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Preliminary notes on the development of an electrical tickler chain for sole (Solea solea L.)

by

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Introduction:

The sole, Solea solea L., is today the most important Dutch commercial species. This species is mainly fished by double rigged beam-trawlers. In recent years the number and weight of the tickler chains has increased. This was possible owing to the increase in engine power. A 800 hp beamtrawler is no exception nowadays. This type of vessel is towing a weight up to 2000 kg of chain in front of each ground rope. The number of tickler chains increased up to 15. It is known that soles are burrowed in the ground, especially during the day-time. Therefore tickler chains have to be used to chase them out of the ground. Unfortunately the increase in the weight of chains has also led to an increase in damage done to immature fish. To lessen this and to economize on the exploitation costs, the number of tickler chains has to be reduced. However, a decrease of the number of tickler chains would lead to a lower catch. The aim of our present study is to investigate the possibility of replacing the heavy tickler chains by light electrical ticklers without reducing the catch. This report gives the first results of our trials.

Material and methods:

Our experiments were for the main part carried out in polythene aquarium tanks (100 x 90 x 60 cm) connected to the laboratory closed circulating seawater system at the Institute at IJmuiden (salinity 31.8 $^{0}/oo$). However, work was also done outdoors in a former oyster basin in the Scheldt estuary, Yerseke (30 x 10 x 1.5 m). The water level could be regulated by a system of sluices in combination with the tide (salinity 28 $^{0}/oo$).

The puls generator we used produced pulses of capacitor discharge shape. The peak voltage can be regulated in steps between 2.5 and 60 V. The puls frequency can be regulated continuously between 1-50 impulses per second (ips.). The pulse cycle can be interrupted in a frequency of a 1/2 - 10 Hz. The discharge capacitors have a total capacity of 9520 µF to be regulated in steps viz. 2 x 34, 9 x 68 and 13 x 680 µF. A more detailed description of the puls generator is given by Boonstra and De Groot (1970), in a paper also presented at this Council Meeting to the Gear and Behaviour Committee.

The electrode array used in our laboratory experiments consisted of four copper litze wires (Ø 4 mm) in a square frame. The wires were alternatively positive and negative with 30 cm distance between them.

The soles used in the experiments ranged from 15-30 cm in length. In each experiment 3 or 4 individuals were used. Only one experiment was carried out each day and after about 4 experiments the soles were

- replaced -

replaced by fresh ones, to eliminate the possibility of adaptation or learning.

Laboratory experiments were also undertaken to estimate the relationship between temperature and behaviour. With a thermo-regulator and a cooling unit the behaviour of soles to electrical stimuli in a temperature range from 6-20°C were studied.

In the experiments done in the oyster basin an electrode array mounted in a frame, of 2 x 2 m, was utilized. The distance between the six electrodes was 35 cm and they were alternatively positive and negative. Owing to the dimension of the basin more experiments could be done each day by shifting the position of the frame.

Results:

The results of our laboratory experiments are given in Table I. In this table the experiments on the temperature influence upon the behaviour are not incorporated. The data given are based upon soles which were covered with sand before the experiment started. All other data have been omitted. The results show that a flight reaction under "normal" conditions hardly occurs. The animal will dig itself deeper into the sand. However, with an electrical stimulus it was possible to evoke a behaviour which resembled very much the behaviour described by Bateson (1890). He observed that when food was thrown in soles after an interval perceived it, and with a "writhing-jump" started in searching the bottom. This was also described by Kruuk (1963) as the "Omega-jump". At the end of the night the sole, he states, a nocturnal animal becomes active rather suddenly. It throws the sand off its back with a jump.

This jump, in our experiments, was caused by a short volley of pulses during which the fish became paralyzed (electro-narcosis) and curled up, while the fish had an opportunity to swim away during the off-period of the pulse cycle. This, from our point of view, is the only possibility to chase the sole out of the sand by means of electrical stimuli. The voltage needed in our laboratory experiments did not have to exceed 8 V, with a pulse repetition rate of 40-50 per second, and interruption of the pulse cycle of about 1/2 Hz. The pulse length (RC) had to be approximately 0.7 m sec.

The temperature, in the range 6-20°C, did not influence the behaviour as far as the reaction to electrical stimuli is concerned.

The experiments in the oyster basin, up till now, confirm the results described above. Owing to the mass of data gathered in these experiments, only a selection is presented in Table II. The pulse length used in these experiments is even shorter, appr. 0.2 m sec., than in the aquarium experiments. The pulse length, however, could not be established properly as the pulse shape was not exactly a condensor discharge shape, but had more resemblance to a quarter sine shape. This must be due to the long cables (50 m) from the pulse generator to the electrodes, as this was the only difference between the two series of experiments.

Discussion:

The first results given in this preliminary notes, may very likely show us the way to our aim to replace the heavy tickler chain by light electrical ticklers. It was possible to evoke with interrupted electrical stimuli a specific jump. This jump might be utilized in commercial fishing. The interruption in the pulse cycle can probably be reached by an array of electrodes in paralel with the ground rope. The electrical stimulus could probably be continuous. With a moving net the needed interruption would be achieved by the passing of the electrodes over the fish. However, the electrodes have to be strong as well as light to withstand constant chafing over the bottom.

If this turns out to be very difficult to realize a possible solution might be found in rigging the electrodes transverse to the ground rope, running from the beam to the ground rope. In that case the pulse cycle would have to be interrupted to evoke the "writhing or omega jump". During the experiments we also did some observations on the behaviour to electrical stimuli of a few other species of flatfish, viz. plaice, flounder, dab, brill. It turned out that it was impossible to evoke the typical jump observed in sole in these species. We could paralyze them, but the burrowed fish would not swim. An explanation may be found in the body musculature. The musculature of the sole (Soleidae) enables him to curle up easily and to perform in its natural behaviour the jump. The other species belong taxonomical to other flatfish families (Pleuronectidae, Bothidae) with a body musculature developed on different lines.

References:

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TABLE I

Results of the laboratory experiments. The resistance (R) between the electrodes at 10°C is 0.54 ohm.

exp. nr.	volt.	pulse freq.	pulse cycl.	uf cap.	numb. fish invest.	no react.	dig-in	flight	electro narc.	sand layer, cm
1	2.5	35	cont.	2720	3	+	-	-	-	1
2	6	35	cont.	2720	3	+2	-	+1	-	1
3	4	35	cont.	2720	3	-	-	+2	+1	1
4	4	1-50	cont.	2040	3	-	+	-	-	5
5	6	35	2	2040	3	-	-	+	-	5
6	8	30	cont.	2040	3	-	+	+	+	5
7	8	30	½	2040	3	-	-	+	-	5
8	12	25	½	2040	3	-	+2	-	+1	5
9	20	22	½	3400	3	-	-	-	+	5
10	6	25	½	2040	4	-	+	-	-	5
11	8	25	½	2040	4	-	-	+1	+3	5
12	8	20	cont.	2040	4	+1	+2	-	+1	5
13	12	15	cont.	1360	4	+	-	-	-	5
14	8	50	½	1360	4	-	+3	+1	-	5
15	8	15	cont.	1360	4	-	+	-	-	5
16	8	40	1-½	1360	4	-	-	+	-	5
17	8	45	¾	1360	4	-	-	+	-	5
18	8	45	¾	1360	4	-	-	+	-	5
19	8	40	cont.	1360	4	-	-	+2	+2	5
20	6	50	¾	1360	4	-	-	+	-	5
21	6	50	¾-½	1360	4	-	-	+	-	5
22	6	50	½	1360	4	+1	-	+3	-	5
23	6	50	½	1360	4	-	-	+3	+1	5
24	6	50	½	2040	4	-	-	+	-	5
25	8	50	½	1360	4	-	-	+	-	5
26	8	50	½	1360	4	+1	-	+3	-	5
27	12	50	½	1360	4	-	-	+	-	5
28	8	50	½	1360	4	-	-	+	-	5
29	8	40	½	1360	4	-	-	+3	+1	5
30	8	50	½	1360	3	-	-	+2	+1	5

TABLE II

Results of the experiments in the oyster basin. The resistance (R) between the electrodes at 7°C is appr. 0.3 ohm.

exp. nr.	volt.	pulse freq.	pulse cycl.	uf cap.	numb. fish invest.	no react.	dig-in	flight	electro narc.	sand layer, cm
70	50	50	½	680	10	-	-	2	8	10
71	35	50	1	680	10	-	-	5	5	10
72	35	50	1	680	5	-	-	4	1	10
73	35	50	1	680	2	-	-	2	-	10
74	35	50	1	680	3	-	-	-	3	10
75	28	50	½	680	3	-	-	-	3	10
76	50	50	½	680	8	-	-	8	-	10
77	50	50	1	680	9	-	-	1	8	10
78	35	50	¾	680	5	-	-	-	5	10
79	20	50	cont.	3400	15	-	-	15	-	10
80	60	50	½	544	5	-	-	5	-	10