

REPORT OF THE SYMPOSIUM ON
STOCK ENHANCEMENT IN THE MANAGEMENT OF FRESHWATER FISHERIES

Held in Budapest, Hungary
31 May – 2 June 1982
in conjunction with the
Twelfth Session of EIFAC

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PREPARATION OF THIS DOCUMENT

This report of the Symposium on Stock Enhancement in the Management of Freshwater Fisheries summarizes the first of a series of two symposia to be held by the European Inland Fisheries Advisory Commission (EIFAC) on the topic of management of inland waters.

The present report will be supplemented by a Proceedings reproducing in full the text of the contributions submitted as listed in Appendix 1. The report of the second symposium will be produced following the meeting of the Thirteenth Session of EIFAC in 1984.

Distribution

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ABSTRACT

The Symposium on Stock Enhancement in the Management of Freshwater Fisheries, held in Budapest, Hungary, 31 May to 2 June 1982, discussed two aspects of management of freshwater fisheries by manipulation of stocks.

The first of these was stocking with native species and it was concluded that there is a general paucity of information on the success and failure of current stocking practices in most species.

The second aspect was the introduction of species exotic to the European national faunas. Here, the risks of such introductions were discussed and it was recommended that the formulation of a Code of Practice to reduce the risk of such adverse effects should be undertaken.

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INTRODUCTION

Following the recommendations of the International Consultation on Fishery Resources Allocation (Vichy, France, 1980) and its own discussions during its Eleventh Session (Stavanger, Norway, May 1980), EIFAC felt that subsequent sessions should examine closely the current situation for managing stocks of fish in European inland waters. Because the whole topic of management is too large for coverage during any one symposium, it was recommended by the Commission that the subject be covered in two symposia - one on biotic aspects of management to be held in conjunction with the Twelfth Session of EIFAC and one on abiotic aspects to be held with the Thirteenth Session of EIFAC.

There has been a long-standing concern with the effects of introductions of exotic species into European rivers and lakes. Furthermore, whilst stocking with native or introduced species is common management practice, there is very little evidence for or against its biological or economic effectiveness. Therefore, the first Symposium on management addressed the twin problems of introductions and stockings in an effort to define guidelines for both practices in European waters.

The Symposium considered these two specific aspects of stock manipulation in seven sessions as follows:

- Session 1 Stocking with non-salmonids
- Session 2 Stocking with brown trout
- Session 3 Stocking with salmon
- Session 4 Introductions and transplantations - case histories and experience with some species
- Session 5 Introductions - country reviews and Lake Kinneret case
- Session 6 Introductions - ecological and practical aspects
- Session 7 Summary, conclusions and recommendations

The body of this report consists of the reviews presented at each of the sessions together with any discussions arising. The papers referred to by numerical key in the text are those presented at the Symposium and relevant to the session which are listed in Appendix I and will be printed separately in the Proceedings of the Symposium. Any additional references are listed at the end of the relevant session.

SESSION REVIEWS

SESSION 1: STOCKING WITH NON-SALMONIDS

(a) PIKE AND CYPRINIDS (B. Steinmetz) (Papers Nos. 1, 2, 3, 13, 31)

Stocks of pike are heavily fished in the Netherlands as about 25 percent of the 14 million Dutch sports-fishermen fish, at least occasionally, for this species in the 100 000 ha inland waters (1). (The 200 000-ha Lake IJssel is excluded from these figures.) The goals for management of pike are in general to maximize the populations, and to improve the numbers of large fish.

These goals are pursued by responsible angling clubs and associations by (i) stocking pike fingerlings (4–6 cm) and occasionally larger pike; and (ii) catch and release fishing. The Organization for the Improvement of Inland Fisheries, amongst others responsible for the production of fish for stocking, produced over 1 million pike fingerlings per year for stocking during the last few years.

Research was started in 1974 to evaluate the value of stocking with fingerlings in two “natural” closed waters. The results of that year raised the question as to whether the stocked fingerlings contributed to the biomass or merely replaced natural recruitment. Moreover, experiments in drainable ponds suggested that the length of vegetated shoreline was of major importance. Therefore, from 1975 onward the study focused on the possible factors governing the abundance of pike. Two more closed waters were selected and, by intensive sampling in autumn, it was determined that:

- (i) The total biomass of pike smaller than 54 cm (fork length) is highly dependent on the area of vegetation, and corresponds to a maximum of 100 to 120 kg of pike per hectare of pike habitat;
- (ii) The biomass of pike smaller than 41 cm is determined by the biomass of pike larger than 41 cm and smaller than 54 cm. Stocking with pike fingerlings and pike up to 23 cm did not increase the pike population.
- (iii) Pike smaller than 41 cm are normally found within the submersed vegetation, whereas pike between 41 and 54 cm long are most frequently caught in the vegetation belts but sometimes outside these. Pike over 54 cm appeared to inhabit the unvegetated area and vegetated area, depending on the accessibility of the vegetation belts and the dimensions of the water.
- (iv) Reduction of the density of the prey fish populations due to winter kills was not reflected in the biomass of pike smaller than 54 cm/ha of pike habitat.

These results show that maximization of pike populations depends primarily upon the available pike habitat. Therefore, habitat engineering is a better management tool than stocking.

These findings are to a certain extent confirmed by experience in Finland (13) where about 18 million pike fry and fingerlings were stocked in 1980 with very little apparent effect on pike catches.

The stocking of northern pike has reduced the survival of many other species through predation. Salmonids are particularly vulnerable and in Ireland where pike are not native, the introduction of this species has almost eliminated populations of the more esteemed salmon and brown trout (47).

In the Netherlands more and more angling clubs and associations have started removing portions of bream (*Abramis brama* L.) stocks with the aim of improving the growth of this species (and thus the value of the fisheries for angling) (2). The results, however, are sometimes doubtful. To examine the effectiveness of this practice, two waters were selected to study whether poorly grown bream could increase their growth when feeding conditions were improved. One lake had a small but fast-growing bream population and the other had a dense population of small, slow-growing bream. A number of slow-growing fish were transplanted into the lake where conditions for growth were better.

The enhancement of growth rate and condition of these bream was striking, even better than that of the autochthonous bream, which indicates that bream adapted to poor conditions can exploit the available food supply more efficiently than the latter. It looks as if there are mechanisms which stabilize bream population density at a level more or less specific to each water body. A factor may be predation by invertebrate organisms on larvae of bream which may influence the year-class strength. There are reasons to conclude that the growth rate is density-limited. Therefore, if one decides to remove a

part of a bream population to improve growth, seining should be done up to about 200 kg/ha per year.

Studies are continuing to find the mechanisms governing year-class strength and feeding conditions for bream and to apply this knowledge for management purposes.

In the southern part of the Netherlands, ponds are used very intensively for fishing, i.e., at up to 14 000 visits per ha. The main fish species fished are carp reared by aquaculture and wild roach which are stocked by the anglers' associations responsible for the management of the fish stock.

The stocking of roach and bream is subsidized - about 150 000 kg per year to a maximum of 40 percent of the total cost. The roach and bream are caught by professional fishermen, but there have been doubts about the value of such stocking. Samples of roach gathered every winter in the years 1973 to 1980 at different stocking sites were brought to experimental ponds where they were held until the beginning of July (3).

The survival of roach caught by seining and distributed by fish dealers is low; mean values of 22–24 percent over eight years/winter seasons. It became clear from the experiments that handling, and storage in fish dealers' storage units even for as short a time as 24 h, seems to be harmful. Roach caught by fishermen and brought straight to the experimental ponds showed survival rates of more than 90 percent, suggesting that seining and transporting can be done without much harm. However, lower survival rates were found, possibly due to storage by the fishermen themselves. Use of a tranquillizer during transport increased the survival of roach stored for 72 h, more than five times in some cases. Unfortunately, chemical therapy of this kind cannot be used in the flowing water storage systems used by fish dealers.

The first carp were introduced into Finland in 1981 (31), since when it has become clear that juveniles do not survive their first winters in natural waters. To avoid this, one-summer old fingerlings have to be housed indoors during this period. They are fed with dry salmon feed once or twice a week, till the water temperature drops below 2.5°C.

The fish are introduced to the ponds in the spring when the water temperature has risen to 6°C. During the second winter these carp are stocked in the same ponds as the brood fish.

A survey of carp stocking by the Porla Fish Culture Station showed returns of 13 000 two-year old and older tagged carp to vary between 0 and 32 percent. However, returns are probably influenced by high tag loss and by the Finnish fishermen being unfamiliar with carp so that fishing methods are not yet adapted to the species.

The best stocking results were obtained with two or three-year old carp at least 10–20 cm in length. A weight increment of 1 000–1 800 g per summer could be attained in eutrophicated or heavily vegetated waters. Despite an initial lack of interest, the species is becoming more popular in the south of Finland.

After thirty years in Finland, carp does not appear to have damaged either other fish species or the ecosystem of the receiving water, nor have any new fish diseases or parasites been observed as a result of the introduction.

(b) EEL (C. Moriarty/D. McCarthy) (Papers Nos. 5, 6, 7, 8)

Eel stock enhancement is unique because we are dealing with the capture and overland transport of young fish rather than assisting or encouraging the breeding of the species.

The practice of transporting small eels to waters at some distance from the coast has a long history. The assessment of the effects of transportation in terms of improving the yield is a very much more recent development and the papers presented to this Symposium may be said to provide the first general review of the subject.

The history of eel stocking in Sweden reaches back for more than 200 years to 1770 and the building of elver ladders was recommended by Trybom in 1893 (4). Eels were introduced to the Danube system in Bavaria in 1881 and stocking was intensified in the fifties (54). Small-scale stocking experiments began in Finland in 1894 and regular transportation has been in progress for the past 20 years (7). In Ireland the transport of glass eels began in Lough Neagh in 1933 and to the lakes of the Shannon system in 1959 (6). In Poland stocking began a few dozen years ago and has been more intense and regular since 1950 (5).

Three different situations raise the need for the artificial transport of young eels. Firstly, the natural migration upstream has been impeded over centuries by the construction of dams and weirs. *Secondly, the number of young eels entering certain rivers from the sea have declined.* *Thirdly,* because of the existence of natural barriers or because the mouths of rivers are too far removed from the normal geographical range of migrating eels, highly suitable eel habitats have no native stocks.

Disruption of the ascent of eels by the construction of dams is reported from Finland, Germany, Ireland and Sweden. In Ireland the harnessing of the largest river, the Shannon, for electricity resulted in a decline in eel catch after the building of the dam near its estuary in 1928.

A decline in the commercial eel catch in Sweden is attributed to a reduction in the numbers of elvers and small yellow eels migrating from the Baltic (8). Physical changes in the North Sea have been suggested as a cause for this.

Problems caused by natural barriers are reported from Germany, where the upper part of the River Rhine, including Lake Constance, has had practically no eels because of the presence of high falls at Schaffhausen. An analagous problem exists in Ireland, where in many river systems there is no obvious physical barrier but where yellow eels take so long to migrate through lakes in the downstream regions of river systems that the upstream lakes contain only sparse eel populations.

The Danube catchment has no natural eel population since the river flows into the Black Sea. Eel populations in Finnish fresh waters have probably never been dense because of Finland's northern position and its distance from the Atlantic. Young eels have, however, been caught migrating upstream in Finland. They proved to be females and relatively large, 27–54 cm in length.

All the countries reporting use or have used glass eels, elvers and yellow eels for stocking. In Finland, problems have been encountered in glass-eel planting because the lakes are frequently still ice-bound or very cold early in the year when supplies become available. The possibility of rearing to fingerling stage for release in the warmer months is being considered. Yellow eel stocking appears to present no such problems.

Sources of eels for stocking vary from country to country. In Ireland, nearly all stocking is based on the transfer of glass eels and elvers from the lower reaches of rivers to the upper portions of the same rivers. Finland and Sweden have in the past imported glass eels from other countries.

Yellow eels for Finland came mainly from Denmark until the Danish authorities prohibited the export of young eels. In Sweden yellow eels, often about 35–45 cm in length, are sorted out from the commercial catch in the Straits of Oresund and on the west coast. In recent years intermediate-sized eels have been cultured for stocking purposes in a fish farm using heated water. Lake Vanern, the largest lake in Sweden, has been stocked since 1960 with small yellow eels trapped at dams downstream of the lake. A similar operation has been in progress on the River Shannon in Ireland where yellow eels of up to 40 cm in length are captured at an elver ladder.

In Germany, the annual demand for glass eels is about 7 t and is met from a fishery on the River Ems and by imports from France. About 40 t of yellow eels are stocked per year, of which about 50 percent are planted in the waters of the state of Schleswig-Holstein.

In Finland the relatively large introductions of glass eels made in the sixties resulted in a dramatic increase in catch which rose from 9 t in 1976 to 63 t in 1980.

German statistics apparently showed no increase in eel catch in general following a number of years of increase in stocking rate. It is suggested that eel stocks in general may be increasing, or at least kept stable, while the catches reflect a decrease in fishing effort. There are now considerably fewer fishermen and fishing installations than in the past.

In the Shannon system in Ireland the commercial catch has in the past few years shown a fairly steady increase as a result of stocking. The catch in 1980 was more than double the mean for the sixties which was made before the elver transportation programme could have shown any effect. In the same period, the catch-per-unit effort of yellow eels in Lough Derg, the most downstream lake in the system, increased by 62 percent.

In Sweden and Poland increases in yield as a direct result of increasing the rate of stocking have been apparent. The suitability of differing lake types for eel management in Poland was undertaken on 454 lakes, where morphometric, environmental and eel management data was collated for a period of 24 years (1950–73). This resulted in the formulation of an equation which shows clearly that relatively shallow lakes with well developed shore lines are the most suitable for eel management.

Various rates of stocking with glass eels and yellow eels have been proposed. In Sweden 100 glass eels or 20 yellow eels per hectare for lakes of medium and high productivity and 25 glass eels or 5 yellow eels per hectare for lakes of low productivity are recommended. Various stocking rates have been formulated for Polish waters depending on lake typology: in “vendace lakes” 64.4 elvers to produce 1 kg of commercial eel catch and 45.5 elvers to produce 1 kg in “pike-perch” lakes. Based on the available figures for stocking rate and catch on Lough Neagh, stocking at a rate of 350 glass eels per hectare has been proposed for Ireland. This will require an annual transportation of 9 t of glass eels.

There are many problems in estimating the survival rates of the stocked eels. There is virtually no information on the numbers of eels which enter rivers without

obstructions. Furthermore, the numbers of yellow eels planted are difficult to determine with accuracy.

In spite of these difficulties, estimates of the numbers of eels which must be stocked to produce a given number of market-sized eels have been made. In Finland yellow eel stockings have yielded catches by ordinary fishing methods of 27.4 percent of the number of stocked eels. Rotenone treatment of stocked lakes gave a survival rate after nine years of 72 percent in one case and 20 percent in another. The high survival was accompanied by poor growth, the mean weight of caught specimens being only 60 g. The eels in the low survival lake were of a reasonable size, averaging 600 g. The overall production in Finland is 72 kg market eel per 1 000 stocked. In Poland the commercial and recreational eel catch combined yield on average 1 kg of eel from a stocking of 11.7 elvers.

Catch rates in Germany give 7.9–12 percent return for glass eels in Lake Constance, 1.24–6.55 percent in four rivers in Oberfranken and as high a survival as 50 percent for fingerlings planted in lakes in Schleswig-Holstein. It is estimated that real survival of eel in Poland taking into account a natural stocking of 0.5 kg/ha, is 15 percent. The Lough Neagh catches are given only by weight but an estimate of 4 market eels to the kilogramme would give a numerical annual yield of 2.5 million. The annual stocking rate is 13.8 million so a survival of 18 percent may be calculated.

Making the assumption that all fishery statistics are underestimates of the true production of watercourses, we may be sure that the calculations of yield per hectare are minimal and do not exaggerate the actual yields. Lakes in Schleswig-Holstein yield commercial catches about 5–15 kg/ha and maximum yields of from 25 to 50 kg could be achieved. Lough Neagh usually yields between 15 and 20 kg/ha, with a recorded maximum of 26 kg. In Poland it has been estimated that recreational catches are 2.6 times higher than the commercial catch and the real eel yield amounts to 4.6 kg/ha of total area of Polish inland waters; however, yields of up to 60 kg/ha have been recorded in particular lakes.

Very few figures which combine stocking rates in young eels per hectare with yield in kilogrammes per hectare are available. The data in the papers presented to this Symposium may be summarized in a brief table (Table I).

Table I.

Relationship between numbers of glass eels stocked and the catch of market size eels for various European inland waters

		Glass eels per ha	Catch (kg) per ha
<u>Germany</u>	rivers	480	4.5
	lakes	246	2.4
<u>Ireland</u>	Lough Neagh	354	15–20
	Shannon lakes	340	1.4
<u>Poland</u>	lakes approx.	100	7.0

The greatest yield is given by Polish lakes and the poorest yield comes from the Shannon, which has nearly as high a stocking rate as Lough Neagh. The Polish and German figures both refer to the means of a number of lakes. Within Poland, a correlation between stocking rates and yield was observed, given a constant fishing effort.

The observation that in back waters of the River Rhine eel anglers catch between 10 and 24.6 kg/ha, as much as ten times the catch of commercial fishermen in the same waters, suggests that the low annual yields may reflect inadequate catching methods rather than poor stocks.

The interaction between eels and other species is discussed in several of the papers. Predation on crayfish and young trout has been mentioned but in northern countries excellent crayfish and trout rivers are good eel rivers as well. Eels have been said to bring about a reduction in populations of cyprinids, pike and tench while intensification of the coarse fish catch may improve the yield of eels. Overstocking of eels results in retarded growth and lower size. In Ireland it was noted that the greatest concentrations of eels recorded co-exist with good stocks of other fish species. In Finland it is considered that no negative effects of stocking with eels have been found.

The possibility of transmission of disease carried by glass eels was mentioned with particular reference to Infectious Pancreatic Necrosis. This virus has been isolated in glass eels and as a result the Swedish authorities prohibited import of elvers from France. A quarantine station has been established so that elvers may be kept in isolation and screened for disease.

The financial implications of eel stocking were calculated in the case of Finland. After adjusting values to accord with inflation an annual outlay of 82 000 Finnish marks for stocking has been found to yield a catch worth 600 000 marks; about seven times the stocking expenses.

To summarize, the present state of the practice of eel stocking appears to be as follows:

The survival rate from glass eel to market eel, in spite of the very long time interval of nine years and over, is high. Figures of well over 10 percent survival are reliably reported.

Recommended stocking rates are variable, from about 100 to 350 glass eels/ha represent the extremes applied to productive waters.

In general, the highest yields in terms of weight of market eels per hectare result from the highest rate of stocking. It appears that in many cases the fishing effort has not been adequate to make full use of the enhanced stocks.

There have been no clear indications of damage to other fisheries as a result of eel stock enhancement undertakings. It appears that in general the eels are availing themselves of food supplies which are not being fully used by other species although competition between eel and some cyprinids such as bream may arise. Furthermore, predation by eels on other species seems to have little or no effect on yields.

It may be concluded that the enhancement of eel stocks is both profitable for eel fishermen and beneficial to inland fisheries in general. From this point we must proceed to making a more accurate evaluation of stocking and harvesting arrangements so that the stocking programmes may be planned to ensure the most effective distribution of the young eels.

(c) COREGONIDS (P. Tuunainen) (Papers Nos. 9, 10, 11, 12, 13, 42)

Introduction

Four reports on coregonids (9–12) dealing with the role, results and profitability of Coregonus laveretus stocking in Finland, and the growth and production of C. muksun

and C. peled stocked into a small forest lake in Finland were submitted to the Symposium. In addition, two reports (13 and 42) included coregonids among other stockings and introductions of fish into Finland. Geographically, these reports cover only a small part of the area of distribution of coregonids and only a few of the species. Such important countries as Canada, Poland and the U.S.S.R. have not reported at this Symposium. However, some research results and experiences in the countries have been referred to by the authors of the above reports.

Recently, Finnish water courses have been stocked with the following coregonid species: C. pidshian, C. lavaretus, C. oxyrhynchus, C. muksun, C. peled, C. albula. Most of these whitefish were stocked as fry but 27 million autumn fingerlings were also stocked in 1980.

Importance of the species

Without going too deeply into coregonid taxonomy it is obvious that different whitefish species give very different results when stocked or introduced into the same body of water. Good examples of this are the results of introductions of C. peled and C. lavaretus fry into Lokka Reservoir in Finnish Lapland (Mutenia, 1982). The catch of stocked C. peled formed 9–12 percent of the total catch while the corresponding catch of C. lavaretus was less than 2 percent. This indicates that the ecological requirements or niches of even very closely related species can differ considerably.

Hybridization between native and introduced species or between various introduced species has taken place in some cases, yielding a new stock different from either parent. This important phenomenon has not been dealt with in the papers submitted to this Symposium, but from other studies (e.g., Heikinheimo-Schmid, 1982) it is clear that it can, for example, affect the utilization of food resources by whitefish and thus the production.

The results of stockings with fry or fingerlings of species already present in a lake indicate that whereas stockings with fingerlings could decrease the native stock, stockings with fry usually had no effect.

Importance of the size of the fish stocked

The results of stocking with newly-hatched larvae of whitefish compared with stocking one-summer old fingerlings confirm the value of the latter. The yield to the fishery varied between 0 to 15 kg per thousand of larvae in nine lakes, but with fingerlings yields ranged from 2 to 187 kg per thousand in eight lakes (9 and 10). Furthermore, with increase of the size of the fish stocked, the possibility of total failure decreased.

Young whitefish older than one summer have only been stocked in a few cases in Finland and the results have not yet been published. Adult whitefish were transferred to Finland in the nineteenth century and in half of the small forest lakes where such transplantations were made, whitefish became the dominant species in the catch. In only three lakes of the 58 studied, did the transplantations fail completely. In the Oulujoki watercourse, stocking of 109 small forest lakes with whitefish fry resulted in recaptures from 91 lakes, natural reproduction in 56 lakes and failure in only 18 lakes.

Importance of the environment

A suitable physical and chemical environment is also important for successful stocking or introduction. Physico-chemical factors influence the biocenose of a lake in several ways. With a few exceptions, abiotic factors will not cause mass mortality of

whitefish larvae in normal conditions in northern Finland, although unfavourable conditions can cause retardation of growth. However, natural mortality of one-summer old fingerlings in lakes may be much higher in the first autumn than in the following years (11), at least part of which mortality may have been caused by physico-chemical factors which differed from those of the rearing ponds. The results of introductions of whitefish larvae have generally been very poor in southern Finland as compared to the results obtained in northern Finland. The only exception to this is the introduction of *C. oxyrhynchus* fry into Lake Pyhajarvi, southwest Finland, which has resulted in a stock yielding annual catches of over 100 t. This same trend has also been observed when adult whitefish were transplanted, but the reasons for this remain unexplained.

Despite the possible significance of abiotic factors, more attention has been paid to the influence of biotic factors, such as food supply and predators, inter- and intra-specific competition for food and the effects of fishing on whitefish stocks. In one of two lakes inhabited by *C. muksun* and *C. peled* the zooplankton production utilizable by the next trophic level was estimated to be about 400 kg/ha from June to September (12). Large species were more abundant here than in the other lake where the corresponding zooplankton production was only 130 kg/ha. Stocking density in both of the lakes was 140 whitefish fingerlings per hectare. In the less productive lake the similarity of food between the two whitefish species was very high indicating high competition, which was reflected in lower growth rate and higher natural mortality. In the more productive lake the true fish production was 70 percent of the theoretical productivity based on zooplankton production and was even higher in the more oligotrophic lake. When the competition for food was not high, large zooplankton species were preferred by whitefish. It may be concluded that many of the lake eco-systems in northern Finland have vacant niches for whitefish because of over-exploitation of fish stocks and because of damage to suitable nursery and spawning areas caused by the construction of installations for hydro-electric power stations, regulation of lake level, dredging of rivers, etc. This explains the especially good yields obtained from stockings with one-summer old fingerlings.

The relation between whitefish and vendace populations was discussed in two cases, the first of which confirmed the dominance of vendace over whitefish that has been observed in many earlier studies. In the second it was found that a remarkable increase in vendace population had very little influence on the yield of stockings with whitefish fingerlings. Salojarvi suggested that inter-specific competition for food in this case only exists during the first summer and this was thus avoided by stocking fingerlings instead of fry. However, further information is needed on this question.

Importance of fishing

The importance of fishing has only been mentioned insofar as possible decreases in inter- and intra-specific competition for food are concerned. Its role in controlling the abundance of predators remains more obscure.

Observations on whitefish production

Much higher levels of production were generally obtained from stockings with whitefish fingerlings than with fry. The average yield per thousand stocked fingerlings in northern Finland was 120–150 kg and the corresponding figures for fry were 2–4 kg (min. 0, max. 15 kg). Some information on the biomass and yield levels in the lakes in northern Finland were also given. In one case the estimation of *C. lavaretus* biomass originating from stocking with fingerlings was 6.1 kg/ha and the annual yield, 1.6 kg/ha. In another case, yields of 0.9–3.3 kg/ha were reported. In small forest lakes in Finland

(11) a theoretical annual net yield of 4 kg/ha for *C. peled* and of 2 kg/ha for *C. muksun* were obtained in the same lake, where abundant perch, pike and roach stocks were also present. In another lake with a very small pike population and with a perch population that was not too abundant, the theoretical annual net yield for *C. peled* was estimated to be 31 kg/ha and for *C. muksun* 23 kg/ha. The importance of predation, especially by *Esox lucius* as a cause for high natural mortality of whitefish was, therefore, stressed.

Importance of whitefish stockings to fishery

Stocking with whitefish provides better employment as a result of fingerling production and the increases in the fishery also create supplementary activities in depressed areas producing an increase in income, an increase in recreational possibilities, maintenance of social infrastructure of the society, as well as conservation of fish stocks (9).

Based on the influence of stockings on whitefish catches and the costs of fishing, a net profit of about 30–60 percent on investments for stocking with fingerlings is obtained. Because of the higher yield that can be caught for the same fishing cost as a result of stocking activities, this profit may be even higher.

In Finland there is great demand for whitefish on the market, a fact which has allowed a commercial fishery to develop on suitable lakes. Whitefish is also a favourite target species for subsistence fishermen. The extensive whitefish stocking programme in Finland (27 million fingerlings in 1980) can best be understood in this framework.

Other aspects of whitefish stocking

One aspect of stocking with whitefish not dealt with in the reports is the accumulation of heavy metals and pesticides in fish. Finnish experience shows that, of the species stocked into the natural waters, coregonids usually contain less methyl mercury than predatory fish species. Methyl mercury has recently shown to be the most harmful contaminant in fish of natural waters in Finland and the commercial fishery for pike, perch and burbot especially, has been restricted because of an excessively high level of this contaminant in their flesh in many water areas. Thus, the good quality of whitefish as food should also be kept in mind when evaluating the importance of whitefish stockings. Another important impact of stocking with whitefish lies in their competition with other salmonids especially with arctic char. In the long run stocking with coregonids, and above all with *Coregonus lavaretus* (*sensu* Svardson 1979), has meant the almost total elimination of Arctic char in many Swedish lakes.

Supplementary references

Heikinheimo-Schmid, O., (About the food of whitefish in a natural and regulated lake.)
1982 Riista- ja kalatalouden tutkimus-laitos, Monistettu ja julkaisu, (4):1–64 (in Finnish)

Mutenia, A., (A reservoir is not a lake.) Suomen Luonto, vuosikirja, (1981):62–4 (in
1982 Finnish)

(d) GENERAL DISCUSSION

Participants from several countries confirmed the apparent uselessness of stocking waters with fry and fingerlings of pike. It was felt by the meeting that this practice was generally neither economically nor ecologically justifiable, although in rare cases where there are unpredictable and frequent changes in water level in spring stocking with pike it could be useful.

Some differences of opinion were expressed on the impact of eel stocking on populations of other species within the stocked water. For instance, Sweden noted a severe decline in crayfish populations, which may disappear completely from waters subject to heavy stocking with eels. Furthermore, in Ireland it has been observed that eel dig up and eat salmon eggs and thus cast some doubt on observations indicating no effects of eel stocking on salmonids.

When asked to comment on the status of Chinese carp introductions in the Danube, Holcik replied that grass carp, bighead and silver carp are all regularly caught in large quantities in the river. Similarity of conditions between the Danube and the native rivers the Amur and Yangtze would suggest that all three species could breed and although fry have not been caught due to the swiftness of current, there are indications from both the Tiza River and the Danube itself that reproduction is occurring if only sporadically. The three species are also caught in the Danube delta in Romania and it is felt that although some of these fish are escapees from the intensive aquaculture in the region, many also originate from fish breeding above the iron gates and being swept downstream. This problem is under study.

The introduction of roach into Ireland has proved to be a nuisance as the fish are competing with the preferred trout. Continued spread of the species by anglers using it as bait illustrate the way in which an unwanted introduction may be further disseminated by carelessness or lack of understanding. Much of fishery management in Ireland aims at eliminating this species and at replacement stocking with brown trout. Unfortunately, the introduction of roach has also brought in a digenian trematode parasite dangerous to local fish. There is also a tendency to spread unwanted species involuntarily concealed within shipments of juveniles or fry of other similar species. In this way, the undesirable *Carassius auratus gibelio* has been disseminated throughout Yugoslavia along with carp.

SESSION 2: STOCKING WITH BROWN TROUT (G.J.A. Kennedy) (Papers Nos. 14, 15, 16, 17, 18, 19, 20, 21, 25)

The papers in this session highlight the varied approaches of different workers toward optimizing the returns from brown trout stocking - given the problems of water type and quality which may be unique to each country. Although in some areas of research there is a fair consensus of agreement, on other aspects it appears that a definitive strategy cannot be reasonably extended throughout the brown trout world, e.g., in relation to the requirements of local strains of trout. The main aspects of the work described in these papers can be considered under several headings:

Optimum size of trout for stocking

Where this factor has been studied, it is fairly well agreed that larger fish give better returns. Each increase of 3 cm in the mean size of stocked trout doubled the return of two-year old fish in Norway, and in other comparative experiments two-year old summer stocked fish (13–16 cm length) gave three to twelve times better return than one-year olds (5–6 cm length) stocked at the same time (14). This difference between yearling and two-year old fish, with the former giving no returns at all to anglers was also noted in large Irish lakes (17). However, yearling fish gave returns to anglers in smaller lakes, but in this case the genotype of the fish was more important than the slight size differences of about 2.5 cm. This was not the case with two-year old fish, as size at stocking was found to be more important than genotype in relation to plantings in large Irish lakes. Of the other authors who touched on this subject, Marchant and Moreau (16) recorded the best returns (up to 90 percent) from hatchery trout of takeable size stocked

during the fishing season in heavily fished areas; Toivonen *et al.* (20) recommended minimum stocking sizes of 18–25 cm; and Williams (25) noted that stocking of trout which were smaller than the takeable size in polluted waters was of little benefit.

Optimum time of stocking

This factor has been widely investigated and there is general agreement that spring stocking of brown trout gives much better returns than autumn stocking in both rivers and lakes. Four examples of experiments illustrating this point have been given for Norwegian lakes and rivers, and attributed to starvation of the autumn stocked fish in the harsh winter conditions. The good survival and angling returns noted from spring-stocked two-year old hatchery trout compared with the poor survival of autumn yearlings in Irish lakes, despite the high autumnal standing crops of benthic organisms, confirms this opinion. An absence of surface food organisms in the autumn may have some influence on this. In Wales most stocked trout had a lower food consumption for 40–50 days after stocking, and for this reason it has been recommended that stocking was not carried out in the autumn before the harsher conditions of winter (15 and 21). In France, hatchery trout grew more quickly than wild trout after a period of initial weight loss following stocking, possibly because the former eat more than wild trout. However, very low returns from autumn stocked legal and sub-legal sized trout have also been recorded as compared to those which were spring stocked, although this was attributed to downstream movement rather than mortality. In Finland spring stockings gave much better results than autumn stockings (19, 20). No distinction between spring and autumn stocking is made in Denmark, where the latter is still regularly incorporated into the stocking programme to facilitate the assessment of natural recruitment by electrofishing (18).

Strains of stocked trout

Differences between hatchery and wild strains of trout have been investigated both in terms of their stamina and their survival after stocking. Wild strain yearling trout survived significantly better than yearlings of hatchery origin when stocked in small Irish lakes (17), but when two-year old trout of both types were stocked in larger lakes then size on stocking was more important than genotype. Hatchery strain trout were considered “soft fleshed” and “tamer” than wild strain trout, and concluded that these factors led to poorer survival of the hatchery strain in an alien and competitive environment. Tests on the relative hardiness of wild and hatchery trout confirm that few of the latter could match the stamina of wild fish (16). As a result of this, it has been suggested that fish-farming techniques suppressed the process of natural selection, and that in future hardiness should be bred into fish for stocking. A similar suggestion was made that breeding programmes in Denmark should be aimed at producing “optimal” wild trout strains for stocking as fish reared from local wild parents are possibly superior to those of unknown hatchery origin (18). Hatchery-reared trout tend to retain a silvery appearance for a considerable period after stocking and this may make them more conspicuous to predators (15, 21). In Norway, the selective breeding of different strains of trout is already being carried out, and the survival of each has been found to vary considerably according to the type of water into which they are stocked (14).

Movements of stocked trout

Various degrees of movement have been noted in the introduced trout. In Welsh rivers the majority of stocked trout moved less than 1 km, generally in a downstream direction (15, 21 and 25). The extent of movement was greatest in fast-flowing rivers and more limited in the deeper, slow-flowing waters. In Norway, the migrations of stocked

trout are "in general very short" (14). However, in Finland, captures of stocked trout have been made up at 100 km downstream from the point of stocking - even in less polluted areas, and for this reason stocking with brown trout in lakes with outlets is not recommended (19). Low returns from autumn-stocked trout six months before the angling season in France are also attributed to a downstream movement of "several kilometres" (16). Here, it was also noted that stocked fry which did not acquire a territory retained a tendency for downstream movement for about ten days after emergence, and that this occurred mainly at night. However, distances for fry dispersal have not been quantified in this work. In Denmark, the dispersal of fry and other stocked trout is assumed to be limited (18) and one of the main principles of stocking schemes here is that the stocking material is distributed as widely as possible in a river system in order to make full use of the total production capacity.

DISCUSSION

Discussions centred on three main, interconnected aspects of trout stocking; the advantages of wild versus hatchery-reared fish, the apparent competition between brown trout and rainbow trout and migration of stocked trout. In France less importance is attached to immediate effect of stocking, such as high catch rates, than to the long-term establishment of fish in rivers. To this end stocking with male fish gives poor yields but eventually produces established populations which resist catching and survive better in the natural environment. The importance of acclimating fish, or choosing genetic strains that resist overly easy capture by fishermen or by other predators was also mentioned, although in the U.S.A. it is generally considered preferable to have many vulnerable hatchery-reared trout available to the fishery than to have fewer wild trout. In Norway the lack of wild trout makes it necessary to use hatchery-reared fish, which can be acclimated to the wild situation and result in steadily rising catches. By contrast, in the Netherlands, continued stocking with rainbow trout in brackish waters, over a period of 14 years, has failed to compensate for a steady decline in catch levels achieved after the initial stocking.

Some of the decline in catches noted from other waters may be due to migration away from the stocking site. This is especially applicable where fish are transferred from one system to another and tend to return to their home system, a tendency that may be counteracted by acclimation for about a month prior to stocking. Migration is also common among rainbow trout, many introductions of which may originally have been from the steelhead (migratory) strain. In any case, it is possibly better to distinguish between the needs for stocking into closed systems, and those rivers and lakes which are open and thus permit migration to occur.

The apparent competition between brown and rainbow trout, which tends to be resolved in favour of the brown trout in the natural system, may not in fact be true competition and the two species may coexist unless excessive densities of both species are present.

SESSION 3: STOCKING WITH SALMON (H.J. Egglshaw) (Papers Nos. 22,23,24)

Introduction

Recent advances in our understanding of the factors affecting the growth, survival and production of juvenile salmon from natural spawning have allowed stock enhancement programmes to be defined more clearly than has been the case in the past. Techniques are available for results of management programmes to be monitored and evaluated, and reports on specific projects in different countries are appearing in the

literature. In addition, some general accounts of salmon propagation and related topics have been published. These include the EIFAC Technical Paper entitled "Ecological diagnosis in salmonid streams" (Cuinat et al., 1975), a report on propagation in England and Wales (Harris, 1978) and a guide to stream enhancement published by the Government of Canada (Stream Enhancement Research Committee, 1980). Egglshaw et al. (1982) have completed a guide to stocking, which is to be published soon.

Stock enhancement in the management of salmon fisheries may require the application of several techniques, but usually involves a programme of planting juvenile stages.

When salmon stocking can be carried out

In general, artificial stocking for salmon fisheries improvement should have one of the following objectives:

- (i) To extend the area of smolt production. This will usually mean stocking above obstructions or barriers, which hinder or prevent the upstream migration of spawning adults, and would need to be repeated each year. There may be opportunities to artificially stock a river that contains no natural stock of salmon because of its geographical location.
- (ii) To repopulate a river which is recovering from pollution or other harmful effect. Stocking should continue until a spawning run of adults had built up.
- (iii) To supplement natural production where, through detailed survey, census or observation, this is judged to be less than the carrying capacity of the water (e.g., because of inadequate recruitment). The stocking would continue until a larger spawning run had been attained.
- (iv) To maximize smolt production through the fullest use of nursery areas. This would involve more specialized knowledge and techniques, e.g., increasing the rate of egg and larval development by using a warmer water supply or making successive plantings in the same growing season, and would need to be repeated each year.

Alternative and additional management techniques for increasing salmon stocks in a river should also be considered. These could include increasing the spawning escapement, transferring spawning fish from other areas, or improving the conditions in the river (e.g., improving water quality, removing obstructions, constructing fish passes or making physical improvements to the bed, etc.). There is a fairly extensive literature on these subjects (e.g., Berg, 1964; Ducharme, 1972; Hunt, 1969; Jones and Howells, 1975; Netboy, 1968; Smart, 1965; White and Brynildson, 1967). It should be borne in mind that, although juvenile salmon and trout and other fish species occur together in streams some spatial separation has been recognized (Elson, 1967; Symons and Heland, 1978; Egglshaw and Shackley, 1982; Kennedy and Strange, 1982) and it is important to know the type of habitat preferred by salmon of different sizes if stock enhancement projects are to be successful.

The stages to plant - advantages and disadvantages

Eggs of salmon may be planted out when freshly fertilized ("green" ova) or after some weeks incubation, when they have developed pigmented eyes ("eyed" ova). These stages have to be buried, either directly (Sedgwick, 1960) or in boxes (Vibert, 1949; Egglshaw et al., 1982), in the gravel of the stream bed. Eggs cannot be planted out or handled between the "green" and "eyed" stages, otherwise huge mortalities will occur.

Eggs can be held in a hatchery and unfed or “swim-up” fry planted out, or the fry can be fed for various periods and planted out as fed fry, parr or smolts (i.e., when their freshwater life is almost complete).

(i) Planting freshly fertilized ova

Advantages: No hatchery facilities are required.

Disadvantages: Great care is needed in selecting sites, avoiding areas which may be subject to erosion or siltation, or which could be left dry in low water. Must be planted out within 24 h after being fertilized, and river conditions may then be unsuitable. Low survival rates to fry emergence have been observed.

(ii) Planting “eyed” ova

Advantages: Can be planted out over a long period, about three weeks, depending on temperatures, so the best sites and conditions can be chosen. Fairly robust and can be safely handled. Survival rates to fry emergence are usually high. They are often planted out in boxes, which offer some protection from flood conditions.

Disadvantages: Great care needed in selecting sites. Hatchery facilities are required, therefore more costly.

(iii) Planting unfed fry

Advantages: Avoids the heavy losses that occur in some rivers during the egg and early larval (alevin) stages. Is simpler and less time-consuming than planting eggs, a team of three workers can plant 70 000 fry per day (as against 35 000 eggs). Fry can be evenly distributed over the stream bed.

Disadvantages: Need to be planted out at a precise stage, with well developed pigmentation and only a small amount of yolk sac still present; otherwise suffer heavy losses if planted out too early (swept downstream) or too late (starvation). Additional hatchery facilities required for larval development, increasing the costs. Have to be planted out in low discharge conditions.

(iv) Stocking with unfed fry and parr

Advantages: Can be planted out at almost any time, provided discharge conditions are not severe. Large mortalities which can occur to eggs and unfed fry in some areas may be reduced.

Disadvantages: Extensive hatchery facilities required, and fish need to be fed. Production costs are, therefore, high.

(v) Stocking with smolts

Advantages: Good survival from egg to smolt stage when kept in hygienic conditions. Large numbers can be produced in a relatively small area. Can be useful in preserving stocks in rivers which have poor or damaged spawning grounds. May be necessary in selective breeding projects.

Disadvantages: Fully equipped hatchery facilities required. Fish need correct diet and regular attention. High post-release mortality. Hatchery smolts have a lower survival than wild smolts and poor returns as adults are often observed. Smolts generally are not robust, hatchery smolts particularly so, and require gentle handling (24). The optimum smolt for best survival may be difficult to produce.

(vi) Obtaining stock

Stock for planting may be purchased or adult salmon may be trapped and held to provide eggs and milt. Trapping methods and holding techniques have been described by Fort and Brayshaw (1961), Clay (1961), Piggins (1967) and Struthers (1982). Considerable care is required in keeping fish free from disease in holding tanks or ponds (Piggins, 1972). With suitable facilities, long-term selective breeding projects can be attempted (Calaprice, 1973) to improve the quality of returning adults (Piggins, 1967; Peterson, 1971). The importation of eggs and fry from other river systems carries the risks of spreading viral diseases and introducing stock of unsuitable genetic composition (Moller, 1970). The best policy is to obtain eggs or fry from the same river system which is to be stocked or, failing that, from a nearby river.

Survival and growth of stocked salmon

(i) Evaluation

Any stock enhancement programme should be monitored to establish its success or failure. This evaluation allows suitable modifications to be made to the programme and the most effective techniques to be adopted. When ova or fry are planted in streams, population estimates can be made in late summer or autumn to determine survival and growth rates. The number of juvenile salmon present in a section of stream is estimated by isolating it with stop-nets and catching the fish enclosed using electric stunning apparatus. The Leslie/De Lury successive removal method based on, usually, four electro-fishings is normally applicable. When fry are stocked their dispersal during the first growing season is fairly limited, usually being no further than 300–400 m downstream and 100 m upstream of the stocked area. Population estimates in several sections of stream allows the total number of survivors to be determined (Egglshaw and Shackley, 1973). During their downstream migration to the sea large parr and smolts can be caught in a trap located at a suitable point on the stream. Either the whole run of fish is caught or, if only a proportion is caught, mark and recapture experiments are made to determine the total number of migrants.

(ii) Survival

When green ova are planted there are usually high mortalities to the emerging fry stage, possibly owing to winter flood water disturbing the eggs, and this loss results in low numbers of parr and smolts. In severe conditions artificial redds are sometimes destroyed completely (23). Eyed ova, whether planted in boxes or directly in the gravel bed, and unfed fry give much higher, and similar, survival rates (Egglshaw and Shackley, 1980) (23). From eyed ova survival to fry in late summer was 17.5–19.4 percent in each of three years in a stream in Northern Ireland (23), to fry in autumn in a Scottish stream 11.1–14.8 (Egglshaw and Shackley, 1980) and to fry one year later in Northern Ireland 10.3 percent (Kennedy and Strange, 1981). Survival of fry is dependent on various factors, including the planting density and the presence of trout and older age classes of salmon. Instantaneous mortality rates (M per day) during their first growing season of fry planted in tributaries of the River Tummel, Scotland, were 0.0068–0.0125 for plantings at 2.0–3.5 m^2 , and were usually 0.012–0.014 at plantings of 5 m^2 (22). When fry were planted at 3.6–29.3 m^2 in another, productive stream the values of M per day during the first growing season were related to the initial stocking density (D_p) by the formula $M = 0.00637 + 0.00444 \log_{10} D_p$ (Egglshaw and Shackley, 1980).

When a stream in Northern Ireland contained trout and salmon parr the survival of salmon stocked as eyed ova (at 6.2 m² overall stream density) was less than half that found when other fish were absent (23). However, presence of 1 + age-class salmon did not increase mortality of 0+ salmon in the stocked tributaries of the River Tummel where trout populations were low (22).

The survival of stocked salmon is lower when large numbers of trout fry are present (23). Egglisshaw and Shackley (1977) observed that mortality rates of wild salmon in their first year were related to their densities at the beginning of the season and, more closely, to the densities of salmon and trout combined. Mortality rates (M per day) of stocked salmon in the River Tummel tributaries in the year following their first growing season were, at 0.0014–0.0039, low when compared with natural populations (22).

(iii) Growth

Growth of juvenile salmon is dependent on population density, temperatures, food resources and the presence of other fish. At the end of the first growing season, Egglisshaw and Shackley (1980) found a mean weight (W_0 , g) of stocked salmon in one stream was inversely related to the population density (D_0 , No.m²) and the biomass (B_1 , g m²) of 1 + salmon present, giving the relationship $\log_{10}W_0 = 0.6584 - 0.0558 D_0 - 0.0352 B_1$. Salmon fry were larger (mean 62 mm) in a section of stream from which all the fish had been removed, than they were (mean 52 mm) in a section containing trout and salmon parr (23).

Handling and transport of smolts

There has been considerable expansion in recent years in smolt rearing and research to improve methods and techniques. Smolts produced in hatcheries have a lower survival than those produced naturally and, although some of the factors affecting survival of wild smolts are known, much less is known about those affecting hatchery smolts. In natural populations the transformation and migration of smolts are started by environmental factors, which presumably include the most favourable conditions for survival. Hatchery-produced smolts may be released at a less than optimum stage and in unpromising conditions. In addition, high mortalities can be experienced after handling and transport to the stocking site. Soivio and Virtanen (24) have studied the physiological effects on Baltic salmon smolts of transporting them from four inland fish farms to coastal stocking sites in Finland. Samples were taken just before transport in fresh or salt water and after a five-days recovery in fresh water at the stocking site. The blood haematocrit values (15–23 percent less) and haemoglobin concentrations were lower following transport, as were the plasma glucose concentrations (6–75 percent less), liver glycogen content (25–29 percent less), and muscle lipid content. These data on blood oxygen-carrying capacity and reduction in energy reserves are typical of stressful states. To moderate the effects of transportation and to decrease the energy costs of osmoregulation, fish should be kept in salt water and fed during recovery. The physiology of the smolts remained unbalanced for five days after transport and, to reduce delayed mortality, smolts should be released at a critical stage, stress should be minimized, and time for recovery allowed at the stocking site, during which the fish must be fed.

DISCUSSION

The importance of measuring the physio-chemical characteristics of smolts as an index to their state of health was emphasized. This can be used to give data for correlation with data on the rate of returns.

It was pointed out that the enhancement of smolt stocks above natural or man-made obstacles is not always desirable as returning fish are unable to return to their original freshwater habitat and may thus accrue below the obstacle. Such stockings, however, can make up for badly damaged bottoms where natural hatching cannot be expected.

Transport may affect fry survival and tranquillizers are sometimes used to reduce mortality when marking or during transport or long holding periods.

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SESSION 4: INTRODUCTIONS AND TRANSPLANTATIONS - CASE HISTORIES AND EXPERIENCE WITH SOME SPECIES

- (a) ALEWIFE AND SALMONIDS (J.Holcik) (Papers Nos. 15, 26, 27, 28, 29, 30)

Introduction

The papers submitted to this session were devoted to the results of introductions of one clupeid - the alewife (*Alosa pseudoharengus*) (26) and four salmonids: the brook trout (*Salvelinus fontinalis*) (29), the lake trout (*Salvelinus namaycush*) (30, 15), the coho salmon (*Oncorhynchus kisutch*) (27) and the Danubian huchen (*Hucho hucho hucho*) (28). Apart from the huchen, which is native to Europe, all other species are of North American origin.

Purpose of Introductions

The species under consideration were transplanted or introduced for various purposes. Alewife have been transplanted into several reservoirs in the southeastern United States (Virginia and Tennessee) to expand the forage base for piscivorous pelagic game fish and especially for large predators such as the striped bass (*Morone saxatilis*), white bass (*Morone chrysops*) and the walleye (*Stizostedion vitreum vitreum*). The brook trout is one of the earliest exotic species transferred to Europe. The first introductions were in 1876–90 to England, Sweden, Norway, Czechoslovakia and Switzerland and later also to other countries. The original introduction was for angling and aquaculture. The prime motivation for the introduction of lake trout into Finland and Sweden was for stocking lakes, to compensate for the decline of native salmonids, to enhance the fishery in lakes subjected to adverse effects by hydro-electric development and to fill a vacant trophic niche. The last two species of salmonids are among the least known. The transplantations and introductions of the Danubian huchen were made by several European countries for angling, compensation for decreasing stocks of the native diadromous salmonids, to reduce the density of coarse fish populations as well as to save this valuable fish from extinction. The impetus for the coho salmon transfer to France is due to the increasing demand for salmon in this country, which is not satisfied by the declining stock of the sea trout (*Salmo trutta m trutta*) and Atlantic salmon (*Salmo salar*).

Results obtained

The alewife established a reproducing population in Claytor Lake, a mainstream hydro-electric impoundment of the New River in Virginia, two years after introduction and has subsequently become a major component of the fish community. Its biomass was estimated to vary from 25 to 50 percent relative to that of the total reservoir fish community. It was found to be a preferred prey of such pelagic predators as striped bass, white bass or walleye but tended to be avoided by the basses, *Micropterus salmoides*, *M. dolomieu*, *M. punctulatus*, which preferred littoral habitats. It was not found at all in the stomach contents of black and white crappie (*Pomoxis nigromaculatus* and *P. annularis*). Alewife growth in this reservoir exceeds all growth rates documented for other landlocked populations and because of this, only a limited portion of the population is vulnerable to predators. The growth of white bass and walleye significantly increased after the establishment of the alewife whereas the growth of bass, crappie and sunfish (*Lepomis* sp.) declined. The population of *Lepomis* stunted due to reduced predator pressure as the pelagic predators switched to alewife. Severe kills, common in this species in the Great Lakes were also observed in Claytor Lake, but the population

was found to recover rapidly due to highly successful reproduction. Alewife are not only highly size-selective planktivores which reduce the composition of the zooplankton toward the smaller forms, thus producing a potentially significant adverse impact on other planktivorous species living in the same lake but the species may also be considered to be a true predator as it feeds on the young of at least five other fish species. Downstream migration of alewife from Claytor Lake has resulted in its becoming established in Bluestone Lake, over 100 km downstream, thereby giving it potential access to nearly half of the continental United States.

Experience obtained from introductions of brook trout into Norway confirm that this species is rarely able to establish self-reproducing populations and under normal circumstances it is usually suppressed by the native brown trout. However, long-term observations coupled with many stocking and testing experiments in Norway reveal that brook trout may survive and thrive in acid waters with pHs as low as 4.5. The brook trout is more tolerant to waters which have been seriously altered by acid precipitation than Atlantic salmon, brown trout and rainbow trout (Salmo gairdnerii). In such water bodies brook trout usually grow faster than the other salmonids tested and have better condition and quality. Indeed in some acid waters, the brook trout is the only species of fish.

In Finland and Sweden (30, 47, 15) stocking experiments with lake trout were performed over the last 25 years in lakes of different sizes and types and also in the sea. The species is also cultivated in fish farms. It was found that lake trout should be stocked at lengths of between 20 and 25 cm in spring or autumn into large and deep, clear lakes. Good results (in terms of catch) were also obtained from small lakes but only if they too were deep and clear. Poor results were obtained in man-made lakes, dystrophic lakes as well as in the sea and in brackish waters. The example of Lakes Pallasjarvi and Inari, where the catch of lake trout is 237 and 100 kg per 1 000 stocked individuals, respectively, indicates that good results are obtained only when stocking is both massive and repeated each year. Full naturalization was observed in Lake Pallasjarvi and probably also in Lake Inari. The diet of this species is composed mainly of vendace (Coregonus albula) and of the whitefish (Coregonus lavaretus). Cultivation of lake trout brood fish and juveniles in fish farms is easier than that of Atlantic salmon or sea trout.

In Sweden introductions have, in most cases, not been successful and natural reproduction of lake trout is only assumed. The growth rate of this species differs significantly according to the type of fish community in the lake studied. In lakes with complex fish communities growth was good, but in lakes with simple ichthyocenoses growth was poor. It has been observed that the lake trout can easily switch among prey species according to their density and availability. No harmful influence on native fish communities has been observed either in Finland or Sweden. However, both in the Finnish and Swedish lakes introduced lake trout feed on some apparently valuable fish such as coregonids and the Arctic char, which should affect the density of these species to some degree. Interestingly enough, however, the growth of dwarfed Arctic char has increased considerably after the introduction of lake trout, resulting in improved fisheries for both species.

The introductions of coho salmon into France were carried out by several official and private institutions for mariculture in cages. However, some 60 thousand yearlings of this species were released into the Varenne River in Upper Normandy by chance in 1974 and 1975. First recaptures were made in 1975 in the Varenne and in some neighbouring rivers. A special search for coho revealed that upstream migration into the Varenne lasted only until 1977 after which the species disappeared completely. There is

nevertheless some indication that successful natural spawning had occurred. The mean length of the recaptures was 343 mm and the mean weight 1.6 kg. The coefficient of condition equalled that of native Atlantic salmon but was lower than that of sea trout from the same area. The coho conserved its natural biological cycle in the Varenne: the smolts migrated to the sea in the year of stocking and returned to the river after about 18 months. Taking into account the poor results with the cultivation of coho in cage-culture, as well as the environmental conditions in the sea around the French coast and in neighbouring rivers, the authors conclude that the possibility of establishing coho and other Oncorhynchus species in France is very limited. As a result, more attention should be paid to the possible risks and negative impacts of introductions of exotics and to the conservation and development of the native Atlantic salmon and sea trout. Introductions of kokanee (Oncorhynchus nerka) have on the whole failed in inland waters and the Baltic. Hopefully, however this species might have a role to play in the future especially for aquaculture (47).

The Danubian huchen was transplanted into Czechoslovakia, Poland, England, Switzerland, Belgium, France, Sweden, Spain and also into Morocco and Canada. Of 38 attempts registered, only eight were successful, i.e., naturalization occurred only in 21 percent of trials. The species still lives in four rivers outside its natural area of distribution - two rivers lying between Czechoslovakia and Poland, one river in France and one river in Spain - and is limited to the rather short upper reaches. Ignorance of the ecology of this species, stocking with fish that were too young, the low quantity of fish stocked and the short duration of the introduction attempts are the main reasons for failure. The slight information available on predation in the huchen indicates that this species may substantially reduce the population density of species living in the same waters and in some cases the density of huchen has had to be limited in order to prevent decline in the stocks of other more valuable species such as brown trout or grayling (Thymallus thymallus). As the top predator of the preferred ecosystem, the huchen may be of use for the control of populations of overcrowded forage species, however, it is unable to form dense populations and is therefore unable to replace the diadromous salmonids. As this valuable species is now threatened with extinction within its European range, it is recommended that it be restocked into rivers inside its original area of distribution. However, if huchen is to be introduced outside its natural geographic range, strict precautions must be taken to avoid undesirable effects.

Conclusions

Although limited with regard to the number of species studied, the papers presented to the Symposium still allow some general conclusions to be drawn:

- (i) In most cases introductions or transplantations have been less successful than expected with regard to their predicted benefits.
- (ii) When introducing exotic species into new environments there is almost always a risk of negative influence on the indigenous species, as only seldom is the new species segregated ecologically. Thus, both competition and predation should be anticipated even with forage fish.
- (iii) There is an urgent need to increase knowledge of the ecology of fishes which should include study of their behaviour and physiology.
- (iv) Decision-makers should conduct benefit/risk analyses based on ecological studies prior to stocking with any fish not indigenous to a region.

- (v) In spite of the general lack of success and the adverse effects of introductions, the transfer of exotic species into natural ecosystems need not be rejected because, in some water bodies with artificially altered environments, the exotic species may have higher resistance and better vitality, as is shown in the example of the brook trout in Norwegian acid lakes and streams.

DISCUSSION

In the United States the transfer of alewife has not only been less successful than anticipated, but may be classified as disastrous. Its habit of eating other fish and larger zooplankters may result in gross modifications of the ecosystem which, now the species has access to the Mississippi Basin, may well have far-reaching consequences.

Lake trout in Sweden have had no discernible deleterious effects although they feed on whitefish. Here, the whitefish are not favoured by the fishery and lake trout may be viewed as a convenient way of converting unusable species into useful fish flesh. The fact that, in Poland, whitefish are perfectly acceptable - indeed preferred by the consumer - indicates the way in which the judgement of the success or failure of an introduction may depend on local social attitudes. In Sweden, where lake trout and Arctic char are stocked together, the cropping of young Arctic char by the trout improves the growth of the remaining char.

(b) CYPRINIDS AND PIKEPERCH (J.Dahl) (Papers Nos. 32, 33, 34, 35, 36, 37)

The papers reviewed in this group describe case histories on the effects of introductions of species which were not present in the locality beforehand.

Two papers dealt with the introduction of herbivorous fish; one described experiences with heavy stockings of silver carp in a lake in the German Democratic Republic (32), the other described the first experiences with experimental stocking with grass carp in Denmark (33). Paper 34 described the experiences of transferring barbel to a river system in the U.K. where it did not previously occur.

The last group of papers dealt with pikeperch; one on the adverse effect of an unintentional introduction of pikeperch into an East Anglian water system (36) and one an historical account of the naturalization of pikeperch in the Danish freshwater fish fauna (35).

Silver carp and grass carp

When a hypertrophic lake in the German Democratic Republic was heavily stocked with 10 000 two-year old silver carp the amount of zooplankton per unit area decreased in the epilimnion but this decrease was to a certain degree compensated by the littoral zooplankton which was unaffected by the heavy silver carp population (32).

The indigenous pikeperch and perch in the lake were severely affected as these species spawn in the sub-littoral and their fry depend on zooplankton in the limnion. By contrast, white bream and roach, which spawn in the littoral and the fry of which feed there, were not affected. The same was true for bream which even showed better growth than average, although this was probably more related to the fact that the original bream stock had been heavily reduced some years before the experiment, so the remaining specimens obtained a growth which was better than normal.

When the numbers of silver carp were reduced in 1981 by harvesting, the survival of pikeperch fry was markedly improved.

From a management point of view, a stocking rate of 1 000 two-year old silver carps per ha or less is to be preferred in order not to cause adverse effects on some of the indigenous species.

As the results with first and preliminary stocking experiments with grass carp in small water bodies in Denmark are very variable it is as yet too early to evaluate the possibilities of this species under Danish climatic conditions (33). Grass carp seem to have been adversely affected by long-lasting ice cover in some cases, which was not surprising as the waters in question were all heavily vegetated, shallow and stagnant. The observed weight increments in different experimental water bodies also varied considerably - from 23 to 146 percent during the first growing season. The effect of grazing has been equally variable from almost no effect to very heavy grazing. In one or two cases, the activity of grass carp was followed by a reduction in visibility due to sudden plankton blooms -remedial action by additional stocking with silver carp was attempted in one locality.

Barbel

Barbel did not occur in the River Severn in the U.K. before 1956 in which year 509 fish were stocked in the river. An additional 102 barbel were stocked into the Avon tributary in 1964 (34).

Before barbel were stocked, the most important fishery was for chub and dace and the river was renowned for its very popular coarse fishery. The introduction of barbel into the River Severn, however, appears to have been a great success (34). This was demonstrated by calculating the "relative importance value" for each type of fish appearing in the anglers' catches, based upon angling censuses on three sites of the river. It appears that barbel has replaced chub in the catches at two of the three sites. At the third site, chub (and bream) are still dominating the catches but also there barbel seem to increase its share. The introduction of the barbel into the Severn does not appear to have resulted in any competition with the chub, and the barbel may be considered as a bonus rather than a substitute. The authors state that the success of the barbel in the Severn was not foreseen and that it is fortunate that it has proved to be an additional species without detrimental effects.

Pikeperch

Good pikeperch stocks have been created in about 70 lakes in Denmark either by direct stocking or they have spread to other lakes within the same river system from stockings elsewhere in the system (35). Most Danish lakes are by nature considered to meet the requirements of this species. The pikeperch has become a fortunate addition to the national fish fauna not only from the commercial fisherman's point of view, but it is nowadays also a highly praised sport fish. In the Danish turbid lakes where the fish population is dominated by what in Denmark has hitherto been considered as valueless fish species, the pikeperch has proved to be a more efficient predator than the pike because of its pelagic mode of life.

The positive experiences with pikeperch in Denmark stand in contrast to the story of the accidental introduction of pikeperch into the Middle Level Drainage System in the Anglian region of the U.K. (36).

Even if previous more or less international introductions of this species - which is not indigenous in England - do not seem to have had notably bad effects in other parts of the country, the introduction in 1963 of pikeperch into Norfolk's Great Ouse Relief

Channel and its rapid spread since then in the Middle Level Drainage System seem to have had dramatic and deleterious effects on the original fish fauna.

In certain parts of the system, a drastic decrease of the stocks of cyprinids has been demonstrated and there seems to be a close relation between this decline and the appearance of the pikeperch in the system. The Anglian Water Authority has, therefore, during the past few years introduced a control programme aiming at reducing as much as possible the pikeperch population in the system. The programme is based upon a close collaboration with the anglers through their clubs, and aims at restoring the previous balance between predators and prey. The control programme contains a series of options to achieve an aim for a 9:1 ratio of cyprinid biomass to predator biomass - both pike and pikeperch - as a basis for a subsequent natural expansion of the cyprinid populations. The programme includes various combinations of predator culling by the anglers themselves and restocking with cyprinids, mainly roach and bream, by the Anglian Water Authority. The cull system was launched in 1980 and a three-year research project on predator/prey relationships within the Middle Level System has been started. Preliminary results during 1981 suggest that the cull has been very successful in reducing pikeperch biomass to a low level. However, the presence of numerous young pikeperch and pike from the spawnings in 1980 and 1981 indicates that the cull must be intensified and accompanied by massive restocking with cyprinids.

Should this action fail, then fishery managers in the U.K. will have a persistent problem of some magnitude on their hands and the popularity of the pikeperch in the U.K. will remain restricted.

Stock enhancement, it appears, is essentially a matter of preferences and attitudes, even of habits. In Denmark cyprinids are considered valueless both by the commercial fisherman - he cannot sell them - and by the anglers - they will not eat them. In England and many other parts of Europe, fishing for cyprinids (coarse fishing) is a highly praised sport. It is highly surprising for Danes to see every summer British angling tourists sitting day after day along the banks of Danish streams fishing for cyprinids and, after a day's catch, releasing them all again. This brings up the question for whom are we managing our fish stocks?

DISCUSSION

Pikeperch introductions into East Anglia in England are currently regarded as a problem. In closed waters, where the species meets with only indifferent breeding success, it has existed in limited numbers and has been well received. Once transferred to open waters (rivers) where breeding is much more successful, the species has undergone an explosive expansion and has preyed heavily on the cyprinids preferred by anglers. Control measures have attempted to restore a ratio of 9:1 in favour of the cyprinids, and it is hoped to maintain this ratio by educating anglers to the palatability of the fish. This would transform what is essentially a bad introduction into a useful resource.

In Hungary pikeperch stocks in Lake Balaton are diminishing in response to eutrophication. In reply to a question, J. Dahl said that it is not possible to determine whether the same thing is happening in Denmark, although populations in some hypertrophic lakes may be showing signs of reduction.

Romanian experience shows that pikeperch stocking is needed to maintain its populations in eutrophication environments. Usually fertilized eggs are planted into ponds and lakes. In ponds low numbers give very good results, but more intensive

stocking tends to be counterproductive. In larger lakes with more complex populations, higher levels of stocking can be maintained.

In France the introduction of the pikeperch was initially thought to be affecting stocks of whitefish but, in fact, this predation is now thought to be unimportant and the introduction is accepted as successful.

(c) CRAYFISH (K. Westman) (Papers Nos. 38, 39, 40, 42)

Introduction

Since 1860, the disastrous crayfish plague fungus Aphanomyces astaci has caused great losses to the populations of the native crayfish species occurring in Europe. Numerous unsuccessful attempts have been made to control the plague but no resistant strains of the endemic crayfish species have developed and European crayfish species seem to be incapable of re-establishing themselves in chronically infected water courses. Crayfish fisheries as well as the management of the crayfish stocks strongly declined in Europe during the first half of this century mainly due to the plague.

Interest in developing freshwater crayfish fisheries increased again during the seventies due to the availability of promising crayfish plague-resistant North American species, especially the signal crayfish, Pacifastacus leniusculus.

The resistance of the American crayfish species to the plague fungus most probably results from the fact that the plague also originates from North America and consequently the crayfish species in the U.S.A. and Canada have gradually developed a high resistance against the disease. The plague fungus was most probably transported to Europe with the American crayfish species originating from the Mississippi River delta in Louisiana.

Exotic crayfish species introduced into Europe

Orconectes limosus was introduced from North America to Germany in 1890 and spread over a part of northwestern Europe without being affected by the plague. On the basis of this it was quite correctly assumed that other American crayfish might also be resistant to the plague.

In order to restore crayfish production and to revive the earlier important crayfish fisheries a total of four exotic crayfish species have been introduced into European Inland waters from North America. Consequently, the present situation in Europe is that there are four native and four exotic, self-reproducing freshwater crayfish species. The endemic crayfish species are: Astacus astacus, A. leptodactylus, Austropotamobius pallipes and A. torrentium. The exotic crayfish species are: Orconectes limosus, Pacifastacus leniusculus, Procambarus clarkii and P. acutus.

O. limosus has spread over the whole of Central Europe and it occurs in the Federal Republic of Germany, the German Democratic Republic the Netherlands, Belgium, France and Poland.

Signal crayfish, P. leniusculus, has been introduced into almost all European countries. Procambarus clarkii has been transferred to France and to Spain, and P. acutus only to Spain. These two new species have formed naturally reproducing populations at least in Spain.

Results of introductions of signal crayfish, *P. leniusculus*, into Sweden, Finland and France

Among the exotic crayfish species introduced into Europe, the signal crayfish is by far the most interesting and promising and is, therefore, also stocked and spread in the greatest numbers.

Even if the papers submitted to the Symposium give information on the introduction of this crayfish species in only three European countries, the information is of special interest as it deals with the experience obtained in those countries where the signal crayfish were first introduced, i.e., Sweden, Finland and France.

In Sweden the signal crayfish was first introduced over 20 years ago and it has already been stocked in 260 lakes and rivers. In Finland the signal crayfish has a 15-year history and 52 small lakes are stocked with the species. In France this crayfish species was brought in in 1973 and it has since been introduced in about ten water bodies. The signal crayfish has been stocked in all three countries both as adults, transferred directly from the U.S.A. and Canada, and newly-hatched juveniles, produced from a brood stock in controlled cultivation systems in Sweden.

On the basis of reports (37, 38, 40), the following conclusions may be drawn on the introductions of signal crayfish into Sweden, France and Finland:

- Signal crayfish greatly resemble the native crayfish species in appearance. The body weight in relation to length is considerably higher in Pacifastacus than, for example in Astacus, due to the bigger size of the chelipeds in the former.
- The taste of Pacifastacus when traditionally prepared is as good as that of the highly appreciated Astacus.
- Signal crayfish seem to be able to form reproductive populations within a wide range of living conditions even up to north Sweden and north Finland.
- According to studies made in the same lakes, signal crayfish seem to grow faster and become sexually mature earlier than the native A. astacus.
- The egg production of Pacifastacus is higher than that of Astacus.
- Despite the high reproductive potential, the development of signal crayfish populations has been very slow in Sweden and Finland, but evidently considerably faster in the more favourable conditions in France. Probably no population of signal crayfish has yet reached its carrying capacity in the whole lake or river, but in Sweden it has been observed that local populations seem to be even denser than the former Astacus populations.
- According to observations made in Sweden, Finland and France, the signal crayfish seems to tolerate fishing pressure. Yearly removal of legal-size (9 cm in Sweden and 10 cm in Finland) or bigger (France) Pacifastacus from the experimental lakes seems not to have caused any harm to the populations or to their renewal.
- Signal crayfish seem to be more active and aggressive than, for example, the native A. astacus; and Pacifastacus is easy to catch with traditional methods and traps. In Sweden, a local yield of 55 kg/ha is registered and a maximum of 60 signal crayfish in one trap at one emptying.

- Signal crayfish are already commercially exploited in some Swedish lakes and the price is as high as for Astacus, i.e., about 50 Swedish Kr./kg to the fisherman.
- These and other observations indicate that signal crayfish are able to develop populations which are economically viable, i.e., populations which are able to support fishing and give profitable results.
- Signal crayfish show high though not complete resistance to the crayfish plague fungus. Stress conditions may cause a reduction of resistance leading to death of such infected animals.
- Signal crayfish harbouring hyphae of the plague fungus Aphanomyces astaci may spread the disease if stocked into or migrating to new water areas, thus causing harm to the highly susceptible indigenous crayfish species. Cultivated signal crayfish juveniles may, however, be free of the plague fungus.
- No signs of uncontrolled, vigorous reproduction and spread of the signal crayfish have been observed in any of the water bodies stocked with the species.
- Except for the spreading of the crayfish plague, no harmful effects of the signal crayfish have so far been observed in Sweden, France or Finland, either to the native crayfish populations or to the aquatic ecosystem. However, the niches of Pacifastacus and at least one of the native crayfish species in Europe, A. astacus seem to overlap to such a great degree that competition for living space will probably occur.
- No communicable fish or crayfish diseases were transferred with the signal crayfish imported from North America but a couple of previously unknown Branchiobdellidae parasites were found on the exoskeletons of Pacifastacus imported into Sweden and Finland.
- No signs of hybridization of Pacifastacus and A. astacus have been observed.
- Signal crayfish is easy to cultivate for production of juveniles for stocking purposes.

Paper 42 lists the characteristics that are desirable for fish and crayfish species considered for introductions. Signal crayfish seem to fulfil a majority of these conditions but there are still quite many open, uninvestigated questions, for example, concerning the accumulation of heavy metals and pesticides, and the long-term impact signal crayfish may have on an ecosystem. Until these and other consequences that are not sufficiently well known have been studied, it is premature to make any final assessments of the introductions of the signal crayfish.

Even if the signal crayfish have proved to be very promising and might be a good substitute for the native crayfish species in a number of former crayfish waters infected by the crayfish plague, the other North American crayfish, Orconectes virilis that is widely spread in Europe is fast reproducing but is little appreciated and of low economical value (38). No information was given concerning the other two crayfish species introduced into Europe from North America, i.e., Procambarus clarkii and P. acutus.

Risks relating to the introduction of exotic crayfish species

There are approximately 300 freshwater crayfish species in North and Central America but for the most part crayfish have several outstanding negative features. For example, they are mobile, aggressive, tolerant to a wide range of habitat conditions and

so capable of spreading rapidly within a wide range of living conditions; omnivorous and so have a wide trophic spectrum; often excellent accumulators of heavy metals and pesticides; host for a wide range of commensals and epizootics; and competitive, cannibalistic and feed on fish and so could carry spores and viruses of fish and crayfish diseases into new environments. Consequently, there is a great need for adoption of procedures to reduce the risk of adverse effects arising from the introduction or transfer of inland crayfish species.

The good results obtained in the restoration of native Astacus populations in Finland after construction works by stocking native crayfish (39), prove that in the management and restoration of former crayfish waters the possibilities offered by the native crayfish species should not be underestimated and forgotten.

DISCUSSION

In Spain two distinct climatic regions have been stocked with introduced species. In the colder north, Pacifastacus introductions show a very positive evolution and will eventually replace the native species which have been eliminated by fungus. In warmer southern waters Procambarus clarkii and P. acutus now show great success as, because of their high price, they form the basis for a fishery producing about 2 500 t/year and supporting some 700 families. In 1981 these species have been further disseminated throughout the rice-growing areas where ecological effects include the increase in the number of predatory birds feeding on crayfish, the reduction in areas of the kinds of plants used by carp fry and conflicts with aquatic moles and rats for living space.

It was pointed out that crayfish should be considered within any code of practice for the introduction of exotic fish species, and that because of their special nature, they may well require special provisions either within the code or within an associated protocol.

SESSION 5: INTRODUCTIONS - COUNTRY REVIEWS AND LAKE KINNERET **CASE W.R. Courtenay) (Paper Nos. 41, 42, 43, 44, 45, 53)**

Before reviewing the papers from Session 5, some further comments on certain papers dealing with introductions of exotic fishes included in Session 4 are in order. In most cases presented, a rationale for an introduction existed. For the majority, that rationale was to enhance fisheries. Brook trout (Salvelinus fontinalis) were introduced in Norwegian waters where acidity had resulted in a decline of native brown trout (Salmo trutta) and exotic rainbow trout (Salmo gairdneri). Lake trout (Salvelinus namaycush) were introduced in Finland and Sweden to enhance fisheries in lakes influenced by hydro-electric development and to fill a vacant niche in large, deep, coldwater lakes; best success, however, was achieved with lake trout introductions in small, deep clearwater lakes, or large lakes with populations of dwarfed whitefish, stickleback, introduced Mysis and smelt, and no adverse impacts on native fishes were reported. Carp (Cyprinus carpio) were introduced in Finland to establish a new sport fishery, with the greatest success in southern Finland. Silver carp (Hypophthalmichthys molitrix) were stocked intensively in the German Democratic Republic, resulting in a lack of survival of fry of perch (Perca fluviatilis) and of pikeperch (Stizostedion lucioperca). Barbel (Barbus barbus) were introduced in Great Britain and became a popular sport species, apparently increasing the fish biomass without impacting other fishes. Pikeperch, introduced for over a century in Denmark, have contributed to commercial and sport fisheries without negative impacts on native fishes being indicated; nevertheless, when

this same fish was introduced to Great Britain, severe declines in prey species were observed.

France witnessed a decline in certain native crayfishes following range expansion by an American crayfish, introduced some 70–80 years earlier. Concern was also expressed that escape from culture facilities of recently-imported crayfishes of American origin carries potential for further damage to native crayfish stocks as has happened in Spain. France also attempted to introduce coho salmon (*Oncorhynchus kisutch*) but these efforts failed for several reasons; nevertheless, it was realized that potential problems with the exotic outweighed potential benefits, and risks to native salmonids were recognized. The status of the endangered Danube salmon (*Hucho hucho*) was reviewed, including its history of introductions as a fishery resource and for survival of the species; the recommended course of action to assure a future for this fish is a species recovery programme.

These comments on papers from Session 4 are included to illustrate that there can be successes as well as unexpected mistakes when utilizing exotic species in fisheries management and aquaculture. Results are not always predictable. This signals the need for caution when contemplating the use of exotic species in open waters and where they can be expected to escape from culture facilities into open waters. The introduction of an exotic species requires its removal from the wild or from hatchery stocks, usually in its country of origin, and its release into often very different waters. For species collected from open waters, this results in the removal of that species from the checks and balances with which it evolved and its injection into waters containing different, few or no checks and balances. In either case, taking fish stocks from open waters or from hatcheries for introductions or stockings, we are typically introducing or stocking only a confined sample of the genetic spectrum of that species.

Session 5 included case histories of other introductions of exotic species and, in most cases, the results of those introductions.

France has 11 species of exotic fishes of which five were introduced as early as the last century (41). These are the Danube salmon, rainbow trout, brook trout, lake trout, pikeperch, mosquitofish (*Gambusia affinis*), black bullhead (*Ictalurus melas*), rock bass (*Ambloplites rupestris*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*M. salmoides*). Both black bullhead and pumpkinseed are considered nuisance species, while the present status of smallmouth bass is uncertain. The introduction of pikeperch was accompanied by a serious epizootic, a digenetic trematode, which has caused damage to native fishes in several rivers. Pressures are increasing for additional introductions such as coho salmon, chinook salmon (*Oncorhynchus tshawytscha*) and several Chinese carps.

At least 15 exotic fishes and one crayfish have been introduced to Finland over the past 130 years (42). These included the sterlet (*Acipenser ruthenus*), Siberian whitefish (*Coregonus peled*), pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), sockeye salmon (*O. nerka*), chinook salmon, rainbow trout, brook trout, lake trout, splake (*Salvelinus fontinalis* × *S. namaycush*), carp, tench (*Tinca tinca*), brown bullhead (*Ictalurus nebulosus*), smallmouth bass, largemouth bass and the signal crayfish (*Pacifastacus leniusculus*). Of these, Siberian whitefish, lake trout, tench, brown bullhead and signal crayfish established reproducing populations; establishment of brook trout in open waters is questionable. Those exotics demonstrated or thought to have importance in fisheries management are Siberian whitefish, brook trout, lake trout, splake, carp, tench and signal crayfish. Potential adverse impacts of these introductions appear to be

restricted to signal crayfish which show niche overlap with, and the possibility of spreading the crayfish fungus, Aphanomyces astaci to, the native crayfish, Astacus astacus.

Ireland appears to have had eight species of native fishes at the end of the last glacial age but now hosts at least 20 species of freshwater fishes (43). Documented introductions are those of Arctic char, rainbow trout, carp, dace (Leuciscus leuciscus), roach (Rutilus rutilus) and tench; undocumented releases included northern pike (Esox lucius) and black bullhead; probably introduced were bream (Abramis brama) and rudd (Scardinius erythrophthalmus); possible introductions include minnow (Phoxinus phoxinus), stone loach (Nemacheilus barbatulus) and perch. Of the documented and undocumented introductions, rainbow trout, northern pike, carp, dace, roach and tench are established, with rainbow trout and carp having restricted reproducing populations. Although these introductions are generally viewed as positive, northern pike have adversely impacted brown trout, dace and roach caused a decline in salmonid production in one location, and roach have been implicated in displacement of brown trout and rudd.

Romania has been the recipient of 15 non-native fishes since the last century (44). Those of foreign origin include vendace (Coregonus albula), powan (C. lavaretus), rainbow trout, brook trout, grass carp (Ctenopharyngodon idella), silver carp, snail or black carp (Mylopharyngodon piceus), chebuchek (Pseudorasbora parva), smallmouth buffalo (Ictiobus bubalus), largemouth buffalo (I. cyprinellus), black buffalo, (I. niger), black bullhead, mosquitofish and pumpkinseed. Of these, chebuchek, all three buffalo, mosquitofish and pumpkinseed are established. Exotics considered significant in fisheries are rainbow trout and Chinese carps (grass carp, in particular, for which substantial biological information on this species in Romania was provided). Introductions of grass carp were accompanied by four exotic parasites: a protozoan (Trichophyra sinensis), a monogenetic trematode (Dactylogyrus lamellatus) and two intestinal parasites (Bothriocephalus and Khawia). The chebuchek, gambusia and pumpkinseed are considered nuisance species.

At least 96 exotic fish species have been introduced in the 48 contiguous United States, all but nine having been released since the second world war (45). Thirty-nine species are presently established, 14 others were previously established, and another nine were intentionally released but failed to establish. Of the seven species introduced for food and sport, only the brown trout, bairdiella (Bairdiella icistia) and orangemouth corvina (Cynoscion xanthurus) are generally regarded as beneficial; carp are mostly regarded as trash fish, and the ide (Leuciscus idus), rudd and tench, never popular, are declining in range for unknown reasons. Grass carp and four tilapias (Tilapia aurea, T. hornorum, T. mossambica and T. zilli) have been employed in vegetation control; all, but particularly the tilapias, are controversial. Only one species, the wakasagi (Hypomesus nipponensis), was introduced as a forage fish. The other established exotics are aquarium fishes. A preliminary literature review indicates that 168 native fishes have been transplanted beyond their known historical ranges, mostly for sport and as bait releases.

The following fishes have been introduced to Lake Kinneret, Israel, within the past two decades (Ben Tuvia, 1981): European eel (Anguilla anguilla), rainbow trout, bighead carp, carp, silver carp, largemouth buffalo, tench, European seabass (Dicentrarchus labrax), Tilapia galilaea (= Sarotherodon galilaeus), thinlipped grey mullet (Liza remada) and grey mullet (Mugil cephalus). Rainbow trout, tench and European seabass failed to survive, and the status of largemouth buffalo is questionable. Although

carp and Tilapia galilaea have become established, their populations are supplemented by stocking. Mullet are also stocked as fingerlings. Only carp do not contribute significantly to the Lake Kinneret fishery. European eel, accidentally introduced to the lake with mullet, remain rare. Proper fishery management of Lake Kinneret is dependent upon stocking and introductions, policies which apparently have not adversely impacted the native blue tilapia (Tilapia aurea = Sarotherodon aureus).

Supplementary reference

Ben-Tuvia, A., Man-induced changes in the freshwater fish fauna of Israel.
1981 Fish.Manage., (12)4:139–48

SESSION 6: ECOLOGICAL AND PRACTICAL ASPECTS (DISCUSSIONS) (N.-A. Nilsson) (Paper Nos. 47, 48)

Niche theory

The introduction of exotic species into native fish communities has been a popular approach toward the management of oligotrophic lakes during the past century. The high level of risk involved, however, all but precludes the usual approach to fish introductions which are as likely to be damaging as successful. Three case histories of introductions, looked at retrospectively, suggest that in some cases, at least, the outcome of an introduction may be predictable. For north-temperate, oligotrophic waters, the greatest likelihood of success lies in the use of species that have co-evolved in glacial refugia but may have become allopatric through the vagaries of redistribution following glacial recession. The risks involved in planting new species may be greatly reduced through a priori consideration of several ecological principles such as niche theory, interactive segregation, dominance-subordinance, and resource partitioning. Each of these hierarchically-associated principles is consistent with the concept of niche, both fundamental and realized, and major niche dimensions of candidate species for introduction should be quantified whenever possible and compared with those species comprising the indigenous fish community. A resulting high level of niche complementarity of the candidate species with the various components of the native community will increase the likelihood of success of an introduction.

The niche concept itself has caused some confusion ever since it was first introduced. It soon became clear that the early seemingly inflexible concept that “two or more species cannot live in the same niche” was not sustainable, mainly because niches very often do overlap or even temporarily seem identical. Hutchinson's definitions of “fundamental” versus “realized” niches, as well as his definition of “the N-dimensional hypervolume” as a convenient tool to study niches mathematically, has given rise to an ever-growing literature on “niche overlap”, “niche breadth”, etc. Hand in hand with these discussions, the concepts of “interactive segregation” and “species dominance” have developed. Recent findings that trophic competition between fish species forces them to segregate into their “realized niches” have given a clue to monitoring introductions of exotic species, including sub-species, stocks, etc.

Here it is suggested that the introduction of “exotics” leads to one of the following results. The introduced stock:

- (i) is rejected, because there is no “vacant niche” or predators graze down the population at early stages;
- (ii) hybridizes with very closely related stocks, formerly adapted to the ecosystem;

- (iii) eradicates a stock that is either an “ecological homologue” or a very available prey;
- (iv) finds a “vacant niche” within the community, which means that it adapts to resources that are not fully exploited by other species, and finally makes it able to survive as a member of the community.

On the whole, the Symposium felt that niche theory is practical from the point of view of space and food and frequently introductions are justified on the basis that some portion of the ecosystem is unexploited by existing fish communities - hence the concept of the vacant or potential niche. It was also felt that fish living within given communities possess genetic characteristics conditioned to such communities. When the species are transferred these characteristics may be out of phase with those of the recipient community which may well not be adapted to receive introductions from other ecosystems. This is especially true of simple communities which have particularly strong interspecific relationships that are more easily disrupted by exotics.

Much of the success of introduced species in Romania may be interpreted in the light of niche theory and it is predicted that similar changes in species composition and abundance will occur within the Danube as its water regime is changed by the abstraction of about 30 percent of its water for irrigation. The relative positions of certain introduced salmonids and cyprinids in streams changed according to variations in vegetation pattern arising from deforestation. Furthermore, the grass carp has achieved its present wide distribution as it is the only herbivore other than the native rudd. Introductions into Lake Balkhash in the U.S.S.R. have demonstrated that the productivity of an ecosystem depends wholly on the amount of energy available to it, thus the introduction of new species into an already structured and developed fish community cannot lead to an increase in yield, although clearly extinctions of indigeneous forms may well occur (28).

Code of Practice

Christopher Kohler of the American Fisheries Society Exotic Fish Section explained the rationale behind the proposed code of practice for introductions of exotic fishes into the inland waters of the United States (51). General discussions on the practical aspects of such codes centred around the difficulties in implementation. In general, most countries in Europe possess adequate legislation for either completely excluding or intelligently considering introductions, although there are international implications to the problem for which no mechanisms yet exist. There are also certain loopholes in existing laws, particularly where importation of fish are for scientific purposes, for experimental aquaculture and for the aquarium fish trade. However, despite these rigorous procedures accidents occur. For instance, Finland studied the introduction of Pacifastacus in great detail before it was finally admitted. However, prior to this, importations into Sweden spread rapidly into Finland. Similarly, wels and ide suddenly appeared in the waters of central Jutland from which they were previously absent. The problem thus appeared to be not whether countries have legislation but whether they have control over the implementation of such legislation. In view of the failures of such established procedures and an alternative or supplement to established practices must lie in the education of the users of the waters as to the dangers of such introductions.

SESSION 7: CONCLUSIONS AND RECOMMENDATIONS

(a) STOCKING

Management practices change from time to time, not only between countries but within one country, especially when alterations to the environment external to the fishery such as pollution, eutrophication or animal protection movements dictate a change in the nature of the fish community (see Appendix III). For instance, existing management practices in the United Kingdom cater for coarse fish anglers who do not consume their catch - presumably initially a response to the large number of coarse fishing waters that have arisen during the industrialization process. Catch and release fisheries are now under pressure by protection movements and may conceivably have to be abandoned at some time in the future. In Denmark the policy has been to manage for initially more valuable food fishes, but the incursion of British anglers over the last two to twenty years has to an extent changed these habits to encourage the tourist trade. Ironically, an increasing number of Danish anglers are now taking up coarse fishing.

While considering the angler as the top predator in the system, it sometimes seems that he is satisfied with the mere process of stocking disregarding its rationale. This has been true in the U.K., where anglers have always felt and indeed frequently demand, stocking as a solution to bad catches. However, more recently there is a growing feeling that stocking is not the answer to all management problems, especially in the face of falling water quality. It is now suspected that fish stocked into open systems move great distances or suffer high mortalities when confronted with unsuitable conditions. In the Netherlands, persistent stocking has, in fact, produced too much fish and anglers are becoming concerned with managing waters by other means. Eradication of over-dense stocks, partial cropping and the cessation of the habit of returning captured fish to the waters are all increasing, and in areas where stockings have ceased it is now clear that stocks stay stable or even improve.

Although there is a general paucity of information on the success or failure of current stocking practice in most species, some general conclusions were drawn from the presentations and discussion on specific groups:

- Pike populations are limited by the availability of suitable habitats. Stocking with additional individuals has no appreciable effect on populations of the species and may therefore be considered unprofitable.
- Stocking with cyprinids is considered to be of decreasing importance in the Netherlands for the maintenance of stocks with the exception of small, heavily-fished angling waters, although very little is known as to the effectiveness of this practice. Improvements in survival of stocking material seem possible by increased care in catching and transport and furthermore by minimizing storage time.
- Eel stocking is widespread in Northern European waters and has proved both ecologically and financially successful. Some data on stocking and recapture rates are available although somewhat sparse and more accurate evaluations of these parameters needs to be made.
- Stocking with coregonids, principally in Finland, has shown to be important to the maintenance of the fisheries in certain lakes where there has been a net profit on investments for stocking. Stocking with the various species continues to be under close investigation by Finnish scientists.

- Extensive work has been carried out on stocking with brown trout and many of the major factors regulating success or failure have been described. In general the larger the size of fish stocked the better the recapture rate. Better survival is also noted with spring stocked, rather than autumn stocked fish. Wild strains of trout are preferable to those reared in hatcheries, for this reason hardiness should be bred into trout reared in fish farms for stocking.
- The literature and state of knowledge on salmon stocking is perhaps the most complete of any European species. An extensive bibliography already exists setting out guidelines for procedures, timing and density of stocking.

(b) INTRODUCTIONS

Experience with introductions reported in Europe and North America has generally either had little effect in that species failed to become established, or has had a negative impact on existing fish communities. In some cases, for instance, introductions of salmonids into specific waters for which the introduced species was better adapted than native species, e.g. acid waters, or the introduction of barbel into the Severn river in the U.K. has proved successful. Variable experiences with other species, including grass carp and pike-perch indicate that the success or failure of an introduction is highly subjective and is essentially a matter of local attitudes. These being so, common discussion between countries is desirable where an introduction risks crossing national frontiers.

Introductions of crayfish into Europe can generally be considered to have been beneficial, particularly those of *Pacifastacus leniusculus*. Other possible candidates for introduction pose greater risks and proposals for their transfer to European waters need to be very carefully evaluated.

On the basis of the above conclusions it was felt that EIFAC needs to continue work on both topics considered by the Symposium. To accomplish this the Symposium recommended to EIFAC that it adopt a code of practice to reduce the risk of adverse effects arising from the introduction or transfer of inland fish species.

It further **recommended** that EIFAC set up a Working Party on Stock Enhancement with the following terms of reference:

- (i) To review and recommend to EIFAC a code of practice for the regulation of the introduction of exotic species and procedures for its implementation; and
- (ii) To review the present status of stocking and to elaborate guidelines for stocking with various species groups forming part of established fishery management practices.

The Symposium also **recommended** that selected papers made available to the meeting should be edited and published as a Supplement to the Proceedings of the meeting.

Finally, the Symposium wished to record its gratitude to the Convenor of the Symposium, Professor T. Backiel, for his considerable energy and efforts in organizing and chairing the meeting.

APPENDIX I

LIST OF CONTRIBUTIONS

<u>NO.</u>	<u>NAME OF PAPER</u>	<u>AUTHOR</u>
1.	The composition of northern pike (<u>Esox lucius</u> L.) populations in four shallow waters in the Netherlands and the frequency of occurrence of individuals stocked as fingerlings	Grimm
2.	The effect of transplanting poorly grown bream (<u>Abramis brama</u> L.) from one Dutch lake to another	Cazemier
3.	Survival of roach (<u>Rutilus rutilus</u> (L.)) caught with seine nets	Riemens
4.	Stocking of fish in Sweden as seen from a tagging perspective	Enderlein
5.	Effectiveness of eel stocking into Polish lakes	Leopold and Bninska
6.	Stock enhancement in the Irish eel fishery	Moriarty
7.	The enhancement of eel stocks in Finland: A review of introduction and stockings	Pursiainen and Toivonen
8.	The eel stocking programme of Sweden	Wickstrom
9.	The role of whitefish (<u>Coregonus lavaretus</u> L.) stockings in fisheries management in Finland	Salojarvi
10.	Results and profitability of whitefish (<u>Coregonus lavaretus</u>) stocking in north Finland	Salojarvi
11.	A comparative study of the growth and production of the native whitefish (<u>Coregonus muksun</u>) and the introduced whitefish (<u>C. peled</u>) stocked in the same small forest lakes in southern Finland	Pruuki, Pursiainen and Westman
12.	Food supply of the native whitefish (<u>Coregonus muksun</u>) and the introduced whitefish (<u>C. peled</u>) stocked in the same small forest lakes in southern Finland	Hakkari, Selin and Westman
13.	A review of fish stockings in Finland	Westman, Auvinen, Ikonen, Tuunainen, Sumari and Eskelinen
14.	Brown trout stocking in Norway	Aass
15.	Results of the introduction of lake trout (lake charr, <u>Salvelinus namaycush</u>) into Swedish lakes	Gonczi and Nilsson
16.	Repeuplement de <u>Salmo fario</u> dans les milieux aquatiques du sud ouest de la France: Ecologie et influence sur le milieu	Moreau et Reyes
17.	The importance of genotype, size on stocking and stocking date to the survival of brown trout (<u>Salmo trutta</u> L.) released in Irish lakes	O'Grady

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| 18. | Liberation of trout (<u>Salmo trutta</u> L.) in Danish streams | Rasmussen |
| 19. | Brown trout stockings as a compensation method in polluted areas in central Finland | Sipponen and Hakkari |
| 20. | Results of Brown trout (<u>Salmo trutta</u> m. <u>lacustris</u>) stockings in Finnish lakes | Toivonen, Auvinen, Ikonen, Alapass and Kokko |
| 21. | Factors influencing the supplementation of brown trout stocks in some clean water rivers | Williams |
| 22. | Salmon smolt stock enhancement in the River Tummel, Scotland | Egglishaw |
| 23. | Factors affecting the survival and distribution of salmon (<u>Salmo salar</u> L.) stocked in upland trout (<u>Salmo trutta</u> L.) streams in Northern Ireland | Kennedy |
| 24. | Physiological effects of stocking stress on salmon | Soivio and Virtanen |
| 25. | The introduction of salmonids and the supplementation and management of salmonid populations in rivers recovering from industrial pollution | Williams |
| 26. | The impact of a transplanted forage fish, the alewife (<u>Alosa pseudoharengus</u>) on a reservoir fishery in southeastern United States | Kohler |
| 27. | L'introduction du saumon du Pacifique (<u>Oncorhynchus kisutch</u>) en France | Euzenat et Fournel |
| 28. | Review of experiments with introduction and acclimatization of the huchen <u>Hucho hucho</u> (Linnaeus, 1758) (Salmonidae) | Holcik |
| 29. | Studies of the brook char (<u>Salvelinus fontinalis</u> Mitchill) in Norway | Grande |
| 30. | Results of lake trout (<u>Salvelinus namaycush</u>) stockings in Finland in 1955–81 | Tuunainen, Mutenia and Simola |
| 31. | Introduction of carp (<u>Cyprinus carpio</u>) in Finland | Ahlfors, Kummu and Westman |
| 32. | Heavy silver carp stocking in lakes and its influence on indigenous fish stocks | Barthelmes |
| 33. | Introduction of grass carp (<u>Ctenopharyngodon idella</u> Val.) into Denmark | Markman |
| 34. | The introduction, spread and influence of the barbel (<u>Barbus barbus</u>) in the River Severn (Great Britain) | Churchward, Hickley and North |
| 35. | A century of pikeperch in Denmark | Dahl |
| 36. | The impact of zander (<u>Stizostedion lucioberca</u> (L.)) in the United | Linfield |

- Kingdom and the future management of affected fisheries in the Anglian region
37. Introduction of the North American crayfish (Pacifastacus leniusculus) in Sweden Furst
 38. Presence en France d'especes exotiques d'ecrevisses provenant d'introductions recentes Leurent, Vigneux et Vigneux
 39. The restoration of the crayfish (Astacus astacus) stock in River Siikajoki, Finland Pursiainen and Westman
 40. Introduction of the American crayfish (Pacifastacus leniusculus) in Finland; Impact on the native crayfish (Astacus astacus) Westman and Pursiainen
 41. Introduction et acclimatation de poissons d'eau douce en France - historique et bilan Allardi
 42. A review of fish and crayfish introductions made in Finland Westman and Tuunainen
 43. The effects of freshwater fish introductions into Ireland Fitzmaurice
 44. Introduction de nouvelles espèces de poissons dans les pêcheries d'eau douce de la Roumanie Bacalbasa-Dobrovici
 45. The exotic ichthyofauna of the United States exclusive of Alaska and Hawaii Courtenay and Taylor
 46. Some consideration on the role of introduced species of fish in the management of inland fisheries Holcik
 47. The niche concept and the introduction of exotics Nilsson
 48. Ecological effects of fish introductions and invasions on endemic fish communities in previously glaciated waters of Canada Ryder and Kerr
 49. Advantages and disadvantages of the introduction of non-indigenous fish species for the health of indigenous fishes Reichenbach-Klinke
 50. Parasite range extension by introduction of fish to Hungary Molnar
 51. A recommended approach for evaluating exotic fish introductions in Northern Hemispheric countries Kohler and Stanley
 52. A bibliography of Hungarian works on introduced East Asian herbivorous fishes Pinter
 53. Exotic fish species acclimatized in Hungarian natural waters Toth and Biro

APPENDIX II

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APPENDIX III

SUMMARY OF RESPONSES TO THE QUESTIONNAIRE ON STOCKING FISH IN EUROPE

by

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In 1981 a simple questionnaire was distributed to the correspondents of EIFAC. Responses came from 13 countries: Austria, Belgium, Czechoslovakia, Cyprus, Germany F.R., Hungary, Ireland (Rep.), The Netherlands, Norway, Poland, Sweden, Switzerland and the U.K. (for England and Wales).

In all of these countries stocking streams, rivers, reservoirs and lakes is a common practice.

The total number of fish species reported as being stocked is 30 and the list for Europe is very likely not complete (see Table).

Out of these fishes, 10 species have been introduced from outside Europe, some fairly recently like Chinese carps, Salvelinus namaycush and Coregonus peled, and stocking with these species has apparently become a common practice in a few countries.

With regard to priorities, brown trout is in the lead (11 countries, all kinds of waters), then come rainbow trout, pike (8 countries), eel and common carp (7 countries).

All types of water bodies are being stocked and most species are used for both running and standing waters. A few species are stocked only into rivers and coregonids are only stocked into lakes (see Table).

The fishes used for stocking come from hatcheries (reported by all countries), from ponds (reported by 9 countries) or from natural stocks. Thus, rearing fish for stocking and also transfers from one water body to another, are reported from England and Wales, Cyprus, Germany F.R., Ireland, Norway, The Netherlands, Poland and Switzerland.

Systematic assessment of stocking is reported from Austria, Czechoslovakia, Ireland, Norway and Switzerland and partially - with respect to some fish and some water bodies - from Germany F.R., Hungary and Poland.

There is a variety of opinion on the efficiency of stocking. Austrian, Hungarian and Swiss questionnaires claim that stocking is efficient. Norway considers stocking of salmon to be successful as do England and Wales with respect to rainbow trout released into reservoirs. Stocking eels into lakes has been proved efficient in Poland and the German experts consider it necessary, hence, some success has probably been observed. Releasing coregonids into lakes has been successful in Poland and is considered necessary in "eutrophicating lakes" in Germany F.R., and so is stocking running water with brown trout wherever spawning grounds have been destroyed. However, the views from Ireland are that releasing salmonids in various stages (from eyed ova to yearlings) has not been so successful as expected.

The effects of stocking rivers and reservoirs with pike are reported from Germany as variable as is stocking with carp for sport fishing. Ireland reports increased success of stocking "cyprinid waters" under careful management. There is no clear evidence on the

efficiency of stocking “coarse fish” in England and Wales and on other species but coregonids and eel in Poland. Czechoslovakia claims “moderate efficiency”, Cyprus that stocking is “efficient to moderately efficient”, Belgium and Sweden report all possible degrees of efficiency. The Dutch response is that stocking is either moderately efficient or inefficient.

The 13 responses to the questionnaire on stocking do not cover the whole of Europe and, because of the simple nature of the questionnaire, lack many important details of information. Nevertheless, they have revealed several interesting phenomena and views. Considering how common and widespread is this medium of management, one wonders why there are so few published accounts and critical studies on stocking fish.

This conclusion confirms the view shared among some participants of the Eleventh Session of EIFAC that the subject was worth reviewing at an international level. One should refer to the Report of the EIFAC Workshop on Mass Rearing of Fry and Fingerlings of Freshwater Fishes (EIFAC Technical Paper No. 35) where it was stated that more than 31 species were cultivated in Europe, and most of them were used for stocking. The question about survival, growth, behaviour and recapture of the stocked fish deserves due attention. The responses to the questionnaire, obviously, do not answer this question but reveal that:

- (1) a fair number of species is stocked, hence, they are considered useful supplements to the original populations and fish communities.
- (2) reservations as to the efficiency of such a stock enhancement are fairly common among fishery experts
- (3) it is well established that effects depend on diverse conditions.

SPECIES (AND SUB-SPECIES) OF FISH STOCKED INTO
VARIOUS INLAND WATERS AS REPORTED BY COUNTRIES

	<u>Running waters</u>	<u>Reservoirs</u>	<u>Lakes</u>	<u>Waters not specified</u>
1. Sturgeon (<u>Acipenser ruthenais</u>)	H			
2. Atlantic salmon	GB; IR; N; S	IR		
3. Lake trout (<u>Salmo trutta</u>)		D; PL	A; CH	
4. Brown trout	A; B; CS; CH; A; B; IR; GB; D; GB; IR; PL; S	N	IR; N; S	
5. Rainbow trout	A; CS; GB; S	A; CH; CY; GB	IR; CS; S	N
6. Char (<u>Salvelinus alpinus</u>)		A; CH	A; CH; CS; S	N
7. Brook trout (<u>Salvelinus fontinalis</u>)	CS; S		CS	N
8. Namaycush (<u>Salvelinus namaycush</u>)		CH		
9. Danube salmon (<u>Hucho hucho</u>)	CS; PL			
10. Small white fishes (<u>Coregonus albula</u>)			PL	
11. White fishes			A; CH; D; PL	
12. Peled (<u>C. peled</u>)			PL	
13. Grayling	A; CH; CS; PL; S			
14. Pike	B; CH; CS; D; H; NL; PL	A; B; CH; CS; D; H; PL	A; CH; D; PL	
15. Roach	B; GB	B; CY	PL	
16. Grass carp			H; PL	
17. Bream		PL	PL	
18. Tench	A; CS; H	CS	PL	
19. Nase (<u>Chondrostoma nasus</u>)	CS			
20. Crucian carp			PL	
21. Common carp	A; B; CS; D; H	A; B; CS; CY; D; PL	H; PL	
22. Silver carp		H	H; PL	
23. Bighead carp		H	H; PL	
24. Sheatfish (<u>Silurus glanis</u>)		H	H	
25. Catfish (<u>Ictalurus punctatus</u>)		CY		
26. Eel	B; CH; CS; D; NL	B; CH; CS; D	A; CH; D; PL	
27. Pike-perch	CS; NL; PL	CS; PL	A; PL; S	
28. Perch	CH	CY	CH	
29. Large mouth bass		CY		
30. Mosquito fish (<u>Gambusia</u>)		CY		

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