

Management of the fish stocks in Lake IJssel, The Netherlands

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Abstract

The development of the commercial fishery of Lake IJssel, a 184 000 ha eutrophic freshwater lake, over the period 1947-1987 has been described. Although by sanitation the number of fishing companies decreased from 906 in 1947 to 100 in 1987, the total effort increased and caused the present over-exploitation of the stocks of eel and pikeperch, caught mainly with fyke nets and gill-nets respectively. Because of this over-exploitation the fishermen have expanded the marginal fisheries on cyprinids, and on spawning smelt. Different management measures were taken, and active gear like two-boat seines and bottom trawls were banned. The total amount of fishing gear was not limited until the total fyke net effort was limited in 1986. The system of data gathering on the fish stocks and the fishery is described, together with the calculation of the research efforts. The absence of a registration system for the fishing effort per company, and for the spatial distribution of the fishing effort, together with the consequential absence of an annual evaluation of the catch per unit effort by the fishermen themselves, hampered the fisheries management process. An effort registration system will be implemented in the near future.

1. Introduction

Following the construction of Lake IJssel in 1932 by damming a brackish water sea bay (Zuiderzee), the ecosystem took some 5 years to stabilize (Havinga 1945). After the Second World War the character of the fishery there changed because of the trade-off between active and passive fishing. At the moment there are about 100 fishing companies, employing some 300 people in the fleet. In addition, about 600 people are employed in associated industries (product processing, making and repairing nets, boat construction etc.). Apparently the management measures taken were not strict enough to avoid over-exploitation of the stocks of eel (*Anguilla anguilla*) and pikeperch (*Stizostedion lucioperca*) with fyke and gill-nets. The management aim of the organizations of commercial fishermen, for the fish stocks in the 184 000 ha Lake IJssel, is a yield which guarantees the viability of the present 100 companies. This aim is not translated into quantified objectives like required yield in terms of weight, or desirable spawning stock biomass and population structure.

In this contribution the development of the fishery is described on the basis of the yield, the fishing gear and the management implemented. Further, the present efforts for

monitoring the fishery and the fish stocks are sketched. An method of organizing the management process, using both long- and short-term evaluation of the fishery by the fishermen themselves, is presented as a possible way to prevent the uncontrolled increases in fishing effort which now occur periodically.

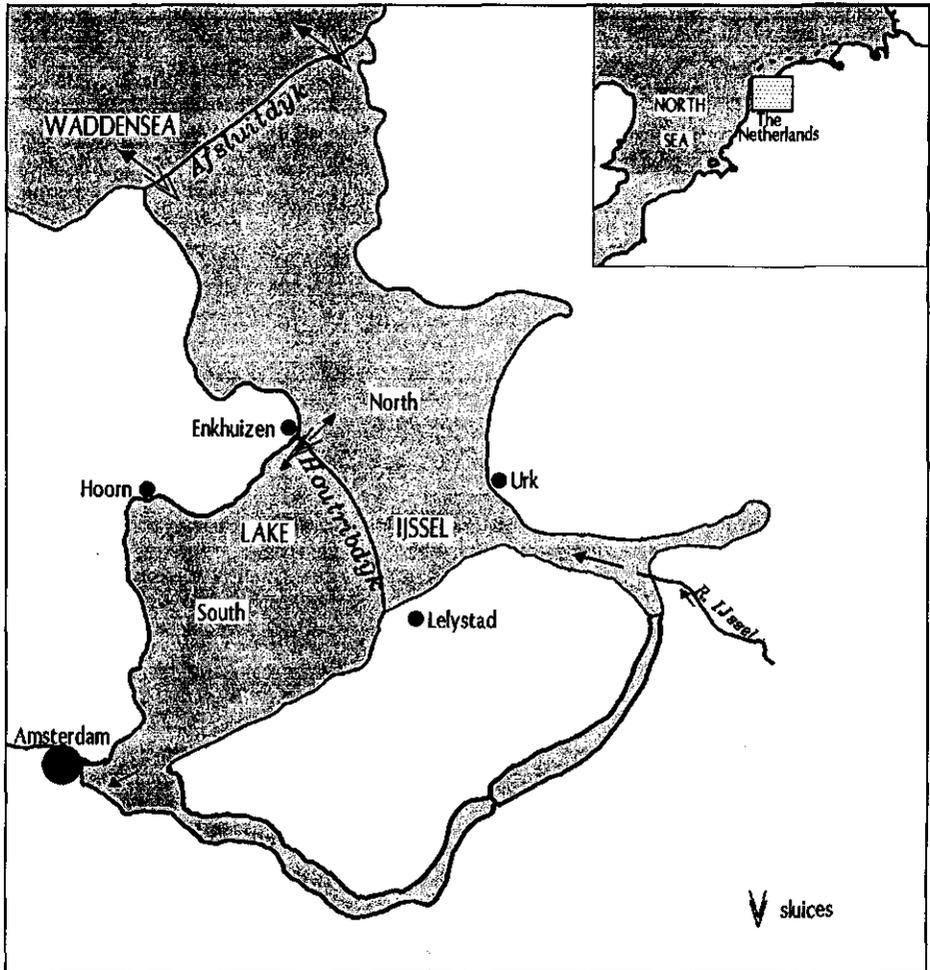


Figure 1. Lake IJssel and its geographical position. The dam dividing the lake into northern and southern parts was constructed in 1975. Since its construction the surface of the lake has been diminished by successive impoundments (1942, 1957, 1968) to 55% of its initial surface area. Arrows = direction of flow.

Table 1. The use of the different types of fishing gear in the Lake IJssel fishery from 1947 onward.

| | Years | | | | | | | |
|---------------------|-------|------|------|------|------|------|------|------|
| | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 | 1985 |
| Eel | | | | | | | | |
| fyke nets | | | | | | | | |
| long line | | | | | | | | |
| bottom trawl | | | | | | | | |
| eel boxes | | | | | | | | |
| summer fyke nets | | | | | | | | |
| Pikeperch and perch | | | | | | | | |
| two-boat seines | | | | | | | | |
| gill-nets cotton | | | | | | | | |
| gill-nets multif | | | | | | | | |
| gill-nets monof | | | | | | | | |
| Smelt | | | | | | | | |
| fyke nets | | | | | | | | |
| summer fyke nets | | | | | | | | |
| Cyprinids | | | | | | | | |
| beach seines | | | | | | | | |

2. Lake IJssel

The mean depth of Lake IJssel, which is eutrophic, is 4.3 m, with some gullies in the middle up to 8 m deep (Figure 1). These gullies were formed by tidal movements in the old Zuiderzee and are now partly filled with fine-grained sediments. The shallowness of the lake and the flatness of the bottom gives potential for the use of boat seines, bottom trawls, (bottom) gill-nets and summer (open water) fyke nets.

The main water supply of Lake IJssel is from the River Rhine (70%), which drains into the lake via the River IJssel. The chloride content of the lake is about 200 mg/l. The main drainage occurs during low tide in the Waddensea via the sluices in the closure dam in the north. The mean retention time of the water in the lake is about 6 months in the northern part and about 12 months in the southern part.

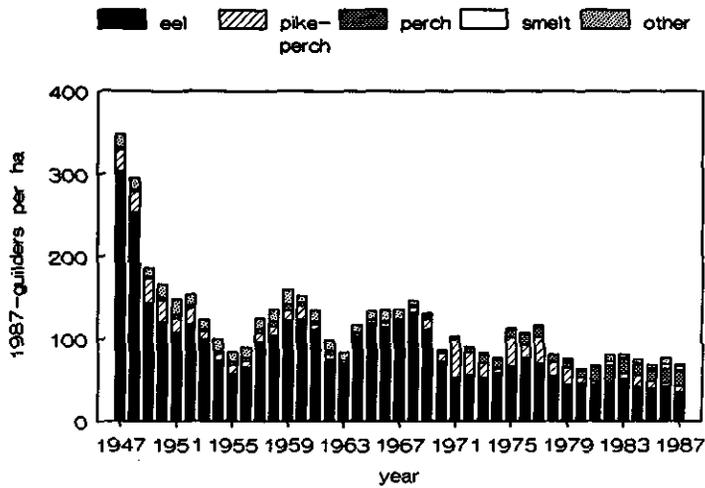


Figure 2. The landings of eel, pikeperch, perch, smelt and other categories from Lake IJssel in terms of their value in Dutch guilders per hectare (1987 prices) in the period 1947-1986.

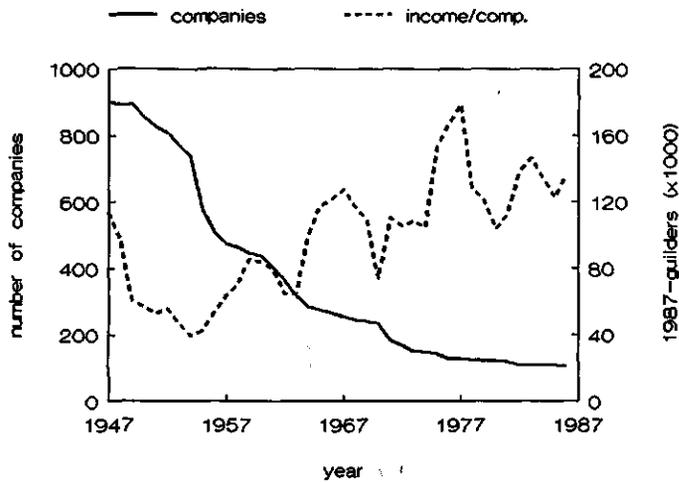


Figure 3. The number of fishing companies and the mean value (1987 prices) of the yield per fishing company from Lake IJssel in the period 1947-1986.

Good estimates of the biological productivity of the lake do not exist. Total P is about 270 $\mu\text{g/l}$ in the northern and 130 $\mu\text{g/l}$ in the southern parts of the lake. Chlorophyll content is about 70 and 45 $\mu\text{g/l}$ respectively. Eutrophication has caused the dominance of Cyanophyceae (*Aphanizomenon flos-aquae*, *Microcystis aeruginosa*) in the northern part of the lake. In the southern part green algae (*Scenedesmus* sp.) and diatoms are dominant in spring and Cyanophyceae (*M. aeruginosa*) in summer. The main zooplankters are *Daphnia hyalina*, cyclopoid copepods, *Bosmina coregoni*, *B. longirostris* and *Chydorus sphaericus*, a similar spectrum to that found in other eutrophic lakes in The Netherlands.

The macrofauna comprises *Neomysis integer* (Mysidacea), *Gammarus tigrinus* (Amphipoda) and *Asellus aquaticus* (Isopoda), which are important food items for eel, perch (*Perca fluviatilis*) and ruffe (*Gymnocephalus cernua*). The bottom fauna is represented by chironomid larvae, Tubificidae and molluscs (*Dreissena polymorpha*) and is important for eel, ruffe, bream (*Abramis brama*) and roach (*Rutilus rutilus*).

The major fish species present are eel, the percids pikeperch, perch and ruffe, the cyprinids bream and roach, flounder (*Platichthys flesus*) and smelt (*Osmerus eperlanus*). Recently, increasing but small numbers of sea trout were observed. The population dynamics of pikeperch and perch and the impact of the fishery is described by Willemsen (1977, 1983). The present status of the eel fishery is analysed by Dekker (1987).

3. Description of the fishery

3.1 Landings

Eel has always made the major contribution to the earnings of the fishery, followed by pikeperch and perch (Figure 2). Apart from these species, some income has been derived from the by-catches of the bottom trawl eel fishery, which consist mainly of smelt, ruffe and juveniles of various other species. Recently additional income has also arisen from the by-catches of the fyke net fishery for spawning smelt. However, the total income of the fishery has decreased and this is to be attributed to a decline in total landings, because the price per unit weight of eel, pikeperch and perch showed no decreasing trend throughout the period 1947-1987. Because of the decrease in the number of fishing companies the income per company increased (Figure 3).

The landings, assessed by weight, show the unreliability of the catches of pikeperch, which reflect the combined effects of year-class variation and intensive exploitation by the fishery (Figure 4).

The present seasonal character of the fishery is exemplified by a monthly mean over a five year period (1982-1986) (Figure 5). At the end of the summer, fishermen switch from fyke net fishing for eel, to gill-net fishing for pikeperch and perch. There is no closed season for eel. The closed season for the gill-net fishery is from mid-March to 1st July. The winter gill-net fishery can be interrupted by ice cover.

3.2 Development of the fishery

Traditional methods for catching eel used to employ fyke nets in the littoral zone, baited long lines and bottom trawls (Table 1). Some of these methods were very similar to those used in the old Zuiderzee. The effort in the long line fishery decreased with a decrease

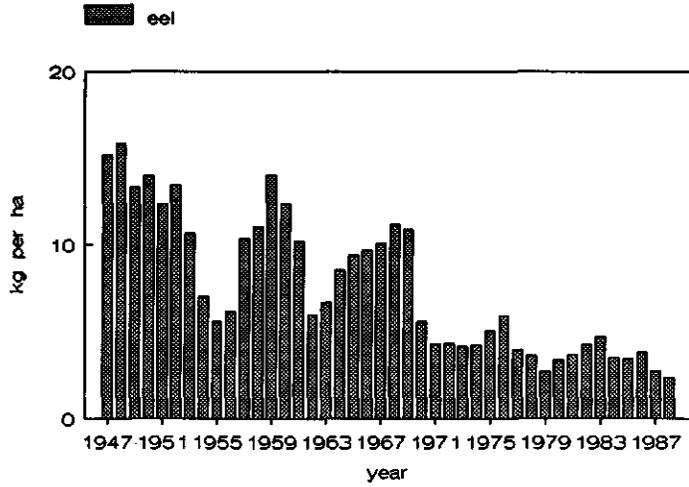


Figure 4a. Landings (kg/ha) of eel from Lake IJssel in the period 1947-1988.

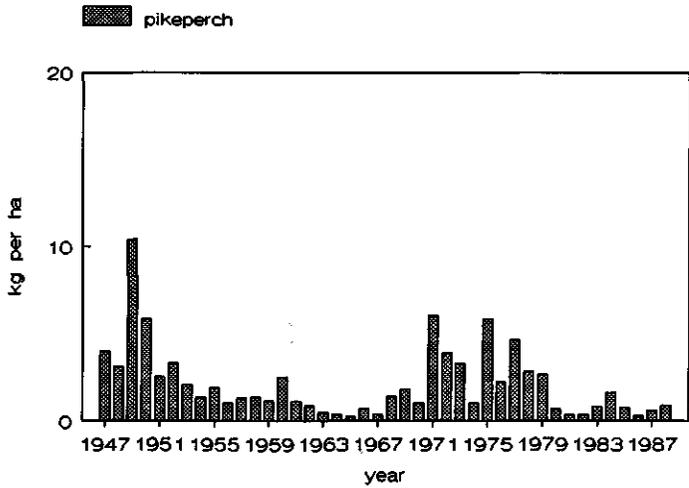


Figure 4b. Landings (kg/ha) of pikeperch from Lake IJssel in the period 1947-1988.

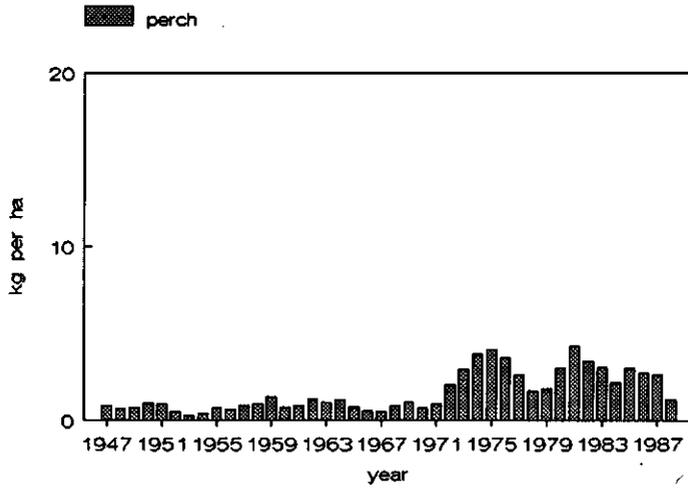


Figure 4c. Landings (kg/ha) of perch from Lake IJssel in the period 1947-1988.

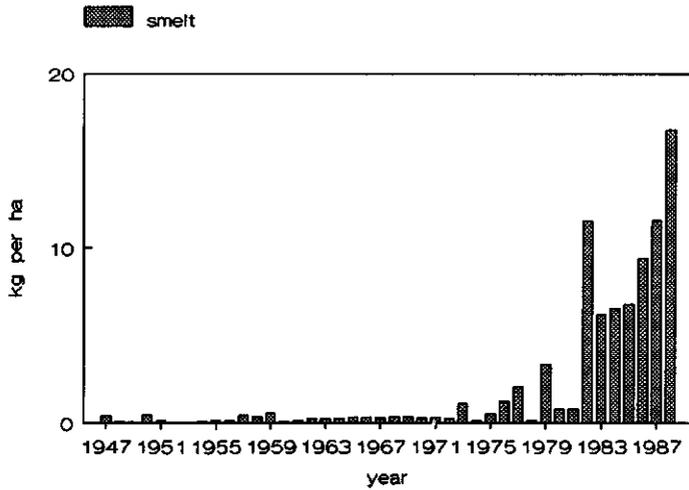


Figure 4d. Landings (kg/ha) of smelt from Lake IJssel in the period 1947-1988.

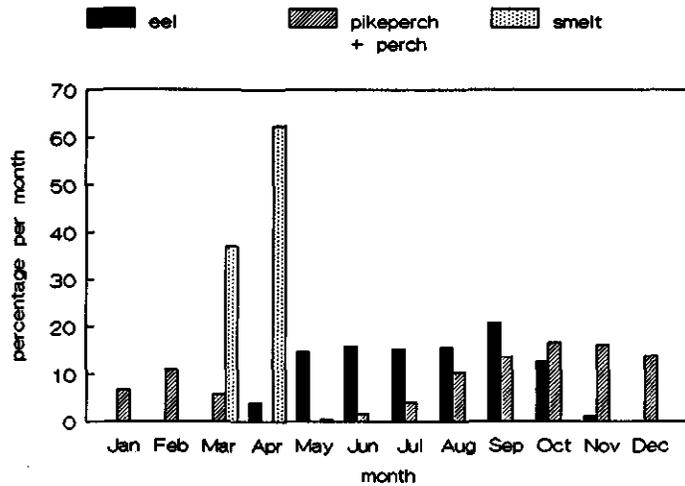


Figure 5. Seasonal pattern of the fishery. Landings per category and per month are a mean for the years 1982-1986.

in the stock of large eels, which was due to intensive bottom trawling and fyke net fishing. Bottom trawling was especially practised in the gullies. Trawling used to be forbidden from Saturday until Monday (16:00 hours), but it was completely banned in 1970 because it took too many juvenile pikeperch and perch in the by-catch. The by-catch had comprised mainly little smelt and ruffe and had been landed as 'industrial fish'.

As the ban on trawling was anticipated by the fishermen, they had already started to use eel boxes in 1967. Eel boxes are a kind of wooden eel pot (Deelder 1971). As with long lines, when baited with smelt, they catch larger and less fatty eel than the better quality eel caught with bottom trawls and fyke nets. Fatty eel can be smoked and the price of smoked eel is twice as high as that of fresh eel. In 1971 the fishermen start setting fyke nets at the edges of sand banks in the open water zone, whereas in 1973 they started to use the smaller summer fyke nets in the open water (Oudelaar 1983). These nets are linked to each other and can be set and anchored as quickly as a gill-net. Their total number has increased tremendously, to 30 000 in 1987. Some fishermen have broadened the base width of these summer fyke nets from 1.4 to 2.0 m. Since 1st June 1987 the maximum width allowed is 1.5 m and the maximum height 1.0 m.

The two-boat seine (length 160-200 m; depth 3 m; mesh size 92 mm) was a very efficient method for catching pikeperch and perch. It was banned in 1963 and the consequence of this was an increasing investment in gill-nets. These were cotton gill-nets until they were replaced by multifilament nylon gill-nets around 1960. At that time 92 mm stretched mesh was used. In 1967 and 1974 the minimum mesh size was enlarged to 96 and 101 mm respectively. After the ban on bottom trawling in 1970 the number of gill-nets in the fishery also increased. The first monofilament gill-nets appeared in 1975 and had

substantially replaced multifilament nets by 1987. At present some 70 companies have around 100 gill-net units of 80-85 m length each, totalling nearly 600 km of gill-net.

The spring fyke net fishery for spawning smelt used to be directed to large specimens (over 10 cm) for human consumption, with smaller smelt being landed as industrial fish. However, from 1982, smaller smelt has also been landed for human consumption, since which time the fyke net effort has increased manyfold. The fyke nets used are open water summer fyke nets as well as the traditional littoral fyke nets.

Finally, beach seining is used to catch roach and bream to stock angling waters elsewhere.

4. Organization of the management process

The fishing rights for Lake IJssel are state-owned. Fishermen acquire a permit for fishing. The state has set corporate prescriptions concerning the use of different types of fishing gear, closed seasons, minimum mesh sizes and minimum sizes of fish which may be taken (Table 2).

Table 2. General prescriptions for the commercial fishery in Lake IJssel in 1987.

| Category | Specification |
|-------------------|---|
| Effort limitation | 47 500 fyke net units (since 1986) (= 30 000 summer (open water) fyke nets (=1 unit) and 3 500 normal fyke nets (=5 units) in 1986 maximum base width of summer fyke nets 1.5 m; maximum height 1.0 m (since 1987) |
| Closed periods | closed season for fishing pikeperch and perch 15 March - 1 July no gill-net fishing between Saturday 16.00 hours and Monday 08.00 hours (since 1979) |
| Minimum mesh size | fyke nets 20 mm stretched mesh or rings of 13 mm inner diameter in the rear end (since 1985) gill-nets 101 mm stretched mesh since 1974 |

The fisheries management is executed by the state. A distinct management board with full responsibility for fisheries management of the lake has never existed. The government merely installed advisory committees (1955-1956; 1964-1966; 1974-1984) or these were set up by the initiative of the organization of commercial fishermen (from 1987 onwards). In these committees the interests of commercial and sport fishermen, as well as fishery biologists and economists of governmental bodies, are represented. Management recommendations drawn up by these committees are channelled directly, or via the master organization of commercial fishermen (since 1987), to the Ministry of Agriculture and Fisheries for eventual implementation. In general the Ministry awaits a committee recommendation before a management measure is implemented. Nevertheless, a direct political route was followed for the ban on bottom trawling in 1970. This decision was made by the national parliament and implemented directly.

Table 3. The monitoring system for the fish stocks and the fishery in Lake IJssel. Consultations, planning, preparations etc. excluded.

| Type of monitoring | Method | Time & labour required | Time taken - man hours | | |
|---|--|--|------------------------|-----|--|
| 1. Eel | | | | | |
| 1.1 Immigration of glass eel | Regular samples in dam inlet in the period Feb-June | 100 nights — 1 person, 8 hours per night | 800 | 800 | 2 440 |
| 1.2 Size and sex composition of eel stocks in the lake | Trawling with a 1 mm trawl in the period April-Nov on 10 sites | 100 trawl hours in 4 weeks — 5 persons Data processing | 800 60 | 860 | |
| 1.3 Density and biomass of bottom fauna | Bottom samples at 30 sites, 3 samples per site, mixed for 1 sample | Twice a year (combined with 1.2) extra effort: 4 persons, 0.5 week Processing of samples — 3 per day — 1 person Data processing | 160 160 60 | 380 | |
| 1.4 Size and sex composition | Market sampling, 10 samples of 100 eels | Collecting, processing, otolith storage Data processing (age reading) | 120 280 | 400 | |
| 2. Other species | | | | | |
| 2.1 Larval density | 40 hauls with larvae nets perpendicular to the shore | 2 weeks — 5 persons Determination — 1 person — 3 months Data processing | 400 480 60 | 940 | 2 370 (without larvae programme and recent expansion of 2.4:1430) |
| 2.2 Indexing YCS and growth of 0-group perch and pikeperch | YFS with a 20 mm trawl at 2 sites in a selected area in October | 2 weeks — 6 persons Data processing | 480 40 | 520 | |
| 2.3 Abundance and size structure of fish of all age groups except eel | 25 trawl hauls with 20 mm trawl at 15 sites over all of the lake in October | 2 weeks — 6 persons Scale reading cyprinids 4 weeks — 1 person Data processing — 2 weeks — 1 person | 480 160 80 | 720 | |
| 2.4 Size and age structure of the catch of perch and pikeperch ** | Sampling pikeperch and perch landed 10 times per fishing season July-March for measuring and taking scales | 2 persons — 4 hours per sampling Age reading from scales (n=700), 1 person — 80 scales per day Data processing including back-calculations | 80 70 40 | 190 | |

** Recently this category has been expanded to include assessment of length, weight, sex and stage of maturity. Fish are bought at auction for this. Time required 2 persons - 2 days per month = 256 man hours.

5. Data from the fishery and the fish stocks

5.1 Catch and effort data

Following a European Community agreement in June 1975 the fishermen were no longer obliged to auction their fish. The landing statistics available are thought to cover at least 90% of the fish caught, with the *proviso* that for 1975 and 1976 alone, they may not account for more than 60% of eel landings.

At the moment the fishing effort is only known officially in terms of the number of fishing companies and the number of fyke nets used. The number of normal (large) fyke nets is limited by the sites available. The total number of fyke nets was fixed at 3500 in 1986 but their exact increase with time is not known. All fyke nets are now registered using tags supplied by the government (*Table 2*).

There is no registration of the number of gill-nets in use, neither on the ratio of multi- to monofilament nets. The efficiency of gill-netting increased after 1983-1984, because of the use of electronic fish-finders.

5.2 Monitoring

Monitoring the fish stocks, and the composition of the catches of eel, pikeperch and perch now takes about 4700 man-hours/yr or 2 man-years each year (*Table 3*). Eel monitoring costs the most. Larval surveys for pikeperch and perch took about 1400 man hours (0.7 man/yr) but provided a poor basis for predicting the year-class strength (YCS) of the fish at the time they recruited to the gill-net fishery. By contrast, the autumn young fish surveys (YFS) for 0-group pikeperch and perch (when the fish are about 7 months old) are a good basis for predicting this, and the larval surveys were discontinued as soon as this was appreciated (Willemsen 1977) (*Figure 6*). Trawl surveys were set up in the 1960s.

5.3 Specific research

In Lake IJssel most specific research deals with standardization of sampling methods, assessing efficiency and selectivity of commercial fishing gear, and the development of alternative commercial fishing gear. Experimental fishing with gill-nets of different mesh sizes (Oudelaar 1976) and different materials (multifilament and monofilament) (Schaap 1987) has been carried out. At the moment specific research is directed towards assessing the impact of summer fyke nets on the survival of 0- and 1-group pikeperch and perch. The extra mortality these nets cause, in the period before recruitment to the gill-net fishery, diminishes the accuracy of the prediction of the year-class strength in gill-net catches made from the autumn survey of 0-group fish. Research has also been carried to see if a beam trawl with an electric field could be selective for eel.

For a more rational exploitation of the eel stocks in the lake, the minimum mesh size of the fyke nets was increased from 18 to 20 mm in 1985. Alternatively, fishermen were allowed to install 2-4 metal rings with inner diameters of 13 mm in the rear-end of the 18 mm netting.

Mortality of juvenile pikeperch and perch caught with fyke nets is very high, up to about 50% of a year-class being taken (Willemsen 1985). Special experiments have been

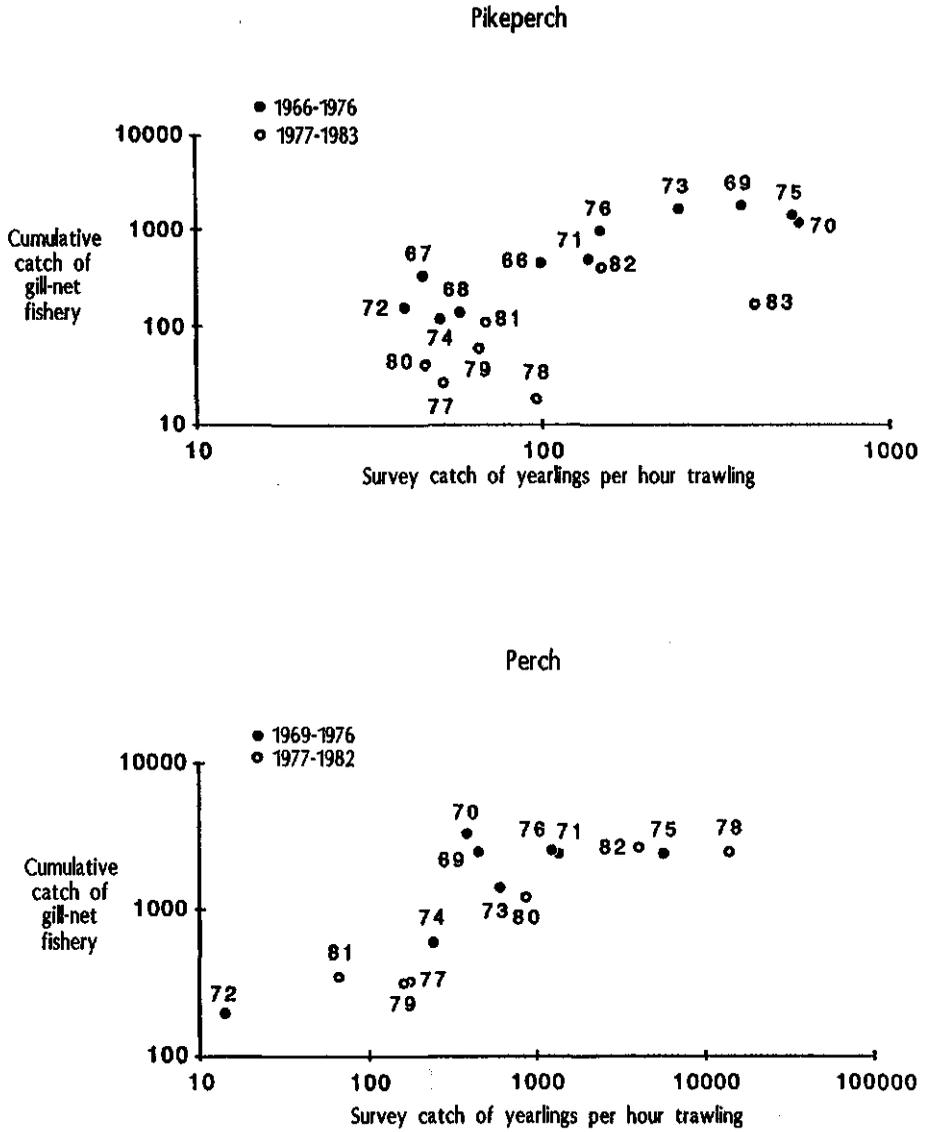


Figure 6. Correlation of survey and commercial catches of pikeperch and perch. Plots show relationship between year-class strength (YCS) as deduced from catches of 0-group fish (yearlings) per hour of trawling during the young fish survey (YFS) in autumn and the cumulative yield in numbers of the same year-class in the gill-net fishery.

carried out to avoid this by-catch. The different forms of net-like barriers in the front hoop of the fykes have been tested to prevent small fish from being caught. These constructions had an unacceptably negative effect on eel catches.

A system for monitoring fishing effort is now on its way. Its development and implementation will cost around 1 man year in time, and it is regarded here as specific research. Every fishing company will be monitored annually with regard to number, type and size of fishing gear used. The information will be collected from the fishermen by inquiries. Once set up at 5 harbours the monitoring programme will entail a time investment of about 180 man-hours/yr (10 evenings of 6 hours by each of 3 persons). Computer input and data processing will cost an extra 60 man-hours.

6. Management

Management goals, as for example, for specific yields, have never been set. The organizations of commercial fishermen still stress the importance of a viable fishery in which the present number of fishing companies (100 in 1987) can survive. The rationalisation of 1932-1976, when the number of companies was reduced from 1600 to 129 was stimulated by state subsidies for fishermen who by their own initiative left the fishery.

The most important management measures taken so far are:

- The ban on two-boat seining for pikeperch and perch (1963).
- The ban on bottom trawling for eel (1970).
- The gradual increase of the minimum mesh size for gill-nets from 92 to 96 to 101 mm stretched mesh.
- The limit on the total number of fyke net units (1986).

Both the ban on trawling and the limit on fyke nets were based principally on the undesirable by-catches of young pikeperch and other species that they made. Remarkably, the effect of these practices on the over-exploited eel stock was only of secondary interest. The decrease in the catches of larger eels made with long lines and eel boxes provided sufficient evidence to warrant limiting the number of summer fyke nets somewhat earlier (*Figure 7*).

As the ban on bottom trawling (1970) was imposed rather suddenly, there was a strong drive in subsequent years to compensate for what was regarded as a loss of high quality, fatty 'trawl eel'. This also affected the fishery for pikeperch and perch. Here the increase in fishing effort was a combination of more gill-nets, and in the last decade, more monofilament gill-nets. These latter are about twice as efficient as multifilament nets.

The fishery has dwindled as a result of the almost unlimited increase in passive fishing gear per fishing company. At the moment pikeperch is not only severely over-exploited by the gill-net fishery, but its survival in the younger stages might be seriously diminished by the fyke net fishery for eel, which species is also severely over-exploited. It is, however, difficult to estimate the extent to which the fyke net fishery influences the survival of pikeperch. More research on this is required, but it is already clear that the more recent pikeperch year-classes, which were abundant as 0-group fish, did not provide the high recruitment to the gill-net fishery expected (*Figure 6*). Young perch may have a higher survival rate than pikeperch after being caught in the fyke nets (*Figure 6*).

The Lake IJssel fishermen are now looking for types of 'escape fisheries'. They want permission to motorize their beach seines for catching bream and roach. They also install

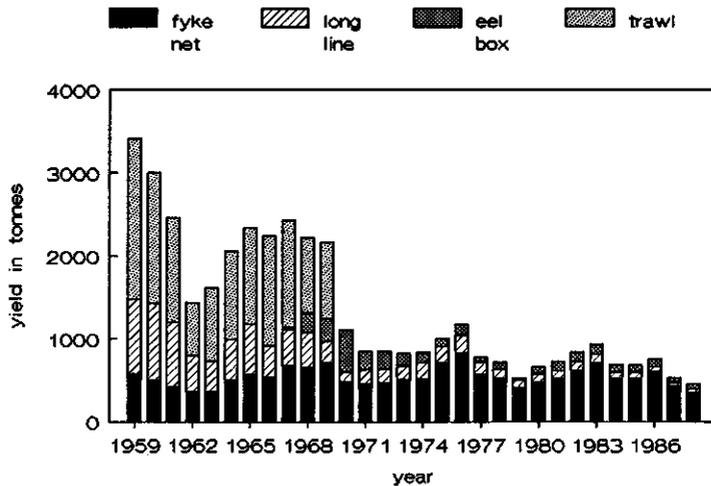


Figure 7. Total landings (tonnes) of eel caught with different types of fishing gear (bottom-trawl, fyke net, long line, eel box) in Lake IJssel in the period 1959-1988.

increasing numbers of fyke nets at the edges of the lake in March when smelt has its spawning run. Specific research has to be directed to the possible adverse effects of this fishery on the stocks of smelt in the lake.

The state could not have foreseen that it had to play an even more active role in the management of the fishery than it already did by rationalisation, bans on fishing gear, and setting minimum mesh sizes for particular types of gear. More specifically, a more enduring long-term type of organization of the fisheries management of Lake IJssel has to be pursued. An important aspect of the management process will be the short-term (annual) evaluation of the state of the fishery by the fishermen themselves. A pre-requisite for this is the dynamic description of the fishery in terms of yield, effort and spatial distribution of the effort, made possible by the registration system for catch and effort data which is to be implemented in the near future.

Once the registration system is implemented, it will require a relatively few man-hours/yr to keep the system working. In the past the fishermen were unwilling to co-operate in setting up the registration system. Maybe the fisheries biologists were not firm enough and did not stress that the evaluation of the fishery was necessary and was seriously hampered by lack of data on the fishing effort. They might not have anticipated the strong warning signal issued by the fishermen themselves in their own short and long-term evaluations of the progress of the CPUE index of the Lake IJssel fisheries.

The implementation of the registration scheme for fishing effort must not endanger the existing core of the monitoring programme, but should run in parallel with it. The monitoring programmes used since the sixties has revealed, among other things, a

valuable time series of data on variations in the growth and recruitment of the 0-groups of pikeperch and perch. The variations revealed will be used to help devise future management strategies for perch and pikeperch.

Acknowledgment

Rijkswaterstaat Dienst Binnenwateren supplied the data on the present water quality of Lake IJssel.

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