FiskDir. Skr. Ser. HavUnders., *18*: 69–76.

A STAGING SYSTEM FOR LARVAL COD (*Gadus morhua* L.)

By

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ABSTRACT

FOSSUM, P. 1986. A staging system for larval cod (*Gadus morhua* L.). *FiskDir. Skr. Ser. HavUnders.*, *18*: 69–76.

A staging system of larval cod is described. The system is based on the resorption of the yolk mass and the cell layers surrounding it combined with eye, mouth and gut development. A determination key is given. Each stage is described in detail.

INTRODUCTION

Correct aging is very important in field investigations of the growth and mortality of larvae. Different methods have been used to age cod larvae. An example of a morphometric method is the use of standard length as an index of larval age. However, shrinkage due to catching and preservation is too high and unpredictable for practical use (HAY 1982). Other morphometric methods are based on eye-diameter or myotomal-height measurements and swimbladder or gut development, but all of these methods are quite inaccurate.

In contrast to morphometric methods, aging with help of daily increment counting in the otoliths has been tried. However, otoliths in cod larvae seem unsuitable for this method, as the growth in number of zones seems to be dependent on the growth in the larval period and do not equal one ring per day (BERGSTAD 1984).

In the present work cod larvae have been staged in accordance with the utilization of the yolk mass and the resorption of the remnants of the yolk sac when the yolk mass is resorbed, together with the development of the mouth.

MATERIALS AND METHODS

The larvae used in this work are from:

a) Laboratory experiments performed at the Institute of Marine Research in 1976. These larvae were unfed and are used to study the duration of the yolk sac stages (1–6) at 5°C (ELLERTSEN *et al.* 1980).

b) Laboratory experiments performed at the Institute of Marine Research in 1982. These larvae were fed rotatoria (*Brachionus plicatilis*) and plankton organisms collected in the sea outside the Institute (cop. nauplii, bivalve larvae, veligers of *Littorina*, cop. eggs and polychaet larvae). These larvae were used to study the duration of the post-yolk-sac stages (7–10) at 7°C.

c) Fast-growing larvae from concrete-enclosure experiments performed at Flødevigen Biological Station in 1977 (ELLERTSEN *et al.* 1981).

d) Fast-growing larvae from the Hyltro-pond experiment in 1983 (KVENSETH and ØIESTAD 1984). This pond is located at Austevoll Research Station and the same larvae were also used to study the duration of the post-yolk-sac stages.

The larvae caught during the investigations in the Lofoten area in the period 1979–1984 are staged according to the present system, and a brief presentation of the system is given in ELLERTSEN *et al.* (1984).

All of the larvae were preserved in 10 ‰ sea water with 4% formalin. Larvae from the laboratory were collected with a pipette, and the larvae from the pond and enclosure, with nets.

RESULTS AND DISCUSSION

In the present staging system based on different developmental stages, the period from hatching to the end of stage 6 has a duration of 8 days at 5 degrees C. The duration of stages 7, 8 and 9 seems to be independent of larval growth. Larvae kept at maintenance food level in the laboratory at 6–7°C, had the same stage duration as fast-growing larvae in a concrete enclosure and pond experiment at 7–8°C. The duration of stage 9 is somewhat uncertain, fast-growing larvae from the Hyltro-pond in Austevoll in 1983 were in this stage when they metamorphosed at 30 days age. In the laboratory, however, it was not possible to keep the larvae for such a long time, but all the larvae were in this stage at the termination of the experiment 21 days after hatching. Stages 7 and 8 were of equal duration both in the laboratory and in the enclosure and the pond. The reason for the independence of larval growth on the duration of the post-yolk-sac stages can be that the rest of the cell layers which enclosed the yolk mass will not give any energetic surplus to the larvae when they are resorbed. If this resorption had given the larvae an important energy input, larvae under bad

feeding conditions would have to use this energy pack at a faster rate than larve under good feeding conditions. A differentiated resorption rate dependent on the feeding conditions of the larvae can perhaps take place when the larvae are in a mixed feeding situation when they rely on both endogenous and exogenous energy input, stages 5 and 6. However, very few food particles are found in the gut of larvae in stages 5 and 6 in field investigations (ELLERTSEN *et al.* 1984) and no different stage durations were found between larvae in stages 5 and 6 exposed to different feeding regimes in the laboratory, pond and enclosure. The best stages for a comparison of feeding response of larvae in the first-feeding period, when exposed to different feeding regimes in the sea, are stages 7 and 8. Both of these stages are of relatively short duration. A comparison between post-yolk-sac larvae exposed to different feeding regimes is given in ELLERTSEN *at al.* (1984). Some of the most used characters in the description and the determination key are shown in Fig. 1.

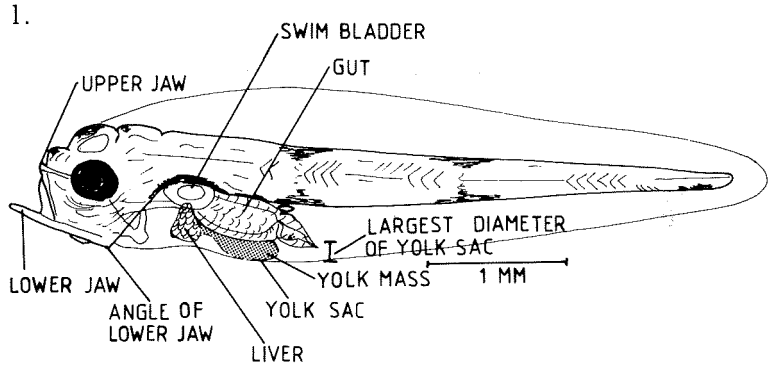

Fig. 1. Some of the most used characters in the larval cod staging system.

DESCRIPTION OF THE DIFFERENT STAGES

Stage 1 (Fig. 2): The yolk sac is egg-shaped. The eyes are incompletely pigmented (brownish). The gut is tube-formed and thick-walled, being smooth on the inside. This stage is seldom found in the field because of its short duration. Duration 0–¼ day after hatching (5°C).

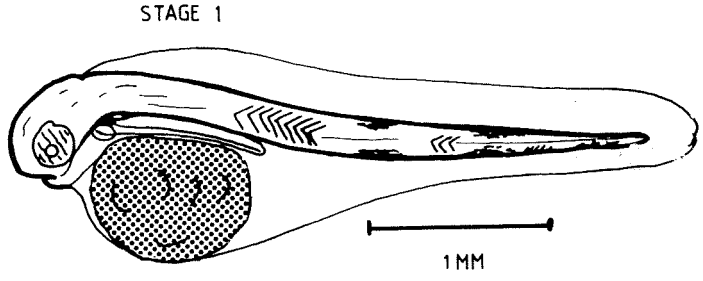

Fig. 2. Cod larvae in stage 1.

Stage 2 (Fig. 3): The yolk sac is spherical. The eyes are incompletely pigmented (greyish-brown). The gut is tube-formed and thick-walled, smoth on the inside, ¼–2 days after hatching (5°C).

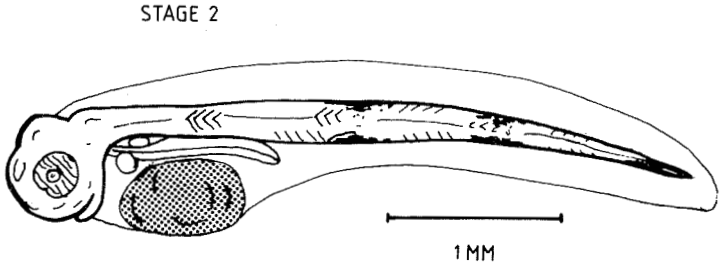

Fig. 3. Cod larvae in stage 2.

Stage 3 (Fig. 4): The yolk sac is elliptical, the eyes completely pigmented (black), the wall of the gut is thin and smooth on the inside. The gut can be distended and is separated into gut and rectum. The liver is round, the larval jaw is overshot and unangled. This stage is present in the period 2–3 days after hatching (5°C).

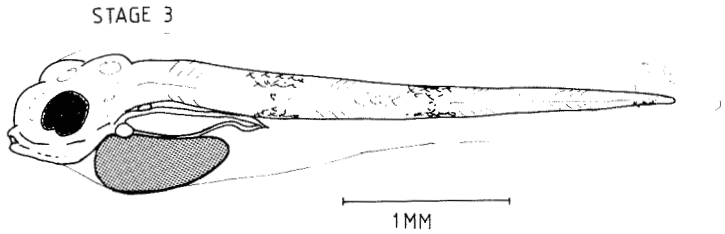

Fig. 4. Cod larvae in stage 3.

Stage 4 (Fig. 5): The yolk sac is cylindrical, the wall of the gut is thin and smooth on the inside, but can be irregular against the hindgut. The liver is irregular, the jaws are equal in length, or the jaw is overshot. The lower jaw is angled and the basis of the preorbial fin is found at this angle or in front of it. This stage is present in the period 3–4 days after hatching (5°C).

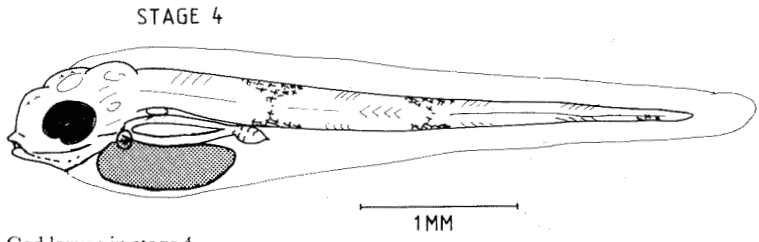

Fig. 5. Cod larvae in stage 4.

Stage 5 (Fig. 6): The yolk sac is cylindrical or wedge-shaped. The largest vertical diameter through the yolk sac is larger or equal to the myotomal height measured above the swimbladder. The inside of the gut is irregular. The liver is irregular. The larva has an underhung jaw, and the angle in the lower jaw is found in front of the preorbial fin. The mouth is functional. This stage is present in the period 4–6 days after hatching (5°C).

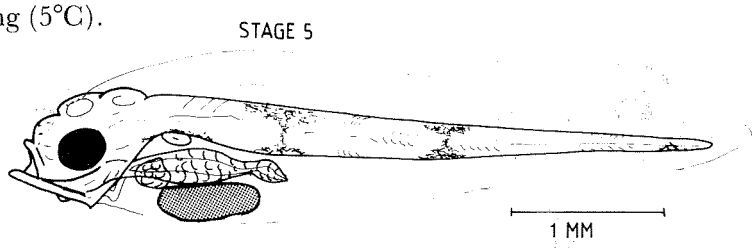

Fig. 6. Cod larvae in stage 5.

Stage 6 (Fig. 7): A remnant of the yolk sac is present. The largest vertical diameter through the yolk sac is less than the myotomal height measured above the swimbladder. The mouth is functional, and the larva is found with gut content. This stage is present in the period 6–8 days after hatching (5°C).

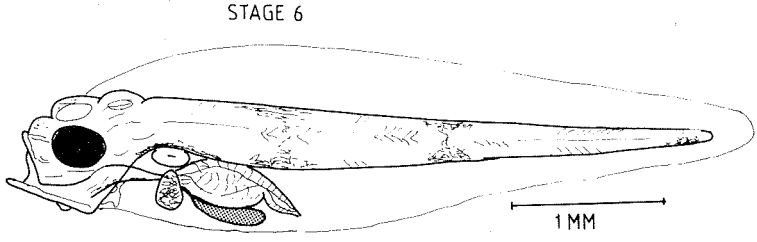

Fig. 7. Cod larvae in stage 6.

Stage 7 (Fig. 8): The yolk sac is either empty or some small granules of yolk mass can be seen. This stage is present in the period 8–10 days after hatching (6–7°C).

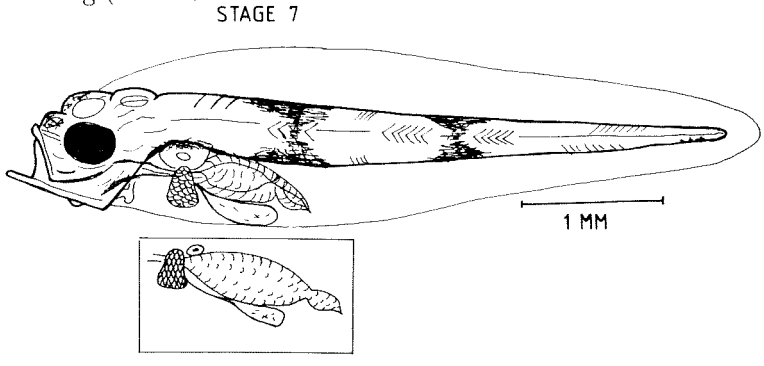

Fig. 8. Cod larvae in stage 7.

Stage 8 (Fig. 9): The cell layers which enclosed the yolk sac are reduced to a string under the gut. This stage is present in the period 10–16 days after hatching (6–7°C).

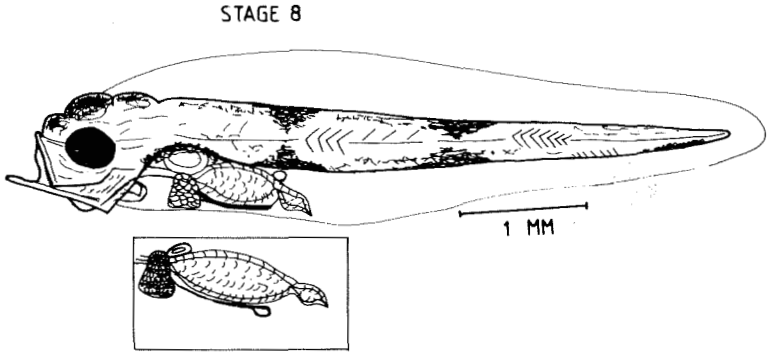

Fig. 9. Cod larvae in stage 8.

Stage 9 (Fig. 10): The string under the gut is broken up into fragments. This stage has a duration of about two weeks from day 16 after hatching.

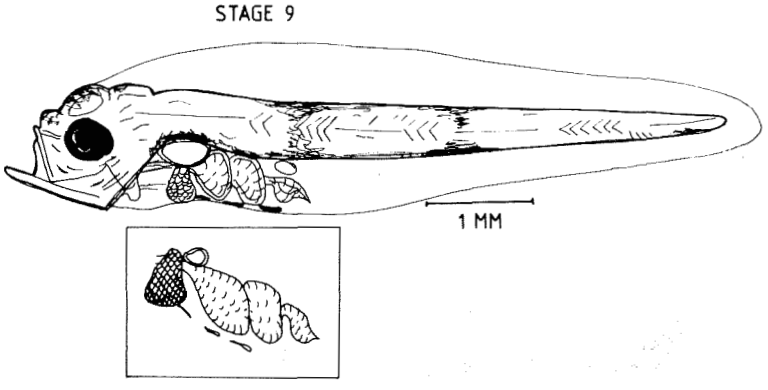

Fig. 10. Cod larvae in stage 9.

Stage 10 (Fig. 11): There is nothing left of the yolk sac or of the cell-layers which enclosed it.

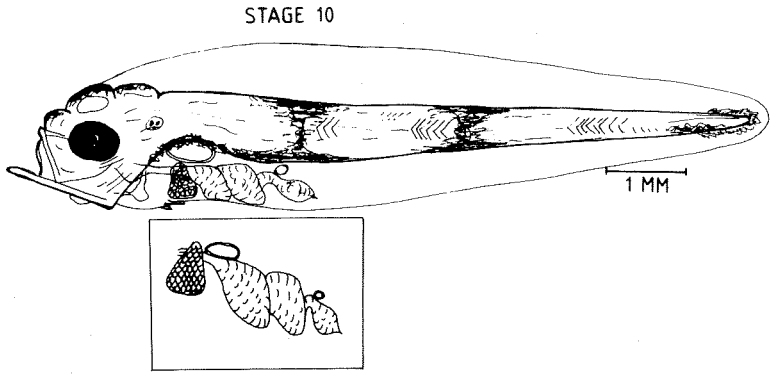

Fig. 11. Cod larvae in stage 10.

DETERMINATION KEY OF LARVAL COD

A: The eyes are transparent (greyish or brown).
The yolk sac is eggshaped or spherical.
1) The yolk sac is egg-shaped — STAGE 1
2) The yolk sac is spherical — STAGE 2

B: The eyes are completely pigmented (black).
The yolk sac is elliptical or cylindrical if present.
1) The mouth is overshot and, if the lower jaw is angled, the angle in the jaw is found behind or at the basis of the preorbial fin. The mouth is not functional.
a) The lower jaw is not angled — STAGE 3
b) The lower jaw is angled — STAGE 4
2) The mouth is underhung, the lower jaw is clearly angled, and the angle in the lower jaw is found in front of the preorbial fin. The mouth is functional.
a) There is yolk mass left in the yolk sac.
i) The largest vertical diameter through the yolk sac exceeds the myothomal height measured above the swimbladder — STAGE 5
ii) The largest vertical diameter through the yolk sac is less than the myothomal height measured above the swimbladder — STAGE 6
b) There is no yolk mass left.
i) The yolk sac is still present, small granules of yolk can be found — STAGE 7

ii) The yolk sac is reduced to a string under the gut — STAGE 8
iii) The string under the gut is broken up into fragments — STAGE 9
iiii) There is nothing left of the yolk sac — STAGE 10

Some preliminary results with the use of the key by five untrained persons are shown in Table 1. They had the greatest problems in distinguishing stages 3 and 4, and stages 5 and 6. Of 37 larvae in stage 3, 4 were graded as stage 2 while 13 were graded as stage 4. Of 35 larvae in stage 4, 10 and 6 were assigned to stages 3 and 5, respectively. If stages 6 and 7 larvae were staged wrongly, they were assigned to stages 5 and 8, respectively.

Table 1. Some preliminary results when the key is used.

Stage (N)	N=3	N=4	N=5	N=6	N=7	N=8
Determined to be N-1	4	10	1	16	0	0
Determined to be N+1	13	6	1	0	5	1
Determined to be N.....	20	19	23	32	15	12
Numbers of larvae.....	37	35	25	48	20	13

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Received 15 August 1985
Printed february 1986