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EXPERIMENTS TO INCREASE NUMBERS OF GREEN
TURTLES THROUGH THE RELEASE OF THE YOUNG
(VII. Aoumigame zōshoku horyu shiken)

By

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1. OBJECTIVES

To provide for the conservation and propagation and to further understand the ecology of the green turtles of the Ogasawara Islands, studies were carried out on artificial hatching, rearing, and the tagging and releasing of green turtles.

2. RESEARCH METHODS

1) Ecological studies

Observations on capture conditions, biological measurements of captured turtles, hauling out movements, and nesting behavior of gravid females, as well as tagging were conducted between March and November 1975.

2) Culture studies

Eggs collected from green turtle nests between May and July were transported to the Fishery Center's hatching facility where they were reburied for incubation, and the resulting hatchlings were then reared. In addition, age-I and age-II juveniles from earlier hatchings were also reared and observed until March of the following year.

Translator's Note: Several of the place names may have been incorrectly translated.

Translated from the Japanese by Tamio Otsu, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812, August 1981.

3. RESULTS AND CONSIDERATIONS

1) Ecological studies

(1) Condition of capture and measurements of turtles.

The catch of green turtles during the fishing season (March-August) is shown in Table 1. A total of 58 turtles (total weight 6,115 kg) were captured. As compared with last year's results, this year's catch was greater by three turtles but less by 407 kg in total weight. The locations of capture, condition of capture, and biological measurements are given in Table 2. The turtles caught include 47 taken at Hahajima, 9 at Chichijima, and 2 at Mukojima. As compared with the results last year, there was a sharp decline in catches around Chichijima. Although there were 22 females and 22 males in the catch, females clearly outnumbered males in the catches made after May.

The carapace-length and body-weight frequencies of 44 turtles, by sex, are shown in Figures 1-1 and 1-2, respectively. The carapace lengths of males ranged from 65.7 to 98.4 cm and averaged 90.0 cm. Their body weights ranged from 65.7 to 127.0 kg, and averaged 99.9 kg. In the females, the carapace lengths ranged from 72.5 to 101.2 cm, averaging 91.4 cm, and the body weights from 46.5 to 160.0 kg, averaging 113.7 kg. The females were thus larger than the males. The males were on the average smaller in carapace length by 3.8 cm, and in weight by 9.3 kg, and the females were smaller by 3.6 cm in carapace length and 11.0 kg in weight than those taken last year.

Table 1.--Monthly catches of green turtles in the Ogasawara Islands during the 1975 season.

Month	Areas		
	Mukojima	Chichijima	Hahajima
March	47.0 (1)		239.0 (2)
April			¹ 1,802.5 (17)
May	46.5 (1)	371.0 (4)	¹ 2,920.5 (28)
June ²			
July ²			
August		688.0 (5)	
Total	93.5 (2)	1,059.8 (9)	4,962.0 (47)

Unit: Kilograms (number).

¹Estimated values.

²Fishing for green turtles is prohibited in June and July.

Table 2.--Measurements of captured green turtles.

Date 1975	Location of capture	Condition at capture	Sex	Body weight (kg)	Carapace length (cm)	Carapace width (cm)	Total tail length (cm)
3/14	Hahajima - off Nishiura	Copulating	F	137	96.3	76.3	30.7
3/14	do.	do.	M	99	88.4	70.1	47.3
4/16	Hahajima - off Oniwa	do.	M	116	93.7	71.9	47.0
4/16	do.	do.	M	100	—	—	—
4/26	Hahajima - Okuzurewan	do.	F	125	95.7	76.8	30.5
4/26	do.	do.	M	90	85.1	69.0	47.0
4/30	do.	do.	M	125	95.6	74.1	54.5
4/30	do.	do.	M	97	89.9	70.4	47.5
4/30	Hahajima - off Meijima	Afloat	M	90	86.0	68.9	48.2
4/30	Mukojima - off Kitanoshima	do.	F	46.5	72.0	60.0	17.0
4/30	Hahajima	Copulating	M	102	90.8	72.5	31.0
4/30	do.	do.	F	131	98.5	75.2	26.7
4/30	Hahajima - Okuzurewan	—	M	114.5	96.0	76.5	49.8
4/30	do.	—	M	82	85.7	72.2	44.7
5/4	Chichijima - off Nihoniwa	Copulating	M	67	83.9	63.4	44.5
5/6	Hahajima - off Mukojima	—	F	88	86.5	65.8	26.0
5/6	Hahajima - off Shihoniwa	—	F	67	82.7	62.5	26.7
5/6	Hahajima	—	M	125	98.4	78.5	49.5
5/8	Hahajima - Okuzurewan	Copulating	M	127	98.4	77.8	50.5
5/8	do.	do.	F	117.5	93.0	73.4	22.5
5/8	do.	Afloat	M	114.5	94.0	77.5	36.4
5/12	Chichijima - Futamiwa	do.	M	85	89.0	72.4	47.5
5/12	Chichijima - off Minamijima	—	M	113	96.6	77.2	50.0
5/16	Hahajima	—	F	122	95.4	74.4	29.4
5/16	Hahajima - Okuzurewan	Copulating	F	145	100.2	79.6	32.0
5/16	do.	do.	M	102	92.7	75.2	54.0
5/17	Hahajima	—	M	89	88.0	69.0	42.0
5/17	do.	—	F	103	91.3	72.4	30.8
5/17	do.	—	F	72	81.0	60.9	24.8
5/17	do.	—	F	130	95.4	75.6	27.2
5/17	do.	—	M	80	83.0	67.3	40.4
5/17	do.	—	M	113	97.8	76.6	55.0
5/18	do.	—	F	146.5	95.7	77.2	30.5
5/18	do.	—	F	61	73.5	59.2	19.3
5/18	do.	—	M	99	90.4	73.9	47.5
5/18	do.	—	M	68	65.7	63.0	29.3
5/18	do.	—	F	93	84.2	68.2	27.9
5/28	Hahajima - Okuzurewan	—	F	123	92.2	72.6	30.0
5/31	Chichijima - Yakibahama	Hauling out	F	106	96.4	73.0	29.0
8/5	Chichijima - Futamiwan	do.	F	160	¹ 105.2	² 95.5	36.4
8/6	Chichijima - John Beach	do.	F	132	101.2	75.9	33.2
8/11	Chichijima - Buta Kaigan	do.	F	125	98.8	78.4	30.9
8/12	Chichijima - Ohama	do.	F	132	¹ 105.2	² 102.1	—
8/14	Chichijima - Buta Kaigan	do.	F	139	98.6	80.0	30.2

¹Carapace length measured along curvature.²Carapace width measured along curvature.

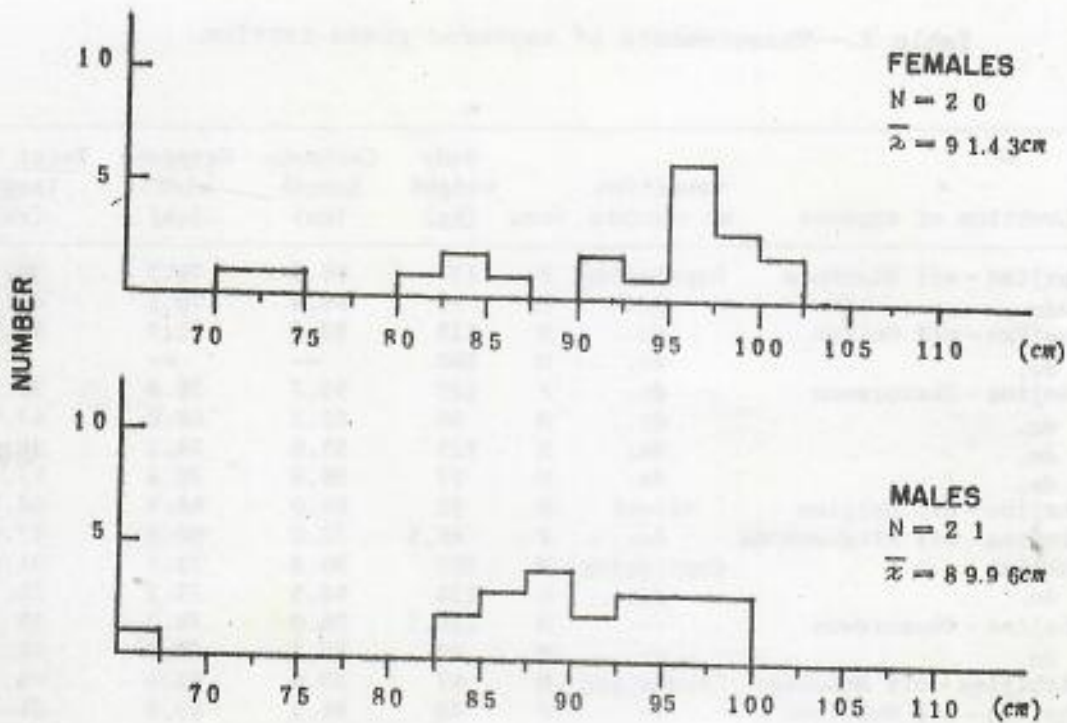


Figure 1-1.—Carapace-length frequencies, by sex, of captured green turtles.

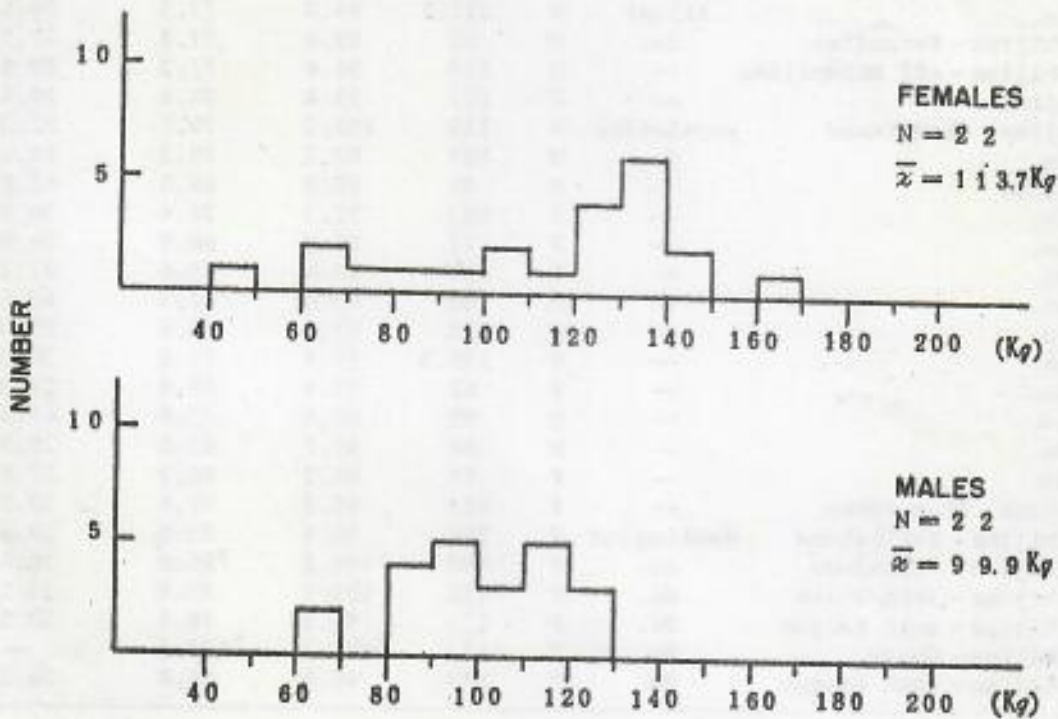


Figure 1-2.—Body-weight frequencies, by sex, of captured green turtles.

(2) Observations on turtles hauling out.

The sandy beaches used by the female turtles to lay their eggs were generally the same as those in previous years (Figure 2). The number of turtles hauling out was estimated by counting the tracks on the sand (Table 3). The data indicate that turtles came ashore in greatest numbers at Hirashima and Okuzure on Hahajima, at Matsuyama Kaigan and Minami Hatsuneura on Chichijima, and at Ohama on Mukojima.

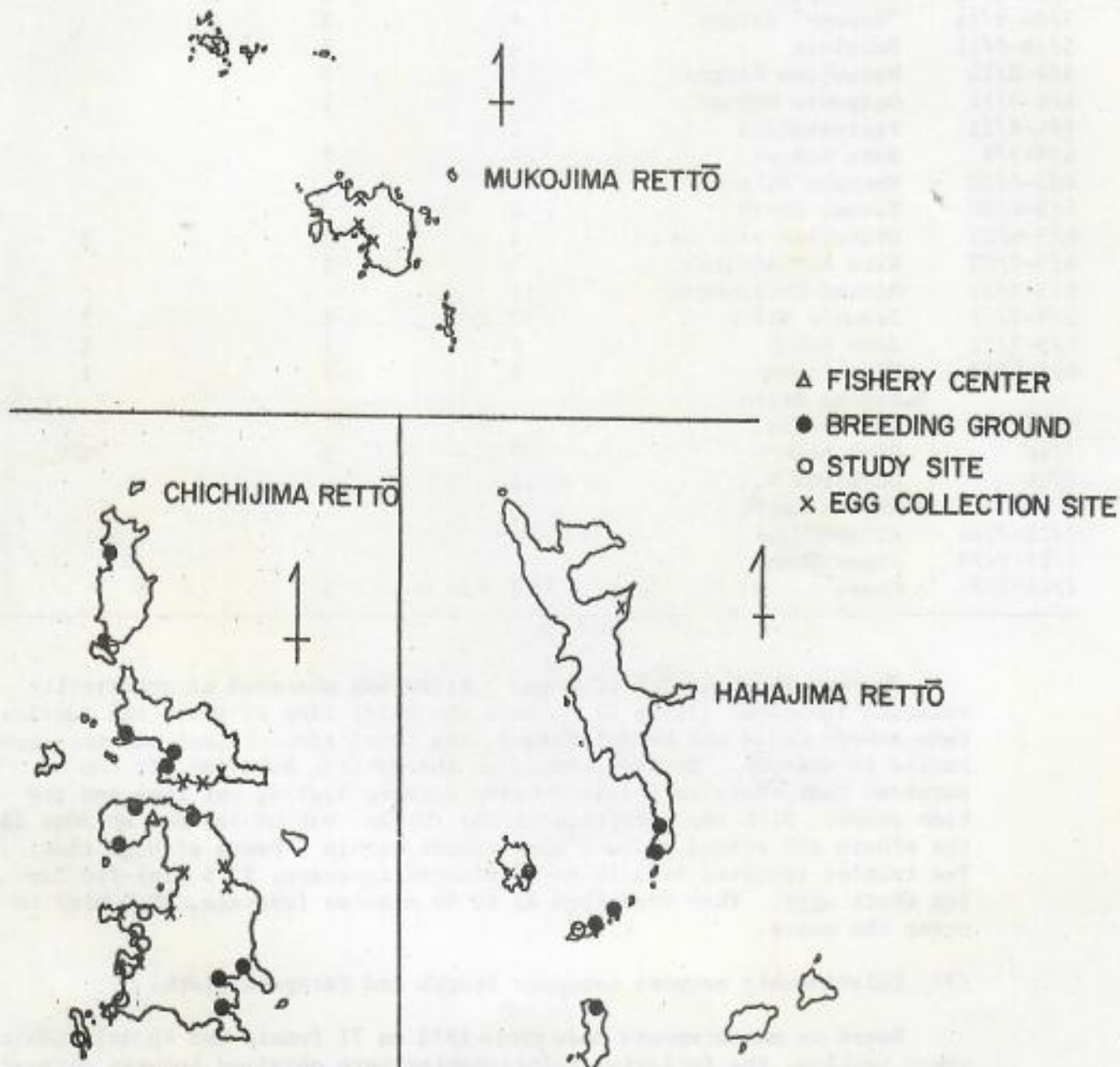


Figure 2.—Breeding grounds of green turtles and study sites.

Table 3.--Data on green turtles hauling out at nesting beaches as determined from tracks in sand.

Date 1975	Location	Number of holes dug	Number of holes in which eggs were deposited	Number of nests from which eggs were collected
5/24-8/11	Chichijima Rettō			
5/24-8/11	Yakibahama	11	3	2
5/24-8/11	"Kopepe" Kaigan	6	4	1
5/24-8/11	Sakaiura	4	1	
6/4-8/11	Matsuyama Kaigan	13	2	
6/4-8/11	Ogigaura Kohama	6	1	1
6/4-8/11	Yagiyamahama	2		
6/5-7/4	Buta Kaigan	9	1	1
6/3-6/20	Mansaku Kaigan			
6/3-6/20	Tamana Beach	2		
6/3-6/20	Ototojima east coast	4	1	1
6/3-7/22	Kita Hatsuneura	9	2	
6/3-7/22	Minami Hatsuneura	11		
6/3-7/22	Jeannie Beach	12	1	1
6/3-7/22	John Beach	6	1	1
6/5-6/13	Minamijima	4	1	1
	Hahajima Retto			
6/17	Okuzurewan			
7/18	Hirashima	39	5	2
7/18	Mukōjima	12		
	Mukōjima Retto			
7/11-7/24	Kitanoshima			
7/11-7/24	Higashihama			
7/11-7/24	Ohama	8	1	

The nesting behavior of green turtles was observed at arbitrarily selected locations (Table 4). Since the exact time at which the turtles came ashore could not be determined, the total time of haul out for each turtle is unknown. However, based on the nesting behavior, it can be surmised that there is a relationship between hauling out time and the tide phase. With the exception of the turtle that hauled out on June 15, the others all seemed to have come ashore within 2 hours of high tide. The turtles required from 16 to 18 minutes (average, 17.5 min) for laying their eggs. They took from 25 to 66 minutes (average, 49.5 min) to cover the nests.

(3) Relationship between carapace length and carapace width.

Based on measurements made since 1973 on 71 female and 46 male adult green turtles, the following relationships were obtained between carapace length and carapace width (also see Figures 3-1 and 3-2):

Table 4.--Nesting behavior of green turtles.

Activity	6/15/75	6/16/75	6/28/75	7/18/75	7/27/75	8/11/75
Number of eggs	109	112				
Time hauled out			2036		12057	12057
Started digging nest		12220	2043	10135		2231
Ended digging nest		2357		0210		2259
Started laying eggs		2357		0210		2259
Ended laying eggs	0600	0015		0228		2315
Started covering nest	0600	0015		0228		2315
Ended covering nest	0625	0110		0334		2222
Returned to sea	0631	0115	0142	0338	0131	0013
					2225	0016
Age of turtles in months	5.3	6.3	18.3	9.0	18.0	3.6
Ebb tide, time (height in centimeters)	0340 (56)	0439 (53)	0309 (54)	0755 (34)	0235 (46)	0254 (33)
Ebb tide, time (height in centimeters)	1546 (26)	1636 (38)	1436 (25)	1940 (76)	1406 (29)	1422 (29)
High tide, time (height in centimeters)	0907 (95)	1016 (89)	0757 (102)	1524 (87)	0747 (106)	0316 (112)
High tide, time (height in centimeters)	2243 (101)	2326 (99)	2119 (105)	0100 (98)	2035 (110)	2042 (115)
Study site	Buta Kaigan	Yakibahana	Yakibahana	Hirashina	Hirashina	Ugigaura Kaigan Matsuyama Kaigan
Observations		Dug 2 holes but stopped because of rocks; shifted location and deposited eggs in third hole.	Dug 4 holes but struck rocks and tree roots each time. Returned to sea without laying eggs.	Deposited eggs in first hole dug.	Dug a hole but because of rocks abandoned it and returned to sea without laying eggs.	Deposited eggs in second hole dug.

¹Not time at start of digging since turtle was first seen when it was already in midst of digging.

$$\text{Females: } CL = 1.1803 CW + 6.21$$

$$\text{Males: } CL = 1.2277 CW + 2.72$$

where CL = carapace length and CW = carapace width.

(4) Feeding habit.

Green turtles are herbivorous. There are no records on the feeding habits of green turtles in the Ogasawara Islands except for data on the stomach contents of three adults and one juvenile that had been butchered (Table 5). There were 34 species of marine algae in the stomachs. The brown algae were most numerous (19 species), next was the red algae (9 species), followed by the green algae (6 species). In addition to the algae, few small animal species (e.g., Hydrozoa) and a piece of vinyl plastic that probably had been ingested along with the algae, were found in the stomachs.

In terms of weight, the greatest proportion was composed of brown algae, and in the stomachs of the two turtles that had just hauled out on the nesting beach, brown algae comprised 72 and 99 percent of the total food contents, respectively. In the juvenile turtle, the green algae, *Codium adhaerens*, was most plentiful, indicating that green turtles may be feeding very selectively on certain algae.

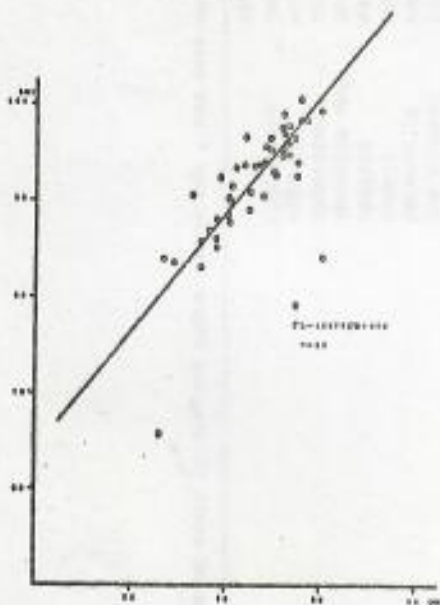


Figure 3-1.--The relationship between carapace length and carapace width in male green turtles.

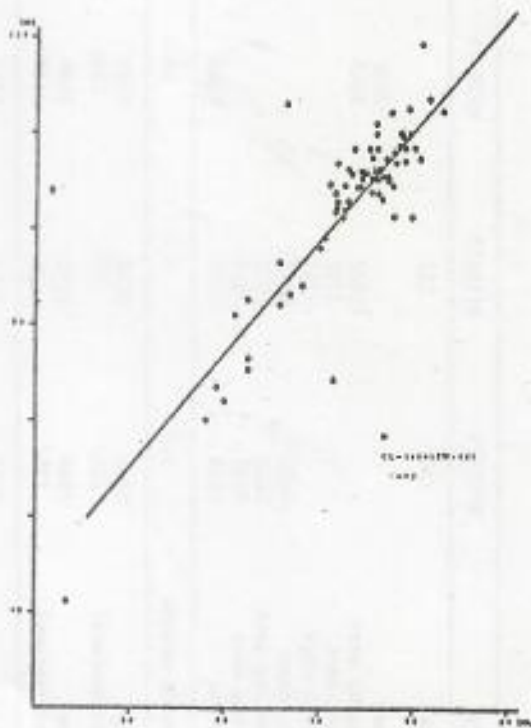


Figure 3-2.--The relationship between carapace length and carapace width in female green turtles.

Table 5.--The stomach contents of green turtles.

Date of capture	9/19/74	8/5/75	8/10/75	5/15/75
Location of capture	Chichijima off Yakiba	Chichijima John Beach	Chichijima Buta Kaigan	Hahajima
Turtle	Juvenile	Hauled out	Hauled out	Offshore turtle
Carapace length (cm)	48.4	102.1	98.8	95.4
Body weight (kg)	17.3	132.0	125.0	122.0
Stomach contents				
CHLOROPHYTA				
<u>Ulva pertusa</u> Kjellman	r	--	--	--
<u>Ulva fasciata</u> Delile	r	--	--	--
<u>Dictyosphaeria cavernosa</u> Boergesen	r	--	--	--
<u>Dictyosphaeria veraluisii</u> W. v. Bossae	r	--	--	--
<u>Avrainvillea riukiensis</u> Yamada	--	--	--	--
<u>Codium adhaerens</u> C. Agardh	c	--	--	rr
<u>Codium tomentosum</u> Stackhouse	--	r 0.8%	--	--
PHAEOPHYTA				
<u>Dictyopteris undulata</u> Okamura	--	r	+	r
<u>Chlanidophora repens</u> Okamura	r	r	--	r
<u>Zonaria stipitata</u> T. et K.N.	--	r	+	--
<u>Homoeostrichus flabellatus</u> Okamura	--	--	+	r
<u>Padina minor</u> Yamada	--	r	--	--
<u>Sargassum duplicatum</u> J. Agardh	r	--	--	--
<u>Halothrix ambigua</u> Yamada	--	--	--	--
<u>Endarachne binghamiae</u> J. Agardh	--	--	--	rr
<u>Petalonia fascia</u> Kuntze	--	--	--	rr
<u>Cystoseira prolifera</u> J. Agardh	+	--	--	rr
<u>Turbinaria ornata</u> J. Agardh	r	--	--	r
<u>Sargassum tosaense</u> Yendo	--	--	--	--
<u>Sargassum sp.</u>	rr	--	--	r
<u>Sargassum micracanthum</u> Yendo	--	--	--	+
<u>Trichogloea requienii</u> Kitzing	r	r	--	--
<u>Padina commersonii</u> Bory	--	--	+	--
RHODOPHYTA				
<u>Liagora setchellii</u> Yamada	--	r	--	--
<u>Rhodochorton howei</u> Yamada	--	r	--	--
<u>Galaxaura</u>	r	--	--	--
<u>Rhodopeltis borealis</u> Yamada	--	r	--	--
<u>Jania niponica</u> Yendo	r	--	--	--
<u>Corallina mediterranea</u> Areschaug	r	--	--	--
<u>Rhodymenia intricata</u> Okamura	--	--	r	--
<u>Plenosporium pusillum</u> Yamada	--	rr	--	--
<u>Centroceras clavulatum</u> Montagne	r	--	--	--
OTHER				
Kaya species (?)	rr	--	--	--
Hydrozoa sp.	rr	--	--	--
Small shells (?)	rr	--	--	--

Legend: c = Plentiful. + = Average. r = Few. rr = Rare.
% = The percent composition of brown algae in total weight of stomach contents.

(5) Tagging and recaptures.

To determine the growth rate, migratory habits, and the age when they return to shore, green turtle tagging was conducted between June 15 and November 25, 1975. In 16 experiments, 752 turtles were tagged and released. These included 39 turtles that escaped from a damaged rearing enclosure and thus were considered "natural releases." Two tagging methods were used (Figure 4). One method involved the attachment of a plastic tag to the inside edge of the left front flipper and the other, notching the posterior edge of the carapace. The tagging data are presented in Table 6.

The tagged turtles included 5 that had just hauled out, 4 juveniles (estimated age-III and age-IV turtles), 2 that had been reared at the Ueno Aquarium, 27 age-II turtles, 464 age-I turtles and 250 age-0 turtles reared at our Fishery Center. The carapace-length and body-weight frequencies, by age, of the tagged turtles are shown in Figure 6. Figure 5 shows the release localities of the tagged turtles.

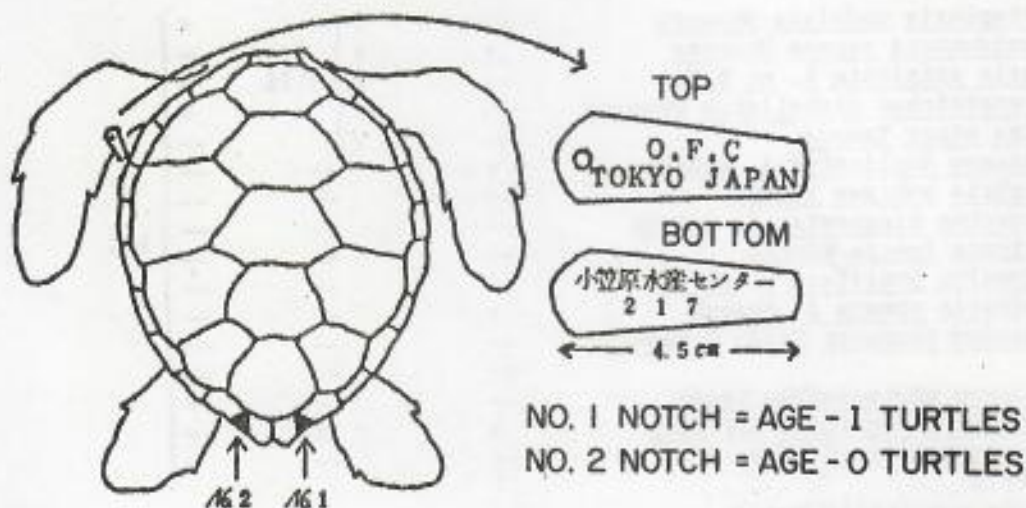


Figure 4.--Tagging methods used on green turtles.

Table 6.--Tag release data.

Release date 1975	Release location	Number of turtles released	Carapace length (cm)		Carapace width (cm)		Body weight (kg)		Tagging method	Age
			Range	Average	Range	Average	Range	Average		
6/15	Chichijima-Buta Kaigan	1	194.0		288.3				Plastic tag	Egg-laying female
6/25	Chichijima-Omura Kaigan	4	45.7-67.5	52.5	36.9-55.4	42.6	10.5-46.0	22.1	do.	Juvenile
6/25	do.	27	22.8-30.0	27.4	19.1-27.2	23.5	1.1-4.3	3.1	do.	Age-II
6/25	do.	47	22.9-26.7	24.6	18.9-23.3	20.0	1.8-2.8	2.2	do.	Age-I
6/28	Chichijima-Yakibahana	1	104.8		2100.2				do.	Egg-laying female
7/3	Chichijima-inside fishing port	39	15.8		13.2			0.6	"Natural release"	Age-I
7/19	Hahajima-Hirashima Kaigan	1	190.0		284.2				Plastic tag	Egg-laying female
7/19	do.	1	198.5		290.0				do.	do.
7/22	Anijima-Tanzana Kaigan	30	14.2-17.4	15.7	11.6-15.2	13.3	0.5-0.9	0.7	Carapace notched	Age-I
7/22	Chichijima-John Beach	40	13.0-19.2	15.9	11.2-16.1	13.7	0.3-1.1	0.7	do.	do.
7/23	Chichijima-Buta Kaigan	30	16.9-21.4	19.0	14.7-18.1	16.3	0.8-1.7	1.2	do.	do.
7/23	Anijima-Uguisubana	40	14.7-21.6	17.8	12.8-18.2	15.4	0.5-1.7	1.0	do.	do.
7/27	Chichijima-Kohama	1	197.0		292.0				Plastic tag	Egg-laying female
7/30	Anijima-Takiooura	62	14.8-19.9	16.9	12.9-16.7	14.4	0.6-1.3	0.9	Carapace notched	Age-I
7/31	Otoejiima-Kurohama	48	16.4-21.4	18.2	13.8-17.8	15.5	0.7-1.7	1.0	do.	do.
8/1	Chichijima-Yakibahana	41	20.2-25.4	22.9	16.6-20.7	19.1	1.3-2.4	1.9	do.	do.
8/12	Hahajima-Okiwan	47	21.2-27.8	24.8	16.6-22.8	20.5	1.4-3.2	2.3	Plastic tag	do.
8/20	Chichijima-Sekafura	18	21.6-27.5	24.6	18.1-22.1	20.4	1.6-3.3	2.3	do.	do.
9/10	Chichijima-Miyanoheza	8	21.1-25.7	23.5	17.8-21.4	19.7	1.5-2.8	2.1	do.	do.
9/10	do.	53	13.2-24.1	20.3	10.9-20.7	17.0	0.4-2.3	1.8	Carapace notched	do.
10/22	Oshima-off Namiukiminato	1	199.7		295.0				Plastic tag	Male adult
10/22	do.	1	171.9		263.5			42	do.	Juvenile
11/25	Chichijima-Miyanoheza	250	10.1-14.4	12.6	8.6-12.0	10.6	0.1-0.6	0.4	Carapace notched	Age-0

¹Carapace length measured along curvature.²Carapace width measured along curvature.

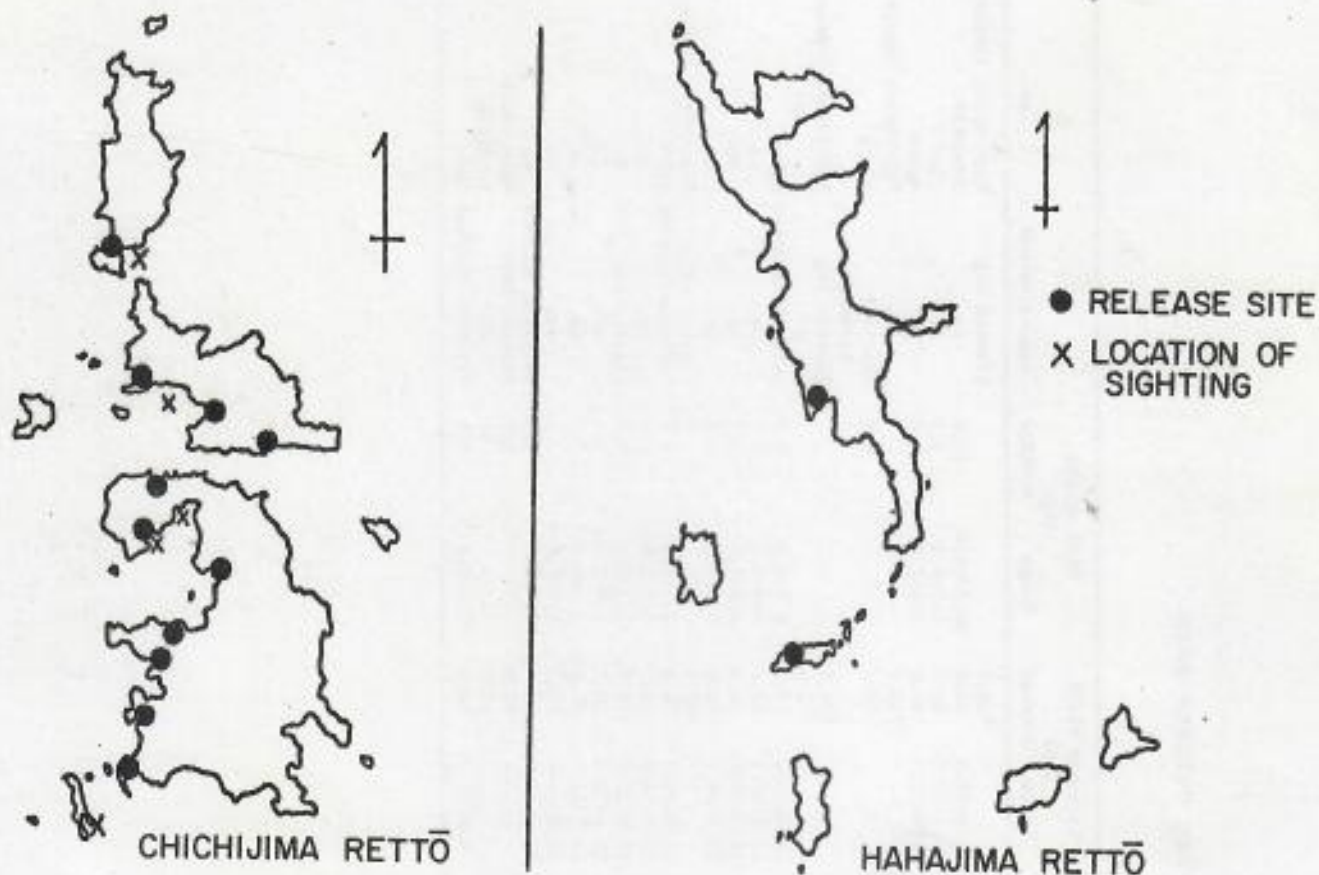


Figure 5.--Locations of release of tagged green turtles.

2) Culture experiments

(1) Egg collecting and hatching experiments.

As in previous years, eggs were collected from the regular nesting areas (Figure 2). A total of 1,069 eggs from 11 clutches were collected and of these, 1,054 were transported to the Fishery Center for hatching. At the time of nest excavation, the tip of each egg was marked and the egg placed in a sand-filled plastic container for transport. Also, 796 eggs were obtained from captured

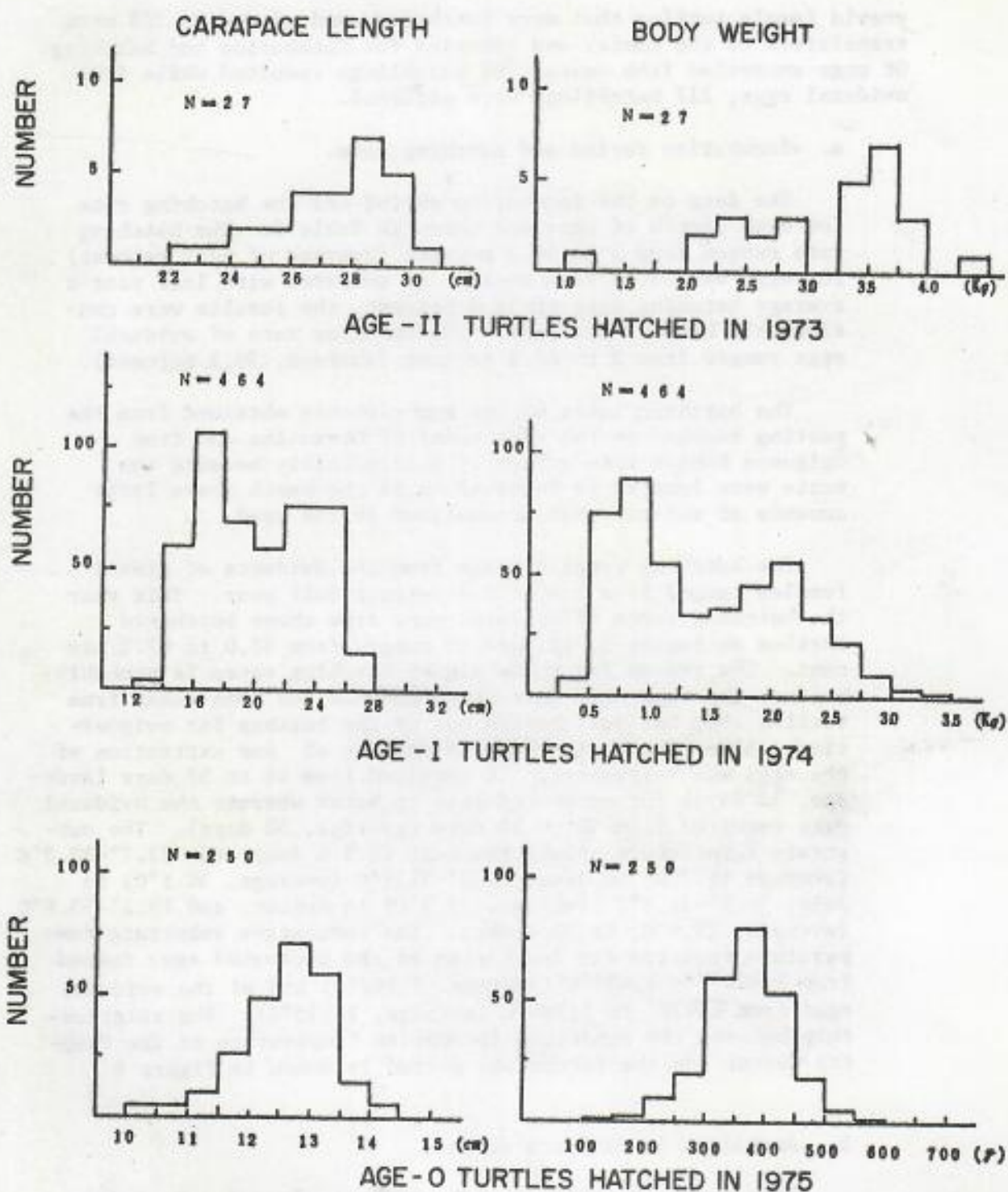


Figure 6.—Carapace-length and body-weight frequencies, by age, of green turtles tagged and released in the Ogasawara Islands.

gravid female turtles that were butchered, and of these, 788 were transferred to the Center and reburied for incubation and hatching. Of eggs excavated from nests, 708 hatchlings resulted while from oviducal eggs, 217 hatchlings were obtained.

a. Incubation period and hatching rate.

The data on the incubation period and the hatching rate for each clutch of eggs are shown in Table 8. The hatching rate ranged from 0 to 97.3 percent (average of 67.2 percent) for eggs excavated from nests. As compared with last year's average hatching rate of 58.8 percent, the results were considerably better this year. The hatching rate of oviducal eggs ranged from 0 to 67.2 percent (average, 26.1 percent).

The hatching rates of the egg clutches obtained from the nesting beaches on the east coast of Ototojima and from Ogigaura Kohama were extremely poor possibly because the nests were located in depressions in the beach where large amounts of moisture had accumulated in the sand.

The hatching rates of eggs from the oviducts of gravid females ranged from 5.6 to 9.4 percent last year. This year the hatching rates of oviducal eggs from three butchered turtles on August 5, 12, and 18 ranged from 42.0 to 67.2 percent. The reason for these higher hatching rates is probably because the eggs were more developed and had been taken from turtles that had just hauled out on the beaches for oviposition. Also, the period between capture of and extraction of the eggs was very short. It required from 48 to 57 days (average, 52 days) for excavated eggs to hatch whereas the oviducal eggs required from 50 to 54 days (average, 52 days). The substrate temperature around the nest (0.5 m deep) was 23.7°-29.2°C (average 26.7°C) in June, 29.3°-31.1°C (average, 30.1°C) in July, 30.9°-31.6°C (average, 31.3°C) in August, and 29.2°-30.8°C (average, 29.9°C) in September. The cumulative substrate temperature required for incubation of the excavated eggs ranged from 1,423° to 1,499°C (average, 1,462°C) and of the oviducal eggs from 1,478° to 1,580°C (average, 1,535°C). The relationship between the substrate incubation temperature at the Fishery Center and the incubation period is shown in Figure 8.

b. Anomalies in carapace scutes.

This year's hatchlings, like last year's, also included those with anomalous numbers of carapace scutes. Table 9 shows the incidence of atypical numbers of scutes among the hatchlings from excavated eggs (3.8-7.8 percent; average, 5.8 percent) and oviducal eggs (8.0-28.8 percent; average, 17.2 percent). Also, as shown in Figure 9, the total number of carapace scutes found normally is 13 (vertebral scutes 5, left

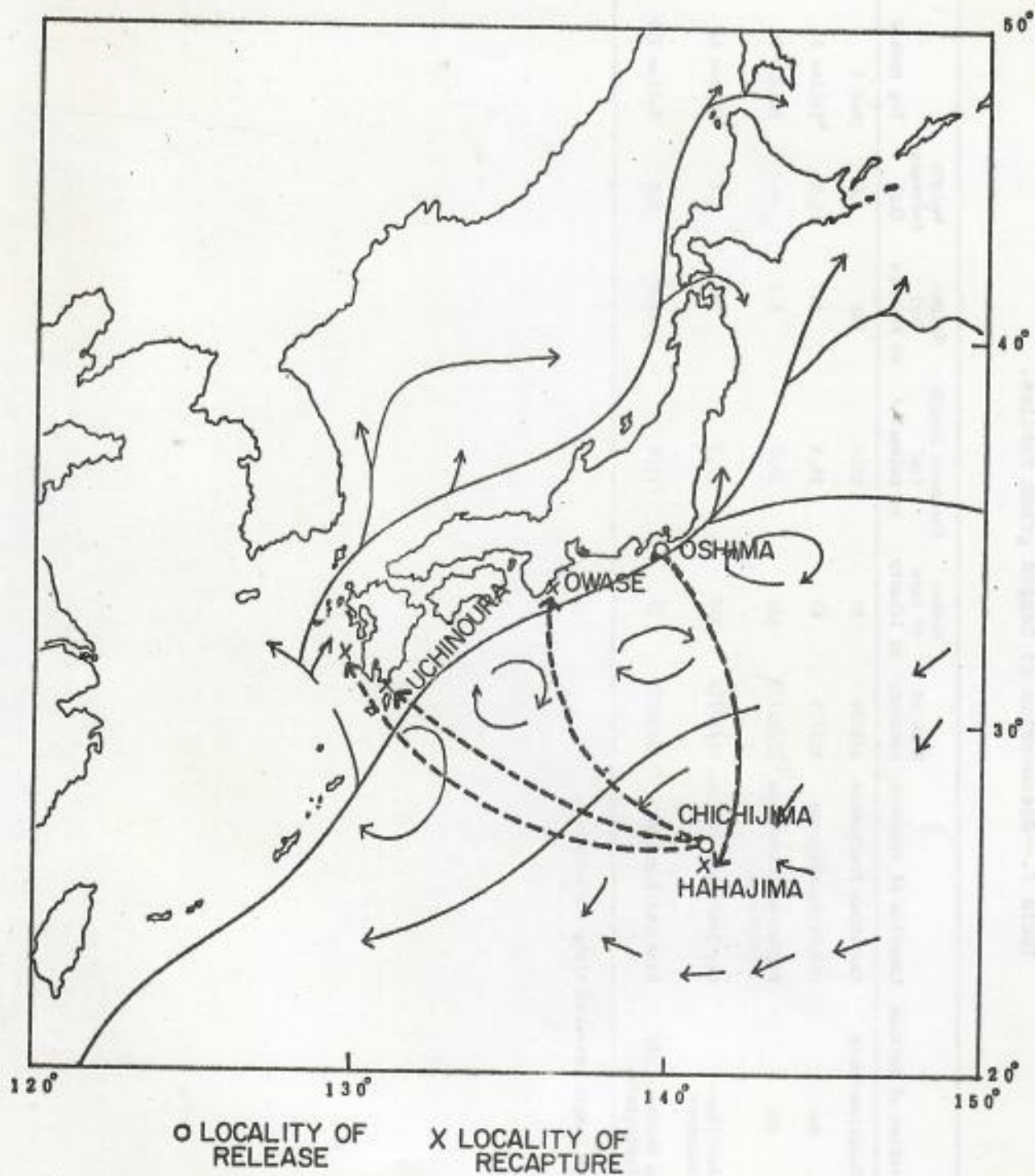


Figure 7.--Locations of green turtle tag recoveries and schematic representation of currents in Japanese coastal waters.

Table 7.—Recoveries of tagged green turtles.

Release date	Location of release	Location of recovery	Date of recovery	Number of days at liberty	Carapace length (cm) at release	Weight (kg) at release	Weight increase (kg)	Tag number
12/8/73	Chichijima-Ooura	Kagoshima Prefecture	2/5/74	59	92.4	105	7.0	Red 5
6/25/75	do.	Chichijima-Kuroiwa	8/9/75	45	28.8	3.7	1.1	Yellow 5
6/25/75	do.	Kagoshima Prefecture Uchinoura	10/11/75	110	28.7	3.3	—	Yellow 13
11/12/74	Chichijima-Sakatara	Mie Prefecture-Owase	10/16/75	338	27.7	3.4	2.1	Yellow 66
10/22/75	Izu Oshima - off Namiukiminato	Habajima-Nagahama	11/20/75	29	¹ 71.9	42.0	2.0	Yellow 210

¹Carapace length measured along curvature.

Table 8.--Collecting and hatching green turtle eggs.

Date of collection, 1975	Locality of collection	Number of days between ovi-position and collection	Date eggs were deposited	Date of hatching	Number of eggs				Mortality			
					Days required for hatching	Deposited	Collected	Reported	Hatched	Eggs decomposed	During embryonic development	Percent hatched
5/28	Yakibahama	3	5/23/75	7/30/75	56	97	96	96	79	17	0	82.3
6/3	Ocoajmas - east coast	5	5/29/75	7/25/75	57	75	58	38	2	53	3	3.5
6/4	Ogigaura Kobana	(3)	(6/1-3/75)	—	—	90	85	0	85	0	0	0
6/5	"Kopepe" Beach	2	6/03/75	7/23/75	52	114	114	109	3	0	0	97.3
6/13	Jeannie Beach	(2)	(6/11-12/75)	7/31/75	49-50	96	96	76	18	4	4	79.2
6/13	Minami Shima	(5)	(6/8-10/75)	8/02/75	53-55	83	83	56	26	1	1	67.5
6/14	John Beach	2	6/12/75	8/02/75	51	97	97	85	5	6	6	88.7
6/15	Buta Kaigan	0	6/15/75	8/03/75	49	109	109	102	5	2	2	93.6
6/17	Yakibahama	1	6/16/75	8/03/75	48	122	122	119	112	5	2	94.1
6/17	Hirashima	(10)	(6/7-10/75)	7/28/75	48-51	107	107	105	20	85	0	19.1
6/17	do.	(7)	(6/10-12/75)	7/31/75	49-51	97	97	94	66	28	0	70.2
6/3	Fishery Center	Eggs from oviduct	—	7/27/75	54	—	2118	118	7	111	0	5.9
6/25	do.	do.	—	8/14/75	50	—	1117	117	8	109	0	6.8
7/2	do.	do.	—	—	—	—	47	47	0	47	0	0
8/5	do.	do.	—	9/25/75	51	—	120	118	80	39	0	67.2
8/12	do.	do.	—	10/03/75	53	—	119	112	47	65	0	42.0
8/15	do.	do.	—	—	—	—	151	151	0	151	0	0
8/18	do.	do.	—	10/06/75	50	—	124	124	75	49	0	60.5
7/30	Inside fishing port	Soon after hatching.	—	—	—	—	—	—	36	—	—	—

() = estimated data in parentheses.

17 eggs preyed upon by sand crabs.

*Eggs removed from oviduct of gravid female caught 5/16, butchered 6/3.

*Eggs removed from oviduct of gravid female caught mid-May, butchered 6/25.

*Eggs removed from oviduct of gravid female caught late May, butchered 7/2.

*Eggs removed from oviduct of gravid female caught 8/4, butchered 8/5.

*Eggs removed from oviduct of gravid female caught 8/10, butchered 8/12.

*Eggs removed from oviduct of gravid female caught 8/5, butchered 8/15.

*Eggs removed from oviduct of gravid female caught 8/13, butchered 8/18.

*Natural hatching.

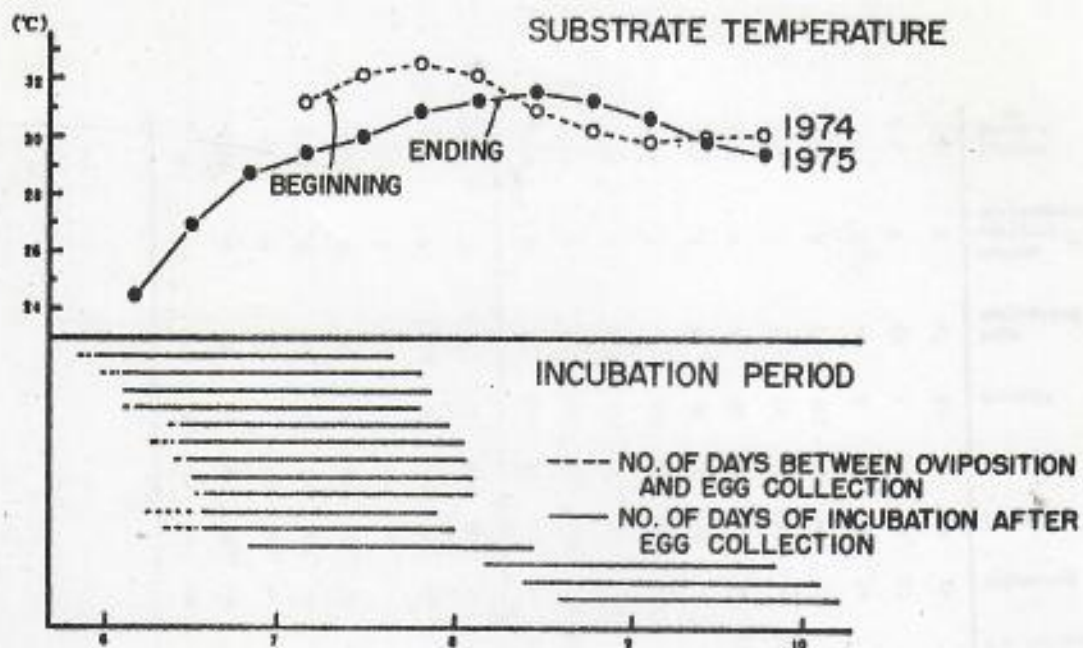


Figure 8.--Substrate temperature and number of days required for hatching (incubation period).

Table 9.--The occurrence of scute anomalies.

Item	Type of eggs			Excavated eggs			Eggs from oviduct			
	Date of hatching	7/20	7/25	7/28	7/31	8/2	8/3	9/25	10/3	10/6
Total number of hatchlings	79	109	20	142	142	142	214	80	47	75
Number of scute anomalies	3	5	2	9	11	13	23	8	8	6
Percent scute anomalies	3.8	4.6	6.3	6.3	7.8	6.1	28.8	14.9	8.0	

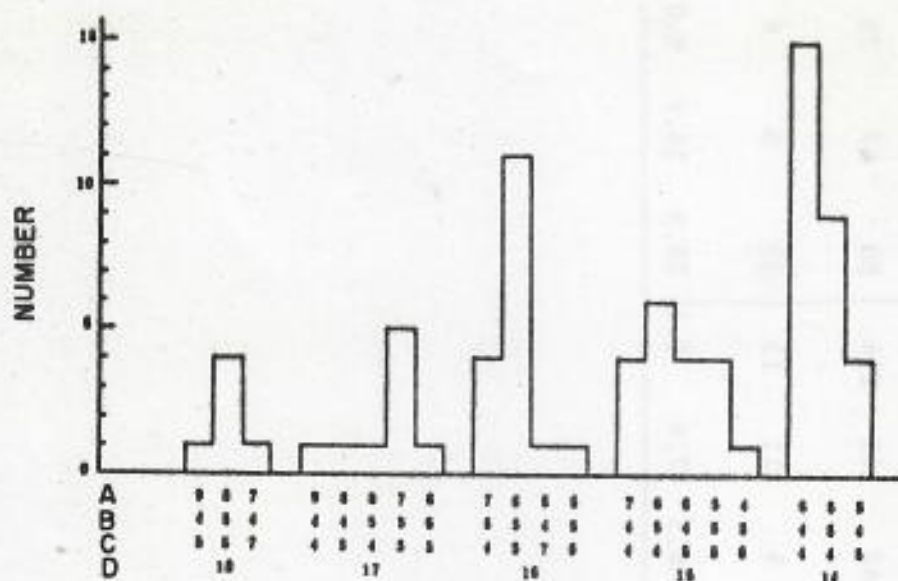


Figure 9.--The occurrence of scute anomalies, arranged by various groupings.

- A - Number of vertebral scutes.
- B - Number of left lateral scutes.
- C - Number of right lateral scutes.
- D - Total number of scutes.

lateral scutes 4, and right lateral scutes 4). However, there were hatchlings with 14 to 18 scutes. As compared with that obtained last year, the range in the numbers of supernumerary scutes was narrower this year.

(2) Rearing experiments.

a. Rearing facilities.

The newly hatched turtles were placed in three rearing tanks, each measuring $1.2 \times 1.0 \times 0.2$ m. Between 150 and 200 hatchlings were put into each of the three tanks. After 10-15 days, they were transferred to three larger tanks ($1.5 \times 3.0 \times 1.0$ m) and the water level was increased as the hatchlings grew. Age-I and age-II turtles were reared in three concrete tanks ($1.5 \times 3.0 \times 1.0$ m) and an outdoor tank ($7.8 \times 3.7 \times 0.5$ m).

b. Feeding.

Similar to last year, the hatchlings were fed beginning 3-5 days following hatching. They were given small pieces of scad mackerel, *Decapterus* sp., wahoo, *Acanthocybium* sp., saury, *Cololabis saira*, sardine, *Sardinops melanosticta*, and various inshore species of fish. The size of the food offering was increased as the turtles grew larger. Also, in addition to these natural foods, prepared food (pellets) was also fed. Leafy vegetables, such as cabbage and lettuce, were also given.

c. Rearing of age-0 hatchlings.

The results of rearing age-0 hatchlings are shown in Table 10. Between July 20 and August 14, 1976, 1,069 hatchlings were obtained. Of these, 585 died within 2 months. The mortality rate (54.8 percent) was about the same as last year but after November, the mortalities decreased considerably.

d. Rearing of age-I turtles.

In Tables 11-1 through 11-5 are shown the results of rearing various groups of age-I turtles that had hatched during 1974. Mortality rates were low and the groups developed satisfactorily until these young turtles were utilized in feeding experiments using pelletized food and also in tagging experiments. Twelve age-I turtles were kept for rearing to the adult stage, and the results of their development are shown in Table 12.

The carapace length and body weight of these juveniles increased rapidly between August and November, but their growth slowed down significantly between December and March. This

Table 10.--The results of rearing age-0 green turtles (hatched in July-August 1975).

Item	Date of observations							
	8/22/75	9/22/75	10/20/75	11/20/75	12/19/75	1/20/76	2/20/76	3/19/76
Number being reared	651	484	456	450	1200	199	199	198
Number died		207	28	6	0	1	0	1
Survival rate (%)		68.2	94.2	98.7	100	99.5	100	99.5
Average body weight (g)	50.9	132.6	271.6	427.5	682.4	746.0	816.0	886.2
Average carapace length (cm)	6.40	9.18	11.43	13.25	15.18	15.99	16.23	16.94
Average carapace width (cm)	5.53	7.96	9.73	11.18	12.80	13.52	13.73	14.38
Total weight increase (kg)		25.8	66.7	70.6	35.1	12.0	13.9	13.9
Total weight of food given (kg)		45.3	71.3	113.3	55.9	36.6	28.8	27.2
Daily feeding rate (%)		3.08	2.73	2.31	1.62	0.80	0.60	0.58
Food conversion ratio		1.76	1.07	1.60	1.59	3.05	2.07	1.95

¹250 individuals were released on November 25, 1975.

Table 11-1.--Results of rearing age-I green turtles (hatched July 16-30, 1974).

Observation	Date of observation		
	4/17/75	5/18/75	6/23-27/75
Number being reared ¹	138	138	³ 140
Number died	² (7)	0	0
Survival rate (%)	40.4	40.4	40.9
Average body weight (g)	1,445.9	1,481.6	1,869.0
Average carapace length (cm)	20.61	20.90	23.91
Average carapace width (cm)	17.25	17.30	19.56
Total weight increase (kg)	6.0		57.2
Total weight of food given (kg)	59.0		166.8
Daily feeding rate (%)	0.94		1.79
Food conversion ratio	9.83		2.92

¹Total hatched = 342.

²Number in parentheses include accidental deaths and "missing" individuals.

³With the exception of seven individuals kept for continuous rearing, the rest were released.

Table 11-2.--Results of rearing age-I green turtles (hatched September 2-4, 1974).

Observation	Date of observation		
	4/2/75	5/5/75	6/2/75
Number being reared ¹	85	85	85
Number died	2	0	0
Survival rate (%)	49.1	49.1	49.1
Average body weight (g)	762.4	785.5	850.4
Average carapace length (cm)	16.43	16.75	17.15
Average carapace width (cm)	14.12	14.13	14.35
Total weight increase (kg)	0.6	2.0	5.5
Total weight of food given (kg)	29.2	35.4	32.9
Daily feeding rate (%)	1.45	1.68	1.69
Food conversion ratio	47.99	17.70	5.98

¹Total hatched = 173.

Table 11-3.--Results of rearing age-I green turtles
(hatched September 27-21, 1974).

Observation	Dates measured		
	4/17/75	5/16/75	6/28/75
Number being reared ¹	169	² 68	64
Number died	1		4
Survival rate (%)	46.4	100	94.1
Average body weight (g)	533.1	456.8	608.9
Average carapace length (cm)	14.79	14.45	15.76
Average carapace width (cm)	12.55	12.28	13.20
Total weight increase (kg)	3.2		10.0
Total weight of food given (kg)	34.5		40.0
Daily feeding rate (%)	1.30		2.86
Food conversion ratio	10.78		4.00

¹Total hatched = 364.

²100 of the turtles deleted because of the feeding experiment.

Table 11-4.--Results of rearing age-I green turtles
(hatched September 25-30, 1974).

Observation	Dates measured	
	4/26/74	5/26/74
Number being reared ¹	46	46
Number died	1	0
Survival rate (%)	29.3	29.3
Average body weight (g)	518.8	591.3
Average carapace length (cm)	14.48	14.93
Average carapace width (cm)	12.47	12.79
Total weight increase (kg)	3.1	3.3
Total weight of food given (kg)	14.0	17.1
Daily feeding rate (%)	1.94	2.23
Food conversion ratio	4.52	5.18

¹Total hatched = 157.

Table 11-5.--Results of rearing age-I green turtles
(hatched October 11-17, 1974).

Observation	Dates measured		
	4/17/75	5/19/75	6/16/75
Number being reared ¹	80	73	71
Number died	3	7	2
Survival rate (%)	47.9	43.7	42.5
Average body weight (g)	362.8	416.9	526.8
Average carapace length (cm)	12.79	13.45	14.73
Average carapace width (cm)	11.09	11.61	12.75
Total weight increase (kg)	3.9	4.1	7.9
Total weight of food given (kg)	15.1	26.9	32.9
Daily feeding rate (%)	1.77	2.83	3.47
Food conversion ratio	3.87	6.56	4.17

¹Total hatched = 167.

reduced growth corresponded to the period of falling water temperatures and also to a significant reduction in feeding rate. Thus, the average growth in carapace length during the 8-month period (August-March) was from 26.2 to 37.4 cm, and average growth in body weight was from 2.9 to 8.1 kg.

e. Rearing of age-II turtles.

Table 13 shows the results of rearing seven age-II turtles that had hatched during 1973. The results were similar to that of age-I turtles in that age-II turtles grew well in the summer and poorly in the winter. During the same 8-month period, the average carapace length increased from 34.3 to 40.8 cm, and the average body weight from 7.0 to 12.4 kg.

Table 12.--Results of rearing age-I green turtles (hatched in 1974).

Observation	Date of observation							
	8/14/75	9/20/75	10/19/75	11/19/75	12/18/75	1/19/76	2/19/76	3/19/76
Number being reared	12	12	12	12	12	12	12	12
Number died		0	0	0	0	0	0	0
Survival rate (%)		100	100	100	100	100	100	100
Average body weight (g)	2,921.7	4,312.5	5,573.3	6,469	7,182	7,543	7,998	8,127
Average carapace length (cm)	26.2	29.9	32.2	34.4	35.8	36.6	36.8	37.4
Average carapace width (cm)	21.5	24.6	26.7	28.7	29.6	30.3	30.6	31.0
Total weight increase (kg)		16.69	15.13	10.75	8.6	4.3	5.5	1.5
Total weight of food given (kg)		32.1	31.3	33.3	16.7	14.0	11.4	10.5
Daily feeding rate (%)		2.00	1.82	1.45	0.70	0.49	0.40	0.38
Food conversion ratio		1.92	2.07	3.09	1.96	3.21	2.09	6.85

Table 13.--Results of rearing age-II green turtles (hatched in 1973).

Observation	Date of observation							
	8/14/75	9/20/75	10/19/75	11/19/75	12/18/75	1/19/76	2/19/76	3/19/76
Number being reared	7	7	7	7	7	7	7	7
Number died		0	0	0	0	0	0	0
Survival rate (%)		100	100	100	100	100	100	100
Average body weight (g)	7,013	8,133	9,366	10,224	11,147	11,749	12,194	12,377
Average carapace length (cm)	34.3	37.3	--	38.7	39.5	40.2	40.5	40.8
Average carapace width (cm)	29.3	32.0	31.8	33.0	33.5	34.2	34.3	34.8
Total weight increase (kg)		7.84	8.63	6.01	6.46	4.21	3.12	1.28
Total weight of food given (kg)		21.57	20.70	28.11	14.97	13.62	10.38	8.94
Daily feeding rate (%)		1.10	1.17	1.32	0.69	0.53	0.40	0.36
Food conversion ratio		2.75	2.40	4.68	2.32	3.24	3.33	6.98