Movements of the Fish in Response to Sound Stimuli with Reference to Sound-Intensity

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Introduction

In a previous paper (1957) it was reported that anchovy (*Engraulis japonicus*) could perceive such low frequency sounds as the gun, and they escaped from the sound stimuli.

We have carried out the experiment using the other species of fish. Our experiments dealt with the study of : (1) Intensity range of perception of vibrations (2) Frequency range of perception of vibrations (3) Effect of repeated sound stimuli. In present paper we discussed the problem (1).

The experiments were performed to ascertain the effect of the sound stimuli to the behaviours of fish, by changing the sound-intensity.

In the experimental procedures, attempts were made to avoid certain errors of a physical nature, and to measure the vibrations produced in the water, as to intensity, frequency and wave characteristics.

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Methods and materials

Methods

Sources of sounds in the water. In our experiment two sources of vibration were employed. (1) The fire-work under the water : (Piccapon, SEIKOSHA Company) frequency is about 250 cps., and length of duration 1/15 sec. (2) Striking the bottom of a floating cask with a bat, frequency is about 500 cps., length of duration 1/5 sec.

Measurement of sound-intensity. The intensity of the sound in the water was measured initially with a hydrophone (a piezo electric crystal of barium titanate, OKI Electric Industrial Company) and two high-gain amplifiers. Some observations were made with an oscilloscope. The hydrophone was attached to a vertical bar so that all comparative measurements could be carried out at the exact same distance from the water surface and at the accurate known position in the net (the floating "live cage"). The absolute intensity of the *sound-pressure* in the water was measured with a VU-meter each time.

Recording of the behaviours of fish. Both the direct observation and the analysis of a motion picture were made to record the movements of fish in response to the sounds.

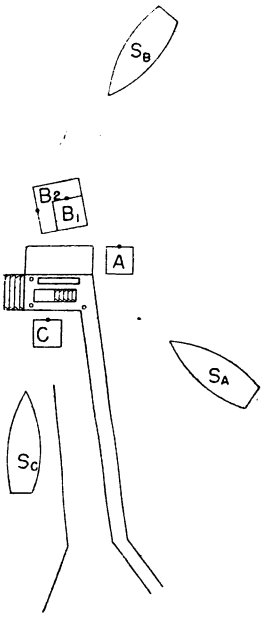

Fig. 1. Experimental arrangement
A, B, C : position of the floating 'live cage'.
• shows the position of hydrophone.
SA, SB, SC : The source of sound.

A SPECINE camera with 15 mm. and 25 mm. objective, was operated at a film speed of 24 frames per second.

Experimental arrangement. Experiments were carried out on the open sea around the Station. Experimental arrangement is shown in Fig. 1. No variation in wave characteristics was detected at any station. Water temperature was about 25 °C.

Materials

The following fish were used in the present experiment.

Conger japonicus BLEEKER B. L. 470 mm
Astroconger myriastar (BREVOORT) B. L. 450 mm
Rhyncocymba nystromi (JORDAN et SNYDER) B. L. 300 mm
Scomber japonicus (HOUTTUYN) B. L. 190 mm
Trachurus japonicus (TEMMINCK et SCHLEGER) B. L. 135 mm
Fugu niphobles (JORDAN et SNYDER) B. L. 145 mm
Fugu chrysopes (HILGENDORF) B. L. 130 mm

Results and discussion

By changing the distance between the source of sound and the fish, we can adjust the sound-intensity. The characteristic curve of the sound-intensity to the distance from the source of sound is shown in Fig. 2. The data then are consistent with the view that there is a linear relation between the sound-intensity and the distance.

The experiments were repeated several times at the same sound-intensity, and with

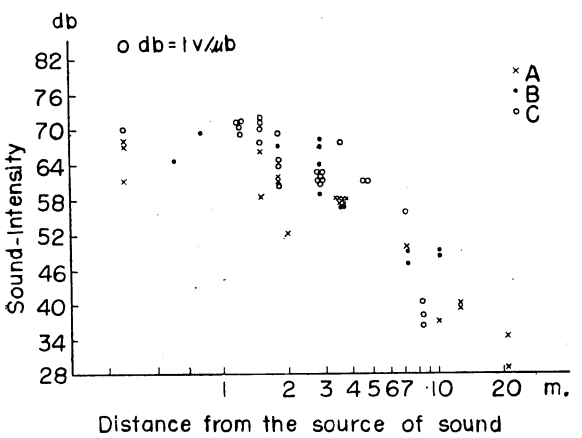

Fig. 2. Sound-intensity under the water of Piccapon

one source of sound they were done over 40 times using one species of fish.

The behaviours of fish in response to the sound stimuli were as follows. The schooling-fish as mackerel were swimming around along the edge of the floating "live cage." With a pop, they suddenly stopped, falling out of line, escaped from the source of sound to the opposite side, and returned to normal swimming after 30 sec. ~ 2 min. Conger eel did not make a school and swam by eel-like motion, but they escaped from the sound quickly, when the stimuli were made stronger. We applied, therefore, the term of 'positive response', when the fish escaped from the sound stimuli, and used 'negative response', when we could not observe any demonstrable effect on the behaviours of fish in response to the sound.

Experiment with the fire-work (Piccapon). Examples of the experimental protocol are shown in Tables 1 and 2. And the results are summarized in Table 3.

Horse mackerel (*Trachurus japonicus*) responded positively to the stimuli, in cases of the sound-intensity-range between 57 db. and., 80 db. but they did not show any demonstrable difference in their behaviours in response to the sound range between 47 db. and 56 db. Mackerel (*Scomber japonicus*) showed positive response to sounds over 58 db. and the similar tendency was also observed in puffers (*Fugu niphobles* and *F. chrysopes*).

Table 1. The response of *Trachurus japonicus* to Piccapon

No.	Sound-intensity		Station	Response to the sounds
	db.	μb.		
1	53	446	A	−
2	56	630	A	−
3	66	2,000	A	±
4	67	2,240	B_1	±
5	65	1,800	B_1	±
6	80	10,000	B_1	+
7	75	5,600	B_1	+
10	73	4,460	B_1	+
11	73	4,460	B_1	++
12	74	5,000	B_1	++
21	57	710	B_2	++
22	57	710	B_2	++
23	59	890	B_2	++
24	—	—	B_2	+++
27	67	2,240	B_2	+++
28	64	1,580	B_2	++
30	68	2,500	B_2	+++
33	—	—	B_2	+++
34	69	2,800	B_2	++
35	49	280	B_2	−
37	49	280	B_2	−
38	49	280	B_2	−
39	48	250	B_2	−

Table 2. The response of *Scomber japonicus* to Piccapon

No.	Soud-intensity		Station	Response to sounds
	db	bμ		
1	58	790	A	±
2	58	790	A	+++
3	58	790	A	±
4	58	790	A	+
5	58	790	A	+
6	58	790	A	++++
7	58	790	A	+
8	62	1, 250	A	++
9	61	1, 120	A	+++
10	47	224	A	−
11	50	316	A	−
12	67	2, 240	A	+
13	59	890	A	+
14	61	1, 120	A	+
16	68	2, 500	A	++
18	67	2, 240	A	+
19	40	100	A	−
20	39	89	A	−
21	60	1, 000	C	±
22	61	1, 120	C	+
23	61	1, 120	C	±
26	62	1, 250	C	++
27	67	2, 240	C	+
29	68	2, 500	C	+++++
30	68	2, 500	C	+++++
31	69	2, 800	C	±
32	56	630	C	−
34	64	1, 580	C	±

One species of conger eels (*Rhyncocymba nystromi*) was not affected in their behaviours until much stronger stimuli were given to them. On the other hand, the behaviours of the other conger eels were not affected at all with the fire-work under the water.

Table 3. The responses of the fishes to Piccapon

Species	Positive response	Negative response
Trachurus japonicus	57——80 db.	47——56 db.
Scomber japonicus	58——69 db.	39——56 db.
Fugu niphobles	65——68 db.	56 db.
Fugu chrysopes	65——68 db.	56 db.
Rhyncocymba nystromi nystromi	69——71 db.	36——68 db.
Conger japonicus	——	36——71 db.
Astroconger myriaster	——	36——71 db.

From these observations, it was made clear that the effective sound-intensity varied from one species to the next.

The sensitivity of fish to the sound of the fire-work under the water can be arranged in the following order ; *Trachurus japonicus, Scomber japonicus, Fugu niphobles, Fugu chrysopes, Rhyncocymba nystsromi nystsromi, Conger japonicus, Astroconger myriaster.*

Experiment by striking the bottom of the cask. Next, we will discuss the results of the experiment using a knock at the bottom of the floating cask with a bat as the sound source. we made the sound-intensity from 20 db. to 48 db.

Conger eel (*Rhyncocymba nystsromi nystsromi*) responded positively to the sound ranging from 37 db. to 48 db. but not to the sound below 36 db.

Mackerel (*Scomber japonicus*) also responded to the sound of intensity between 35 db. and 38 db. However, horse mackerel (*Trachurus japonicus*) were less sensitive than mackerel. These stimuli did not give any effect to the other conger eel (*Conger japonicus, Astroconger myriaster*).

The sensitivity of fish to the sound by striking the bottom of the cask can be arranged in the following order ; *Scomber japonicus, Trachurus japonicus, Rhyncocymba nystromi nystromi, Conger japonicus, Astroconger myriaster.*

As mentioned above, the effects of the sounds on fish varied from one species to the next with reference to the sound-intensity. This fact will have some significance in fishing.

Summary

The behaviours of fish in response to the sound stimuli were observed by using the fire-work under the water and by striking the bottom of the cask as the source of sound. It is now made clear that the critical sound-intensity to affect the bahaviours of fish varies from one species to the next, and mackerel, (*Scomber japonicus*) and horse mackerel (*Trachurus japonicus*) are rather sensitive fish, but conger eels except *Rhyncocymba nystromi nystromi* are less sensitive.

Reference

SUYEHIRO, Y. et al., 1957 : A study on the effect of gun noise upon fish.