NRA FISHERIES 35

SNAILWELL FISH FARM REPORT 1989

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ABSTRACT

This report describes the improvements to the fish farm facilities and fry rearing performed at Snailwell since December 1988. Pond management regimes are discussed as are the pond dynamics and production data. Management of ponds for the 1990 production year is detailed and recommendations for the further improvement of the fish farm site are made.

1 Introduction

Snailwell Fish Farm is situated some five miles from Newmarket and has been used by NRA Central Area for maintenance of fish after fish removal and rescue operations. The site is leased from a local farmer. The fish farm facilities on this site consist of nine drainable ponds, varying in area from 301 m^2 to 564 m^2 and a small disused hatchery, covered with a polythene tunnel. Both hatchery and ponds are supplied with water from the River Snail, a spring-fed river which rises approximately half a mile away. There is a small office and two large hangers for the storage of equipment.

The broad philosophy of fish production requirements in the Central Area was reviewed by Peter Barham, John Adams and the Fish Production unit in 1988. In essence, there was a need for large numbers of bream (and to a lesser extent, roach) which until 1989 could be supplied by removals from Grafham Water, and thereafter by a network of large-scale ORSUs developed in conjunction with the Fish Production Unit. At the same time, the need for a more diverse range of species was identified, in particular chub, dace, grayling and barbel. These species are best reared in highly manageable, drainable ponds of which eight were available at the Snailwell site. Following discussions with the Fish Production Unit, a joint management strategy was developed for 1989, involving the use of eight of the nine Snailwell ponds for larval rearing. The remaining pond would be used by the Central Area for fish rescue operations. Future on-site rearing would be closely allied to identified Central Area requirements.

2 Restoration of ponds

After a site visit on 17 January 1989, several observations were made relating to the condition of rearing ponds. It was necessary to use a small excavator (Kamatsu) for some of the work outlined, on ponds 2, 3 and 8 and this, together with all manpower, was arranged by Peter Barham.

Minimum maintenance was required on pond 1. A central drainage channel was made in the silt on the pond bottom to allow full drainage of the pond. Macrophytes were removed and the pond was allowed to dry out completely. Pond 2 required much more work to restore it to full use and it needed the use of a small excavator. Essentially, the same problems were encountered as for pond 1, but the macrophytes had proliferated to a much greater extent, due largely to the seepage of water from the inlet chamber. Pond 3 was in a similar condition to pond 2. In pond 4, a large layer of silt had built up at the inlet end and needed to be reduced significantly. The draining of pond 5, which was full at the time reduced the seepage of water to pond 4. Pond 5 was drained, the inflow of water stopped and the pike and other fish removed. All macrophytes were then removed and the pond bottom was allowed to dry out. All macrophytes were removed from Pond 6, the raceway, and the seepage was stopped from pond 5 and the inlet chamber. Pond 7 was in good condition and required only minor maintenance to restore it to full use. Pond 8 was completely choked with reeds and their removal required the use of an excavator. The banks of the pond were improved after some infilling. Pond 9 was left for use by the Central Area fisheries.

3 Production management

3.1 Pond management strategies

Pond rearing methodologies have been developed at Costessey and Brampton over the last two summers by Fish Production. The broad prerequisite of fish production in ponds is the provision of suitable food conditions for larval growth. This involves the stimulation of phytoplankton and rotifer production, followed by the production of large numbers of zooplankton which would be cropped by the larvae. The management of such production depends upon the nutrient status of the pond after filling, additions of seed plankton and, ultimately, accurately determining the appropriate time of larval introduction. Fine-tuning of such methods is always necessary to ensure that any given pond achieves the desired production level. This depends upon the likely nutrient input by the pond bottom, the nutrient status of the infilling water, the presence of algae and macrophytes, other fish, which can be both competitors and predators, and invertebrates. With these aspects in mind, pond rearing methodologies were developed for the rearing of grayling Thymallus thymallus and chub Leuciscus cepahlus larvae at Snailwell.

The initial work in the winter months ensured that the ponds were fairly dry, although this varied from pond to pond. The few frosts that were experienced during the spring months of 1989 did not affect the snail population within some ponds, although this was postulated to not be of great significance, except for the transfer of eye fluke. Close inspection in early May ensured that no fish were present in the ponds themselves, although the threat of their introduction when filling up with water from the river Snail did present a problem. The silt layer in each pond was almost completely oxidised following the initial restoration. Pre-treatment with spray herbicide and pesticide was not deemed to be necessary due to the apparent absence of significant weed growth and invertebrate predators.

3.2 Stimulation of plankton production

The ponds were filled from the River Snail on 12th and 16th May 1989. Each was screened, with the exception of pond 8, with a D-net during this process to prevent the introduction of fish such as sticklebacks and large invertebrates. During pond filling, nutrient was added to the pond water. A mesh bag containing the appropriate amount of inorganic fertiliser was suspended in the inflowing water to dissolve and distribute evenly the nutrients within the pond. In most culture systems, algal production is only limited by the absence of inorganic phosphate and additions of this alone is sufficient to stimulate an algal bloom. At Snailwell, due to the unknown nutrient nature of the water supply, additions of nitrate were also required, and the fertiliser NPK was selected. Doses were calculated on the volume of the pond in order to achieve a concentration of > 10 mg l^{-1} nitrate. At this time, it was apparent that pond 3 was leaking through the pipework inside the outlet chamber, but it was impossible to achieve a satisfactory seal when the pressure bung was placed in the inner end of the chamber. Consequently, pond 3 was not used for rearing. A similar problem existed in pond 7, but after sealing with a pressure bung in the inner end of the chamber, the pond was filled and fertilised. All ponds required slight topping-up during the rearing period. This was achieved by removing the central cap from the pressure bung in the inlet chamber and allowing a small trickle of water into the pond. This inflow was stopped before additions of herbicide to each pond.

Within two to three days after fertilisation, it appeared that the expected phytoplankton bloom had not occurred in some ponds. To rectify this, 'green water' from a zinc tank on the Snailwell site was used to 'seed' the ponds, and after a further few days, phytoplankton blooms were observed in all ponds. A similar procedure was necessary to seed zooplankton into the ponds as it was also clear that the desired zooplankton species were not present in either the River Snail or the ponds themselves. Several nets full of large Cladocera were taken from a pond at Costessey and transferred to the Snailwell ponds, to act as brood plankton. Within five to eight days, numbers of appropriately-sized zooplankton were very high in most ponds. It was at this point that the larvae were introduced (see 4) into ponds 1, 2, 4, 5, 6 and 8 (pond 7 not holding water at this stage). Grayling larvae were introduced into pond 1 and chub larvae into the remainder.

The status of the phytoplankton and zooplankton populations were monitored during the production period. Second phytoplankton blooms were observed in July in ponds 4 and 8, followed by blooms of tiny Cladocera. In ponds 2, 5 and 6, zooplankton numbers were severely depleted by mid-July. It was likely that any subsequent phytoplankton blooms in these ponds were affected by treatments with the herbicide Clarosan. Ponds 5 and 2 were drained down and most fry transferred to ponds 1 and 7 respectively between late-July and early-August. This was to take advantage of large zooplankton populations in those ponds, and because pond 5 developed a leak. The site was visited at least twice weekly and temperature measurements were taken on most occasions.

3.3 Supplementary feeding

By early September, it was apparent that food had become depleted in all ponds. A floating fish food (size 4 pellets) was scattered on the surface of all ponds on 13th September and the fry began feeding within minutes in most ponds. Within several days, feeding responses were observed in all ponds. Pond temperatures dropped over the latter part of the summer, but feeding continued in each pond. The aims of feeding at this time was to ensure that the fry had sufficient food for maintenance, preventing the loss of stored reserves and overall condition, and to transfer the fry from a natural food diet to an artificial one before winter rearing in tanks at Brampton and Costessey. Feeding was continued on an ad hoc basis (approximately twice weekly) until the ponds were drained-down at the end of October.

3.4 Control of macrophyte and filamentous algae

During the rearing period, the growth of macrophytes and filamentous algae in each pond was carefully monitored. Additions of the herbicide Clarosan were deemed necessary on several occasions to prevent proliferation of weed to large extents. Water quality did not appear to be affected after such treatments, but a steady inflow of water was maintained two to three days after treatment through the pressure bung as before. Weed raking and cutting was performed on most ponds during the rearing period, particularly on ponds 2, 7 and 8. This was performed both before and after Clarosan treatment. After several attempts to control the filamentous algae with a dose of 5 ppm, a high dose level of 10 ppm was necessary in most cases. Pond 5 could not be treated during the summer rearing period due to the high flow rates through this pond. As a consequence, both algal and macrophyte growth was extensive and required continual management.

4 Larval production

The high value of the Snailwell site, in terms of the size and condition of each pond to be used for rearing, necessitated a change to the usual stocking methods employed by Fish Production. The aim was to ensure that each larva stocked had been first-fed for up to two weeks in order to ensure that the "critical period" between endogenous and exogenous food had been passed. The larvae would grow in the controlled conditions of the hatchery, where mortality could

be easily assessed, and would attain a larger size, thus enabling the larva to exploit larger food items. This would reduce food/size restrictions on larval feeding in the first few days of release into the pond. Further, stocking of larvae with food in their gut system would aid their maintenance for several crucial hours until a meal was taken within the pond.

Larval rearing strategies usually involve the feeding of egg yolk suspension, or rotifers for the early stages of development and, later, small zooplankton or nauplii of the brine shrimp _Artemia_ to the developing larvae. The disadvantage of these methods are several. Egg yolk suspension causes water quality problems and blocks the fine-meshed filters at the outlet end of the trough systems. Additions of rotifer-rich water can also cause a reduction in water quality, and introduce high numbers of bacteria to the closed rearing systems. Accurate determination of rotifer numbers to estimate food intake is also very difficult, and thus mortalities may occur through low nutrition. With zooplankton, the food must be sieved to ensure that only appropriately-sized individuals are fed to the larvae. These may be extremely small and low in number in any given sample, thus requiring the collection of much plankton-rich water. _Artemia_ nauplii have other distinct problems in that they do not survive for long in fresh water, and may be too large for first-feeding larvae.

The species that were targetted for Snailwell were grayling and chub. Grayling were spawned during April at Brampton, the broodstock coming from a variety of sources. The results of the spawning and rearing trials are reported in the Grayling Research Report 1989. Briefly summarising the early rearing methodologies employed, grayling larvae were sufficiently large to feed directly on _Artemia_ nauplii and zooplankton. Hence, these larvae were reared for several weeks on the natural food diet before being introduced into pond 1 at the end of May and early-June.

Chub larvae, however, were much smaller and an alternative food source was required. A dried food preparation was therefore used in preference to natural food to ensure that the larvae stocked-out were well fed, and had an improved chance of survival. The diet was specifically produced for larvae of egg-laying fish species and is therefore appropriate, nutritionally, for all cyprinid larvae. This food was produced in a fairly uniform particle size, small enough for the smallest of cyprinid larvae, and floated when added to the water. Thus, less food was required at each feeding time due to the slow-sinking nature of the food, increasing the time of feeding opportunity by the larvae. Significantly, water quality was also not compromised because of the more efficient feeding method.

Male and female chub were electrofished from the River Tud, Norwich, on 8th May 1989, and six females were handstripped of eggs after hormonal induction of ovulations, on 10th May. Larvae hatched after 5 to 7 days at 18 °C but did not swim-up and accept food particles until some 5 to 6 days later. Feeding was essentially minimal in quantity, but frequently applied, at 2-hour intervals through the day. Feeding with rotifer-rich water during unattended periods was attempted by an automatic pumping and distribution system, but this resulted in overfilling of the trough systems and small but significant mortalities during the following day. This may have been due to a reduction in water quality, but more probably it was bacterial infections after the addition of this pond water to the trough systems. The larvae were maintained on the intensive feeding regimes for between 8 to 12 days after swimming-up and were deemed to have reached the appropriate size for stocking. Monitoring of the zooplankton populations at Snailwell was intensive at this time and, initially, ponds 2 and 8 were the first ponds to have sufficient numbers of small Cladocera, at an ideal size for chub larvae. Larvae were stocked into these ponds on 26th May, the eggs being produced some 16 days before and the ponds being filled 14 days previously. Zooplankton numbers had increased by 30th May in the remaining ponds (4, 5 and 6) and accordingly, the remaining larvae were introduced (20 days after spawning and 15 days after filling the ponds). Therefore, a two-week interval between pond filling and reaching the appropriate stage for larval stocking was established for Snailwell at temperatures around 20 °C.

The larvae were in a robust condition when introduced into the ponds, with no mortalities being observed after the 90 minute journey from hatchery at Costessey to Snailwell. All larvae were fed on the morning when moved, the orange-coloured food being visible in their foreguts. Significantly, large numbers larvae were observed in pond margins for two to three weeks after stocking, suggesting that initial survival was high and the transition from artificial to natural food was very successful. After this time, fry became more difficult to track due to the greater escape response from the Secchi disk and fry movements were seldom noted, until artificial feeding commenced in late summer.

5. Individual pond management and fry production results

The results for the individual ponds are presented. Table 1 summarises and details the overall production levels for the Snailwell site.

5.1 Pond 1

12.5.89	Pond filled from R. Snail
15.5.89	Fertilised with 4.7 kg NPK (Est. Vol = 112 m^3)
19.5.89	Seeded pond with two small nets full of zooplankton (from Costessey)
30.5.89	389 grayling fry, 2.5 to 5 cm in length, introduced
7.6.89	Pond observed to be full of large zooplankton
9.6.89	731 grayling fry, 2.5 to 5 cm in length, introduced
14.6.89	Water turbid, a grey colour (chalk suspension ?)
19.6.89	Water turbid, as 14.6.89
27.6.89	DO reading of 124 %
3.7.89	DO reading of 57 %
7.7.89	Treated with Clarosan @ 5 ppm, due to a large accumulation of filamentous algae (Vaucheria)
18.7.89	Large swarms of Cladocera present - unexploited by grayling which are not visible in the pond now.
21.7.89	up to 5000 chub fry transferred from pond 5 to pond 1 to exploit the large numbers of Cladocera
1.8.89	Treated with Clarosan @ 10 ppm - filamentous algae was persistent.
13.9.89	Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond
14.9.89	Fish fed - first observed feeding in chamber
15.9.89	Fish fed
18.9.89	Fish fed
19.9.89	Fish fed
20.9.89	Fish fed
22.9.89	Fish fed

25.9.89 Fish fed
26.9.89 Fish fed
27.9.89 Fish fed
29.9.89 Fish fed
3.10.89 Fish fed
4.10.89 Fish fed
10.10.89 Fish fed

17.10.89 Pond drained and fish removed

The duration of the draindown was approximately 30 minutes. All fish were caught in a keepnet, the majority of the chub were in the outlet chamber before the pond was lowered. The sealing bung was in the internal end of the outlet chamber.

Area of pond = 301 m^2

Total number of chub removed = 4114

a subsample of 30 chub was measured

6.0 5.8 5.9 6.4 5.3 5.8 5.9 6.4 5.9 6.3

6.0 6.0 5.2 5.3 6.4 5.9 5.4 6.1 6.5 6.3

6.0 5.4 5.6 6.6 5.6 5.5 6.4 6.2 5.9 5.3

mean length = 5.91 +/- .07 cm (2.8% mv)

range 5.2 - 6.6 cm

fry density = 13.7 m^{-2}

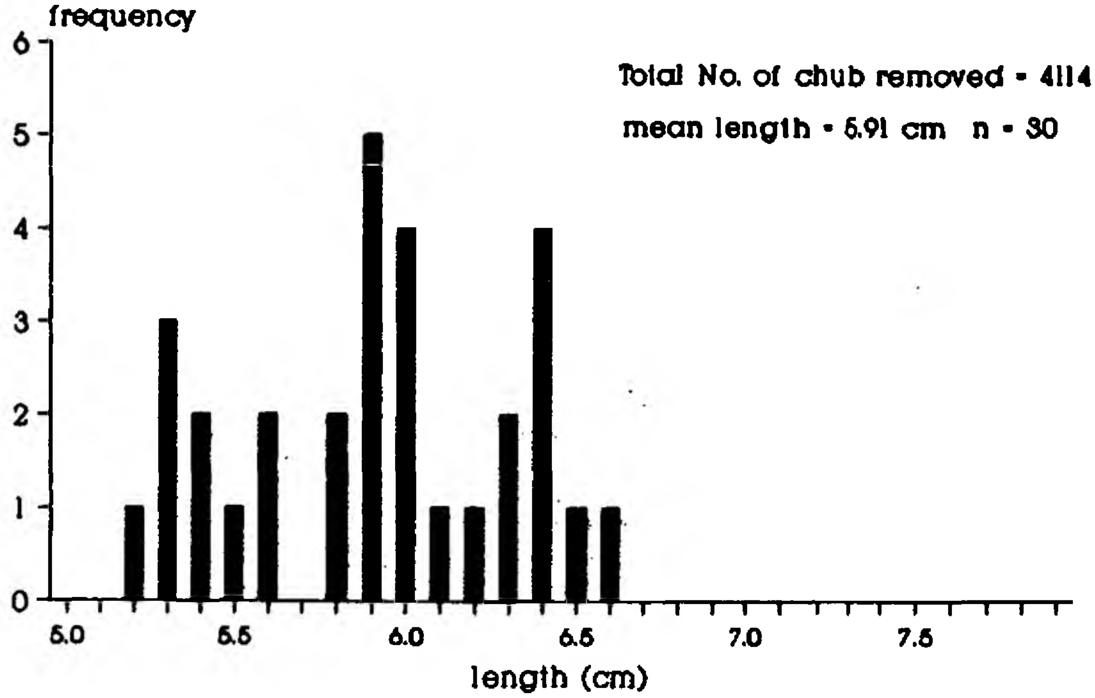
estimated fry mean weight = 1.95 g

biomass = 8022 g

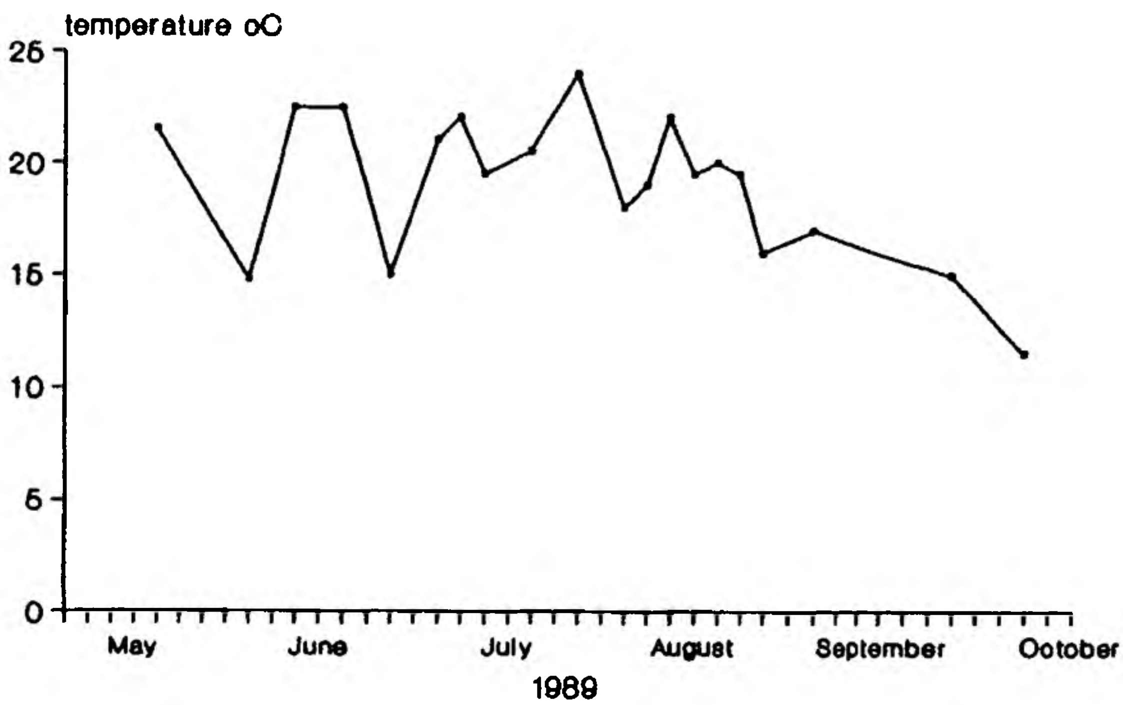
standing crop = 26.6 g m^{-2}

All chub were introduced into external tanks at Brampton.

Length/frequency distribution of a subsample of 0+ chub removed from pond 1



Temperature profile of pond 1 at Snailwell



5.2 Pond 2

12.5.89	Pond filled from R. Snail
15.5.89	Fertilised with 5.3 kg NPK (Est. Vol = 126 m^3)
19.5.89	Seeded pond with two small nets full of zooplankton (from Costessey)
26.5.89	Introduced 5,500 larval chub into pond 2
7.6.89	Pond observed to be full of small zooplankton (- larval chub at this size can take large ones)
14.6.89	Clear water - many swarms of large Cladocera
19.6.89	Clear water, as for 14.6.89
27.6.89	DO reading of 56 %
3.7.89	DO reading of 56 %. Serious food depletion
7.7.89	DO reading of 97%
1.8.89	Treated with Clarosan @ 10 ppm - filamentous algae was persistent.
8.8.89	Drained-down, most fish transferred to pond 7. Draindown reasonably successful, but problems with filamentous algae and in-pond reeds. About 70 % of fish successfully removed, remainder left in pond. Pond refilled. 10 - 15 fish killed on draindown, up to 100 escaped into R. Snail Fish size (cm) : 5.5 5.9 6.1 5.6 5.3 6.0 5.4 5.4 mean length = 5.65 cm. Estimated wt 1.65 g (3,300g)
13.9.89	Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond
14.9.89	Fish fed - first observed feeding in chamber
15.9.89	Fish fed
18.9.89	Fish fed
19.9.89	Fish fed
20.9.89	Fish fed
22.9.89	Fish fed
25.9.89	Fish fed
26.9.89	Fish fed
27.9.89	Fish fed
29.9.89	Fish fed
3.10.89	Fish fed
4.10.89	Fish fed

10.10.89 Fish fed

17.10.89 Pond drained and fish removed

The duration of the draindown was approximately 45 minutes. All chub were caught in a keepnet, the majority of the fish were in the outlet chamber before the pond was lowered. The sealing bung was in the external end of the outlet chamber.

Area of pond = 305 m^2

Total number of chub removed = 1071

a subsample of 30 chub was measured (cm)

7.7 8.5 7.4 7.8 8.3 7.7 7.8 8.0 7.8 7.3

8.2 7.5 7.8 7.0 7.9 8.0 7.3 7.5 7.8 7.7

8.2 7.5 7.0 7.8 7.6 7.8 8.5 7.6 7.3 8.4

mean length = 7.76 cm +/- .07 (2 % mv)

range 7.0 - 8.5 cm

fry density = 3.5 m^{-2}

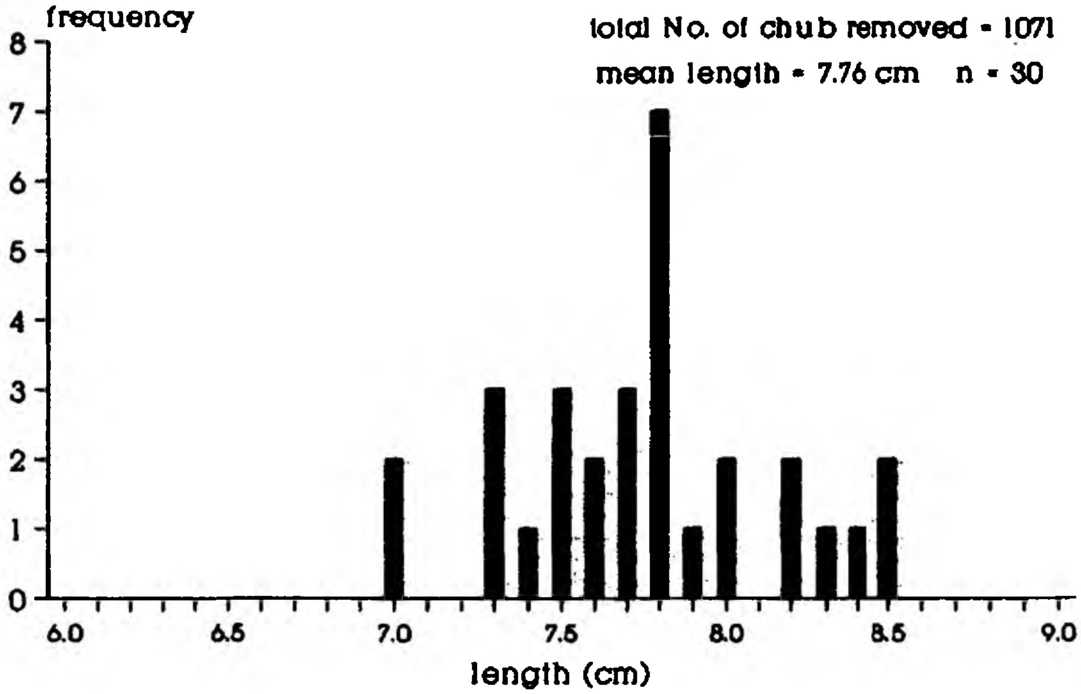
estimated fry mean weight = 7 g

biomass = 7497 g

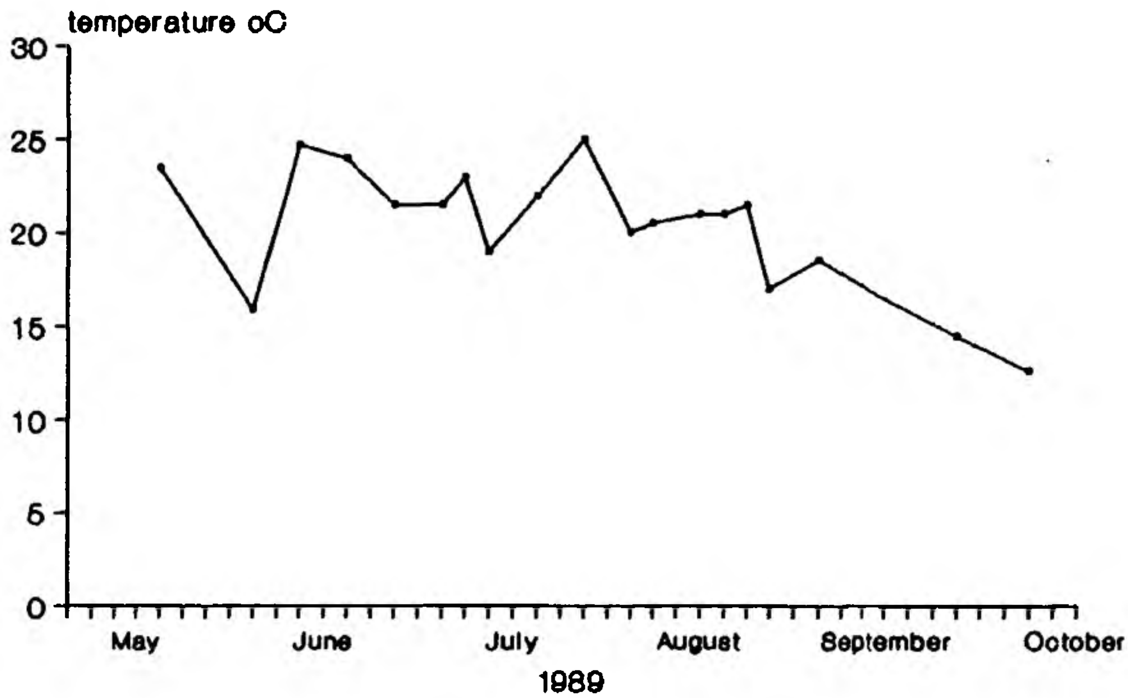
standing crop = 24.6 g m^{-2}

All chub transferred to the Sapiston River at Sapiston village.

Length/frequency distribution of a subsample of 0+ chub removed from pond 2



Temperature profile of pond 2 at Snailwell



5.3 Pond 3

15.5.89	Pond 3 filled from R. Snail, and fertilised with 5.25 kg NPK (Est. Vol = 126 m^3)
22.5.89	*Cladocera* seeded into pond, temperature very low due to large amounts of water flowing through the pond. Pond allowed to drain. Problem thought to be a leak at the outlet end of the pond. Pond drained.

5.4 Pond 4

15.5.89	Pond filled from R. Snail and fertilised with 6.5 kg NPK (Est. Vol = 157.5 m^3)
22.5.89	Seeded pond with two small nets full of zooplankton (from Costessey)
30.5.89	Introduced 5,500 first-fed larvae into pond
14.6.89	Fairly turbid still, some swarms of *Cladocera*
19.6.89	Pond water clear
27.6.89	DO reading of 113 %
3.7.89	DO reading of 202 % (in weed). *Cladocera* becoming limited but still reasonably abundant
7.7.89	DO reading of 160 %. Treated with 5 ppm Clarosan to kill *Vaucheria*.
18.7.89	Few *Cladocera* observed, much weed (filamentous algae and macrophytes)
26.7.89	Many tiny *Cladocera* at surface of water
1.8.89	Treated with Clarosan @ 10 ppm - filamentous algae was persistent.
4.8.89	Opened inlet valve on bung to top-up pond
13.9.89	Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond
14.9.89	Fish fed - first observed feeding in chamber
15.9.89	Fish fed
18.9.89	Fish fed

19.9.89	Fish fed
20.9.89	Fish fed
22.9.89	Fish fed
25.9.89	Fish fed
26.9.89	Fish fed
27.9.89	Fish fed
29.9.89	Fish fed
3.10.89	Fish fed
4.10.89	Fish fed
10.10.89	Fish fed

18.10.89 Pond drained and fish removed

The duration of the draindown was approximately 1 hour. All chub were caught in a keepnet, the majority of the chub were in the outlet chamber before the pond was lowered. The sealing bung was in the external end of the outlet chamber.

Area of pond = 420 m^2

Total number of chub removed = <u>4501</u>

A subsample of 30 chub was measured (cm)

6.4 6.5 6.2 6.8 6.2 6.3 5.9 6.7 6.5 6.7

6.6 6.5 6.5 5.4 6.2 7.2 6.2 6.0 6.4 6.5

6.4 6.9 6.2 5.9 6.7 6.7 6.0 6.7 6.4 6.4

mean length = <u>6.4</u> +/- .07 cm (1.9 % mv)

range 5.4 - 7.2 cm

fry density = 10.7 m^{-2}

estimated fry mean weight = 3.1 g

biomass = 13,953 g

production = 33.2 g m^{-2}

All chub transferred to the Sapiston River at Sapiston village.

5.3 Pond 3

15.5.89 Pond 3 filled from R. Snail, and fertilised with 5.25 kg NPK (Est. Vol = 126 m^3)

22.5.89 Cladocera seeded into pond, temperature very low due to large amounts of water flowing through the pond.
Pond allowed to drain. Problem thought to be a leak at the outlet end of the pond. Pond drained.

5.4 Pond 4

15.5.89 Pond filled from R. Snail and fertilised with 6.5 kg NPK (Est. Vol = 157.5 m^3)

22.5.89 Seeded pond with two small nets full of zooplankton (from Costessey)

30.5.89 Introduced 5,500 first-fed larvae into pond

14.6.89 Fairly turbid still, some swarms of Cladocera

19.6.89 Pond water clear

27.6.89 DO reading of 113 %

3.7.89 DO reading of 202 % (in weed). Cladocera becoming limited but still reasonably abundant

7.7.89 DO reading of 160 %. Treated with 5 ppm Clarosan to kill Vaucheria.

18.7.89 Few Cladocera observed, much weed (filamentous algae and macrophytes)

26.7.89 Many tiny Cladocera at surface of water

1.8.89 Treated with Clarosan @ 10 ppm - filamentous algae was persistent.

4.8.89 Opened inlet valve on bung to top-up pond

13.9.89 Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond

14.9.89 Fish fed - first observed feeding in chamber

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25.9.89 Fish fed
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27.9.89 Fish fed
29.9.89 Fish fed
3.10.89 Fish fed
4.10.89 Fish fed
10.10.89 Fish fed

18.10.89 Pond drained and fish removed

The duration of the draindown was approximately 1 hour. All chub were caught in a keepnet, the majority of the chub were in the outlet chamber before the pond was lowered. The sealing bung was in the external end of the outlet chamber.

Area of pond = 420 m^2

Total number of chub removed = 4501

A subsample of 30 chub was measured (cm)

6.4 6.5 6.2 6.8 6.2 6.3 5.9 6.7 6.5 6.7

6.6 6.5 6.5 5.4 6.2 7.2 6.2 6.0 6.4 6.5

6.4 6.9 6.2 5.9 6.7 6.7 6.0 6.7 6.4 6.4

mean length = 6.4 +/- .07 cm (1.9 % mv)

range 5.4 - 7.2 cm

fry density = 10.7 m^{-2}

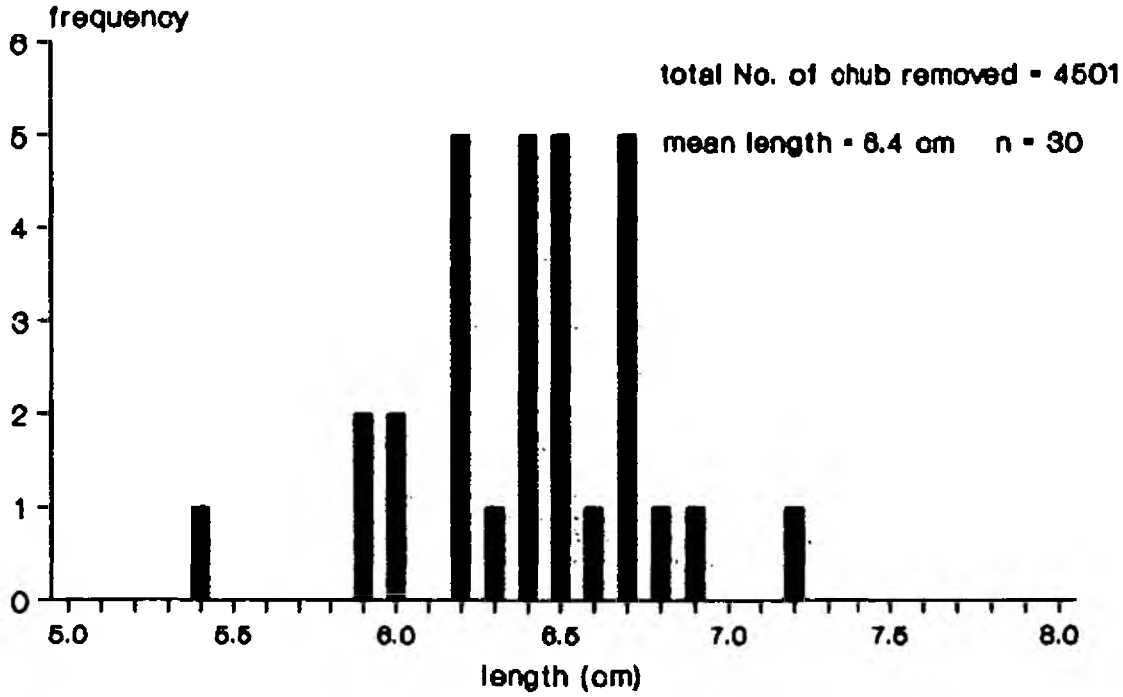
estimated fry mean weight = 3.1 g

biomass = 13,953 g

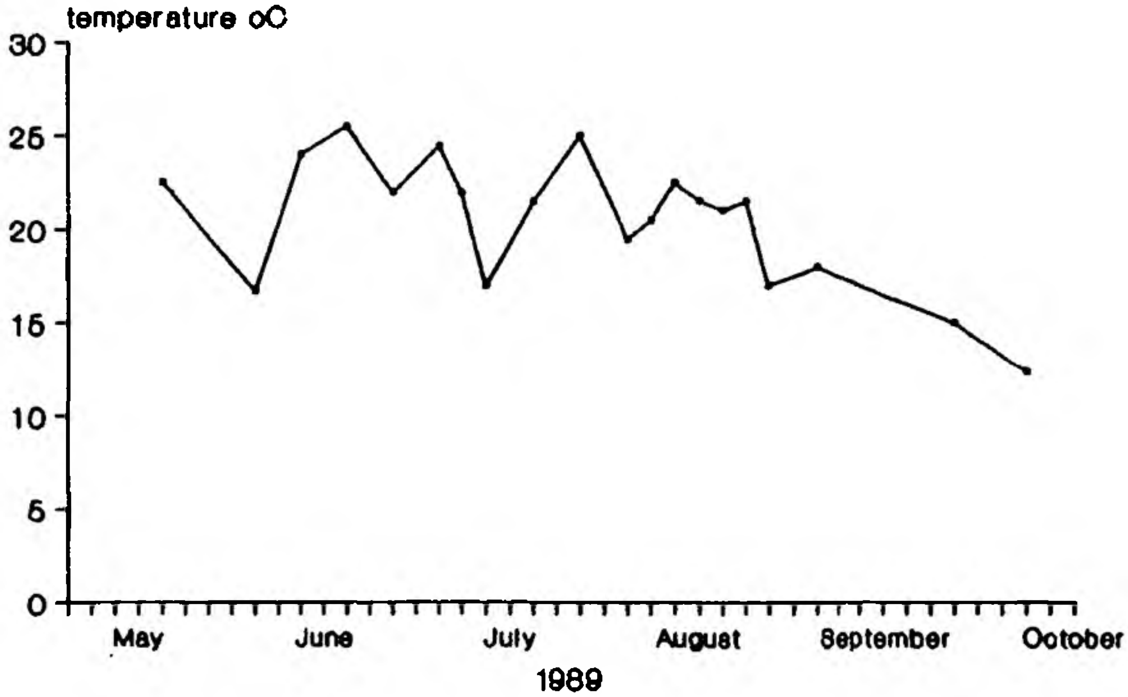
production = 33.2 g m^{-2}

All chub transferred to Sapiston Brook

Length/frequency distribution of a subsample of 0+ chub removed from pond 4



Temperature Profile of Pond 4 at Snailwell



5.5 Pond 5

15.5.89	Pond filled from R. Snail and fertilised with 7.3 kg NPK (Est. Vol = 175 m^3)
22.5.89	Seeded pond with two small nets full of zooplankton (from Costessey)
30.5.89	Introduced 6,500 larval chub into pond
14.6.89	Slightly turbid water - many swarms of large appropriately-sized *Cladocera*
19.6.89	Clear water, plankton in abundance, some weed
21.6.89	Treated with Clarosan @ 6 ppm to kill filamentous algae (*Vaucheria*) and macrophytes
27.6.89	DO reading of 108 %
3.7.89	DO reading of 140 %. Zooplankton levels much lower than before, weed dying back
7.7.89	DO reading of 174 %
14.7.89	Small leak detected in pond
18.7.89	Water level low, possibly due to small leak from the outlet chamber. Reflected in the lower temperature
21.7.89	Summary of Measures carried out at on Pond 5

Problem: Pond 5, containing fingerling chub of length 3.5 to 4.0 cm, was found to be leaking (14th July 1989) and the food level in the pond itself was very low.

Aim: To transfer the fingerling chub from pond 5 to pond 1 where there is a much higher food level.

Pond 5 was treated with Clarosan in late-June to kill an increasing amount of filamentous algae, and also some macrophytes. On this morning, the dead algae was removed by raking, with a careful eye being cast over all clumps of weed for the presence of chub, sticklebacks and common newts. All fish removed in this period were placed directly into pond 1, which contained great numbers of very large *Cladocera*.

The pond was drained over a two hour period in the afternoon. The air temperatures were in excess of 25 °C and no adverse effects of such warm conditions were observed in any subsequently caught. Weir boards were placed in the outlet chamber to the level of the pond and a metal screen was in place for the first part of the drain down. The pressure bung was removed from the exterior of the chamber and the weir boards gradually removed to lower the level of the pond water. Whilst the screen was in place, few fish came through the chamber to the capture point at the external edge of the monk. After the removal of the screen and further weir boards, an increasing number of fish were caught. Fry were caught in D nets which were frequently emptied and rotated. Some chub, up to 1,500, remained in the pond. All fry caught in this way were placed into pond 1 and losses were less than 10. Some fry, 20 to 50, are now present in the R. Snail. The pond was refilled and the inlet left open for 3 days. It was not possible to place the pressure bung at the pond end of the outlet chamber to prevent the slow leak.

1.8.89 Treated with Clarosan @ 10 ppm

13.9.89 Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond

14.9.89 Fish fed - first observed feeding in chamber

15.9.89 Fish fed
18.9.89 Fish fed
19.9.89 Fish fed
20.9.89 Fish fed
22.9.89 Fish fed
25.9.89 Fish fed
26.9.89 Fish fed
27.9.89 Fish fed
29.9.89 Fish fed
3.10.89 Fish fed
4.10.89 Fish fed
10.10.89 Fish fed

30.10.89 Pond drained and fish removed

These fish were the remaining fish from the draindown performed in August, where the majority of fish were transferred to pond 1.

The duration of the draindown was approximately 30 minutes. All chub were caught in a keepnet, with the majority of the chub being netted towards the outlet chamber during draining. The sealing bung was in the external end of the outlet chamber.

Area of pond = 439 m^2

Total number of chub removed = 1345

A subsample of 30 chub was measured (cm)

7.9 7.3 7.2 6.8 7.6 6.8 7.8 7.6 7.0 7.6

6.9 7.3 7.5 6.9 6.4 7.4 6.9 8.0 7.7 7.7

7.5 7.4 7.2 7.3 7.7 7.2 7.1 6.5 7.5 7.3

mean length = 7.30 +/- .38 cm (1.9 % mv)

range 6.4 - 8.0 cm

fry density = 3.06 m^{-2}

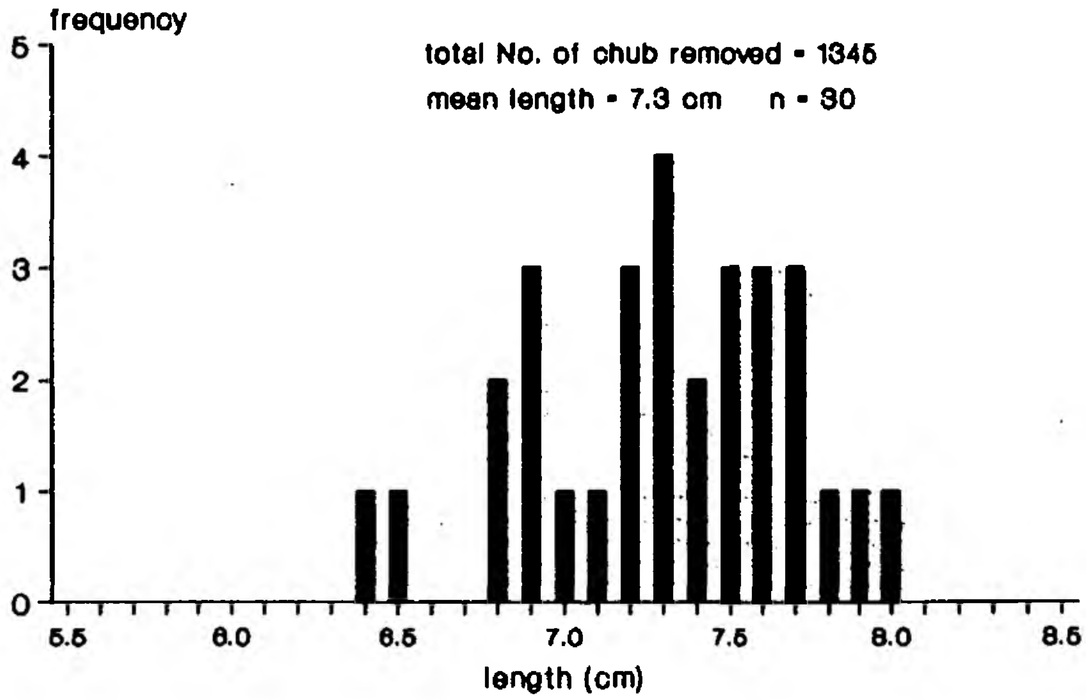
estimated fry mean weight = 6.2 g

biomass = 8339 g

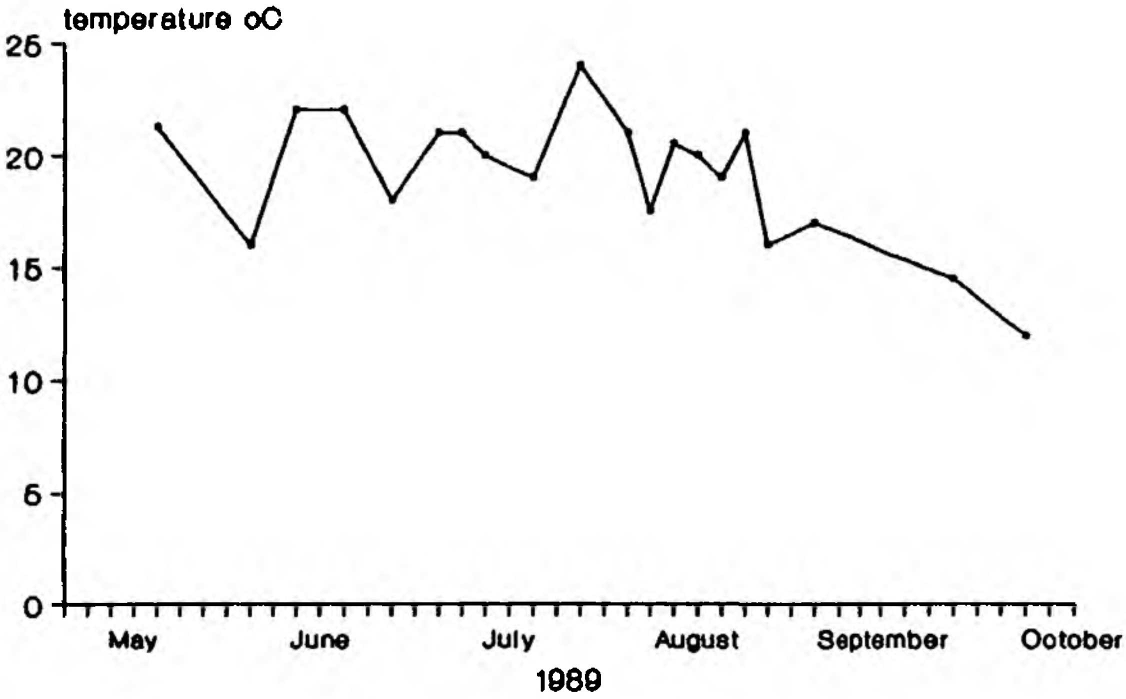
standing crop = 19.0 g m^{-2}

All chub transferred to R. Little Ouse at Santon Downham.

Length/frequency distribution of a subsample of 0+ chub removed from pond 5



Temperature profile of pond 5 at Snailwell



5.6 Pond 6

16.5.89 Pond filled from R. Snail and fertilised with 6 kg NPK (Est. Vol = 195 m^3)

22.5.89 Seeded pond with two small nets full of zooplankton (from Costessey)

30.5.89 Introduced 6,000 larval chub into pond

14.6.89 Very turbid water - many swarms of large Cladocera observed with looker. Many larvae in this pond at the raceway end, great affinity for the marginal cover.

19.6.89 Clear water - zooplankton of several species visible

27.6.89 DO reading of 128 %

3.7.89 DO reading of 163 %. Serious food depletion.

7.7.89 DO reading of 109 %, treated with 5 ppm Clarosan

18.7.89 Intense brown algal bloom, possible oxygen depletion

13.9.89 Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond

14.9.89 Fish fed - first observed feeding in chamber
15.9.89 Fish fed
18.9.89 Fish fed
19.9.89 Fish fed
20.9.89 Fish fed
22.9.89 Fish fed
25.9.89 Fish fed
26.9.89 Fish fed
27.9.89 Fish fed
29.9.89 Fish fed
3.10.89 Fish fed
4.10.89 Fish fed
10.10.89 Fish fed

30.10.89 Pond drained and fish removed

The duration of the draindown was approximately 1 hour. All chub were caught in a keepnet, the chub were in the raceway end of the pond at the commencement of draining. The sealing bung was in the internal end of the outlet chamber.

Area of pond = 315 m^2

Total number of chub removed = 7118

A subsample of 30 chub was measured (cm)

5.8 5.8 5.5 5.8 5.6 5.0 5.6 5.3 5.6 5.9

5.6 5.0 5.3 6.2 5.5 5.5 5.4 5.4 6.4 4.4

5.6 5.4 5.4 5.4 5.5 5.1 5.3 6.3 5.9 6.5

mean length = 5.57 +/- .435 cm (3.4 % mv)

range = 4.4 - 6.5

fry density = 22.6 m^{-2}

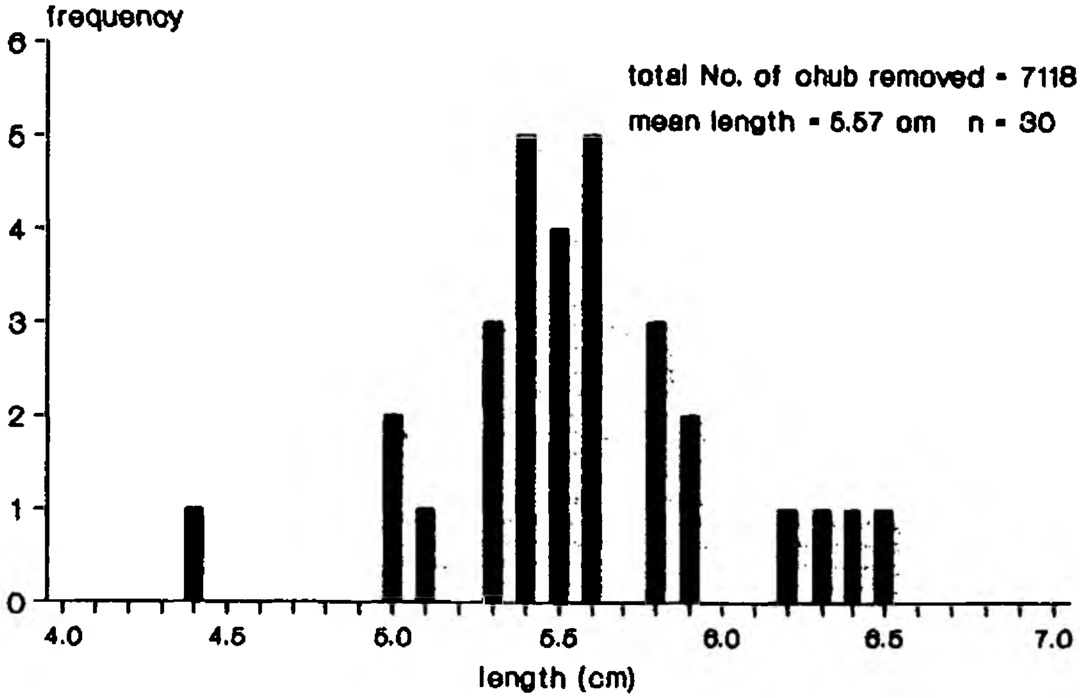
estimated fry mean weight = 1.7 g

biomass = 12,100 g

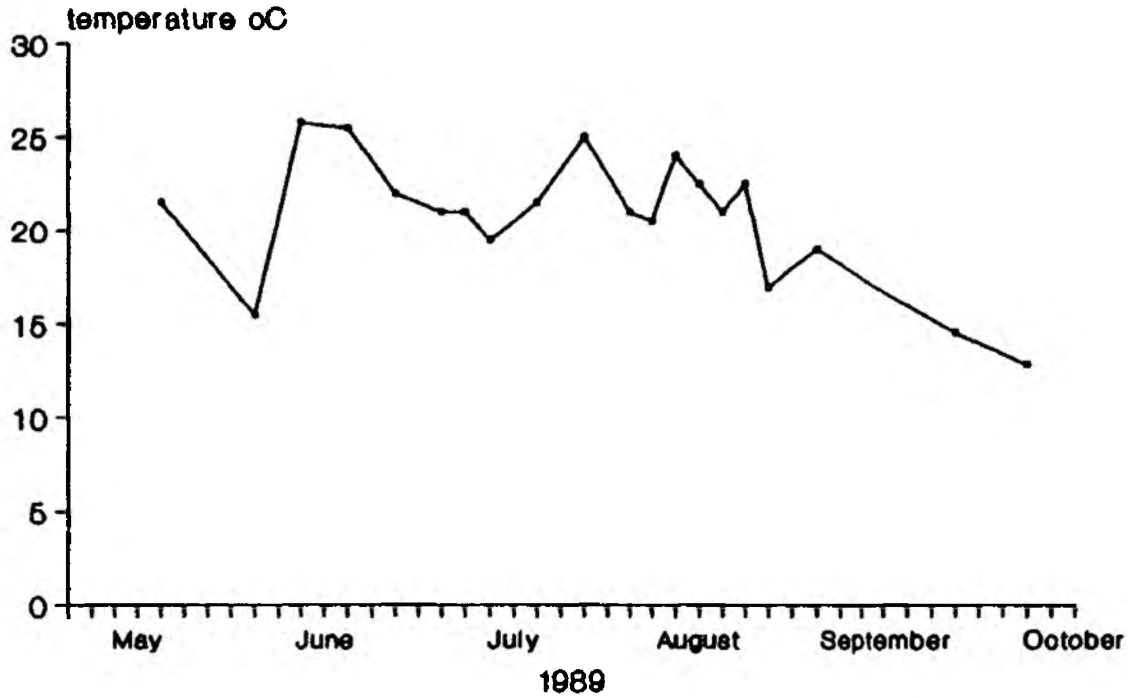
production = 38.4 g m^{-2}

All chub transferred to external tanks at Brampton.

Length/frequency distribution of a subsample of 0+ chub removed from pond 6



Temperature profile of pond 6 at Snailwell



5.7 Pond 7

This pond was originally left to fill, but a leak in the outlet chamber was apparent. A pressure bung was placed in the pond end of the outlet chamber to prevent the water from leaking through the chamber drain pipe, and the pond was filled. The aim was to use this pond for the growing-on of fry from another pond in which the food was depleted after a large population of zooplankton had been established.

19.6.89 Pond filled from R. Snail

21.6.89 Fertilised with 6 kg NPK (Est. Vol = 250 m^3)

27.6.89 DO reading of 142 %, 45 cm Secchi disk reading

3.7.89 DO reading of 195 %, 47 cm Secchi disk reading

7.7.89 DO reading of 77 %

18.7.89 bloom persisting, a few Cladocera observed

26.7.89 Large numbers of Cladocera

8.8.89 Introduced approximately 2,000 chub fry into pond.

Fish size (cm) : 5.5 5.9 6.1 5.6 5.3 6.0 5.4 5.4
mean length = 5.65 cm. Estimated wt 1.65 g (3,300g)

10.8.89 Some chaoborus observed in pond, and mayfly larvae

13.9.89 Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond

14.9.89 Fish fed
15.9.89 Fish fed
18.9.89 Fish fed
19.9.89 Fish fed
20.9.89 Fish fed
22.9.89 Fish fed
25.9.89 Fish fed
26.9.89 Fish fed
27.9.89 Fish fed
29.9.89 Fish fed
3.10.89 Fish fed
4.10.89 Fish fed
10.10.89 Fish fed

19.10.89 Pond drained and fish removed

The chub in this pond were those transferred from pond 2 in August. Chub were subsequently transferred after the bloom was established and represents their second plankton bloom.

Area of pond = 511 m^2

Total number of chub removed = <u>1902</u>

A subsample of 30 chub was measured

8.6 8.8 8.9 9.2 9.2 9.0 9.1 8.6 9.0 8.4

9.8 9.3 8.6 9.0 8.9 8.7 9.1 9.5 9.6 8.8

8.8 9.0 8.6 8.7 9.6 8.0 8.4 8.3 8.6 8.5

Mean length = 8.89 +/- .415 cm (1.9 % mv)

range 8.0 - 9.8

fry density = 3.7 m^{-2}

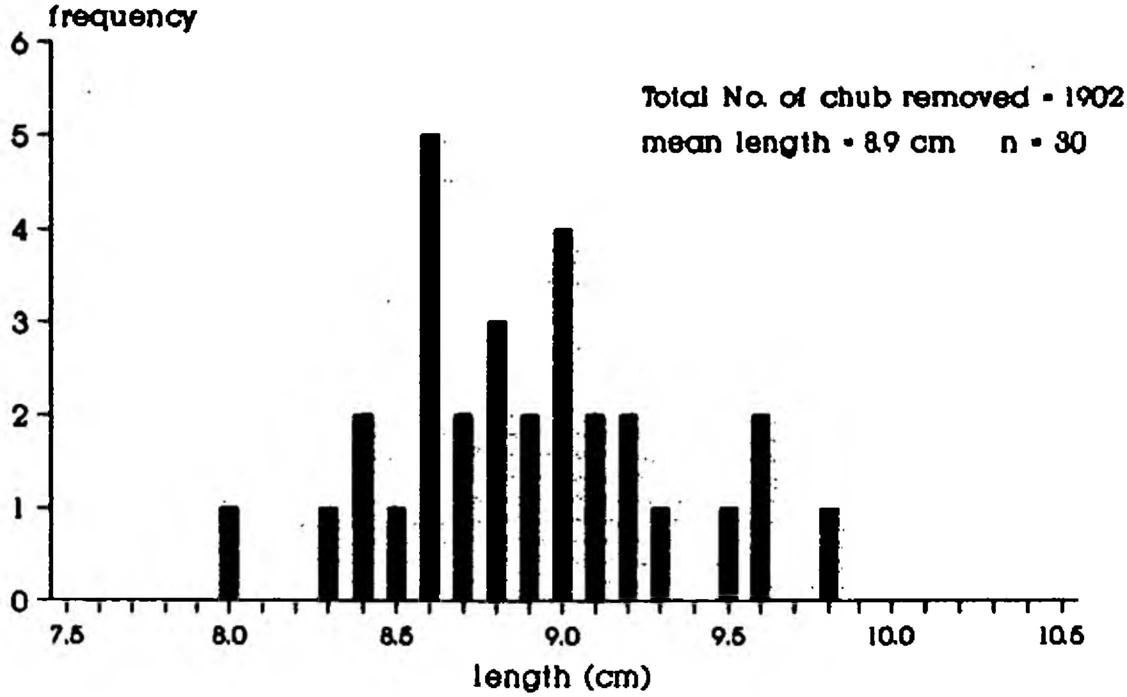
estimated fry mean weight = 10.9 g

biomass = 20,732 g

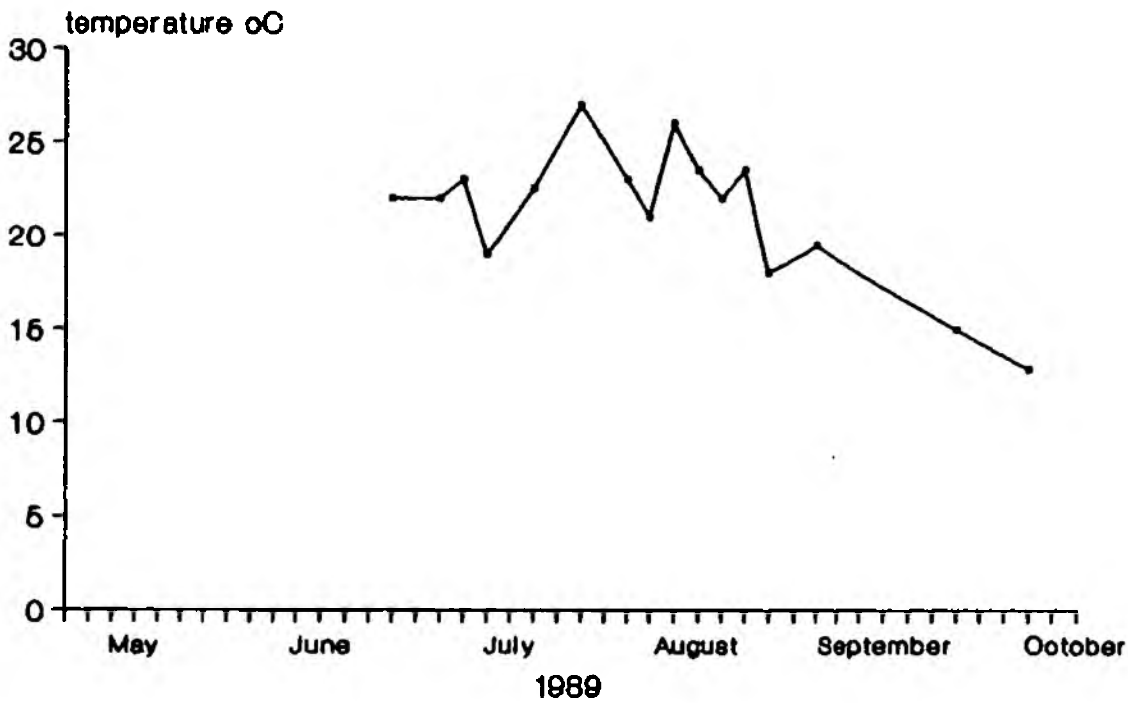
standing crop = 40.6 g m^{-2}

All chub were transferred to the R. Little Ouse at Santon Downham.

Length/frequency distribution of a subsample of 0+ chub removed from pond 7



Temperature Profile of Pond 7 at Snailwell



5.8 Pond 8

12.5.89	Pond filled from R. Snail
15.5.89	Fertilised with 11.4 kg NPK (Est. Vol = 273 m^3)
19.5.89	Seeded pond with two small nets full of zooplankton (from Costessey)
26.5.89	Introduced 6,000 larval chub into pond 8
2.6.89	Introduced 3,000 larval chub into pond 8
7.6.89	Pond observed to be full of medium-sized zooplankton - appropriate size for the first-fed chub larvae
14.6.89	many swarms of appropriate-sized <u>Cladocera</u>
19.6.89	Water clear, large numbers of <u>Cladocera</u>
27.6.89	DO reading of 124 %
3.7.89	DO reading of 245 %. A second bloom of very small <u>Cladocera</u>
7.7.89	DO reading of 54 %
18.7.89	No Cladocera observed
13.9.89	Commenced feeding with size 4 pellets - all fish in outlet chamber due to low water levels and little cover in pond
14.9.89	Fish fed - observed all over the pond surface. Quickly started feeding on the artificial food
15.9.89	Fish fed
18.9.89	Fish fed
19.9.89	Fish fed
20.9.89	Fish fed
22.9.89	Fish fed
25.9.89	Fish fed
26.9.89	Fish fed
27.9.89	Fish fed
29.9.89	Fish fed
3.10.89	Fish fed
4.10.89	Fish fed
10.10.89	Fish fed
17.10.89	Fish fed
18.10.89	Fish fed
24.10.89	Pond drained and some fish removed

25.10.89 Pond drained and some fish removed

This pond was drained on consecutive days, the 24th and 25th October. On the first day, a 3" pump was used to lower the pond level by 12" to aid the collection of fry. The drain plug was pulled to collect the fish, but only 700 fish were caught initially. The pond was set to refill slightly over night. On the second day the pond, now partially full, was drained in two separate attempts. Initially, a further 800 fry were removed, but the persistent problem was the prevention of the fry penetrating through the net which was used to confine them at the outlet end of the pond. Further, the level of soft mud was very deep, up to 2 feet deep at the outlet end, preventing also the simple, complete draining of the pond. At the second attempt on this day, the net was dragged down the pond when most water had been removed and this succeeded in moving most fry to the outlet end. The stranded fry were collected, with some perishing in the event. It was apparent that sticklebacks outnumbered the chub fry by a factor of 3:1.

A further draindown was performed on 7th November. This involved draining for about ten minutes, removing any chub that had moved into the outlet chamber. The pond was then resealed to prevent any further draining.

Area of pond = 479 m^2

Total number of chub removed = 5569 + 729 (7.11.89)
= 6298

A subsample of 30 chub was measured (cm)

5.4 4.9 5.4 4.6 4.7 5.5 4.7 5.6 4.8 4.7

4.8 4.7 4.7 5.1 5.2 5.2 5.6 4.9 4.5 5.0

4.8 4.8 5.6 4.4 5.2 5.1 5.3 4.9 5.0 4.8

mean length = 5.00 +/- .339 cm (3 % mv)

range 4.4 - 5.6 cm

fry density = 13.1 m^{-2}

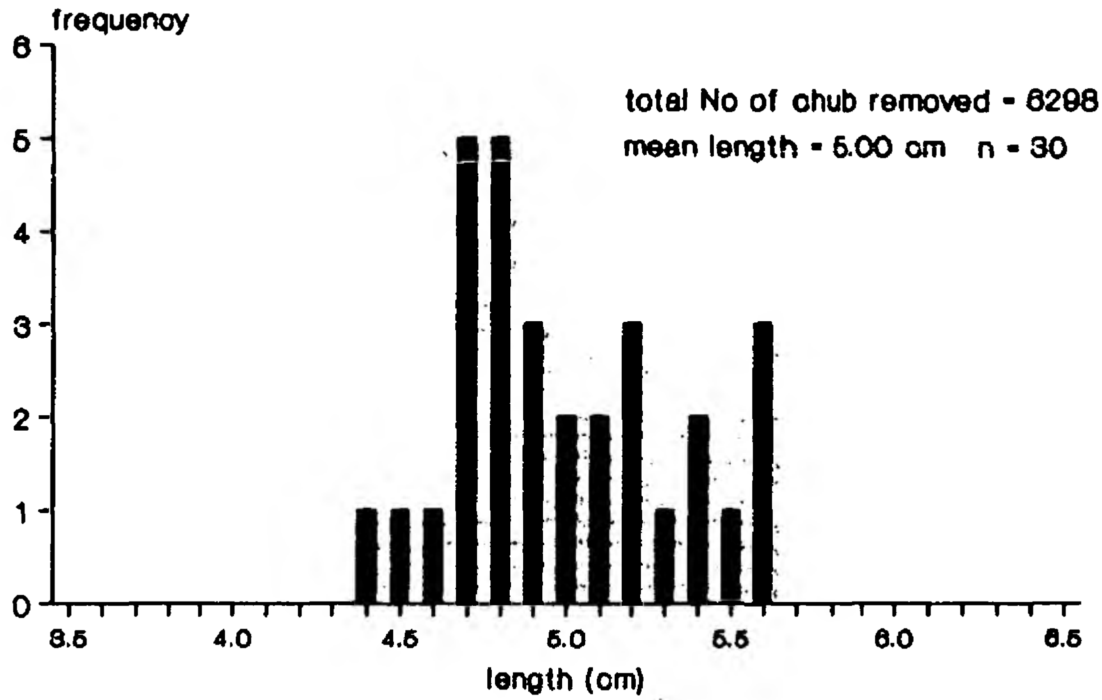
estimated fry mean weight = 1.2 g

biomass = 7558 g

production = 15.8 g m^{-2}

All chub transferred to external tanks at Brampton.

Length/frequency distribution of a subsample of O+ chub removed from pond 8



Temperature profile of pond 8 at Snailwell

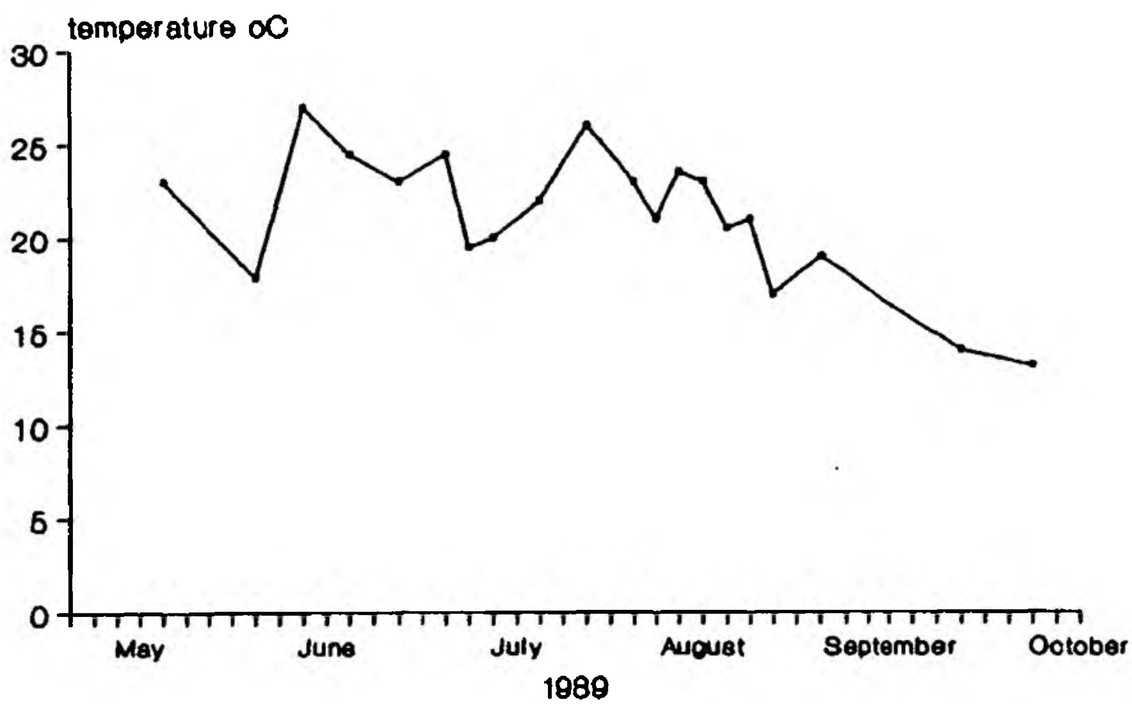


Table 1 Production Figures for Snailwell 1989

Total number of chub produced = 26.349

Estimated survival = $\frac{26.349}{32500}$

= 81.1 %

Stocking density = $\frac{32500}{1958}$

= 16.5 m^{-2}

Estimated survival density = $\frac{26.349}{1958}$

= 13.5 m^{-2}

Estimated overall production = $\frac{78.2 \text{ kg}}{2770 \text{ m}^{-2}}$

= 28.2 g m^{-2}

Production

	Po	I	S	S%	l	P
Single bloom	4	5500	4501	82	6.4	33.2 g m^{-2}
	6	6000	7118	XX	5.6	38.4 g m^{-2}
	8	8000	6298	74	5.0	15.8 g m^{-2}

	Po	I	S	S%	l	S/C
double bloom	5	6500	1345	84	7.3	19.0 g m^{-2}
	1		4114		5.9	26.6 g m^{-2}
	2	5500	1071	54	7.8	24.6 g m^{-2}
	7		1902		8.9	40.6 g m^{-2}

(estimated production in pond 2 until 8.8.89 = 17.8 gm^{-2})

(estimated biomass in pond 2 after draindown = 6.5 g m^{-2})
(estimated production in pond 2 after draindown = 18.1 g m^{-2})

(estimated biomass introduced in pond 7 = 6.45 g m^{-2}
(estimated production in pond 7 after stocking = 34.1 g m^{-2}

6. Discussion

The six serviceable ponds were used for the rearing of larvae of two species, grayling and chub. 1,120 grayling were introduced into pond 1, which was the most shallow and was the nearest to the R. Snail and a total of 32,500 chub larvae were introduced into ponds 2, 4, 5, 6 and 8.

Water quality remained excellent and most important, the level of the River Snail was high enough for filling and maintaining pond levels. However, at the end of the production period, water flow had reduced and it is hoped that this will increase through the winter period.

6.1 Grayling production

The grayling larvae were not observed almost immediately after their introduction into pond 1. There may be several reasons for their demise. Throughout the early summer months, water temperatures were high, particularly in the more shallow ponds such as ponds 1 and 2. Thus, the upper lethal temperature for grayling larvae may have been exceeded during this time. Pond 1 was situated close to the River Snail and the cover afforded by this stream for piscivorous birds, such as kingfisher, may have predisposed pond 1 to high levels of avian predation. The shallow nature of the pond would also have aided predation by such birds. A further possibility was that the grayling may have succumbed to a bacterial infection which was present in grayling larvae maintained at Brampton during the same period. No mortality was observed in pond 1,but feeding by piscivorous birds may have removed any carcasses.

6.2 Chub production

Production levels in the ponds containing chub larvae were very high and exceeded expectations for natural production systems. The highest production level was in pond 6, the raceway, at 38.4 g m^{-2}, which was 15 % greater than any other pond and 33 % greater than the mean for the farm. It is difficult to determine exactly why the performance of chub in this pond was better than in the other ponds. It may be a function of the timing of larval introduction, such that the pond contained large populations of zooplankton. From the records taken however, the flora and fauna of pond 6 did not appear to be significantly greater than the other ponds on the farm. It is possible that the design of the pond itself may have lead to enhanced production due to the cover afforded by marginal plants and the terrestrial input at the inlet end of the pond. Also, macrophytes and filamentous algae were not able to proliferate in the pond because of the concrete bottom, which suggests that all nutrients added were available to phytoplankton rather than higher plants. These aspects would lead to enhanced phytoplankton and zooplankton production. The production levels in future years would be of great interest in revealing the possible role of the pond design and shape in improving yields.

Production levels in ponds 1, 2, 4, 5 and 7 were also very high, suggesting that the site as a whole can be very productive when the appropriate management strategies are used. Phytoplankton blooms were delayed in some ponds, perhaps due to low numbers of phytoplankton in the River Snail and/or in the ponds before filling. Seeding with green water considerably improved the blooms and ensured that the zooplankton were well supplied with food. Similarly, zooplankton levels were virtually nil and seeding overcame the low numbers present. Proliferation of zooplankton did vary between ponds but larval stocking was timed to coincide with the production of the appropriately-sized zooplankton, and in sufficient quantities. Ponds 2 and 8 were the first to be stocked, and for the remaining ponds, it was delayed for four days until the food status was satisfactory. Growth of chub was excellent in all ponds, with some fish reaching 6.1 cm in length by August, and 9.8 cm by October. This implies that the ponds were not overstocked and further, there was sufficient food available to them in the latter part of the summer months. This suggests also that after the depletion of zooplankton, the fry must have switched to other food sources, such as chironomid larvae or Gammarus which were present in the river and ponds, and terrestrial insects at the water surface.

Production levels in pond 8, however, were lower than expected and were significantly lower than the mean for the farm, at 15.8 g m^{-2} (56 % of the mean value). It was apparent that during the draindown, sticklebacks outnumbered chub fry 3 : 1. Clearly, the numbers of stickleback in the River Snail were low generally, and less than 10 were caught usually in the screening nets during the filling of most ponds. With this information, and taking the small size of individual stickleback into account, it was apparent that virtually all sticklebacks had been produced in pond 8 after filling. The source of the sticklebacks may have been from pond 9, which overflowed several times into pond 8 during the year but more likely it is probably due to pond 8 not being screened during filling. It does reinforce the fact that sticklebacks present a considerable threat to fry production in ponds. The importance of this cannot be overstressed as sticklebacks act as both competitors and predators. They are able to reproduce quickly due to a continual gametogenic cycle, stimulated by favourable environmental conditions. Consequently, several mature stickleback will have a severe impact on the production of the desired cultured species. Thus, the potential growth of the chub fry in pond 8 was impaired by the presence of in the order of 18,000 sticklebacks and an estimated 15 g m^{-2} of chub production was lost. Survival of chub larvae in pond 8 was not much lower than other ponds, again suggesting that the sticklebacks were not predating heavily on them, but rather competing for a limiting food resource.

Survival levels were very high, with an estimated 20 % mortality through the whole production period. This reinforces the use of the first-feeding methods as overall survival is very strongly related to the initial two to three weeks of life of a larva. It also suggests that the food status of those ponds was satisfactory at the time of stocking. The lowest survival was observed in pond 2, where only 54 % of the estimated numbers of larvae stocked were recaptured. It is possible that in this pond the food status was not optimal at the time of stocking, leading to poor survival initially, but production within that pond throughout the summer rearing period was still high. With the exception of pond 8, invertebrate predator levels were very low in all ponds. This is almost certainly a consequence of the ponds being dry through the previous winter and the screening of the pond when being filled. Low predator levels would also have had a great bearing on the initial and ultimate larval survival.

High water temperatures were maintained in all ponds throughout the summer months, although absolute temperature levels were not any higher than would be recorded in a typical UK summer. Thus, if water temperature had any bearing on the high production levels, then it is likely that it would a function of the total number of days maintained at temperatures over 20 °C rather than the number of days at extreme temperature levels, such as over 25 °C.

The fry that had reached a suitable size for stocking out were placed directly from the farm into the wild. A total of 3247 chub fry were introduced into the Little Ouse at Santon Downham, and a further 5572 were stocked into the Sapiston Brook, a tributary of the Little Ouse. The remaining 17,530 fry, were transported to Brampton for winter rearing. These fish will be stocked out in the spring months having reached the size for release.

The predictions for production at Snailwell were based on an informed pond area of approximately 500 m^2 each, giving at total area of 3000 m^2 over 8 ponds. It was also predicted that a 50 % survival rate would be achieved with stocking at 20 larvae m^{-2}, producing 30,000 fish. In fact, the total pond area has been shown to be 3117 m^2, with only 5 ponds (1958 m^2) being fully utilised during 1989 due to leakage problems. The production of over 26,000 fish in this area, most fish being in excess of the target 5 cm length, is thus a significant achievement.

In conclusion, the operation of Snailwell has been shown to be of great value in this first trial, and it is a relatively small step to improve yields. The particular value of drainable ponds was revealed in the absence of predators, both invertebrate and piscine. Similarly, the ponds were quickly drained and refilled which is of great importance when second production cycles are required. Also, the ponds were easily harvested, ensuring that the fry are not damaged on removal. Water quality was excellent and this cannot be over-emphasised. However, the fall-off in flow during the summer months requires careful management of this resource. Considering that this has been operated as a semi-intensive system with some losses through bird predation and competition with stickleback, the overall production levels are excellent, confirming the great value of the site.

7 Proposed improvements to the fish farm facilities and rearing methodologies

Potential production levels at Snailwell are high, given that the basic prerequisites for this have already been satisfied i.e. drainable ponds, excellent water quality, high water temperatures in summer, low predator numbers, fry easily harvested. The following recommendations are designed to improve the yields and ease the overall management of the site.

7.1 Pond maintenance and improvement

In 1989, eight ponds were allocated for fish production purposes. Three of these ponds still require some repair work to retain the water when filled. The outlet chambers in particular are in need of renovation in ponds 3, 5 and 7 and this should be performed during winter 1989/90. Each of these three outlet chambers requires sleeving with plastic pipework, and then sealing the plastic pipe in the old pipes with cement. The approximate cost of the 6 m of Ultrarib pipe is £ 52.70 per pond, for 25 cm pipe. The size must be checked with a sample before any significant purchases are made.

Further work is necessary to improve the draining of all ponds to prevent the accumulation of standing water during the winter months. The organic matter deposited in 1989 will aid this process and work is already in hand to ensure that all ponds are dry before winter commences in earnest. Further spoil is required in the bottom of pond 8 to raise the level of the bottom to above that of the outlet pipe. The appropriate stone would be hoggin, or a slightly smaller size.

A further problem is the use of pond 9, which was used for the maintenance of fish taken from fish rescues. The storage of fish from other waters on a rearing site is incompatible with the rearing of young, unchallenged fry. The risk of disease introduction would be high if the fish had arrived in a highly stressed state, and certainly the observed mortality was high amongst these rescued fish in the summer months. Also, in order to maintain fish in this pond, a considerable amount of water was necessary to maintain water quality in the pond, to the detriment of all other ponds and the feeder channel. Pond 9 frequently overspilled into pond 8, causing some of the chub to escape and risking the possibility of introduction of predators and disease into the rearing pond. In view of these problems, it is proposed that pond 9 would be drained and used for fish culture purposes. In exchange, several external tanks should be made available by Fish Production at the NRA Central Area site at Brampton, where the fisheries teams are based, for such purposes. If approved, pond 9 would also the addition of stone as directed for pond 8 to improve the drainage and profile of the pond bottom. Action for all pond improvements should be implemented as soon as possible if the ponds are to benefit from the winter period.

7.2 Fry production in 1990

The target species for Snailwell in 1990 are grayling and dace, in response to a specific requirement in the Central Area (other species to be produced if required). Grayling and dace are spawned and reared at the same time during the production year, which ensures efficient management of the fish farm site. One species is to be spawned and first-fed at Costessey, the other at Brampton from mid-March to mid-April, ensuring that hatchery facilities are fully utilised at each site. Correspondingly, the ponds at Snailwell are then to be filled, fertilised and stocked in mid to late-April. In this way, the production at Snailwell is coordinated within the Fish Production programme. Table 2 details the expected production levels for the site.

7.3 Enhancement of fry production

The chub fry reared at Snailwell in 1989 were grown solely on naturally produced food until the end of August, most ponds being able to sustain fry growth for three months before food became limited. In September, the feeding of artificial food by hand was necessary for maintenance, to prevent significant fry stress through starvation. Thus, there is a requirement for a feeding system for the latter part of the production period even if the present low stocking densities were maintained in future years. This need would be accentuated if dace and grayling are to be the major species reared at this site. Both species would be introduced into the ponds some four to six weeks before the chub were stocked in this year's production due to their advanced spawning time. Thus, their natural pond food would be exhausted somewhat earlier than observed in 1989. This need is not unexpected, but it highlights the potential yield of the site if artificial food was fed from an earlier point in the first summer. With a fully automatic feeding system, the stocking densities could be increased markedly as the food source would not then be a limiting factor in fry production. The appropriate management regime would be to stock larvae at high densities in fertilised ponds as in 1989, and as food becomes limited, artificial feed would be given. The potential yields for the Snailwell site are given in Table 2, both with and without supplementary feeding. There is effectively a 50 % increase in production if an artificial feeding strategy is adopted, with improved survival and growth being likely over less intensive methods. Considering that dace and grayling fry are several weeks in advance over chub, and thus have a longer growing season, the yields may well be greater than the estimates given. A further requirement for the establishment of a feeding system is that of artificial aeration. Two compressors would be necessary to maintain dissolved-oxygen levels in the ponds during the warm summer months. Table 3 gives a breakdown of those costs which are available at present.

The potential problems of employing a feeding system are several. Primarily, the initial cost is significant and some time would be required to evaluate the system. The risk of vandalism and theft at Snailwell are increased by the fact that it is a remote site, with no permanent staffing. Perhaps the greatest risk is that with a power failure, aeration would cease, and with the increased stocking levels in the ponds, the oxygen levels would quickly fall. In this event, the provision of a back-up generator would also be necessary to ensure that power failures do not cause oxygen levels to be depleted. Several feeding systems are being evaluated at present, and all of these aspects are being considered.

A potential compromise would be hand feeding the fry, for maintenance and growth, on a regular basis through the summer period. This would produce smaller fish than if an automatic system was used, but survival should not be affected, this being determined during the plankton-feeding stage. If the 1989 winter rearing trials are successful, it should be possible to rear fry of less than 5 cm to stockable size, and thus survival would be the most critical factor in fry production rather than the absolute size at which they were harvested from the ponds.

Table 2 Potential production levels at Snailwell

Total pond area at Snailwell = 3680 m^2

Ideal stocking denisity of fish

A) No supplementary feeding		B) With supplementary feeding	
dace / barbel	= 20 m^{-2}	dace / barbel	= 40 m^{-2}
grayling	= 10 m^{-2}	grayling	= 15 m^{-2}

Maximum numbers of larvae required for the whole site.

dace / barbel	= 73,600	dace / barbel	= 147,200
grayling	= 36,800	grayling	= 55,200

A suitable production programme for Snailwell is detailed below. A mixed culture system would be desirable on this adaptable site. Polyculture of barbel with all other species will be investigated.

Pond Nos	Total area m^2	Species	Numbers introduced	Survival %	size g	Expected Numbers (total)	Production g m^{-2}
A) No supplementary feeding (maintenance ration fed from July)							
1 - 5	1822	dace barbel	36500	60 - 80	2	22000 - 29200	24 - 32
6 - 9	1860	grayling	18600	60 - 80	3 - 4	11100 - 14900	24 - 32
B) With supplementary feeding							
1 - 5	1822	dace barbel	73000	60 - 80	2	43800 - 58400	48 - 64
6 - 9	1860	grayling	27900	60 - 80	3 - 4	16700 - 22300	36 - 48

Table 3 A breakdown of costings for the installation of feeding and aeration systems at Snailwell

1. Feeding system

Timers	5 channel, 12 volt with photocell	£ 240.00
	4 channel, 12 volt with photocell	£ 199.00
Feeders	12 volt vibrofeeder with Paxton cowlings	
	9	£ 500.00
	18	£ 999.00
Connector boxes		
	9	£ 70.00
	18	£ 135.00
Cable	1000 m, .75 mm sq twin cable, PVC sheathed	£ 200.00
Timer boxes, 2		£ 220.00
Batteries, 3 x 65 amp hour heavy duty 12 volt		£ 144.00
Installation		£ 150.00
Total cost	9 feeders	£ 1714.00
	18 feeders	£ 2278.00

2. Aeration system

1 x compressor
airtubing
pipework

Total cost (being evaluated) @ £ 2000.00

3. Generator

Generator and starter
battery
switch gear

Total cost (being evaluated) @ £

7.4 Prevention of avian interference

The effects of predation by birds at Snailwell was thought to be a possible cause of grayling fry mortality in the rearing trials. It is proposed that netting should be erected over pond 1, 2 and 3 to prevent a variety of birds, from kingfisher, heron, duck and other waterfowl, predating on the fish or eating artificial food from the feeders. Certainly, netting would be required on all ponds if automatic feeders were installed.

7.5 Broodstock maintenance

The River Snail provides two of the four boundaries of the farm, and is available for the maintenance of broodstock. The habitat is largely pool and riffle and some modifications have been made to remove extensive silt beds, although these have reformed due to the low flows in recent months. Further work is still required to ensure that there is sufficient water for the maintenance of fish. In particular, grayling would be the ideal species to introduce into the river. Downstream migration of fish would prevented by the installation of a grating at the downstream boundary of the river. There is sufficient production in the river to sustain a small population of up to twenty females. However, all flow from the river is presently being directed through pond 9 and the river bed around the farm is dry. In order that broodfish are introduced, pond 9 must be drained to allow sufficient water to flow in the river.

7.6 Miscellaneous notes and points for discussion

7.6.1 Sheep

Sheep grazing should be encouraged, but larger animals such as cattle should not be held on the site as damage has been caused to the pond sides. It would be of great benefit to the ponds if, when fully dry, hay or other forage could be placed on the pond bottom. This would encourage the sheep to move and eat in the pond, causing the silt layer to be broken up by their feet and hopefully giving the sheep an opportunity to defaecate in the pond. Both of these effects would enhance pond plankton production when refilled in the spring.

7.6.2 Mowing

Mowing should be carried out twice-yearly to control nettles and thistles, for the purpose of site tidiness and ease of other management operations.

7.6.3 Entrance gate

This requires refurbishment or replacement.

7.6.4 Hatchery

The polytunnel over the hatchery is now tearing, and the polythene should be removed to prevent it blowing round the site. Brickwork should be renovated. The electricity supply to the hatchery should be disconnected for safety reasons.

7.6.5 Amphibia

The frog/toad spawning area on site should be renovated for conservation reasons.

7.6.6 Mains water supply

The mains water supply to the office appears to be leaking underground and this should be examined.

7.7.7 Consents

Abstraction/discharge consents for the farm should be discussed.

7.7.8 Lease

The possibility of increasing the number of ponds at Snailwell, or making any modifications should be discussed with respect to the terms of the lease.

8 Summary

Snailwell Fish Farm represents an important asset which has been used successfully in 1989 for the production of chub. Over 26,000 chub fry were produced under managed conditions in seven ponds. Some fry have been stocked out with the remainder being grown-on at Brampton and Costessey. In 1990, the production of the early-spring spawning dace and grayling is designed to be coordinated within the proposed Fish Production programme, with effort being concentrated at this site in April. It is anticipated that with the provision of artificial feeds during the summer period, production will be significantly increased over that achieved in 1989 and the production targets outlined in Table 2 should be achievable within one season.