WHITE FISH AUTHORITY

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Technical Report 162

Comparison of results in turbot R & D to November, 1978 with performance forecast in 1975.

November, 1978.

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Turbot - Summary of main progress by White Fish Authority to 1978 (TR 162)

	Performance data to 1975	Performance used in forecast economic evaluation (Ref.4) based on data to Dec. 1975	Performance to 1978
Egg incubation method	Static	Static	Flowing
Egg stocking density	58 eggs/litre	58 eggs/litre	5000 eggs/l
Egg production period (weeks)	8	-	13
Weight of fertile eggs obtained (g)	475	-	1019
Survival to weaning stage (%)	0.4	10	26.3
Duration of live feed (days)	120	79	61
Artemia required per larva produced (g)	> 3.0	-	< 1.7
Survival through weaning (%)	45.2	50	62.6
Initial size at weaning (mm)	35	25	20
Duration of weaning (days)	83-147	33	21
Minimum nursery residence (days)	360	360	218
Size suitable at transfer to cages (g)	60	60	40
Ongrowing time to 500g (days)	674	510	484
Survival during ongrowing (%)	95	95	95
Max. stocking density (kg/m^3)	25	75*	60
Max. cage size tested (m^3)	3	21	25
Age at min. harvest weight of 500g (days)	1060	870	790

*stocking density achieved with plaice.

Comparison of results in turbot R & D to November, 1978 with performance forecast in 1975

INTRODUCTION

Early White Fish Authority experience of farming marine flatfish in sea cages was gained with plaice (1969 - 1973). From 1971 attention was increasingly turned to turbot, a species considered to be more attractive to farm commercially (Refs. 1-3) and a number of small scale growth trials were performed with wild origin stock in order to obtain basic growth and husbandry data.

In the W.F.A's economic review of 1975 (Refs. 4 and 5) it was concluded that both turbot and Dover sole could be produced by farming at a cost below their respective market values (1975 prices) with the proviso that data obtained with other species be verified with turbot.

By 1975 sufficient data had been gained on the fattening stages and subsequently effort was directed into the technically more difficult areas of hatching and larval rearing.

As a first priority it was decided to attempt the production, from the hatchery, of large numbers of turbot juveniles. With this aim in mind all reliance on collection of wild stock fish off the beaches was halted after 1976 and all supplies of juveniles have subsequently been produced from the hatchery.

The earliest attempts to rear turbot from the egg were made in 1973 with eggs supplied by the Ministry of Agriculture, Fisheries and Food Laboratory, Lowestoft.

With the increase in numbers of brood stock held at the W.F.A's farming units most egg production since 1974 has come from the latter sources. Problems in production of viable eggs have been highlighted since 1974 and additional brood stock management and husbandry investigations have become necessary.

The trials in the period since 1974 are split into the following sections:-

1. brood stock handling and fertile egg production.
2. production of juveniles of suitable size and quality for subjecting to weaning trials.
3. weaning of juveniles so produced on to inert diets.
4. reduction of water heating requirements in the nursery stages.
5. investigation of growth period in sea cages to a minimum market size of 500g.

TRIAL NO. 1.1 1973 to 1978 SEASON

Aim

To maintain a resident brood stock in onshore tanks with spawning occurring under as near natural conditions as possible.

Method

Brood stock were maintained in $24m^3$ onshore tanks at Hunterston at seawater temperature between $7^o - 16^oC$. During winter power station discharge water was used to maintain a minimum temperature of 7^oC. A specific water flow rate of $0.03 - 0.06m^3/kgh$ was maintained.

Discussion

Egg production has been variable. All egg production has been by artificial stripping, no natural release of eggs occurring in the brood stock tanks. In 1977, of the 23 female brood stock (all either 5 gp. or 7 gp. and branded for identification) only 11 produced fertile eggs. An analysis of the viable egg production showed that 94.3% of these were obtained from 6 females. Refs. 6 and 7.

The probability of obtaining fertile eggs decreased with successive strippings. There were large variations in egg size from year to year and during a particular season. Table 1 presents details of egg production at Hunterston.

Conclusions

The performance of individual fish varies greatly from year to year with a very large proportion of eggs (perhaps over 90%) being obtained from a small proportion of the total stock (perhaps less than 25%). Thus the production of fertile eggs in quantity is not repeatable without holding about 5 times the theoretical number of brood stock which, in commercial terms, represents only a very small increase ($<1.0\%$) in total farm costs.

TRIAL NO. 1.2 (1977-1978 seasons)

Aim

To maintain a resident brood stock in floating sea cages with maturation occurring under as near natural conditions as possible.

Background

The turbot hatchery established at Ardtoe in 1973 has relied on egg supply from outside sources. In order to put less reliance on outside supplies a resident spawning stock was established in sea cages with incubation facilities built within the hatchery.

Method

Two $7m^3$ floating cages were constructed in 1977 to accommodate separately male and female spawning stock turbot. In the 1977 season manual stripping was undertaken at the sea cage site and fertilised eggs transported to the hatchery, however, in 1978 brood stock were transferred to onshore tanks prior to egg release.

Discussion

With the introduction of a local brood stock it was possible to increase the quantity of eggs handled by 70% (see Table 2) by better spacing of the batches.

Conclusion

It is beneficial to have a resident brood stock alongside the hatchery under one management.

TRIAL NO. 1.3(1977/78 season)

Aim

To investigate a method of inducing gonad maturation of resident spawning stock by manipulation of the photoperiod and temperature.

Background

During the years 1974 to 1976 the brood stocks resident at Hunterston spawned over a 10 week period commencing in May. The restrictions imposed by the short season during which eggs were available, greatly limited the scope of each year's investigations into the production of weaned fish for further rearing and, on the commercial scale, an extended hatchery season is of highly significant importance in increasing utilisation of farm rearing facilities.

The results of the work by the M.A.F.F. (Ref. 8) on induced gonad maturation of dabs was applied, with certain modifications, to advance the spawning period of some stock at Hunterston and Ardtoe.

Method

Stock were maintained in two tanks each of $11m^3$ at densities of 1 fish per m^3 and 2.5 fish per m^3 approx.

Temperature was maintained in the range 11^{o} - $13^{o}C$ throughout the spawning period. Photoperiod control was such that short day length was applied in November - December 1977 (6 hours) and long day length in January - April 1978 (18 hours).

Discussion

This first attempt produced no significant advancement of the spawning time. Stock continue to be held on the advanced season photoperiod regimes, with one stock, following discussion with the M.A.F.F., being under a continual long daylength (16 hours) regime.

TRIAL NO. 2.1 (1974 season)

Aim

To produce large numbers of juveniles of suitable size for weaning trials.

Method

During 1974 larval rearing tanks of $2.7m^3$ and $1.0m^3$ volume were installed in a small turbot hatchery at Ardtoe (Ref. 9) together with a live food production unit.

Turbot larvae were released into the rearing tanks and were fed up to day 8 on rotifers, Brachionus plicatilis, cultured on a mixture of algal species. As soon as the largest larvae reached 6mm body length newly hatched brine shrimp, Artemia salina nauplii were presented. As the larvae grew, ongrown nauplii were fed and, at 30mm, adult Artemia and mysid shrimps were introduced.

The turbot larvae were transferred to the nursery unit at the metamorphosis stage when weaning on to inert diets commenced.

Culture was under static water conditions of 18° - 22°C up to day 60.

Discussion

A total of 1,764 turbot were produced from 6 separate batches of eggs. Best batch survival through larval development was 1.1% at day 45, the greatest mortality occurring before day 20, giving a survival from day 20 - day 45 of 35%.

Conclusions

1. Given a supply of viable eggs it was possible to produce a significant number of metamorphosed turbot using large scale rearing tanks of between $1.0m^3$ - $2.7m^3$.

2. Although live foods were cultured and found acceptable to turbot larvae it was recognised that the length of time larvae fed on live feeds should be reduced and, preferably, eliminated by commencing weaning at a smaller size than 35mm.

3. Strict control over environmental parameters was essential for culturing live feeds. Investigation of the nutritional value of various algal species was required.

4. Under static conditions weed growth in the larval rearing tanks caused serious husbandry problems including entrappment of larvae and limited production.

5. Larval rearing should be conducted at a higher temperature than 18°C to promote growth rate and feeding response.

6. Considerable difficulty was encountered in producing ongrown *Artemia* in even the modest quantity required.

TRIAL NO. 2.2 (1975-1977 season)

Aim

To improve the larval rearing method for the production of a large number of juvenile turbot.

Method

Following an unsuccessful season in 1975 (Ref. 10), when too many changes were introduced simultaneously, attempts were made in 1976 and 1977 to repeat the 1974 rearing system using improved facilities and techniques (developed in 1975).

Additional tanks were incorporated into the hatchery to provide in total 2 at $2.7m^3$, 2 at $0.9m^3$, 2 at $0.5m^3$, 3 at $0.2m^3$ and 5 at 80 litres (Ref. 11).

Variable heating (up to 26°C) was installed in each tank along with 24 hour day illumination: a maximum of 22°C was employed.

In 1977 two additional $0.5m^3$ tanks were installed (Ref. 12) and the use of the smallest tanks was discontinued.

Discussion

Production of turbot larvae in 1976 and 1977 is given in Table 2.

Improvement in larval survival (day 2 - 20) from 9.7% in 1976 to 44.2% in 1977 was noted. Early larval mortalities in 1976 were attributed to sudden temperature change and consequently the rearing through yolk sac was at 18°C in 1977, the temperature only being raised to 22°C after first feeding had commenced. As a result of lower tank temperature rotifers were cultured in larger quantities before adding to the larval rearing tank on or soon after larval release.

The feeding of algae and *Artemia* in 1976 and 1977 was as in Trial 2.1. Due to the higher nutritional value of newly-hatched nauplii ongrown *Artemia* were not used after 1975. Cumulative consumption of rotifer and *Artemia* up to day 20 was calculated as about 500 rotifers and about 10,000 Artemia per larva.

Fish were transferred to the nursery for weaning at 25mm length at between day 36 - 51. Artemia feeding lasted from day 5 - day 60 with up to 33 days of overlap with inert diets.

TRIAL NO. 2.3 (1978 season)

Aim

Production of large numbers of turbot juveniles for weaning trials.

Method

A purpose built hatchery was brought into operation during the 1978 season (Ref. 13). This included 3 x 2.7m^3, 2 x 900 l and 2 x 1.6m^3 larval rearing tanks equipped with heaters, lighting, aeration and supplied with heated water.

Discussion

Production of turbot larvae in 1978 is given in Table 2. Larval survival day 2 - 20 was much reduced compared to 1977 and was associated with a number of factors.

1. Commissioning problems with the live food unit restricted its output of algae and rotifers during the critical period of high demand with subsequent loss of turbot larvae due to starvation.

2. A comparison with 1977 shows that in 1978, although slightly more fish were reared from fewer batches, individual egg batches were disproportionately larger. If, as is now suggested, larval survival is correlated to tank surface area and assuming that near maximum production unit area was achieved in 1977, the tanks in 1978 were considerably over-stocked with eggs (Ref. 13).

TRIAL NO. 3.1 (1974 season)

Aim

To wean turbot juveniles on to an inert diet with high survival.

Method

3 x $1m^3$ tanks were stocked with a total of 1,749 fish of three different initial sizes, 0.13g, 0.5g and 1.0g (20mm, 30mm, 35mm). Weaning from adult Artemia commenced with stunned Mysid shrimps, followed by cod roe/fish paste and then moist pellet (2.5mm size WFA6:40% moisture). An overlap of diets occurred at each stage.

Discussion

Survival was dependent on fish size at the start of weaning. At a weight of 1.0g survival of 59.1% was achieved, at 0.5g 46.1% and at 0.13g 3.5%. Weaning to full acceptance of the pellet diet took up to 201 days (Ref. 14).

Conclusion

Although the survivals obtained were considered acceptable, the procedure was too lengthy and the initial fish size too large for larger scale production.

TRIAL NO. 3.2 (1976 season)

(There was no trial in 1975 as hatchery production was zero, see para. 2.2.)

Aim

To improve the method of weaning turbot juveniles on to a moist pellet diet, by reducing both initial fish size and duration of weaning.

Method

6 x $1m^3$ tanks were stocked with fish of different ages (day 30 to 60) in the size range 10 - 35mm. Weaning was undertaken in two stages with an extruded wet paste followed by a moist pellet. With the minimum pellet size available being 2mm diameter, the latter diet was only introduced once fish length exceeded 30mm. Live feed was overlapped for up to 66 days during weaning (Ref. 15).

Discussion

From a total of 10,887 fish of mean length 19mm, 2,050 fish survived (18.8%). Again, it was apparent that survival depended on initial larval size, with larvae of 20mm and above giving survivals of 38.7% - 44.4% and smaller larvae survivals ranging from 9.4 to 1.3%. See Table 3.

Conclusions

The larval size at first feed had been reduced to 20mm with only a slight reduction in survival.

The duration of weaning had been reduced by 135 days.

TRIAL NO. 3.3(a) (1977 season)

Aim

To wean turbot larvae on to a dry inert diet after the method developed by the M.A.F.F. in 1976.

Background

Larval weaning survivals of 10% to 70% were reported by the M.A.F.F. when weaning turbot of length 6 - 17mm on to dry, high fat, salmon starter diet (Ref. 16).

Method

8 x 220 l circular plastic tanks each equipped with continuous automatic feeders were linked through a recirculation system incorporating a gravel filter. Temperature was maintained at 18° - 21°C.

Graded dry feed of size 250 - 500 μ was provided to batches of larvae (18 and 22mm) with a short overlap with Artemia (7 days) and to further batches (14-18mm) with a longer overlap (24 - 46 days). (Ref. 17.)

Discussion

A short overlap period between live and inert diet proved to be unsuccessful with groups of larvae of 18.2mm and 22.2mm mean length. Over a dual feed period of 7 days larval survival was 5.0% and 6.4% (counted 8 days after last live feed).

A longer overlap period of 24 - 46 days gave poor survivals with groups of larvae of 14mm, 16mm, 18mm and 18mm mean length. Survival 4 - 7 days after last live feed were 7.4%, 0%, 2.9% and 17.8% respectively.

Conclusion

A short overlap period of 7 days proved unsuccessful irrespective of the initial size of larvae used.

An extended overlap period of up to 46 days gave poor survivals with larvae of mean size 14mm to 18mm.

TRIAL NO. 3.3(b) (1977 season)

Aim

To wean turbot larvae of above 19mm on to a dry inert diet over an extended dual feed period.

Method

8 x 220 l circular plastic tanks each equipped with continuous automatic feeders were linked through a recirculation system incorporating a gravel filter. Temperature was maintained at 18° - 21°C.

Dry feed of size 500 µ was provided to batches of larvae of mean size 19mm to 30mm with an overlap of 21 - 63 days.

Discussion

With a 21 day overlap, batches of larvae of mean length 20mm, 21.4mm and 22.0mm, gave survivals of 53.4%, 47.0% and 69.9% respectively.

Two batches, of 19mm size, gave survivals of 44% and 49% after a 55 day dual feed.

Similar results were obtained with 4 batches of 25mm mean length weaned over a 63 day period. Survivals of 40 - 45% were achieved. A batch of mean length 30mm achieved a 74% survival under the same conditions.

Conclusions

Survivals of 40% and above were achieved in ten separate batches. An overlap period above 21 days did not appear to be beneficial in terms of weaning survival.

The 1978 season weaning trial should employ larvae of 20mm initial length and wean over a 21 day period.

TRIAL NO. 3.4 (1978 season)

Aim

To assess the growth and survival with various dry and moist weaning diets fed to larvae of 20mm initial length.

Method

5 x 900 litre circular tanks equipped with automatic feeders and heated water (18^{o} - 23^{o}C) were used with 24 hour illumination over each tank.

Each tank was stocked with 750 fish of mean length 20-23mm. The weaning procedure was identical, with live feed being overlapped for the first 21 days of the 42 day weaning period. Of the 4 diets that were tested, 2 were proprietary dry and 2 were made to W.F.A. formulations. (cod roe paste and moist pellet crumble of 500 µ size).

Discussion

Survivals of 7.2% and 29.3% were achieved with the dry diets compared to 68.5% to 99.3% with the moist diets. Although the highest survival and best growth rate (3% body length increase per day) were achieved with extruded cod roe paste, further weaning to a moist pellet introduced a subsequent loss of up to 10%.

Acceptable and repeatable survivals of 68 - 76% were obtained using moist crumbles of 500µ size: such diets had the additional benefit of eliminating further weaning to ongrowing diets.

The progress from 1976 to 78 is summarised in Table 3.

Conclusion

It is considered that a basically reliable weaning technique has been established. None-the-less attempts should continue to be made to reduce both the initial size of larvae and duration of weaning.

TRIAL NO. 4 (1976 to 1978 season)

Aim

To reduce the water heating requirement in the nursery stages (if not conducted at a site supplied with waste heat from an external enterprise).

Background

A major cost in the production of turbot juveniles (away from supplies of free or low cost heated seawater) is the heating of ambient seawater sufficiently to obtain adequate growth over the first 10 months (Ref. 4).

In previous years water was not recirculated and was heated through to up to 12^{o}C above ambient.

Method

Reduction in heating cost was attempted in four ways:-

1. reduction in specific flow rate.
2. introduction of heated water recirculation.
3. manipulation of hatchery season to move nursery season to warmer ambient period.
4. applying different temperature/time histories to reduce the overall heat input.

Discussion

Trials in 1976 established that the specific water flow rate could be reduced to 0.018 - 0.022m^3/kgh in nursery tanks stocked at 20 - 25kg/m^2 with savings of up to 63% in energy consumption (Ref. 6).

Trials started in 1978 are demonstrating that it is feasible to recycle 90% of heated water in a recirculation system stocked at a density of 10kg/m^3. It is too early to evaluate this trial further.

TRIAL NO. 5

Aim

Investigation of growth period from nursery to a minimum market size of 500g in sea cages.

Method

Successive year groups of turbot of wild and hatchery origin have been transferred into sea cages of $3m^3$ volume and held at densities of 30 fish per m^3 to 270 fish per m^3. Growth and survival to market size has been monitored (Refs. 18 and 19).

Discussion

Growth is summarised in Fig. 1. The forecast growth of the 1974 hatchery fish (Refs. 4 and 5) was surpassed. At day 800 from hatching the mean weight of the largest population had reached 512g, approximately 75 days ahead of prediction and over 250 days ahead of the best growth achieved by wild origin turbot held in sea cages.

Over the 484 day ongrowing period in the cages a survival of 98.8% was achieved. The final stocking density in 1976 was $56.4kg/m^3$. In the 1978 growth trial the most dense population is calculated to be at over $70kg/m^3$ (Nov. 78) with measurement scheduled for December 1978.

Growth of later year groups of hatchery origin turbot have not demonstrated such fast growth on transfer to the sea cage site (in 1976 and 1977) due to two important factors. Firstly, a parasitic infection, identified as *Trichodina*, had serious debilitating effect. Subsequent infections have been controlled and investigation into effective treatment continues but overall growth rate is retarded. Secondly, ambient seawater temperature has been noticable lower during the spring and summer period of maximum growth in 1977, and especially in 1978; the pattern of autumn and winter temperatures remained similar (see Fig. 1).

TABLE 1

Turbot egg production - Hunterston. Artificial stripping under natural holding conditions

	Fertile egg production (g)	No. of brood stock	Mean egg count (No./g)	Egg count range (No./g)	Length of spawning season
1974	1239	29	1170	1120-1200	12:7-19:8
1975	426	20	1320	1240-1400	15:5-8:8
1976	471	23F 13M	1100	-	24:5-6:8
1977	472	23F 13M	1220	1052-1426	7:6-19:7
1978	400	7F 5M	-	-	12:5-26:7

TABLE 2 **Ardtoe hatchery progress in turbot production 1973 - 1978**

	1973	1974	1975	1976	1977	1978 (a)	1978 (b)
Fertile eggs handled (g)	10	475	259	591	814	1019	542
Proportion of fertile eggs locally produced (%)	0	0	0	0	28	72	-
No. of batches of eggs handled	1	6	8	16	19	15	9
Average size of egg batch (g)	10	79.1	32.3	36.9	42.8	67.9	60.2
Survival, day 2 - 20 (%)	0.22	1.26	1.65	9.7	44.2	3.5	5.2
Survival day 20 - start of weaning (%)	16.0	31.7	0	36.2	59.2	54.1	53.8
No. of fish at start of weaning	4	1764	0	10887	8753	9388	
Survival through weaning (%)	(c) 75	45.7	-	18.8	28.7	55.4	
No. of weaned fish	3	807	-	2050	2515	5200	

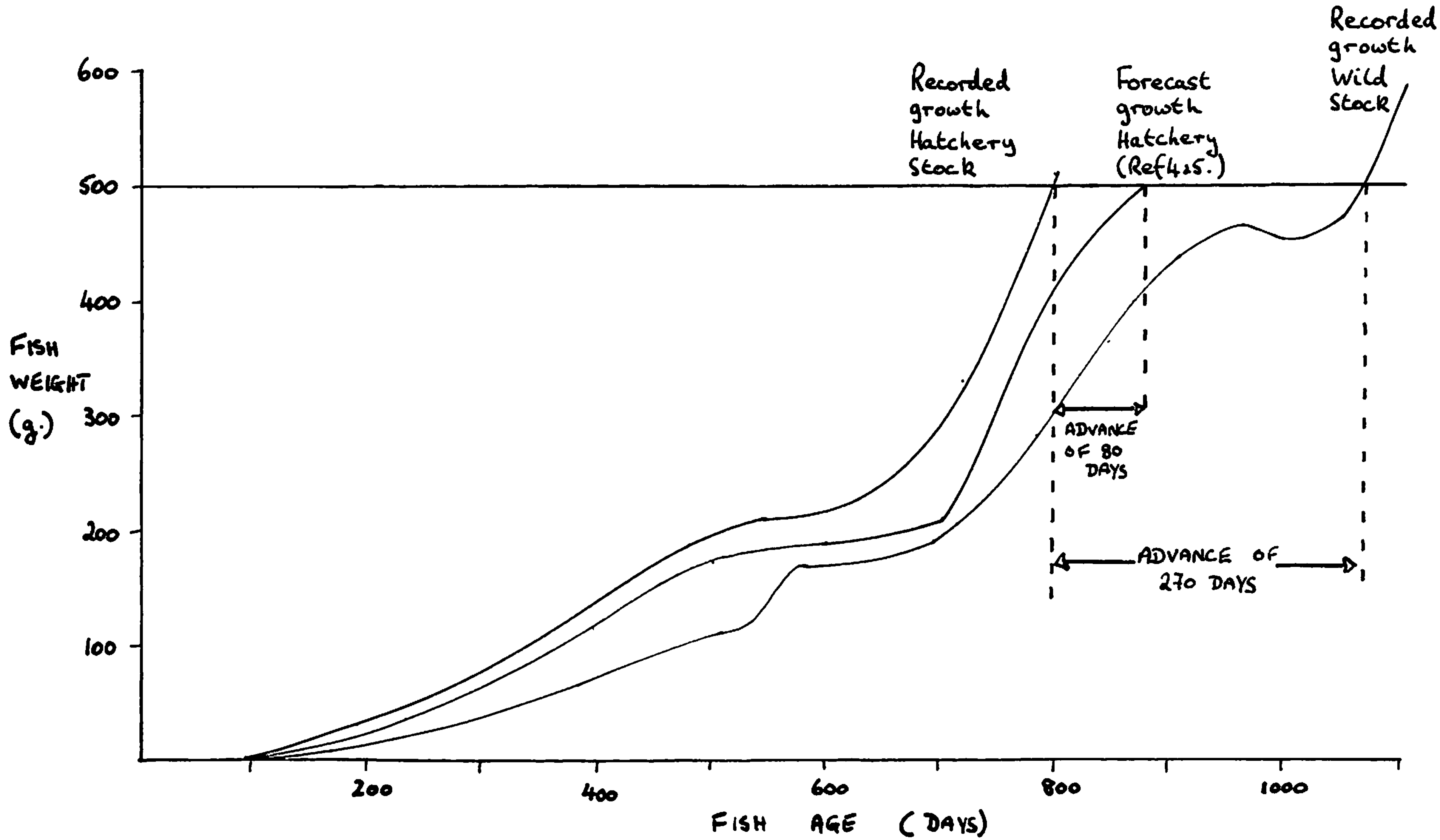
Notes: 1978 (a) total egg production with overall survival rates
(b) survival rates in batches when rotifer production adequate
(c) note only 4 fish involved in trial

TABLE 3

Progress in weaning technique 1976 - 1978

	1976	1977	1978
Survival through first weaning phase (%)	18.8	34.3	Not recorded
Survival from first phase to fully weaned stage (%)	17.7	24.0	62.6
Initial size range for good weaning survival (mm)	23.0-27.0	19.1-25.0	21.4-23.8
Corresponding weaning survival (%)	38.7-44.4	40.3-69.9	68.5-99.3
Size range for poor weaning survival (mm)	14.0-18.0	14.2-18.2	20.8-22.5
Corresponding weaning survival (%)	1.3-9.4	0-17.8	0-29.3

FIG. 1. GROWTH OF TURBOT TO A MARKET WEIGHT OF 500g.



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