CATCH EFFORT SAMPLING STRATEGIES

THEIR APPLICATION IN FRESHWATER FISHERIES MANAGEMENT

EDITED BY

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Chapter 23
The applicability of catch per unit effort (CPUE) statistics in fisheries management in Lake Oulujärvi, Northern Finland

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With a view to standardizing and rationalizing the collection of CPUE data, a study was made of the sources of variability (effect of fishing season, place, wind conditions, fisherman and the saturation of gill nets). The data were collected from Lake Oulujärvi, Northern Finland, between 1974–87. The material consists of 155 144 lifted gill nets. The gill nets were divided into four different groups according to their mesh sizes. The CPUEs of vendace, whitefish, pike and burbot were studied. The frequency distributions of CPUE data were normalized by transformation $(1/(1 + \mathrm{CPUE}))$. Gill net saturation was observed in winter fishing. Significant differences were observed between years, months and fishing areas. Wind affected the vendace catches off open shores in October, but not those of whitefish. CPUE can be a useful index of the size of a given fish stock, if the sources of variability are minimized through standardization of data collection. A decreasing trend in CPUE does not always indicate overexploitation, if recruitment depends on population size. There are indications that in some cases CPUE can increase as a function of increasing fishing effort, as in vendace fishing in Finland. This means that factors affecting the success of recruitment should be known when the CPUE index is used for making decisions in fisheries management.

23.1 Introduction

According to the Finnish Fisheries Act, the fishing rights and the responsibility for fisheries management belong to the owners of water areas. Water areas (lakes and rivers) in general are jointly owned by the landowners in the associated village. Fisheries management under joint ownership is organized at meetings of the owners (Fisheries Associations), who decide on a policy and elect an executive committee to realize the policy. Associations of the owners for a given water area, e.g. a central lake and the rivers and lakes flowing into it, form a larger management unit, known as a Fisheries Area. The Fisheries Areas also include representatives from clubs for sports fishermen and the unions of professional fishermen.

The Fisheries Areas and Fisheries Associations of the water owners manage most of the Finnish fisheries and, according to the Fisheries Act, these should be run on a sustainable basis.

There are thousands of fisheries management units in Finland and the persons involved in fisheries management are ordinary fishermen, without any formal education in fisheries management or fish biology. Therefore they need simple, rapid, cheap and efficient methods of estimating the state of the most important fish stocks. The morphoedaphic index (Ryder, 1982) was developed for this purpose, but there are indications that it does not work in Finnish conditions (Myllymaa & Ylitolonen, 1977; Lindström & Ranta, 1988; Ranta & Lindström, 1989).

There are in fact very few methods suitable for use by ordinary fisheries managers in estimating the state of fish stocks at the local level in Finland. The fishing effort (number of licences sold) is generally known, but the total catch and catch by species is unknown. Therefore the CPUE cannot be obtained from fisheries statistics. The CPUE can be calculated, however, from the data collected by a given group of fishermen (book-keeping fishing). Generally, the CPUE is assumed to be proportional to the average density of a fish stock (Gulland, 1983). The most serious problems connected with the fishing effort and CPUE are their great variability and the difficulty of measuring and standardizing them.

The purpose of this paper is to study the sources of variation of the CPUE obtained from fishing records kept in Lake Oulujärvi. The sources of variation studied are 'saturation' of gill nets, and the effects of the fishing area, season, fisherman, target species and wind conditions. Only gill net fishing was considered. The final objective was to draw up recommendations for ordinary fisheries managers on how to standardize the collection of CPUE data and how to apply CPUE to local decision-making in the management of fisheries.

23.2 Study area

Lake Oulujärvi is the central lake in the Oulujoki water system, which drains into the Gulf of Bothnia (Fig. 23.1). It is one of the largest lakes in Finland and its main physical characteristics are presented in Table 23.1.

Lake Oulujärvi is an exceptional Finnish lake in many respects besides its size. The number of private Fisheries Associations is only 14 and large parts of the lake (especially the open pelagic areas) are state-owned (areas 1 and 10, see Fig. 23.1). The whole lake belongs to one Fisheries Area (the Oulujärvi Fisheries Area). The Oulujärvi fisheries have been studied for nearly 20 years (Salojärvi *et al.*, 1981, 1985; Hyvärinen, 1989), which is not the case with most Finnish lakes. The prerequisites for efficient and successful fisheries management are thus good.

The number of fishermen has increased since the beginning of the 1970s, and currently stands at *c.* 8000. Many types of gear are used in Lake Oulujärvi, such as gill nets of different mesh sizes, seines, trawls, fyke nets, wire traps, hooks on long lines, and rod fishing by spinning and lures (summer angling and ice fishing).

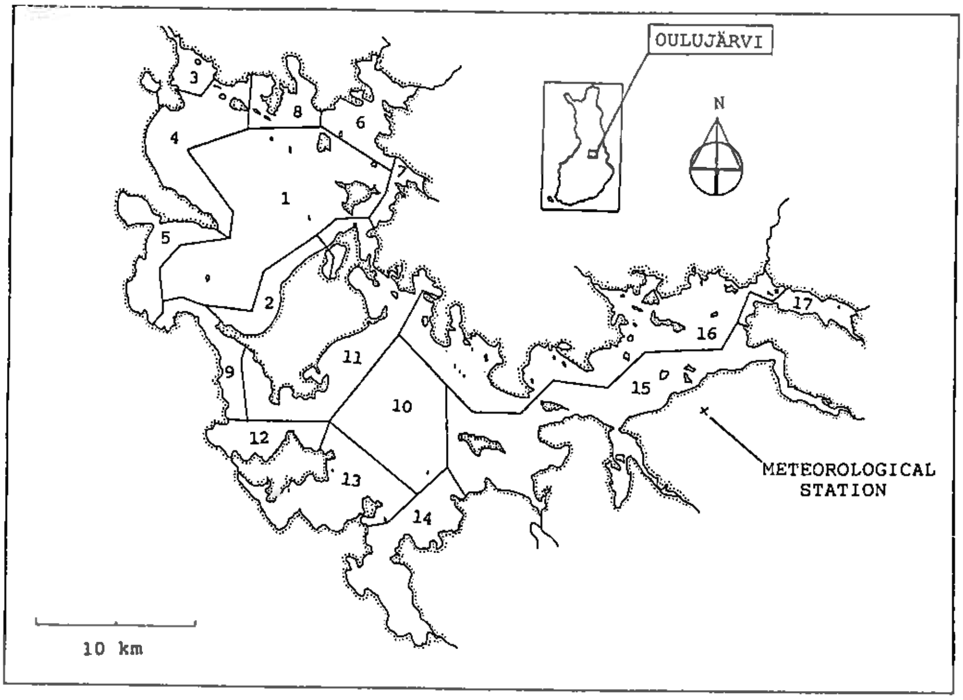

Fig. 23.1 Map of the study area. The CPUEs of the species in the numbered areas are compared using the analysis of variance (ANOVA). Borders also delimit the areas of the Fisheries Associations

Table 23.1 The main physical characteristics of Lake Oulujärvi (National Board of Waters, Finland 1977)

Physical characteristics	
Drainage basin	19 506 km^2
Mean water surface (natural shore line)	928 km^2
Minimum water surface (regulated)	778 km^2
Maximum water surface (regulated)	944 km^2
Amplitude of water level regulation	2.7 m
Maximum depth	36 m
Mean depth	7.6 m
Mean elevation above sea level	121 m
Mean outflow	216 m^3 sec^{-1}

Gill nets are the most important fishing gear and their number has increased from less than 10 000 in 1973 to *c.* 15 000 at present. Marked changes in the gear have taken place during the last 20 years. In the early 1970s, seines were the most important gear used by professional fishermen. At the end of the 1970s and the beginning of the 1980s, mainly gill nets were used (Arvola, 1989). Professional fyke net fishing for whitefish was introduced in 1984 and trawlers entered the fishery in 1987.

Standardized fishing effort has been estimated with sample surveys since 1984. The effort is calculated for the different gears by multiplying the number of fishing days by the mean number of gears used (Salojärvi *et al.*, 1990). There are indications, however, that for the purpose of estimating the CPUE index, it is very difficult to get reliable estimates of effort by this method. In regulating the fishing effort the Fisheries Associations and Fisheries Area use 'gear units'. The basic unit is a gill net (length 30 m and height 3 m). A seine is equalled to 30 units and a fyke net to 10 units. The total number of gear units used at present is estimated to be 41 000 and the total allowable number of gear units is 90 000. This means that no active regulation of fishing effort has taken place, because the lake is thought to be underexploited.

During the last 15 years the total annual catch from Lake Oulujärvi has varied between 350 and over 600 tonnes (Fig. 23.2). Over 90% of the total fish catch is composed of six species: whitefish, vendace, perch (*Perca fluviatilis* L.), pike (*Esox lucius* L.), burbot (*Lota lota* L.) and roach (*Rutilus rutilus* (L.)). The catch of stocked brown trout (*Salmo trutta* L.) is now *c.* 15 tonnes. The catch variation is mainly due to the strong fluctuation of the vendace stock. Marked changes in the species composition have also occurred since the early 1970s. Fish stocking has considerably increased the whitefish and brown trout catches from the lake. More than half of the total catch (*c.* 60%) is taken with gill nets and these are the most important gear in subsistence and recreational fishing. Most of the professional catch (*c.* 90%) is taken with trawls and fyke nets.

23.3 Material and methods

Book-keeping data (daily records of catches grouped by species and gear) were collected from fishermen between 1974–87, inclusive. These data comprise the number and type of gears lifted each fishing day, the catch in kilograms for each species and the fishing area. The nets were classed by mesh size as follows: under 20 mm, 27–33 mm, 34–40 mm, over 40 mm (bar length).

The mean CPUE index for a given species and net class in each sample was calculated from the following equation:

$$\text{CPUE} = \Sigma\ (Y/n)/N \qquad (1)$$

where CPUE is the mean catch per unit effort for a given species and net class, Y is the catch in weight of a given species in one lift, n the number of nets lifted and N the number of lifts.

The saturation of gill nets was studied, because in winter fishing the interval between lifts varies from one day to two weeks and this can affect the catchability of the nets. A graphical study of the mesh size >40 mm, the net class used most in winter, was made. To achieve this the CPUE for each year, when nets were lifted at different intervals, were compared.

To identify how net fishing in Oulujärvi was directed towards different species by the season and mesh size, it was assumed that if the catch of a given species

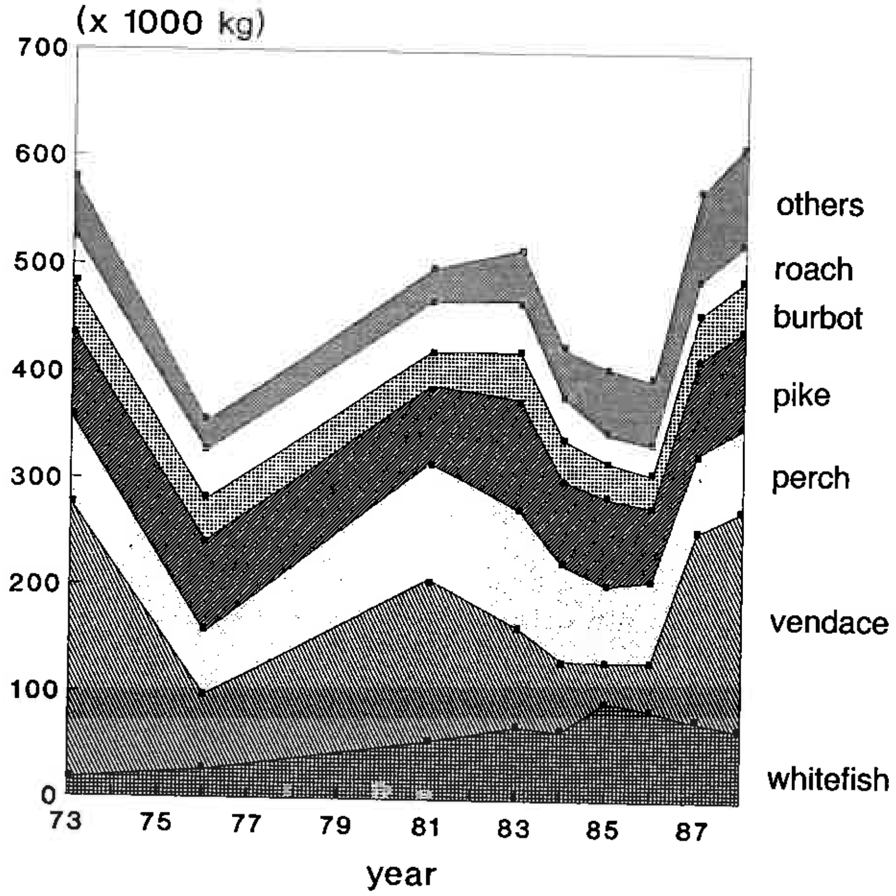

Fig. 23.2 Total catch in Lake Oulujärvi grouped by species in the years 1973–88 (Salojärvi *et al.*, 1990)

was more than 50% of the total catch in one lift, fishing was directed to that species. If the catch of any one species was not more than 50% of the total catch in one lift, it was assumed that the fishing target was mixed species.

The differences in CPUE between years, months and areas were studied using ANOVA tests. Similarly, ANOVA analysis was used to test for differences in the CPUE of two fishermen fishing in the same area (area 11, see Fig. 23.1) and the effects of wind direction on CPUE in three fishing areas (areas 5, 11 and 16, see Fig. 23.1).

Data on wind direction were available from the meteorological station of the airport of Kajaani (Fig. 23.1). The wind observations were made every third hour and the measurements were averages of ten-minute periods. For statistical analysis the direction of the wind was divided into four sectors. If at least four values for a day were placed in the same sector, this was accepted as the prevailing direction of the wind. If eight values for a day were divided equally between two sectors, the wind was considered to be variable. In all other cases the wind was also treated as variable. In the statistical tests, the CPUE for a given day was compared with the wind of the day when the nets were set.

CPUE data have been shown to be negatively distributed with a binomial distribution highly skewed to the right (e.g. Bannerot & Austin, 1983; Virapat, 1986). To use parametric tests different kinds of transformations are needed (e.g. logarithmic, square root or reciprocal) (Sokal & Rohlf, 1981; Ranta *et al.*, 1989). The frequency distribution of the book-keeping data was studied by tests of normality and by examining the correlation of the standard error to the square of the sample means. The statistical calculations were made with a VAX computer and the statistical software of SAS (SAS Institute Inc., 1985).

23.4 Results

The CPUE of gill nets (mesh size >40 mm) lifted at varying intervals indicates that saturation occurs (Fig. 23.3); thus the CPUE could actually be higher if the nets are lifted at shorter intervals. This leads to the conclusion that the catch can be increased in winter fishing by shortening the intervals between lifts. The number of fishing days is unimportant in winter fishing; only the number of lifts is significant. In winter mainly pike and burbot are caught and gill net saturation should be considered if the CPUE of these species is standardized.

In Finnish lakes different kinds of nets are used to catch different fish species. Small mesh nets (<=20 mm) are used for vendace and the best fishing season is autumn associated with spawning in Lake Oulujärvi (Fig. 23.4(a)). Gill nets with mesh sizes of 27–33 mm and 34–40 mm are used to catch mixed species, but in October they are used mainly for whitefish fishing (Figs. 23.4(b) and (c)) on the spawning grounds around the lake. Gill nets of mesh sizes over 40 mm are used to catch pike and burbot (Fig. 23.4(d)), but the best fishing seasons for these two species differ. The best season for pike is in spring, because in Lake Oulujärvi pike spawn in May, and the best season for burbot is in winter, from December to April; burbot spawn in February. In standardizing the CPUE the target species of gill net fishing should therefore be considered.

Analysis of the CPUE data showed that the frequency distributions of CPUE were highly skewed and were close to negative binomial distributions. A positive linear correlation was also found between the standard error and the square of the sample means of the CPUE for gill nets. In such a case reciprocal transformation ($1/x$) is recommended (Sokal & Rohlf, 1981; Ranta *et al.*, 1989), but because of zero catches the transformation $1/(1+x)$ was used.

Analysis of variance (ANOVA) tests showed significant differences ($P<0.05$) in CPUE between years, months and areas. The results were similar with all the

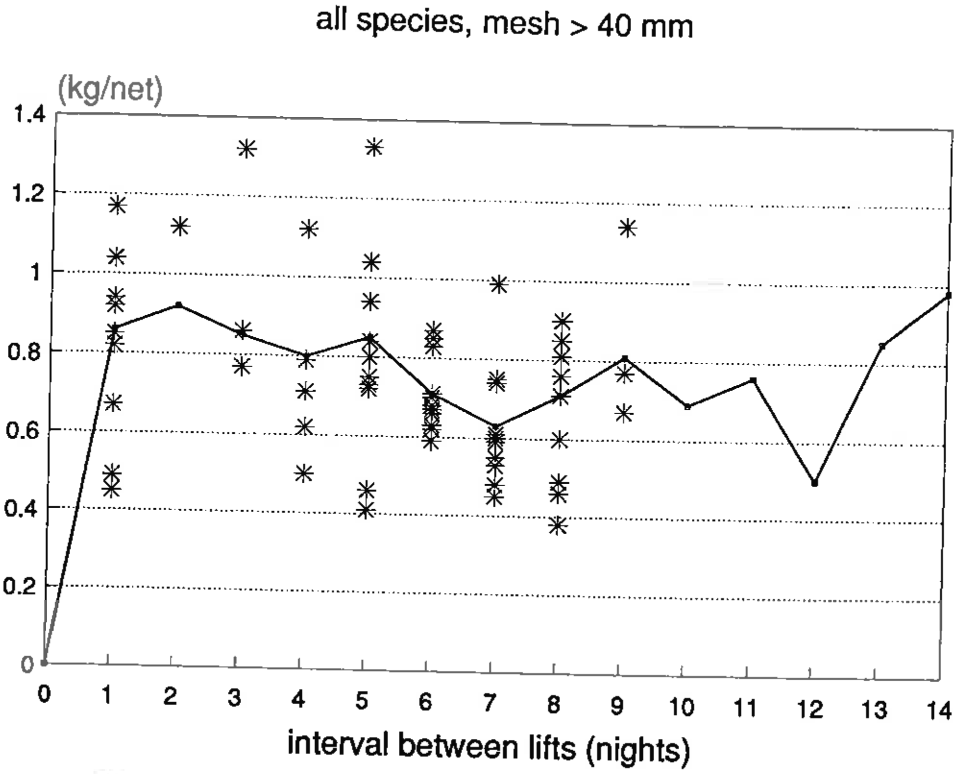

Fig. 23.3 Mean catch per net (mesh size >40 mm) for all species in each year (data for December, January–April) when nets were lifted at different intervals. Only cases for which there were at least ten observations are presented. The line indicates the mean catch per net for all data in December, January–April

species studied (vendace, whitefish, pike and burbot). There were also significant differences ($P < 0.05$) between fishermen fishing in the same area (area 11, see Fig. 23.1) in the CPUE of vendace and burbot, but not in the CPUE of whitefish or pike (Table 23.2). The reason for the significant differences between fishermen in the CPUE of vendace lay in the size of the nets used for catching these fish. The significant differences in the CPUE of burbot were due to the fact that one of the fishermen used trammel nets. Another reason for the difference in the catches was evidently the choice of fishing places. For example, Area 11 is rather large (see Fig. 23.1).

Wind direction seemed to affect the vendace catches in September in area 11 and in October in areas 5 and 11, but not in area 16 (Figs. 23.1 and 23.5(a)–(c)). Areas 5 and 11 are open to southern and eastern winds and area 16 is relatively sheltered, which could explain the differences in the results (Table 23.3). The results also agree with observations made by local fishermen. In the present data the whitefish CPUE did not seem to be influenced by the wind (Table 23.3).

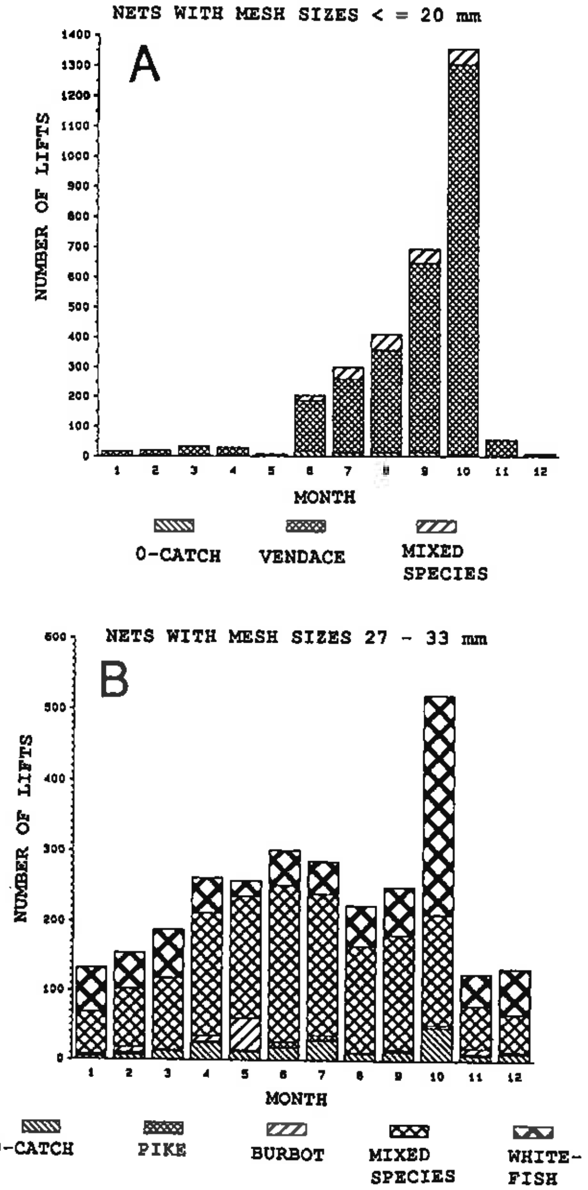

Fig. 23.4 (a)–(d) Fishing for a given species with different mesh sizes in different fishing seasons

The CPUE indices for the species studied reveal wide variation between months during the study period (1974–87) (Figs. 23.6(a)–(e)). Part of this variation can be explained by the low number of lifted nets. For all the species the standard error of the sample means is large until the number of lifts is at least 100 (Figs. 23.7(a)–(d)).

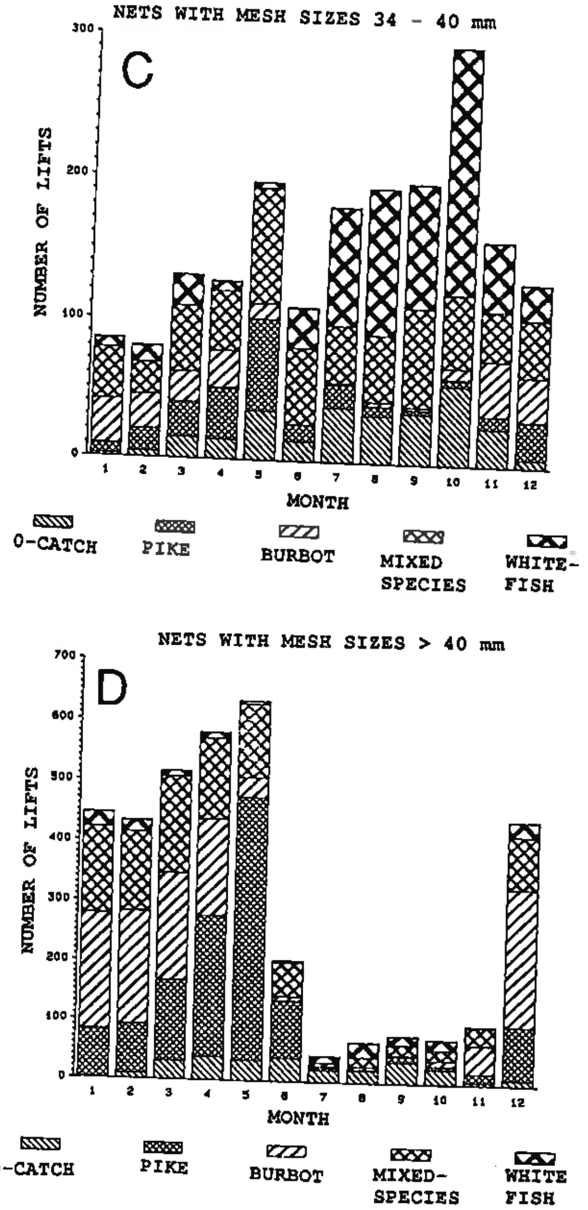

Fig. 23.4 Continued

Pike catches have been relatively stable since 1974, though a slight increase can be seen in the 1980s. A similar trend is seen in the CPUE curve for the winter months (January, February, March and April) (Fig. 23.6(d)). By contrast, the CPUE curve for May is at a much higher level and shows a decreasing trend from 1974 to the beginning of the 1980s, followed by a marked increase up to 1985. Since 1985 the CPUE of pike has again decreased, but is still at a very high level.

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Table 23.2 Values of F (from analysis of variance) for transformed data (1/(1 + CPUE)) of different species grouped by year, month, area and fisherman. The tested samples were chosen separately for each species. Under each F-value are shown the samples tested for the years, months and areas. Tests for two fishermen's catches were done for data from area 11. Nets for vendace were of mesh size <=20 mm, for whitefish 27–40 mm, for pike >40 mm and for burbot >40 mm. **P < 0.05

Species	Years	Months	Areas	Fishermen
Vendace	48.39**	48.82**	44.84**	19.33**
Samples	74, 78–87	6–10	5, 11, 14, 16	
Whitefish	24.04**	49.22**	34.54**	0.01
Samples	74, 78, 81–86	5–10	5, 6, 11, 14, 15, 16	
Pike	12.01**	50.12**	7.67**	2.41
Samples	79–87	12, 1–5	5, 6, 9, 11, 14, 15, 16	
Burbot	6.18**	115.37**	20.22**	17.75**
Samples	79–87	12, 1–5	5, 6, 9, 11, 14, 15, 16	

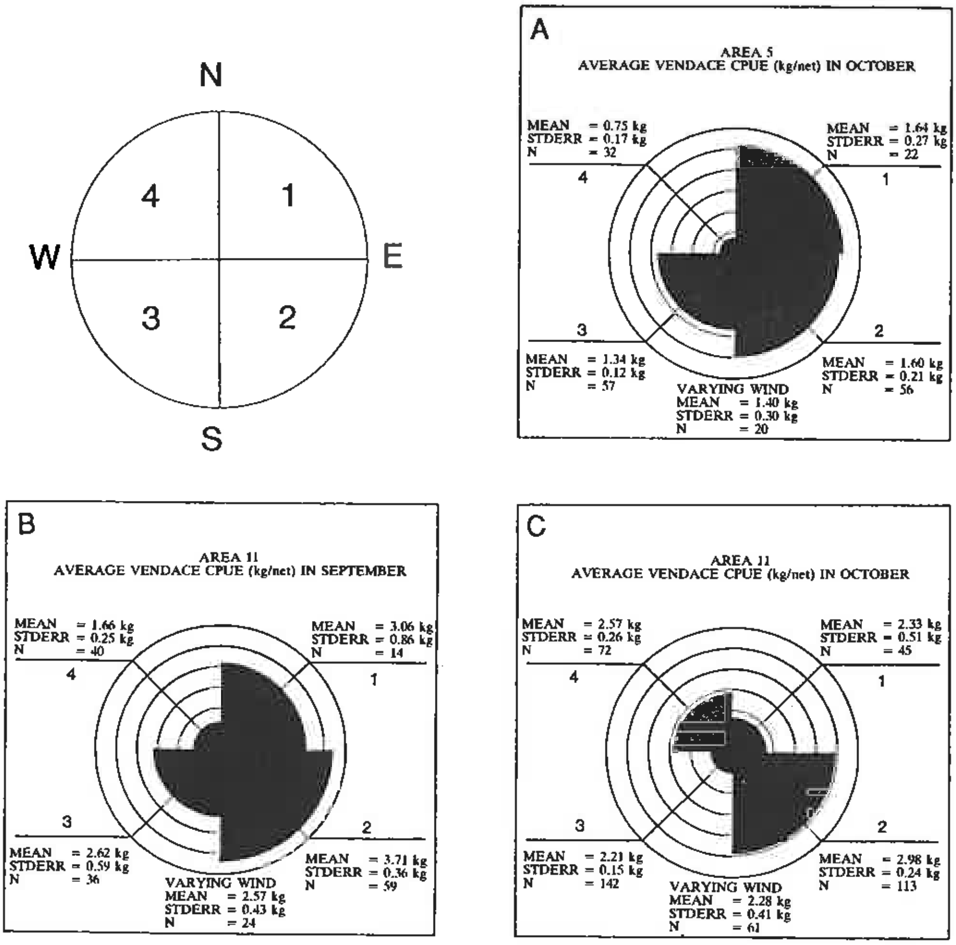


Fig. 23.5 (a)–(c) Monthly mean catch rates (kg/net) for vendance in areas 5 and 11 in relation to wind direction. The cases in which the analysis of variance (ANOVA) showed differences significant at the 95% confidence level are highlighted. (N = number of lifts, STDERR = standard error)

Table 23.3 Values of F (from analysis of variance) for transformed data (1/(1 + CPUE)) of vendace and whitefish tested for influence of wind direction (categorized as sectors 1 to 4 and variable) in three months and areas. Nets for vendace of mesh size <=20 mm and for whitefish of mesh sizes 27–40 mm.

Area	V August	V September	V October	W August	W September	W October
Area 5	1.75	1.45	5.03**	1.18	1.90	1.97
Area 11	1.43	5.80**	4.69**	0.97	0.94	0.36
Area 16	0.58	1.25	0.84	1.38	0.78	0.55

Burbot catches have varied by 10 tonnes during the study period (1973–88) (*c.* 30–40 tonnes) and the CPUE has varied even more (December) (Fig. 23.6(e)). There are indications that the CPUE of burbot is inversely correlated to the CPUE of pike.

The CPUE of vendace shows clear fluctuation (Fig. 23.6(a)). The CPUEs for September and October, in particular, follow the known fluctuation in the vendace stock in Lake Oulujärvi. The catch of vendace was high at the end of the 1970s. Although no catch statistics are available, this was indicated by serious problems in marketing the professional vendace catch at that time.

Whitefish catches increased considerably from 1973–85 and since then the catch has slowly decreased (Figs. 23.6(b) and 23.6(c)). The CPUE from whitefish was calculated for two net classes (mesh size 27–33 mm and 34–40 mm). The CPUE trends for different months (1974–87) are contradictory and the variation in CPUE was very high at the end of the 1970s and the beginning of the 1980s (Figs. 23.6(b) and 23.6(c)). There are many reasons for this, such as deficiencies in the CPUE data and the low number of lifted nets (Fig. 23.7(a)). The main cause, however, is stocking with peled fingerlings, which was initiated in the mid-1970s.

The peled whitefish behaves differently from the endemic whitefish forms. Schooling behaviour is more typical of this whitefish as it lives in shallower and more sheltered areas than the local forms. Both of these factors increase the variability of the CPUE.

The biomass of the whitefish stocks showed a considerable increase in the 1980s (Fig. 23.8), which had possibly already begun at the end of the 1970s. The biomass of the peled whitefish is unknown and therefore the total whitefish biomass in 1977–82 is also unknown. The whitefish biomass and CPUE for gill net fishing could be compared only after 1983 and the comparison indicates that there is a positive relationship between these two variables, though no statistical significance was found (Figs. 23.9(a) and 23.9(b)).

23.5 Discussion

Kennedy (1951) showed that the fishing effort exerted in Great Slave Lake by a net cleared of fish after a certain interval was not generally directly comparable

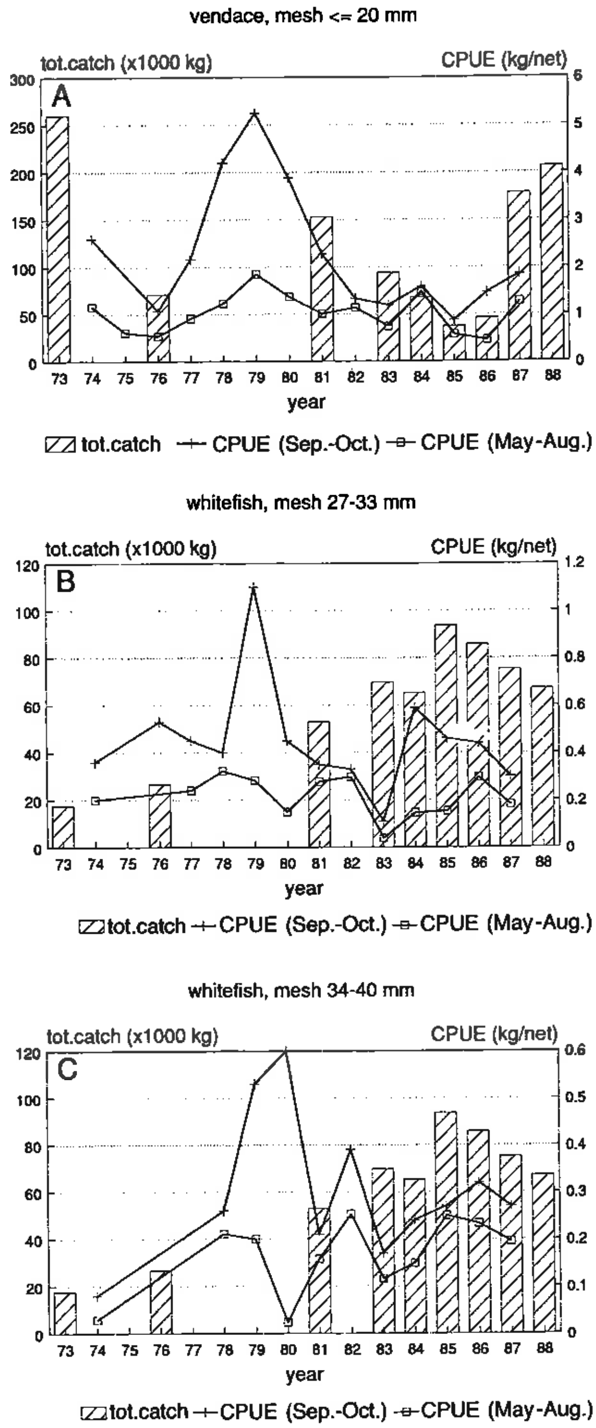


Fig. 23.6 (a)–(e) Average pike, burbot, whitefish and vendace CPUE (kg/net) from book-keeping data compared with total annual catch of the respective species. The vendace CPUE was calculated for a net mesh < = 20 mm, the pike and burbot CPUE for >40 mm and the whitefish CPUE for two mesh size classes, 27–83 mm and 34–40 mm, separately.

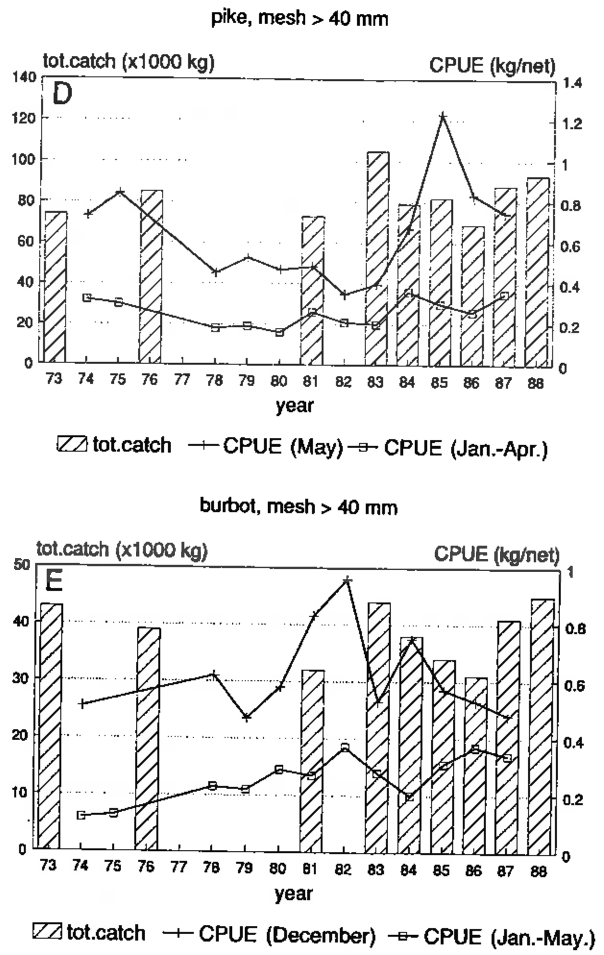


Fig. 23.6 Continued

with the fishing effort exerted by a similar net that is cleared of fish after a different interval. He showed that the greater the catch per net that can be made when nets are cleared daily, the smaller will be the relative increase in the catch per net when they are cleared every two days. He also showed that it is possible to 'saturate' nets, after which they will catch no additional fish. The idea of the saturation of gill nets has also been suggested by Van Oosten (1935) (ref. Kennedy, 1951) and Baranov (1948). Meth (1970) (ref. Hamley, 1975) suggested that saturation depends on the twine material: nylon nets can be expected to be saturated sooner than the less efficient cotton nets, and the longer the nets are in the water, the smaller will be the advantage of nylon over cotton.

In the ice-free season in Finland, nets are usually lifted once a day. Consequently the material collected during summer is homogeneous and standardization of the effort is not complicated by saturation of the nets. During winter, the situation is

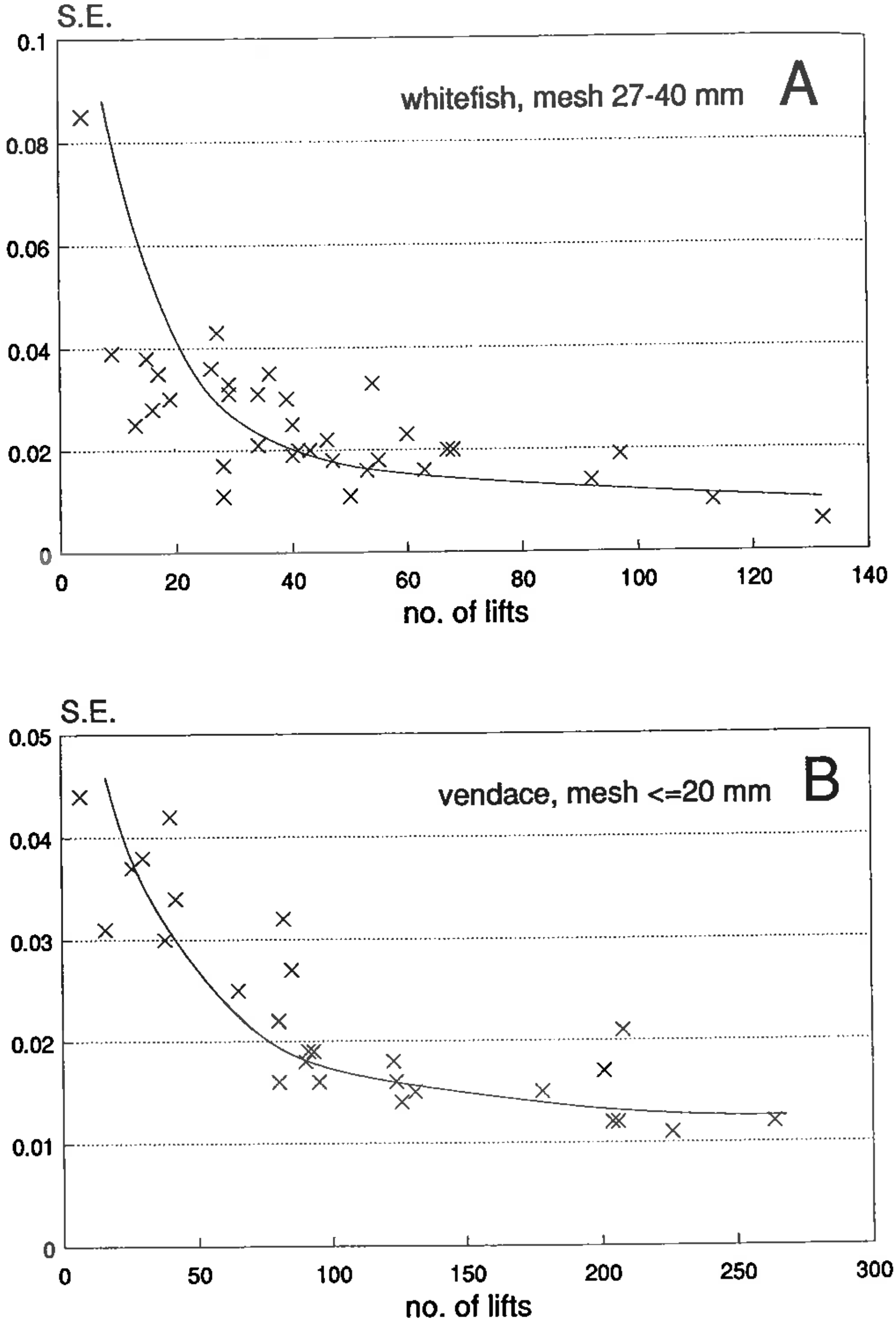
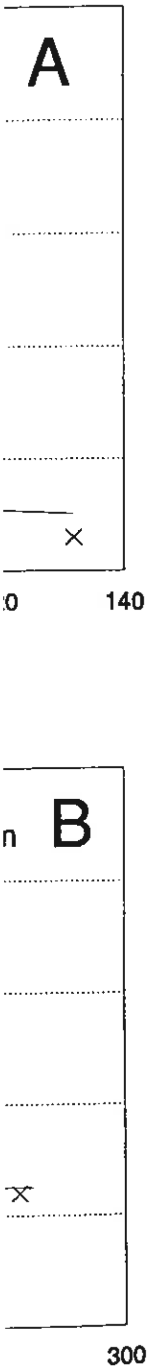


Fig. 23.7 (a)–(d) Standard errors of means (from transformed data) shown in Fig. 23.6 compared with number of observations in each sample. (Line drawn by hand)



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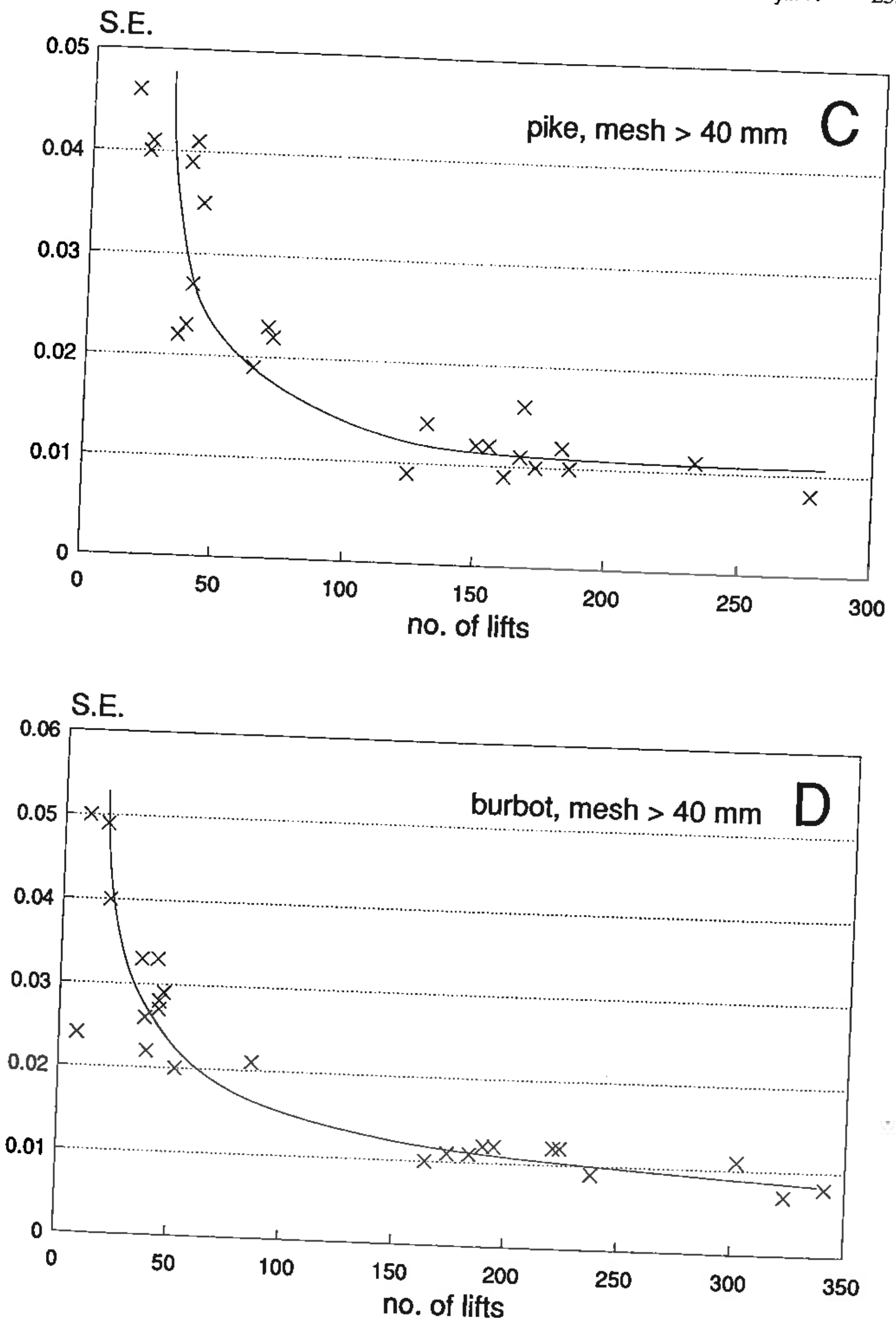

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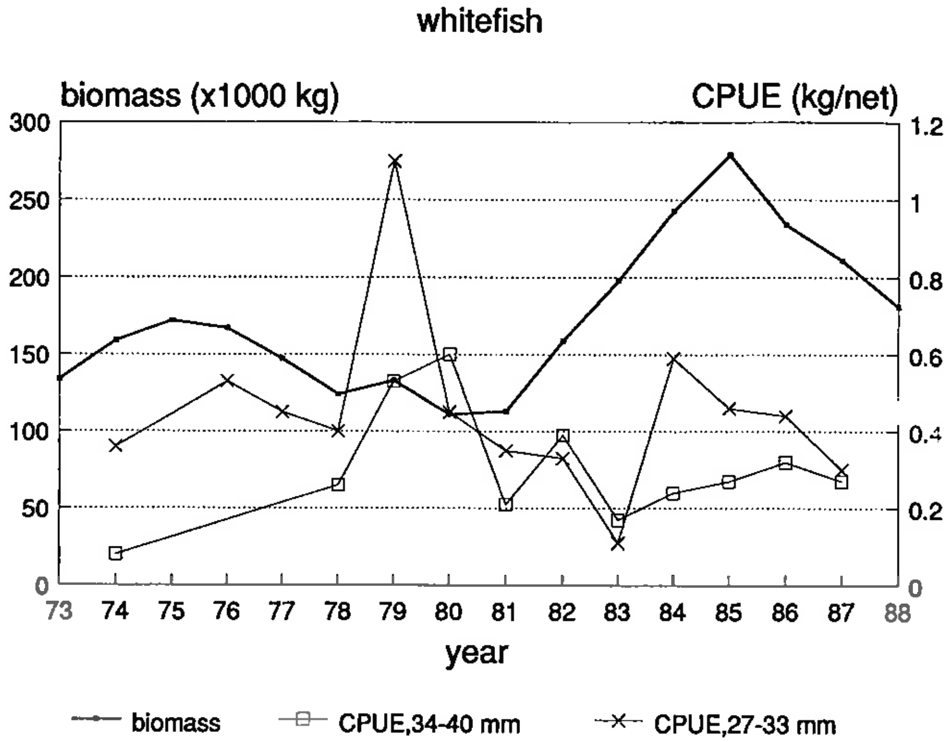

Fig. 23.8 Average whitefish CPUE (kg/net), (mesh sizes 27–33 mm and 34–40 mm) in October and September and the biomass of whitefish stock (>=3 years old) calculated by virtual population analysis (Salojärvi *et al.*, 1990)

different, because the interval between lifts varies greatly between fishermen. The present data were not good for studying the saturation effect. There were few observations relating to nets lifted at different intervals, but under otherwise similar conditions, e.g. the same year, month and area, and all the known sources of variation could not be taken into consideration at the same time. However, the present results concur with those of Kennedy (1951).

Collins (1987) studied the increased catchability of the deep monofilament nylon gill net and its expression in a simulated fishery. His simultaneous catch comparison between the two gears showed that deep nets were 1.7 times more efficient (but varied seasonally) for whitefish. The increase in efficiency exceeded that expected from the increase in area of the deeper nets. In this study the height and length of the nets were not strictly standardized. The nets used by the fishermen were *c.* 2 m deep and 30 m long.

Every fishing gear can catch a large variety of species, and many different species occur on most fishing grounds. Very few fisheries are based solely on single species. In practice the interpretation of catch and effort data concerning one species has to take into account the effects on the fisherman's tactics and strategy of possible catches of other species. Gear saturation effects are also more

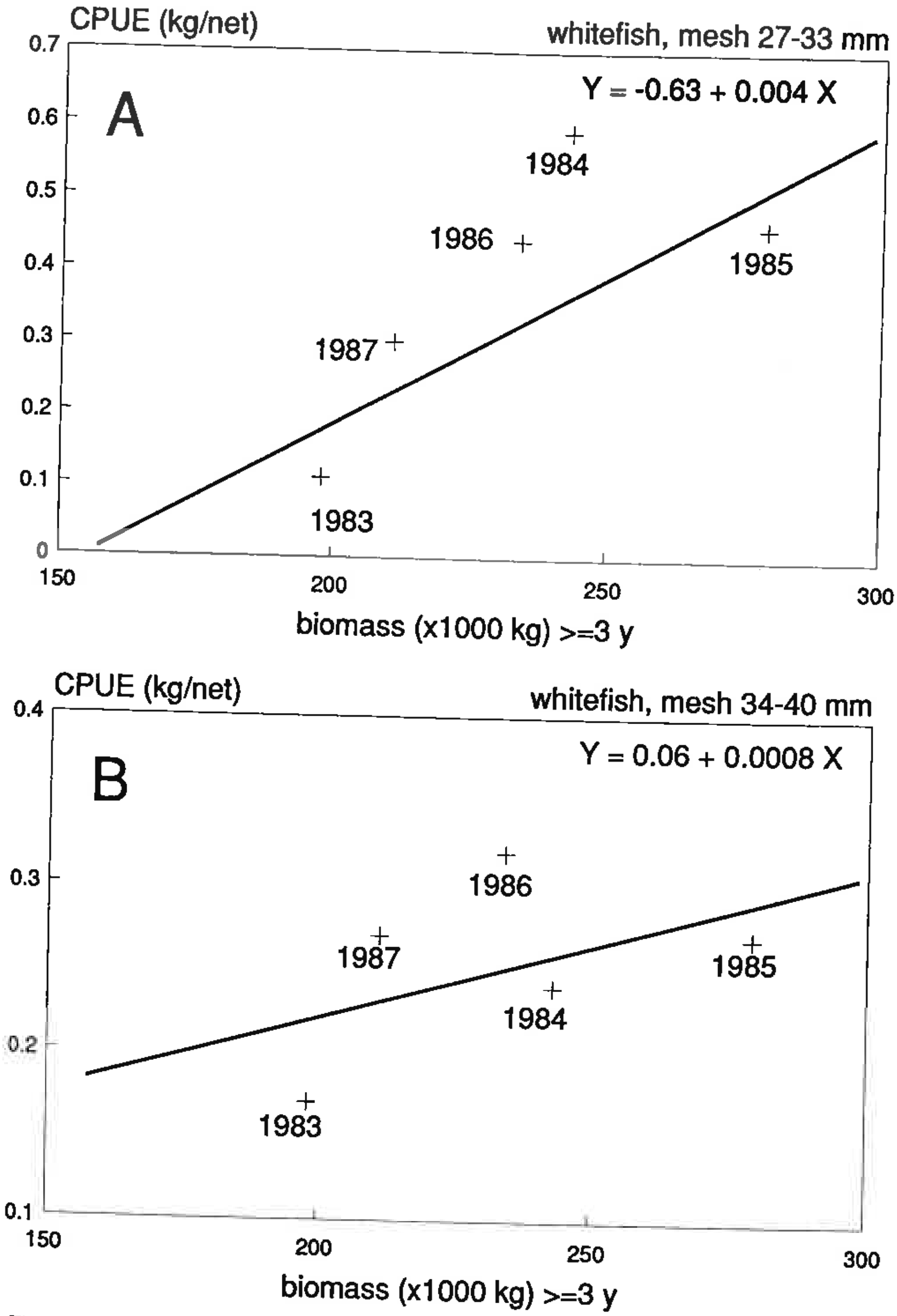

Fig. 23.9(a)–(b) The relationship between whitefish biomass (> = 3 years old) and the CPUE (mesh sizes 27–33 mm and 34–40 mm) of gill net fishing in the years 1983–87. Regression analysis showed no statistical significance

complicated when a mixed-species catch is concerned. Because of saturation, it is possible that the CPUE for a given species will decrease when the stock size of other species is increasing, even if the stock size of the studied species is stable. The results from Lake Oulujärvi indicate that the best season for collecting book-keeping data on gill net fishing is the principal fishing season for the species being studied (usually the spawning season).

Eberhardt and Gilbert (1975) give instructions for estimating the number of test fishings necessary in various situations. The sample size is evaluated by the ratio of the means and coefficient of variation and normal or log normal distribution of the data is assumed. The data of Lake Oulujärvi showed a close to negative binomial distribution with a large number of zero catches. Thus transformation by ($1/1 + CPUE$) was required to normalize the data. The standard errors of the normalized data were of a high level until the sample size was at least 100.

There are indications in many fisheries around the world that weather conditions have a marked influence on the catches (e.g. Harden Jones & Scholes, 1976; Taggart & Legget, 1987; Rose & Legget, 1988). According to the local fishermen, the wind direction in Lake Oulujärvi affects the vendace catches and has some influence on the whitefish catches. They have also suggested that the effect of the wind is different in different parts of the lake. The results of this study at least partly confirm these observations.

In Lake Oulujärvi there are three fishing methods which require more detailed analysis. The data provided on trawling comprise the total catches of different species and the number of fishing hours in every month; therefore these results are sufficient for analyses. Fyke net and seine fishing are also important, due to the fairly large vendace and whitefish catch, but the fishermen using fyke nets and seine nets are not obliged to report their catch. There is thus a need to collect statistics from all fishermen using such gears. Even when these three fishing methods are treated separately, there is still rather wide variation, for example in the total catch. To decrease the variation, the remainder of the material can be divided between households selling their catch and households fishing for recreation or subsistence.

As CPUE is, at least in theory, proportional to the average density of a fish stock, it can serve as an index of the size of the fish stock (Gulland, 1983). The results obtained for whitefish after 1983 are in agreement with this conclusion. It is generally believed that there is an inverse relationship between stock size and fishing effort and that CPUE is inversely related to fishing effort. These assumptions may not hold, however, for all fish species. If the recruitment of a species depends on the size of the spawning stock, the CPUE of that species can increase with the fishing effort. There are indications from Finland (e.g. Huusko, 1990) that the CPUE of vendace increased, when the fishing effort was increased. Gear selectivity is another problem, which may result in an inverse relation between the CPUE of a given species and the stock density, due to density-dependent growth. In this case, however, the CPUE is positively related to the size of the catchable stock.

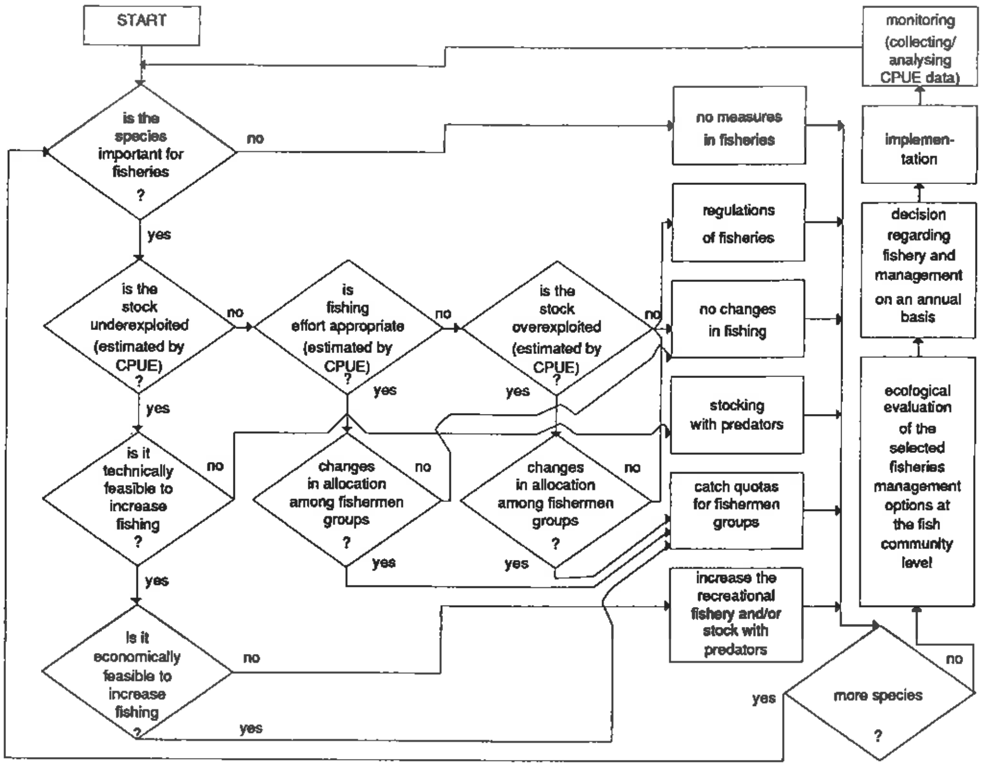

Fig. 23.10 Decision scheme for Fisheries Areas. The CPUE data are collected and analysed in the monitoring box and used in evaluating the state of a given stock in the under-/overexploitation or appropriate fishing boxes

23.6 Application to fisheries management

To regulate fisheries properly, the status of the important fish stocks should be known. Evaluation of the state of the fish stocks is mostly based on the fisheries managers' own experience and on interviews with other fishermen. Instead of this circumstantial evidence, the CPUE by species and by gears could serve as a useful and objective index. The material needed to calculate the CPUE can be collected rapidly (from two to four weeks) and cheaply (material collected from normal fishing), and the CPUE can be calculated using simple mathematics. Problems are posed, however, by the variability of the CPUE and the difficulty in interpreting the results.

If the collection of the CPUE data is standardized, the variance can be kept reasonably low, and the CPUE of a given species can be considered to be an index of the catchable stock size. For standardization, the CPUE data for a given species should be collected during the best fishing season with standardized gear and fishing techniques and using the same fishing places from year to year. In

Lake Oulujärvi the best fishing season for vendace is September-October, for whitefish October, for pike May and for burbot December. If gill nets are used for data collection, the number of observations (lifts) should be at least 100 in each sample. It is preferable to collect CPUE data from unselective gear, such as seine, trawl and fyke nets. The information obtained from the routine fishing records could usefully be supplemented by taking fish stock samples.

The interpretation of the CPUE data can be a difficult problem. The CPUE can reasonably be assumed to be positively related to the stock size, or at least to the catchable stock size. However, the CPUE of predator species may be inversely related and the CPUE of dense pelagic planktivorous small-sized species positively related to the fishing effort. More ecological research is needed, for example on the density-dependent mechanisms of population regulation.

It may be that the CPUE of gill nets is not a very accurate index of stock size from the statistical point of view, but there are very few practical alternatives. Moreover the CPUE has other uses. It is an index of fishing profitability and can be used to determine the prices of fishing licences, though the demand for licences may be more suitable for this purpose. It can also be used to compare the fishing efficiency of different gears.

Fisheries management operations are generally considered species by species. The fishing effort (number of licences sold) is the regulator and the opinions and feelings of fisheries managers are the indicator of the effect of fishing on the fish stocks. It is recommended that, instead of this circumstantial evidence, the catch per unit effort (CPUE) could be used as the indicator of the state of the fish stocks. As shown in the decision scheme presented in Fig. 23.10, the CPUE index could be used together with other information to determine whether the fish stock is underexploited, overexploited or properly fished.

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