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Trapping Survey for the Red Frog Crabs (*Ranina Ranina*) Using the Baited Tangle Nets and Pots in Offshore Tanegashima, Japan

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Abstract: *The trial operation of the baited tangle nets and pots were done to sample the red frog crab (Ranina ranina) from offshore Tanegashima, Japan. The baited tangle nets were made of PA nylon multifilament with five different mesh sizes (37.8mm, 50.5mm, 75.8mm, 97.0mm and 121.2 mm of). The pots were made of PE nylon multifilament with 15mm mesh size. Both traps were attached at 5m intervals along the line randomly and were lowered onto the seabed for about 5-hr soak time before being taken. A total of 96 crabs R. ranina consisted of 61 males (64%) and 35 females (36%) was caught primarily with the baited tangle nets. The size frequency of males and females was ranged from 67.2 to 138.5mm and from 50.4 to 128.6mm respectively. In term of foraging behavior, males were more abundant in this area. The CPUE for the baited tangle nets was ranged from 2.8 ± 0.58 to 5.4 ± 2.41. The number of the legal-sized crabs (≥ 93mm) was half time higher than undersized crabs (< 93mm), and most of them were males. The use of a larger mesh size seems to prevent the crabs from further damage and is optimal with respect to clearing-time and escapement of the juvenile crab from the nets. None of R. ranina was found in the pots.*

Keywords: *baited tangle net, circle-shaped pot, sex ratio, red frog crab, Tanegashima*.

1. INTRODUCTION

In Japan, the spanner crab or the red frog crab *Ranina ranina* (Linnaeus, 1758), locally known as "**Asahigani**", is an important edible crab abundant in the coastal waters of Tanegashima, Japan. Geographically they are imperially distributed in the Indo Pacific region in sandy substrata at depths between 10 and 70 m from Hawaii, Japan, Formosa, Philippines, and Australia through the Indonesian Archipelago to East Africa (Onizuka, 1972). Some aspects of the reproductive biology of *R. ranina* has been widely reported to describe their mating behavior (Iwata et al., 1987; Skinner and Hill, 1987); spermathecal structure (Gordon, 1963; Hartnoll, 1979); oogenesis (Minagawa et al., 1993; Ichikawa et al., 2004); fecundity (Fielding and Haley, 1976; Brown, 1986; Krajangdara and Hemtanon, 1998; Krajangdara and Watanabe, 2005); sexual dimorphism (Minagawa, 1993); male reproductive biology (Minagawa et. al., 1994); or female reproductive cycle (Onizuka, 1972, Fielding and Haley, 1976; Tahil, 1983; Brown, 1986; Minagawa et al., 1993). Other studies (Minagawa, 1990a; 1990b; Minagawa and Murano, 1993; Minagawa and Takashima, 1994; and Kirkwood et al., 2005) focused on larval and juvenile development in *R. ranina*.

In many countries, population of this crab is exploited commercially using bottom gill net in the Andaman Sea off Thailand and the Gulf of Mannar, India (Krajangdara and Watanabe, 2005; Kasinathan, 2007), trawl nets, baited tangle nets and baited traps in Queensland, Australia (Brown, 1986; Skinner and Hill, 1986; Kennely, 1989; Kennely and Craigh, 1989; Kennelly et al., 1990), trap nets known as "Sangbaw" in Central Tawi-Tawi, Philippines (Tahil, 1983), baited nets in Hawaii Sea (Onizuka, 1972), and baited crab traps known as " Benthol" in Jolo-Sulu and Camiguin Island-Philippines (Vicente et al., 1986) as well as "Toyama Kago" in Japan Sea (Sinoda and Kobayashi, 1969).

Among fishing techniques aforementioned, the baited trapping are known as an effective method for catching *R. ranina*. However, there are many factors need to be examined prior to use the baited traps to collect crabs such as trap design, the trapping mechanism, combination of mesh sizes, the bait arrangement, soak-time of traps, spatial heterogeneity and short-term temporal variability on sampling abundances. Geographical factors such as fishing ground, season, current sped in the bottom water, etc. should also be carefully considered. In this paper we considered the first 4 of these factors in determining the best way of catching *R. ranina* by using the baited tangle nets with five different mesh sizes as well as the circle-shaped pots as an alternative gear instead of traditional crab trap e.g. "Toyama Kago". This includes examining the size and sex ratio of *R. ranina* in this fishing ground, and providing recommendations for future application.

2. MATERIAL AND METHODS

2.1. Study Site

The fieldwork was carried out on sandy substrata offshore Tanegashima, Japan (30^{0}27'170" N, 130^0 50'385" E) with the sea depth varied from 40 to 80 m; the same fishing grounds as those used by commercial fishermen (**Figure 1**). The surface water temperature ranged from 27 to 29 °C throughout the trials. Spanner crabs were main species target collected over 6 daytrips of May 2003.

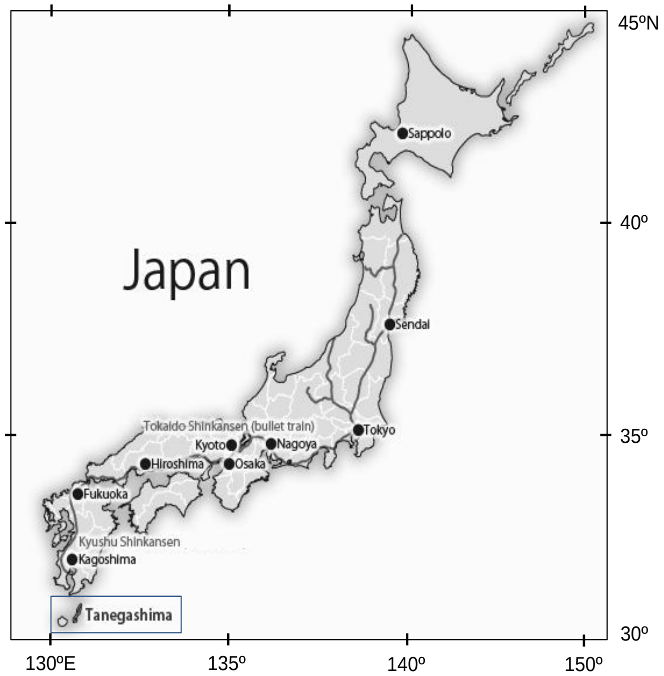

Figure1. *Location of trapping survey for R. ranina in offshore Tanegashima, Japan*

2.2. Experimental Design

In this survey, the number of crabs in the baited tangle net and the circle-shaped pot were investigated (**Figure 2**). The baited tangle nets were made of Polyamide (PA) orange nylon multifilament # 4, which was suspended over mild metal flat frames (3mm diameter) enclosing an area of 50 × 50cm with 0.45 hanging ratio. Five different mesh sizes (37.8mm, 50.5mm, 75.8mm, 97.0mm and 121.2mm) were tested. The number of meshes was varied from 9 to 29; while the net length was ranged from 1,091 mm to 1,096 mm with the same net height 500 mm. The circle-shaped pots were made by Polyethylene (PE) nylon multifilament # 6 (15mm mesh size) with 0.50 hanging ratio. It contains 226 meshes; 3,385 mm net length; and 450mm net height respectively, which fastened around two galvanized iron ring frames (8mm diameter); the larger one of 235cm perimeter was placed on the bottom and the smaller one of 75cm on the top as open funnel entrance. The detailed specification of both gears can be seen in **Table 1**.

The Pacific mackerel (*Scomber japonicas*) scraps (approx. 50g) were used as bait and placed on a metal bar in the middle of each tangle net frame or placed in a polyvinyl container of each circle-shaped pot. Both traps were attached at 5 m intervals along the line randomly and were lowered onto the seabed for a given soak-time during which individual *R. ranina* and other species were purposely attracted to the bait and become entangled on the nets or fell into the pots before reaching the bait. When the traps were hauled, the crabs were disentangled from the nets or entrapped in the pots, counted, sexed, measured, and then recorded. The number of males and females caught by the nets was determined from their eating behavior. The body size of the crabs was expressed in terms of carapace length (CL), which was measured by placing a vernier caliper to the nearest 0.1 mm from the posterior edge of the eye orbit to the posterior margin of the carapace. The data were set into 10 mm size classes based on carapace length. The legal-sized crabs were determined as ≥ 93 mm CL; while undersized crabs were < 93 mm CL. Ovigerous females were determined as ≥ 70 mm CL; while the minimum size of sexual maturity in female was between 50 mm and 61 CL. The catch per unit effort (CPUE) was expressed as the number of crab per hour per individual trap.

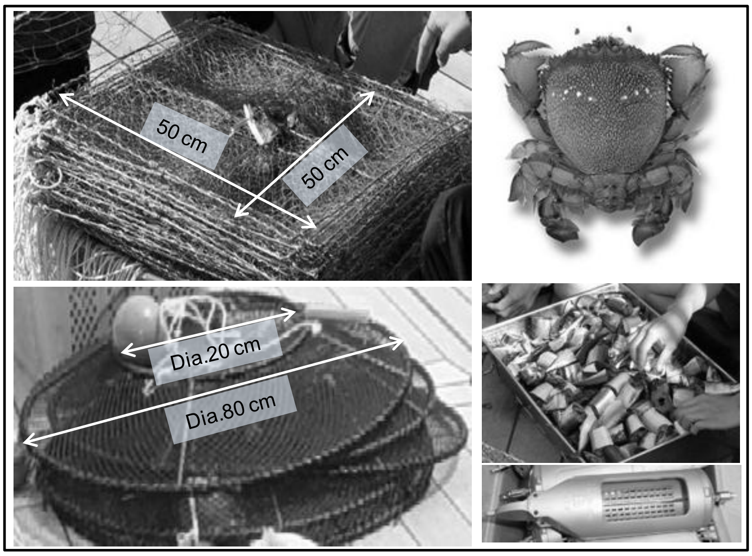

Figure2. *Baited tangle nets (upper-left) and circle-shaped pots (bottom-left) used for capture R. ranina (upper-right) from offshore Tanegashima, Japan. The Pacific mackerel Scomber japonicus scrap was used for bait and put it on a metal bar in the middle of each tangle net frame (upper-left) or placed in a polyvinyl container of each circle-shaped pot (bottom-right).*

Table1. *Specification of the baited tangle net and the circle-shaped pots.*

Type and number of trap	Shape and size	Webbing	Mesh size (mm)	Mesh number	Net length (mm)	Net height (mm)	Hanging ratio
Baited tangle net, 200 units	Square-shaped (3 mm metal) 500x500 mm,	PA, nylon multifilament, orange # 4	37.8	29	1096	500	0.45
			50.5	22	1111	500	0.45
			75.8	14	1061	500	0.45
			97.0	11	1067	500	0.45
			121.2	9	1091	500	0.45
Circle-shaped Pot, 20 units	Circle-shaped (8mm iron) **Top panel**: 200mm dia. (75cm perimeter) **Bottom panel**: 800mm dia. (235cm perimeter)	PE, nylon multifilament, black # 6	15.0	226	3385	450	0.50

Site, time, and technique for setting and hauling were done in Nansei Maru training vessel 175 GT belong to Faculty of Fisheries Kagoshima University, Japan. Setting was from stern, while hauling was from starboard side using a line-hauler. A total of 200 baited tangle nets were arranged into 4 sets of 50 nets. The 50 nets on each set were spaced 50 m apart. Each set comprised all nets of a given mesh size arranged randomly and left on the seabed for about 5-hr soak-time before being taken. A total of 20 circle-shaped pots were divided into 4 sets of 5 pots and inserted between the baited tangle nets in operation. The traps were arranged randomly with the same method and deployed in different location following day.

2.3. Statistical Analysis

The Kruskal-Wallis test, the analysis of variance by ranks, was employed to investigate if the total catches of the five different mesh sizes of the baited tangle nets were significantly different. A post-hoc analysis test was performed using the Multiple Comparison to see which catch differed significantly among the traps. The Mann-Whitney test was used to determine whether catch size differed between male and female as well as between the baited tangle nets and the circle-shaped pots (Conover, 1980). All statistical tests were evaluated at the 95% confidence level.

3. Results

A total of 96 crabs *R. ranina* was collected from different mesh sizes of baited tangle nets during the survey, consisted of 61 males (64%) and 35 (36%) females (Table 2). The overall ratio of males to females was 1.7:1. Of all crabs caught, 61.5% were legal-size (≥ 93 mm carapace length) and 64.4 % of which were males. Further, 38.5% were undersize crabs and 62.2% of which were also males. The size frequency of males and females was 67.2-138.5 mm and 50.4-128.6 mm respectively, indicating that the average size of males caught by the nets was larger than females (**Figure 3**). To describe the attained size of individual crab, the study on age and growth are required. The Mann-Whitney test, however, showed that there was no significant difference in the carapace length size between males and females ($T = 1.3816$, $p > 0.05$). The details of catch numbers and sex ratio of males to females in correspond to the mesh sizes used were recorded under following numbers: 27 crabs (26:1) for 37.8 mm, 14 crabs (2.5:1) for 50.5 mm, 15 crabs (1:2.8) for 75.8 mm, 17 crabs (4.7:1) for 97.0 mm, and 23 crabs (2.3:1) for 121.2 mm, respectively. Statistically, there was no significant differences in the total catch among the five mesh sizes used (Kruskal-Wallis test, $H = 10.1879$, $p > 0.05$). The results also revealed that there was no significant correlation between mesh sizes and the catch size of *R. ranina* (regardless sex) as shown in **Figure 4**.

The CPUE ± SD of the baited tangle nets was determined as follows: 5.4 ± 2.41 for 37.8 mm mesh size, 2.8 ± 0.58 for 50.5 mm, 3.0 ± 1.73 for 75.8 mm, 3.4 ± 1.26 for 97.0 mm, and 4.6 ± 2.32 for 121.2 mm respectively. The ovigerous females with carapace length (CL) were ranged from 78.33 to 128.58 mm. The minimum size at the maturity of female was from 50.40 to 60.75 mm CL. In term of foraging behavior, the males were more abundant than female in this area. None of *R. ranina* was found in the circle-shaped pots.

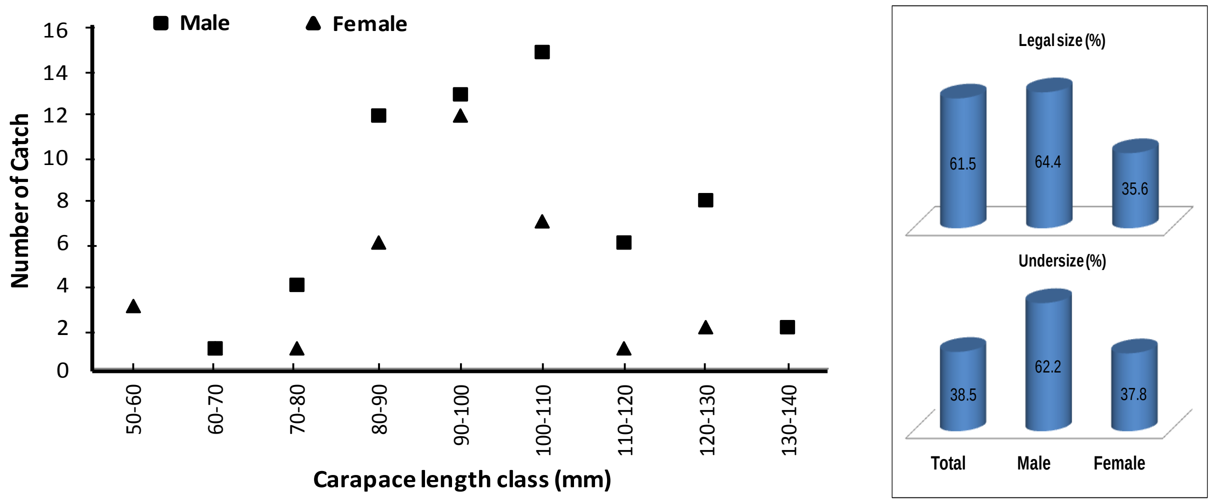

Figure3. *Relationship between carapace length class and catch number of R. ranina (Left). The proportion of all crabs caught between legal size (≥ 93 mm CL) and undersize crabs (< 93 mm CL) (Right).*

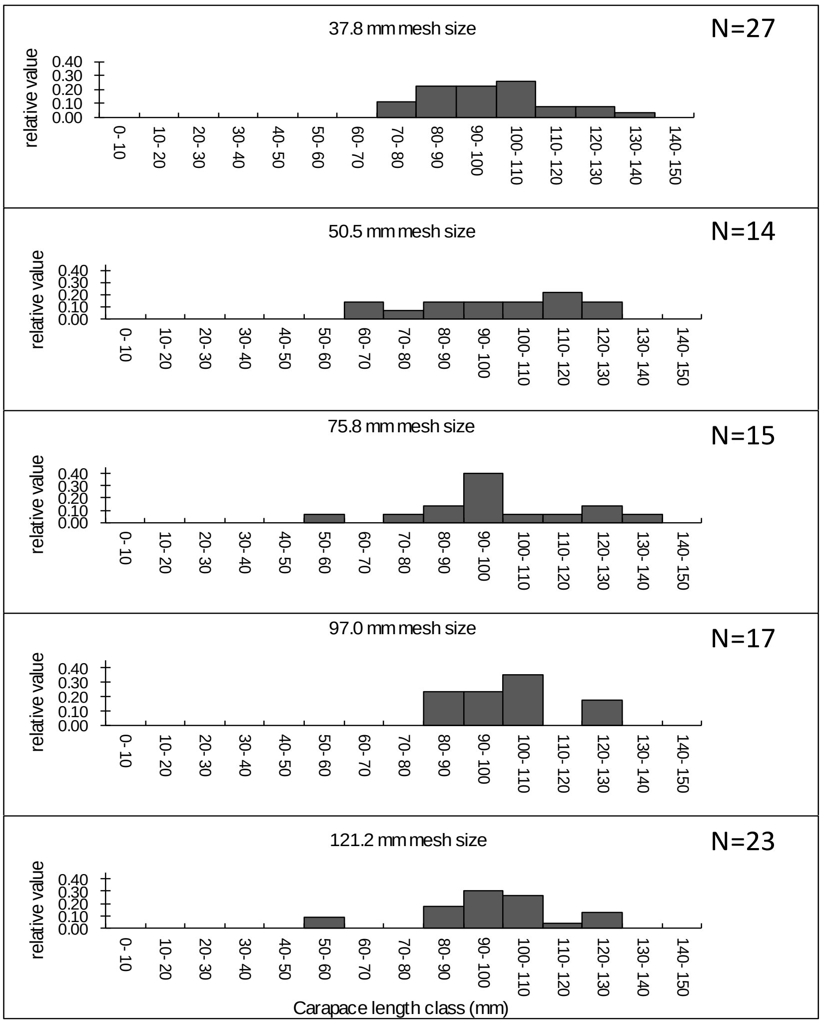

Figure4. *Relative frequency of catch calculated from carapace length class according to mesh sizes used and number of samples.*

4. DISCUSSION

The results clearly demonstrated that the baited tangle nets were the best way of catching *R. ranina* in this fishing ground. The similar result was reported by Sumpton *et al*. (1995) when targeting *R. ranina* using tangle nets with different combination of mesh sizes in Australia. The greater efficiency of the baited tangle nets can be attributed to the way they are laid on the sea bottom; this allows crabs crawl over them from any direction while they follow the bait odor. Hill and Wassenberg (1999) estimated the speed of crab movement towards the bait was about 4 cm/sec. Within in 30 min, *R. ranina* could be attracted as far as 70 m from the bait. This attraction is highly influenced by the direction of the water current and bait odor. Circle-shaped pots, on the other hand, have funnel entrance on the top, which crabs must crawl to reach the bait, resulted in the greater time required by crabs to find the entrances of pots. The baited tangle nets targeting crab *R. ranina* that are very susceptible to entanglement since they have flattened dactyls and narrow joints, while circle-shaped pots do not. The similar mechanism of entanglement in the baited tangle net for *R. ranina* was found in the lift-nets for the orange mud crab *Scylla olivacea* in Thailand (Jirapunpipat, 2008), the mud crab *Scylla serrata* in Indonesia and India (Cholik and Hanafi, 1992; Mohapatra et al., 2011), the blue crab *Callinectes amnicola* in Negeria (Lawal-Are, 2010), and the four-lobed swimming crab *Thalamita sima* in Japan (Vasquez Archdale et al., 2010).

The use of bait polyvinyl container in the circle-shaped pot seems to be ineffective for catching *R. ranina* since it may not strong enough to allow crabs follow the bait odor trail compared favorably with the baited tangle net (See **Figure 2**). It is suggested to use the wire container for the future application to provide better results. Observation on the condition of the bait at the time of hauling showed that the bait quantity was enough in the circle-shaped pots because no crab had been caught, but most the bait was consumed in the baited tangle nets as a result of food competition between the crabs. In term of foraging behavior, males and legal size are more abundant in this fishing ground. On the other hand, males responded more rapidly than females to the bait resulted in males were more catchable in the baited tangle nets than females. The similar results were also reported by Fielding and Haley (1976), Kennelly (1998), and Chen and Kennelly (1999). The contrary results were reported by Brown (1986), Skinner and Hill (1987), Kennely and Craig (1989), and Kennely (1992). Regardless the sex, Hill and Wassenberg (1999) recorded the period of *R. ranina* responded to the bait rose to a peak between 12 and 21 min after the net was placed on the bottom and then declined.

The hanging ratio of the netting panel can be more correlated for the entangle functions. To be compared, therefore, the excess number of meshes in the panel frame of the baited tangle net should be set at the same hanging ration as 0.45. From this trial, it was clearly found that the legal-sized crabs were half time higher than undersized crabs. Further, the large proportion of legal-sized crabs was males ranged from 80-110mm CL class (**Table 2**). This implies that intensive fishing pressure probably removes members of the large size classes. There was no significant correlation between mesh sizes and the size of *R. ranina* caught in the baited tangle nets indicating that the tested mesh sizes (37.8~121.2mm) were acceptable for commercial tangle net fishery in Tanegashima. However, it is suggested that the use of a larger mesh size seems to prevent the crabs from further damage and to make retrieving easier. According to Sumpton et al. (1995) a mesh size between 25 mm and 85 mm proved to be most effective for minimizing damage whilst maintaining catch rates. The lost of dactyls (a major cause of post-release mortality) was greater in the 25 mm mesh of *R. ranina*. Furthermore, Kennely et al. (1990) observed the effect of disentanglement from commercial tangle traps on the mortality rate of undersized crabs of *R. ranina* and concluded that about 60-70% of crabs with one or more dactyls removed died within 50 days, whilst 100% of crabs which lost whole limbs (after being pulled off nets) died after 8 days. Kirkwood and Brown (1998) evaluated the mortality rates of undersized crabs of *R. ranina* with four different levels of injury associated with limb removal and release from baited tangle nets. The results showed that individuals with one periopod or cheliped sustaining greater mortality (up to 90%) than crabs that had no limb damage or one to three dactyli removed (less than 25%). The mortality rate of undersized of *R. ranina* especially juvenile crabs is very crucial for sustainable fisheries management since the juvenile crabs having slow growth that is dealt with their slow metabolism indicating that this species would be likely to recover slowly from overexploitation. From this trial, we suggested using the larger mesh to allow the juvenile crabs escape from the net.

Table2. *The number of male and female R. ranina collected from baited tangle-nets with different mesh sizes*.

Carapace length class (mm)	Number of male and female by mesh size (mm)										Total	
	37.8		50.5		75.8		97.0		121.2			
	M	F	M	F	M	F	M	F	M	F	M	F
< 50												
50-60						1				2		3
60-70			1	1							1	1
70-80	3		1			1					4	1
80-90	5	1	2			2	4		1	3	12	6
90-100	6		1	1	1	5	3	1	2	5	13	12
100-110	7		2			1	4	2	2	4	15	7
110-120	2		2	1	1				1		6	1
120-130	2		1	1	1	1	3		1	2	8	2
130-140	1				1						2	
> 140												
Total	26	1	10	4	4	11	12	5	7	16	61	35
CPUE ± SD	5.4 ± 2.41		2.8 ± 0.58		3.0 ± 1.73		3.4 ± 1.26		4.6 ± 2.32			

The baited tangle nets have many advantages over the circle-shaped pots; they are easily constructed, require less material and low cost, more easily stacked and occupy less space on deck. They can also be fished with much shorter soaking times, so that they can be used more frequently.

5. Conclusion

From this survey, it was concluded that the baited tangle nets were outperformed the circle-shaped pot in view of catching efficiency. The circle-shaped pot catches none of red frog crabs, because of the failure with the bait container. For the baited tangle nets, there was no significant correlation between mesh sizes and the size of captured crabs. The use of a larger mesh size seems to prevent the crabs from further damage and is optimal with respect to clearing-time and escapement of the juvenile crabs from the net. Males and legal size were more abundant in this fishing ground.

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