The behavior of yellowtail fish Caesio cuning (Bloch, 1791) to determine escape vent construction

by Cek Turnitin

The behavior of yellowtail fish *Caesio cuning* (Bloch, 1791) to determine escape vent construction

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Abstract. The escape vent is an instrument that allows selective capture of fish. However, fish respond differently to fishing gear, and, therefore, their design must be adapted to fish behavior. This research aims to observe yellowtail fish (*Caesio cuning*) behavior inside the pot to determine the best position and shape of the escape vent to release the undersized yellowtail. This research was conducted as an experiment using a pot of size: L x B x H: 100 x 75 x 32.5 cm. The yellowtail behavior was observed using two underwater cameras for nine zones inside the pot. Three different shapes of escape vents i.e., ellipse, circle, and rectangular shape, were used to investigate the best shape of escape vent to release undersize fishes. The result showed that yellowtail tends to swim around the whole zone. Zone 3 (rear, left) has the highest percentage of fish swimming around, 51.67% of them, followed by zone 1 (rear, right), 15%. Most fishes escaped from zone 1. The placement of a circle-shaped escape vent in zone 1 increases the escape chance of undersized yellowtail.

Key Words: Escape vent, vent shape, pot, yellowtail fish *Caesio cuning* (Bloch, 1791).

Introduction. There has been a paradigm shift in the fishing philosophy, primarily due to the alarming rate of decline of major fish stocks and the improved understanding of the impact of fishing on habitat and ecosystem. There has been an increasing demand for selective fishing (Hall & Mainprize 2005) during the last decades.

Developing selective fishing gears requires knowledge of fish behavior to set up suitable design, construction, and use that could minimize unintended by-catch and reduce injuries and mortality of trapped fishes. Pot is one of the potential fishing gears that is suitable for developing selective fishing gears. One method to develop pot as the selective fishing gear was to use an escape vent (Zhang et al 2021; Broadhurst et al 2020).

The response of fishes and marine biota to the fishing gears is unique for each of them. Consequently, further investigation is required to develop a suitable escape strategy that matches the species and fishing gear. The escape vent is the typical technique used to reduce undesired catches of the pot, such as crab (Boutson et al 2009; Archdale et al 2007), lobster (Jury et al 2001; Clark et al 2018) and fish (Ferno 1993; Bayse 2015; Bayse et al 2016).

The present study focuses on yellowtail fish (*Caesio cuning*) in Panggang Island of Seribu Islands, Indonesia. Yellowtail fish (*C. cuning*) is an economically important species that is caught using a wire mesh pot in Seribu Islands (Iskandar et al 2021). However, due to high by-catch, the development of fishing gear should consider the effort to reduce by-catch. The fish behavior of yellowtail fish in relation to the pot and escape vent to improve size selectivity of fishing gear has never been studied yet. This research aimed to determine behavior of yellowtail fish to develop suitable escape vent to reduce undersize fishes by-catch and increase the survival rate after escapement.

Material and Method

Research site. The experiment was carried out in the Panggang Island of Seribu Islands, located in the northern part of Jakarta in July 2021 (Figure 1). Generally, fishers in Panggang Island used pot for catching yellowtail fish and other demersal fishes such as grouper and red snapper.

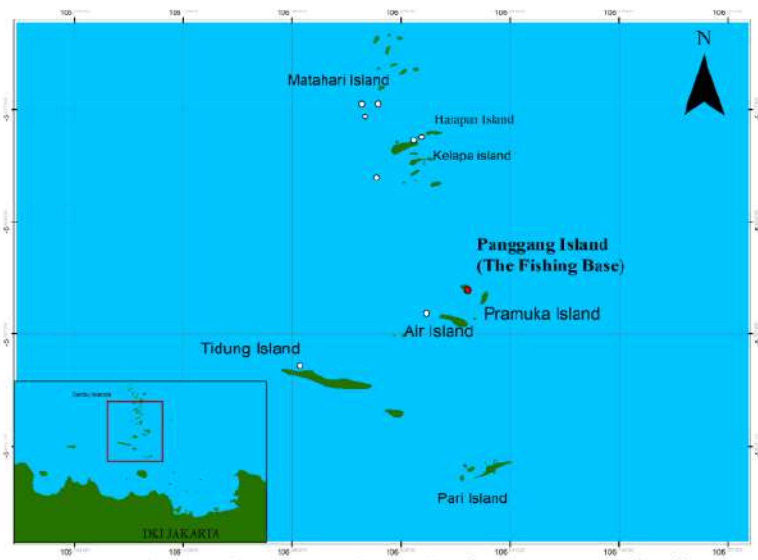

Figure 1. Location of experiment in the Panggang Island.
Source: Google Earth

Research design. The experiment was conducted to investigate the fish behavior and suitable setup of escape vent to release undersize yellowtail fish. The live yellowtail fishes used in this experiment were obtained from pot fishing in the Seribu Islands water. The fish caught from the pot fishing were put in the water tank and transported to a fish cage in Panggang Island. A total of 100 yellowtail fishes were collected and kept in a net cage of size 3 x 3 x 2 m for this series of experiments. Fishes were acclimatized for 3 x 24 hours at net cage before using them in the experiment. The fishes were measured for total length (TL) before the experiment was conducted. The total length is measured from the most forward point of the head, with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed. The total length (TL) of fish ranged from 14.8 mm to 27.9 mm. Three fishes were used to observe fish behavior (Figure 6), and four-five fishes were used to observe the escape process and to determine the best escape vent position (Figure 9).

Experimental pot. A square wire mesh pot was used in this experiment (100 cm x 75 cm x 32.5 cm). Fishers commonly use this pot to catch yellowtail fish. All parts of the pot were made of wire mesh with a maximum aperture of 2.5 cm. A horse neck-shaped mouth located at the side of the panel allowed fish to enter and prevented their escape from the pot (Figure 2).

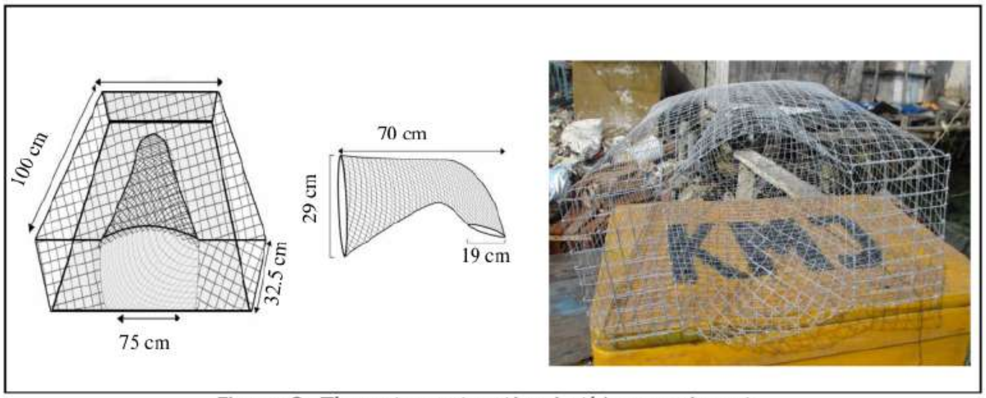

Figure 2. The pot construction in this experiment.
(Source: Authors' personal archive)

Three fishes were placed inside the pot through the mouth, and they were let to swim inside it to assess fish behavior inside the pot. The fish behavior was observed in relation to their movement pattern, zoning preference, and escape process. The observation was repeated five times. Each observation was carried out within 1 hour. Two underwater cameras 1/3" Sony Super HAD CCD 650TVL were mounted on the top and left side of the pot (Figure 3a). The pot was divided into nine zones to analyze fish behavior movement and zoning preference (Figure 3b).

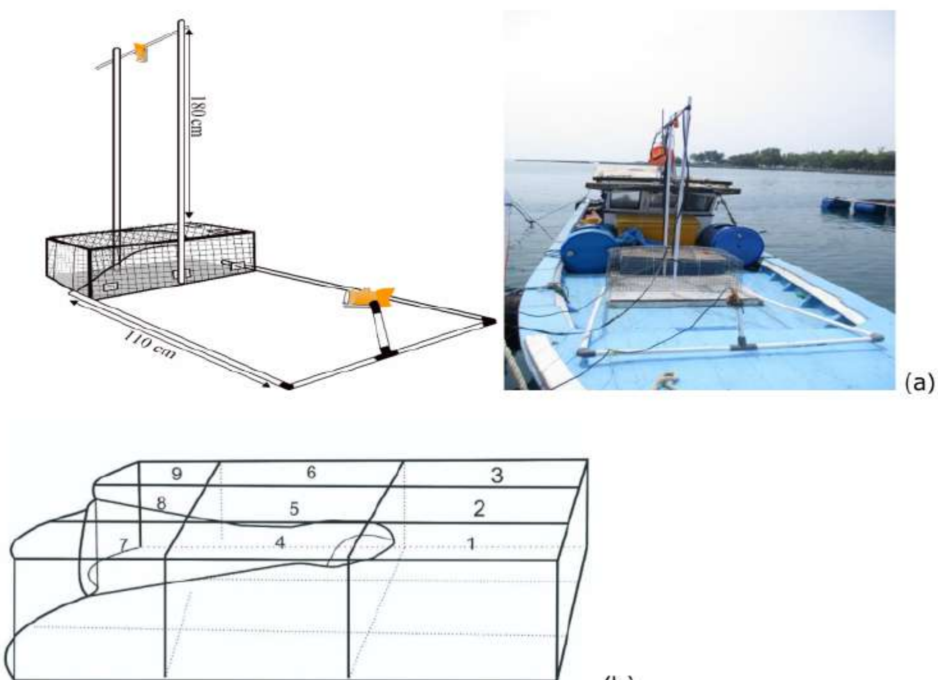

Figure 3. Camera setup (a) and the nine zones in the pot for fish behavior study (b).
(Source: Authors' personal archive)

Escape vent construction. The escape vents are designed to release undersize or non-target fishes caught in the pot (Miller 1995). Appropriate construction of escape vents was examined by comparing three different vent shapes, namely circle, rectangle, and ellipse with same length of 7 cm (Figure 4). These shapes of escape vents were designed based on the shape body of yellowtail fish which flat, wide, and elongated. A total of nine escape vents were installed on a single pot (three spots for each shape of escape vents). Three random combinations of escape vents were setup in three sides of the pot: left, right, and upper side of the pot (Figure 5).

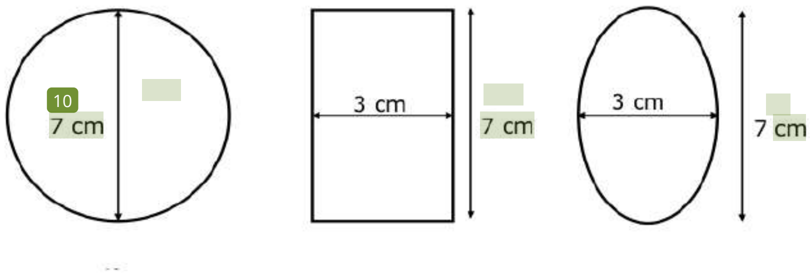

Figure 4. Three different shapes of escape vent: circle (a), rectangle (b), and ellipse (c). (Source: Authors' personal archive)

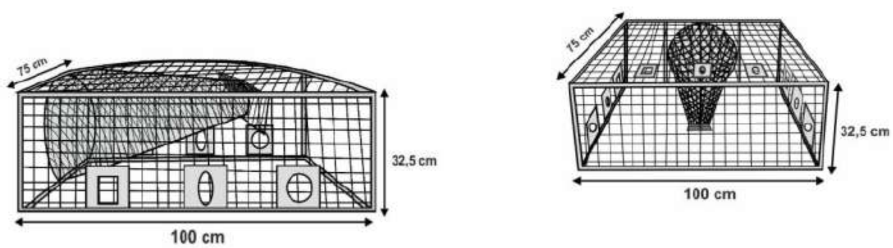

Figure 5. Escape vent shape located on different positions. (Source: Authors' personal archive)

The escape process and number of yellowtail fish that escaped through the escape vent were observed to determine appropriate escape vent construction, and the observation was be repeated five times. In one run, four to five yellowtail fishes were placed inside the pot. The time required for escaping was recorded. A fish was used only for one trial to avoid any recognition and selection of the escape vent position. The trial was repeated five times.

Data analyses. Fish behavior observation which included fish movement and the escape process, was analyzed descriptively using Kinovea software package. The swimming pattern of yellowtail fish inside the pot was analyzed using the tracking method (Marchesan et al 2005). Results of analyses were tabulated to identify the moving pattern, zoning preference, and escape process. The result was used to determine the appropriate escape vent position to release yellowtail fish.

Results and Discussion

Fish movement pattern. Generally, after fish entered the pot, fish moved calmly in schooling to explore the existing zone. Most fish swim calmly and move around, but few fish showed aggressive behavior to find an escape route. It can be seen at 3rd repetition that fish move to every single zone to find the route for escapement (Figure 6). Yellow, blue, and purple lines in Figure 6 indicated the movements of each yellowtail individual.

After the fourth repetition, fish schooling tends to move in zones 1, 2, 3, 4, 5, and 6. Dominant movements of three yellowtail individuals are primarily visible in zones 3, 6, and 9. It can be seen that fish movement pattern was different among repetition, which indicated individuals behave differently. Ferno (1993) stated that the behavior of fish inside a pot is species-specific and different among individuals. Several species of fish exhibit diel rhythms in swimming and feeding. At another condition, fish enter into the trap and move actively around the pot to find the hiding place (Sahainenia et al 2012). Captured fish tend to mill around, push against the netting and exhibit burst swimming behavior in attempts to escape (Bagdonas et al 2012).

Fish inside the trap were observed to swim in circles. They swam in either a clockwise or counter-clockwise direction without preference. When fish arrive at the pot, their behavior will be influenced by the "short-range" senses such as vision and lateral line stimulation (Thomsen et al 2010).

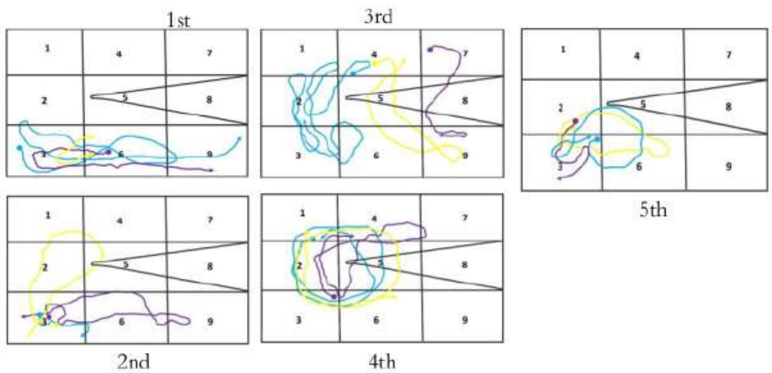

Figure 6. The movement pattern of yellowtail fish inside the pot.
(Source: Authors' elaboration)

Escape mechanism. The result indicated that the yellowtail fish mostly preferred to be at zone 3 and zone 1. The percentages of fish occupancy at zone 3 and 1 were 51.6% and 15%, respectively (Figure 7). Fishes tend to stay at zone 3 and 1 to escape. The escape attempts frequency indicated the tendency of fishes to escape through zones 1 and 3 at those zones. The escape attempt is a fish trial to escape from the pot through a pot aperture. Fish trial to escape from the pot was indicated by wounds on the fish head (Figure 8). The highest attempt frequency occurred at zone 3 and 1 with 83 and 32 trials, respectively.

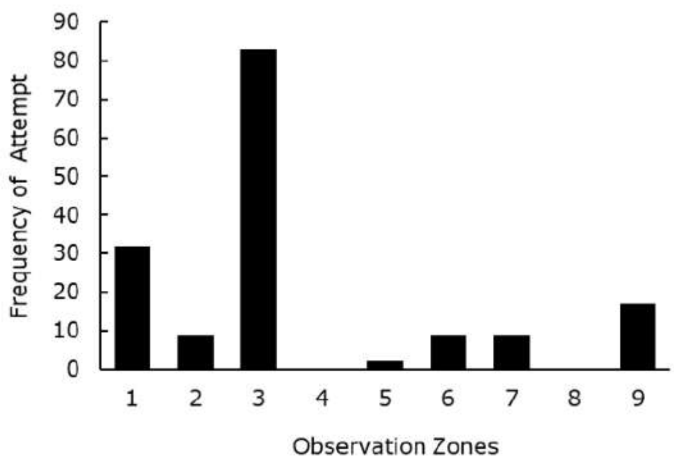

Figure 7. Fish occupancy at different zones

(Source: Authors' elaboration)

Figure 8. Damage on the fish head after escape trial
(Source: Authors' personal archive)

The escape process of yellowtail fish at this experiment was divided into two types. First type: fish entered inside the pot and swam directly to zone 1 to escape. The second type: fish entered the pot, swam around the pot, detected the area with the escape, and escaped (Figure 9). The 3^{rd} test showed that fish entered the pot and swam around 1, 2,3, 5, and 6 zones, then swam back to zone 1 to escape. In the 4^{th} test, fish only swam and moved within zone 2 which was located in front of the mouth, then escaped through the escape vent.

The escape process of fishes from the pot indicated a different tendency. Similar behavior was found in cod. They were observed to swim in circles similar to that observed in a large tank; they swam in either a clockwise or a counter-clockwise direction without preference, then escaped (He & Inoue 2010). Inside behavior is dominated by cod escaping the pot through the entrance (Ljungberg et al 2016). Other research found that fishes were entering and escaping the trap mostly through the entrance funnel (Renchen at al 2012). Folkins et al (2021) found that 37% of halibut fish that entered the pots escaped through the entrance funnel. However, the escape process through the entrance was not observed in this experiment. Fishes' attempt to escape through pot aperture is related to panic and stress behavior (Thomsen et al 2010). In this experiment, the escape vent acted as the funnel for fish to escape. Based on Figure 9, fish moved around the pot to find an escape route, but they didn't move to the pot entrance to find an escape route there. The mouth type of wire pot used in this experiment is horse neck, which deters some fish from escaping through the entrance.

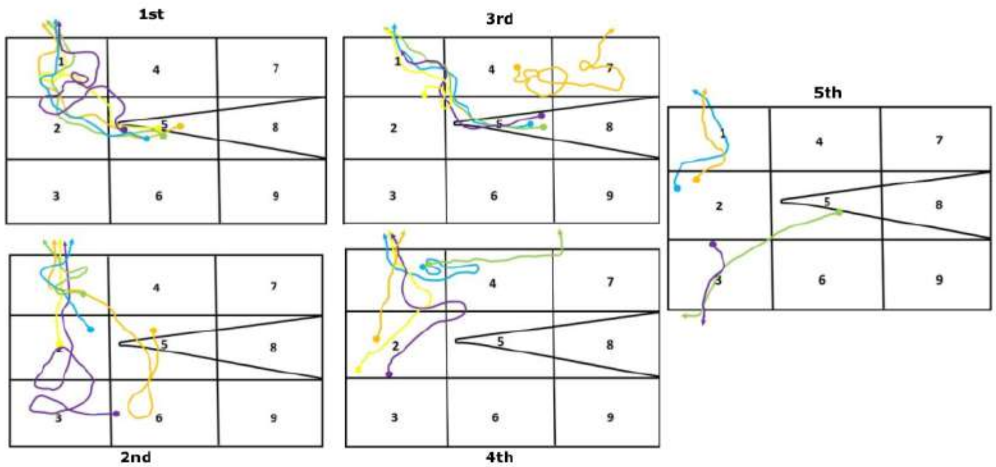

Figure 9. The escape process from the pot of yellowtail fish.
(Source: Authors' elaboration)

The time needed to escape. The time required for yellowtail fish to escape varies significantly. The fastest time needed to escape after the fish was put inside the pot was 5 seconds. The longest time needed by yellowtail fish to escape was 1,318 seconds (Figure 10). The escape vent has an essential role for the yellowtail fish to exit. This experiment demonstrated that all fishes escape from the pot through the escape vent. The average time for fish to exit through the escape vent was 178.9 seconds. Folkins et al (2021) found that 41% of fishes exited the entrance funnel and rapidly swam out within 6 to 187 seconds. The time to escape is different for different species. The average escape rates tended to be high for cod (0.39) and low for saithe (0.22) (Anders et al 2017).

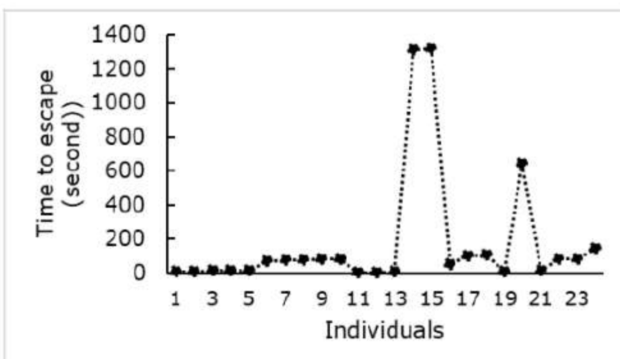

Figure 10. The time needed by yellowtail fish to escape.
(Source: Authors' elaboration)

Escape vent construction. The result revealed that yellowtail fish mostly escaped from the pot through the rear left escape vent pot: 20 individuals did this, representing 83,3 % of the total individuals. The number of yellowtail fish that escaped from the rear right escape vent pot and front left escape vent pot was only two individuals, representing 8,3 % of total individuals. The circle escape vent has the highest number of escapements, with 20 individuals (83,3 % % of the total escapements), while the rectangular escape vent was used by four individuals (16,7 % of the total escapements). No fish escaped through the ellipse escape vent. The position and shape of escape plays an important role in fish escapement from the pot (Boutson et al 2009; Shepherd et al 2002). Different species will use suitable escape vent positions and shape to escape. Shepherd et al (2002) found that an escape vent located near the bottom is the most effective vent to release undersized black sea bass. While Boutson et al (2009) also found that vent located at the lower part of the side panel given the best performance to allow the escape of immature-size crabs by side-crawling escape behavior through the vents. Regarding the vent shape, Miller (1995) suggested adjusting the vent shape to the body shape of the catch target species. Appropriate escape vent shape gives more opportunity for fish to exit through the escape vent. The rectangular escape vent is the appropriate shape to release the undersize of blue swimming crab (Boutson et al 2009). Everson et al (1992) found that circular vent is the most appropriate shape to reduce undersize spiny lobsters *Panulirus marginatus*. Treble et al. (1998) found that a circular escape vent was better suited for lobster and round fish. The rectangular shape was designed according to the flat body shape of crabs since it is known that the size of the body limited the crab escape from the escape vent. The cylindrical escape vent was designed according to the cylindric body of lobster and round fish.

Conclusions. This study observed yellowtail fish behavior and escape mechanisms inside the pot. Generally, after fish enter the pot, they move calmly in schooling to explore the existing zone. The escape process of yellowtail fish during this experiment was divided into two types. The first type is where the fish enter the pot and swim directly to zone 1 to escape. The second type is where the fish enter the pot, swim around to know the pot area, and then escape. The fastest time needed to escape after being put inside the pot was 5 seconds. The longest time needed by yellowtail fish to escape was 1,318 seconds. Experiment results indicated that yellowtail fish mostly escaped from the pot through the rear left escape vent with a circle shape.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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