1	69.7	91.0	.501	.645	.766	
SV-12-18*	M	645	---	---	150.5	75.5	103.4	.502	.687	.730	
SV-12-19*	M	180	---	---	102.9	55.1	67.8	.535	.659	.813	
SV-12-20*	M	470	---	---	135.1	71.8	89.1	.531	.660	.806	
SV-12-21*	M	355	---	---	125.1	67.8	82.2	.542	.657	.825	
SV-13- 1	M	460	346	114	139.7	68.6	89.6	.491	.641	.766	
SV-13- 2	M	490	371	119	138.6	70.5	89.5	.509	.646	.788	
SV-13- 3	F	450	323	115	139.0	65.2	92.0	.469	.662	.709	
SV-13- 4	F	250	175	75	112.4	60.5	71.9	.538	.640	.841	
SV-13- 5	M	450	300	150	138.0	72.0	90.3	.521	.654	.797	
SV-13- 6	M	560	400	125	145.4	75.1	97.2	.517	.669	.773	
SV-13- 7*	M	640	---	---	152.1	75.4	97.2	.496	.639	.776	
SV-13- 8	F	475	364	111	140.5	66.7	90.2	.475	.462	.739	
SV-13- 9	M	550	410	140	145.3	70.0	94.6	.482	.651	.740	
SV-13-10	M	480	355	125	148.9	74.7	97.4	.502	.654	.767	6 fishes
SV-13-11	M	470	350	120	139.2	69.4	89.8	.499	.645	.773	271 shrimps
SV-13-12	M	460	344	116	137.8	68.5	87.4	.497	.634	.784	
SV-13-13	M	560	413	147	149.4	73.8	96.1	.494	.643	.768	
SV-13-14	F	390	270	120	131.0	61.4	82.3	.469	.628	.746	
SV-13-15	M	580	---	---	150.8	74.7	99.1	.495	.657	.754	
SV-13-16	M	325	230	95	121.0	67.7	80.4	.560	.664	.842	
SV-13-17	M	340	---	---	122.3	69.6	81.2	.569	.664	.857	
SV-13-18	M	356	245	105	123.8	65.0	80.8	.525	.653	.804	
SV-13-19	M	430	304	126	137.6	71.3	87.0	.518	.632	.820	
SV-14- 1	F	460	298	116	135.4	65.2	87.4	.482	.645	.746	
SV-14- 2	M	480	348	132	137.5	72.9	88.6	.530	.644	.823	3 fishes
SV-14- 3	M	530	408	122	146.8	72.7	97.4	.495	.633	.746	221 shrimps
SV-14- 4	M	610	477	133	152.8	73.6	99.3	.482	.650	.741	
SV-14- 5	M	530	394	136	147.3	70.7	96.2	.480	.653	.735	

Remarks. Animals with an asterisk were tagged and released for growth analysis under natural conditions.

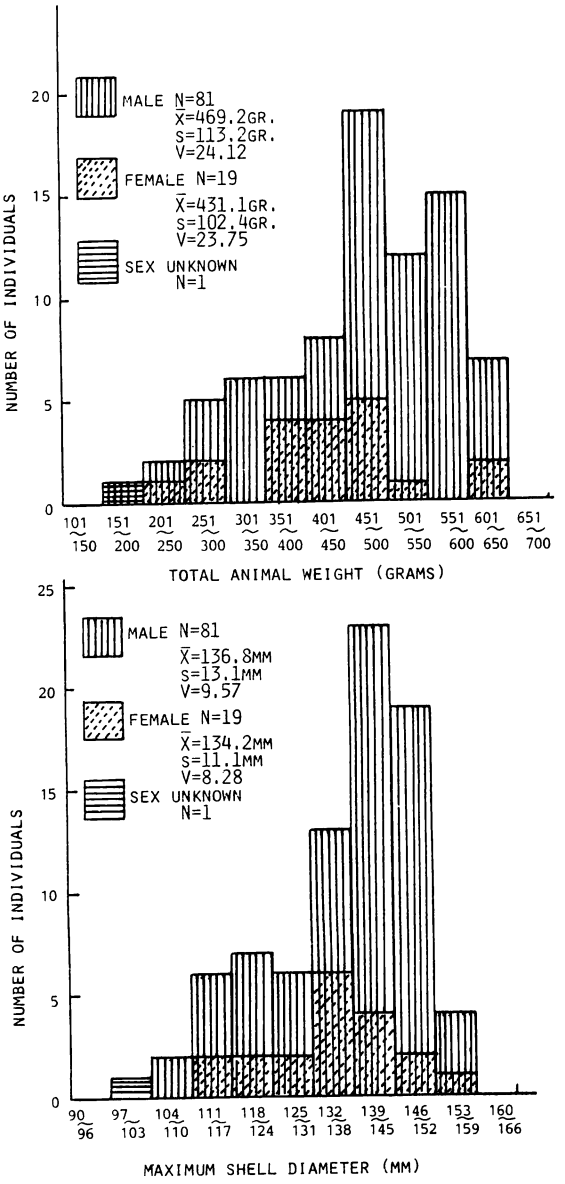


Fig. 7. Weigth and size distributions of the specimens of *N. pompilius* captured from the Suva area during Aug. 29-Sept. 9, 1983.

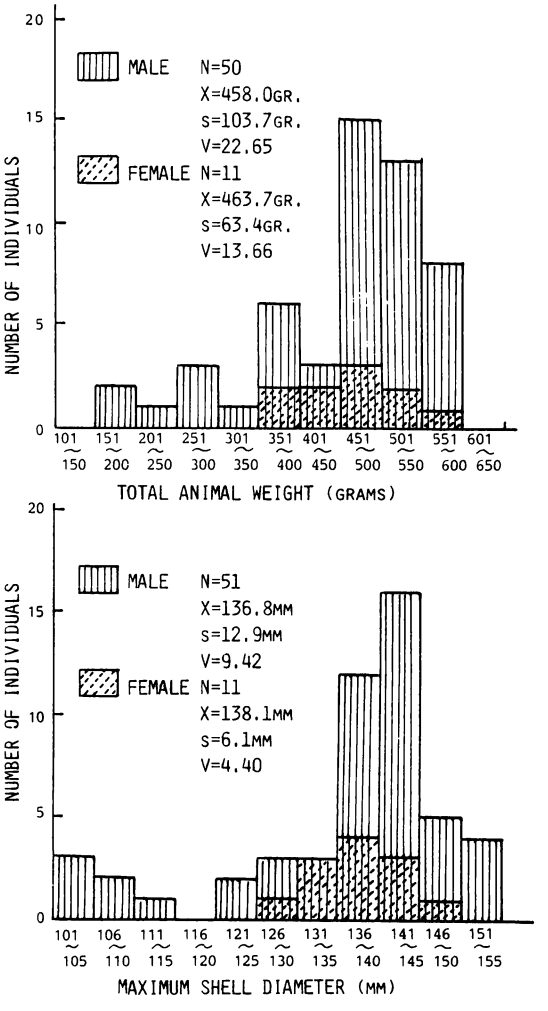


Fig. 8. Weight and size distributions of the specimens of *N. pompilius* captured from the Pacific Harbour area during Sept. 19-22, 1983.

Table 4. Biological data of *Nautilus pompilius* captured from off Pacific Harbour, Viti Levu island, the Fiji Islands (September, 1983).

Specimen	Sex	Weight (g)			Shell size (mm)			Form ratios			Associated animals
		Total	Tissue	Shell	D	B	H	B/D	H/D	B/H	
PH-1- 1	M	477	347	130	141.1	70.9	91.8	.502	.651	.772	4 fishes
PH-1- 2	M	360	225	135	136.6	72.2	89.8	.529	.657	.804	136 shrimps 5 crabs
PH-2- 1	F	360	247	113	130.9	67.2	83.8	.498	.637	.783	3 fishes 98 shrimps
PH-3- 1	M	365	258	107	131.4	65.5	83.7	.498	.637	.783	
PH-3- 2	M	435	319	116	136.6	68.8	87.1	.504	.638	.790	
PH-3- 3	M	540	395	145	145.8	75.0	94.2	.514	.646	.796	
PH-3- 4	M	475	339	136	142.6	71.4	91.8	.501	.644	.778	
PH-3- 5	F	515	---	---	149.2	71.1	91.8	.519	.648	.801	
PH-3- 6	M	525	---	---	144.4	74.9	93.5	.494	.660	.749	2 fishes
PH-3- 7	F	435	310	125	140.2	66.9	89.0	.517	.635	.814	346 shrimps
PH-3- 8	M	475	351	124	142.2	70.3	93.8	.494	.660	.749	1 crab
PH-3- 9	M	470	325	145	140.5	72.6	89.2	.517	.635	.814	
PH-3-10	M	405	292	113	137.6	67.8	90.4	.493	.657	.750	
PH-3-11	F	476	---	---	143.6	67.5	90.3	.470	.629	.748	
PH-3-12	M	596	---	---	150.2	73.8	96.8	.491	.644	.762	
PH-3-13	M	515	371	144	147.4	70.9	95.2	.481	.646	.745	
PH-3-14	M	510	---	---	146.6	71.9	97.1	.490	.662	.740	
PH-4- 1	M	515	393	122	141.0	72.0	87.9	.511	.623	.819	
PH-4- 2	M	380	256	124	130.9	69.8	87.3	.533	.667	.800	
PH-4- 3	M	480	346	134	142.9	70.9	92.4	.496	.647	.767	
PH-4- 4	M	365	250	115	127.5	67.7	84.8	.531	.665	.798	
PH-4- 5	M	470	355	115	139.3	70.3	93.1	.505	.668	.755	
PH-4- 6	M	577	453	124	140.2	73.4	91.1	.524	.650	.806	
PH-4- 7	M	517	385	132	144.5	70.9	92.8	.491	.642	.764	
PH-4- 8	M	470	343	127	138.3	67.4	89.6	.487	.648	.752	1 fish
PH-4- 9	F	562	440	122	138.9	68.4	89.7	.492	.646	.763	125 shrimps
PH-4-10	M	467	350	117	135.4	71.0	87.6	.524	.647	.811	
PH-4-11	M	---	---	125	131.6	72.5	84.3	.522	.638	.819	
PH-4-12	F	485	---	---	142.5	67.7	91.1	.475	.639	.743	
PH-4-13	M	505	367	138	143.4	74.9	91.5	.522	.638	.819	
PH-4-14	M	455	321	134	140.4	70.1	91.0	.499	.648	.770	
PH-4-15	M	275	190	85	113.5	61.3	72.9	.540	.642	.841	
PH-4-16	F	360	254	106	126.8	67.1	81.5	.529	.643	.823	
PH-5- 1*	M	295	---	---	122.9	67.1	80.2	.546	.653	.837	
PH-5- 2*	M	175	---	---	100.1	54.3	65.5	.542	.654	.829	
PH-5- 3*	M	315	---	---	107.5	66.4	77.6	.618	.722	.856	
PH-5- 4	M	560	440	120	145.4	70.2	94.4	.483	.649	.744	
PH-5- 5*	M	530	---	---	142.7	75.9	91.0	.532	.638	.834	2 fishes
PH-5- 6*	M	280	---	---	105.2	62.4	73.3	.593	.697	.851	486 shrimps
PH-5- 7*	M	220	---	---	110.0	57.5	96.3	.523	.630	.830	
PH-5- 8*	M	365	---	---	121.7	64.1	77.8	.527	.639	.824	
PH-5- 9	M	555	429	126	143.8	69.9	93.1	.486	.647	.751	
PH-5-10*	M	180	---	---	102.8	53.6	65.3	.521	.635	.821	

Table 4. Continued.

Specimen	Sex	Weight (g)			Shell size (mm)			Form ration			Associated animals
		Total	Tissue	Shell	D	B	H	B/D	H/D	B/H	
PH-6- 2	M	463	339	124	144.8	69.9	96.0	.483	.663	.728	
PH-6- 3	M	475	331	144	138.2	71.0	87.0	.514	.630	.816	
PH-6- 4	M	460	---	---	139.3	69.3	92.7	.497	.665	.748	
PH-6- 5	F	428	306	122	137.6	63.0	85.9	.458	.624	.733	
PH-6- 6	M	545	410	135	147.9	73.8	98.3	.499	.665	.751	
PH-6- 7	F	490	355	135	141.5	70.1	89.0	.495	.629	.788	
PH-6- 8	F	445	---	---	135.4	68.2	89.1	.504	.658	.765	
PH-6- 9	M	475	335	140	143.9	72.2	90.6	.502	.630	.797	4 fishes
PH-6-10	F	545	---	---	132.7	65.6	83.5	.494	.629	.786	329 shrimps
PH-6-11	M	515	390	125	141.8	72.3	91.4	.510	.645	.791	1 crab
PH-6-12	M	585	---	---	154.4	74.2	100.3	.481	.650	.740	
PH-6-13*	M	560	---	---	153.5	75.1	99.9	.489	.651	.752	
PH-6-14*	M	500	---	---	138.3	69.7	89.6	.504	.648	.780	
PH-6-15	M	565	430	135	150.7	73.7	98.3	.489	.652	.750	
PH-6-16*	M	500	---	---	137.7	72.8	86.9	.529	.631	.838	
PH-6-17	M	550	---	---	140.3	71.3	92.1	.508	.656	.774	
PH-6-18	M	560	443	117	141.4	73.1	95.1	.517	.673	.769	
PH-6-19	M	510	388	122	142.9	72.8	94.7	.509	.663	.769	

Remarks. Animals with an asterisk were tagged and released for growth analysis under natural conditions.

observation of behaviours (unfortunately, all animals have already died or been dying before arrival). Soft and shell parts of the remaining specimens were removed separately, and weighed. They were used for various laboratory works such as analyses of gonad development, stomach contents, genetic and morphological variation and oxygen isotope, etc. Cameral liquid in the last chamber of selected 22 specimens from the Suva area was extracted with a hypodermic syringe (0.05 ml accuracy) to analyze the oxygen isotope ratio and the relationship between cameral liquid volumes and the last septum thicknesses (TANABE *et al.* in this volume).

Sex Ratio and Size and Weight Distributions

Among the animals captured from off Suva Harbour the numbers of males and females are 81 (80.2 % to the total) and 19 (18.8 %) respectively. Similarly, in the water off Pacific Harbour, males (N = 50 ; 82.0 % to the total) were captured more abundantly than females (N = 11 ; 18.0 %). Only one unsexed young was collected from the Suva area. Concentration of a single sex at a location and a difference in the depth distribution between males and females were not observed in the areas studied (Tables 1-4).

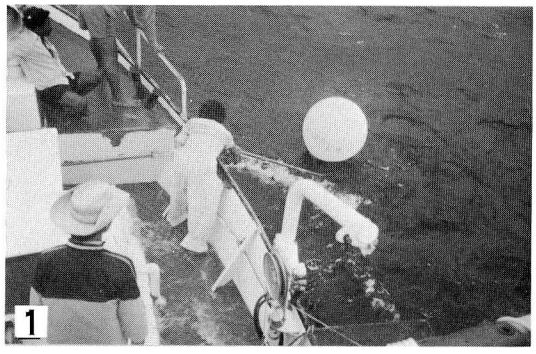
Size and weight distributions of the sample from the Suva area (Fig. 7) show that males are relatively larger and heavier than females. Alternatively, in the sample from off Pacific Harbour, mean values of total animal weight and shell size in females are slightly larger than those in males (Fig. 8). The reason for this appears to be the abundance of immature males of less than 125 mm in shell diameter in the latter sample.

(Kazushige TANABE)

Plate 2

Explanation of Plate 2

Fig. 1. Pulling the rope with buoy to haul up traps.
Fig. 2. A trap pulled up on board.
Fig. 3. Moving the trap astern.
Fig. 4. A nautilus and shrimps trapped.
Fig. 5. Five nautili, a shark and shrimps trapped.
Fig. 6. Measuring dimentions of *Nautilus* shells.
Fig. 7. Measuring weight of *Nautilus* specimens.
Fig. 8. Putting the collected nautili into a water tank installed on board.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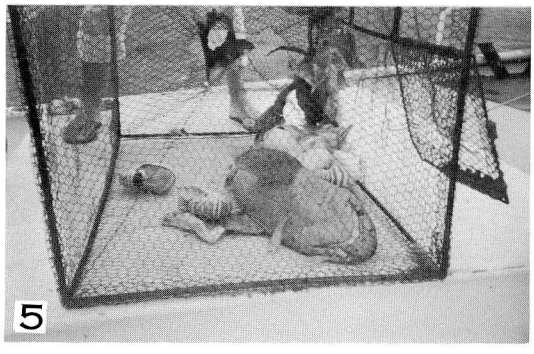
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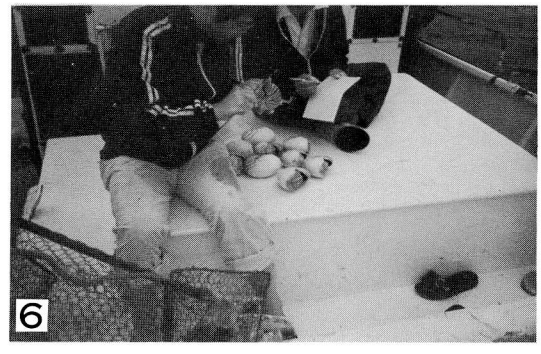
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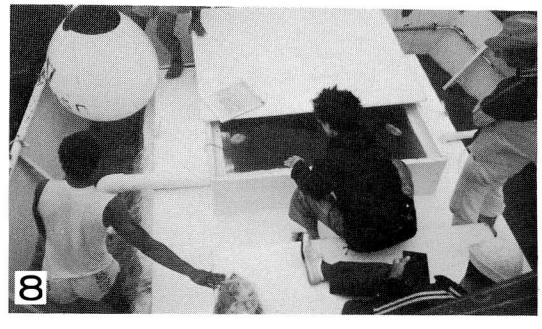
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