Management and Ecology of Lake and Reservoir Fisheries

EDITED BY

I. G. COWX

Hull International Fisheries Institute
University of Hull, UK

Fishing News Books
An imprint of Blackwell Science

Blackwell
Science

A Division of Blackwell Science Ltd
Editorial Offices:
Osney Mead, Oxford OX2 0EL
25 John Street, London WC1N 2BS
23 Ainslie Place, Edinburgh EH3 6AJ
350 Main Street, Malden
MA 02148 5018, USA
54 University Street, Carlton
Victoria 3053, Australia
10, rue Casimir Delavigne
75006 Paris, France

Other Editorial Offices:

Blackwell Wissenschafts-Verlag GmbH
Kurfürstendamm 57
10707 Berlin, Germany

Blackwell Science KK
MG Kodenmacho Building
7-10 Kodenmacho Nihombashi
Chuo-ku, Tokyo 104, Japan

Iowa State University Press
A Blackwell Science Company
2121 S. State Avenue
Ames, Iowa 50014-8300, USA

First published 2002

Set in Times and produced by
Gray Publishing, Tunbridge Wells, Kent
Printed and bound in Great Britain by
MPG Books Ltd, Bodmin, Cornwall

DISTRIBUTORS
Marston Book Services Ltd
PO Box 269
Abingdon
Oxon OX14 4YN
(*Orders:* Tel: 01865 206206
Fax: 01865 721205
Telex: 83355 MEDBOK G)

USA and Canada
Iowa State University Press
A Blackwell Science Company
2121 S. State Avenue
Ames, Iowa 50014-8300
(*Orders:* Tel: 800-862-6657
Fax: 515-292-3348
Web: www.isupress.com
email: orders@isupress.com)

Australia
Blackwell Science Pty Ltd
54 University Street
Carlton, Victoria 3053
(*Orders:* Tel: 03 9347 0300
Fax: 03 9347 5001)

A catalogue record for this title
is available from the British Library

ISBN 0-85238-283-9

Library of Congress
Cataloging-in-Publication Data
Management and ecology of lake and reservoir fisheries/edited by I.G. Cowx.
p. cm.
Proceedings of a meeting held in Hull, UK in April 2000.
Includes bibliographical references (p.).
ISBN 0-85238-283-9
1. Fishery management–Congresses. 2. Freshwater fishes–Ecology–Congresses. I. Cowx, I. G. (Ian G.)

SH328.M33 2001
333.95′6–dc21 2001043018

For further information on
Fishing News Books, visit our website:
www.blacksci.co.uk/fnb/

Contents

II Anthropogenic activities/rehabilitation and mitigation

III Management

Chapter 24
Management of fisheries in a large lake – for fish and fishermen

T. VEHANEN*, P. HYVÄRINEN
Finnish Game and Fisheries Research Institute, Manamansalontie 90, FIN-88 300 Paltamo, Finland

M. MARTTUNEN, P. KYLMÄLÄ
Finnish Environment Institute, Helsinki, Finland

H. TERVO
University of Oulu, Thule-institute, Oulu, Finland

Abstract

Fishermen exploiting fish stocks, for example, for professional or recreational purposes, form a heterogeneous group. Combining the aims and views of these different groups operating in the same lake is an important task for managers. Therefore, in addition to the biological effects of management activities, the aims of the fishermen and economic impacts should be considered. Guidelines from a project conducted in Lake Oulujärvi, one of the largest lakes in Finland are described. The study combined biological information of the lake's fish stocks and the objectives of people exploiting the lake. Possible interactions between fish species were modelled. The economic value of Lake Oulujärvi's fisheries and its direct and indirect impacts on employment in the area were also measured.

Keywords: fisheries management, modelling, stocking, socio-economic factors, *Salmo trutta*, whitefish.

24.1 Introduction

The manipulation of fish stocks and fishing, alongside the physical rehabilitation of the environment, are usually the main tasks for fisheries management in lakes. In addition to biological aspects, socio-economic factors are also important when management decisions are made (Hickley & Tompkins 1998). Fishermen exploiting fish stocks form a heterogeneous group, for example, professional fishermen and the associated fishing sector often stress economic values, whereas many recreational fishermen point out the importance of leisure values. Combining the aims and views of these different stakeholders operating in the same lake is currently an important task for managers.

*Correspondence: Finnish Game and Fisheries Research Institute, Manamansalontie 90, FIN-88 300 Paltamo, Finland (email: vehanen@tp.rktl.fi).

Fish stocking and introductions are widely used management methods, annually involving billions of individual stocked fish in managed fisheries (Cowx & Welcomme 1998). When a stocking programme is planned, careful examination of the possible effects of stocking should be carried out (Cowx 1994; Hickley 1994). In addition to measuring the success of the stocking operation, information on the possible adverse effects and interactions with other fish species should be evaluated. Here, effective models are needed to help managers in the planning of stocking operations (e.g. Jørgensen 1988; Stefansson & Palsson 1998).

In this chapter the current status of Lake Oulujärvi's fish stocks and fisheries were examined, and possibilities for their future development in relation to management and socio-economic aspects were assessed.

24.2 Materials and methods

24.2.1 *Study lake*

Lake Oulujärvi (27°10′N, 64°20′E) has an area of 928 km^2, with a mean depth of 7.6 m and a maximum depth of 36 m. The lake has been regulated since 1951 for hydropower purposes, and the average annual amplitude of the water level is 1.9 m. The colour of the water is below 80 Pt mg L^{-1} and the total phosphorus below 20 μg L^{-1}.

There are about 50 professional fishermen working in the lake annually. Vendace, *Coregonus albula* (L.), and whitefish, *Coregonus lavaretus* (L.) sl., are the main target species for professional fishermen. The largest part of their catch comes from trawling, although gill nets and fyke nets are also used. Annually, slightly less than 4000 households use mainly gill nets and angling in the recreational fishery. In addition to vendace and whitefish, recreational fishermen target predatory species, like brown trout, *Salmo trutta* L., and pike, *Esox lucius* L.

24.2.2 *Population estimates*

Catch statistics from Lake Oulujärvi have been collected since 1973 (Salojärvi 1991; 1992). Virtual population analysis (VPA) was used to estimate the number of vendace, brown trout, pikeperch, *Stizostedion lucioperca* (L.), and whitefish from 1973 to 1995. Two commercially-important types of whitefish exist in the lake: the indigenous blue whitefish (number of gillrakers [mean ± SD] 33.5 ± 3.2) and the stocked northern densely-rakered whitefish (number of gillrakers 52.5 ± 4.2) (Salojärvi 1992). These whitefish were analysed separately. Pikeperch stock in Lake Oulujärvi plummeted in the 1950–1960s due to overfishing and a slight lowering in water temperature (Colby & Lehtonen 1994). The stocking of pikeperch fingerlings was started on a large scale in the mid-1980s, and pikeperch standing stock in 1995 rose due to this stocking. Due to damming and dredging of the spawning rivers, the brown trout catch in Lake Oulujärvi is almost totally based on the stocking of 2–3-year-old fish.

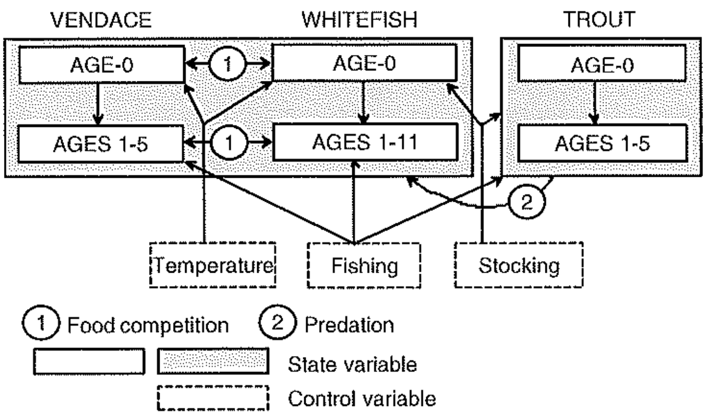

Figure 24.1 A diagram of the most important interactions in the computer model used to model the interactions between fish species in Lake Oulujärvi

24.2.3 *Modelling*

A computer model was used to simulate vendace, whitefish and brown trout stocks and their interactions in Lake Oulujärvi. Pikeperch stock was excluded from the simulations because it only started to recover at the end of the observation period (1973–1995). The model used was designed to work with 1–3 species at a time, and it was executed by Excel® and Visual Basic® (Marttunen & Kylmälä 1997).

The basic processes simulated in the model are fish growth, reproduction and mortality (Fig. 24.1). These can be guided by fish stocking, fishing and water temperature. The deterministic model (Fig. 24.2) requires data on the fish populations in the beginning of simulation, parameters for different interactions (e.g. stock–recruitment curve and density dependent growth, etc.), and information on guiding factors (fish stocking, fishing, temperature). Some of the relationships are optional, but most are obligatory. The model was calibrated using fish data from Lake Oulujärvi. A detailed description is given by Marttunen & Kylmälä (1997).

24.2.4 *Fishermen's opinion inquiry*

The opinions and views of the fishermen were collected by personal interviews and postal questionnaires. A questionnaire was mailed to all the professional fishermen (50) and a random sample of 300 people were selected from the recreational fishermen. Another questionnaire was sent to those who did not reply to the first one. The questionnaire included 26 questions concerning three main themes:

(1) the current status of fish stocks and fisheries in the lake;
(2) conflicts between different groups exploiting the lake; and
(3) views and means for further development of the lake.

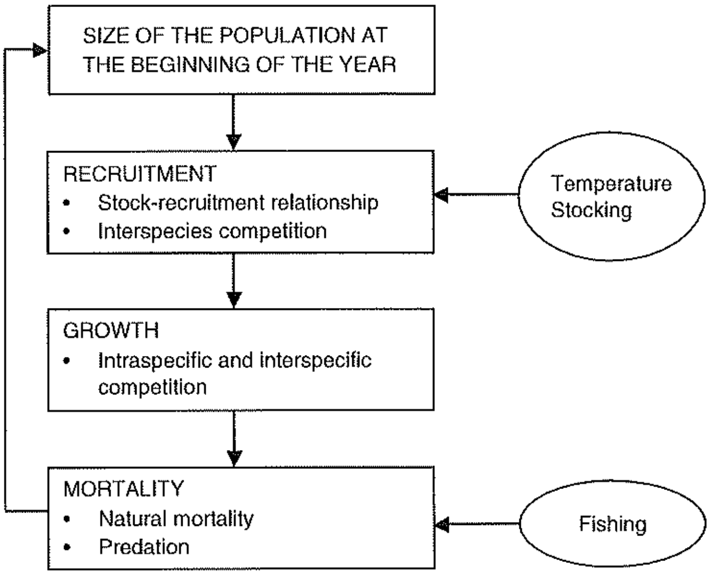

Figure 24.2 Diagrammatic representation of the computer model used to determine the interactions between fish species in Lake Oulujärvi

The answers were analysed in three different categories:

(1) professional fishermen;
(2) local recreational fishermen; and
(3) recreational fishermen not living in the area, but having a country cottage by the lake (non-local recreational fishermen).

To widen the information received from the postal questionnaire, 21 people were interviewed individually. The interviewees were stakeholders in the lake's fisheries: commercial entrepreneurs related to fishing, local and national authorities, professional fishermen, researchers and representatives of fishing organisations. The interview followed the structure of the mailed questionnaire, the themes being the same.

24.2.5 *Economic analysis*

The economic value of Lake Oulujärvi's fisheries in 1995, and its direct and indirect impacts on employment in the area, were evaluated. There are several stakeholders involved in Lake Oulujärvi's fisheries and the economy related to it. Professional fishermen and recreational fishermen exploit the fish stocks in the lake. The State of Finland and municipalities in the area have invested in the infrastructure. Other groups related to fisheries are tourist entrepreneurs, fish industries and trade, fish hatcheries and farms, the power company regulating the lake, and industries and households in the area. The economic analysis was based on the postal questionnaire sent to the fishermen and on interviews with representatives of the above mentioned groups. When conducting the interviews, field data from which an evaluation of the cost of the manipulation of fish stocks in 1995 and the annual cost of investing in the physical rehabilitation of the environment were also obtained.

The aim of the economic analysis was to estimate the total annual cash flow of the rehabilitation of the environment, manipulation of fish stocks and fishing activities in the lake area. In addition to the cash flows, the impact on employment (direct and indirect) was evaluated. This was conducted by combining the results of the questionnaires and interviews with the results of some former studies dealing with employment impacts of fisheries and tourism in the Lake Oulujärvi area and in the Lake Inari area in Finland (Tervo & Mäenpää 1996).

Cash flows of the fisheries were estimated for different groups of fishermen. The contribution of professional fishermen to the total cash flow was estimated according to the value of their annual catches, based on wholesale market prices. The difference between retail and wholesale prices was taken into account when evaluating the fishmongers' contribution to the total monetary flow. Annual fishing costs were evaluated on the basis of the postal inquiry, according to the value of the equipment owned by the fishermen, how often they renewed it and the fixed fishing costs. This was done to estimate the employment impact on the trade sector (and also to check if their fishing activities were profitable or not). Fishing costs for the recreational fishermen were evaluated in the same way. Because recreational fishermen do not sell their catches, their contribution to the total cash flow was estimated according to their fishing costs. More sophisticated methods to evaluate the recreational values of the fishing activities were not applied, because the approach was one of cash flow, not a proper benefit-cost analysis (Tervo & Mäenpää 1996).

24.3 Results

24.3.1 *Fish populations in Lake Oulujärvi*

Between 1973 and 1995 the annual catch of indigenous blue whitefish varied between 20 and 60 t. This whitefish stock peaked three times during the study period: at the beginning of 1973, in the mid-1980s and at the beginning of the 1990s (Fig. 24.3). After the stocking of northern densely-rakered whitefish began, the catch rose to 50 t in the middle of the 1980s. Despite higher numbers of fish being stocked annually, catches declined and have not recovered since the mid-1990s.

Vendace catches ranged between 50 and 350 t. Fluctuations in vendace stock were much larger than those in blue whitefish stock, with peaks in 1973, 1977, 1987 and 1994–1995 (Fig. 24.3).

Brown trout catch in Lake Oulujärvi varied from a couple of 1000 kg to slightly less than 50 t. The maximum catchable stock was 50 000 fish (Fig. 24.3), consisting mainly of 2–3-year-old stocked brown trout. Pikeperch catch was 10 t in 1996, but rose rapidly due to recruits from increased stockings.

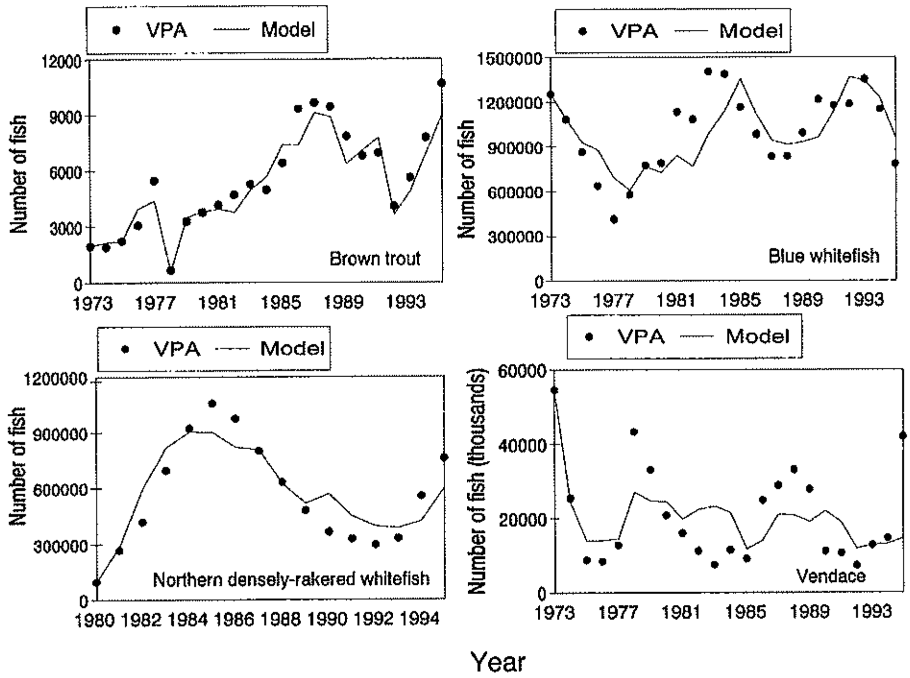

Figure 24.3 Population size of brown trout (1–5 lake years old), blue whitefish (2–10 years old), northern densely-rakered whitefish (2–8 years old) and vendace (1–5 years old) in Lake Oulujärvi estimated by VPA (•) and by the deterministic computer model (—)

24.3.2 *Modelling*

The calibration of the model indicated that in addition to the stock–recruitment curve, the recruitment of vendace and whitefish was affected by the number of competing species (either vendace or whitefish) present in the lake, i.e. the model indicated a slight competitive interaction between the species. Although natural mortality of whitefish and vendace depended on predation by brown trout, predation only slightly increased the predictability of the model and did not explain the fluctuations in whitefish and vendace stocks. Natural mortality of brown trout depends mainly on the amount of their primary prey, vendace, in the lake.

The model could successfully simulate the fluctuations in whitefish and brown trout stocks (Fig. 24.3). Although the level of vendace stock could be simulated within the given relationships, the fluctuations in stock were not satisfactorily modelled, suggesting that factors other than those included in the model act on the stock.

Approximately 40 000 brown trout have been stocked annually in Lake Oulujärvi and this was used to assess the effects of either halving the number of brown trout stocked or increasing the stocking rate by 50%. The model indicated that halving the number of stocked trout would result in a 28% decline in the average catches of brown tout, but would raise the annual vendace catch by 14%, and also have a slight positive effect on the whitefish catch (Table 24.1). Raising the annual stocking to 60 000 fish

Table 24.1 The effect of the different number of brown trout stocked annually in Lake Oulujärvi on brown trout, vendace and whitefish according to modelling

	Number of 1-year-old fish	Population size	Mean weight of fish	Total catch
Annual stocking 20 000 brown trout				
Brown trout	−18	−18	20	−28
Vendace	14	12	0	14
Blue whitefish	8	7	−2	5
Northern densely-rakered whitefish	6	14	−2	12
Annual stocking 60 000 brown trout				
Brown trout	1	22	−14	16
Vendace	−19	−25	0	−17
Blue whitefish	−10	−14	3	−6
Northern densely-rakered whitefish	−8	−25	3	−13

The numbers indicate the percentage change to actual average stocking density from 1973 to 1995 (*ca.* 40 000 brown trout).

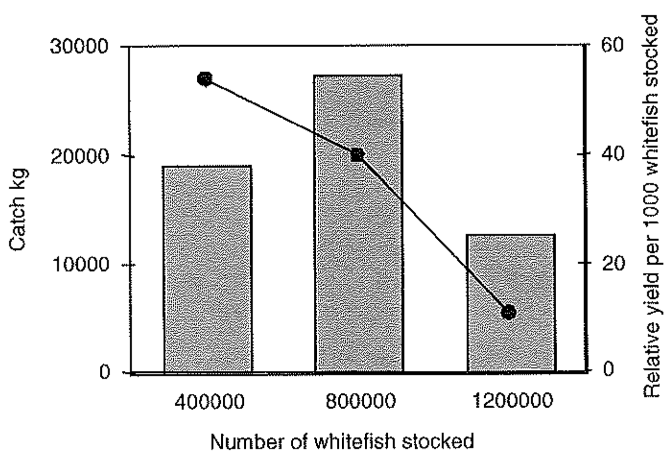

Figure 24.4 The average annual whitefish catch from three different stocking densities and the relative yield (yield per 1000 fingerlings stocked) from stocking simulated by the deterministic model

would increase the trout catch by 20%, but have a negative effect on the size of harvested fish, and on vendace and whitefish catches (Table 24.1).

The number of stocked northern densely-rakered whitefish varied widely. Simulation of different stocking densities suggested that stocking at high densities (close to 1 million juveniles annually, Fig. 24.4) is wasteful. Both the total catch and relative yield per thousand stocked whitefish juveniles declined rapidly at high densities.

The model suggested that food supply, i.e. the amount of the primary prey fish vendace (Vehanen, Hyvärinen & Huusko 1998), is an important factor that affects the

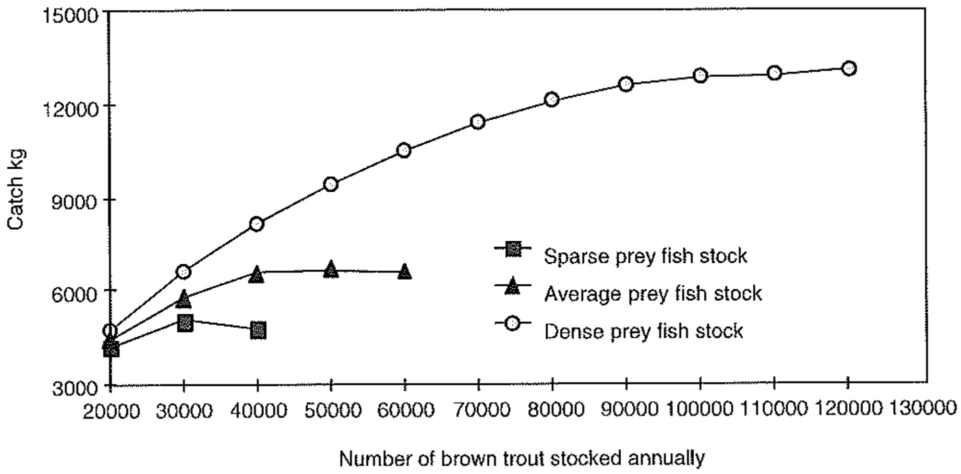

Figure 24.5 Relationship between brown trout yield from stocking and annual number of brown trout stocked in three different prey fish scenarios. See text for details

results of brown trout stocking. The results of brown trout stocking were modelled for three scenarios:

(1) poor food supply when the density of 1+-vendace in the beginning of the year was about 7 million fish;
(2) average food supply, density of 1+-vendace 11 million fish (average in the lake); and
(3) good food supply, density of 1+-vendace 19 million fish.

The results indicated that food supply has an effect on the results of stocking (Fig. 24.5). When the density of prey fish is high, the yield from the stocking can be nearly doubled, compared to a low prey fish density.

24.3.3 *Fishermen's opinion inquiry*

Altogether, 275 people (78.6%) replied to the questionnaire. There were marked differences in the views of the different groups exploiting the lake. The strongest motive for fishing was income among the professional fishermen, and relaxation and outdoor activity for recreational fishing. Professional fishermen were more content with the current catches of the lake, but dissatisfaction was higher among the recreational groups (non-local recreational fishermen, Fig. 24.6). Dissatisfaction was more prevalent with respect to catches of the most valued sport fishes – brown trout and pikeperch.

Professional fishermen targeted vendace (the most sought after species in more than 80% of the answers), whereas the most sought after fish species among recreational fishermen were predatory salmonids (more than 50% of the answers), brown trout and landlocked salmon, *Salmo salar* L. The difference between local and non-local

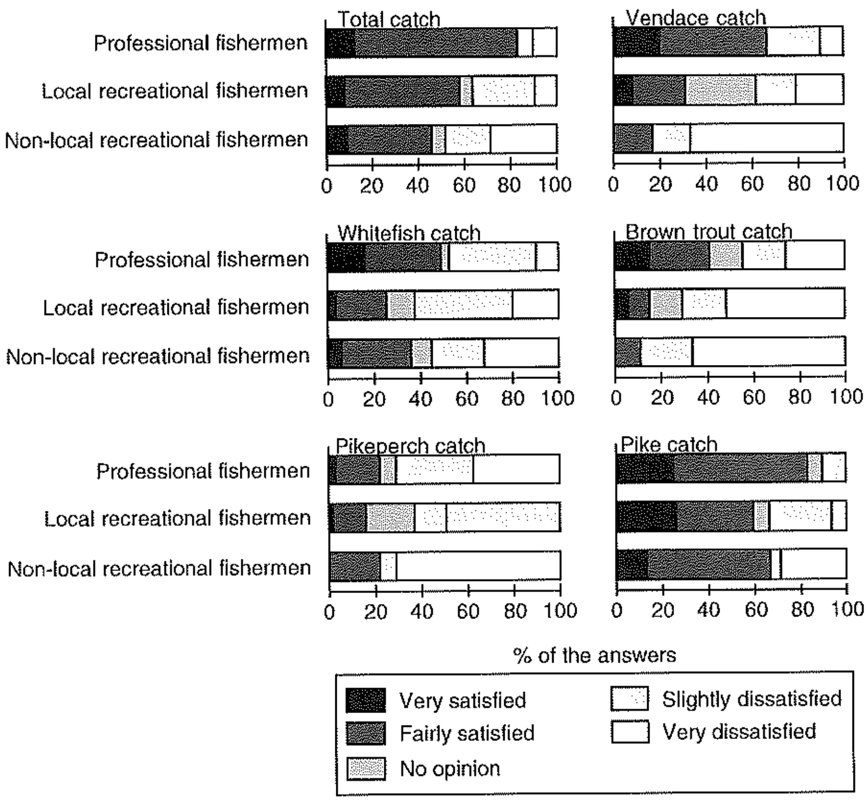

Figure 24.6 Distribution of answers from the opinion survey when fishermen were asked about their satisfaction about their total catch or catch of different fish species in Lake Oulujärvi in 1995

recreational fishermen was evident in the attitudes towards rainbow trout, *Oncorhynchys mykiss* (Walbaum), a non-native species which is usually stocked as table-sized fish. More than half (53.8%) of the non-local recreational fishermen classified rainbow trout as their most desired species, whereas the percentage among local recreational fishermen was 37.4% and only 17.6% among professional fishermen. In addition to targeting different species, there were also differences in the desired mean sizes of harvested fish among the different fishing groups. In general, all groups wanted to catch larger fish than they do at present (brown trout, pikeperch and whitefish), but the desired size of fish was largest among professional fishermen and smallest among non-local recreational fishermen.

Fishermen were asked if any fishing method used in the lake conflicts with other methods used. In the majority of the answers (50% among professional fishermen, 67% among local and 87% among non-local recreational fishermen) trawling was named as a fishing method that conflicts with the use of other fishing methods (e.g. gill nets, pound nets) in the lake.

An important question concerning the management of fisheries is response to gear restrictions. Fishermen were given three different restrictions, specifically aimed at preventing undersized brown trout and pikeperch getting caught in gill nets, which is a problem in the lake. These were:

(1) excluding mesh sizes 27–40 mm from the gill nets;
(2) excluding mesh sizes 27–55 mm; and
(3) to establish a closed, no-fishing area around the stocking sites.

Most of the local fishermen (60%), both professional and recreational, were ready to accept and follow the restriction of 27–40 mm mesh sizes, but the non-local fishermen resisted (60%) this restriction. A wider mesh restriction was opposed by all groups (>60%). Closed regions around stocking sites were accepted by all fishermen (>60%). However, among those interviewed, some professional fishermen had a strong aversion to the closed regions because they felt that 'a professional fishermen needs access to fish wherever he wants, because he is fishing for his livelihood'. A number of persons interviewed also related mesh size limits to the size of stocked fish; if table-sized fish are used, mesh restrictions are not needed but if fish are stocked as juveniles, restrictions are needed to preserve undersized fish.

Fishermen were asked about the guidelines for the future development of the fisheries in the lake. Most professional fishermen felt the current situation was acceptable. Slightly less than 40% of the local recreational fishermen shared the same opinion, but even more (42.7%) felt that action towards aiding recreational fishing should be taken in the future. This opinion was shared among the majority of the non-local recreational fishermen.

24.3.4 *Economic analysis*

The annual economic value of Lake Oulujärvi fisheries was estimated at 20 million FIM (3.36 million Euro) annually (Table 24.2). The largest individual money flow, about half of the total value, comes from the fees and expenditure of the recreational fishermen.

Table 24.2 Summary of the estimated cash flow in Lake Oulujärvi's fisheries in 1995

	Million Euro
Production of hatcheries and fish stocking	0.25
Annual costs of investments	0.08
Professional fish catch	0.62
Fish trade and industry	0.34
Expenses of the recreational fishermen	1.77
Expenses of fishing tourism	0.10
Wages not mentioned elsewhere	0.03
Indirect incomes	0.17
Cash flow altogether	3.36

Table 24.3 Summary of the estimated effect of Lake Oulujärvi's fisheries on employment in the area in 1995

	Man years
Professional fishing	16.8
Hatcheries and fish stocking	3.2
Fishing authorities	0.3
Researchers	0.5
Fish trade	3.7
Fish industry	0.5
Expenses of the professional fishermen	1.8
Expenses of the recreational fishermen	3.9
Expenses of the fishing tourism	1.0
Total direct effect	31.9
Total indirect effect	8.0
Total man years	40.0

Another economically-important component was the value of the catch of the professional fishermen. The effect of the fisheries on employment in the area was estimated at 40 man years annually. Most of the jobs come from professional fishing (Table 24.3), but fish trade and fish hatcheries in the area also have a notable effect on employment.

24.4 Discussion

The study in Lake Oulujärvi illustrated the importance of combining information from several sources when management decisions are made. In many cases the primary goal of fisheries management is to manage fish stocks effectively according to principles of sustainable development (Cowx 1998). The present results show that different groups of fishermen have different objectives for their activities in the lake, which need to be taken into account when management actions are considered (e.g. Hickley & Tompkins 1998). In addition, management actions may also influence the economic value of the lake's fisheries, when, for example, balancing the exploitation of fish stocks between professional and recreational use.

Fish stocks in Lake Oulujärvi fluctuate naturally but are also heavily influenced by fish stocking. The large, natural fluctuations of vendace have particularly important effect on the total catches of the lake. Due to the damming of large rivers in the area, the stocks of migratory salmonids have decreased and the role of fish stocking as a management tool is especially important.

Both the intraspecific and interspecific interactions may have an effect on the results of fish stocking (Gunn, McMurtry, Bowlby, Casselman & Liimatainen 1987; Lachance & Magnan 1990). However, these effects are difficult to outline and quantify without suitable data, and a model to calculate and visualise the interactions is important for management. For example, the stocking of northern densely-rakered whitefish increased the catches of this whitefish form, but results varied. Output from the model indicated that high stocking densities result in poorer catches. In addition, modelling suggested that the yield from the stocking of brown trout was highly dependable on the amount of suitable prey fish species, vendace, indicating strong interspecific relationships (e.g. Stewart, Kitchell & Crowder 1981; Stewart & Ibarra 1991). The best results from trout stocking could be obtained when the stocking density is adjusted according to the fluctuations in vendace stock. However, a model is always a simplification of nature and many factors may remain unaccounted. In Lake Oulujärvi, uncertainty in fisheries management comes mainly from the effect of the recent increase in the pikeperch stock, together with the lack of knowledge of the amount of its primary prey, smelt, *Osmerus eperlanus* (L.) (Vehanen *et al.* 1998). Also, the long-term effects of increased fishing mortality on vendace after the start of trawling in 1987 remains to be followed up.

Assessment of the outcome of management actions on the different group of fishermen is important (Salmi & Auvinen 1998). In many cases, as in Lake Oulujärvi, recreational fishermen favour predatory species like brown trout, whereas professional fishermen consider brown trout as a competitor of their primary target fish, vendace. When the purpose is to ensure the best conditions for both professional and recreational fishing, a balance in the amount of stocked predatory species should be found which ensures that predation against vendace does not rise to too high a level, but also satisfies the catch expectations of recreational fishermen. In the current situation of high vendace stock, professional fishermen tended to be satisfied with their catches, but the recreational fishermen were especially dissatisfied with the catches of predatory brown trout and pikeperch. Therefore, increased stocking of these species is often demanded. However, it is often forgotten that gear restrictions to protect the undersized fish from exploitation are often more effective at increasing catches than increased stocking (e.g. Gigliotti & Taylor 1990). To be effective, gear restrictions should be approved by all groups of fishermen. However, according to this study this is not currently the case.

Although the economic value of the lake's fishery is sometimes forgotten by management, it is of special interest to the local authorities. Currently both the economic value and the effect on employment of Lake Oulujärvi's fisheries in the area are considerable. The tendency in the area is to try to increase further the economic income by investing in fishery-related tourism. In many cases this approach has been effective (Møller & Petersen 1998). However, to attract a considerably larger number of fishery tourists, larger catches of sport fish are needed, as are larger investments in fish stocking and infrastructure, but considerable uncertainty in the profitability of the investment remains.

In the development of the lake's fisheries, the different views of the fishermen have to be balanced in an ecologically and economically viable way. It is important that information on the basis of management action is discussed and shared with all the groups exploiting the lake. For example, through informing the fishermen about the effectiveness of gear restrictions it is possible to gain their approval. It is more sensible to increase catches of predatory species by increasing the size of harvested fish rather than increasing the stocking volume. When the needs of the different groups of fishermen are taken into account, both recreational and professional fishermen can work effectively in the same lake.

References

Colby J. & Lehtonen H. (1994) Suggested causes for the collapse of zander, *Stizostedion lucioperca* (L.), populations in northern and central Finland trough comparisons with North American walleye, *Stizostedion vitreum*, (Mitchill). *Aqua Fennica* **24**, 9–20.

Cowx I.G. (1994) Stocking strategies. *Fisheries Management and Ecology* **1**, 15–30.

Cowx I.G. (1998) (ed.) *Stocking and Introduction of Fish.* Oxford: Fishing News Books, Blackwell Science, 456 pp.

Cowx I.G. & Welcomme R.L. (eds) (1998) *Rehabilitation of Rivers for Fish.* Oxford: Fishing News Books, Blackwell Science, 260 pp.

Gigliotti L.M. & Taylor W.W. (1990) The effect of illegal harvest on recreational fisheries. *North American Journal of Fisheries Management* **10**, 106–110.

Gunn J.M., McMurtry M.J., Bowlby J.N., Casselman J.M. & Liimatainen V.A. (1987) Survival and growth of stocked lake trout in relation to body size, stocking season, lake acidity, and biomass of competitors. *Transactions of the American Fisheries Society* **116**, 618–627.

Hickley P. (1994) Stocking and introduction of fish – a synthesis. In I.G. Cowx (ed.) *Rehabilitation of Freshwater Fisheries.* Oxford: Fishing News Books, Blackwell Science, pp. 247–254.

Hickley P. & Tompkins H (1998) (eds) *Recreational Fisheries: Social, Economic and Management Aspects.* Oxford: Fishing News Books, Blackwell Science, 310 pp.

Jørgensen S.E. (1988) *Fundamentals of Ecological Modelling.* Amsterdam: Elsevier, 391 pp.

Lachance S. & Magnan P. (1990) Performance of domestic, hybrid, and wild strains of brook trout, *Salvelinus fontinalis*, after stocking: the impact of intra- and interspecific competition. *Canadian Journal of Fisheries and Aquatic Sciences* **47**, 2278–2284.

Marttunen M. & Kylmälä P. (1997) Kalakantojen hoitomalli Inarijärven kalaistutusten vaikutusten arvioinnissa. *Suomen ympäristö* **117**. (in Finnish with English abstract).

Møller M.M. & Petersen J.D. (1998) The Funen sea trout project, Denmark – a development project for the environment and tourism. In P. Hickley & H. Tompkins (eds) *Recreational Fisheries: Social, Economic and Management Aspects.* Oxford: Fishing News Books, Blackwell Science, pp. 70–79.

Salmi P. & Auvinen H. (1998) Local conflicts in Finnish Lake Fisheries. In P. Hickley & H. Tompkins (eds) *Recreational Fisheries: Social, Economic and Management Aspects.* Oxford: Fishing News Books, Blackwell Science, pp. 116–128.

Salojärvi K. (1991) Recruitment mechanisms of the vendace (*Coregonus albula* (L.)) in Lake Oulujärvi, northern Finland. *Aqua Fennica* **21**, 163–173.

Salojärvi K. (1992) Compensation in whitefish (*Coregonus lavaretus* L. s.l.) populations in Lake Oulujärvi, northern Finland. *Finnish Fisheries Research* **13**, 31–48.

Stefansson G. & Palsson O.K. (1998) A framework for multispecies modelling of Arcto-boreal systems. *Reviews in Fish Biology and Fisheries* **8**, 101–104.

Stewart D.J. & Ibarra M. (1991) Predation and production by salmonine fishes in Lake Michigan, 1978–88. *Canadian Journal of Fisheries and Aquatic Sciences* **48**, 909–922.

Stewart D.J., Kitchell J.F. & Crowder J.B. (1981) Forage fishes and their salmonid predators in Lake Michigan. *Transactions of the American Fisheries Society* **110**, 751–763.

Tervo H. & Mäenpää I. (1996) Inarijärven kalataloudellinen kustannus-hyötyanalyysi. *Suomen ympäristökeskus monisteita* **2** (in Finnish).

Vehanen T., Hyvärinen P. & Huusko A. (1998) Food consumption and prey orientation of piscivorous brown trout (*Salmo trutta*) and pikeperch (*Stizostedion lucioperca*) in a large regulated lake. *Journal of Applied Ichthyology* **14**, 15–22.