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Introduction.

in the post war years and upto the mid 1950's the stretch of the Sawbridgeworth Angling Society's water on the River Stort extending from the iron bridge at Tednambury down to Feakes Lock betwwen Sawbridgeworth and Harlow marshes provided mixed fishing of a good quality of which roach were the most popular fish. During this period large catches were made regularly and day ticket money taken from visiting anglers provided a sizeable revenue for the Society. From the mid 1950's however, there was an apparent change in the fishing with mainly large fish being caught in the upper (Tednambury)section and the lower (Station Road and Sheering) sections still containing a large head of undersized roach and a miscellaneous collection of undersized perch, rudd and dace with some larger fish mixed in amongst them, gudgeon and pike were also included in the list. This was reflected in the fact that venues for senior competitions were nearly always on the upper sections to avoid the anglers, fishing to asize limit, from being plagued by small fish. Conversely junior competitions were preferred to be held on the lower sections where the less experienced anglers could be assured of a good "weigh in". This situation continued for several years until in the mid 1960's most competitions in the upper sections realised very few fish and catches were also deteriorating in the lower sections, catches finally reached the lowest ebb in 1970 when it was very difficult to catch a fish anywhere on the water. It was at this time when many theories were being advanced concerning the apparent disappearance of fish from the water that the writer became more than casually interested in the problem and in the early Spring of 1972 offered, together with Dr G.Legg to carry out a general ecological survey of the water if financial assistance could be given to cover nominal cost of ~~equipment of~~ equipment and chemicals.

Plan of work,methods and problems.

The aim of the project was to carry out a thorough ecological survey presuming that the results of such a survey would explain the disappearance of fish and any other abnormalities in the water.To this end the project was divided between the two workers,Dr Legg being responsible for chemical analyses,plankton,plants and physical conditions,the writer for bottom sampling and the fish.

The list of chemicals and equipment required for the tests are shown in Appendix I and include provision for determination of dissolved oxygen,nitrate and ammonia.The analytical techniques were taken from two books ---Practical Field ECology., Mclean and Ivimey Cook and Methods in Hydrobiology, Freshwater Biology,. Jürgen Schwoerbel.

Physical conditions to be tested were standard including flow rate,turbity,and temperature.Equipment for these tests is listed in Appendix I. and II.

The survey of plants was divided into two parts,a qualitative surveyof the vascular plants and algal plates placed in the water for a set peroid and then removed and examined for attached algae which it was hoped would give an indication of the degreeof pollution of that particular part of the water.

Bottom sampling proved to be one of the most difficult problems of the survey as the bed of the River Stort is variable in character being gravellyin places and muddyin others.The problem was to trap and hold the top layer of fine sediment in which most of the animals lived.To this end many samplers were considered and designed.The obvious choice of sampler was the Birge Ekkman grab but in the absence of the genuine article a replica was constructed but with little success,the chief problem being the leaking of sediment.
Such a sampler would have to be attached to a pole and operated from a boat.

Saw cylinder. This was constructed from lengths of plastic piping to the standard design but found to be unsatisfactory due to the variable bed of the river.

Various types of shovel were considered and eventually a ~~eventually a~~ Dittmar type selected. The disadvantage in this type of sampler was found to be its tendency to push fine sediment ahead of it and also to plough too deeply into the bottom.

After several trials with various suction and current devices one of the former was selected the design of which can be seen in fig . The principle employed is that seen in the ingenious device used to remove ~~The principle~~ detritus from aquariums and it is upon this same that the device is based. The main disadvantage is that the samples obtained consist of quantities of water which have to be transported.

Sorting of the samples was to be carried out using sieves of various size mesh including that obtained from filter units from horticultural irrigation systems.

The fish, as no licence could be obtained to net or trap fish for examination specimens were obtained whenever possible —from angling competitions, unofficial netting and mortality. Each fish examined alive was subjected to a standard set of external feature observations described in the relevant section, Dea d fish were given as good a post mortem examination as possible with available facilities and these results are again described in their own section.

The main problem encountered over the whole project was lack of time. Sampling and water testing programmes originally drawn up had to drastically pruned in order to become realistic and still retain statistic feasibility. Eventually it was decided that sampling would take place once a month even this meaning that most of the intervening spare time period wo^u^ld be taken up with sorting samples.

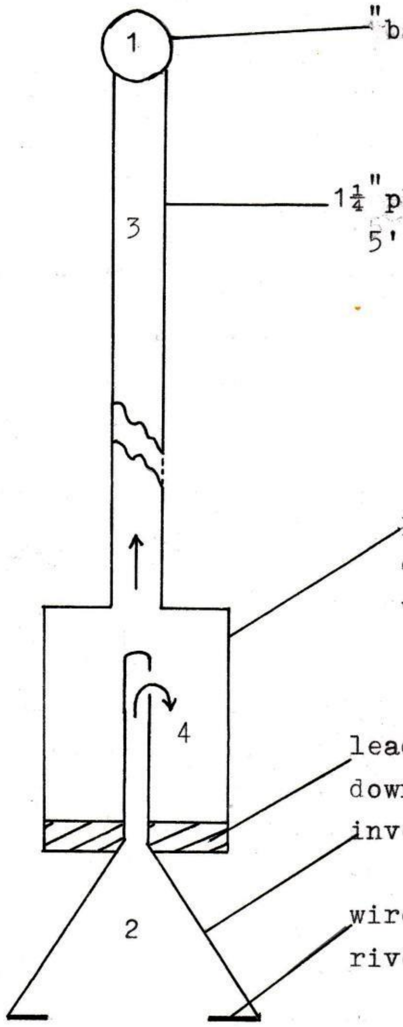


Fig.1. Bottom sampler.

Operation.

a) Apparatus is lowered into water with "ball" valve in position. b) tube is rotated to stir up bottom and c) valve is removed allowing water to flow into funnel and container d) apparatus is taken out of water, container is opened and sample removed.

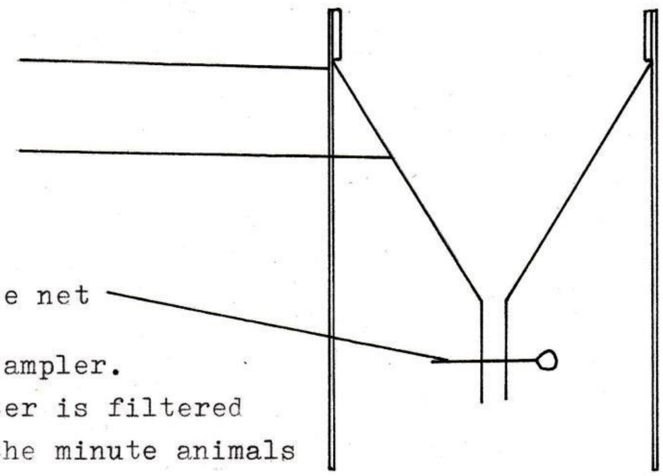


Fig.1a. Legg plankton sampler.
A known volume of water is filtered through the net and the minute animals remaining are collected when the clip is opened.

The area of the survey orginally intended to cover the whole of the water had to be reduced to the middle pound between Burtons Mill and Sheering Milllocks.This pound was easily and quickly accessible—important when time is an important factor—it also possessed a variety of habitats found over the whole stretch and including long straight "dead"stretches, inlets and outlets to backwaters and a varying bottom or bed.

Results of the survey.

Unfortunately,having prepared the programme for a 12 month survey and obtained all the necessary equipment Dr Legg was unexpectedly offered a lecturer's post in Sierra Leone which he subsequently accepted leaving the country in July 1972. The loss of half the man power from the survey meant that much of what we had originally intended could not now be completed. As a result the writer decided to concentrate upon the fish, obviously closest to anglers hearts,chemical sampling consisting of dissolved oxygen,nitrate and ammonia and the placing of algal plates int he water.Chemical sampling would consist of water taken at intervals on a diurnal basis with samples taken at 3hr periods.

Chemical sampling.

Due to various circumstances few figures have so far been obtained for this part of the survey those available and including ~~those~~ data from the LeeConservancy, whose information was open for our inspection,show diurnal variation due to a variety of factors.Broadly the picture is as follows:-

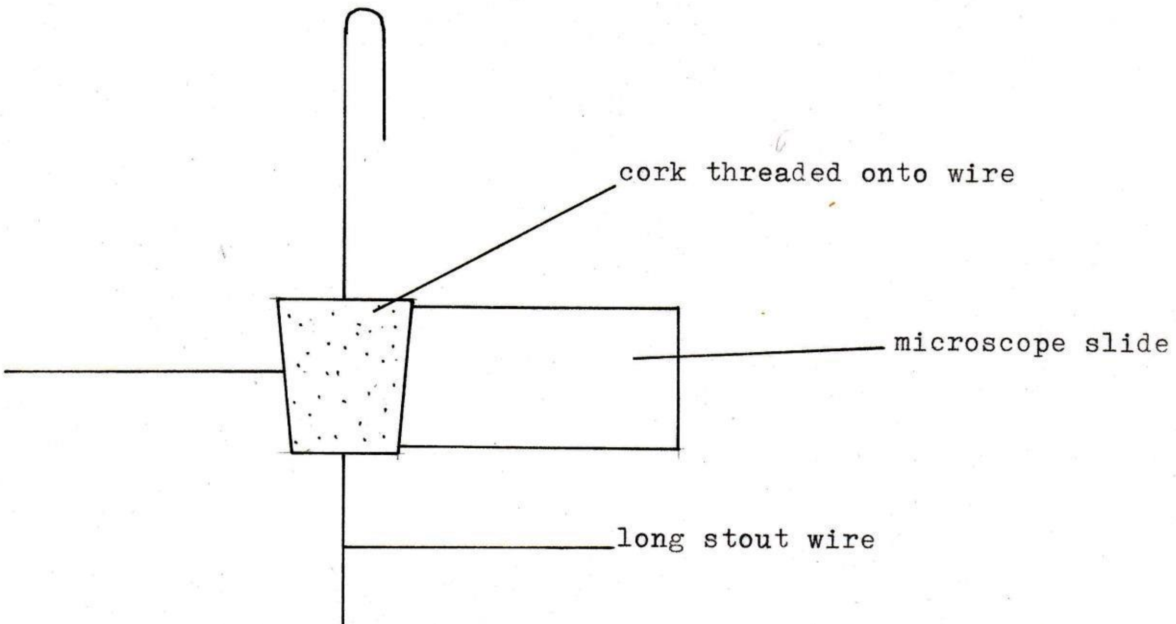
Polluted water from the Bishops Stortford sewage works is introduced into the river via the Hallingbury Brook at Twyford.The first thing that happens to this water rich in organic matter is that decomposition takes place whereby nutrient salts are produced,these salts all contain oxygen which must be obtained from the water whichconsequently becomes deoxygenated.

This gives the typical foul zone where fish life is non-existent, large plants are rare and only organisms adapted to live in poorly oxygenated conditions can thrive. The nutrient salts produced in this zone pass downstream acting as a fertiliser which causes plant life to flourish. On the river Stort algal plates, described later, have shown that the first deoxygenated zone extends from Twyford to somewhere in the region of Wallbury Dells at Spelbrook. Downstream of Spelbrook lock the river is heavily fertilised by the converted sewage and this is essentially the same situation as that found at SAwbridge worth. The effect of the fertilistion is to cause the rapid growth of plant life, mainly the filamentous green algae, in much the same way as a piece of manured dry land produces a rich crop. The rapid and prolific production of these minute and filamentous plants means that a lot of oxygen is put into the water in the daytime as the plants absorb sunlight providing an energy source for reactions by which they make their foodstuffs, As the oxygen is put into the water in the daytime so it is taken out during the night when the plants convert the foodstuffs made during the day into the utiliseable sugars they need for growth and productivity. The net result is that although oxygen levels are high in the light they take a dive at night reaching their lowest point at about 5 or 6a.m. in the summer, add to this the waste products contributed by the continuous death and decomposition of the algae which die as fast as they grow coupled with high ammonia levels from the sewage then a condition is produced in which the water, whilst not being seriously polluted is definetly not conducive to healthy fish growth and reproduction.

<u>Algal plates.</u>

These plates were in fact ordinary 3x1" microscope slides exposed in the water in two different ways, either on split corks threaded on a central wire(Fig2) or on the bottom attached to a brick(Fig2a). Recently the former method only has been used.

Fig.2. Apparatus for immersion of algal plates in water.



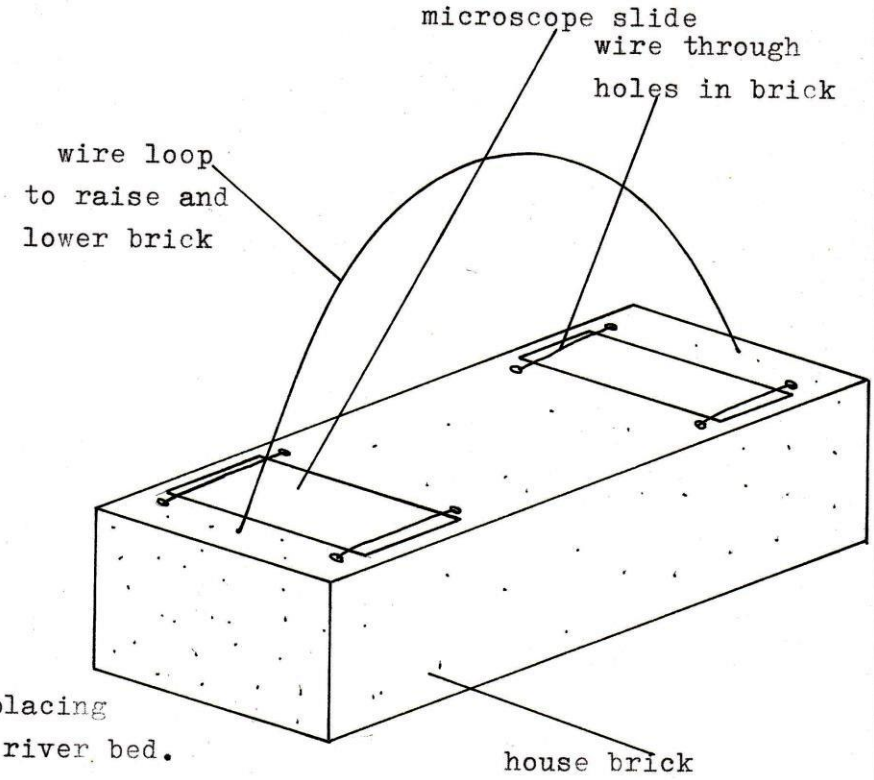


Fig.2a.
Apparatus for placing algal plate on river bed.

Fig.2b.Table showing decline in fishing from 1945–1973 between Tednambury and Feakes Lock.

Year.	Tednambury.	Burtons–Sheering Mill.	Moors.
1945–1955.	Good roach fishing in all sections with other species frequently captured.		
1955–1960.	Decline in roach fishing, larger fish only being caught.	Fishing still good but small fish more apparent than large especially in the Moors section.	
1960–1965.	Only large fish caught occasionally e.g. large roach, tench and carp.	Small fish mainly but in noticeably fewer numbers.	Many small fish.
1965–1970.	Very poor, few fish caught.	Angling poor, fish only being taken from areas of backwater inflow e.g. Maltings Point and Burtons Mill.	Hardly any fish caught,
1970–1973.	Some fish caught bream and rudd the former probably disturbed from the Silk Mill backwater bydredging and disturbance.	Some roach and perch especially at the Maltings Point. Many small roach and rudd as a result of the Westland Green introduction.	Very few fish and only in the dead stretch prior to Feakes Lock.

The first slides to be used were roughened with abrasive grits and marked into squares with a diamond pencil to facilitate plant attachment and counting respectively.Later,plain slides weresubstituted counting being done by using microscope fields.

Slides were placedin the water in several different places over the period of the initial survey most information being derived from those spaced out over large distances.The results from these slides are shown in the accompanying tables and may be broadly described as follows:-

Algal plates at Twyford nearest the sewage outflow from the Hallingbury Brook showed no green growth but rich aggregations of fungi and bacteria.Downstream at Wallbury DElls some patches of green unicellular algae were present together with a lot of brown algae most probably <u>Rhizochloris</u>.Near Tednambury the slides were very green,the above organisms still being present but now masked by filamentous alg ae.SLides at SAwbridgeworth, Station Road were essentially the same as those at Tednambury. Those at the Deeps,near Harlow marshes,showed all the above mentioned organisms but in much lesser amounts and numbers.

These slides show the badly polluted conditions at Twyford, poor oxygen levels and high organic matter content in the water.At Wallbury Dells the situation is slightly better but between this point and Tednambury the complete breakdown of organic matter into nutrient salts,mentioned in the section on chemical analysis,has taken place resulting in the "bloom" of green filamentous algae living on the rich food supply. This situation continues down to Sawbridgeworth until at the Deeps most of the nutrients have been used up and the effect of the sewage pollution at Bishops Storford is just beginning to fade.

<u>Fish.</u>

<u>History of Fishing.</u>

When the survey was first started ana attempt was made to trace the history of fishing on the Stort.

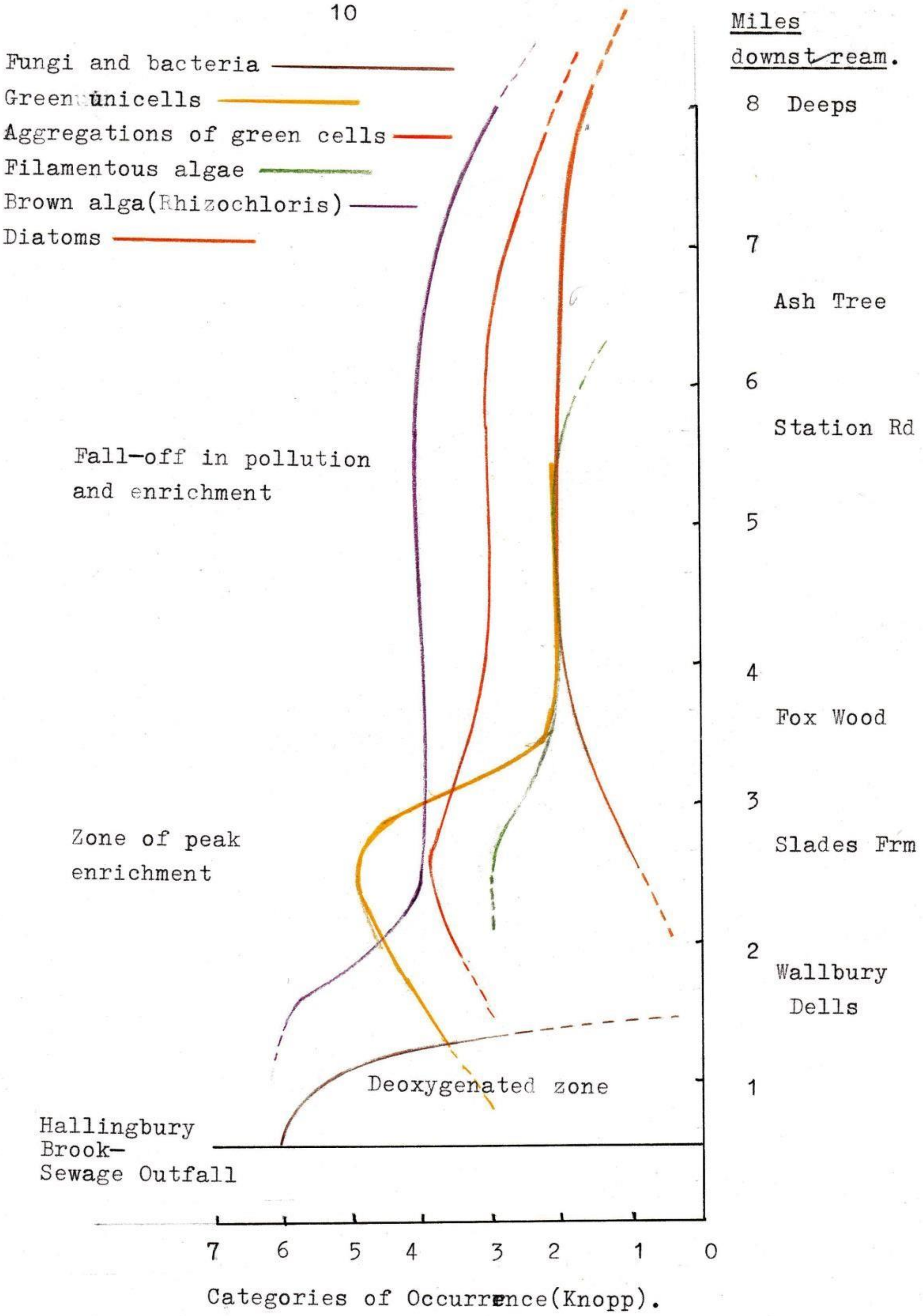


Fig.3.Succession of organisms downstream from main source of pollution as shown by algal plates.

Unfortunately little concrete information was available due to bad record keeping not thought necessary at a time when large catches were being made regularly. Traditionally roach were the main quarry and the fish most commonly caught upto the middle of the 1950's. During the first part of the author's fishing life which beganin 1955 fish of a large variety were being caught throughout the stretch, these fish and their location upto the time of the survey are shown below;-

The roach(Rutilus rutilus).

Caught over the whole water in all sizes upto 1½lbs.

Bream.(Abramis brama)

A shoal of large specimens in the "dead stretch" downstream of Tednambury lock. Ocassioal specimens caught over the whole water but no, or very few, small ones.

Rudd(Scardinius erythrophtalmus).

FEw caught until recently as a result of introduction.

Gudgeon(Gobio gobio).

Originally found over the whole water with special concentrations at places of outflow and inlet---the outflow of the backwater from the Silk Mill, the two backwater overshots by the Bombhole and before Kecksy's Bridge, cattle drink below same Maltings outflow, inflow point of the stream from Vantorts and Moor Pool.

Perch(Perca fluviatilis).

Whole stretch. Especially Maltings, Station Road bridge, Kecksys bridge and Moor Pool area.

Pike(Esox lucius) .

In same places as the perch, odd specimens being seen over the whole water. Particularly good place being confluence of the back-water and the main river at Maltings Point.

Eel(Anguilla anguilla).

Widely distributed but not often fished for.

TenchTinca tinca).

Odd specimens taken usallyin the large size range.

Crucian carp(*Carassius carassius*).
Caught more often in recent year s,often intermixed with shoals of fish of different types.

Dace(*Leuciscus leuciscus*).
Rarely caught in the main river but common int he faster pieces of backwater.

Chub(*Leuciscus cephalus*).
Again mostly in the backwaters especially at Sheering Mill.

Trout(*Salmo trutta*).
Very scarce,but known to have existed inthe past in the backwaters

Minnow(*Phoxinus phoxinus*).
Mainly in backwaters especially Bomb Hole and Moor Pool.

Stone Loach(*Noemacheilus barbatulus*).
Backaters again,especially Moor Pool.Bullhead(*Cottus gobio*), being recorded from the Pishiobury backwater.

Three-spined stickleback(*Gasterosteus aculeatus*).
Widely spread over all river and backwaters being regarded as a nuisance fish and observed in all hand netting carried out.Increased in past year s with changing conditions.

Various types of fish included in this list,it will be noted, are not ~~not~~ native to the Stort.Amongst these are included crucian carp and rudd,to a lesser extent bream and tench.Many of these fish are the result of casual introductions over the years carried out with no record of either condition,age,suitability or numbers of fish involved and no regard paid to the effect which sudden introductions could have on the existing fish pop--ulation.Records exist in memory of introductions of roach and crucian carp from overstocked ponds and lakes,rudd from the same source and bream from Rickmansworth.At one time when the lack of ifsh was first becoming apparent in the upper stretch the entirepopulation of the middle pound was moved,by electro-fishing, and reintroduced at Tednambury.One can/only hazard a guess as to the effect of this wholesale moving of a population from its natural environment into one which had already proved hostile to those which had existed there.In recent years,several thousand rudd and roach where introduced from gravel pits at Westland ~~gr~~

Green for which exact information, ~~exact~~ except numbers, is available. The fish were netted from disused gravel pits by kind permission of the owner who wished the numbers to be reduced. The fish were taken from two pits, the first containing rudd and goldfish, the second rudd and roach. Unfortunately, as is usual, no fish were examined regarding suitability before the main netting took place when all were found to be in good codition being put into the Stort at the wharf Station Road. Information concerning the population structure and growth rates can be seen in Figs . ?

Observations carried out on these fish over the weeks following their introduction showed that they formed into several large shoals each patrolling part of pound. No dead fish were observed and catches for the juvenile competitions held on this section realized large weigh-ins.

The outline history of the decline of the fishing is described in the introduction but may be broadly described as followsin Fig. 6

Disease, Parasites and Mortality.

Any fish found dead or caught as a result of netting or in a competition was subjected to an external examination of the body generally, the gills, eyes, fins and vent. If the fish was dead then the body was opened, the gut inspected and squashes or smears made of any organ having an abnormal appearance.

As the fish, especially those examined dead, came in batches it seems reasonable to describe these examinations separately. They may be divided into several sections.:-

a) Small dead fish at FEakes lock.

b) Perch caught off the Maltings Point.

c) Electro-fishing with equipment on approval in the Station Road area and backwater leading upto the railway from Station Road.

d) Unofficial netting of the Moor Pool to discourage people from fishing this "out of bounds" piece of water.

e) Large roach found dead over the whole water but mainly concentrated in the middle pound where, presumably, shoals these fish can or could survive at places where the water is oxygenated by pipe outflows or mill races.

F)Findings of odd fish.

Section a)3/5/72. Many (20) tiny dead roach and possibly some dace 1"–2½" in lenght were observed in the mouth of Feakes lock. All fish were in good condition and had been eating filamentous green algae and copepods.No apparent reason was found for their death and they were probably victims of a spasmodic deoxygenation of the water as described in the section on chemical analyses, caused by agitation of the muddy bottom or the prolific weed growth.

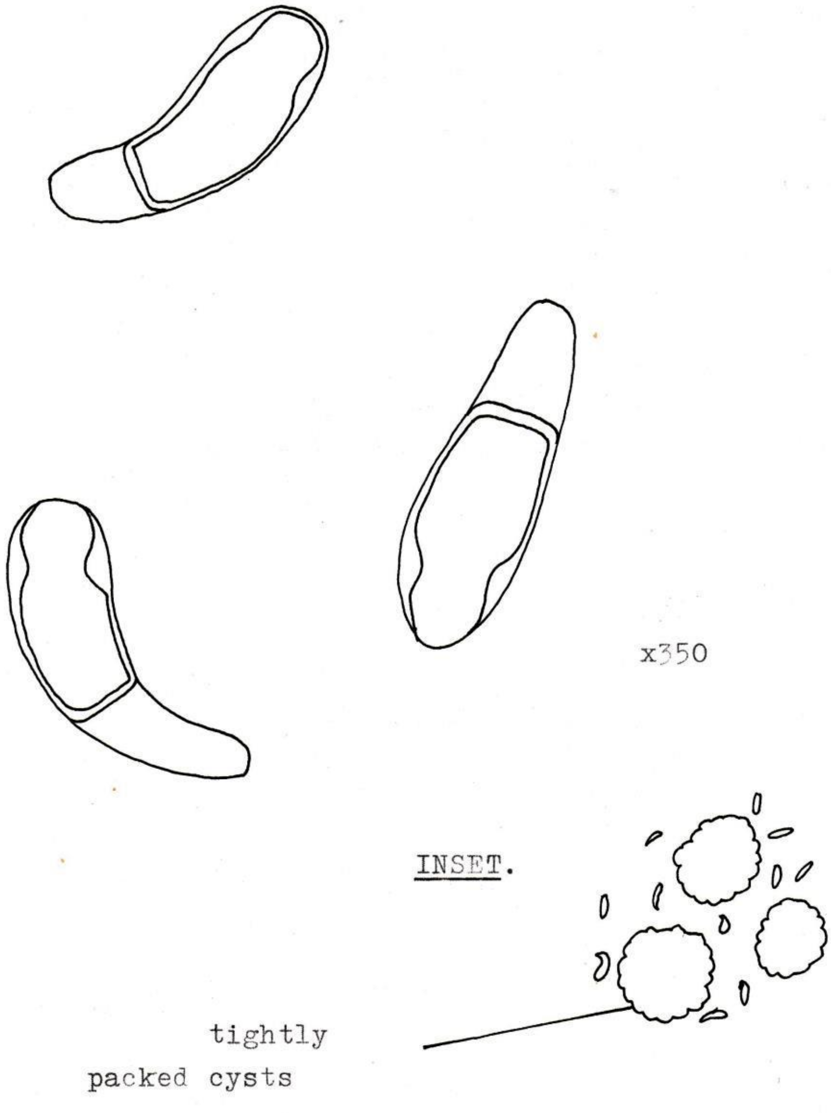
b)These perch were caught by anglers on 23/1/72 and ranged from 7¼–11½".These fish appeared quite healthy and were returned to the water.They did however have a somewhat stunted appearance and an unusual bluish sheen,their dark colouration may have been due to colour adaptation to their surroundings.These fish had distended abdomens and gave the appearance of being in spawn.

c)The growth data from fish obtained by this electro–fishing are included in the section on growth,those captured being mainly roach and dace 4"–10" all in good condition as were two chub taken from the archway where the railway crosses the river.

d)This netting produced several hundred fish of various sizes and including roach,dace,perch,pike and minnows.Roach were by far the most common fish ~~encutered~~ encountered and their growth data and size has again been included in the relevant section.Several of the roach had Argulus attached to them in the caudal region, Numbered in the catch were some large roach (10"–12")obviously old fish and some of these had ulcerated fins and patches on the body with associated fungal growth.One fish had a small mass of tissue extruded from the vent which will be mentioned in the following section.All medium and small size fish were in good condition despite odd cases of "black spot" and Argulus infection. The large ~~roac~~roach observed to be ulcerated or otherwise abnormal were retained to be passed to Mr Dave Burke at the Nutritional REsearch Unit,Huntingdon,due to a misunderstanding however this did not take place and the material wasted.

e)THis next section concerns the finding of large dead roach mainly during the summer months and is one which the writer feels needs careful interpretation if the correct results are to be realised.

Fig.4. Microscopic organisms observed in smear of diseased female gonad from roach RS 30.



The problem is complex and is set out as follows:-

1)25+ large(10½"-12")dead roach were recovered between 12/3/72 and 28/7/72 and 11/5 and 6/6/72.These periods coincide with the spawning time of roach and also regular patrols of the water to assess spawning activity.

2)Large roach were observed behaving peculiarly,swimming head up or head down,recovering balance and swimming in circles before tipping up into the vertical position again.This behaviour was observed both by the writer and also independently by other people on different parts of the water. This behaviour appeared to be a prelude to death as a dead fish was usually found on the same spot the same or the next day.

3)Most fish were slightly decomposed despite regular (daily) patrols of the water and it was possible that these fish died and sunk to the river bottom only rising to the surface when decomposition had commenced.

4)Most fish were female and full of spawn.

5)Inspection of the female gonad showed it to be fully formed regarding size but with poorly formed eggs,the gonads were nearly always cream in colour with white flecks.Squashes of these white flecks stained and examined microscopically showed them to contain vast numbers of minute bodies and cysts presumably protozoan Fig.4 .IN one case,as with that mentioned in d)MoorPool netting,the gonad had collapsed and was partly extruded through the urino-genital pore.This gonad showed the infection described above.The extruded gonad was observed firmly "insitu" and had not collapsed as a result of post mortem decomposition.

From these notes it will be seen that the problem is complex but has been summarised as follows:-

All the fish found dead were old (9-10yrs)almost at the end of their natural life span.The peculiar behaviour can possibly be explained by attachment of the water louse Argulus which must cause irritation and which has been shown to cause unusual swimming positions in the Angel fish(Kollatsch 1959) ,this does not however explain the deaths.It would thus seem that these fish are dying of a disease of some kind but until it can be shown that young fish are also infected in this way then the problem must be kept in perspective and must be most reasonably regarded as something affecting only older fish.

f) Finding of odd fish. Over the period of the initial survey several dead fish were taken from the water comprising pike, crucian carp, perch, chub, roach and gudgeon. Pike mostly came from the middle section and unfortunately were mostly too decomposed for useful autopsy, they ranged in size from jack pike (1–2lbs and less) upto approximately 8lbs, they were mostly found dead during the summermonths and could have been, especially in the larger sizes, the result of spawning mortality. The occurrence of jack pike shows that the pike at least are having a measure of spawning success and are presumably feeding upon the hordes of sticklebacks which have been shown to be one of their favourite food items (Hartley 1939).

Fish such as chub and perch were usually regarded as having been hooked badly when found dead due to their greedy and often fatal habit of bolting an angler's bait. Examination of a single chub and several perch found dead over the survey period showed nothing to refute this statement.

One gudgeon was collected for the writer by an angler who observed the fish swimming in apeculiar position which corresponded closely to that shown by the roach. Several small gudgeon were collected by another angler from the middle section and reported asfew from many fish being turned up by the discharge from a pipe at Lawrences. This discharge has not been noted but occurring on a Saturday morning may carry the washings from machinery cleaning and will bear further investigation.

Several fish including roach and crucian carp were examined with cuts mainly on their backs and are probably the results of injury from boat propellers.

Lastly in this section the occurrence of the eye fluke Diplostomum will be mentioned. This parasite was found to a greater or lesser extent in allfish, native to the river, which were examined dead. The parasite is transfered to the fish when the latter eats a water snail.

The snail itself has already become infected by eating the dropping of a water bird,the cycle is complete when the water bird eats an infected fish and thus becomes infected itself.The parasite rests in the eye lens of the fish where it forms an opaque mass, this must interfere with vision but in turbid river such as the Stort vision can be of little use and fish usually find most of their food by smell in any case.

<u>Recovery of introduced fish.</u>

This deals with the fish introduced into the river from Westland Green during the summer of1972 and subsequently a few of which were recovered and 10 of these retained in the same autumn.These fish as mentioned,were still in good condition but most had the water louse Argulus attached to them in the tail region.Ten fish were retained in atank over the Winter in river water with an aerating pump,nine of the fish were rudd and one roach.Several died during the Winter and finally all within a space of 3 wks in the Spring.Several of the fish showed loss of orientation and isolation from the others before becoming fungus covered and dying.One had a rotted tail fin.Some fish sank when they died and others floated.Due to the inexactness of the experiment and the lack of scientific control the results can be considered of little use except perhaps to show the way in which a population of fish can dwindle and disappear maybe a situation which is reflected in the river itself.

Age, Size and Growth.

Due to the difficulty in electro-fishing or netting with regard to the Lee Conservancy byelaws a complete sample of fish taken from a stretch of water was unobtainable. In the absence of proper sampling techniques the only obtainable fish were those taken dead from the water, one session of trial electro-fishing and the netting of the Moor Pool to prevent illegal fishing.

Large numbers of fish must be measured and their scales read and recorded before reliable results can be obtained and at the present time this number has not been reached to the writers satisfaction. Nevertheless provisional graphs of growth rate for roach have been prepared and are shown in the following figures.

Information for the construction of these graphs was obtained by the standard method of scale reading, measurement and back-calculation. Scales were measured either by scale projection or in the case of small scales by projection from a microscope onto a mini screen.

The scales were divided into 4 batches. The first of these comprised all the scales available from fish taken from the Stort. As fish do not increase in length in direct proportion to their scale size a correction factor is usually involved to obtain the correct length of fish per annum i.e. an older fish will increase more in girth per year than in length whilst its scales still grow at a constant rate. Calculation showed a correction factor to be unnecessary for the fish examined and the results are shown in Fig 5 . This graph shows good growth rate of somewhere in the region of 1 inch per year body length. The fish show a constant growth even increasing upto 1 inch per year when the fish reach old age. Maximum size seems to be in the 11½–12" range. It must be emphasised that these graphs are based on average figures taken from 100+ fish and within this number are fast and slow-growing individuals. Several sets of measurements from fish recovered from the middle sectio were observed to be almost identical when back-calculated and these fish were all spawned in the same year and could probably have been brothers and sisters belonging to the same shoal which was spawned in a "good year" in this case 1963.

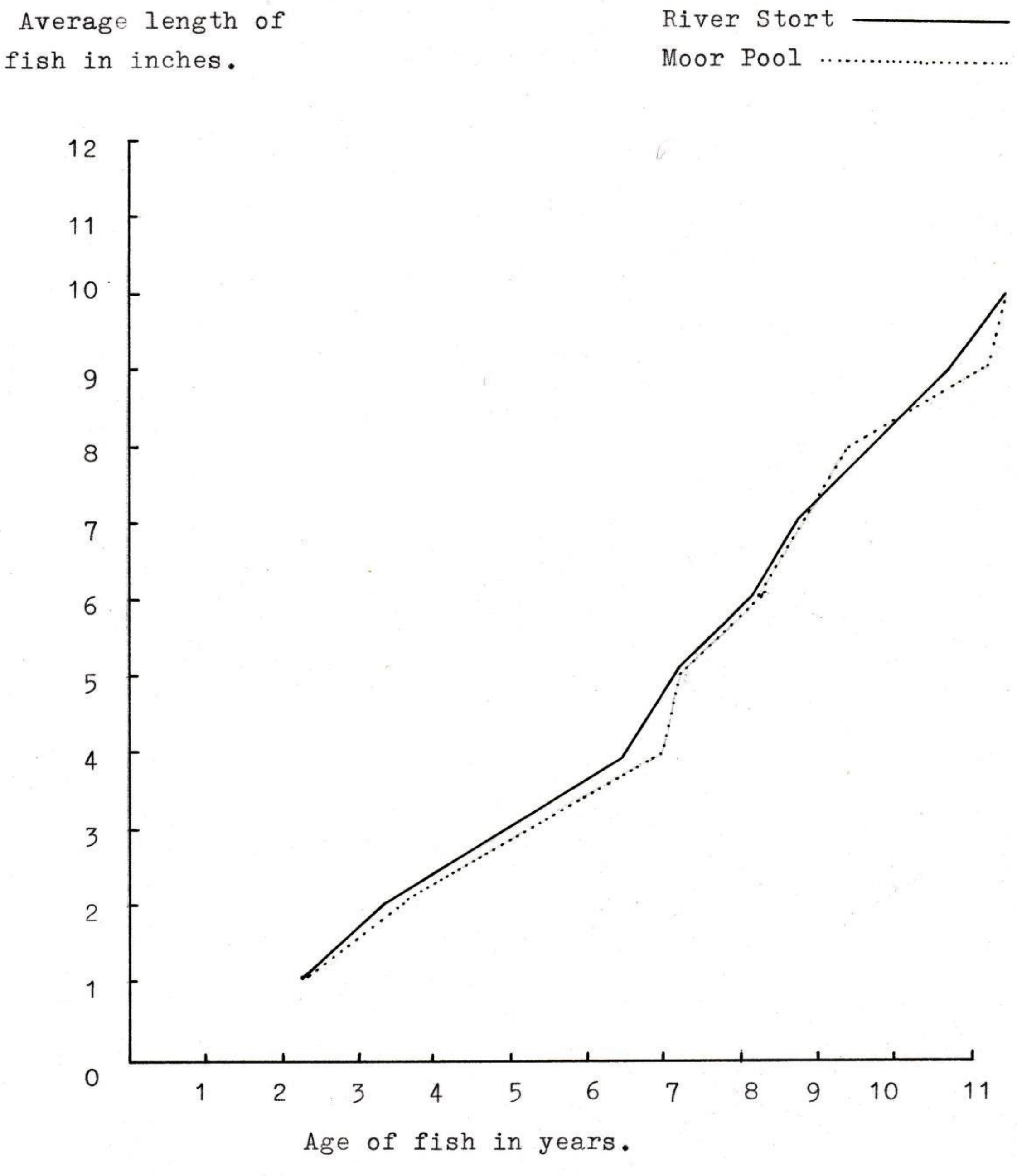


Fig.5.Annual growth of River Stort roach expressed in length.

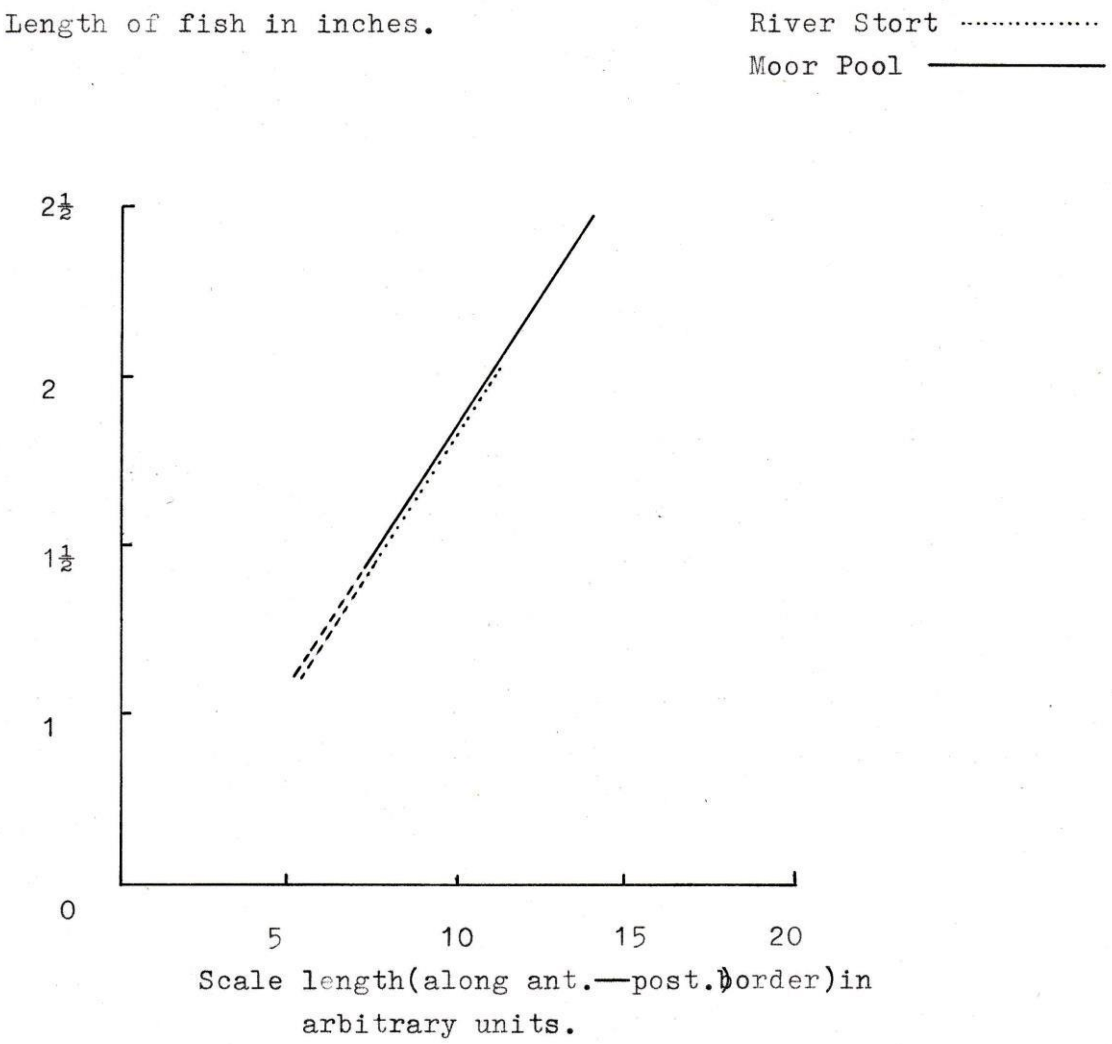


Fig.7.Growth rate in the first period of life of young roach from the Stort and the Moor Pool.

Alongside the graph of Stort fish is shown a line plotted for MoorPool fish.This line is essentially identical to that for main river fish and in any case these were probably derived from the main river during flooding.

Graph 7 shows the fry examined from the Moor Pool and Feakes Lock.The scales from these fish were very tiny and difficult to read accurately.It seems however that these fish support the back-calculation from the main river fish in that those being 1 yr old i.e. from June 1972 to June 73 were on average $2\frac{1}{4}$" in length. Fish recovered from Feakes lock in May 1972- were on average $1\frac{3}{4}$" in length further supporting the back-calculation.

Graph 6 shows the fish introduced from Westland Green.Data for this graph,plotted for rudd,is insufficient but it has been included for interests sake.It shows that the fish,although being, rudd,as compared with roach in the Stort show a significantly lower growth rate due to overcrowding,thus at 3 years Westland Green rudd were only 3" as against5" for Stort roach and at 5 years $5\frac{1}{4}$" against 7" in the Stort roach.The graph whilst not qualifying for serious examination shows a situation similiar to that of a stunted population.In this case the older fish grow fastest,this could possibly be attributed to a different diet or better ability to feed,it is more likely however that the older fish were the original introductions to the pits and that their progeny shown in the lower part of the graph are the fish which are having to battle for food in reduced supply and are consequently a little stunted.

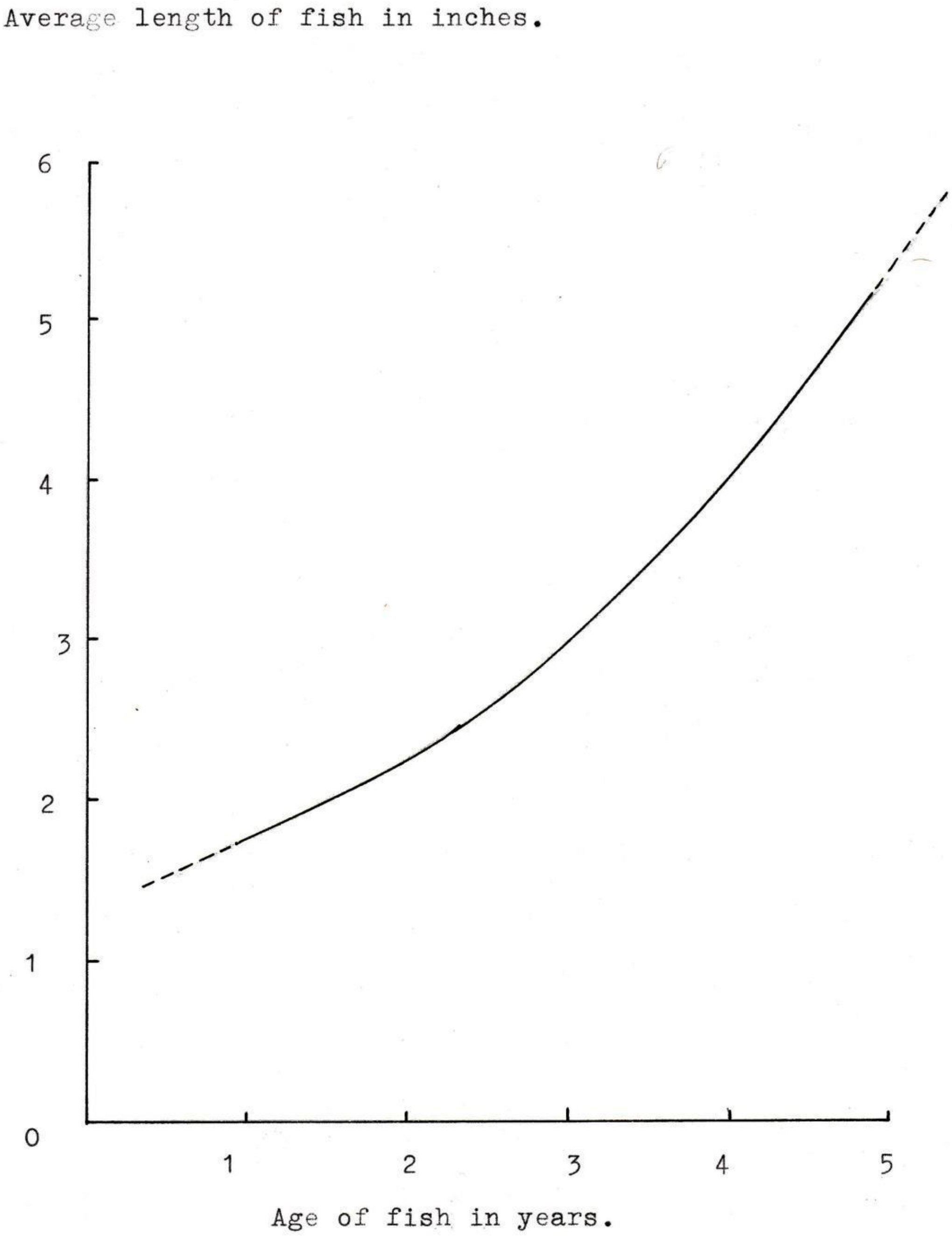


Fig.6.Annual growth expressed in length of rudd from Westland Green.

Discussion.

The results of the initial survey whilst not having produced a conclusive explanation forthe disappearance of fish life from the river has neverthe less supplied very many significant and interesting observations and records upon which ideas may be fairly based and which must provide a pointer for further work.In this discussion all available information will be reviewed and put on record---many theories regarding fish disappearance have been advanced over the years based mainly on casual observations by anglers which,whilst not standing upto scientific examination and reasoning,neverthelss very often have an underlying truth which must not be disregarded.These theories will be reviewed in the light of the information and observations obtained by the writer and ne w ideas advanced and discussed.

The first fact to be presented is that work described in the prceding sections has shown the Stort to be polluted by poorly treated sewage effluent.This fact ~~is~~ in itself ~~theclusiveandydoes much to explain many observations made i n~~ is conclusive and does much to explain many observations made in the river today.People have at various times blamed the riv er bottom for fish deaths or disappearance.As every angler and casual observer knows the river bed is covered by a fine dirty mud or silt deposited from the effluent itself and from the decomposing plant material.During the summer the river bottom gives forth bubbles of gas and sometimes erupts in extreme cases,at such times the water loses much of its oxy gen to the over active decomposition of this silt.Also during warm weather clumps of brown or green slime are seen to rise to the surface,this slime is merely thousands of tiny microscopic plants growing very fast inthe rich water of the effluent,as they grow fast so they work fast producing a lot of gas,in this case oxygen,and not being firmly attached to the silty river bottom lose hold and are buoyed upto the surface by the bubbles of gas of their own making.Both these processes,whilst not being typical of a healthy river are n not acutely dangerous to fish life unless they occur on an exaggerated scale as a result of a period of hot sunny weather and low flow rate and must be considered only contributory to and notthe main reason for the disappearance of fish.

Another common theory often advanced is that 3-spined sticklebacks have reportedly been witnessed eating the spawn of other fish. It is possible that as with most other types of fish sticklebacks do eat spawn but it is unlikely that this occurs on such a scale as to affect a whole population, after all the reason that fish lay many thuosands of eggs at one time is in the hope, and to cater for the fact, that only two fishor eggs must survive in order to replace th e two fish which laid them. It is far more likely that stickle backs were either present in small numbers before the pollution or were introduced at a time when the pollution first began. When the population of the other fish began to fall as a result of this pollution the stickleback which can tolerate a mild level of pollution found that it had a lot of river and alot of food to itself and consequently it s numbers exploded to the levels we know at the present time. It would be a great surprise that if, when the quality of water in the river improved, the stickleback, once again finding itself in competition with other fish had forced upon itself a reduction in numbers to somewhere in the region of its former status.

The writer believes that the problem is complex and cannot be ascribed to a single cause. The following observable facts can be set out:-

Firstly the flow in the main river is sluggish, the bottom very muddy and weedy, only large fish are caught in few numbers.

Secondly, in the backwaters the flow is mainly brisk, the bottom clean, usually gravelly and although fishing is not allowed in backwaters fish of all sizes can be observed.

These facts suggest that flow rate is an important factor regarding the success of fish life, not only ensuring good oxygen levels in the water but also, if not more important, keeping fine sediment on the moveand not allowing the accumulation of decomposing mud banks. It is thought that this fine sediment could easily smother both fish eggs and fry preventing hatching and clogging the gills of young fish.These same small fish would fine it very hard to survive in the priodically deoxygenated conditions of the main river, It will be noted that the eggs of sticklebacks are laid in nests and both these and the young which hatch out are shielded from the rain of fine sediment and given a good supply of oxygen by the fin movements of the adult stickle back.

Death of eggs and fry over a number of years would very soonresult in a drop in fish numbers as the older fish died off.It is thought that the situation would be essentially the same as that witnessed at Tednambury where only larger size fish were caught after a time.This can be explained by the cessation of spawning or spawning success ~~at more or less~~ fairly completely over one or more seasons,this would create a cut-off of young fish to replace those dying of old age,disease or predators the remaining fish would grow larger and become old giving that situation found during the 1950's when few or no small fish were caught in the Tednambury section.The situation was probablyrepeated at Sheering Mill where due to the abundance of small fish the population was probably differently structured to that in the upper reaches consisting of many small and medium sized fish of the same age as those of a larger size upstream. As only the larger size fish were being caught inthe 1950's then it can be assumed that the success of spawning was being affected some years earlier(if a sizeable fish is taken to be 5years old) and this can probably be related to the increased inefficiency of the sewage works as a result of overloading from the swelling population of Bishops Stortford in the post war years.The downstream extension of the zone of pollution must have stayed fixed for some time with its lowest point in the region of Tednambury where an effect detrimental to the fish life could be felt. The peak of inefficiency of the sewage works was probably seenin the late 1950's when the zone moved right down to

Sawbridgeworth and brought about the disappearance of the large numbers of medium and small size fish which had, previous to this time, been thriving in the lower Sheering Mill section

It is thought that the process of fish disappearance is more likely to be associated with something basic such as spawning which would have a long term effect rather than a sudden fatal pollution leaving only a nucleus of surviving fish, a pollution of this nature would soon pass through, once again leaving conditions suitable for fish life, which would soon increase.

Evidence obtained from dead roach collected during the spawning periods of 1972-73 suggest that disease may also be interfering with spawning. Although as described inthe relevant section these fish were old and near the end of their life span they did nevertheless have gonads in a developed but diseased condition which would have affected spawning. As described in the section this disease is something of a mystery but would typically be spread in a gradual downstream movement giving a picture similar to the fish disappearance ascribed to sewage pollution above. An idea wasput forward that the disease could be carried by the water louse _Argulus_ which transferred the disease to the fish when feeding upon the latter. It was thought that fish living in the backwaters in fast flowing water would be less likely to become diseased as the water louse [illegible], being saucer-shaped, would find it more difficult to attach itself to a fish in faster water. This idea lost some weight when fish netted from the Moor Pool, living in fast water, were found to have water lice attached to them although these same fish could conceivably have been swept over the weir in time of flood from the main river.

The Future.

The future of the Stort concerning angling and all plant and animal life isxx dependent upon events affecting the sewage pollution.It was known for some time that sewage effluent containing an unacceptable level of harmful substances was being discharged into the Stort but due to economic and political circumstances little was done to catch up with the increasing inefficiency of sewage works along the river caused by overloading from the increased population of the area.The local,Sawbridgeworth,sewage works originally produced a good quality effluent as witnessed by the good fishing at the outflow,it was closed in the 1960's after deterioration and discharge is now directly into t the trunk sewer to Rye Meads.A temporary pl ant designed in Holland for use in small v villages or hamlets was installed at Bishops Storford until eventually the construction of a new works wa s put in hand and which is scheduled to be completed this Autumn.Several members of the Angling Society including the writer paid a visit to the almost finished works by the kind permission of Mr Dave Marpole,chief chemist,who also gave a guided tour to explain the benefits and working of the new system which has the advantage that it can be added to as demand requires without loss of efficiency. Briefly,the new works situated in Jenkins Lane to the East of the old site consists of several large sedimentation tanks,oxygenation channels and grass plot discharge areas. These latter are designed to give a "better than average" effluent regarding dissolved and suspended organic matter over high levels of which have caused the trouble in the river upto the present time.The grass plots of the old sewage works which used to be the only process apart from filtration for kraakin breaking down the sewage had been allowed to fall into d decay and contributed very much to the decline in the quality of effluent from the old works.

The effluent produced by the new works,whilst still polluting the river,as axxy any addition to the river by

Man must be,the effect will be much reduced and any adverse effects will have died away by the time the water reaches Sawbridgeworth.Nutrient salt enrichment of the water will still take place but in alow concentration which will,it is hoped,be beneficial in stimulating reasonable levels of weed and fish food.

Even though the quality of water in the river should soon be satisfactory to fish life their is still remaining the legacy of years of sewage pollution in the banks of fine sediment which have accumulated on the river bottom both directly from the sewage and indirectly from the excessive weed growth stimulated by the sewage.This fine sediment, especially noticeable in the slower or "dead " parts of the river,is known as septic silt by fishery biologists and becomes active in warm weather being susceptible to eruption liberating quantities of gas into the water which can be observed by any angler or casual passer-by.These eruptions are usually on a small scale when they do little or no harm but occasionally, when conditions are favourable as after a period of warm weather and low rainfall whole portions of the river bed erupt dispersing large quantities of decomposing organic matter into the water resulting in the complete deoxygenation and fish deaths.This threat to the fish life is most likely to occur during the warmer summer months when fish fry and eggs are about and must have contributed much in recent years to the disappearance of fish fry from the river.The obvious solution to this problem is to remove this mud by dredging thus presenting a clean bottom with clean water flowing over it which should give fish every chance of a good comeback. Unfortunately,this dredging,which has already started mainly to provide easier mooring for the ever increasing army of summer boat traffic,must be carried out with care and forethought if the intial effect on the fishery is not to be detrimental and take some years to rectify itself. At the moment dredging is carried out throughout the year irrespective of whether the fish are spawning or the weather is hot and sunny and flow rate low,the effect of disturbing the river

contd...

bottom in these conditions could have a disastrous effect by causing an artificial eruption of the mud and effectively deoxygenating the whole water.The dredging at the moment is too severe,the bottom being dug out deeply right into the bank leaving no marginal weed to provide shelter and food for the fish.In several places where dredging has already taken place the bottom must be a veritable desert as the water is now too deep to allow weed growth which needs light,not found at depth in a turbid river like the Stort.Deep holes in ariver are fine if they are surrounded by weeds in natural depth water into which the fish can flee from danger and also find their food.

It was mentioned earlier that dredging is taking place mainly for the convenience of the boating fraternity on the river.Boats have always used the river for which the navigation is intended but boats and boat traffic have changed over the years and nowadays the Stort is becoming victim to the small pleasure craft owner who,will, in the next few years it seems,if the sharp rise in the number of moorings and boatyards are any indication,be crowding both themselves and everybody else off the river in much the same way as the selfishness and impersonality of the motor car has reduced motoring for pleasure into a race,danger and frustration. The writer believes that on a medium-sized river such as the Stort with a low flow rate,due to artificial enlargement of the channel by dredging and canalization,the number of boats should be limited in order to preserve everbody's pleasure, both boat owner and angler alike,and to reduce the amount of water let away by each craft as it passes through a lock.

Weedcutting is carried out in ahalf-hearted manner every year by both the Angling Society and the Waterways Board.This weedcutting is spectacular in its effect but only prunes the weeds causing them to sprout even further,cut weed left in the river can rot and deoxygenate the water and if,as is usually the case with the Waterways Board it is carried out in mid summer when weed growth is strongest and boat traffic heaviest then it must account for much of the mortalityof fish eggs and fry which are dependent at this time of the year on the weed growth for food and shelter.

Restocking.

The question of restocking is one which has reeived a lot of attention of late both within the Angling Society and also on a nationwide scale.The restocking of a body of water with fish,and especially a relatively uncontrollable body such as a river regarding flow rate,boat useage,dredging and ownership,is always a dicey business but the points which should be borne in mind are set out as follows:-

a)Restocking with fish which anglers will return to the water at the end of the day,aims to produce a balanced population

b) to ensure a continuous flow of sizeable fish.In order to avoid imbalance e.g.too many small fish,few large fish etc,. the existing population must be accurately determined regarding numbers and rate of growth compared with age.

c) The potential ability of the water to support fish life must be known,that is the amount of food available,its type and suitability.This determines the number and type of fish to be introduced and is again information which can be gained by examination of the existing population—what they eat,-and how much in comparison with age,size and growth rate.

Before any restocking which is going to give a satisfactory result,can take place the above facts must be known.This is a difficult task in any water but made especially so in a river by the changing conditions,both those in Nature and those engineered by Man in the way of dredging and weedcutting.

As the water quality of the Stort is obviously going to improve and dredging of at least part of the water is taking place a favourable environment for fish life must be created and it is this new water and its ability to hold fish which it is proposed to study in the second part of the project.

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C.Van.Duijn.Jnr. Diseases of fishes. 3rd Edition.

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T.T.Macan and E.B.Worthington. Life in Lakes and Rivers.

Reprints of various scientific papers kindly given on request by V.M.Brown,Head of Fish Section,Water Pollution Research Laboratory,Stevenage.

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Ian R.Ball. The relative susceptibilities of some species of freshwater fish to poisons. 1-Ammonia. Water Research Vol 1 pp.767-775.

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Appendix 1.

List of chemicals and chemical analyses.	Supplier.
Test for dissolved oxygen.	
Winkler method.	
MAnganous sulphate. 500gms.	Frank W. Joel.
Sodium thiosulphate. 500gms.	" "
Concentrated hydrochloric acid. 1 litre.	Solmedia Ltd.
Sodium hydroxide. 100 gms.	"
Starch solution. "	"
Ammonia.	
Nessler Reagent. 100mls.	"
Ammonium chloride.100gms.	"
Nitrate or nitrites.	
Sodium hydrogen sulphate. 100gms.	"
Diaminothanatetra acetic acid. 100gms.	"
Zinc dust. 100gms.	"
Dissolved organic matter.	
Sodium hydrogen sulphate.	
Potassium permanganate.100gms.	"
Chlorides.	
Potassium chromate.100gms.	"
Silver nitrate.	"
Dissolved carbon dioxide.	
Phenolphthalein.100gms.	"
Sodium hydroxide. 100gms.	"
Oxalic acid.100gms.	"
Methyl orange.100gms.	"

Procedures and techniques for the chemical analyses were standard as described in McLean and Ivimey Cook—Practical Field Ecology (see refs).

Appendix II.

General Apparatus.

Glassware.		Quantity.	Supplier.
Pipettes	1ml.	2	Solmedia Ltd.
"	5ml.	1	"
Burette.	25ml	1	"
Distillation flask.		1	"
Conical flask.	250ml	1	"
Measuring cylimder.	100ml	1	"
Assorted pyrex beakers.			
Reagent bottles.	1 litre.	2	R.B.Radley Co.Ltd.
" "	250ml.	2	"
Water sampling bottles.	125ml.	10.	Solmedia Ltd.
Necked vials with plastic stoppers.	3x1"	2 gross.	"

Miscellaneous equipment.

Plastic petri dishes.	G.L.
Filter paper.	
Wires to support corks for algal plates.	
Corks for same.	
White plastic water sampling bottles.100mls.x30.	Solmedia Ltd.
Plastic trays for carrying equipment.	
Stop watch.	Mr D.Verlander.
Aquariums x3.	R.J.R.
Aerating pumps for same.	"
Binocular microscope.	Dr K.Snow.
Macan Shovel with net,	R.J.R.
Large fry net.	"
Maximum and Minimum thermometer. x3	
Polythene gloves. 1dozen.	Frank W.Joel.
Turbidity guage.	G.L.
Distilled water.2 litres.	Frank W.Joel.
Guaze mat.	R.B.Radley Co.Ltd.
Retort stand clamp.	"
Polythene funnels. x2	Solmedia Ltd.
Steriform(40% formaldehyde).5gals.	