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# Simple method of categorizing salmonid fisheries using management data

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**Abstract**. This study solves the problem of evaluating the quality of salmonid fisheries in the Czech Republic using catch and stocking statistics provided by the Czech and Moravian Anglers Unions for the years 2000–2010. The quality of 200 salmonid fisheries belonging to Czech Anglers Unions (Local Organization for North Moravia and Silesia, South Bohemian Board) and the Moravian Anglers Union was evaluated. Using factor analysis they were each placed in one of five categories (A–E). Fisheries with the highest catches and stocking of fish were evaluated as "TOP salmonid fisheries", classification A, which is based mainly on their indigenous ichthyofauna in terms of the significant species *Salmo trutta* m. *fario* Linnaeus, 1758 and *Thymallus thymallus* Linnaeus, 1758 (Salmonidae). There are only a small number of fisheries in the highest rated categories A and B, which make up 2% of all the fisheries. Most of the fisheries (68%) were placed in category D. Comparison of the quality of these organizations is very difficult as they are each regulated and managed differently.

**Key words**. Ichthyology, fishery, salmonid fisheries, *Salmo trutta* m. *fario*, *Thymallus thymallus*, Salmonidae, stock, catch.

## INTRODUCTION

Salmonid fisheries are among the most valuable in terms of the yield of fish and the most demanding in terms of management and financial cost. Recently, there has been a significant annual decrease in the catch and an incidental decline in the interest of anglers. To reverse this tendency, there is a need to adjust the managerial interventions, mainly by determining the stocks of fish and adjusting the rules so that they comply with the different attributes of the different fisheries.

Populations of brown trout *Salmo trutta* m. *fario* Linnaeus, 1758, and grayling *Thymallus thymallus* Linnaeus, 1758, the indigenous species in the Czech ichthyofauna, are becoming more vulnerable due to a lot of abiotic and biotic factors. Lack of mature fish for spawning (Kouřil et al. 2008), high mortality due to fishing by anglers, minimal waterway flow (Spurný et al. 2008) and many other factors, which have a strong affect not only on the number and size of catches but mainly on the survival of populations of the different species of fish.

The catches of these salmonids has declined notably in recent decades. Catches of grayling are declining rapidly in spite of an increase in stocking rates and tightening of the rules governing fishing for this species. The decline in the catches of both the above mentioned species is largely compensated by stocking with non-indigenous salmonid species, namely rainbow trout *Oncorhynchus mykiss* Walbaum, 1792 (Salmonidae) and brook trout *Salvelinus fontinalis* Mitchill, 1814 (Salmonidae). Each user of these salmonid fisheries (local organizations of fishing unions) usually manages these fisheries differently. Every user is supposed to take measures to ensure that particular biological conditions prevail in the river and to control the level of fishing pressure. Because of this, it is important to find indicators that can be used to compare the salmonid fisheries managed by the different users.

The aim of this study was to find a criterion for evaluating salmonid fisheries data based on anglers catches and stocking of fish. Further effort was made to define the different categories of salmonid fisheries using the criteria identified. In conclusion, the groups of people using the fisheries (fishing unions) were compared with each other by pertinence of fisheries to particular categories.

## MATERIAL AND METHODS

Categorization of salmonid fisheries was based on the management records of all the salmonid fisheries of the South Bohemian Board ("SBB", *Local Organization for North Moravia and Silesia* ("LoNMS") and Moravian Anglers Union ("MAU") for the years 2000–2010. For this period of eleven years we processed the records of 216 salmonid fisheries covering a total area 1853 hectares (in SBB there were 49 fisheries, of which 6 were initiated or discontinued during this period, in LoNMS the data for 104 fisheries was processed, of which 13 were initiated or discontinued during this period, for the MAU it was 63 and 9 fisheries, respectively).

As the primary documents, summary of data of catches and stocking were used for categorizing salmonid fisheries. Summary catch data of all three unions monitored in 2000–2010 were of the numbers and mass of each the species: *Salmo trutta* m. *fario*, *Thymallus thymallus, Oncorhynchus mykiss* and *Salvelinus fontinalis*. The fish stock data from all three unions were of the numbers in terms of the different age groups: $Po_2$ (*Salmo trutta* m. *fario* 2 years old), $Li_1$ (*Thymallus thymallus* – 1 year old), $Pd_2$ (*Oncorhynchus mykiss* – 2 years old) and $Si_2$ (*Salvelinus fontinalis* – 2 years old). All numbers and masses of fish caught and numbers of fish added to the stocks in years 2000–2010 in the areas monitored were expressed in terms of one hectare of water in order to compare the results.

The categorization of the salmonid fisheries was done using a multidimensional statistical analysis, called factor analysis (FA). The parameters median values of stock and mass of fish and catches of fish were used as input data for the multidimensional analysis of the data for the years monitored. A matrix consisting of 12 columns of medians (input parameters) and 200 lines with the data for the particular fisheries was created. The factor analysis revealed the underlying variable that accounts for the pattern of correlations in the data set and identified the crucial and clear factors (using the rotation method Varimax). Subsequently, based on these factors the input parameters for the scores of each of the fisheries were calculated. Fisheries factor scores were used as criteria for categorizing fisheries in terms of the quality of their catches and stocking level of fish. Based on these criteria the intensity of management of the fisheries was determined. This revealed five different categories of salmonid fisheries. Finally, the performance of each of the fish unions were compared using a one factor variation analysis (ANOVA) and Scheffes' multiple comparison. Fisheries for which the data was incomplete were not included in this comparison.

## RESULTS

### Classification of the level of management of the salmonid fisheries of the Fishing Unions monitored

Level of management was assessed mainly on the management of indigenous species of fish (*Salmo trutta* m. *fario* and *Thymallus thymallus*). The clear factors revealed by the factor analysis were named 1 *Salmo trutta* m. *fario* and 3 *Thymallus thymallus*, as they were identified mainly in terms of the input parameters for these preferred species of fish (Fig.1). The clear factors are positioned close to the axes of the factor diagram. The table and graph in Fig. 1 indicate that catch Po (inds/ha), catch Po (kg/ha) and stock Po strongly affected and stock Li (inds/ha) had only a medium effect on factor 1. The characteristics Li (inds/ha) and catch Li (kg/ha) and also partially stock Li (inds/ha) had the biggest influence on factor 3. Categorisation of salmonid fisheries primarily focused on management of *Salmo trutta* m. *fario* and *Thymallus thymallus*. Based on the picture presented it is apparent that the factors that influenced the catches and stocking of indigenous species of salmonids was factor 1 and factor 3.

The salmonid fisheries were categorized in terms of management from most to least intensively managed using criterion α, which was the sum of 50% of the value of factor 1 – *Salmo trutta* m. *fario* plus 50% of that of factor 3 – *Thymallus thymallus*). The final categorization of the salmonid fisheries was not only based on species *Salmo trutta* m. *fario* and *Thymallus thymallus* but

also on *Oncorhynchus mykiss* and *Salvelinus fontinalis*. Mentioned factors are combination of all original signs, they were only assigned with lower onuses. Eight of the 10 most intensively managed salmonid fisheries are in the Moravian Anglers Union (occupying the first 5 positions on the list) and the other 2 are fisheries in the *Local organization for North Moravia and Silesia* (6th and 8th place). In the 50 most intensively managed fisheries are fisheries of all three organizations: 1 salmonid fishery of the South Bohemian Board (2% of all the South Bohemian Board fisheries evaluated), 22 of the *Local organization for North Moravia and Silesia* (22% of the *Local organization for North Moravia and Silesia* fisheries evaluated) and 27 of those of the Moravian Anglers Union (46% of the Moravian Anglers Union fisheries evaluated). Of the less intensively managed salmonid fisheries three are fisheries of the South Bohemian Board (numbers 423 057, 423 010, 423 024), one of the Moravian Anglers Union (number 463 052) and one of the *Local organization for North Moravia and Silesia* (number 473 105). Salmonids fisheries 423 057 and 423 010 in SBB are both managed differently from the other fisheries. A complete list of salmonid fisheries ranked from the most to the least intensively managed is available at the authors e-mail address: petrchalupax@seznam.cz.

Fisheries were categorized into one of 5 different categories (A–E) based on the quality of the management (Fig. 2). This was done using criterion α. Salmonid fisheries in category A had α values ranging from 3.5–2.5, in category B: 2.5–1.5, in category C: 1.5–0.5, in category D: 0.5–dot 0.5 and in category E: dot 0.5–dot 1.5. In category E are the least intensively managed salmonid fisheries (in terms of mainly *Salmo trutta* m. *fario* and *Thymallus thymallus*), which

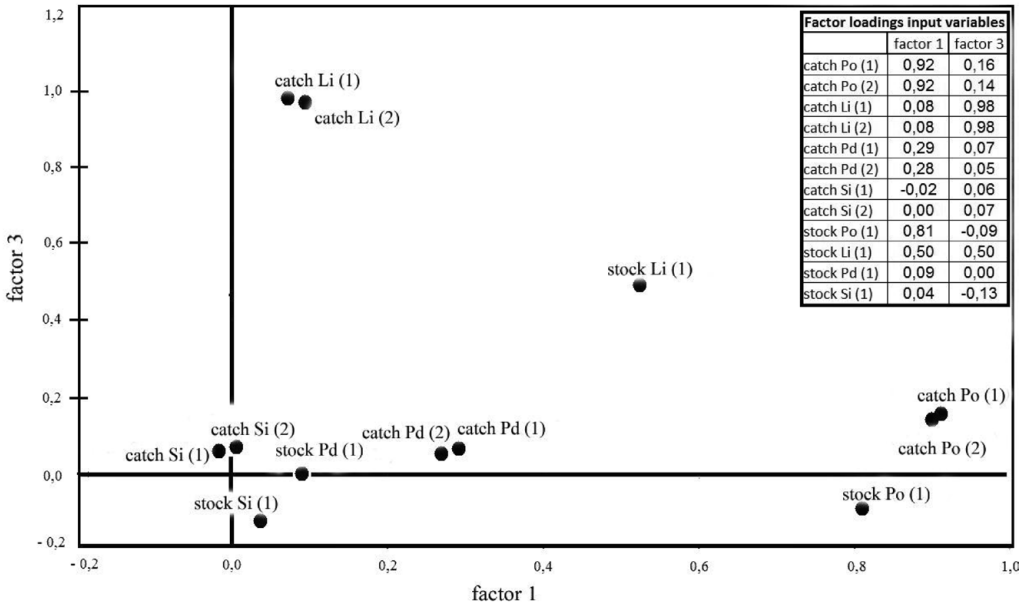


Fig. 1. Factor analysis of the catches and stocking rates of four species of salmonid recorded for salmonid fisheries in the Czech Republic, using the Varimax rotation method. Abbreviations: Po – *Salmo trutta* m. *fario*, Li – *Thymallus thymallus*, Pd – *Oncorhynchus mykiss*, Si – *Salvelinus fontinalis*, catches in inds/ha (1) and stocking rates in kg/ha (2).

Table 1. Stocking rates and catches of *Salmo trutta* m. *fario* and *Thymallus thymallus* recorded for the five categories of fisheries. Numbers are medians; numbers in brackets are means of median values. Small letters before some numbers: [a)] means that no extreme median value was recorded; [b)] means that there is no need to declare the stocking rates of the the species of fish currently in this category of salmonid fishery

| category of fishery | *Salmo trutta* m. *fario* | | | *Thymallus thymallus* | | |
|---|---|---|---|---|---|---|
| | stocking rate (inds/ha) | catch (inds/ha) | catch (kg/ha) | stocking rate (inds/ha) | catch (inds/ha) | catch (kg/ha) |
| A | 272–3272 (1264) | 58–375 (196) | 14–100 (56) | 325–621 (467) | 1–39 (19) | 0–13[a)] (6) |
| B | 287–561 (480) | 33–146 (79) | 10–35 (21) | 164–452 (327) | 23–31 (27) | 7–10 (8) |
| C | 167–1050 (462) | 18–155 (72) | 5–40 (20) | 0–667[b)] (279) | 0–20 (9) | 0–7 (3) |
| D | 69–1185 (332) | 0–85 (24) | 0–25 (7) | 0–500[b)] (91) | 0–12 (1) | 0–4 (0.4) |
| E | 0–877[b)] (142) | 0–28 (7) | 0–7 (2) | 0–167[b)] (17) | 0–1 | 0 |

make up 16% of the salmonid fisheries evaluated statistically. Most of the fisheries are in category D, which makes up 68% of those evaluated. In the other two categories (C and B) are only salmonid fisheries of the *Local Organization for North Moravia and Silesia* and Moravian Anglers

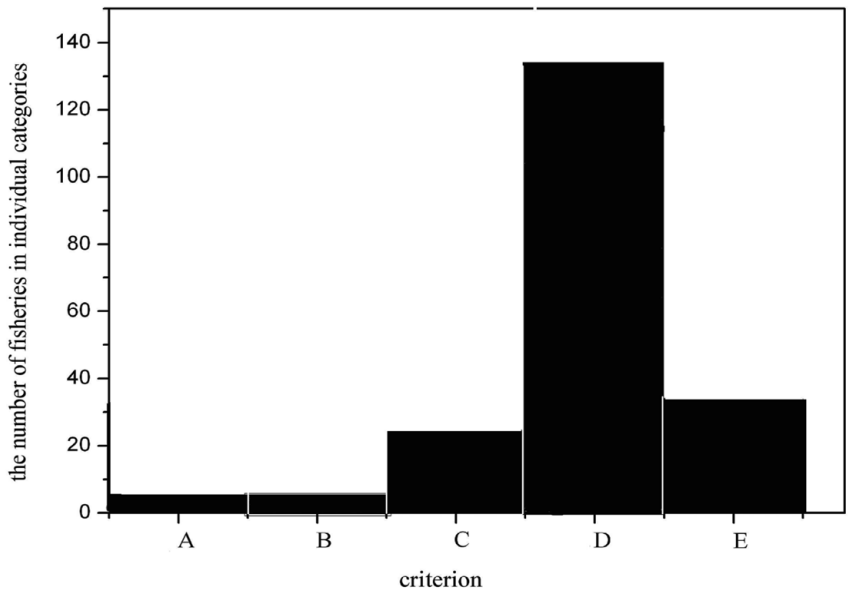


Fig. 2. Frequency distribution of the five categories of salmonid fisheries in the Czech Republic based on an evaluation of the quality of management. Fisheries with the highest catches and stocking rates of fish are in category A.

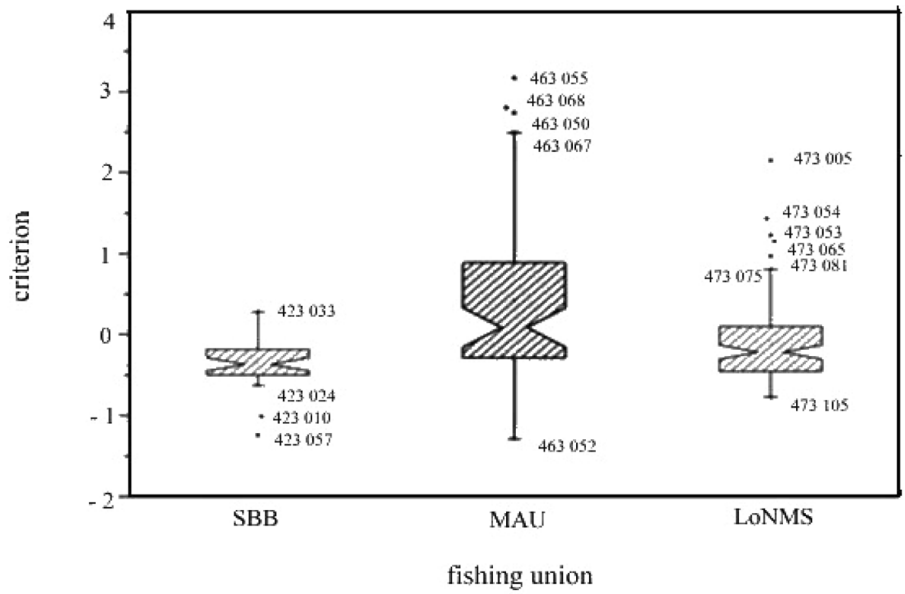


Fig. 3. Level of management recorded for the fisheries of the three fishing unions in the Czech Republic from 2000–2010 classified using Scheffe's multiple comparisons. Abbreviations: SBB – South Bohemian Board, LoNMS – *Local Organization for North Moravia and Silesia,* MAU – Moravian Anglers Union; • small black dots indicate the highest or lowest levels of management recorded in the three fishing unions; small numbers are registration numbers of the fisheries.

Union, which make up 14% of those evaluated. The most intensively managed salmonid fisheries are in category A and make up only 2% of those evaluated. For the Moravian Anglers Union 59 salmonid fisheries were evaluated statistically, of which 20 are in categories A, B and C, and 39 in categories D and E. For the *Local Organization for North Moravia and Silesia* 98 salmonid fisheries were evaluated statistically, of which 86 are in categories D and E and 12 in categories B and C. For the South Bohemian Board 43 salmonid fisheries were evaluated statistically, of which are in categories D and E. The level of stocking and catches recorded for the different categories of fisheries is given in Table 1 (in terms only of *Salmo trutta* m. *fario* and *Thymallus thymallus*). There are only 4 fisheries in category A and they are the most visited fisheries of the Moravian Anglers Union (average attendance at these 4 fisheries is 430 per hectare, average attendance for all the fisheries in the Moravian Anglers Union is 160 per hectare).

**Classification of the level of management of the different fishing unions**

On the basis of criterion α, variation analysis ANOVA and Scheffes' multiple comparison of groups (Fig. 3) it is apparent that the most intensively managed salmonid fisheries are those of the Moravian Anglers Union ($p<0.001$). There were no statistically significant differences in the management of the fisheries of the South Bohemian Board and those of the *Local Organization for North Moravia and Silesia* ($p=0.125$). The expectation was that there would be statistical significant differences in the management of the salmonid fisheries in particular angler's unions. According to the statistical analysis the Moravian Anglers Union manages its salmonid fisheries the most intensively. This statement is supported by the fact that during the years 2000–2010

approximately 593 inds/ha/year of Po, Pd, Li a Si were added to waters of the Moravian Anglers Union that contained trout, 531 inds/ha/year of particular salmonid species to those of the South Bohemian Board and 472 inds/ha/year to those of the *Local Organization for North Moravia and Silesia*. During the years 2000–2010 recreational anglers caught approximately 199 inds/ha/year of different species of salmonids in fisheries of the Moravian Anglers Union, whereas those in the South Bohemian Board caught 62 inds/ha/year and in the Local organization for North Moravia and Silesia only 56 inds/ha/year. In addition, in 2010 the Moravian Anglers Union was stocking species of salmonids at a rate of 230 inds/ha more than in 2000, whereas the increase in stocking by the South Bohemian Board was only about 3 inds/ha and that of the Local organization for North Moravia and Silesia about 122 inds/ha. Catches of salmonids over the eleven-year period monitored decreased in 2010 compared to 2000 by about 33 inds/ha in the fisheries of the Moravian Anglers Union, 39 inds/ha in those of the South Bohemian Board and about 54 inds/ha in those of the *Local organization for North Moravia and Silesia*. Because the categorization of the fisheries was based on the management of stocks of *Salmo trutta* m. *fario* and *Thymallus thymallus*, the farming of these species was the most intensive in the fisheries of the Moravian Anglers Union. The fisheries of this Union were stocked with approximately 301 inds/ha/year of *Salmo trutta* m. *fario* and 203 inds/ha/year of *Thymallus thymallus* over the eleven years period of this study. Over the same period those of the South Bohemian Board were stocked with approximately 250 inds/ha/year of *Salmo trutta* m. *fario* and 134 inds/ha/year of *Thymallus thymallus* and those of the *Local Organization for North Moravia and Silesia* were stocked with 284 inds/ha/year of *Salmo trutta* m. *fario* and 100 inds/ha/year of *Thymallus thymallus*. Also the catches of the recreational anglers of salmonids in the fisheries of the Moravian Anglers Union were the highest (approximately 53 inds/ha/year of *Salmo trutta* m. *fario* and 10 inds/ha/year of *Thymallus thymallus*). The corresponding figures for the recreational anglers of the South Bohemian Board were approximately 10 inds/ha/year of *Salmo trutta* m. *fario* a 1 inds/ha/year of *Thymallus thymallus* and those of the *Local organization for North Moravia and Silesia* were approximately 31 inds/ha/year of *Salmo trutta* m. *fario* and 6 inds/ha/year of *Thymallus thymallus*. Based on the management of indigenous salmonids the fisheries of the Moravian Anglers Union are the most intensively managed. In terms of managing stocks of *Oncorhynchus mykiss* and *Salvelinus fontinalis* the highest stocking with *Oncorhynchus mykiss* and *Salvelinus fontinalis* is recorded for fisheries of the South Bohemian Board (approximately 121 inds/ha/year of *Oncorhynchus mykiss* and 26 inds/ha/year of *Salvelinus fontinalis* over the period 2000–2010). In contrast the Moravian Anglers Union stocked their fisheries with approximately 78 *Oncorhynchus mykiss* and 11 *Salvelinus fontinalis* per ha/year and the *Local Organization for North Moravia and Silesia* stocked their fisheries with approximately 80 *Oncorhynchus mykiss* and 8 *Salvelinus fontinalis* per ha/year over the same period of time. The highest catch of *Oncorhynchus mykiss* recorded over the period 2000–2010 was recorded in the fisheries of the Moravian Anglers Union (52 inds/ha/year) and of S*alvelinus fontinalis* in the fisheries of the South Bohemian Board (6 inds/ha/year). The statistical analysis of these results revealed that the intensity of management of the fisheries of the South Bohemian Board and *Local Organization for North Moravia and Silesia* was lower than that of those of the Moravian Anglers Union.

## DISCUSSION

The categorization of salmonid fisheries was done on the basis of the intensity of the management in terms of stocking rates and catches of fish recorded for the fisheries of the fishing unions. The results presented are distorted as the minimum size of the fish that can be caught in the various salmonid fisheries is determined throughout the Czech Republic by the following law and regula-

tion: law Nr. 99/2004 Sb. and regulation 197/2004 Sb. For example, the minimum size for *Thymallus thymallus* was set at 40 cm in 2005 for each of the salmonid fisheries of the South Bohemian Board. Recreational anglers can keep individuals of *Thymallus thymallus* that are 30 cm or more in length when fishing in the fisheries of the Moravian Anglers Union and *Local organization for North Moravia and Silesia*. Thus, it is clear that the catch of *Thymallus thymallus* recorded for the fisheries of the South Bohemian Board over the eleven years monitored is undervalued compared with other unions. In addition, there are differences in the rules governing fishing in the different fisheries such as „Catch and release", restrictions on using bait, lower daily limit on the number of fish that can be caught, duration of the fishing season, allowing only the use of the current fishing technique, minimum size of fish that can be caught, etc., were not taken into account. According to Cox et al. (2002), the differences in the rules can make certain fisheries more attractive than others for anglers which can result in a reduction in the angling pressure on particular salmonid fisheries (Johnston et al. 2011). Anglers view these rules as adversely affecting fishing quality (Beard et al. 2003) even though they may catch a similar or higher number of fish (Parker et al. 2007). That is, the above mentioned problems associated with differences in the rules governing fishing at the different fisheries can have both positive and negative effects (Johnston et al. 2011) for recreational anglers of the different unions (Arlinghaus & Mehner 2004), which influences the angling pressure on particular fisheries and exploitation of the fish population there (Post et al. 2002), which may be reflected in the number of fish caught. For example, Johnston et al. 2011 found out that after implementation of "Catch and release" and restrictions on the bait that can be used angling pressure decreased by about 90%. Thus it is clear that the categorization of salmonid fisheries based on the intensity of management is not as objective as first thought.

Next factor that influences the outcome of this study is the level of stocking. Law Nr. 99/2004 Sb. requires the users of fisheries to manage them in the way determined by the relevant authority – i.e. not all the fisheries stock the same species of salmonid in the same numbers. In years 1990–2000 a decrease in the stocking of *Salmo trutta* m. *fario* of about 18% and of *Thymallus thymallus* of about 57% was recorded in salmonid fisheries in the Czech Republic. Whereas in years 2000–2010 there was a greater decrease in the catches of both *Salmo trutta* m. *fario* (66%) and *Thymallus thymallus* (81%) in the fisheries of the three unions monitored (these values are very close to the average for the whole Republic). These decreases occurred despite the increase in stocking level of *Salmo trutta* m. *fario* of about 15% (i.e. about 131 inds/ha) and *Thymallus thymallus* of about 69% (i.e. about 232 inds/ha) recorded for the fisheries of these unions. This is confirmed by Spurný & Mareš (2001). In their study the decline in the catches of salmonids in the years 1990–1999 either ceased or was only moderate. Whereas in a subsequent study Spurný et al. (2010) report a rapid decrease in the catches of salmonids in the years 2000–2009. This occurred not only in the Czech Republic but also in other countries in Europe (Zimmerli et al. 2007, Burkhardt & Holm 2009, Hertig 2006, Gustafsson 2009). Currently, stocking is the main method used to maintain and moderate the fluctuations in the populations of *Salmo trutta* m. *fario* and *Thymallus thymallus* (Halačka et al. 2008, Randák & Žlábek 2004). The next task is to generate fishing environments that are attractive to recreational anglers. Furthermore, this will result in the regeneration of devastated populations or reintroduction of fish into streams where they have become extinct or alternatively the introduction of fish (van Poorten et al. 2011, Randák & Žlábek 2004, Baer et al. 2007). The important question is how many and which species of salmonids should be used for stocking the salmonid fisheries. Adámek et al. (1997) suggest stocking rates of 500–1000 inds of $Po_2$ (*Salmo trutta* m. *fario* – 2 years old) and 100 inds $Li_1$ (*Thymallus thymallus* – 1 year old) per hectare of salmonid stream, but stresses that stocking rate should not exceed the rearing capacity of the stream (Libosvárský et al. 1971, Zalewski et al. 1985). Baer et al. (2007) are of the opinion that it is advantageous to stock those fisheries with a low popu-

lation of *Salmo trutta* m. *fario* with peaceful individuals of this species. This will increase the intensity of recreational angling for a limited period of time following their release (fisheries that are stocked with such a fish subsequently record greater catches). Next problem is that created by the genetic origin of salmonids used for stocking. In the second half of the 20th century (not only in the Czech Republic but also elsewhere (Arlinghaus et al. 2002, van Poorten et al. 2011, Youngson et al. 2003), there was no control over the stocking and transporting salmonids between the different basins. This resulted in a reduction in the genetic variability of *Salmo trutta* m. *fario* not only in different basins but in different streams and of populations of fish adapted to local conditions (Youngson et al. 2003, Ferguson 1989, Halačka et al. 2008).

Due to the overfishing of salmonid fisheries (Johnston et al. 2011), many abiotic anthropogenic factors, e.g., regulation of streams, loss of natural habits, etc. (more information in Spurný et al. 2008), effects of predatory fish (Hertig 2006, Stewart 2005, Čech 2005, Spurný & Růžička 1999, Grmela 2008) and uncontrolled recreational angling (e.g. transport of fish between basins) there have been significant decreases in the abundance fish, loss of biological diversity in streams (Cowx et al. 2010), loss of genetic variability (Ferguson 1989) and reduction in the production of fish for artificial spawning (Kouřil et al. 2008). This has resulted in there being insufficient numbers of *Salmo trutta* m. fario and *Thymallus thymallus* for all users of fisheries. Also the way in which the management of recreational angling is controlled is very important. Local angling Unions do not consider the origin of the salmonids and regularly stock their fisheries with in sufficient numbers of *Salmo trutta* m. *fario* and *Thymallus thymallus*. Subsequently, they show in created salmonid fisheries categorisation higher management intensity. Local angling Unions don't consider the origin of the salmonids and regularly stock their fisheries with insufficient numbers of *Salmo trutta* m. *fario* and *Thymallus thymallus*. This can result in there being insufficient fish for stocking salmonid fisheries (e.g. because of the lack of "original" generation fish). Also, this local organisations can show lower management intensity (on the other hand, the improvement of biological diversity of stream and genetic variability preservation occurs – demands of conservative biologists comes up (van Poorten et al. 2011). Also stocking with non-native species of salmonid (*Oncorhynchus mykiss* and *Salvelinus fontinalis*) has advantages in terms of recreational angling. Angling unions try to compensate for the decreases in catches of *Salmo trutta* m. *fario* and *Thymallus thymallus* by stocking with non-native species of salmonid. This was because of the decrease in the interest of recreational anglers for fishing at salmonid fisheries, which between 2003 and 2009 decreased by about 13.2% in Czech Republic (Spurný et al. 2009). This resulted in a reduction in the revenue from fishing permits, which is used to buy or produce fisch for stocking the salmonid fisheries of the angling Unions. If they are not allowed to manage their salmonid fisheries by stocking them with *Oncorhynchus mykiss* and *Salvelinus fontinalis*, then the management of these fisheries will become increasingly more difficult. Certainly, there is a whole range of problems that affect the categorization of these salmonid fisheries – abiotic anthropogenic factors (regulation of streams, habitat loss, small hydroelectric power plant, etc.), biotic factors (fish-eating predators), pressure from recreational anglers (disproportionate fishing strain, disproportionate catches of certain species (Johnston et al. 2011); specialisation on catching trophy fish (Isermann et al. 2005); the selectiveness of recreational anglers in terms of species of fish (increase in the interest in catching fish with highly valued meat and attractive in terms of angling – salmonid angling) and size of fish – minimum size of fish that can be caught (Lewin et al. 2006) and recreational angling management (e.g. stocking with non-native salmonids (Halačka et al. 2008) and increasing the distribution of non-native species of fish (Cowx et al. 2010).

In this discussion we have only considered the effect of the type of management and rules governing the catching of fish by anglers. It is clear they determine to a large extent the intensity of management and categorization of the different fisheries.

## CONCLUSION

This categorization of the salmonid fisheries using statistical methods reflects the effect of a complex of factors associated with the current level of management (intensity level) of these fisheries and their attractiveness for different types of recreational anglers. In order to categorize the salmonid fisheries more objectively factors other than the intensity of management need to be taken into consideration. If all the salmonid fisheries in the Czech Republic were managed in the same way as in MAU, for example, it would be easy to compare the utilization of these fisheries. If restrictive (maybe necessary) practices similar to those operating in SBB are not generally adopted throughout the Czech Republic in the future, we shall have to find new criteria for evaluating the quality of the management of salmonid fisheries.

In conclusion, it is noteworthy that the meaning of recreational angling is mostly ignored and underrated not only by politicians in different countries (Arlinghaus et al. 2002), but also by the public (Cowx et al. 2010). Recreational angling is not only a way of obtaining consumable fish (Burger 2002) but also an activity that satisfies the different social and recreational needs of individuals (Arlinghaus et al. 2002) in terms of leisure time activity (Metcalf et al. 2010). Furthermore, the lobby representing recreational angling is one of the strongest arguing for the preservation and restoration of damaged water ecosystems and activities aimed at increasing the biological diversity in water ecosystems (Cowx et al. 2010; Arlinghaus et al. 2010). The categorisation of salmonid fisheries could provide a new way of improving the management of salmonid fisheries, increasing the biological diversity of streams, providing different types of recreational angling in salmonid fisheries and finally a way of maintaining sustainability in terms of recreational angling and the salmonid associations that occur in surface waters.

A c k n o w l e d g e m e n t s

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## REFERENCES

Adámek Z., Vostradovský J., Dubský K., Nováček J. & Hartvich P. 1997: *Rybářství ve volných vodách* [*Fishery in Natural Waters*]. Praha: East Publishing, 205 pp (in Czech).

Arlinghaus R., Mehner T. & Cowx I. G. 2002: Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. *Fish and Fisheries* **3**: 261–316.

Arlinghaus R. & Mehner T. 2004: Determinants of management preferences of recreational anglers in Germany: Habitat management versus fish stocking. *Limnologica* **35**: 2–17.

Arlinghaus R., Cooke S. J. & Cowx I. G. 2010: Providing context to the global code of practice for recreational fisheries. *Fisheries Management and Ecology* **17**: 146–156.

Baer J., Blasel K. & Diekmann M. 2007: Benefits of repeated stocking with adult, hatchery-reared brown trout, Salmo trutta, to recreational fisheries? *Fisheries Management and Ecology* **14**: 51–59.

Beard Jr. T. D., Cox S. P. & Carpenter S. R. 2003: Impacts of daily bag limit reductions on angler effort in Wisconsin walleye lakes. *North American Journal of Fisheries Management* **23**: 1283–1293.

Burger J. 2002: Consumption patterns and why people fish. *Environmental Research* **90**(2): 125–135.

Burkhardt-Holm P. 2009: Klimawandel und Bachforellenrückgang gibt es einen Zusammenhang? Resultate aus der Schweiz. *Umweltwissenschaften und Schadstoff Forschung* **21**: 177–185.

Čech M. 2005: [*Diet of Great Cormorant* (*Phalacrocorax carbo*) *at the Vltava River in Vyšší Brod in Winter Period 2004/2005*]. Unpubl. Report. České Budějovice: Hydrobiologický ústav AV ČR, 18 pp (in Czech).

Cox S. P., Beard T. D. & Walters C. 2002: Harvest control in open-access sport fisheries: hot rod or asleep at the reel? *Bulletin ofMarine Science* **70**: 749–761.

Cowx I. G., Arlinghaus R. & Cooke S. J. 2010: Harmonizing recreational fisheries and conservation objectives for aquatic biodiversity in inland waters. *Journal of Fish Biology* **76:** 2194–2215.

Ferguson A. 1989: Genetic differences among brown trout, Salmo trutta, stocks and their importance for the conservation and management of the species. *Freshwater Biology* **21**: 35–46.
Grmela J. 2008: [*The Assesment of the Development of Damages Caused by Fish-eating Mammalian Predators in Czech Fishery*]. Unpubl. Final Thesis. Brno: Mendel University, 32 pp (in Czech).
Gustafsson P. 2009: Östergötlands elfiskeprogram – miljöövervakning i vattendrag 2003–2008. *Länsstyrelsen Östergötland Linköping*, 77 pp.
Halačka K., Papoušek I., Kohout J., Vetešník L., Lusk S., Mendel J. & Šlechta V. 2008: [Population and genetic structure of trout (Salmo trutta) and grayling (Thymallus thymallus) as a basic for a successful fishery management]. Pp.: 72–76. In: Kopp R. (ed.): [*Proceedings of the XIth Czech Ichthyological Conference*, *3–4 December 2008*]. Brno: Mendel University, 262 pp (in Czech).
Hertig A. 2006: *Populationsdynamik der Äschen* (*Thymallus thymallus*) *im Linthkanal mit besonderer Berücksichtigung der Habitatnutzung der Äschenlarven*. Unpubl. Thesis. Zürich: Zürich University, 161 pp.
Isermann D. A., Willis D. W., Lucchesi D. O. & Blackwell B. G. 2005: Seasonal harvest, exploitation, size selectivity, and catch preferences associated with winter yellow perch anglers on South Dakota lakes. *North American Journal of Fisheries Management* **25**: 827–840.
Johnston F. D., Arlinghaus R., Stelfox J. & Post J. R. 2011: Decline in angler use despite increased catch rates: Anglers' response to the implementation of a total catch-and-release regulation. *Fisheries Research* **110:** 189–197.
Kouřil J., Mareš J., Pokorný J., Adámek Z., Randák T., Kolářová J. & Palíková M. 2008: [*Breeding Salmonid Fishes*, *Grayling and Whitefish*]. České Budějovice: University of South Bohemia, 141 pp (in Czech).
Lewin W. C., Arlinghaus R. & Mehner T. 2006: Documented and potential biological impacts of rekreational fishing: Insights for management and conservation. *Reviews in Fisheries Science* **14:** 305–367.
Libosvárský J., Lusk S. & Krčál J. 1971: [*Management of Trout Fisheries*]. Brno: Ústav pro výzkum obratlovců, 156 pp (in Czech).
Metcalf S. J., Moyle K. & Gaughan D. J. 2010: Qualitative analysis of recreational fisher response and the ecosystem impacts of management strategies in a data-limited situation. *Fisheries Research* **106:** 289–297.
Parker B. R., Schindler D. W., Wilhelm F. M. & Donald D. B. 2007: Bull trout population responses to reductions in angler effort and retention limits. *North American Journal of Fisheries Management* **27**: 848–859.
Post J. R., Sullivan M., Cox S., Lester N. P., Walters C. J., Parkinson E. A., Paul A. J., Jackson L. & Shuter B. J. 2002: Canada's recreational fisheries: The invisible collapse? *Fisheries* **27**: 6–17.
Randák T. & Žlábek V. 2004: [Comparison of reproduction parameters of hatchery-reared and wild brown trout (Salmo trutta m. fario) populations]. Pp.: 72–76. In: Kopp R. (ed.): [*XI. Czech Ichthyological Conference. Proceedings of the International Conference held in Brno 3 and 4 December 2008*]. Brno: Mendel University, 262 pp (in Czech).
Spurný P. & Růžička P. 1999: [Evaluation of predation pressure cormorant (Phalacrocorax carbo) on trout fisheries of National Park Podyjí]. Pp.: 236–241. In: Spurný P. (eds.): [*50 Years of the Study Programme of the Fishery Specialization at Mendel University of Agriculture and Forestry in Brno*]. Brno: MZLU, 265 pp (in Czech).
Spurný P. & Mareš J. 2001: [*The Evaluation Assurance Level of Performance of the Fishing Rights Fishing Unions of the Czech Republic in the Years 1990–1999*]. Brno: Mendel University of Agriculture and Forestry, 77 pp (in Czech).
Spurný P., Kopp R., Sukop I., Mareš J. & Vítek T. 2008: [Methodology for sustainability indicators, surface water ecosystems in terms of climate change]. In: Žalud Z. (eds.): [*Biological and Technological Aspects of Sustainability of Controlled Ecosystems and their Adaptability to Climate Change – Indicators of Ecosystem Services*]. *Folia University Agriculture et Silviculturae Mendel University in Brno* **4**: 75–116 (in Czech).
Spurný P., Mareš J., Kopp R., Fiala J. & Vítek T. 2009: [*Socio-economic Study of Sport Fishing in the Czech Republic*]. Brno: Mendel University of Agriculture and Forestry, 38 pp (in Czech).
Stewart D. C., Middlemas S. J., Gardiner W. R., Mackay S. & Armstrong J. D. 2005: Diet and prey selection of cormorants (Phalacrocorax carbo) at Loch Leven, a major stocked trout fishery. *Journal of Zoology*, *London* **267**: 191–201.
van Poorten B. T., Arlinghaus R., Daedlow K. & Haertel-Borer S. S. 2011: Social-ecological interactions, management panaceas, and the future of wild fish populations. *Proceedings of the National Academy of Sciences of the United States of America* **108**: 12554–12559.
Youngson A. F., Jordan W. C., Verspoor E., McGinnity P. & Cross T. 2003: Management of salmonid fisheries in the British Isles: towards a practical approach based on population genetics. *Fisheries Research* **62**: 193–209.
Zalewski M., Frankiewicz P. & Brewinska B. 1985: The factors limiting growth and surival of brown trout, Salmo trutta m. fario L. introduced to different types of streams. *Journal of Fish Biology* **27**: 59–73.
Zimmerli S., Bernet D., Burkhardt-Holm P., Schmidt-Posthaus H., Volanthen P., Wahli T. & Segner H. 2007: Assessment of fish health status in four Swiss rivers showing a decline of brown trout catches. *Aquatic Sciences* **69**: 11–25.