International Council for the Exploration of the Sea

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FURTHER EXPERIMENTAL STUDIES ON CLYDE HERRING EGGS AND LARVAE

by

I. G. Baxter
Marine Laboratory, Aberdeen, Scotland

Results of preliminary experiments carried out at the Marine Laboratory in 1973 on the survival of herring eggs and larvae reared in water from different locations in the Firth of Clyde were presented at last year's Council Meeting (Baxter and Steele 1973). These studies have continued, and in this paper results are given of a further experiment carried out during the spring of 1974.

Material and Methods

The water used in this experiment was taken from two locations in the Clyde: Ballantrae Bank, the spawning and hatching ground of Clyde spring spawning herring, and Irvine Bay, an important area through which the larvae normally drift northwards to the nursery areas in the inner reaches of the estuary. Sea water from Loch Ewe, an unindustrialised area on the north-west coast of Scotland, was used as a control. Eggs were obtained from ripe herring caught by trammel net on Ballantrae Bank on 21 February 1974. Immediately after capture, male and female gonads were dissected from the fish and stored in glass jars in vacuum flasks for transportation to the laboratory where artificial fertilisation was carried out. Eggs from four females, 29-31 cm in length, were fertilised on small glass plates (20x 3cm) Half of the eggs from each female were fertilised with milt from a single male in Ballantrae Bank water and half in the control water from Loch Ewe. After washing, the plated eggs were transferred to the incubation tanks. Half of eggs from each female, fertilised in Ballantrae Bank water, and half of those eggs fertilised in Loch Ewe water were incubated in Ballantrae Bank water. The remaining half of the eggs from each fertilisation were incubated in Loch Ewe water.

During incubation the water in each of the two tank systems was circulated continuously to ensure that the developing eggs were adequately ventilated. Fresh Ballantrae Bank and Loch Ewe sea water was introduced so that every five days the water in each system was renewed. Time-temperature histories of the incubating eggs were the same for each water treatment. The temperature for most of the incubation period was maintained between 7.5°C and 8°C. However, on one occasion, due to a fault in the refrigeration equipment of the constant temperature room, the temperature of the water rose to about 12°C over a period of 3-4 hours before the fault could be corrected. According to Schubel (1974) temperature fluctuations of this order during incubation do not significantly affect hatching success or survival of larvae.

About two days before hatching commenced the eggs were transferred to 10-litre plastic containers, so that the larvae from each parent, fertilisation treatment and incubation treatment could be identified. Counts were

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About two days before hatching commenced the eggs were transferred to 10-litre plastic containers, so that the larvae from each parent, fertilisation treatment and incubation treatment could be identified. Counts were

made of daily hatchings from all treatments and of the dead eggs remaining on the plates when hatching had finished.

Larvae from the eggs incubated in Ballantrae Bank and Loch Ewe water were then reared in three different types of water: Ballantrae Bank, Irvine Bay and Loch Ewe. The treatments were as follows:-

Six hundred larvae hatched in a 24-hour period from the same parent and same incubation water (300 from each fertilisation treatment) were divided into three groups of 200 larvae and transferred to three rearing tanks containing (a) Ballantrae Bank water, (b) Irvine Bay water, and (c) Loch Ewe water. Nine replicate tanks for each water treatment were set up in this way over a four-day period, i.e. from hatchings 17-20 days after fertilisation.

These larvae were reared in 25-litre tanks with continuous water circulation for a period of seven weeks. The temperature of the water was maintained between 8°C and 8.5°C and the time-temperature histories for all the tanks were the same. Dead larvae were removed daily from each tank and the numbers recorded. Ten days after hatching, brine shrimp nauplii were introduced to the tanks as food. Each tank was provided with approximately equal numbers of nauplii. Feeding with brine shrimp nauplii was continued daily and in addition, occasional supplies of micro-zooplankton were obtained from Loch Ewe and fed to the larvae; equal volumes of these organisms were supplied to each tank.

During the major part of the experiment supplies of fresh sea water were obtained from each locality in the Clyde and Loch Ewe at approximately weekly intervals. Samples of water for chemical analysis were taken on each occasion when collections were made, and also at weekly intervals from tne tanks in which the eggs and larvae were being reared. From these water samples measurements were made of salinity, nutrients (phosphate, silicate, nitrate, nitrite and ammonia), oxygen and BOD and base metals (copper, cadmium and lead).

Results

The eggs were fertilised on 21 February and hatching commenced on 8 March, i.e. 15 days after fertilisation. Although some hatching continued until 21 March, 70% of the eggs hatched in a three-day period, 19-21 days after fertilisation. Table 1 gives the number of days after fertilisation to 50% hatch for eggs fertilised in Ballantrae Bank and Loch Ewe water. There were no consistent differences between the times taken for the eggs to hatch in the two types of water.

Hatching success was not related to either fertilisation or incubation water treatments but there were statistically significant differences between parents (Table 2).

The survival of larvae was high compared with the results obtained in the 1973 experiment when only 28% of larvae reared in Irvine Bay water and 67% in Ballantrae Bank water survived to ten days after hatching. In the 1974 experiment larval mortality in the different water types was negligible up to 14 days after hatching. Percentage survival of larvae in the different water types is given at weekly intervals in Table 3. Although a considerable proportion of the larvae were observed to be feeding soon after the introduction of the Artemia nauplii there was a high mortality of larvae during the fourth week after hatching, when up to about 70% of the larvae died in some of the tanks. The survival of larvae varied considerably between individual tanks but were were no significant differences between water types. Variations in survival appeared to be associated with differences between parents.

Results from the chemical analyses of different water types sampled from the tanks in which the eggs and larvae were reared are presented in Table 4. In 1974 the water from the Clyde had much lower nitrate and BOD values than in 1973 when nitrate levels of 10.3 and 35.0 µg at/l and BODs of 1.14 and 2.31 mg/l were recorded for Ballantrae Bank and Irvine Bay water respectively.

Discussion

Results from the experiment carried out in 1974 suggest that the quality of the water in the Clyde during the spring of 1974 was much more favourable for the survival of herring eggs and larvae than in 1973. During the past 16 years measurements of the annual production of herring larvae over Ballantrae Bank spawning ground have been made from intensive plankton surveys in that locality (Saville et al. 1973). Estimates of larval abundance in 1973 were very low compared with the average values for previous years. Preliminary results for 1974 indicate that the abundance of recently hatched larvae was very high with values similar to those in the mid-sixties when the spawning stock was much larger. Statistics for the Clyde trammel net fishery for spawning herring on Ballantrae Bank over the past ten years are given in Table 5. Catch per landing data suggest that the spawning stock in 1974 was much smaller than in years 1965-70. The high values of larval abundance obtained in 1974 therefore suggest that survival of larvae during the pre-feeding stages may have been much higher in 1974 than in years when the spawning stock was greater.

Results from the chemical analyses of the waters used in the experiments in 1973 and 1974 indicate that BOD and nitrate values were much lower in 1974 than in 1973. Differences in water quality between these years may be attributed to changes in hydrographic conditions. As a result of high rainfall in in the late autumn and winter of 1973-74 there was a rapid displacement and flushing out of the water in the Clyde basin which would tend to reduce the concentration of pollutants while in the autumn and winter of 1972-1973 below average rainfall tended to depress the rate of water exchange and dispersal of pollutants from the inshore areas of Ballantrae Bank and Irvine Bay.

While there is some evidence from the larval surveys over Ballantrae Bank that the initial survival of larvae from herring spawning in 1974 was high, there is no indication at this stage whether this year class is likely to survive in sufficient numbers to have a major impact on the fishery. However, if the 1974 year class proves to be above average in strength the results from these experiments carried out in 1973 and 1974 suggest that the 'good' water quality during the early development of eggs and larvae may have been relevant.

References

Baxter I.G. and Steele J.H.	1973	Mortality of herring larvae in the Clyde sea area. ICES CM 1973/E:23 (mimeo).
Saville A., Baxter I.G. and McKay D.W.	1973	Relations between egg production, larval production and spawning stock size in Clyde herring. IABO International Symposium on the Early Life History of Fish (Oban 1973).
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Table 1

Days after fertilisation to 50% hatch of herring eggs reared in different water types

Fertilisation water	Incubation Water: Loch Ewe		Incubation Water: Ballantrae Bank	
	Loch Ewe	Ballantrae Bank	Loch Ewe	Ballantrae Bank
Female Parent				
1	20	20	20	20
2	19	19	19	20
3	21	20	21	21
4	20	20	20	21

Table 2

Percentage hatch of eggs reared in different water types

Fertilisation water	Incubation Water: Loch Ewe		Incubation Water: Ballantrae Bank	
	Loch Ewe	Ballantrae Bank	Loch Ewe	Ballantrae Bank
Female Parent				
1	87.4	90.6	78.5	81.4
2	94.7	93.8	97.9	92.5
3	97.8	97.5	97.9	97.1
4	90.3	88.8	93.4	93.1

TABLE 3

PERCENTAGE SURVIVAL OF LARVAE IN DIFFERENT WATER TYPES

Water type				LOCH EWE							BALLANTRAE BANK							IRVINE BAY						
Weeks after hatching				1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Tank No.	Days after fertilisation	Female Parent	Incubation water																					
1	17	2	Loch Ewe	99.0	98.5	98.5	76.5	49.0	38.0	35.0	97.5	96.5	96.0	70.5	53.0	43.0	39.5	99.5	99.5	93.0	60.5	45.0	41.5	35.5
2	18	2	Ballantrae Bank	99.0	98.5	97.5	67.5	37.5	33.5	27.5	100	99.5	99.0	73.5	49.0	47.5	46.5	99.5	99.5	99.5	55.0	38.0	33.5	25.0
3	18	2	Loch Ewe	99.5	99.5	99.0	64.0	44.5	39.0	35.5	99.0	99.0	98.0	69.0	49.0	36.0	33.0	100	100	100	55.0	45.0	39.5	32.5
4	19	4	Loch Ewe	97.0	96.5	96.5	67.5	50.0	45.0	38.0	100	99.0	98.5	59.0	43.0	39.5	31.0	99.0	97.0	88.0	37.5	33.5	27.5	19.0
5	19	4	Ballantrae Bank	100	99.5	99.0	53.0	36.0	30.0	25.5	99.0	98.5	93.0	37.0	32.0	28.5	17.0	99.5	99.5	99.5	57.0	49.5	42.5	24.0
6	20	3	Loch Ewe	99.5	99.0	93.0	43.5	34.0	31.5	26.0	100	98.5	97.5	51.5	38.5	35.0	27.5	99.5	99.0	98.0	40.5	37.0	34.5	24.0
7	20	3	Ballantrae Bank	100	100	99.0	41.5	33.0	30.5	27.5	99.5	99.0	94.5	57.5	55.5	42.5	30.0	98.5	97.5	95.5	40.0	34.0	30.5	20.0
8	20	1	Loch Ewe	99.5	99.0	90.5	34.5	26.5	19.0	13.0	100	100	93.5	33.0	30.0	21.5	11.5	100	100	91.0	20.0	34.0	13.5	6.5
9	20	1	Ballantrae Bank	90.5	98.5	90.0	30.0	22.5	18.0	13.0	99.0	96.5	87.0	40.0	33.0	19.5	7.5	99.0	99.0	84.5	31.0	25.0	18.0	7.5
All tanks combined				99.1	98.7	95.9	53.1	36.9	31.6	26.8	99.3	98.5	95.2	54.6	42.0	34.8	27.1	99.4	99.0	94.3	44.6	36.2	31.2	21.0

Table 4

Measurements of chemical parameters of different types of waters used in the experiments

	Loch Ewe	Ballantrae Bank	Irvine Bay
Salinity (‰)	34.6	33.7	32.9
Phosphate (µg at/l)	0.2	0.5	0.7
Silicate (µg at/l)	2.6	6.0	7.7
Nitrate (µg at/l)	3.5	5.1	12.2
Nitrite (µg at/l)	0.3	0.4	0.5
Ammonia (µg at/l)	1.6	1.8	1.9
O_2 (mg/l)	9.6	9.7	9.7
B.O.D. (mg/l)	0.45	0.50	0.55
Copper (µg/l)	1.48	1.55	1.96
Cadmium (µg/l)	0.36	0.22	0.25
Lead (µg/l)	0.96	0.75	0.90

Table 5

Catch statistics for trammel net fishery for spawning herring on Ballantrae Bank, 1965-74

	No. of landings of boats.	Catch (crans)	Catch/Landing (crans)
1965	163	2 913	17.9
1966	229	3 252	14.2
1967	165	1 690	10.2
1968	180	1 885	10.5
1969	136	1 711	12.6
1970	124	1 173	9.5
1971	119	878	7.4
1972	193	752	3.9
1973	113	598	5.3
1974	187	1 261	6.7