

Proceedings of the

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EIFAC SYMPOSIUM ON INTERACTIONS BETWEEN SOCIAL,  
ECONOMIC AND ECOLOGICAL OBJECTIVES OF INLAND  
COMMERCIAL AND RECREATIONAL FISHERIES AND AQUACULTURE

Antalya, Turkey, 21-24 May 2008



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EUROPEAN INLAND FISHERIES ADVISORY COMMISSION

PROCEEDINGS OF THE EIFAC SYMPOSIUM ON INTERACTIONS  
BETWEEN SOCIAL, ECONOMIC AND ECOLOGICAL OBJECTIVES OF  
INLAND COMMERCIAL AND RECREATIONAL FISHERIES AND  
AQUACULTURE

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## PREPARATION OF THIS DOCUMENT

A symposium on “Interactions between social, economic and ecological objectives of inland commercial and recreational fisheries and aquaculture”, was organized in conjunction with the twenty-fifth session of the European Inland Fisheries Advisory Commission (EIFAC) in Antalya, Turkey, from 21 to 24 May 2008.

This Occasional Paper contains the conclusions and recommendations of the symposium to the subsequent EIFAC session and papers presented at the symposium that are additional to those published in a special issue of Fisheries Management and Ecology. The Report of the symposium on “Interactions between social, economic and ecological objectives of inland commercial and recreational fisheries and aquaculture, Antalya, Turkey, 21-24 May 2008 was published in 2008 as EIFAC FAO Fisheries and Aquaculture Report No. 871<sup>1</sup>. That report contains next to the symposium report also the agenda and list of participants.

This document was prepared by Mr Ian Cowx, Mr Ryan Taylor, Mrs Sam Walton, Ms Natalie Angelopoulos, Ms Michelle Smith, Ms Karen Twine and Ms Chloe Davies (Hull University, UK) and Mr Raymon van Anrooy of the FAO Subregional Office for Central Asia (SEC). All papers were lightly edited and were not necessarily fully checked for accuracy of the information. All views and opinions expressed are the views of the authors of the paper and not of EIFAC or the editors. It was agreed that bibliographic citations would be presented according to Fisheries Management and Ecology style. The authors of the report would like to thank Mr Ramazan Celebi and Mr Erkan Gozgozoglu (Ministry of Agriculture and Rural Affairs – MARA, Turkey) and their staff, Mr Yilmaz Emre (Mediterranean Fisheries Research, Production and Training Institute – AKSAM, Turkey) and his staff, Mr Ibrahim Okumus (Rize University, Turkey) Mr Robert Arlinghaus (Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Germany), Mr Phil Hickley and Mr Miran Aprahamian (Environment Agency, UK), Mr Eric Hudson (Centre for Environment Fisheries and Aquaculture Science, UK), Mr Laszlo Varadi (Research Institute for Fisheries, Aquaculture and Irrigation, HAKI, Hungary), Mr Arjo Rothuis (Ministry of Agriculture, Nature and Food Quality, the Netherlands), Mr Sedat Yerli (Hacateppe University, Turkey), Mr Andy Thorpe (University of Portsmouth, UK), Mr Atilla Ozdemir (Central Fisheries Research Institute, Turkey), Ms Annarita Colagrossi, Ms Dila Altin, Ms Deniz Ozkan, Ms Aysegul Omur, Mr Gerd Marmulla and Mr Thomas Moth Poulsen (FAO), and many other assistants provided by the local hosts, for their collaboration in the preparation and organization of the symposium and in making it the success it became. General thanks for their important contributions to the presentations and discussions are due to all who attended the symposium.

### **Distribution:**

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<sup>1</sup> <ftp://ftp.fao.org/docrep/fao/011/i0423e/i0423e.pdf>

EIFAC

Proceedings of the symposium on “Interactions between social, economic and ecological objectives of inland commercial and recreational fisheries and aquaculture, Antalya, Turkey, 21-24 May 2008.

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## ABSTRACT

The symposium on Interactions between Social, Economic and Ecological Objectives of Inland Commercial and Recreational Fisheries and Aquaculture, was organized in conjunction with the Twenty-Fifth Session of the European Inland Fisheries Advisory Commission (EIFAC) in Antalya, Turkey, from 21 to 24 May 2008.

The symposium objectives were:

- 1) To review the wide range of socio-economic and ecological interactions between fisheries and aquaculture and the roles of various stakeholders with respect to these interactions.
- 2) To identify where future research should focus and propose measures to decrease interactions that compromise sustainable development and management, and promote interactions that contribute to sustainability.
- 3) To provide information to policy and decision makers to contribute to the general awareness of trends in socio-economic and ecological interactions within and between the sector and other rural sectors.
- 4) To facilitate dialogue between scientists, researchers, fisherfolk, aquaculturists and policy and decision makers on the motives, interactions and interests of stakeholders.
- 5) To advise EIFAC on appropriate management and development measures and tools for inland fisheries and aquaculture in Europe.

This Occasional Paper in conjunction with a special issue of *Fisheries Management and Ecology* represents the proceedings of the symposium. The symposium made considerable progress towards understanding the interactions between ecological/environmental and socio-economic/governance objectives for fisheries and aquaculture. There was a broad recognition that inland fisheries and aquaculture need to shift from a sectoral view where they are treated in isolation to an integrated, multi-disciplinary systems view.

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## CONTENTS

|  | <b>Page</b> |
|--|-------------|
| Obituary Professor Ibrahim Okumus  | vii         |
| Social, economic and ecological objectives of inland commercial and recreational fish and aquaculture. <i>I.G. Cowx &amp; R. Van Anrooy</i>  | 1           |
| Effluent treatment concepts for trout aquaculture in dependence on production intensity. <i>P.-D. Sindilariu, R.Reiter &amp; H. Wedekind</i>   | 6           |
| Management strategies to protect and restore sturgeon biodiversity in Bulgaria. <i>T. Hubenova, E. Uzunova &amp; A. Zaikov</i>   | 21          |
| Ecological status of inland waters of Muğla. <i>M. Barlas, F. Yilmaz, B. Yorulmaz &amp; H. Kalyoncu</i>  | 34          |
| Preliminary study on the status of sturgeon populations ( <i>Acipenser</i> sp) in the South Eastern Black Sea Coast (Kızılırmak-Yeşilirmak Basin) in the early 21 <sup>st</sup> century. <i>M Zengin, S. U. Tiril, M. Dağtekin, M. Gül &amp; H. Eryildirim</i> | 44          |
| <i>Ameiurus melas</i> (Rafinesque) – pest or possibility. <i>Cvijanović, M. Lenhardt, A. Hegediš, Z. Gačić &amp; I. Jarić</i>  | 56          |
| Diet of great cormorant ( <i>Phalacrocorax carbo</i> ) in the Special Reserve of Nation "Stari Begej – Carska bara", northern Serbia. <i>S. Skorić, Ž. Višnjić-Jeftić, A. Hegediš, Z. Gačić, M. Lenhardt, V. Djikanović, V. Poleksić &amp; B. Rašković</i>     | 64          |
| Fishing activities and pollution risk in the Köyceğiz Lagoon System. <i>B. Yorulmaz, M. Barlas, F. Yilmaz &amp; N. Özdemir</i>   | 72          |
| Investigations on the fishing of the exotic Pacific mullet ( <i>Mugil so-iuy</i> ) caught on the Black Sea Coast. <i>M. Zengin &amp; S. V. Yerli</i>   | 79          |
| The effect of dissolved oxygen on sediment-water phosphorus exchange in Mogan Lake. <i>A. Topçu &amp; S. Pulatsü</i>   | 87          |
| Gillnet selectivity for pike, <i>Esox lucius</i> , in Lake Karamık, Turkey. <i>I. Balik</i>  | 93          |
| Ichthyofauna of the Çobanlar Stream (Samsun, Turkey). <i>N. Polat, S. Uğurlu &amp; Ş. Kandemir</i>   | 100         |
| Lessons available from anglers' records: Case study of the Brno reservoir (Czech Republic). <i>Z. Adámek &amp; P. Jurajda</i>  | 104         |
| The economic value of recreational fishing: an example of a Hungarian multifunctional pond fish farm. <i>G. Gyalog, E. Békefi &amp; L. Váradi</i>  | 112         |
| Sociological analysis of sustainable fisheries management of the endemic pearl mullet in the fishing villages of Lake Van, Turkey. <i>H. Nalçaoğlu &amp; M. Sari</i>   | 120         |
| Socio-economic potential of angling native trout in Turkey. <i>T. Ersal, B. Kalaç, &amp; T. Sanalan</i>  | 127         |
| Socio-economic analysis and marketing patterns of the fish farming industry in Trabzon, Turkey. <i>M. Dağtekin, O. Ak &amp; F. Emeksiz</i>   | 133         |
| Interactions between conservation, economic and social objectives of sturgeon culture in Russia: problems and possibilities of optimization. <i>M. Chebanov &amp; E. Galich</i>  | 140         |

|  |     |
|--|-----|
| Consumers' willingness to pay for organic trout. <i>M. Disegna, C. Mauracher &amp; I. Procidano</i>  | 149 |
| Use of narrow-clawed crayfish ( <i>Astacus leptodactylus</i> Esch.) in recreational and commercial fisheries and aquaculture in Bulgaria. <i>A. Zaikov, T. Hubenova &amp; P. Vasileva</i>      | 161 |
| The role of women in fisheries and aquaculture in Turkey. <i>A. Ç. K. Benlí, A. Velioglu &amp; R. Celebi</i>   | 173 |
| Conflict of interests between commercial and recreational fishing in Annecy Lake (France). <i>C. Sebi &amp; D. Gerdeaux</i>  | 179 |
| Fisheries management in Turkish lagoons. <i>H. Deniz &amp; R. Celebi</i>   | 188 |
| The state of inland fishing in Lithuania. <i>V. Kesminas &amp; G. Svecevičius</i>  | 201 |
| Recovery programmes for endangered freshwater fish in Flanders, Belgium. <i>A. Dillen &amp; K. Vlietinck</i>   | 207 |
| The impact of the new EU fish health regime arising from Directive 2006/88/EC on ecological interactions of aquatic animals in Europe. <i>E.B. Hudson</i>                                      | 218 |
| Optimization of freshwater fisheries in Russia. <i>S. Brazhnik &amp; Y. Sechin</i>   | 221 |
| Salmonids of the Neretva river basin - present state and suggested sustainable selection programme to protect and strengthen the populations. <i>S. Muhamedagić, H.M. Gjoen &amp; M. Vegra</i> | 224 |
| The contribution of Akgöl and Paradeniz Lagoons for fisheries in Göksu Delta (Turkey). <i>A. Velioglu, R. Celebi &amp; A. Ç. K. Benlí</i>  | 234 |
| Abstracts for unpublished papers or papers published in Fisheries Management and Ecology   | 239 |

**Obituary**  
**Professor Ibrahim OKUMUŞ**  
**Pioneer of Turkish Aquaculture**

Professor İbrahim OKUMUŞ was the Chairperson of the International Symposium on “Interactions between social, economic and ecological objectives of inland commercial and recreational fisheries and aquaculture”, Antalya, Turkey, 21-24 May 2008, held in conjunction with the 25th Session of the European Inland Fisheries Advisory Commission (EIFAC). He was one of the scientific pioneers of Turkish aquaculture and worked tirelessly to promote its sustainable development at a national level and especially internationally. One of his great projects was the development of a Roadmap for Turkish Marine Aquaculture Site Selection and Zoning Using an Ecosystem Approach to Management.

Professor Okumuş was educated at Çukurova University where he completed his Masters degree in 1986 in the field of animal husbandry. Three years later he went to The Humberside College of Higher Education in Grimsby, UK and graduated with a Diploma in Fisheries Management in 1990. Between 1990 – 1993 he studied at the University of Stirling in Scotland earning his PhD. He spent much of his career at the Karadeniz Technical University researching, teaching and supervising students, as well as carrying out his administrative responsibilities in the fisheries department.

During his career he supervised eleven M.Sc and eleven Ph.D students and worked on more than 18 aquaculture projects, many of which related to local trout species. He was acutely aware of the environmental aspects of aquaculture and strove to reduce the impact of aquaculture on the environment. At the same time he saw the potential of fish farming and knew the importance of maintaining good relationships between all the stakeholders. He was also the coordinator of the Socrates/Erasmus programme in Turkey, an European student exchange facility, from 2004 to 2007. Professor Okumuş was appointed to Rize University, as Dean of the Faculty of Fisheries and Pro-Rector in 2007.

Professor Okumuş passed away on 5 December 2008; just a few months after the Symposium he chaired for EIFAC. His death can be regarded a great loss for the Turkish and European aquaculture industry. Professor Okumuş is survived by his wife Leyla OKUMUS and three daughters, Gülşah, Bilgen and Bengisu.



# **Social, economic and ecological objectives of inland commercial and recreational fisheries and aquaculture**

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## **Background and objectives**

Sustainability is at the core of efforts to develop and manage inland fisheries (i.e. commercial and recreational) and aquaculture in Europe. Sustainability in this context includes social, economic and ecological (or more broadly environmental) aspects, which are shaped by functioning governance structures and management institutions. Previous EIFAC symposia have shown that in many cases sustainability is not viewed from all these three aspects in an integrated manner.

The FAO Code of Conduct for Responsible Fisheries and the EU strategy for sustainable development of European aquaculture recognize that the sector should take an approach where farming and fisheries technologies, social and economic issues, natural resource use, biodiversity conservation and governance are integrated to enhance sustainable management.

Interactions between social, economic and ecological objectives of inland fisheries and aquaculture are numerous, and include amongst others:

- Improvement in ecological status of rivers, lakes and other water bodies
- (Re-)stocking for commercial and recreational fisheries
- Recovery and conservation of depleted/threatened stocks
- Collection of fish from the wild for aquaculture
- Harvesting by commercial and recreational fisheries for human consumption
- Catch-and-release recreational fishing
- Employment and income generation by capture fisheries and aquaculture
- Pollution of inland water bodies by aquaculture
- Escapes of fish from farms and introduction of alien species
- Increase of eutrophication through water discharge from farms or other sources
- Harvesting of protected species
- Conflicts between resource users, non-users and interest groups, and competitiveness of the sector compared to other sectors
- The role of fisheries within society and in cultural and religious traditions, and
- Enactment of new and enforcement of current policies, and decisions on water use.

Interactions between social, economic and ecological objectives are particularly relevant considering the ongoing shift from a dominance of commercial towards recreational fisheries. This raises issues of economic rent, angling tourism, ethics of exploitation and competing objectives between biodiversity conservation and expansion of recreational fishing opportunities. A Seminar organized by the European Association of Agricultural

Economists (EAAE) on the “Economics of aquaculture with respect to fisheries<sup>2</sup>” (Civitavecchia, Italy, December 2005) identified there is a great need to explore these interactions further to identify appropriate solutions that balance private and public use of goods now and in the future.

Similarly, the General Fisheries Commission for the Mediterranean/ADRIAMED organized an Expert Consultation in Rome, Italy (November 2003) on “Interactions between aquaculture and capture fisheries<sup>3</sup>”. That consultation highlighted the importance of interactions between capture fisheries and aquaculture in terms of impact on biodiversity, restocking of depleted stocks, space and water competition, marketing and the livelihoods in fishing communities with particular emphasis on the Mediterranean area. Unfortunately, discussions on this subject have mainly focused on the marine environment and inland fisheries have received little attention. The EIFAC symposium aimed to address this gap.

This issue is particularly relevant in inland waters in Europe because of obligations under the EU Water Framework, Bird and Habitats Directives. Conflicts could potentially arise within the fisheries and aquaculture sectors because of needs to protect biodiversity and improve the ecological status of waters. Resolution of such conflicts was discussed at the symposium.

The principal aim of the symposium was to provide a forum for those working on specific socio-economic and ecological aspects of inland fisheries and aquaculture in Europe (including researchers, natural and social scientists, environmental scientists, fisherfolk, aquaculturists, economists, planners, government officials, NGO representatives, and other stakeholders), to review the interactions between socio-economic and ecological objectives in fisheries and aquaculture, exchange experiences and discuss solutions to imbalances in sustainable development and management of the sector.

The specific objectives of the symposium were:

- To review the wide range of socio-economic and ecological interactions between fisheries and aquaculture and the roles of various stakeholders with respect to these interactions.
- To identify where future research should focus and propose measures to decrease interactions that compromise sustainable development and management, and promote interactions that contribute to sustainability.
- To provide information to policy and decision makers to contribute to the general awareness of trends in socio-economic and ecological interactions within and between the sector and other rural sectors.
- To facilitate dialogue between scientists, researchers, fisherfolk, aquaculturists and policy and decision makers on the motives, interactions and interests of stakeholders.

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<sup>2</sup> “The Economics of aquaculture with respect to fisheries” Proceedings of the 95<sup>th</sup> EAAE Seminar, Civitavecchia (Rome), Italy, 9-11 December 2005. K.J. Thomson and L. Venzi (eds), November 2006.

<sup>3</sup> “Interactions between aquaculture and capture fisheries: a methodological perspective”. *Studies and Reviews. General Fisheries Commission for the Mediterranean*. No. 78. Rome, FAO. 2005. 229p Cataudella, S.; Massa, F.; Crosetti, D. (eds.) <http://www.fao.org/docrep/009/a0141e/A0141E00.htm#TOC>

The symposium examined interactions, in accordance with the following four thematic areas:

- 1) *Ecological interactions* (including among others, rehabilitation of aquatic systems, pollution, global warming overexploitation, species introductions, restocking of inland water bodies for fisheries and extensive culture, use of natural stocks for aquaculture production, organic and inorganic waste, organic aquaculture, use of fish to feed fish, aquatic animal health issues, utilization of chemicals, therapeutants and hormones). Competition for resources between commercial fisheries, recreational fisheries and aquaculture and with other resource users was one of the key issues under this theme.
- 2) *Economic interactions* (issues might include among others markets and market opportunities, equity issues, income issues, recreational fisheries evaluation, opportunity costs of resource use, value of natural common property resources)
- 3) *Social interactions* (employment and gender issues, alternative uses of resources, cultural aspects of resource harvesting and consumption, stakeholder participation in integrated planning)
- 4) *Governance interactions* (including latest developments with regards to the EU Water Framework and Habitats Directives, forthcoming policy regulations, directives and management plans, codes of practices and guidelines, competition between stakeholders for allocation of public and common-property-goods, legislation and zoning, conservation areas)

### ***Conclusions and recommendations***

The symposium made considerable progress towards understanding and resolving the interactions between ecological/environmental and socio-economic/governance objectives for fisheries and aquaculture. There was a broad recognition that inland fisheries and aquaculture need to shift from a sectoral view where they are treated in isolation to an integrated, multi-disciplinary systems view.

The conclusions of the symposium can be summarized as:

- There are a considerable number and range of inter- and intra-sectoral users. It also recognised the management conflicts and synergies that exist between recreational and commercial fisheries and aquaculture and other aquatic resource users. These arise, for example, from stocking and introductions to meet angler demand versus protection of biodiversity or development of hydropower production versus fisheries interests. As a consequence, there is a need to balance promotion of aquaculture and inland fisheries with biodiversity protection.
- One of the inherent problems recognised throughout the inland fisheries and aquaculture sectors in Europe was the lack of basic socio-economic data, and an understanding of socio-economic concepts on which to support promotion of the sectors. Economic research tends to be too narrowly focussed on the economic aspects and is poorly linked to social interactions and environmental issues.
- This problem is exacerbated by weak political, and often institutional, support (i.e. operational resources and finance) to help resolve conflicting

ecological/environmental and socio-economic objectives arising from user interactions.

- The EU Water Framework Directive is a major driver of the inland fisheries sector management and development. As a consequence, the intrinsic ‘value’ of water and water bodies, is likely to increase, which will exacerbate competition over the resource and its environs.
- Aquaculture – like farming – is not immune to the growing trend towards intensification of resource use (e.g. water use limitation through recirculation, automatic systems, increasing productivity). This driver could help ameliorate conflicts over resources, but could also have adverse ecological consequences.
- There is a worrying increase in tensions arising from sectors of society that consider exploitation of fisheries to be unacceptable.
- For a variety of reasons, the preference of policy makers seems to be moving from supporting commercial fisheries towards promotion of recreational fisheries. This has not necessarily been reflected in the co-opting of recreational fishers (or recreational fishers associations) into formal management structures.
- While there is a recognized growing demand for fish for consumption, it was also acknowledged that this trend might develop with respect to aquaculture for restocking purposes; this is in view of the common need to restore fish populations and improve the quality of aquatic ecosystems in many EIFAC member countries (under the EU WFD).
- River governance, particularly in terms of trans-boundary management of water resources that are used for fisheries purposes, is inadequate in large parts of the EIFAC region. In this respect, the construction of dams – and water retention and abstraction policies – may have severe consequences downstream, potentially causing conflicts and socio-economic and ecological hardships to the sector.
- The wider society has generally only limited understanding of inland fisheries issues, and particularly of how the inland fisheries sector is contributing to ecological and socio-economic objectives of society; this calls for an increase in efforts to raise awareness and education on inland fisheries.
- Management of inland fisheries continues to have problems being recognized as an equal partner by other users who fail to take full account of multiple user needs and objectives. Many of these problems arise from poor communication and dialogue between user groups and fisheries interests, lack of empathy of the needs and aspirations of each other, lack of finance and knowledge on integrated management of inland fisheries and aquaculture that melds economics, social issues and biology.

It was recommended that the appropriate responsible bodies take the following actions:

- Develop toolboxes, quantitative models and indicators for high quality socio-economic assessment of inland fisheries and aquaculture in data-poor situations. This should include best practice examples and case studies that are sufficiently robust to account for regional variability in ecological, social and economic conditions.

- Promote development of interdisciplinary fisheries research and management methods, approaches and decision-making that link economic, sociological and psychological expertise (coined socio-economics) with the traditional fisheries biological approach.
- Improve communication, information transfer and public outreach of inland fisheries and aquaculture issues to non-fishery stakeholders and to those charged with taking decisions on the development and management of the aquatic environment.
- Develop and promote a more structured approach to recreational fisheries management to take due account of the importance of the activity to local and regional economies.
- Develop and promote alternative employment opportunities for those currently engaged in commercial fisheries to maintain and enhance livelihoods and revenue opportunities. Also, due consideration should be given to gender equity.
- Carry out forward-looking research to examine the ecological and socio-economic implications for inland fisheries/aquaculture of attaining the 2015 targets from the EU WFD – at the national and local level – so as to support managerial decision-making in an *ex-ante* manner.
- Assess the future direction of European inland aquaculture to ameliorate any likely ecological costs whilst maximizing the various (alternative) opportunities that aquatic ecosystems might generate.
- Generate and communicate research on the economic value of recreational fishing as a lever to promote the evolution of managerial decision-making in a manner that equates to stakeholder prevalence in the sector.
- Ascertain the nature of the interaction between commercial and recreational fishing in terms of participation in governance, management of the fisheries resource, and IUU fishing.
- Assess the demand on aquaculture for fish for stocking and adjust the range of products, species and sizes to address the needs of conservation, rehabilitation and (recreational) fisheries that apply stocking.
- Establish a European-wide mechanism for examining, preventing and mitigating of transboundary water resource access and availability issues and problems, which pays proper attention to fisheries sector needs and requirements.
- Address emerging issues via a project management type approach so as to better facilitate the availability of financial and other critical resources.
- Develop (technical) guidelines on recreational fisheries and inland capture fisheries related sectors, to contribute to responsible development and management of these sub-sectors.

# Effluent treatment concepts for trout aquaculture in dependence on production intensity

P-D. SINDILARIU, R. REITER & H. WEDEKIND

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**Abstract** In- and outflow nutrient concentrations from 13 German trout farms were monitored. The farms had a significant effect on the effluent quality and the macro-invertebrate fauna. Inflow nutrient concentration, type of rearing units, feeding intensity and the effluent treatment method were the factors predicting effluent nutrient concentration by 50 to 88 % for most nutrient fractions except total suspended solids (TSS) where these factors lead to a predictability of only 13 %.

Based on these results, different treatment options were monitored for their treatment performance. Sedimentation basins for the total farm effluent had no or minor treatment effects. The examined micro-screen was quite effective on particulate nutrient treatment, measured as total phosphorous (TP), biological oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD) and total suspended solids (TSS), resulting in treatment efficiencies of 29 – 53 %, which was less than expected from literature data. Finally a constructed wetland showed the highest treatment efficiency compared to the other treatment options with nutrient reduction rates of > 35 % for TP, COD, BOD<sub>5</sub>, TSS and total ammonia nitrogen (TAN). Additionally, different processing methods for the treatment of micro-screen backwash sludge, such as sedimentation and further treatment in constructed wetlands were discussed. From these results and data from literature, treatment strategies for trout farms in dependence on rearing system and feeding level were developed.

## Introduction

The demand on aquaculture products worldwide is constantly increasing (FAO 2006). In the European Union's aquaculture, rainbow trout (*Oncorhynchus mykiss* (Walbaum)) is the most important finfish species cultured, with a total production of 215,207 t in 2003 (European Commission 2006). More than 90 % of European aquaculture farms are small and geographically dispersed (Varadi *et al.* 2001) and in particular the trout production sector is mainly characterized by regionally rooted enterprises with an average annual production of 100 t or less (MacAlister Elliott 1999).

Trout production as with any other animal production produces wastes. Aquaculture waste, by definition, includes all materials that are not removed through harvesting. The principal wastes are uneaten feed, excreta, chemicals and therapeutics (Bergheim & Asgard 1996). The aquaculture wastes were discharged through the farm effluent, if not extracted through effluent treatment.

The effect of trout farm effluents on adjacent ecosystems is a function of the amount and type of pollutants and the assimilative capacity of the receiving system (Rosenthal 1994; Piedrahita 2003; O'Bryen & Lee 2003). Potential environmental problems that can arise from aquaculture effluents are (reviewed in Sindilariu 2007):

1. Reaction on nutrient enrichment

2. Effect of suspended solids (TSS)
3. Oxygen depletion in the effluent
4. Direct toxic effects
5. Impact on wildlife

To prevent the potentially negative effects of nutrient rich trout farm effluents, and potential conflicts with other users, effluent nutrient management is required. Removal through “end of pipe” cleaning facilities is needed (Cripps & Bergheim 2000).

In this contribution, the factors influencing effluent nutrient concentration were identified through the survey of the in- and outflow data from 13 trout farms in Southern Germany. In addition, the effect of the farm effluent on the macro-invertebrate fauna was examined at six of these farms. Subsequently different effluent treatment methods were scrutinized and an effluent treatment concept in dependence of production intensity is developed.

## **Material and methods**

### *Monitored trout farms*

Thirteen trout farms were examined for their inflow and outflow water quality. All farms were situated in Southern Bavaria (Germany). Six farms take their inflow water from brooks, inflow amount 100 – 800 Ls<sup>-1</sup>, while seven farms were fed by spring water, inflow amount 25 – 120 Ls<sup>-1</sup>. On 163 days between end of 2005 and end of 2007 farm in- and outflow water was sampled. The following factors with a potential impact on effluent nutrient concentration were recorded and scaled to be integrated in a multifactor regression model.

### *Rearing units*

The rearing units used for fish production have to be classified in self-cleaning units, or non self-cleaning units (Willoughby 1999). Self cleaning units are characterized by a fast export of suspended particles out of the system, like concrete raceways or circular tanks (Milden & Redding 1998; Wheaton & Singh 1999). In this study, six farms used earthen ponds only as rearing units; three farms used concrete raceways only. The other four farms used a mix of concrete and earthen ponds and raceways. The amount of concrete raceways per farm was scaled from 1.0 for earthen ponds exclusively to 2.0 for concrete raceways exclusively. For the other farms the amount of raceways compared to ponds was scaled as fraction and added to 1.0.

### *Amount of feed applied / production intensity*

For each farm, the fish farmer noted the amount of feed applied per day. Additionally the amount of inflow water was measured. Flow measurement was performed with a flow meter (model HFA, Höntsch inc.), measuring the mean flow velocity. Through multiple measurements, the total water could be calculated.

Consequently the production intensity per year (Pi) was calculated as the amount of feed applied per day (f), in dependence on the amount of inflow water (Q, Ls<sup>-1</sup>) on a yearly base ( $P_i = (f \cdot 365) / Q$ ). The production intensity of the trout farms ranged from 200 to 3,370 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup>. All farms applied energy rich extruded feed.

### *Effluent treatment device of the farm effluent*

Six farms used no effluent treatment scaled as treatment option 1.0. Four farms used sedimentation basins, with a certain fish stock, scaled as treatment option 2.0. One of these farms used a constructed wetland, described below, for the treatment of about 20 % of the total effluent. This treatment option was scaled with 2.2. Sedimentation basins without fish were scaled as treatment option 3.0. The fifth farm used a micro-screen as effluent treatment, option 4.0 and the sixth farm used two consecutive micro-screens, a coarser one in the farm (as intermediate treatment) and a fine one as 'end of pipe' treatment, scaled as option 5.0.

#### *Macro invertebrate fauna*

At six farms the macro invertebrate fauna up- and downstream the fish farm was sampled. The sampling stations for a farm were selected to have high habitat similarity (structure, insulation, current) and for the downstream station mixing between river water and the trout farm effluent and no self-purification should occur (Boaventura *et al.* 1997). At each sampling station, the macro invertebrates were collected by "kick sampling and collection" (DIN 2006), twice per station with a clearance time of at least one month. Samples were then identified and compared to the German standard methods for the examination water, wastewater and sludge (DIN 2006), and after von Tümpling & Friedrich (1999). For each sampling station a saprobic index with confidence interval was calculated from the collected species and their abundance confirmed (DIN 2006). The index can range between 1.0 for unaffected brook water to 4.0 for highly polluted water.

#### *Effluent treatment devices examined*

The following effluent treatment devices applied in the monitored trout farms, were closer examined.

**SEDIMENTATION BASIN WITH FISH:** The sedimentation basin consists of two chambers, separated by a wooden wall. In the basin the whole effluent ( $90 - 100 \text{ L s}^{-1}$ ) of a farm consisting exclusively of earthen fish ponds was treated. The production intensity (amount of feed applied) is about  $280 \text{ kg (L s}^{-1})^{-1} \text{ yr}^{-1}$ . The in- and outflow of the sedimentation basin was sampled on 12 days between July and November 2006. In the basin a small stock of large rainbow trout existed which were irregularly fed.

**SEDIMENTATION BASIN WITHOUT FISH** This basin contains a baffle at the inflow to lower the flow velocity. On the bottom of the basin sedimentation cones were implemented. The settled sludge was extracted daily from the basin, by opening the bottom drain of the sedimentation cones. In the basin  $30 - 40 \text{ L s}^{-1}$  outflow from several raceways used for trout production were treated. The basin was fish-free. Nine samples were taken between July and September 2007. In the sampling period, the production intensity in the raceways was between 1000 and  $1260 \text{ kg (L s}^{-1})^{-1} \text{ yr}^{-1}$ .

**MICRO-SCREEN AS 'END OF PIPE' TREATMENT** The examined micro-screen is a drum filter with a mesh size of  $63 \mu\text{m}$  (FAIVRE Sarl 120-16). It is situated at the outflow of a farm operating exclusively with raceways. After the drum filter  $40 \text{ L/s}$  (50 %) of the water is discharged, the rest is recirculated. In the sampling period from April until October 2007, 15 samples from the drum filter in- and outflow were taken. During the sampling period the production intensity in the farm was about  $1700 - 3000 \text{ kg (L/s)}^{-1} \text{ yr}^{-1}$ .

**CONSTRUCTED WETLAND** In one of the monitored fish farms, a constructed wetland was used to treat a part (20 %) of the total farm effluent, about  $23 \text{ L s}^{-1}$ . The constructed

wetland consisted of a pre-sedimentation basin, a surface flow (SF) wetland and a sub surface flow (SSF) wetland. For wetland construction, spare fish ponds were used. The SSF wetland had a gravel root zone consisting of 18 – 32 mm gravel. During the sampling period from November 2005 until February 2007, 11 samples from wetland in- and outflow were taken.

#### *Water sampling and analysis*

Sampling of water probes was conducted by automated water samplers. They were positioned at the in- and outflow of the device to be examined. The samplers run for 24 hours. Every 10 minutes a sub sample was collected. The sub samples were mixed to 24 hour pooled samples and transported to the lab for analysis.

The water samples were analysed for the following parameters measured in  $\text{mgL}^{-1}$ : total nitrogen (TN), total ammonia nitrogen (TAN), nitrite nitrogen ( $\text{NO}_2\text{-N}$ ), nitrate nitrogen ( $\text{NO}_3\text{-N}$ ), total phosphorous (TP), phosphate phosphorous ( $\text{PO}_4\text{-P}$ ), biological oxygen demand in 5 days ( $\text{BOD}_5$ ), chemical oxygen demand (COD), and total suspended solids (TSS). The physicochemical properties of the water samples were determined following German standard methods for the examination of water, wastewater and sludge (DIN 2006). For  $\text{BOD}_5$  the total oxygen consumption of the original probe was assessed, including nitrification and the particulate matter in the sample was not destroyed prior to measurement.

#### *Data analysis*

To identify the main effects on the effluent nutrient concentration, a multivariate regression model was calculated. The following model assumption was used:  $Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \varepsilon_{ijkl}$ , where  $Y_{ijkl}$  is the relevant effluent nutrient concentration,  $\mu$  is the overall effluent nutrient concentration,  $\alpha_i$  is the inflow nutrient concentration,  $\beta_j$  rearing unit,  $\gamma_k$  used effluent treatment device,  $\delta_l$  feeding amount in  $\text{kg(L/s)}^{-1}\text{year}^{-1}$  and  $\varepsilon_{ijkl}$  is the random residual error. The factors were identified as relevant at a probability level of  $\alpha < 0.05$ . The residuals were tested for homogeneity and normal distribution. All statistical calculations were performed with SAS 8e.

For the examined treatment methods, differences ( $\Delta p$ ) between inflow and outflow concentrations were calculated for each parameter as well as each pair of simultaneously taken samples. The relative treatment efficiency ( $\% \Delta$ ) was calculated for each parameter as  $\% \Delta = (\Delta p / c_{in}) \cdot 100 \%$ , with  $\Delta p = \text{inflow-outflow concentration in } \text{mgL}^{-1}$  and  $c_{in} = \text{inflow concentration in } \text{mgL}^{-1}$ .

For the  $\Delta p$  data of each parameter a Shapiro-Wilk test for normality was performed, with a significance level of  $\alpha < 0.05$ . When the  $\Delta p$  data were normally distributed, then the one sample students t-test was performed, in order to evaluate if  $\Delta p$  is significantly different from 0. When normality for the  $\Delta p$  data was rejected, then the Wilcoxon-Test (signed rank test) was used to test whether  $\Delta p$  is significantly different from 0.

## **Results**

### *Monitoring of farm effluents*

EFFECT OF FISH FARMS: For all measured nutrients fish farming showed a significant increase in effluent nutrient concentration, compared to inflow concentration. Except for

NO<sub>3</sub>-N, where a significant decrease in the effluent concentration was measured (Table 1).

**Table 1:** Mean in- and outflow concentrations with standard deviations, and differences ( $\Delta p$ ) from all monitored trout farms, with the indication of significance of  $\Delta p$ .

| Water parameter (mgL <sup>-1</sup> ) | Average inflow (SD) | Average outflow (SD) | Difference $\Delta p$ (SD) | Significance of $\Delta p$ |
|--------------------------------------|---------------------|----------------------|----------------------------|----------------------------|
| TN                                   | 5.35 (1.37)         | 5.79 (1.55)          | 0.44 (0.85)                | 0.0001                     |
| TAN                                  | 0.038 (0.030)       | 0.467 (0.402)        | 0.429 (0.408)              | 0.0001                     |
| NO <sub>2</sub> -N                   | 0.031 (0.048)       | 0.081 (0.061)        | 0.049 (0.049)              | 0.0001                     |
| NO <sub>3</sub> -N                   | 5.28 (1.23)         | 5.09 (1.25)          | -0.18 (0.54)               | 0.0001                     |
| TP                                   | 0.038 (0.034)       | 0.132 (0.100)        | 0.095 (0.106)              | 0.0001                     |
| PO <sub>4</sub> -P                   | 0.015 (0.024)       | 0.055 (0.051)        | 0.038 (0.050)              | 0.0001                     |
| BOD <sub>5</sub>                     | 1.57 (0.07)         | 3.73 (1.90)          | 2.13 (1.74)                | 0.0001                     |
| COD                                  | 5.89 (4.42)         | 8.95 (3.69)          | 3.06 (3.35)                | 0.0001                     |
| TSS                                  | 6.70 (14.69)        | 6.73 (4.47)          | 0.03 (14.51)               | 0.0001                     |

EFFECT ON MACRO INVERTEBRATE FAUNA: The saprobic index increases in the trout farm effluent, compared with the inflow index. However for the farms operating with a low production intensity of 280 and 300 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup>, the shift in the saprobic index between up- and downstream sampling station was not significant. At higher production intensities the difference between up- and downstream macro invertebrate fauna is more pronounced, as well as for the farm operating at 200 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup>.

#### *Modelling of effluent nutrient concentration*

The effluent nutrient concentration can be predicted by 50 – 88 % through four main factors: feed amount applied, inflow nutrient concentration, rearing unit used and effluent treatment device. Solely for TSS the predictability is about 13 % (Table 2).

An increase in the amount of feed applied in the fish farm, resulted in a significant increase in the effluent nutrient concentration for all measured nutrients. The inflow nutrient concentration had a direct effect on all nutrients except TAN. Self cleaning farms released more TN, NO<sub>3</sub>-N and BOD<sub>5</sub>, while less NO<sub>2</sub>-N and TSS were discharged. The effluent treatment units, showed a significant effect in reducing TP, BOD<sub>5</sub> and COD. For PO<sub>4</sub>-P they led to a slight increase in the effluent concentration.

#### *Effluent treatment devices*

In- and outflow nutrient concentrations of the examined effluent treatment devices are summarized in Table 3.

**Table 2.** Estimates for the regression model on effluent nutrient concentration, in dependence on relevant trout farm factors (\* indicate significant estimates p = probability value for each factor and the whole model, R<sup>2</sup> predictability of the whole model).

| Water parameter<br>mg l <sup>-1</sup> | $\mu$    |       | Inflow concentration |       | Rearing unit |       | Effluent treatment |       | Feeding kg(Ls <sup>-1</sup> ) <sup>-1</sup> yr <sup>-1</sup> |       | 100 R <sup>2</sup> | P     |
|---------------------------------------|----------|-------|----------------------|-------|--------------|-------|--------------------|-------|--|-------|--------------------|-------|
|                                       | Estimate | P     | Estimate             | P     | Estimate     | P     | Estimate           | P     | Estimate   | P     |                    |       |
| TN                                    | -0.237   | 0.364 | 0.906*               | 0.001 | 0.487*       | 0.011 | -0.084             | 0.204 | 0.075*   | 0.001 | 0.88               | 0.001 |
| TAN                                   | 0.053    | 0.405 | 0.370                | 0.445 | 0.016        | 0.790 | -0.023             | 0.248 | 0.049*   | 0.001 | 0.82               | 0.001 |
| NO <sub>2</sub> -N                    | 0.112*   | 0.001 | 0.709*               | 0.001 | -0.035*      | 0.022 | -0.010             | 0.056 | 0.002*   | 0.001 | 0.50               | 0.001 |
| NO <sub>3</sub> -N                    | -0.498*  | 0.048 | 0.914*               | 0.001 | 0.492*       | 0.004 | -0.031             | 0.599 | 0.013*   | 0.037 | 0.86               | 0.001 |
|                                       |          |       |                      |       |              |       |                    |       |  | 8     |                    |       |
| TP                                    | 0.020    | 0.349 | 0.333*               | 0.038 | 0.025        | 0.248 | -0.014*            | 0.044 | 0.011*   | 0.001 | 0.63               | 0.001 |
| PO <sub>4</sub> -P                    | -0.006   | 0.494 | 0.658*               | 0.001 | -0.007       | 0.465 | 0.008*             | 0.012 | 0.005*   | 0.001 | 0.74               | 0.001 |
| BOD <sub>5</sub>                      | 0.329    | 0.421 | 0.912*               | 0.001 | 0.785*       | 0.038 | -0.347*            | 0.005 | 0.184*   | 0.001 | 0.68               | 0.001 |
| COD                                   | 2.461*   | 0.002 | 0.686*               | 0.001 | 1.417        | 0.080 | -0.636*            | 0.022 | 0.210*   | 0.001 | 0.61               | 0.001 |
| TSS                                   | 8.118*   | 0.001 | 0.728*               | 0.001 | -4.384*      | 0.015 | 0.516              | 0.346 | 0.156*   | 0.022 | 0.13               | 0.001 |

SEDIMENTATION BASIN WITH FISH: The examined sedimentation basin showed no treatment effect on any of the measured nutrient parameters. The theoretical overflow rate in the basin was 0.0012 ms<sup>-1</sup>.

SEDIMENTATION BASIN WITHOUT FISH: The sedimentation basin without fish, showed significant treatment effects for TP and COD of 32 and 26 %, respectively. For all other nutrient parameters no significant treatment effect was measured. The theoretical overflow rate in the basin was 0.0022 ms<sup>-1</sup>.

MICRO-SCREEN: The micro-screen had a significant treatment effect on TP, BOD<sub>5</sub>, COD and TSS of 25 – 41 %, respectively. For the other nutrient fractions no effect was found.

CONSTRUCTED WETLAND: The wetland had a high treatment effect on TAN, TSS and BOD<sub>5</sub> of 82, 64 and 59 %, respectively. TN, TP and COD showed lower treatment efficiencies of 6, 37 and 40 %, respectively. The dissolved nutrients NO<sub>2</sub>-N, NO<sub>3</sub>-N and PO<sub>4</sub>-P increased significantly in the wetland outflow by 140, 12 and 42 %, respectively.

## Discussion

The results from in-and outflow monitoring indicate that the production intensity is the main factor influencing effluent nutrient concentration and the biological quality of the effluent. On the other side, effluent treatment is the only factor positively influencing the effluent nutrient concentration. The rearing unit plays a certain role in the distinct nutrient distribution. From these findings and the results of the examined effluent treatment devices, an effluent treatment concept in dependence on production intensity can be developed.

**Table 3.** Inflow and outflow nutrient concentrations of the monitored effluent treatment devices (\* indicate that the difference ( $\Delta p$ ) between inflow and outflow is significant  $P < 0.05$ ).

| Water parameter (mgL <sup>-1</sup> ) | Sedimentation with fish <i>n</i> = 12 |                  | Sedimentation without fish <i>n</i> = 9 |                   | Micro-screen <i>n</i> = 15 |                   | Constructed wetland <i>n</i> = 11 |                   |
|--------------------------------------|---------------------------------------|------------------|---|-------------------|----------------------------|-------------------|-----------------------------------|-------------------|
|                                      | inflow (SD)                           | outflow (SD)     | inflow (SD)                             | outflow (SD)      | inflow (SD)                | outflow (SD)      | inflow (SD)                       | outflow (SD)      |
| TN                                   | 6.03<br>(1.31)                        | 5.60<br>(0.879)  | 7.53<br>(0.579)                         | 7.45<br>(0.714)   | 7.74<br>(0.637)            | 7.91<br>(0.710)   | 6.23*<br>(1.04)                   | 5.88*<br>(0.983)  |
| TAN                                  | 0.182<br>(0.044)                      | 0.183<br>(0.034) | 0.890<br>(0.194)                        | 0.883<br>(0.176)  | 1.19<br>(0.440)            | 1.23<br>(0.236)   | 0.706*<br>(0.286)                 | 0.124*<br>(0.098) |
| NO <sub>2</sub> -N                   | 0.062<br>(0.014)                      | 0.060<br>(0.016) | 0.017<br>(0.012)                        | 0.015<br>(0.003)  | 0.041<br>(0.010)           | 0.042<br>(0.011)  | 0.023*<br>(0.003)                 | 0.050*<br>(0.041) |
| NO <sub>3</sub> -N                   | 5.40<br>(0.885)                       | 5.04<br>(0.491)  | 6.51<br>(0.419)                         | 6.34<br>(0.301)   | 6.20<br>(0.358)            | 6.16<br>(0.306)   | 5.03*<br>(0.641)                  | 5.43*<br>(0.607)  |
| TP                                   | 0.073<br>(0.033)                      | 0.072<br>(0.036) | 0.305*<br>(0.162)                       | 0.206*<br>(0.078) | 0.299*<br>(0.146)          | 0.201*<br>(0.044) | 0.165*<br>(0.087)                 | 0.103*<br>(0.026) |
| PO <sub>4</sub> -P                   | 0.068<br>(0.037)                      | 0.072<br>(0.040) | 0.087<br>(0.026)                        | 0.094<br>(0.025)  | 0.120<br>(0.051)           | 0.113<br>(0.040)  | 0.054*<br>(0.038)                 | 0.077*<br>(0.040) |
| BOD <sub>5</sub>                     | 2.63<br>(0.433)                       | 2.97<br>(1.05)   | 5.17<br>(0.870)                         | 5.09<br>(2.24)    | 7.98*<br>(3.52)            | 5.92*<br>(3.28)   | 4.84*<br>(1.86)                   | 2.00*<br>(0.720)  |
| COD                                  | 10.86<br>(3.42)                       | 11.66<br>(4.40)  | 9.44*<br>(3.44)                         | 6.97*<br>(2.65)   | 14.39*<br>(7.84)           | 10.20*<br>(3.90)  | 8.80*<br>(5.51)                   | 5.29*<br>(3.91)   |
| TSS                                  | 9.10<br>(3.51)                        | 10.22<br>(4.92)  | 5.63<br>(4.88)                          | 3.76<br>(1.69)    | 6.31*<br>(3.93)            | 3.73*<br>(2.52)   | 4.88*<br>(2.11)                   | 1.74*<br>(0.538)  |

### Monitoring of farm effluents

Trout farming, and the rearing of fish with energy rich extruded feed, has a significant effect on the effluent water quality. This is not surprising, as other studies already found significant nutrient increases in trout farm effluents, at least for some of the measured nutrient parameters (Boaventura *et al.* 1997; True *et al.* 2004; Viadero *et al.* 2005; Maillard *et al.* 2005). Also the macro-invertebrate fauna shows a specific shift in individuals and species distribution (Camargo 1994, Doughty & Mc.Phail 1995, Loch *et al.* 1996, Selong & Helferich 1998). This shift is more pronounced with increased production intensity (feed applied) (Selong & Helferich 1998). However, the actual production intensity is not always represented through the biological macro-invertebrate assessment, as production intensity is a short term figure, while the macro-invertebrates integrate disturbance is over a long period of time (at least one year). Consequently, a higher impact on the aquatic fauna is found than the actual production intensity might predict (Camargo 1994), as found for farm 1 with the lowest feeding amount and a relative high impact on the invertebrate community. This high impact might date from earlier or very short time disturbances not detected in the sampling period.

The new result of this study is the statistical proof, that there are only three factors mainly influencing the effect of trout farming on the effluent nutrient concentration: the amount of feed applied, the rearing unit used and the effluent treatment.

**INFLOW NUTRIENT CONCENTRATION:** Farm inflow nutrient concentration has a high impact on the effluent concentration for most nutrient fractions. This reveals the crucial importance of simultaneously sampling of inflow and outflow, in order to assess the effect of trout farming (Foy & Rossel 1991; Rennert 1994).

**FISH FEEDING:** Fish feeding is the only factor with an effect on all nutrient fractions. With increased production intensity the effluent nutrient concentration increases. Fish

feed is the only nutrient source added to the fish farming system (Bergheim & Asgard 1996). From the introduced feed a part remains uneaten (feed wastes). From the ingested nutrients, the undigested part is excreted as particulate faeces (Cho *et al.* 1994; Piedrahita 1994; Bergheim & Asgard 1996; Cho & Bureau 1997; Green *et al.* 2002), containing mainly organic carbon and phosphorus (Cripps 1994; Kelly *et al.* 1997, Cripps & Bergheim 2000). The digested nutrients are partially retained in fish body mass (Schreckenbach *et al.* 2001). The rest is excreted as dissolved nutrients through the gills, mainly as ammonia and via urine as phosphate and ammonium (Steffens 1985; Cho *et al.* 1994; Cho & Bureau 1997; Bureau & Cho 1999; Green *et al.* 2002; Roy & Lall 2004).

From trout aquaculture two waste streams were emitted, the particulate nutrients from uneaten feed and faecal excretion and the dissolved nutrients from gills and urea excretion. The final distribution in the effluent between the two streams depends on the local physical, chemical and biological conditions (Brinker 2005).

**REARING UNITS:** These conditions are influenced by the kind of the rearing units used. They have a significant effect on some nutrient fractions. For example, the lower release of NO<sub>3</sub>-N and TN from ponds is due to denitrification occurring in the pond sediments. Here oxygen free areas occur, with sufficient carbon sources from settled faeces, enhancing denitrification (Tchobanoglous *et al.* 2003) of the naturally nitrate rich inflow water. Partial denitrification leads to the increased NO<sub>2</sub>-N release from ponds. Additionally less BOD<sub>5</sub> is exported from ponds, compared to raceways, as heterotrophic digestion is one of the first processes occurring in oxygen rich environments (Tchobanoglous *et al.* 2003). The reason for the higher release of TSS from ponds, compared to raceways is not clear. The most reasonable cause is the occurrence of flooding events prior to sampling. Through the long water retention time in ponds, a generally higher TSS outflow from ponds can be expected. However, also other studies had major problems in predicting TSS outflow from trout aquaculture (Roque d'Orbcastel *et al.* 2008).

**EFFLUENT CLEANING DEVICES:** The effluent treatment devices have a positive effect on the nutrient concentration of the fractions containing also particulate matter as TP, BOD<sub>5</sub> and COD (Cripps & Bergheim 2000). With increased efficiency and technical improvement of the treatment unit, the effluent nutrient concentration decreased. Only for TSS, where the main effect from mechanical treatment should be supposed (Cripps & Bergheim 2000), no effect was found. Probable over- and underestimation of TSS in water sampling due to insufficient mixing of the effluent (Brinker *et al.* 2005 a) and the occurrence of flooding events have a high impact on the general predictability of TSS export from aquaculture farms.

For phosphate (PO<sub>4</sub>-P) the treatment devices had a negative impact. The leaching of PO<sub>4</sub>-P from particulate phosphorous in trout faces is very high especially during the first 24 hours (Stewart *et al.* 2006). Thus, especially sedimentation basins (Cripps & Bergheim 2000) and constructed wetlands lead to increased PO<sub>4</sub>-P leaching (Sindilariu *et al.* 2007).

#### *Treatment devices examined*

The treatment efficiency increased from the sedimentation basin with fish, to the sedimentation basin without fish, to the micro-screen and the constructed wetland.

**SEDIMENTATION BASINS:** Sedimentation relies upon the density differences between particulate waste and the surrounding water (Cripps & Kelly 1996). The settlement velocity of suspended solids depends on the particle surface and dimension, its specific weight and the flow velocity of the surrounding water (Tchobanoglous *et al.* 2003). Baffles are often incorporated to promote quiescent conditions (Cripps & Bergheim 2000).

The sedimentation basin with fish was well designed, the incorporation of a baffle, promoting quiescent zones and a low overflow rate of  $0.0012 \text{ ms}^{-1}$ , much less than the recommended flow velocities of  $0.017 \text{ ms}^{-1}$  (Henderson & Bromage 1988) should lead to an effective particle retainment. Only the presence of fish, especially when fed, lead to high re-suspension rates of already settled particles and additional nutrient leaching (Stewart *et al.* 2006). Thus, no treatment effect of the basin could be measured. Nevertheless in four of the 13 monitored fish farms sedimentation basins with fish were used.

The sedimentation basin without fish, had a higher overflow rate of  $0.0022 \text{ ms}^{-1}$ . However, here significant treatment effects for TP and COD were measured. Additionally, for this basin a fast separation and removal of settled sludge from the primary flow was realized through regular flushing of the sedimentation cones. Thus, high re-suspension and leaching rates of the settled nutrients (Lefebvre *et al.* 2001; Stewart *et al.* 2006) were avoided. The use of sedimentation is not inherently wrong, highly effective separators were successfully applied (Lawson 1995), but sometimes the application is inadequate (Henderson & Bromage 1988; Cripps & Bergheim 2000).

**MICRO-SCREEN:** The examined micro-screen had higher treatment effects than the sedimentation basins. Here an additional significant effect on BOD<sub>5</sub> and TSS was measured. The screen treatment effect was much below the expected treatment efficiency. Normally drum filter with a mesh size below  $80 \mu\text{m}$  have suspended solids removal efficiencies ranging from 10 % (Wedekind 1996) over 19 % (Bergheim *et al.* 1993) to 65 % (Brinker & Rösch 2005), 70 % and 90 % (Bergheim *et al.* 1998) as lower treatment efficiencies and 75 % (Bergheim *et al.* 1998) to 87 % (Brinker & Rösch 2005), 91 % (Bergheim *et al.* 1993), 99 % (Bergheim *et al.* 1998) and more than 99 % (Wedekind 1996) as upper treatment efficiency. The examined screen with a TSS efficiency of 41 % is at the lower margin of the expected treatment range. This can be explained by regular occurring leakages on the filter gauze and a slightly too small dimensioning of the drum filter compared to the treated water volume.

**CONSTRUCTED WETLAND:** The constructed wetland had the highest treatment efficiency compared to the other treatment units. The wetland provided in addition to the mechanical sedimentation and filtration, a highly effective biological treatment of TAN and BOD<sub>5</sub> (Schulz *et al.* 2003; Sindilariu *et al.* 2007). Only for TP the treatment efficiency is in the range of the examined sedimentation basin without fish and the micro-screen. TP is only retained in the wetland, and no effective extraction of phosphorous from the wetland occurs, as extraction through plant growth is of minor importance in highly loaded wetlands (Tanner & Sukias 1995; Brix 1997; Stottmeister *et al.* 2003; Vymazal 2005). Thus, high leaching rates of PO<sub>4</sub>-P from the trapped particulate phosphorous occur in the wetland, as the precipitation potential of the filter matrix is limited and fast saturated (Arias *et al.* 2001; Del Bubba *et al.* 2003; Seo *et al.* 2005). The significant increase of NO<sub>2</sub>-N and NO<sub>3</sub>-N is mainly due to partial

nitrification, as it is one of the most important treatment effects of constructed wetlands (Platzer 1999; Stottmeister *et al.* 2003). A potential problem of SSF constructed wetlands are short service lifetimes of the root zone filter, especially when used for the treatment of high hydraulic loads of particle rich farm effluents with no mechanical pre-treatment (Sindilariu *et al.* 2008)

### *Strategies for effluent nutrient treatment*

With increasing production intensity, nutrient concentration and the effect on the aquatic biology increases in the farm effluent. Improved effluent treatment is the only way to balance this increase. Thus, with increasing production intensity the effluent treatment efficiency has to increase, in order to undercut potential pollution thresholds and remain below critical concentrations, which produce severe impacts on the effluent ecosystem. The kind of effluent treatment device is dependent on the effluent characteristics (influenced by the production intensity and the type of rearing units used) and the treatment efficiency of the particular effluent treatment device.

Consequently, for low production intensities, no effluent treatment is affordable (Schobert *et al.* 2001). At a low to medium production level (about 350 – 700 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup>, for self cleaning units) sedimentation should be sufficient as effluent treatment device (Sindilariu 2007). Maximum treatment efficiencies of up to 60 % of TSS can be reached (Sindilariu 2007). With a daily or twice a day extraction of the settled solids, re-suspension and leaching of dissolved nutrients can be avoided (Steward *et al.* 2006). Fish should be anyway totally excluded from the basins as they prevent successful sedimentation.

At an higher annual production, (about 700 – 1,150 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup>, for self cleaning units) micro-screens should be effective enough for successful treatment (Sindilariu 2007). Efficiency can be improved through the application of special binder added feed, leading to a significant improve on screen treatment efficiency up to 88 % for TSS (Brinker *et al.* 2005 b, c). The micro-screen backwash sludge has to be further processed. In a first step sedimentation is the most successful alternative (Sindilariu *et al.* unpublished). Alternatively a second micro-screening step (Bergheim *et al.* 1998) or the application of a flocculation chemical and subsequent belt filtration (Ebeling *et al.* 2006) can be applied. The settled sludge can be applied as agricultural manure (Donaldson & Chadwick 2006). The overflow of the second dewatering step can get a successful final treatment in a constructed wetland (Sindilariu *et al.* unpublished).

Depending on the self cleaning ability of the rearing units, the application of a biological effluent treatment device, like constructed wetlands is needed. Biological treatment shows reduced efficiency at high TSS loads (Eding *et al.* 2006). Sub surface flow constructed wetlands are most efficiently combined with prior TSS treatment. As standalone treatment unit, constructed wetlands are only successful at low production intensities (Sindilariu *et al.* 2007). At high intensities the combination with a sedimentation basin and a surface flow constructed wetland, has a high treatment effect, especially for farms using ponds as rearing system, as shown above. At an intensive production level (higher than 1,200 kg (Ls<sup>-1</sup>)<sup>-1</sup>year<sup>-1</sup> for self cleaning units) dissolved nutrient concentrations exceed the set pollution margins (Sindilariu 2007). The combination of constructed wetlands with prior micro-screening is a solution for high production intensity (Sindilariu 2007).

## Conclusions & recommendations

1. Trout aquaculture has an impact on the effluent nutrient concentration and biological status of the receiving effluent. The strength of the effect is dependent on the amount of feed applied, the type of rearing units used in the farm and the kind and efficiency of the effluent treatment used.
2. Effluent treatment efficiency increases from sedimentation basins with fish, showing no treatment effect over sedimentation basins without fish, to micro-screens and constructed wetlands, showing an effect on all nutrient fractions.
3. The specific effluent treatment concept is dependent on the production intensity and the effluent nutrient thresholds. However, with increasing production intensity a development of the treatment system from sedimentation, over micro-screening, to the combination of sedimentation or screening with biological effluent treatment in constructed wetlands, can be recommended.
4. A detailed cost calculation for the different treatment possibilities is needed in order to facilitate the decision of trout producers to effectively apply effluent treatment.

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# Management strategies to protect and restore sturgeon biodiversity in Bulgaria

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**Abstract** Sturgeons are among the most endangered fish species worldwide. Six sturgeon species are native to the Black Sea and the Danube River: beluga (*Huso huso*), Russian sturgeon (*Acipenser guldenstaedti*), stellate sturgeon (*A. stellatus*), sterlet (*A. ruthenus*), ship sturgeon (*A. nudiventris*) and Atlantic sturgeon (*A. sturio*). Nowadays only four reproduce in the Lower Danube River; Atlantic sturgeon is extinct from the region and fishermen occasionally report catching ship sturgeon, but this needs confirmation. This is the result of degradation of the environment over the past 60 years by intense anthropogenic activities coupled with commercial exploitation of the high value sturgeon products, caviar in particular, and considerable poaching and illegal trade in the products. Recent observations in the Lower Danube have indicated that all sturgeon populations are close to extinction. In this paper national and international attempts to protect the sturgeons in Bulgaria are summarized. The system of measures for sustainable management and protection, which have been applied in the last 10 years in Bulgaria and the critical evaluation of their efficiency are outlined.

## Introduction

The order Acipenseriformes includes approximately 25 species divided into two families Acipenseridae and Polyodontidae (Birstein 1993). The Danube River and the Black Sea region are inhabited by six sturgeon species: Russian sturgeon (*Acipenser guldenstaedti* Brandt & Ratzeberg), ship sturgeon (*Acipenser nudiventris* Lovetsky), stellate sturgeon (*Acipenser stellatus* Pallas), sterlet (*Acipenser ruthenus* L.), Atlantic sturgeon (*Acipenser sturio* L.) and beluga (*Huso huso* L.).

Sturgeon species of the Black Sea basin are of high economic importance to the people living along the Danube River and other rivers of the Black Sea Basin. Since the mid-20th century, the annual catches of sturgeons in the Lower Danube River has steadily decreased, signalling the unfavourable status of these populations (Bacalbasa-Dobrovici 1997; Bacalbasa-Dobrovici & Patriche 1999; Reinartz 2002; Paraschiv & Sucio 2006). Nowadays all sturgeon species in Bulgarian waters are present in critically low numbers (Vassilev & Pehlivanov 2003; Bloesch *et al.* 2006), and two, *A. sturio* and *A. nudiventris*, seem to be extinct (Bacalbasa-Dobrovici & Holčík 2000). The reasons for this situation are: the sturgeon's life history is characterized by a long-live span, late maturity, intermittent spawning frequencies and long migratory movements (Ambroz 1964; Bemis *et al.* 1997). Negative human impacts such as over-fishing, increased fishing pressure (a result of increased number of fishermen and more effective fishery equipment), barriers to migration and water pollution have reduced the number of

sturgeon. For example, the construction of the Iron Gate I dam (1972) and Iron Gate II dam (1984) have prevented spawning migrations of sturgeon into the Upper and Middle Danube, the Lower Danube remains the only river in the Black Sea basin where sturgeon are present. Their main spawning grounds used to be located near Beluga, between river km 1866 and 1766 in the contemporary Slovak-Hungarian stretch (Hensel & Holcik 1997). Currently, the main spawning grounds are located approximately 1000 km downstream of Beluga under the Iron Gate II dam, between river km 863 and 755 (Vassilev 2003).

Several studies have shown depletion in the population structure of the Danube sturgeons, leading to their endangered species status (Ceapa, Williot & Bacalbasa-Dobrovici 2002; Vasilev & Pehlivanov 2003; Lenhardt *et al.* 2006). They are now the focus of a variety of nature-protection organizations. For example, in 1996 all sturgeon species were included in the Red Book (IUCN, Red List of Threatened Animals). Since 1 April 1998, all species of the order *Acipenseriformes* were in the list of species under the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES Appendix II). In the Bulgarian Red Book of endangered species *A. nudiventris* is included, as rare and *A. sturio* is considered extinct.

At the end of the 1990s, the countries of the Lower Danube began to implement different programmes for investigation, conservation and restoration of the sturgeon stocks (Navodaru & Staras 2002; Raikova *et al.* 2004; Lenhardt, Hegedis & Jaric 2005; Reinartz 2006). The Sturgeon Action Plan was accepted in December 2006 and aimed to co-ordinate activities on conservation and restoration of the Danube sturgeons (Bloesch *et al.* 2006).

The aim of this study is to outline the current status of the wild sturgeon populations in the Bulgarian part of the Danube River and the Black Sea, and management practices applied in Bulgaria, to protect and restore the sturgeon populations.

## **Materials and methods**

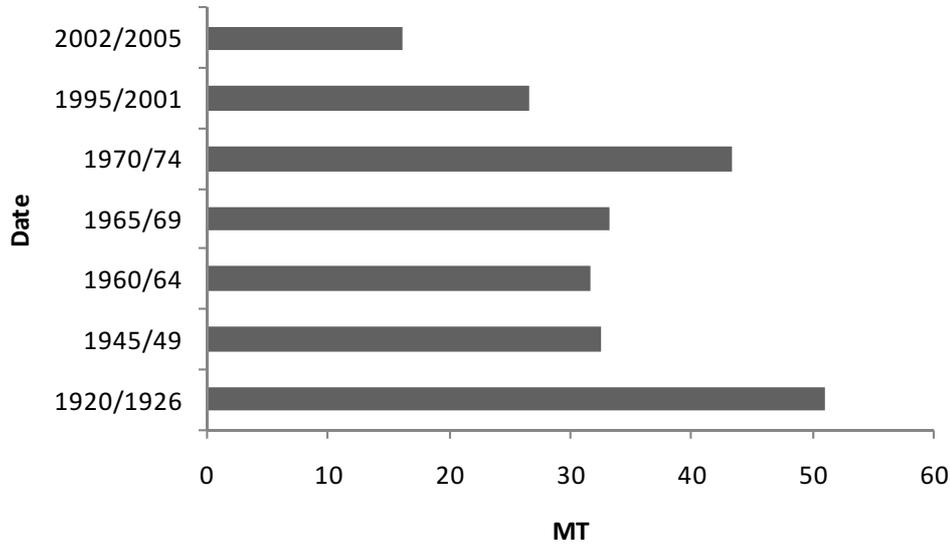
The National Agency of Fisheries and Aquaculture at the Ministry of Agriculture and Food Supply provided statistical data about sturgeon catches, aquaculture production and restocking activities over the last 20 years. A total of 31 published sources, personal communications, and author observations were used in this study. The taxonomy of fishes was based on the review of Eschmeyer (2006).

## **Results**

### *State of natural sturgeon stocks in the Bulgarian part of the Danube River and the Black Sea*

Sturgeons have been the object of commercial fishing activities in Bulgaria for centuries, mainly in the Danube River (about 90% of the total catch) and less in the Black Sea (remaining 10% mainly along the Northern coast near Romania and to the South of Sozopol). Sturgeon catch data have been kept in Bulgaria since the 1920s

(Drenski 1928). During the period 1920-1926 catches in the Bulgarian sector of the Danube River varied from 30 to 72 t yr<sup>-1</sup>, with an average of 51 t yr<sup>-1</sup> (Fig. 1).



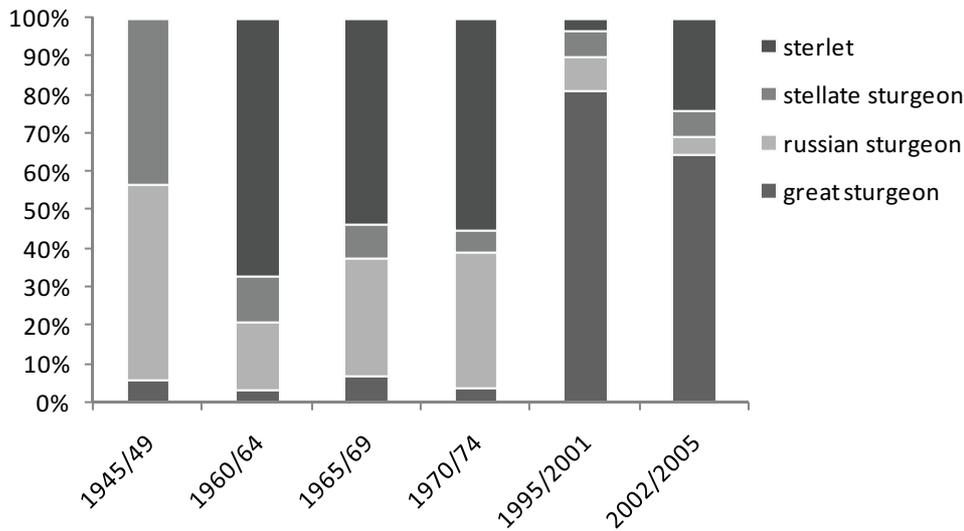
**Figure 1.** Sturgeon catches in Bulgaria since 1920s.

In 1942, approximately 64 t of sturgeons were caught. During 1945-1949 the average catch of sturgeons was 32.5 t yr<sup>-1</sup>. The most fishes caught were *A. gueldenstaedti* and *A. stellatus* (Table 1), which comprised respectively 50.8 and 43.4% of the total catches. *Huso huso* was only 5.8%. In the period 1960-1974 catches increased and the average total catch for each 5-year period varied from 150.5 to 196.5 t (31.5 to 43.3 t yr<sup>-1</sup>), i.e. no significant change was observed in the total quantity of the catch.

**Table 1.** Catch per year for 3 species of sturgeon, *H. huso*, *A. gueldenstaedti* and *A. stellatus*.

| Year    | <i>Huso huso</i> | <i>A. gueldenstaedti</i> | <i>A. stellatus</i> | Total |
|---------|------------------|--------------------------|---------------------|-------|
| 1996    | 5.3              | 0.7                      | -                   | 6     |
| 1997    | 11.5             | 1.8                      | -                   | 13.3  |
| 1998    | 12.3             | 2.2                      | -                   | 14.5  |
| 1999    | 10               | 2                        | -                   | 12    |
| 2000    | 0.9              | -                        | 0.3                 | 1.2   |
| 2001    | 0.3              | -                        | -                   | 0.3   |
| 2002    | 3.5              | 2                        | 3                   | 8.5   |
| 2003    | 0.6              | -                        | 0.3                 | 0.9   |
| 2004    | 2.5              | 0.5                      | 1                   | 4     |
| 2005    | 0.6              | -                        | -                   | 0.6   |
| Total   | 47.5             | 9.2                      | 4.6                 | 61.3  |
| Average | 4.75             | 0.92                     | 0.46                | 6.13  |

Changes occurred in the species caught (Fig. 2). The considerable changes in the structure of catches were one of the first signals of disturbance of sturgeons stocks. *A. ruthenus* dominated the catch in the 1960s and comprised 58.3% of the whole catch, followed by *A. gueldenstaedti* (28.7%), *A. stellatus* (8.5%) and *H. huso* (4.6%). The total fish catch from the Danube River was about 600 t yr<sup>-1</sup> during the 1980s (according to the official statistics data of the state companies), or which sturgeons contributed about 80 t yr<sup>-1</sup>, 80% were *H. huso*.



**Figure 2.** Percentage catches of sturgeon from 1945 to 2005.

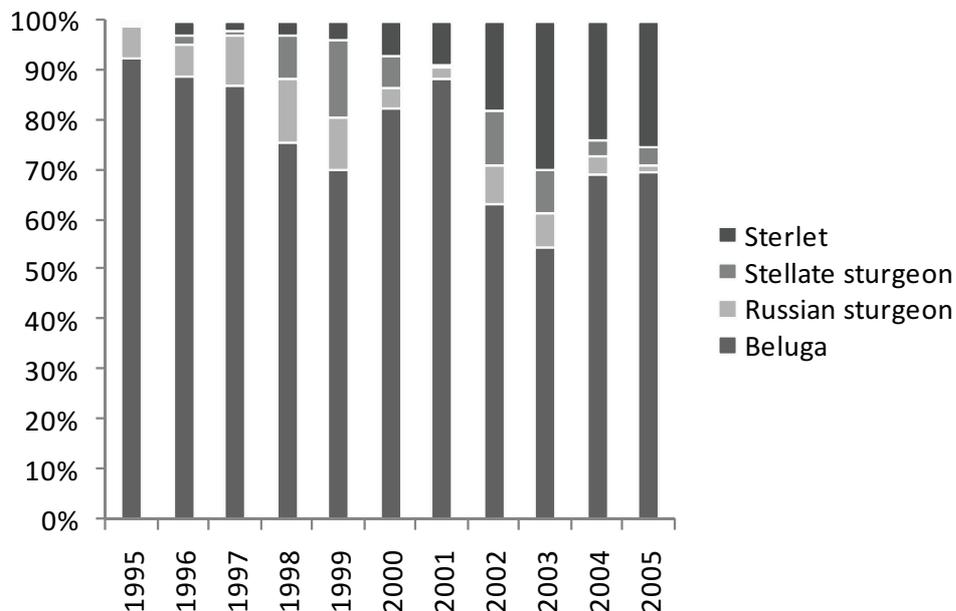
Since 1995, sturgeon catches have drastically decreased to 26 t yr<sup>-1</sup> for the period 1995-2001 and 26 t yr<sup>-1</sup> for the period 2002-2005 (Table 2, Fig. 1). However, *H. Huso* was still the dominant species in the last 10 years and for the period 1995-2001 it represented 81.12% of the total sturgeon catch, followed by *A. gueldenstaedti* (8.91%), *A. stellatus* (6.39%) and *A. ruthenus* (3.57%) (Fig. 2).

**Table 2.** Sturgeon catches from 1995-2005.

| Year  | Beluga (t) | Russian sturgeon (t) | Stellate sturgeon (t) | Sterlet (t) | Total (t) |
|-------|------------|----------------------|-----------------------|-------------|-----------|
| 1995  | 13.6       | 0.9                  | 0.1                   | 0.1         | 14.7      |
| 1996  | 23.5       | 1.7                  | 0.5                   | 0.8         | 26.5      |
| 1997  | 30.7       | 3.6                  | 0.2                   | 0.8         | 35.3      |
| 1998  | 31.2       | 5.3                  | 3.7                   | 1.2         | 41.4      |
| 1999  | 27         | 4                    | 6                     | 1.5         | 38.5      |
| 2000  | 18.4       | 0.9                  | 1.4                   | 1.6         | 22.3      |
| 2001  | 6.6        | 0.16                 | 0.03                  | 0.66        | 9.1       |
| 2002  | 9.9        | 1.2                  | 1.7                   | 2.8         | 15.6      |
| 2003  | 8.21       | 1                    | 1.3                   | 4.5         | 14.1      |
| 2004  | 9.9        | 0.5                  | 0.5                   | 3.4         | 14.3      |
| 2005  | 13.2       | 0.3                  | 0.7                   | 4.8         | 18.9      |
| Total | 192.21     | 19.56                | 16.13                 | 22.16       | 250.7     |

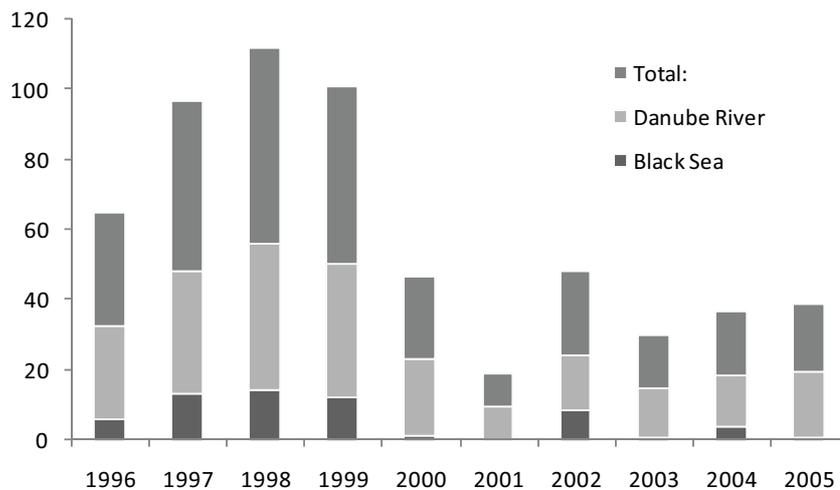
Between 2002 and 2005, *H. huso* was the dominant species caught contributing 64.5% of the total catch (average catch 16 t yr<sup>-1</sup>) (Fig.2), followed by *A. ruthenus* (24.3%), *A. stellatus* (6.6%) and *A. gueldenstaedti* (4.7%), an increase of approximately 6.8 times the previous period. In total, about 80% of all sturgeon species were caught in the Lom and Vidin region (river km 570-850).

Based on published data and sturgeon catches in the Danube River the following trends were identified. During 1945-2005 *A. gueldenstaedti* and *A. stellatus* lost their dominant role (respectively 50% and 43% of the total sturgeons catch, Fig. 2); currently they contribute <7% of catches (Fig.3). *A. ruthenus* showed the strongest change dropping from 58% of the total sturgeon catch between 1960 and 1975) (Fig.2) to less than 5% in the following period, although there has been an increase during the last 2-3 years up to 20% (Fig.3). Beluga catches fluctuated widely. Prior to the 1980s, *H. huso* catches were insignificant (< 5%) of the total catches (Fig. 2) but during the last 20 years have contributed approximately 80% of total catches (Fig. 3). Consequently, Russian sturgeon and the stellate sturgeon are not important for the black caviar yield, produced mainly from Beluga because of its higher quality and market price.



**Figure 3.** Percentage catches of sturgeon from 1995 to 2005.

In total, Black Sea catches of sturgeon species were 3-4 times lower than the Danube River, but in some years (2003-2001) it was 15-30 times lower (Fig. 4). Currently, sturgeon catches in the Black Sea do not exceed 15 t annually (Table 1). The catches of *H. huso* contribute 77% (Table 2), *A. gueldenstaedti* 15%, and *A. stellatus* only 7.5%. *Huso huso* is usually caught in the south – in the region of Ahtopol -Tzarevo - Rezovo by baited hooks. In the north (near to the Romanian border) the usual catch is Russian sturgeon and rarely *A. stellatus*. There are several cases when sturgeon species were caught in fixed trap nets, but this happens occasionally. The female sturgeons caught in the Black Sea are mostly at an early stage of maturity and consequently of no commercial value.



**Figure 4.** Comparison of sturgeon catches between the Danube River and the Black Sea.

## Management strategies concerning the endangered Sturgeons in Bulgarian Waters

### *Restocking activities*

Restocking of the River Danube is an alternative to mitigate the negative impacts on the sturgeon populations in the region. By the end of the 1990s, in conjunction with different conservation projects and to fulfil CITES recommendations concerning the protection of sturgeon stocks, attempts were being made in Bulgaria for artificial propagation and production of restocking material from sturgeons. In 1998, juvenile *A. gueldenstaedti* produced in the Perpen Chobanov fish farm (in the village of Boljartsi) were released into the river near Rousse (river km 493) (Zlatanova 2000; Vassilev 2005).

Since 2003, restocking has been done according to an Order of the Minister of Agriculture and Forestry and the Minister of the Environmental protection and Waters. It obliges the people who receive black caviar export quotas, to restock the Danube River according to their own choice, which is usually *H. huso* and/or Russian sturgeon, based on the rule that a minimum 30 fish and a maximum of 120 fish must be restocked for every 1 kg of caviar exported.

In the period 1998-2005, more than 711 000 sturgeons were released into the Danube River: approximately 670 000 were Russian sturgeon, weighing between 10 And 1 000 g, 37 000 beluga, weighing from 20 to 500 g and 2125 serlets, weighing 15 to 100 g (Table 3). Russian sturgeon contributed 94.5% of all fish released into the river, the Beluga was 5% and the sterlet was 0.3%.

During the period 2006 and 2007, caviar export quotas for Bulgaria were not released by CITES because the export companies were not obliged to restock the Danube River. For that period only 2000 Russian sturgeon with an average weight of 5 g were released.

Since 2007, restocking of the Danube River has been the main task within the framework of the National Program for Support of the Stable Growth of Fish Resources, which was accepted by the Minister of Agriculture and Food Supply in 2008. Accordingly, in 2008 the Danube River was restocked with 30 000 Russian sturgeon and 20 000 Beluga. Financial support was from IARA. An important requirement of this programme is the restocking is of juvenile fish of

**Table 3.** Number of sturgeon released into the Danube River.

| Year      |                  | Release site on Danube River |                  |
|-----------|------------------|------------------------------|------------------|
|           |                  | Vidin rkm 790                | Svishtov rkm 570 |
| 1998-2001 | Russian sturgeon | 0                            | 200,000          |
| 2002      | Russian sturgeon | 42300                        | 20230            |
|           | Sterlet          | 1000                         | 1125             |
| 2003      | Beluga           | 5300                         | 0                |
|           | Russian sturgeon | 115500                       | 45817            |
| 2004      | Russian sturgeon | 67000                        | 144126           |
| 2005      | Beluga           | 31950                        | 0                |
|           | Russian sturgeon | 0                            | 35000            |
| 2006      | Russian sturgeon | 2000                         | 0                |

Danube origin. This has not always been taken into consideration in recent restocking events where both native and hybrid species were used. For example, Siberian sturgeons (*A. baeri*), Adriatic sturgeons (*A. naccarii*) and hybrids grown in fish farms were previously released into the Danube (Reinarz 2002 & Vasilev 2005). Considerable attention has to be paid to the restocking of two extinct species, Ship and Atlantic sturgeon. The results from the implementation of the Ministry of Environment and Water restocking project in the Danube River have to date been unsatisfactory.

#### *Aquaculture development*

The significant decrease of sturgeon catches and the implementation of different restrictions for their catch promoted a serious interest in artificial rearing of sturgeons for the production of both meat and caviar. The beginning of sturgeon aquaculture in Bulgaria was in 1995, when the first sturgeon fish farm was built. The farm is situated in the Southern part of Bulgaria near the city of Plovdiv at a distance of more than 300 km from the Danube River. In 2001 a second sturgeon fish farm was established - Beluga located directly on the banks of the Danube River near the town of Vidin, at river km 790. Sturgeons are also reared in other places in the country, but on a smaller scale. By 2005, there were 5 officially registered sturgeon fish farms, but more are planned, mainly net cage farms. Formerly, Esetra Commerce Ltd., Beluga Ltd. и Aquamash Ltd. was the main producer of restocking material, fish for consumption and caviar.

In the past, producers relied mainly on imported fertilized eggs, mainly from Russia, Krasnodar and Astrakhan, for stocking material. Presently it is from sexually mature specimens, grown on the fish farms.

The main object of rearing has been for the Russian sturgeon (Tables 4 and 5). Beluga, stellate sturgeon and sterlet have been reared in smaller quantities. The production of stocking material is in tanks until the fish weigh 5-20 g. Thereafter, they are moved into nets cages and during the first year the juveniles usually reach 300-500 g.

**Table 4.** Production (number specimens) of sturgeon stocking material from aquaculture (Source: NAFA)

| Species              | 2002   | 2003    | 2004    | 2005    | 2006   | 2007   |
|----------------------|--------|---------|---------|---------|--------|--------|
| Beluga               | 0      | 21380   | 7,230   | 112,960 | 0      | 0      |
| Sterlet              | 0      | 0       | 6,100   | 155,550 | 0      | 0      |
| Russian sturgeon     | 65,000 | 205,606 | 108,440 | 49,550  | 64320  | 24897  |
| Stellate sturgeon    | 0      | 0       | 0       | 385     | 0      | 839    |
| Paddlefish           | 0      | 0       | 32,500  | 445     | 0      | 0      |
| (Russian x Siberian) | 0      | 0       | 0       | 55,000  | 0      | 0      |
| Total:               | 65,000 | 226,980 | 154,270 | 373,890 | 64,320 | 25,736 |

**Table 5.** Production (t) of market-size sturgeons from aquaculture (Source: NAFA).

| Species           | 2002 | 2003  | 2004 | 2005   | 2006  | 2007  |
|-------------------|------|-------|------|--------|-------|-------|
| Beluga            | 0    | 3.4   | 3.7  | 21.5   | 27.66 | 46.16 |
| Sterlet           | 0    | 0.3   | 0.1  | 2.2    | 2.5   | 4.58  |
| Russian sturgeon  | 80   | 144   | 6.7  | 281    | 113.5 | 142.8 |
| Stellate sturgeon | 0    | 0     | 0    | 0      | 15.11 | 2.1   |
| Paddlefish        | 0    | 0     | 2.3  | 0.05   | 0.005 | 0.007 |
| Total:            | 80   | 147.7 | 12.8 | 304.75 | 158.7 | 195.6 |

Fish for consumption are mainly reared in cage farms. The biggest cage farm in the country is located at the Kardzhali dam, where water temperature throughout the greater part of the year is 20-23 °C and the oxygen concentrations about 6 mg.L<sup>-1</sup>. During the second year of rearing, the Russian sturgeon reaches an average weight of 2-3 kg. During the third year, the males and the females are separated using ultrasound, when at an average weight of 4-5 kg. Sex determination without using ultrasound can be done during the fourth year, at a weight of 6-7 kg; when a white coating on the heads of maturing male fish is used as an indicator of sex dimorphism. The males are mostly used for consumption on the home market; the total quantity of fish from all sturgeon fish farms in the country sold was about 80 t. The females are reared to Sexual maturity in females occurs from 6 years old fish, but caviar is only produced from 9 year old fish. About 2-2.5 t of caviar is produced from beluga grown in aquaculture.

In 2003, the paddlefish (*Polyodon spathula*, Walbaum) was introduced into Bulgaria (Hubenov *et al.* 2004) because of its faster growth and high commercial value. It is mainly for rearing in the inland water bodies, mostly in reservoirs. During the first year

it can reach an average weight of 150-200 g, during the second, when reared in ponds or reservoirs it can reach more than 2 kg (Hubenova *et al.* 2007).

### *Legislative framework*

Active procedures on a legislation level concerning sturgeon species in Bulgaria were undertaken at the end of 1995, when the following laws, acts and orders came into force:

- Order by the Minister of Agriculture and Forestry and by the Minister of Environmental Protection and Waters from 2003, which binds the right for caviar export with the obligation to restock the Danube River with 30-120 sturgeon fingerlings against the export of one kg of caviar.
- The “Action Plan for Sturgeons in the Bulgarian Parts of the Danube River and the Black Sea” (Raikova *et al.* 2004), which was elaborated in 2004.
- The Law of Fisheries and Aquaculture (State Gazette, No. 94/11.2005). According to the Article 35, Paragraph 6 of this Law the catches by using bottom hooks from 01.12.2007 was forbidden.
- The Biodiversity Act (State Gazette from 10.2005), Appendix 2 and 3 have included the ship sturgeon and the Atlantic sturgeon as endangered species and their catches have been forbidden.
- Order by the Minister of Agriculture and Forestry and by the Minister of Environmental Protection and Waters from 2006, which disallows sturgeon catches in the Bulgarian Black Sea.
- Order by the Minister of Agriculture and Food Supply and by the Minister of Environmental protection and Waters for moratorium of sturgeon catches for a period of 8 years in the Bulgarian section of the Danube River implemented since May 2008.

From an international aspect the following events and acts have been carried out:

- Meeting of the Black Sea countries on protection and sustainable management of the sturgeons populations in the Black Sea Basin organized by CITES Secretariat and the Ministry of Environmental Protection and Waters in Bulgaria, in 2001;
- Regional Strategy for sturgeon management developed by Bulgaria, Romania, Serbia & Montenegro and the Ukraine in 2003;
- In November 2005 the Government of the USA banned import of beluga caviar from the countries of the Danube, the Black Sea, and the Caspian Sea regions (Bulgaria, Georgia, Rumania, the Russian Federation, Serbia & Montenegro, Turkey and the Ukraine);
- National Action Plan for sturgeon management in fishing waters by Serbia & Montenegro (Lenhardt, Hegedis & Jaric (2005);
- 10-year catch moratorium implemented since May 2006 by the Romanian Government;
- Action Plan for Conservation of Sturgeons in the Danube River Basin 2006.

The unfavourable status of sturgeon populations in the Danube River and the Black Sea was a result of a combined effect, including: over-exploitation, poaching, habitat loss and disruption of spawning migration (Bloesch *et al.* 2006). First data about the declining catches were reported at the beginning of the 20th century. One century later, catches have continued to decline because of increased fishing pressure resulting from improved fishing equipment and the increased number of fishermen. There are several reasons for the long-term delay of adequate measures and implementation for the protection and restoration of sturgeon stocks in that region: 1) the high economic value of sturgeon caviar and meat, and the great demand for them on the world market; 2) the policy of respective authorities in Bulgaria to protect the socio-economic status of sturgeon fishermen, but later analysis showed that despite the high profitability of this activity, only a small percentage of the people make their living from sturgeon.

We should also report that official statistics of catches are inaccurate. The Danube fishery statistics in Bulgaria, as well as the fisheries statistics as a whole, were destroyed for about 10 years during the transition period. There is also lack of data about poaching and these catches can exceed legal ones many times (Bacalbasa-Dobrovici & Patriche 1999; Vassilev & Pehlivanov 2003).

In the 10 years since the first activities to protect and conserve sturgeon populations were implemented there has been little positive effect on the status of sturgeon populations. The different instruments used by the Bulgarian authorities to regulate catches during the breeding season, such as gear restriction, minimum size requirements, restrictions imposed by CITES (such as the quotas for caviar) have not lead achieved the effect desired. One of the main reasons for this has been the considerable delay in the implementation of these measures. The former State Fisheries Inspectorate (now the Agency for Fisheries and Aquaculture) only managed to implement the Fishing Licensing System and to re-establish collection of data for the Danube River and the Black Sea fisheries in 1995. Now this process has been placed under the regulation of the Fisheries and Aquaculture Act (2005), and should be implemented more efficiently.

Serious attempts have been made to ban fishing by all Danube countries. A moratorium has been implemented since May 2006 by the Romanian Government and since May 2008 by the Bulgarian Government, under the Action Plan for the Conservation of Sturgeons in the Danube River Basin (2006). This might be the only means to avoid the complete extinction of sturgeons in the Danube River (Bloesch *et al.* 2006).

The results expected will not be seen quickly and the moratorium will only be effective if the poaching is terminated. However, there are some complications that remain, including insufficient staff and financial resources to control the ban on fishing and the prerequisite for export quotas for caviar from sturgeon aquaculture. This conceals the selling of caviar from wild fish populations on the market under the banner of farm production. Biochemical studies (gene markers) and adequate labelling and control of products will hopefully overcome these problems.

Sturgeon restocking activities in Bulgaria, during the last few years has not been systematic and the quantity of the released fish has not been enough. The estimated quantity of restocked juveniles has varied, but it has decreased during the last two years because of the zero-trade quotas for caviar export from wild populations. Insufficient wild bred stock at existing hatcheries in the country has prevent the production of

enough fingerlings for stocking and the production of stocking material is relatively expensive and requires financial support from the Government that is not forthcoming.

Sturgeon aquaculture has the capacity to solve this problem and an increase of sturgeon farming is the way to restore natural population coupled with reduction in fishing pressure. Also captive rearing of sturgeons is an alternative source of caviar for the market (Pikitch *et al.* 2005). However, considerable capital investment in research programmes directed towards increasing the efficiency of sturgeon production, enhancing the survivability of released individuals, tracing of survivability and migration of tagged specimens is also necessary.

In conclusion, this study shows the need for adequate measures to protect the stocks including: increasing the control on sturgeon protection on behalf of the authorized bodies IARA and the National Forestry Management, to stop poaching; increasing the quantities of restocking material mainly from beluga; tagging and estimating survival to different ages; increase production capacity and efficiency of farms; development of programme to support fish farms in the country to produce stocking material, for example through financial support by the Government, low-interest credits, structural funds financial support by the EC; protection of the regions where sturgeon spawn; investigations about sturgeon population status (age-and size structure); use of genetic tools to support identification of poached fish from aquaculture production. The strengthening and harmonization of the national legislation and the implementation of the Action Plan for Conservation of Sturgeons in the Danube River Basin should be directed towards achieving sustainable management and restoration of the natural habitats and migratory movements of the sturgeons. In conjunction with the existing national and international instruments, the action plan might provide important instruments and mechanisms to avoid the extinction of the sturgeons in the Danube River and the Black Sea.

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# Ecological status of inland waters of Muğla

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**Abstract** Muğla is located in the basins of Büyük Menderes, Dalaman and Eşen rivers and surrounded by the Mediterranean Sea in the South and the Aegean Sea in the West. Major water sources in the province are; Eşençay, Dalaman, Tersakan, Yuvarlak, Namnam, Dipsiz-Çine, Sariçay streams and rivers, Kocagöl and Köyceğiz lakes, and Bereket and Mumcular dam lakes. In this study, water quality features (physicochemical and biological) and fish fauna of these water sources were investigated and most of the sampling sites on these water sources were found in good status. 32 fish taxa (26 species and 6 subspecies) belonging to 15 families were found to be living in the region. Tourism activities, tourist-boat traffic, trout farms and gravel pits are threatening these sources. The sampling points with “good” status should be protected. Water management based on river basins should be developed and monitoring programmes for surface and ground waters must be achieved.

## Introduction

Water sources are among the most threatened habitat types. Urbanization, agricultural run off, greenhouse farming, untreated urban effluent, shipping and gravel pits have altered the landscape of Turkey for years resulting in a substantial loss of habitats and biodiversity. Recognizing that biodiversity as well as the functions and services provided by aquatic ecosystems have changed markedly, limnological studies now receive greater attention throughout Turkey. In Muğla province, lakes, especially Köyceğiz Lake, received more attention than running waters from limnologists (Yerli 1989; Özdemir *et al.* 1995; Buhan 1998). Köyceğiz Lake is influenced by several external factors such as sulfuric springs, Mediterranean seawater and a relatively strong and changing wind. The water body is divided in two layers of differing hydrology so the lake can be classified as meromictic (Kazancı *et al.* 1992). Besides natural lakes, dam lakes were also studied in the area (Yılmaz 2004; Özdemir *et al.* 2007).

Stressed systems by anthropogenic factors often show a reduction in species richness, with a change in the number of individuals within a species and a predominance of stress-tolerant species (Johnson *et al.* 2006). This change was used early in the 1900s by Kolkwitz and Marsson (1902) in the development of the Saprobien system to assess the effects of organic pollution on stream systems. A number of approaches have been developed to evaluate the ecological effects of stress on stream ecosystems, especially in the last two to three decades, (Metcalf 1989; Woodiwiss 1964; Chandler 1970; Lorenz *et al.* 2004). Ecosystem analysis using benthic environment and physical and chemical features together has recently been conducted on running waters in the study area (Kazancı & Dügel 2000; Barlas *et al.* 2001a; Barlas *et al.* 2002; Yorulmaz *et al.* 2003; Balık *et al.* 2005).

Also, detailed studies on freshwater fishes in the study area were carried out (Balık 1975; Balık 1995; Bogustkaya 1996; Bogustkaya 1997). Recent studies the fish fauna of inland waters of Muğla were examined (Barlas *et al.* 2000; Özdemir *et al.* 2003; Dirican & Barlas 2004; Onaran *et al.* 2006). Yılmaz *et al.* (2000) and Yılmaz and Öğretmen (2001) studied the *Ladigesocypris ghigii*, an endemic species in Muğla area.

There are many legal instruments that relate to nature conservation in general. The Environment Law in 1983 and the related Decree-Law concerning the establishment and functions of the Ministry of Environment in 1991 are the major legal instruments regulating environmental conservation of Turkey. Instruction for Water Pollution Management (SKKY) was issued by the Council of Environment as a book in 1988 (Resmi Gazete 1998).

The EU recently passed legislation, the Water Framework Directive (WFD), focused on improving the ecological quality of inland and coastal waters (Water Framework Directive, 2000). The main objectives of the EU Water Framework Directive are protecting all waters, covering all impacts on waters, achieving good quality (good status) classes for all water bodies and water quality definitions in terms of biology, chemistry, hydrology and morphology (Hering *et al.* 2006). It is aimed to identify the quality classes and to determine ecological status of major water sources in Muğla province in this case study.

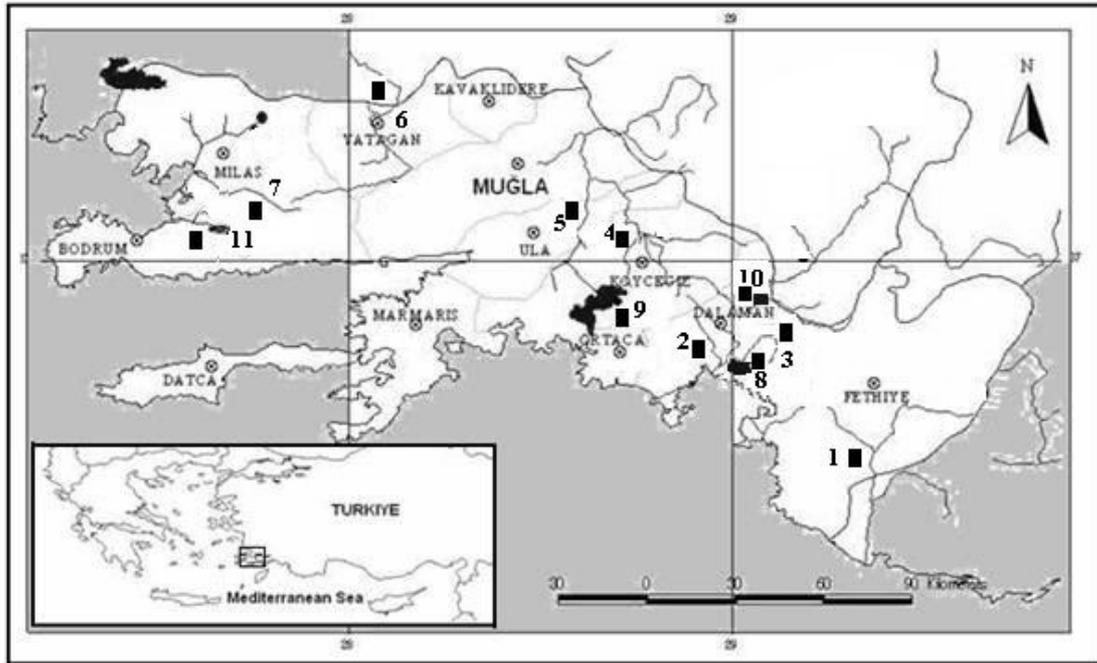
## Materials and methods

Muğla, located between 36° 17' and 37° 33' Northern latitude and 27° 13' and 29° 46' Eastern longitude, has 13 328 km<sup>2</sup> surface area and a very rough terrain. The province is located in the basins of Büyük Menderes, Dalaman and Eşen rivers and surrounded by the Mediterranean Sea in the South and the Aegean Sea in the West. Muğla province is rich in terms of freshwater sources with major water sources in the province being the Eşençay and Dalaman rivers and Köyceğiz Lake (Anonymous, 1998). In this study, ecological statuses of major water sources of the area were evaluated and the data used were obtained at certain intervals in the period between 1997 and 2007.

Physical-chemical metrics, representative of nutrient status (nitrogen and phosphorus fractions) and acidity (pH) status as well as oxygen conditions (dissolved oxygen and BOD<sub>5</sub>) and water hardness were measured for each site for all water bodies. Benthic macroinvertebrates were collected with a hand net (50X30cm; 500 µm mesh size) by sweeping the sampling site 100 m in length (Plafkin *et al.* 1989). On running waters, the number of sampling sites was chosen according to the size of the water body. Biological water quality classes were determined according to LAWA (1980). The fish samples were caught mainly by electro-fishing in the area of research; cast-nets and fishing lines were also used when required. The fish samples collected were fixed by 4% formaldehyde solution in the field.

In total, 58 sites were sampled on major waters sources in the study area at certain intervals in a ten year period (Fig. 1). The streams used in this study were classified into three groups; small sized streams (0-49 km long), middle sized streams (50-99 km long) and large sized streams (100-150 km long). Lakes were classified into three groups according to their surface area; small sized lakes (0-150 ha), medium sized lakes (150-250 ha) and large sized lakes (≤250 ha) (Tables 1 & 2).

The ecological quality of each sampling site was pre-classified based on physical, chemical and biological data, expert judgment of the field researchers having sampled the water sources and the additional knowledge derived from previous studies on these water sources.



**Figure 1.** Study Area and Stations; 1-Eşençay River 2-Dalaman River 3- Tersakan Stream 4- Yuvarlakçay Stream 5- Namnam Stream 6- Dipsiz-Çine River 7- Sarıçay Stream 8- Kocagöl Lake 9- Köyceğiz Lake 10- Bereket Dam Lake 11- Mumcular Dam Lake

**Table 1.** Overview of sites on running waters

| Stream name        | Length (km) | Stream type  | Location          | Number of sites |
|--------------------|-------------|--|-------------------|-----------------|
| Eşençay River      | 146         | Large sized stream, flows up to Mediterranean sea                      | Fethiye           | 7               |
| Dalaman River      | 120         | Large sized stream, flows up to Mediterranean-Aegean sea (border line) | Gölkhisar-Dalaman | 7               |
| Tersakan River     | 30          | Small sized stream, flows up to Mediterranean sea                      | Dalaman           | 4               |
| Yuvarlakçay Stream | 14          | Small sized stream, flows up to Köyceğiz Lake                          | Köyceğiz          | 4               |
| Namnam Stream      | 30          | Small sized stream, flows up to Köyceğiz Lake                          | Ula-Köyceğiz      | 3               |
| Dipsiz-Çine River  | 88          | Medium sized stream, flows up to Büyük Menderes stream                 | Yatağan-Aydın     | 7               |
| Sarıçay Stream     | 50          | Medium sized stream, flows up to Güllük Bay-Aegean sea                 | Milas             | 3               |

**Table 2.** Overview of sites on lakes

| Lake name | Surface area(ha) | Lake type  | Location | Number of sites |
|-----------|------------------|--|----------|-----------------|
| Kocagöl   | 249              | Medium sized oligotrophic natural lake flows up to Mediterranean sea | Dalaman  | 3               |
| Köyceğiz  | 5400             | Large sized natural lake flows up to Aegean sea by a 8 km channel    | Köyceğiz | 7               |
| Bereket   | 120              | Small sized dam lake for energy production on Dalaman river          | Dalaman  | 4               |
| Mumcular  | 143              | Small sized dam lake for water supply both drinking and agricultural | Bodrum   | 5               |

Each site was assigned to one of the five quality classes (high, good, moderate, poor and bad) referring to the physical-chemical and biological water quality methods and expert judgments. On running waters Sabrobien system (LAWA 1980) was used to evaluate the biological water quality and The Book of Instruction for Water Pollution Management issued by the Council of Environment (SKKY) was used for physical and chemical water quality. On lakes, only physical and chemical water quality was determined according to The Book of Instruction for Water Pollution Management (1988).

#### *Fish Farming on Inland Waters of Muğla*

Inland waters of Muğla have an important potential in terms of fish farming of trout. This also helps to show the ecological water quality of water sources, but all these fish farms are located in upper parts of inland waters. On Eşençay River there are 38 medium sized fish farms with a capacity of 5546  $t yr^{-1}$  achieved. On Dalaman River there are two fish farms with the capacity of 125  $t yr^{-1}$ . On Yuvarlakçay stream there is a fish farm with a capacity of 900  $t yr^{-1}$ . On Namnam stream there is one fish farm with a capacity of 150  $t yr^{-1}$  and on Sarıçay stream there is a fish farm with a capacity of 100  $t yr^{-1}$ . In three farms around Milas fish farming on ground water is operated on ground ponds for culturing of sea origin species; Gilt-head bream and Sea bass with a capacity of 55  $t yr^{-1}$  (Table 3). In this study marine fish farms were not evaluated.

## **Results**

Most of the sites on water sources were of 'good' status. Biological water quality classification results were parallel to physical and chemical water quality classification (Table 4).

On the Eşençay River, six of seven sampling points along the stream were in high quality status, only the sixth site was found to be good quality status according to Instruction for Water Pollution Management (SKKY). According to biological water quality, the fifth site was in high status, the sixth site in moderate status and others were in good status. On the Dalaman River, according to both Sabrobien system and SKKY the third and seventh stations were found in moderate status while the others were all

classified as good status. All three stations on Tersakan Stream were found in good status according to both classification systems. The first station on Yuvarlakçay stream was labelled high status and the second station good status according to both systems. The third station was deemed to be of moderate status according to SKKY while it was found poor status according to Sabrobien system. The last station was labelled as moderate status according to both classifications systems.

**Table 3.** Fish Farming on inland waters of Muğla

| Locality           | Number of farms | Annual Capacity ( $T_{yr^{-1}}$ ) |
|--------------------|-----------------|-----------------------------------|
| Eşen River         | 38              | 5546                              |
| Dalaman River      | 2               | 125                               |
| Yuvarlakçay Stream | 1               | 900                               |
| Namnam Stream      | 1               | 150                               |
| Sarıçay Stream     | 1               | 100                               |
| Ground ponds       | 3               | 55                                |
| Total              | 46              | 6876                              |

**Table 4.** Ecological status of stations on inland waters of Muğla

| Water source   | Method    | 1 st.    | 2 st.    | 3 st.    | 4 st.    | 5 st. | 6 st.    | 7 st.    |
|----------------|-----------|----------|----------|----------|----------|-------|----------|----------|
| Eşençay R.     | Saprobien | Good     | good     | good     | good     | high  | moderate | good     |
|                | SKKY      | High     | high     | high     | high     | high  | good     | high     |
| Dalaman R..    | Saprobien | Good     | good     | moderate | good     | good  | good     | moderate |
|                | SKKY      | Good     | good     | moderate | good     | good  | good     | moderate |
| Tersakan S.    | Saprobien | Good     | good     | good     |          |       |          |          |
|                | SKKY      | Good     | good     | good     |          |       |          |          |
| Yuvarlakçay S. | Saprobien | High     | good     | moderate | moderate |       |          |          |
|                | SKKY      | High     | good     | poor     | moderate |       |          |          |
| Namnam S.      | Saprobien | Good     | good     | moderate |          |       |          |          |
|                | SKKY      | Good     | good     | moderate |          |       |          |          |
| Dipsiz-Çine R. | Saprobien | moderate | good     | moderate | good     | good  | high     | good     |
|                | SKKY      | good     | good     | good     | good     | good  | good     | moderate |
| Sarıçay S.     | Saprobien | moderate | moderate | Poor     |          |       |          |          |
|                | SKKY      | good     | moderate | poor     |          |       |          |          |
| KocagölL.      | SKKY      | moderate | moderate | poor     |          |       |          |          |
| Köyceğiz L.    | SKKY      | moderate | moderate | poor     | moderate | poor  | moderate | moderate |
| Bereket D. L.  | SKKY      | good     | good     | good     | good     |       |          |          |
| MumcularD.L    | SKKY      | good     | good     | good     | good     | good  |          |          |

According to both systems the first and second stations on the Namnam stream were found as good status where as the third was found to be of moderate status. The first and third stations on the Dipsiz-Çine River were found in moderate status, the sixth station was found in high status and the others were found to be of good status according to Sabrobien system. According to SKKY only the last station was found in moderate status while the others were found in good status. According to the Sabrobien system the first and second stations were found in moderate status and the last was found to be of poor status on the Sarıçay stream. According to the SKKY classification system used on the lakes; two of the three stations on Kocagöl Lake were deemed moderate status

where the remaining site was classified as poor status. On Köyceğiz Lake five of the stations were classified to be of moderate status and two of the stations were classified as poor. All the stations on Bereket and Mumcular Dam lakes were classified as having a good status.

#### *Freshwater fishes of inland waters of Muğla*

According to the results of the studies, 26 species and 6 subspecies belonging to 15 families are present in the research area. In terms of distribution of the fish species, it was found that 20 species live in Köyceğiz Lake, 14 species live in Dipsiz-Çine River and 12 species in Eşen River, 11 species in the rivers Tersakan and Yuvarlakçay, 10 species in Sarıçay River and less than 10 species, usually 6-7, are found living in the other rivers and 3-4 species in dam lakes. 13 species of the Cyprinidae family were determined in the region and 6 species of the Mugilidae family were found intensively in Köyceğiz-Dalyan area. *Salmo trutta macrostigma* (Duméril 1858), a natural trout, was observed at the upper zones of Eşen River. An endemic species, *Ladigesocypris ghigii* (Gianferrari 1927) was found living in Dalaman and Marmaris area. Exotic species like *Tilapia zilli* (Gervais 1848), *Carassius carassius* (Linnaeus 1758) and *Lepomis gibbosus* (Linnaeus 1758) were also found to be living in the Muğla province (Table 5).

#### **Discussion**

Assessing the ecological quality classes of water sources is a fundamental objective of Water Framework Directive (European Commission,2000). It is therefore important to identify the ecological status of water sources in Turkey. Some of the stations are identified in different quality classes according to the classification methods used. Biological water quality classification systems (Sabrobien system was used in this study) evaluate the presence of the organisms that reflects the ecological status but traditional systems only evaluate the physical-chemical features (SKKY was used in this study). The presence of organisms also depends on the benthic structure and morphology of the water bodies.

Gravel pits are one of the major impacts affecting running waters. On the sixth station of the Esen River there is a gravel pit and the stream body is damaged by this. The third station on the Dalaman River is moderately polluted by fish farming, but after the third station the situation has improved by the fast flow caused by the nature of the river bed. There is no pollution source on the Tersakan Stream. The high capacity trout farm (900 t yr<sup>-1</sup>) on the Yuvarlakçay stream affects the third and fourth stations; Dügel (1995) and Barlas et al. (2000), reported that the highest BOD<sub>5</sub> and nutrient levels, which reflects the organic pollution, among all the stations on the Yuvarlakçay was found on the station that was affected by the trout farm. The third station on the Namnam stream was affected by the gravel pit and the first station along the Dipsiz-Çine River was polluted by a restaurant and the small trout pond of the restaurant located near the station. The third station is polluted with the agricultural activity on the Dipsiz-Çine River. The Sarıçay stream is one of the most endangered water sources around Muğla, with its main problem resulting from the waste discharge of Milas.

**Table 5.** Fish taxa inhabiting inland waters of Muğla

| Stations<br>Fish species            | Esen R. | Tersakan R. | Yuvarlakçay | Nannam R. | Sarıçay R. | Dipsiz-Cine R. | Dalaman R. | Köyceğiz L. | Kocagöl L. | Mumcular D. L. | Bereket D. L. | Other Sources |
|-------------------------------------|---------|-------------|-------------|-----------|------------|----------------|------------|-------------|------------|----------------|---------------|---------------|
| <i>Anguilla anguilla</i>            | +       | +           | +           | +         | +          | +              | +          | +           | +          |                | +             |               |
| <i>Salmo trutta macrostigma</i>     | +       |             |             |           |            |                |            |             |            |                |               |               |
| <i>Leuciscus cephalus</i>           | +       | +           | +           | +         | +          | +              |            |             |            | +              | +             |               |
| <i>Leuciscus smyrnaeus</i>          |         |             |             | +         | +          | +              |            |             |            |                |               |               |
| <i>Barbus plebejus escherichi</i>   | +       | +           | +           | +         | +          | +              |            | +           |            |                |               |               |
| <i>Barbus capito pectoralis</i>     |         |             |             |           |            | +              |            |             |            |                |               |               |
| <i>Capoeta capoeta bergamae</i>     | +       | +           | +           | +         | +          |                |            | +           |            |                |               |               |
| <i>Ladigesocypris ghigii ghigii</i> |         | +           | +           | +         |            |                |            | +           |            |                |               |               |
| <i>Cyprinus carpio</i>              |         |             |             |           | +          |                |            | +           |            | +              |               | +             |
| <i>Carassius carassius</i>          | +       |             |             |           |            |                |            |             |            | +              |               | +             |
| <i>Pseudorasbora parva</i>          |         |             |             |           | +          | +              |            |             |            |                |               |               |
| <i>Alburnus orontis</i>             |         |             |             |           |            | +              |            |             |            |                |               |               |
| <i>Alburnoides bipunctatus</i>      |         |             |             |           |            | +              |            |             |            |                |               |               |
| <i>Vimba vimba tenella</i>          |         |             |             |           |            | +              |            |             |            |                |               |               |
| <i>Cobitis taenia</i>               |         |             | +           |           | +          |                |            | +           |            |                |               |               |
| <i>Cobitis simplicispina</i>        |         | +           |             |           |            | +              |            | +           |            |                |               |               |
| <i>Orthrias angorae</i>             |         |             |             |           | +          | +              |            | +           |            |                |               |               |
| <i>Aphanius fasciatus</i>           |         |             |             |           |            |                |            | +           |            |                |               |               |
| <i>Siluris glanis</i>               |         |             |             |           |            |                |            | +           |            |                |               |               |
| <i>Mugil cephalus</i>               | +       | +           |             |           |            |                | +          | +           | +          |                | +             |               |
| <i>Liza ramada</i>                  | +       | +           | +           |           |            |                |            | +           |            |                |               |               |
| <i>Liza labeo</i>                   | +       |             |             |           |            |                |            | +           |            |                |               |               |
| <i>Liza aurata</i>                  |         |             |             |           |            |                |            | +           | +          |                |               |               |
| <i>Liza saliens</i>                 | +       |             |             |           |            |                |            | +           |            |                |               |               |
| <i>Chelon labrosus</i>              |         |             |             |           |            |                | +          | +           |            |                | +             |               |
| <i>Tilapia zilli</i>                |         |             | +           |           |            |                |            | +           |            |                |               |               |
| <i>Blennius fluviatilis</i>         | +       | +           | +           |           |            |                |            |             |            |                |               |               |
| <i>Gobius ophicephalus</i>          |         | +           | +           |           |            |                |            |             |            |                |               |               |
| <i>Gambusia affinis</i>             |         | +           | +           |           | +          | +              |            | +           |            |                |               |               |
| <i>Lepomis gibbosus</i>             |         |             |             |           | +          | +              |            |             |            |                |               | +             |
| <i>Morone labrax</i>                |         |             |             |           |            |                |            | +           |            |                |               |               |
| <i>Atherina boyeri</i>              | +       |             |             |           |            |                |            | +           |            |                |               |               |
| Total                               | 12      | 11          | 11          | 6         | 10         | 14             | 3          | 20          | 3          | 3              | 4             | 3             |

Kocagöl Lake has an oligotrophic character because of its geological structure. The mixture of sea water and the presence of H<sub>2</sub>S were detected on the deepest station on Kocagöl Lake. Köyceğiz Lake is the most important water body of the inland waters of Muğla. The main causes of ecological problems include; tourism activities, tourist-boat traffic and agricultural activities. The trout farm on the Yuvarlakçay stream also affects Köyceğiz Lake because this stream is the principle water source that feeds the lake. Because of its importance to tourism, 491 tourist boats belonging to 6 agents were licensed here and another 100 tourist boat are on duty without license. There is intensive agricultural activity (green housing and citrus fruits) around Köyceğiz Lake with most of the farmers using significant amounts of chemicals (mainly pesticides and fertilizers) to earn more.

All stations on Bereket and Mumcular Dam Lakes were in good status and their status should be kept. We can conclude that Muğla area can be regarded rich in terms of fresh

water fish fauna. However, gravel pits, agricultural, tourist and urban activities have negative impacts on the habitat of the species.

As a result, gravel pits on inland waters must be controlled and this control should be maintained. Fish farms must be allowed for extensive farming. The discharge on Sarıçay stream must be prevented. The tourist-boat traffic and agricultural activities on Köyceğiz Lake should be controlled and monitored and tourist boats working by solar energy must be supported. Use of chemicals in agriculture must be under a strict control and monitoring programmes need to be developed for inland waters of Muğla. Governmental and non-governmental foundations must work together to protect inland waters, covering all impacts on waters to achieve good quality ('good status') classes and apply water quality definitions in terms of biology, chemistry, hydrology and morphology.

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# **Preliminary study on the status of sturgeon populations (*Acipenser* sp) in the South Eastern Black Sea Coast (Kızılırmak-Yeşilirmak Basin) in the early 21<sup>st</sup> century**

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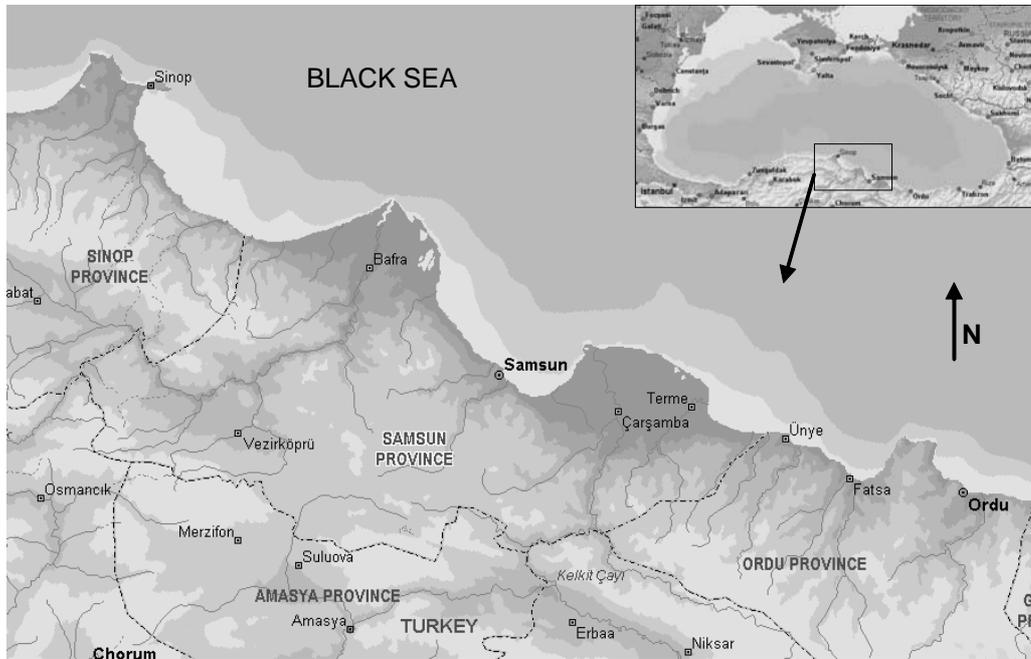
**Abstract** The Kızılırmak and Yeşilirmak regions were the most important spawning areas of anadromous sturgeons in the Black Sea coast of Turkey until the end of 1980s. Since then, four hydroelectric and irrigation dams were built on these rivers and they blocked spawning migrations and destroyed spawning habitat of sturgeons. However, overfishing of sturgeon for caviar production at the river mouth caused a dramatic decline of stocks in the second half of the 20th century. Nowadays, sturgeon are extremely rare in the South Eastern Black Sea and they are listed under CITES as an endangered species. This study gives information about the current status of sturgeon populations (*A. stellatus*, *A. gueldenstaedti*, *Huso huso*) around the Black Sea coast of Turkey between 2004 and 2008 based on accidentally captures in different fishing nets and from illegal marketing in the early 21st century. It is recommended a management strategy is implemented for the Yeşilirmak Basin to protect and recover the sturgeon populations.

## **Introduction**

Sturgeons were fished intensively in the Yeşilirmak-Kızılırmak basin (Samsun) between 1940 and 1970 with catches up to 150 t in some years, but these have declined gradually due to the overfishing, pollution and the construction of two dams on these rivers since the 1980s (Çelikkale *et al.* 2004; Ustaoglu and Okumuş 2004) and today they are near extinction. As a result, a legal arrangement was put into place in 1973 to ban sturgeon fishing in mouths of rivers flowing into the Black Sea (Anon 1975). As from 1977, catches of all sturgeon species bigger than 140 cm except *Huso huso* were banned (Anon 1977). This status was kept until 1997. After 1997, all the species were protect (Anon 1997). Since the beginning of the 1990s sturgeon populations have become critically endangered but they are still being fished. In the Yeşilirmak-Kızılırmak basin they are captured as a bycatch in bottom trawls and the individuals > 1.5-2 kg are marketed illegally. This study examines habitat-population interactions and fishing of sturgeon in the Yeşilirmak-Kızılırmak basin which is an important spawning and feeding area for the Turkish Black Sea basin.

## **Materials and methods**

This study was conducted in the Samsun fishing area, in the middle of the Black Sea, between 2004 and 2007. This area is located along the middle of the Black Sea coast of Turkey; between  $37^{\circ}47' L, 41^{\circ}09' N$  east and  $35^{\circ}57' E, 41^{\circ}47' N$  west (Fig. 1). The continental shelf into which the Yeşilırmak and Kızılırmak rivers discharge is situated between Ünye and Bulancak in the east, Sinop and Gerze in the west and the river areas in which the sturgeons historically migrate most frequently for spawning are along the southern coast of the Black Sea. The Yeşilırmak and Kızılırmak rivers have been heavily degraded by human activities since 1980. The region is an important trawl fishing ground and the other fishing occurs (Zengin 2006). Despite the area being an important fishery, it is more productive than other regions with regard to benthic macro fauna. This is because the continental shelf of the Southern Black Sea coast is generally very narrow and around Samsun, deposits from the rivers Kızılırmak and Yeşilırmak have created extensive shallow grounds. These shallow grounds support productive benthic macro fauna which support the fish stocks. There is reason to believe, however, that intensive trawling in this region has a negative effect upon spawning grounds and regeneration of a range of species (Knudsen & Zengin 2006).



**Figure 1.** Study area.

Data were provided from different sources; mostly by indirect ways since sturgeon fishing is forbidden by Turkish authority. A strong cooperation and communication network (fax, telephone, website, email) was set up between fisheries cooperatives, fishermen and researchers to report accidental catches of alive or dead fish. “Local contact persons” in Provincial and District Directorates of MARA Samsun, Ordu, Sinop cities were appointed. Direct observation was carried out monthly around feeding habitats and spawning migrations in the Yeşilırmak and Kızılırmak rivers.

Some live sturgeons were tagged and released at different locations (Hopa-Trabzon-Ordu-Samsun-Kızılırmak&Yeşilırmak basin-Sinop-Sakarya). The tags used were plastic

with special marks on (*number and address*). The tags were placed on the end of the dorsal fin. In order to ease collection of samples, small rewards such as t-shirts, caps, some fishing equipment and posters were offered. A total of 40 individuals were tagged between 2007 and 2008. The mean length and weight of tagged sturgeons released were 58.1 (37-91) cm and 895.9 (168-2900) g, respectively.

The reported and directly measured data were recorded on standard Survey- Information Registration forms. This form held information on; (1) date, (2) fishing zone (sea, river, fish market, store, and restaurant), (3) the fish sample (dead-alive), (4) fishing gear / fishing method, (5) the distance from coast, (6) fishing depth, (7) the fish species (morphological features were taken into consideration for identification of the fish species (Holcik 1989)), (8) total length, (9) body weight ,(10) sex (M/F), (11) gonad weight, (12) gonad maturation stages, (13) stomach content, (14) market price of the fish.

## Results

### *Species and seasonal distributions*

Three species were caught around the Yeşilırmak-Kızılırmak basins; *Huso huso* (44.3%), *Acipenser stellatus* (35%), and *Acipenser gueldenstaedti* (20.8%). In the early 1980s five species *H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio* and *A. nudiventris*. (Geldiay & Balık 1988; Edwards & Doroshov 1989) were reported around the Turkish Black Sea coast. *Acipenser sturio* was considered very vulnerable to fishing in the Kızılırmak-Yeşilırmak basin by Edwards and Doroshov (1989).

Bycatch of sturgeon species was higher in autumn, winter and spring than in summer (Table 1). This trend was mainly associated with intensive trawling, especially in Samsun during all seasons except the summer, and spawning and feeding migrations of the sturgeon towards the Southern Black Sea coast occur during the autumn, winter and spring periods.

**Table 1.** Seasonal distribution of the sturgeon species between 2004 and 2008 in the Kızılırmak-Yeşilırmak basin

| Seasons     | <i>A. gueldenstaedti</i> | <i>Huso huso</i> | <i>A. stellatus</i> | Total |
|-------------|--------------------------|------------------|---------------------|-------|
| Spring      | 8                        | 20               | 24                  | 52    |
| Summer      | 7                        | 6                | 5                   | 18    |
| Autumn      | 11                       | 11               | 10                  | 32    |
| Winter      | 5                        | 29               | 13                  | 47    |
| General (%) | 31 (20.8)                | 66 (44.3)        | 52 (35)             | 149   |

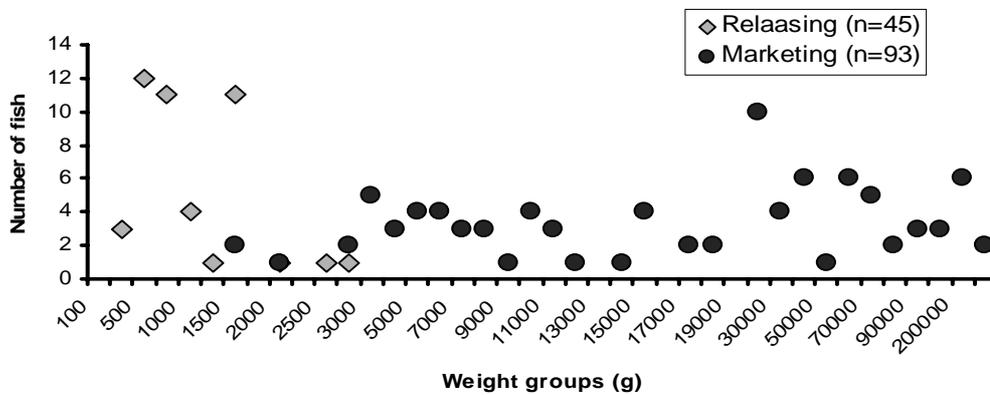
### *Illegal fishing and bycatch rates*

Fifty-five percent of the bycatch of sturgeon species was in commercial bottom trawl nets in Samsun. This was followed by gill-nets (35%) (bottom and pelagic). A small number were caught by encircling nets (5.4%), dredge nets (2%) and line and hook (2.6%). The trawl fishery operates along the Black Sea coast of Turkey and targets other fish species. (Knudsen & Zengin 2006). Gill-nets operate in the waters near the coast; note bottom gill-nets (demersal-benthic) are more destructive at catching sturgeon

than surface gill-nets. Fishing with encircling nets for bonito and Pacific mullet operate between September and December, and May and June, respectively. Almost all of the captured individuals in the river were caught by traps and heavy hook and line gear.

Sturgeons are mostly caught illegally or accidentally between October and April when commercial trawl fishing intensifies in the fishing grounds beyond 3 miles from the shoreline in the province of Samsun (Anon 2006). Most beluga (*H. huso*) are caught by bottom trawl nets (54.7%).

The majority of the accidentally caught sturgeons (65.4%) were sold illegally on local or public markets (Fig. 2). Although the sturgeons are caught accidentally, the high value of the flesh in large cities encourages the illegal sale of individuals larger 1.5-2 kg; the majority of fish released after capture were <2 kg, mainly *A. gueldenstaedti* and *A. stellatus*. Forty of the 62 individuals released to the sea were done so to determine bio-ecological characteristics of the species.



**Figure 2.** Distribution of the released and tagged sturgeons that were caught accidentally, in terms of weight s (pooled data; 2004-2008).

The price of sturgeon in local stores and luxury restaurants’ counters is 40-45 Turkish new liras (TRY)/ kg. The market is mainly *Huso huso* because the growth characteristics of the species (due to its larger size) and spawning and feeding migration behaviour from the northern Black Sea towards the south during the autumn–winter period mean it is caught and retained in the trawl fishery. Beluga sturgeons reaching weights of 250-300 kg are highly sought after and encourage sales.

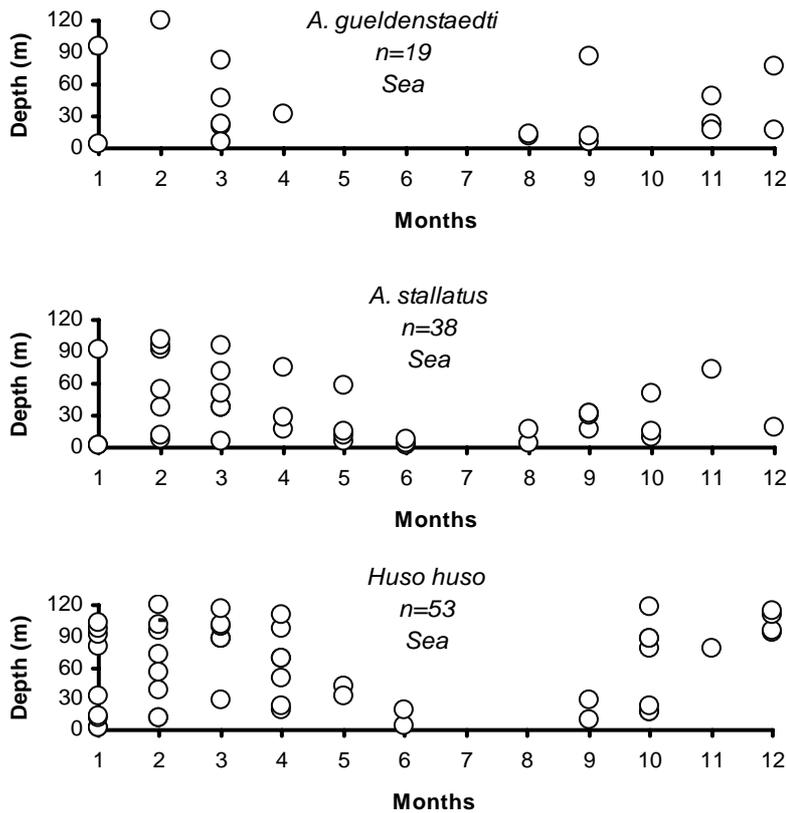
*Migrations: sea and river*

In the southern Black Sea, sturgeons are found as deep as 120 m with an average depth of 50.2 (2-123.3) m, but there is no evidence of seasonal variation in depth distribution (Fig. 3). All three species were mainly found between October and May. This may be related to fishing being banned in the region during the summer period. Adult populations move towards the river mouth during the spring period (April- May) as they migrate into the fresh water (river). Nine individuals were reported from the Yeşilirmak River in the studies on Yeşilirmak-Kızılırmak Rivers between the 2004-2008 years, but none was reported from the Kızılırmak River; four individuals were *A. gueldenstaedti*

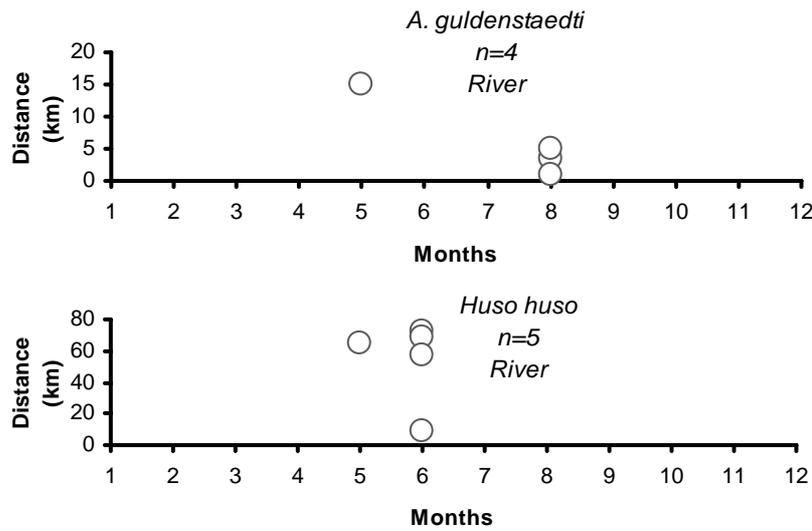
and five *Huso huso* (Fig. 4). The fish were sexually mature, except for two *A. Gueldenstaedti*, observed in August some 55-56 km upstream near the Hasan Uğurlu Dam and Hydroelectric Power Station.

### Length-weight relation

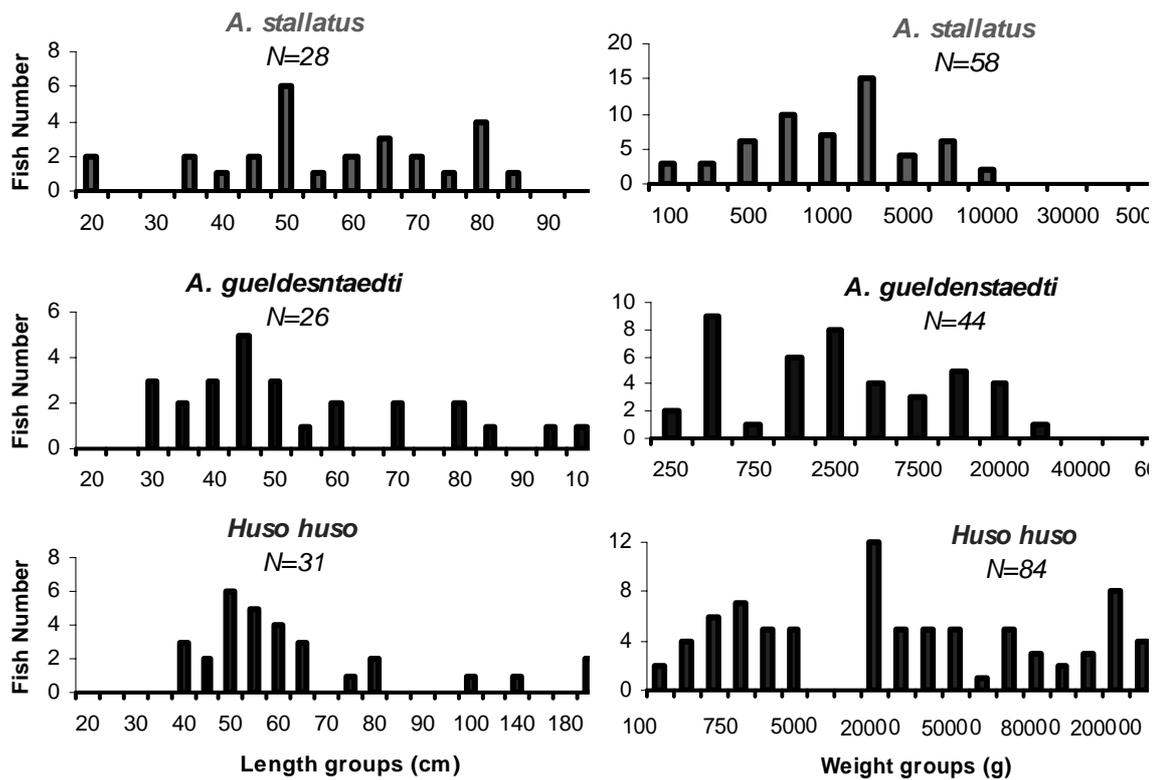
The length weight relation parameters for the sturgeon species are given (Table 2). The majority of fish caught were in the range of 30-80 cm, but with an average length of 60.1 cm for *A. stellatus*, 78.0 cm for *Huso huso* and 78.7 cm as for *A. gueldenstaedti*, equivalent to 1967.6, 52752.1 and 7569.9 g, respectively. The maximum size of *H. huso* was 395 cm (353 kg) compared with 100 (10 kg) and 200 cm (60 kg), respectively for *A. stellatus* and *A. gueldenstaedti* (Fig. 5). The differences in the length and weight parameters of these species, were due to differences in growth characteristics; the length weight coefficient  $b$  was higher than 3 for *H. huso* indicating allometric growth, suggesting this species increases proportionally more in weight more than length as it gets larger. Length and weight composition for each species in the Southern Black Sea are similar to the Northwest Black Sea-Danube delta at 100-120 cm (6-8 kg), 150-200 cm (40-70 kg) and 200-256 cm (145-400 kg) respectively for *A. stellatus*, *A. gueldenstaedti* and *H. Huso* (Vassilev & Pehlivanov 2003; Ciolac & Patriche 2005).



**Figure 3.** Monthly vertical distributions of the sturgeon's populations in the Kızılırmak-Yeşilirmak littoral.



**Figure 4.** Monthly migration of the sturgeon's population in the Yeşilırmak river (distance is from river mouth to sampled localities).



**Figure 5.** Length and weight compositions of sturgeon in the Kızılırmak-Yeşilırmak basin (2004-2008 period; pooled data).

**Table 2.** Length weight relationship parameters for sturgeons (2004-2008 pooled data)

| Species                  | a      | b      | $r^2$  | n  | Length range (cm) | Weight range (g)     |
|--------------------------|--------|--------|--------|----|-------------------|----------------------|
| <i>A. gueldenstaedti</i> | 0.0037 | 3.0609 | 0.9552 | 26 | 78.7 (40-200)     | 7569.9 (217.7-60000) |
| <i>A. stellatus</i>      | 0.0031 | 3.0081 | 0.7513 | 26 | 60.1 (37-100)     | 1967.6 (125-10500)   |
| <i>Huso huso</i>         | 0.0007 | 3.4665 | 0.9506 | 31 | 78.0 (40-359)     | 52752.1 (196-353000) |

*Reproductive behaviour*

Observations on spawning migrations were limited (Table 3): (1) reproduction migration was observed only in the Yeşilirmak River and its shelf area; (2) adult sturgeons (*Huso huso*, and *Acipenser gueldenstaedtii*) migrate in spring and early summer in this river (similar to the Danube; Ciolac & Patriche 2005); (3) all fish caught had mature gonads - immature and early maturity stages were generally found in the sea. Although adult sturgeons were found in the Yeşilirmak River, no evidence of spawning was found based larvae and juvenile surveys. It is possible mature fish return to the sea without any finding suitable spawning opportunities and suitable habitat. This is because dams on the Yeşilirmak and Kızılırmak rivers now block access to the most important areas for spawning, especially on the Kızılırmak River where three barriers/dikes have been constructed on different sections for flood prevention along the Bafra plain. This situation is less impacting on the Yeşilirmak River with no barriers on the first 65 km stretch from the river mouth. Also the stream bed in the Yeşilirmak, across the Çarşamba flat, is a deeper and larger delta area than in the Kızılırmak. However, increasingly unfavourable environmental conditions and illegal catching on the river prevent fish from spawning.

**Table 3.** Reproduction parameters for sturgeon populations in the Kızılırmak-Yeşilirmak basin (TL: total length, W: body weight, GW: gonad weight)

| Species                  | Date     | Locality   | Habitat | Depth (m) | TL-W (cm-kg) | Sex | GW (g) | Gonad maturity stage |
|--------------------------|----------|------------|---------|-----------|--------------|-----|--------|----------------------|
| <i>A. gueldenstaedti</i> | 15.3.05  | Yakakent   | Sea     | 21        | 150-14.5     | F   | 2000   | Immature             |
|                          | 15.4.05  | Kızılırmak | Sea     | 18.3      | 200-30       | F   | 3600   | Early mature         |
|                          | 22.8.05  | Yeşilirmak | Sea     | 12        | ?-10         | M   | ?      | ?                    |
|                          | 1.1.05   | Yeşilirmak | Sea     | 12        | ?-20         | M   | ?      | ?                    |
|                          | 10.4.07  | Kızılırmak | Sea     | inshore   | ?-27         | F   | 5000   | Early mature         |
|                          | 9.5.07   | Yeşilirmak | River   | -         | 170-60       | F   | 9700   | Mature               |
|                          | 14.5.07  | Yeşilirmak | River   | -         | ?-70         | F   | 8500   | Mature               |
|                          | 24.10.07 | Samsun     | Sea     | -         | ?-25         | F   | 8000   | Early mature         |
|                          | 25.11.07 | Samsun     | Sea     | -         | ?-25         | F   | 3500   | Early mature         |
|                          | 2.12.07  | Dereköy    | Sea     | 77.8      | 107-5.5      | F   | 92     | Immature             |
| <i>A. stellatus</i>      | 27.12.07 | Samsun     | Sea     | -         | ?-21         | F   | ?      | Immature             |
|                          | 25.3.05  | Terme      | Sea     | 95.2      | 80.2-2       | F   | ?      | Immature             |
|                          | 26.4.07  | Samsun     | Sea     | inshore   | ?-6.5        | F   | 2800   | Mature               |
|                          | 16.4.05  | Kızılırmak | Sea     | 50.3      | ?-18.7       | F   | 2700   | Immature             |
|                          | 2.6.05   | Yeşilirmak | River   | -         | ?-77.5       | F   | 16000  | Mature               |
|                          | 15.2.06  | Yeşilirmak | Sea     | 73.2      | ?-150        | F   | ?      | Immature             |
| <i>Huso huso</i>         | 18.2.06  | Terme      | Sea     | 104.3     | ?-300        | M   | ?      | Immature             |
|                          | 10.5.07  | Yakakent   | Sea     | 32        | ?-60         | M   | ?      | Immature             |
|                          | 16.5.07  | Yeşilirmak | River   | -         | ?-36         | F   | ?      | Mature               |
|                          | 16.6.07  | Yeşilirmak | River   | -         | ?-42         | F   | 7400   | Mature               |
|                          | 3.12.07  | Kızılırmak | Sea     | 93.3      | 220-90       | F   | 2152   | Immature             |
|                          | 26.1.08  | Terme      | Sea     | 110       | 265-152      | F   | 2873   | Immature             |
|                          | 24.2.08  | Terme      | Sea     | 100.7     | 359-353      | F   | 18500  | Immature             |

### Feeding habits

The stomach contents of sturgeons from throughout the southern Black Sea littoral suggest they feed on benthic and benthopelagic macrofauna (Table 4). A variety of factors such as; feeding ground characteristics, season, water temperature, food availability (Polyaninova 1996) and predator species determine feeding behaviour. While *H. Huso* feeds in the benthopelagic (horse mackerel, whiting, and gobies) and pelagic (anchovy), *A. Gueldenstaedti* feeds on crustaceans and molluscs in the benthic. The diet of beluga was predominantly anchovy (Berg 1948) reinforcing the impression that this species is connected with the anchovy autumn-winter migration along the southern Black Sea. On the contrary, *A. gueldenstaedti* shows a feeding strategy depending on benthic (Table 4) (Berg 1948; Zolotarev *et al.* 1996).

### Discussion

Historically, few studies have been performed on the abundance and distribution and bio ecology sturgeon in the southern Black sea coast. There is a study on taxonomic features of the sturgeon species distributed in a region (Geldiay & Balık 1988). Edwards & Doroshov (1989) compared habitat-population-migration and fishing relations of sturgeon populations in the early 1980s with the 1940s. Accordingly, it is possible compare the status in the Kızılırmak-Yeşilirmak basin described in this paper with the period between 1940 and 1980, between 1980 and 2000, a period of transition in the market economy in Turkey. The features that designate the state of sturgeon populations for each period are given in Table 5.

**Table 4.** Some feeding parameters about on the sturgeon’s populations in the Kızılırmak- Yeşilirmak basin (TL: total length, W: body weight)

| Species                  | Date       | Locality | Habitat | Depth (m) | TL-W (cm-kg)         | Stomach contents            |                   |
|--------------------------|------------|----------|---------|-----------|----------------------|-----------------------------|-------------------|
|                          |            |          |         |           |                      | Prey name                   | Number-weight (g) |
| <i>A. gueldenstaedti</i> | 8.10.06    | Samsun   | Sea     | 7.5       | 71-1.6               | <i>C. gallina</i>           | 1-?               |
|                          | 2.12.07    | Dereköy  | Sea     | 77.8      | 107-5.5              | <i>C. gallina</i>           | 4-?               |
|                          |            |          |         |           |                      | <i>A. cornea</i>            | 1-?               |
|                          |            |          |         |           |                      | <i>M. galloprovincialis</i> | 1-?               |
|                          |            |          |         |           |                      | <i>C. crangon</i>           | 2-?               |
| 12.8.07                  | Yeşilirmak | River    | -       | 41.7-0.2  | <i>C. gallina</i>    | 1-?                         |                   |
| <i>Huso huso</i>         | 3.12.07    | Dereköy  | Sea     | 93.3      | 220-90               | <i>C. gallina</i>           | 1-?               |
|                          | 26.1.08    | Terme    | Sea     | 110       | 265-152              | <i>E. encrasicolus</i>      | 78-741            |
|                          |            |          |         |           |                      | <i>E. encrasicolus</i>      | 88-834.6          |
|                          |            |          |         |           |                      | <i>T. trachurus</i>         | 9-148.5           |
|                          |            |          |         |           |                      | <i>E. encrasicolus</i>      | 129-1225          |
| 24.2.08                  | Yeşilirmak | Sea      | 100.7   | 359-353   | <i>T. trachurus</i>  | 2-33.7                      |                   |
|                          |            |          |         |           | <i>M. m. euxinus</i> | 2-31.2                      |                   |
|                          |            |          |         |           | <i>G. niger</i>      | 3-29.1                      |                   |

Sturgeon stocks were overexploited in terms of both species number and amount from the early 1940s and stocks along the coast of Turkey are now included in the CITES “Endangered species” list (CITES 2006). Prior to construction of dams on the rivers in the late 1970s, 6 sturgeon species were found; *H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio*, *A. nudiventris*, *A. ruthenus* (Çelikkale 2004); the number of species

decreased to 4 at the end of the 1980s (*H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio* (Edwards & Doroshova 1989)), and 3 at the beginning of the 2000s (*H. huso*, *A. gueldenstaedti*, *A. stellatus*). Despite legal protection, sturgeon are still captured as bycatch in the trawl fishery in the Samsun region and sold illegally. In addition, gillnetting in the coastal areas and mollusc dredging increase pressure on the sturgeon stocks along the coast.

Along the southern coast of Turkey the main sturgeon species caught was the beluga in the Yeşilirmak-Kızılırmak littoral; most weighed between 100-350 kg but did not contain caviar. The majority of fish caught now are immature female *H. huso* suggesting that *H. huso* does not migrate for spawning to the rivers in this region. Instead it is likely that *H. huso* and *A. gueldenstaedti* migrate along the southern coast of the Black Sea in the autumn-winter to coincide with the pelagic anchovy migration followed by migration to the rivers for spawning. Further evidence of migration was gained from fish caught that had suture marks that were possibly the result of fish released after aquaculture experiments at Batum Oceanography and Fishery Institute, Georgia, and Kerch YugNiro Research Institute, Ukraine, before and after 2000 (Shlyakhov 2003). These aquaculture studies were performed on the mature individuals caught from the wild. Alternatively, the suture scars could be from fishes harvested for caviar via the surgical operation and returned to the wild.

Another indication in relation to the migration behaviours of the sturgeon species, distributed on the coast of the southern Black Sea is the results, gathered from the marking experiments. Further evidence of migration was gained from a marked individual *A. gueldenstaedti* weighing around 2 kg, caught on the Bulgarian coast at Galata on 10 December 2006; this fish was reared at Sapanca foundation, İstanbul University Faculty of Aquaculture and released at the mouth of the Sakarya River in July 2006. Also *A. gueldenstaedti* caught on the coast of the River Kızılırmak on 8 December 2006, one *A. stellatus* caught in the River Perşembe on 13 February 2007, one *H. Huso* caught at the mouth of the River Sakarya on 4 December 2007. were marked, released and recaptured 275 km west (143 days), 15 km east (9 days) and 4 km-west (2 days) respectively from the localities where they were released. Sturgeon population thus appear to exhibit long distance migration over in short time intervals.

Data on catch, population, habitat and migration characteristics migrate into the Yeşilirmak River to spawning; no data were available for the Kızılırmak River suggesting it is no longer used for spawning. It is crucial to create a conservation area below the first dam in the north of the Kızılırmak Rive and downstream of the Yeşilirmak basin and Çarşamba delta. The Yeşilirmak delta, wetland area in terms of freshwater fishes and bird variety, is under pressure from uncontrolled agriculture and urbanization and has not been conserved adequately, but an administration plan study has been started by the Ministry of Environment and Forestry for this region. Its actions include closing down the gravel extractions from the stream beds, assigning appropriate spawning areas over the river, and immediate rehabilitation of the stream bed.

Despite unfavourable ambient conditions and anthropogenic affects, the region provides valuable opportunities to recover the sturgeon stocks and effort must be put in to conserve these important, critically endangered species.

**Table 5.** Historically changes in the status of sturgeon populations in the Kızılırmak-Yeşilirmak basin

|                        |   |  |   |   |
|------------------------|---|--|---|---|
| I. PERIOD (1940-1980)  | <ul style="list-style-type: none"> <li>-No environmental degradations in the Kızılırmak and Yeşilirmak river basins</li> <li>-Low level of urbanization and population growth (Özesmi 1999).</li> <li>-No pollution</li> <li>-Dams not yet constructed</li> <li>- fishing technology not developed</li> <li>-Only 27 trawlers in the late 1970s (Knudsen &amp; Zengin 2006)</li> </ul>  | <ul style="list-style-type: none"> <li>-6 species exist and stocks exploited (<i>H. huso</i>, <i>A. gueldenstaedti</i>, <i>A. stellatus</i>, <i>A. sturio</i>, <i>A. nudiventris</i>, <i>A. ruthenus</i>) (Çelikkale <i>et al.</i> 2004)</li> <li>-Ongoing anadromous migration</li> </ul>                           | <ul style="list-style-type: none"> <li>-Primitive “<i>karmak/hook</i>” estuarine fishing</li> <li>-Fishing mainly between Feb. and Jun.</li> <li>-High price of caviar</li> <li>-Best capture fisheries between 1950s and 1970s (Öker 1956)</li> <li>-A little caviar export to Europe (DPT 1962)</li> </ul>  | <ul style="list-style-type: none"> <li>-First expert on caviar processing was invited from Germany (Anonym 1966)</li> <li>-First measures were taken to protect stocks and caviar production in 1960s (Çakıroğlu 1968)</li> <li>- Fishing first prohibited in estuaries in 1973</li> <li>-Fishing all species except <i>Huso huso</i> bigger than 140 cm prohibited in 1977 (Çelikkale <i>et al.</i> 2004)</li> </ul> |
| II. PERIOD (1980-2000) | <ul style="list-style-type: none"> <li>-Rapid urbanization, industrialisation and population growth</li> <li>-4 dams constructed on Kizilirmak and Yesilirmak</li> <li>-Bafra and Carsamba plains improved for cultivation (Özesmi 1999).</li> <li>-Rivers basin degradations started</li> <li>-High dikes constructed on Kizilirmak</li> <li>-Pollution increased</li> <li>-Fishing technology and effort increased after liberalisation in early 1980s</li> </ul> | <ul style="list-style-type: none"> <li>-Main species are <i>H. huso</i>, <i>A. sturio</i>, <i>A. stellatus</i> and <i>A. gueldenstaedti</i></li> <li>-Few migrate for spawning</li> <li>-Pressure on <i>A. sturio</i></li> <li>-Not many beluga over 250 kg contain caviar (Edwards &amp; Doroshova 1989)</li> </ul> | <ul style="list-style-type: none"> <li>-Illegal fishing and very low caviar production</li> <li>-Low productivity of fishing in estuaries</li> <li>-Spring fishing with so-called <i>morina nets</i></li> <li>-45 fishermen were active at the end of 1980s (Zengin <i>et al.</i> 1992)</li> <li>- Fishing effort increased (104 trawlers)</li> <li>-Big pressure on sturgeons due to illegal fishing and trawling (Knudsen &amp; Zengin 2006)</li> </ul> | <ul style="list-style-type: none"> <li>-Fishing banned for all species (Anon 1997)</li> <li>-The first experts invited from FAO to advise on stock enhancement (Edwards &amp; Doroshova 1989)</li> <li>-Insufficient and inefficient control mechanism</li> <li>-Caviar and flesh on black market</li> </ul>  |
| III. PERIOD (2000-)    | <ul style="list-style-type: none"> <li>- Serious degradation on rivers and estuaries</li> <li>-Intensive urbanization, industrialization and population growth</li> <li>-A new dam on Yesilirmak</li> <li>-Pollution originated from industrial, domestic and agriculture</li> <li>-Very high fishing effort</li> <li>-Demersal stocks collapsed in littoral zone (Knudsen &amp; Zengin 2006)</li> </ul>  | <ul style="list-style-type: none"> <li>-Very few specimens belonging 3 species (<i>H. huso</i>, <i>A. stellatus</i> and <i>A. gueldenstaedti</i>)</li> <li>-Reproduction migration only in Yeşilirmak river (This study)</li> <li>-Large beluga migrate for feeding depending on anchovy (This study)</li> </ul>     | <ul style="list-style-type: none"> <li>-Some catch occurs mainly in trawl fishing and gillnets as by-catch (This study)</li> <li>-123 trawlers (Knudsen &amp; Zengin 2006)</li> <li>-Ongoing black market for flesh from fish &gt; 1.5-2 kg</li> </ul>  | <ul style="list-style-type: none"> <li>-Under protection in CITES as endangered stocks (CITES 2006)</li> <li>-Insufficient protection and control measures</li> <li>-Little awareness in fishermen community for protection</li> <li>-Some civil initiative-MERKODER- and nationwide research projects-CFRI-started in early 2000s</li> </ul>   |

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## ***Ameiurus melas* (Rafinesque) – pest or possibility**

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**Abstract** Since the nineteenth century, numerous importations of North America catfishes for aquaculture have resulted in the spread of these species in European inland waters. After more than one hundred years, the negative impact of their introduction on natural ecosystems is evident. However, ictalurid catfishes are still reared in aquaculture, so the aim of this paper was to investigate the condition of reared and wild black bullhead. A total number of 296 specimens were collected from three different sites along the Tisza River, during October and November in 2005. In May 2006, 150 specimens were obtained from an aquaculture facility near Sombor, Serbia. Reared black bullhead specimens were 2+ year old, whilst wild specimens ranged in age from 1+ to 4+. Fulton's condition factor and length-weight relationships were compared. In addition, given that wild specimens were collected with different fishing gears (nets, electro-fishing, fishing rods and traps), the potential of different gears for efficient exploitation of these resources was investigated.

### **Introduction**

Biological invasions are common-place in nature (Lodge 1993), facilitated by climatic, geotectonic or other natural events. Nevertheless, human impacts on biodiversity through the introduction of alien species and eradication of indigenous species, is increasing. Introductions of exotic fish species in Europe were either intentional or unintentional, and motives ranged from aquaculture and improvement of wild stocks, ornamental purposes, for sport, biological control and accidental releases. Analyzing the relative importance of these categories, Welcomme (1988, 1991, 1992) found that introductions made for aquaculture purposes have always comprised a significant part of the total, and have steadily increased in importance. Since the early 1970s they have accounted for well in excess of 50% of all introductions made. Copp *et al.* (2005) defined the so-called "tens rule", which stated that only 10% of all introductions result in the establishment of viable populations, and only 10% of these established populations may be regarded as pests and weeds. However, there is increasing concern over the potential impact (adverse or beneficial) of introduced species on native species, ecosystems, local and national economies, and societies, through either direct or indirect effects (e.g. parasites or pathogens). Forty-four fish species native to the United States, are threatened by non indigenous fish species, with an additional 27 native fish species harmed by introductions (Piemental *et al.* 2000). Even if the economic benefits from the introduction of non indigenous fish through sport fishing for example are accounted for, conservative estimates put the economic loss due to exotic fish at more than \$1 billion annually (Piemental *et al.* 2000).

The family Ictaluridae contains five genera and 25 species restricted to North America and north-eastern Central America. They inhabit large rivers and slow flowing streams, lakes and ponds. In the nineteenth century, numerous importations of ictalurid catfishes were made to Europe. According to Wheeler (1978), the first introduction occurred in France in 1871, followed by Belgium (1884), then Germany and England (1885). The introduction of 50 specimens to water bodies in Germany in 1885 was the key event that led to their definitive acclimatization. Borne (1891, *cited in* Sotirov 1968) claimed: “I believe that now, in 1891, bullhead can be regarded as naturalized”. Most of these catfish introductions were claimed to be *Ameiurus nebulosus*, but Wheeler (1978) suggested that *Ameiurus melas* is now widespread in Europe. These two species are similar and often confused. Moreover, it is known that *A. melas* can hybridize with *A. nebulosus* (Boschung & Mayden 2004). This can explain the low tDNA divergence between these sister species (Hardman and Page 2003), although naturally occurring hybrids do not appear to be common in collections.

Across Europe, numerous dams were constructed for river regulation and as hydropower plants, which lead to water flow lag. Since black bullhead inhabits soft substrates of sluggish sections of creeks and rivers, as well as backwaters, channels, swamps and impoundments, this was excellent opportunity for further expansion of its range.

Ictalurid catfish were introduced to Serbian waters in two ways: firstly, they were released in Croatian fish-ponds before World War I, and secondly, their range expanded from northern neighboring countries through the rivers Danube, Tisza, Tamis and Begej. Bullhead acclimatization was rapid, with Koca and Protic (Sotirov 1968) indicating high abundances in the Danube-Tisza-Danube (DTD) channel. Karaman (1952 *cited in* Sotirov 1968) reported the presence of bullhead in open waters around Smederevo, while Jankovic (1965 *cit. in* Sotirov 1968) reported the expansion of their population in the Serbian part of the Danube. Finally, Sotirov (1968) concluded that over a 20-30 year period ictalurid catfish had successfully inhabited all lowland rivers in the north – Danube, Sava, Tisza, DTD channel, Begej, and that its expansion had reached relative stability in terms of geography and abundance as early as the 1940s.

Catches of black bullhead in Serbia are not negligible, but adopted commercial catch sorting techniques put them in “Mix I” and “Mix II” along with roach, nase and perch. It is therefore very hard to single out the specific contribution of this species to total catch values. Sotirov (1968) provided catch statistics of the “Šaran” fishing company from Novi Sad over the period 1959 – 1962. This data showed that the proportion of this species in the total catch ranged from 4% to 10%, depending on the year. Catches were highest in spring and autumn, presumably due to low water levels and decreases in water vegetation, which allows for the use of drift nets.

Taking into account everything previously mentioned, there is a rising question about the economic potential of black bullhead in Serbian waters. This species is still produced commercially throughout Europe, indicating a demand. The aim of this paper is to investigate and compare wild populations and reared ones and assess their “accessibility”.

## Materials and methods

During October and November 2005, 296 black bullhead specimens were caught in the Serbian part of the Tisza River (Fig. 1). A total of 115 specimens were caught on the “Dead Tisza channel” (N 45°28'32.88”, E 20°03'26.45”), on 10 October 2005, near Čurug, with cage traps (90x45x45cm). Despite the large number of traps laid in this area (6-10 traps/ha, as a tool for pest control), these specimens were taken from a single trap. From the “Yellow channel” sampling site (N 46°00'49.02”, E 20°00'26.45”), near Kanjiža, on 23 October 2005, 116 specimens were caught with 3 fishing rods. Professional fishermen caught 65 specimens on “DTD channel” (N 45°32'13.71”, E 20°01'00.45”), near Bačko Gradište using gillnets, during the period between 4 and 6 November 2005.

Reared specimens (n=150) were taken from “Alov” fish farm (N 45°48'17.40”, E 19°11'25.82”), near Sombor, on 26 May 2006.



**Figure 1.** Map of sampling sites: 1. “Alov” fish farm, Sombor (N 45°48'17.40”, E 19°11'25.82”), 2. “Yellow channel”, Kanjiža (N 46°00'49.02”, E 20°00'26.45”), 3. “DTD channel”, Bačko Gradište (N 45°32'13.71”, E 20°01'00.45”), 4. “Dead Tisza channel”, Čurug (N 45°28'32.88”, E 20°03'26.45”)

The age of black bullhead was determined by otolith examination. Otoliths were prepared according to adapted method of Secor *et al.* (1992), and they were analyzed by two independent researchers. Body mass ( $M$ ) was measured on electronic weighing scales ( $\pm 0.01$ g). A digital picture of each specimen was taken with Nikon CoolPix 4500 digital camera. Standard length ( $L_s$ ) was measured in Image Tool 3.00 ( $\pm 1$ mm).

Correlation and regression analysis of body length ( $L_s$  - standard length) and body mass, according to Ricker (1975), were performed on log transformed data for every sampling site. Fulton's condition factor ( $C$ ) was also estimated, according to the equation:

$$C = (M / L_s^3) \times 100$$

where  $M$  is body mass, and  $L_s$  is standard length. Correlation, regression and analysis of Fulton's condition factor were also performed on 90 specimens from the 2+ age class, from Sombor ( $n = 30$ ), Čurug ( $n = 30$ ) and Bačko Gradište ( $n = 30$ ). The sample from Kanjiža was excluded, as it predominantly consisted of 1+ age class.

For testing the hypothesis about the equality of the two population regression coefficients, we used the formula:

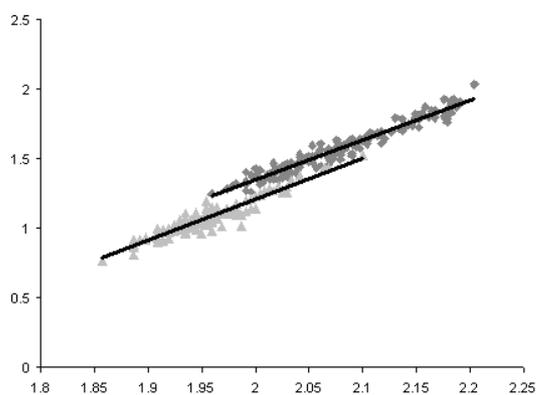
$$t = (b_1 - b_2) / S_{b_1-b_2}$$

where  $b_1$  and  $b_2$  are regression coefficients of the two populations and  $S_{b_1-b_2}$  is the standard error of the difference between regression coefficients (Zar 1984). The critical value of  $t$  for this test has  $(n_1-2) + (n_2-2)$  degrees of freedom.

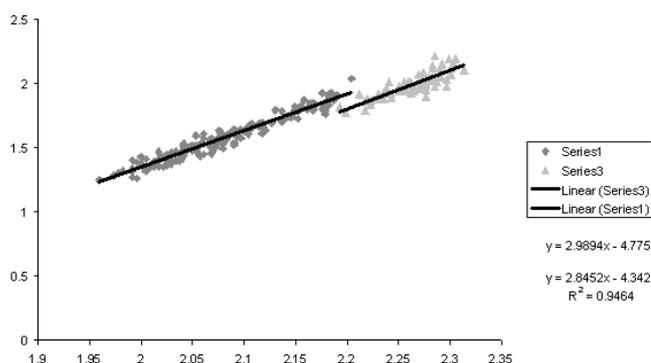
## Results



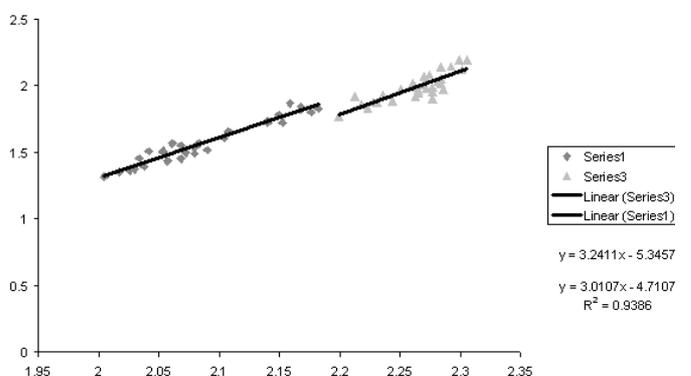
**Figure 2.** Difference in slope of two regression lines. Series1 (Sombor,  $n=150$ ); Series3 (Čurug,  $n = 115$ )



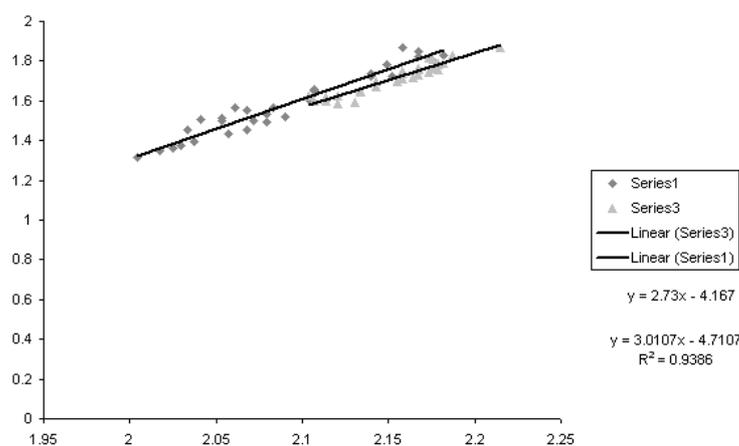
**Figure 3.** Difference in slope of two regression lines. Series1 (Sombor,  $n=150$ ); Series3 (Kanjiža,  $n = 116$ )



**Figure 4.** Difference in slope of two regression lines. Series1 (Sombor,  $n=150$ ); Series3 (Bačko Gradište,  $n = 65$ )



**Figure 5.** Difference in slope of two regression lines (2+ age class). Series1 (Sombor,  $n=30$ ); Series3 (Bačko Gradište,  $n = 30$ )



**Figure 6.** Difference in slope of two regression lines (2+ age class). Series1 (Sombor,  $n=30$ ); Series3 (Čurug,  $n = 30$ )

For age determination, otoliths were inspected, except for samples from Sombor fish farm, as they were all known to be in the 2+ age class. Otoliths from 66 Čurug's

specimens were inspected and it was concluded that specimens belonged to 1+, 2+, 3+ and 4+ age classes, with an average age value of 2.41. From the sampling site Kanjiža, otoliths from 39 specimens were inspected, and there were two age classes (1+ and 2+), although the average age value was 1.05. Age classes 2+ and 3+ were identified from the otoliths of 52 specimens from Bačko Gradište sampling site, with an average age value of 2.57.

Standard length ( $L_s$ ) for specimens from Sombor fish farm ranged from 91 to 160 mm, and body mass ( $M$ ) ranged from 17.68 to 108.43 g. The highest values for standard length and body mass belonged to the sample from Bačko Gradište, with 206 mm and 164 g respectively. Minimal values at this sampling site were  $L_s=156$  mm and  $M=58$  g. At the sampling site Čurug,  $L_s$  ranged from 93 to 169 mm, and  $M$  ranged from 16.17 to 87.55 g. The Kanjiža sampling site had the lowest values for both body length ( $L_s$ ) and body mass ( $M$ ). Range for  $L_s$  for this site is from 72 mm to 126 mm, and range for  $M$  is from 5.86 g to 33.48 g.

Log transformed data were used for correlation and regression analyses of body length and body mass. Coefficient of regression ( $b$ ) was highest at sampling site near Bačko Gradište ( $b=2.9894$ ), followed by the sampling site near Kanjiža ( $b = 2.9162$ ), Sombor ( $b = 2.8452$ ) and Čurug ( $b = 2.6453$ ). A comparison of the differences in slope of the two regression lines showed that there was a significant difference ( $P < 0.05$ ) between Sombor and Čurug (Figure 2), as well as between Sombor and Bačko Gradište (Fig. 4), with  $t$ -test values of  $t= 0.42277$  and  $t = 1.01001$ , respectively. There were no significant differences ( $P > 0.05$ ) between Sombor and Kanjiža sampling sites ( $t = 2.40247$ , Figure 3). For the 2+ age class, 30 specimens from each site were compared, except for the sampling site Kanjiža, as they were predominantly 1+ age class. At Sombor, 2+ specimens ( $n = 30$ ), have a  $b$  value 3.0107, with  $b$  equal to 3.2411 and 2.73 for Bačko Gradište and Čurug, respectively. T-test values  $t=0.54485$  (Sombor vs Bačko Gradište) and  $t = 0.18435$  (Sombor vs Čurug) show that there was a difference between these populations (Figs 5 & 6).

Specimens from Sombor fish farm had the highest value of  $C$  (2.1739), followed by Čurug ( $C = 1.80571$ ), Kanjiža ( $C = 1.63593$ ) and Bačko Gradište ( $C = 1.59863$ ). Furthermore, for the 2+ age class, 30 specimens from each site were compared, except sampling site Kanjiža. The value for  $C$  was highest at sampling site Sombor ( $C = 2.05819$ ), followed by Čurug ( $C = 1.78311$ ) and Bačko Gradište ( $C = 1.59746$ ).

## Discussion

The results obtained by this study suggest that commercial use of black bullhead from the wild could have economic potential. Specimens obtained from Kanjiža, in comparison with specimens from Sombor fish farm, show that there was no significant difference ( $p>0.05$ ) between the regression coefficients ( $b = 2.9162$  and  $b = 2.8452$ , respectively) of these populations. According to Ricker (1975), this  $b$  value shows that the food obtained by wild specimens was adequately nourishing, and that their increase in body mass was similar to reared specimens. However, these specimens were caught with fishing rods and they were mostly in the 1+ age class, in contrast to the 2+ specimens from Sombor. Nevertheless, this shows the potential for exploitation in this locality.

Specimens from other sampling sites (Čurug and Bačko Gradište), in comparison to specimens from Sombor, showed a significant difference ( $p < 0.05$ ) between regression coefficients ( $b = 2.6453$  and  $b = 2.9894$ , compared to  $b = 2.8452$ , respectively). Furthermore, this shows that the regression coefficient ( $b$ ) of specimens from Bačko Gradište was higher than that for the fish farm sample (Sombor). Comparison of the 2+ age class from sampling sites Sombor and Čurug, as well as Sombor and Bačko Gradište, showed that there was a significant difference ( $p < 0.05$ ) between regression coefficients ( $b = 3.0107$  to  $b = 2.73$  and  $b = 3.0107$  to  $b = 3.2411$ , respectively). However, specimens from sampling site “Bačko Gradište” again showed a higher coefficient ( $b$ ) than the ones from Sombor, which indicates that the increase in body mass is higher in wild specimens than in reared ones. This could also indicate that food composition is, perhaps, better in the wild than in the fish farm, so further investigation into the possibility of exploitation of the Bačko Gradište sampling site is needed.

Values of Fulton’s condition factor ( $C$ ), were higher for specimens from aquaculture ( $C = 2.1739$ ) than for the rest of sites, Čurug ( $C = 1.8057$ ), Kanjiža ( $C = 1.6359$ ) and Bačko Gradište ( $C = 1.5986$ ). Even for the 2+ age class, Fulton’s condition factor ( $C$ ) was higher for specimens from sampling site Sombor ( $C = 2.0582$ ), than for Čurug ( $C = 1.7831$ ) and Bačko Gradište ( $C = 1.5975$ ).

According to Željko Djanić (*pers. comm.*), working at “Alov” fish farm near Sombor, diseases that reduce number of reared specimens of black bullhead (especially in later age) are *Saprolegnia sp.* (during February), Picornaviruses (during May) and *Columnaris* bacteria (during July). It is very likely that these diseases also influence wild populations (at similar times of the year), as there are few reports of old wild *A. melas* and they mostly belong to 1+, 2+, 3+ and 4+ age classes. These findings could indicate that the best period for harvesting wild black bullhead would be at the end of summer and the beginning of autumn, when water levels are low and fish are generally larger following the summer growth period. Another issue to be addressed is the selection of appropriate and effective fishing gears. Standard gill nets, which were used at sampling site Bačko Gradište by professional fishermen, seem to be efficient in terms of body mass and body length selectivity. However, this catch was made over a period of two days. Fishing rods prove to be efficient, as demonstrated by the fact that authors managed to collect 116 specimens in just 3 hours. One drawback of this method is its selectivity of young age classes (predominantly 1+). Electric fishing proved to be ineffective when it was tested at Sombor (N 45°57’08.53”, E 20°04’30.36”). A total of only 10 specimens, with an age range of 0+ to 3+ were caught during a 3 hour period. It was therefore not used in this study. This finding is in accordance with Louette and Declerck (2006) who also suggested that the use of electric fishing and gill nets for mass removal of black bullhead are not appropriate. Perhaps the most efficient tool was fish traps. This type of trap is commonly used for pest control. When checked every 1-2 days, approximately 6-10 traps/ha can catch large numbers of *A. melas* specimens.

With the existence of a market demand for black bullhead, there is a need for further research into wild black bullhead populations. Locations that were assessed in this study should be investigated for population density ( $\text{kg ha}^{-1}$ ), some aspects of the reproductive cycle and the natural diet of this species. The harvest of this “pest” from the wild would not only provide a marketable resource but also facilitate the recovery of indigenous species by alleviating competitive interactions with black bullhead.

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# Diet of great cormorant (*Phalacrocorax carbo* L.) in the Special Reserve of Nation "Stari Begej – Carska bara", northern Serbia

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**Abstract** The great cormorant colony located in Special Reserve of Nature "Stari Begej – Carska bara" is the largest colony in the Serbia, approximately 440 nesting pairs, representing more than 1/3 of nesting cormorant population in Serbia. Close to the colony there are two rivers, Tizsa and Begej, as well as fishfarm Ečka – the largest carp fishfarm in Europe. The aim of this work is to analyse diet of cormorants and their negative effects on fish farms. As samples for analyses, we have used fish regurgitated by great cormorants collected in the colony during the nesting season and pellets collected on roosting places during the winter. Fish injuries resulting from unsuccessful cormorant attacks were also analysed. The damage, induced by cormorants in investigated fish ponds, was calculated taking in consideration analysis and results obtained by all three methods mentioned above.

## Introduction

The number of cormorants in Europe has been being increasing since 1980's (Lindell *et al.* 1995). Until 1960s, in Serbia, cormorants nested in six colonies: Obedska bara, Zemun, Kobilj, Carska bara, Apatin i Bački Monoštor (Mikuška 1977). During the second half of the 20th century, large-scale ameliorative and regulatory works in Vojvodina caused sudden ecological disrupt and loss of moor lands, negatively effecting the colonies. In the nesting birds of Vojvodina list, the great cormorant is stated as an endangered species (Ham 1979). In late 1980's and early 1990's cormorant colonies started to re-establish along the great rivers in Vojvodina and in the beginning of this century they re-established populations in southern/south-eastern from Vojvodina, at the Vlasinsko Jezero Lake (Simonov 2001) as well as south-western, in Drina River.

Special Reserve of Nature "Stari Begej – Carska bara" with the surrounding, rivers Tisza and Begej, as well as Ečka fishpond, present an excellent settlement for numerous bird species, especially swamp birds. Until 1957 the great cormorant nested in the Carska Bara Swamp and at that time there was only one nest with three fledglings (Popović 1960). Human intolerance towards this species was present at that time as well and from 1948 to 1951 there were 35 birds killed (Pekić 1958). The beginning of 20th century was marked with great cormorant re-establishing its presence on the Carska

Bara Swamp. In 1998, this colony was inhabited by 100 or 110 bird couples, while in the previous years this colony consisted of only 2-3 nesting pairs (Puzović 1999). Data from 2007 shows recovery of this colony, with around 440 nesting couples.

Great cormorant, as a fish-eating bird, is in expansion, especially in inland water bodies. Studies of growing cormorants' colonies influence to river and pond fishes have taken place in many countries in Europe (Suter 1997; Veldkamp 1995; Opačak *et al.* 2004; Gwiazda 2004; Adamek *et al.* 2007). Rapidly or moderately growing colonies of cormorants led to fisherman/fish farmers' disaffection and their attempts to limit number of birds in colonies, thus limiting their influence to waters and ponds. Such studies have not been carried out in Serbia.

One of the problems caused by cormorants nesting near the fish ponds Ečka is indirect losses due to unsuccessful attacks on fish, causing wounds and stress. Injured fish, which have escaped from cormorant or if its size was significant enough and the cormorant could not swallow it, suffer from scars or necrosis.

The aim of this study is to assess cormorants' diet analysis during the nesting and the winter period to determine impacts on fish stocks. This study assesses indirect damage to fish, caused by cormorants' unsuccessful attacks. The study area was selected for its importance for swamp birds, this area borders with a large fishing farm system "Ečka" (5 ponds, totalling 2250 acres), thus causing a conflict between, in one hand - species and habitat protection, and fish farming in the other hand.

## Materials and methods

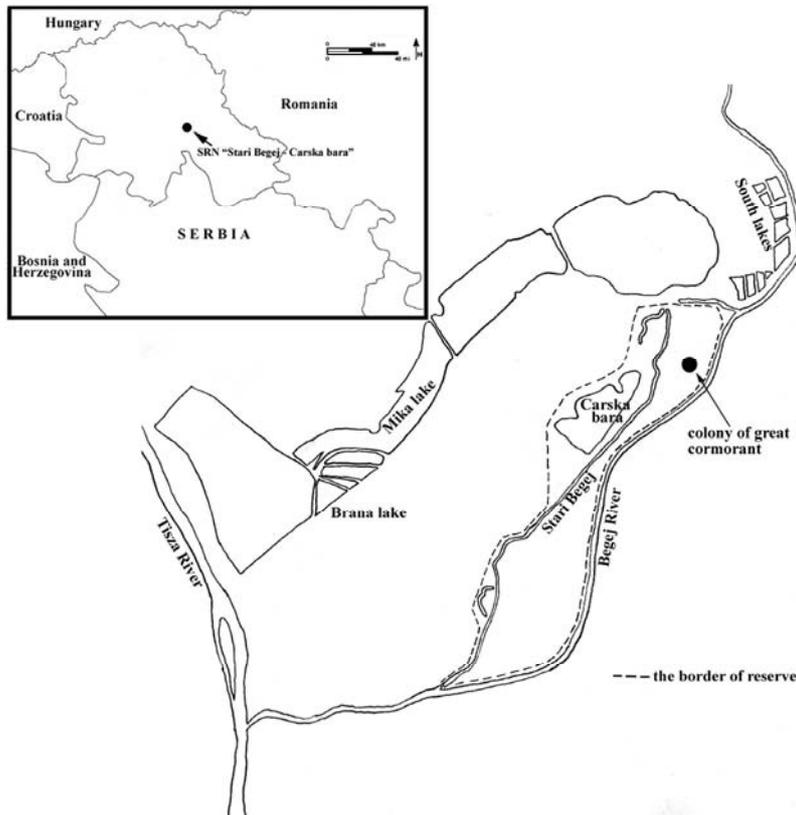
The Special Reserve of Nature "Stari Begej – Carska bara" is located in the Central Banat Administrative Region of the Autonomous Province of Vojvodina (45°16' N, 20°25' E) and it is regarded as one of the oldest reserves of nature (protected by law) of Serbia (Fig. 1). "Stari Begej – Carska bara" was given protection in 1955, and as of 1994 the reserve gained special status. As Ramsar site, it was declared in 1997, and IBA site from 2000. The reserve is surrounded by the rivers Tisza and Begej, as well as Ečka Fishing Farm (5 ponds, totalling 2250 acres), regarded as the biggest carp pond in Europe. This is also the oldest fish farm in Serbia, established in 1892.

Target species of fish farming include carp (*Cyprinus carpio*) with 80 % of share, grey bighead (*Arystichthys nobilis* L.) with 10 % - share, grass carp (*Ctenopharyngodon idella* L.) with 5 % - share, while the other kinds of fish (European catfish *Silurus glanis* L., pikeperch *Sander lucioperca* L, pike *Esox lucius* L.) totals up to 5 %.

Cormorant` diet analysis was assessed during the spring (breeding season) and winter period. Samples were collected from the colony, during the nesting season, in the period of incubation and of the most intensive feeding of cormorant nestlings period (April – June). Samples consisted of fish vomited by the nestlings or thrown down from nests. Determination of samples was performed in laboratory. In case of fully preserved fish samples, length and weight was recorded.

Cormorant`s diet during the winter was studied using pellet analyses. Pellets were collected during the November and February at the cormorants' night roosting location, which has been located at the Stari Begej (Old Begej River) for last few years. Determination was performed according to the fish bone remains found in pellets,

primarily parts of head skeleton: otoliths, pharyngeal bones and chewing pads. Determination method included comparative osteology collection IMSI as well as the Remains Determination Key (Marz 1987).



**Figure 1.** Map of research area

Samples for analyses of fishes' injuries caused by cormorants were collected during the autumn fishery season and fish transfer from one pond to another. One year old injured fish were randomly selected during autumn (November) relocating period from one of the ponds Južno (consist of 5 ponds in the area of 2 ha) to another. Two and three year old wounded fish were collected simultaneously from ponds Brana (29 ha, two-year old) and Mika (188 ha, three-year-old) at the sorting desk in on-growing carp ponds Ečka. Two-year-old carp (common and mirror) were collected just after injuring caused by cormorant attack. Besides carps (common and mirror) five other fish species were examined (pike, European catfish, prussian carp *Carassius gibelio* L., grasscarp, and black bulhead *Ictalurus melas* Le Sueur). According to company documentation, Južno ponds stocked 25000 head/ha of one month-old carps and 633 kg/ha of two-and three year-old carp.

Digital images of injured fish (JPEG format, 1024 X 768 pixel resolutions) were handle with commercial program Motic Images Plus 2.0 using tools for calculates and displays area statistics. In order to show differences between injured and healthy fish a ratio of individual weight (grams) and total length (TL in mm), fish condition coefficient (Fulton's coefficient of condition,  $FCC=(W/TL^3) \bullet 100$ ) was used. Statistical differences

between FCC values were evaluated by means of the nonparametric two-tailed Mann-Whitney test.

Samples of carp skin were taken near the wound or the scar, using standard histological technique of paraffin embedding and haematoxylin and eosin staining, HE. For histological analysis and microphotographs, Leica DM LS light microscope equipped with the DC 300 camera was used. Patohistological analysis of the lesion of carp skin made by cormorant were carried out in order to assess the degree of damages and estimate the potential of regeneration.

## Results

During the nesting period, 94 fish caught by cormorants were collected, of which 49 fish were complete and showed no signs of digestion. During this period two kinds of fish dominated the diet, carp with 29.8 % of share and Prussian carp with 60.6 % of share (Table 1). The other species were sporadically included in diet. Standard length of fish included in cormorants' diet was between 7.6 cm and 33cm. The biggest prey was pike with 33cm of length. Average length of the prey was 17.4 cm. The caught fishes were between 13.3 to 347g of weight. Standard length of the two most representative kinds included in diet is  $11.9 \pm 3.9$  cm for Prussian carp and  $15.7 \pm 3.3$  cm for carp. Average weight of Prussian carp was  $124.6 \pm 70.4$  g at the beginning of April and  $136.4 \pm 16.3$  g in May. Economically significant species carp, grass carp and pike represented one third of cormorants diet during the nesting period.

**Table 1.** Diet composition during breeding season of great cormorant

| Species                                       | N  | %    | Fish length, mm |      |      | Fish mass, g |      |      |
|---|----|------|-----------------|------|------|--------------|------|------|
|   |    |      | Mean            | Min. | Max. | Mean         | Min. | Max. |
| Mirror carp ( <i>Cyprinus carpio</i> )        | 24 | 25.5 | 158             | 110  | 200  | 161.1        | 51   | 347  |
| Scaly carp ( <i>Cyprinus carpio</i> )         | 4  | 4.3  | 156             | 144  | 168  | 118          | 106  | 130  |
| Prussian carp ( <i>Carassius gibelio</i> )    | 57 | 60.6 | 146             | 76   | 235  | 135.56       | 13.3 | 276  |
| Pike ( <i>Esox lucius</i> )                   | 1  | 1.1  | 330             |      |      | 225          |      |      |
| Burbot ( <i>Lota lota</i> )                   | 2  | 2.1  |                 |      |      |              |      |      |
| Black bulhead ( <i>Ictalurus melas</i> )      | 4  | 4.3  |                 |      | 223  |              |      | 216  |
| Bighead goby ( <i>Neogobius kessleri</i> )    | 1  | 1.1  | 120             |      |      | 33           |      |      |
| Grass carp ( <i>Ctenopharyngodon idella</i> ) | 1  | 1.1  | 135             |      |      | 40           |      |      |
| Total   | 94 |      | 174.2           | 76   | 235  | 118.7        | 13.3 | 347  |

Seventeen species of fish (211 specimens) were found in 49 cormorants' pellets (Table 2). A cormorant's pellet contained the remains from 1 to 24 fish specimens (median = 4.3). In qualitative composition there were nine species of Cyprinid which makes 50% of all identified species in diet and they made 50% of quantitative composition. The remains of Prussian carp were found in 28 pellets, being a predominant prey (27.49%) during winter season. It is interesting that in the beginning of winter season dominant food included tri species of the *Gymnocephalus* spp., while, after that, cyprinid species dominated in cormorant's diet. Economically significant fish species, such as carp, European catfish, pike and pikeperch are represented in cormorants' winter diet at around 15 %.

The area of mirror carp body injured by cormorants occupied from  $4.53\pm 3.76\%$  one-old-year,  $7.64\pm 7.47\%$  two-old-year, to  $2.53\pm 3.33\%$  three-old-year (Table 3, Figure 2). Both types of wounds: the damaged epithelium (scars) and deeper sub-dermal wounds were recorded in all age categories of the mirror carp. The maximal extent of scars (23.15%) in individual mirror carp were recorded in two-year-old and maximal area of deep sub-dermal injure (8.38%) were recorded in same age category. In one two-year-old common carp scars amount 63.05% of body surface. The maximal injured area of body surface in pike was 19.24% in European catfish 4.49% and in 41.7%. The biggest individual fish injured by cormorant were 2700 (mirror carp), 966 (common carp), 1575 (pike), 2300 (European catfish), 631 (grass carp) and 315 (Prussian carp).

**Table 2.** Diet composition of great cormorant during winter

| Species  | November 2007 |       | February 2008. |      | TOTAL |       |
|--|---------------|-------|----------------|------|-------|-------|
|  | N             | %     | N              | %    | N     | %     |
| Carp ( <i>Cyprinus carpio</i> )                  | 6             | 6.82  | 7              | 5.69 | 13    | 6.16  |
| Prussian carp ( <i>Carasius gibelio</i> )        | 12            | 13.63 | 46             | 37.4 | 58    | 27.49 |
| Roach ( <i>Rutilus rutilus</i> )                 | 7             | 7.95  | 11             | 8.94 | 18    | 8.53  |
| Bream ( <i>Abramis brama</i> )                   | 3             | 3.41  | 1              | 0.81 | 4     | 1.89  |
| White-eye bream ( <i>Abramis sapa</i> )          |               |       | 1              | 0.81 | 1     | 0.47  |
| Silver bream ( <i>Bilcca bjoerkna</i> )          |               |       | 10             | 8.13 | 10    | 4.74  |
| Nase ( <i>Chondrostoma nasus</i> )               |               |       | 1              | 0.81 | 1     | 0.47  |
| Bighead carp ( <i>Aristichthys nobilis</i> )     |               |       | 1              | 0.81 | 1     | 0.47  |
| Barbel ( <i>Barbus barbus</i> )                  |               |       | 1              | 0.81 | 1     | 0.47  |
| Pike ( <i>Esox lucius</i> )                      | 1             | 1.14  |                |      | 1     | 0.47  |
| Perch( <i>Perca fluviatilis</i> )                | 3             | 3.41  | 10             | 8.13 | 13    | 6.16  |
| Pikeperch ( <i>Sander lucioperca</i> )           | 6             | 6.82  | 10             | 8.13 | 16    | 7.58  |
| Ruffe ( <i>Gymnocephalus cernuus</i> )           | 23            | 26.14 | 10             | 8.13 | 33    | 15.64 |
| Balons ruffe ( <i>Gymnocephalus balloni</i> )    | 26            | 29.54 | 6              | 4.88 | 32    | 15.16 |
| Striped ruffe ( <i>Gymnocephalus shratcery</i> ) | 1             | 1.14  | 2              | 1.63 | 3     | 1.42  |
| Asp ( <i>Aspius aspius</i> )                     |               |       | 4              | 3.25 | 4     | 1.89  |
| European catfish ( <i>Silurus glanis</i> )       |               |       | 2              | 1.63 | 2     | 0.95  |
| TOTAL  | 88            |       | 123            |      | 211   |       |

**Table 3.** The area of wound origin by cormorant strikes as percentage (mean± standard deviation) of total body surface.

| Species                         | age | n  | TL(mm)     | W(g)         | scars (%) | deep injures (%) | total (%) | FCC     |
|---------------------------------|-----|----|------------|--------------|-----------|------------------|-----------|---------|
| <i>Cyprinus carpio</i> (mirror) | 1   | 44 | 219.5±0.9  | 81.75±51.7   | 4.5±3.8   | 0.49±0.8         | 4.5±3.8   | 2.1±0.8 |
| <i>Cyprinus carpio</i> (mirror) | 3   | 36 | 407.5±5.5  | 1327.8±610.3 | 2.6±3.4   | 0.39±0.4         | 2.5±3.3   | 1.9±0.3 |
| <i>Cyprinus carpio</i> (common) | 3   | 6  | 278.3±7.2  | 338.33±224.7 | 14.1±7.3  | 0.33±0.2         | 14.2±7.2  | 1.4±0.2 |
| <i>Cyprinus carpio</i> (common) | 1   | 2  | 198.5±2.1  | 139.5±50.2   | 5.5±3.6   | 0.33             | 5.6±3.9   | 1.7±0.1 |
| <i>Silurus glanis</i>           | 3   | 2  | 590±8.55   | 1660±905.1   | 3.9±0.8   | 0                | 3.9±0.8   | 0.8±0.1 |
| <i>Esox lucius</i>              | 3   | 9  | 495.3±5.3  | 977.2±386.3  | 10.4±5.7  | 2.07±2.7         | 11.5±5.1  | 0.8±0.1 |
| <i>Ctenopharyngodon idella</i>  | 2   | 3  | 333.3      | 451±272.9    | 25.1±21.5 | 0.23             | 25.1±21.3 | 1.0     |
| <i>Carassius gibelio</i>        | 1   | 7  | 222.4±1.1  | 220.86±50.3  | 18.8±8.8  | 2.41             | 19.2±8.0  | 2.1±0.7 |
| <i>Ameiurus melas</i>           | 1   | 1  | 275        | 288          | 6.7       | 1.37             | 8.1       | 1.4     |
| <i>Cyprinus carpio</i> (mirror) | 2   | 42 | 322.2±45.7 | 628±348      | 6.5±6.6   | 3.45±6.7         | 7.6±7.5   | 1.7±0.2 |
| <i>Cyprinus carpio</i> (common) | 2   | 12 | 310.7±32.1 | 525.92±174.8 | 18.4±15.9 | 0                | 18.4±15.9 | 1.7±0.2 |

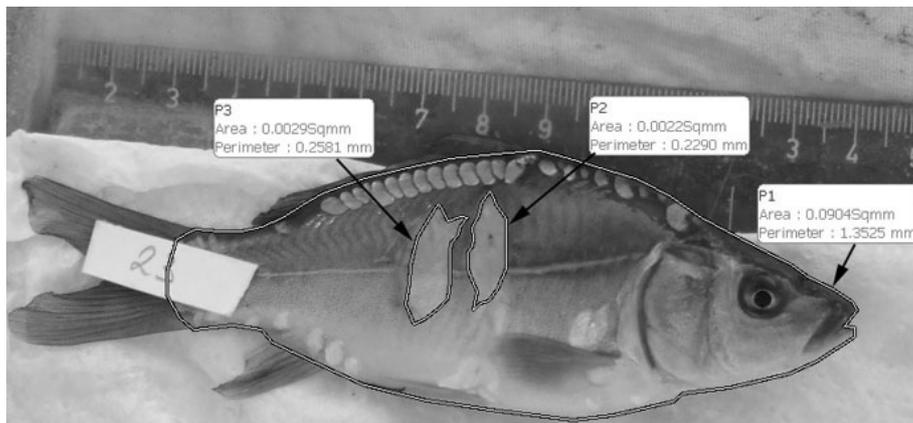
The difference between FCC in healthy (Table 4) and wounded (Table 3) one- year- old mirror carp are statistically significant on 0.05 levels (Mann-Whitney U test). There is not any statistically significant difference ( $p>0.05$ , Mann-Whitney U test) between

healthy and injured two- year-old mirror carp in FCC (Table 3.4). Also, no difference ( $p>0.05$ , Mann-Whitney U test) in FCC were found between mirror carp with deep sub-dermal wound and mirror carp with scars. The statistically significant difference ( $p=0.34$ ) in FCC not exist between healthy and injured two-year-old scaly carp (Table 3.4).

According to pathohistological analysis on injured carp skin can be notice hyperplastic epidermis and spongiotic infiltrated with lymphocytes. Identified epithelial hyperplasia most probably is a result of wound healing and inflammation. Stratum spongiosum of the dermis and the hypodermis heavily infiltrated with leucocytes indicating inflammation.

**Table 4.** Healthy mirror carp, basic data. FCC (Fulton’s coefficient of condition).

| Species                         | age | n  | TL(mm)     | W(g)        | FCC       |
|---------------------------------|-----|----|------------|-------------|-----------|
| <i>Cyprinus carpio</i> (mirror) | 2   | 19 | 349±64.5   | 770.3±381.9 | 1.68±0.3  |
| <i>Cyprinus carpio</i> (mirror) | 1   | 7  | 135.4±13.5 | 47.1±14.3   | 1.85±0.2  |
| <i>Cyprinus carpio</i> (scaly)  | 2   | 6  | 365.8±26.2 | 901.7±197.9 | 1.84±0.28 |



**Figure 2.** Marked scars area of injured fish

## Discussion

Cormorant diet depends on habitat. Roach (*Rutilus rutilus* L.) and perch (*Perca fluviatilis* L.) are the main prey items of cormorants in Switzerland (Suter 1997). Roach, bream (*Abramis brama* L.) and perch are the most significant prey species of cormorants nesting in NW Overijssel, Holland (Veldkamp1995). In France, bream is the most representative diet of cormorants during winter season on rivers, while silver bream (*Blicca bjoerkna* L.), rudd (*Scardinius erythrophthalmus* L.) and roach are also regular prey (Santoul 2004). Analyses of diet of cormorants nested near carp ponds of Donji Miholjec in Croatia as well as in Golysz in Poland, show that carp was dominant in diet at around 70% (Opačak 2004; Gwiazda 2004). Both sites recorded very low presence of Prussian carp: 1.1 % in Croatia, and 4.3 % in Poland. Similarly, Prussian carp was not recorded in diet of cormorants nesting in the Kopački Rit Swamp in Croatia, although being the dominant catch for fishermen of that area (Mikuška 1983). Opposite to the Kopački Rit, this study asserted Prussian carp as dominant prey of cormorants of the Carska Bara – Stari Begej habitat (60.64% - nesting season; 27.49% - winter season; 37.7% - total). Economically significant fish species (carp, grass carp,

grey bighead, pikeperch, European catfish and pike) participate in cormorant's diet with about 20%. In Tisza and Begej River, Prussian carp dominates over other cyprinid species, its abundance is associated with a decrease in the number of native autochthonous species. Whereas fishpond supply with water from these rivers, contains a significant amount of trash fish entering the fishpond. On the other hand, during traditional fish farm management, when ponds are not emptied entirely during fish harvesting, an opportunity is provided for trash fish to contaminate future farmed stocks. The results of this study indicate that commercially less valuable species may replace commercially important fish species in cormorant's diet in traditional fish farm management (semi-intensive management).

One of the primary concerns for fisheries managers is mortality of fish discards and escapees that is induced by capture and escape. Other problem includes either cormorants which may cause damage to livestock or farm facilities directly, indirectly or both. Direct damage results when the fish is killed or seriously injured by the cormorant and is therefore lost for production. One year old carp is the most endangered age class, because in spring season during the breeding period of great cormorant, these fish specimens contribute about 30% in their diet (mirror carp – 25.5%; common carp – 4.25%). Other age classes of carp were not recorded in cormorant diet in spring season.

Indirect damage is highly variable, and includes non-lethal wounding of fish; chronic stress with a consequent reduction in feeding efficiency or health; transfer of harmful disease-causing organisms, including bacteria, viruses and parasites; and sometimes even physical damage to the animal enclosure system leading to escapement. Scaring of healed wounds reduces the commercial value of afflicted fish.

Often, the indirect damage caused by a cormorant can result in a greater economic loss than that caused by direct damage. Two and three year old carp specimens are more exposed to indirect damage.

FCC uses for comparison between healthy and wounded fish in the case of two-year-old carp (mirror and common) did not show statistically significant difference, contrasting to study of Adamek *et al.* (2007). The reason of this discrepancy lay in fact that fish from pond Brana were collected shortly after injured. The maximum size of wounded fish (carp 50 cm long ; 2700 g and 8 mirror carp weighting over 2 kg) is in general agreement with Davies *et al.* (1995) who concludes that cormorants can attack fish of over 2 kg in weight. It must be stressed that the size spectrum of wounded fish increases during pond draining at harvesting, including bigger fish that are reported in this case study.

This study indicates cormorants cause damage on economically significant fish species in fishponds, and that future investigation could bring precise and more detailed data about their impact.

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# Fishing activities and pollution risk in the Köyceğiz Lagoon System

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**Abstract** The Köyceğiz Lagoon System is located in south-western Turkey and was declared a Special Protection Area in 1988. The area is composed of terrestrial structures of various qualities around Köyceğiz Subsidence Lake. It is a brackish lake which is fed by springs and several streams. Major commercial fish species are gray mullet (*Mugil cephalus* (L.)), eel (*Anguilla anguilla*(L.)), sea bass (*Dicentrarchus labrax*(L.)), gilt-head bream (*Sparus aurata* (L.)), common carp (*Cyprinus carpio* (L.)) and blue crab (*Callinectes sapidus* (Rathbun)). Fishing activities are carried by DALKO (Dalyan Fisheries Products Cooperation). In the last few decades, the amount of fish caught by DALKO decreased from 440 t to 180 t. The lagoon system and the beach are very important for sea turtles (*Caretta caretta* (L.), *Trionyx triunguis* (Forskål)), but they are under pollution pressure from agricultural run-off and untreated urban waste. Heavy boat traffic on the canals between the lake and the sea causes heavy metal pollution, stress on fish and wave-damage to reed beds. In this study, the present situation of the lagoon system and fishing activities are evaluated.

## Introduction

Lagoons are coastal bodies of water that can be permanently or temporally connected to the sea. Lagoons are mostly shallow and contain mixohaline or brackish water and are usually quite biologically productive and when compared to the other water sources, they have unstable physical and chemical features. Water depth in these habitats is limited, there is an abundance of organic matter and nutrient content to support the growth of flora and fauna. In the Mediterranean area, lagoons characteristically have mixed populations of brackish or euryhaline fish which enter in the spring and attempt to return to the sea in autumn (Dill, 1990). There have been many studies conducted on the lagoons that cover 75% of the coastal area around the world (UNESCO 1982; Buhan 1998; Marshall & Elliott 1998; Akin *et al.*, 2005). The lagoons in Mediterranean area form 8.5% of surface area and 45% of the number of the approximate 130 lagoons worldwide (Crivelli 1991), illustrating the importance of Mediterranean lagoons.

In Turkey, the number of lagoons in which fishing has been conducted over the years is 36, however only in 12 of them fishing is actively conducted today. The fish catch yield has declined in recent years due to damage of the lagoon structures. Köyceğiz Lagoon System is one of the most important active lagoon systems, it is a sensitive but productive habitat for Turkey and the Mediterranean (Kazancı *et al.* 1992), producing a yield of 32 kg ha<sup>-1</sup> in 2007. This system covers nearly 15% of the all lagoons along the coast of Turkey. It has been declared as “Special Protected Area” in 1998 by the Turkish Ministry of Environment and Forestry.

Köyceğiz Lake can be divided into Köyceğiz basin and Sultaniye basin, which have physical, chemical and biological differences. Due to the morphological features of the lake, the water body is divided in two layers of differing hydrology therefore the lake is classified as meromictic (Kazancı *et al.* 1992). The farming of citrus fruits and the use of greenhouse farming is intensively carried out in the surrounding land. Honey bee farming and forestry products are other important commercial activities in the area.

There are 491 registered and 100 unregistered boats in the area, of these registered vehicles, 359 work for six agencies, transporting tourists on the lake and into lagoon systems. 265 of these boats belong to Dalyan town and 94 belong to Köyceğiz.

On the Lagoon System, only commercial fishing is practiced, sport fishing is not permitted. Yerli (1989) has conducted a study on the growth parameters of mullet and other commercial fish species, as well as the limnology of the lagoon system. Buhan (1998) obtained detailed data on mullet and described problems occurring within the lagoon fishery. Classifying the mullet according to breeding periods with summer mullets ((*Mugil cephalus* (L.), *Liza saliens* (Risso)) and winter mullets (*Liza ramada* (Risso), *Liza aurata*(Risso), *Chelon labrosus* (Risso)) in two groups.

#### Study area

Köyceğiz Lake and Lagoon System are located 36° 45'' and 37° 15'' North latitude and 28° 22' 30'' and 28° 52' 30'' East longitude in Muğla, the Southwest of Turkey. The lagoon system covers an area of 5400 ha and is connected to the sea by a 10 km long canal (Fig. 1). The width of the canal varies between 5-70 meters and the depth between 1-6 m. Fishing on the lagoon system in Köyceğiz Lagoon System has been practiced since 1971, will 80% of the fish farming is practiced along the canal. The farm is situated in that location because the channel system is a more suitable habitat than the lake, even though the lagoon system is richer in terms of benthic invertebrates and planktons. In addition to the main fish trap in the Dışbüyükü location, there are 3 more fish traps on Sülüngür Lake.



**Figure 1.** Köyceğiz Lagoon System.

## Results

Köyceğiz Lagoon System contains a rich diversity of fish fauna. There have been detailed studies on the fish fauna of lagoon system and running waters that enter Köyceğiz Lake (Yerli 1989). Bilecik (1993) reported fish species in Köyceğiz Lagoon system and Buhan (1998) studied the commercial fish species in the lagoon. Barlas *et al.* (2000) reported 8 species and 2 subspecies among the fish fauna of Yuvarlakçay stream. Özdemir *et al.* (2003) reported five fish species from Namnam stream. Balık *et al.* (2005) reported 13 fish taxa belong to 9 families from Yuvarlakçay stream. Yılmaz *et al.* (2006) reported 20 fish taxa from Köyceğiz Lake, 6 fish taxa from Namnam stream and 11 fish taxa from Yuvarlakçay stream. In total, these researchers reported 64 fish taxa from Köyceğiz Lagoon System and the running waters that flow into lake (Table 1).

**Table 1.** Fish species of Köyceğiz Lagoon system and running waters of Köyceğiz Lake Basin

| Fish species                      | References          | Fish species                        | References |
|-----------------------------------|---------------------|-------------------------------------|------------|
| <i>Mugil cephalus</i>             | a, b, c, f, g, h    | <i>Phycis phycis</i>                | b, h       |
| <i>Liza ramada</i>                | a, b, c, d, g, h    | <i>Aphanius fasciatus</i>           | g          |
| <i>Liza saliens</i>               | a, b, c, g, h       | <i>Engraulis encrasicolus</i>       | b, h       |
| <i>Liza carinata</i>              | b, c, h             | <i>Tilapia sp.</i>                  | b, h       |
| <i>Liza aurata</i>                | b, g, h             | <i>Tilapia zillii</i>               | d, f, g    |
| <i>Liza labeo</i>                 | g                   | <i>Mullus barbatus</i>              | b, h       |
| <i>Oedalechilus labeo</i>         | a, b, h             | <i>Boops boops</i>                  | b, h       |
| <i>Chelon labrosus</i>            | a, b, c, g, h       | <i>Sarpa salpa</i>                  | b, h       |
| <i>Sparus aurata</i>              | a, b, h             | <i>Pagellus acarne</i>              | h          |
| <i>Dicentrarchus labrax</i>       | a, b, h             | <i>Spicara smaris</i>               | b, h       |
| <i>Anguilla anguilla</i>          | a, b, d, e, f, g, h | <i>Xyrichtys novacula</i>           | b, h       |
| <i>Pagellus mormyrus</i>          | a, h                | <i>Sparisoma cretense</i>           | b, h       |
| <i>Diplodus annularis</i>         | a, h                | <i>Trachinus araneus</i>            | b, h       |
| <i>Diplodus sargus</i>            | b, h                | <i>Uranoscopus scaber</i>           | b, h       |
| <i>Diplodus vulgaris</i>          | b, h                | <i>Scomber scombrus</i>             | b, h       |
| <i>Knipowitschia caucasica</i>    | f                   | <i>Sphyraena sphyraena</i>          | b, h       |
| <i>Epinephelus aeneus</i>         | a, b                | <i>Scorpaena scrofa</i>             | b, h       |
| <i>Lichia amia</i>                | a, b, h             | <i>Trigla lyra</i>                  | b, h       |
| <i>Morone labrax</i>              | g                   | <i>Bothus podas podas</i>           | b, h       |
| <i>Cyprinus carpio</i>            | a, g, h             | <i>Remora remora</i>                | a, b, h    |
| <i>Silurus glanis</i>             | a, g                | <i>Capoeta capoeta bergamae</i>     | b, d, g, h |
| <i>Leuciscus cephalus</i>         | a, d, e, f, g       | <i>Capoeta capoeta angorae</i>      | f, g       |
| <i>Leuciscus smyrnaeus</i>        | g                   | <i>Gobius ophiocephalus</i>         | d, g       |
| <i>Leuciscus borysthenticus</i>   | f                   | <i>Blennius fluviatilis</i>         | d, f, g    |
| <i>Barbus plebejus escherichi</i> | a, d, e, f, g       | <i>Cobitis taenia</i>               | d, g       |
| <i>Atherina boyeri</i>            | f, g                | <i>Cobitis vardarensis kurui</i>    | f          |
| <i>Atherina spp.</i>              | h                   | <i>Cobitis simplicispina</i>        | g          |
| <i>Gambusia affinis</i>           | b, d, f, g          | <i>Ladigesocypris ghigii</i>        | e          |
| <i>Dasyatis pastinaca</i>         | b, h                | <i>Orthrias angorae</i>             | e, g       |
| <i>Sardinella aurita</i>          | b, h                | <i>Ladigesocypris ghigii ghigii</i> | f, g       |
| <i>Synodus saurus</i>             | b, h                |                                     |            |

a: Yerli, 1989; b: Bilecik, 1993; c: Buhan, 1998; d: Barlas *et al.*, 2000; e: Özdemir *et al.*, 2003; f: Balık *et al.*, 2005; g: Yılmaz *et al.*, 2006; h: Akin *et al.*, 2005

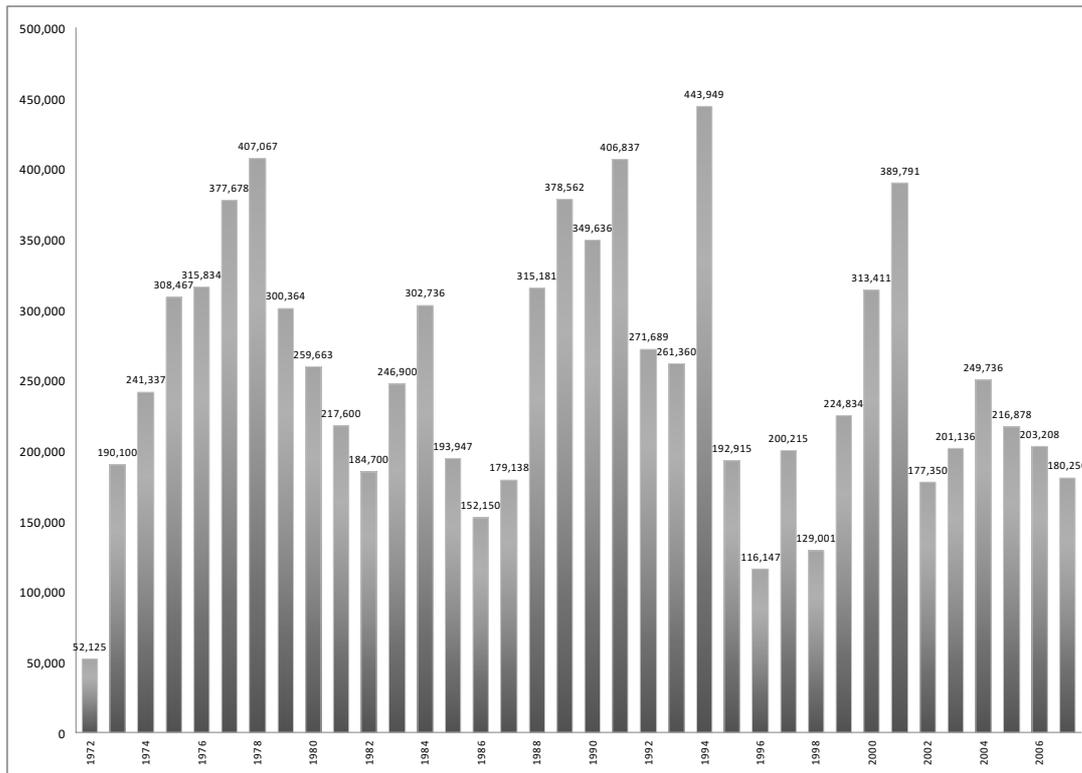
In addition to the fish fauna, other important organisms in the lagoon system are; *Penaeus kerathurus*, *Callinectes sapidus*, *Sepia officinalis*, *Loligo vulgaris*, *Octopus*

*vulgaris* and *Caretta caretta* in Köyceğiz (Bilecik 1993). In recent years, blue crab, *Callinectes sapidus* (Rathbun 1896) have been consumed by tourists in the area this species is also an important food for Nile soft-shelled turtle, *Trionyx triunguis* and loggerhead turtle, *Caretta caretta*.

### Fisheries in Köyceğiz Lagoon system

Fishing activities are carried out by Dalyan Fisheries Products Cooperative (DALKO) in Köyceğiz Lagoon system. The lagoon system belongs to State and is rented by DALKO through two year contracts. DALKO has 691 members and 49 personnel are employed by DALKO, the company gets help from rural policemen and the Environmental Protection Agency. These prevent the poaching of fish and other wildlife species, as well as regulate rules for fishing in the lagoon system.

According to DALKO (Figure 2) during the period between 1972–2006, the commercial catch in Köyceğiz Lagoon varied from the lowest catch of 52.125 t in 1972 to the highest catch of 443 949 t in 1994. Mullet is the main commercial fish on Köyceğiz Lagoon system (Table 2), in 2006 160.386 t mullet were caught. 5 t of Gilt head bream and 5 t of sea bass were also produced from the lagoon. Eel is also an important fish species caught in the lagoon, most of the eels catch is exported because it is not often consumed by Turkish people.



**Figure 2.** Fish yield (kg) of DALKO between 1972 and 2006 (Data obtained from DALKO)

According to Dill (1990), the average yield for Turkish lagoons is between 36.4 kg ha<sup>-1</sup> yr<sup>-1</sup> to 60 kg ha<sup>-1</sup> yr<sup>-1</sup> and the average yield from Köyceğiz Lagoon System was 59 kg

ha<sup>-1</sup>. McAllister (1993) reported that the average yield on Köyceğiz Lagoon System was 43 kg ha<sup>-1</sup>. In 2006 the actual average yield was 33.4 kg ha<sup>-1</sup>.

**Table 2.** Fish yield in 2006 by DALKO

| Fish            | Yield kg |
|-----------------|----------|
| Mullet          | 160,386  |
| Gilt-head bream | 4662     |
| Sea bass        | 4964     |
| Eel             | 9438     |
| Grouper         | 489      |
| others          | 311      |
| Total           | 180,250  |

Fish traps on Köyceğiz Lagoon System are constructed from wooden material and canes (Table2). The fishing activity is practiced throughout the year and is mostly dependent on the mullet fishery. All species caught belong to Mugilidae family, but it was observed that most of the species caught in summer were *Mugil cephalus* and *Liza saliens* while most of the species caught in winter were *Liza ramada*, *Liza aurata* and *Chelon labrosus*. The highest yield of mullet was in February with 32 025 t (Table 3).

**Table 3.** Fish yield according to monthly records in 2006 (kg).

| Fish Period | Mullet  | Gilt-head bream | Sea bass | Eel  | Grouper | Others | Total   |
|-------------|---------|-----------------|----------|------|---------|--------|---------|
| January     | 10,250  | 125             | 84       | 4229 | 43      | 74     | 14,805  |
| February    | 32,025  | 343             | 413      | 5209 | 54      | 19     | 38,063  |
| March       | 27,559  | 91              | 735      | 0    | 63      | 0      | 28,448  |
| April       | 5934,   | 153             | 544      | 0    | 48      | 0      | 6679    |
| May         | 2390    | 317             | 527      | 0    | 39      | 0      | 3273    |
| June        | 1911    | 297             | 330      | 0    | 46      | 45     | 2629    |
| July        | 9333    | 701             | 387      | 0    | 63      | 50     | 10,534  |
| August      | 18,716  | 856             | 251      | 0    | 37      | 31     | 19,891  |
| September   | 19,165  | 190             | 521      | 0    | 23      | 0      | 19,899  |
| October     | 4835    | 159             | 288      | 0    | 13      | 0      | 5295    |
| November    | 14,911  | 803             | 402      | 0    | 22      | 21     | 16,159  |
| December    | 13,357  | 627             | 482      | 0    | 38      | 71     | 14,575  |
| Total       | 160,386 | 4662            | 4964     | 9438 | 489     | 311    | 180,250 |

## Discussion

According to our observations, and personal conversations with farmers, high amounts of pesticides are applied in the region to help with intensive cultivation. The residues of pesticides accumulate in the soil and can be carried to the lagoon via surface waters and by drainage canals.

There are important citrus fruit farms around Namnam, Yuvarlakçay and Köyceğiz Lake. Due to the use of pesticides, there has been ecosystem destruction and as a result a decrease in fish yield. Farmers are in direct contact with pesticide suppliers. The use of these substances is unregulated and increasing. The use of pesticide must be controlled by organizations such as the Ministry of Agriculture. All farmers must be registered and hold a ration card so that the usage can be monitored. Alternative

biological methods should also be recommended to the farmers, organic farming and alternative farming should be supported in the region.

The monitoring of physical and chemical characteristics of the lagoon system is regularly conducted by Environmental Protection Agency for Special Areas, but a detailed monitoring project must be developed for the region. Since 2002, domestic waste has been prevented from entering the lagoon system by the activation of waste water purification in Köyceğiz and Dalyan.

Another issue is the introduction of exotic species such as *Tilapia zillii*. According to the fisheries in the area, after the introduction of this species to the system, many native fish species have been affected, especially common carp, *Cyprinus carpio*. Research into the effects of this species should be undertaken to gain a better understanding of these. This species has a rapid growth rate and reaches sexual maturity rather early. The introduction of such species to both the lake and lagoon must be under control by Governmental organizations.

The cooperative must be supported and use modern techniques for lagoon fishing. Fish caught in the lagoon should be evaluated in terms of their suitability to be marketed. As it is seen in Tables 2 and 3, the fisheries of the region are mainly dependent on the mullet fish that are caught in traps during the spawning migration period. The population should not be dominated by younger age classes that do not have the ability to breed. To prevent this, migration and breeding periods of mullet should be explained by seminars to the fisherfolk. Such seminars could also develop the knowledge of fishermen regarding the fish trap fishery, to understand geological, meteorological, hydrographical and hydrobiological data that affects productivity. This will help fishermen to determine the optimum fishing conditions (Yerli 1989). Scientific solutions must be developed for marketing and selling the fish caught in the lagoon.

Reed fields surrounding the lakes and lagoons provide a convenient habitat for many invertebrate and vertebrate species. These reed fields and the shallow canal bottom are also important resources for fish to feed on and use as a substrate to lay eggs upon. Boat traffic and the noise of boat motors affect fish migrations and damage these reed fields. The tourist-boat traffic on lagoon system must be regulated to reduce disturbances and support should be given to boats powered by solar energy or other sustainable resources. As a note, last year (2007) one boat powered by solar energy took trips in the lagoon. The motors of boats must be assessed, less powerful motors should be allowed in the fishery as powerful motors can damage the bottom of canal. Boats must not discharge their bilge waters into the lagoon.

The local people as well as visitors should be educated regarding the sensitivity of the Köyceğiz Lagoon System. Governmental and Non-Governmental organizations should play an active role in protecting the lagoon system. Ecological trips with educated guides should be arranged to promote the natural and ecological beauty of the region.

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# Investigations on the fishing of the exotic Pacific mullet (*Mugil so-iuy*) caught on the Black Sea Coast

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**Abstract** Pacific mullet (*Mugil so-iuy*), an egzotic species of the Black Sea, start to appear in the Black Sea Turkish coastline in May, when the sea temperature is around 16-17 °C. They yield a high catch during the period between May 15 and July 15. This is also the period during which egg-bearing fish draw closer to coastal waters and lay their eggs. These fish which come close to the coast at the start of reproduction are caught by fishermen using nets called “snail nets”. The catch per unit effort (CPUE) of these nets is 31.2±23.4 kg/boat/day. Immature fish accounted for 35.2% and 23.0% of the catch in 2002 and 2003, respectively.

Catching Pacific mullet, which is a species new to the ecosystem in the Black Sea, also exerts a heavy pressure on egg-bearing individuals due to the concentration of catching during the reproductive period of the species. This pressure should be relieved. The minimum fishing size of 35 cm stipulated for Pacific mullet by the Ministry conflicts with the size of first maturity of the species (40 cm). The minimum harvest length of this species should be increased to 45 cm and harvesting should be restricted to 15-20 days in the period between 1 and 30 June.

## Introduction

Pacific mullet (*Mugil so-iuy*) named Russian mullet by Turkish fishermen live naturally in the Vladivostok region of Amour Basin. *Mugil so-iuy* is an euryhaline species and was introduced to Şabolat Lagoon in the north coast of the Black Sea, but acclimation of the species was unsuccessful and stock of Pacific mullet was exhausted in 1970 (Ünsal 1991). It is reported that the Pacific mullet, seen since 1990 in the Southern Black Sea, acclimated well to the Black Sea’s ecosystem and has created a dynamic stock (Okumuş and Başçınar 1997). The population showed high salinity tolerance and is fully adapted to fresh water which allows them to colonize extensive near-shore areas of the sea and to occupy specific ecological niches (Serkov 2004). They have migrated up to the Aegean Coast (Kaya *et al.* 1997). Instead of the decreased fish stocks in the Black Sea at the beginning of 1990s, the Pacific mullet gained important economic status and appeared in the catches of coastal fishermen more than expected (Zengin *et al.* 1998). Ünsal (1992) and Kaya *et al.* (1997) reported a new occurrence of this species in the Black Sea. Okumuş and Başçınar (1997) studied the population structure, growth and reproduction of Pacific mullet captured at the south side of the Black Sea.

It is aimed to report the characteristics of the capture fisheries for Pacific mullet, which is caught during its reproductive stage and to suggest some measures for the protection

of the stocks despite being exotic to the Black Sea and the ecological interaction with native grey mullet species.

## Material and methods

This research was implemented along the Trabzon coast when the Pacific mullet move to these coastal waters for reproduction between May and July (Okumuş & Başçınar 1997) in 2002 and 2003. The data about fish catches was from samples brought to the Trabzon Bazaar. An index of CPUE was used as an indicator of fishing intensity to show changes in yield as a result of the fishing efforts. The improving scale suggested by Holden and Raitt (1974) was taken as a reference (Phiri and Sharikihara 1999) for this aim. The length at first sexual maturity was obtained by using the lengths of individuals at the immature stage (stages of I and II) and the lengths of individuals at the mature stage (stages of III, IV and V) (Holden & Raitt 1974).

## Results

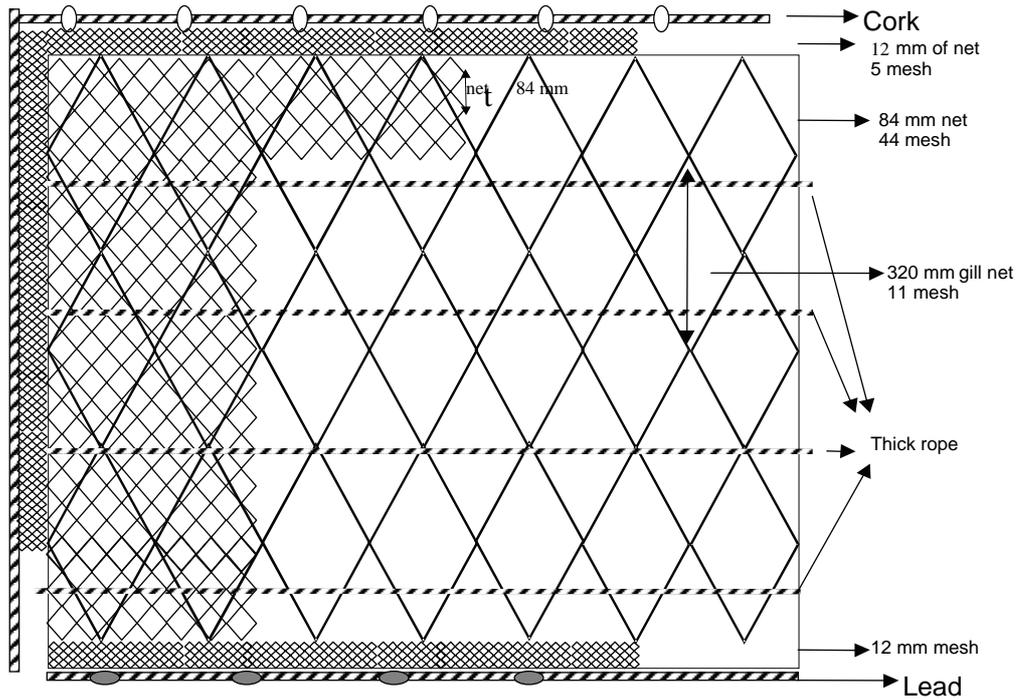
### *Capture methods*

Pacific mullet is seen along the Black Sea coasts of Turkey from the middle of May when the sea temperature is about 16-17 °C and the salinity is about 17-18‰ (Table 1). Generally, it has been observed that their optimum fishing time is between 15 May and 15 July. With the effect of water temperature it has been determined that the earliest fishing time is 7 May; the latest is 19 August. Wooden fishing vessels with lengths about 8.8 (6-12) m and motor powers about 59.4 (25-205) HP are used for Pacific mullet fishing. The plan of the design of gillnets used for Pacific mullet fishing and the situation of the net during the operation is shown in Figures 1 and 2, respectively. The capture operation is implemented three times (2-4) per day and one operation takes 4 or 5 hours.

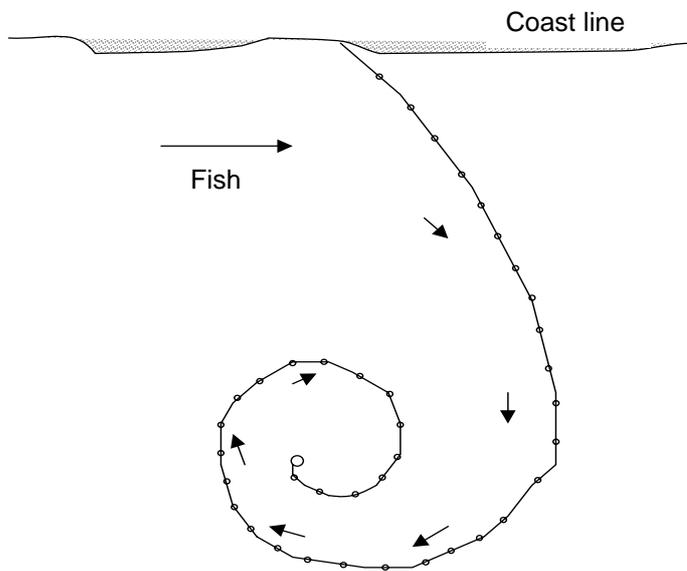
**Table 1.** The months with intense catch of Pacific mullet along the coast of South Black Sea, and water temperatures during these months

| Years             | Starting of the fishing | Ending of the fishing | Catching time (days) | <sup>1</sup> Surface water temperature (°C) |      |      |
|-------------------|-------------------------|-----------------------|----------------------|---|------|------|
|                   |                         |                       |                      | May   | June | July |
| <sup>2</sup> 1997 | 19 May                  | 1 July                | 42                   | 22.3  | 23.7 | 26.1 |
| <sup>2</sup> 1998 | 12 May                  | 26 June               | 44                   | 16.9  | 22.3 | 24.5 |
| <sup>2</sup> 1999 | 20 May                  | 15 June               | 35                   | 18.1  | 25.5 | 25.0 |
| <sup>2</sup> 2000 | 13 May                  | 15 June               | 32                   | 15.2  | 20.5 | 23.8 |
| <sup>2</sup> 2001 | 20 May                  | 15 June               | 25                   | 15.3  | 19.3 | 25.3 |
| <sup>3</sup> 2002 | 31 May                  | 12 July               | 43                   | 13.8  | 19.8 | 25.1 |
| <sup>3</sup> 2003 | 25 May                  | 27 June               | 32                   | 15.1  | 20.8 | 22.8 |

1 From the records of Trabzon Central Fisheries Research Institute 2: data from Samsun Fish Bazaar 3: Data from this study



**Figure 1.** Design of a Pacific mullet net

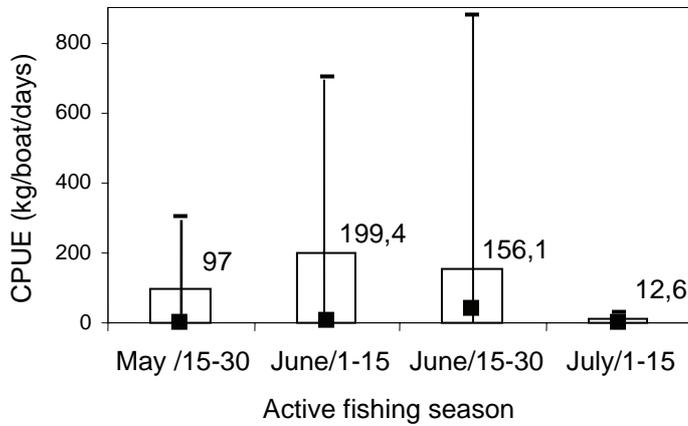


**Figure 2.** Position of a Pacific mullet net during the fishing operation

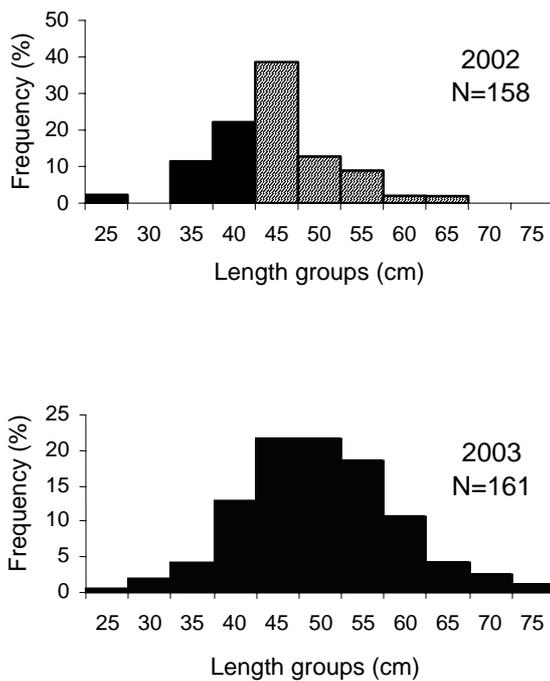
### *The properties of fishing*

The catch per unit effort for Pacific mullet was assessed with (voli) nets during fishing in the May-July period. The catch per unit effort (CPUE) of these nets is  $31.2 \pm 23.4$  kg/boat/day, ranging between 1.5-875.0 kg/boat/day. The fishing amounts in unit power decreases at the beginning of the fishing period and reach the highest between 1-15 June and 15-30 June (Fig. 3). The distribution length-frequencies of the landed fish are

shown in Figure 4. The average total lengths of the population is 46.5 (SE = 0.58,  $n = 158$ ) cm and 51.8 (SE = 0.67,  $n = 161$ ) cm for two years.



**Figure 3.** Minimum and maximum CPUE for the Pacific mullet 2002 – 2003

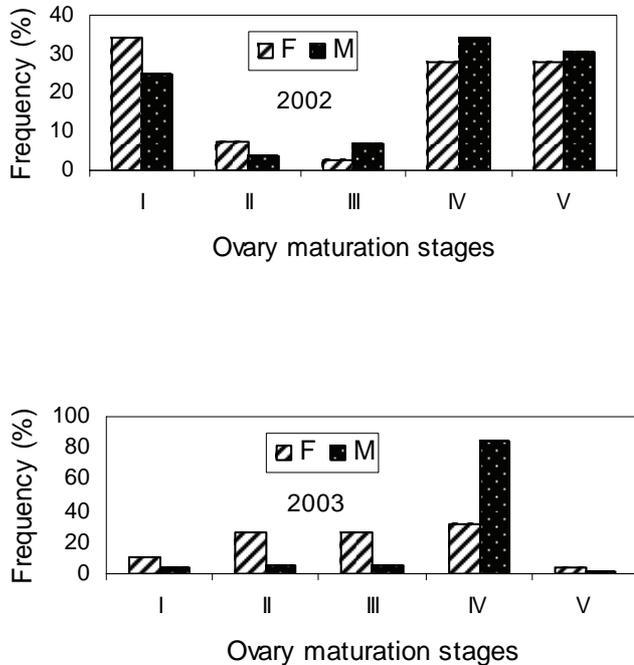


**Figure 4.** Length – frequency distribution Pacific mullet landed between 2002 – 2003. The distribution of length of all individuals (male and female) having a length of greater than 40 cm (hatched bars) is shown for 2002 (constituting the minimum first maturity length)

*Length at the first maturity*

In 2002 and 2003 35.9% and of 19.8%, respectively of individuals had not reached maturity. The proportion male and female individuals having not reached the first maturity was 28.9% and 19.8% in 2002, and 9.1% and 37.8% in 2003 (Fig. 5). In the

population of Pacific mullet, the length when 50% of fish reached first maturity ( $L_c$ ) is 47.2 cm for the female individuals; 43.6 cm for a minimum length and 51.4 cm for a maximum length. For the male individuals  $L_c$  is 40.4 cm, 37.6 cm for a minimum length and a 43.6 cm for a maximum length (Fig. 6).



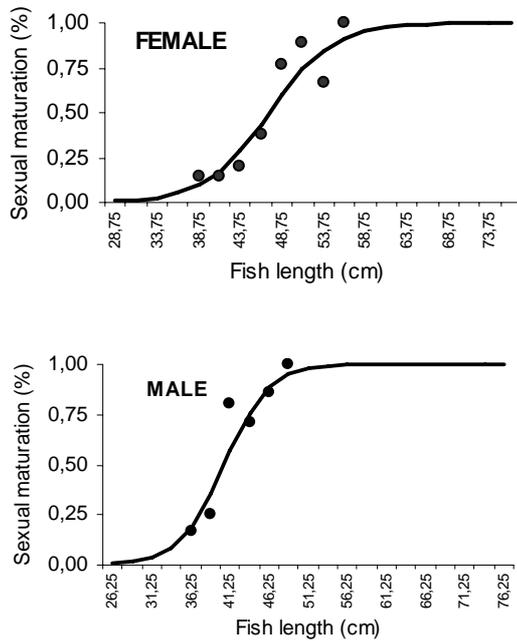
**Figure 5.** Development stages of Pacific mullet gonads during the capture periods

## Discussion

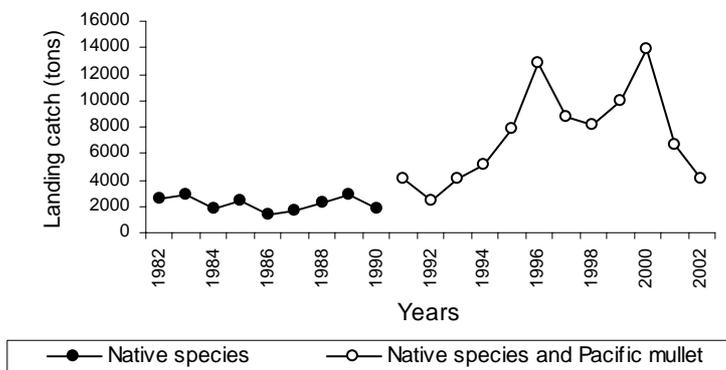
Pacific mullet became important, entering the Black Sea and established itself among the native grey mullet species (*Mugil cephalus*, *Liza aurata* and *Liza saliens*) stocks (Zengin *et al.* 1998). Landings of grey mullet exhibit a decreasing trend, (Fig. 7) related by the arrival of Pacific mullet to the Black Sea. Pacific mullet reach a length of 60 cm in 5 years after hatching (Okumuş & Başpınar 1997). Possibly the only tool to reduce the interaction between Pacific mullet and the local species is minimum catch size to control Pacific mullet stocks and held establish a balance between native mullet species.

There is no precise description of the distribution of Pacific mullet migration to date, but it is reported that the *Mugil so-iuy* winter on the Crimean coasts of the Northern Black Sea and usually under the ice in the gulfs connected to the sea (Shilyakhov & Charova 2003).

The fishing season for Pacific mullet is 25 days at minimum, 44 days at maximum and 36 days on average (Table 1). In this period fish approach the coastal waters until a depth of 3 – 3.5 m (Fig. 8). Fish catches reach their maximum level between 1 and 30 June (Fig. 3).

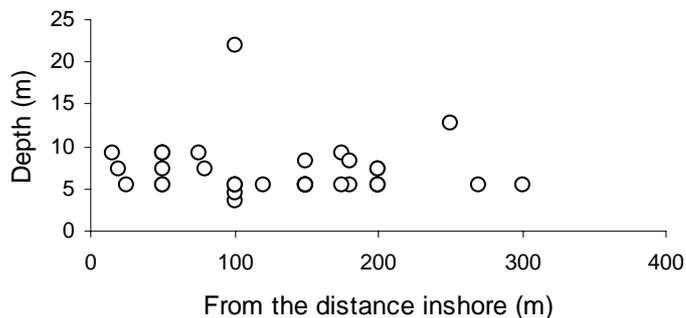


**Figure 6.** Size at first maturity for female and male Pacific mullet



**Figure 7.** Grey mullet catches along the South Black Sea coasts.

The intensity of fishing of the Pacific mullet, completely in the reproductive period of the fish, forms an important fishing pressure on the reproductive female stock. Fish catches declined from 12-13 000 t in 2000 to 4000 t in 2001-2002 (Fig. 7). It is necessary to reduce this fishing pressure suggesting the minimum length restriction of 35 cm (total length) for the Pacific mullet is not sufficient, with regards either the reproduction biology or the stock management. The minimum sized at first maturity of the Pacific mullet population in the Northern Black Sea, is 37.6 cm for males and 43.6 cm for females, average for both is 40 cm (Fig. 6). Approximately 19.8% and 35.9% of the fish caught had not matured (Fig. 4). The percentage of the male and female individuals having not reached maturity in the period May-July was 35.2% and 23.5% respectively for the years of 2002 and 2003 (Fig. 5).



**Figure 8.** The distance and depth of fishing zone for the Pacific mullet

Fishing for Pacific mullet, a very new species for the Black Sea ecosystem, has to be re-examined, taking into consideration the population specifics of this species. Today's minimum fishing restriction length of 35 cm has to be modified to 45 cm. A minimum fishing restriction length of 38 cm (standard length) is applied in the Northern Black Sea coasts (Shilyakhov and Charova 2003). This minimum length restriction is not sufficient for the survival of the stock of this species. In addition the quantity of fish caught needs to be determined and declared each year.

Stock management strategy for fish caught during their reproduction period should be applied for Pacific mullet, for example using total allowable catch (TAC). The most suitable example to this application is *Arctoscopus japonicus* (Masuda *et al.* 1984; Zengin 2001). A similar monitoring programme can be applied for the capture of Pacific mullet in Turkey. In the long term, after having determined the quantity to be taken from the stock (TAC) each year (Van Beek *et al.* 1990) based on the landings (catch should be recorded separately from native species of the mullet), the fishing must be restricted to 15 - 20 days, between 1 and 30 June (Fig. 3), to ensure fishing is sustainable.

Although it has an omnivores, benthic organisms are the principal foods of the Pacific mullet. The species is an opportunist species (Zaitsev & Mamaev 1997) but also acts as a plankton consumer against organisms like *Mneoipsis leidy* and competes with sturgeons sharing the same habitat (Tsarin 1997). Thus it is necessary to research the feeding competition with the native mullet species and related species and its possible impact on survival of native grey mullet species.

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# The effect of dissolved oxygen on sediment-water phosphorus exchange in Mogan Lake

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**Abstract** Aerobic and anaerobic phosphorus release from the sediment of shallow and eutrophic Mogan Lake was investigated in experiments. During the study period, water temperature was held stable at  $20\pm 1^{\circ}\text{C}$  in laboratory conditions, daily total soluble orthophosphate (SRP), dissolved oxygen and pH measurements were done. Phosphorus release from sediment was estimated by using the differences of daily SRP concentrations, sediment volume and the sediment surface area. In aerobic conditions, the concentration of SRP ranged between  $4.21\pm 0.20\text{ mg m}^{-3}$  and  $7.94\pm 0.25\text{ mg m}^{-3}$  and the estimated P flux changed from  $-0.087\text{ }\mu\text{g m}^{-2}\text{d}^{-1}$  to  $0.083\text{ }\mu\text{g m}^{-2}\text{d}^{-1}$ . In anaerobic conditions overlying water SRP concentration fluctuated between  $6.19\pm 0.18\text{ mg m}^{-3}$  and  $19.60\pm 0.29\text{ mg m}^{-3}$ , and sediment phosphorus release ranged between  $-0.048\text{ }\mu\text{g m}^{-2}\text{d}^{-1}$  and  $0.147\text{ }\mu\text{g m}^{-2}\text{d}^{-1}$ . In this study sediment phosphorus release in anaerobic conditions were found to be approximately two fold higher than under aerobic conditions and in the continuing eutrophication in Mogan Lake the drivingly factor was thought to be water chemistry.

## Introduction

Eutrophication in the world is a major environmental issue. Of the key factors causing eutrophication phosphorus has been identified as the most crucial one. For this reason, in aquatic environments numerous mechanisms have been proposed to be responsible for the release of phosphorus from lake sediments into lake water. In these systems it is hard to monitor the release of phosphorus from sediments and the causal factors of phosphorus release in the long term. The factors causing the release were examined in a laboratory by Drake & Heaney (1987), Boers & Hese (1988) and Sinke *et al.* (1990). Phosphorus can be released from sediment under aerobic and anaerobic conditions. However, release of phosphorus into anaerobic lake water may be greater when compared with the release of phosphorus into aerobic lake water (Shaw & Prepas 1990; Nguyen *et al.* 1997).

In sediment phosphorus release mechanisms the most important causal factor is the dissolved oxygen concentration of the water. Absorption of phosphorus into ferric iron complexes prevented phosphorus release into aerobic lake water (Kleeberg & Schlunbaum 1993). Cerco (1989) investigated the effects of water temperature, dissolved oxygen and nutrient concentration on the exchange of nutrients in sediment-water interface in shallow and eutrophic Gunston Lake and determined that sediments tended to release phosphorus at low dissolved oxygen concentrations but no effect of temperature was apparent.

Phosphorus release from the peaty sediments of the shallow and eutrophic Loosdrecht Lakes (Netherlands) were studied in the laboratory in a continuous flow system. The highest release rates (up to  $4 \text{ mg m}^{-2}\text{d}^{-1}$ ) were determined in August and the lowest ( $0.2 \text{ mg.m}^{-2}\text{d}^{-1}$ ) in winter. According to the researchers temperature was found to be the most impotent factor controlling release; only temperatures above  $13^{\circ}\text{C}$  allowed release in summer (Boers & Hese 1988). Sinke *et al.* (1990) calculated the phosphorus fluxes over the sediment-water interface using measured concentration gradients in the pore water of eutrophic Loosdrecht Lakes (Netherlands) and compared the fluxes with the measured phosphorus fluxes under laboratory conditions. It was demonstrated that phosphorus fluxes measured in laboratory were significantly correlated with the pore water characteristics.

This study aims to determine the effects of aerobic and anaerobic factors on the quantitative release of phosphorus level from littoral sediment of Mogan Lake into the overlying water. The research was carried out under standardized laboratory conditions.

## Materials and methods

### *Sediment and water samples*

Mogan Lake is located in the close vicinity of Ankara (20 km far from the city centre) which is a shallow (average depth  $\sim 2.8 \text{ m}$ ), eutrophic and alluvial lake with a total watershed area of  $925 \text{ km}^2$  and volume of  $10.20 \text{ million m}^3$ . The whole area is internationally protected for its wetland habitat. The major sources that affect water quality and trophic status of the lake are mainly agricultural runoff, untreated or semi-treated domestic effluents and industrial wastewaters from marble plants located in the west side of the lake (Boşgelmez *et al.* 2005).

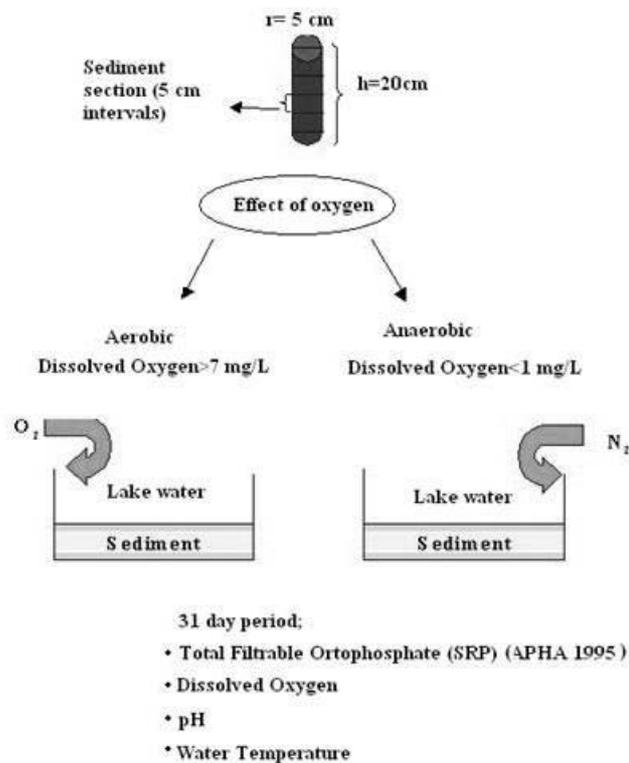
Sediment samples were collected at a selected station in the middle of the Mogan Lake's west side by using a plexiglass tube with 50 mm diameter and 20 cm height, and overlying water was taken above the sediment by siphoning in March 2005. Another study was conducted to find out the potential phosphorus release into Mogan Lake between July 2004 and June 2005. The amount of the released phosphorus and some physical characteristics of the overlying water are given in Table 1.

**Table 1.** Measured phosphorus release and some physical properties of the overlying water in Mogan Lake (Topçu 2006)

| Date           | Phosphorus release ( $\mu\text{g.m}^{-2}\text{d}^{-1}$ ) | Water temperature( $^{\circ}\text{C}$ ) | Dissolved oxygen( $\text{mg.L}^{-1}$ ) | pH             |
|----------------|--|---|--|----------------|
| July 2004      | 0.042  | $24.90\pm 0.06$                         | $6.21\pm 0.00$                         | $8.83\pm 0.01$ |
| August 2004    | 0.032  | $25.60\pm 0.07$                         | $6.15\pm 0.00$                         | $7.83\pm 0.00$ |
| September 2004 | 0.033  | $23.25\pm 0.14$                         | $6.97\pm 0.01$                         | $8.32\pm 0.00$ |
| October 2004   | 0.018  | $18.25\pm 0.14$                         | $6.20\pm 0.00$                         | $8.51\pm 0.00$ |
| November 2004  | 0.002  | $5.28\pm 0.11$                          | $10.13\pm 0.01$                        | $8.82\pm 0.00$ |
| December 2004  | 0.020  | $5.48\pm 0.05$                          | $9.33\pm 0.00$                         | $8.88\pm 0.00$ |
| January 2005   | 0.018  | $5.68\pm 0.05$                          | $9.52\pm 0.00$                         | $8.88\pm 0.00$ |
| February 2005  | 0.009  | $6.90\pm 0.04$                          | $8.98\pm 0.01$                         | $8.71\pm 0.00$ |
| March 2005     | 0.017  | $12.55\pm 0.03$                         | $7.72\pm 0.03$                         | $7.48\pm 0.01$ |
| April 2005     | 0.044  | $15.54\pm 0.02$                         | $7.83\pm 0.01$                         | $8.03\pm 0.01$ |
| May 2005       | 0.043  | $18.83\pm 0.01$                         | $8.43\pm 0.01$                         | $8.53\pm 0.01$ |
| June 2005      | 0.062  | $22.42\pm 0.01$                         | $8.86\pm 0.01$                         | $8.78\pm 0.01$ |

### Experimental study

Samples were analyzed in the laboratory without further treatment. In the laboratory, collected sediments were put into the aquaria and the overlying water was replaced very carefully in order not to disturb or resuspend any sediment. Sediment to overlying water was held at a proportion of 1/3. The experiment was conducted in an aerobic ( $\text{DO}_2 > 7 \text{ mg L}^{-1}$ ) and anaerobic conditions ( $\text{DO}_2 < 1 \text{ mg L}^{-1}$ ) (Premazzi & Provini 1985; Ruban & Demare 1998; Temperate & Pedrozo 2000). During the 31-day experiment, water temperature was stable ( $20 \pm 1^\circ\text{C}$ ) and by measuring the overlying water's daily SRP concentrations, the effects of dissolved oxygen on phosphorus release was determined (Fig. 1).



**Figure 1.** The experimental study design

#### *Estimation of phosphorus flux at the sediment-water interface*

Phosphate flux was measured in both aerobic and anaerobic conditions between 1 April and 1 May. Furthermore daily dissolved oxygen, pH and water temperature were measured. Phosphorus flux was calculated according to Ruban and Demare (1998) taking into account:

$\Delta C$  = the difference of SRP concentration

$\Delta t$  = during the period considered

$V$  = the volume of the lying sediment

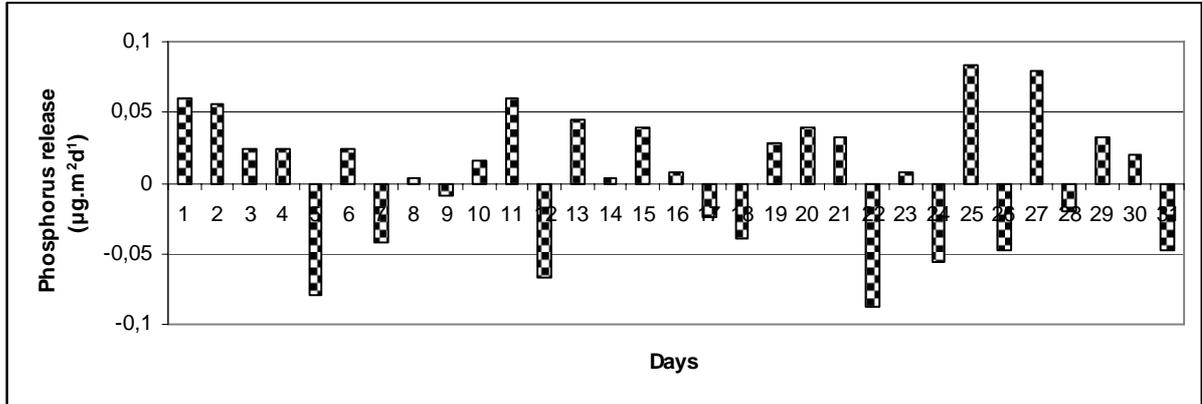
$S$  = the sediment surface area

Hence the flux (in  $\mu\text{g m}^{-2}\text{d}^{-1}$ ) =  $\phi$

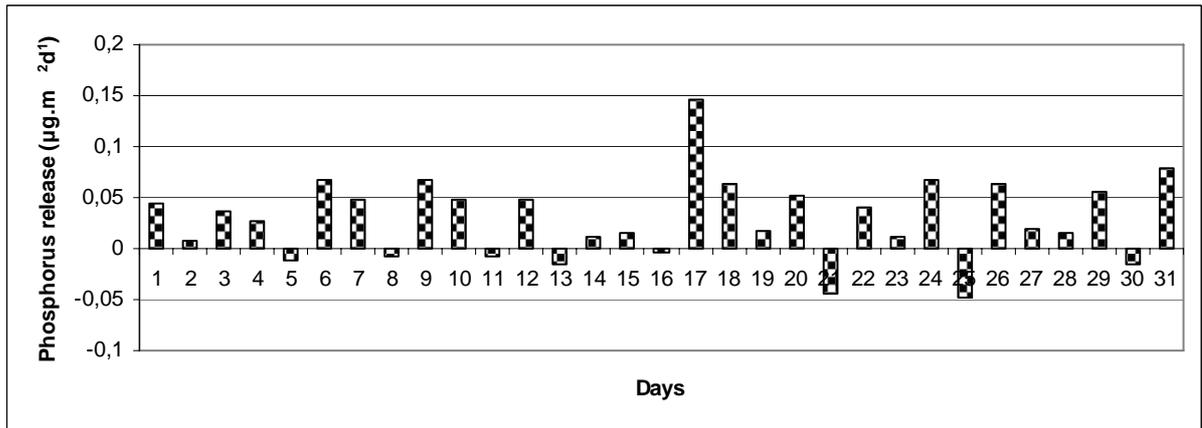
$$\phi = \Delta c \cdot V / \Delta t \cdot S$$

## Results

Sediment phosphorus fluxes are reported as the average flux in replicate samples and are presented in Figures 2 and 3.



**Figure 2.** Measured aerobic phosphorus flux



**Figure 3.** Measured anaerobic phosphorus flux

In aerobic and anaerobic conditions dissolved oxygen concentration and pH values were found to be 8-8.5 mg L<sup>-1</sup>, 7.2-8.0 and 0.7-0.9 mg L<sup>-1</sup>, 7.5-8.9, respectively. In aerobic conditions, the minimum phosphorus flux was -0.087 µg m<sup>-2</sup>.d<sup>-1</sup> (22<sup>th</sup> day) and the maximum value was 0.083 µg m<sup>-2</sup>.d<sup>-1</sup> (25<sup>th</sup> day). On the other hand, in anaerobic conditions flux changed between -0.048 µg m<sup>-2</sup>.d<sup>-1</sup> (25<sup>th</sup> day) and 0.147 µg m<sup>-2</sup>.d<sup>-1</sup> (17<sup>th</sup> day) (Fig. 2, 3).

## Discussion

Lennox (1984) investigated the exchange of phosphorus between the epilimnetic (shallow zone) sediment and water column in Lough Ennell (Ireland). Experimental results indicated that phosphorus release is possible under both aerobic and anaerobic

conditions. Aerobic release was determined as  $0.025 \text{ mg m}^{-2}\text{d}^{-1}$  while in anaerobic conditions it was measured as  $0.183 \text{ mg m}^{-2}\text{d}^{-1}$ . In Mogan Lake the anaerobic phosphorus release was greater than the aerobic phosphorus release; in this context the data derived from this study support the findings of previous authors. This study suggests sediment phosphorus release is not correlated to aerobic or anaerobic conditions (Fig. 2, Fig. 3).

Shaw and Prepas (1990) investigated the relationships between phosphorus in bottom sediments of seven Alberta Lakes; trophic status of all lakes varied from meso-eutrophic to eutrophic. The calculated potential phosphorus release from sediments to lake water ranged between  $0.04 \text{ mg m}^{-2}\text{d}^{-1}$  and  $1.5 \text{ mg m}^{-2}\text{d}^{-1}$ . In a previous study, nine eutrophic Alberta Lakes in summer months the phosphorus release rates were determined between  $0.01$  and  $2.31 \text{ mg m}^{-2}\text{d}^{-1}$  (unpublished data). In this study, sediment phosphorus release rates in anaerobic conditions were quantitatively higher than the release rates measured in aerobic conditions.

Under aerobic conditions the sediments were a sink of phosphorus. Whereas, under anoxic conditions, the sediments were a source of phosphorus until the overlying water column attained orthophosphate concentration of  $1$  to  $1.4 \text{ mg L}^{-1}$  (Cercó 1989). In Mogan Lake, overlying water's orthophosphate concentration was found to be ranged between  $45.85 \pm 3.98 \text{ mg m}^{-3}$  (July) and  $112.10 \pm 0.91 \text{ mg m}^{-3}$  (November) during the synchronized study (Topçu 2006) conducted in situ. Explaining the very low phosphorus release and the data derived from this study is in accordance with Cercó (1989)'s determinations.

In Esthwaite Water (England), a productive lake, the rate of release of phosphorus from intact sediment cores was measured in the laboratory as a function of the pH of overlying water. The measured maximum phosphorus release rate was  $75 \text{ mg m}^{-2}\text{d}^{-1}$  at  $\text{pH}=10.5$ . It is determined that, phosphorus release from the littoral sediments may equal or exceed both external sources and hypolimnetic inputs during periods of high pH associated with times of maximum algal biomass (Drake and Heaney 1987). In Mogan Lake, it is difficult to say that pH is the effective factor on the phosphorus release mechanism due to the minimal fluctuation of pH level minimal both in aerobic ( $7.2-8.0$ ) and in anaerobic conditions ( $7.5-8.9$ ).

Pore water chemistry in Mogan Lake was monitored for a year (July 2004-June 2005) in the middle of the west side of the lake. Phosphorus fluxes over the sediment-water interface were calculated using measured concentration gradients in the pore water. Minimum and maximum phosphorus releases were found  $0.002 \text{ } \mu\text{g m}^{-2}\text{d}^{-1}$  in November and  $0.062 \text{ } \mu\text{g m}^{-2}\text{d}^{-1}$  in June. In addition, overlying water's high TFe ( $152.00 \pm 7.21 \text{ mg m}^{-3}$ - $526.40 \pm 10.30 \text{ mg m}^{-3}$ ) and SRP ( $18.68 \pm 1.16 \text{ mg m}^{-3}$ - $66.75 \pm 1.52 \text{ mg m}^{-3}$ ) concentrations led to low phosphorus release (Topçu 2006). In laboratory conditions, phosphorus release level was found to be low in both aerobic and anaerobic conditions. This transport is diffusional, but strongly dependent on the biological processes which promote the diffusion upwards as also indicated by the oxygen-dependent phosphorus release rates. It is determined that phosphorus release level was not high enough to affect the trophic level of the lake. In conclusion the low release of phosphorus in the laboratory for both aerobic and anaerobic conditions is supported by the high TFe and SRP concentrations of overlying water obtained in the lake study and thus this has no serious threat to lake recovery currently, but needs further investigation.

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# Gillnet selectivity for pike, *Esox lucius*, in Lake Karamık, Turkey

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**Abstract** Gillnet selectivity parameters the pike, *Esox lucius* L., were estimated from catches taken by five experimental gillnets of stretched mesh sizes of 36, 40, 44, 50 and 60 mm in Lake Karamık, Turkey. The length selectivity of each mesh size was described by four different models (normal location, normal scale, gamma and lognormal) of the ‘Share Each Length’s Catch Total’ (SELECT) method. According to model deviance values, lognormal model gave the best fit for gillnet selectivity of pike. Estimated modal lengths were 20.4, 22.7, 25.0, 28.4 and 34.0 cm for 36, 40, 44, 50 and 60 mm mesh sizes, respectively. Modal length and spread increased with mesh size.

## Introduction

Pike, *Esox lucius* L. is a commercially important freshwater fish species in Turkey. Unfortunately, pike stocks were overexploited by fishermen. Exploitation of fish stocks is dependent on availability, fishing effort and gear selectivity (Huse *et al.* 2000). In Lake Karamık, key fishing methods were gillnets and trammel nets because of ease of use, low cost, and possibility to be set at any depth and in areas with difficult bottom conditions. Knowledge of the size selectivity of fishing gear types is crucial to fisheries management in order to establish a maximum sustainable yield (Millar & Holst 1997; Huse *et al.* 2000), allowing exploited fish stocks to be assessed and regulated (Regier & Robson 1966; Hamley 1975). To minimize gear selectivity the length frequency distribution of fish populations are adjusted (Carol & Garcia-Berthou 2007). In general, indirect estimates of gillnet selectivity are obtained by comparing the observed catch frequencies across several mesh sizes (Millar & Holst 1997). The length frequency distribution of the population and the selectivity parameters are thus estimated simultaneously (Hovgård & Lassen 2000). Different approaches to indirect estimates have been used to obtain the selection curve using various manipulations of the selection equation. Holt’s method (1963) is one of the most commonly used methods for estimating gillnets selectivity. However, this method is restrictive. Recently, the SELECT method has been used (Millar & Holst 1997; Millar & Fryer 1999; Millar 2000). This is a statistical model that estimates gillnet selection curves from comparative gillnet catch and provides a cohesive approach to selectivity analyses.

Several studies of gillnet selectivity have been carried out for a variety of marine species using the SELECT method (Madsen *et al.* 1999; Huse *et al.* 2000; Poulsen *et al.* 2000; Dos Santos *et al.* 2003; Grégoire & Lefebvre 2003). But, gillnet selectivity studies using the SELECT method for freshwater fish species are scarce (Albert 2004; Psuty-Lipska *et al.*, 2006; Carol & Garcia-Berthou 2007).

The aim of this study was to model the size selectivity of gillnets used in commercial pike fishery in Lake Karamık. The results are of major importance for improving the management of pike in this fishery.

## Materials and methods

### *Study area*

Lake Karamık (38° 29' N and 30° 55' E) is in the west of central Anatolia region of Turkey. It is a small (38 km<sup>2</sup>) and shallow (average depth 2-3 m) lake, at an altitude of 1067 m and annual mean water temperature is 14°C. Lake Karamık is eutrophic, with most of surface area of the lake was covered by vegetation (Gündüz 1984; Şen *et al.* 1994). The main species in this lake are *Esox lucius*, *Cyprinus carpio*, *Alburnus orontis*, *Gambusia affinis*, *Cobitis turcica*, *Knipowitschia caucasica* and *Astacus leptodactylus*. However, during our study period only *E. lucius* and *C. carpio* were commercially exploited, preferred fishing methods included gillnets, trammel nets and traps.

The study was conducted between March 2002 and February 2003. Sampling was carried out monthly at three different localities of the lake using monofilament gillnets of mesh sizes (stretched mesh) of 36, 40, 44, 50 and 60 mm. Each net had a length of 100 m and a hanging ratio of 0.50. All nets were set in the afternoon and lifted the following morning. Nets were hauled individually, the catch removed and the species separated and fish length measured (fork length, FL, mm).

The gillnet selectivity was estimated by the SELECT method through R code developed by Millar (<http://www.stat.auckland.ac.nz/~millar/selectware/R/gillnets/gillnetfunctions.R>). The length selectivity of each mesh size was described by four different models (normal location, normal scale, gamma and lognormal) of the 'Share Each Length's Catch Total' (SELECT) method (Millar & Fryer 1999).

## Results

During the study a total of 1237 pike were caught. The largest group of specimens (369 pike) were caught by gillnet with a mesh size of 44 mm, while largest mesh size of 60mm was least productive.

Gillnet selectivity was estimated from catch data (in Table 1) and selectivity curves are shown in Figure 1 for mesh sizes. Model deviance of lognormal model was lower than those of normal location, normal scale and gamma models. These results showed that lognormal model gave the best fit for pike in Lake Karamık. In addition, it was determined that the model deviances from the gamma and lognormal selection curve models were not influenced by the fishing power assumption.

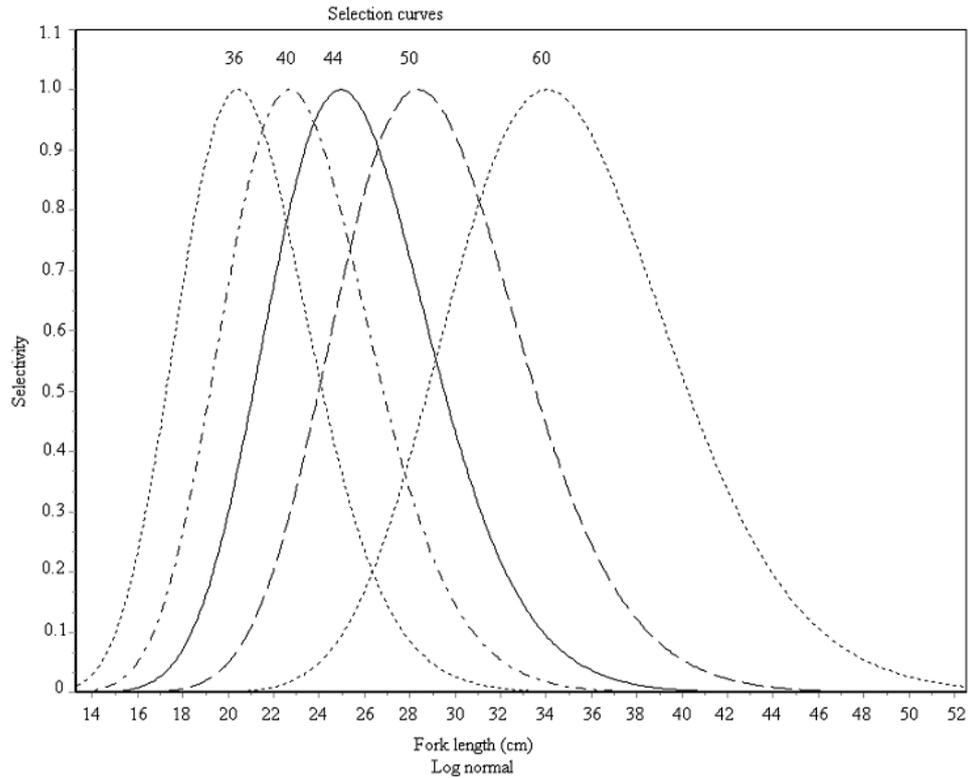
The residual plot reveals some curious features of these data. It appears that the fishing power of the largest mesh (60 mm) was less than modelled because of the predominance negative residuals. This result showed that gillnet of mesh size of 60 mm caught higher than expected catch of these sizes of pike.

**Table 1.** Length-frequency distributions of pike caught by gillnets of different mesh sizes (36, 40, 44, 50 and 60 mm).

| Fork length (cm) | Mesh size (mm) |     |     |     |     |
|------------------|----------------|-----|-----|-----|-----|
|                  | 36             | 40  | 44  | 50  | 60  |
| 18               | 5              | 1   | 0   | 0   | 0   |
| 19               | 26             | 8   | 0   | 0   | 0   |
| 20               | 16             | 26  | 1   | 1   | 0   |
| 21               | 35             | 59  | 8   | 0   | 0   |
| 22               | 23             | 44  | 34  | 1   | 0   |
| 23               | 15             | 26  | 79  | 4   | 0   |
| 24               | 11             | 17  | 73  | 23  | 0   |
| 25               | 9              | 19  | 44  | 38  | 0   |
| 26               | 4              | 21  | 19  | 50  | 2   |
| 27               | 4              | 6   | 19  | 36  | 3   |
| 28               | 5              | 7   | 17  | 15  | 6   |
| 29               | 1              | 5   | 12  | 11  | 13  |
| 30               | 5              | 4   | 6   | 9   | 8   |
| 31               | 1              | 1   | 4   | 8   | 6   |
| 32               | 0              | 4   | 6   | 5   | 6   |
| 33               | 2              | 0   | 1   | 4   | 1   |
| 34               | 1              | 0   | 1   | 3   | 5   |
| 35               | 0              | 0   | 0   | 1   | 1   |
| 36               | 0              | 1   | 1   | 2   | 1   |
| 37               | 0              | 1   | 0   | 0   | 2   |
| 39               | 0              | 0   | 0   | 0   | 1   |
| 41               | 1              | 0   | 0   | 0   | 0   |
| 42               | 0              | 0   | 0   | 0   | 1   |
| 45               | 0              | 0   | 0   | 0   | 1   |
| Total            | 200            | 290 | 369 | 261 | 117 |

**Table 2.** Selectivity parameters for various models. The model deviance is the likelihood ratio goodness of fit statistic and it has 94 degrees of freedom for each of the models shown.

| Model                               | Equal fishing powers               |                | Fishing powers $\alpha$ mesh size  |                |
|-------------------------------------|------------------------------------|----------------|------------------------------------|----------------|
|                                     | Parameters                         | Model deviance | Parameters                         | Model deviance |
| Normal location (Fixed spread)      | $(k, \sigma) = (0.56683, 3.83534)$ | 405.02         | $(k, \sigma) = (0.579, 3.888)$     | 397.78         |
| Normal scale (Spread $\alpha m_j$ ) | $(k_1, k_2) = (0.583, 0.089)$      | 503.90         | $(k_1, k_2) = (0.597, 0.088)$      | 506.22         |
| Gamma (Spread $\alpha m_j$ )        | $(\alpha, k) = (0.012, 47.639)$    | 411.60         | $(\alpha, k) = (0.012, 48.639)$    | 411.60         |
| Lognormal (Spread $\alpha m_j$ )    | $(\mu_1, \sigma) = (3.036, 0.142)$ | 371.36         | $(\mu_1, \sigma) = (3.057, 0.142)$ | 371.36         |



**Figure 1.** Selection curves of mesh sizes for lognormal model. Modal length and spread values for mesh sizes were given in Table 3. As seen in Table 3, both modal lengths and spreads increased with mesh size.

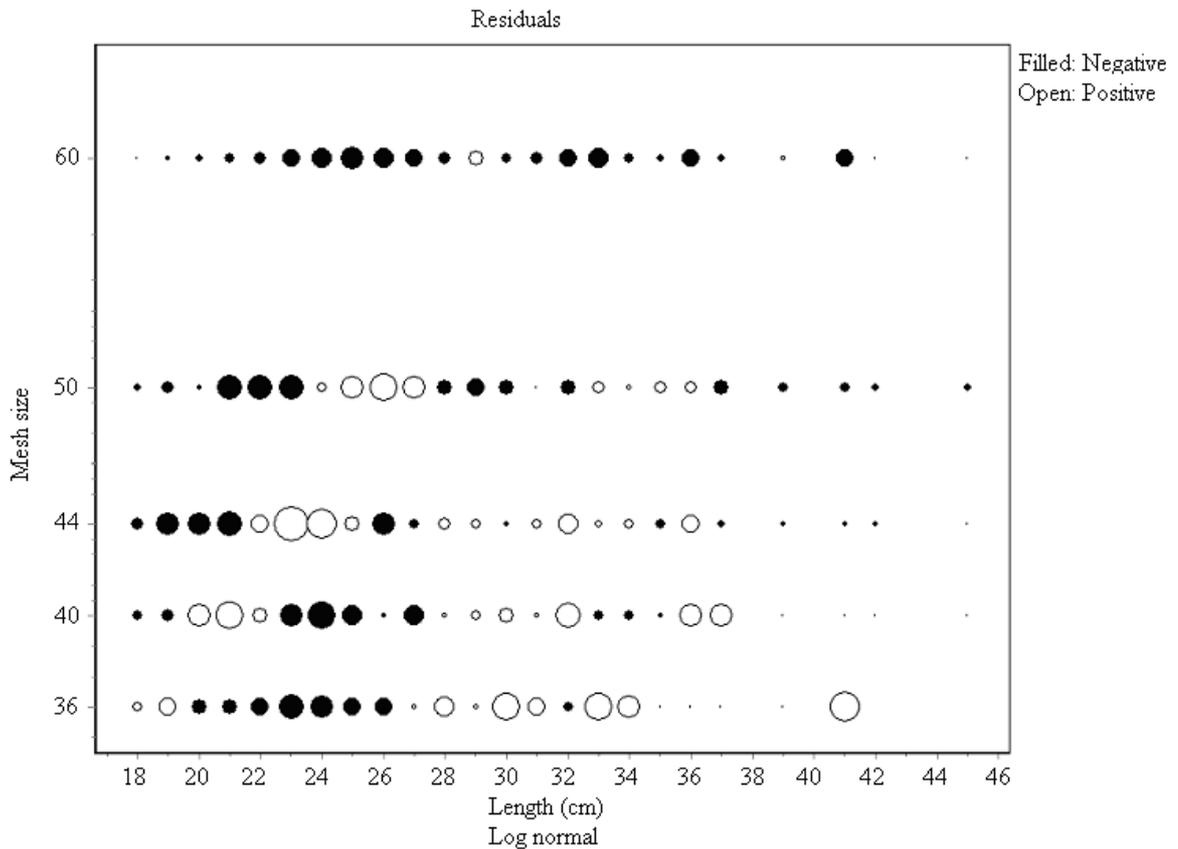
## Discussion

The lognormal model gave the best fit for gillnet in Lake Karamık. In general, gillnet selectivity curves may approach normal curves when most fish are wedged or gilled (Hamley 1975). However, when a large proportion of fish are tangled in the net, catch data are skewed to the right, fitting better to gamma or lognormal models or multimodal models (Hamley 1975; Kurkilathi *et al.* 1998). In most studies, selectivity curves take unimodal form (Hamley 1975) and the best fit was also achieved using a normal scale model (Poulsen *et al.* 2000). Carol and Garcia-Berthou (2007) reported that the normal scale had the best fit for *Alburnus alburnus*, *Rutilus rutilus*, *Squalius ceohalus* and *Scardinius erythrophthalmus*, while normal location for *Cyprinus carpio* and *Chondrostoma miegii*. On the other hand, lognormal model gave the best fit for *Barbus graellsii* and *Sander lucioperca*. Psuty-Lipska *et al.* (2006) found that the bimodal model was the best fit for gillnet selectivity of *Perca fluviatilis*.

Recently, studies in several fish species have shown that bimodal curves may yield better fit than unimodal models (Poulsen *et al.* 2000; Fujimori and Tokai 2001; Dos Santos *et al.* 2003; Erzini *et al.* 2003). But, in our study the bimodal model was not available in the gillnet functions of SELECT.

**Table 3.** Modal lengths and spread values.

| Mesh size (mm) | Modal length (cm) | Spread |
|----------------|-------------------|--------|
| 36             | 20.420            | 3.012  |
| 40             | 22.689            | 3.346  |
| 44             | 24.958            | 3.681  |
| 50             | 28.362            | 4.183  |
| 60             | 34.034            | 5.020  |



**Figure 2.** Deviance residuals plot for the lognormal selection curve fits.

Deviance residual plot showed that positive and negative residuals were nearly equal for mesh size of 36, 40, 44 and 50 mm. But, negative residuals were predominance for 60 mm mesh sized net. If the deviance residuals are clustered on one-side with positive or negative area, the model is judged unsuitable (Dobson 1993; Tokai & Mitsuhashi 1998). The results showed that gillnet selectivity for pike may vary with fish sizes. Especially large pike have very sharp and numerous teeth. Therefore, in the fishing with gillnets probability of capture of pike by entangling in the teeth was higher for large individuals.

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# Ichthyofauna of the Çobanlar Stream (Samsun, Turkey)

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**Abstract** The research was conducted to determine the fish species inhabiting in the Çobanlar Stream within the Yeşilirmak Delta between April 2004 and July 2005. Electric fishing, cast netting, fishing line and fisherman's dip net were used to catch fish samples. As a result of evaluated individuals caught from the study area, 12 species belonging to 4 families (Cyprinidae, Esocidae, Mugilidae, Gobiidae) were identified. This paper gives the diagnostic characteristics of these fish.

## Introduction

The first record of the fish fauna in Turkey was reported by Abbott in 1835 (Kuru, 2004). Foreign researchers that visited the country between 1835 and 1940 collected fish samples from throughout Turkey and placed them in museums located in London, Hamburg, Belgrade and Bucharest, before publishing scientific reports regarding their findings. A large part of the inland fish fauna of Turkey has been determined by both native and foreign researchers since 1940, these ichthyofauna investigations intensified after 1970. These studies were generally directed towards large freshwater systems. It is important to study fish species that inhabit smaller freshwater rivers or lakes, as it enables us to document the existence of unknown fish species as well as species that have high economical importance. This research was conducted in the Çobanlar Stream which, to date, had not been investigated from the viewpoint of fisheries.

## Materials and methods

The investigation area was located in the southeast of Samsun province (36°00'-37°00' east longitudes, 41°00'-41°30' north latitudes). The samples were captured using various equipment and techniques. Metric characters were measured by dial caliper with 95% confidence limits and a fish measurement scale. All meristic characters were counted by lancet and fish needle under a stereoscopic binocular microscope. For the genus and species identifications, the following were referred to: Berg 1962, 1964, 1965; Kuru 1975, 1980; Whitehead *et al.* 1986; Fischer *et al.* 1987; Szczerbowski 2001; Mater *et al.* 2002.

**Table 1.** Fish species biometric measurements.

| Family     | Species   | Diagnostic Characteristics          |                    |                    |                    |                      |                    |                    |               |                |              |               |             |             |        |
|------------|---|-------------------------------------|--------------------|--------------------|--------------------|----------------------|--------------------|--------------------|---------------|----------------|--------------|---------------|-------------|-------------|--------|
|            |   | SL(mm)                              | SL/BD              | SL/HL              | HL/ED              | HL/ID                | ID/ED              | D                  | V             | A              | P            | L.lat         | L.tran      | PT          | N      |
| Cyprinidae | <i>Alburnus chalcoides</i><br>(Güldenstädt)         | 63-95                               | 4.73-5.21          | 4.17-4.37          | 2.99-3.32          | 3.96-4.59            | 0.65-0.84          | III 8              | II 9          | III 13-14      | I 16-17      | 63-65         | 11-12       | 2.5-5.2     | 3      |
|            | <i>Capoeta tinca</i><br>(Heckel)                    | 95-155                              | 4.27-4.87          | 4.07-4.57          | 3.55-4.41          | 2.58-2.95            | 1.24-1.65          | IV 8 (9)           | II (7) 8 (9)  | III 5          | I 17-19      | 71-82         | 13-16/9-12  | 2.3-4-4.3-2 | 34     |
|            | <i>Carassius gibelio</i><br>(Bloch)                 | 56-138                              | 2.45-2.87          | 2.13-3.82          | 2.70-4.69          | 2.45-3.91            | 1.05-1.42          | IV (14) 16-18      | II 7-9        | III 5          | I 14-18      | (29) 30-32    | 6-7/6-7     | 4-4         | 30     |
|            | <i>Squalius cephalus</i><br>(Linnaeus)              | 76-170                              | 4.07-4.82          | 3.78-4.27          | 3.91-4.19          | 2.44-2.98            | 1.39-1.85          | III 8              | II 7-8        | III 7-8        | I 14-17      | 43-46         | 6.5-7.5/3-4 |             | 8      |
|            | <i>Rhodeus sericeus</i><br>(Pallas)                 | 41-68                               | 2.88-3.15          | 4.00-4.68          | 2.51-3.28          | 2.37-2.66            | 1.07-1.32          | III 9              | II 6-7        | III (8) 9 (10) | I 9-11       | 4-7           | 5-6/3-4     | 5-5         | 32     |
|            | <i>Rutilus rutilus</i><br>(Linnaeus 758)            | 83-130                              | 3.12-3.65          | 4.00-4.46          | 3.51-4.23          | 2.24-2.82            | 1.50-1.56          | III 9-10           | II 8          | III 10-11      | I 15-17      | 43-48         | 8-9/3-4     | 6-6         | 2      |
|            | <i>Vimba vimba</i><br>(Linnaeus 758)                | 140                                 | 3.91               | 4.04               | 3.50               | 3.04                 | 1.15               | III 8              | II 9          | III 16         | I 16         | 57            | 11/5        | 5-5         | 1      |
|            | <i>Scardinus erythrophthalmus</i><br>(Linnaeus 758) | 73-90                               | 3.55-3.81          | 4.03-4.41          | 3.12-3.49          | 2.32-2.82            | 1.26-1.35          | III 8              | II 7-8        | III 10         | I 13-15      | 39-40         | 7-7.5/3     | 3.5-5.3     | 5      |
|            | <i>Esox lucius</i> Linnaeus                         | 180-255                             | 5.81-6.10          | 3.19-3.23          | 5.51-6.35          | 4.66-5.32            | 1.17-1.30          | VII-VIII           | II 9-10       | VII-VIII       | I 13-15      | 120-126       | 14/14-17    |             | 4      |
|            | Mugilidae   | <i>Mugil cephalus</i><br>(Linnaeus) | SL(mm)<br>147-155  | SL/BD<br>4.57-4.81 | SL/HL<br>4.06-4.14 | HL/ED<br>3.70-3.81   | HL/ID<br>2.38-2.36 | ID/ED<br>1.55-1.65 | D1<br>IV      | D2<br>I 8      | A<br>III     | P<br>II 15-16 | Sq<br>45-50 | PC<br>2     | N<br>2 |
| Gobiidae   | <i>Neogobius gymnotrachelus</i><br>(Kessles 1857)   | SL(mm)<br>78-95                     | SL/BD<br>4.53-4.83 | SL/HL<br>3.28-3.48 | HL/ED<br>4.27-4.33 | HL/ID<br>12.43-14.27 | ID/ED<br>0.30-0.34 | D1<br>VI           | D2<br>I 15-16 | V<br>I 5       | A<br>I 12-13 | P<br>16-17    | Sq<br>57-58 | N<br>3      |        |
|            | <i>Proterorhinus marmoratus</i> (Pallas 1814)       | 34                                  | 4.50               | 3.47               | 4.67               | 10.32                | 0.45               | VI                 | I 16          | I 5            | I 13         | 15            | 43          | 1           |        |

**SL:** Standard length **BD:** Body depth **HL:** Head length **ED:** Eye diameter **ID:** Interorbital distance **D:** Dorsal fin **D<sub>1</sub>:** First dorsal fin **D<sub>2</sub>:** Second dorsal fin **V:** Ventral fin **A:** Anal fin **P:** Pectoral fin **L.lat.:** Lateral line scales **L.tran.:** Line transversal scales **Sq:** Number of scales on a line between the back of the head and the beginning of the caudal fin in the fish without lateral line **PT:** Pharyngeal teeth **PC:** Number of pyloric caeca **N:** Specimen number.

## Results

In this study, twelve species belonging four families from the Çobanlar Stream were identified. Biometric measurements and counts of fish species were recorded (Table 1).

## Discussion

Our findings were similar to previous data recorded in similar research projects. The investigation area had relatively high fish diversity, although twelve taxa have been determined in this study, further investigations may reveal that other fish species subspecies may be present. Individuals caught and identified included; *Alburnus chalcoides*, *Capoeta tinca*, *Carassius gibelio*, *Squalius cephalus*, *Rhodeus sericeus*, *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Vimba vimba* from Cyprinidae; *Esox lucius* from Esocidae; *Mugil cephalus* from Mugilidae; *Neogobius gymnotrachelus*, *Proterorhinus marmoratus*.

This stream is a natural resource and provides a proportion of the protein requirements for the people living in the area. *Esox lucius* and *Mugil cephalus* inhabit the stream and have an economic importance but these species are illegally exploited by the people in the area. Consequently, the continuity of life in the stream is threatened. There is no doubt that the introduction of species that are of economical importance, due to their high meat yield, could relieve the pressure on fish stocks and contribute to the national development of Turkish fisheries.

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# Lessons available from anglers' records: Case study of the Brno reservoir (Czech Republic)

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**Abstract** The majority of open water bodies of the Czech Republic are managed by the anglers' unions. Angling has considerable effect on fish stocks but appropriate management approaches to address these impacts are often lacking. According to internal rules of the Czech angler unions, recording the outcomes of angling events and fish caught and taken is obligatory for all anglers. Thus, the anglers' records provide a very important and valuable source of information about the exploitation effort, stocking efficiency (rate of return), fish growth, natural recruitment, fish assemblage composition and other stock characteristics. These figures are of particular importance in bigger reservoirs, where the evaluation of fish assemblage structure, abundance and biomass is quite difficult. An example from Brno reservoir is presented to show the utility of anglers' records for the evaluation of angling effort, fish assemblage composition, trends of water quality development and interspecific relationships in fish community.

## Introduction

Recreational fisheries (angling) are the sole user of fish stocks in open water bodies of the Czech Republic. It can affect fish populations but appropriate management approaches to address these impacts are often lacking (Arlinghaus 2006). According to the internal rules of angler unions operating in the Czech Republic (Czech Anglers' Union and Moravian Anglers' Union) recording information about the angling event into the "File of records about angling performances and catches" is obligatory for an angler before angling commences and is after the angling event is completed. Thus, the anglers' records provide a very important and high valued information about the particular fishing ground attendance, stocking efficiency (rate of return), fish growth, natural recruitment, fish assemblage composition (see also Drašík *et al.* 2004). These figures are of particular importance in bigger reservoirs, where the evaluation of fish assemblage structure, abundance and biomass are very difficult and inaccurate.

Brno reservoir is situated in the immediate neighbourhood of the city of Brno (450 000 inhabitants). It results in strong exploitation of the reservoir for recreational purposes (angling, swimming) and water sports (sailing, water-skiing, boating, wind-surfing).

Comprehensive limnological investigations, including the monitoring of pollution sources in the watershed, have been performed in the reservoir from the early 1990s through to the present day, which showed poor water quality in the reservoir and

surrounding catchment. The influence of industrial, municipal and agricultural pollution (point, diffuse and aerial sources) resulted in an excessive inflow of nutrients and other pollutants (heavy metals, organic compounds, radioactivity) into the reservoir. Improper landscape management during the previous period of agriculture intensification resulted in pronounced sediment erosion. On average, 63.8 t P and 1707.9 t N are transported to the Brno reservoir annually. The reservoir has become eutrophic, which is characterised by considerable summer stratification of dissolved oxygen concentrations – whilst over-saturation (up to 16.6 mg L<sup>-1</sup> O<sub>2</sub>) occurs in the euphotic layer; very low concentrations or even anaerobic conditions are regularly recorded in the hypolimnion during June – early September. Nutrients, iron and manganese are liberated and released from thick bottom sediments during the anaerobic conditions (Drábková & Maršálek 2004). Thus one of the tasks for fish biologists was to contribute to the restoration process of the Brno reservoir environment by evaluating the fish assemblage using angler records and to consider if (and how precise) do these records reflect the changes in water quality.

## Material and methods

Brno reservoir (259 ha) is situated in the middle stretch of the Svatka river, which is an important stream for the southern Moravia region (Czech Republic). From the fisheries point of view, Brno reservoir is particularly important for recreational fishing. The operation of the reservoir was initiated in early 1940s and its main objectives were to protect the city of Brno from flooding and to optimise the discharges for downstream drinking-water abstraction, industry and irrigation. Its dam has a hydropower water plant.

For the purposes of the evaluation, data recorded in angler records about the angling events in the “File of records about angling performances and catches” were summarized and elaborated. The entry about angling performance includes the date and the name (or number) of the fishing ground at the beginning of fishing. All fish caught that are above the legal size limit and expected to be retained must be immediately recorded after landing. All other fish caught in an angler’s possession, which are below the size limit, must be recorded after finishing the angling performance, summarizing the number of fish and their weight for each species separately.

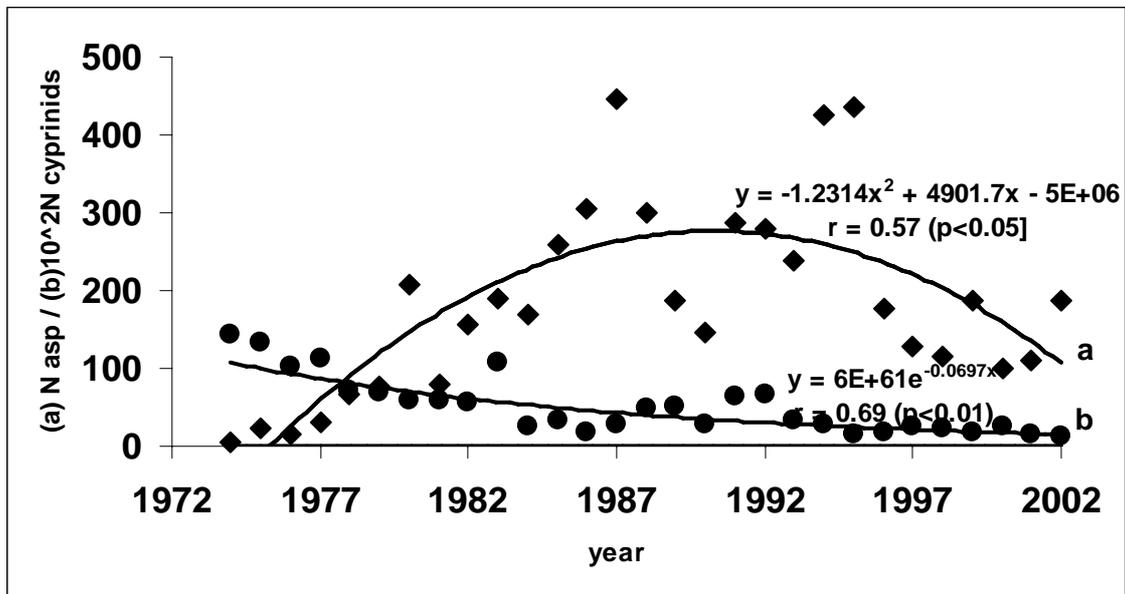
Data about angling intensity and efficiency, and fish species and size composition on Brno reservoir were available since the 1970s from anglers’ records with exception of angling performance. The recording of each (not only successful) angling performance was introduced in 1991. Both figures about stocking rates and angler catches in individual years were provided by the headquarters of the Moravian Anglers’ Union.

## Results

Mean annual angling effort intensity in Brno reservoir between 1991 and 2006 was 54 816 ± 10 393 angling trips (man/day performance). Mean annual angling yield amounted to 32 690 ± 7411 kg (27 293 ± 7428 fish individuals), which corresponds to an angling yield of 148 ± 34 kg per ha. Cyprinid species predominated anglers’ catches (Table 1). Common carp (*Cyprinus carpio*) represents 39.5 and 70.3% by number and biomass of the total angling yield from the reservoir, respectively. Common bream (*Abramis brama*) is also of importance contributing 42.2 and 18.7% of catch by number

and biomass, respectively. Catches of other non-predatory cyprinid coarse fish (tench, *Tinca tinca*, chub, *Leuciscus cephalus*, nase, *Chondrostoma nasus* and herbivores) do not exceed several tens of individuals fish per year.

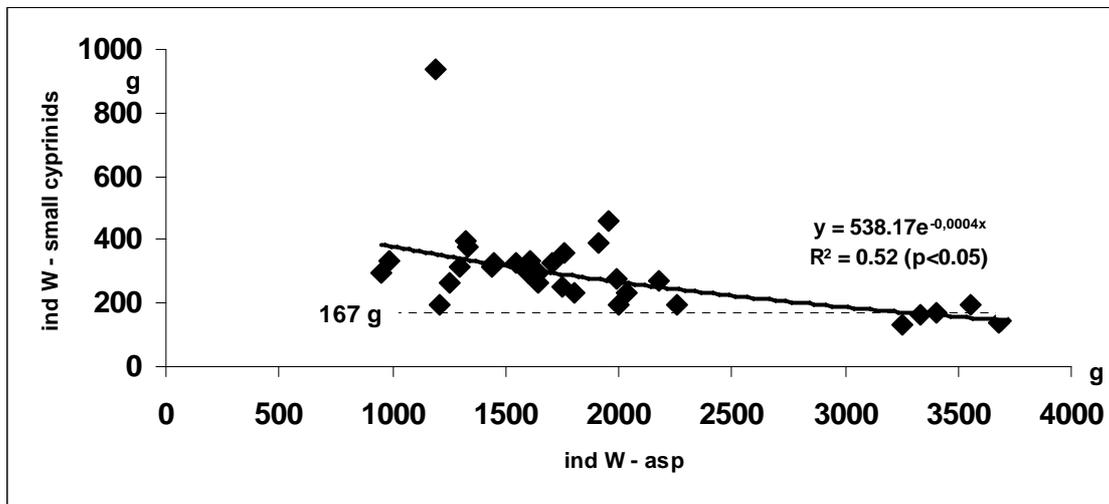
At present, asp (*Aspius aspius*) is an important predatory fish in the reservoir with 0.8 and 1.0% proportion on total catches. Records of asp only appeared in anglers' records in 1974 (Fig. 1). The average individual weight of the catch of small cyprinids (besides bleak, *Alburnus alburnus*, and roach, *Rutilus rutilus*, also rudd, *Scardinius erythrophthalmus*, crucian carp, *Carassius carassius*, Prussian carp, *Carassius gibelio* and others) showed a long-term exponential relationship ( $y = 538e^{-0.0004x}$ ,  $n = 33$ ,  $P < 0.05$ ) with the average weight of asp, thus offering evidence about the impact of the asp population upon small cyprinids. The size of small cyprinids appears to be related to the size of asp; as asp decline in mean size their impact on small cyprinid recruitment through predation seems to decline the mean size of small cyprinids increases. (Fig. 2). The mean size of small cyprinids in 1961–1973 (period before asp appeared in angler records) was 167 g (44–287 g) and rose to 940 g in 1994. The biggest asp caught by anglers was 8.10, 7.60 and 7.20 kg in 1988, 1992 and 2002, respectively.



**Figure 1.** The course of annual catch rates of asp (a) and small game cyprinids (b) in numbers of individuals (n.)

On average 7044 individual pike (*Esox lucius*) are released each year, which corresponds to 4.3% rate of return in angler catches. Zander (*Sander lucioperca*) is the most important predatory fish species of Brno reservoir, but as with pike, their catch rates have decline in recent years. On average, 530 one-year-old equivalent individuals (879 kg) are recorded in anglercatches every year with a long-term mean size around 1.5 kg. Mean annual stocking rate is equivalent to 9121 one-year-old individuals, which corresponds to a 5.8% recapture rate. Capture of European catfish (*Silurus glanis*) is rare in Brno reservoir. On average, 6 catfish (52 kg) are caught each year, which corresponds to a 0.7% recapture rate. Catfish individuals weighing 38.5, 59 and 71 kg were caught by anglers in 1976, 2002 and 2006, respectively. Perch, *Perca fluviatilis*, are one of the dominant species in angler catches with 869 individuals (270 kg) caught

each year, which represents 0.8% of the total angling yield from the reservoir. A perch weighing 1.20 kg was recorded in 2004.



**Figure 2.** The relationship between mean size of asp and small game cyprinids in anglers' records. Note: 167 g - the mean size of small game cyprinids in anglers' records before asp appearance in 1974.

Eel, *Anguilla anguilla*, yield has decline over time but individual size have increased, suggesting no recruitment to the population. On average, 177 individuals (140 kg) are caught each year, representing a 3.3% recapture rate. The annual mean catch of salmonids (rainbow trout, *Oncorhynchus mykiss*, brook trout, *Salvelinus fontinalis*, brown trout, *Salmo trutta m. fario*) and grayling, *Thymallus thymallus*, amounted to 108 individuals (43 kg).

## Discussion

The proximity of a big city, valuable nature and landscape features, good availability by road and/or shuttle bus and boat traffic and regular fish stocking are important prerequisites for high interest of anglers in this fishing ground. However, the unfavourable status of the fish stocks in Brno reservoir has been often mentioned in relation to water quality. Adámek (2000) used angler caches to better understand the relationship between water quality and fish stocks in the Brno reservoir. It appears that annual stocking is the biggest determinant of cyprinid catch and return rates (Table 1). This is because of their predominance in the fish assemblage and the enormous interest of Czech anglers in common carp, which is regularly released in amounts exceeding the limit of annual stocking programme. On the other hand, the angler interests in other non-predatory cyprinid coarse fish have declined in recent years, which support the tendency of these cyprinids to become overpopulated; a trend that is undesirable from the point of view of water quality management.

Fish are capable to develop a considerable pressure upon the other biotic items of water ecosystem (“top down” effect) (e.g. Komarkova 1998, Lammens 1999, Romare *et al.* 1999). In water bodies with “put and take” angling management, the development of a fish assemblage corresponding to the water quality requirements is extremely difficult. Anglers often concentrate their effort on fish species that are desirable for helping

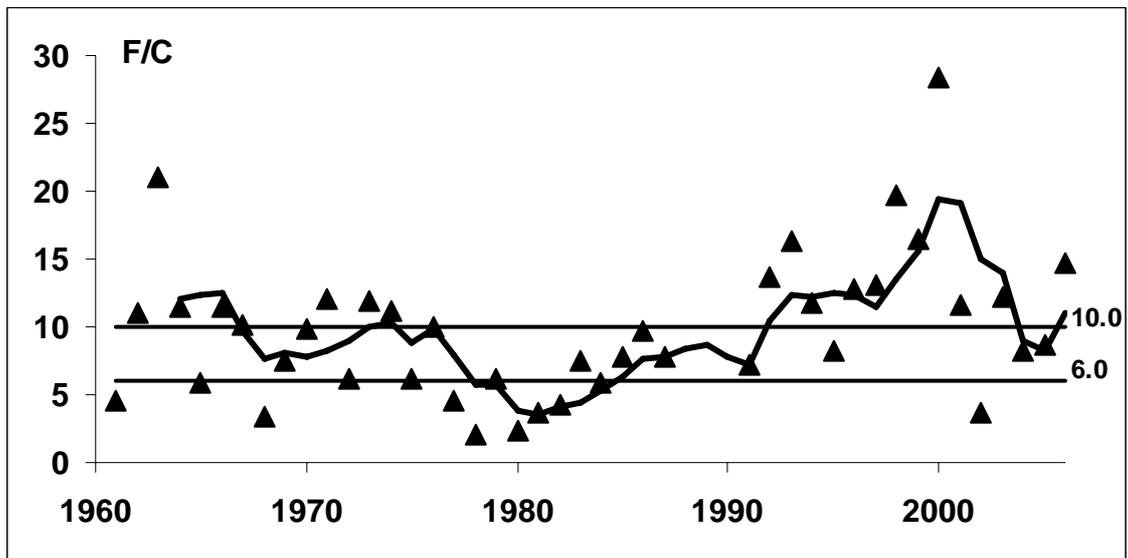
maintain good water quality (predators) because they control the benthivorous and planktivorous cyprinids and/or they require enhanced stocking with undesirable (from the water quality point of view) fish like common carp (Arlinghaus & Mehner 2003) making any effort for “biomanipulation” inefficient (Adámek 1993).

**Table 1.** Mean annual stocking numbers, catches and rate of return in Brno reservoir (1992-2002). Note: \*Herbivorous fish - grass carp, *Ctenopharyngodon idella*, silver carp, *Hypophthalmichthys molitrix* and bighead carp, *Aristichthys nobilis*; \*\* Others - roach, *Rutilus rutilus*, rudd, *Scardinius erythrophthalmus*, ruffe, *Gymnocephalus cernuus*, Prusian carp, *Carassius gibelio*, crucian carp, *Carassius carassius*, bleak, *Alburnus alburnus* etc.; % of limit – percentage of fish released according to the stocking limit assigned by the Ministry of Agriculture, rate of return – percentage of fish individuals captured in relation to number of fish individuals released

| Fish species                              | Stocking rate |              | Catches |       |                    |
|---|---------------|--------------|---------|-------|--------------------|
|   | Number        | % of maximum | Number  | kg    | Rate of return (%) |
| Brown trout, <i>Salmo trutta m.fario</i>  |               |              | 29      | 11    |                    |
| Rainbow trout, <i>O. mykiss</i>           | 371           |              | 74      | 29    | 19.9               |
| Brook trout, <i>Salvelinus fontinalis</i> |               |              | 2       | < 1   |                    |
| Grayling, <i>Thymallus thymallus</i>      |               |              | 3       | 2     |                    |
| Pike, <i>Esox lucius</i>                  | 7044          | 78.0         | 300     | 619   | 4.3                |
| Carp, <i>Cyprinus carpio</i>              | 18834         | 121.1        | 10760   | 22338 | 57.1               |
| Tench, <i>Tinca tinca</i>                 | 75            |              | 96      | 70    | 128.0              |
| Bream, <i>Abramis brama</i>               | 4518          | 123.4        | 11485   | 5948  | 254.2              |
| Chub, <i>Leuciscus cephalus</i>           |               |              | 65      | 30    |                    |
| Barb, <i>Barbus barbus</i>                |               |              | 2       | 3     |                    |
| Nase, <i>Chondrostoma nasus</i>           |               |              | 16      | 13    |                    |
| *Herbivorous fish                         | 145           |              | 19      | 72    | 13.1               |
| Asp, <i>Aspius aspius</i>                 | 0             | 0.0          | 217     | 325   |                    |
| Perch, <i>Perca fluviatilis</i>           |               |              | 869     | 270   |                    |
| Zander, <i>Stizostedion lucioperca</i>    | 9121          | 82.8         | 530     | 879   | 5.8                |
| Wels, <i>Silurus glanis</i>               | 882           | 101.2        | 6       | 51    | 0.7                |
| Eel, <i>Anguilla anguilla</i>             | 5432          |              | 177     | 140   | 3.3                |
| **Others                                  | 3132          |              | 2567    | 984   | 82.0               |
| TOTAL                                     |               |              | 27217   | 31785 |                    |

The proportion of the non-predatory to predatory fish biomass (F/C ratio) is a simple expression of the balance in particular fish community (Holčík & Hensel 1972)

supplying useful information with respect to other biotic components of the ecosystem. Values between 3.0 and 6.0 indicate optimal ratio whilst values  $>10$  demonstrate undesirable condition of fish community with strong prevalence of non-predatory fish. In the Brno reservoir, the F/C ratio was constantly raising after its considerable decline in late 1970s, reaching its highest value in 2000 as indicated by decreasing portion of predators in anglers' catches (Fig. 3). Since 1983, the F/C value has exceeded the upper threshold of optimum of 6.0) and since 1992 even the level 10.0, which is considered as an upper limit of a well-balanced fish assemblage composition. After a certain decline in mid-1990s, it showed an increasing tendency (Fig.5) until a sudden drop in 2001-02 caused by a severe decline of water level due to reconstruction works on the dam hydropower turbines, resulting in enormously successful fishing for zander ( $>30$  kg per ha on average) in the inflow area of the reservoir.



**Figure 3.** The course of the F/C coefficient in 1961 – 2006. Note: Values between 6.0 – 10.0 indicate optimal ratio between non-predatory and predatory fish biomass.

Undesirable development of fish composition in Brno reservoir corresponded with worsening water quality and regular occurrence of cyanobacterial water blooms over past 10 –15 years. It is difficult to judge what was the primary cause – did the populations of predatory species decline due to the deterioration of water quality or did the water quality decline due to decreasing biomass of predatory fish and progressing ichthyo-eutrophication?

The asp population arises exclusively from natural recruitment, because no stocking was been provided since 1983, despite this species being included in the original (but still valid) stocking programme. In the 1980s, there were signs of asp overpopulation, peaking in early 1990s, as reflected by the dramatic decline in small cyprinids like bleak and roach. Subsequently, the lowest catch rates (both in terms of abundance and biomass) were recorded since early 1990s. On average, the annual catch of asp amounted to 201 individuals (333 kg).

In addition to asp spawning in the main tributary, zander also spawn naturally in the reservoir, as indicated in high values of the return rates. The reservoir provides very good habitat conditions both for spawning and the fry of zander and perch (Adámek, unpubl.). The shoreline with a shallow hard-bottom littoral in the lower part provides very good conditions for zander and perch fry, whilst the upper canyon-shaped part corresponds fully to the requirements of adult and older fish.

Regarding the other fish species of angler interest, pike is regularly stocked as advanced fry, and to a lesser extent as one- or two-year-old fish, but their occurrence in angler catches has declined in the last 20 years. European catfish was stocked in rather low number but regularly and catches are low. Glass eel have been stocked irregularly due to unstable deliveries. As a consequence, annual eel yields have declined, accompanied by increasing individual size. Nevertheless, its average rate of return amounting to 3.3% is high, influenced by irregular stocking and possible downstream migration from upper water bodies. Poupě (1979) reported the former return rate of eel from the Brno reservoir as 7.2%.

Salmonid catches are registered quite frequently – usually as a consequence of release of rainbow trout and brook trout or due to downstream migrations from upper trout fishing grounds and/or trout ranching streams (brown trout and grayling). Salmonid fish occurrence suggests there is good water quality in the upper part of the reservoir (inflow area).

Currently, the rules of Brno reservoir fisheries management are subject to re-elaboration associated with partial draining to remove sediment. Thus, fish rescues and their safe transfer to other fishing grounds are crucial and will require careful supervision of public, media, scientific and animal welfare institutions. Anglers' records about exploitation of the fish assemblage in the reservoir will be useful to help make decisions about how to proceed with this action. However, despite their usefulness, the validity of data obtained from angler records must be treated with caution because they are influenced by angler preferences for certain fish species and tendencies to overestimate their catch (particularly regarding fish size). Nevertheless, as demonstrated in this study the information they provided might be worthy for general evaluation of the composition and prosperity of the fish assemblage.

### **Acknowledgement**

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# The economic value of recreational fishing: An example of a Hungarian multifunctional pond fish farm

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**Abstract** The multifunctionality of Hungarian aquaculture has become an important issue as it is increasingly recognised that pond farms contribute to rural wealth not only through the production of fish, but also by the social benefits of services and ecological functions, which are frequently undervalued.

Recreational fishing and related tourism will play a key role in the multifunctionality of aquaculture, as angling provides high economic value to society. Whilst the economic value of commercial fisheries and aquaculture can be estimated in a relatively easy way through the analysis of market statistics, the economic value of recreational fisheries is not fully reflected in the market price of fishes caught and fishing licenses or day tickets. However, using the so-called “travel cost method”, data on angling-related transactions can be used to estimate the total economic value of recreational fishing. This paper demonstrates a case study on the economic valuation of angling in a Hungarian multifunctional pond fish farm.

## Introduction

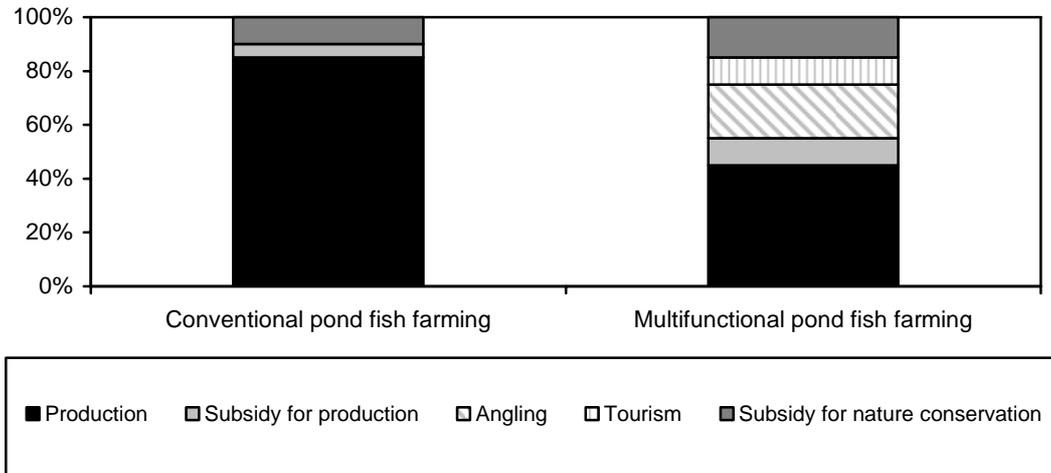
With the increasing dominance of hypermarkets and supermarkets in the fish retail sector in Hungary, the traditional pond fish farmers are faced with many problems in marketing their production of fish and the farm’s gate selling price hasn’t been raised for years due to the asymmetric bargaining power of the parties. Given the continuously increasing production costs, the producers are urged to:

- Find new marketing channels or methods, or
- Diversify their profile through multifunctional operation. The increased number of income sources reducing the share of revenues from wholesale marketing of farmed fish (Figure 1).

Considering the relatively high value attached to recreational fishing (Shrestha *et al.* 2002; Barnes *et al.* 2002; Loomis 2005) the introduction of angling ponds in farms could address the problem of decreasing profits in two ways. On the one hand, as the anglers buy and take home the caught fish, it helps to market a share of produced fish at a higher price (angling centres generally apply higher prices for caught fishes than the wholesale prices), without transportation and harvesting costs. Whilst on the other hand angling raises the non- traditional income sources of farms: entrance tickets and revenues from related tourism-based services (e.g. buffet, angler-shop, restaurant, camping).

This paper investigates the econometric background of a selected Hungarian fish farm that operates a 3 ha angling pond with approximately 1000-1500 visitors per year. The case study focuses on the question of the optimal entrance ticket price, which allows the

farm's management to obtain the maximum share of the total value attached to recreational pond-fisheries in the given region.



**Figure 1.** Structure of the revenue in conventional pond fish farms and multifunctional pond fish farms in Hungary (Váradi 2007).

### The Aranyponty Angling Centre in Szarvas

The investigated farm is located near Szarvas, south-eastern Hungary. Although there are many opportunities to fish in natural waters in this area due to the abundance of rivers and cut-off lakes, this is the only angling centre of this kind in this area. The closest major angling centres are 50-60 km from Szarvas. The farm's total pond surface is 150 ha, of which 3 ha are open to anglers. The angling centre is open every day from April to September, between sunrise and sunset. In the grounds of the Angling Centre, the owner operates a buffet and a small shop for selling bait and other accessories. The price of the entrance ticket was 1200 HUF in 2004 (the investigated year). The visitors also had to pay to take away caught fish. According to the current legislation related to recreational fishing, every visitor has to be registered by name and postal address. A total of 1227 tickets were sold, most of them to local people. As there are many weekend houses along the cut-off lake in Szarvas, during the summer many people from other regions of Hungary spend their free time in the town. This accounts for approximately 200-400 visits to the farm during the fishing season.

### Material and methods

The Zonal Travel Cost Method was used to analyse the demand for the local angling centre. The method is widely used to assess the value of parks, lakes and other sites which are used for recreational activity. The basic premise of the Travel Cost Method (TCM) is that the total costs incurred by individuals to enjoy a given recreational activity can be used as a surrogate price for access to the site. The model assumes that the recreational fishermen don't make a distinction among the costs (price of entrance tickets, the cost of travelling to the angling site, the cost of time, price of baits, etc.), all these cost are aggregated before making a decision to visit the angling site.

The TCM can be applied in two alternative methods: the individual or the zonal method. In this case the zonal method was used, to reduce data collection.

The Zonal TCM is applied by collecting information on the number of visits to the site from different zones, which can be defined as circular zones around the site, geographical regions or administrative districts. Assuming a normal (decreasing) demand curve for recreational activities, the zones further from the investigated recreational sites typically have fewer visitors per zone, as the travel cost (and the travel time) increases while the other costs are generally the same. By regressing the data for different zones, the following trip generating function (so-called first-stage demand function) can be drawn:

$$V = F (TC, TT, I, S),$$

Where  $V$  represents the visitation rates (number of angler days/ zone) from the different zones,  $TC$  represents the travel cost (and other costs incurred),  $TT$  represents the travel time, which is generally monetized,  $I$  represents the income level of the different zones and  $S$  represents other socio-economic or any other variables which could affect visitation rates. The coefficient of  $TC$  and  $TT$  must be negative to successfully apply the model (with the increase of travel cost and travel time, the visitation rate decreases), while the coefficient of  $I$  is generally positive, indicating, that a higher income results in higher visitation rates. (In case of some inferior recreation sites the coefficient of the income variable can be negative. Ahmed et al. 2007)

Once this trip generating function has been determined, it can be used to define a real demand curve (so-called second-stage function) for the angling centre. This is done by considering what impact an increase in entrance ticket price would have on aggregate demand, and using this to trace out a curve. In practice it means that it can be calculated what impact a 200 HUF increase in ticket price would have on visitation rates from a given zone through analysing the visitation rates from those zones and which inhabitants spend 200 HUF or more on travelling to the angling centre. Generally linear, log-linear, reciprocal, linear-log and double-log function forms are applied in TCMs, each of them has some advantages over the others. In this case the linear type regression was chosen (Gürlük *et al.* 2007).

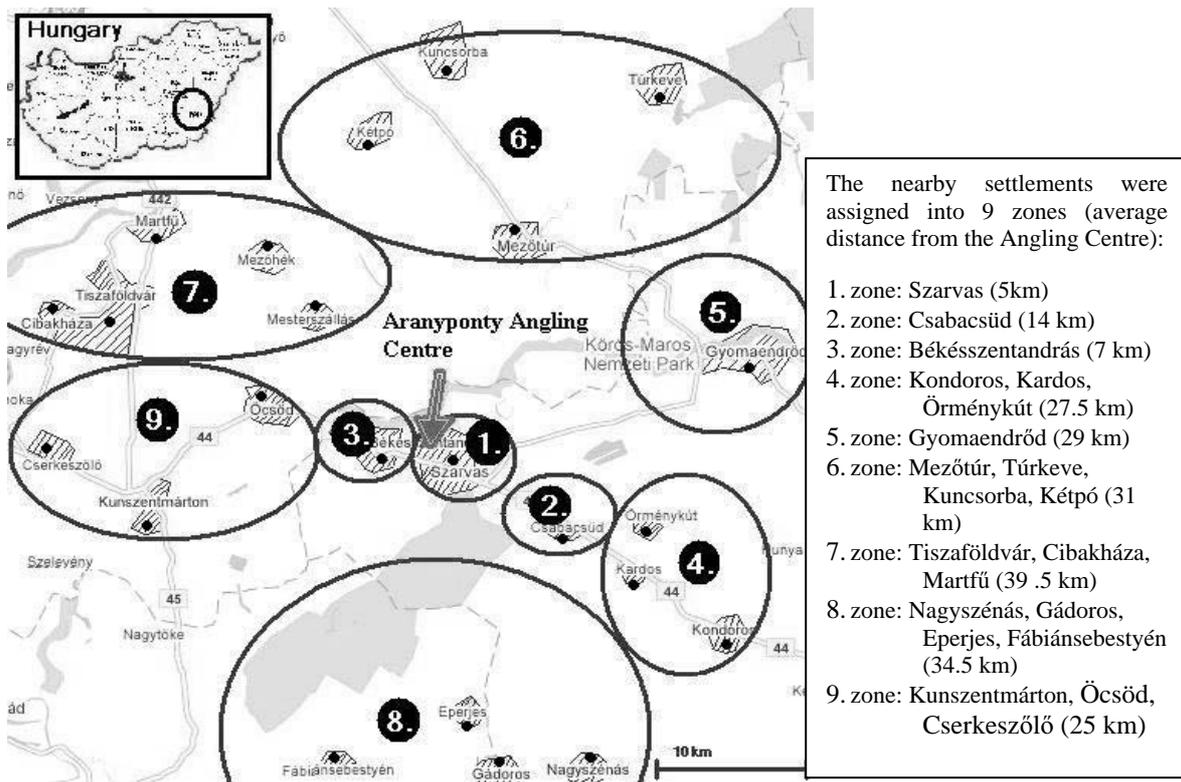
Once the real demand function for the angling centre is determined, the  $TR$  (Total Revenue) function can be traced out as it is the multiplication of the ticket price and the estimated number of visitors (which is a function of the price of the entrance ticket), at every price level. In case of a normal, decreasing (Marshallian) demand curve, this  $TR$ -function has a so-called reversed U-shape, which reaches its maximum at a definable price level. Considering that the total costs of the angling centre are more or less fixed (as the major share of it is not a function of visitors), the  $\Pi$ -function (Profit-) function can be traced out by the subtraction of the fixed cost from the  $TR$ - function.

## Results

The data on the number and addresses of visitors were collected from the Angling Centre's registration system. The income and population statistics were taken from the Hungarian Statistical Central Office's (HCSO) homepage. The visitor statistics for 2004 were analysed. That year 1227 entrance tickets were sold, the price of the tickets was

1200 HUF. As the presence of multi-destination trips can disturb the application of the Travel Cost Method, the visitors were separated into 3 groups:

a) The *first group* (called local group) contained 510 visits, which originated from the nearby (less than 40 km) settlements around Szarvas. These visits (of course one visitor can buy entrance tickets more than once a year) are almost surely made up of one-day, single-purpose trips by the anglers, which provide a good background to the use of the travel cost model. Nine zones were created in this small region (Fig. 2).



**Figure 2.** Specification of the travel zones in the *first group* of visitors (one-day, single-purpose trips)

Statistics on the income of settlements were not available; therefore no income variable was used. The total cost (ALL COST) is the total price of the entrance ticket (P), the travel cost (TC) and the cost of travel time (TT).

To calculate the TC, the average price of fuel in 2004 was used (243 HUF/litre – HCSO) and the fuel consumption was calculated to 7.5 litres per 100 km. As the average size of the angling groups were 2 people per trip, the total travel cost per trip was halved to get the travel cost per person. To estimate the cost of travel time (TT) the widely used rate of 1/3 of the national average wage rate was applied (see Chen *et al.* (2004) and Gürlük *et al.* (2007)). To measure the time spent on travel a 60 km/h average speed was used. Similar to methods used by Chen et al (2004) and Bülov *et al.* (2007) a home dummy variable (HD) equal to unity was used when travel originated from Szarvas, the nearest town. This is needed because of the large visitation rate from Szarvas. (Table 1.)

**Table 1.** Variables in the *first group*'s regression model

| Zone  | Number of angler days<br>(Tickets sold) | Population | Visitation rate (V)<br>(Tickets/Pop.) | Total costs (HUF)/<br>angler<br>(ALL COST)<br>(P+TC+TT) | Home dummy<br>(HD) |
|-------|---|------------|---------------------------------------|---|--------------------|
| 1.    | 250                                     | 18 497     | 0.0135                                | 1 324   | 1                  |
| 2.    | 15                                      | 2 077      | 0.0072                                | 1 547   | 0                  |
| 3.    | 22                                      | 4 107      | 0.0054                                | 1 373   | 0                  |
| 4.    | 7                                       | 7 240      | 0.0010                                | 1 881   | 0                  |
| 5.    | 20                                      | 15 381     | 0.0013                                | 1 918   | 0                  |
| 6.    | 124                                     | 30 578     | 0.0041                                | 1 968   | 0                  |
| 7.    | 27                                      | 25 164     | 0.0011                                | 2 178   | 0                  |
| 8.    | 24                                      | 12 788     | 0.0019                                | 2 054   | 0                  |
| 9.    | 22                                      | 13 907     | 0.0016                                | 1 819   | 0                  |
| Total | 511                                     | 129 739    |                                       |   |                    |

As expected, in the first group, the linear TCM can be applied very successfully; the dependent variable is explained by the independent variables at the rate of 88.1 %, which is statistically significant in a 0.001 probability level. The results indicate that travel cost is a significant ( $P < 0.03$ ) determining factor of the angling visitation rates. (Table 2.)

**Table 2.** Regression results in the first group

| Variable               | Est. coefficient | <i>P</i> -value |
|------------------------|------------------|-----------------|
| Constant               | 1.530E-02        | <0.02           |
| Total costs (ALL COST) | -6.717E-06       | <0.03           |
| Home dummy (HD)        | 7.105E-03        | <0.02           |
| $R^2 = 0.881$          |                  |                 |
| $F$ statistic = 22.22* |                  | 0.0015          |

Among the first group of zones, using the regression results the linear first-stage demand function can be written for the Aranypony Angling Centre as follows:

$$V = 0.0153027 - 0.0000067 \text{ ALL COST} + 0.0071047 \text{ HD}$$

b) The *second group* of visitors consisted of those anglers travelling from a distance of 40-90 km, and whose visits theoretically might be attributed to the single purpose of spending a day in the Angling Centre. However, it is estimated that only 60-70 percent of the tickets sold (594 in this group) were the result of a one-day, single-purpose trip, which is typical from a TCM point of view. The rest of the anglers were probably on holiday in Szarvas (a proportion of them own weekend houses in Szarvas), in this case the travel cost doesn't affect the visitation rates. Therefore, as expected, the coefficient of the ALL COST variable was considerably lower in the regression, which means, that the visitation rate is not so sensitive to changes in the costs (Table 3).

The European nomenclature of territorial units (NUTS) was used to create the zones in this group of visits, 8 NUTS of 4 level regions were selected to be the zones in this group (Table 3). The method of calculation of the *TC* and *TT* were the same apart from the average speed. In the second group an average speed of 70 km h<sup>-1</sup> was assumed during the travel from the zone to the Aranypony angling centre. An attempt was made

to include an income variable (I), but it did not have any significant effect on visitation rates. The regression results for the *second group's* zones are listed in Table 4.

**Table 3.** Specification of the travel zones in the second group

| Statistical region | Number of angler days (Tickets sold) | Population | Visitation rate (V) (Tickets/Pop.) | Total costs/ angler (ALL COST) (P+TC+TT) HUF | Income/ person/year (I) 1 000 HUF |
|--------------------|--------------------------------------|------------|------------------------------------|--|-----------------------------------|
| Békéscsabai        | 118                                  | 74 453     | 0.00158                            | 2415   | 411                               |
| Gyulai             | 115                                  | 53 431     | 0.00215                            | 2796   | 332                               |
| Békési             | 59                                   | 42 109     | 0.00140                            | 2415   | 267                               |
| Sarkadi            | 6                                    | 25 611     | 0.00023                            | 3035   | 180                               |
| Szeghalmi          | 50                                   | 43 471     | 0.00115                            | 2534   | 275                               |
| Orosházi           | 96                                   | 54 134     | 0.00177                            | 2248   | 325                               |
| Mezőkovácsházi     | 28                                   | 45 703     | 0.00061                            | 2892   | 230                               |
| Karcagi s          | 22                                   | 47 428     | 0.00046                            | 2953   | 326                               |
| Total              | 494                                  | 813 157    |                                    |  |                                   |

**Table 4.** Regression results in the second group

| Variable               | Est. coefficient | P-value |
|------------------------|------------------|---------|
| Constant               | 5.389E-03        | <0.03   |
| Total costs (ALL COST) | -1.584E-06       | 0.067   |
| $r^2 = 0.468$          |                  |         |
| $F$ statistic = 5.28*  |                  | 0.061   |

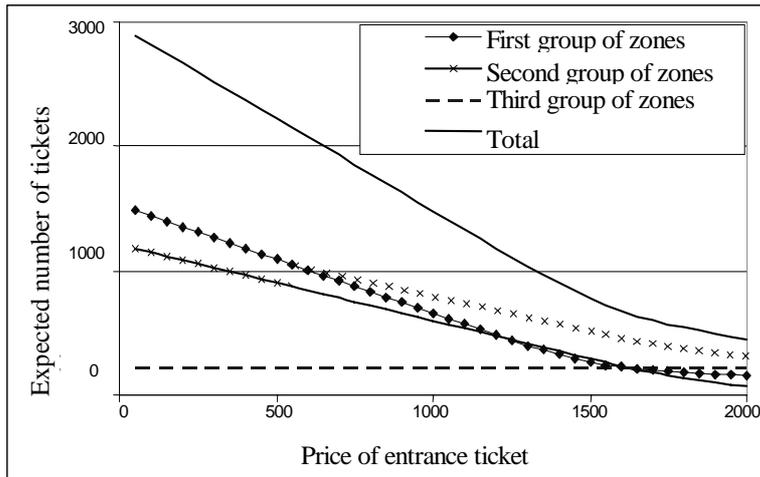
Among the second group of zones, using the regression results the linear first-stage demand function for the Aranyponty Angling Centre was:

$$V = 0.0053891 - 0.000001584 \text{ ALL COST}$$

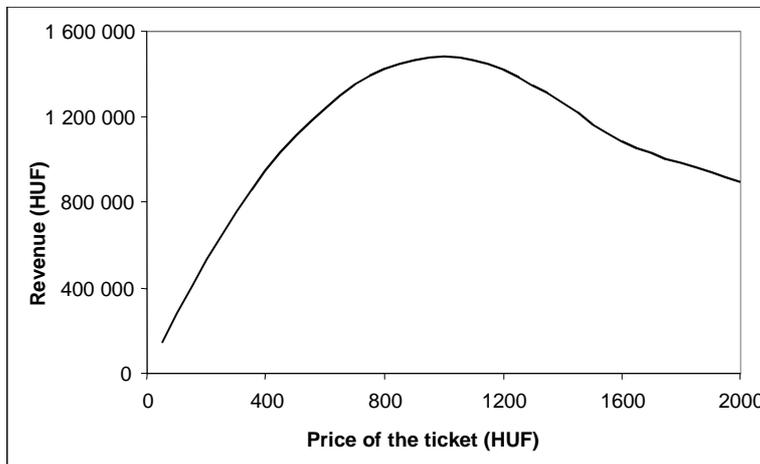
c) The third group consisted of 222 visits, which were made by visitors from remote regions (>90 km away), who were surely on holiday in Szarvas, and not visiting only for the purpose of one day fishing. In the regression analysis only the income variable (I) showed any significance ( $P < 0.1$ ), the ALL COST variable, as expected did not show any significance. For this reason in later analysis (building the second-stage demand function) the visits from this group of zones were considered as stable (222 at every price level) in the range of 0 - 2000 HUF per ticket.

The next step of the econometric analysis was the building of the second-stage demand trip. To estimate the relationship between the number of visitors and the price of an entry ticket, estimated coefficients from the regressions were used to calculate visitation rates from all the 3 groups of each zone of origin as the price of an entry ticket were increased and decreased in 50 HUF increments (Fig.3).

As the Angling Farm's revenue from the sale of entry tickets is equal to the multiplication of the number of tickets sold and the price of the tickets, it is easy to determine the Total Revenue function. For example, according to the regression results with a ticket price of 1000 HUF the farm could sell 1480 tickets in a season, which would mean 1 480 000 HUF revenue from entrance fees (Fig. 4). Of course the angling shop and the buffet would generate additional revenue.



**Figure 3.** The expected number of visits at different price levels in the Aranyponty Angling Centre (Inverse type of the Marshallian “inverse demand function”)



**Figure 4.** The Total Revenue (TR) function of the Aranyponty Angling Centre

Considering the relatively stable level of the total cost of the farm, according to the TCM presented in this study, the maximum profit can be captured at a ticket price of 1000 HUF. This means that the election of the 1200 HUF price level by the Farm’s management was too high, as the actual level of revenue is lower than the optimal revenue by 60 000 HUF. However the farm has other incomes related to angling; the profit from the buffet and the angling shop is a function of the number of anglers, therefore a higher number of ticket sales results in higher profit. This means that the optimal ticket price for the farm’s management is below 1000 HUF as indicated above, the number depends on the profit made on the angler’s average additional spending.

### Conclusions

Recreational fishing is an important recreational activity in Hungary, 3.2% of the total population are registered anglers. Analysis of the behaviour and preferences of visitors to a Hungarian Angling Centre suggests that the anglers prefer natural waters and conditions compared to the angling centre’s ponds. The maximum possible revenue based on the applied TCMs is relatively low compared to the high value attached to recreational fisheries.

The higher catch rates in angling centres don't appear to be a sufficient factor in attracting the anglers away from natural waters. These farms must take steps towards creating a near-natural environment in the farms (planting waterside trees, leaving some part of the natural reed bed, shaping the ponds with curves, peninsulas, etc.) in order to attract more recreational fishermen and raise the demand for entrance tickets to the farm.

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# **Sociological analysis of sustainable fisheries management of the endemic pearl mullet in the fishing villages of Lake Van, Turkey**

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**Abstract** The sociological research was carried out in eight fishing villages where the main income source is the pearl mullet fishery. The research has four main objectives: (1) determining main fishing inclinations (2) finding out social, cultural and individual sources of positive and negative attitudes toward external intervention to traditional fishing practices for use in sustainable fisheries management in the area (3) compiling preferences regarding alternative sources of income (4) determining general demographic structure, communal and cultural status of the fishermen living around Lake Van. The research demonstrated that during the spawning season fishing practices are determined by a complex set of sociological factors. It is commonly accepted that to change already existing attitudes is not an easy task. The research has concluded that education and “openness to innovations” are two major factors, which show a statistically significant relationship with attitudes toward the ban on fishing during the spawning season. The research also concluded that the economic loss caused by the ban could at least partly be compensated by offering alternative sources of income to those who suffer from the loss. As far as the alternative source of income is considered, the surveyed villagers indicated that their choice would be cattle breeding.

## **Introduction**

The need to conduct a sociological analysis in the coastal villages of Van Province was born out of a simple question: despite efforts towards conservation and sustainable fisheries management of the endemic pearl mullet, why were some of the villages responding positively to the ban on spawning season fishing whilst others were being resistant?

Over the years, the combined efforts of the Fisheries Department of Van Yuzuncu Yil University (particularly those of Professor Mustafa Sarı), local NGOs (e.g. The Association of Nature Observers), international organizations (e.g. UNDP), national NGOs, the media and a host of volunteers most of which are university students, have resulted in exceptional advances towards the conservation of the species and the sustainability of pearl mullet fishing. The overall population of the species has increased, fishing productivity has tripled, the average size of pearl mullet has increased from 16.5 cm to 19.5 cm, and the average number of fish per kilogram has decreased from 17 to 11. The observational evidence has given no signs of visible differences between the villages resisting the ban and those approving it. Given the fact that, on the

surface, there are no significant differences amongst the villages observed, there must be a “deeper” reason or set of reasons resulting in the structural difference in the attitudes towards illegal fishing activity and the ban on fishing during the spawning season.

To investigate this, a sociological survey has been designed with four main objectives:

(1) To determine the villager’s basic tendencies and fishing practices (2) to identify social, cultural and individual differences between the fishermen who favour the spawning season fishing ban and those who oppose it (3) to determine preferred alternative income sources to recuperate income losses resulting from the ban (4) to generate general demographic, social, and economic data on the fishing villages. A total of 4966 villagers were surveyed and a sample of 248 respondents was chosen using geographical cluster sampling. The clusters were chosen using a quota technique in order to include attitudes towards the ban on spawning season fishing. As a result eight villages with different attitudes were chosen. Out of the eight villages surveyed, three (Çitören, Çelebibağ, and Yalındüz) are known to be against the ban and winter fishing, three (Yeşilsu, Engilsu, and Dereağzı) are supportive of the ban and support winter fishing, and two (Karahana and Gölağzı) show mixed attitudes. Each one of the eight fishing villages is designated as a cluster and then a systematic random sampling technique applied to each cluster to determine the actual respondents. In the actual application of the survey, a total of 241 questionnaires were completed with success.

The questionnaire contained a total of 59 questions in six categories: (1) basic demographical information (2) fishing practices (3) use of means of mass communication, physical mobility, and perception of the status of the villages (4) household income sources (5) (potential) alternative income sources (6) social-cultural-individual openness index.

### **The concept of openness to innovations**

Although observational evidence determined that there is no visible indicator governing the villager’s attitude towards the fishing ban in the spawning season, the same category of evidence (and experiential insight coming out of participant observation for more than a decade) has hinted that villager’s attitudes cannot be reduced to a simple moment of decision. This paper describes the major conclusions in order to shed some light on how the notion and the consequent concept of “openness to innovations” were reached.

Firstly, the academic and NGO work on the conservation and sustainable management of pearl mullet fisheries has been producing positive results so far. There is a large body of knowledge accumulated through this process, which is not limited by the technicalities of fishing practice and administrative/judicial dimensions. Perhaps more important than these issues a third type of knowledge has been developed: ethnographic. To scientists and activists dealing with pearl mullet, this is the most valuable resource. The core component of this knowledge is *active participation* and systematic grass roots public education. When placed next to such experience and knowledge, this research could only be considered as a simple step hoping to systematize certain notions regarding the lifestyles, socio-economic conditions, and values of Lake Van fishermen. Therefore, in designing the research concepts, corresponding variables and survey questions understanding was based on a diverse, mostly non-systematic, partly recorded

but very strong insight generated from below. This insight can be presented in the form of three propositions: (1) When implementing external intervention towards a social change, the human and ecological factors must be given equal weight (2) these two sets of factors indeed form an indivisible whole (3) any external intervention to a local community must be carried out with a thorough understanding of the community under consideration and by procedures which are not alien to them.

As far as Van province and the fishermen of Lake Van are concerned, the main challenge regarding the introduction of an innovation (e.g. winter fishing, fishing with larger mesh size nets etc.) has a lot to do with a general openness to the outside world, to the world beyond the mental limits of village life. As a rapidly modernizing country, Turkey has been struggling to digest modern life on all levels and this process has been particularly difficult for people living in the rural areas of the country. The same insight is even truer for the provinces located in the east, Van being one of them. It would be more than ironic to say that modernity has entered Turkey *from the West*. In this respect, the notion of transcending the communal limits was considered to be a key issue in the design of the research.

Secondly, the local knowledge and experience described above has proven that education and vertical public communication are very effective tools in the implementation of innovations, even if those innovations have an economic cost to the local people. Therefore, special attention was paid to the learning capacity of the villagers and the notion of education was not limited to formal education only. Aside from formal education, access to mass media and physical mobility were considered as important vehicles for what has been called “transcending the communal limits.”

Finally, there is the issue of the differences in attitudes toward innovations, which, as previously stated, was the initial motivation to conduct this research. In light of the above ideas, it was intended that a larger issue of openness, which extends to different areas of life beyond fishing practices be pinpointed. Thus, the concept of “openness to innovations” was operationally defined as:

“Openness” is a concept designed to demonstrate the degree and ability of the heads of households living in the fishing villages of Van province to isolate themselves from traditional, cultural and social pressure mechanisms and within their relations with the community at large, their willingness to adopt democratic and ecological values including consideration of public good.

The resulting openness index was composed of three axes, each of which is composed of six variables. These axes are (1) social openness (2) cultural openness and (3) individual openness.

## **Results**

It should be noted that the research did not yield a crystal clear, uni-dimensional, simple answer to the initial question. Rather, it is concluded that a web of complex factors have contributed to shaping the attitudes of the villagers towards innovations in sustainable fisheries management in Lake Van. A few important factors can be collected under three headings: (1) education (2) the need for alternative income sources and (3) openness to innovations index.

### Education

If it were assumed formal education is a major factor contributing to a more enlightened, unselfish, and considerate point of view toward the benefits of the general public, the following hypothesis would be valid: as the years of formal education increase, the attitude toward the ban on spawning season fishing would be more positive. In other words, more educated people would be more supportive of the ban and winter fishing.

Table 1 shows the list of villages surveyed with three types of signs next to them: (+) indicating a positive attitude toward the ban; (-) indicating a negative attitude toward the ban and (+/-) indicating mixed attitudes toward the ban. The next column shows the head of the household's average years of formal education in an incremental fashion. As the table shows, more education is associated with positive attitudes toward the ban on spawning season fishing with the exception of one village (Yeşilsu).

**Table 1.** Average years of formal education received by the head of the household in villages and attitudes towards the ban on spawning season fishing.

| Name of village | Average years of formal education | <i>n</i> |
|-----------------|-----------------------------------|----------|
| Yeşilsu (+)     | 3.62                              | 29       |
| Çitören (-)     | 3.73                              | 30       |
| Yalındüz (-)    | 3.91                              | 32       |
| Çelebibağ (-)   | 4.39                              | 31       |
| Total average   | 4.66                              | 241      |
| Engilsu (+)     | 4.68                              | 31       |
| Karahan (+/-)   | 4.81                              | 32       |
| Dereağzı (+)    | 6.09                              | 33       |
| Gölağzı (+/-)   | 6.26                              | 23       |

Those villages that are in favour of a change in fishing style mostly have average education levels above the total average education score (4.66 years). It should be noted that in this table the attitudes are derived from observational evidence, not from the survey. However, the survey did have questions measuring actual attitudes of the villagers. The hypothesis is tested on the basis of an index formed from eight questions asked to the villagers concerning winter fishing, the ban on spawning season fishing, consuming fish carrying eggs, etc. It should also be emphasised that there is a striking parallel between observational evidence regarding the attitudes and actual findings of the research.

A correlation test between attitudes and years of formal education showed a statistically significant positive correlation between years of formal education and attitudes (Pearson's  $r = 0.153$  at 0.05 level). Although the correlation is not very strong, it can be said that there is a positive relationship between education and attitudes.

### *Need for alternative income sources*

It is commonsense that depriving a person of his/her income source for whatever reason causes trouble. In other words, people normally don't want to experience a downward change in their economic status, especially by external intervention trying to create a change in attitudes, which may result in income losses. Obviously the struggle for sustainable fisheries management of the endemic pearl mullet in Lake Van is a case in point. What is suggested to the fishing communities is to give up the "easy fishing, easy money" formula and adopt a more troublesome method of fishing which promises an increase in income in the long term. In order to avoid outright refusal of the proposal of sustainable fishing (ban on spawning season fishing during summer time and encouragement of winter fishing), alternative income sources for those who have seen a loss of income must be considered. This commonsensical assumption can be validated by a simple cross tabulation procedure comparing alternative income sources and attitudes toward the ban. In this comparison, alternative income sources refer to the actual engagement in activities outside farming, animal husbandry and fishing. The results demonstrate that those who do not have an alternative income source are more likely to hold negative attitudes toward the ban (65%).

In lieu of the general philosophy regarding social change through external intervention, top-to-bottom imposition of alternative income generation suggestions is considered to be only partly effective, if at all. In policy formation, it is imperative that any external suggestion must consider the lifestyles, belief systems, attitudes and social and political statuses of the actual beneficiaries. In short, if one is hoping for a positive change in any community, the preferences of that particular community must be determined. To this end the survey included questions regarding alternative income sources.

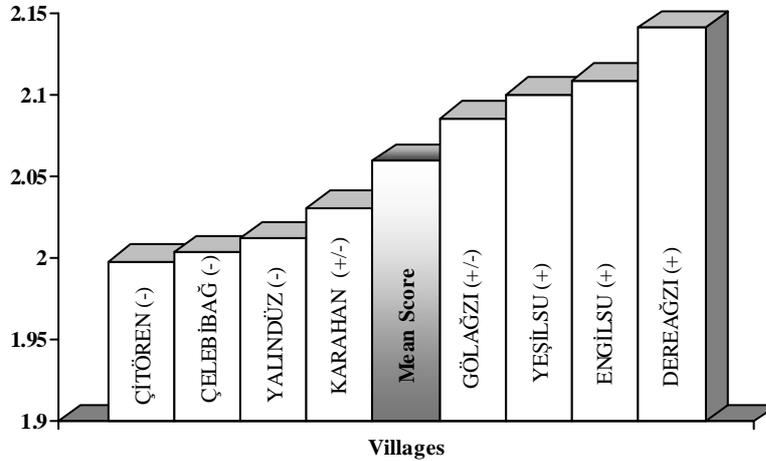
When given a number of alternative income sources, a majority of respondents (47%) preferred cattle breeding. The reason behind this choice seems obvious, most of the households in our sample actually do engage in cattle stock farming, it is therefore a type of investment Van villagers are familiar with. Cattle breeding is also the preferred choice because cattle rather than sheep are widely considered as an investment in the area. In contrast, suggestions like tourism did not yield favourable responses (8%) despite the supposedly great tourism potential of the area. This result, once again, confirms the need to consult the people targeted by external intervention.

### *Openness to innovations index*

Previously the notion of "openness to innovations" was described in terms of transcending the communal limits. The survey had quite a large number of variables pertaining to this situation. Those variables are, in fact, not limited with what is called "openness to innovations" index questions. However, the results presented here are intended to focus particularly on the index generated by utilizing 18 variables located on three axes, "social," "cultural," and "personal" openness. It should be noted that the distinction between the axes are not drawn by solid and unquestionable lines of demarcation. On the contrary, the distinction between, say, the categories of "social" and "cultural" is, mostly arbitrary and organic connections exist between the two. The same is true for all three axes. The production of these hypothetical categories is largely nominal and only to a certain degree essential.

This paper presents the aggregate effect of the index instead of dealing with each and every axis for the villages surveyed. On a scale of four opinions (absolutely disagree,

disagree, agree, absolutely agree), the respondents have answered a total of 18 questions. Each answer is converted into a score ranging from zero (absolutely disagree) to three (absolutely agree). In the end a range of scores between 1.33 and 2.67 for individual respondents was obtained.



**Figure 1:** Line-up of villages according to scores in openness index.

Turning back to the initial question, this index can be utilized as a tool in understanding at least one dimension of the villager's attitudes towards the ban and other pertinent external interventions. Is openness to innovations a factor in villager's attitudes? Figure 1 demonstrates a line-up of villages with respect to the attitudes toward the ban (observational evidence) and their position in the openness index. It is clear that the villages that do not favour a change in the traditional methods of fishing are also those that score below the mean in the openness index. It should be noted that this line up is based on the observational evidence.

In a correlation test between the two indices of actual attitudes toward the ban and openness to innovations, the observational evaluation of the villages is again confirmed. This test yields a positive correlation between the attitudes and openness (Pearson's  $r = .193$ , at  $P < 0.01$  level). In other words, those individuals who favour external intervention into their fishing practices are more likely to score highly in the openness to innovations index. In fact, examining each village in terms of the actual attitudes and openness scores clearly demonstrates that those villages observed to favour the external intervention have higher scores in the openness index.

## Conclusions

This paper focussed on three outcomes of a sociological survey conducted in the coastal villages of Lake Van, Van province. The research was designed to answer a particular question and to draw a general picture of the villages investigated. The question was about the factors contributing to different (positive and negative) attitudes toward external intervention to the villager's traditional fishing practices. The outcomes discussed are (1) the relationship between years of formal education and villager's

attitudes (2) villager's preferences to alternative income sources and (3) the relationship between "openness to innovations index" and attitudes.

As for the first and third issues, the research has demonstrated positive relationships between the variables, which can be formulated in two propositions:

- (1) As the years of formal education increase, attitudes toward the external intervention into traditional fishing practices become more positive.
- (2) The level of openness to innovations, which is described as the ability to mentally transcend the limits of communal life, is a factor contributing to positive attitudes towards the external intervention.

The second outcome concerns the villager's preferences towards alternative income sources. Alternative income sources are thought to be a significant factor towards sustainable fisheries management of pearl mullet since the introduction of new fishing techniques and the ban on spawning season fishing have economic costs for the Lake Van fishing communities. The majority of those surveyed indicated that the preferred alternative income source is cattle stock farming.

As emphasised, no successful external intervention into the established patterns of life can be considered complete without involvement of the affected individuals. This is only a part of a very long process of social change intended to contribute to the long-term informal communication between the stakeholders involved in the implementation of sustainable fisheries management of the endemic pearl mullet in Lake Van. It is evident that the findings of the research are open to debate and must be further tested both with scientific examination and interpersonal communication.

# **Socio-economic potential of angling native trout in Turkey**

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**Abstract** Turkey inhabits the head waters of streams and rivers draining to 4 different basins, namely Black Sea, Mediterranean, Persian Gulf and the Caspian. As a consequence, the inland waters of this region have a vast aquatic diversity. These waters populate different varieties of native trout. Trout fishing (species specific) has a remarkable potential for angling tourism and is a spectacular attraction for the fishing enthusiasts. However, overexploitation, commercial fishing, untreated aquaculture waste disposal and ineffective control measures of government officials are some of the threats that we encounter in our fishing areas in Turkey.

## **Introduction**

Rastgele-Der, Society of Amateur Anglers has been established in 2002 with an objective of developing angling in Turkey. Wastrels is an expression used among anglers meaning good luck in fishing (or like the Petri heil in German). Our core aim is to improve conservation of aquatic habitats especially that of native trout, which is the most fragile freshwater species and yet the most valued sport fish. The society has played a significant role in the improvement of Fishing Regulations from the renewal of the Circular for Amateur Fishing in 2006 with increasing efforts in struggling to conserve native trout species against threats such as overexploitation, pollution, over fishing and poaching. However, surrounded by three different seas (Mediterranean, Black and Marmara Sea) and inhibiting the headwaters of the main rivers of the Middle East flowing to 4 different basins, Turkey is unfortunately not capable of governing and managing this aquatic potential properly.

Anglers, not principally nature scientists or professionals like the aqua culturists, are only nature enthusiasts. Our benefit depends on the sustainability of the aquatic nature. As an angling association, our main purpose in attending such a symposium is actually to increase the attention of the governing authorities, global investors and especially the worldwide anglers to the vast potential Turkey inherits in fishing and actually fly fishing native trout. Sustainability of native trout stocks is the core of our interest and focusing on the socio-economic aspects of game fishing for native trout will be the method of this paper in reaching this end.

## **The natural potential**

Turkey is a special place to study trout; first and foremost because it has received few to no introductions of non-native trout. Tortenese wrote in the 1950 s “*I am sure that no fry ever came from other countries. Such condition being nowadays rare, the study of these salmonids has an outstanding interest*”. The streams of Turkey, unlike U.S.A and the European continent, have the potential of different native trout specimens. This fact actually attracts the attention of not only natural scientists but also of trout anglers who seek fishing different trout specimens from all around the world. What actually affects

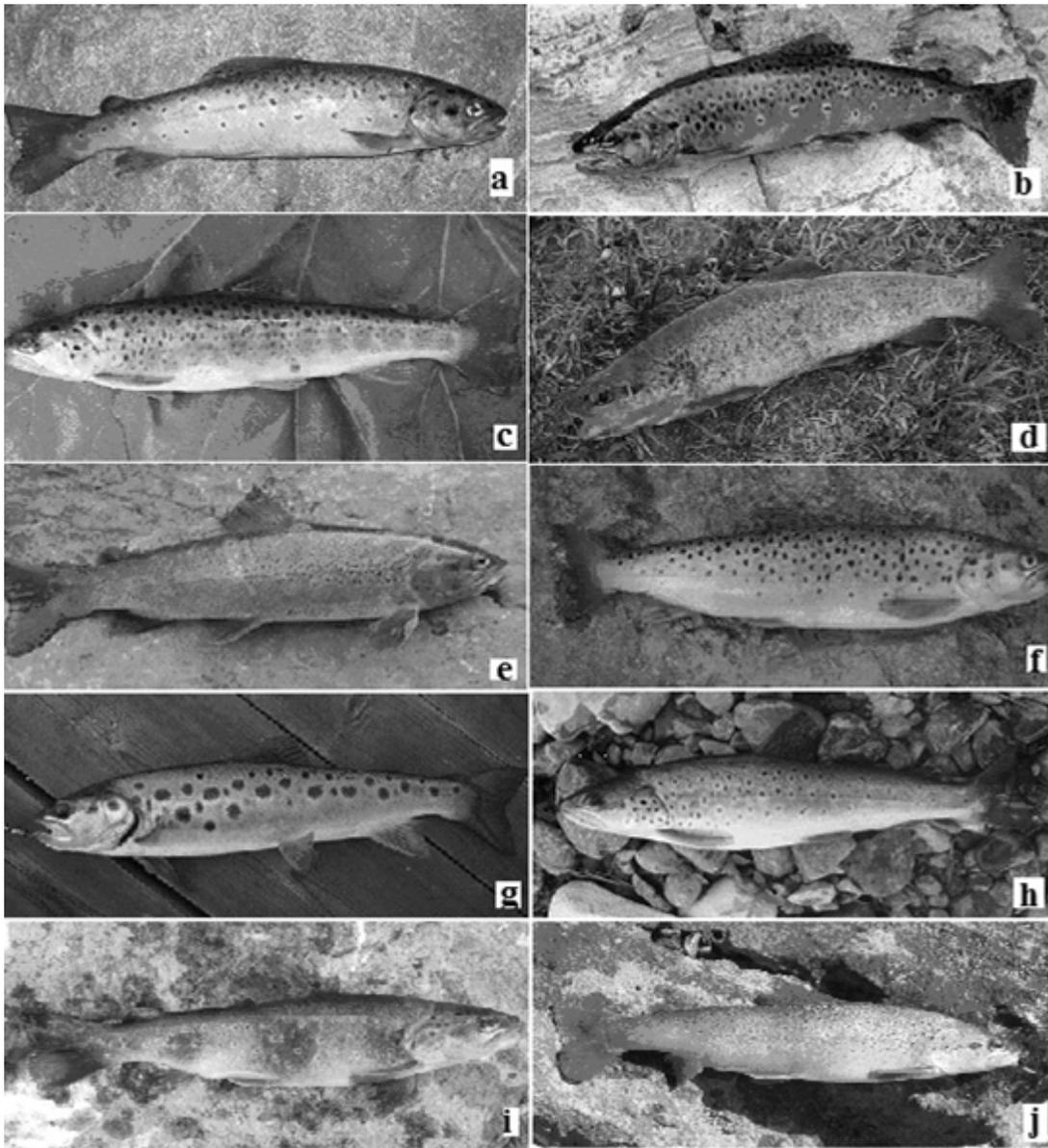
the specimen variation is that the headwaters of rivers flow in to four different basins (the Mediterranean, Black, Caspian and the Persian Gulf). All originate from Turkey and have different climatic, terrain and chemical characteristics (Figure 1).



**Figure 1.** Turkish rivers and how they link to the Mediterranean Sea, Black Sea, Caspian Sea and the Persian Gulf.

Turkey has a remarkable geography for trout anglers. Trout caught in waters flowing to different basins shows different physical characteristic and colorings. Following fascinating photos of different specimens of brown trout fished by Rastgele-Der members reinforces this thesis (Figure 2).

However, even with all the specimen richness of Trout in Turkey, not all streams are favourable for fly fishing as you occasionally need several meters of casting distance in the waterway. Many of these streams where the best populations of native trout are found in Turkey are moderate or small headwater streams and thus the fishing tactics most well-suited to such streams are those used generally for small-stream fishing in mountainous or highland areas. When analyzing the topographic classification of Turkish rivers it is best to divide the country into 4 regions, Central and Eastern Anatolia Region, Central and Eastern Black Sea Region, Western Black Sea and the Aegean Region and the Mediterranean Region.



**Figure 2.** Physical differences between trout caught from different basins. Brown trout from the Aegean region (a & b); Western Black Sea region (c); Southern Eastern Anatolia (Sub Species *Platycephalus*) (d); Mediterranean region (e); Eastern Black Sea region (f); Central Black Sea – Abant Lake (*Salmo trutta abanticus*) (g); North East Anatolia region (h); South East Anatolia (i & j).

#### *Central and Eastern Anatolia Region*

The topography of Turkey, starting from the central Anatolian plain, ascends as one travels east into mountainous highlands and ends at the borders with Georgia, Armenia, Iran, Iraq and Syria. This region produces two main rivers, Euphrates and Tigris that traverse Mesopotamia and flow into the Persian Gulf. In the numerous headwaters of these two rivers, one can find native trout that have inhabited these waters for millions

of years. However, as the topographic characteristics differ from one drainage to the next, the streams of Central and Eastern Anatolia will be studied separately in this paper.

In the Eastern Anatolia region, the best populations of native trout are generally found in headwaters where stream flow is low or moderate and the source springs are located at high altitudes where the elevation is steep. However the region is neither heavily populated nor wooded, and gradually lowering into the bottomlands of the valleys the streams generally receive tributaries which increase the flow and at these lower altitudes the streams lose gradient with a wide catchment basin creating a favourable condition for fly fishing. An example is the stream from the headwaters of Fırat (Euphrates).

The headwater streams located in Central Anatolia other than the Euphrates and Tigris actually are the waters of the rivers Seyhan and Ceyhan that drain to the Mediterranean sea and the stream basins of these waters are quite flat. They are fast-flowing, spring fed streams flowing steadily in a highland plateau at an altitude of 1700 m. The head water named Soğuksu is actually one of the best locations in Turkey for fly fishing. This stream gently flows through pastures and meadows of grass which is inhabited by an endemic sub-species of brown trout called *Platycephalus* only found in this region of the world (Figure 3).



**Figure 3.** *Platycephalus* angled in Soğuksu Stream

#### *Central and Eastern Black Sea Region*

This region should also be studied in two different sub-categories as both areas differ from each other in topographic character.

The Central Black Sea region includes many small streams under dense vegetation. The flow rate of these streams varies from season to season as the headwater springs are quite small and are affected by the highland melting snows during the spring. Most of the streams only reach a satisfactory level of flow and steepness where the human populations get denser which as a result restricts trout waters that could be fished.

The Eastern Black Sea region on the other hand has an exceptional number of streams with excellent water quality, varied flow rates and densely wooded vegetation which provide the classic mountain landscapes trout fishers admire. The streams on the side of the Kaçkar Mountains that drain to the Black Sea basin also have native sea trout stocks

(*Salmo trutta labrax*) with huge trophy sizes. The rivers that you can find both *Salmo trutta macrostigma* and *Salmo trutta labrax* are the Fırtına, Çağlayan and İkizdere rivers located in the eastern part of Black Sea region. These 3 rivers have a high flow rate but a declining gradient closing to the sea which creates a favourable condition for fly fishing

This region of the country, which already is enjoyed by tourists interested in Alpinism, trekking and camping, has a remarkable potential in trout fishing but only if appropriate measures are taken.

#### *Western Black Sea and the Aegean Regions*

There are several ranges of mountains like the Yıldız in the west of the İstanbul metropolitan area which have several small free-stone streams draining to the Black Sea with a medium rate of flow but with a soft steepness which is perfect for fly fishing. However, the region is highly dense in population with well developed transportation facilities which affects the native trout populations inversely.

The Aegean on the other hand, especially the Biga Peninsula could be called as the heaven of native trout. The fish of this region have been genetically identified as being of Black Sea origin (although draining to the Aegean Sea) and are very bright coloured with fascinating physical characteristics. The streams flow from the highlands in a steadily descending attitude with lots of pools generated. The streams of the region however, are under extensive fishing pressure. The native trout has only survived in the highlands close to the springs or in national parks and protected conservation areas. The highland streams have a consistent flow rate during the spring season when the snow melts until the mid-summer in July. The climate is not favourable for the fish after July as the temperature of the water rises and the flow rates decreases tremendously.

#### *Mediterranean Region*

The streams of the Mediterranean have an excellent character for fly fishing. The streams flow out from the rocky cliffs of the Taurus Mountains into valleys where they drain to the Mediterranean Sea. The flow rate is very high and trout habitat lasts for kilometres, with streams flowing through steep pine-forested valleys, providing an idyllic setting for fly fishing. Some of the rivers are, Manavgat, Aksu, Alakır, Köprüçay and Dim. These are fascinating trout angling destinations but not all are inhabited exclusively by native trout any longer. The Aksu river has a flow rate of  $1343 \text{ hm}^3 \text{ yr}^{-1}$  and the Köprü River  $555 \text{ hm}^3 \text{ yr}^{-1}$ .

### **Trout economy**

Trout is a fish that has fascinated millions of people on our globe and actually not only in the northern hemisphere, but with the scientific developments of the 19<sup>th</sup> century, in the south as well. You can now fish trout in the rivers of Kenya in Africa or in lakes in Patagonia of South America. Humans have taken this marvellous creature to the lands they migrated or travelled. And with the spread of trout, so did angling. Today angling for trout, especially fly fishing accounts for millions of dollars of income to local and

national economies. “*A trout is too precious to be caught once*” being the motto of many anglers. Trout fishing is often catch and release and this behaviour would promote sustainability of trout in over pressured areas.

Rastgele-Der Society of Amateur Anglers in Turkey within this framework intends to develop and promote fly fishing trout in the rivers of Turkey with the aim of attaining sustainable management of trout stocks and being able to adopt a management strategy. For this reason there is need for an in-depth economic analysis of the fishing sector both in the world and in Turkey that will act as a comparative indicator of the economic and natural value that we possess, and which I believe are often unaware of.

# Socio-economic analysis and marketing patterns of the fish farming industry in Trabzon, Turkey

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**Abstract** The coast of Turkey extends for 8333 km and is surrounded by three ecologically different seas, 33 rivers of 178,000 km, over 200 natural lakes, 168 dams and over 750 ponds, all of which should increase the potential for the fish production of Turkey. In 2007, fish yield in Turkey was 544 773 t (TUIK data), 426 996 t from the sea and inland waters and 118 227 t from fish farming. Declines in natural stocks lead to an increasing demand for fish produce that could only be met by aquaculture. The socio-economic status of the fishing industry in Trabzon city was investigated, including the fishing family composition, level of education, fish processing and marketing. The survey was conducted on 20 farms, from a total of 62 that have product catching certificates.

## Introduction

Increasing demand for fish products has resulted in the growth of fish farms worldwide to meet a substantial part of the world's food requirement, of which China contributes a major portion. Total production from fish farming reached (inland and marine) 7.4 million t in 1980, 16.8 million t in 1990, 35.5 million t in 2000 and 47.8 million t in 2005 (FAO 2007). Fish farming provides important services including supporting nutritional well-being, providing feedstock for the industrial sector, making contributions to rural development, increasing export opportunities, more effective administration of natural resources and conservation of biological diversity.

Farming is a multi-disciplinary science, not only bio-technical and environmental factors, but also socio-economic issues. Economic research assists both farmers and policy makers (Shang 1994). Sector-oriented economic studies and analyses in aquaculture are important to determine the profitability of aquaculture resources and the efficiency of resource usage, but also to improve operational management, evaluate new production techniques in terms of economics, to display market potential and to find new research areas (Neiland 1994).

In Turkey, aquaculture began with rainbow trout in the private sector in Sakarya-Akyazı in 1986. Public institutions were founded by the Konuklar Government Production Farm in Konya and Eskişehir Çifteler. The first serious marine aquaculture institution was founded for the production and farming of young bream, *Abramis brama* (L.) and perch, *Perca fluviatilis* L., under the leadership of Yasar Holding in İzmir-Cesme, 1985 (Çelikkale & Ark 1999). Aquaculture is growing rapidly in Turkey, over the last 10 years production has reached 118 277 t, increasing approximately 250%, with the total aquaculture production increasing by 22% (URL 1).

There has been an increasing demand for juvenile fish by institutions, these demands have been met and juveniles are now being exported to other European countries. Turkey contributes 25% to the European bream and perch markets and it is estimated to exceed 80 million t by 2030. Turkey also plays an active role in regional policies for aquaculture (URL 2); it is these developments that make Turkey stand out amongst European countries.

#### *Site description and general information*

Trabzon is located at 38° 30' - 40° 30' east meridian and 40° 30' - 41° 30' north parallels in an area of 664 km<sup>2</sup>. Its northern neighbour is The Black Sea. The rivers in Trabzon are Karadere, Solaklı, Değirmendere, Foldere, Karadere, Kalenia, Yanbolu, Küçükdere and Manahos. Lakes in the Trabzon are, Uzungöl, Balıklıgöl, Aygır Lake, Black Lake and Sera Lake (URL 3). Fish farms in Trabzon city are founded on these riverbeds. Sea cages are a big part of Trabzon production and are placed at Yomra. Aquaculture in Trabzon began in 1976 by Albako and sea cages were introduced in 2004. Trabzon production reached 2043 t in 2005 and 2463 t in 2006, contributing to the total aquaculture production of Turkey (TUIK 2007). Considering all fish species in Trabzon, rainbow trout, *Oncorhynchus mykiss* (Walbaum) farming is prevailing in freshwater and sea production. Beside this, perch farming began in these companies in 2007.

There is a wide distribution of the 62 aquaculture companies between districts; the majority are in Maçka and most companies that have <10 t capacity are small family enterprises, but there appears to be a rapid expansion in Yomra and Akcaabat, especially for marine production, to meet demand (Table 1; Tarım II; Mudurlugu 2007).

**Table 1.** The place and capacity (t yr<sup>-1</sup>) of the companies in Trabzon.

|            | Total | Fresh water | Marine | Capacity |       |     |          |
|------------|-------|-------------|--------|----------|-------|-----|----------|
|            |       |             |        | ≤10      | 10-30 | 30≥ | juvenile |
| Merkez     | 3     | 3           | -      | 3        | -     | -   | -        |
| Akçaabat   | 4     | 4           | -      | 3        | 1     | -   | -        |
| Araklı     | 2     | 2           | -      | 1        | 1     | -   | -        |
| Arsin      | 2     | 2           | -      | 1        | -     | 1   | -        |
| Çaykara    | 7     | 7           | -      | 4        | 1     | 2   | -        |
| Düzköy     | 2     | 2           | -      | 2        | -     | -   | -        |
| Hayrat     | 1     | 1           | -      | 1        | -     | -   | -        |
| Maçka      | 20    | 20          | -      | 11       | 5     | 2   | 2        |
| Sürmene    | 4     | 4           | -      | 4        | -     | -   | -        |
| Şalpazarı  | 3     | 3           | -      | 2        | 1     | -   | -        |
| Tonya      | 4     | 4           | -      | 1        | 3     | -   | -        |
| Vakfıkebir | 3     | 3           | -      | 2        | 1     | -   | -        |
| Yomra      | 7     | 5           | 3      | 3        | 1     | 3   | -        |
| %          | 100   | 95          | 5      | 62       | 22    | 12  | 3        |
| Total      | 62    | 59          | 3      | 38       | 14    | 8   | 2        |

Forty six companies produced 1 569 186 kg of juveniles and received €509 985 of subsidies from the General Directorate of Agriculture Production to produce juveniles. Of these subsidized farms 74% are in the Trabzon Agriculture Provincial Directorate. As a result of this support, the costs of inputs have declined and companies have tried to increase the production to get more support (Tarım II. Mudurlugu 2008). This study

examines the socio-economic status of the most important companies involved in aquaculture in Trabzon.

### **Materials and methods**

Data were obtained using a questionnaire presented to the aquaculture companies. Records from the Agriculture Provincial Directorate and the research results of this study were used, together with publications and statistical data from the Turkish Statistical Institute and World Health Organization.

The 62 companies that have industrial licenses were categorized into three groups with production  $\leq 10$  t, 10-30 t and  $\geq 30$  t. Seven questionnaires were distributed to the first and second groups and six to the third group. Twenty companies were randomly selected and interviewed face to face using a questionnaire with 39 questions. The questionnaire involved general information such as the age of the participant, education background, experience and general matters about management structure, sources of finances, income and expenditure account and general problems in production and marketing. Variable costs, gross production value per capita farm and gross margin were calculated for each farm. Variables appear to be dependent on production and deviate according to production level (Rehber & Çetin 1998).

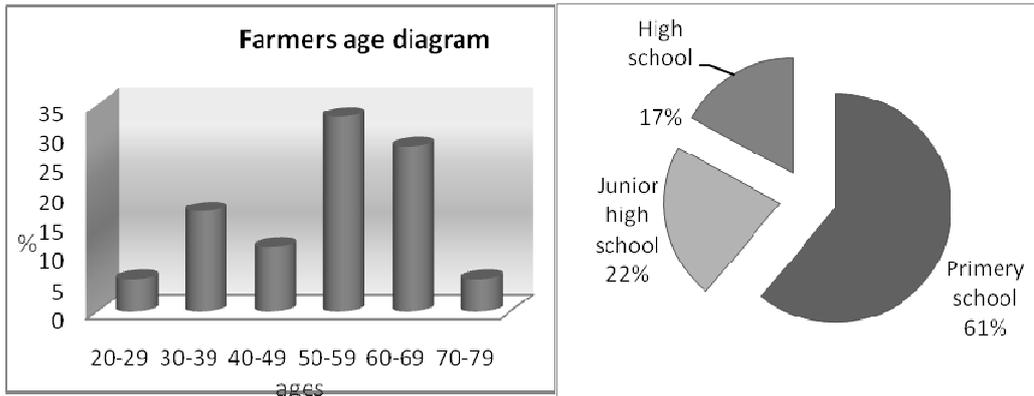
In the variable costs of aquaculture, seed, medicine, chemicals, warming and lighting, fuel pooling, fish larvae, seasonal workers and transportation fees were considered. To calculate gross production value of aquaculture, the amount of production and the average fish prices were multiplied. In the gross margin analysis, each production field was considered individually. The gross margin of aquaculture was calculated by subtracting the variable expenses from the gross production revenue (Erkuş 1995; İnan 1998). The gross profit margin was compared with market prices at each marketing stage to determine the most profitable markets (Abott 1966).

### **Results and discussion**

The youngest person to participate in the questionnaire was 29 years of age and the oldest 72 years; the majority of participants were over 50. According to the questionnaire, 61% of the producers were primary school graduates, 21% were secondary school graduates and 17% were high-school graduates. The education level of the producers in Trabzon was low (Fig. 1).

About 61% of companies had a Bağ-Kur state insurance, 33% were retired from the state scheme and 6% had insurance in private pension. The size of families involved in fish farm production varied with 61% having between 3 and 5 family members, 28% with 6-8 family members and 6% with 9-11 family members, the remainder had 0-2 family members.

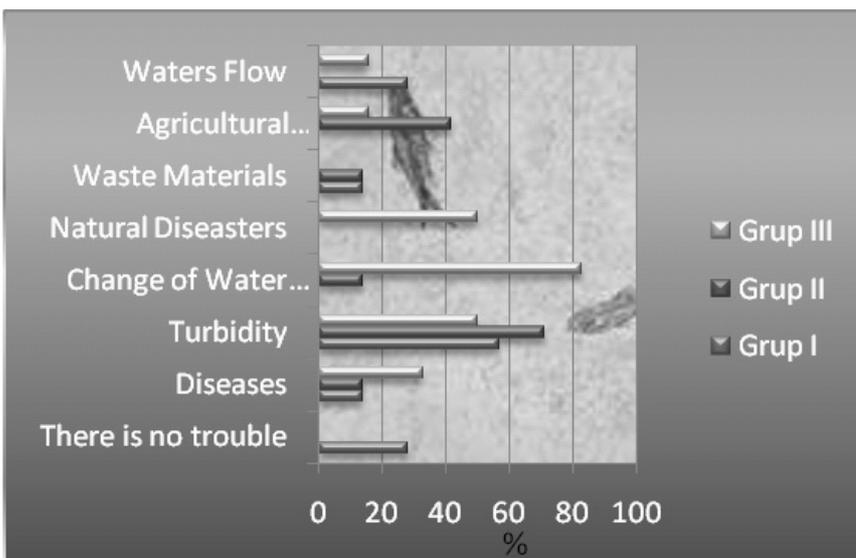
Ninety percent of companies were single proprietorship and 10% were incorporated companies. Incorporated companies were generally producers from Trabzon and Rize. Five percent of companies were established on land owned by private individuals, 20% on land belonging to public institutions and 75% to the owner of the company; 70% of the land on which the trout companies were founded was on private property (Rad 1999). This proportion was similar for companies in Trabzon.



**Figure 1.** Age and level of education of the producers.

About 33% of companies viewed aquaculture as a hobby, 33% were recommended to start production and 22% because of the potential high profit. Sixty percent of producers considered their capacity to increase production but only 70% of participants had the scope to increase their capacity, with the remaining 30% having no possibilities. Potential to increase production varied between 20 and 500%. Thus it appears that institutional support and profitability affect outcomes. Revenue was used by 15% of the participants to expand the company, 25% of them to fund new companies and 5% of them to make investment in another sector. Producers occasionally funded new companies at sea or in reservoirs in other provinces.

Only 10% of fish farms have not faced any difficulty. Major difficulties faced were turbidity for Group I farms (57%) and household waste, including faecal matter (71%) for Group II farms. The Ministry of Environment and forestry fertilization studies found that some farmers were affected by chemicals used in agriculture. Farms that are far from sources or water and cages in the sea have been affected water temperature changes, especially marine aquaculture farms that have to harvest in July (Figure 2).



**Figure 2.** Problems faced in aquaculture production.

Gross margin was calculated from the average production of aquaculture was €11 100 for Group I, €26.193 for Group II and €389 390 for Group III. Excluding Group I, gross margin is higher than 50% (Table 2 and 3).

**Table 2.** The gross production value, variable costs and gross margin (€)

|                        | Group 1   | Group 2   | Group 3    |
|------------------------|-----------|-----------|------------|
| Gross Production Value | 24.230,00 | 55.730,00 | 627.019,00 |
| Variable costs         | 13.130,00 | 29.537,00 | 237.629,00 |
| Gross Margin           | 11.100,00 | 26.193,00 | 389.390,00 |

**Table 3.** The percentage distribution of variable costs of aquaculture production unit (€)

| Cost Items          | Group I | Group II | Group III |
|---------------------|---------|----------|-----------|
| Feed                | 26.45   | 60.858   | 357       |
| Packing             | 630     | 2898     | 32.605    |
| Transportation      | 1260    | 2898     | 48.907    |
| Electric            | 1260    | 2898     | 16.302    |
| Drugs and chemistry | 630     | 2898     | 16.302    |
| Temporary worker    | 0       | 0        | 0         |
| Fuel-oil expenses   | 630     | 2898     | 48.907    |
| Marketing expenses  | 1260    | 2898     | 48.907    |
| Unexpected expenses | 1890    | 2898     | 48.907    |

### *Marketing*

Producers usually have several partners; these are farm-owned markets, restaurants or manufactures in Trabzon, Samsun, Ankara and Istanbul, and wholesale fish markets. This side of aquaculture is thriving. Small farms and farms located around tourist places sell their products easily, especially in the summer season. Indeed farms in tourist areas have difficulties in supplying enough products, for example farms which can produce over 100 t will have sold most of their products (Table 4).

**Table 4.** Aquaculture marketing ways (%)

|                        | Group I | Group II | Group III |
|------------------------|---------|----------|-----------|
| Markets                | 94.9    | 35       | 12        |
| Retail sale            | 3.7     | 0        | 6         |
| Auctions               | 0       | 0        | 54        |
| Other farming sale     | 0       | 38       | 13        |
| Restaurants and Hotels | 1.2     | 27       | 6         |
| Processing manufacture | 0       | 0        | 9         |

### *Price definition*

Producers define the prices depending on supply and demand; they collectively set the price around 200-250g fish/1€, but do not always obey this price. In winter, prices decrease because of competition from wild marine catches. Producers which sell via auctions do not set their own prices. Fish dealers make about 11% marketing margin, retail sellers about 24% and markets about 35%.

### *Marketing services*

Marketing services depend on 4 factors. First is the company's access to the market for which the companies have no problems. Second is the distance to the market which are located around city and district centres; again companies did not experience problems, even small companies far from the city and district centre, because they can sell their product locally. Third is the demand per company and the fourth is the availability and type of vehicles, used in transportation. In short, distribution services are effective. Both the agents and producers transport the fish to the external and internal consumption centres, using high quality packaging that maintains the quality of the product. The product is checked twice during distribution, firstly during transportation from the production site to wholesale market, and secondly from the wholesale market to the final consumer buying areas. Carriage from the wholesale markets to the domestic markets in the other cities is mainly (80%) through the use of hired vehicles.

Having a strong market position depends on the effectiveness of the market infrastructure. There are five marketing channel but the biggest problem appears to be competition from abundant wild resources. For example, too many anchovy on the market can cause the price of other fishes to fall.

Although most owners of enterprises are not experienced in marketing, their gross margin would seem to be at a high level, especially those enterprises with a capacity of  $>10 \text{ t yr}^{-1}$  that have an advantage of selling their products, unless they do not use an agent.

As a result of the consistent growth of the sector and increase outputs, it is expected that there will be some difficulties in marketing, resulting in a decrease in profits, and the enterprises should take the necessary precautions to prevent this scenario. Subsidies for 'Supporting of stockbreeding' have depressed the costs of production and enterprises have had a tendency to increase production. Enterprises should take into account the marketing risks for the future, when increasing their production capacity, although it is thought that growth in production in the sector will continue, especially using cage-culture for marine species. It is appears that the enterprises do not intend to employ experienced technical staff, especially enterprises with a capacity of  $>10 \text{ t yr}^{-1}$ , and this may constrain sector growth.

In addition to cold storage, suitable processing techniques are needed to make further progress, such as filleting and smoking techniques. An association of fish farmers that teamed up with producers had difficulty putting this development into practice because of decisions regarding the selling price of the fish, thus the fish farmer association would benefit from collaborations with the market. This would benefit the development of new species such as sea bass, black sea trout, *Salmo trutta labrax* and turbot, *Psetta maxima*, as markets would be developed in harmony.

Chemicals used for agricultural purposes should be applied with caution in river basins where culture activity takes place. The release of domestic discharge to water sources in the centre of some populations can have negative effects on production and so precautions should be taken to reduce this risk. Enterprises that suffer from temperature variability and water quantity problems would benefit by introducing a re-circulation system.

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# **Interactions between conservation, economic and social objectives of sturgeon culture in Russia: problems and possibilities of optimization**

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**Abstract** After the implementation of flow regulation in the larger rivers in the former Soviet Union between 1950 and 1970, the stability of sturgeon populations in natural water bodies has been maintained by a large-scale system of state sturgeon hatcheries. Approximately 100 million juveniles have now been released into the rivers and seas of Russia. Since 2000, a sharp decline in sturgeon abundance has been observed, possibly due to economical and social problems. These problems have resulted in the poaching of a high number of immature sturgeons and a lack of modern technology at sturgeon hatcheries that would increase the number of juveniles and female individuals. Sturgeon hatcheries did not catch even 10% of the targeted number of mature female individuals. More than 50 % of sturgeon juveniles, released in 2004–2007, were reared from the farmed breeders from the living gene bank of South Branch Federal Centre of Selection and Genetics for Aquaculture (Krasnodar, Russian Federation), including critically endangered *H. huso*, *A. nudiventris* and *A. stellatus*. In this paper, the outlook of sturgeon meat and caviar production in Russia, which had an output of 3000 t in 2007, is discussed and new structure of sturgeon development optimisation is discussed. The innovative express method of early diagnostics of sex in sturgeons has proven to be very useful in the course of males that are used for meat production from 2 years of age. The saved immature females can then be successfully used for broodstock formation.

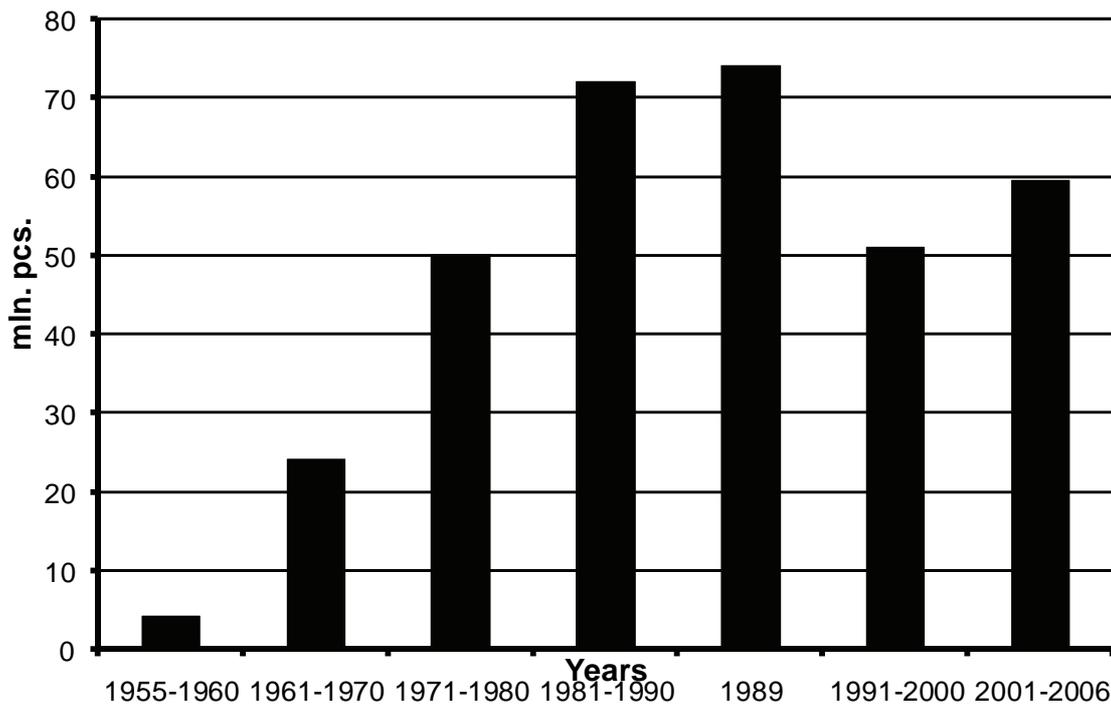
## **Introduction**

The sharp decrease in sturgeon catches in the Azov and Caspian basins proves the necessity of sturgeon culture strategy development under the current geopolitical, economical and ecological conditions. Obviously it should be based on an integrated system analysis of commercial return for hatchery-bred sturgeon fingerlings, with acknowledgement of shortfalls caused by poaching and irrelevant biotechnology as well as poor technological backgrounds of state sturgeon hatcheries compared to world aquaculture achievements. The existing forms of commercial sturgeon culture need to be reviewed and possibly increased, in order for them to operate to the highest potential. In 2007, the total capacity of sturgeon aquaculture was 3000 t in Russia, considerably exceeding the amount caught in the natural water bodies. Worldwide developments have proven greater possibilities for the conservation of many fish species under the controlled conditions of aquaculture.

*Release of sturgeon juveniles and catch dynamics in the Sea of Azov and Caspian Sea*

By the mid 20<sup>th</sup> Century when dam construction was initiated on the main rivers, Volga, Kura, Don, Kuban and Dnepr, basic technologies were available for artificial reproduction such as induced spawning, artificial insemination, incubation, adhesive eggs, larval rearing. These have been in use in the hatcheries on rivers that were subjected to impoundments. The hatcheries and nurseries have since reached large scale productions of juveniles for stocking with standard technology. The process involves the capture of wild spawners in rivers, induced ovulation, artificial insemination of eggs, incubation and larvae rearing on live food, in indoor or outdoor ponds of around 2 ha. The juveniles remain in the ponds for approximately one month until the fingerlings reach between 1-4 g.

The release of juveniles in Russia is mostly concentrated in the Ponto-Caspian area and in the Siberian Rivers. In the North of the Caspian Sea the release of all species was around 75 million between 1970 and 1980, this number decreased to 60 million by the end of 1990 and the first years of the 21<sup>st</sup> Century (Fig. 1).



**Figure 1.** Release of sturgeon juveniles in the Caspian basin by Russian hatcheries.

In the Azov Sea area the release of fingerlings has been maintained at relatively similar level since 1970, with 14-15 million of *A. gueldenstaedtii* and 15-17 million of *A. stellatus*, both weighing 2-3 gr. In addition 500 000 *Huso huso* of 50 g and 200 000 *A. ruthenus* were released by South Branch Federal Center of Selection and Genetics for Aquaculture (Table 1).

**Table 1.** Release of sturgeon juveniles in the Azov-Kuban region during 1974-2006.

| Stage | Year      | <i>A. gueldenstaedtii</i> |      | <i>A. stellatus</i> |      | Total<br>(million) |
|-------|-----------|---------------------------|------|---------------------|------|--------------------|
|       |           | million                   | %    | million             | %    |                    |
| I     | 1974-1984 | 7.3                       | 30.5 | 17.3                | 69.5 | 24.6               |
| II    | 1985-1990 | 8.7                       | 37.1 | 19.2                | 62.9 | 27.9               |
| III   | 1991-1996 | 11.2                      | 47.5 | 13.5                | 52.5 | 24.7               |
| IV    | 1997-1999 | 13.3                      | 46.8 | 15.1                | 53.2 | 28.4               |
| V     | 2000-2006 | 7.3                       | 72.3 | 2.8                 | 27.7 | 10.1               |

The index of commercial return for released fingerlings is dependent on weight and was calculated to be between 1-3%. The commercial catch of sturgeon amounted to 28 000 per year and caviar production reached more than 2000 t.

After the dissolution of the Soviet Union and in connection with the lack of a unitary control system, fisheries suffered due to large scale poaching, a decline in natural propagation a decrease in artificial reproduction capacity. The total amount and commercial catches have suffered a sharp decline. Up until 2000, the official catches of sturgeon in the Caspian and Azov Seas was 500 t, caviar production was about 13 t (Table. 2).

**Table 2.** Sturgeon caviar production and export data.

|                      | 1996   | 1997   | 1998   | 1999   | 2000   | 2001   |
|----------------------|--------|--------|--------|--------|--------|--------|
| Production (t)       | 82.0   | 103.0  | 41.0   | 16.43  | 12.84  | 14.71  |
| Export (t)           | 17.1   | 22.9   | 8.0    | 9.1    | 7.71   | 7.78   |
| Export (US\$ x 1000) | 4344.1 | 6970.2 | 2247.9 | 2528.5 | 3377.2 | 3538.6 |

Fishing for sturgeon in the Sea of Azov has been prohibited since 2000, with the exception of catching the species for research and enhancement purposes. The decline in sturgeon catches led to the bankruptcy of a major part of rural cooperative enterprises that were involved in fisheries. 50% of fishermen were dismissed, leading to a lower efficiency of commercial fisheries and other negative social consequences such as poaching.

#### *Sturgeon hatchery stock enhancement*

The efficiency of fish stocking is not precisely known, in the Caspian Sea 16 million 30 to 50 day old juveniles of beluga were released annually from 1970, but records show that only 0.1% of these were harvested as adults (Khodorevskaya *et al.* 1999; Williot *et al.* 2002). For the Russian sturgeon 20-40 million juveniles (2-3g) were released between 1980 and 1983, this number was not sufficient to stabilize the population and 40-60 million more were released between 1986 and 1990. After this, the hatchery produced fish represented 25-30% of the catch. The number of spawners for all sturgeon species in north of the Caspian Sea was over 3.5 million in 1991 and then 500 000 in

1997 (Khodorevskaya *et al.* 1997). In the case of *Huso huso* the total fecundity of the populations was 10 billion eggs in 1976-1980 and less than 2 in 1990-1995 (Khodorevskaya 1999).

In the Azov Sea basin, all rivers are dammed and there is no natural recruitment, the present stocks have been supported for the last 25 years entirely by stocking. There are 9 sturgeon hatcheries in the Azov Sea basin. The simplified stocking strategy was aimed solely at the release of large number of hatchery-reared juveniles (Chebanov *et al.*, 2002).

During last 20 years, before the ban on fishing for sturgeon, the average coefficient of commercial return amounted to 0.46%. One problem towards the farming of sturgeon is the short period of time that the migration run of mature females takes. These are used for artificial reproduction and due to the fact that dams are constructed close to the sea, the female availability is restricted in time and within 12-15 days. In this time the hatcheries have to insure the production of 30 million juveniles.

The large-scale hatchery productions were maintained despite a decrease in available brood stocks during last five years. The number of Russian sturgeon females used for spawning in the Kuban's hatcheries during the 1996-2000 period decreased from 368 to 151 and that of stellate sturgeon from 761 to 230. The decline in females has been observed in this century, only 21 females of Russian and 2 of stellate sturgeon were used for hatchery enhancement in 2007. The restoration of the sturgeon population structure in the Sea of Azov is not possible without developing a sturgeon living gene bank and domestic brood stocks.

### *Sturgeon Living Gene Bank*

All of the Russian sturgeon Living Gene Bank (Krasnodar), at total of 12,000 individuals, includes 24 intraspecific groups of the 6 endangered sturgeon species (Table 2), including *A. gueldenstaedtii*, *A. nudiventris*, *A. ruthenus*, *A. stellatus*, *H. huso*. The sturgeons of the Living Bank have been reared at 3 different experimental farms, including a hatchery with a natural temperature regime and warm water farms (Chebanov 1998).

**Table 3.** Endangered species in the Russian sturgeon Living Gene Bank (VU - vulnerable; CR - critically endangered; EN - endangered).

| Species                   | Number of year-classes | Number of intraspecific biological groups or populations | National status | International status (IUCN 1996) |
|---------------------------|------------------------|--|-----------------|----------------------------------|
| <i>A. gueldenstaedtii</i> | 9                      | 3  | VU              | EN                               |
| <i>A. stellatus</i>       | 14                     | 3  | VU, H           | EN                               |
| <i>A. ruthenus</i>        | 18                     | 7  | CR              | CR                               |
| <i>A. nudiventris</i>     | 1                      | 2  | H               | EN                               |
| <i>A. persicus</i>        | 2                      | 2  | CR              | EN                               |
| <i>H. huso</i>            | 10                     | 4  | EN              | CR                               |

The electronic system of morphometric data measurement from digital images enables the fast collection of preliminary information during the process of brood stock assessment and further morphometric analysis in the laboratory. The experimental data

of general morphometric, genetic, hatchery-biological and other characters of all fish groups presented in the bank, have been collected in the database after the systematisation and processing.

The viable progeny, for the first time in sturgeon culture, was obtained from the farmed spawners of giant, Russian, Persian, stellate and ship sturgeons. For the past few years, approximately 20 million fingerlings, over 50% of released juveniles obtained from farmed spawners, were released into the Sea of Azov. In the future, due to a small number of wild breeders in the Sea of Azov (Chebanov & Billard 2001), individuals for stock enhancement will be provided by progeny obtained from farmed brood stock. It is necessary to provide monitoring of reproductive and other biological characteristics of these brood stocks and its progeny.

Analysis of size, weight and reproduction indices of farmed breeders compared with wild spawners, showed that under optimal conditions, the farmed individuals reached their maturity 1.5 to 2 times earlier and that their reproductive cycles were 2 times shorter (Chebanov & Billard 2001). Monitoring and comparative analyses of the differences between wild and farmed fish of different species and intraspecific groups of sturgeons should include; growth, age at maturity, relative fecundity, morphological and physiological indices. The morphological analysis of cultured sturgeon allows a minimisation of the consequences resulting from a casual selection of individuals for artificial breeding.

#### *Early sexing and staging of farmed sturgeon by using ultrasound technique*

The lack of external sex dimorphism in sturgeon does not enable early separation of females from males by visual methods before they become sexually maturity at 5 to 10 years of age. Traumatic methods as biopsy have previously been used to sex sturgeon, if conducted later in their rearing, males reach commercial size. It would be more profitable to only rear females for caviar production.

A non-invasive ultrasound technique is efficient for sexing individuals and can determine maturity stages in fish from the Federal Gene Bank. Females at maturity stages I-II, III and IV, as well as males at stages II and III-IV are very distinctive. This technique can also facilitate the process of valuation for heterogeneous domestic brood stock, enabling the accurate prognosis of fish maturation in the successive spawning season (Chebanov *et al.* 2004). Therefore, the ultrasound method, which takes less than 10 seconds per fish, can successfully examine gonad development offering new possibilities for the selection of individuals, enabling farms to hold on to immature females until they produce eggs.

The application of innovative aquaculture biotechnology and rearing control, such as the ultrasound technique, along with genetics and physiological monitoring of sturgeon brood stocks, could contribute a considerable income towards the genofond conservation and the development of an economically substantial sturgeon culture.

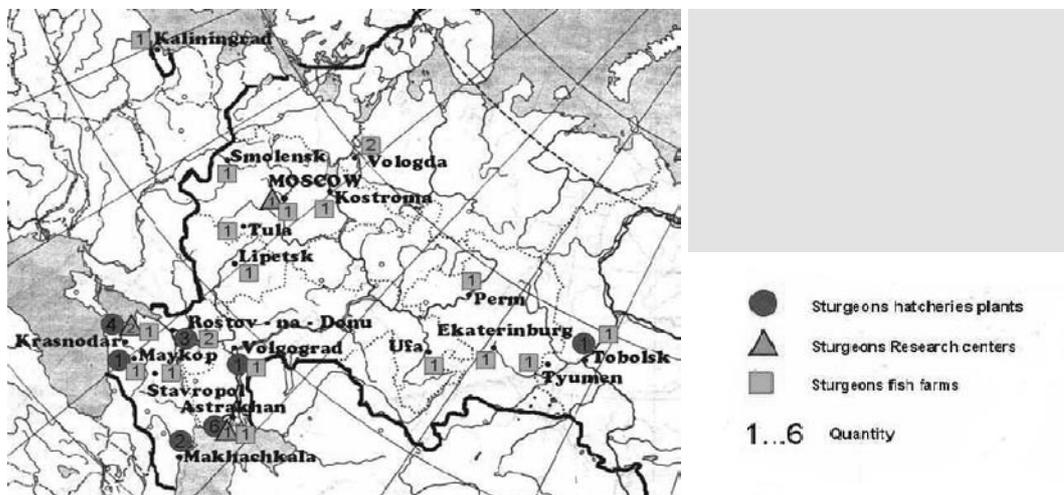
#### *Current commercial sturgeon culture in Russia and possibilities of its optimisation*

The broad development of commercial sturgeon culture should be considered as a measure to satisfy the demand for sturgeon meat. This could reduce poaching and the

selling of sturgeon meat and caviar on the black market. The development of sturgeon culture should contribute to the recovery of natural populations in the Sea of Azov, Caspian Sea and Siberian rivers.

The initiation of federal and regional programmes for sturgeon population enhancement were a specific feature in the Russian Federation over the last few years, for example the Krasnodar Territory principal program, that was devoted to the sturgeon genofond conservation and offered financial support for the commercial sturgeon culture in the littoral regions. The cost of feed for 50% of sturgeon farms have been covered by the Krasnodar Territory regional budget, as well as 30% of pedigree stocking materials expenses.

From 1994 to 2007, the number of sturgeon farms increased from 19 to 260 in Russia and the gross annual production increased from 200 to 3000 t, while the total production of other farmed freshwater fish species has decreased nearly 3 times (Figure 2).



**Figure 2.** Locations of different sturgeon enterprises in the Russian Federation.

### *Sturgeon production system*

Sturgeon species, mostly bester, are produced in monoculture, either in small ponds measuring a few hectares with in intensive feeding systems so that they reach market size within 24 months or in larger ponds of 100 ha, in a ranching system where they reach market size in 30-36 months. They can also be farmed in polyculture, ponds with substitution by paddlefish and silver carp.

Several production systems for sturgeon aquaculture could be used, such as; industrial waste-heat effluent, traditional ponds for carp culture, raceways or cages in freshwater or brackish waters in the Volga delta and Kuban rivers. More than 75 % of sturgeons produced in warm water farms at power station have been used for meat.

Sturgeon ranching in deltaic lakes and brackish lagoons of up to 1 000 ha, provide promising opportunities and require limited investments and not much artificial feed. Using 3-5-g juveniles, a commercial weight of 1.5-2 kg can be reached within 24-26 months, with a survival rate of 34-38 %. Experimental works have shown an efficiency of ranching in deltaic lakes and brackish lagoons that produced up to 1600 t of

sturgeons. Production and economic data of Russian commercial sturgeon culture for 2004-2007 are presented in the Table 3.

#### *Sturgeon caviar and meat production forecast*

Approximate forecast data obtained while extrapolating the modern trend of sturgeon production development in Russia have shown that sturgeon meat production capacity could reach 3700 t in the year 2008 and 4500 t in the year 2009. According to expert evaluation, market demand in Russia of sturgeon meat would be 15,000 t at a stable meat price of 12-13 Euro, and up to 20,000 t if the price dropped to 8 Euro.

**Table 4.** Characteristics of commercial sturgeon culture in Russia.

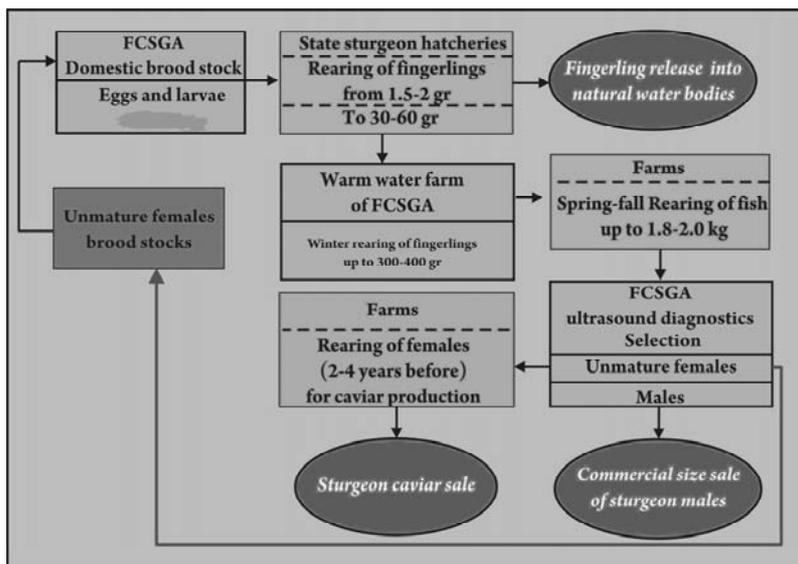
|  | 2004  | 2005  | 2006  | 2007    |
|--|-------|-------|-------|---------|
| Meat (t x 1000)  | 2.5   | 2.8   | 2.4   | 2.8     |
| Caviar produced from ovulated eggs (t)   | 1.0   | 2.0   | 3.5   | 5.0     |
| Wholesale price per 1 kg of meat, (Euro)   | 8.5   | 9.0   | 11.5  | 13      |
| Wholesale price per 1 kg of caviar (at farm gate) ( Euro)                        | 450   | 600   | 800   | 850     |
| Number of sturgeon feeding plants/number of plants involved in caviar production | 120/4 | 150/6 | 250/9 | 260/10  |
| FCR  | 3.0   | 2.8   | 2.3   | 2.2     |
| Duration of production cycle time necessary for commercial sizes, (age in years) | 3/6   | 3/5   | 3/5   | 2.5/5.5 |
| Production costs per 1 kg of meat, (Euro)  | 6.5   | 6.0   | 5.5   | 5.5     |

The demand for caviar if the market price remains at the present level, would be approximately 40-50 t. The estimate for 2009 is that the production could increase to 12-14 t, obtaining eggs from live fish. The production facilities of existing projects would enable the rearing of 11500 t of sturgeons and more than 100 t of caviar.

#### *Possibilities of sturgeon culture optimisation*

An advanced scheme of sturgeon brood stock management has been offered in order to increase the efficiency of sturgeon culture and caviar production in Russia and to reach the target for economical, social and ecological objectives. These are based on the non-invasive ultrasound technique to determine the maturity of females at an early stage. The brief description of the scheme is given below. Sturgeon culture optimisation activities also require joint efforts between state sturgeon hatcheries, sturgeon farms and Federal Center of Selection and Genetics in Aquaculture (Fig. 3).

In 2007, Russia produced about 3000 t. of commercial sturgeons with a mean weight of 1.8 kg, females typically contributed 60% to this total volume. As a result, approximately 1800 t, or 1mln immature females were sold at market. Taking into account the growth rate and weight gain of females from hatching to maturation it could take until 2011-2012 to produce 7000 t of mature (with caviar) females with caviar or 800 t of caviar. At the same time, the total weight of females saved for caviar production has not been greater than 1500 t.



**Figure 3.** Optimal scheme of interactions between different elements of a new sturgeon aquaculture structure.

## Conclusion

In order to reach economical, social and ecological objectives of sturgeon culture optimisation in Russia, it is important to take the following steps;

- 1) To improve sturgeon hatchery technology.
- 2) To develop different types of sturgeon culture that will help overcome existing problems such as poaching and selling on the black market. They should also emphasize the regional level of financial support, solving social problems in the littoral regions.
- 3) To apply new schemes for the optimal structure of sturgeon culture, with joint and coordinated efforts of state sturgeon hatcheries, sturgeon farms and Federal Center of Selection and Genetics in Aquaculture. This should enable the acceleration of brood stock formation and the efficiency of increased caviar production, due to application of early sexing and the ultrasound method for determining the stage of maturity.

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# Consumers' willingness to pay for organic trout

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**Abstract** Although the demand for organic products is increasing across Italian consumers, there is currently a restriction or no real supply of certificated organic fish. Various pilot projects have been carried out over recent years to define the main standards for organic fish farming and particular attention was devoted to organic trout farming. This paper estimates the potential demand for organic trout in Italy and the Willingness to Pay (WTP) for this "new" product. The paper exposes the results of a survey on consumers based on the Italian region of Veneto carried out by using a face-to-face questionnaire. This survey investigated the main consumption habits and analyze the socio-economic factors eventually affecting consumers' WTP, and determine the consumers' WTP a premium price. The results indicated that consumers demonstrate a willingness to pay a premium price to purchase better quality products.

## Introduction

It is a relatively common and shared opinion that aquaculture will have an important role in satisfying a steadily increasing demand for fish, since quantities potentially caught in the wild have nearly reached their absolute limit<sup>4</sup>. Aquaculture seems therefore to promise abundant resources for the production of food and may also play a key role in reducing the current pressure on overburdened wild fisheries. Despite these considerations, many studies have warned that aquaculture could negatively affect the environment, for example, by generating processes of both genetic and ecological contamination, by spreading pathogens and diseases, chemical pollution as well as pollution derived from feed waste. For reasons of food quality and environmental protection, consumers have traditionally stimulated the demand for healthy food. Generally, consumers are increasingly sceptical of the safety of conventional foods and therefore, the crisis generated by the discovery of dioxin-contaminated food and a series of livestock diseases (such as *Bovine Spongiform Encephalopathy*) has increased the demand for organic food. Within that context, the production of food through organic aquaculture appears to be a very good way to supply a market sector with safe and certified products as the main purposes of organic practices are namely the improvement of food quality and of its safety, by implementing environmental friendly processes. While organic farming already enjoys a certain importance for both the production and consumption of some food products, organic aquaculture still stands at an early stage. Although no official statistical data are available concerning the global production of certified organic aquaculture products, it is estimated that the total

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<sup>4</sup> Aquaculture production is globally growing at an average rate of 9% per year since 1970, compared with a 2.9% rate for terrestrial farmed meat production and 1.3% for capture fisheries over the same period (FAO, 2002).

production in 2000 stood at round 5000 t and was mainly concentrated in some European countries. This quantity represents about 0.01 percent of the total global aquaculture production and about 0.25 percent at a European level (FAO 2002). The fishes that are most commonly produced through organic practices are namely salmon, trout<sup>5</sup> and crayfish.

The main reason for the relatively slow initial growth of organic aquaculture is the absence of internationally recognized and universally accepted regulations and standards for producing and handling organic aquaculture products<sup>6</sup>. However, in many countries there are now several organic labelling bodies which provide the market with the main standards for the production of organic fish as well as with a series of criteria for the labelling process (EU Commission 2005; De Francesco 2003). A regulation which was recently approved by the European Commission (see Reg. 834/2007) and deals with the certification of organic food has also taken aquaculture into consideration. Consequently, there are good reasons to argue that in the very near future there will be a significant development in the supply of fresh organic fish not only across Europe, but also in Italy. A series of studies have been conducted in Italy to evaluate the technical pre-requisites and the economical feasibility of a standardized certification process for organic farming focusing mainly on sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*) (Uniprom 2002; De Francesco 2003) and rainbow trout (*Oncorhynchus mykiss*) (API 2007). As for the demand from local consumers, the first of the aforementioned studies evaluates the potential demand for both sea bass and sea bream and also provides an estimate of the consumers' Willingness to Pay (WTP) a premium price<sup>7</sup> for buying and consuming these organically farmed fishes.

Trout as a product has different marketing characteristics to both sea bass and sea bream. Trout is a freshwater fish as well as an aquaculture (breeding) product and generally this is the main reason why the consumption of this fish is relatively low. In the culture of trout, production costs<sup>8</sup> and consequently market prices are much lower than those for sea bass and sea bream. This may explain why domestic purchases of trout are very high and why the species is one of the fishes which are most commonly eaten by Italians, although there are strong differences along the peninsula (in Northern Italy, for example, trout counts for about 10-15% of the total consumption of fish) (Ismea 2007).

Having realised the results of the previous studies could not be extended to the trout market, it was decided that an investigation would be undertaken into the potential demand for organically farmed trout. The aim of this paper is to estimate consumers' WTP for the consumption of organically farmed trout. The paper will discuss the main results of a survey which was carried out in the Italian region of Veneto by means of face-to-face interviews, with an eye on the consumers' WTP a premium price for this

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<sup>5</sup> In Europe the production of organic farmed trout is concentrated in France and Switzerland (round 220 t per year), Great Britain (318), Ireland (120), Germany (60), Spain (50) and Austria (10) (ISMEA, 2007).

<sup>6</sup> Organic aquaculture was not included either in the EU Reg. 2091/92 regarding the certification of organic food and its labelling nor in the EU Reg. 1904/99 concerning to the organic terrestrial animal husbandry.

<sup>7</sup> Premium price is the additional percentage charged for organic products when compared with conventional products prices.

<sup>8</sup> The average ex firm price for sea bass and sea bream is respectively 7 and 6.7 €/kg, whereas for trout this stands at 3.3 €/kg (Icram-API, 2007).

new product, and investigate the main consumption habits and the most relevant socio-economic factors affecting consumers' WTP.

## **Materials and methods**

### *Contingent Valuation Method*

Contingent Valuation (CV) is a survey-based direct method (i.e. survey by questionnaire) for an evaluation of market and non-market goods (Arrow *et al.* 1993); this method involves creating a hypothetical market situation for a given good or service (Carson *et al.* 2001) and it is also the most commonly employed technique used to estimate consumer WTP (Hanneman 1984). WTP can be defined as the difference in monetary value between consumers' surplus before and after improving a certain food product. Respondents face a hypothetical purchasing situation in which they are invited to associate WTP to a certain premium, expressed either as a sum of money or as a percentage going beyond the reference price (Carmona-Torres & Calatrava-Requena 2006). This tool allows market researchers to quantify the value consumers give to certain products by associating the value with the amount of money they are willing to pay to purchase such products (Kawagoe & Fukunaga 2001). Since 1980, there has been an increasing interest in CV, mainly in the literature devoted to environmental evaluations (Bishop & Heberlein 1979). Recently, several more references that have appeared in papers covering consumers' WTP for attributes linked to food safety and quality. These generate a supplementary support for the use of CVM, especially as many such papers deal namely with the WTP for consuming organically produced food.

Before carrying out interviews, researchers have to define the different price premiums (the so-called "starting points") and this step may be carried out according to various criteria, such as a pilot test or through an iterative selection. In this study we assume that if respondents answer questions concerning the purchase of conventional trout and their knowledge of organically produced food, they will have the pre-requisites that are necessary for defining the price they are willing to pay for organic trout. The adopted reference price is the average price of conventional trout according to the information released by the Italian National Association of Aqua-farmers (API).

### *Survey methodology*

The questionnaire was administered to a sample of 321 individuals in some Provinces (Venice, Padua and Treviso)<sup>9</sup> of the Veneto Region. The sample was stratified first according to the population sizes of the various provinces considered and then by the age of the local inhabitants (the starting point being the data provided by the National Statistical Bureau). The survey was carried out in November-December 2007 and face-to-face interviews were collected near large-scale retail supermarkets, fish shops and markets. The questionnaire is divided into four sections with questions on: 1) main habits as far as the consumption and purchase are concerned; 2) knowledge and

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<sup>9</sup> We decided to carry out the analysis in this region as the productive units for trout are mainly concentrated here than in any other area of the country (Veneto features namely 78 companies of aquaculture that count for 22% of the entire availability of such companies across the Italian peninsula; in 2007 they produced also 10,300 t of trout) (Icram-API, 2007). Another explanation for that choice derives by the fact that Northern Italy features also the highest consumption rate of trout at national level.

domestic consumption of organically produced food; 3) WTP for the consumption of organic trout, frequency and non-purchase reasons. In this section respondents were also asked to define their eventual interest in the introduction of organic trout in refectories according to recently approved regional law; 4) respondents' socio-economic characteristics.

As far as the WTP is concerned, respondents were asked to answer a dichotomous choice question which was then followed by an open-ended question.

### *The model*

To evaluate the WTP for organically farmed trout we adopted the Amemiya (two-stage) model (Amemiya 1978, 1979), which is a generalization of the models previously developed by Tobit (Tobin 1958) and Heckman (Heckman 1979). This approach consists of two different regression models. The first regards the decision to pay or not to pay (selection stage), while the second stage refers to the sum of money consumers are willing to pay (i.e. the maximum WTP), after having made the decision to pay (outcome stage). Different sets of explicative variables can be used in the estimation of the two models, so that we also detect if the two decisions (stages) are dependent or not. The Probit model is applied to carry out the first stage of such an analysis.

In this study,  $WTP_i^*$  is the propensity or ability of a respondent to pay for a particular good, i.e. a latent variable<sup>10</sup>,  $i = 1, \dots, N$  where  $N$  is the sample size,  $\mathbf{x}_i$  a vector of  $k$  independent variables referred to  $i$ -esimo respondent,  $\mathbf{a}$  a vector of coefficients ( $k \times 1$ ) which remains constant within the whole sample, and  $\eta_i$  a Gaussian variable  $\eta_i \sim N(0, \sigma^2)$ .

There is generally a linear relationship between  $WTP_i^*$  and the matrix consisting of  $\mathbf{x}_i$  variables:

$$WTP_i^* = \mathbf{a}'\mathbf{x}_i + \eta_i \quad (1)$$

While  $WTP_i^*$  cannot be observed, we can observe WTP and state the following relations:

$$\begin{aligned} WTP_i = 0 & & WTP_i^* \leq 0; & (2) \\ WTP_i = 1 & & WTP_i^* > 0; \end{aligned}$$

From the equation (1) and (2), and from the assumption made on stochastic terms, we get the probability that a respondent (drawn randomly) is willing to pay (Maddala, 1983):

$$\Pr(WTP_i = 1) = \Pr(\mathbf{a}'\mathbf{x}_i + \eta_i > 0) = \Pr(\eta_i > -\mathbf{a}'\mathbf{x}_i) = \Phi(\mathbf{a}'\mathbf{x}_i) \quad (4)$$

where  $\Phi(\cdot)$  is the distribution function for a standard normal variable.

A positive (negative) sign of a coefficient in the estimated model increases (decreases) the probability to pay. Following the application of the Probit model we can obtain the inverse Mill's Ratio (MR):

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<sup>10</sup> Latent variable are the ones we cannot observe directly, we can anyway infer their existence and availability thanks to the properties of an observed variable which has been previously directly measured.

$$MR_i = \begin{cases} \phi(\mathbf{a}'\mathbf{x}_i)/\Phi(\mathbf{a}'\mathbf{x}_i) & \text{if the respondents } i \text{ replay 'yes'} \\ \phi(\mathbf{a}'\mathbf{x}_i)/(1-\Phi(\mathbf{a}'\mathbf{x}_i)) & \text{otherwise} \end{cases} \quad (5)$$

where  $\phi(\cdot)$  is the density function for a standard normal variable.

In the second stage the regression model is estimated, including MR as an independent variable:

$$WTP_i = \mathbf{b}'\mathbf{x}_i + \beta MR_i + \varepsilon_i \quad (6)$$

$\beta$  is the covariance between the stochastic terms of the equations about of the two stages (Amemiya 1978, 1979). If  $\beta = 0$ , the decision to pay and how much to pay are independent.

## Results

### *Consumer's Profile*

The sample consists of a total of 321 individuals whose main socio-economic characteristics are shown in Table 1. As expected, 69% of the sample is made up of women, as grocery shopping is mostly a female activity. The average respondent is 48 years old and the highest frequency correspondents of people fell into 40-49 age range, followed by those that are 60 and over. As for their education, 39% of the respondents have successfully completed high school and 18% held a university or postgraduate degree. More than a half of the respondents (57%) are employed, 21% are housewives and 18% are retired. The average size of households stands at 3.6 people, the mode is a family consisting of 4 members and 51.6% of households don't include people under the age of 14. The modal income category after tax is from 20,000 to 30,000 Euro.

As for their habits in terms of consumption and purchase, 80% of respondents buy fish once per week and the majority (88%) regularly consume fish at home rather than away-from-home (12%). Respondents mainly consume fresh fish (88%) rather than frozen/deep-frozen fish unpacked (26%) or packed (18%), while only 2% of the people interviewed purchase cooked fish. With regards to fish consumers, approximately 30% of them regularly buy trout, mainly in hyper/supermarkets (52%) but there is also a relevant share of consumers who buy fish at fish shops (44%) and at the market (42%), while a mere 4% refer directly to fishermen. As far as the consumption of organic products is concerned, almost all the interviewees have some knowledge of this food category while only 6% of the people interviewed, mainly men who are on average aged 55, have no idea what organic food is. 57% of the people included in the sample are real consumers of organic products; this ratio has to be divided into: habitual consumers (47% are purchasing and consuming organic food at least once per week); occasional consumers (42%, 1-2 times per month); unusual consumers (the remaining 11%, consume organic food only a few times per year). As for the main reasons they purchase organically grown and farmed products, respondents mentioned that they are more healthful (60%) than the traditional ones; moreover, they don't contain GMO (43%). For those who are not used to purchasing organic food, this behavior derives from them not perceiving any relevant differences with conventional products (48%); moreover, the price of organic food is considered as too high (35%) and such products are also conceived as not really interesting or attractive (9%).

**Table 1.** Socio-economic characteristics of the sample

| <b>Gender</b>                                  | <b>Frequency</b> | <b>Percent</b> | <b>Mean</b> | <b>Std.dev.</b> |
|--|------------------|----------------|-------------|-----------------|
| Male   |                  | 31.5           |             |                 |
| Female   | 220              | 68.5           |             |                 |
| <i>Total</i>                                   | 321              | 100.0          |             |                 |
| <b>Age groups</b>                              |                  |                | <b>48.0</b> | <b>13.5</b>     |
| 20-29  | 21               | 6.6            |             |                 |
| 30-39  | 73               | 22.9           |             |                 |
| 40-49  | 92               | 28.8           |             |                 |
| 50-59  | 56               | 17.6           |             |                 |
| >60  | 77               | 24.1           |             |                 |
| <i>Total (no answer: 2)</i>                    | 319              | 100.0          |             |                 |
| <b>Education level</b>                         |                  |                |             |                 |
| University                                     | 58               | 18.2           |             |                 |
| High school                                    | 124              | 38.9           |             |                 |
| Lower secondary school                         | 91               | 28.5           |             |                 |
| Primary school                                 | 46               | 14.4           |             |                 |
| <i>Total (no answer: 2)</i>                    | 319              | 100.0          |             |                 |
| <b>Occupation</b>                              |                  |                |             |                 |
| Employed                                       | 181              | 56.7           |             |                 |
| Housewife                                      | 66               | 20.7           |             |                 |
| Student  | 7                | 2.2            |             |                 |
| Pensioner                                      | 58               | 18.2           |             |                 |
| Unemployed                                     | 5                | 1.6            |             |                 |
| Other  | 2                | 0.6            |             |                 |
| <i>Total (no answer: 2)</i>                    | 319              | 100.0          |             |                 |
| <b>Household size</b>                          |                  |                | <b>3.6</b>  | <b>1.0</b>      |
| 1 person                                       | 4                | 1.3            |             |                 |
| 2 people                                       | 49               | 15.4           |             |                 |
| 3 people                                       | 79               | 24.8           |             |                 |
| 4 people                                       | 143              | 45.0           |             |                 |
| more than 4                                    | 43               | 13.5           |             |                 |
| <i>Total (no answer: 3)</i>                    | 318              | 100.0          |             |                 |
| <b>Household with people aged 14 and under</b> |                  |                |             |                 |
| 0  | 163              | 51.6           |             |                 |
| 1 person                                       | 75               | 23.7           |             |                 |
| more than 1                                    | 78               | 24.7           |             |                 |
| <i>Total (no answer: 5)</i>                    | 316              | 100.0          |             |                 |
| <b>Province of residence</b>                   |                  |                |             |                 |
| Venice   | 97               | 30.5           |             |                 |
| Treviso  | 105              | 33.0           |             |                 |
| Padua  | 116              | 36.5           |             |                 |
| <i>Total (no answer: 3)</i>                    | 318              | 100.0          |             |                 |
| <b>Income level</b>                            |                  |                |             |                 |
| < 10.000                                       | 7                | 2.6            |             |                 |
| 10.000-19.999                                  | 56               | 20.9           |             |                 |
| 20.000-29.999                                  | 98               | 36.6           |             |                 |
| 30.000-39.999                                  | 59               | 22.0           |             |                 |
| > 40.000                                       | 48               | 17.9           |             |                 |
| <i>Total (no answer: 53)</i>                   | 268              | 100.0          |             |                 |

### *WTP and demographic characteristics*

43% of respondents are willing to purchase organic trout with an average price of 8.1 euro (2.6 euro of *premium price*<sup>11</sup>) and a median price of 8 euro. Analyzing the kind of products trout consumers prefer, it emerges that 70% prefer more transformed fish, particularly fillet of organic trout (90%), smoked fillet (26%) and hamburger of organic trout (10%).

As for the frequency at which purchases of this new product occur, 53% of consumers are ready to buy it 1-2 times per month, while 21% would buy it more often, i.e. once per week.

The remaining 57% of respondents are not interested in purchasing organic trout. The disinterest of respondents that more or less regularly consume conventional trout products derives from the fact that the organic version is not considered any better than the traditional one and also by a general diffidence towards the certification and real goodness of organic food. As for those respondents who do not consume conventional trout, they wouldn't buy organic trout because they simply do not like that kind of fish (58%). At least 41% of the sample would introduce the organic trout in refectories (even though 30% of these consumers aren't willing to purchase organic trout by and for themselves). An interesting interaction has to be noted between the premium price (€/kg) consumers are willing to pay for purchasing and consuming organic trout and their socio-demographic characteristics (Table 2). As far as the age of the consumer is concerned, we are able to observe that as age increases, the premium price expected to be paid decreases. To go into even more detail, people included in the age group up to 44, show a greater readiness and willingness to pay extra for organic trout. The higher the education level of the consumer is, the higher the willingness to pay is too. Household size and its composition also affect the WTP; in particular larger households – including people aged under 14 - are related to the highest value registered for *premium price*. The WTP is also higher in people in employment and there is a notable difference in the average values of the premium price if you take into consideration the professional situation of the respondent (2.9 €/kg for employed people vs. 2.3 €/kg for housewives and retired people). Intuitively, consumers with higher incomes are much more inclined to pay extra for organic trout.

### *Results of regression models*

The two regressions from the Amemiya model were first estimated using all the variables of interest (for the complete list of independent variables see Table 3), then a stepwise robust regression was also carried out (the cut-off value  $\alpha = 0.05$ ). Following Alberini *et al.* (2005), income was introduced into the regression model specifying two different variables. The first is denoted by income and is equal to the mean of each income category, in cases where this information was not provided by the respondent we put a 0; the second variable, denoted by missing income, is a dummy variable (a value of 1 was added in cases where people being interviewed didn't state their annual income – i.e. 17% of the sample -, 0 in all other cases).

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<sup>11</sup> In our study, the *premium price* is the difference between the amount of WTP that respondent is willing to pay and the average conventional trout price, i.e. 5.5 €/kg according to the information released by the Italian National Association of Aqua-farmers (API).

**Table 2.** Average *premium price* vs socio-economic features of the respondents

| <b>Gender</b>                                  | <b>WTP</b> | <b>interv.</b> | <b>Age</b>            | <b>WTP</b> | <b>interv.</b> |
|--|------------|----------------|-----------------------|------------|----------------|
| Female   | 2.6        | 90             | ≤ 44                  | 2.9        | 53             |
| Male   | 2.7        | 42             | From 45 to 60         | 2.5        | 50             |
| Total  |            | 132            | > 60                  | 2.5        | 29             |
|  |            |                | Total                 |            | 132            |
| <b>Education Level</b>                         | <b>WTP</b> | <b>interv.</b> | <b>Household size</b> | <b>WTP</b> | <b>interv.</b> |
| Primary school                                 | 2.3        | 14             | 1-2 persons           | 2.4        | 18             |
| Lower secondary school                         | 2.4        | 37             | 3 persons             | 2.5        | 41             |
| High school                                    | 2.7        | 51             | 4 persons             | 2.6        | 50             |
| University                                     | 3.0        | 30             | more than 4 persons   | 3.1        | 22             |
| Total  |            | 132            | Total                 |            | 131            |
| <b>Household with people aged 14 and under</b> | <b>WTP</b> | <b>interv.</b> | <b>Occupation</b>     | <b>WTP</b> | <b>interv.</b> |
| 0  | 2.5        | 78             | Employed              | 2.9        | 74             |
| 1 person                                       | 2.8        | 28             | Housewife             | 2.3        | 28             |
| 2 persons                                      | 2.9        | 17             | Pensioner             | 2.3        | 26             |
| More than 2 persons                            | 3.4        | 7              | Other                 | 1.9        | 4              |
| Total  |            | 130            | Total                 |            | 132            |
| <b>Annual income category</b>                  | <b>WTP</b> | <b>interv.</b> | <b>Province</b>       | <b>WTP</b> | <b>interv.</b> |
| ≤ 19.000                                       | 2.5        | 13             | Venice                | 2.4        | 34             |
| 20.000 - 29.000                                | 2.3        | 42             | Treviso               | 2.7        | 46             |
| 29.000 - 39.000                                | 3.1        | 28             | Padua                 | 2.7        | 50             |
| 40.000 - 49.000                                | 2.5        | 20             | Total                 |            | 130            |
| ≥ 50.000                                       | 3.1        | 8              |                       |            |                |
| Total  |            | 111            |                       |            |                |

The software STATA was used for analysis. Stepwise results are presented in Table 4. The first stage of the model (Probit regression) shows the increasing probability of obtaining a WTP if the interviewee has a university degree, likes trout, eats fish often at home would buy organic fish and prefers transformed products, would introduce organic trout in refectories or there aren't people aged under 14 within the family. If the interviewee eats usually frozen/double-frozen fish (packed or unpacked) and no fresh fish, the probability of getting a WTP for organic trout diminishes.

The *MR* coefficient which was estimated after the second stage is statistically significant, so the two stages are dependent. The main determinants of the *premium price* are the willingness to buy organic trout, and in particular transformed products, living in Padua or Treviso, unlike Venice, having a family with more than two boys/girls aged under 14, being in favour of the introduction of organic trout into refectories. Moreover, in the case where the income increases by 1 euro, the premium price increases by 0.0187 euro. Finally, for those who have a good knowledge of organic foods, are often buying frozen/double-frozen fish packed, are 47-59 years old and unemployed or students, a reduction of their respective WTP has been estimated.

**Table 3.** List of independent variables

| Independent variables       |  |
|-----------------------------|--|
| never                       | 1 = never buying fish; 0 = otherwise   |
| once a week                 | 1 = buying fish only once a week; 0 = otherwise (reference category)                       |
| many times per week         | 1 = buying fish more than one time per week; 0 = otherwise                                 |
| home                        | 1 = usually eating fish at home; 0 = otherwise   |
| away                        | 1 = usually eating fish away-from-home; 0 = otherwise (reference category)                 |
| fresh                       | 1 = usually eating fresh fish; 0 = otherwise (reference category)                          |
| frozen fish unpacked        | 1 = usually eating frozen/deep-frozen fish unpacked; 0 = otherwise                         |
| frozen fish packed          | 1 = usually eating frozen/deep-frozen fish packed; 0 = otherwise                           |
| cooked                      | 1 = usually eating cooked fish; 0 = otherwise  |
| trout                       | 1 = usually buying trout; 0 = otherwise  |
| super/hypermarket           | 1 = generally buying fish in super/hypermarket; 0 = otherwise (ref category)               |
| fish shop                   | 1 = generally buying fish in a fish shop; 0 = otherwise                                    |
| fish market                 | 1 = generally buying fish in a fish market; 0 = otherwise                                  |
| fisherman                   | 1 = generally buying fish directly from fisherman; 0 = otherwise                           |
| organic food                | 1 = knowing organic food; 0 = otherwise  |
| buy organic food            | 1 = buying organic food; 0 = otherwise   |
| organic fish                | 1 = would buy organic fish; 0 = otherwise  |
| transformed                 | 1 = preferring buy transformed fish; 0 = otherwise   |
| menu1                       | 1 = he/she would introduce organic trout in the refectories; 0 = otherwise                 |
| menu2                       | 1 = he/she wouldn't introduce organic trout in the refectories; 0 = otherwise              |
| menu3                       | 1 = he/she hasn't young people in family; 0 = otherwise                                    |
| menu4                       | 1 = he/she doesn't know; 0 = otherwise (reference category)                                |
| Socio demographic variables |  |
| Sex                         | 1 = being male; 0 = otherwise  |
| Age ≤ 38                    | 1 = ≤ 38 years old; 0 = otherwise  |
| Age 39 – 46                 | 1 = 39- 46 years old; 0 = otherwise  |
| Age 47 – 59                 | 1 = 47-59 years old; 0 = otherwise   |
| Age ≥ 60                    | 1 = ≥ 60 years old and over; 0 = otherwise (reference category)                            |
| Padua                       | 1 = living in Padua; 0 = otherwise   |
| Treviso                     | 1 = living in Treviso; 0 = otherwise   |
| Venice                      | 1 = living in Venice; 0 = otherwise (reference category)                                   |
| Primary                     | 1 = having attended primary schools; 0 = otherwise   |
| Secondary                   | 1 = having attended secondary schools; 0 = otherwise (reference category)                  |
| University                  | 1 = having a university degree; 0 = otherwise  |
| Employed                    | 1 = being employed; 0 = otherwise (reference category)                                     |
| Housewife                   | 1 = being a Housewife; 0 = otherwise   |
| Pensioner                   | 1 = being a Pensioner; 0 = otherwise   |
| Other job                   | 1 = being Unemployed/Student/other; 0 = otherwise  |
| comp 12                     | 1 = family with 1-2 persons; 0 = otherwise   |
| comp 3                      | 1 = family with 3 persons; 0 = otherwise   |
| comp 4                      | 1 = family with 4 persons; 0 = otherwise (reference category)                              |
| comp >4                     | 1 = family with more than 4 persons; 0 = otherwise   |
| young 0                     | 1 = family with no young under 14; 0 = otherwise (reference category)                      |
| young 1                     | 1 = family with one young under 14; 0 = otherwise  |
| young 2                     | 1 = family with two youngs under 14; 0 = otherwise   |
| young >2                    | 1 = family with more than two youngs under 14; 0 = otherwise                               |
| Missing income              | 1 = respondents do not state their income category; 0 = otherwise                          |
| Income                      | The mid-point of each income category; 0 if respondents do not state their income category |
| Mill Ratio                  | Inverse Mill's Ratio   |

**Table 4.** WTP determinants

| Independent variables | First stage*                 | Second stage**   |
|-----------------------|------------------------------|------------------|
| home                  | 0.9288 (0.4486) <sup>a</sup> |                  |
| frozen fish unpacked  | -0.7936 (0.3588)             | -0.3868 (0.1908) |
| frozen fish packed    | -1.0766 (0.3399)             |                  |
| trout                 | 1.1230 (0.3125)              |                  |
| organic food          |                              | -1.2691 (0.3241) |
| organic fish          | 1.8712 (0.3671)              | 1.0156 (0.2198)  |
| transformed           | 1.3717 (0.2617)              | 0.8464 (0.2104)  |
| menu1                 | 1.4340 (0.3010)              | 0.8519 (0.2203)  |
| menu3                 | 1.4935 (0.3546)              | 0.5396 (0.2007)  |
| Treviso               |                              | 0.3853 (0.1622)  |
| Padua                 |                              | 0.4376 (0.1637)  |
| University            | 0.6848 (0.3490)              |                  |
| Age 47 – 59           |                              | -0.3593 (0.1600) |
| Other job             |                              | -0.5767 (0.2782) |
| young >2              |                              | 1.2330 (0.4955)  |
| Income                |                              | 0.0187 (0.0069)  |
| Missing income        |                              | 0.7401 (0.3296)  |
| Mill Ratio            |                              | -0.6093 (0.2800) |
| constant              | -3.8382 (0.6215)             | 0.5785 (0.4269)  |

\* Number of obs = 240; Pseudo R2 = 0.6283; Log pseudolikelihood = -61.82979.

\*\* Number of obs = 240; Adjusted R-squared = 0.52416.

<sup>a</sup> Robust Std. Err. in brackets.

## Discussion

The main results of this research may be summarized as follows.

Potential consumers of organic trout amount to 43% of the sample. The figure is relevant when compared with the number of usual consumers (29%).

The consumption of trout is quite decisive for the purchase of organic trout, and a pre-existing consumption of organic food (in particular of organic fish) is even more important; the decision to purchase organic trout is strongly linked to the importance given to safe food.

WTP for organic trout is related to specific socio-demographic features of the consumers e.g. education level and income, living in a household with boys/girls aged under 14.

The *premium price* for organic trout is on average 2.6 €/kg. This result compares well to other studies, such as De Francesco (2003) who have estimated a *premium price* equal to 2.25 €/kg for sea bass and sea bream.

On average WTP is equal to 8.10 €/kg. If we compare the average selling price of the trout (5.5 €/kg) and the average *premium price* for organic trout (2.6 €/kg), we can argue that the selling price of organic trout may be augmented by up to 47%. This increase in price may even cover the supplementary production costs involved in the farming of organic trout. The increase in production costs of organic sea bass and sea bream has been estimated as equal to 30%.

It is important to note that this result has been obtained in a virtual market, i.e. in

absence of competition from other companies; secondly the selling price of trout is low in comparison to the prices of other types of fish.

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# Use of narrow-clawed crayfish (*Astacus leptodactylus* Esch.) in recreational and commercial fisheries and aquaculture in Bulgaria

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**Abstract** In Bulgaria three freshwater crayfish species are present as native: *Astacus leptodactylus* Esch., *Astacus astacus* L. and *Austropotamobius torrentium* Schrank. All of them are under some form of protection, and are included in various legal documents. Bulgaria is among the few countries in Europe, where there are no introduced freshwater crayfish species. Crayfish are raised in ponds up to a marketable size or used for re-stocking of natural water bodies in the country. This study presents the results from research on the gonad development, fecundity and the rearing of narrow-clawed crayfish – one of the most important crayfish species in the country. This investigation was carried out on spawners and juveniles, reared under controlled conditions in tanks or ponds. The efficient management of crayfish should be aimed at an optimal increase and the ecologically friendly use of the stock in nature and the enhancement of astaciculture.

## Introduction

Freshwater crayfish are a valuable biological resource, which is of substantial significance both from an economical and an environmental point of view. Bulgaria is one of the few European countries where there are no introduced freshwater crayfish species (Zaikov & Hubenova 2007). Three indigenous species are found within the countries borders: narrow-clawed crayfish *Astacus leptodactylus* Esch., noble crayfish *Astacus astacus* L. and stone crayfish *Austropotamobius torrentium* Schrank (Bulgarkov 1961; Souty-Grosset *et al.* 2006; Zaikov & Hubenova 2007). Each species is under some form of legal protection (Table 1), and in Bulgaria this is regulated by the Fisheries and Aquaculture Law. The latter two species, the noble crayfish and the stone crayfish, are included in the Convention on the Conservation of European Wildlife and Natural Habitats, Bern (1979).

Regarding the quantitative and qualitative evaluation of existing stocks of freshwater crayfish, the country is significantly lagging behind other European countries, where such monitoring has traditionally been implemented for many years. In Bulgaria recreational fishing for crayfish is done on a very limited scale. It is practiced by a small number of people using crayfish traps, or catching crayfish by hand in shallow areas of lakes, small rivers and streams. The Fisheries and Aquaculture Law states that anyone who owns a fishing license can catch crayfish during the permitted season (15 May - 15 October), with a daily limit of 50 crayfish. The cost of an annual fishing license is 13 EUR.

**Table 1.** Legal protection of crayfish species in Bulgarian water bodies

| Species  | Form of protection  |
|--|---|
| Narrow-clawed crayfish,<br><i>Astacus leptodactylus</i> Esch.    | Seasonal prohibition on capture from 15 October to 15 May. Only crayfish over 80 mm in size are allowed to be caught. The use of electricity, bottom trawling and dragging, sedative substances and explosives are not allowed for catching crayfish. |
| Nobile crayfish<br><i>Astacus astacus</i> L.                     | The Fisheries and Aquaculture Law prohibits their capture, movement, transport and trade throughout the year.   |
| Stone crayfish,<br><i>Austropotamobius torrentium</i><br>Schrank | The Fisheries and Aquaculture Law prohibits their capture, movement, transport and trade throughout the year.   |

In commercial practices crayfish are caught from natural populations in the large water basins of the country. The capture of crayfish for commercial purposes requires a special license, which is issued for one year at a cost of 150 EUR. The license is only valid for a specific region and the holder of the license is not allowed to catch crayfish in water basins outside those included in the license. Only five commercial crayfish fishing licenses have been issued in the country, indicating that very few people (or at least very few people with the correct permission) are occupied in the business.

In Bulgaria there are no aquaculture facilities that have been specifically designed and constructed for the culture of crayfish. In some of the small to medium sized reservoirs where fish are reared, narrow-clawed crayfish are also caught. These have reproduced naturally without any special care. These catches represent approximately 20 % of the annual marketed catch (Zaikov & Karanikolov 2000; Zaikov 2001; Zaikov & Hubenova 2007), however there are no official statistics on the quantity of produce sold. The crayfish are sold at wholesale prices of 3 to 4 EUR per kilogram, and in retail stores the price reaches 7-8 EUR per kilogram.

Of the 3 discussed species, the narrow-clawed crayfish *A. leptodactylus* Esch., is of the greatest economical importance for the country as it represents a resource which to a certain extent is exploited for recreational, commercial and aquaculture purposes. In recent years it has been the subject of intense study in Bulgaria, mainly focusing on the production of one year old crayfish in aquaculture, which could be used to restock some natural water bodies, or reared up to market sizes in fish farms.

In this article the results of research on the reproductive potential of the narrow-clawed crayfish are presented. Its incubation and rearing to one-summer-old in aquaculture conditions is also investigated to indicate the feasibility of using them for the restocking of inland water bodies and extensive culture.

## Materials and methods

In this study juvenile and sexually mature individuals were used, reared all year round in earthen ponds.

In order to determine the minimum size at which male narrow-clawed crayfish reach

sexual maturity, one-summer-old crayfish ( $n = 93$ ) with body weight 1.52-19.50 g were studied during the months of August, September and January. The analysis was made on the basis of microscopic observations on the maturity stage of the testis. After dissection the testes were preserved in 4% formalin and prepared for paraffin inclusion. Sections 5-6  $\mu\text{m}$  thick were coloured with hematoxylin and eosin. The microscopic observations were carried out with a Nikon MICROPHOT-SA. For female individuals the time sexual maturity was reached was determined on the basis of macroscopic observations on one-summer-old individuals ( $n = 52$ ), with body weight 9.47 to 19.44 g, during the autumn-winter period (November-December). The deposition of eggs on the pleopodal legs of the crayfish was taken as a marker for sexual maturity.

In the determination of the fecundity of female crayfish the following indicators were recorded: absolute (number of ovarian eggs) and working (number pleopodal eggs) fecundity, and GSI, %. Absolute fecundity was determined for 27 sexually mature crayfish with average body weight 38-40 g and body length 11 cm in September. After dissection the ovaries were weighed, preserved in 4% formalin, and then the number of ovarian eggs of each individual was counted. The working fecundity (number of pleopodal eggs) was determined in 71 sexually mature crayfish in the month of May. The pleopodal eggs with embryos, just prior to hatching, were removed with tweezers from the pleopods of the females, and were counted separately for each individual. Correlations between the number of ovarian and pleopodal eggs, and some external body features were established.

In order to determine the reproductive potential of the male narrow-clawed crayfish the following indicators were recorded: period for mass copulation, rate of participation of the males in the reproductive process, interval between two consecutive copulations of a single male crayfish. Eight variants were tested with different proportions of male ( $n=24$ ; BW, g 43.25 and TL, cm 10.82) to female ( $n=92$ ; BW, g 31.23 and TL, cm 10.5) individuals – from 1:1 to 1:8.

In order to determine the influence of varying incubation conditions on hatch rates, eggs were placed in hatching incubators which were in turn placed into tanks or directly into earth ponds. The hatching incubators are wooden boxes with 50 individual chambers (10 x 8 x 8 cm) and in each chamber is placed a single female crayfish with eggs at the “eye spots” phase of development. For the incubation in tanks a total of 270 females with an average weight of 31 g were placed in to 6 hatching incubators in 2 tanks. The larvae produced, were grown in the tanks up to a strong stage (30 days old) and were fed with boiled egg yolk and zooplankton. For the incubation of embryos in ponds, hatching incubators were placed directly in to two earth ponds (0.14 ha and 0.4 ha). 330 and 258 females were stocked respectively with an average weight of 34 g.

In order to determine the influence of the stocking density on the growth and survival rate of the crayfish up to a strong stage (30 days after hatching), 3 different stocking densities were tested: 196, 392 and 784 individuals  $\text{m}^{-2}$ . Crayfish juveniles with an initial body weight of 30.4 mg were reared in tanks and fed zooplankton. The growth and survival rate were recorded.

The influence of the type of feed on the growth and survival rates of crayfish up to 30 days after hatching was established with the use of 4 types of food offered *ad libitum*: zooplankton, carp pellets, meat meal and soy-bean meal. The crayfish juveniles with initial body weight of 30.4 mg were reared in tanks at stocking density of 4 ind. $\text{l}^{-1}$ . The

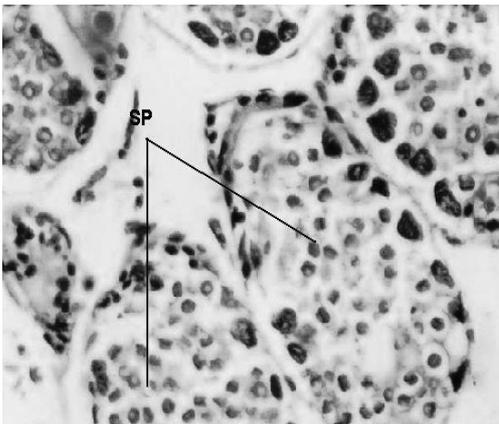
following indicators were measured and recorded: growth rate, specific and daily growth rate and survival rate.

Narrow-clawed crayfish were reared up to one-summer-old in earth ponds at two different stocking densities (stocked with 10 day old juvenile crayfish). They were reared in polyculture with 5 day old bighead carp larvae. The crayfish and bighead carp were fed ground sunflower grain and wheat during the vegetation period.

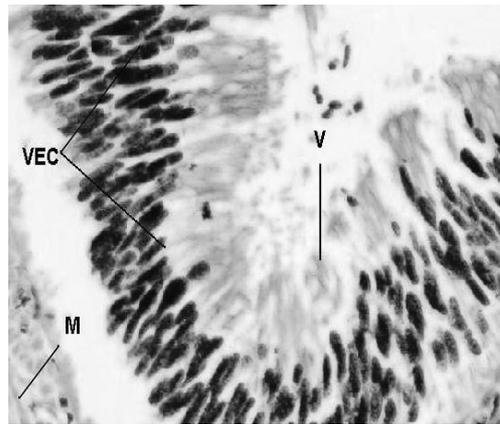
## Results

### *Maturity*

Male crayfish reared in earth ponds reached maturity at an average age of 6-7 months for individuals with body length over 6.4 cm. In histological sections, spermatozoa in the testis (Fig. 1) were observed as well as changes in the sperm ducts that allow the passage and deposition of spermatozoa in the lumen (Fig. 2). The smallest female crayfish which had reached maturity at one-summer-old and which had pleopodal eggs, were of a body length of 7.0 cm. The average working fecundity established for that group was low – 38.8 pleopodal eggs per individual.



**Figure 1.** Cross-section of the testis of one summer old crayfish with body weight over 10 g (4 months old, end of September). Testis cysts containing spermatozoon (SP), HE, magn.x200



**Figure 2.** Cross-section of the efferent tubule of one summer old crayfish with body weight over 10 g (4 months old, end of September). The muscle fibres (M) and vacuolized epithelial cells (VEC), containing vacuoles (V) are visible in the wall of the seminal duct, HE, magn.x200

### *Fecundity*

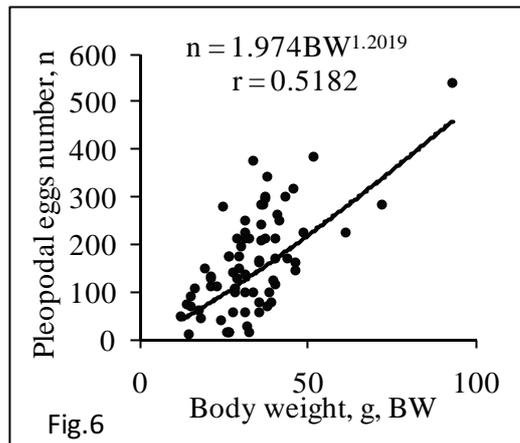
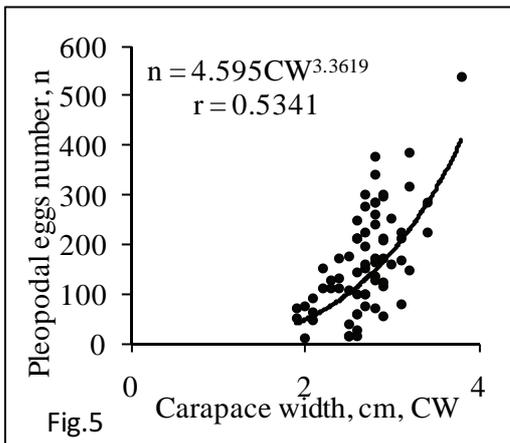
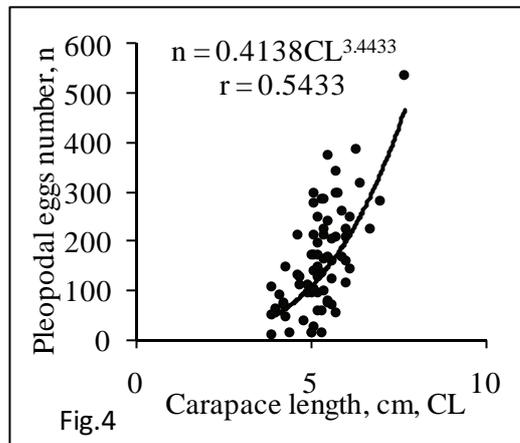
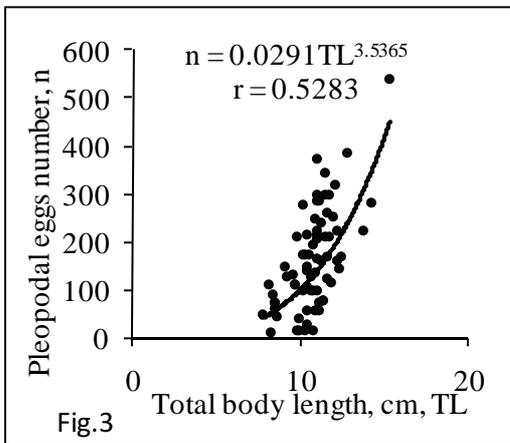
The absolute fecundity (number of ovarian eggs) of the narrow-clawed crayfish reared in aquaculture is 371.56 oocytes and it varies between 196 and 639 (Table 2). The gonadosomatic index is 2.56 %. The average working fecundity is 162.7 pleopodal eggs, and it varies between 11 and 538 (Table 3). With an increase in body weight, the number of pleopodal eggs also increases and their numbers were highest in the weight group of over 70 g. The absolute fecundity is positive correlated to the body weight ( $F=8.0454BW^{1.0672}$ ,  $r = 0.8307$ ,  $n = 27$ ) and body length ( $F = 1.2679TL^{2.3512}$ ,  $r = 0.6267$ ,  $n = 27$ ). Significant correlation was also observed between the number of pleopodal eggs and the body weight and length and with the carapace length and width (Figs 3-6).

**Table 2.** Absolute fecundity of narrow clawed crayfish in aquaculture

| <i>n</i> | Body weight, g | Total length, cm | Ovarian weight, g | GSI, %    | Oocyte number |
|----------|----------------|------------------|-------------------|-----------|---------------|
| 27       | 38.39±9.59     | 11.39±1.03       | 0.98±0.35         | 2.56±0.75 | 371.56±124.1  |

**Table 3.** Working fecundity of narrow-clawed crayfish in aquaculture

| Weight groups | <i>n</i> | Body weight, g | Total length, cm | Number of pleopodal eggs |
|---------------|----------|----------------|------------------|--------------------------|
| up to 30 g    | 28       | 22.93±1.07     | 9.49±0.17        | 104±64.68                |
| 30 to 50 g    | 39       | 37.35±0.79     | 11.25±0.08       | 184.9±91.97              |
| 50 to 70 g    | 2        | 56.51±6.65     | 13.2±0.71        | 304.5±115.26             |
| over 70 g     | 2        | 82.62±14.9     | 14.75±0.78       | 410.5±180.31             |
| Average       |          | 33.48±12.86    | 10.71±1.36       | 162.7±104.1              |



**Figure 3.** Relationship between fecundity (pleopodal eggs) and total length (TL), carapace length (CL), carapace width (CW) and body weight (BW) in *A. leptodactylus*

### *Reproductive potential of male crayfish*

The reproductive process of the narrow-clawed crayfish begins with the deposition of a spermatophore on the body of the females, ventrally-caudally on the cephalotorax at the base of the first to third pair of walking legs. It was established that a single male crayfish can place a spermatophore on 8 female individuals, i.e. to inseminate them. In the majority of cases two copulations occur without an interval between them or within 1-3 days and are independent of the tested proportions of males to females.

### *Egg incubation*

The results obtained from the egg incubation in tanks are shown in Table 4. In the two test variants with different numbers of female individuals, in one tank an average of 133 to 154 crayfish larvae were obtained from one female, with a hatch rate of 85-88 %. The survival rate of the crayfish juveniles up to the 30 days age was 45-47 %. The eggs incubated in the hatching incubators placed in ponds, resulted in a lower hatch rate in the range of 65-70%.

**Table 4.** Results obtained from egg incubation in tanks

| Features   | I tank | II tank |
|--|--------|---------|
| Density of female crayfish, ind.tank <sup>-1</sup> | 150    | 120     |
| Average number of pleopodal eggs from 1 female     | 150    | 180     |
| Total hatched juveniles.tank <sup>-1</sup>         | 20,000 | 18,500  |
| Hatchery rate, %                                   | 88     | 85      |
| Survived juveniles up to 30-days                   | 9,400  | 8,300   |
| Survival rate of juveniles up to 30-days, %        | 47     | 45      |
| Survival rate of females, %                        | 98     | 95      |

### *Fry Densities and Feeding*

When rearing crayfish up to an age of one month at different stocking densities, survival rate was within 31.9 to 67.5 %, with the highest values recorded at the lowest densities (Table 5). The highest survival rate is correlated with the highest average body weight of 108.4 mg.

When crayfish juveniles were fed with various types of food (zooplankton, carp pellets, meat meal, soy-bean meal), the highest survival rate of 71.88 % was achieved with zooplankton feeding, which correlates with the highest body weight at the end of the 30-day rearing period - 89.93 mg (Table 6).

### *Pond rearing of summerlings*

The results obtained from rearing crayfish up to one-summer-old, at different stocking densities, in ponds are shown in Table 7. The highest yield of 764 kg.ha<sup>-1</sup>, and highest survival rate of 52%, were achieved with an initial stocking density of 210 000 ind.ha<sup>-1</sup>.

**Table 5.** Growth and survival rates of crayfish reared to one month old at different stocking densities

| Density Replication     | 784 ind.m <sup>-2</sup> |      | 392 ind.m <sup>-2</sup> |      | 196 ind.m <sup>-2</sup> |       |
|-------------------------|-------------------------|------|-------------------------|------|-------------------------|-------|
|                         | 1                       | 2    | 1                       | 2    | 1                       | 2     |
| Initial body weight, mg | 32.6                    | 35.6 | 33.4                    | 30.3 | 30.8                    | 36.5  |
| Growth rate, mg         | 39.2                    | 46   | 60.8                    | 56.4 | 76.7                    | 71.9  |
| Final body weight, mg   | 71.8                    | 81.6 | 94.2                    | 86.6 | 107.5                   | 108.4 |
| Survival rate, %        | 31.9                    | 36.9 | 50                      | 52.5 | 67.5                    | 62.5  |

**Table 6.** Growth and survival rates of crayfish reared to one summer old on different diets

| Features                  | Zooplankton | Carp pellets | Meat meal | Soy-bean meal |
|---------------------------|-------------|--------------|-----------|---------------|
| Survival rate, %          | 71.88       | 68.13        | 50.43     | 48.12         |
| SGR, %·day <sup>-1</sup>  | 3.56        | 3.2          | 2.25      | 2.12          |
| DGR, mg·day <sup>-1</sup> | 1.99        | 1.75         | 1.2       | 0.95          |
| Final body weight, mg     | 89.93       | 80.42        | 61.88     | 58.91         |

**Table 7.** Main results from rearing crayfish up to one-summer old age in ponds

| Density ind.ha <sup>-1</sup> | Pond 1 | Pond 2 |
|------------------------------|--------|--------|
| Crayfish juveniles           | 27000  | 210000 |
| Herbivorous fish juveniles   | 150000 | 100000 |
| Survival rate %              |        |        |
| Crayfish juveniles           | 38.7   | 52     |
| Herbivorous fish juveniles   | 33.3   | 55.7   |
| Yield kg.ha <sup>-1</sup>    |        |        |
| Crayfish juveniles           | 115    | 764    |
| Herbivorous fish juveniles   | 900    | 557    |
| Total yield                  | 1015   | 1321   |

## Discussion

The period in which the narrow-clawed crayfishes reach sexual maturity depends on a number of factors, the most important of which are the volume and quality of the water and feed, the temperature conditions and those related to somatic growth. The different areas of *A.leptodactylus* distribution are characterized by different climatic conditions that determine the age and indirectly the body size at which the crayfish reach sexual maturity. Under the conditions found in Bulgaria, the size at which narrow-clawed crayfish reach maturity (males over 6.4 cm; females over 7.0 cm), and are able to take part in the reproduction in the first winter of their life (Hubenova *et al.* 2004), are near the sizes indicated by other authors for various other regions. Alechnovich & Kulesh

(1996), Burba (1996), Kulesh & Alechnovich (1997) reported that in the Eastern distribution areas of *A. leptodactylus* (Belarus, Lithuania and from Karelia to the Caspian Sea) the females with a length 68-75 mm and the males with a length of 67mm are sexually mature. In Western areas (Switzerland) the body length of the crayfish, when they take part in the reproduction for first time, is 73-76 mm (Stucki 1999). In Turkmenistan the minimum length of mature crayfish is 75 mm and in Poland is 83 mm.

A main reproductive indicator, directly linked to the sustained development of the various natural and cultivated populations of the narrow-clawed crayfish is fecundity. The number of ovarian eggs (absolute fecundity) has been the focus of many studies (Koksal 1988; Alekhnovich & Kulesh 1996; Kulesh & Alechnovich 1997; Hosseinpour & Karimpour 1999; Harlioglu & Turkgulu, 2000). Absolute fecundity directly affects the number of individuals in any water basin, and to a great extent is specific to the organisms inhabiting the different water bodies, and the results obtained vary widely, with a range from 60 to 1628 oocytes (Koksal 1988; Alekhnovich & Kulesh 1996; Hosseinpour & Karimpour 1999). The values that were established for the absolute fecundity of the narrow-clawed crayfish, reared in aquaculture in this study, were within the range of other authors indicated for different latitudes. Compared to data for the absolute fecundity of the narrow-clawed crayfish in some natural populations in the country (dam-lake Kardzhali and dam-lake Pyasachnik) (Hubenova, Vasileva & Zaikov 2002; Vasileva *et al.* (2006 a), the absolute fecundity of the crayfish reared in aquaculture is higher. This is most likely due to the sufficient quantity of natural food in the ponds, during the period of the oocytes formation in the ovary (Holdich & Lowery 1988; Koksal 1988).

Working fecundity of the narrow-clawed crayfish fluctuates in a wide range, with variations from 0 to 280 pleopodal eggs (Cherkashina 1970, 1975; Alekhnovich & Kulesh 1996; Hosseinpour & Karimpour 1999). The data reported on the working fecundity of the narrow-clawed crayfish, reared in aquaculture, are comparable with the data for populations, inhabiting the southern regions of the range of the species (Cherkashina 1970, 1975; Hosseinpour & Karimpour, 1999). However, the working fecundity of the cultivated individuals is lower compared to that of the natural populations in dam-lake Pyasachnik (Hubenova *et al.* 2005; Vasileva *et al.* 2006a), likely due to the higher crayfish densities in the ponds, which could result in higher losses of eggs.

An important factor for sustaining natural populations or for predicting the number of crayfish juveniles from aquaculture is the proportion of the absolute and working fecundity. In this study it was determined that the absolute fecundity is 55% higher than the working fecundity, which is also supported by other authors (Jarvelkung 1958; Momot 1967; Lindqvist & Louerkari 1975; Lahti & Lindqvist 1983; Huner & Lindqvist 1991; Hubenova-Siderova *et al.* 2000), who indicated a proportion of 50-68 %.

The ratio of males to females in the brood stocks and the optimal utilization of the reproductive potential of the male crayfish are of significant interest both from a theoretical and practical point of view. Cukerzis (1989) points out the fact that a single male can copulate with 2-3 female crayfish. According to Fedotov (1993) up to 5 the females can be mated, in most cases however the number is no more than 3. The same author recommends a male to female ratio of between 1:2 and 1:3. Arrignon (1981)

states that for commercial purposes *A. leptodactylus* can be reared at a density of 50 ind.m<sup>-2</sup>, with a male to female ratio of 1:3, and Sevilla (1988) considers this to be the maximum limit at which progeny can be sustained. The data from the present research show that a single male crayfish is able to place a spermatophore on 8 female individuals (i.e. to inseminate them), which allows a significant decrease of the number of males in the brood stocks (Vasileva *et al.* 2006b). Mass deposition of spermatophores on the female's body is observed for a relatively short period of time - 5 days, when the water temperature reaches 7.5-8<sup>0</sup> C, which is in accordance with the values indicated by Koksál (1988) and Aidin (1998).

Various methods are applied in the incubation of crayfish eggs (Koksál 1988; Ackefors & Lindqvist 1994). The incubation method applied in this study of placing hatching incubators in tanks is highly efficient, possibly due to the degree of control that can be exerted over the incubation process. The newly hatched crayfish enter tanks where they start to feed on zooplankton, which is considered the most appropriate food for growing larvae in the early stages of their development (Nefedov & Naumova 1978; Austin, Jones, Stagnitti & Mitchell 1997). The survival rate of brood crayfish (95-98%) and the hatch rate (85-88%) are high, and this allows the production of a large number of larvae. When the hatching incubators were set in ponds the survival rate of the brood stock and the hatchery rate were lower compared to the incubation of the eggs in tanks. The main reason for this is the occurrence of the ectocommusal *Epistylis sp.* (Zaikov *et al.* 2000) on the crayfish and embryos, and also mechanical damage on eggs incurred during the catching of the brood crayfish (silting up and stripping of the eggs).

The growth of crayfish during the early stages of their development is directly related to the stocking density and the choice of appropriate foods, matching their physiological requirements (Struzynski & Niemiec 2001; Ulikowski & Krzywos 2004). The correlation between the initial stocking density and the survival and growth rates of the narrow-clawed crayfish juveniles has been studied by Koksál (1988), Ulikowski & Krzywos (2004), Ulikowski & Krzywos (2006), Mazlum1 & Kemal (2007). Within the range of densities tested in this study, there is a tendency for the growth and survival rates to be decreased with increased stocking density, which is in line with the information from Ulikowski & Krzywos (2004), Ulikowski & Krzywos (2006), Mazlum1 & Kemal (2007). Johnsson & Edsman (1998) point out the risk that at higher densities molting crayfish are more vulnerable to intra and inter-specific predation and this vulnerability increases with non simultaneous molting.

The results from the experiment carried out for feeding the crayfish juveniles up to a strong stage, with four different food types, confirm the fact that live zooplankton is an adequate food resource for many hydrobionts, including the juvenile narrow-clawed crayfish (Zaikov *et al.* 2000). This type of food is closest to their natural diet, and allows a high growth rate to be achieved. The highest recorded values for the growth and survival rate during feeding with zooplankton are close to those recorded by other authors for similar experiments with larvae of *Cherax destructor* (Austin *et al.* 1997) and *Cherax quadricarinatus* (Jones 1995). The closest results to the variant where zooplankton was used for food were achieved when the crayfish were fed with carp pellets with a protein content of 32 % and fat content of 8%. This makes pellet feed a suitable substitute to natural food, when there is only a limited quantity in the water body. The values for the survival rate in the different tests are similar to that recorded for the growth rate. The crayfish fed with zooplankton and pellets have the highest

survival rate and growth rate (71.88% and 68.13% respectively), while in the other two feed tests it is lower (48-50%). The results show that out of the tested types of food, the zooplankton and pellets meet to the highest extent the physiological demands of the juveniles, so these methods of rearing result in the highest survival rates.

The results from rearing crayfish up to one-summer-old in ponds show the possibility of achieving high yields (764 kg.ha<sup>-1</sup>) with a low food conversion ratio (1.6-1.9). The final weight of the crayfish (7-12 g) do not vary much with the different densities and are close to those indicated by Cherkashina (1978) – 6.5 g, when a similar stocking density was tested. The growth of aquatic vegetation (mainly *Chara* sp.) in the basin with the highest crayfish density had a positive effect on survival rate, and produced a relatively good growth rate. According to Koksal (1988) besides being a source of food, this type of plant plays a significant role in increasing the survival rate, as it offers shelter during moulting. This decreases the occurrence of cannibalism, especially at higher densities.

In conclusion, aquaculture seems to represent an important tool for production of juvenile crayfish. Both one-month-old juveniles and one-summer-old crayfish can be reared up to marketable sizes in specialized farms, or used for stocking natural water bodies to ensure the sustainable development of natural populations.

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# The role of women in fisheries and aquaculture in Turkey

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**Abstract** This review examines the participation and roles of women within the fisheries and aquaculture sector in Turkey, looking at their direct involvement in fishing and fish production as well as their indirect association with related activities (Marketing and distribution, processing, administration, management and public sectoral work, research, education and training).

Women represent approximately 50% of Turkey's population and 25% of the labour force. More than 120,000 people were fully engaged in fisheries activities in 2006. Studies have shown that of all the various fishing sectors, participation of women was highest in fish processing (approximately 70%) followed by marine aquaculture and inland aquaculture. Although there is limited data on women's roles in the Turkish fisheries sector as a whole, women are known to play only a very minor role in fish capture (1.93%). This participation is usually in the form of small scale activities on lakes or as support to sea going spouses. Where women are employed in the aquaculture sector (12%), they are mainly involved in hatchery and live food units. Women also play an important role in administration, fisheries research, education and training as reflected by the numbers of female graduates employed in such fields. The marketing of fresh products for local markets was found to be predominantly carried out by men. Women are also temporarily and permanently involved in activities such as fish vaccination and the construction and manufacture of nets.

## Introduction

Turkey, situated at the junction of two continents, has three percent of its landmass (Thrace) in Europe and 97 percent (Anatolia) in Asia. This large peninsula is surrounded by three major water-bodies; the Mediterranean Sea, the Aegean Sea and the Black Sea. In addition the Sea of Marmara, a large inland sea is located within the countries borders. Its mainland coastlines comprise: 1695km on the Black Sea, 2805 km on the Aegean Sea and 1677 km on the Mediterranean Sea. Along these coasts and around inland water bodies there are many locations deemed as favourable for fisheries activities, owing to favourable geographic positions, climate, water resources (Table 1) and topography (Yildiz 2004).

In 2006 the total fishery production was 661.991 t, with 80% originating from marine and inland fisheries (including crustaceans and molluscs) and 20% from aquaculture. This value represents 6% of the total world fishery production. The Turkish marine fishing fleet, licensed by MARA (Ministry of Agricultural and Rural

Affairs) consists of more than 18,000 sea going vessels, and a further 3000 in inland waters. It is known that more than 120,000 people are fully engaged in fisheries and aquaculture activities. However, the employment data for the fisheries sector is not sex desegregated so the proportion of women within this figure is unclear. There is also no published data on the roles of women in the fisheries sector (Anon 2007).

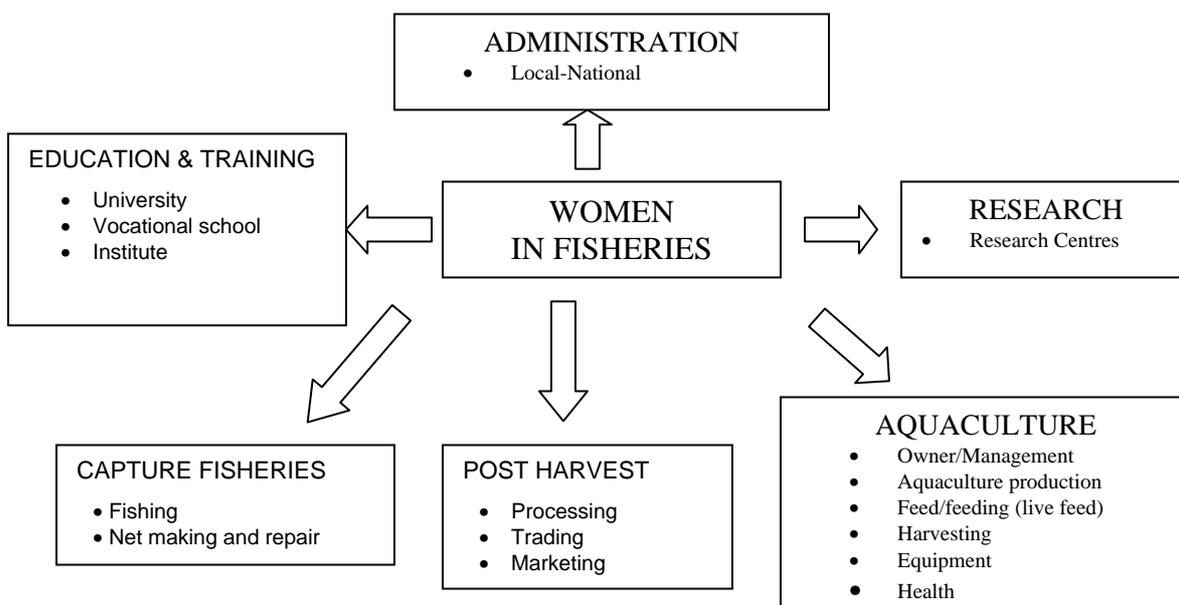
**Table 1.** Fisheries Resources in Turkey (MARA 2006)

| Production Areas   | Number | Size (ha)         | Length (km) |
|--------------------|--------|-------------------|-------------|
| Natural Lakes      | ~200   | ~906.118          | -           |
| Dam Lakes          | 223    | 409.841           | -           |
| Ponds              | 1000   | 28.800            | -           |
| Rivers and Streams | 33     | -                 | 177.714     |
| Seas               | -      | 24.607.200        | 7.816       |
| <b>TOTAL</b>       |        | <b>25.951.959</b> |             |

In Turkey, women constitute around 50% (35,209,723) of the total population (70,586,256) and approximately one-fourth of the labour force (26.5%)(Anon 2007). This study will review the participation and roles of women in the fisheries and aquaculture sector as well as related activities using data form MARA records, sector studies, OECD reports and related websites.

***Where are the women in fisheries?***

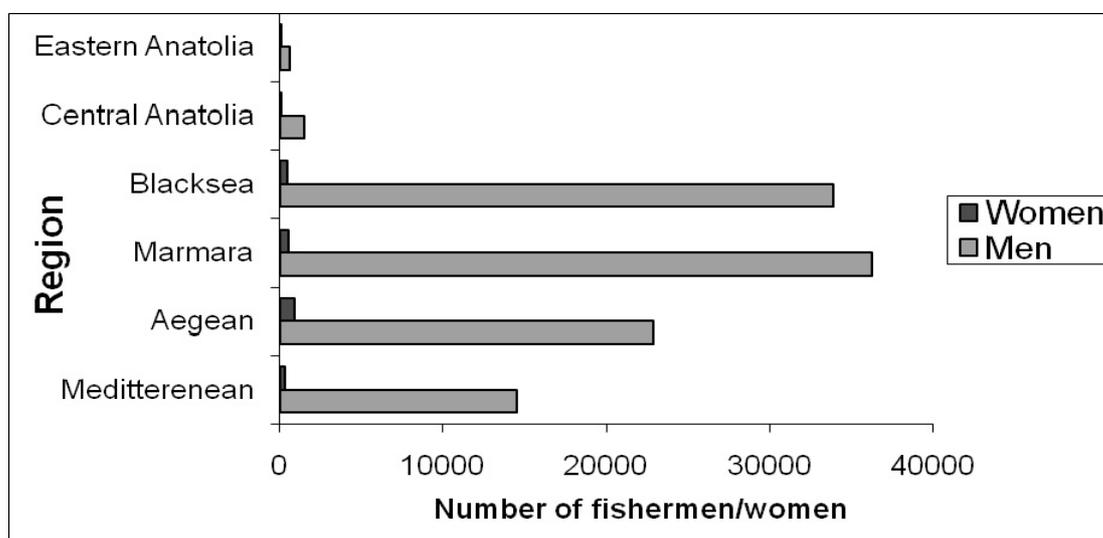
It is important to acknowledge from the outset that the gender issues surrounding the participation and roles of women in both capture and aquaculture sectors are not unique to fisheries. The fisheries sector, like many sectors in Turkey, is seen as mainly male dominated. The role of women in fisheries can be summarised as follows: (Fig 1)



**Figure 1.** The schematic summary of the women in fisheries and aquaculture in Turkey

### *Women in capture fisheries*

In many regions of the developing world men and women are engaged in complementary activities in capture fisheries. In Turkey however, women play only a very small part in fish capture with very few working on vessels. According to MARA records, only 1.93% of all licensed fishers are women. Of these, most women are employed in small scale fishing enterprises on lakes or they may play a supporting role to seagoing spouses in larger scale activities. Women commonly work part time as fishers alongside their spouses in the early morning and then doing other activities such as house keeping, childcare, animal husbandry and agriculture for the remainder of the day. The relative proportions of men and women licensed to fish in marine/inland waters and the regional distributions of this licensing are shown in Figure 2. In inland waters the proportion of women operators is 1.8% whilst in marine waters it is 1.9%.



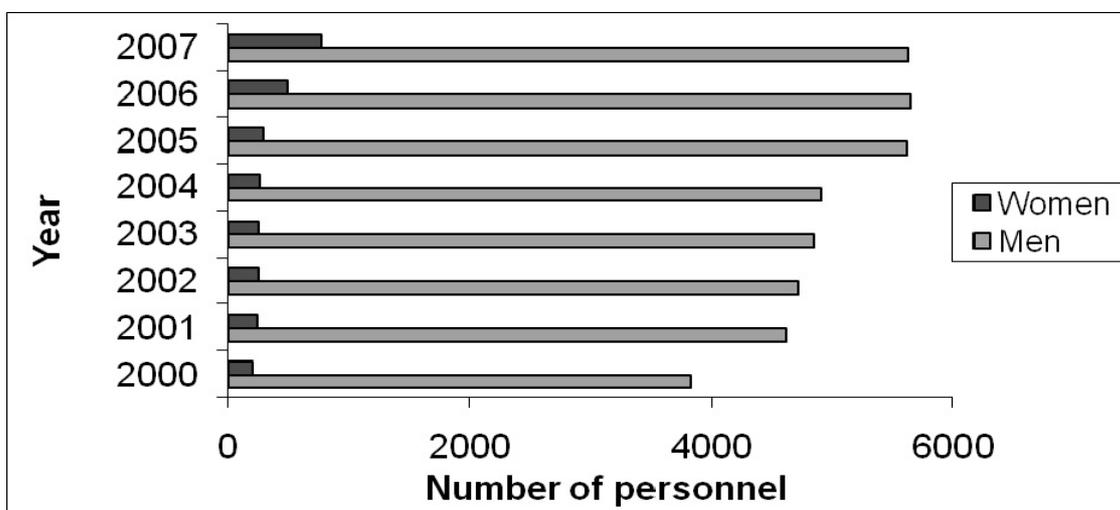
**Figure 2.** The amount of licensed fisher women and men in 2007 according to inland, marine fisheries and region.

### *Women in aquaculture*

The role of women in aquaculture, like their role in the rest of the economy, is shaped by the changing division of labour in society. With the unprecedented growth of aquaculture and the diminishing fish harvests of recent years, aquaculture appears to be a promising route to achieve food and nutritional security in developing countries (FAO 2004). It now represents the fastest growing food sector in the agricultural industry (FAO 2006). Where women are employed in aquaculture they are predominantly involved in actual production than managerial roles. Women rarely hold senior management positions in the aquaculture sector and men have more promotion opportunities. Jobs in aquaculture are widely perceived as being dangerous and uncomfortable for women. As a result women have a low representation in the sector (12% of aquaculture workforce), are usually in jobs of lower importance and often on a temporary basis (FAO 2006). Despite similar

working hours and conditions, women's salaries are lower than their male counterparts in the private sector.

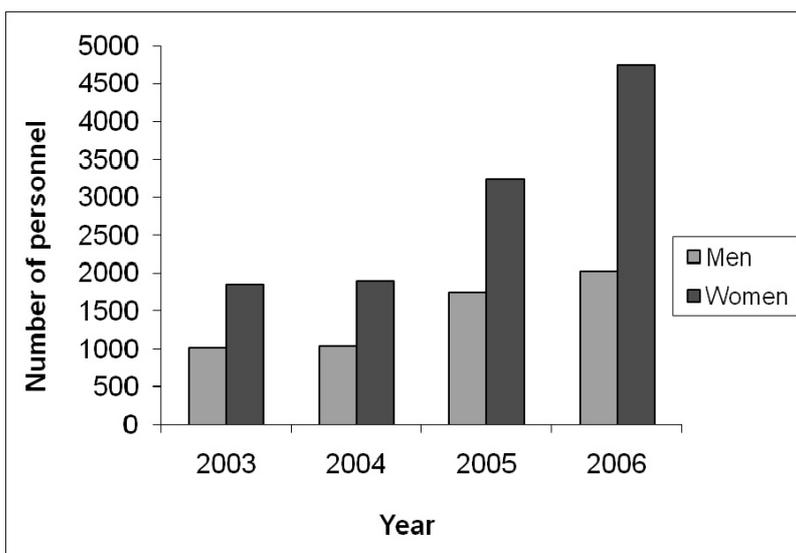
Women who own or manage fish farms are extremely few in numbers (39 out of 1,197 fish farm owners are women) according to available data. However, there are some large aquaculture companies that keep no record of the numbers of women employed and their specific roles. In their role as technical staff, women are often responsible for hatcheries and live food units. In addition, women often play a role in other activities such as research, feeding and harvesting and fingerling production for stocking into ponds and cages. In marine culture, vaccination of fish is also carried out by women labourers that generally work on a part time basis, without insurance and are paid either seasonally or daily. The numbers of technical staff employed in aquaculture over the last eight years is shown below (Figure 3).



**Figure 3.** The number of women and men in Turkish aquaculture.

#### *Women in post harvest activities*

The handling, processing, and marketing of fish products are essential complementary functions of all food production systems. Processing of aquatic products is considered to be women's work. Women have always predominated in the fish processing sector on small-scale private, cooperative, or industrial levels (Fig. 4). Many factories have a preference for women, as they are considered better handlers and processors of fish. There is no discrimination in salary; on the contrary, women usually earn more than men, as processors are paid a basic salary plus a percentage per kilo of processed product. Although women represent the majority of technical posts in the industry (about 70%), they are rarely able to break into the male dominated ranks of senior administration or factory management. Women do not play an important role in the wholesale and gross marketing of fresh products in the major provinces because of the unsuitable working hours. Indeed, the fish markets in Turkey are mainly male dominated and no recorded data has been found on the number of workers in the fish markets. But there are still some women in the fishery departments of large supermarkets.



**Figure 4.** The number of women and men in the fish processing sub sector.

#### *Women in research, education and training*

As of 2007, there was 762 academic staff in employment in the fisheries faculties and departments of Turkish universities. Of this total, about 215 staff are female and half of them are educated to at least PhD level. The number of graduate students from Fisheries faculties is estimated around 9,500 and 40% of this number are women. Women play an important role in administration and fisheries research, reflected in the numbers of female graduates in fisheries related fields. 38 % percent of the female employees are in administration in MARA and another 13% in four research institutes. The rest perform miscellaneous office jobs.

More women are found in administrative roles than in all other activities. As far as educational qualifications of female employees are concerned, a similar pattern of distribution of educational qualifications is found among males.

Based on the data made available to this study, it appears that more and more women are studying in the fisheries faculty. However, they are involved in different sectors such as financial, marketing, and other governmental institutions and private sectors not related to fisheries.

#### **Conclusion and Recommendations**

Women's participation in fisheries and aquaculture can be taken into account by planners and policy-makers. Based on the key findings of the report, some proposals for improving women's positions in the fisheries sector in Turkey are made here:

- Provide opportunities for a professional education
- Promote jobs with stability and future prospects, and promote equal pay for equal work.
- Improve working conditions

- Provide training courses that permit women to expand into work activities currently dominated by men.
- Improve the educational levels of women.
- Equal access to credit and participation in market development for women is needed to consolidate their position as traders.

In conclusion, fishery and aquaculture can play a key role in the contribution of women to the rural economy, rural development of Turkey and provide an extra income for their families. Women can be trained for small scale enterprises such as micro algae and ornamental fish production to provide additional income for the family. The effectiveness of fisheries and aquaculture should be increased to elevate women's economic liberty and family income. New financial instruments should be developed and promoted to increase the contribution of women to the sector.

### **Acknowledgements**

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# Conflict of interests between commercial and recreational fishing in Annecy Lake (France)

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**Abstract** The management of fishery in Lake Annecy, France were examined. Two groups of fishermen share the resource: recreational and professional fishermen. The development of the recreational fishery creates conflicts with commercial fishery and both types of fishery generate heavy pressure on the resource; some species survive because of stocking of young fish. Although there are regulatory instruments for each category, implementation of regulatory policy is difficult because of tension between the two groups. Economic analysis revealed three important points: (i) stocking of young fish was unfavourable to commercial fishermen; (ii) an atypical fish market in Annecy; (iii) problems related to enforcement of regulations on the lake. Implementation of new regulatory instruments is proposed to resolve these conflicts.

## Introduction

Competition between recreational angling and commercial net fishing is prevalent in Lake Annecy, France (Balland 2004); the resource is fully exploited and cannot withstand extra fishing effort without being threatened. The sport fishery has gained such importance (1200 boat licences and 600 angling licences for recreational angling) that commercial net fishery has become marginalised (4 commercial fishermen since 1998). Also, fishing of species like char, *Salvelinus alpinus* L., is maintained only because of intensive stocking of young fish. Regulations (set up by Prefectural Decrees) are defined for commercial and recreational activity and are implemented since the late 1990s to control aggregated fishing effort. The implementation of these restrictions has caused discontent and conflict between commercial and recreational fishermen (Genty & Robert 2000). Fish wardens have been assigned to implement rules. A compulsory system of fish logbooks (for both groups) has been introduced since 1986. It permits a complete inventory of the resource and the fishermen (Gerdeaux 2006). The resulting statistics are useful to determine the level of pressure applied to the resource. The species distribution (principally char, and whitefish, *Coregonus lavaretus* L.) between each group is unequal and creates tension: char yield is unfavourable for commercial fishermen, as they focus on harvesting more whitefish. Although the new regulations are more equitable based on scientific input, and reduced tension between both groups, new conflicts broke out in May 2007 and recreational fishermen accused the commercial fishermen of overfishing whitefish. A group labelled “Angry recreational fishermen”, was set up and petitioned for the abolition of commercial fishery in Annecy Lake (Cheul 2007). In response, articles were published in French gazettes on “Should commercial fishery be maintained in Annecy?” This paper examines the importance of the commercial fishery, and examines whether commercial fishing should be maintained on the lake.

This study discusses the functioning of a fishery exploited by two types of agents whose interests are divergent: profit versus recreation, net fishing versus angling; a recurrent problem found in many fisheries (Arlinghaus & Cooke 2005; Cooke & Cowx 2006, Brown 2004; Coleman 2004; Kearney 2001, 2002). It also considered the argument of Gomez & Tenet (1998) that recreational fisheries generate higher surplus than commercial activity, while acknowledging that they did not take into account all the actors implied in the commercial social surplus, e.g. the restaurants.

## **Review of catch and markets**

Information was collected from the annual compulsory and voluntary fishing logbooks. Thanks to that statistics we know the evolution of the resource stock and the behaviours of both recreational and commercial fishermen. In order to complete this inventory on Annecy lake fishery, and to have precise details on the commercial activity, several interviews have been done with recreational and commercial fishermen, but also with restaurants, hotels, fish shops, supermarkets during the year 2007.

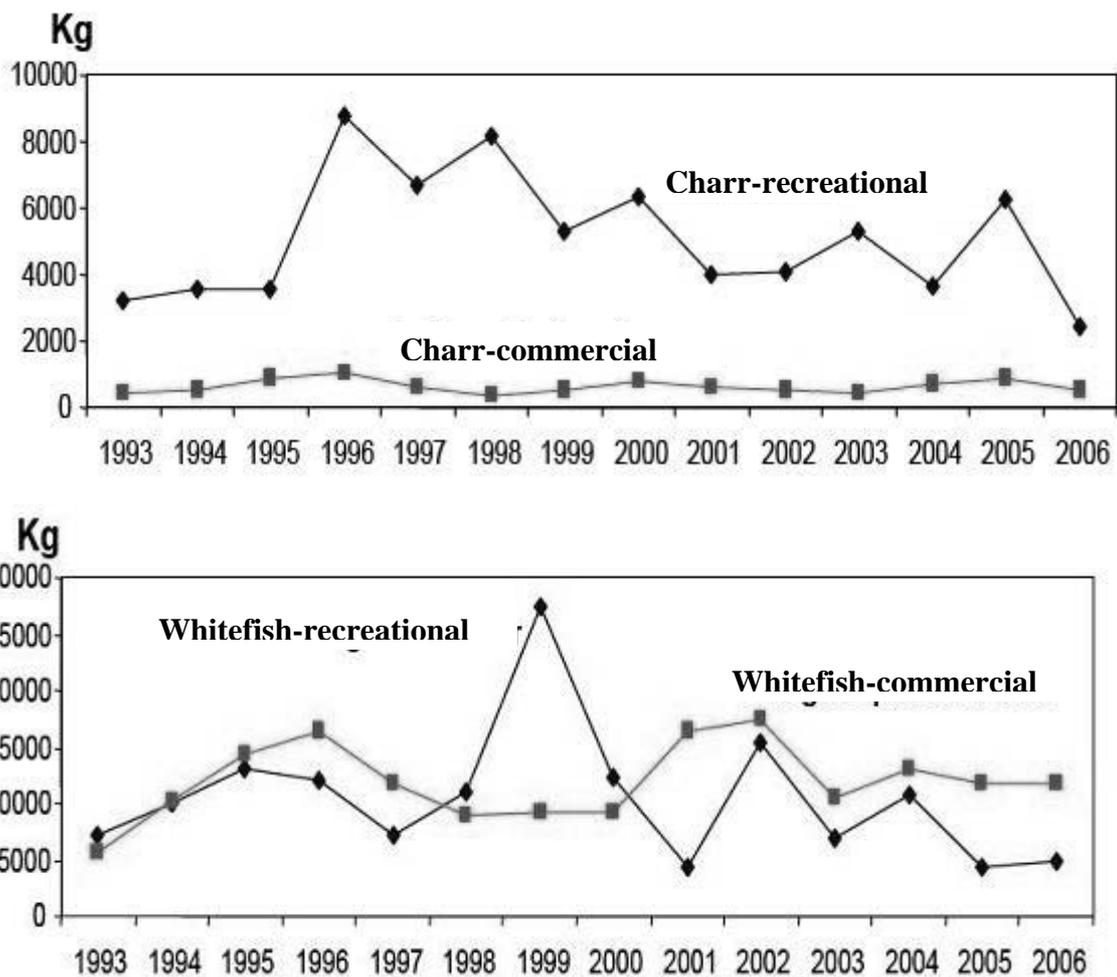
### *Regulatory instruments and distribution of resource*

The principal fishing norms are the following: fishing seasons (fishing is strictly prohibited during reproduction, i.e. winter), protected areas and species, quotas on harvest for recreational fishermen (8 fish per day per species for char and white fish), mesh size for commercial fishermen and minimum landing size (26 cm for char, and 38 cm for whitefish). The price of fishing licences are (year 2007): 105 Euros for a boat licence, 68 Euros for onshore fishing for recreational activity and 1050 Euros for commercial fishermen.

Char and whitefish are the main target species (although trout, pike and crayfish are caught), and these create the conflicts between recreational and commercial fishermen. Fish harvesting is shared equally between the two groups. However, more indepth analysis suggests char production is quasi-exclusive to sport fishing (5 t for recreational activity and 500 kg for commercial activity in 2005), and that whitefish is harvested more by commercial fishermen (11 t for commercial activity and 5 t for recreational activity in 2005) (Fig. 1).

### *Distribution of the costs*

Due to technical constraints on commercial fishermen, char harvesting is low; the number of nets and their size do not favour this type of fishing. Char fishing is done at depths > 30m, where they cannot use their nets. It may also explain the low output of char fishing for commercial fishermen. However, char is the most profitable fish in the lake. Commercial fishermen would like to increase their gain, but they do not seem to have the financial and technical means to do so. Fishing of char is possible only because of stocking of young fish. Each year about 100 000 juveniles are released into the lake. Each group invests in replenishing the stock of the young fish: 80% of this finance comes from sport fishing, the remainder from commercial sources. Apparently, the sport fishermen harvest more than they invest in char, compared with commercial



**Figure 1.** Production of char (upper) and whitefish (lower) for each type of fishermen (purple line corresponds to professional harvesting; blue line corresponds to recreational fishermen)

fishermen. Recreational fishermen have the resources for stocking the young fish, and they have used it to claim their actual share. This unequal share is caused by technical constraints and not quantity limits. Commercial fishermen are interested in increasing their contribution to stocking but only if they obtain better fishing gears. One alternative might be to modify their fishing methods; for instance one could decrease the mesh size, and commercial fishermen could then satisfy their demand for char. However, this production chain is unfavourable for commercial activity because char is very profitable, mainly because supplies are low. The sport fishermen use their higher stocking input to limit commercial exploitation and justify the asymmetrical distribution of harvest that affects directly the profitability of the commercial fishery in terms of markets. Indeed the local community in Annecy (hostels, restaurants, fish shops) depends on the commercial fishery, and vice versa. The stocking of young fish thus represents one cause for conflict.

### *Analysis of the fishery market*

The fish from Annecy Lake is a differentiated product, commercialized in a market with imperfect competition. On the one hand, fish from Annecy lake distinguishes itself from the other products because to its geographical label that guarantees the origin of the commodity `` Wild fish from Annecy Lake – 2700 ha, 4 professional fishermen". It guarantees a very high quality of fish (the fish is sold very fresh and non-eviscerated), while fish coming from rival lakes are eviscerated and sold in higher quantity.

In terms of supply, professional fishermen from Annecy Lake have a high market power, considering there only four (prefectural decree), and thus the competition in Annecy lake is low. The price of fish does not vary on total harvest, and individual supply is fixed. Demand is also very high, especially for char fish. There are five types of customers: the restaurants, the fish shops, a seafood wholesaler, private individuals and supermarkets. Whitefish is also a profitable commercial product, since it is caught in higher quantities and sold at a good price; professional fishermen harvest about 30 fish daily. The catch is sold fresh and instantly on the quayside.

In terms of market, the suppliers, i.e. professional fishermen, create a rationing scenario, because catch of the four fishermen cannot satisfy the demand. This rationing problem might be explained by prices versus quantities effects. Either the fish price is too low: if the price increases the demand will decrease, the supply is insufficient. The fishermen don't, however, have the gear to increase the total production and there is substitution from other lakes, particularly Lake Lemans where production is high. The low price of fishes from Lemans Lake threatens Annecy fishermen.

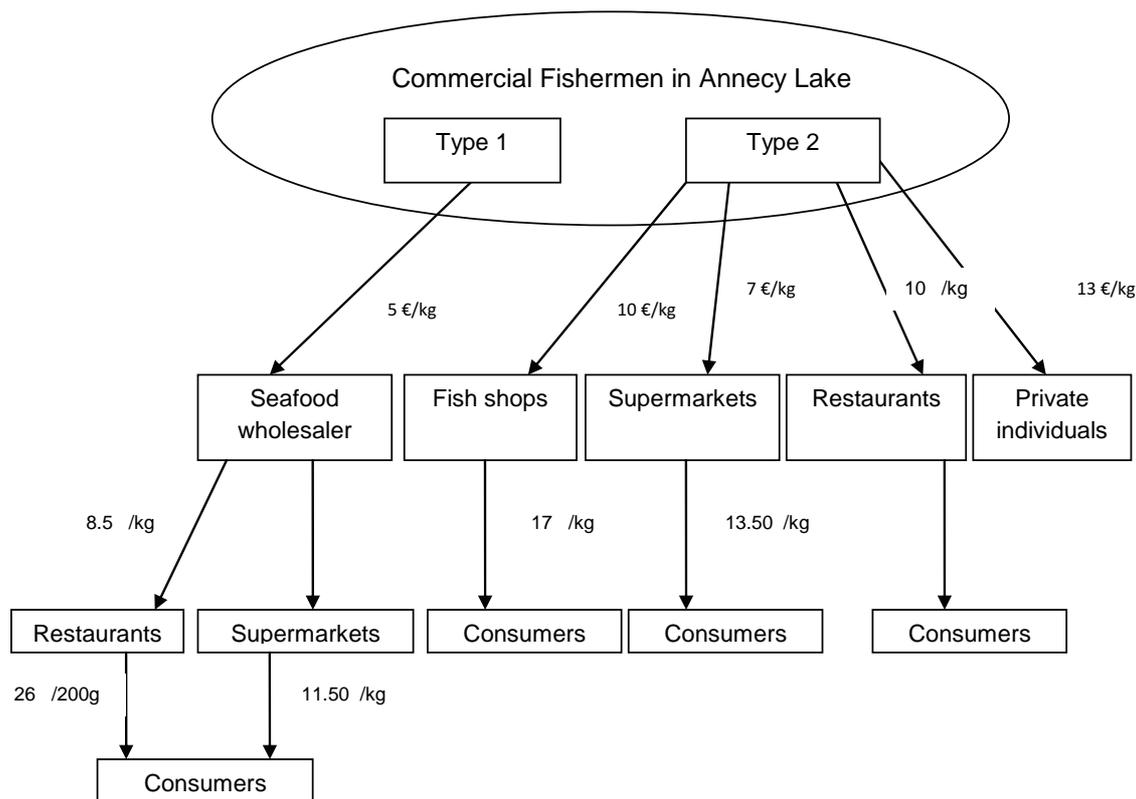
One other feature is that the four fishermen don't have the same sales objectives: two sell their catch to the seafood wholesaler, at a low price (5 € kg<sup>-1</sup> for whitefish whilst the others (Type 2) supply the rest of the demand at a higher price (40 € kg<sup>-1</sup> for char and 13 € kg<sup>-1</sup> for whitefish to private individuals). This price discrimination is justified for two reasons (Figure 2):

SEARCHING COST (transaction costs): the Type 2 group devotes more time to find customers, and bears additional costs compared with type 1 (delivery, clientele, etc.). A few customers, such as restaurants, prefer to deal with type 2. They are willing to pay for assured delivery of the quantity and quality of fish.

QUEUE EFFECT. For Type 1, the only customer is the fish wholesaler while Type 2 satisfies the residual demand that permits it to increase the value of the harvest. This latter type has no guarantee that they will sell all their fish, but they are unable to meet the residual demand. This queue effect permits them to command high prices. They favour sale to restaurants (and individuals) that have a higher willingness to pay for Annecy fish. Often fish shops cannot satisfy demand and they lose customers; thus they secure customers through a waiting list to inform customers when Annecy fish are available.

### *Rationing problem*

The direct sale of fish to restaurants and individuals represents an additional cost in terms of effort by commercial fishermen (compared to the sale to fish wholesaler), but it is also an advantage in terms of profits. The value added is made essentially on the



**Figure 2.** The different actors on Anancy Lake fishery market. Pricing is for whitefish.

restaurant and private individual sales. Some fishermen (Type 2) increase the fish value as much as possible, but are not able to satisfy the whole demand (in particular fish shops and supermarkets). Thus, the rarity and the notoriety (in terms of quality) of the Anancy fishery increase prices. The principal competitor to commercial activity is sport fishing. Professional fishermen would prefer to increase their output of char, which is very low at present, but recreational fishermen have the advantage. Anancy Lake fishing remains an attractive occupation only if fishermen split up the demand and practice discriminatory pricing. However, some fishermen explain that their occupation is not viable, and they think the fishery could be more profitable if the authorities would permit them to fish with more sustainable and effective gears (particularly for char). They believe that it would also avoid fishing traffic. On the whole, if the demand increases, prices will automatically increase, new entrants would like to enter the commercial fishery until the supply meets demand. However, this fundamental economic principle does not work for Anancy Lake because the number of professional fishermen is bound and fixed to four, and entrance of new fishermen is strictly prohibited. The supply level is constant and hence lower than demand.

*Black market*

The existence of a black market might be justified by sport fishermen having high incentives to sell fish: the price is high, daily quota is also high (8 fish per day per species), and supply is low (particularly for char). Balland (2004) called these clandestine fishermen the Undeclared Professional. For instance, in the US, commercial

fishermen are sometimes in competition with the illegal production sold by sport fishermen. During controls, fish wardens catch recreational fishermen in the act with boats equipped with navigation radars (Coleman 2004). In Annecy Lake, a small number of recreational fishermen fish commercially. The fish market can also be justified by the incentives of restaurants to buy fish from recreational fishermen so that they do not pay taxes.

Char has a high market value and represents an asset for local restaurants. The professional harvest is low and uncertain (for instance sensitive to climate variation), thus some sport fishermen are really encouraged to sell their surplus fish. However, Jean Falquet declared ``Don't believe all that stories. For some sport fishermen, fishing is not only a recreation..." (Cheul 2007b), but in June 2007, a restaurant in Annecy was involved in a lawsuit because it had illegally bought fried fish from a non-commercial fisherman (Cheul 2007a). The fish logbook gives transparency at the stock level and technique of fishing, but they are not systematically maintained and it is difficult for the committees to verify sport fishermen logbooks, partly because they are understaffed. Four years before, a full time salaried employee was appointed to control and monitoring fishing rules. Today, only one part-time warden does the supervision on Annecy Lake, so there is little enforcement. During a general meeting, recreational fishermen denounced the lack of fish wardens and the lack of supervision. Professional fishermen also remarked the controls were quasi-ineffective and they could sell their harvest on the black market for a higher price. Increased surveillance and increased fines are the best way to avoid this problem of the black market

#### *Inter- sector conflicts*

Regulations are established for each group of fishermen including: fishing season, daily and annual quota (for recreational fishery), the size of catch, fishing gear for sport fishermen, mesh size (for commercial fishermen), and number of professional fishermen (no limit for the number of recreational fishermen). There are also implicit regulations, such as: the price of a fishing licence, and replenishment of stock of young fish. Even if there are norms, fishing regulatory instruments are not suitable, and do not take into account: (i) high fishing pressure and high mortality rate of the released fish, (ii) growing conflict between professional and recreational fishermen, (iii) growth of sport fishery. The fishing system is not so complex in principle: the area is limited and there are few species of fish. It might thus be easy to implement rules of extraction. However the share of resources between both groups is difficult to determine. On the one hand, one must regulate extractions rules, and on the other, one must manage the conflicts. Rules need to be defined with caution: it is important not to favour (or to be prejudiced with) one group to the detriment of the other group. Norms should be based on sustainable and efficient development on the resource, but should be also shared fairly through negotiations between both groups.

Decreasing the quota of the recreational fishermen and implementing a quota for commercial fishermen could be an efficient measure. According to logbook statistics, 20% of recreational fishermen harvest 80% of the aggregate recreational quantity (Gerdeaux 1991). The implementation of a daily quota is efficient only if the actual quota is reduced by half (Gerdeaux 1996). The best way to reduce this effective resource pressure is to intervene on the 20% of diligent fishermen. Gerdeaux proposed

the following alternative: either a limited number of fishing days per week (for instance four days allowed per week, and each recreational fisherman would choose which day in the week he/she would like to fish). But it may generate high monitoring costs, and its implementation may also be difficult. A bi-weekly quota besides the daily quota could be set, for instance 32 fishes for 15 days. The implementation of a quota for professional fishermen might also be a good way to control conflicts between the groups. More precisely, this quota could be effective at reducing the whitefish production, which is higher for the commercial fishermen. These quotas for recreational and professional fishermen would decrease the fishing yield of each species, and would make the share more equitable.

Sport fishing gear may be improved to decrease mortality of the released fishes. The mortality rate is difficult to assess. On the whole, 60% of catches are released by recreational fishermen (Fisheries and Oceans Department, 2002). However, an unknown proportion of these die after release (Cooke *et al.* 2002). To avoid the mortality of the released fishes, the fishing gear might be better adapted to do less harm to released fish. An alternative barbless hook may replace the present hook that is used. However recreational fishermen might be hostile to this new fishing gear, since it will decrease their chance to catch fish. If the barbless hook is implemented in the lake, one can maintain the actual quota, since fishermen might have a limited range and mortality of released fish will decrease.

The mesh size regulation (for commercial fishermen) is also an efficient way to regulate resource extraction; a 2 mm increase in mesh size delays the entrance of whitefish in professional fishery by 6 months. It is thus possible to change the share of the resource, and the change might be adequate because it has a direct impact on the professional's welfare.

The number of professional fishermen is limited to four. If this number is lower it would not be possible to publish catch statistics. On the contrary, the addition of one commercial fisherman was deemed to have a negative effect on fish stocks in Annecy. There is no limit on the number of recreational fishermen, but it is stable and limited to 1200 boat licences. An efficient regulation could be reducing the fishing pressure by limiting access to recreational fishermen. Prohibiting fishing seems particularly difficult to justify and to implement, although in some regions of France, permits are restricted and available only to the local population (residents in Alsace, North of France).

If the principal objective is to decrease the number of sport fishermen, one can increase the price of fishing licence. Indeed, increasing the cost of a licence is a good way to limit entry. However, this regulation might discourage sport fishermen who don't come very often to the lake, and might have little impact on the "passionate" or "performing" fishermen, and thus have little consequence on resource extraction (20% of sport fishermen harvest 80% of the total production). Moreover, the increase in fishing licence price might be unreasonable, i.e. the licence must not imply problems of equity in limiting access to lower the revenues.

The monitoring or enforcement of fishing rules is inefficient on the lake. Authorities might be able to implement credible threats, such as fines or sanctions that could dissuade clandestine fishermen to sell fishes on the black market, and also illegally to restaurants that buy fish illegally. This fine might have not only a positive effect on fishing pressure but also a restorative effect. For instance the fine would be paid to

increase stocking of young fish; to assure implementation of this regulation, fishing controls are necessary. The Annecy Lake is state property, the resource is threatened, and thus it is important that authorities control fraudulent activities.

There are also implicit regulations, such as replenishment of the stock of young fish. We saw that sport fishing invests 80% in replenishment of char stock, hence why they justify the high harvest of char. A shift in contribution of each type of fishermen is an important parameter in fishery management. For instance, if commercial fishermen were allowed to invest more in stocking young fish plus fair gear, their production will increase, and could satisfy demand. Also, to decrease the pressure and the conflicts on whitefish harvesting, one could invest in stocking this species of fish. However, stocking whitefish is for the moment too costly and not efficient.

This descriptive study gives a glimpse of the origins and consequences of fishing pressure and conflict in Annecy Lake. As for many other cases of recreational and commercial cohabitation, the market is specific (particular context: species and different fishing areas), but conflicts that stem from this are worldwide. We understand that, due to the growing pressure on recreational fishing, regulations should maintain commercial fishing in Annecy Lake (the turnover of restaurants, hostels, fish shops, depend on this fishery). It might be interesting to prove the efficiency of the above regulatory scenarios with the help of an economic theoretical model. The utility function of a recreational fisherman might depend on quality and quantity of fishing like Andersen (1980; 1993). Adding the commercial fishery, we could study the impact and the implementing cost of these regulatory instruments (Sutinen & Johnston 2003, Pereira & Hansen, 2003). More specific to Annecy lake, we could introduce a limited offer (exogenous number of fishermen), and study how to neutralize the black market.

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# Fisheries management in Turkish lagoons

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**Abstract** Turkey, as a country, has great potential for fisheries and aquaculture; with 8333 km of coast line, many rivers with 177 714 km total length, nearly 900 000 ha of natural lakes and 300 000 ha of dam lakes. In 2002 Turkey had 627 847 t total fisheries production, and it shows with its annual production as one of the most important fishing countries in the region. Turkey has 72 lagoons along the 8333 km long coastline. However, in recent years, due to increases in the tourism facilities, unconsciously and uncontrolled utilisation, disposal of industrial and domestic waste to the lagoons and siltation, many lagoons today are not utilisable. The majority of irrigation systems which have been constructed, or are under construction, are in the productive deltas which also possess large lagoons. Besides this lack of environmental awareness, lagoons have remained as discharge places for used and polluted waters. At the end of these studies, various management models are proposed for the Turkish lagoons.

## Introduction

### *General view*

Total fisheries production in Turkey increased from 662103 t in 1992 to 500 260 t in 2002. The main part of Turkish fish production comes from the fishery catches (Table 1). In 2006, catches reached over 533 048 t, strongly dominated by marine catches which contributed in total wild fish supply for around 80.6% of national total fisheries production.

Aquaculture is a relatively young industry in Turkey; it started with rainbow trout culture in the early 1970s and little happened in terms of sea farming until 1985 when gilthead sea bream and sea bass culture started in the Aegean Sea. Today both freshwater and sea farming play an increasingly important role in the production of fishery products. In 2006 its share of total fishery production was around 20 % by volume. The sector can be characterised by limited species and system diversity, small farms, a production oriented approach and in the case of sea farming an export dependent market.

Aquaculture is an important economic activity in the coastal and rural areas of many countries. It offers opportunities to alleviate poverty, creates employment, helps community development, reduces overexploitation of natural aquatic resources, and contributes towards enhancing food security. It is estimated that the aquaculture sector in Turkey provides employment for around 25 000 people.

### *Natural condition*

As a county bordered on three sides by the seas, Turkey provides very rich sources in relation to fisheries potential with its lakes, ponds, dam lakes, rivers and spring waters. With the shores extending 7816 km. and rivers running 177 714 km, its sea and inland water resources have a surface area greater than that of its forests and nearly equal to that of agricultural lands. There exists a total water area of around 26 million hectares which is suitable for fishing and aquaculture (Table 2).

**Table 1.** Total fisheries production in Turkey (2006)

| Production             | Volumes (t) |
|------------------------|-------------|
| Marine catches         | 488,966     |
| Freshwater catches     | 44,082      |
| Total catches          | 533,048     |
| Freshwater aquaculture | 56,694      |
| Marine aquaculture     | 72,249      |
| Total Aquaculture      | 128,943     |
| Total Production       | 662,103     |

**Table 2.** Fisheries resources of Turkey (Source: The Ministry of Agriculture & Rural Affairs)

| Marine Resources                          |        | Length (km) | Surface Area (ha) |
|---|--------|-------------|-------------------|
| Black Sea, Aegean sea and Mediterranean,  |        | 7144        | 23,475,000        |
| Sea of Marmara, Bosphorus and Dardanelles |        | 1189        | 1,132,200         |
| TOTAL                                     |        | 8333        | 24,607,200        |
| Freshwater Resources                      | Number | Length (km) | Surface Area (a)  |
| Natural Lakes                             | 200    | -           | 906,118           |
| Dam Lakes                                 | 159    | -           | 342,377           |
| Ponds                                     | 750    | -           | 15,500            |
| Rivers                                    | 33     | 177,714     | -                 |

### *Lagoons along the Turkish coastlines of Turkey*

Lagoons are a class of estuary linked by the common characteristic of having a single or more restricted connection to the sea. At present, no adequate classification scheme exists which is based on quantifiable characteristics that would enable lagoons to be ordered according to biologically and hydrodynamically relevant data (Miller *et al* 1990).

The importance of wetlands, of which lagoons are fully entitled representatives, is fully acknowledged and needs no re-statement here. Their economic value stems from their direct economic use, indirect use through environmental services, and non-use or preservation value (Barbier 1989). The latter are gaining substantial existence value and a greater heritage value, due to the destruction of the past and present degradation of Mediterranean wetlands (Hollis 1992).

The Turkish lagoons as a whole represent a complex of approximately 36 000 ha with outstanding importance for wildlife, an under-exploited fishing potential and severe threats from pollution, silting and human activities.

The coastline of Turkey is about 8 300 km in length and is traditionally divided into four marine zones; all of them dotted with lagoons.

#### *Black Sea Lagoons*

The Black Sea is a semi-enclosed basin whose inshore waters present estuarine characteristics, significant pollution loads and high hydrodynamic state. Along its southern border, salinity ranges between 16 and 18 ppt, rarely exceeding 21 ppt. Surface water temperatures show a winter minimum of around 7°C and a maximum of around 25°C in summer. Surface waters are very dynamic, with main currents flowing from west to east.

The Turkish coast does not have large lagoons, the only exception being the lagoon system at the outlet of the Kızılırmak River, and the only delta area along the southern border of the Black Sea.

There are 14 lagoons in the Black Sea coast. Their overall surface area is 3 130 ha with a yearly fish production of about 131 t, which is almost completely produced by the lagoon complex of Bafra, where unit production is about 56 kg/ha<sup>-1</sup>.

#### *Lagoons of the Sea of Marmara*

The Sea of Marmara is a small-enclosed basin linking the Black Sea to the Aegean Sea. Salinity is less than 30 ppt due to the Black Sea waters flowing from east to west. During the summer, pure seawater enters through the Dardanelles Strait. Surface temperatures range from approximately 6°C in winter to around 24°C in summer. There are 12 lagoons along the Sea of Marmara and their overall surface area is 2 650 ha.

#### *Lagoons of the Aegean Sea*

The Aegean coast stretches from the border with Greece southward to the Dalaman Peninsula, which is conventionally used to delineate the border with the Mediterranean Sea. It is an oligotrophic full strength saline sea with a complex coastline profile dotted with many islands that create complex current patterns. Salinity is typically around 38 ppt.

Due to their limited number, major rivers that flow into the Aegean have only local effects in reducing salinity in the estuarine areas. On average surface temperatures are higher than in the Black and Marmara Seas and increase from north to south, from around 11°C in winter to around 24°C in summer. Pollution and high nutrient levels occur in a limited number of places, the industrial zones of Izmir and Dalaman in particular.

The Aegean coastline is the richest in terms of lagoon number, area and fish production. There are 28 lagoons along the Aegean coastline and their total surface area is about 20

000 ha with yearly catches of about 562 t. Two lagoons – Bafa and Köyceğiz – account for 60% of the total area.

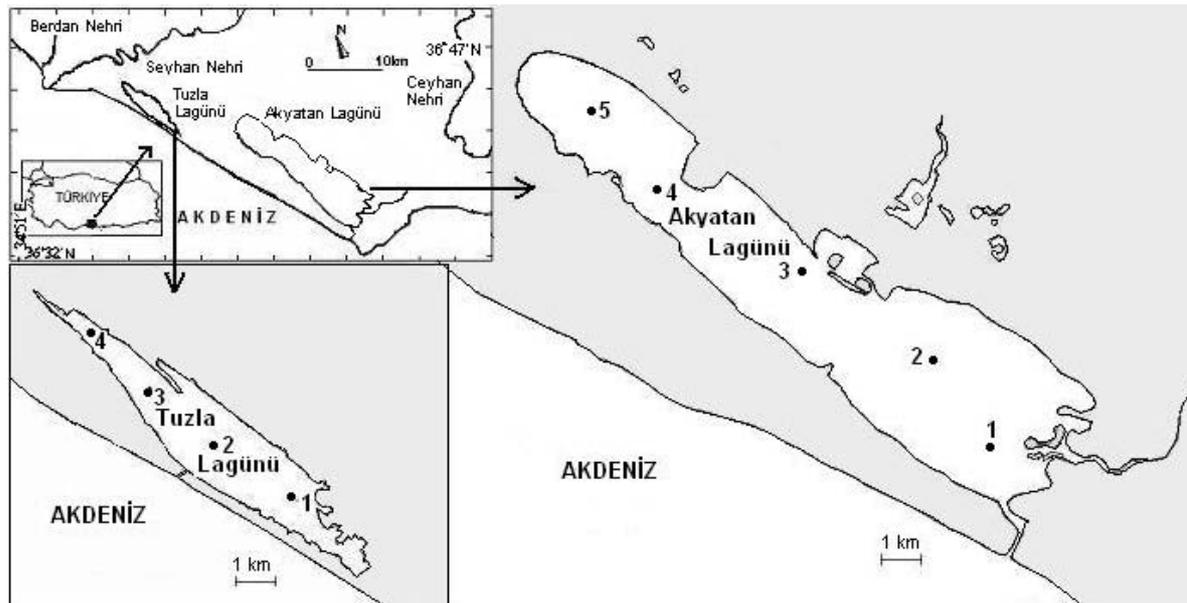
### *Mediterranean Sea*

The Mediterranean Sea along the Turkish coasts presents a fairly stable salinity of 39 ppt and the highest surface temperatures found in the whole Mediterranean Basin. Summer temperature is around 28°C, whereas in winter it is around 18°C. There is a small increase in the temperature averages along the coast from west to east.

Like the Aegean, it is a true oligotrophic sea with the lowest productivity among the Turkish marine areas. Industrial pollution shows a peak in the Iskenderun Bay, İçel and, to a lesser extent, Antalya, due to the discharges of their industrialised area. Other sewage inflows also come from the major tourist centres and the proliferation of large holiday housing settlements.

The lagoons along Turkey’s Mediterranean coast are mainly found in the delta areas of the only two major fluvial systems of this coast: the Meriç River, near Silifke, and the Seyhan and Ceyhan Rivers in the Cilician Plain (Çukurova).

Going from north to south, there are 17 lagoons making up a total area of 11 600 ha and an overall production of 183 t in 1995.



**Figure 1.** Akyatan and Tuzla Lagoons in Mediterranean coastline.

### *Protected lagoons of Turkey*

#### NATIONAL PARKS

NP.1 Dilek Peninsula and Menderes Delta National Park (Dilek Yarımadası Menderes Deltası Milli Parkı ). Park since 1966, in 1993 it includes the Menderes Delta area. Main lagoons: Karina Gölü (= Dil Gölü) , Mavi Gölü, Kara Göl.

NP.2 Gelibolu Peninsula National Park (Gelibolu Yarımadası Tarihi Milli Parkı). One lagoon: Anafarta Gölü.

NP.3 - Bafa Gölü; declared on 8 July 1994.

#### SPECIALLY PROTECTED AREAS

SPA.1 - Göksu Deltası. It includes the lagoons of Akgöl and Paradeniz; total area 4 350 ha; declared on 2<sup>nd</sup> March 1990; incorporated in the list of Ramsar Treaty on 17 May 1994.

SPA.2 - Köyceğiz Gölü ve Dalyanı.

SPA.3 - Patara. It includes the lagoon of Gelemiş Gölü; total area 19 000 ha; declared on 18<sup>th</sup> January 1990.

#### NATURE CONSERVATION AREAS

NCA.1 Yumurtalık Gölü: declared on 8 July 1994; total protected area: 16 430 ha.

NCA.2 Sarıkum Gölü: declared 30 July 1987; total protected area: 785 ha.

#### WILDLIFE CONSERVATION AREAS

WCA.1 Kızılırmak Deltası (Samsun): declared Site for the Preservation and Reproduction of Waterfowl on 1979; it includes Cernek Gölü; protected area: 13 125 ha.

WCA.2 Simenlik Gölü (Terme): Declared Site for the Preservation and Reproduction of Waterfowl on 1975; protected area: 16 043 ha.

WCA.3 Homa Dalyanı (Izmir): declared Site for the Preservation and Reproduction of Waterfowl on 1980; it comprises Homa Lagoon and Çamaltı Salt Marshes (Çamaltı Tuzlası); protected area: 8 000 ha.

WCA.4 Akyatan Gölü (Adana): declared Site for the Preservation and Reproduction of Waterfowl on 1987; protected area: 7 500 ha.

WCA.5 Gökçeada (Çanakkale): declared on 1988; protected area: 28 204 ha.

WCA.6 Seyhan Nehri ve Tuz Gölü (Adana): declared Site for the Preservation and Reproduction of Waterfowl on 28 December 1995; protected area: 5 796 ha.

#### SITE AREAS OF THE REGIONAL COUNCILS FOR THE PROTECTION AND CONTROL OF NATURAL AND CULTURAL HERITAGE (SA):

SA.1 Samsun, Merkez : Kızılırmak Deltası, I. Derece Doğal Sit Alanı: decision No.1908/21 April 1994.

SA.2 Sinop, Merkez : Sarıkum Gölü, I. Derece Doğal Sit Alanı : decision No. 1198/21 November 1991.

SA.3 Kırklareli, Demirköy : İgneada, Mert, Erikli, Hamam Gölü : decision No.944 / 11 July 1991 and 1683/24 November 1994.

SA.4 Edirne, Enez: Dalyan, Işık Taşaltı Gölleri, decision No.2232/17 March 1995.

SA.5 Edirne, Enez: Karagöl ve Bataklığı, decision No.1908/7 February 1992.

SA.6 Edirne, Keşan: Tuzla Gölü (Gala), decision No.1733/10 February 1994.

SA.7 İstanbul, Küçükçekmece: Soğuksu Çiftliği, İç & Dış Kumsal, decision No.9509/13 November 1976 (GEEAYK).

SA.8 Sakarya, Adapazarı: Poyrazlar Gölü Doğal Sit Alanı, decision No.2916/16 January 1993.

SA.9 Çanakkale, Biga: Güvenalanı Hoyrat Gölü, decision No.2211/13 January 1995.

SA.10 Çanakkale, Çardak: Doğal Sit, decision No.2441/27 May 1995.

SA.11 Çanakkale, Gökçeada: Adanın Tamamı Sit Alanı, decision No.2813/16 November 1992 and 2135/11 November 1994.

SA.12 İzmir, Dikli: Çandarlı, Dalyan Gölü, Bakıçay, decision No.4274/10 March 1993.

SA.13 Muğla, Köyceğiz: Kaunos Antik Kenti Dalyan, decisions No.3722/27 March 1990; 2342/15 November 1994.

SA.14 Antalya, Kaş: Patara Antik Kenti, Gelemiş Köyü, decision No.719/20 June 1987; 1273/14 April 1990 and 4933/17 June 1995.

SA.15 Adana, Yumurtalık: Yumurtalık Lagünü, decision No.1609/19 November 1993.

## **Management of Turkish lagoons**

### *Classification criteria*

The main activity in Turkish lagoons is traditional fishing, which is carried out in 43 lagoons, representing 64% of the total surface. Different types of nature and wildlife protection have been declared for an outstanding 83% of the lagoon surface, amounting to 23 water bodies. However, the ban on this activity in protected areas is not fully enforced.

### *Current fishery management of the Turkish lagoons*

The same model of traditional fishery management is currently adopted by almost all Turkish lagoons where this activity is still in use. The only notable exception is the lagoons of the Kizilirmak Delta, where the need to keep their freshwater characteristics does not allow the adoption of a permanent pass and the use of a fixed fishing trap.

Lagoon fisheries are usually managed as follows: From June to January, the fishermen trap the fish inside the lagoon by closing the fishing barrier; a fixed trap usually made of a paling framework and marsh reed and fences placed at the lagoon mouths to the sea. The fishermen do this when they believe that enough fish have entered the lagoon, then catching the fish trapped in commences immediately after the closure of the barrier.

Beside the fishing barrier, different kinds of stationary or moving nets may also be employed to make catching quicker and more complete. Inside the lagoon, fishermen mainly use stationary gear such as trammel nets, long lines and fyke nets.

From an ecological point of view, the lagoon fish stock is an exclusive function of the following factors; natural recruitment and the lagoon's natural capacity to entrain and retain the colonizing stages that immigrate. To summarize, this management scheme exploits the lagoon as a simple fishing trap, representing merely a basic level of lagoon exploitation for fishing purposes. By definition and for the considerations given below, this practice involves several constraints to the optimal use of the lagoon environment and its fish resources.

The traditional structure has several limits hampering its present functionality. As it stands, it will not be able to meet any increased fish production resulting from possible improvement measures:

- the structure as a whole is poorly selective, allowing the capture of undersized fish;
- its maintenance costs are high in terms of workforce and materials, which should be replaced every year;
- the total fish holding capacity of the standard fishing chamber is less than 10 m<sup>2</sup> since the largest part of it is taken up by a deep V-shaped slide entrance for fish, which frequently forces the fishermen to fish in overcrowded conditions, causing damage to the fish and reducing implicitly its market value;
- the reed fences are not a suitable barrier against the blue crabs, which enter the capture chamber and eat the fish trapped inside, which cannot escape attack;
- its home-made construction does not make the "kuzuluk" a suitable tool for catching eels due to their ability to escape loose barriers;
- walls of the catching chambers are made of reed fences and rusted iron grids with rough surfaces which may damage fish skin after prolonged stocking, thereby reducing their commercial value.

Moreover current regulations on the use of the fishing installation does not really prompt a strict control of fish flows into and out of the lagoon, for the following main reasons:

- when the barrier is open, juveniles can enter the lagoon and adult fish can return to the sea;
- there are no special side entrances to allow fingerlings to move towards the lagoon;
- there are no enclosures for the temporary stocking of undersized fish that become trapped in the fishing installation which are not suitable for the market.

#### *Need of rehabilitation*

The lagoons are usually shaped by the interactions between sedimentation processes of both marine and fluvial origin and hydrological factors such as wind driven currents inside and along-shore currents outside the water body, which contribute to them being characterized as highly dynamic environments. Left undisturbed, these processes

generally lead to the lagoon's gradual disappearance by silting up, followed by the creation of new lagoons as a result of the new sedimentary and dynamic patterns. This natural evolution of the lagoon environment could be greatly affected by man-made activities, which play a key role either in providing stability or in accelerating their extinction.

At present the destruction of a lagoon is generally acknowledged, but lagoons are nevertheless subject to a string of threats that makes them prone to ecological disasters and to an uncertain future.

The Turkish lagoons visited during the surveys have been classified according to the major risks their ecology faces and categorised according to their apparent need of rehabilitation. The selected parameters are:

- absence of freshwater: no permanent inflow apart from rain and run-off;
- absence of sea water: pass usually silted up or absent;
- shallowness: a water depth of less than half meter;
- submerged vegetation: a dense mattress of aquatic plants in the whole water column spread across more than 50% of the total area;
- sedimentation: an active process, whether from the freshwater inflows, floods or sea movements;
- pollution: risk of contamination by agrochemical, industrial waste waters and domestic sewage;
- new settlements: the area is affected by a considerable building activity;
- floods: risk of flood during the rainy season from nearby river or drainage network.

Most of the lagoons along the Turkish coastline would benefit from some rehabilitation intervention. For a large number of lagoons the pace of their environmental degradation and the importance of preserving the existing activities, as well as their rich wildlife, suggest that rehabilitation measures are not only necessary, but indeed pressing.

#### *Need to enhance the fishing production*

With few exceptions, all lagoons show a downward trend in their landings. If we add to this the once productive but now abandoned lagoons, the overall situation of lagoon fishing appears dire: the average unit production is less than 25 kg ha<sup>-1</sup>. Without including Köycegiz Lagoon, which alone accounts for about 40% of the total lagoon catches, this figure falls to only 17.5 kg ha<sup>-1</sup>.

Even if we allow for the likelihood that the producers' declared landings are below the actual figures, overall production is far lower than the average potential of the Mediterranean lagoons, which is estimated to be at about 57 kg ha<sup>-1</sup>. This gap becomes even greater when compared with the average production of lagoons managed according to the advanced criteria of valliculture, well above 100 kg ha<sup>-1</sup>, not to mention the much higher output of integrated valliculture, where intensive fish farming is introduced.

### *Management models for lagoons*

The application of the management models outlined below does not include the creation of the rehabilitation works recommended to restore or protect the lagoon environment. Their implementation is largely independent of the vocational exploitation of the lagoon and is based mainly on considerations concerning its existence, both present and future.

The management models for the Turkish lagoons are as follows:

- environmental conservation,
- environmental conservation plus traditional fishery,
- traditional fishing,
- adapted valliculture (extensive and semi-intensive lagoon *farming*),
- adapted integrated valliculture (extensive, semi-intensive and intensive aquaculture),
- recreation,
- research,
- education,
- research and education.

The lagoons of Turkey have been arranged according their potential suitability to the above mentioned models.

#### *Environmental Conservation*

This model applies to lagoons where the protection of their rich wild fauna is a priority and local inhabitants do not claim the need to exploit the environment for fishing or other uses. The water body is therefore managed as a wildlife preserve where the only human activities allowed should be surveillance, scientific research and education. The opportunity of giving space to ecological tourism along watched nature trails should be encouraged, provided that wildlife is not disturbed, particularly during the breeding seasons.

#### *Environmental conservation and traditional fishery*

This model applies to those lagoons where the protection of their rich wild fauna remains a priority, while at the same time there is a well established local fishing activity that causes negligible disturbance to wildlife. Water management should give priority to the preservation of favourable habitats for migrating and nesting birds, as well as the associated fauna and flora. Control of water level and quality of freshwater inflow require the greatest attention to prevent alterations that would hamper the particular characteristics of these environments.

The traditional fishing activities practiced in these lagoon systems should be maintained and upgraded by means of low impact technologies, such as increased stocking of target fish and more selective fishing equipment. Rehabilitation interventions, if necessary, should be aimed at creating or preserving favourable environmental conditions for both the target fishing species and the natural components.

The lagoons that may enter this category of management model are many water bodies to which some protection status is already granted.

#### Traditional fishery

Where wildlife and other natural characteristics are not prioritized and where more sophisticated fishing management forms cannot be applied for economic reasons, traditional fishing becomes the eligible choice.

Generally speaking, the creation or maintenance of a lagoon environmentally favourable to fish also helps the conservation of its wildlife; in some well known cases even to excess, for instance the numbers of fish-eating birds increase with the increase in the fish population. Average production figures remain in the lower limit of the production range for lagoon environments.

The present practice could be upgraded by improving the fixed capture devices and the fish juveniles stocking management. More selective fishing practices that prevent the killing of under-size fish should be adopted. The model is a sort of simplified valliculture, mainly because a proper water management system, one of the most typical features of valliculture, cannot be implemented. The greater the control over the environment, the better the final output. Specific training is also recommended for the local fishermen.

#### *Adapted valliculture*

The most advanced management of Mediterranean lagoons takes its name from the Italian word "valli", which means embanked portions of a usually brackish-water lagoon. This technology actually developed in the coastal wetlands along the northern Adriatic coasts in the last half century. Average yearly production is between 100 and 150 kg ha<sup>-1</sup>.

Since the valliculture model foresees a closer control on fish and the environment than in the case of the traditional lagoon fishing, its application requires the fulfilment of more specifications that can be summarized as follows:

- the introduction of systems for a complete management of water supply and circulation by means of sluice gates; as a consequence the modification of certain water quality parameters;
- the close control of fish migratory movements by means of hydraulic control and the operation of the fishing installation;
- the selective fishing of sizes and species by means of the fishing installation;
- the stocking of live fish to overcome dangerous climatic conditions;
- the temporary stocking of seed fish of selected species under controlled environmental conditions;
- the introduction of live organisms as an integration to the natural diet of selected species.

The main diverging points from the "original" model, under the prevailing conditions in Turkish lagoons, are:

- the control of sea water by means of sluice gates;

- the control of fresh water by means of sluice gates, due the conflict involved with agriculture and justifying the importance of fisheries;
- the optimization of the lagoon water circulation by means of an internal network of ditches, since they are hardly economically justified.

The adoption of this tailored valliculture model requires first of all the modification of the applicable fishing legislation.

#### *Integrated aquaculture*

The rising running costs together with the decline of production have forced the extensive aquaculturists to look for alternative solutions aimed at increasing their landings. The actions undertaken to complement the extensive aquaculture (valliculture) production can be summarized as follows:

- give priority to the farming of valuable species: mainly bass for climatic reasons, but also bream and eels, according the practice of intensive farming in either concrete tanks or earth ponds placed in separate sectors;
- introduce only the hatchery-reared seed fish of selected species;
- enhance the lagoon's natural productivity by discharging the effluent of the intensive sector into the water body;
- introduce fingerlings and yearlings of bream to avoid the risk of their wintering since they reach a marketable size already at the end of the first rearing season;
- culture of new species, in particular extensive and semi-intensive shrimp farming in earth ponds, intensive fattening of salmon and sea trout; the latter two take place only during the cold season and use the facilities of the intensive sector that are not used at that time for bass and bream (which are wintering in dedicated facilities);
- work the pond bottom by means of appropriate machinery to aerate and oxidize it and to release the nutrients trapped in the sediments;
- improve the wintering facilities so that even the extreme climatic conditions that may take place - however rarely - can be faced (introduction of artificial heating devices);
- semi-intensive ponds for a polyculture of selected species, usually bream and mullet.

These innovative practices could raise the production by well over 200 kg ha<sup>-1</sup>, depending on the size of the intensive sector and that of the semi-intensive ponds.

#### **Discussion**

Various actions are available for increasing fish output in lagoons at a sustainable level. They should take place under conditional circumstances, highlighted by a careful integrated management plan and after an impartial environmental impact application and cost-benefit analysis.

### *Applicable models for fish production enhancement*

The enhancement of traditional fishing and the introduction of sustainable aquaculture practices is one of the most powerful means for preserving the lagoon environment from major damage while making a renewable use of the available resources.

### *Environmental conservation and traditional fishing*

It entails issues common to each model suggested, since it is widely accepted that the creation or maintenance of a lagoon environment favourable to fish also helps the conservation of its habitat and wildlife.

In applying this model priority should be given to those interventions aimed at the protection of the wildlife and the peculiar features of the ecosystem.

Fishermen should be trained on the naturalistic importance of the lagoon environment and local authorities should encourage their participation in all initiatives concerning lagoon wildlife management, including sharing the benefits of possible ecotourism activities.

Where possibilities exist for upgrading the traditional fishing activity, these should be enacted using low-impact technologies. The fishing installations should be modernised once their economic feasibility is assured. Actions to introduce forms of extensive and semi-intensive aquaculture should be applied to the recovery and preservation of the biological diversity. This model is applied to the lagoons of the Goksu River Delta.

On the other hand, where special environmental conditions severely limit changes, consideration should be made of substantially maintaining the traditional fishing practice. Main interventions should be focused on the preservation of the water quality and water balance of the wet area. Only limited measures to sustain the fishing activity should be implemented and, once its feasibility is ascertained, the controlled introduction of hatchery-reared selected species might be allowed. This model is applied to the lagoons of the Kizirilmak River Delta.

### *Integrated aquaculture*

Once it is duly tailored to the specific conditions of some Turkish lagoons, the integrated aquaculture model should be applied as a suitable means to reshape the aquaculture enterprises managing the lagoons.

The enterprise production is then enhanced through the combination of different forms of intensive and semi-intensive farming. The extensive lagoon culture is then to be enhanced by a careful combined management of the intensive aquaculture outputs: quality seed fish, energy content of the effluents, modern infrastructure and marketing schemes. Under these circumstances, the technical and economic feasibility of a highly efficient fishing installation and an improved water exchange are justified by the high rentability of the model. This model is applied to Akyatan Lagoon.

### *Adapted valliculture*

Where the size and richness of the lagoon, the attitude of fishermen toward aquaculture practices and the climatic conditions permit, introduction of modified Italian valliculture schemes are recommended. Provided it is economically feasible, a careful fresh water regulation should be achieved that will allow water quality in the lagoons to be governed.

Modern fishing installations and infrastructures should be implemented. A diversified exploitation of available water bodies and a sound dosing of quantitative proportions among species should be assured by a careful control over natural migratory movements of fish, *in situ* hatchery production of seed fish, and temporary stocking of valuable undersized stocks under controlled conditions. This model is applied to the lagoons of the Meric River Delta.

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# The state of inland fishing in Lithuania

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**Abstract** Over the last 11 years, commercial fishing enterprises caught on average between 1500 and 1700 <sup>t</sup> of fish in inland waters of Lithuania. The main share (75 %) of commercial fish catches was landed from the Curonian Lagoon. Catches in the Kaunas Lagoon, rivers, and lakes amounted 7 – 8 %, 10 – 11 %, and 5 – 6 % of the total fish catches, respectively. Amateur fishermen catch approximately 1350–1500 <sup>t</sup> of fish per year. The current situation in inland fisheries shows that there are a number of urgent issues which need attention: the social importance for local communities of the, relatively small, commercial catches in inland water bodies (1); the need for improvements in the rationale for the allocations for the restoration of fish resources (fish restocking) (2); the need for more scientific investigations into fisheries (3); statistical data on fish catches in inland waters do not reflect the real situation and so there is a need for improved methods of collecting information on fish stock exploitation (4); the conflict between amateur and professional fishers persists (5); fish stock protection and control is insufficient (6); poaching has not yet been eradicated (7); the development of commercial and amateur fishery and fishing tourism is not suitably coordinated (8). Taking into consideration the problems posed, the structure of inland fishery in Lithuania is to be reconsidered in the nearest future.

## Introduction

Both commercial and recreational fisheries are conducted in inland waters of Lithuania, as in those of other European countries. The significance of commercial fishery in inland waters has been declining recently, due to many factors, while the recreational fishery has been rapidly expanding. Four main branches of the commercial fishery have been traditionally undertaken in Lithuania, according to the fishing type and structure of inland water bodies, i.e. river, lake, water reservoir and the Curonian Lagoon fisheries. At present, commercial fishing is carried out only in the lower reaches of the Nemunas River where mainly (about 90 %) smelt *Osmerus eperlanus* (L.) is landed and eels *Anguilla anguilla* (L.) are caught in the estuary. Commercial fishing is banned in other rivers of the republic. The majority of lakes where commercial fishing is conducted are small and the consequent small fish catches there are more suitable for amateur fishing practices. It is therefore possible to forecast that commercial fishing is likely to persist only in large lakes in the near future, in line with long-established traditions of the commercial fishery. The Curonian and Kaunas Lagoons have the largest commercial fish catches. Fish resources in these water bodies are and will be exploited intensively and sustainably.

In 2004, catches by Lithuanian commercial fishing enterprises in various water bodies amounted to 160 665 <sup>t</sup>, with catches in inland waters constituting a comparatively small share of 1595 <sup>t</sup> (i.e. about 1 % of the total catch in Lithuania).

The Ministry of the Environment performs regulatory functions as well as those of policy implementation on the restoration (restocking), preservation and monitoring of fish resources in inland waters. Functions performed by the Ministry of Agriculture include: implementation of the general European Union and Lithuanian fishery policies; regulation and policy implementation on the restoration (restocking), preservation and monitoring of fish resources in marine waters; research into pisciculture and fisheries; development of aquaculture. Fishing in Lithuania is regulated by the fishery law and rules for commercial and amateur fishing.

### **Professional fishery in Lithuanian inland waters**

Statistical data on commercial fishery in inland waters are presented in Table 1. Over the last 11 years commercial fishing enterprises caught from 1500 to 1700 tones of fish in inland waters on average. The main share (75 %) of commercial fish catches was landed from the Curonian Lagoon, catches, which almost doubled over a decade. The fishery in the Lagoon is intensive, but fish stock exploitation is sustainable. The Curonian Lagoon is a eutrophic water body of high biological productivity, predominantly inhabited by populations of bream- zander- smelt (Gerulaitis *et al.* 1994). That is one of the basins of the Baltic Sea which has the most abundant fish resources. There commercial catches had amounted to 60 – 80 kg/hectare for many years (Maniukas 1959). According to official statistics, in 1992 – 1996, after the restoration of Lithuania's independence, a significant decline was recorded in commercial catches which could be explained by the reorganization of fishery economics and for political reasons (Lithuanian fishermen could no longer fish in the central part of the Lagoon belonging to Russia). Yet, even then fish catches in the Lagoon were larger than in all inland water bodies. Since 1996, with improvements in the recording of fish catches, fish hauls have been increasing and have exceeded 1000 tones.

Thirty three species were recorded in commercial catches, which, as in previous years, were dominated by roach and bream. In 2000 – 2005 roach constituted 36 % and bream 28 % of commercial catches. Landing of smelt was also quite abundant in recent years; they made up 13.5 % of total catches. Zander (6.8 %), perch (3.4 %) and ruffe (2.7 %) were also common in catches. The share of vimba in catches increased significantly and amounted to 3.5 %. Due to decreased water contamination, landings of vimba, twaite-shad, sea-trout and salmon as well as those of predatory fish have been increasing. Catches in the water area belonging to the Kaliningrad region were larger and varied from 2000 to 2400 <sup>t</sup>. In summary, the abundance of the majority of the main commercial fish populations has not changed significantly over the last years, although, fishing intensity, as measured by commercial catches, has increased (Repečka 2006).

Catches in the Kaunas Lagoon varied from 61 to 230 <sup>t</sup> per year, constituting 7 – 8 % of the total amount of fish caught in inland waters on average. The majority of fish species in the Kaunas Lagoon have been very intensively exploited recently. To reduce fishing intensity in the Kaunas Lagoon, it was recommended to ban commercial fishing at weekends and holidays. The number of bream fishing nets has been decreased, bream catch quotas are being reduced, and the minimum mesh-size of fishing nets has been consistently increased. In 2005 the quota for the total catch (160 <sup>t</sup>) in the Kaunas Lagoon was introduced. We expect these measures to reduce the impact of commercial fishing on fish resources in the Kaunas Lagoon and to help preserve stocks of these fish.

Until 1970 fishing was conducted in the large rivers of Lithuania – the Nemunas, Neris, Šventoji, Baltijos Šventoji, Nevėžis and Minija. Commercial catches amounted to 430 – 450 t per year (Bružinskienė & Virbickas 1988). In larger rivers, salmon, sea-trout, asp, bream, roach, smelt and other valuable fish species were caught using various fishing methods. However, commercial catches continued to decrease due to water contamination, dam construction and decrease in fish resources. Lately, river fishing has been restricted to the lower reaches of the Nemunas River and to catching eels migrating from lakes to rivers. On average, 10 – 11% of the total fish catch in inland waters are landed from rivers. The dynamics of fish catches in rivers has remained stable over a number of years, with 163 – 199 tones of fish being caught on average. The year 2004, was an exception with a catch of only 94 t. Smelt from the lower reaches of the Nemunas River made up over 90 % of hauls in rivers. Eels migrating from lakes constituted only a small part.

Fish caught in lakes make up 5 – 6 % of the total amount of fish caught in inland waters. In general, due to the imperfections in the reorganization of fishery structure, co-operation, stock exploitation and stocktaking systems, catches in lakes have decreased drastically. On average, over the last 10 years fish catches dropped from 113 to 34 tones (Table 1).

**Table 1.** Fish catches (t) by Lithuanian commercial enterprises

| Year       | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|------------|------|------|------|------|------|------|------|------|------|------|------|
| Curonian   |      |      |      |      |      |      |      |      |      |      |      |
| Lagoon     | 652  | 784  | 1053 | 1167 | 1095 | 1258 | 1096 | 1313 | 1292 | 1237 | 1168 |
| Kaunas     |      |      |      |      |      |      |      |      |      |      |      |
| Lagoon     | 61   | 81   | 103  | 104  | 148  | 112  | 106  | 142  | 139  | 230  | 150  |
| Rivers and |      |      |      |      |      |      |      |      |      |      |      |
| polders    | 93   | 84   | 175  | 178  | 168  | 175  | 178  | 199  | 163  | 94   | 190  |
| Lakes and  |      |      |      |      |      |      |      |      |      |      |      |
| water      |      |      |      |      |      |      |      |      |      |      |      |
| reservoirs | 113  | 126  | 100  | 83   | 85   | 59   | 69   | 58   | 64   | 34   | 39   |
| Total      | 919  | 1073 | 1431 | 1532 | 1497 | 1605 | 1449 | 1711 | 1657 | 1595 | 1547 |

In total, almost 3 thousand people catch fish in Lithuanian waters using commercial fishing gears. However, the income earned from this business is often insufficient to meet the basic needs of family members and to guarantee social security. This situation is caused by the fact that the majority of commercial fishing enterprises are small-scale, with low investment capacity and competitiveness. Under current commercial exploitation conditions, it is difficult to make a profit in an average Lithuanian lake. The situation in the coastal zone of the Curonian Lagoon and the Baltic Sea is similar. The value of the total annual production in inland waters reaches only about €1.0 million, with the annual value of fish produced by a single fisherman annually being less than €570. These figures clearly show that the current orientation of inland water fisheries towards small-scale commercial fishing is unsustainable.

## **Recreational fishery**

Recreational fishing is allowed on most water bodies in Lithuania. Recreational fishing is regulated by rules of amateur fishing which specify permissible fishing tackle and methods. These include the use of spinners, rods, fishing nets and creels as well as underwater fishing tackle. Fishing of some rarer and protected species in rivers is carried out under license. This includes fishing for salmon in restored salmonid rivers, as well as fishing for sea-trout, vimba, lamprey and smelt in extremely productive rivers or river spots in which there are abundant resources. Owners of water bodies are entitled to organize licensed fishing in water bodies under their ownership. Licensed fishing is also carried out in some protected territories where shoals of fish accumulate and where ordinary fishing is prohibited or restricted. License-holders must observe rules of licensed fishing.

The large number of anglers has a great impact on Lithuanian fish resources. Unfortunately, stocktaking of catches by amateur fishermen has always been very approximate. For instance, in 1989 a member of the Lithuanian Society of Hunters and Fishermen caught 10.5 kg of fish per year on average. The number of such members in that year amounted to 95 thousand. Hence, their total haul must have been 997.5 tones. According to the data of the investigation carried out by V. Žiliukienė in 1994 (personal report), in lakes, an angler used to catch 1.68 kg of fish on average per day. Recent studies have proved that the daily fish catch has not changed much and varies from 1 to 2 kg on average. As angling intensity has been increasing recently, the total amount of fish caught is now very large. According to the data provided by scientists, amateur fishermen catch approximately from 1350 to 1500 <sup>t</sup> of fish per year. The number of people going fishing actively (i.e. spending money on this form of recreation) in Lithuania is about 0.3 million. Anglers of the country spend €20.5 million per year on fishing. The amount of money circulating in the recreational fishery is much larger than the total sum of money circulating both in the commercial fishery and aquaculture. It is possible to forecast that when the living standard in Lithuania reaches that of Western Europe, the yearly service market in Lithuanian recreational fishery will be estimated at €200 million EURO.

## **Scientific research and monitoring**

As a result of the intensified exploitation of fish resources, scientific research and monitoring has become extremely important. Scientific investigations and monitoring are carried out in most water bodies, especially in those where intensive commercial fishing is conducted. However, as we have noted, these investigations have not always been coordinated among various institutions. All investigations can be classified according to their scope and objectives into monitoring studies and purposive scientific investigations. Monitoring studies are long-term, complex and are conducted following coordinated and agreed methods. Purposive scientific investigations are performed when it is necessary to investigate water bodies or fish populations, when unforeseen problems of one or another kind arise, when it is necessary to answer questions promptly and then make proper decisions. In Lithuania investigations and monitoring of the state of commercial fish populations and resource exploitation are conducted continuously.

## Conclusion

In the very near future, commercial fishing will persist only in main water bodies – large lakes, the Curonian and Kaunas Lagoons and the lower reaches of the Nemunas River. 92 % of the lakes in Lithuania have areas of less than 50 hectares and so this has a potentially very large impact. Amateur fishing will get priority in most water bodies. .

To summarize, the current situation in inland fishery proves that there are a number of urgent problems that need solving in the future:

1. Commercial catches in inland water bodies (with the exception of the Curonian and Kaunas Lagoons) are not large, but are socially important for the local inhabitants.
2. There is insufficient rationale for allocations for the restoration of fish resources (fish restocking).
3. There is insufficient scientific research into fisheries.
4. Statistical data on fish catches in inland waters do not reflect the real situation and the system of collecting information on fish stock exploitation is imperfect.
5. The conflict between amateur and professional fishers persists.
6. Fish stock protection and control is insufficient and poaching has not yet been eradicated.
7. The development of commercial and amateur fishery and fishing tourism is not suitably coordinated.

Taking into consideration the problems posed above, the regulation of Lake Fisheries is to be reconsidered in the near future. It is proposed that commercial fishing should not be conducted in small lakes (with an area of less than 50 hectares). According to the project, only specialized commercial fishing, i.e. fishing of those species that are not caught by amateur fishermen (smelt, vendace, bleak, ruffe, etc.) is to be carried out in lakes with areas of between 50 and 200 hectares. Commercial fishing could be carried out in lakes larger than 200 hectares, with the fishing intensity dependent on the lake type, stock size and allocated fishing quotas. No fishing using commercial fishing gears will be conducted in rivers, with the exception of the lower reaches of the Nemunas River and fishing of eels migrating from lakes.

In conclusion, it is forecasted that, during the 2007 – 2010 period, catches landed in inland waters using commercial fishing tackle will amount to 1830 – 1870 <sup>t</sup>, 1350 <sup>t</sup> of which will be caught in the Curonian Lagoon, 160 <sup>t</sup> in the Kaunas Lagoon, 200 <sup>t</sup> in rivers and polders and 120 – 150 <sup>t</sup> in lakes (Kesminas 2005). Catches are to grow only in lakes, with other water bodies being sustainably exploited.

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# Recovery programmes for endangered freshwater fish in Flanders, Belgium

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**Abstract** In Flanders, several fish species are endangered due to water pollution and habitat deterioration. However, water quality is improving and efforts are being made to restore habitat quality, allowing natural recovery of several fish species. For other species, an integrated approach for protection and recovery of their populations is required. Fish stocks are built up with respect to genetic origin. Mathematical models were developed and used to evaluate habitat suitability. Reintroduction is considered when both water quality and habitat are suitable. Appropriate measures in relation to habitat demands of fish are being taken with relevant partners involved in integrated water management; stopping biodiversity loss and the EU Habitats Directive are the policy frame for these measures. The angling sector also finances scientific research as part of the fish permits proceeds.

## Introduction

In Flanders, of 40 freshwater fish species, about 15 species are considered to be endangered and another 5 species are considered to be extinct (Red list of Fish Species in Flanders 1998, Research Institute for Nature and Forest, <http://www.inbo.be>). Possible reasons for this decline are poor water quality and habitat deterioration. Water quality has been negatively influenced by domestic and industrial wastewater and run-off water from agriculture and traffic for several decades. In the 1980s, water quality was so poor that several rivers contained few or no biological life. However, since the 1990s serious efforts have been made in wastewater treatment and the impact of domestic wastewater on the quality of Flemish surface waters has gradually decreased since. By the end of 2006, domestic wastewater treatment covered about 66% of all households (Van Steertegem 2007).

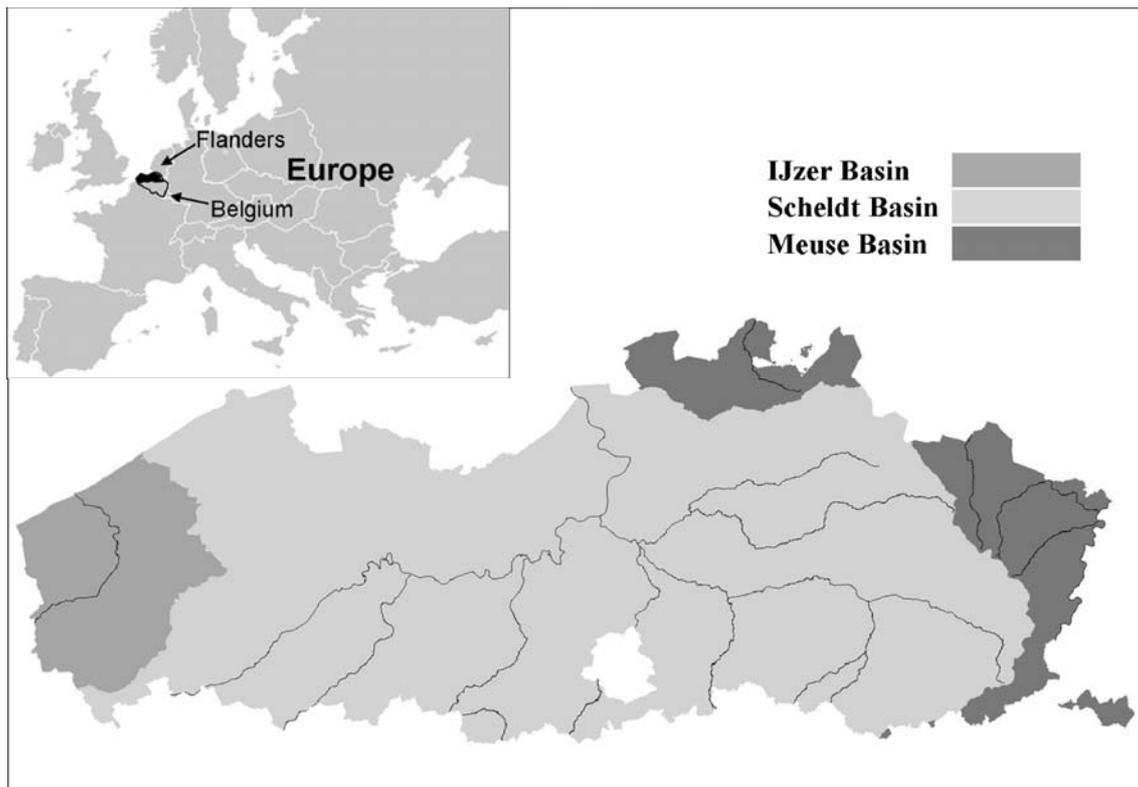
Since the early 1960s Flemish watercourses have been straightened into channels and fragmented by weirs and dams strongly reducing the overall habitat quality and obstructing fish migration. Since the 1990s an increasing number of river restoration projects have been carried out. Additionally, in several watercourses habitat structure has improved naturally. Furthermore an inventory of fish migration barriers of principal waterways has been made by the Flemish Environment Agency ([www.vismigratie.be](http://www.vismigratie.be)), and a programme for solving these migration barriers has been developed. According to this programme 14% of all migration barriers have been solved by 2006 and numerous projects to enhance fish migration are planned and will be carried out in the future.

Since water quality and habitat structure diversity are gradually improving, new opportunities arise for the recovery of rare and endangered fish species. The Agency for

Nature and Forests of the Flemish Authorities, responsible for the management of fish stocks and the freshwater fisheries policy in Flanders, exploits these opportunities to protect and enhance fish populations in Flanders.

## Methods

Flanders, the northern part of Belgium, is a densely populated region in the central part of Western Europe, inhabited by about six million inhabitants on an area of 13 522 km<sup>2</sup>. The principal rivers in the two major river basins in Flanders (Meuse and Scheldt) are depicted in Figure 1.



**Figure 1.** Principal rivers in the two major river basins in Flanders (Meuse and Scheldt).

The principles and objectives of biodiversity as pointed out in international agreements and Conventions and European legislation such as the Habitats Directive (92/43/EEC), the Water Framework Directive (2000/60/EC) and the Eel Regulation (2007/1100/EC) are the policy framework based on which the Agency for Nature and Forests carries out a sustainable management of fish stocks in Flanders. The watercourse management itself is the responsibility of several external partners, spread over different levels of local and regional interest. To maximize the chances of recovery for freshwater fish, the Agency has developed a systematic step by step approach in the form of Fish Protection Programmes and Fish Recovery Programmes. The scientific input of these programmes is guaranteed by the Research Institute for Nature and Forest, an independent research institute of the Flemish Authorities.

### *Fish Protection Programmes*

Fish Protection Programmes aim to protect populations of threatened and rare fish species by the conservation and management of their habitat. Due to water pollution and habitat loss these populations are generally small and scarce, and very often have a distribution limited to the upstream parts of the rivers. Most of these species are listed on Annex II of the Habitats Directive. Furthermore, a few species have a naturally low occurrence, e.g. barbel, *Barbus barbus* (L.) and minnow, *Phoxinus phoxinus* (L.). For these species required habitat is scarce in Flanders due to geographical conditions. Therefore Fish Protection Programmes primarily aim at species which have low abundance because of human influences.

The first step in each Fish Protection Programme is to investigate both historical and actual distribution of a species and its current status. The actual distribution is digitalized into a geographical information system allowing quick and easy access to distribution maps. Secondly, general ecology, habitat demands and eventual bottlenecks are examined. Based on these data, scientific models are developed to evaluate the habitat suitability of Flemish watercourses for the species in question. In addition genetic research provides necessary information of the genetic diversity of the available stock of the species. Very often this diversity is rather poor due to habitat fragmentation causing genetic processes such as inbreeding. Therefore measures for protection and enhancing genetic variation in natural broodstock are undertaken. Removal of migration barriers and creation of spawning and nursing habitats in the river are the two most practiced measures. Based on habitat research, specific recommendations for the management of watercourse sections for the species are discussed with the different watercourse managers. Finally, fish populations are regularly monitored to evaluate success of measures undertaken. When needed, additional measures are taken. Fish Protection Programmes have been developed for amongst others, bullhead, *Cottus gobio* (L.) and brook lamprey, *Lampetra planeri* (Bloch). Some of the proposed measures for these species are very specific for a local river section.

For instance, for brook lamprey in the River Abeek, an adjusted aquatic weed removal schedule involved the description of different methods of weed removal to be used in different sections of the river. In some sections, aquatic weeds are naturally scarce and hence weed removal was discouraged. For other sections it was proposed to limit the removal of aquatic weeds to just one river bank and to alternate the right and left river bank in respectively even and uneven years, and to limit the period of weed removal from the last week of June to the third week of July. Also it was agreed to stop the clearing of sludge in the River Abeek because of the detrimental impact on the larvae of brook lamprey which live in the river bottom.

### *Fish Recovery Programmes*

While Fish Protection Programmes involve species for which natural recovery still is possible, they are specifically carried out for species for which natural recovery is either impossible due to the lack of nearby source populations, either very unlikely to happen on the medium long term due to the presence of migration barriers or to the small population size of nearby populations. Therefore reintroduction is considered as a policy measure to obtain self-sustaining populations.

Typically, a Fish Recovery Programme starts with a preliminary study in which the feasibility of the Recovery Programme is investigated by collecting the available scientific data on the species and relating these to the policy framework. If the opportunities for a successful reintroduction are good, the preliminary study is followed by a detailed multi-disciplinary research and management program, which consists of seven major parts based on the IUCN guidelines for reintroductions (<http://www.iucnsscrg.org/reintroduction.html>).

## ECOLOGY

Different aspects of ecology of the target species are investigated (e.g. Dillen *et al.* 2004). In a reference situation where the species is still present in normal abundances, relevant variables concerning water quality, spawning habitat, juvenile, sub-adult and adult habitat are measured and linked to population densities of the respective life stage by comparing habitat availability with habitat use. Based on these data, scientific models are developed to evaluate the habitat suitability for the species by estimating the population densities in certain parts of a watercourse.

## EVALUATION OF REINTRODUCTION SITES

In a selection of Flemish rivers all habitat variables were measured and used to develop models to assess habitat suitability for the species (e.g. Dillen *et al.* 2008a). Since this approach allows determination of which watercourse sections are suitable and which is not, a list of potential watercourse sections for reintroduction of the species can be made. Furthermore, since the models determine which variables are responsible for low habitat suitability, it is possible to formulate specific recommendations for habitat improvement. However, if habitat is unsuitable due to natural habitat change since extirpation, it is decided not to reintroduce the species in that habitat rather than trying to adjust habitat structure. Ecology of species has been studied and evaluation of reintroduction sites has been done for chub, *Leuciscus cephalus* (L.), dace, *Leuciscus leuciscus* (L.) and burbot, *Lota lota* (L.). Burbot has become extinct in Flanders since the 1970s. Natural occurrence of dace is nowadays limited to only a few small relict populations in two river basins. Recently chub was only found in the River Meuse. Historical data show that all three species were omnipresent in almost all Flemish river basins before 1930, indicating a very rapid decline.

For each of these three species, habitats suitable for reintroduction were indicated and measures to enhance other habitats according to the needs of the species were taken. One of the most frequently proposed measures is the input of large and of small woody debris. Woody debris deflects the current resulting in the formation of meanders, a heterogeneous sedimentation and a diversified pool-riffle pattern. It may also enhance the formation of undercut river banks. Allowing the colonization of river banks by common alder *Alnus glutinosa*, (L.) and European ash, *Fraxinus excelsior* (L.) provides shaded areas and prevents erosion of river banks naturally. It also enhances formation of undercut river banks by fixating the river bank from collapsing.

## POPULATION GENETICS

Ideally the genetic composition of the source population used as brood stock for reintroduction should be closely related to the original native stock and show similar ecological characteristics to the original population. Furthermore, genetic variation in

the brood stock should be as high as possible to avoid genetic deterioration of reintroduced populations. Therefore Evolutionary Significant Units (ESU) and Management Units (MU) are determined on which genetic management of populations is based both for brood stock as for natural populations. In Flanders, this has been studied for northern pike, *Esox Lucius* (L.), brown trout, *Salmo trutta fario* (L.), chub and burbot (Maes *et al.* 2003; Van Houdt *et al.* 2003; Van Houdt *et al.* 2005a; Van Houdt *et al.* 2005b; Van Houdt *et al.* 2006).

#### AVAILABILITY OF SUITABLE RELEASE STOCK

For a successful reintroduction a stock must be guaranteed available on a regular and predictable basis. Therefore artificial breeding of fish in aquaculture is applied to obtain a sufficiently high number of individuals, thereby reducing the need to disturb wild populations. Since most target species are not available in commercial hatcheries, aquaculture techniques were developed within the hatchery facilities of the Flemish Authorities (Shiri Harzevili *et al.* 2003; Shiri Harzevili *et al.* 2004; Vught *et al.* 2003a; Vught *et al.* 2003b; Vught *et al.* 2008). Within these hatcheries, eggs are fertilized and hatched resulting in fish fry which are grown in earthen ponds during their first summer before release in nature. This process has been studied and optimized for northern pike, brown trout, dace and burbot. More recently, a study was initialized to optimize the artificial breeding of chub.

#### REINTRODUCTION

Young-of-the-year fish obtained from the Flemish hatchery facilities are then reintroduced into a small number of selected watercourse sections with suitable habitat by releasing them at low densities (e.g. 30 individuals/100 m river length). Since many fish species happen to spawn only after they have reached a certain age, and some species may fail to spawn in some years, stocking is repeated for several consecutive years to obtain a self-sustaining population. Typical densities of release average between 1500-3000 individuals per watercourse per year. In Flanders, reintroduction has been carried out for chub, dace and burbot. Chub has also been reintroduced about 15 years earlier but in different watercourses. Restocking, here defined as replenishing existing natural populations which are on a decline with fish of a similar genetic constitution, is done for northern pike and brown trout.

#### MANAGEMENT PROGRAMME

Scientific recommendations resulting from previous research components of the Fish Recovery Programme are discussed with relevant partners to obtain an appropriate watercourse management considering the specific needs of the species. Very often the appropriate management implicates a change of method for removing aquatic weeds and riparian vegetation or a change of method for removing sludge from the river bottom. All these activities generally have a negative impact on fish populations, especially on endangered species, and proposed measures aim to reduce this impact to an absolute minimum. Since most rivers in Flanders are situated in agricultural or inhabited regions it is rather exceptional not needing to adjust water management. Other measures are for example the safeguarding of surveyed spawning sites, the creation of vegetated buffer sites along the river banks to diminish erosion or detrimental effects of pesticides or fertilizers, restoring lateral connectivity and reducing the overflow of superfluous wastewater which happens to occur when the capacity of sewer systems is exceeded. Finally, besides water managers, the local population and all relevant interest

groups such as anglers are well informed about the Fish Recovery Programmes and the ecological interactions to facilitate dialogue between the different stakeholders.

#### EVALUATION OF RECOVERY

The outcome of each Fish Recovery Programme is monitored by fish stock assessment and evaluated. Whenever necessary, reintroduction strategy or water management measures are adjusted. The information of evaluations is regularly published both in scientific as in popular literature. Currently the outcome of the latest reintroductions of burbot, chub, and dace are being investigated. Previous reintroductions of chub in different watercourses have already been studied in the past.

## Results

### *Fish Protection Programmes*

The distribution and abundance of Flemish fish populations is well documented by several monitoring and fish research programmes (Dumortier *et al.* 2005; Dumortier *et al.* 2006). Digital maps are now available with the distribution of each endangered species. This information, together with suggested measures for watercourse management, is then incorporated in river basins management plans which in turn are discussed with the relevant partners. Fish Protection Programmes in the different river basins in Flanders are listed in Table 1.

**Table 1** distribution of different fish species for which Protection Programmes are proposed or being implemented for all Flemish river basins. Concerned fish species are brook lamprey, *Lampetra planeri* (Bloch), bullhead, *Cottus gobio* (L.), spined loach, *Cobitis taenia* (L.), weatherfish, *Misgurnus fossilis* (L.), bitterling, *Rhodeus sericeus* (Bloch), stone loach, *Barbatula barbatula* (L.) and schneider, *Alburnoides bipunctatus* (Bloch).

| Species         | <i>L. planeri</i> * | <i>C. gobio</i> * | <i>C. taenia</i> * | <i>M. fossilis</i> * | <i>R. sericeus</i> * | <i>B. barbatula</i> * <i>A. bipunctatus</i> |
|-----------------|---------------------|-------------------|--------------------|----------------------|----------------------|---|
| River basin     |                     |                   |                    |                      |                      |   |
| Brugse Polders  |                     |                   |                    |                      |                      | x   |
| IJzer           | x                   |                   | x                  |                      | x                    | x   |
| Leie            |                     |                   |                    |                      | x                    |   |
| Canals of Ghent |                     |                   |                    |                      |                      |   |
| Upper Scheldt   | x                   | x                 |                    |                      |                      | x   |
| Lower Scheldt   |                     | x                 |                    |                      |                      |   |
| Dender          | x                   | x                 |                    |                      |                      | x   |
| Dijle           | x                   | x                 |                    |                      |                      | x   |
| Demer           | x                   | x                 |                    |                      |                      | x   |
| Nete            | x                   | x                 | x                  | x                    |                      |   |
| Meuse           | x                   | x                 | x                  | x                    |                      | x   |

\* Species of annex II of the Habitats Directive.

### *Fish Recovery Programmes*

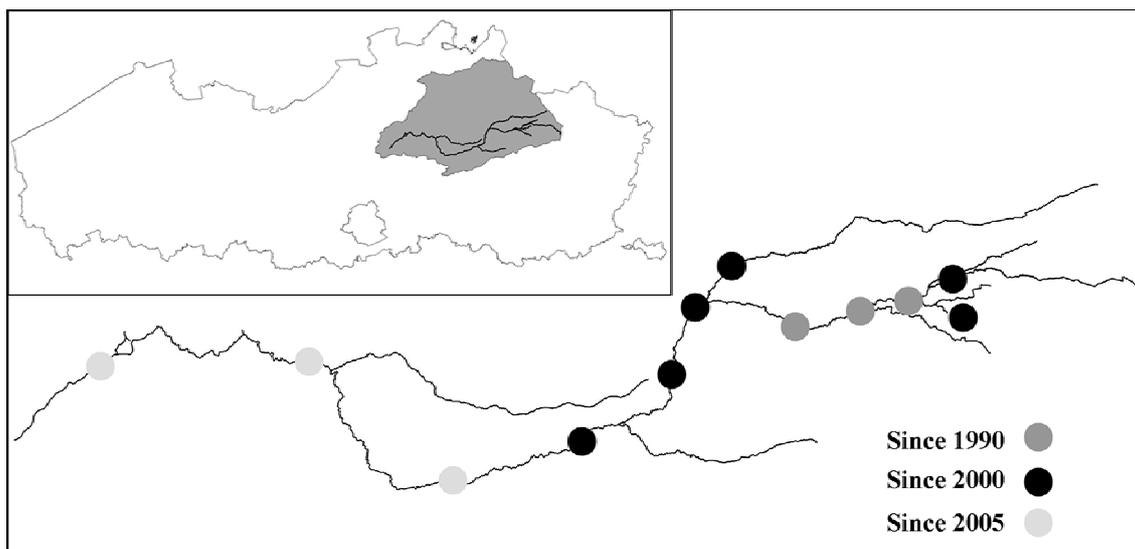
Recovery programmes have been set up and are currently being carried out for three rheophilic species: burbot, chub, and dace. For each species the habitat use and preference for different life stages (age 0+ and age 1+ or older) have been studied and habitat suitability models have been developed. Furthermore spawning habitat requirements have been studied by literature, or, when the available information was too scarce, by a field study in a natural reference situation. Water quality demands of each species were investigated by comparing existing fisheries data from reference situations with water quality data.

For each of the three species an evaluation protocol was set up as a tool to assess suitability of watercourse sections for the species. Each protocol thus evaluates watercourse suitability based on water quality, available habitat for different life stages, and spawning habitat.

An example of how this protocol was used is given for the burbot. For this species water quality is evaluated by three variables: percentage of oxygen saturation, biological oxygen demand and ammonium-nitrogen. Habitat suitability for sub-adult and adult burbot is evaluated by the developed habitat suitability model in which the most important habitat variable was the presence of undercut banks. Spawning habitat and larval and juvenile habitat was determined by three variables: a relatively low stream velocity ( $< 10 \text{ cm s}^{-1}$ ), presence of overhanging cover (trees and bushes on the river bank) and the presence of aquatic vegetation (both submerged and emerged vegetation). The protocol was used to assess 10 different Flemish watercourses for their suitability for the burbot. When either water quality requirements or habitat demands for one of the life stages or for spawning were not fulfilled, it was decided not to reintroduce the burbot in that particular watercourse section. Instead, measures were proposed and discussed with watercourse managers to improve habitat suitability. Finally, it was decided to limit the first reintroduction to three different watercourses in which all demands were fulfilled, so that the outcome of reintroductions could easily be assessed. A similar approach was used for dace and chub.

The next step in the Recovery Programme is to optimize artificial spawning under hatchery conditions, which has been successfully carried out for burbot and dace, and is now being investigated for chub. Also, genetic studies have been carried out for burbot, chub and dace and proper source populations for the breeding programme have been selected.

Chub was the first species for which a recovery programme was started. From the early 1990s reintroductions were carried out for consecutive years in the Nete basin and in the River Zwalm. A self-sustaining population of chub is now present in most of the Nete basin and, consequently, reintroductions of chub in the Nete Basin were stopped since about 8 years. Figure 2 shows the gradual expansion of the population of chub in the River Grote Nete in time and space. In the River Zwalm a self-sustaining population of chub has been established after only one year of reintroduction.



**Figure 2.** Expansion of the population of chub in the River Grote Nete in time and space.

## Discussion

### *Fish Protection Programmes*

Although distribution of bullhead is still limited to only a few small tributaries, its local population sizes generally are high (Vandelannoote *et al.* 1998). Recently two populations of bullhead were found in tributaries where the species had not been observed for many years. However, in another tributary, an illegal diffuse pollution of manure decimated the bullhead population which still recovering.

Evolution of brook lamprey is rather difficult to follow since this species is much more difficult to capture. Brook lamprey is now slowly recolonizing a watercourse section in the River Sassegembeek that was organically polluted up to 2005, but measures have been taken to stop this pollution. Both adult and larval brook lampreys have been observed since water quality in this river section improved. However, since most measures in these Fish Protection Programmes have only recently been taken, possible effects on bullhead, and brook lamprey populations might not yet have reached their full extent and further monitoring of populations is required.

### *Fish Recovery Programmes*

Scientifically based Fish Recovery Programmes can establish self reproducing populations. The rapid establishment of a self-sustaining chub population in the River Zwalm after only one year of reintroduction is rather exceptional, and, based on other experiences with chub reintroductions, reintroductions have to be repeated for several consecutive years for about a decade. This implies that reintroduction broodstock must be guaranteed available on a regular and predictable basis for several consecutive years.

Burbot reintroductions have now been carried out for three consecutive years in the rivers Grote Nete, Maarkebeek and Bosbeek. Preliminary recaptures of burbot have shown good survival and growth of individuals (Dillen *et al.* 2008b), but spawning and

survival and growth of eggs and larvae is yet to be investigated since recaptured burbot had not reached full maturity. Within a few years the success of the current reintroduction programmes can be evaluated.

### *Watercourse management*

Based on the principles of integrated water management, the necessary management measures to protect and enhance populations of endangered species are carried out in harmony with the different functions of the watercourse and in consultation with the competent water managers.

The required management measures for fish species are not always feasible because of practical, budgetary or technical reasons. For example, in agricultural areas mowing of water vegetation or clearing of sludge is often applied to maintain certain water levels. In inhabited areas, water quantity management is mainly focussed on local flood prevention by maintaining safe water levels. On a local scale, agreements for specific watercourse sections are made between the responsible fish stock manager (Agency for Nature and Forests) and the relevant water managers with respect to the different functions of the watercourse. Most of the time these agreements contain an adaptation to the mowing or clearing regime. Concrete agreements are included in the contract specifications with the firms who carry out the maintenance of the watercourses. Additional specific agreements are possible on a local scale. In the example of an adjusted management of the River Abeek to protect brook lamprey, a local commission has been set up in which representatives of the Agency for Nature and Forests, the competent water managers and local farmers are united to discuss and approve concrete agreements. Local farmers and water managers in this commission are given specific information about life cycle and ecological demands of brook lamprey so that they understand the necessity of specific measures and agreements. This approach results in a high local and social support for biodiversity measures. On the other hand local farmers and water managers have the assurance that the local commission can be rapidly summoned and undertake countermeasures when problems with water levels should arise. Since the setup of this local commission and the agreed measures have been put into practice eight years ago, water levels have been stable within safety levels. Additionally, in 2008 the Flemish Environment Agency started the rehabilitation of the River Abeek, including the construction of fish migration facilities and several improvements of the structural diversity of the watercourse. Fish stocks will be assessed in the future to evaluate the effect of the different measures with particular interest in populations of bullhead, brook lamprey, dace, chub and burbot.

The approach of adjusting maintenance programmes of watercourses to protect and enhance populations of endangered fish species reconciles the different ecological and socio-economic targets between the different stakeholders even though these targets sometimes might appear contradictory.

### *Angler involvement*

In Flanders, anglers need to purchase a permit to fish in public inland waters. This permit is to be renewed on a yearly basis. The proceedings of these fish permits are allocated to the Fisheries Fund of the Flemish Authorities. This fund is used to enhance

public inland fisheries and to protect and enhance populations of endangered fish. It is managed by the Agency for Nature and Forests which comes under the Flemish minister responsible for inland fisheries. Representatives of angler associations can submit proposals for the appropriation of a part of this fund. Furthermore, this fund finances the scientific research needed to recover and protect fish stocks in Flanders. Each angler thus contributes to the recovery of fish stocks. The fund also finances information campaigns on fisheries legislation and on Fish Protection Programmes. For example, each angler receives a free brochure with relevant information about fisheries legislation and policy and about ecology of endangered fish species. This increases the awareness and support of anglers for specific Fish Protection and Recovery Programmes.

### *Future developments*

The Water Framework Directive demands that a good surface water status has to be achieved by 2015. For artificial and heavily modified bodies of water a good ecological potential and good surface water chemical status has to be reached. For fish migration, specific targets are set in Flanders. In execution of the Water Framework Directive for each of the 11 river basins in Flanders management plans are implemented. Further steps in wastewater treatment will be taken the next years. All these measures will result in an improvement of ecological quality of watercourses in Flanders. Together with measures taken in the Fish Protection and Recovery Programmes a significant amelioration of fish stocks is expected in most river basins in Flanders. Recently, The Agency has prepared eel management plans according to the Eel Regulation.

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# **The impact of the new EU fish health regime arising from Council Directive 2006/88/EC on ecological interactions of aquatic animals in Europe**

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**Abstract** Aquatic animals in aquaculture production businesses, ‘put and take’ fisheries and those in the wild exist within the same ecosystem and their health and welfare is interdependent. Though the health controls established alongside the single market in 2001 introduced the first Europe wide controls for aquaculture health, there were many opt out clauses. The new regime arising from Council Directive 2006/88/EC which will operate from 2008 across all EU member states will require a much more structured approach with authorisation and registration of aquaculture farms, dealers, transporters and processors. By 2009 this will result in a public register of aquaculture production businesses across Europe accessed through an EU portal facilitating trade whilst ensuring health and other controls are taken into account. This paper discusses the measures arising from the regime, particularly the data streams this will generate and how they might be utilised, the role of government in minimising risks from the interactions between wild and farmed stocks to control disease and the use of codes of practice to drive up industry standards in areas such as bio-security. The new controls also offer the potential to help inform those charged with governance of other controls in the aquatic environment such as the Water Framework Directive (Council Directive 2000/60/EC) and the Habitats Directive (Council Directive 92/43/EEC) and there will be an opportunity to discuss this through the workshop.

## **Introduction**

Though there have been European controls for fish health since the single market was created in 1992 through Council Directive 91/67/EC there has been no Europe-wide requirements for the registration or authorisation of aquatic production businesses. In the UK there has been a registration system for fish and shellfish farms since 1985 and a database of farm related information has become an essential part of understanding how trade operates and for informing our risk based approach to controls on trade. The controls essentially apply to sites holding species susceptible to the diseases listed in Council Directive 91/67/EC, knowledge of trade (movement and mortality records) and their disease status become compulsory when zones or farms wish to be declared free of certain diseases allowing live fish to be traded freely with sites of equivalent health status. Similar controls on imports from third countries and trade with the rest of Europe are constrained by these health requirements under current arrangements. Across most of the EU this information is not in an easily shared and analysable format and thus prevents sharing of this valuable knowledge base.

Since the creation of the single market and the first EU fish health regime under Council Directive 91/67/EC the EU has enlarged to 27 Member States and aquaculture has expanded to include a greater range of species and farming environments. There has also been agreement on the World Trade Organisation trade rules aligned to OIE (world organisation for animal health) manuals for methods, which need to be taken into account to eliminate challenges under these agreements. This directive anticipated a review of its implementation in 1996 and resultant protracted review has resulted in a new Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof and on the prevention and control of certain diseases in aquatic animals, which comes into effect on 1<sup>st</sup> August 2008.

### **The new Aquatic Animal Health Directive 2006/88/EC**

This Directive covers health controls for crustaceans in addition to fish and bivalve molluscs and requires the authorisation of all aquaculture production businesses, including farms and cropping waters across the EU. Member states are also required to authorise 'put and take' fisheries but may by derogation choose to register them instead.

Under the new directive Member States must maintain a good overview of the disease situation in their aquaculture production businesses and controls applied to trade should be risk-based basis taking account of the risk aquaculture sites pose to wild stocks. Details of sites, their locations, species, health status and farm type should be on a public register by August 2009 and accessible through an EU portal. The location data includes a requirement for GIS (Graphical Information Systems) coordinates allowing accurate mapping. Similar EU requirements for a public register will apply to data under the Alien Species Regulation (Council Regulation (EC) No 708/2007) and under the Feed Hygiene Regulations (Regulation (EC) No 1831/2003). Under the UK Better Regulation agenda it is important that where these sites/businesses are the same the information is both joined- up and not in conflict.

There will be conditions for authorisation including the requirement for records to be kept for movements of aquatic animals (both live and dead) on and off sites and of mortalities. Furthermore a general requirement for notification of suspicion of disease outbreaks of any of the enlarged list of diseases extends this responsibility to anyone with such a suspicion.

### **Discussion**

The information held by Member States on the aquatic animal trade is often held within several government agencies, which often operate independently, and an integrated picture is not available across the various aquatic production business areas and in some only at a regional level. The new Directive in generating a requirement for a public register available through an EU portal ensures this data becomes available more generally to trade and government alike is able to inform Member State policy development. Such a detailed data structure holds the promise of a system where scientifically based risk assessments can be made based on the nature of the business and their activities. These in turn can inform decisions on governance whether these are driven by environmental controls, on biodiversity grounds or those for aquatic animal health.

In the UK we have developed such a multi agency system in house over the last eight years and this is currently being adapted to capture all data items related to risk and provide all the deliverables for the public register. It provides a platform for various related government agencies to share their data in one server based live system accessible across the Internet through permission-controlled access. The system has proved very popular with trade partners as it permits online applications and we are currently looking to adapt the system to incorporate data traditionally held at the farm level. This could permit for example single entry of data on movements and mortalities by farmers either directly on the system or a sub-data system where data is electronically transferred from existing farm control programmes. Such systems offer the promise of well-informed policy development for the future and improved governance of the aquatic environment.

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Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 laying down requirements for feed hygiene

# Optimization of freshwater fisheries in Russia

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**Abstract** Improving the regulation and organisation of Russian freshwater fisheries needs to be addressed urgently. This should be completed with all aspects of social, economic and environmental needs in mind. In view of the limited availability of inland fishery resources in the country, fishing is regulated by means of a Total Allowable Catch (TAC) this is an adopted strategy that can protect fish populations, if calculated correctly and if the regulation is adhered to. However there is currently increased competition for resources as the number of fishing companies and individual fishermen has gone up, leading to reforms in legislations as control has become more difficult. Catches of species such as sturgeon, white fish, salmon, and pike perch mostly exceed TAC volumes. Other species, including roach and perch are harvested within their TAC limits, leading to changes in biocenoses. In order to ensure the preservation of fish stocks, the allocation of TACs should be calculated annually based on current fish populations, the number of users and fishing gear for each individual water body.

## Introduction

The total amount of freshwater fisheries in Russia is made up of 22.5 million hectares of lakes, 8.9 million hectares of reservoirs and more than 525 000 km of rivers. These resources are far from being fully exploited; only 44% of lakes, 40% of reservoirs and 7% of rivers are used in fishing industry. At present, a considerable part of potentially important fishery water bodies are not used. In most cases, the reason for this lack of use is low productivity and a low number of valuable fish species, the existence of which would make development of these areas more profitable. Conversely, in other areas, there is a large number of highly productive water bodies located in other regions, but these have underdeveloped infrastructure and therefore, the cost of transportation to and from these areas exceed the value of catch.

At the end of 1980s freshwater fish catch in Russia (excluding the Volga river region) reached 120 000 t yr<sup>-1</sup>. In reality, the total catch, including poaching and recreational fishing, reached 200-220 000 t yr<sup>-1</sup>. In 2006 the official fish catch amounted to 65 000 t yr<sup>-1</sup>, while the actual fish catch reached 180 000 t. The reason for the general decrease in catch volume is economical, in particular the increase in the cost of petroleum. This leads to the abandonment of distant freshwater resources previously used as fisheries, to an increase in the use of reservoirs located in areas with more developed infrastructure. Fishing in districts in Russia that are heavily populated, results in the resources becoming increasingly exposed to pressures which can lead to them being over exploited to a point where, production potential is decreased and an intensification of fishing efforts does not increase the volume of the catch.

In comparison to the decrease of fish resources noticed in the European part of Russia, which is the most populated area, there is a progressive increase in the use of fisheries resources in Siberia and in the Far East of the country. An extension of regulated fishing

to the unused and underused reservoirs would provide an opportunity to raise total fish catch to approximately 300 000 t yr<sup>-1</sup>.

Limited resources of reservoir fisheries that are situated in the European part of Russia need to have reductions in their use. That is why at present all types of fishing within Russia contribute to a total allowable catch (TAC). TAC is an adopted strategy of exploitation, calculated to be a biologically safe quantity of fish to be caught based on the current condition of fish reserves. According to the laws of Russia, TAC is set up every year for each particular type of fish in a particular reservoir. To follow TAC recommendations, constant monitoring volumes harvested is necessary in order to prohibit catch after overstepping the limits.

Scientific research into freshwater fishery resources and the calculation of TAC in Russia is part of combined research that is under the control of 15 research institutes that have 19 affiliated structures. These organizations annually conduct research into 68 of the largest and most intensively exploited fishery waters. These include; 28 reservoirs with a total area of 3.6 million hectares, 28 lakes with total area of 10 million hectares and 22 rivers with total length of 38 500 km. Locations where there are smaller fishery waters under lower exploitation pressures are studied every few years. For the last decade TAC has been constantly estimated for more than 600 stocking units (i.e. water bodies) for 77 freshwater fish species.

However, the formation of new economic relationships in the mid 1990s in Russia and growing competition for resources have led to a considerable increase in the number of fishing companies, therefore, controlling their catch has become practically impossible. Numerous reforms of fishing regulation structures have resulted in the complete destruction of a previously effective monitoring system of fish catch. As a result the amount of actual fish catch volume that is unaccounted for by official statistics, has increased dramatically, making official statistics for total catch and species diversity unreliable.

At present fishing in most of the exploited reservoirs is aimed at catching valuable species such as sturgeon, salmon, whitefish, pikeperch and large bream. As a general rule, fishing companies and fishermen do not declare the catch of these valuable fish species because the actual amount of valuable fish caught exceeds the volumes approved by the TAC. On the other hand, the catch of less valuable fish species such as roach, perch, crucian carp, is lower than TAC recommendations. This situation within a fishery has a negative impact on the ichthyofauna and lowers the fishing status of reservoirs.

The biggest lake in the European part of Russia is Ladozhskoye, which is a good example of this. In 1998 the percentage of whitefish, sparring, pikeperch and bream caught averaged 85%. In 2001 it was 80% and decreased to only 64% in 2007. In the same years, the percentage catch of less valuable fish species averaged 15-20% and it has increased up to 25-30% since then. The situation is similar with fishing in other large water bodies. For example, in 1985 catches of roach and crucian carp in Cymlyan reservoir averaged 25.3% of the total fish catch. In 2006 this increased up to 50%. From 1982 to 2006 the catch of pike in Rybninskiy reservoir reduced by 4.2 times. In Kuybyshevski reservoir catch of pike reduced by 3.6 times, pikeperch catch reduced by 2.7 times. In Volgogradskoye reservoir bream catch reduced by 3.9 times, pikeperch by 4 times.

Between 2000 and 2006, the difference between official fish catch and TAC recommendations varied from 0.4 to 0.58 in favour of the TAC. Such noticeable difference could be explained by a considerable increase in poaching. According to economic assessments for inland freshwater reservoirs that were made at the end of 2006, the TAC predictions stood at 163 200 t yr<sup>-1</sup> with a total production value for raw and frozen fish of 6.1 billion RUR, producing a profit on average of 2.48 billion RUR after the deduction of costs involved. According to official statistics, fish catch in 2006 was 61 500 t with value of 2.6 billion RUR making 0.95 billion RUR profit. As a result of this shortfall in TAC volumes, the total VAT and profit tax shortages amounted to 597 million RUR. The total loss in averaged to 864 million RUR.

There is a requirement in this situation to undertake steps to try again to put order into the industry. The existing limits to fish catch seem to be an insufficient regulation. Therefore, to support TAC further, it is necessary to introduce additional policies. This could be in the form of an annual distribution of Total Allowable Catching Load (TACL) per reservoir or part of it.

The adoption of TAC and TACL restrictions can offer the possibility for an annual calculation of the optimum number of fishermen and fishing gears for each fishery. Catch volumes for fisherman can vary greatly over many years depending on fluctuating fish populations and fishing gears available. To successfully determine TACL, there is a requirement that basic criteria be addressed and that information used, should be based on local and up to date environmental knowledge. Important criteria could include both annual calculations of catch and fishing effort (to determine quantity of fishing gear per fisherman). The definition of 'the total number of fishermen allowed' and 'acceptable fishing gears' can be linked with the allocation of fishing regions to users. This will strengthen the user's responsibility, and reduce negative consequences of anthropogenic impacts on freshwater bioresources.

Another issue arising from freshwater fishing in Russia is the excessive use of large mesh nets. These nets catch larger individuals, resulting in the reduced reproduction potential within several populations and an increase in the number of fish that have a slow growth rate. In addition, a decrease in the use of diverse ranges of fishing gears has had a negative impact on the exploitation of fish resources, because it is impossible to catch the high diversity of fish species that live in the reservoirs. The use of scientifically recommended types and number of fishing gear would result in increased species diversity within a catch in recommended volumes. This will then help to increase the fisheries status of the reservoirs.

## **Conclusion**

In conclusion, the implementation of the proposed methods to optimize freshwater fishing in Russia could make it possible to increase the profitability. These profits offer the financial potential to broaden the fisheries regulations and their enforcement, to increase fish reproduction by hatcheries, tap into new fishery resources and develop further research on the resources.

# Salmonids of the Neretva river basin - present state and suggested sustainable selection programme to protect and strengthen salmonid populations

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**Abstract** The Neretva river is the largest tributary (225 km) entering the Adriatic Sea, and it covers 20% of the total water basin of Bosnia and Herzegovina. The Neretva river is home to several salmonids, and three of them are endemic: softmouth trout (*Salmothymus obtusirostris oxyrhynchus*), marble trout (*Salmon Marmoratus*) and dentex trout (*Salmo dendex*). Brown trout (*Salmo trutta m.fario*) is an autochthonous trout of the Neretva River. Fabricated constructions and activities in the river have partly destroyed the biotype of these salmonids. The unplanned restocking of the Neretva, by introducing autochthonous species (grayling, rainbow trout, brook trout) is an issue in this area.

The main objective of the proposed protection plan, discussed in this study, is to plan and develop a sustainable breeding program to ensure the conservation of each of the autochthonous trout species in the Neretva and its tributaries. The rehabilitation of vital fish stocks will be supported by training people involved in fisheries, aquaculture and ecology. All these activities will be based at the restored Center for Fisheries “Neretva” – Konjic.

## Introduction

### *Bosnia and Herzegovina and its water resources*

Bosnia and Herzegovina is the one of the youngest European countries. Formerly a constituent republic of Yugoslavia, Bosnia and Herzegovina declared its independence in March 1992. It is situated in South-eastern Europe, on the west part of the Balkan peninsula, with an area of 51.129 km<sup>2</sup>. Bosnia and Herzegovina is mostly landlocked, except for 26 kilometres of coastline along the Adriatic Sea. The Bosnia region is the largest geographic region of the country and it is mostly mountainous, with moderate continental climate typified by warm summers and cold winters. At higher elevations, short, cool summers and long, severe winters with snow are common. A Mediterranean climate, with warm summers and mild winters, dominates in the Herzegovina region in the southern part of the country.

Bosnia and Herzegovina is very rich in natural resources, especially water resources, and its 10.000 km of streams puts it into the group of the richest countries of Southeast Europe in terms of hydro-potential. The fresh waters of Bosnia and Herzegovina lie within two major basins. 75% of the area covered by freshwater is found in Black Sea or Danube basin and 25% in the Adriatic Sea basin.

The major stream of the Black Sea basin is the Sava river, which runs along the northern border of Bosnia and Herzegovina, into which almost all bigger rivers flow in Bosnia and Herzegovina (Una, Sana, Vrbas, Ukrina, Bosna, Drina). The only tributary flowing directly into the Adriatic Sea is river Neretva, although, hydro-graphically a huge number of rivers flow underground to the Adriatic Sea.

In contrast to the wealth of rivers and streams, Bosnia and Herzegovina has only a few lakes. The largest one is Boracko lake in the Neretva river watershed. Reservoirs have been constructed on the rivers Drina, Neretva, Vrbas, and Trebisnjica, which are significantly larger than the natural lakes in country.

All rivers and lakes with the exception of the Bosna river and the downstream reaches represent extraordinary potential for fisheries and aquaculture owing to their high biological and chemical-physiological characteristics.

Bosnia and Herzegovina has a rich ichthyofauna. About 140 (sub)species of fish, from 14 orders and 26 families live on a permanent or occasional basis in its inland waters. Some of them are endemic species: *Salmothymus obtusirostris oxyrhynchus* (Steindachner), *Salmo dentex* (Hecke), *Leuciscus turskyi* (Heckel), *Chondrostoma knerii* (Heckel), *Phoxinellus pstrossii* (Steindachner), and some of them have a small areal distribution: *Salmo marmoratus* (Cuvier), *Leuciscus svallize* (Heckel & Kner), *Aulopyge hügelii* (Heckel). About 15 fish non-native species have established themselves in bosnian waters from Eurasian and American waters including: *Ctenopharyngodon idella* (Valenciennes), *Oncorhynchus mykiss* (Walbaum) and *Salvelinus fontinalis* (Mitchill).

### *The Neretva River*

Naron is the Roman name for Neretva, the longest affluent river entering the Adriatic sea in the Western Balkans and with the biggest discharge. By its characteristics, Neretva is a typical mountain river with strong hydropower potential. It is formed as numerous springs converge under the Lebšnik and Zelengora mountains in south-western BiH at an altitude of 1095 m.

The total length of the river is 218 km, 200 km of which belongs to Bosnia and Herzegovina, whereas the lower reaches flow through Croatia into the Adriatic Sea. Its bigger tributaries are the mountain streams and smaller rivers of the Lađanica, Rakitnica, Ljuta, Neretvica, Rama, Drežanka, Buna, Bregava and Trebižat.

In its upper reaches the Neretva runs through the valley between the high Bosnian mountains. This part of the Neretva River basin has a predomonantly rural community and a lot of untouched natural habitat. The middle reaches of the Neretva river have been significantly modified. More than 50 years ago, the first hydroelectric dam was built in this area. The dam was 80 m high and it changed river into a 30 km long hydroelectric power plant reservoir called Jablaničko lake.. In the 1980s, three more

dams were built which formed reservoirs – Grabovica, Salakovac and Mostar. The construction of these reservoirs dramatically changed the ecosystem within the river.

Operation of the hydroelectric dams in the middle reaches of the Neretva river results in significant drops in water levels in the Neretva in the summer, altering the natural habitats of aquatic organisms. The lower course of the Neretva river flows through the karst system which slows the flows significantly.

The water of the Neretva river is of A class quality and it is the one of the coldest rivers in the world. Annual average water temperature is 8-10 °C. Dissolved oxygen concentrations range between 9 and 10 mg L<sup>-1</sup>. These physical-chemical characteristics of Neretva river present an optimal environment for salmonids and associated types of fish.

### **Salmonids of the Neretva River**

The Neretva river provides the main salmonid habitat in the Adriatic part of the West Balkans and is home to numerous salmonid species, three of which are endemic: Neretva softmouth trout, *Salmothymus obtusirostris oxyrhynchus* (Steindachner), Marble trout, *Salmo marmoratus* (Cuvier), and Dentex trout, *Salmo dentex* (Heckel). Brown trout, *Salmo trutta m.fario* (Linnaeus), and Grayling, *Thymallus thymallus* (Linnaeus), inhabit similar habitats to the endemic salmonides. Salmonids from the Neretva basin show considerable morphological, ecological and behavioural variation.

ADRIATIC TROUT, *Salmothymus obtusirostris* (Heckel) is an endemic trout to the Adriatic sea basin of the Western Balkans and the only one representative of the monophyletic genus *Salmothymus* with four subspecies: Neretva softmouth trout, *Salmothymus obtusirostris oxyrhynchus* (Steindachner), Solin salmon, *Salmothymus obtusirostris salonitana* (Karaman), Evilmouth trout, *Salmothymus obtusirostris krkensis* (Karaman), Zeta softmouth trout *Salmothymus obtusirostris zetensis* (Hadžišće).

NERETVA SOFTMOUTH TROUT (*Salmothymus obtusirostris oxyrhynchus* (Steindachner)) shows the most pronounced morphological characteristics featuring a 'softmouth', all the other subspecies are more or less brown trout-like. Neretva softmouth trout have the largest population of all subspecies and it can only be found in the Neretva river, and its tributaries Ljuta, Draženka, Buna and Trebižat. Up until the construction of the dam on the Neretva, this softmouth trout was abundant in the upper course of Neretva. Unfortunately, populations are now in decline in this area.

This trout is characterized by its striking similarity in appearance to brown trout and grayling. It has characteristically shaped head, extended skull near the eyes and the snout is considerably extended. The mouth is relatively small, fleshy and soft and the teeth are mostly covered by fleshy folds. The basic colour of this trout is the dark olive green with salmon-like round spots extending to the caudal fin. Usually, these spots are orange with black outlines but rare specimens have been found with red spots.

The Neretva softmouth trout lives only in schools in deeper and stiller parts of the river. It spawns in spring (March-April), but occasionally it spawns as late as mid may. The average length of this species is 25-40 cm and the average weight is 2 kg (Maximum weight is 4-5 kg). It feeds on zoobenthos, mostly insects, but also on other river

organisms. Because of its unique features and the many primitive salmonid characteristics on its body (short and soft jaws, small mouth, short teeth), softmouth trout are considered to be one of the oldest species of trout.

MARBLE TROUT, *Salmo marmoratus* (Cuvier). is the biggest species of salmonid in the Adriatic sea basin and the second largest European trout species. large individuals have been captured in the Neretva River, weighing up to 30 kg. It is an endemic species of the Adriatic area. Its natural range extends from the southwest Alps, along the western Balkans towards the southeast. It can be found in the rivers that flow from the Alps and into the Po river (Italy), the Soča river (Slovenia), the Neretva river (B&H), the Morača and Zeta rivers (Monte Negro) and in some Albanian rivers.

The marble trout has an elongate and cylindrical morphology. An identifying characteristic of this species is its head, which gave rise to its name „Marble trout“. The head makes up 20-25 % of its total body length. It has developed powerful jaws and teeth. Marble trout have a unique body colour. Basic colouration varies from red-grey to dark green. It has dark stripes all over its body, giving the skin a marbled effect, especially on the head. It spawns from the end of November to January on sandy or gravelly river bars. Marble trout are predatory and feed mostly on fish.

The status of DENTEX, *Salmo dentex* (Heckel) has always been questionable, mainly due to inadequate original descriptions and a paucity of sightings. According to literature sources, this trout historically lived in the Neretva. However, it has never been established if it was genetically distinct form other species or if it was hybrid between different species/subspecies. The dentex's head is small and pointed and its mouth is large with teeth that cover jaws, tongue and palate. This has lead to the name Dentex. The body of the dentex is elongated, moderately flattened and tapering to the tail. There are x-shaped black spots on both sides of the body. Fins are also covered with black spots. Along the lateral line, between black spots, there are small spots of reddish colour.

BROWN TROUT, *Salmo trutta m.fario* Linnaeus is an autochthonous trout of the Neretva river. There are two genetically well recognized autochthonous lines of Brown trout found in the river - *Mediterranean line* and *Adriatic line*. The *Danube line* and *Atlantic line* of brown trout are also present. There are a number of hybrids between these lines, which are better suited to certain conditions than those of pure autochthonous lines. As a result autochthonous lines are threatened. As well having genetic differences, the different strains of brown trout also display unique characteristics in their morphology. The *Mediterranean line* and *Adriatic line* differ from other trout because of the great number of very small, red and black dots which are uniformly distributed all over the body.

Besides this, a large number of the fish in this group have four, more or less prominent, ring like dark bands, which surround the head and body - the coverage of these bands increases around the caudal fin area. Brown trout colouration is very variable, and it can vary from a green hue to a brown hue. Body colour primarily depends on the environment in which the Brown trout lives. The body of the brown trout is elongated and well adjusted to powerful and fast flowing waters in which it lives in. Spawning takes place from the beginning of November till the end of January. In this period mature individuals migrate upstream to spawn on shallow, gravel stretches. The growth of Brown trout depends on environmental conditions. It is mainly dependant on the

quantity and quality of food items in its diet. Therefore, Brown trout, which live in mountain river streams characterised by small discharges and a limited supply of food, may only reach a maximum weight of 2 kg. In bigger streams, Brown trout can weight up to 5 - 6 kg. The brown trout feeds on a variety of organisms such as insects, larvae and even small fish.

In addition to the aforementioned salmonid species in the Neretva River and its tributaries, non- native species such as the rainbow trout and the brook trout can also be found. They are introduced into these waters by fishermen via stocking programmes aimed at improving sport for anglers. If they do not get caught, these salmonids migrate downstream towards the sea to spawn.

### **The state of fish population in the Neretva River**

Over the last fifty years the negative human impact on freshwater ecosystems has become very pronounced in Bosnia and Herzegovina. The Neretva River and its ecosystem were strongly disturbed by dam construction during the middle of the last century. As a result, the middle reaches of Neretva River became a cyprinid zone whereas before it was primarily suitable for salmonids. Now the dominant fish species are pike-perch, carp and catfish. Changing physico-chemical water parameters and the destruction of suitable habitats has led to the complete suppression of autochthonous salmonid population. The construction of dams has also restricted longitudinal connectivity, preventing fish migration during spawning times. This has decreased numbers of salmonids to the limits of extinction in the upper course of the Neretva River.

Heavy industrialisation in the Neretva Valles region has greatly influenced the shortage of salmonid fish, and in some regions they have been completely extirpated. The ecosystems and fish in the Neretva are highly influenced through man made constructions and activities, especially during the latest war. During the war (1992-1995), in most parts of the Neretva River, fish was the only source of food. Therefore, fish were caught with nets, explosives, electricity, poison chemicals and with all available equipment for mass capture. Due to a lack of legislation, mass capture practices continued until 2000. Even today, it is hard to deal with this type of crime.

Unmonitored and incompetent restocking of the Neretva River and its tributaries presents a unique problem and a great threat to the survival autochthonous salmon.

Angling associations are carrying out fish stocking of the Neretva River without competent supervision. In such cases numerous fish species (grayling, rainbow trout, brook trout, brown trout – Atlantic and Daubing lines) are introduced to the river and in most cases they are pushing out autochthonous fish species through competitive interaction and interbreeding. Hybrids are often much more resilient to habitat changes than autochthonous species.

Global climate changes have had and continue to have a strong influence on Neretva River and its flora and fauna. Constant oscillation of water levels, a lack of water during summer, increased water temperature, etc. have led to disruption in the reproductive cycle of fish. Unsuccessful spawning and increased fry mortality due to the impacts of climate change have reduced overall recruitment.

The Neretva River and its tributaries were the subject of great scientific interest in the 1960s and 1980s. Numerous scientific and research papers connected to Neretva river and its fish population were published. During the period 1992- 2000 scientific research in this region was not advisable. After the year 2000, autochthonous salmonids from the Neretva have become the subject of numerous national and international scientific expeditions. Research based on morphological and morphometric characteristics produced an overview of the present status of the fish population in the river. Based on this overview, recommendations for measures to be introduced to protect and preserve autochthonous species (especially endemic salmonides), can be made.

The upper course of the Neretva River represents a typical salmonid reach (brown trout and grayling zone). In this part of the river salmonids are the dominant fish population (91.2% salmonids). This salmonid population is predominantly made up of brown trout (74.4%), with rainbow trout contributing 2.0% to the population. The proportion of endemic salmonides (Neretva softmouth trout and marble trout) in the population is critical, they participate just 7.4% of the total fish population.

Genetic analysis of salmonids in the upper reaches, indicated that brown trout - *Adriatic line* are dominant in this part of the Neretva River (68%). Danubian and Adriatic lines make up 16% and 11% of the population respectively. Neretva softmouth trout are the least abundant species in this sample (5%). Marble trout were not found in this investigation. Salmonid fish species contribution was only 14.6%.

**Table 1.** The composition of the fish population in the upper course of the Neretva river (from the source down to Jablanica lake)

| Family            | Species  | Quantity     |              |
|-------------------|--|--------------|--------------|
|                   |  | absolute (n) | relative (%) |
| <i>Salmonidae</i> | Brown trout ( <i>Salmo trutta m.fario</i> )                      | 261          | 74.4         |
|                   | Marble trout ( <i>Salmo marmoratus</i> )                         | 2            | 0.6          |
|                   | Softmouth trout ( <i>Salmothymus obtusirostris oxyrhynchus</i> ) | 24           | 6.8          |
|                   | Rainbow trout ( <i>Oncorhynchus mykiss</i> )                     | 7            | 2.0          |
|                   | Grayling ( <i>Thymallus thymallus</i> )                          | 26           | 7.4          |
| <i>Cyprinidae</i> | European chub ( <i>Leuciscus cephalusalbus</i> )                 | 1            | 0.3          |
|                   | Eurasian minnow ( <i>Phoxinus phoxinus</i> )                     | 15           | 4.3          |
|                   | Gudgeon ( <i>Gobio gobio</i> )                                   | 4            | 1.1          |
| <i>Cottidae</i>   | Bullhead ( <i>Cottus gobio</i> )                                 | 11           | 3.1          |
| Total             |  | 351          | 100.0        |

Following dam construction and subsequent reservoir creation in the middle reaches of the river, cyprinid fish species became dominant in the community due to habitat changes (72.3%) (Table 2). Salmonids represent only 14.6% of the community, the remainder is made up of perch (14.6%) and other species (2.1%).

The proportion of salmonids in the community is higher in the lower reaches of the Neretva River, from Mostar reservoir downstream to the Croatian border, compared with middle course of river. In this part of the river, the salmonids make up more than half of total fish population (57.2%). Soft mouth trout represent 13.6% of the fish community. This species together with brown trout are the most dominant species in this part of the river (40.9%). In this region, marine fish (herring and mullet) are occasionally caught. Cyprinids contribute 24.9% of the community composition.

**Table 2.** Fish community composition in the middle reaches of the Neretva river (from the Jablanica lake to the mouth of the river Buna)

| Family               | Species  | Quantity     |              |
|----------------------|--|--------------|--------------|
|                      |  | absolute (n) | relative (%) |
| <i>Salmonidae</i>    | Brown trout ( <i>Salmo trutta m.fario</i> )      | 24           | 2.4          |
|                      | Lake trout ( <i>Salmo trutta m.lacustris</i> )   | 54           | 5.5          |
|                      | Rainbow trout ( <i>Oncorhynchus mykiss</i> )     | 30           | 3.1          |
| <i>Cyprinidae</i>    | Carp ( <i>Cyprinus carpio</i> )                  | 76           | 7.7          |
|                      | Sval ( <i>Leuciscus svallize</i> )               | 246          | 25.1         |
|                      | European chub ( <i>Leuciscus cephalusalbus</i> ) | 95           | 9.7          |
|                      | Prussian carp ( <i>Carassius gibelio</i> )       | 43           | 4.4          |
|                      | <i>Alburnus arborella</i>                        | 222          | 22.6         |
|                      | <i>Chondrostoma knerii</i>                       | 28           | 2.9          |
| <i>Percidae</i>      | Pike-perch ( <i>Sander lucioperca</i> )          | 143          | 14.6         |
| <i>Centrarchidae</i> | Pumpkinseed ( <i>Lepomis gibbosus</i> )          | 15           | 1.5          |
| <i>Anguillidae</i>   | Eel ( <i>Anguilla anguilla</i> )                 | 6            | 0.6          |
| Total                |  | 982          | 100.0        |

**Table 3.** The composition of fish populations in the lower course of the Neretva river (from the mouth of the river Buna into the Neretva down to Croatia)

| Family                | Species  | Quantity    |             |
|-----------------------|--|-------------|-------------|
|                       |  | absolute(n) | relative(%) |
| <i>Salmonidae</i>     | Brown trout ( <i>Salmo trutta m.fario</i> )                      | 102         | 27,3        |
|                       | Marble trout ( <i>Salmo marmoratus</i> )                         | 3           | 0,8         |
|                       | Softmouth trout ( <i>Salmothymus obtusirostris oxyrhynchus</i> ) | 51          | 13,6        |
|                       | Rainbow trout ( <i>Oncorhynchus mykiss</i> )                     | 47          | 12,6        |
|                       | Grayling ( <i>Thymallus thymallus</i> )                          | 11          | 2,9         |
| <i>Cyprinidae</i>     | Sval ( <i>Leuciscus svallize</i> )                               | 18          | 4,8         |
|                       | <i>Rutilus rubilio rubilio</i>                                   | 11          | 2,9         |
|                       | European chub ( <i>Leuciscus cephalusalbus</i> )                 | 14          | 3,7         |
|                       | Eurasian minnow ( <i>Phoxinus phoxinus</i> )                     | 28          | 7,5         |
|                       | <i>Chondrostoma knerii</i>                                       | 22          | 5,9         |
| <i>Gasterosteidae</i> | Three-spined stickleback ( <i>Gasterosteus aculeatus</i> )       | 40          | 10,7        |
| <i>Cottidae</i>       | Bullhead ( <i>Cottus gobio</i> )                                 | 11          | 2,9         |
| <i>Anguillidae</i>    | Eel ( <i>Anguilla anguilla</i> )                                 | 8           | 2,1         |
| <i>Clupeidae</i>      | <i>Alosa falax nilotica</i>                                      | 5           | 1,3         |
| <i>Mugilidae</i>      | Flathead mullet ( <i>Mugil cephalus</i> )                        | 3           | 0,8         |
| Total                 |  | 374         | 100,0       |

### **Sustainable selection programme to protect and strengthen the salmonid populations**

The studies reviewed in this project show the differences in fish communities along the river continuum and highlight the importance of developing ways to advance, protect and strengthen the Salmonid populations of the Neretva. The continuing decline in the these populations, especially of endemic species, could bring about their extinction the very near future. Institutional Collaboration between Academic Institutions in Agriculture, Forestry and Veterinary Medicine in Norway and Bosnia & Herzegovina, Croatia and Serbia & Montenegro 2006-2009, Norwegian University of Life Sciences and the Faculty of Agriculture and Food Sciences of the University of Sarajevo has initiated the project “Sustainable Selection Program for salmonid strains of the Neretva River”. The main objectives of the project are to:

- establish programmes for population improvement and artificial reproduction of salmonids of the Neretva river
- collection of brood stock of autochthonous and endemic salmonids from various locations of the Neretva watershed
- DNA-typing of broodstock to assess genetic variation and optimise mating scheme
- artificial reproduction and rearing of fry and fingerling of salmonids
- further broodstock selection and management, assisted by simulation programmes
- rehabilitate vital fish stocks and increase the natural populations of salmonids
- restocking of the Neretva river and its tributaries with fingerlings
- education and specialized training in Norway

To start realising the aims of the project, Konjic Municipality and Faculty of Agriculture and Food Sciences with the material and technical support of Norwegian University of Life Sciences had to establish the Center for fisheries „Boracko lake“ – Konjic. The centre is a national institution for advancing, protecting and strengthening autochthonous and endemic salmonid populations.

The role of the Centre is to:

- rear fry and fingerlings of autochthonous and endemic salmonids for restocking into the Neretva river and its tributaries
- educate pupils, students, fishermen and farmers
- carry out scientific and research works

Endemic salmonid species are given priority in the breeding program as these populations are the most at risk of extirpation/extinction (Marble trout, Neretva soft mouth trout, dentex trout and achromous brown trout).

This Center for fisheries will organize the permanent education for pupils (of primary and secondary schools), students, anglers and farmers. Beside that, students of Faculty of Agriculture and Food Sciences and other Faculty would be able to do practice work in fields of aquaculture and fisheries. The Center will organize seminars from time to time.

The Turkish International Cooperation and Development Agency was involved in the appointment and development of this important institution and a significant collaboration of domestic institutions on this project are expected.

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# The contribution of Akgöl and Paradeniz Lagoons for fisheries in Göksu Delta (Turkey)

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**Abstract.** In this study, the role and contribution that Akgöl and Paradeniz Lagoons make to fisheries resources in the Göksu Delta was summarised. The Göksu Delta is situated on the Southern part of Turkey along the Mediterranean coast. It has two lagoons known as Paradeniz and Akgöl that have formed as a result of the accumulation of sediment carried by the Göksu River, the lagoons areas are 390 and 1200 ha respectively. Both water bodies have an influence on each others salinity: Paradeniz is a brackish water lagoon (12-39 ppt), with a seasonal salinity pattern mainly influenced by Akgöl and via the drainage channels. Akgöl is a quasi freshwater lake (1-4 ppt) in which the salinity only increases slightly towards the connection with Paradeniz. Fishing in the two lagoons is undertaken throughout the year using methods such as; trammel nets, traps, fish barrier and cast nets. Fyke nets are only used only in Akgöl. The Kurtulus cooperative, which is the organisation of the lagoons fishermen, consist of 106 members. Total productivity was around 50 t in 2007. The dominant fish species include; grey mullet, sea bass, sea bream, carp and blue crab.

## Introduction

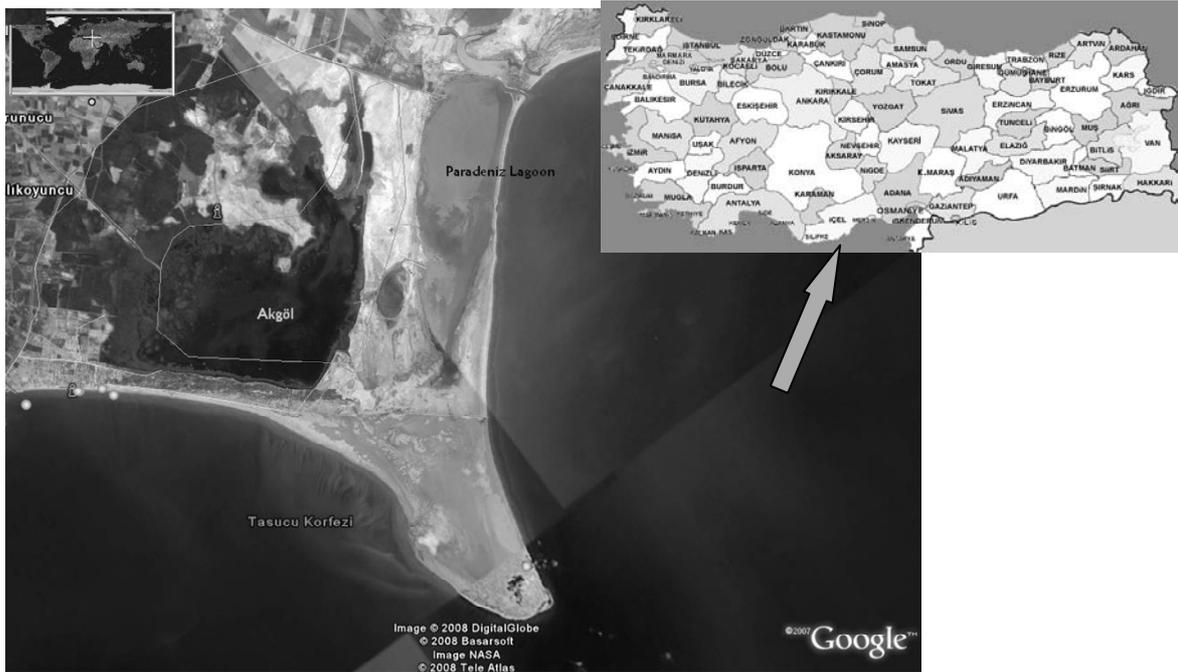
Lagoons are shallow coastal bodies of water that are separated from the ocean by a series of barrier islands which lie parallel to the shoreline. Inlets can be either natural or man made, these cut through barrier islands and facilitate the movement of tidal currents that transport water into and out of the lagoons. Due to the fact that lagoons are characteristically shallow, they are strongly influenced by precipitation and evaporation, these natural occurrences result in fluctuating water temperatures and salinity levels. Despite wide variations in the previously mentioned water parameters, lagoons can be fragile ecosystems that are susceptible to pollution effects from public waste, industrial and agricultural runoff (Hill 2007). These environments have a great deal of important ecologic aspects, providing shelter for endemic or threatened species of plants and animals, making them good economical cultural and scientific resources (Deniz 2004).

Turkey has 8333 km of coastline, with 72 lagoons as covering 36 000 ha. Of these sites, 14 are located in the Black Sea, 12 in the Marmara, 29 in the Aegean and 17 Mediterranean Sea. The main activity in these lagoons is traditional fishing which, is permitted in 43 out of the 72 lagoon systems (STM 1997). Recently, the most detailed research into Turkish Lagoons was conducted (STM 1997) with the assistance of the World Bank and Turkey's Ministry of Agriculture and Rural Affairs. Akgöl and

Paradeniz, the two lagoons surveyed in this project, are situated on the western side of the Göksu Delta in the South of Turkey. Apart from STM (1997), there has been no literature that discusses any previous specific management measures aimed at the native fishery supported by these two lagoons.

## Location

The Göksu Delta (Fig. 1) is situated on the Southern part of Turkey along the Mediterranean coast. It has two lagoons known as Paradeniz and Akgöl which, have formed as a result of the accumulation of sediment carried by the Göksu River, the lagoons areas are 390 and 1200 ha respectively.



**Figure 1.** The map of Paradeniz and Akgöl Lagoon Complex in Göksu Delta.

### *General characteristics*

Akgöl is roughly triangular in shape, with its longer axis extending in an E-W direction (Figure 2). The lagoon is a quasi freshwater lake (1-4 ppt) (Table 1), fed with fresh water via two SHW drainage channels that discharge along its landward side. Between 1940-1950 it was connected to the sea by a channel located along its seaward side (DKHD 1992), nowadays, it is only connected to the sea via the Paradeniz Lagoon by a narrow channel that was excavated by the State Hydraulic Works (SHW). As a result, the salinity of Akgöl slightly increases nearest to their connection.

Paradeniz is a brackish lagoon (12-39 ppt) (Table 1) with a seasonal salinity pattern that is primarily influenced by influxes of fresh water from Akgöl, via the drainage channels. Paradeniz has a long roughly triangular shape, with its longer axis extending in a NE-SW direction (STM 1997). Unlike Akgöl, the Paradeniz Lagoon has a permanent connection to the sea in the south east. It also has a manmade connection with the sea, separated by a narrow sand strip; this creates a connection in times of high south easterly winds that cause flooding.



**Figure 2.** Akgöl Lagoon.

**Table 1.** Parameters of the two lagoons.

| Lagoons   | Air temperature (°C) | Water temperature (°C) | Salinity (ppt) | Depth (m) |
|-----------|----------------------|------------------------|----------------|-----------|
| Akgöl     | 9.4-27.8             | 10-32                  | 1-4            | 0.7       |
| Paradeniz | 9.4-27.8             | 10-29                  | 12-39          | 0.8-1     |

### *Fisheries*

Fishing in the two lagoons is conducted all year round, the methods that are predominantly used include; fishing barrier (Fig.3) and stationary or moving nets, other methods used are trammel nets, twine traps, fish barrier and cast nets. Fyke nets are only used in Akgöl (STM 1997). Fishing at the fish installation is mainly carried out from June to January when the barrier is closed, this accounts for 25-45% of the total catch (Crivelli & Rosecchi 1992). From March to June the fish barrier is kept open to facilitate the migration of fish. The Kurtulus cooperative, which is the organisation of the lagoons fishermen., consists of 106 members, with 4 vessels. Total productivity is around 50 t in 2007. The dominant fish species include; grey mullet, sea bass, sea bream, carp and blue crab.

### *Conservation Status*

The Turkish Ministry of the Environment creates legislations to protect the environment and its rich natural diversity, as well as the fauna and flora that have a national importance. They declared the Göksu Delta, a Specially Protected Area (SPA) in 1990, the boundaries of this SPA include the Paradeniz and Akgöl lagoon complex. In 1994, they declared the Delta to be a Ramsar Site and in addition, in 1996 the Ministry of Culture declared the site to be a Natural Site Area.



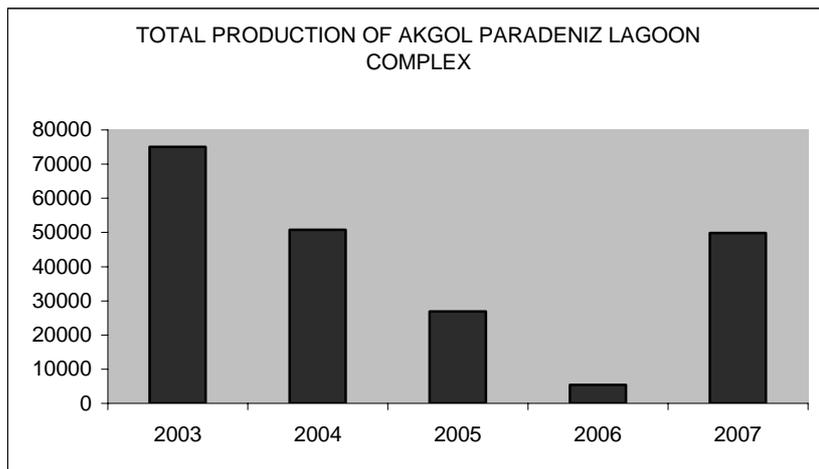
**Figure 3.** The fishing barrier in the Paradeniz lagoon

### Data collection

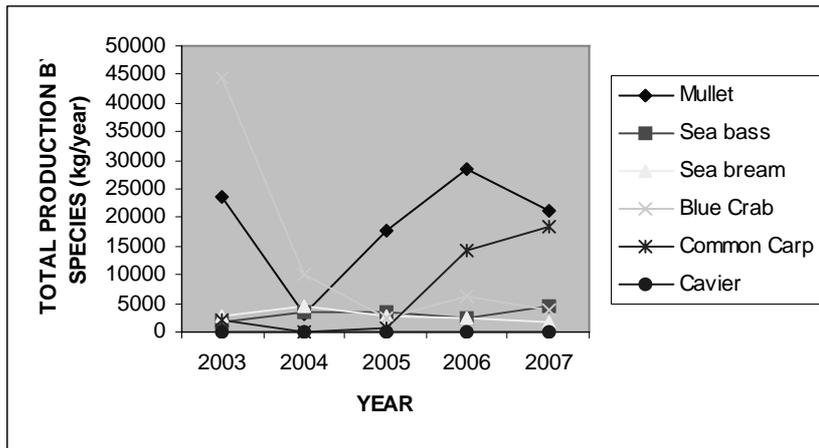
The data used for this study were obtained from the following companies and organisations; Kurtuluş cooperative, Ministry of Agriculture and Rural Affairs, General Directorate of Agricultural Production and Development, and Mersin Province Agricultural Directorate records.

### Results

Mean total productivity of the lagoons has declined from about 75 t to 5t between 2003 and 2007, although there was an increase in 2007 (Figure 4). The dominant species that make up the fisheries of the lagoons are: grey mullet, sea bass, sea bream, carp and blue crab (Figure 5).



**Figure 4.** The total production of the two lagoons according to years.



**Figure 5.** The total production by species of the two lagoons according to years.

### Conclusions and recommendations

The Paradeniz and Akgöl lagoons receive water which has drained from the Göksu Delta and surrounding farmland on which, there is an intensive use of pesticides and manure. As a result, the water is consequently loaded with pesticides and nutrients.

The traditional fishing activities that are conducted in the lagoons should be upgraded to low-impact technologies. An introduction of extensive and semi-intensive forms of aquaculture should be applied to induce the recovery and preservation of the biological diversity. In addition, the fishing barrier should be modernized.

The Göksu Delta has a 'high conservation' status; therefore, rehabilitation studies can not be applied. For that reason, the conservation status should be overlooked for this area. The channel that is located between sea and lagoon should be deepened and widened. The effectiveness and sustainability of these lagoons in the fishery production of Göksu Delta can be increased by appropriate management actions.

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**Abstracts for unpublished papers or papers published in  
Fisheries Management and Ecology**

## **Session on Ecological interactions**

### **Meta-analysis of lethal and sublethal impacts of catch-and-release recreational angling on European fish species**

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Catch-and-release is thought to constitute a viable way to reconcile social and ecological objectives of recreational fisheries management. However, its success depends on hooking mortality rates to be low and sublethal impacts to be negligibly as regards the fitness of individual fish post release. We conducted a meta-analysis of the published literature on the lethal and sublethal impacts of catch-and-release on European fish species. In total, 214 hooking mortality rate estimates for 17 fish species were identified in 100 published studies. The average hooking mortality rate was  $15.6 \pm 20.3$  %. The most robust fish species belonged to the family of Cyprinidae, whereas the most sensitive ones were Percidae. Hooking mortality was significantly related to water temperature, type of bait and hook type. In addition, a suite of sublethal impacts can occur on released fish. In conclusion, catch-and-release can induce minimal impacts on fish, but this necessitates appropriate angler behaviour.

### **Determination of trophic situation of sarımsaklı dam lake (Kayseri, Turkey)**

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Water samples were monthly collected from four different stations on Sarımsaklı Dam Lake from May 2001 to June 2002 to determine the trophic situation of lake. Additionally, physical parameters of water such as temperature, dissolved oxygen, electrical conductivity (EC), pH, and light permeability were measured in the field. Status of KOI, surface active substance, sulphur, nitrite, nitrate, total nitrogen, phosphate, total phosphate, and oxygen saturation were analyzed in Environment Ministry Reference Laboratory. Zooplankton samples were collected with a plankton net with mesh size of 55  $\mu\text{m}$  horizontally and vertically, and they were fixed with 4% formaldehyde. The species were identified according to published data. The results of the light permeability, basic water quality parameters, and dominant zooplankton species indicated that the lake studied was eutrophic. Furthermore, biotic index supported to this result. The examined Lake in study area was partly polluted with different sources, because the study area is liable to human activities. If the pollution is not prevented, it may endanger the lives of living organisms here in future. Knowledge

on the trophic situation of Sarımsaklı Dam Lake is not well established, so all of the zooplankton species determined are new records.

### **The response of a brown trout population and the perception of the situation by anglers after ceasing trout stocking**

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Since the mid 1980's, the amount of industrial discharge was stepwise reduced in a German river. To test the extent to which natural reproduction alone will preserve the local brown trout (*Salmo trutta* L.) population and the angling yield, respectively, stocking with brown trout was stopped in 2001. The development of the trout population was studied by electro-fishing between 2001-2007, angling yield (1987-2006) was derived from official statistics and local anglers were asked to complete an opinion questionnaire. Each year a natural reproduction and a stable stock of trout above 20 cm were observed. Moreover, the trout yield by anglers increased after stocking ceased and approximately 60% of the anglers were convinced that stocking is unnecessary. According to this study, a stocking stop in a river with an adjusted brown trout population will not lead to a decreasing brown trout stock, decreasing yield or unsatisfied anglers.

### **The possible effects of global warming on fisheries and aquaculture in Turkey**

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Global warming is the increase in the average temperature of the Earth's near-surface air and oceans in recent decades and its projected continuation. The global average air temperature near the Earth's surface rose  $0.74 \pm 0.18$  °C during the 100 year period ending in 2005. The negative effects of global warming on fisheries and aquaculture can be summarized as higher inland water temperatures, changes in sea surface temperatures, drought, sea level rise, changes in precipitation quantity and location, increase in frequency and intensity of storms. The possible effects of global warming on fisheries and aquaculture in Turkey can be seen in that changing in lake water levels and river flows, partially and totally drying out of lakes, decreasing in the amount of underground and spring water volume, increasing in the water temperature in water sources, introducing new alien species. Climate changes may affect fisheries and aquaculture directly by influencing fish stocks and hence production quantities and efficiency, or indirectly by influencing fish prices or the cost of goods and services required by fishers and fish farmers.

## **Traditional carp pond farming in Poland as an example of sustainable aquaculture**

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Aquaculture is a very fast developing branch of food production. However, this fast development, usually focused only on one species might be very harmful for environment and cause serious damage. Sustainable development in aquaculture means such system of production which is environmentally non-degrading, technically appropriate, economically viable and socially acceptable, which conserves land, water and animal resources. A very good example for sustainable aquaculture is traditional carp production in earthen ponds. Carp ponds have very positive influence on environment as they accumulate large amount of bygones from supplying waters, creates very good habitats for thousands species of fauna and flora. Ponds are also very well accepted by inhabitants to such stage, that many people treat ponds as natural water bodies. From economical side ponds produce very good quality consumable fish and great amount of restocking material for lakes, rivers and other waters. But economic viability now is the “weak point” of traditional pond aquaculture and should be strengthened. Sustainable development is described also as such management which gives possibilities for the system to operate into the indefinite future without declining because of exhausting or overloading resources. This definition might be also considered from opposite perspective i.e. how long given system already exists in unchanged form. Due to this, carp ponds are very good example of “sustainable production system”. From total ponds area in Poland only app. 20 - 25% are ponds built after Second World War. The largest areas make ponds older than 100 years, and in this app. 15% comprise ponds older than 500 hundred years. All ponds are managed due to the Dubisch system, developed almost 150 years ago in Landek Carp Farm, near Golysz, Poland.

## **Impact of invasive alien species in aquaculture**

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Aquaculture, the farming of aquatic organisms, although a very old tradition, has flourished in the last few decades to supplement traditional supplies from marine capture fisheries that are waning. Aquaculture is, however, becoming increasingly dependent on alien species. In Europe they account for over 70% of the aquaculture production, both in quantity and value. In this review, the role of aquaculture in the spread of alien and invasive species throughout Europe is analysed and options for mitigating the dependence on alien species and thereby minimising potential negative impacts on biodiversity are considered,. It is pointed out that there is potential for aquaculture, which is becoming an increasingly important food production process, not to follow the past path of terrestrial food crops and husbanded animals with respect to their negative influences on biodiversity.

## **Determination of current status on freshwater aquaculture in Mediterranean region of Turkey using socio-economic indicators**

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This research study was conducted in 8 provinces (Adana, Antalya, Burdur, Hatay, Icel, Isparta, Maras and Osmaniye) located in Mediterranean region of Turkey. Data were collected from 198 fish farms by face to face survey technique. In the study, current status of fish farms was determined based on mainly socio-economic indicators. In the context of this research, survey results indicate the characteristics of fish farmers demographically, socially and economically. Firstly, fish farmers are in the middle class of age (66.5%), educated at high school or below (78.3 %). Fish farms are classified according to property ownership generally as private farm (76.8 %). On the economic standpoint, farmers do fishery in concrete pools at land (87.9%), they use their own sources for their finance (72.2 %), employ generally less than 9 people who has no professional knowledge (55.9%), has capacity vary 2-16 ton (62.6 %), prefer spring water (53.6 %) and have tendency for investment for their future. The basic aim of this study is to discuss tendencies for the future in fish farming using socio-economic data obtained from fish farmers and provide solution to the problems and make fish farming more profitable.

## **Effect of supplementary stockings of juvenile brown trout, *Salmo trutta* L., on yield in a Norwegian mountain reservoir**

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2) *Øystre Slidre Fjellstyre, Heggenes, Norway*

The effect of supplementary stockings of juvenile (age 0+) hatchery-reared brown trout, *Salmo trutta* L., on annual yields was assessed in a Norwegian mountain reservoir during a 29-year-period (1979-2007). The fishery is mainly carried out with benthic gill-nets by local fishermen. During the study period, annual releases ranged from zero to 52500 fish (19.8 ha<sup>-1</sup>). No stockings have been carried out since 1997. The annual yield varied from 1650 to 5653 kg, corresponding 0.62 to 2.13 kg ha<sup>-1</sup>. A multiple regression showed that exploitation rate in terms of number of gill nets, and mean weights of 6+ fish (age when catchable size was reached), explaining 64% for the variability in the catches. Stocked fish seemed to contribute to a small extent to the yield or CPUE, exhibiting no positive correlation with stocking density. The lack of any significant contribution from stocked fish is probably due to a competitive bottleneck in the eroded epibenthic zone, causing high juvenile mortality. If the stockings should continue, we recommend releasing fish with body lengths of >15-20 cm.

## **Parasites of exotic and translocated fish species in the inland waters of Turkey**

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One of the most persistent risks inherent with movements of living organisms around the world is that pathogens and parasites associated with the organisms be spread to new hosts in the receiving area. Pathogens introduction associated to fish introduction is a little studied topic in Turkey. The paper provides a review of the current state of knowledge on parasites of exotic and translocated fish species living in Turkish freshwater bodies.

## **Adaptation of mirror and common carp introduced to reservoirs: a contribution to the solution of the choice problem**

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In addition to 664 small reservoirs, 555 large dams constructed in Turkey, another 210 large and 44 small dams are still under construction. Regarding their fishery potential, these dams creating large lakes behind, provide a significant source of income to the inhabitants living around. Introduction of fish species into these dams is under the responsibility of DSI, and mirror carp, known as a warm water fish have been introduced into most of the man-made reservoirs in Turkey, regardless the geographical location which controls the climatic conditions. During the last decade some arguments have arisen on the adaptation and spawning of mirror carp and the success of this application in Anatolia where typical cold continental weather conditions prevail. In the meantime depending on some irregular observations, common carp was introduced some reservoirs as an alternative to mirror carp. Neither governmental organizations nor universities have any long term monitoring studies on the growth and reproduction of mirror and common carp introduced into reservoirs. In this study growth, based on the data obtained through 4 years of observation, mirror and common carp populations monitored living in the same reservoir which is located in Yozgat-Central Anatolia having hard climatic conditions. Our results revealed that mirror carp has better growth and higher absolute fecundity than that of common carp.

## **Sustainable use of sterlet and development of sterlet aquaculture in Serbia and Hungary**

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Sterlet (*Acipenser ruthenus* L.) is endangered due to over-fishing, river regulation and dam building as well as water and sediment pollution. Serbia and Hungary have

common sterlet populations in the Danube and Tisza Rivers. The highest recorded annual catch of sterlet in the past 4 decades was 79,978 kg (1988) and 37,000 kg (1990) in Serbia and Hungary, respectively. While both the sport and commercial fishery of sterlet are represented in Hungary, only commercial fisheries exist in Serbia. The aquaculture technology and rearing of sterlet is well-developed in Hungary while in Serbia, even though a market demand for this species exists, the aquaculture of sterlet has not developed till nowadays. A project aiming at the sustainable use of sterlet has been started in Serbia and Hungary to establish and to develop a common practice in the protection and utilization of the common natural resources, by which, sustainable use is promoted.

### **Introduced crayfish *Pacifastacus leniusculus* (Dana) utilization and effects on inland fishery**

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The signal crayfish *Pacifastacus leniusculus* (Dana) was introduced from California to Sweden in 1959, and to Finland in 1967. The crayfish plague had depleted the crayfish stocks in the late 19<sup>th</sup> and early 20<sup>th</sup> century. No recovery or resistance have been detected. The signal crayfish was considered to be a homologue of the native noble crayfish *Astacus astacus* L. in Scandinavia. This new species was introduced in to a number of the Finnish freshwaters since late 1980s. The noble crayfish catch was 1.6-3.7 million specimens in 1986-2000. The signal crayfish appeared into the statistics in 2001 with 0.65 million specimens. In 2006 the catch was 1.6 million noble and 5.2 million signal crayfish. This increase of the crayfish catch is expected to continue. The rapid growth will appear in many economical and social changes in the inland fisheries, and perhaps lead to some ecological consequences as well. In the paper the catching development of the signal crayfish, especially from the point of view of methods, costs and manpower is examined and compared with the noble crayfish catching. In average, more efforts are directed to the utilization of the signal crayfish than is traditionally used in catching noble crayfish.

### **Fish based assessment of ecological status of Finnish lakes loaded by diffuse nutrient pollution from agriculture**

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The Water Framework Directive of EU provides that pressures to surface waters due to diffuse loading of nutrients have to be taken into account in determination of their ecological status. Therefore we examined, by using a Finnish data set of fish communities in 178 lakes, the possibilities to assess the effects of agriculture-induced nutrient loads on the ecological status of lakes. The lakes were divided to reference (n=100) and affected

sites (n=78) based on an expert judgement. Fish sampling was conducted by standardized gillnet test fishing. A fish based classification tool of four parameters (EQR4) was applied in assessing the ecological status of lakes. The parameters included were mean total biomass of fish per gillnet night, number of fish individuals per gillnet night, biomass proportion of cyprinid fishes, and the presence of indicator species. The preliminary analysis resulted in a median EQR4 value of 0.78 (good status) for reference lakes and 0.56 (moderate status) for affected lakes. Thus, our classification tool gave a reasonable output for differently loaded lakes.

### **Responses of fluvial fish assemblages to agriculture in boreal zone**

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The effect of agriculture on fish communities was studied with electrofishing data from 108 sites along 27 medium-sized rivers running in organic soils in central and northern Finland. The intensity of agriculture was quantified as the percentage of the above catchment area used for agriculture (range 0.3 – 31.0 %). Water quality data showed high correlations with the intensity of agriculture especially in suspended solids, total phosphorus and chemical oxygen demand (correlation coefficients 0.71 – 0.90). The density of several fish species, e.g. bullhead (*Cottus gobio*), alpine bullhead (*C. poecilopus*), minnow (*Phoxinus phoxinus*), and brown trout (*Salmo trutta*) responded with diminishing densities to the intensity of agriculture. On the other hand, the density of perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*), for example, increased significantly along the intensity of agriculture. A fish-based index developed for the evaluation of the ecological integrity of rivers correlated negatively with the intensity of agriculture.

### **Wild stocks of lake-migrating brown trout near extinction in Finnish Lake District: rapid recovery actions needed**

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Wild stocks of brown trout collapsed as a result of human actions in Finnish inland waters during the last century. Dams stopped migrating individuals, and low water quality and stream dredging weakened reproduction. The fall of migratory stocks was finalized by overfishing, mainly gillnet fishing on lakes. Consequently, the egg production of migratory stocks has diminished to negligible level. Remaining stocks are distinct, mixed with continuous stocking, and probably losing their genetic diversity. During last decades, various recovery actions have been carried out: stream channels have been restored, fishways have been built, and eggs and smolts have been

introduced. Gillnetting has been regulated, but slightly, and catch-and-release of wild trout is spreading in sport fishing. However, these measures seem to be inadequate, and almost no recoveries of migratory populations have been reported. The problem of by-catch in intensive gillnetting keeps populations threatened and creates dispute between stakeholders.

### **Does coexistence affect the growth and condition of native crucian carp *Carassius carassius* and introduced goldfish *C. auratus* in small ponds?**

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Despite its long history of introductions in Europe, and its demonstrate adverse genetic impact on native crucian carp *Carassius carassius*, the Asiatic cyprinid, goldfish *Carassius auratus*, has been little studied where introduced and its ecological impacts remain unknown. To address this, we examined growth in crucian carp and goldfish in quasi-natural ponds of Epping Forest (London, England), both in sympatry and allopatry. The growth trajectories in allopatry and sympatry revealed much faster growth of goldfish in sympatry than allopatry. Crucian carp growth trajectories were similar in allopatry and sympatry but in sympatry crucian body condition values were significantly higher (*t*-test,  $P < 0.001$ ) than in allopatry. These results may simply reflect differences among ponds in food availability, with goldfish-only ponds coincidentally having greater resources, or alternatively that co-existence incites these congeners to maximize growth potential, with associated ramifications for reproductive output. The implications for crucian carp conservation are discussed.

### **A new fish based index for monitoring the ecological status in rivers – A contribution to Water Framework Directive**

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We collected electrofishing data from 902 rapids from the Rivers in Finland. Together with the fish data we collected information on land use, channel modification and water chemistry to understand the level of human alteration in the rivers. Discriminant function and correlation analyses were used to select fish variables that most efficiently classified the undisturbed reference sites and human impacted sites to proper classes and responded to human alteration. Five variables were selected for the index: the number of fish species, proportion of sensitive species, proportion of tolerant species, proportion of cyprinid individuals, and density of age-0+ salmonids. The value for each metrics (between 0-1) was calculated according to a point estimate for classical probability. The index value was the mean from the five metrics. An independent new data set was used

to test the index. The index is used to estimate the ecological classification of river according to EU Water Framework Directive.

### **Fishing activities and pollution risk on Köyceğiz-Dalyan Lagoon System**

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Köyceğiz-Dalyan lagoon system, declared as a Special Protection Area in 1988, is located in south-western of Turkey. The area is composed of terrestrial structures of various qualities around Köyceğiz Subsidence Lake. It is a brackish lake which is fed by springs and several streams. The lagoon system and the beach is very important for sea turtles (*Caretta caretta*, *Trionyx triunguis*). Fishing activities are carried by DALKO (Dalyan Fisheries Cooperation) and the major commercial species are grey mullet (*Mugil cephalus*), eel (*Anguilla anguilla*), sea bass (*Dicentrarchus labrax*), gilt-head bream (*Sparus aurata*), carp (*Cyprinus carpio*) and blue crab (*Callinectes sapidus*). The amount of fish caught by DALKO decreased from 440 t to 180 t in last decades.

The lagoon is under pollution pressure of agricultural run-off and untreated urban waste. Heavy tourist-boat traffic on the canals between the lake and the sea causes heavy metal pollution, stress on fish and wave-damage to reed beds. In this study present situation of the lagoon system and fishing activities are evaluated.

## **Session on Governance**

### **Global Code of Practice of Recreational Fisheries to Reconcile Social and Economic Objectives for Sustainability**

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Lack of consideration and guidance about what constitutes good recreational fishing practice is hampering progress towards a coherent approach towards sustainable recreational fisheries on a global scale and is thus weakening the sector. This paper presents a recent initiative by the European Inland Fisheries Advisory Commission (EIFAC) and its Working Party on Recreational Fisheries towards development of a Global Code of Practice for Recreational Fisheries (CoP). In total 11 topical areas are addressed including intuitional and policy framework, enforcement, fish welfare, recreational fisheries practice, management and research. The resulting document complements other Code of Conducts that exists for fisheries in general, but is specifically framed for recreational fisheries. Its adoption by international, national and

local bodies is encouraged as well as dissemination of its content in an easily palatable way to anglers and other recreational fishers.

### **Trout stocking revisited: An interdisciplinary approach to stakeholder participation and co-management**

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Following a long tradition, about 60-115 million brown trout fry equivalents of widely unknown genetic composition are stocked annually in Swiss running waters. Evaluations of survival rates are sparse and their results are mixed. In a recent survey, anglers, nevertheless, indicated they wish to keep stocking at the current or even higher level. In an interdisciplinary stakeholder participation and education program, we are now assessing the coupling of ecological and social aspects related to stocking. Mark-recapture studies of stocked 0+ trout and stock assessments are conducted in cooperation with angling clubs in different types of streams to assess stocking success. Alongside this instructed experience we conducted repeated surveys of the anglers' mental models of how fish population dynamics work and of their motivation to conduct stocking.

### **From strict guidelines to adaptive stocking in subarctic Lake Inari**

P. T. HEINIMAA

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The regulation of the subarctic Lake Inari initiated in 1941 as the outlet River Paatsjoki was closed by a dam. Due to environmental changes the total catch collapsed from 248 t to 78 t per year in 1960's. Compensation actions initiated in mid 1970's and large stocking obligation, introduction of new fish species and restoration of fishing possibilities created the bases for increasing fishery. Total catch peaked in 1989 at 560 t and professional fishery peaked at 400 t thus following by a collapse in mid 1990's due to the fluctuation of vendace (*Coregonus albula*) stocks. Recreational and subsistence fishing recovered since early 1980's and are nowadays responsible for 75 % of the total catch. Initially the Lake Inari and its tributaries were managed separately and this gave only little possibilities to adjust the stockings to changing food, environment, fish stock and fishing conditions. Due to the increase of vendace stock it became important food storage for the predators. As the vendace stock collapsed, brown trout (*Salmo trutta* m. *lacustris*) and arctic charr (*Salvelinus alpinus*) catches collapsed and the predators became strongly infested by parasites making them unattractive for fishers. In 1996 the adaptive stocking policy was adopted and in 2001 also court orders for management practices were changed making it possible to adjust the stockings. Nowadays catches of

the predatory salmonids are larger than before the regulation. Governmental financial aid for fisheries has varied in different decades thus creating a solid infrastructure for the fishing activity of different stakeholders.

### **Inland Fisheries of Turkey**

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Turkey fish production in 2006 was 661,991 t. Of this figure , 44,082 t come from inland capture fisheries and 56,694 t come from inland aquaculture production. Turkey has 200 natural lakes with 906.118 ha area, 206 dam lakes with 342,377 ha area, 953 small dam lakes with 15,500 ha and 33 rivers, 177,714 km long and many streams. Main species of inland capture fisheries are common carp, sand smelt, Tarek, crayfish, pike, catfish, mullet. Fisheries management is under taken by the Ministry of agriculture and Rural Affairs, its provincial offices and Research institutes. All inland water resources are hired to the private sector and fishermen cooperatives. Hiring is based on stock assessment. Inland fisheries are regulated and managed with a notification prepared by the Ministry of Agriculture and Rural Affairs that posses some restrictions and responsibilities to the people involved in fisheries for both commercial and Sport fishing. The restrictions are on fishing time, fish size, fishing area and fishing methods and equipment. Research on ecology, stock assessment and selective fishing equipment must be improved. Management plans must be prepared for each water source with a participatory approach.

### **Turkish fisheries management towards sustainable exploitation of resources**

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Being surrounded both by the Mediterranean and Black Sea, Turkey is a leading fisheries country in its region. Turkish fishery presents a typical artisanal and off-shore fishery with multi-gear and multi-species characteristics, employing about 100 thousand fishermen. 10 species, being comprised mostly of small pelagics, account for approximately 90 % of the total marine catches. Fishing activities are regulated through distinct fishing circulars, under two categories, i.e. “commercial fishing” and “recreational fishing”. Total fishery production in 2005 from marine capture fisheries, aquaculture, inland fisheries and the others (shellfish etc) were 334,248mt, 118,277 t, 46,115 t and 46,133 t respectively, totalling a production of 544,773 t. This contributed 0.6% in the global production. Turkish aquaculture has grown markedly over the last years, having 5th place in Europe. In parallel with Turkey’s accession process to the EU, Turkish fisheries have been subject to a comprehensive review procedures in terms of harmonisation of the fisheries with responsible and active participation from relevant stakeholders. In this connection, newly developed pilot applications have been introduced to create a framework for sustainable exploitation of fisheries resources. Examples are development of a vessel monitoring system, Fisheries Information

System, construction of port offices, regulations on market standards, drafting of preliminary Fisheries Management Plans and a sector strategy. Draft amendments have been made to the existing Fisheries Law 1380, in order to form and strengthen legal basis in terms of enforcement and sanctions for newly introduced applications.

### **Conservation and sustainable fishery management of brown trout in Irish lakes: is roach a real threat?**

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Ireland's freshwater fish fauna was historically dominated by salmonids. Among the native species the wild brown trout (*Salmo trutta* L.) became very attractive to anglers and sport angling makes a significant contribution to the local tourism industry. Thus, brown trout represents an economically important resource with high socioeconomic value. However, brown trout populations are potentially threatened by the introductions of non indigenous fish species. One introduced species roach (*Rutilus rutilus* L.) has been regarded for a long time as a threat to salmonid species because of potential competition for food and space due to their high population density. The present study of the ecological interactions of brown trout and roach in non-polluted Irish lakes using Stable Isotope Analysis (SIA) and gut content analysis (GCA) reveals that in clean waters the two species do not compete for food sources. These results are important for salmonid conservation as well as sustainable management of both coarse and game angling.

### **Economic, social and ecological value of whitefishes on the European North of Russia**

A. NOVOSELOV

*Northern branch of PINRO (SevPINRO)*

Seven species of whitefishes inhabit European North of Russia. There are Arctic whitefish (*Coregonus pidschian*), peled (*Coregonus peled*), Arctic omul (*Coregonus autumnalis*), chir (*Coregonus nasus*), Baltic cisco (*Coregonus albula*), Siberian cisco (*Coregonus sardinella*) and nelma (*Stenodus nelma*). These fishes are traditional objects of commercial fishery in the Barents sea, White sea and Kara sea watersheds. Whitefishes are important for recreational fishery. For example, Arctic whitefish is main subject for winter recreational fishery in the delta of the Severnaya Dvina river. In the ecological aspect whitefishes are unique group which can use as biological indicator for human impact on water ecosystems. Under technogenic influence whitefishes stocks need guard and extended reproduction. For the European North of Russia was designed

program for management of whitefishes stocks. Important part of this program is aquaculture of whitefishes in the large river systems and lakes with using fish hatchery.

### **Fishing tourism, biodiversity protection and regional politics – case of the River Tornionjoki, Finland**

J. SALMI & P. SALMI

*Finnish Game and Fisheries Research Institute, Finland*

Salmon fishery involves a broad range of interest groups and is thus a challenge for fisheries governance. Our paper focuses on the undammed River Tornionjoki between Finland and Sweden, the most important wild salmon (*Salmo salar* L.) river in the Northern Baltic Sea. The marine salmon fisheries have been restricted in order to protect the declining wild salmon stocks and, on the other hand, to secure catches for fishing tourism in the river. The interest groups of the river fisheries have been totally absent from the salmon committees. Consequently they have taken various measures for influencing salmon politics. This social movement has achieved its aims only partly, because of counter reactions by the coastal commercial fishers and their associations. We suggest creating a forum for dialogue between stakeholders in order to reduce the tensions between the commercial fishery and tourism industry.

### **Fishery management in the large lake systems located in the special protected areas of the European north of Russia**

I. STUDENOV

*SevPINRO (Northern branch of PINRO)*

Many special protected areas of nature on the European North of Russia include large and medium lake systems. There are large lake Lekshmozero (54.4 km<sup>2</sup>) and system including 3 large lakes (Kenozero, Dolgoe and Svinoe with total area 68.6 km<sup>2</sup>) situate in the National park "Kenozersky" (Arkhangelsk region). Nosovsko-Luzskaya lake system (about 60 km<sup>2</sup>), including 12 different lakes, locates in the National park "Vodlozersky" (Arkhangelsk region and Republic Karelia). In the landscape reservoir "Kozhozersky" (Arkhangelsk region) place large lake Kozhozero. In the natural reservoir "Nenetsky" (Nenetsky autonomous okrug) locate large lake Golodnaya Guba (186 km<sup>2</sup>). Commercial fishery on all these lakes was earlier, then on various reasons it's stopped. At the present time use of fish resources in the lakes of specifically protected territory is recover. Sport, amateur and scientific fishing are main three directions of modern use of water bioresources in the special protected areas. Identical estimation of total allowable catch (TAC) is the main problem for fishing management which directed on the sustainable use of fish resources.

### **Implementing 'Regional Fisheries Management' In the Mekong Basin**

N. V. MANH

*Chairman, TAB, Hanoi, Vietnam*

The Technical Advisory Body on Fisheries Management in the Mekong Basin (TAB) was established in June 2000. It has four areas of concerns: 1) shared stocks and habitats; 2) external factors impacting on local and national fisheries; 3) shared interests in technical and institutional innovations in fisheries management and development; and 4) global principles of governance. Yet, fisheries management is clearly under the authority of each riparian country. How, then, will 'regional management' be possible? The TAB has two entry points: Uptake of regional concerns in national management and policy-making; and regional networking of national initiatives, where desired outcomes and methodologies applied are agreed and results exchanged by all. As a result, maintenance of critical habitats for regional fisheries, conservation of threatened species, and user involvement in management decision-making, that is, 'regional fisheries governance', are now being discussed at all levels and scales of governments and civil society in the Lower Mekong Basin.

### **Functional vs scenic restoration - challenges to improve fish and fisheries in urban waters**

C. WOLTER

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Urban waters are subjected to multiple uses and thus, typically characterized by higher pollution, nutrient and temperature loads, as well as degraded habitat structures. Fisheries management is commonly restricted to stocking, whilst the European Water Framework Directive (WFD) aims at establishing naturally recruiting diverse fish assemblages. What are the most efficient management ways to meet the WFD requirements?

Two restoration measures, one in urban Berlin and one in the rural vicinity, have been compared according to their fish ecological efficiency. This study aimed to assess the feasibility of successful environmental improvements for fish in urban waters. If the underlying basic bottlenecks have been identified, artificial structures could provide functionally similar fish habitats replacing the natural equivalent in urban river stretches. It was hypothesized, that especially the most heavily degraded waters provide opportunities to improve fish diversity and fisheries very efficiently by artificially improving habitat structures at comparably low efforts.

### **Session on socio-economic interactions**

#### **Examining changes in participation in recreational fisheries in England and Wales.**

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Inland fisheries in England & Wales have a high economic and social value. Managing participation to maximise fishery performance is key to maintaining this status. Atlantic salmon (*Salmo salar*) and sea trout (*S. trutta*) support important net and recreational fisheries and represent a valuable resource, particularly for rural economies. The value

of these migratory salmonid fisheries is estimated to be £128 (€165) million. Similarly, coarse fish (non-salmonid, principally cyprinids) provide catch and release angling; a pastime which puts £971 (€1250) million spend into the economy. The total declared rod catch of salmon and sea trout over the last five years (2002-06) has averaged 18,953 and 30,117 fish respectively in England and Wales. The central tenet to increasing participation in recreational salmonid fisheries is that an increase in stock size will result in more anglers accessing the fishery. This principle was examined for salmon on two rivers; the Usk (Wales) and Lune (England) where exploitation restrictions resulted in an increase in the number of salmon available to anglers. On the River Lune the number of salmon available to anglers post-intervention increased significantly by 79% ( $P < 0.05$ ). There was no significant increase in catch ( $P > 0.05$ ) while the number of anglers decreased significantly by 20% ( $P < 0.05$ ), compared to the situation prior to the intervention. On the River Usk the closure of the net fishery resulted in potentially an additional ~1120 salmon available to anglers. Following closure of the net fishery the rod catch increased by 17%, while the number of anglers decreased by 11%, in both cases the change was not significant ( $P > 0.05$ ). For coarse fisheries, based on catch & release, increased participation is dependent less upon stock manipulation and more upon facilitating the activity. In recent years, urban fishery development programmes have provided improved access to local fishing opportunity. Also, new anglers have been targeted with such campaigns as Get Hooked on Fishing and the Scout Angler Badge. This paper discusses the above, both in relation to availability of angling opportunities and in a wider context.

### **Reconciling ecological and social objectives in managing European eel (*Anguilla anguilla*) stocks – the angler’s perspective**

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In response to the current decline in the European eel (*Anguilla anguilla*) stocks, the European Union (EU) has recently implemented an eel recovery action plan. Accordingly, each member state is expected to provide a management plan on eel until 2008. One challenge to developing management plans for declining fish resources is accounting for stakeholder preferences, particularly anglers and fishers, to reconcile ecological and social management objectives. To tackle this problem with respect to the declining European eel stocks, a maximum difference conjoint task focusing on management strategies for eel was administered to a random sample of anglers ( $N = 640$ ) in northern Germany. The task’s unique nested structure allowed the estimation of 3 separate preference models: (1) eel angling regulations, (2) multi-sector management, and (3) acceptability of the overall package. Angler preferences conformed to

psychological reactance theory in that regulations restricting other sectors were strongly preferred over those that targeted anglers. Overall, greatest preference was expressed to reduce the commercial fishery effort. Despite the strong opposition towards personal restrictions, anglers supported the overall management portfolio as long as an eel recovery success was assured. In conclusion, managers must expect opposition restricting recreational fishing if the success of such measures is uncertain or management measures are designed that affect anglers exclusively.

### **Socio-economic character and importance of fisheries on Danube between Serbia and Croatia**

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Study of socio-economic aspects of use of fish resources on Danube River between Serbia and Croatia was performed by questionnaire (40 commercial and 309 sport fishermen). Analyses was done by the program SPSS (Statistical Package for Social Sciences) and Statistica 6.0 StatSoft. This work present comparative result on both side of Danube River and contains basic data about fishery sector in Serbia. It presents specific issues related to freshwater fisheries, management, policy, protection, exploitation of fishery resources, legislation, statistics, problems, solutions for future strengthening of the national fishery sector. Socio-economic circumstances leads to intensive fishout and jeopardize fish fund as well as ecological factors. Awareness of economical, social, ecological problems is apparent. Lack of systematic regulation and organization in fishing is the major problem. Attitudes, values, experience and behaviour of fishermen make good base for planning of sustainable development in fishing.

### **Profitability and productivity analysis of fishery enterprises in Lake Durusu (Terkos)**

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In this research, profitability and productivity of 22 inland fishery enterprises were investigated. In this study, Cobb-Douglas production function was applied to input-output data which obtained from these fishery enterprises for 2006-2007. Partial productivity analysis of boat, horse power, labour force, labour day of inland fishery enterprises was made. On the other hand, profitability indexes of same fishery enterprises were calculated.

## **Reconciling the conservation objectives for an endangered endemic freshwater fish with those for tourist development on the island of Rhodes (Greece)**

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Only 11 populations of the endangered fish species, gizani [*Ladigesocypris ghigii* (Gianferrari, 1927)] exist on Rhodes' island. These populations inhabit different natural stream systems (except one that lives in a small water-supply reservoir), but all are threatened during summer when the streams are partially drying up or are reduced to isolated pools. This is mainly because natural conditions (poor rainfall and increased summer temperature) combined with surface- and groundwater ion have contributed to a decline of the island's water resources. It is estimated that about 20% of the island's fresh water is used for agriculture, while the rest goes to domestic consumption, mainly to meet the demands of the flourishing tourism industry. Tourism on Rhodes developed rapidly during the 1990s, reaching 10.8 million overnight stays in 1999 declining to 8.6 millions in 2003. However, tourism now mainly occurs between June and September and to meet the increased demand for water during this period, a large dam (60 million m<sup>3</sup>) is being built (completion projected for 2008) in the biggest stream of the island that supports the most viable gizani population. This drive to support tourism, which is the main source of income for the local residents, is having a detrimental impact on conservation objectives for the endangered gizani populations. This paper reviews the steps being taken to manage the island's water resources sustainably, increasing the public's awareness and ownership of the problems with conservation of gizani and to integrate the conservation policy into the development policy of tourism.

### **The inland fisheries of Central Asia:**

#### **Why Production and Consumption Declined - and Suggested Strategies for Rehabilitating the Sector.**

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The dismantling of the Soviet Union and the corresponding independence of the Central Asian states in the early 1990s had severe economic consequences for the Central Asian Region. The transition from command to free-market economies was (and sometimes still is) accompanied by dramatic contractions in production in virtually all primary resource sectors. However, arguably the most catastrophic and ongoing declines in output were to be found in the fisheries sector. This paper shows how a combination of ecological (most notably the introduction of alien invasive species and pollution), economic (increasing ion of water for irrigation and power generating purposes), social (increased impoverishment following the removal of employment guarantees) and governance (collapse of local management structures) affected fisheries production and

consumption in the Central Asian transition economies. In the light of these findings, we provide some general observations as how this decline might be arrested or reversed.

### **The review on Turkey inlands in terms of interaction between social, economic and ecological objectives of fisheries and aquaculture**

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Turkey has a rich country in terms of inland resources comparing with many countries. Generally, all of freshwater ecosystems are suitable for capture fisheries and some of them are convenient for the aquaculture. Each of the catch and aquaculture quantity from the inland waters is nearly % 9-10 of the total annual fishery production in some years. It is expected the great contribution to capture fisheries and aquaculture from inland fisheries due to their capacity and rich potentials. Turkey inland resources have quite range varieties in terms of water quality, trophic status, altitude, climate ecosystem diversity, species diversity etc. Inland resources inventory of Turkey is consisted of 26 basins. There are more than 200 natural lakes, 555 dam lakes and 33 long rivers. Within these lakes, 48 lakes have surface area larger than 500 ha. South Marmara, Lake District, East Anatolia, GAP Region and Lagoon Lakes are represented the main fishing grounds. Turkey inland fish fauna is consisted of 236 species and subspecies which belong to 26 families. Cyprinidae is represents by 116 species (% 49) within Turkey fish fauna. In terms of fish fauna protection status; 102 of them are under the IUCN Red List categories. Recently, eutrophication and water pollution are raising problem for inland waters in Turkey. The social, economic, ecological interactions in terms of fisheries and aquaculture are reviewed within the Turkey inland waters in this presentation.

## **Posters**

### **Estimation of the phosphorus loads caused by cage-cultured rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) farms in Kesikköprü Reservoir, Turkey**

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Aquaculture in freshwater and marine environments is a rapidly developing sector in Turkey, and trout is the major fish species used for cage culture in freshwater systems. According to official records indicate that there were 72 cage farms in reservoirs, with an annual capacity of 4,777 t in 2004. Five rainbow trout cage farms with capacities varying between 15 and 50 t, exist in Kesikköprü Reservoir, one of the inland water areas in Turkey where cage culturing has been performed. This study intended to estimate the phosphorus loads released to Kesikköprü Reservoir from five different

rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) cage farms, which are using pelleted and extruded feed, from April to July 2006.

Phosphorus loads from cage farms during the on-growing season using pellet and extruded feed was estimated according to Ackefors and Enell (1990). Moreover, we compared the phosphorus loads results from cage-cultured and external inputs in the Kesikköprü Reservoir.

### **Some biological characteristics of *Chalcalburnus mossulensis* Heckel, 1843 from Atatürk Dam Lake (Turkey)**

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Being the most important part of the South Anatolian Project, Atatürk Dam Lake with 48 700 hm<sup>3</sup> water deposits and 817 km<sup>2</sup> surface area, is representing very high potential for fishery. Besides of this potential, there are several species coming from naturally Euphrates River. There are about 28 species belonging to 8 families in this basin. The most important species are *Silurus triostegus*, *Acanthobrama marmid*, *Aspius vorax*, *Barbus rajanorum mystaceus*, *Barbus xanthopterus*, *Capoeta capoeta umbla*, *Capoeta trutta*, *Carasobarbus luteus*, *Chalcalburnus mossulensis*, *Chondrostoma regium*, *Cyprinus carpio*, *Leuciscus cephalus orientalis*, *Leuciscus lepidus*, *Tor grypus* and *Liza abu*. In this study some of the biological characteristics of *Chalcalburnus mossulensis* Heckel, 1843 were investigated. Totally 641 specimens were captured monthly by means of gillnets between March 2004 and February 2005. The aim of this study was to determine some biological characteristics such as sex composition, growth in length and weight, length-weight relationships, relationships between total, fork and standard lengths, condition factor, spawning time, and time of sexual maturity of *C. mossulensis* in the dam lake under consideration.

### **The accumulation of heavy metals (Cd, Pb, Hg, Cr) and its state in phytoplanktonic algae and zooplanktonic organisms in Abant Lake -Turkey**

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As Phytoplanktonic dominant algae determined *Choroococcus*, *Microcystis*, *Oscillatoria*, *Spirulina*, *Anabaena*, *Plectonema*, *Euglena*, *Trachelomonas*, *Dinobryon*, *Botryococcus*, *Oocystis*, *Scenedesmus*, *Stigeoclonium*, *Cosmarium*, *Spirogyra*, *Zygnema*, *Oedogonium*, *Cyclotella*, *Melosira*, *Amphora*, *Asterionella*, *Cocconeis*, *Cymbella*, *Diatoma*, *Fragilaria*, *Gomphonema*, *Gyrosigma*, *Navicula*, *Nitzschia*, *Pinnularia* and *Synedra* in Abant Lake. As zooplanktonic dominant organisms determined *Filinia longiseta*, *Synchaeta pectinata*, *Synchaeta littoralis*, *Daphnia*

*longispina*, *Diaphanosoma brachyurum* and *Acanthodiptomus denticornis* in Abant Lake. They widely adapted taxon on the state of an aquatic environment. Abant Lake is two shallow lakes that are under environmental protection status. Accumulation of heavy metals (Cd, Pb, Hg, Cr) in the water and plankton of Abant Lake was studied seasonally, during from April 2000 to December 2002. Higher concentration of all heavy metals was recorded in plankton. Hg was found in lowest and Pb in the highest correlation, however, the concentration of each metal varied seasonally. In addition, the seasonal changes in phytoplankton and zooplankton populations and species abundance were also determinate. Some physical–chemical parameters of water and their correlation with heavy metals were also examined.

### **The Effects of saponin on enzyme activities, hsi and growth rate of rainbow trout (*Oncorhynchus mykiss*)**

M. BAYIR

*Muhammed Atamanalp Ataturk University, The Faculty of Agriculture, Fisheries Department, 25240, Erzurum, Turkey*

Saponin is the active matter of *Verbascum* plant which used in fisheries in East Anatolia of Turkey, utilizing with the anesthetic specifications of plants. In this study the effects of saponin on the enzyme activities (GR and G6PD), hepatic-somatic index and growth rate of rainbow trout were researched. Fish were fed with the two doses of saponin (150 mg kg<sup>-1</sup> and 300 mg kg<sup>-1</sup>) added feeds for 45 days. At the result of the experiment; decrease obtained in all parameters, GR and G6PD enzyme activities, HSI and live weight gaining of rainbow trout according to the doses.

### **The quality properties and management of trout farms effluents**

L. BEYHAN

*Ministry of Agriculture and Rural Affairs, Agricultural Production and Development General Directorate, Aquaculture Department , Ankara, Turkey*

The objective of this study is to draw attention, in the scope of the Turkey's accelerating EU integration activities, to the quality properties of the effluent of trout farm in aquaculture production and environmental interaction and to inform about the methods concerning their management .In this context, depending on the capacities of enterprises, necessary arrangements related to the distance between them should be made and limitations to effluent and its load should be set and put into practice. Constructed wetlands should be constituted, in the places where terrain enables. Feed management concerning the development and use of extrude high-energy feeds should be carried out. The use of antibiotic and chemicals of enterprises should be limited and inspected. The obligation for purification of the effluent of enterprises by transferring through sedimentation ponds, before disposing it into receiver environment should be brought and sedimentation process should be applied to purify phosphorus from waste water.

## **Research on age determination and some population characteristics of chub (*Leuciscus cephalus* L.) in the Çamlidere Dam Lake (Ankara, Turkey)**

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In this study, reliable bony structure for age determination and some population characteristics of 101 chub (*Leuciscus cephalus* L., 1758) from the Çamlidere Dam Lake were investigated between June and August 2006. Different bony structures such as scale, vertebra and otolith were removed from all specimens for age determination and interpreted by three times, independently. Sex composition of population was 71.3% female and 28.7% male. The fork length and weight of specimens ranged 18.5-35.3 cm and 124.40-667.57 g, respectively. Length-weight relationships were estimated as  $W=0.0131FL^{3.0434}$  for females,  $W=0.0142FL^{3.0186}$  for males and  $W=0.0138FL^{3.0276}$  for all individuals. Condition factors of females, males and females+males were calculated as 1.54, 1.51 and 1.52, respectively. Differences between condition factors of females and males were not statistically significant ( $P>0.05$ ).

## **The effect of trout aquaculture facilities on water quality of Kanlıçay stream (Çameli/Denizli)**

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In this study, physicochemical and microbiological parameters of Kanlıçay Stream were investigated to determine the effects of trout aquaculture facilities on water quality. Along this stream, there are 93 trout aquaculture facilities, many of which do not have any clearing pool systems. Five stations were selected on the Kanlıçay Stream according to densities of aquaculture activity. Water quality parameters in each station were measured monthly from January to December 2007. Minimum and maximum values of measured physico-chemical parameters in Kanlıçay Stream were determined in the following ranges (respectively): flow rate, 65-9548 l/sec.; turbidity, 0.15-101.00 NTU; conductivity, 208.00-538.00  $\mu$ mhos/cm; pH 7.55-9.30; temperature, 6.20-18.90 °C; dissolved oxygen, 5.84-10.50 mg/l; chloride, 3.00-22.00 mg/l; organic matter, 1.58-46.86 mg/l; bicarbonate, 73.20-305.00 mg/l; carbonate, 0.00-7.20 mg/l; hardness, 15.00-44.00 °F; calcium, 28.05-95.14 mg/L; total nitrogen, 0.03-3.00 mg/l; ammonia, 0.001-0.69 mg/l; nitrate, 0.94-3.28 mg/L; nitrite, 0.002-0.018 mg/l; ammonium, 0.05-1.53 mg/L; sulphate, 3.00-44.00 mg/l; phosphate, 0.02-1.26 mg/l; acid binding ability, 2.00-6.40 ml acid, oxygen saturation, 56.70-92.00 %; total hardness, 11.00-309.00 mg/l; biochemical oxygen demand, 2.00-14.00 mg/l; chemical oxygen demand, 15.80-38.50 mg/l; chlorine, 0.01-0.87 mg/l; magnesium, 11.20-70.50 mg/l; sodium, 49.00-82.00 mg/l and potassium, 2.00-2.20 mg/l. In generally, it was found that the water quality in the upstream stations was appropriate for trout aquaculture and water was not polluted. On the other hand, in the downstream stations, organic pollution was observed on account of dens trout aquaculture activity as determined by analyses of water quality

parameters, and the level of pollution was higher than the limits proposed by EC Directive for the protection of fish.

### **Histopathology of the tissue of a tubificid worm (*Limnodrilus hoffmeisteri*) exposed to cadmium**

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Although, cadmium is not an essential element for any organism, oligochaetes especially Tubificid worms accumulate large concentrations of cadmium like other freshwater specimens. In addition, some species such as belonging to *Limnodrilus* genera use indicator organisms. The aim of this study is to examine histopathological alterations induced experimentally with cadmium in tubificids worm (*Limnodrilus hoffmeisteri*) exposed for different times and concentrations were compared to controls. Live specimens were collected at 3 sampling sites from Porsuk River. Samples exposed to the contaminant for short periods 6, 12, 24, 48 and 72 h at two different concentrations 0.25 and 0.5 mg/L. Samples were embedded in paraffin blocks and were cut at 5 µm on a microtome. All sections were stained using Hematoxylin & Eosin. Our results showed that no differences (6, 12, 24, 48 h) compared with controls. However after 72 h exposure results showed differences.

### **Conservation sturgeon culture in the Azov and Black Seas basin: achievements, constraints and prospects.**

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Stock enhancement is the main source of *Acipenser gueldenstaeddi* and *A. stellatus* recruitment in the Sea of Azov and Black Sea (30 million juveniles have been released). The hatchery production strategy aimed solely to produce and release the largest possible number of juveniles, utilizing only the most mature brood fish of the spring spawning run. The spawning run was dramatically shortened from several months to just 15 days, and includes only females with advanced gonadal maturity. Conservation of the Azov and Black Seas sturgeon species and their unique spawning ecotypes is currently supported by the Federal Living Gene Bank, which maintains over 12,000 adults of seven critically endangered species. This paper summarizes the results of comparative analysis of biological characteristics such as growth, age of the first sexual maturation, relative fecundity, and morphological and physiological indices in wild and cultured specimens of different species and intraspecific groups of sturgeons. It is shown that there is a need for developing better hatchery technologies to maintain diversity of the stocks, through breeding protocols that maximize the genetic diversity of offspring based on evaluation of parentage and relatedness in farmed stocks by microsatellite loci.

## **CSan River „Catch and Release” fly fishery as a new form of rivers exploitation in Central and Eastern Europe.**

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Angling is very popular form of recreation in Poland. The number of anglers is estimated as 2 million, app. 5.3% of total population. In this approximately 600 000 are members of Polish Angling Association. Until the late 1990s, they usually visited “natural” waters like rivers or lakes, obtained fish were taken for consumption, and even not far ago were important part for household budget. This situation has been changed after political and economical changes, and for last decade more and more anglers in Poland is searching for good quality commercial fisheries. However, as “put and take” fisheries are very common in Poland now, number the of “catch and release” fisheries is very limited. This refers specially rivers. In 2004 Regional Unit of Polish Angling Association in Krosno, Southern Poland, opened first “catch & release” fly fishery on San River. The fishery is famous because of grayling and some brown trout as well. From present perspective this “enterprise” could be evaluated as very good. Four persons were employed as “guards and guides” directly at the fishery. The fishery also creates local demand for tourist accommodation and fishing tackle. Carefully protected area of the fishery is now a reservoir of good quality grayling and brown trout spawners, and generates profits from restocking material production. What is also very important natural reproduction of mentioned species takes place, and increasing number of grayling in San River, down to the fishery, is observed year by year.

However, the example of San River fly fishery, successfully established in 2004, proofs general statement that this kind of natural waters exploitation is very good solution only when certain level of economic development of the society is attained.

## **Effect of dietary supplementation commercial probiotic (Protexin™) on growth and survival of narrow-clawed crayfish(*Astacus leptodactylus* Esch.)**

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The aim of the study was to determined the impact of commercial probiotic (Protexin™) on growth and survival of narrow-clawed crayfish. The two month rearing period was carried out in 600 L tanks(water level 30 cm). The tanks were stocked with crayfish with an average body length of 8.19±0.6 cm and weight of 14.37±2.97 g. The crayfish were stocked in tanks as 15 individuals and the artesian water heated from 12°C to 20±1 °C) was delivered to tanks. The experiment was constituted two groups. Control group were fed with trout feed (49 % protein, % 19 lipid) and the other group were fed with same trout feed added Protexin™ (0.1%) during 60 days. There was no significant effect of Protexin™ usage on growth (P>0.05). Survival rates in control and the other group were determined 40 % and 46.6 %, respectively.

## **Determination of cadmium levels in lake water, sediment, meiobenthos (Chironomidae) and three fish species from Lake Uluabat (a Ramsar site in Turkey)**

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Metals of natural and anthropogenic origin in surface water of aquatic systems can exist in dissolved form or associated with suspended particulate materials. The accumulation of elevated metal concentrations in sediment of aquatic environments can result in biological impact. Lake Uluabat (also known as Lake Apolyont) is one of the most Important Bird Area (IBA) not only in Turkey but also in Palearctic region, have eutrophic freshwater lake on the South side of the Sea of Marmara. Concentration of cadmium was measured in abiotic [lake water (n=80), sediment (n=80)] and biotic component [meiobenthos (Chironomidae larvae, n=80) and some tissues (gill, liver and muscle) of three fish species *Esox lucius* (n=25, age=3-5), *Carassius gibelio* (n=30, age=3-5) and *Scardinius erythrophthalmus* (n=32, age=3-4)] of food chain between August 2004 and July 2005 from 12 sites within the Lake Uluabat. In addition, results for levels in samples were compared with Turkish and international water quality guidelines, as well as literature values were reported. The cadmium concentration in the lake water, sediment and Chironomidae larvae were found as in the range of trace-0.025 mg L<sup>-1</sup>, trace-14 mg kg<sup>-1</sup>, 0.22-13.69 mg kg<sup>-1</sup> respectively. The metal concentrations found in the tissues of the three fish species varied considerably. The accumulation order of lead in fish samples for liver was found to be *Scardinius erythrophthalmus* > *Carassius gibelio* > *Esox lucius*; for muscle *Scardinius erythrophthalmus* > *Esox lucius* > *Carassius gibelio*; for gill *Esox lucius* > *Carassius gibelio* > *Scardinius erythrophthalmus*. Cadmium from various pollutant sources were observed to accumulate in the lake. The results emphasize the need for monitoring in order to improve the water quality management in this lake.

## **A study on demographic structure of trout farmer workers in Fethiye region at Muğla**

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The total fisheries production is approximately 130 million tones year<sup>-1</sup> in the world. World aquatic production in 2006 is about 52 million tonnes (excluding aquatic plants). Production of aquaculture Turkey reached 128.943 tonnes in 2006. The share of aquaculture in total fisheries production has reached to 24,2 % in 2006 compared to 6% in 1996. There are 77 trout farms, where 57 are at Fethiye, in Mugla. These farms of total aquaculture capacity are 8255 tones/year. Fethiye region is leader for the trout farming, whatever quality of aquaculture for trout or number of the trout farms. In the Fethiye region, trout aquaculture was begun at the 1982. In this study, surveys wee

carried out on trout farms, workers and their employers. As a result of these data to be detected of the workers, works trout farms in Fethiye region, of demographic structure.

### **Effects of microalgae added diets on fatty acid composition of European Sea Bass (*Dicentrarchus labrax* L., 1758) juveniles**

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There are few studies on nutritional value of microalgae in marine fish diets. The effects of PUFAs (Polyunsaturated Fatty Acids) enriched microalgae included diet on fatty acid composition of European Sea Bass (*Dicentrarchus labrax* L., 1758) juveniles was investigated in this study. One thousand juveniles of which initial mean weight was  $4.28 \pm 0.05$  g. were fed during 60 days. Fish were fed with one control and one experimental diet included 10% microalgae powder (Algae Rich). Mainly, 16:0, 16:1, 18:0, 18:1n-9, 18:2n-6, 20:5n-3 (eicosapentaenoic acid, EPA), 22:6n-3 (docosahexaenoic acid, DHA) fatty acids of feeds and fish fillets were examined. DHA/EPA ratios in fish fillets observed both for the control groups and the experimental groups were found as 1.83 and 1.81 respectively. These results indicate that microalgae added diet supported n-3 and n-6 fatty acids levels of sea bass juveniles. EPA and DHA levels in the feeds were found adequate for sea bass juveniles.

### **Inland Aquaculture in Turkey**

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Turkey's inland resources are varied in terms of water quality, trophic status, altitude, climate, ecosystem diversity and species diversity. Turkey provides high potential for fisheries and aquaculture with 8333 km cost line, and more than 200 natural lakes of these, 48 lakes have a surface area larger than 500 ha and total 33 rivers with their 177 000 km length. Finally, total available water surface area reach to 25 million ha. Total fishery production was 662.103 t in 2006. This is comprised of 489.079 t from marine fisheries (73% of the total), 128,943 t from aquaculture (20% of total), 56,694 t inland fisheries (9% of the total). At the beginning, inland aquaculture sector focused on carp production. In the last decades trout production became more popular instead of carp because of the low consumption and high production of carp from wild sources. Total inland fish farms are 1.187 number with 57 170 t production capacity per year. 171 farms operate in cage culture, 995 numbers of them are land based culture

### **Replacement of commercial fish meal with sand smelt meal (*Atherina boyerii* Risso,) in fish diets**

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During the past decades, rapid increment has occurred in feed manufacture industries due to improvements in aquaculture knowledge and production technologies. The use of fish meal in different areas as well as aquaculture has increased demands of this feed ingredient. Recently a sharp decrease has observed in the capture of fish used as fish meal source. Due to these problems, the mentioned demands could not be compensated and a seeking for alternative protein sources commenced. Therefore, experimentations on the use of plant protein sources were realized but the complete replacement of animal protein sources with vegetal ones found to be inconvenient for at least some cultivated fish species. On the other hand, sand smelt (*Atherina boyerii* RISSO, 1810), a species abundant in fresh and marine Turkish waters seems to have a good potential to be used as ingredient in commercial feed because of its continuous supply, low price and preference for human consumption. As a result, the use of this fish meal as an alternative protein source in stead of commercial fish meal is evaluated in this study.

### **Effects of three Carassius (Cyprinidae) species [*C. auratus* (L.), *C. carassius* (L.) and *C. gibelio* (Bloch)] in the inland waters of Turkey.**

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Information concerning the distribution, life history and biology of the three carassius species, along with its uses by humans and impacts to aquatic ecosystems was compiled. These species can impact, directly or indirectly aquatic macrophytes, water quality and aquatic fauna. This information is used to understand invasion problems of Carassius genus in Turkey.

### **Recirculation aquaculture systems using for the brown trout egg incubation**

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*Central Fisheries Research Institute*

The aim of this study is to compare of the brown trout egg incubation performance differentiation, between recirculation aquaculture system (RAS) and open system. Recently, because of the increasing demand to spring water resources and need to freshwater of RAS systems is very low, using of RAS in aquaculture is highlight in the worldwide. Incubation of trout eggs in the RAS will be able to a model for mainly rainbow trout and brown trout in the Eastern Black Sea Region of Turkey, which has low spring water, whereas it has high potential for inland and sea cage trout farming. Since the escape of individuals from RAS is completely prevented, there is not negative effect on wild population. The success of the incubation was compared between the open system used spring water and closed system used UV, physical and biologic filters.

## **Study about nitrogen and phosphorous release into an Italian river coming from an intensive Italian farm: comparisons between laboratory and field research**

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The aim of the research was the evaluation of the quantity of nutrients (nitrogen and phosphorous) released from an intensive trout farm in a small river of the Italian central Appennine. Fish production, feed administered and water quality were monitored from the farm. In laboratory, the farming conditions were reproduced with help of some metabolic devices. At the end of experiment the feed consumption, the nitrogen and phosphorous retained and released were compared in the two different conditions. Other parameters (initial and final fish mean weight, unitary and total biomass, specific growth rate and food conversion rate) were monitored. All the data were evaluated in order to determine the impact of the nutrients on this inland water body.

## **Plasmatic and tissular parameters as indicator of welfare status of rainbow trout (*Oncorhynchus mykiss*) reared in intensive and extensive condition**

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The work aimed to determine the welfare status of rainbow trout, weighing  $50 \pm 15$  g, intensively reared in two concrete raceways at different stocking density until the commercial size so to reach final load of  $40 \text{ kg/m}^3$  and  $20 \text{ kg/m}^3$ , respectively. Throughout the fattening phase, plasmatic parameters and hepatic glycogen content were determined at seasonal intervals and compared with those of rainbow trout at the same age and mean weight, reared in extensive condition in an artificial reservoir. The results of the present work show that the final load reached at the end of the trial provided significant differences of the monitored parameters between rainbow trout reared in raceways and those held in the reservoir.

## **Concentrations of some heavy metals in water, sediment and tissues of two fish species (*Cyprinus carpio* and *Carassius carassius*) from the Geyik Dam Lake (Southwestern-Anatolia), Turkey**

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The concentrations of heavy metals (Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn) were measured in the water, sediment and tissues (muscle, gill and liver) of two fish species

(*Cyprinus carpio* and *Carassius carassius*) from the Geyik Dam Lake, Turkey. Results for levels in water compared with national and international water quality guidelines, as well as literature values were reported for streams and rivers. Comparisons were made of metal concentrations in water and sediment with those in the muscle, gills and liver of *Cyprinus carpio* and *Carassius carassius* caught from the Geyik dam Lake.

### **Non-governmental fisheries organizations in Turkey**

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There have been a couple of fishery organizations such as fishery cooperatives, unions and associations in Turkey.

There are currently 522 fisheries cooperatives, 13 cooperatives unions ( East Black Sea, Sinop, Samsun, İstanbul, Marmara, Balıkesir, Çanakkale, İzmir, Muğla, Antalya, Adana, Mersin, Hatay Regional Unions) and one central cooperative union representing the catching sector and aquaculture sector has 11 fisheries aquaculture producer unions.

Furthermore, there are one Fishery Federation and 5 societies and associations representing any kind of fishery and aquaculture sector. These are; Fisheries Advertisement Society, Aquaculture Association, Muğla Aquaculture Union Association, Aquaculture and Fisheries Association and Bluefin Tuna Culture and Export Association.

### **Mortality ratio and stock analysis of vimba (*Vimba vimba tenella* (Nordmann)) population in Karacaoren I Dam Lake (Burdur-Turkey)**

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In this study, 808 vimba (*Vimba vimba tenella* (Nordmann, 1840)) individuals captured during October 1996- April 1998 from Karacaören I Dam Lake and mortality ratio and stock size were estimated. Age distribution of *V. v. tenella* varied from 0- VII and 73.51 % of the investigated samples was belong to I- II age group. The fork length was ranged between 11.7- 27.8 cm. The growth parameters of vimba population were found as  $L_{\infty} = 43.39$  cm,  $K = 0.0863$  and  $t_0 = -4.7615$ . The mortality rates of vimba, according to constant parameter system were calculated as;  $Z = 0.71 \text{ y}^{-1}$ ,  $M = 0.27 \text{ y}^{-1}$  and  $F = 0.44 \text{ y}^{-1}$ . The survival rate of the vimba is determined as 49.16 %, exploitation rate as 62 %. Mean number and mean biomass of fish, bigger than 18 cm length, in population have been estimated as 762328 and 95044 kg respectively. With the simulations of fishing mortality rates belong to each length group, it was determined that maximum sustainable yield (MSY) could be obtained with increase 40 % increase of the present effort.

**Distribution, population estimation and economical importance of medicinal leech, *Hirudo medicinalis* (L. 1758, Hirudinidae) in Eastern Anatolia, Turkey**

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The medicinal leech (*Hirudo medicinalis*) is used intensively in the medical industry and is listed in Appendix II of the 1987 *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) because of recent decreases in populations due to environmental pollution, and its common trade between countries. In this study, the distribution, population size and economic importance of medical leech in the Eastern Anatolia Region of Turkey was assessed. Samples were collected using a modified unit square design, used for the first time in this study. Medicinal leeches were found in 22 out of the 87 wet field sites studied. The total surface area of wet field sites surveyed was 599642.5 ha, but sites at which leeches were found comprised only 8784.77 ha (i.e. 1.46% of the total wet field area). We estimate that 10.58% (63414.6 ha) of the total wet area surveyed would provide suitable habitat for leech introductions.

**Changing socio-cultural basis for governance interactions: Images of good recreational fishing practices in Finland**

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Transitions in fisher groups, fishing practices and management reflect general changes in the society. During the last decades people's images of good practices in fishing have changed in many countries. In Finland two million recreational fishers operate in various environments from the Baltic coast to lakes and rivers. Fishing has changed from subsistence-based towards more leisure-oriented activities. The use of rod fishing gear has increased, but gill nets and wire traps are still weighty methods. Lately the protection of biodiversity has become an important motivation in management, but the traditional idea of keeping fish stocks abundant for harvesting purposes has kept its position as a vital paradigm. Also the contradictory animal welfare issues are increasingly emphasized. Catch-and-release has gained some popularity during the 1990s, but still more than one half of all Finnish recreational fishers consider it to be pointless torture of an animal. Although the thrill of catching a fish has become more important than retaining the fish for consumption, keeping the caught fish for consumption is not underrated. The starting point of this presentation is that debates about "good" and ethical recreational fishing practices – whether related to catch-and-release, gill net or other fishing - reveal and foster changes in fishing culture and governance. The analysis bases on a collection of reports, newspaper articles and other material.

## **Pond fish farming in the district of Savran in South-Western Region**

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There are several types of pond currently used in aquaculture as using the natural topography of the land. Savran River is in south-western part of Anatolia, where an intensive aquaculture methods in pond are made. The pond is made by means of the construction of the fish farm facility in which the underground and river water are used. The measured values determined for salinity are 0,610% (underground) and 0,115% (river water). In this area, pond aquaculture is carried out by means of purpose-built earthen ponds, generally with water supply and drainage infrastructure incorporated, in order to grow fish such as sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). Also, synthetic pond liners are being used to provide better control on mud-bottom ponds. Brackish water ponds are used for commercial aquaculture production and are the most common in this area. After one and a half year, the 0.1-10 g weight of fingerlings of sea bream and sea bass have grown out in the farming and reached a final market size of 350-410 g and 530-680 g respectively. From this pond, approximately 10 t/ha/year of fish was harvested. In a farm in this region, fish, turbot (*Scophthalmus maximus*) and sturgeon (*Acipenser güldenstaedti*), are also raised in concrete construction, which has been thrown into this construction a year ago, but not harvested yet. The methods of aquaculture in pond have shown that the growth rates of sea bream and sea bass in Savran are higher than the cage aquaculture in the sea. The sophisticated fish farming procedures as related to aquaculture in ponds demand a more manageable and controlled environment. We observed that some advantages of pond culture can be listed as (a) relatively cost effective, particularly if gravity fed and drained, (b) provide some control over growing conditions (*e.g.* nutrient inputs), (c) minimises loss of stock through escapement or predation compared to more extensive operations. Some disadvantages of pond culture can be listed as (a) high land requirement and construction costs (b) little control over ambient environmental conditions (*e.g.* temperature), (c) stock management may be difficult.

## **Body composition and fatty acid profiles of rainbow trout (*Oncorhynchus mykiss* W., 1792) and Russian Sturgeon (*Acipenser guldensteadtii*) fed different experimental feeds**

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Fish oil is the main lipid for energy and essential fatty acid source in commercial aquaculture feeds. Whole body composition and amount of fatty acids of rainbow trout and Russian sturgeon fed the feeds included fish oil; soybean oil and sunflower oil were studied. Rainbow trout juveniles having approximate initial weight of 5.78±0.09 g were fed by experimental feeds included different kinds of oil during 60 days. The fish was fed by a commercial trout feed added different kind of oils with a ratio of 10% and containing approximately 43.5% crude protein, 14.0% crude lipid. Russian sturgeon

juveniles having an approximate initial weight of  $27.23 \pm 0.98$  g were fed experimental feeds containing different kinds of oil for 63 days and the effects of the feeds on fatty acid composition of the fish were studied. The experimental feeds contained 43.79% crude protein and 13.98% crude lipid. At the end of the feeding trials with rainbow trout, whole body fat contents were found 6.1% in the fish oil group, 5.3% in the sunflower group and 5.9% in the soybean oil group. There is no big difference among the groups regarding to lipid accumulation in the liver. At the end of the feeding trials with Russian sturgeon, whole body fat was found 4.65% in the fish oil group, 5.19% in the sunflower oil group and 4.73% in the soybean oil group. Growth performance parameters (HSI, VSI, FCR and SGR) varied significantly among the groups ( $P < 0.05$ ). The fatty acid composition analyses showed that total n-3 and n-6 in the whole body fatty acids and the liver fatty acid contents of fish fed feeds contain different kinds of oil were significantly different ( $P < 0.05$ ). Naturally, in the groups fed vegetable oil, the ratio of total n-6 fatty acids was higher than that in the fish oil group and in the group fed fish oil, the n-3 fatty acid ratio was higher than that in the vegetable oil groups for two species. These results suggest that rainbow trout and sturgeon require both n-3 and n-6 fatty acids and accumulation of these fatty acids in the flesh and liver was affected by fatty acids in the feeds. Therefore, it is possible to use a certain amount of soybean oil or sunflower oil instead of fish oil in rainbow trout and sturgeon diets.

#### **Certain population characteristics and reproductive biology of freshwater mussel *Unio terminalis delicatus* (Lea, 1863) in Gölbaşı Lake (Hatay), Turkey**

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In this study, some growth and reproductive characteristics of *Unio terminalis delicatus* were investigated in Gölbaşı Lake (Hatay). *U. terminalis delicatus* were collected in Gölbaşı Lake and some growth and reproductive parameters were determined. Mean length, width, height and weight were  $7.82 \pm 0.52$  cm,  $3.98 \pm 0.26$  cm,  $2.88 \pm 0.24$  cm and 42.28 g, respectively for the individuals obtained from the lake. Gonadal development of *U. terminalis delicatus* occurred between December and February and glochidia were released in January and February. Length at first maturity was 6.10 cm for male and 6.00 cm. for females. The mean wet meat rate for male and female individuals was 29.16 % and 29.33 %.

#### **Growth performance and biochemical composition of the freshwater mussel *Unio terminalis delicatus* (Lea, 1863) in the Gölbaşı Lake, Turkey**

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The effects of four stocking rates (20, 40, 60, 80 / m<sup>2</sup>) on growth performance of the unio terminalis delicatus were investigated. At the end of 6 month growing period, highest growth was obtained at 40 individuals/m<sup>2</sup>, while best condition factor was acquired at 20 individuals/ m<sup>2</sup> with the spats having on initial size of 0.73±0.03 g. Specific growth rate for length and weight were highest in June and July. The results indicated that the water could be classified as clean when the levels of nitrite (NO<sub>2</sub>), nitrate (NO<sub>3</sub>), ammonia (NH<sub>3</sub>), phosphate (PO<sub>4</sub>) and chemical oxygen demand (COD) were taken into account and that organic matter level was appropriate. Calcium (Ca) level was lower in the area where mussels were mostly located. The results of proximate composition of *U. terminalis delicatus* are determined in this study. The ratio of crude protein, humidity, crude ash, and lipid were 7.99, 86.14, 3.44 % and 1.51%, respectively.

### **The influence of environmental information richness during early ontogenesis on bream's (*Abramis brama*; Cyprinidae) behavior formation**

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The feeding behavior of bream (*Abramis brama*) yearlings kept before the experiment (four months post hatch) under different conditions has been studied. Three variants of conditions, varied in their levels of informational richness, were modeled for keeping young fish prior to the experiments: 1—minimal richness, mimicking conditions of standard commercial hatchery containers; 2—the conditions enriched by a water current; 3—the conditions enriched by modeled impact of predation and feeding by live food. In the following experiments, the conditions were similar for all three groups. It was revealed that the fish grown under the conditions of Variant 1 had a lower learning ability, higher extent of schooling behavior, and lower efficiencies of feeding and defensive behaviors. Similar traits were described in literature as being typical for the fish grown at standard fish farms. The Variant 2 fish had the shortest adaptation period and most efficient feeding behavior but were lacking the skills of defensive behavior. The fish from the 3rd variant had a medium duration of adaptation period and efficient feeding behavior and possessed well-developed skills of defensive behavior. The results have shown that the level of environmental information richness during fish early life stages plays a crucial role in further development of the most important adaptive forms of behavior. Maintaining the young fish in containers with water current facilitates swimming performance and development of feeding behavior. However, such fish, in fact, lack the skills of defensive behavior.

### **Economical And social value of the White Sea offshore fishery for the Arkhangelsk Region (Russia)**

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*SevPINRO (Northern branch of PINRO)*

There are 11 fishing collective farms located on the southern and eastern coast of the White sea in the borders of the Arkhangelsk region. Total population of these villages is

about 5000 people. The biggest fishing collective farms are "Sever" (Dolgoshelye village), "Osvobozhdenie" (Koyda and Mayda villages), "Lenin" (Tamitsa and Kyanda villages) and "Soyana" (Soyana village). The main activities of these farms are coastal fishing, sealing, sea weeds gathering, farming and forest industry. The main subjects of coastal fishery are salmon, humpback salmon, herring, navaga, smelt and flatfish. The main method of fishing is fishing with using of fish traps. Total annual catch of Atlantic salmon in this area during last decade is about 20-30 metric t what is about 60% from total Atlantic salmon catch in the Arkhangelsk region. Regional quotas for humpback salmon, herring, navaga, smelt and flatfish are caught here in full size. Shared weight of coastal fishery is 15-30% in fishing collective farms economic. Shared weight of sealing was before about 50% and now is in average 20-30% due to high fees for using of bioresources. Sealing is conducted irregularly depending on subsidies availability. Sea weeds gathering from storm outbreaks are conducted by inhabitants of the southern coast of the White Sea. This activity is not significant in the fishing collective farms economic. According to presented materials the main activity of fishing collective farms is coastal fishery. About 50% of coastal village population is directly connected to fishing and fish processing.

#### **Effects of supplemental lysine and methionine in Broiler diets on weight gain of juvenile carp (*Cyprinus carpio*)**

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A 75-day growth study was carried out to determine the effects of some feeding stimulants on juvenile carp (*Cyprinus carpio*). Lysine (L) and methionine (M) were added to a normal broiler feed as feeding stimulants in different ratios (0.5L- 2M %, 1L-3M %, 1.5L- 4M %, and none as Control). The commercial broiler feed contained 20% crude protein. The experiment, which included 120 juvenile individuals at total, was conducted in triplicate. The fish were initially weighed one by one ( $6.92 \pm 0.11$  g), and then put into 12 cages (50x50x50 cm) of two fiberglass tanks (210x110x60 cm) and fed three times a day (at 08:00, 13:00 and 18:00 h) with the diets weighing 3% of the mean body weight. The individuals were weighed every 15 days and the amounts of the feed were rearranged according to these weighing results. Oxygen, pH and temperature were measured daily. Live weight gain (%), specific growth rate (SGR), feed conversion ratio (FCR) and feed intake (FI) were calculated at end of the experiment. Better SGR and FCR were observed with 0.5L- 2M % inclusion level ( $P < 0.05$ ).

#### **A study on human effect on the brown trout, *Salmo trutta*, populations in three streams of Upper Coruh River, Turkey**

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Objective of this investigation was a primarily study to determine the effect of human activities on brown trout (*Salmo trutta*) in three streams of upper Coruh River, Turkey. Instantaneous annual rate of total mortality (Z), age-length frequency, and Proportional Stock Density (PSD) were used to estimate the effect of human activities. Instantaneous annual rate of total mortality (Z) of brown trout from Anuri, Kan, and Cenker streams were 0.95, 0.96 and 0.74, respectively. The age of fish ranged 0-6 age for Anuri stream and 0-7 for Cenker and Kan streams and dominant age classes were ages 1 (49.5%) for Anuri, 1 (33.2%) for Cenker and 2 (35.8%) for Kan. The longest lengths for Anuri, Kan, and Cenker streams were as 29.9 cm, 26.1 cm and 34.4 cm, and dominant length classes were 9 cm (14%), 8 cm (18.1%), and 13 cm (9.3%), respectively. Values of Proportional Stock Density (PSD) for Anuri, Kan, and Cenker streams were as 6.4, 6.1 and 11.0, respectively. It may be suggested that differences among the streams occurred because of fishing pressure on populations.

#### **A model county for European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*) culturing in the earth-pond: Milas-Muğla**

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Earth-pond or land-based aquaculture is a under controlling fish culture in the land-base except for fish culture in the dam lake, dam, river and the sea. The accomplishment of land-based aquaculture is dependent on bio-ecological demand of the species, structure of ground and characteristics of the water. In 2006 the Turkey production from aquaculture reached about 128.943 t. In this production carp has included 668 t, trout 57.659 t, bream 28.463 t, bass 38.408 t, mussel 1.545 t and others 2.200 t. The Muğla is a locomotive country of Turkey aquaculture which has suitable conditions for aquaculture. In the point of view for land-based aquaculture, the Milas has very intensive production in the fish culture. There are about 92 culture farms and their capacity of about 2.341 t. In this study aquaculture farms has been visited and questionnaires that directed to the culturists prepared with meet the culturists.

#### **Some hemolymph characteristics of narrow clawed crayfish (*Astacus leptodactylus* Esch.) after exposure to sublethal nitrite concentrations**

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Nitrite, an intermediate product of bacterial nitrification and denitrification processes, can build up in the aquatic environment particularly those receiving effluents from

sewage plants and fertilizers. Elevated ambient nitrite concentrations is a potential health problem for crayfish, since it can alter deeply the defence and often stressful. Hemolymph nitrite, total haemocyte counts (THCs) and hemolymph glucose were examined in narrow clawed crayfish (*Astacus leptodactylus*) (30.02±0.69 g) after 24 h exposure to three different sublethal nitrite concentrations (9, 14, 25 mg/L NO<sub>2</sub>-N). The same parameters were also determined after exposed to different sublethal nitrite concentrations (8, 13, 24, 30 mg/L NO<sub>2</sub>-N) with additional environmental chloride. Hemolymph nitrite levels were elevated significantly parallel with water nitrite in both test groups. However, in the nitrite plus chloride-exposed tests, the accumulation of nitrite in hemolymph was relatively low compared to the nitrite-only tests. While THCs decreased following nitrite exposure, in the nitrite with chloride exposed tests THCs increased in high nitrite levels. Hemolymph glucose levels increased after nitrite exposure, independent of environmental nitrite concentrations.





The symposium on Interactions between Social, Economic and Ecological Objectives of Inland Commercial and Recreational Fisheries and Aquaculture, was organized in conjunction with the Twenty-Fifth Session of the European Inland Fisheries Advisory Commission (EIFAC) in Antalya, Turkey, from 21 to 24 May 2008.

The symposium objectives were:

- 1) To review the wide range of socio-economic and ecological interactions between fisheries and aquaculture and the roles of various stakeholders with respect to these interactions.
- 2) To identify where future research should focus and propose measures to decrease interactions that compromise sustainable development and management, and promote interactions that contribute to sustainability.
- 3) To provide information to policy and decision makers to contribute to the general awareness of trends in socio-economic and ecological interactions within and between the sector and other rural sectors.
- 4) To facilitate dialogue between scientists, researchers, fisherfolk, aquaculturists and policy and decision makers on the motives, interactions and interests of stakeholders.
- 5) To advise EIFAC on appropriate management and development measures and tools for inland fisheries and aquaculture in Europe.

This Occasional Paper, in conjunction with a special issue of Fisheries Management and Ecology, represents the proceedings of the symposium. The Report of the symposium was published in 2008 as EIFAC FAO Fisheries and Aquaculture Report No. 871. The symposium made considerable progress towards understanding the interactions between ecological/environmental and socio-economic/governance objectives for fisheries and aquaculture. There was a broad recognition that inland fisheries and aquaculture need to shift from a sectoral view where they are treated in isolation to an integrated, multi-disciplinary systems view.



Ministry of Agriculture  
and Rural Affairs of Turkey

