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Trial Observation of Filefish Behaviour in a Small Set-net with a Remote Monitoring TV System

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Abstract

The objective of this study is to investigate fish behaviour in a set-net to obtain useful information for designing and modifying fishing gear. A remote underwater TV system, specially designed for fish behaviour research, was invented by the author. This system is comprised of a camera unit, a 500 m long coaxial cable (simultaneously carrying a video signal and electric power), a driver unit, VTR, and monitor TV. The application of this system, enabled the video recording of the numbers of fish entering and escaping through the net funnel. After the experiment, the tape was played back and fish numbers were counted every thirty seconds. It was determined that fish could escape easily from the bag-net when the bag-net was filled with fish. In addition, a dominant periodic component appeared in the time series VTR data. In conclusion, it was suggested that the degree of entering and escaping fish depended on the density of fish in the bag-net and the dominant periodic component was caused by the swimming speeds of fish, the shape of the gear, and its space volume.

Introduction

Understanding fish behaviour is of great importance when designing fishing gear. Good design enhances fishing gear effectiveness, making it more productive and economical[1]. However, to date we have not obtained sufficient knowledge. Direct observation, by an underwater TV system, is the quickest and least expensive way of determining what fish schooling behaviour occurs in the set-net[2]. With this knowledge, a controlled experiment can then be set up to quantify the information. The author has been using underwater TV observational techniques for years to observe small set-nets along the coast of Hakodate city in Hokkaido. It has been found to be a very effective method to study fish behaviour in set-nets. This paper describes the entering (into the bag-net) and escaping (out from the bag-net) behaviours of filefish (*Navodon modeatus*) in a bag-net which were observed by a remote underwater TV system. This study was carried out with the hope that greater understanding of fish behaviour will lead to an improvement in the design of fishing gear currently in use.

Equipments and Methods

Table 1 shows the specifications of the underwater TV camera system which was

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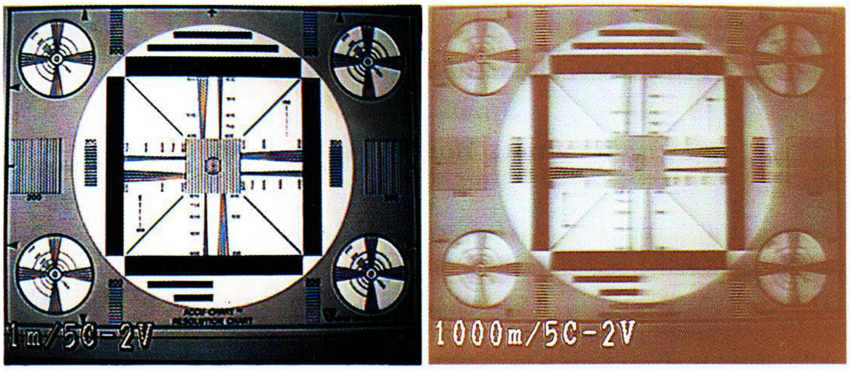

Fig. 1. Photos of video test image of 1 m and 1,000 m cable (5c-2v) length.

put together by the author. The special merit of this system is that the system's power supply features multiplexing of video and power, and also provides a timing pulse for synchronization by a single coaxial cable. Panasonic indicates that the maximum cable length (5c-2v) is 500 m, however the author's past experiment results revealed that a length for greater than the nominal Pnanasonic data on practical use could be used. The video image of 1,000 m was not clear and the resistance of the inner conductor was above 35 ohm (normal 20.5 ohm). Fig. 1

Table 1. Underwater TV camera system

Underwater camera unit	Camera	Panasonic WV-CL110 CCD
	Weight	1.45 kg in air and 0.2 kg in water
	Housing size	120 mm long × 130 mm hight × 70 mm wide
	Housing material	Hard plastic
	Depth rating	70 mm
	Connector	ALL WET 2pin Sea-Con
	Resolution	330 horizontal TV lines
	Sensitivity	10 Lux
	Lens	3.7 mm F1.4
Drive unit	Unit	WV_PS10A
	Power	100 VAC
Cable	Coaxial cable	5c-2v 500 m
	Connector	BNC
	Outer jacket	Polyethylene 1 mm
VTR	Unit	Model SLV-757
	Power	100 VAC
Monitor	Resolution	240 holizontal lines
	Displey size	14 inch color
	Power	100 VAC

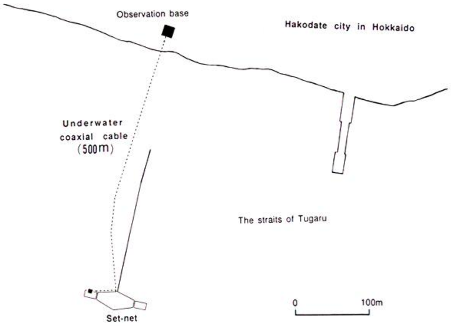

Fig. 2. The small set-net was used in this study. It measures some 70 m long over-all.

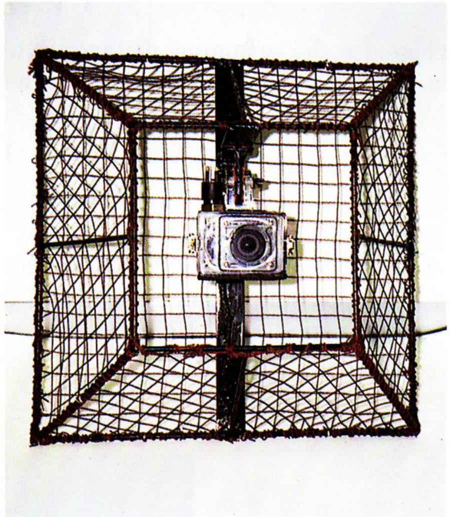

Fig. 3. Guard-net for protection of underwater camera.

shows photos of video test image of 1 m and 1,000 m cable length (cable type 5c-2v).

Fig. 2 shows the small set-net which became the focus of this study. It measures some 70 m long over-all and 6 m wide at the bag-net. The camera was protected by a guard-net (Fig. 3). It was attached firmly to the side wall of the bag-net so as to observe fish behaviour and the number of fish passing through the funnel. It was connected by a coaxial cable to the camera drive unit, VTR and TV monitor were as shown in Fig. 4. The video tape recordings were made over a 15 hour period (about A.M. 4 : 00-P.M. 19 : 00). This was done daily over a period of 1 week during the study. The numbers of entering and escaping fish were each counted every thirty seconds by VTR's playback. The swimming speed at right angles to the camera was calculated by the following equation.

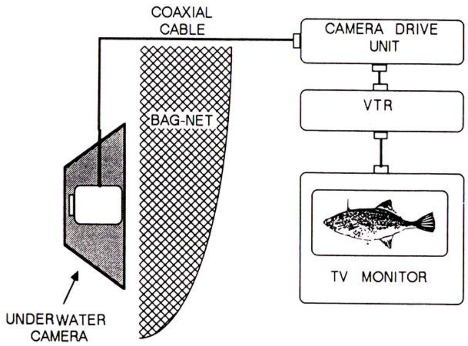

Fig. 4. Installation procedure of the remote underwater TV system.

$$V = Ld/b\Delta t \tag{1}$$

where d is the swimming distance in a time interval Δt, b is the length of fish image on a video plane, L is the real fish length (mean body length of catched samples).

Results

Some parts of the recordings did not show clear fish images due to counter light condition. During this experiment, a weak current (under 5 cm/s) sometimes arised, however it did not seem to affect filefish behaviour. Fig. 5 shows the photo of filefish passing through the funnel in the bag-net. The data analyzed were from the time period just before (10 min) and after (20 min) hauling of the bag-net as it

Fig. 5. Photo of filefish passing through the funnel in the bag-net.

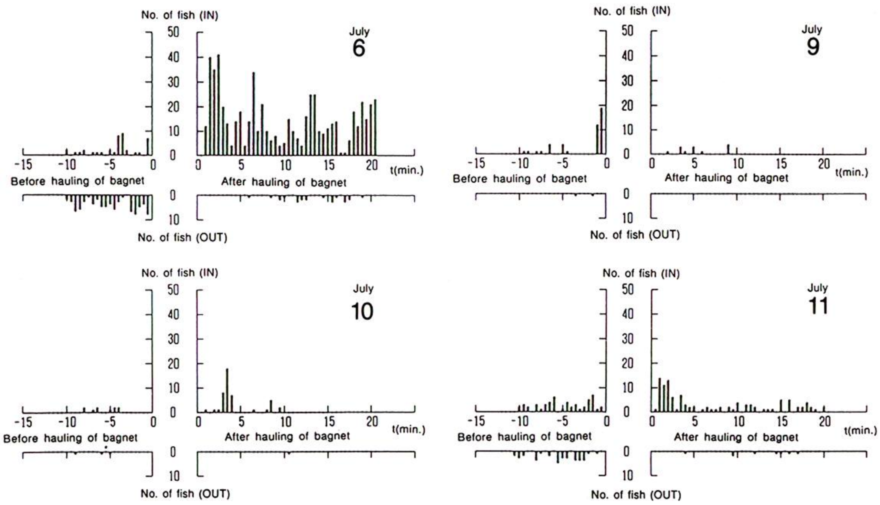

Fig. 6. Observation data just before (10 min) and after (20 min) hauling of the bag-net during the experiment (6, 9, 10 and 11th days of July). The numbers of entering and escaping fish were counted every thirty seconds by VTR's playback.

Table 2. Catch of hauling bag-net and each observation number of fish just before (10 min) and after (20 min) hauling of the bug-net on the 6th, 9th, 10th and 11th of July

Date Time	N_{in}	N_{out}	N_{out}/N_{in} $\times 100$ (%)	N_{in}/min	N_{out}/min	Catch (case)
July 6th						
before	40	84	210	4.0	8.4	200
after	591	23	3.9	29.5	1.2	
July 9th						
before	44	2	4.5	4.4	0.2	—
after	13	0	0	0.7	0	
July 10th						
before	10	3	30.0	1.0	0.3	2
after	45	1	2.2	2.3	0.1	
July 11th						
before	52	39	75.0	5.2	3.9	50
after	108	8	7.4	5.4	0.4	

1 case : About 10 kg, N_{in} : Entering No. of fish to the bug-net, N_{out} : Escaping No. of fish from the bug-net, — : Missing value.

was observed four times during 4 days of experiments. The results are as shown in Fig. 6. and Table 2. Just before hauling the bag-net, the numbers of entering and escaping fish were nearly equal on the 11th of July. This result may be explained by fish density in the bag-net converging to a certain stable condition. However, on the 6th of July, the catch was large, reaching about 2,000 kg, and the numbers of escaping fish was a little larger than those of entering fish. These results suggest that a high fish density in the bag-net negatively affects the rate of entering fish and

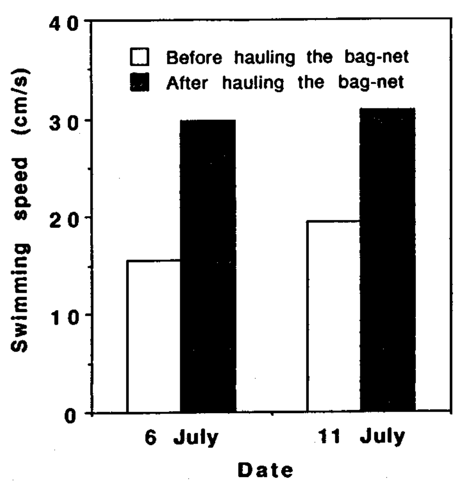

Fig. 7. Difference (6 and 11th days of July) of the mean speeds of entering fish before and after hauling the bag-net.

Table 3. The test for equality between two means of entering speeds of fish (before hauling the bag-net and after hauling the bag-net)

				Pooled Variance Estimate			Separate Variance Estimate		
	F Value	Degree of Free	2-tail Prob.	*t* Value	Degree of Free	2-tail Prob.	*t* Value	Degree of Free	2-tail Prob.
July 6th	1.27	(49, 33)	0.030				−9.66**	81.94	0.000
July 11th	2.07**	(40, 49)	0.426	−7.02**	89	0.000			

Variances of two entering speeds of fish (before hauling the bag-net and after hauling the bag-net) were equal on the 6th of July, and not equal on the 11th of July.
Independent sample *t*-test: **P<0.01.

might also increase the escape rate. Just after hauling the bag-net, they were quite different. The numbers of entering fish were more than those of escaping fish during the observations. It seemed that the entering and escaping behaviours were closely related to the density of fish in the bag-net[5,6]. This similar phenomenon which occured on the 11th day also appeared on the 9 and 10th days of July, the only differance being that the 11th day's catch was large.

Real fish length was decided to 15 cm from the catched samples and the swimming speed was calculated by the equation (1). The differences in the mean speeds of entering fish before and after hauling the bag-net are as shown in Fig. 7. Because it was understood that the distribution of the swimming speed in the net was one of Normal distributions, independent sample t-tests were performed on the entering speeds of fish. The mean values were found to be significantly different at the 95% level in the two categories as indicated in Table 3. The entering speeds before hauling the bag-net were not as high as compared to after hauling the bag-net. It is considered that the entering speeds are also closely related to the density of fish in the bag-net.

Discussion

It semms to suggest that the numbers of fish entering and escaping through the funnel depends on the number of fish in the bag-net and the play-ground[3,4]. In order to consider the effect of a funnel in trap gear, a trap-model is described by simultaneous homogeneous difference equations in the case of a closed system[7~10].

$$A(t+1)=(1-a)A(t)+bB(t) \quad (2)$$

$$B(t+1)=aA(t)+(1-b)B(t) \quad (3)$$

where $A(t)$, $B(t)$ are the number of fish at time t in the bag-net and the play-ground, and a, b are entrance constants. According to the trap-model experiments in the laboratory, when fish density was low, the mathematical model was acceptable only to some extent, but when fish density was high it was very acceptable. Solving equations (2), (3) under the condition; $A(0)=0$, $B(0)=1$, the equation (4) is obtained as the solution about $A(t)$.

$$A(t)=\{1-(1-a-b)^t\}\ b/(a+b) \qquad (4)$$

Then, $A(\infty)$ converges to $b/(a+b)$. If a large school of fish enters the set-net at one time and after that no fish arrive and escape, then equation (4) is acceptable. In Fig. 6, the numbers of entering and escaping fish were nearly equal just before hauling the bag-net. It seems that the numbers of fish in the bag-net converge to a certain figure. It should be noted that the numbers of entering fish after hauling the bag-net tended to change in an oscillatory pattern; especially on the 6th of July. In this case, periodical components can be obtained from the power-spectrum of fluctuations in entering fish[11].

That is,

$$P(N)=\int_0^{\infty} R(\tau)\cos 2\pi N\tau d\tau \qquad (5)$$

where $P(N)$ is power-spectrum, N is frequency, and τ is lag-time (30 sec) in calculation, π is the circular constant, $R(\tau)$ is an auto-correlation function of fluctuation of entering fish, as shown below:

$$R(\tau)=\lim_{T\to\infty} 1/T \int_{-T/2}^{T/2} f(t)\, f(t+\tau)dt \qquad (6)$$

where $f(t)$ is the function of fluctuation, and T is a measuring period (20 min).

Some dominant periodical components were contained in the numbers of entering fish. The most dominant periodical component was 320 sec as shown in Fig. 8. The fish school may be moving along the inner wall of the set-net and some part of this school enters the bag-net when it periodically arrives at the mouth of the funnel. Therefore entering behaviours are generated periodically. Thinking of author's (Fig. 7) and Inoue's[12] results, if the swimming speed was 20 cm/s, the fish would swim 64 m is this period of 320 sec. If this hypothesis is correct, the swimming path in the set-net could be indicated by the example in Fig. 9. This would

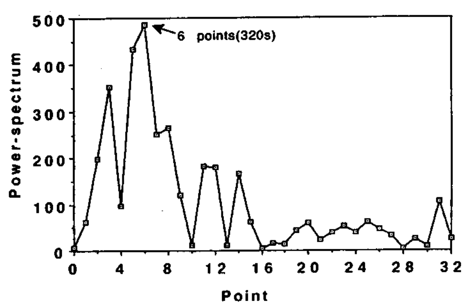

Fig. 8. Result of power-spectrum analysis. The dominant periodical component was 320 sec, contained in the numbers of entering fish: Frequency resolution = 5.208E-04Hz, Foldover frequency = 1.666E-02Hz (Point 32).

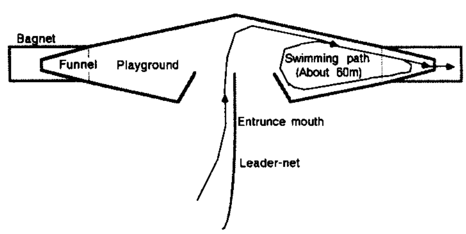

Fig. 9. Example of the swimming path in the set-net. If fish swam at the rate of 20 cm/s, they would cover the distance of 64 m.

suggest that the dominant periodicity is determined by the swimming speeds of fish, the shape of the gear, and its space volume.

Conclusion

The entering and escaping behaviours of fish in a bag-net were closely related to the density of fish in the bag-net. Before hauling the bag-net, the numbers of entering and escaping fish were nearly equal when the fish density in the bag-net converged to a certain stable condition. Just after hauling the bag-net, the numbers of entering fish were significantly more than those of escaping fish.

The entering speeds just before hauling the bag-net were not as high as those observed just after hauling the bag-net.

The fish school periodically arrives at the mouth of the funnel, and some part of the school enters the bag net. This dominant periodicity is determined by the swimming speeds of fish, the shape of gear, and its space volume.

There are many unsolved problems remaining. However, the results obtained here are one step in the investigation of improving the catching mechanism of small set-nets.

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