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Institute of Freshwater Ecology

ROMANIAN FISH POND ENVIRONMENTAL STUDY: Report on a visit in September 1994 to determine the feasibility of, and make recommendations on, an ecological programme to assess the effects of carp ponds on water quality

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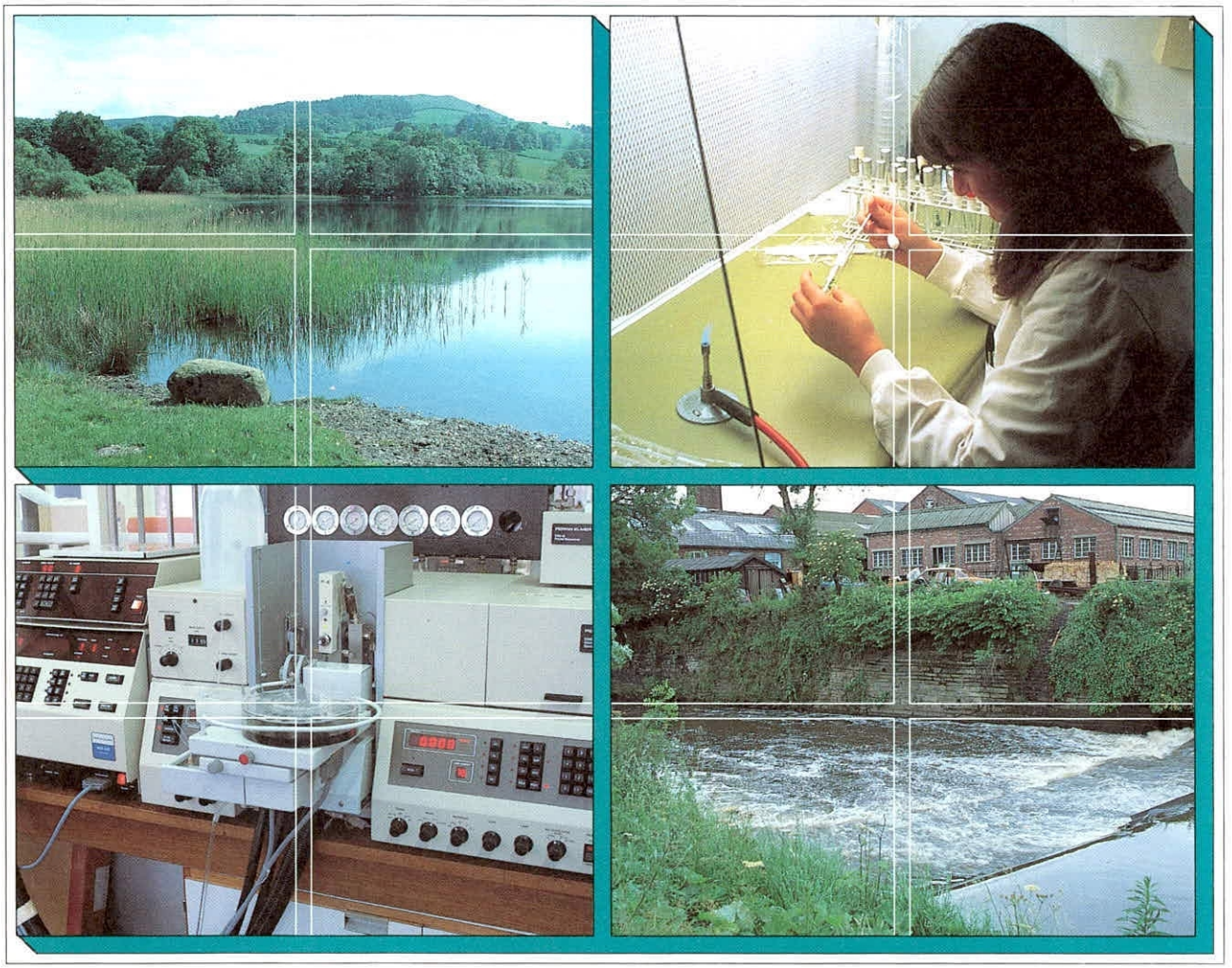
Report to the Natural Resources Institute (October 1994)



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Final report to the Natural Resources Institute
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Summary and Recommendations

1.A three-week visit to eastern Romania was made in order to consider whether carp ponds act as filters and purifiers of the water passing through them; if they do, fish farmers may be justified in requesting that the Ministry of the Environment discontinues its practice of charging fish farmers for the water that they abstract from the major rivers and for the water they return to these systems as 'effluent'.

2. Visits to the Ministry, the fishery research institutes at Nucet, Piatra Neamt, Iasi and Galati, and the commercial farms at Crevidia, Trifesti, Bidesti, Tiganasi, Vladeni, Brates, Cotul Chiului and Ianca, suggest that existing data are not sufficient for establishing whether carp farming improves water quality; the feasibility of mounting a new, year-long environmental programme was thus investigated.

3. Capability in freshwater ecology within the pool of Romanian scientists with whom discussions on project planning, field and laboratory methods, and data acquisition, handling and interpretation were held, is certainly sufficient for the programme envisaged. Problems stemming from the somewhat limited equipment resources in the fishery institutes could be partly solved by a modest input of simple, basic field sampling and laboratory analytical equipment appropriate to the demands of a study that would focus on systems which are mainly less that 2m in depth, and reasonably rich in nutrients and aquatic organisms.

4. Good progress was made towards (i) selecting the scientists and fish farms that should be involved in the new study, and (ii) identifying the main elements of the sampling programmes and the scope of analyses and data recording necessary. However, it is strongly recommended that a 3-day workshop be held in late January/early February 1995 prior to the start of the programme, in order to finalise details on all aspects. The meeting would be led by IFE scientists. Such an exercise would certainly be enthusiastically welcomed by the participants, since it would increase Romanian awareness of 'western' ideas, approaches and technology in a number of limnological areas relating to fishery management.

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Romanian Fish Pond Environmental Study

Report on visit in September 1994 to determine the feasibility of, and make recommendations on, an ecological programme to assess the effects of carp ponds on water quality

I. Background and rationale

1. Fish producers in Romania have to pay the Ministry of the Environment (MOE) for the water passing through their ponds. The charges levied vary (**Table 1** gives some examples), but they commonly form a major component of farm operating costs, and may be as much as those charged for irrigation. There are also financial penalties for discharging effluent with concentrations of various major ions and nutrients, that deviate from norms set by the ministry. Yet, the industry and the fisheries research institutes have suggested that the fish farms actually use very little water, as almost all of it is returned to the watercourse a short distance downstream from the point of abstraction. Moreover, it is felt that the larger ponds used for aquaculture in Romania may act as biological filters and purify the water passing through them. If this is true, the fisheries industry - through the Romanian Fish Producers Association (ROMPESCARIA) - could make a case for a substantial reduction in the charges levied by MOE.

Table 1: Water charges (for both supply and discharge unless otherwise indicated) levied by the Ministry of the Environment on fish farmers

Sources of information	Charges levied
'Vermatta' s.a. - Brailla Ciutea - Neamt 'County' Vladeni Ianca	supply: 40 lei m^{-3}; discharge: 22 lei m^{-3} 5M lei/500ha to 1 m depth i.e.1 lei m^{-3}1 lei m^{-3} 30 lei m^{-3}
Government Decision no. 861/31.12.1992	Surface water, domestic river sources: 65 lei per 1 000 m^3 Danube source: 15 lei per 1 000 m^{-3}

2. The present document follows a proposal for an environmental study to address these issues. It reports on the findings of a 3-week visit made to Romania with the view to assessing the feasibility of mounting a programme to establish the impacts of carp ponds on water quality, and making recommendations on the nature of such a study.

II. Terms of Reference

3. - to identify the factors likely to affect the quality of water passing through carp-rearing ponds

- to establish, from existing data, the extent to which fish ponds may purify water
- to decide whether a new monitoring/surveillance programme is firstly, warranted, and secondly, feasible
- to visit a range of commercial carp farms to the east of the Carpathian Mountains, and discuss with farmers the schedules and methods used for managing the ponds
- to visit a selection of fishery research institutes involved in physical, chemical and biological analysis of freshwaters
- to select the sites for intensive environmental monitoring
- to select the most appropriate scientists/consultants to carry out the monitoring and coordinate the programmes in different parts of the country.
- to design a survey programme for local consultants to monitor changes in inlet water, pond water, and effluent quality over a full year
- to advise on the field, laboratory and data analytical methods and scope of analyses required to assess whether water quality differs between fish farm inlets and outlets
- in collaboration with the project field manager, to draw up contracts for the local consultants required
- to prepare a summary report of findings and recommendations for the field manager before departure from Romania; the report was completed, and copied to those attending the 'round-up' meeting at ROMPESCARIA on 22 September
- to prepare a detailed final report (i.e. this document) for approval by the project manager within four weeks of return to UK; an extra week has been set aside for this purpose.

4. The three-week itinerary is summarised in **Appendix 1**. The various visits were aimed at assessing the suitability of personnel and institutes and fish farms to contribute to a new environmental surveillance and associated analytical work. It is essential that the main strengths of the research bodies in various aspects of water analysis, are integrated with the skills of the commercial fish farmers, in such a way as to capitalise fully on the the field situations provided by the farms. While the main focus would probably be on physical, chemical and biological aspects of water quality, it is necessary to be aware of other issues such as toxic algae, high salinity soils, and fish diseases.

5. Regardless of the financial implications of the results of the proposed study, an objective scientific approach will be adopted throughout.

III. Progress with the individual terms of reference

Factors likely to affect the quality of water passing through carp-rearing ponds

6. The quality of water exiting from a fish pond may, as a result of the filter-feeding activities of e.g. certain zooplankton and fish species, be of superior quality to the water that originally entered the system. However, there are many mechanisms whereby the practices and management of carp ponds have the potential to impair water quality. **Table 2** gives some indication of these, and highlights physical, chemical and biological indicators of impairment. A key determinant of whether there is a net deterioration or improvement, is the timing of pond filling and drawdown/emptying. By enhancing knowledge about the dynamics of the various physical, chemical and biotic components of ponds, the new project could initiate management strategies that maximise the chances of releasing water ('effluent') that is of better quality than the feeder water.

Existing data on the extent to which fish ponds may purify water

7. A considerable body of data on surface water quality in Romania already exists. The MoE, for example, coordinates the sampling of some 400 sites for chemical analysis, and at many of these points water usage (volume) is also monitored twice per month. Data are also available on the quality of water entering and leaving fish farms in regions covered by the Piatra Neamt Laboratory of Aquaculture and Aquatic Ecology (part of CCPPPIP, Galati), but mainly only for the 'vegetative period'. Also, while primarily chemical, analyses are carried out on other pond waters e.g. the Trifesti series, this is only the case when the laboratory service is free-of-charge. With usually a mix of fish including 80% chinese carps, a number of farmers reckon that the effluent they discharge is of better quality as regards COD and organic matter content, than the water supplied to them; again, however there were no data immediately to hand to support this view.

8. At a number of the sites visited during this mission, ponds were manifestly laden with algae - including potentially toxic blue-green species - and thus extremely murky. The almost inevitable, albeit perhaps seasonally restricted deleterious effects of such enhanced algal growth on oxygen demand is a major concern. Ideally, the main goal is to achieve maximum algal production *per se*, but with conversion to fish flesh, not accumulation of algal biomass. In other situations, the movement of fish was plainly contributing to high water turbidity. Especially as this particular visit followed a long spell of very dry weather over the eastern side of the country, these observations do not mean to say that ponds are necessarily always in such an undesirable condition. However, if water of this type were to be released/discharged, it is likely that this 'effluent' would be deemed to be of poorer quality than that originally abstracted from rivers or other sources and used to fill the ponds.

Some preliminary thoughts on areas of work that might be incorporated into the project to assess water quality and any effects of fish farming on this

Water quality parameters to be measured	Possible reasons for changes in water quality parameters
Physical:	
Turbidity	increased disturbance of mud by fish; decreased sedimentation;
Colour	increased disturbance of mud by fish; decreased sedimentation; increased algal growth
Odour	algae; fish; fish products
Chemical:	
Nutrients	waste feed and excretory products; inorganic fertilisation?; increased re-cycling from algae and/or macrophytes;
De-oxygenation	accumulation of organic matter; increased oxygen demand especially under ice
Pesticides	fish medicaments;
Vitamins and other food additives	waste feed and excretory products;
Biological:	
Bacteria	organic and inorganic enrichment;
Algae	organic and inorganic enrichment;
Zooplankton	increased algal (food) biomass;
Benthic invertebrates	increases in organic particles and enhanced primary productivity and algal biomass formation;
Fish parasites	increased numbers of fish;

Is a new scientific programme warranted and feasible?

9. It is contended that a new monitoring/surveillance programme designed specifically for assessing carp pond effects is warranted. For a number of reasons outlined above, specific questions over whether ponds lead to better water quality, cannot be answered by existing data. A new (Know How Fund) project would, nevertheless, include a review of this information. Discussions with environment ministers, commercial farm managers, and fishery engineers and research scientists, suggest that such a programme would be widely and enthusiastically welcomed. The Ministry suggested that any new results should be adequately assessed in the context of its national programme, and the country-wide water quality standards which are to be embodied in a new Water Law that is imminent.

10. Each of the research centres visited has strengths in theoretical and practical aquatic science and/or project co-ordination. The new project would capitalise on these resources. Some thought was given to whether medical schools or agricultural departments. for example, might be better equipped than fishery institutes, for some of the chemical analyses envisaged; however, it was concluded after visiting the various institutes that such 'sub-contracting' is not merited..

11. The outputs envisaged from the new exercise would include information on the following environmental aspects, which would be related to the various activities in the pond managers' calendar: seasonal changes in the quality of feeder water, pond water and outlet (effluent) - as and when these exist - as indicated by (i) physico-chemical analyses, and (ii) assessments of the species composition and abundance of the populations of planktonic algae (phytoplankton), rotifers and micro-Crustacea (zooplankton), and invertebrate communities associated with pond and stream sediments (zoobenthos).

Commercial carp farms visited, and the discussions held with farmers on the schedules and methods used for managing the ponds

12. **Appendix 2** lists the farms and ponds that were visited, and the personnel met at these sites. The visits were usually made in conjunction with tours around the four institute locations discussed in 5 below, and commonly with staff from these institutes. The main aim was to gain information on pond management practices and the schedules of pond fertilisation and fish feed applications, and the timing of (i) pond filling and (ii) drawdown/evacuation for fish harvesting. As these operations may control to a very large extent the seasonal changes in pond water quality, they can also have a considerable bearing on the following:

- the quality of water that is discharged as 'effluent'
- the sampling schedules to be operated in any new field project
- the gathering of the critical data on the quality of incoming and outgoing water (on which MOE charges are based).

13. The visits also provided an opportunity to hear farmers' views on potential sources of enrichment (eutrophication) that are not due to fish-rearing *per se* but could still lead to impairment of water quality and potential fines; diffuse run-off of material from agricultural land and waste from intensive livestock holdings, appeared to be the main issues here. However, while households might also contribute to enrichment through the disposal of sewage, these were not mentioned.

14. While institute research farms and 'non-carp' aquaculture systems were seen (see **Appendix 1**), this report concentrates on commercial farms, and an assessment of their potential as sites for the new study. The visits were thus confined to the following: Crevidia, the Trifesti and Bidesti series of ponds, the Tiganasi ponds, Vladeni, two ponds at Brates and at Cotul Chiului, and Ianca.

15. The farm at Crevidia farm consists basically of two parallel, dammed systems above Lake Buftea (which itself covers 260 ha). The farm operates polyculture and has 170 ha of ponds: 8 ponds for growing fish to 2 y, 2 ponds for 2 y+, and a total of 21 ha put over to the rearing of fingerlings. Total annual production (yield?) is reported to be 200 t. While, in a bad winter, ice (covered with snow and therefore leading to de-oxygenation) may last for 4 months, the average duration for ice is 3 months. No one seems to know whether Lake Buftea (which receives water exiting from the farm) has changed in character since farming operations began. However, carp rearing practices *per se* are unlikely to constitute the main source of enrichment of either the ponds or, perhaps, the lake; the farm systems also receive chicken and duck waste - and there have been instances of massive (storm-driven) inputs of material which wiped out the carp stock in earlier years. Indeed, a retaining wall had to had to be built to prevent such material entering the main pond areas.

16. The farms at Trifesti and Budesti are centred on ponds receiving natural run-off. As neither feeder water quality nor quantity can be controlled in this situation, the volume of the ponds may decrease due to evaporation and low rainfall in summer, and high sediment loadings may be received during storm events at any time. These ponds may be ice-covered for 4 months in the year. The ponds are in 'series' not 'parallel', so, for example, one pond may be used for rearing fish to 1 year, after which these fish are transferred to the next (lower) pond for further growth. After harvesting and draining, by which time the fish have seen 3 summers - this pond is re-filled from the upper pond and natural runoff. The average yield (= total net production in this case?) from this system is *ca* 1000 kg ha^{-1}. The most common mix of fish in these ponds is 30% common carp and 70% chinese carps.

17. It was suggested that quite high fish yields are achieved without fertiliser addition. Certainly, potato, cattle and maize fields extend down to the pond banks. It is very noticeable that the catchments of these waters - and probably the vast majority of the land in this part of the country (apart from the high Carpathians) - are put over to agriculture.

18. The Trifesti ponds connect with those of Budesti, and were constructed to dampen flow extremes (floods) during high rainfall periods. Fish-farming was thus not the primary consideration, when the ponds were constructed. It is felt that as these ponds are situated downstream of the Budesti system, they need less fertiliser application. Nevertheless, *funds permitting*, the following applications are made:

- 2 tonnes organic fertiliser (manure)
- ammonium nitrate to achieve a final theoretical water column concentration of 4-5 mg NO_3.N l^{-1}
- 50-60 kg ha^{-1} of super-phosphate (containing *ca* 20% P by weight) in the cold season after harvesting i.e. directly onto the sediments; this is equivalent to a loading of 12 kg P ha^{-1} y^{-1} (1.2 g P m^{-2} y^{-1}) and, if the pond is 1.5 m in mean depth and 100 ha in surface area (i.e. 15,000 m^3 ha^{-1}), a final theoretical concentration in the water of 0.8 mg P l^{-1}.

19. From Iasi, one could travel relatively easily to some four farm systems that were considered together to be reasonably representative of the range of sites in this (north-west) part of the country: Tiganasi, Vladeni, Negreni and Tansa. However, as Negreni and Tansa are dam lakes that are without Romanian carp and are used for potable water supply, I visited just the Tiganasi and Vladeni farms.

20. The Tiganasi ponds are fed by the Prut and Jijia Rivers. The total perimeter of the Tiganasi farm is some 36 km, and it covers some 1200 ha. The Jijia water supply (*ca* $m^3 s^{-1}$) is considered to be 'clean'. Water is eventually returned *via* a series of collecting channels, to the source river at a point quite near the abstraction point. The farm is operated on a 3-year cycle, with 2-summer-old carps being harvested for market. Cattle manure and - *when funds allow* - chemical fertilisers, are added at weekly intervals depending on algal crop. While a pond sampling programme had been completed, this covered only 3 or 4 dates limited to the July to September quarter. In contrast, the KHF study would aim for a more intensive (at least monthly) commitment throughout a whole year.

21. The Vladeni farm is possibly the largest in Romania, covering a total of 3500 ha. This includes 'systematic' (custom-built) ponds, 'semi-systematic' ponds, 1400 ha of dam lakes (for stocking, irrigation, flood prevention and, to a small extent, aquaculture). This farm is also the one on which Victor Bulgaru and Gheorghe Huianu had recently completed an intensive experiment with Chinese carp: a 1-ha pond yielded 5000 kg!

22. Three dilemmas which fish farmers commonly experience were discussed during this visit. One, the farmer has, by law, to carry out dissolved oxygen, Ph and P and N analyses, and find the funds to carry out these measurements - whether he does these himself or has to contract someone else to do them. Two, the manager feels that the ponds are being polluted from local, un-identified and thus, un-quantified, sources (presumably in addition to his own fertiliser applications). Three, although chinese carps are considered to be one the more environmentally friendly groups of carp because they are believed to clean up a lake, there is a much greater demand for common carps, which are not so clean, and are in fact more expensive, than the chinese species.

23. The Bratesi farm - which was visited from the Galati institute - covers a total 350 ha to 400 ha of ponds. The farm is fed from the Prut and Danube rivers. A brief look at two ponds (surrounded by *Phragmites* which was shedding considerable amounts of pollen onto the waters), suggested that on this occasion at least, these ponds were considerably clearer than many of the other ponds I visited during the 3-week period.

24. In sharp contrast to the swiftly reconnaissance of the Brates area, some 3 hours was spent at the two Cotul Chiului farm ponds (each some 25 ha in area). This included a spell of open water boat work. Samples were taken at the three routinely visited sites on one pond and at just one point (for this occasion) on the second pond. Surface water temperatures measured with an alcohol (not mercury) thermometer were 23°C. Zooplankton was collected by pouring 10 l of water (sampled by hand with a 1-l plastic 'jug') through a 35-μm mesh net; the concentrate of animals was then released through a spring-clip and rubber tube bottom closure on the net, into a plastic bottle. Since, on this occasion, there were no zooplankton organisms visible to the unaided eye, and 'Secchi disc' readings were only 15 cm, it was thought that phytoplankton was abundant. (Not surprisingly, a subsequent microscopic examination revealed considerable populations of Chlorococcales e.g *Golenkinia* sp.). Herons, egrets and cormorants were common,

and frogs were very abundant in these ponds, and stands of flowering *Nymphioides peltata* added to a very attractive scene.

25. The last ponds on my itinerary were those at Ianca which are managed by the 'Vermatta' s.a. whose tinning and distribution factory is in Braila near Galati. It was encouraging to learn that, as the water supply is pumped in to many of the company's ponds, water usage is metered; this would suggest (but see below) that data exists on the rates of water throughput ('flushing') which is a very important factor controlling many aspects of water quality. Most of the discharge is due to draining down of ponds in order to harvest - traditionally from the end of August, through September and October, with the maximum emptying rate occurring in mid-October. However, especially where gravity drawdown is not possible, high pumping costs mean that this schedule cannot be maintained everywhere. As a result, harvesting may be spread over much of the year using e.g. fixed traps. It was also mentioned that fingerlings were added more-or-less year-round. Moreover, while the current mix of fish is said to be ('ideally') 80:20 in favour of common carps, the actual ratio depends on what is supplied from the hatcheries.

26. The two ponds at Ianca are each of 300 ha - originally 'natural'. Water is supplied *via* a system of channels and (4) pumping stations which were designed primarily for field agriculture and irrigation. However, in spite of the earlier assertion regarding metered filling of the ponds, the company cannot afford to flush the systems through as often as it would like - and in any event, the last earthquake wrecked the pipe-work. This is especially serious at Ianca because the distance between the source river (Danube) and this farm is many kilometres. In spite of these problems, the ponds have to be emptied every 3 to 4 years, because of (i) accumulation of organic matter, and (ii) a paucity of calcium, and preponderance of magnesium salts and chlorides in the soils (e.g. 3 g $Cl^- l^{-1}$). Whether this has led to poor results, is not known - but the fish seem to acclimatize to these conditions, and 'production' figures are said to be around 1000 kg ha^{-1} y^{-1} without adding fertiliser or feed.

27. The situation at Ianca suggests that the ponds are very poorly flushed i.e. the hydraulic retention period is long. In the absence of efficient grazing of phytoplankton, this would be expected to result in a high proportion of algal production accumulating as biomass. The preponderance of (potentially toxic) large blue-green algae at the time of this visit, supports this view.

Visits to fishery research institutes involved in pond studies

28. The following were visited - in addition to the Ministry of Water, Forests and Environmental Protection: the Fish Culture Research Station at Nucet; the Piatra Neamt and Galati laboratories of the Centre of Research and Production in Fisheries, Fish Culture and Fish Processing (CCPPPIP), and the Station of Research and Production of Fish (ACVARES) at Iasi. Each of these institutes is involved in physical, chemical and biological analyses of freshwaters. Directors and staff (**Appendix 2**) outlined their research interests and showed me the laboratory facilities, field equipment and libraries.

29. The **Nucet** station was founded in 1940 as the Fisheries Research Station of the University of Bucharest. The main collaboration is still with the Faculty of Biology in that university. There is a total of 100 staff including 17 researchers. All resources are directed towards fishery research, and some 100 ha of earth-dyke ponds are available for this. Some cage-culture included.

Water usage is equivalent to 0.3 $m^3 s^{-1}$ which is some 15% of the average discharge of the feeder river.

30.The site includes the pilot farm for Common Carp culture and this is the most prominent species in their work programmes. However, Chinese carps were introduced in the 1960s. There have now been some 20 years' work - including genetic studies - on improving the spawning success of these fish. A total of 16 fish species are in current use including Pike-perch, Tench, Wels, Choi, Goldfish and Paddlefish. The station has been assessing food conversion and growth characteristics of different races of common carp. Some tests have produced a welcome 'heterosis' but this appears to last for only the first generation. Fry of many species are produced here, and the institute claims annual sales of 200 million which meet the demands of virtually the whole country. It also sells some 20 tonnes of Common and Chinese Carp fingerlings annually.

31. The **CCPPPIP laboratory at Piatra Neamt** developed from the Stegarul Biological Research Station which was set up in 1957 by the University of Iasi as a multi-disciplinary laboratory with departments of geography, geology, pedology and biology. In 1982, it was re-organised into 3 parts:

- the CCCPPIP
- the research station at Bicaz - concerning mainly trout and European salmonids
- the Stegarul station in Piatra Neamt.

32. Much of the work of this station, is based around the Bistrita River system and a number of dam lakes on rivers flowing from the Eastern Carpathian Mountains. This region includes Lake Bicaz which, at 30 km in length and with a maximum depth of 100 m, is the largest lake in Romania (?) and the site of a large trout farm. Trout-farming has also been attempted in a small dam lake, but a freak storm some 5 years ago terminated this venture. Much of the farming is thus of the traditional type, with mixed species of carps, but sturgeon (*Acipenser*) are reared and farmed for caviar.

33. Dr. Caraus' laboratory still reflects the multi-disciplinary nature of its former organisation, even though the main focus is on aquatic ecology and experimental fish culture. Thus, research areas include sediment and water chemistry and bacteriology, phytoplankton, zooplankton and zoobenthos, and toxicology. Much of this research has been carried out so far on large dam lakes and, in the case of Bicaz, from the time of its filling in July 1970. On the fish culture side, areas of main interest are nutrition, genetics, biochemistry and fishery engineering to improve fish culture technology.

34. Bacteriological studies range widely with work on heterotrophic and autotrophic microbes and those contributing to the cycling of N, S, Fe and C. Other investigations concern 'saprobiology', cyto- and fish-genetics, and biochemistry.

35. Algological studies by Drs. Caraus and Porumb centre primarily on environmental work and the use of natural populations as well as cultured algae for fish-farm studies. In common with many of the scientists at Piatra Neamt, the algologists have published a considerable body of literature on pure and applied aspects of their science.

36. Dr. Rodica-Ileana Rujinschi is involved in zooplankton and phytoplankton studies on a wide range of ponds, lakes and the Danube Delta. She has developed techniques that are now used very widely for rearing Asian carps over the first 21 days. At Trifesti farm, for example,

very good results were obtained by replacing the early feeding of the common carps with zooplankton. Zooplankton cultures are maintained in large polythene bags or fibre-glass tanks on the sides of ponds - or even in small ponds. Dr. Rujinschi has also developed a submersible, mesh-cage system with a blue light source to attract zooplankton, for rearing 1-mm *Coregonus* fry to 75-mm fingerlings in 68 days. She could not assess the effects of cannibalism that is likely to be an important factor in oligotrophic waters of the type favoured by these fish, however. It is possible that the technique would be better for eutrophic systems. The techniques have been tested on small pike and *Acipenser*, and *Moina* as well as *Daphnia* are being tested as the food sources.

37. At **ACVARES, Iasi** the main discussions were with the hydrochemists - Platon and Florin Seiler - on the facilities available, what they analyse and the methods used. However, Rodica Palade discussed her zoobenthos and zooplankton work and showed me the microscopes that she uses. A large part of the work of this station centres on sampling at 10 sites on the Bahlui River, at three sites on each of a number of dam lakes (Stinca), at 18 ponds at the Tiganasi Farm, plus a further 6 ponds at the Iasi institute itself. Since it was asserted that sampling was done on a monthly basis, I questioned whether a new programme was actually necessary - for this region of the country at least. The response suggested that most of the work was focused on the research farm. The other places required study (not just to enhance knowledge about pond management, but also to comply with ministry monitoring requirements); however, it appears that few farmers can afford the analytical costs that the institutes have to charge.

38. At **CCPPPIP, Galati** the main scientific discussions (apart from those following a seminar that I gave on eutrophication and phytoplankton ecology) were with Mrs. Maria Fetecau, a phytoplanktologist who also studies macrophytic vegetation, and Liliana Pana, a marine zooplanktologist concerned up to now especially with *Artemia*. Phytoplankton studies are primarily concerned with the interrelationships between the algae and nutrients and zooplankton. Culture work focuses on the chemical and biological control of algal blooms. Sampling of a core group of approximately 10 research sites is done weekly or fortnightly in summer, but usually only once per month in winter. Additional (*ad hoc*) collections of material are made at other farms as and when problems arise. Mrs Fetecau deals with 'problem' or important routine samples first, and works on the backlog of collections in the winter. The discussions covered aspects of, and problems with, the field and laboratory methods adopted for identifying planktonic organisms and estimating their population densities. Some of the material collected from the Cotul Chiului ponds was examined under the microscope, and some ideas on improving and speeding-up the techniques currently used at Galati were considered. I also introduced to this laboratory and a number of the others that I visited, some phyto- and zoo-plankton population assessment techniques that are statistically more robust, yet quicker, than those currently adopted in Romania. There are problems related to poor equipment. As examples, a main centrifuge at Galati has a maximum speed of only 1500 rpm, and at least some of the Romanian microscopes have rather poor optics.

39. While not a research institute, it is worth noting that **'Vermatta' s.a. in Braila** have a chemical laboratory for analyses relating to fish processing as well as the pond water quality. The results obtained are applied to the management of the ponds. The laboratory appeared to be very small in comparison with the analytical programme suggested; the nearest farm to Braila alone consists of 40 ponds. It is difficult to imagine that more than a fraction of the company's total holding of ponds is sampled more than a few times each year. However, some 1M lei (equivalent to

5% of the annual turnover of the firm) is reckoned to be invested in chemical and biological analysis.

The sites for intensive environmental monitoring

40. Ponds and management strategies vary considerably from farm to farm. This is partly as a result of shifting availability of funds for e.g. feed, fertilisers and pumping equipment, and partly in response to seasonal and inter-annual variation in the weather and especially, water availability. Thus, no two ponds are treated similarly in regard to e.g. stocking rates or mixes/proportions of fish species; or harvesting methods (with/without water draw down or pond emptying); or harvesting and recruitment schedules. It is likely that the ponds will also contrast considerably as regards the timing and nature of the introduction of fingerlings, the application of dung or fertilisers, and the harvesting of fish.

41. As it appears that every pond is likely to be unique with regard to its basic structure, location, and the manner in which it is managed, logistical criteria such as proximity to research institutes will be as, if not more, important than scientific criteria such as general water quality, in selecting the study sites.

42. Ideally, the systems selected for study should be simple i.e. with a single inflow and outflow, rather than a more complicated arrangement of water supply and discharge. Ideally too, the sites would be affected largely by fish-farming *per se*, and not significantly by e.g. domestic waste and poultry units. But, in any event, the study would attempt to place the impact of e.g. manuring and fertilisation of ponds, in the context of other sources of enrichment from the catchment.

43. Site selection would also depend on ease of travel between institutes and farms, and the availability of (i) boats for open water sampling, and (ii) personnel that are permanently on site, to make regular notes on the weather, on the appearance of the water, on water inputs, outputs and levels, and on fertiliser/feed applications and other management practices.

44. Taking all of these factors into account, it is recommended that each of the four institutes is involved in deciding on which ponds/farms are to be included in the new project. It is also advised that each institute concentrates on no more than two farm systems, although the number of ponds in each may vary. Nevertheless, I would suggest that Trivesti and/or Bidesti, and Cotul Chiului be included.

Selection of the scientists/consultants to carry out the monitoring and co-ordinate the programmes in different parts of the country.

45. On the basis of their experience, scientific discipline, and work approach, the following personnel who I met, should be given priority consideration for involvement in a new KHF project:

- from the Fish Culture Research Station at Nucet, Dr. Dan Visitu (Director) and Mr Christian Stoicescu (freshwater scientist) in coordinating as well as practical project roles; specialists/trainees in analytical chemistry, phytoplankton (Valentina Mircea?) and zooplankton

also work on this station, but I did not meet all of them; the library at this site will be a valuable asset to the project.

- from the Piatra Neamt laboratories of CCPPPIP, there is a wealth of experience: for example Drs. Ioan Caraus and M A Porumb (algology), Dr. Rodica-Ileana Rujinschi (zooplankton); and the analytical chemists; library facilities are good here too; the overall attention to, and expertise in, chemistry in particular is impressive - and almost certainly stronger than that apparent at the main CCPPPIP station in Galati.

- from the Galati laboratories of CCPPPIP, Mrs Maria Fetecau (phytoplankton ecology) and Miss Liliana Pana (zooplankton).

- from the ACVARES station at Iasi, Dr Florin Seiler and Mr Catalin Platon (hydro-chemistry) and Miss Rodica Palade (zoobenthos).

46. There are undoubtedly other scientists (who I did not meet) who merit participation, and some of these will be included in the project, following further discussions with the Institute directors, the Project Leader and Field Manager.

Recommended features of a survey programme for local consultants to monitor changes in inlet water, pond water, and effluent quality over a full year

47. A survey programme focusing (initially at least) on no more than four sites will be designed for, and in consultation with, the scientific investigators. It is essential that major physical, chemical and biological conditions are monitored at as frequently as possible; it is hoped that sites could be visited 15 times over a 12-month period (i.e. including the ice-over season) - with for example, weekly sampling in the first month of pond filling, and perhaps monthly sampling thereafter (bearing in mind that during some periods, feeder streams, inlet pipes, and outfalls may not be flowing, and the ponds may be empty).

48. At each of the ponds, samples of water (for chemistry and plankton) and sediment (for zoobenthos) will be collected as appropriate. Duplicate samples will be taken at the inflow and the outflow whenever these are running, and from ideally two points, and certainly no more than three points within the ponds themselves. If possible, all sites will be sampled on the same dates. It is hoped that the whole spectrum of analyses envisaged can be carried out at each of the participating laboratories. Thus, carriage/posting of samples between laboratories will be kept to a minimum - except perhaps for *ad hoc* inter-laboratory analytical comparisons, for example.

49. One could sample just at the top and the bottom of a *series* of ponds, regardless of the number of ponds in the series, and still achieve the main aim of assessing the effects of fish-farming on water quality. Only by sampling the top and bottom of individual ponds, however, would one be able to assess the effects of the management strategy of a particular pond. It should also be remembered that many ponds do not have an actual outflow - at least during the summer months, when the main aim is to retain water in the fish-rearing basin. The main effects on water quality could then be assessed by comparing the inflow (as long as this also exists), with the pond water - presumably by taking samples at a point as near to the outflow as possible. Such considerations led to debate on the definition of fish-farm 'effluent'. In some situations at least, the effluent amounts to whatever volume of water is left in a pond and is

discharged (by opening sluice-gates etc), prior to harvesting the end-of-season population. In this case, any qualitative differences between incoming and outgoing water, would be assessed from regular samples from the feeder water/s and the outflow, but if the latter (i.e. the effluent) only 'exists' for a restricted period of the year, it can only be be assessed by sampling over that period. It is thus essential that comprehensive records of water input-output schedules and fluctuations in pond water levels are maintained for each study site.

50. It is important that the teams within each laboratory work closely together, and that scientists from the different laboratories meet frequently (every 6 weeks?); only by maintaining such contact can consistency in approach, and awareness of progress and problems over e.g. sampling schedules, analyses and data handling, be assured.

Advice on the field, laboratory and data analytical methods and scope of analyses required to assess whether water quality differs between fish farm inlets and outlets

51. Discussions have been initiated with the personnel listed above, over field, laboratory and data analytical methods, and the scope of analyses required to assess whether water quality differs between fish farm inlets and outlets. Some literature on chemical methods is available from the Project Field Manager. Some techniques which may be quicker, yet statistically more robust, than the procedures currently used in Romania for the estimation of phytoplankton, zooplankton and zoobenthos are under consideration.

52. From the foregoing considerations, it is plain that the project aims to capitalise fully on the human resources available in the institutes, and assess water quality using a wide range of physical, chemical, and biological techniques and indicators.

53a. *Physical parameters* will include water colour, and transparency/clarity; there may be an opportunity to occasionally investigate the spectral nature of then underwater light field, as this can influence the types of phytoplankton that appear.

53b. *Chemical measurements* should include the dissolved plant nutrients (nitrate-N and ammonia-N, soluble reactive phosphorus (P) and silica (SiO_2), and the particulate or total amounts of N, P and carbon (C). Indicators of chemical and/or microbiological activity should also be recorded; these include chemical and biological/biochemical oxygen demand, as well as oxygen content *per se* and pH. Most of these analyses can be done by the four laboratories. The institutes are also have the instrumentation for determining major ions i.e. calcium, magnesium, sodium, chloride and 'hardness'. However, a review of data on these cations and anions may could show whether it is necessary to carry out as many analyses of these as one would hope to achieve for the traditionally highly fluctuating nutrients, for example.

53c. *Biological assessments* should include, at the very least, the taxonomic composition (to species where possible) and the concentrations of the populations of planktonic algae, rotifers, micro-Crustacea and benthic invertebrates.

53d. If (as at Piatra Neamt, for example) expertise in bacteria and protozoa is available, some consideration might be given to characterising the waters on the basis of these organisms, and obtaining data on de-nitrification. The possibility of undertaking diurnal studies of e.g. oxygen

and pH levels should not be forgotten. Depending on progress with the basic work, there may also be opportunities for additional work on food chains and fish gut analyses, for example.

Drawing up of contracts in collaboration with the project field manager, to draw up contracts for the local consultants required

54. This exercise has not been completed. However, as indicated above, a number of scientists have been identified as being the most likely to be involved in the project. It still remains to select those who will have, for example, the responsibility for coordinating the work of personnel involved in the same disciplines and sites, and others with main roles in overseeing the programme as a whole. In each case, there will responsibilities for collating data as well as maintaining the field and laboratory work schedules.

VI. Workshop to be held prior to the start of the fish pond environmental study - a proposal

Introduction - background and rationale

55. The interest shown in the proposed freshwater ecological study was impressive throughout the three weeks in Romania. Yet, many of the laboratories are poorly resourced and equipped, and the scientists that are likely to be involved in the new study are well aware that funds for it would be somewhat limited. However, a study could be executed, and this would enhance knowledge about the effects of fish pond management on water quality (and thus generate ideas on how to minimise the potential polluting nature of carp farming). In addition, Romanian researchers would be better exposed to UK limnological thinking and practices, and as a consequence the joint venture could lead to the publication of papers in 'Western' journals.

56. The success of the programme envisaged rests very largely on prior planning, and the execution of a number of tasks identified in this report before the field work is likely to commence - in March 1995. These tasks include finalisation of decisions on:

- the composition of the study team
- the study sites
- the scope of the parameters to be measured
- field sampling methods and schedules
- laboratory methods

57. There is also a need to attend to outstanding resource requirements

58. It is thus recommended that a workshop/seminar involving the Romanian scientists identified above, be held before the main programme starts; indeed, such an exercise is vital for bringing the participants together and finalising aspects of the new study, such as participants, study sites, sampling and analytical schedules, and resource requirements.

General features of the workshop

59. The workshop would be held in Romania - preferably at Piatra Neamt or Iasi. It would last for a maximum of three days (excluding travel). It would involve hopefully no more than the approximately 12 selected Romanian scientists who would cover the four areas of major interest to the project i.e. water chemistry, phytoplankton, zooplankton and invertebrate benthos. The workshop would be led by four scientists (from the Institute of Freshwater Ecology, Scotland) with a total of some 70 person-years experience in project planning and a wide range of skills from field sampling, chemical and biological analysis (including taxonomy and identification), to data acquisition, handling, analysis, interpretation and publication.

60. The meeting would also hope to address some obvious problems stemming from the somewhat limited resources that exist in many of the institutes. In this connection, a modest sum of money is likely to be available for basic field and laboratory equipment. It must be borne in mind that the waters of major interest are shallow and thus require relatively simple sampling apparatus. Moreover, as the ponds at least, are often rich in chemical ions and will often manifest dense populations of organisms, relatively small volume sample containers and coarse analytical equipment will be adequate. Discussions already held, suggest that the UK team will be able

to introduce to the local scientists/consultants, a number of techniques that are likely to be statistically more robust, yet quicker, than those currently adopted in Romania. The workshop would also hope to make western literature more available than hitherto, to the local scientists.

Appendix 1: Itinerary.

Sunday, 4th September 1994 - Arrival (Otopeni Airport, Bucharest); to Hotel Palas; evening 'Chez Watson' for briefing, planning, and discussion on itinerary.

Monday, 5th September 1994 - car to Crevidia fish farm and Nucet Institute; return Bucharest.

Tuesday, 6th September 1994 - ROMPESCARIA; Ministry of Water, Forests and Environmental Protection; train to Piatra Neamt.

Wednesday, 7th September - CCCIPP laboratories; car to Stegarul hatchery, Bicaz Lake, and the Red Lake (Carpathian Mountains); return Piatra Neamt.

Thursday, 8th September 1994 - car to Iasi (Hotel 'Moldova') *via* the Vaduri Dam, the Trifesti and Bidesti carp farms, and working lunch in Roman.

Friday, 9th September 1994 - ACVARES Research Station; car to Tiganasi and Vladeni farms; return to Iasi.

Saturday, 10th September 1994 - 'Free' day: a.m. - Museum of History; p.m. limnology discussions and development of a joint IFE-ACVARES-Turkey proposal to the European Union for a study of the effects of bio-filtrating fish species on the effects of eutrophication in dam lakes.

Sunday, 11th September 1994 - Train to Galati (Hotel 'Palace'); boat trip to the Siret River where it joins the Danube at Galati.

Monday, 12th September 1994 - CCPPPIP laboratories; car to Bratesi farm; return to Galati.

Tuesday, 13th September 1994 - a.m. - CCPPPIP laboratories; car to Cotul Chiului farm; return to Galati; p.m. - gave a talk on 'Eutrophication and Phytoplankton Ecology' in Galati, which was attended by fishery researchers and staff from the local university.

Wednesday, 14th September 1994 - Danube steamer to Tulcea (Hotel 'Delta'); Delta Research Institute; ROMPESCARIA Trade Fair.

Thursday, 15th September 1994 - brief appearance at ROMPESCARIA A.G.M.; boat trip into the Danube Delta; return to Tulcea.

Friday, 16th September 1994 - Car to Braila and the 'Vermatta' s.a. fish canning and distribution factory; Ianca farm; car to Constanta (Hotel 'Parc').

Saturday, 17th September 1994 - a.m. - Marine Sciences Institute; Sea Mammal Centre; Zoological Park; p.m. - Free (Romania-Wales rugby match on TV; Archaeological Museum and Black Sea).

Sunday, 18th September 1994 - a.m. - Black Sea ; p.m. - train to Bucharest (Hotel 'Ambassador').

Monday, 19th September 1994 - Work on consultancy report.

Tuesday, 20th September 1994 - a.m. - ROMPESCARIA ; p.m. - hotel and report writing.

Wednesday, 21st September 1994 - a.m. - report writing; p.m. - preparation for round-up meeting.

Thursday, 22nd September 1994 - a.m. completed summary report; p.m. - ROMPESCARIA and circulation and presentation of report at the round-up meeting.

Friday, 23rd September 1994 - a.m. - concluding discussions regarding final report; p.m. - airport and departure from Romania.

Appendix 2: Contacts established.

1. At commercial farms

Crevidia: Viorel Popa (Manager); with Niculae Dimulescu and John Rogers (JR)

Trifesti and Bidesti: Ilea Ciutea (Fish farm manager, and Director of Fishery Enterprise, Neamt 'County'); with Christian Stoicescu; with CS

Tiganasi: with Ilea Ciutea and CS

Vladeni: Victor Bulgaru (Director) and Gheorghe Huianu (Manager); with Catalin Platon (CP)

Brates and Cotul Chiului: with staff from Galati laboratory of PPCCCIP

Ianca (from Vermatta s.a. in Braila): Ing. Maria Iorga (Chief Executive) with staff from Galati laboratory of PPCCCIP

2. At the Ministry of Water, Forests and Environmental Protection

Florin Stadiu (Secretary of State) and Mihaela Popovici (Fisheries Engineer); with Ian Watson and CS

3. At fishery research institutes

the Fish Culture Research Station in Nucet: Dan Visitiu (Director and general manager - fish genetics); Viorica Visitiu (fish biologist); Christian Stoicescu (Freshwater ecology); with JR

the Piatra Neamt laboratory of the Centre of Research and Production in Fisheries, Fish Culture and Fish Processing (CCPPPIP): Dr. Ioan Caraus (Director - algology); Dr. M.A. Porumb (phytoplankton ecology); Dr. Rodica-Ileana Rujinschi (plankton ecology); Rodica Palade (plankton and benthic invertebrate ecology); with CS

the Galati laboratory of CCPPPIP: Eng. Pecheanu Constantin (Head Manager - fisheries engineer); Dipl. Eng. Patriche Neculai (Scientific Secretary and Head of Laboratory - fish genetics); Biolog. Maria Fetecau (phytoplankton and macrophyte ecology); Liliana Pana (zooplankton); Carmen Popa (chemist, and interpreter for my time at Galati)

the Station of Research and Production of Fish (ACVARES) in Iasi: Ing. Cuvinciuc Mircea (Director - fisheries engineer); Catalin Platon (hydrochemistry); Dr. Florin Seiler (hydrochemistry); Dr. Adriana Strat (fish physiology and genetics); with CP

4. At the Romanian Marine Research Institute in Constanta: Dr. eng. Simion Nicolaev (Director); Dipl. eng. Mihaela Laurenta Alexandrov (fisheries engineer and marine plankton ecology); with CS

5. At the Danube Delta Research Institute in Tulcea: Dipl. Eng. Radu Suciu (Senior Scientist - Fish genetics - Sturgeon Research Group); with CS

6. At 'ACVARIUL CONSTANTA' in Constanta:Dr.Mihai-Iosef Mihai (aquatic mammalogy); with CS

7. At the Romanian Fish Producers Association (ROMPESCARIA): Niculae Dimulescu (President); Fishery managers and researchers; with JR, IW and CS

8. Others: Professor Viorel and Mrs. Margareta Morariu (English teachers and interpreters): Professor Dr. Dipl. Ing. Nicolae Bacalbasa-Dobrovici (Galati University - hydrobiology); Professor Fetecau (mathematics and phytoplankton modelling).


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