International Council for the Exploration of the Sea

C.M.1979/B:22
Fishing Technology Committee
Ref.: Demersal Fish Cttee

Fish beahaviour studies as an aid to cod and haddock longline hook design.

by

Ingvar Huse

Institute of Fishery Technology Research
Box 1964, N-5011 Nordnes, Norway

1. INTRODUCTION.

The evolution of the fishing hook to the present form has been very gradual, and only slight alterations have been made since metals became available as material for hooks. This may indicate that the form is close to optimal, or that too little emphasize has been put on research concerning the catching power of the hook. The performance of sport fishing hooks is regularly tested both with regard to gear and fish behaviour. It is therefore probable that these hooks are close to optimal for their pourpose. The various long line hooks have on the other hand mainly been altered to facilitate baiting and gear handling. Their passive role in the hooking proces obviously requires other properties than what is called for in most sport fishing situations, yet the forms are very similar or identical.

In the present paper behavioural sequence analysis is used to generate ideas for better cod and haddock long line hook forms. These forms are then tested out in full scale fishing experiments.

2. MATERIAL AND METHODS.

2.1 Behaviour studies.

Tank tests on the behaviour of cod towards a baited hook were carried out from 26. April to 9. May 1977. The experiment took place in an indoor concrete ring tank with an outer diameter of 12 m, a ring width of 2 m, and a depth of 2 m. A baited hook was suspended 50 cm above bottom. The hook area was monitored by horisontal and vertical TV - cameras. The video tapes were analysed by cathegorizing the behaviour and describing the behaviour sequences by means of these cathegories (behaviour patterns). The data were finally computer analyzed. 30 cod with a mean length of 60 cm were run through a total of 25 tests. Each test lasted for 10 minutes or until a fish was hooked. Hooked fish were taken out of the experiment.

Field studies on the behaviour of haddock towards a baited hook were carried out from 30. October to 1. November 1978. The experiment took place in inshore waters off Misje, Hordaland at depths between 30 and 40 m. The equipment used is described by Fernø et.al. (1977). The observation rig consisted of a low light underwater TV camera mounted on a horizontal frame with 4 hooks suspended from a line in front of the camera. Extra illumination was, when needed, supplied from a 500 W halogen light with a 605 nm filter. The data from the video tapes were treated in the same way as in the tank experiment. 25 tests were carried out. Each test lasted for 30 minutes or until all 4 hooks were occupied.

2.2 Fishing experiments.

3 full scale fishing experiments were carried out. One off Vardø from 25. May to 8. June 1977, one in the Lofoten Area from 6. to 16. March 1978, and one off Vardø from 19. June to 12. July 1978. All lines were set either 10-20 m off bottom or pelagicly at 60 m depth, the latter method being used for haddock. The lines were made of 1,8 to 2,0 mm monofilament nylon with 1 m long 0,8 mm monofilament nylon snoods fastened to the line with swivels. Comparisons were made either between neighbouring hooks or, in the first and second experiment, between neighbouring 50 hook blocks. A total of 19.500 hooks were fished during the 3 experiments.

3. RESULTS AND DISCUSSION.

3.1 Behaviour studies.

The objectives of the behaviour studies were to obtain a general description of the biting behaviour and to select a behaviour pattern upon which a hook design could be based. Such a behaviour pattern would have to be vigourous and occur frequently. Only the behaviour sequences from suching in the baited hook to spitting out or hooking was considered. Following behaviour patterns were used:

1. Bite (B). The fish sucks in the baited hook and closes its mouth.
2. Inhibited bite (Bi). The fish sucks in only part of the bait or does not close its mouth around the baited hook.
3. Pulling (P). The fish swims slowly with the hook in its mouth.
4. Chewing (C). The fish chews at the bait.
5. Jerk (J). With the hook in its mouth the fish moves its head rapidly sidewise.
6. Jerk series (Js). The fish perfoms several very fast contionous jerks from side to side.
7. Rush (R). The fish accellerates rapidly with the hook in its mouth.
8. Spitting out (S). The fish gets rid of the hook.
9. Hooked (H). Not a behaviour pattern. The fish is considered hooked.

Similarly described behaviour patterns are used by Fernø et.al. (1977).

Fig. 1 shows a matrix of transitions from one behaviour pattern to another within the sequences of the cod study. The upper numbers in the squares are observed values, the lower are expected values - (Lemon and Chatfield 1971, Fernald 1977, Huse 1979). The matrix gives the number of occurrances of the various behaviour patterns. Its main function, however, is to show combinations of behaviour patterns which occur more or less frequently than expected. The sums show that jerks occur most frequently followed by rushes. Jerks, however, are more connected to inhibited bites than are rushes. Inhibited bites can mostly be looked upon as experimental artifacts due to habituation and learning (Fernø & Huse 1978). Numbers of rushes and jerks following bites are just about equal (38 to 41). Of behaviour patterns leading to hooking, rushes dominate with 13 out of 17. This may, however, also be an experimental artifact as rushes always also occur after hooking and the exact moment of hooking is difficult to decide.

Fig. 2 gives a flow cart for the sequences starting with a bite in the cod experiment. Each level of squares contains the corresponding behaviour pattern in each of the summed sequences. The sum of rushes in these sequences are 67 while the sum of jerks are 50. Of the 8 fishes hooked at third level (with only one behaviour pattern between bite and hooking) 7 are hooked after a rush.

Fig. 3 gives a behaviour flow chart for the sequences starting with a bite in the haddock experiment. The sum of rushes are 41 while the sum of jerks are 15. Of the 8 hooked fishes at the third level 7 are hooked after a rush. This agrees well with the cod experiment and the overall conclusion must be that the rush should form the basis for long line cod and haddock hook design.

3.2 Hook form.

Fig. 2 and 3 show that hooking frequencie are rather low considering that the force applied by the fish in every rush is sufficient to hook the fish provided that hook form and fish movement allows the hook point to penetrate the inside of the mouth cavity. Fig. 4 indicates that this only occurs with a traditional hook when the shank and snood forms a rather wide angle with fish side in the rush. If this picture is correct, a hook with the point in the line-of-pull, i.e. the point aiming at the hook eye (Fig. 5), should have a higher hooking probability than a traditional hook because it will penetrate for any angle between fish and snood in the rush. The hook shown in Fig. 5 is a Mustad Wide Gap hook chosen to test out this principle in full scale fishing experiments.

3.3 Fishing experiments.

The Wide Gap hook was tested in all 3 fishing experiments. In the first experiment 24 comparisons of 50 hook blocks were fished. The result was a statistically signigicant (P = 0.007) 34% increase in the cod catches for the Wide Gap hooks over the standard hooks which in all 3 experiments were Mustad Norway. Total catches were 303 on Wide Gap and 226 on Norway.

In the second experiment the 50 comparisons yielded a non-significant (p = 0,13) increase of 12% for the Wide Gap. Total catches were 443 to 388 cod. Very patchy fish distribution and a higher proportion of swalloved hooks (41% in the second experiment, 16% in the first) may explain this difference. Swallowed hooks will obviously even out the difference in catching power between the hooks as both hooks secure the fish about equally well when swallowed. Patchy fish distribution will make it hard to obtain a statistically significant result.

To avoid effects of patchiness the third fishing experiment was designed with hook to hook comparison, or rather: the two hook types alternated along the line. The catch of 50 hooks of one type was compared with the catch of the corresponding 50 hooks of the other type. The 26 comparisons gave a statistically significant ($p < 0.001$) increase of 33% in the cod catches for Wide Gap. Total catches were 517 to 415 cod.

During this experiment the hook form shown in Fig. 6, called Rush, was also tested. The point of this hook also aims at the hook eye like with the Wide Gap, but the forms are otherwise quite different. 35 comparisons between Rush and the standard hook gave a statistically significant ($p < 0,001$) increase of 23% in the cod catches for Rush. Total catches were 943 to 765 cod.

The conclusion must be that a long line hook with the point aiming at the hook eye gives a substantially higher catch rate for cod than the standard Norwegian long line hook.

Both the Wide Gap hook and the Rush hook were tested on pelagic long lines for haddock in the third fishing experiment. A block size of 100 hooks in each block was used in these tests. 8 comparisons between Wide Gap and the standard hook gave a statistically significant (p = 0,01) increase of 14% for Wide Gap. Total catches were 441 to 386 haddock. The 9 comparisons between Rush and the standard hook gave a statistically significant (p = 0,01) increase of 10% for Rush. Total catches were 544 to 493 haddock. This shows that the above mentioned basic principle for these hooks also works for haddock. This was to be expected as the behaviour of cod and haddock relevant to hooking seems to be quite similar. An even greater increase for haddock than for cod would not be unlikely since haddock hardly ever swallow the hook. But with the higher fish densities normally experienced in the pelagic haddock long line fisheries, gear saturation and several trials at each hook will masque the real difference in hooking probability. However, the experiment reveals what advantage is to be expected from these hooks in this fishery.

Maybe the most interesting experience gained from this investigation is that a systematic behaviour study can be a very important part of a gear improvement program.

References:

FERNALD, R.D. 1977. Quantitative behavioural observations of Haplokromis burtoni under semi-natural conditions. Anim. Behav. 25:643-653.

FERNØ, A. & HUSE, I. 1978. The effect of experience on the behaviour of cod towards a hook. Int. Coun. Explor. Sea, Gear and Behav. Wk. Group Meet. Bergen:1-3. (Mimeo.) (Unpublished).

FERNØ, A., TILSETH, S. & SOLEMDAL, P. 1977. The behaviour of whiting (Gadus merlangus) in relation to long lines. Coun. Meet. int. Coun. Explor. Sea, 1977(B:44):1-11. (Mimeo.)

HUSE, I. 1979. Betydningen av krokform og redskapsmaterialer ved linefiske etter torsk (Gadus morhua L.) og hyse (Melanogrammus aeglefinus L.) undersøkt ved atferdsstudier og fiskeforsøk. Thesis (cand. real), Univ. Bergen (Unpublished).

LEMON, R.E. & CHATFIELD, C. 1971. Organization of song in cardinals. Anim. Behav. 19:1-17.

1. BEHAVIOUR PATTERN

2. BEHAVIOUR PATTERN	B	B_i	R	J	Js	P	H	S
B								
B_i								
R	38 / 22,8	5 / 22,4	10 / 12,4	14 / 17,6	0 / 1,3	12 / 4,2		
J	41 / 32,3	55 / 31,8	4 / 17,6	8 / 24,9	1 / 1,8	3 / 6,0		
Js	3 / 2,3	0 / 2,3	1 / 1,3	3 / 1,8	1 / 0,1	0 / 0,4		
P	17 / 7,8	7 / 7,7	0 / 4,2	3 / 6,0	0 / 0,4	0 / 1,5		
H			13 / 2,7	2 / 3,8	2 / 0,3	0 / 0,9		
S	40 / 74,9	71 / 73,8	51 / 40,8	82 / 57,6	4 / 4,1	12 / 14,0		
SUM	139	138	79	112	8	27	17	260

Fig. 1. Transition matrix. Upper numbers in squares are observed values, lower numbers are expected values. First behaviour pattern of a transition is given above the square, second at left side.

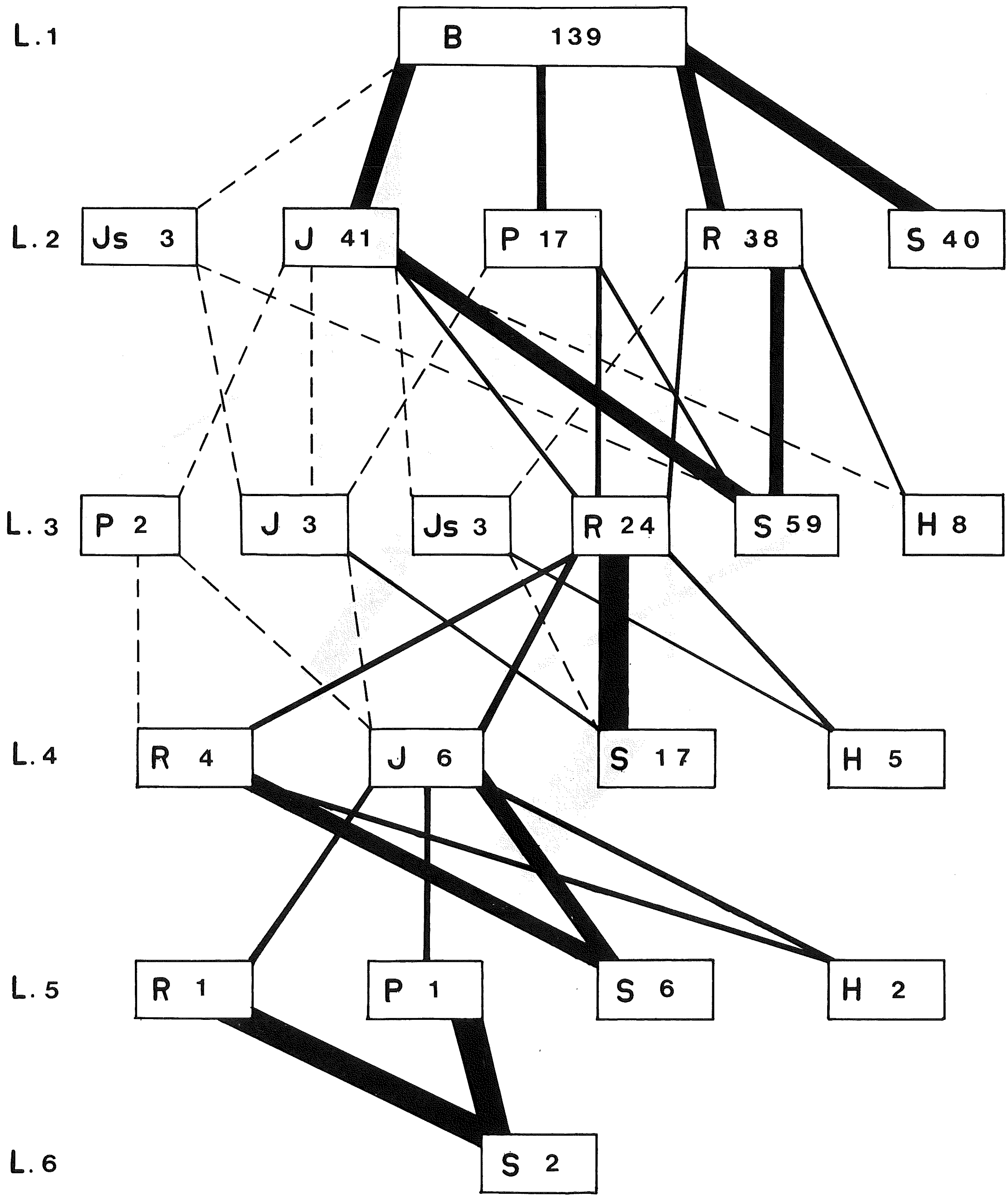

Fig. 2. Behaviour flow chart for cod. L means level. Each level contains the corresponding behaviour pattern in each of the summed sequences. The thickness of the lines indicate the importance of the transitions between two levels. Transitions which represent less than 4 % of the transitions between two levels are dashed.

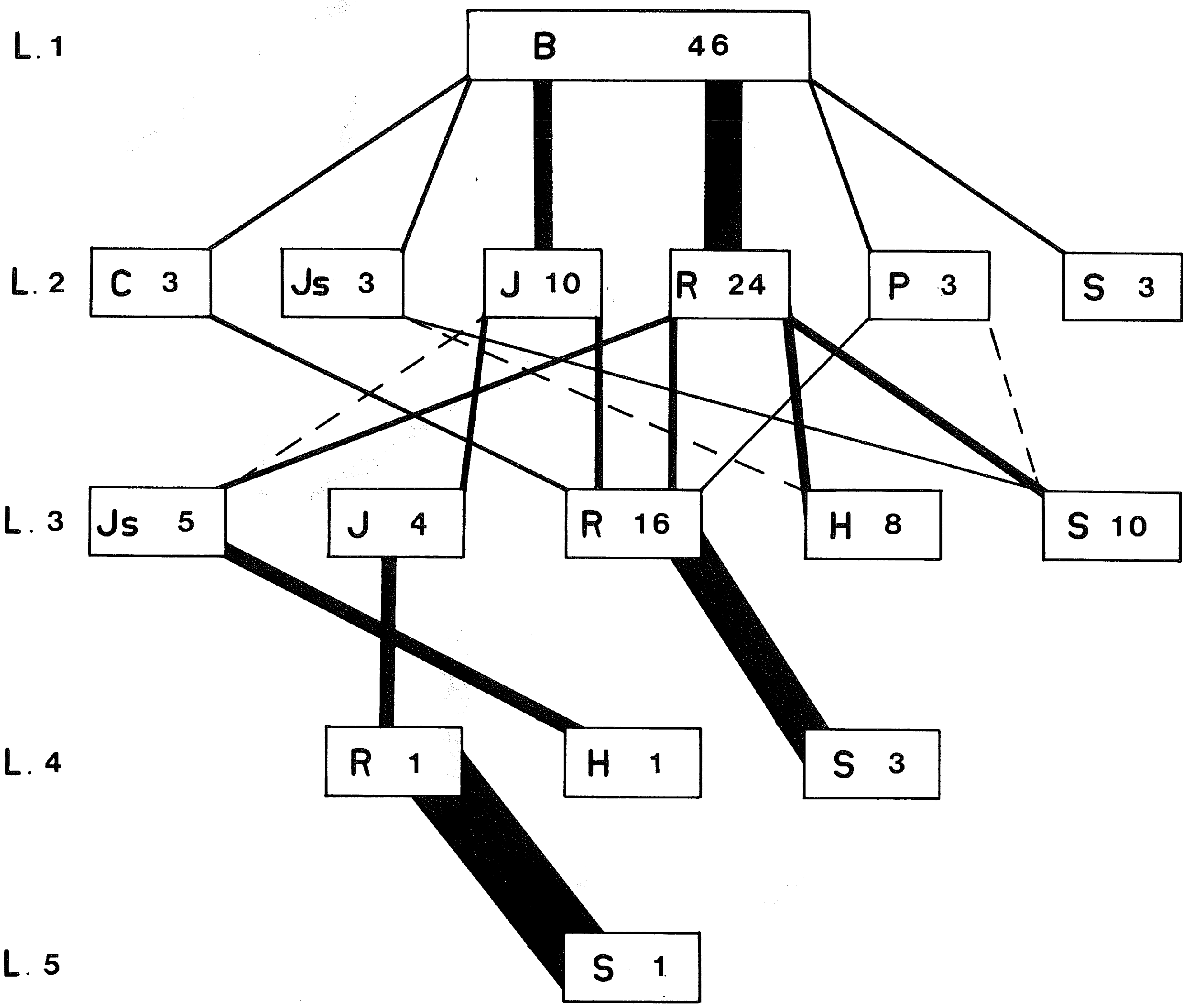

Fig. 3. Behaviour flow chart for haddock.
For further explanation see Fig. 2.

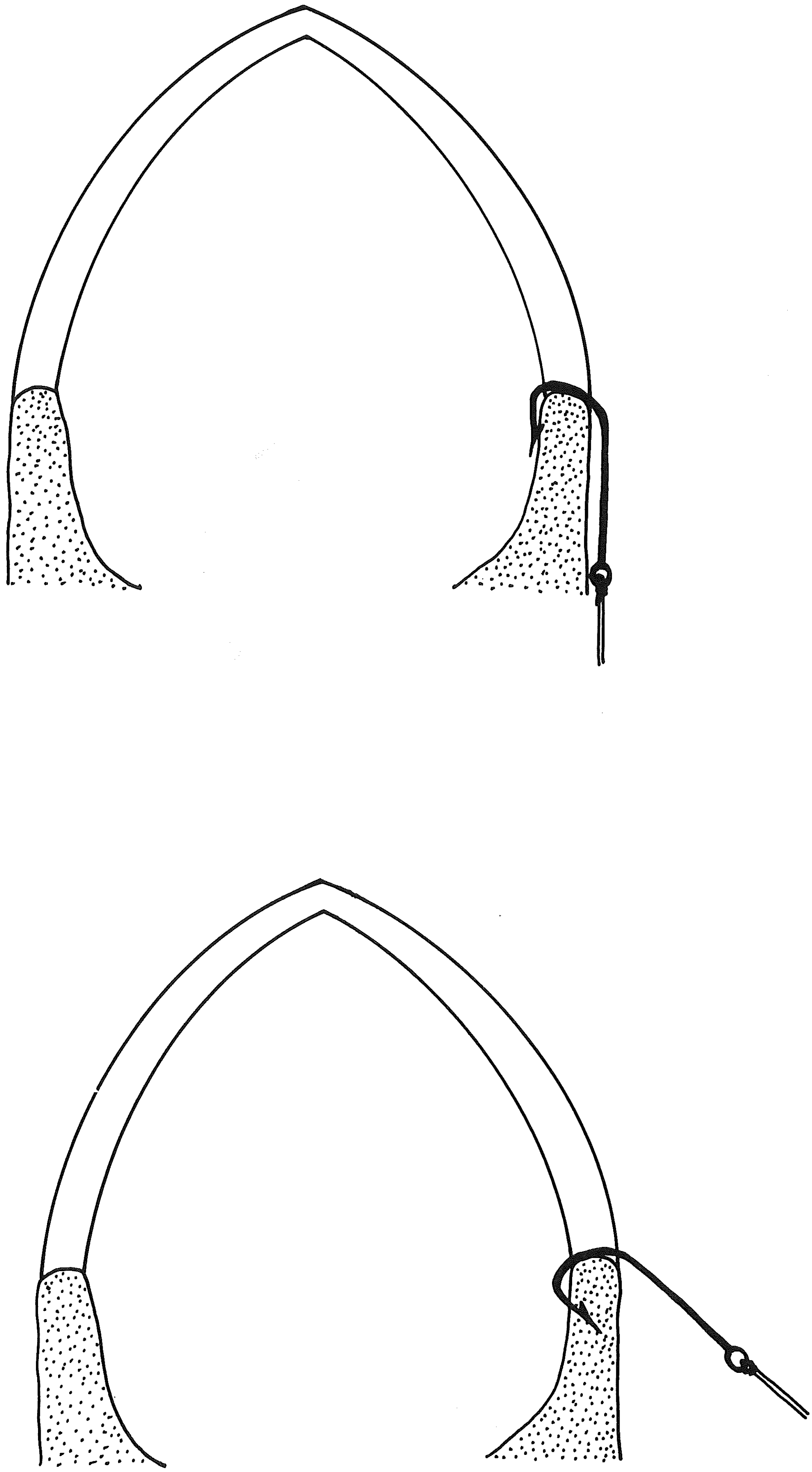

Fig. 4. Simplified horizontal cross section through fish head with standard hook at different angles.

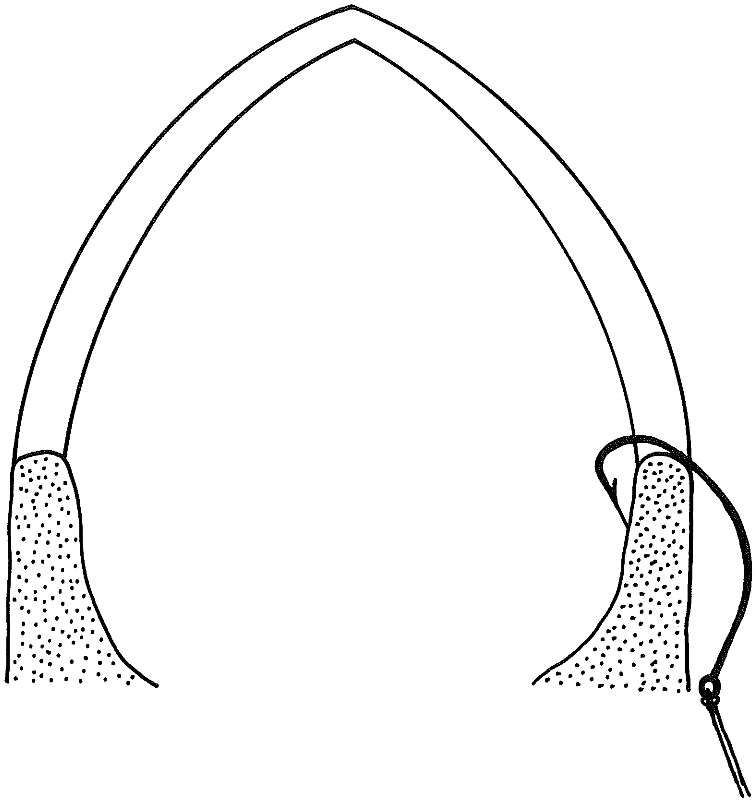

Fig. 5. Simplified cross section through fish head with Wide Gap hook.

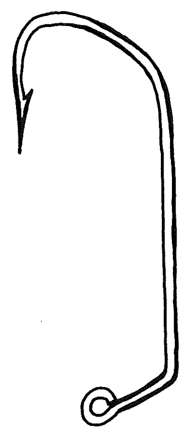

Fig. 6. The Rush hook