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LARGE SCALE HANDLING OF THE LARVAE OF THE MARINE FLATFISH TURBOT, *SCOPHTHALMUS MAXIMUS* L., AND DOVER SOLE, *SOLEA SOLEA* L., WITH A VIEW TO THEIR SUBSEQUENT FATTENING UNDER FARMING CONDITIONS.

by

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ABSTRACT.

Hatchery procedures for the rearing of relatively large numbers of juvenile Dover sole and turbot used by the British White Fish Authority in 1976 are reported.

Production survivals for both species are given and suggest that commercially viable levels can now be obtained with Dover sole for the initial feeding stage on live diets. The techniques for producing turbot larvae in quantity have not shown repeatable results but individual batches would tend to indicate that economic levels of production may be achieved.

RESUME.

Les techniques d'élevage larvaire employées en Grande-Bretagne par la White Fish Authority au cours de l'année 1976 pour l'obtention de nombres relativement importants de juvéniles de turbots et de soles, sont décrites.

Les taux de survie enregistrés pour les deux espèces sont indiqués. Chez la sole, la conduite des stades initiaux de développement sur nourriture vivante semble permettre de produire les quantités nécessaires à une exploitation commerciale. Chez le turbot, par contre, les techniques utilisées n'ont pas, jusqu'à présent, fourni de résultats reproductibles. Pourtant, les conclusions que l'on peut tirer de certains cas particuliers pourraient indiquer que l'obtention de niveaux de production rentables est possible.

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INTRODUCTION.

As part of its work to develop continuing supplies of marine fish to the British consumer, the White Fish Authority has conducted extensive trials to develop commercially orientated techniques for the intensive farming of several species of indigenous flat fish (HOWARD, 1974 ; KINGWELL, 1974 ; KERR and HOWARD, 1975 ; KERR, 1976 a).

Results are presented here of recent experience in mass hatching and rearing the larvae of turbot, *Scophthalmus maximus* L., and Dover sole, *Solea solea* L., fed live diets until a size between 20 and 30 mm in length had been reached, following metamorphosis. The major objective of all the trials reported was to provided the largest number of juveniles possible for weaning to artificial diets and rearing experimentation (KERR, 1976 b) with secondary objectives of providing technical data to allow commercial costs to be examined (WFA, 1976 a) and lastly to improve the rearing systems.

The hatchery systems for both species were first based on the pioneering research conducted by the Ministry of Agriculture, Fisheries and Food (JONES, 1972, 1973 ; JONES et al., 1973 ; SHELBOURNE, 1975) and relevant French experience (GIRIN, 1973, 1974 a, b),adapted where necessary to conform to mass rearing practice.

Growth beyond the 25 - 30 mm stage and subsequent weaning to prepared diets is not considered here but is discussed by GIRIN (1974 b), KERR (1976 b) and SMITH (1976) and reported in Authority publications (WFA, 1973, 1974 a, b, 1975 a, b, c, d, 1976 b, c).

METHODS AND RESULTS.

Dover sole.

Three sizes of glass reinforced plastic (G.R.P.) circular tank (4.5 m^2, 2.0 m^2 and 1.75 m^2), with internal black gel coat, were erected in an insulated building at the Authority's Hunterston Unit, Ayrshire. Each tank was supplied with either ambient or warmed coastal seawater. The latter achieved by passing supplies through a titanium plate heat exchanger (ATV model HXD (4)) utilising the heat from the seawater discharged by the South of Scotland Electricity Board's generating station at Hunterston. Temperatures were monitored by a Cambridge Foster thermograph mounted in a 108 m^3 GRP header tank distributing water to the rearing tanks.

Each of the rearing tanks had a central perforated PVC screen (4.0 mm mesh) overlaid by fine nylon mesh (650 µ) for the egg and early larval stages, leading to an external standpipe to control water level. Illumination was provided for twelve hours of the day (08.00 - 20.00) by one 65 W warm-white fluorescent batten at a water surface intensity of approximately 400 lux. Aeration by 25 mm cube air stones to each tank was continuous and supplied by a Nash Hytor (model MD673) compressor.

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Fertilised eggs were obtained from adult fish captured two to fourteen months prior to spawning in the English Channel and Blackwater estuary and held in 11.0 m^3 black butyl rubber (0.75 mm skin) lined brick tanks. Water temperature was maintained to the contemporaneous temperature of the southern coast of the U.K. by the addition of untreated power station coolant water to the ambient supply. Natural lighting was provided by louvred skylights which were adjusted to give a maximum light intensity of 200 lux. Spawning was allowed to occur naturally, the fertilised eggs being collected daily from the water surface by a fine soft terylene hand net after concentration in one area by a sliding screen.

Eggs were incubated in 0.34 m^2 black polythene baths held in constant temperature rooms (Fearle Bush UCL 45) at a temperature of 12.0° C ± 1° C. Eggs were stocked at a density of 1 x 10^4 per m^2 for up to five days in filtered seawater treated with a single dose of antibiotics (50 i.u. streptomycin sulphate and 50 i.u. sodium penicillin). Dead eggs were siphoned daily from the bottom of the baths.

Twenty-four hours prior to hatching live eggs were weighed. The number was estimated from a counted 1 g sample. They were then transferred in 1.0 L plastic containers to the rearing tanks. Temperature equilibration between the incubation and rearing temperatures was achieved by floating the containers in the rearing tanks which were held in static water conditions without aeration.

When hatching was completed the tanks were flushed for 24 hours at a rate of 1 change of tank volume per day to remove shell debris and hatching enzymes. Thereafter static water conditions were maintained until newly hatched *Artemia salina* L., nauplii were fed on the fifth or sixth day after hatching when gentle aeration was applied continuously. Irrigation, at a flow rate of 1 volume change per day, to remove uneaten *Artemia* was provided for two hours prior to the introduction of the days feed ration. This treatment was maintained until day 70 when irrigation was made continuous at an exchange rate of 5 changes per day.

Temperatures for the first 25 days in the semi-static tanks were not controlled by irrigation but rose slowly with the hatchery ambient air temperature (9.5° - 17° C). On the commencement of irrigation temperatures were held within the range 17° - 20° C.

Larvae were fed initially on *Artemia* nauplii. The cysts were incubated over a 44 hour period at a temperature of 23° C in an insulated hatchery capable of producing 60 x 10^6 nauplii per day. Metamorphosed fish were weaned on to the enchytraeid oligochaete, *Lumbricillus rivalis*, extracted from partially decomposed seaweed by a washing and grading process.

Production data for 1976 is given in table 1.

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Tank No.	Tank size (m^2)	No. stocked	No. at Day 5 (first feeding)	No. at Day 84 (mean size 20 mm)	% survival at Day 84	
					From egg	From Day 5
1	1.75	14,000	7,600	6,900	49.3	90.8
2	1.75	11,900	6,600	6,600	55.5	100
4	1.75	15,750	7,200	7,200	45.7	100
5	4.5	23,000	9,900	9,900	43.0	100
6	4.5	27,000	10,700	10,700	39.6	100
7	4.5	27,000	12,900	12,900	47.8	100
8	2.0	11,300	5,400	5,400	47.8	100
9	2.0	11,300	5,100	5,100	45.1	100
10	2.0	11,300	5,000	5,000	44.2	100
11	2.0	6,300	3,100	3,100	49.2	100
12	2.0	14,000	4,300	4,300	30.7	100
13	2.0	14,000	3,500	3,500	25.0	100
14	2.0	14,000	3,600	3,600	25.7	100
15	2.0	14,000	3,500	3,500	25.0	100
16	2.0	13,000	3,300	3,100	25.4	93.9
17	2.0	14,000	4,000	4,000	28.6	100
18	2.0	16,800	4,500	4,400	26.8	97.8
19	2.0	17,500	2,100	2,100	12.0	100
21	2.0	14,000	3,700	3,400	26.4	91.9
23	2.0	21,000	4,500	4,300	21.4	95.6
24	2.0	14,000	5,200	5,200	37.1	100
26	2.0	14,000	4,000	3,300	28.6	82.5
27	2.0	14,000	6,200	5,400	44.3	87.1
28	2.0	14,000	3,500	3,300	25.0	94.3
		367,150	129,400	126,200	35.24	97.5

TABLE 1 : *Survival of the 1976 production of Dover sole larvae at WFA Hunterston to the end of the live diet feeding period*.*

** Taken from WFA (1976 b)*

Turbot.

Several sizes of tankage were used during the course of the 1976 production, the most commonly used were circular tanks of 2.7 m^3, 0.93 m^3, 0.50 m^3, 0.20 m^3 and 0.08 m^3 volume. All were made of GRP with an internal black gel coat and had flat bases. The tanks were housed in an insulated, heated, sectional building at the Authority's Ardtoe Unit, Argyll and supplied with ambient seawater abstracted via a sand filtration system.

Tank temperatures were controlled by thermostatically operated silicon glass sheathed heaters (Thermal Syndicate Ltd.), the water remaining static for up to the first 25 days from hatching. Vigorous aeration via airstones was supplied from a Blackman (model SIZER) compressor.

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Continuous illumination at high intensity (up to 3,000 lux) was used, supplied either by several 1.5 m warm-white fluorescent battens (Thorn Lighting, A4Z/65) or from 150 watt tungsten filament spot lights (Osram PAR38) suspended 50 cm above the water surface.

Eggs and milt were obtained by manual stripping from 4 to 10 group fish held since juvenile capture (30 mm length) at the Authority's station at Hunterston. Discoloured and non-buoyant eggs were discarded and the remainder fertilised with motile sperm from at least two males. After 30 minutes the water was changed and the eggs incubated at 12.2 ± 0.7° C at a stocking density of 3×10^4 per m^2 in filtered seawater treated with antibiotics (50 i.u. of both streptomycin sulphate and sodium penicillin).

Fertilised eggs were also obtained from the Ministry of Agriculture, Fisheries and Food Laboratory at Lowestoft and from C.N.E.X.O., Brest, France. All eggs were despatched to Ardtoe in insulated containers 24 hours prior to hatching.

The eggs were weighed, the numbers estimated from a counted 1 g sample and transferred to 70 l plastic bags suspended in previously prepared hatchery tanks.

Rotifer and algal cultures were added to the tank prior to release of the hatched larvae in order to culture a rotifer density in excess of 10 per ml at day 4 from hatching. Each tank received a 3.5 % inoculum of algae (by volume) containing 20 ml of a proprietary plant food ("Bio") and 2 ml of a vitamin solution (Crookes, Multi-vitamin), illumination, vigorous aeration and temperature control at 12° C were applied. Two days prior to receiving the fish eggs, rotifers, *Brachionus plicatilis*, were added at a level of 2 per ml and the tank temperature raised to 16° - 18° C. The day after hatching (day 1) the plastic bag was split to approximately 35 cm below the water level and the larvae encouraged to escape by gentle aeration. After 24 hours hatching rates were estimated by siphoning unhatched eggs. Daily counts of rotifer and algal concentration within the tanks and main cultures were made to estimate the required addition of new cultures. When the larval length reached 6 mm (5 - 8 days), newly-hatched *Artemia* nauplii were fed and rotifer feeding was reduced, usually terminating by day 11. Naupliar feeding continued until the metamorphosed juveniles were weaned on to prepared diets at a size of 25 - 30 mm.

Several species of algae were cultured following established procedures (WFA, 1976 e), the most widely used being *Phaeodactylum tricornutum, Monochrysis lutheri, Chaetoceros calcitrans, Isochrysis galbana, Pseudisochrysis paradoxa* and *Chroomonas crotum*. Normally, *Phaeodactylum* was used only in rotifer cultures or metanaupliar cultures of *Artemia*. The other species were added daily to larval rearing tanks, quantities being dictated by availability. Production performance was monitored by taking daily counts of cell density.

Up to 300 l of rotifer culture were maintained at approximately 200 per ml in 30 l aerated flasks at 26 - 30° C under conditions of low intensity background lighting. Cultures were cropped daily, replacing the withdrawn culture with the equivalent volume of algal culture to maintain a feeding density. Daily counts were taken.

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Artemia nauplii were hatched using a 24 hour incubation period at temperatures of 28 - 30° C in an insulated hatchery capable of producing 6 x 10^6 nauplii per day. A 24 hour incubation period was favoured in preference to a 48 hour cycle as it was believed that the majority of the nauplii hatched in this manner contained greater food reserves (WFA, 1975 e).

Production data for 1976 is given in table 2.

Tank No.	Tank size l	Eggs received x 10^3	Eggs stocked x 10^3	First feeding larvae (Day 2) x 10^3	No. at Day 20	No. transferred for weaning+ (20 mm+)	% Survival prior to weaning	
							From eggs stocked	From Day 2
1	80	11.0	5.0	5.0	30	0	0	0
3	80	11.0	5.6	5.6	0	0	0	0
4	932	56.1	31.3	7.5	3,680	3,550	11.3	47.3
5	80	5.5	1.0	1.0	19	19	1.9	1.9
6	500	63.8	23.2	17.9	4,803	4,803	20.7	26.9
7	500	55.0	7.0	7.0	210	210	3.0	3.0
8	3 x 200	44.0	7.9	7.5	656	465	5.9	6.2
9	2 x 80	26.4	1.5	1.5	228	59	0.25	0.25
10	80	13.2	4.0	0.4	151	151	3.8	37.8
11	500	30.8	25.0	25.0	41	41	0.16	0.16
12	2,700	64.9	30.0	8.5	6,000	5,000	16.7	58.8
13	2,700	92.4	55.0	3.0	1,820	1,043	1.9	34.8
14	3 x 200	66.0	30.0	25.0	1,413	1,362	4.5	5.4
15	2,700	44.0	37.0	22.0	8,000	4,491	12.1	20.4
16	500	55.0	40.0	7.0	2,500	520	1.3	7.4
		639.1	303.5	143.9	29,551	21,714	7.2	15.1

TABLE 2 : *Survival of the 1976 production of turbot larvae at WFA Ardtoe to the end of the live diet feeding period*.*

** Taken from WFA, 1976 d.*
+ Nos. of fish above 20 mm length removed from hatchery tanks preparatory to transfer to weaning procedure as discussed by SMITH (1976).

DISCUSSION.

The results obtained during the 1976 production have confirmed SHELBOURNE's (1975) findings that large numbers of metamorphosed sole can readily be produced at a size of over 20 mm. Concurrent economic studies (WFA, 1976 a) have indicated that at a production survival of 33.3 % of larvae at 28 mm from the initial egg stocking, hatchery production would be economic in annual production units of 650,000 and over. The achievement of a gross survival in 1976, at this stage, of 35.2 % (table 1) is encouraging.

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The turbot technology is not so far advanced as indicated by the great fluctuations in larval survival between batches of eggs and repetitive larval rearings. The gross survival of 7.2 % in 1976 is below the level of 10 % necessary for commercial viability (WFA, 1976 a) at present, but the ability to obtain individual survivals in excess of 20 % would indicate that with further work commercially economic survivals could be reached.

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