3 RESEARCH METHOD

3.1 Fish Behaviour Study

3.1.1 Time and location

The fish behaviour study was conducted in Fish Behaviour Laboratory, Tokyo University of Marine Science and Technology in August – September 2005 (fish behaviour towards contrast colour net panel) and December 2005 – March 2006 (fish behaviour study using specific white net panel).

3.1.2 Fish behaviour in relation to contrast colour of the net panel

3.1.2.1 Materials and instruments

Materials and instruments used in the behavioural study towards contrast colour panel are shown in Table 1 and 2. Japanese Jack mackerels was used as test fish (Figure 3). The reason of this is that these fish are a type of pelagic fish and which is target catch of millennium gillnet.

Figure 3. Japanese Jack mackerels (Trachurus japonicus)

The Japanese Jack mackerels used in the experiment was in healthy condition. The average fork length of this fish was around 13-15 cm within maximum body girth ($G_{max}$) was around 12.7-13 cm.

Three net panels used as treatment of transparency (*i.e.* old white, new white, and black painted net) as shown in Table 1. The old white net is the net which has been used for 1.5 years. The reason of the use of this net panel was that most fishermen in Cirebon use old net to catch fish instead of new white net due to
minimize cost.

Table 1. Instruments for the contrast colour net panel experiment

<table>
<thead>
<tr>
<th>No.</th>
<th>Instruments</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>3 net panels (old, new and black painted) (46x53 cm) framed by PVC 16 mm (Figure 4).</td>
<td>Research instrument</td>
</tr>
<tr>
<td>2.</td>
<td>Forcing panel Experimental tank (200x100x50 cm) filled with sea water 30 cm in height (Figure 4). Video recording system (Figure 4), consisted of: • 8 mm Sony handy-cam • underwater camera • multi-viewer • monitor • VHS video cassettes (60 minutes) Thermometer Lux meter Digital camera Stopwatch</td>
<td>As the treatment behaviour Fish tank Recording the fish swimming and behaviour Measuring the water temperature Measuring the light intensities Documentation Counting time needed for fish on entering the net</td>
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</table>

Figure 4 shows the instruments used in the contrast colour net panel experiment. It is showed that the video result of the underwater CCD camera and Sony 8 mm handy camera was displayed into the monitor by the help of multi viewer. The multi viewer is able to make the video result of both cameras displayed in the monitor at the same time. Then, after that the video player helps to record the video camera result in VHS video cassettes.
Figure 4. Instruments used in the contrast colour net panel experiment

The old net was considered less transparent than the new gillnet, whether it would affect the behaviour of fish on passing through the net panel is one of the objectives that will be analyzed. Black painted net panel is representation of nylon gillnet, which most has dark in colour (dark blue). The panel without net were used as control of fish passing through the net.

The using of forcing panel was considered as treatment of conditioned behaviour. Meanwhile, the voluntary behaviour was considered as treatment without the use of forcing panel. The reason of doing the behaviour treatment was to understand the behaviour of fish towards netting panel with or without any obstruction. The net panel was placed on 50 cm from starting point of swimming in the experimental tank (area A) which is located in the right side (Figure. 5).
1. VOLUNTARY CONTROL PANEL WITHOUT A NET

2. CONDITIONED TREATMENT

(Treatment 1: Net panel A, B; Old white, black, new white)

(Treatment 2: Net panel A, B; Forcing panel)

Figure 5. The design of the experimental tank

3.1.2.2 Research procedure

1) The fish were acclimatized for 3 days in the experimental tank.
2) At the beginning of the experiment, fish were allowed to swim freely for about 10 minutes.
3) The net panel were set; each replicates was done for 15 minutes.
4) Randomization of net panels sequence was using RANDBETWEEN on MS-EXCEL.
5) The behaviour toward net panel and number of fish passing through the net were recorded on VHS video cassettes using video recording system.

3.1.2.3 Data analysis

The number of individual passing each of net panel presented in chart. Statistical test for significant difference ($\alpha=0.05$) between the number of individual passed through the net was carried using TWO-WAY ANOVA. Software SPSS ver. 12 was used as the analysis tool for statistical test. The test for significant was done using Scheffe’s method.
3.1.3 Fish behaviour using specific white panels

The fish behaviour using specific white panels was conducted to follow up the result of the fish behaviour towards contrast colour panel. From the result of contrast colour panel experiment, there was an effect of colour (i.e. old white, new white, and black painted) on behaviour of fish passing through the net panel. Moreover, the comparison between the new white and black painted net panel estimated was the highest (further explanation is on results and discussions).

Since it was the highest, then it estimated that black painted or contrasting colour was more visible to fish than old white and new white. It means that fish suppose to recognize more of the existence of this net panel.

Furthermore, on further study, the comparison between each net panel will focused and specified only for the old white net and new white net with an addition of the white dyed net. The reason of using the white dyed net was to add more choices on white transparency.

3.1.3.1 Materials and instruments

The fish used in this study was the same than that on contrast colour panel experiment which was Japanese Jack mackerels. The difference was only in number, totally 24 fish.

The instruments that was used in this study was also similar than that on contrast colour net panel experiment. The things that make this experiment difference than that on the contrast colour net panel experiment was that this experiment was using larger experimental tank which separated in the middle of the experimental tank by the use grey PVC separator (Table 2). The purpose of this action was to larger the swimming track of fish than that on the contrast colour net panel experiment.
<table>
<thead>
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<th>No.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3 net panels (old, new and white painted) (46x53 cm) framed with PVC 16 mm. Grey PVC separator (200x50 cm)</td>
<td>Herding panel (Figure 6), Experimental tank (40x100x50 cm) filled with sea water at 40 cm in height (Figure 6), Video recording system (Figure 6), consisted of: Victor GY-DV 500 DV 8 mm Sony handy cam Underwater camera Thermometer Multi-viewer Monitor Mini DV cassettes (80 minutes) Digital camera</td>
</tr>
<tr>
<td>2</td>
<td>Swimming position (scissors and a hole)</td>
<td>Controlling the fish swimming</td>
</tr>
<tr>
<td>3</td>
<td>Swimming position (scissors and a hole)</td>
<td>Controlling the fish swimming</td>
</tr>
<tr>
<td>4</td>
<td>Swimming position (scissors and a hole)</td>
<td>Controlling the fish swimming</td>
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<tr>
<td>5</td>
<td>Swimming position (scissors and a hole)</td>
<td>Controlling the fish swimming</td>
</tr>
<tr>
<td>6</td>
<td>Swimming position (scissors and a hole)</td>
<td>Controlling the fish swimming</td>
</tr>
</tbody>
</table>

Table 2. Instruments for the fish behaviour using specific white panels
3.1.3.2 Research procedure

For preparation, about 10 Jack mackerels that were used as experimental fish were released from the keeping tank in the morning. They were let to swim voluntarily and get used with the test channel. At night fish were preserved in the temporary holding area. The experimental protocol of this behavioural research is mentioned below.

Before starting the experiment, fish were acclimatized to swim in circling movement for 1 hour. The 16 mm diameter of PVC pipe and 125 cm length used to lead the school of fish moving circling, then pass the panel without a net that was set already (Figure 7).
After 1 hour acclimatization, the trials were started, the netting panel was set then the water temperature and light intensity was measured. Time for each trial of behaviour was 20 minutes. There were 10 replicates of each trial using 3 different types of net (new white, old white, white dyed) and panel without a net as control.

The black herding panel were set one area A-C. The setting time of the herding panel on each area was 1 minutes, after that the time will be counted precisely (Figure 8). The swimming behaviour of each trial was recorded on mini DV.

These procedures will be repeated with 3 different netting panels (new white, old white, white dyed) and panel without a net as control in randomized using the help of RANDBETWEEN on MS EXCEL. In order to prevent habituation, only one experiment will be carried out per day.
3.1.3.3 Data analysis

The number of fish passing through the different colour of mesh panel, the time elapsed and mesh passing behaviour on each trial was analyzed on Sony Mini DV on frame-by-frame basis. Each is expressed on a proportion of the number of fish passed through the test channel in 20 minutes observation period to the control attempt. The using of statistics method of One Way Anova is necessary to see the significance different of mesh passing behaviour.

3.2 Capture Process Experiment

3.2.1 Time and location

Experimental fishing operations were conducted in October-November 2006 Bondet Waters, Cirebon Regency using a commercial fishing unit. The map of experimental fishing operation is on Appendix 1.

3.2.2 Materials and equipments

Millennium gillnet catch was the research objects of this study. The catch of millennium gillnet was measured its length and weight by the help of ruler and weight scale. Nylon string was used to help measuring the maximum body girth ($G_{max}$) as shown in Table 3.

<table>
<thead>
<tr>
<th>No.</th>
<th>Materials</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Millennium gillnet catch</td>
<td>Research object</td>
</tr>
<tr>
<td></td>
<td>Fishing provision (fresh water, rice, and fuel)</td>
<td>Provision of fishing</td>
</tr>
<tr>
<td></td>
<td>Ruler (height max 5 m)</td>
<td>Measuring the total length</td>
</tr>
<tr>
<td></td>
<td>Weight scale (weight max 5 kg)</td>
<td>Measuring the weight of catch</td>
</tr>
<tr>
<td></td>
<td>Nylon string</td>
<td>Measuring the maximum body girth</td>
</tr>
<tr>
<td></td>
<td>Digital camera</td>
<td>Tool of documentation</td>
</tr>
</tbody>
</table>

Millennium gillnet and fishing boat are used in the fishing experiments. The fishing boat was used to transport the fishermen to fishing area and the millennium gillnet is used as the fishing gear. They are both the most important
factors of fishing activity as well as the importance of fishermen as the actors of this activity.

3.2.3 The methods of collecting data

The data recorded in each operation were fishing operation method, time duration for each operation stage and catch number in millennium gillnet according to the captured conditions (snagged, gilled, wedged and entangled) with reference to the species and size. Ten replicates were done and each replicate presented by one fishing operation (setting-hauling). The total length and body length of fish caught will be measured to the nearest centimetre.

Some interviews with the millennium gillnet fishermen were conducted to collect some information about the development of the millennium gillnet in Cirebon.

3.2.4 Research method

The millennium gillnet used in this experiment was 804 m long. The body net consists of 12 pieces of net, measuring 67 m long and 7.8 in depths for each piece. The net webbing was nylon multi-monofilament, with mesh size of 4 inch, respectively. The hanging ratio of the web was 0.45.

Fishing boat of the millennium gillnet was a wooden boat, with specific dimensions: 7 m x 3 m x 1.5 m, powered by a diesel engine of 24 HP (Figure 9). Detailed description of the millennium gillnet is presented in Table 7 and the gear design is shown in Figure 11.
3.2.5 Assumptions

The assumptions used in the experimental fishing were:

1) The possibility of each individual to be caught is the same.

2) The external factor caused by oceanography conditions (i.e. current, tides, temperature, salinity, turbidity) are considered not significant among research nets.
Figure 10. Design of the millennium gillnet in Bondet Waters, Cirebon.
3.2.6 Operation method

1) In the afternoon, around 3 p.m., the fishing boat started the fishing operation and arrived at the location around 4 p.m. Setting process was done on the seabed upright the coastal line by deploying the marking buoy (Figure 11), then piece by piece of the net while the boat moves forward (Figure 12).

![Figure 11. Deployment of the marking buoy in the afternoon](image1.png)

![Figure 12. Shooting net piece by piece](image2.png)

2) The net were soaked underwater around 2-3 hours. After the soaking time ended, the net then piled up on the deck for subsequent operations. The catch number counted and catch size were measured (Figure 13).
3.2.7 Data analysis

The catch data (number of individual) presented in descriptive analysis using graphics and mean values. The captured condition analyzed in the form of proportion of each capture-method category (i.e. gilled, wedged, snagged and entangled).