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Marking Methods for Japanese Surf Clams, *Pseudocardium sybillae**

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Abstract : Mark-release-recapture experiments with four methods for marking Japanese surf clams, *Pseudocardium sybillae* (VALENCIENNES), were carried out in the estuary of Lagoon Hūren-ko, east Hokkaido, in 1982-1983. The marking methods were varied in three ways of the double mark (individual marking : bonded label-paint, paper label-paint and tagged label-paint) and one way of the single mark (group marking : paint), and their efficacies were compared each other. The bonded label-paint mark was the most efficient method, however, both of the paper label-paint mark and the single paint mark were rather a little of efficient in their own ways and the tagged label-paint mark was unavailable.

Introduction

Mark-release-recapture experiments have been effectively applied for ecological researches of population, migration, dispersion and growth, especially on marine animals. A variety of methods has been applied for marking bivalves, such as painting, tagging, sculpture, etc.,[1)-4)] among which sculpture, dye and paint were reported for group marking and glued label for individual marking in case of Japanese surf clam, *Pseudocardium sybillae* (VALENCIENNES) : [*Spisula sachalinensis*, *Pseudocardium sachalinensis* (SCHRENCK)].[5)-8)] However, useful methods for marking surf clams are not established to date. Using four types of marks, author carried out the mark-release-recapture experiments in Lagoon Hūren-ko, east Hokkaido, and efficacies of the marking methods were compared each other to find out a successful method.

Materials and Methods

The Japanese surf clam, *Pseudocardium sybillae* (VALENCIENNES), used in the experiments were collected with a clam dredge net commonly used in the commercial fishing at the coast of Bekkai Town, east Hokkaido, in May 19-24, 1982. The clams were kept alive in Lagoon Hūren-ko with cages until the time of marking. The clams were marked on May 25, 1982. Four marking materials were examined, and these were plastic label (a piece of plastic tape used for Dymo numbering) stuck with chemical binder, paper label stuck with paint, paint and plastic label attached by anchortag on the shell. Using these materials in combination, three types of individual marking methods such as bonded label-paint, paper label-paint and tagged label-paint, and one type of group marking using only paint were applied in the experiment. These marking type were illustrated in Fig 3. Among these marking type, only tagged label-paint might have some substantial ill effect to the animal due to a hole on the shell by drilling.

a. Bonded label-paint (double mark)

The label was the plastic tape supplied in roll form from "Dymo" (Esselte Dymo Ltd., Belgium),

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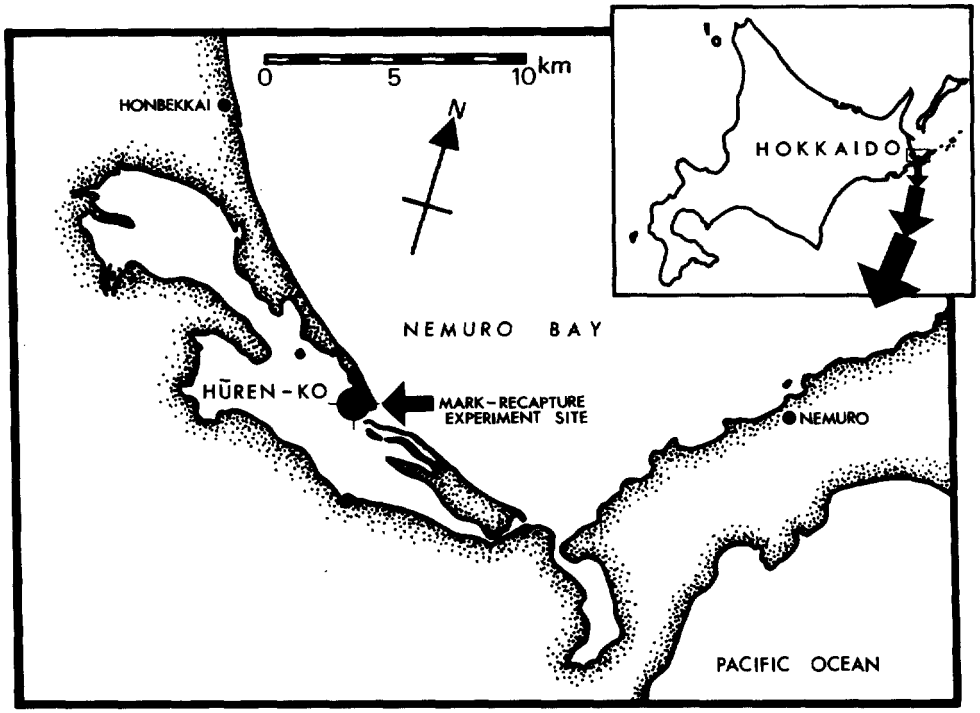

Fig. 1. Maps showing the location of Lagoon Hūren-ko and the mark-release-recapture experimental site.

cut to the size of 6 by 20mm and numbered. The label was stuck to the shell surface with epoxy adhesive, "underwater-bond" (Konishi Co., Ltd., Japan) after being polymerized and hardened mixing two monomers. The paint was the fluorescent red paint, "Loihi color neo" (Sinloihi Co., Ltd.), made of an alkyd resin. The marking was conducted as follows. Epiderm of the marking area was removed from the shell of both valves with a handy motor-driven sandpaper disk and the shell surface was wiped cleanly. This preparative treatment was adopted in every marking method of the present experiment. Then the label tape was glued and bonded onto one side of the valves. The other side of valves was painted in red.

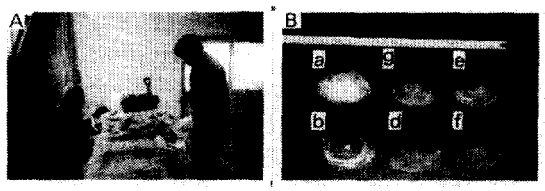

Fig. 2. Photographs showing the marking in a workshop (A) and the marked clams (B), *Pseudocardium sybillae*.
a: bonded label-paint, b: paper label-paint, d-g: tagged label-paint (d: posterior margin, e: ventral m., f: anterior m., g: dorsal m.).

b. Paper label-paint (double mark)

The material of paper label were the waterproof paper made of plastics. After the preparative treatment, one side of the valves was painted and the numbered label paper was pressed onto the

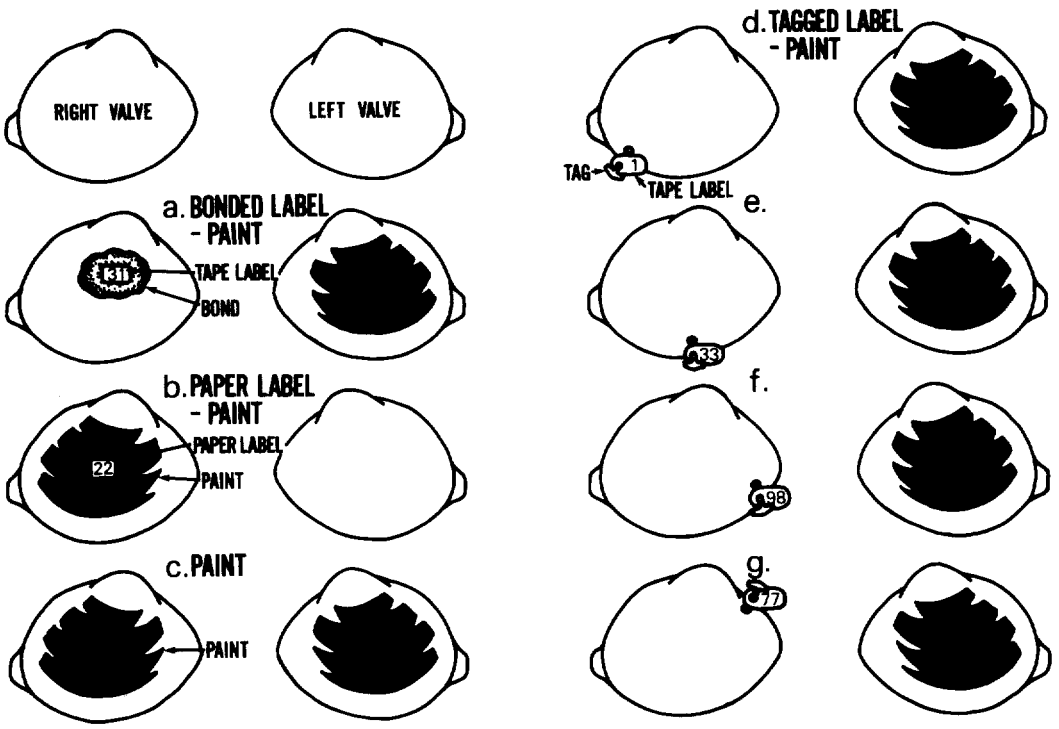

Fig. 3. Illustrations of the surf clams showing the marking methods.

painted area to be adhered to the shell by paint.

c. Paint (single mark)

Both sides of valves were painted after the preparative treatment. No special marks are painted for individual identification.

d-g. Tagged label-paint (double mark)

The "tag" materials were the numbered plastic "Dymo" tape with a punched hole and plastic anchortag "Bano'k 103 Q3" (Japan Bano'k Co., Ltd.). One side of valves was drilled to open a 2mm hole and was thrust by the anchortag with a label. Position of the hole drilled was varied in four ways as follows : d. posterior margin, e. ventral margin, f. anterior margin, g. dorsal margin. Also, the other side of valves was painted.

Four hundred clams were marked. The individual numbers of the clams marked with four different methods were 60 in bonded label-paint, 60 in paper label-paint, 160 in paint and 120 in tagged label-paint, respectively (Table 1). The shell length and the weight of marked clams were measured after marking. The marked clam sizes ranged 22-119mm in shell length and 3-479g in weight respectively (Table 1-2). Six hours were spent for both of marking and measuring with five persons. Thus, the clams were exposed to the air for this term.

Table 1. Release and recapture of marked Japanese surf clams, *Pseudocardium sybillae.* in

Release								
May 26, 1982								
Marking method				Ind. number	Shell length, mm		Body weight, g	
			Marking materials	I	Range	Mean	Range	Mean
Individual marking (Double mark)	Labelling	a.	Bonded label-paint	60	22-112	65.7	3-465	112.2
		b.	Paper label-paint	60	29-119	69.5	3-479	110.5
			total of labelling	120	22-119	67.6	3-479	111.4
	Tagging	d.	Tagged label-paint (posterior margin)	30	72-105	86.3	83-320	158.2
		e.	Tagged label-paint (ventral margin)	30	76-108	88.3	89-350	172.6
		f.	Tagged label-paint (anterior margin)	30	75-106	88.4	86-318	180.1
		g.	Tagged label-paint (dorsal margin)	30	64-105	85.0	58-346	157.5
			total of tagging	120	64-108	87.0	58-350	167.1
Group marking (Single mark)	Painting	c.	Paint	160	30- 99	70.5	—	—
			total	400	22-119	74.6	3-479	139.2

After measuring, marked clams were kept in underwater cages hung at Hashirikotan Harbour in Lagoon Hūren-ko for one night. The clams were released at experimental site at the estuary of Lagoon Hūren-ko on May 26, 1982 (Fig. 1). Depths of the experimental site were 0.3m at low water and 2m at high water.

Primary mortalities after release were observed at several times for a year. All dead clams observed on the sand bottom were collected and measured. The author presumed primary mortalities of dead individuals without growth in the shell. Also, primary survival was calculated as a difference between release individual number and primary mortalities. Recapture experiments were performed twice during the low water time at night of Dec. 2, 1982 (half a year after release) and in the daytime of May 14, 1983 (one year after release). The clams were dug and recaptured with shovels and rakes. Recaptured clams were measured and weighed. The shell length at releasing time of a recaptured clam with group marking (marked only with paint) was estimated by the release ring (growth line) on the shell.

Lagoon Hūren-ko in 1982-1983.

Recapture						Primary mortality		Primary survival	Corrected recapture rate to primary survival, %		
Individual number recaptured			Recapture rate, %								
Dec. 2	May 14	total	Dec. 2	May 14	total	Ind. N. observed	%	%	Dec. 2	May 14	total
J	K	J+K	J/I	K/I	(J+K)/I	L	L/I	(I−L)/I	J/(I−L)	K/(I−L)	(J+K)/(I−L)
4	6	10	7	10	17	4	7	93	7	11	18
5	8	13	8	13	22	4	7	93	9	14	23
9	14	23	8	12	19	8	7	93	8	13	21
2	2	4	7	7	13	6	20	80	8	8	17
0	2	2	0	7	7	17	57	43	0	15	15
1	4	5	3	13	17	12	40	60	6	22	28
0	0	0	0	0	0	15	50	50	0	0	0
3	8	11	3	7	9	50	42	58	4	11	16
7	26	33	4	16	21	17	11	89	5	18	23
19	48	67	5	12	17	75	19	81	6	15	21

Table 2. Frequency distribution of shell length of marked Japanese surf clams, *Pseudocardium sybillae*, released in Lagoon Hūren-ko on May 26, 1982.

Individual number released on May 26, 1982										
Shell length	Marking method									
	Labelling (Double mark)		Painting (Single mark)		Tagging (Doble mark), Tagged label-paint, [Tag]					
	Bonded label-paint abr. [Bond]	Paper label-paint [Paper]	Paint [Paint]	total	Posterior margin	Ventral margin	Anterior margin	Dorsal margin	total	total
mm	a	b	c	a - c	d	e	f	g	d - g	a - g
20— 24	1			1						1
25— 29	4	1		5						5
30— 34	8	3	3	14						14
35— 39	4		2	6						6
40— 44	2	5	7	14						14
45— 49	6	6	5	17						17
50— 54	1	7	2	10						10
55— 59		2	6	8						8
60— 64		2	19	21				1	1	22
65— 69	1	4	14	19				1	1	20
70— 74	5	5	23	33	1			4	5	38
75— 79	7	6	45	58	5	4	1	3	13	71
80— 84	4	4	28	36	11	8	12	9	40	76
85— 89	2		6	8	4	6	6	2	18	26
90— 94	1	3		4	1	4	3	2	10	14
95— 99	4	3		7	4	4	3	1	12	19
100—104	3	1		4	3	3	3	6	15	19
105—109	5	5		10	1	1	2	1	5	15
110—114	2	2		4						4
115—119		1		1						1
total	60	60	160	280	30	30	30	30	120	400

Results

Individual numbers recaptured were 19 (recapture rate : 5%) on Dec. 2, 1982 and 48 (12%) on May 14, 1983 and 67 (17%) in total (Table 1, Fig. 4). The recaptured number on Dec. 2, 1982 was smaller than that on May 14, 1983, because of the recapturing insufficiently performed in nighttime. The recaptured rates (recapture/release) varied among the four different methods and each rate as a total of the two recapturings was 17% for bonded label-paint, 22% for paper label-paint, 21% for paint and 9% for tagged label-paint, respectively. The value of tagged label-paint was lower than those of the other three methods. Besides, the observed primary mortalities also varied by the methods : 7% in both of bonded label-paint and paper label-paint, 11% in paint and 42% in tagged label-paint, respectively. The value of tagged label-paint was also highest among them. The corrected recapture rates (recapture/primary survival) were rather stable : 18% in bonded label-paint, 23% in both of paper label-paint and paint and 16% in tagged label-paint, respectively.

One clam among recaptured individuals with paper label-paint mark was unidentified, because the labeled paper was stripped off and the shell was crashed. Also, one recaptured clam among paint mark individuals was unmeasurable because of crashing. Recapture rates related to the shell length classes (divided in 5mm per class) were calculated on the whole recaptured clams except two unmeasured individuals mentioned above. In this calculation, shell length of recaptured clam was rated to substitute the shell length value at releasing time. The recapture rates on whole divided length classes of 20-119mm ranged 0-100%, while

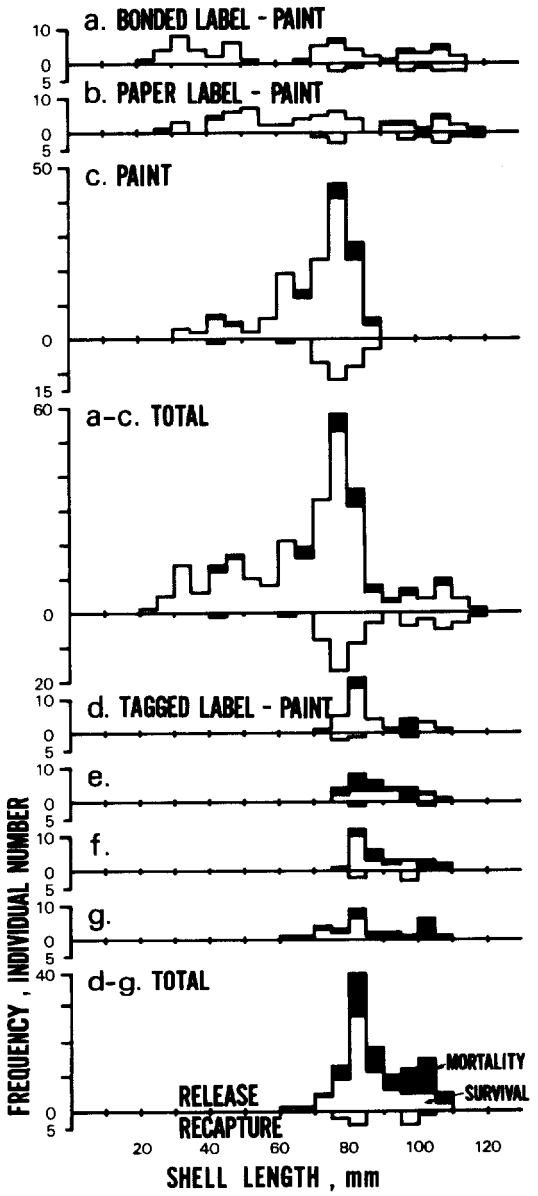

Fig. 4. The frequency distribution of shell length of release and recapture of marked clams, *Pseudocardium sybillae*, in Lagoon Hūren-ko. Shell length of the recaptured clam is diagramed to substitute the shell length value at releasing time.

Table 3. Frenquency distribution of shell length of the recaptured clams and primary mortality of marked clams, *Pseudocardium sybillae*, in Lagoon Hūren-ko. Shell length of the recaptured clam is tabulated to substitute the shell length value at releasing time.

Individual number recaptured on Dec. 2, 1982 and May 14, 1983											Individual number of primary mortality observed									
Shell length mm	Marking method									total	Marking method									total
	Bond	Paper	Paint	total	Tag				total		Bond	Paper	Paint	total	Tag				total	
	a	b	c	a-c	d	e	f	g	d-g	a-g	a	b	c	a-c	d	e	f	g	d-g	a-g
20- 24																				
25- 29																				
30- 34																				
35- 39																				
40- 44			1	1						1		1	1	2						2
45- 49													1	1						1
50- 54																				
55- 59																				
60- 64			1	1						1										
65- 69											1		2	3				1	1	4
70- 74		1	7	8						8								1	1	1
75- 79	2	3	12	17	2				2	19	1		4	5		2	1	1	4	9
80- 84	1		8	9	1	1	2		4	13			5	5	3	5	2	3	13	18
85- 89			3	3						3			2	2		3	3	1	7	9
90- 94												1		1		1	1	2	4	5
95- 99	2	2		4	1		3		4	8	1	1		2	3	4			7	9
100-104	1	1		2		1			1	3						1	3	6	10	10
105-109	2	3		5						5	1	1		2		1	2		3	5
110-114	2	1		3						3										
115-119		1		1						1										
total	10	12*	32*	54*	4	2	5	0	11	65*	4	4	15*	23*	6	17	12	15	50	73*

* : Diversity in the values between Table 1 and this Table 3 is caused by lack of shell length data on crashed clams at recapturing.

Table 4. Frenquency distribution of recapture rate and primary mortality against shell length on marked Japanese surf clams, *Pseudocardium sybillae*, in Lagoon Hūren-ko. Shell length of the recaptured clam is tabulated to substitute the shell length value at releasing time.

Recapture rate (recapture/release, %)											Primary mortality (%)									
Shell length	Marking method				Tag				total	total	Marking method				Tag				total	total
	Bond	Paper	Paint	total							Bond	Paper	Paint	total						
mm	a	b	c	a-c	d	e	f	g	d-g	a-g	a	b	c	a-c	d	e	f	g	d-g	a-g
20- 24	0	-	-	0	-	-	-	-	-	0	0	-	-	0	-	-	-	-	-	0
25- 29	0	0	-	0	-	-	-	-	-	0	0	0	-	0	-	-	-	-	-	0
30- 34	0	0	0	0	-	-	-	-	-	0	0	0	0	0	-	-	-	-	-	0
35- 39	0	-	0	0	-	-	-	-	-	0	0	-	0	0	-	-	-	-	-	0
40- 44	0	0	14	7	-	-	-	-	-	7	0	20	14	14	-	-	-	-	-	14
45- 49	0	0	0	0	-	-	-	-	-	0	0	0	20	6	-	-	-	-	-	6
50- 54	0	0	0	0	-	-	-	-	-	0	0	0	0	0	-	-	-	-	-	0
55- 59	-	0	0	0	-	-	-	-	-	0	-	0	0	0	-	-	-	-	-	0
60- 64	-	0	5	5	-	-	-	0	0	5	-	0	0	0	-	-	-	0	0	0
65- 69	0	0	0	0	-	-	-	0	0	0	100	0	14	16	-	-	-	100	100	20
70- 74	0	20	30	24	0	-	-	0	0	21	0	0	0	0	0	-	-	25	25	3
75- 79	29	50	27	29	40	0	0	0	15	27	14	0	9	9	0	50	100	33	31	13
80- 84	25	0	29	25	9	13	17	0	10	17	0	0	18	14	27	63	17	33	33	24
85- 89	0	-	50	38	0	0	0	0	0	12	0	-	33	25	0	50	50	50	39	35
90- 94	0	0	-	0	0	0	0	0	0	0	0	33	-	25	0	25	33	100	40	36
95- 99	50	67	-	57	25	0	100	0	33	42	25	33	-	29	75	100	0	0	58	47
100-104	33	100	-	50	0	33	0	0	7	16	0	0	-	0	0	33	100	100	67	53
105-109	40	60	-	50	0	0	0	0	0	33	20	20	-	20	0	100	100	0	60	33
110-114	100	50	-	75	-	-	-	-	-	75	0	0	-	0	0	-	-	-	-	0
115-119	-	100	-	100	-	-	-	-	-	100	-	0	-	0	-	-	-	-	-	0
total	17	20*	20*	19*	13	7	17	0	9	16*	7	7	9*	8*	20	57	40	50	42	18*

* : Diversity in the values between Table 1 and this Table 4 is caused by lack of shell length data on crashed clams at recapturing.

Table 5. Frenquency distribution of corrected recapture rate and primary survival against shell length on marked Japanese surf clams, *Pseudocardium sybillae*, in Lagoon Hūren-ko. Shell length of the recaptured clam is tabulated to substitute the shell length value at releasing time.

Corrected recapture rate (recapture / primary survival, %)											Individual number of primary survival calculated									
Shell length	Marking method									total	Marking method									total
	Bond	Paper	Paint	total	Tag				total		Bond	Paper	Paint	total	Tag				total	
mm	a	b	c	a-c	d	e	f	g	d-g	a-g	a	b	c	a-c	d	e	f	g	d-g	a-g
20- 24	0	-	-	0	-	-	-	-	-	0	1	-	-	1	-	-	-	-	-	1
25- 29	0	0	-	0	-	-	-	-	-	0	4	1	-	5	-	-	-	-	-	5
30- 34	0	0	0	0	-	-	-	-	-	0	8	3	3	14	-	-	-	-	-	14
35- 39	0	-	0	0	-	-	-	-	-	0	4	-	2	6	-	-	-	-	-	6
40- 44	0	0	17	8	-	-	-	-	-	8	2	4	6	12	-	-	-	-	-	12
45- 49	0	0	0	0	-	-	-	-	-	0	6	6	4	16	-	-	-	-	-	16
50- 54	0	0	0	0	-	-	-	-	-	0	1	7	2	10	-	-	-	-	-	10
55- 59	-	0	0	0	-	-	-	-	-	0	-	2	6	8	-	-	-	-	-	8
60- 64	-	0	5	5	-	-	-	0	0	5	-	2	19	21	-	-	-	1	1	22
65- 69	0	0	0	0	-	-	-	0	0	0	0	4	12	16	-	-	-	0	0	16
70- 74	0	20	30	24	0	-	-	0	0	21	5	5	23	33	1	-	-	3	4	37
75- 79	33	50	29	32	40	0	0	0	22	31	6	6	41	53	5	2	0	2	9	62
80- 84	25	0	35	29	13	33	20	0	15	22	4	4	23	31	8	3	10	6	27	58
85- 89	0	-	75	50	0	0	0	0	0	18	2	-	4	6	4	3	3	1	11	17
90- 94	0	0	-	0	0	0	0	0	0	0	1	2	-	3	1	3	2	0	6	9
95- 99	67	100	-	80	100	0	100	0	80	80	3	2	-	5	1	0	3	1	5	10
100-104	33	100	-	50	0	50	0	0	20	33	3	1	-	4	3	2	0	0	5	9
105-109	50	75	-	63	0	0	0	0	0	50	4	4	-	8	1	0	0	1	2	10
110-114	100	50	-	75	-	-	-	-	-	75	2	2	-	4	-	-	-	-	-	4
115-119	-	100	-	100	-	-	-	-	-	100	-	1	-	1	-	-	-	-	-	1
total	18	21*	22*	21*	17	15	28	0	16	20*	56	56	145*	257*	24	13	18	15	70	327*

* : Diversity in the values between Table 1 and this Table 5 is caused by lack of shell length data on crashed clams at recapturing.

the rate ranged 0-7% in 20-69mm length, 0-27% in 70-94mm length and 16-100% in 95-119mm length, respectively (Table 4). Also, the corrected recapture rates (recapture/primary survival) ranged 0-8% in 20-69mm length, 0-31% in 70-94mm length and 33-100% in 95-119mm length, respectively (Table 5). In both cases, recapture rates of large individuals were higher than those of small ones. After all, the large clams released at a size of more than about 70mm length were recaptured at high rate.

The growth rates in shell length and weight varied, ranging 0-11% and 2-37% per year respectively, and were depended on the clam size, higher in the small clam and lower in large one. Also, every recaptured clam had an obvious ring on the shell which showed a damage at marking and releasing time and seemed grow slower than natural one.

Discussion

High primary mortality of the tagged label-paint clams caused lower recapture rate (recapture/release), since the value of the corrected recapture rate (recapture/primary survival) corresponded to the others except that being holed at dorsal margin (Table 1). The high mortality will be effected by an open hole of the shell drilled. The surf clam will be influenced and damaged by some hurtful factors with a drilled hole, as the clam usually closes valves tightly under unsuitable conditions. In conclusion, this tagged label-paint method is unavailable because of high mortality and time consuming procedure. Other three methods are adoptable with high rate of survival, however, the both methods of paper label-paint and paint except bonded label-paint are rather a little of efficient. Although the paper label-paint method seemed to be convenient for numerous individual marking due to its simple procedure, the paper sticked by this method was occasionally stripped off from the shell when loosely adhered by painting. The paint method originally lacks the identifiable individual information in itself despite of its simplest procedure, and gives rather a little useful data. On the contrary, the label in the bonded label-paint method adhered firmly on the shell, and an identification numbering on the label remained clearly. Therefore the bonded label-paint marking was the most efficient method. In addition, the marked clams are capable of keeping in sea water relatively soon after marking (about half an hour), as this underwater-bond hardens in water. The damage of desication should be reduced by shortening of the exposure to the air. This method is difficult to adopt to small clam below adout 20mm in shell length even though being dependent on the label size.

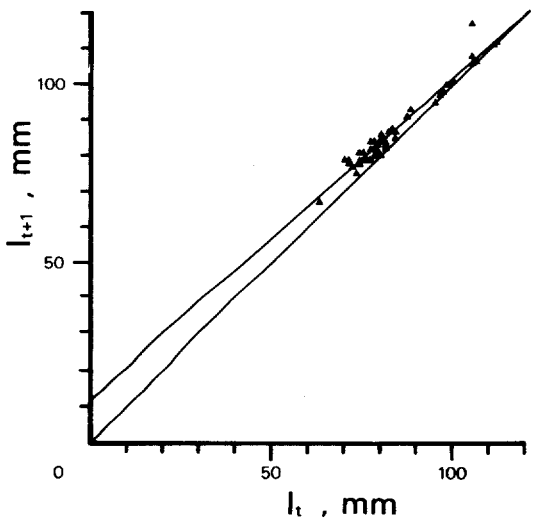

Fig. 5. Walford's growth transformation of shell length of recaptured clams, *Pseudocardium sybillae*, in Lagoon Hūren-ko in 1982-1983.

Recapture rates trended to depend on

Table 6. Calculated shell length of the Japanese surf clam, *Pseudocardium sybillae*, at the age of 1-20 from the von Bertalanffy's growth equation with the result of the mark-recapture experiment in Lagoon Hūren-ko.

t (age of year)	1	2	3	4	5	6	7	8	9	10	15	20
Shell length (mm)	11.9	22.4	32.0	40.5	48.3	55.3	61.9	67.4	72.6	77.3	94.8	105.3

the size of clams, as the large individuals were recaptured at high rates (Tables 3-5). This might be due to low efficiency of recapture and a high mortality of small individuals. A failure in recapture of small clams has a considerable causes, yet the mortality depended on the clam size is left uninformed.

Growth rate was calculated by von Bertalanffy's growth equation with Wolford's growth transformation using a yearly result of recapture on May 14, 1983(Fig. 5).

$$l_{t+1} = 11.7 + 0.904\, l_t \qquad n = 47,\ r = 0.978$$

$$l_t = 122\ (1 - e^{-0.00246 - 0.101t}) \qquad t : \text{year},\ l : \text{shell length in mm}$$

The calculated growth values (Table 6) are lower than those reported on natural surf clams obtained from several fishing grounds.[5),9)] Effects of the handling for marking and the estuary environment on the growth of clams possibly will be causes of the lower growth rate, however, the exact reasons are remained unsolved. Nevertheless, handling effects have to be reduced for successful mark-release-recapture experiments. According to the results of the present experiment, vantage of the bonded label-paint marking method was demonstrated, but several problems are still left to be resolved for more successful results.

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