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Artificial aggregating device for fish and squid eggs

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Abstract. The objective of this study was to assess the ability of artificial aggregating substrates for fish and squid eggs attachment. This study was performed in an area adjacent to Bidong Island on the East Coast of Peninsular Malaysia. The aggregating devices were set up at three different water depths (6 m, 12 m and 18 m) in nine locations. The presence of fish eggs and squid eggs in attractors were collected every two weeks. Scuba diving was used to collect data in different water depths. This study revealed that no fish eggs were recorded on the attractors, but there was a presence of squid eggs in seven locations. In addition, the results also showed that environmental factors such as temperature, salinity, pH and dissolved oxygen (DO) not significantly affect the presence of squid eggs. However, the location and depth of the attractors from the water surface have a significant effect on squid egg attachment in atractor.
Key Words: fish eggs, squid eggs, attractors device, scuba diving, *Loligo* sp.

Introduction. Some species of marine fish and squid lay their eggs on floating objects (King 2007). They commonly lay their eggs on rocks, gravel, sand, holes, the base of sea anemones and aquatic plants (Balon 1990; Gooding & Magnuson 1967). These objects are known as aggregating devices or substrate.

According to Shao et al (2001), fish eggs contain important information of the life history and ecology of fish and other aquatic organisms. They play an important role in environmental impact assessment, fishery stock analysis, fish propagation, seedling release, and fish farming. Also, fish and squid eggs are an important prey in the marine food web (Shao et al (2001). The aggregating devices are able to attract and aggregate fish for spawning, this is becuase the device provides the suitable condition for fish or squid to spawn (Castro et al 2002; Gooding & Magnuson (1967). The study on the aggregating devices is crucial in determining the spawning and nursery grounds of aquatic organisms including fish and squid. In addition, identifying spawning and nursery grounds is a valuable starting point for understanding the effectiveness of aquatic resources management program. This is especially true when selecting the locations of marine protected areas in order to conserve rare and threatened species and to increasing marine resources.

Currently information on the artificial aggregating devices for tropical fishes and squids were very limited available, except a report by Castro et al (1999) who studied fish aggregating devices in the Central East Pacific. However, the studies on aggregating devices for fish and squid eggs attachment in tropical seas, especially in Terengganu waters in Malaysia were poorly conducted. Hence, the objectives of this study were to determine the artificial aggregating device for fish and squid eggs, and to evaluate the relationship between the presence of fish eggs and environmental variables.

Material and Method

Study area. This study was performed in an area adjacent to Bidong Island on the East Coast of the Peninsular Malaysia. The area is situated approximately at latitude 05°35'027''–05°40'250'' N and longitude 103°00'471''–103°07'309'' E (Figure 1). The study was conducted on May to July 2013.

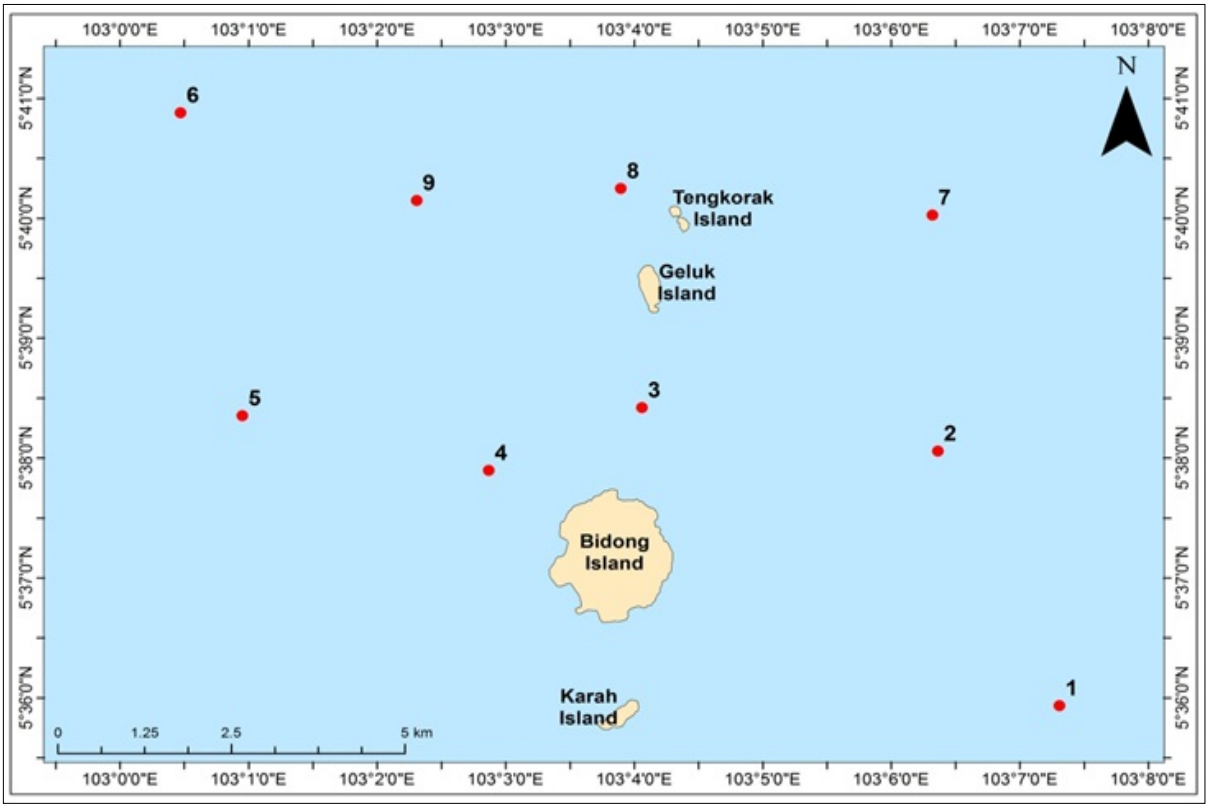

Figure 1. The map of Bidong Island waters shows the location of the study.
The locations of the aggregating devices are marked in red (Ibrahim et al 2014).

Aggregating device preparation. A fish aggregating device has three main components: floats, an attractor and an anchor (Altinagac et al 2010). For this study, each aggregating device had two floats, one plastic float and one Styrofoam float. The plastic float had a 60 cm diameter and the Styrofoam float had a 30 cm diameter. They were used as an attractor float and a flag buoy, respectively. In addition, a 3 kg stone was used as sinker for the buoy flag and 50 kg sand bags were used as anchors. A detailed illustration of the aggregating device is presented in Figure 2. Coconut fronds were used as natural attractors. Every attractor had eleven coconut fronds. The aggregating devices were set up at three different water depths (6 m, 12 m and 18 m) in nine locations around adjacent Bidong Island waters (Table 1) for 3 months from May to July 2013.

Table 1

GPS Coordinates of the sampling stations for aggregating devices

Station	*Latitude*	*Longitude*
1	5°35'935'' N	103°07'309'' E
2	5°38'060'' N	103°06'364'' E
3	5°38'422'' N	103°04'062'' E
4	5°37'899'' N	103°02'870'' E
5	5°38'355'' N	103°00'952'' E
6	5°40'081'' N	103°00'471'' E
7	5°40'027'' N	103°06'322'' E
8	5°40'250'' N	103°03'896'' E
9	5°40'150'' N	103°02'408'' E

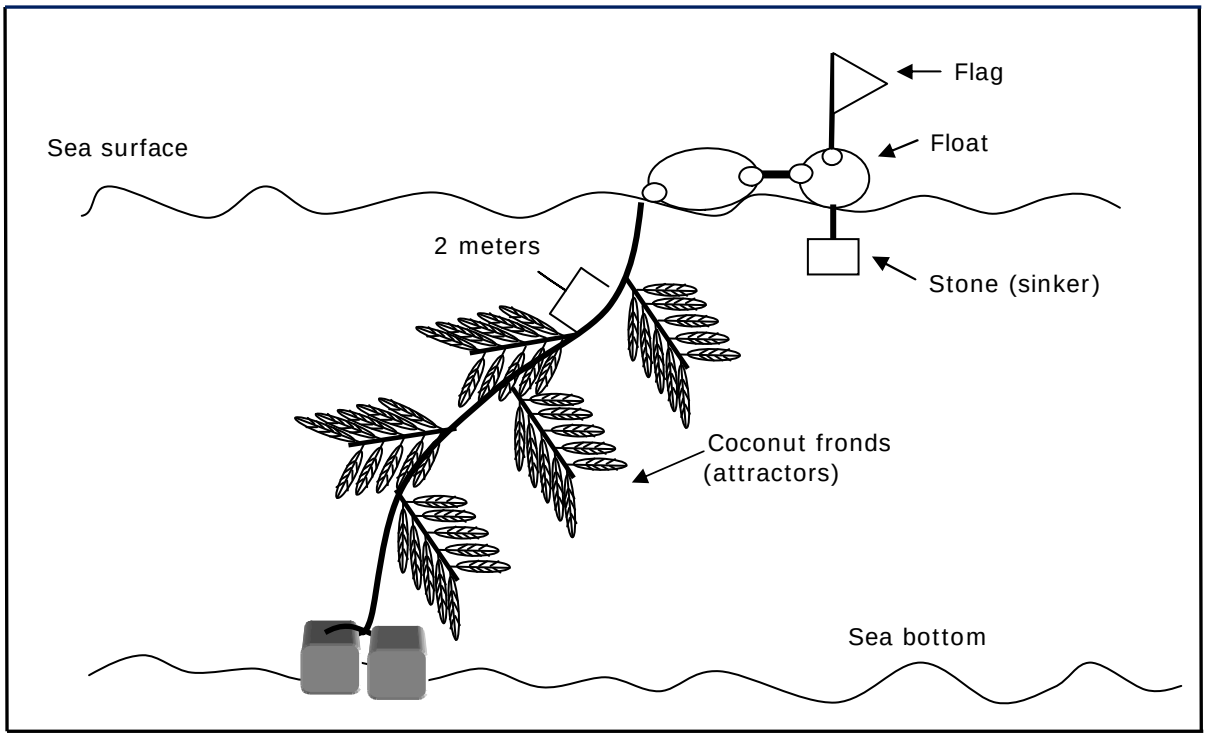

Figure 2. Aggregating devices components.

Data collection. Four coconut leaves from each attractor's of agregating devices were collected every two weeks by a scuba diver to observe the presence of fish and squid eggs in different water depths (6 m, 12 m and 18 m). The collected eggs were preserved in formalin 10% for further identification in the laboratory using light microscopy (Leica 2000, Model Z45V). An underwater camera was also used to observe and record the fish and squid eggs attached to coconut fronds in the water. Environmental parameters such as temperature (^{o}C), salinity (ppt), dissolved oxygen (mg L^{-1}) and pH were measured at every location using a water quality checker (YSI 556 MPS).

Statistical analysis. The fish and squid eggs data were tested with the Kolmogorov-Smirnov test if the data were not normal (KS = 6.434, $p < 0.05$). The Kruskall-Wallis test (non parametric analysis) was used to determine the effect of the position of the aggregating devices and attractor depth on the presence of fish eggs or squid eggs. The Mann-Whitney test was used to verify the difference between the presence of squid eggs and the attractor depth. In addition, a Pearson correlation test was utilized to determine the relationship between the environmental variables and the existence of squid eggs in the attractors. All data analyses were performed using the SPSS 18.0 program.

Results and Discussion. This study found that no fish eggs were recorded on the attractors in any of the locations. However, squid eggs were observed on the aggregating devices (Figure 3). Based on video from the underwater camera, there were several fish species present around the devices, including hard-tail scad (*Megalaspis cordyla*), black kingfish (*Rachycentron canadum*), blackfin scad (*Alepes melanoptera*), Snapper (*Lutjanus lutjanus*), peron's threadfin bream (*Nemipterus peronii*), areolated grouper (*Epinephelus areolatus*), and white-shouldered whiptail (*Pentapodus bifasciatus*). These fish have spawning characteristics where their eggs are pelagic (Premalatha 1998; Russel 1990; Tucker 1999; Shao et al 2001) and thus not attached to any substrate.

According to Balon (1990), several species of fish have been classified as clutch tenders, nesters and used egg scatterer substratum fish, for example *Cololabis saira* (Scomberosocidae), *Merlangius merlangus* (Gadidae) *Cheilopogon heterurus* (Exocoetidae) (Castro et al 2002) and *Exoecoetus* sp. (Hunte et al 1995). However, these species were not observed around the aggregating devices.

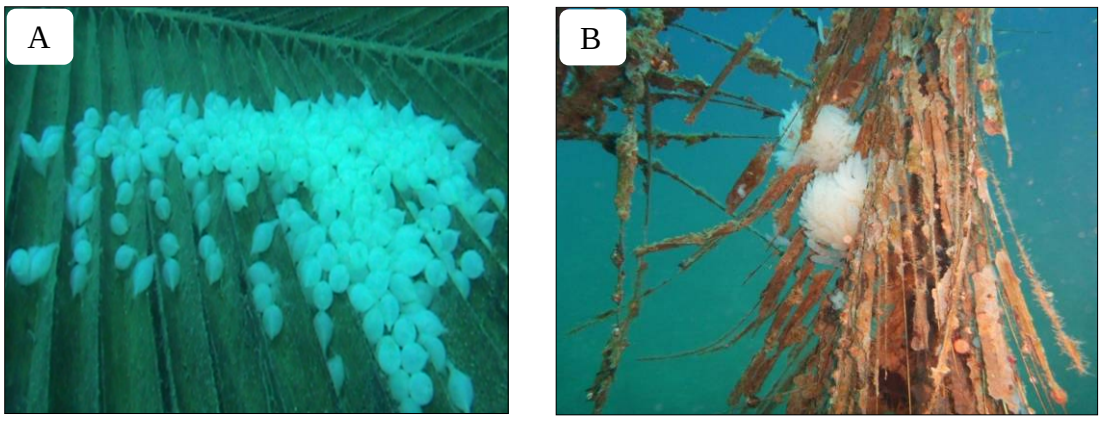

Figure 3. The squid eggs attached to attractors after 2 weeks of immersion (A) and after 10 weeks of immersion (B).

The results showed the presence of squid eggs in coconut frond attractors, which were recorded after 2 weeks and 10 weeks of the experiment. The squid eggs were observed on the aggregating devices in seven locations i.e. station 1, station 2, station 4, station 6, station 7, station 8 and station 9, while squid eggs were not found on devices in station 3 and station 5. This is probably due to the frequent presence of squid predators in the locations of devices in station 3 and station 5. This corresponds with the findings of Cabanellas-Reboredo et al (2014), who reported that squid will avoid spawning locations where there are frequent predators. In addition, Smale et al (2001) have also reported that the presence of predators may cause disruptions in egg deposition and cause the absence of chokka squid (*Loligo vulgaris reynaudii*) in otherwise adequate spawning grounds.

The location of the devices had a significant effect on the presence of squid eggs (Kruskal–Wallis test, $H = 15.901$, $n = 162$, $p = 0.044$). Yet, the presence of squid eggs was not significantly different among the immersion periods (Kruskal-Wallis test, $H = 3.578$, $n = 162$, $p = 0.612$). Nabhitabhata (1996) reported that shape and substrate location or position is more important factors than substrate material for the spawning medium of bigfins squid (*Sepioteuthis lessoniana*). A suitable location for squid spawning substrates is in a somewhat disguised location or a hidden location. Naturally, squids, for example *Loligo* sp*.,* attach their eggs to various substrate types such as sea grass, sponges, stones and coral, as well as man-made substrates like bamboo traps, coconut leaves, pots, PVC pipes, rope and plastic baskets (Nabhitabhata 1996). This study showed that depth and attractor position had a significant effect on the presence of squid eggs ($H = 17.756$, $n = 162$, $p < 0.05$) where the highest existence of squid eggs was recorded at 12 m and 18 m deep. The Mann-Whitney test (Table 2) showed that the total number of eggs was significantly different between 6 m and 12 m water depth and also between 6 m and 18 m water depth. However, there was no significant difference in the presence of squid eggs between 12 m and 18 m water depth (Table 2). These results match the findings of Tallo (2006), who found that the type of attractor and the depth affect the number of eggs attached to the attractor.

Based on the Pearson correlation test (Table 3), the water temperature, salinity, dissolved oxygen (DO) and pH levels did not correlate with the presence of squid eggs. This corresponds with the research of Cabanellas-Reboredo et al (2014), who found that sea surface temperature (SST) did not significantly affects squid spawning preferences. However, interaction between SST and depth has suggested a significant effect on adult squid, prompting them to spawn more in these areas. According to Squires et al (2013) temperature affects egg size where smaller eggs are produced at higher temperatures and the rate of egg laying where eggs are laid faster at higher temperatures. In addition, Cabanellas-Reboredo et al (2014) reported that the presence of squid has a strong relationship with depth and habitat variables where squid tend be attracted to deeper artificial devices and to artificial devices located on sandy bottoms.

Table 2

Effect of depth of attractor to presence of squid eggs

Depth of attractor	*Depth of attractor*	*Result of Mann-Whitney test*
6 meters	12 meters	(Z = -4.314, p<0.05)
6 meters	18 meters	(Z = -3.483, p<0.05)
12 meters	18 meters	(Z = -1.106, p>0.05)

Table 3

Correlation between presence of squid eggs water physic-chemical parameters measured during research, n = 63

	Temperature	*Salinity*	*Dissolved oxygen*	*pH*
Squid eggs	-0.08	-0.08	-0.10	0.05
Temperature		-0.70*	0.63*	-0.11
Salinity			-0.37*	-0.41*
Dissolved oxygen				-0.03

*Correlation is significant at the 0.01 level (2-tailed).

This study showed that fish eggs were virtually absent in the attractor. This study revealed the absence of fish species with specific spawning behavior such as fish groups using egg scatterer substrates, clutch tenders, and nesters in the study areas. However, the eggs of the Chepalopoda species, namely *Loligo* sp., were recorded in the aggregating devices attractors. The presence of squid eggs in the actractors was influenced by the location of the attractor and the attractor position and water depth (Tallo 2006). The presence of squid eggs in the coconut frond attractors is an indication that the attractors were a comfortable site for the squids to spawn. The presence of squid eggs was influenced by the depth of the attractors, where the squid eggs were mostly found 12-18 m water depth, close to the sandy bottom.

Conclusions. The coconut frond attractor was suitable for squid (*Loligo* sp.) aggregating device, but it was not suitable for fish. The depth of the attractors from the water surface had a significant effect on the presence of squid eggs where higher numbers of eggs were found at 12-18 meters deep, closed to sandy bottom. Therefore, the best place for squid egg attachment to attractors is towards the bottom of the water.

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