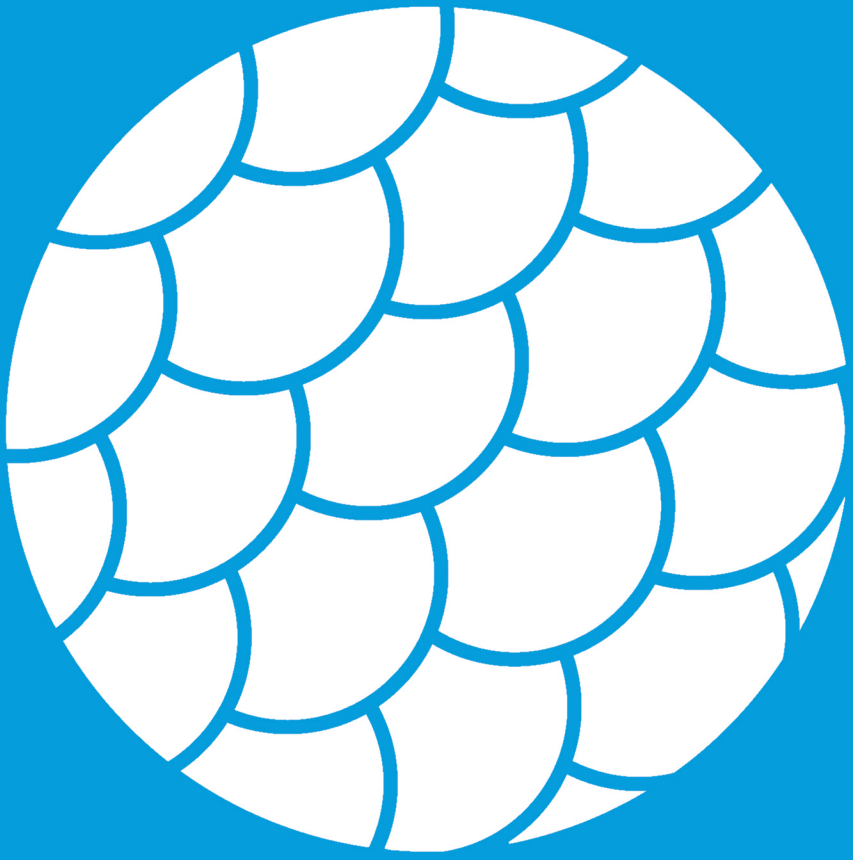
# ECFF 2012

ECOLOGY & CONSERVATION
OF FRESHWATER FISH

INTERNATIONAL CONFERENCE
ON ECOLOGY & CONSERVATION OF FRESHWATER FISH

28TH OF MAY - 2ND OF JUNE 2012
V. N. CERVEIRA - PORTUGAL



## Book of Abstracts

# ECFF 2012

ECOLOGY & CONSERVATION
OF FRESHWATER FISH

28th May – 2nd June 2012

Vila Nova de Cerveira - Portugal

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# PROGRAMME

| | Monday 28th | Tuesday 29th | Wednesday 30th |
|---|---|---|---|
| **08:00h** | | Secretariat opening | Secretariat opening |
| **08:30h** | | **T1 - Ecosystem functioning**<br>Invited Speaker:<br>**Ralf Thiel, DEU** | **T3 - Conservation**<br>Invited Speaker:<br>**Collares Pereira, POR** |
| **09:15h** | | **T1 - Ecosystem functioning**<br>Oral communications | **T3 - Conservation**<br>Oral communications |
| **10:45h** | | **Coffee break** | **Coffee break** |
| **11:15h** | | **T1 - Ecosystem functioning**<br>Oral communications | **T3 - Conservation**<br>Oral communications |
| **13:00h** | | **Lunch** | **Lunch** |
| **14:30h** | | **T2 - Threats to systems and/or species**<br>Invited Speaker:<br>**Garcia-Berthou, ESP** | **T4 - Genetics**<br>Invited Speaker:<br>**A Vollestad, NOR** |
| **15:15h** | Secretariat opening | **T2 - Threats to systems and/or species**<br>Oral communications | **T4 - Genetics**<br>Oral communications |
| **16:45h** | | **Coffee break** | **Coffee break** |
| **17:15h** | Opening session | **T2 - Threats to systems and/or species**<br>Oral communications | **T4 - Genetics**<br>Oral communications |
| **17:30h** | Invited Speaker<br>**A Flecker, USA** | | |
| **17:45h** | | | |
| **18:00h** | | | **Poster session** |
| **18:30h** | | | |
| **19:00h** | **Welcome drink** | | **Art Exhibition** |

| Thursday 31st | Friday 01st | Saturday 02nd | |
|---|---|---|---|
| | Secretariat opening | | **08:00h** |
| | **T5 - Diadromous fishes**<br>Invited Speaker:<br>**Eric Rochard, FRA** | | **08:30h** |
| | **T5 - Diadromous fishes**<br>Oral communications | | **09:15h** |
| | **Coffee break** | | **10:45h** |
| | **T5 - Diadromous fishes**<br>Oral communications | | **11:15h** |
| | **Lunch** | | **13:00h** |
| **Social Programme** | **T6 - Aquatic habitat restoration and Mitigation measures**<br>Invited Speaker:<br>**I G Cowx, GBR** | **VI Minho River basin Iberian Symposium** | **14:30h** |
| | **T6 - Aquatic habitat restoration and Mitigation measures**<br>Oral communications | | **15:15h** |
| | **Coffee break** | | **16:45h** |
| | **T6 - Aquatic habitat restoration and Mitigation measures**<br>Oral communications | | **17:15h**<br>**17:30h**<br>**17:45h**<br>**18:00h** |
| | | | **18:30h**<br>**19:00h** |

# CONTENTS

# OPENING LECTURE

# Fishes as key drivers of ecosystem processes: insights from tropical streams

Alexander S. Flecker

Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY, USA 14853.
asf3@cornell.edu

## Abstract

Fishes can play a fundamental role in shaping the structure and function of stream ecosystems. Here I provide a suite of examples of fishes influencing ecosystem processes in running waters, highlighting our studies in the New World tropics. First, I explore the significance of migratory species as key ecosystem subsidies, not only as material inputs but also as mobile modulators of ecosystem process (Flecker et al. 2010). I show that migratory species such as the flannelmouth characin, *Prochilodus mariae*, strongly modulate biogeochemical cycling of critical elements including carbon and nitrogen. I then address a very different process, seed dispersal, exploring the capacity of frugivorous species such as pacu, *Colossoma macropomum* and *Piaractus brachypomus*, to act as dispersal agents in vast flooded forests of South America. Indeed, we find that pacu can be extremely long-distance dispersal agents due to the abundance of fruit in their diet and slow gut passage time of viable seeds coupled with the high mobility of these fishes (Anderson et al. 2011). I close by discussing some key themes of a research agenda linking freshwater fishes to ecosystem processes. These include the potential for phenotypic variation within fish species to be of sufficient magnitude to be important from an ecosystem perspective, as well as the widespread ecosystem consequences of invasive species. Finally, ecological context is vital for understanding not only the suite of processes that freshwater fishes can control, but the ecological settings where we can expect fishes to be particularly strong ecosystem drivers.

## References

ANDERSON, J.T., NUTTLE, T., SALDAÑA ROJAS, J.S., PENDERGAST, T.H. & FLECKER, A.S. 2011. Extremely long-distance seed dispersal by an overfished Amazonian frugivore. Proceedings of the Royal Society B. 10.1098/rspb.2011.0155. FLECKER, A.S., MCINTYRE, P.B., MOORE, J.W., ANDERSON, J.T., TAYLOR, B.W. & HALL, R.O. 2010. Migratory fishes as material and process subsidies in riverine ecosystems. American Fisheries Society Symposium 73:559-592.

# ORAL COMMUNICATIONS

# Theme 1 - Ecosystem Functioning

*Invited speaker*

# Ecosystem functioning and fish assemblages in European estuaries: important patterns and open research questions

Ralf Thiel

University of Hamburg, Biocenter Grindel and Zoological Museum, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany
ralf.thiel@uni-hamburg.de

## Abstract

To sustain functions and services of estuaries and the other aquatic ecosystems is important for a successful population development and survival of many species including humans. The basis for conserving functioning of estuarine ecosystems is to understand the fundamental set of their characteristics. The analysis of ecosystem functioning of estuaries is a complex issue, which has not been adequately resolved.

Studies in European estuaries during the recent three decades have shown that they can support species-rich assemblages of fishes and fish populations with high abundances. These assemblages and populations have the potential to play an important functional role, e.g., within the estuarine food web. However, many European estuaries are degraded by various human impacts affecting their fish assemblages. In this context, fishes are sensitive indicators assessing the highly variable conditions of estuarine waters over space and time, estuarine habitat quality and loss.

Firstly, the talk summarizes general fish-related aspects important for ecosystem functioning of European estuaries, especially fish species diversity, proportion of habitat use guilds, and fish-ecological functions. Secondly, effects of spatial and temporal dimensions on the structure of the estuarine fish fauna are presented. Thirdly, the importance of fishes within the estuarine food web is described with focus on their predation impact. Fourthly, effects of physico-chemical, morpho-dynamical, trophical and anthropogenic factors on the structure of estuarine fish fauna are presented. Finally, recommendations for further research are proposed.

# Interactions between hatchery fish and wild conspecifics at early-life stages. Effects on mortality, growth and migration

**A. Richard**[1,2], F. Cattanéo[1]

[1] University of Applied Science of Western Switzerland, Earth-Nature-Environment Institute, Route de Presinge 150, 1254 Jussy (GE), Switzerland
[2] UMR CARRTEL INRA, 75 Avenue de Corzent, BP 511, 74203 Thonon, France
alexandre.richard@hesge.ch

## Abstract

Brown trout (*Salmo trutta*) populations have been decreasing over the past 30 years in Switzerland (Fishnetz 2004). Stocking the rivers with 0+ fish reared in hatcheries still remains the most common management practice, even though there are doubts as to the efficiency of these actions on local population dynamics. The increased mortality of farmed versus wild fish is well documented, but other phenomena, such as reduced growth or enhanced migration of fish from both origins, are much more insidious and poorly documented for natural streams. The recent development of half-duplex 12 mm passive transponders tags, coupled with the use of fixed and mobile antennas, enables investigating the fate of the 0+ cohort fish as well as the underlying regulating processes.

An experimental *in situ* survey was conducted on two contrasted rivers to analyze the effects of early stocking (using 'summerlings') on wild 0+ fish. On each river, three reaches were restocked with different densities of hatchery-raised 0+ trout, corresponding to one to five times the natural population density. All stocked and native fish were marked using PIT tags. Fish position was recorded weekly during three months with portable antennas, while downstream migration was continuously monitored by means of fixed devices. Survival, growth, and migration rates for both stocked and wild fish were then evaluated. Preliminary results indicated distinct movement patterns between rivers. Stocked fish moved more than wild fish, both up- and downstream, and their mortality rate was higher. Moreover, survival of wild fish was not affected by stocking densities. Implications of our results are discussed with a highlight on management purposes.

## References

FISCHNETZ. 2004. Sur la trace du déclin piscicole. Final report, EAWAG/OFEFP, Dübendorf, Bern, 198 pp.

# Feeding tactics of fish in relation to prey availability in a stream fish assemblage of the Serra do Mar (southeastern Brazil)

**C. F. Rezende**[1], E. P. Caramaschi[2], J. Lobón-Cerviá[3], R. Mazzoni[4]

[1] Laboratório de Ecologia de Rios do Semiárido, Departamento de Biologia, Universidade Federal do Ceará, Av. Mr Hull s/n, Pici, Bloco 909, 60455-970, Fortaleza, Ceará, Brazil
[2] Laboratório de Ecologia de Peixes, Instituto de Biologia, Departamento de Ecologia, Universidade Federal do Rio de Janeiro, Av. Mal. Trompowski, s/n CCS Bloco A Ilha do Fundão, 21941-590, Rio de Janeiro, RJ, Brazil
[3] Museo Nacional de Ciencias Naturales, CSIC, Madrid, C/ José Gutiérrez Abascal, 2 28006, Madrid, Spain
[4] Laboratório de Ecologia de Peixes, Instituto de Biologia Roberto Alcantara Gomes, Departamento de Ecologia, Universidade do Estado do Rio de Janeiro, Av. São Francisco Xavier, 524, Maracanã, CEP 20550-013, Rio de Janeiro, RJ, Brazil
carla.rezende@ufc.br

## Abstract

Resource partitioning is a major mechanism underlying co-occurrence in fish assemblages. This partitioning may occur across three major partitions, namely habitat, trophic and temporal (Ross 1986). The present study explored feeding tactics and prey use in relation to drift and benthos availability of three fish species (*Astyanax taeniatus*, *Characidium* cf. *vidali* and *Pimelodella lateristriga*) in Mata Atlântica stream (Brazil). Drift and fishes were sampled in diel cycles (six times per day) in five months of 2007 and 2008. Drift rates were typically low with practically no differences between day and night. Both drift and benthos were composed primarily of Simuliidae, Chironomidae and Baetidae. The three fish species showed differences in temporal feeding intensity: *Pimelodella* showed greater feeding intensity at night, *Characidium* was more active during the day and *Astyanax* fed intensively during both, day and night. The diet of *Astyanax* was based predominantly on plants, while diets of the other two species were composed predominately of aquatic insects with the greatest contributions from Simuliidae, Chironomidae and Baetidae. We explored prey size in relation to the size distribution of prey available. The size class 2 to 4 mm in length represented over 50% of the macroinvertebrate drift; benthos and fish diets did not show significant size differences among samples. The three species exploit the most abundant feeding resources available in the environment but segregate their use across temporal scales and prey use such that competitive interactions are minimized.

**Reference**

ROSS S.T. 1986. Resource partitioning in fish assemblages - a review of field studies. *Copeia***,** 352-388.

# What are the production rates of stream-living brown trout?

**J. Lobón-Cerviá[1],** G. Gonzalez[2], P. Budy[3]

[1]Department of Evolutionary Ecology, National Museum of Natural Sciences (CSIC), C/ José Gutierrez Abascal, 2. Madrid 28006 - Spain.
[2]Ichthios, León, Spain
[3]U.S. Geologiocal Survey, Utah Cooperative Fish and Wildlife Research Unit, Utah State University, Logan, UT, U.S.A.
MCNL178@mncn.csic.es

## Abstract

We examined annual production (total production of all age-classes over a year, $P_A$) and turnover ($P/B_A$) ratios, in relation to year-class production (production over the entire life time of a year-class, $P_T$) and turnover ($P/B_T$) ratio of resident brown trout *Salmo trutta*, over 14 years at 12 sites along four tributaries of Rio Esva (Asturias, northwestern Spain). Large spatial (among sites) and temporal (among years) variation in annual production (range 1.9–40.3 g $m^{-2}$ $y^{-1}$) and $P/B_A$ ratio (range 0.76–2.4 $y^{-1}$) typified these populations, values reported here including all the variation reported globally for salmonids streams inhabited by one or several species. When all data were pooled, annual ($P_A$) and year-class production ($P_T$) and annual ($P/B_A$) and year-class P/BT ratios were tightly linked. $P_A$ and $P_T$ were similar but not identical, i.e. $P_T = 0.94*P_A$, whereas the $P/B_T$ ratios were 4 + $P/B_A$ ratios. Recruitment (Rc) and mean annual density ($N_A$) were major drivers of production and their relationships were described by simple mathematical models. While year-class production ($P_T$) was determined ($R^2$ = 70.1%) by recruitment (Rc), annual production ($P_A$) was determined ($R^2$ = 60.3%) by mean annual density ($N_A$). In turn, variation in recruitment explained $R^2$ = 55.2% of variation in year-class P/BT ratios, the latter attaining an asymptote at $P/B_T = 6$ at higher levels of recruitment. Similarly, variations in mean annual density ($N_A$) explained $R_2$ = 52.1% of variation in annual $P/B_A$, the latter reaching an asymptote at $P/B_A = 2.1$. This explained why $P/B_T$ is equal to $P/B_A$ plus the number of year-classes at high but not at low densities.

# The role of pike in the ecosystem in small humic lakes

**J. Tiainen** [1], M. Olin[1], O. Saari[2], K. Nyberg[1], M. Rask[3], J. Ruuhijärvi[3], H. Lehtonen[1]

[1] Department of Environmental Sciences, University of Helsinki, Finland
[2] The Department of Biological and Environmental Science, University of Jyväskylä, Finland
[3] Finnish Game and Fisheries Research Institute, Evo, Finland
joni.tiainen@helsinki.fi

## Abstract

Pike (*Esox lucius*), together with perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) are the most common fish species in Finnish lakes, that are mostly relatively small and humic. As a top predator, pike has a profound role in small lake ecosystems, and pike is also one of the most important fish species in recreational fishing in Finland. The aim of this study was to define the role of pike in the ecosystems of four small (2.1-13.8 ha), nearly pristine forest lakes, by estimating pike densities (Petersen method), biomasses, size structures, growth and diet based on stomach and stable isotope analysis (SIA). According to the preliminary results, pike biomass and density varied between 9-14 kg $ha^{-1}$ and 11-43 ind. $ha^{-1}$. Pike growth in study lakes was slow: 5 and 10 year old pike were on average 33.5 cm and 54.6 cm. However, variation in growth was high: corresponding lengths at ages were 14.6 and 31.8 cm for the slowest growing and 65.2 and 93.9 cm for the fastest growing individual. Generally, pike diet consisted mainly of perch, roach and other pike. The most slowly growing individuals consumed mainly macroinvertebrates instead of fish. SIA showed increasing $\delta^{15}N/\delta^{14}N$ ratio with pike size, indicating increasing trophic level for larger pike, but the variation in the ratio was high reflecting diverse food selection.

# Does the use of alternative food resources induce cannibalism in a size-structured fish population?

**L. Heermann**[1], W. Scharf[1], G. Velde[2,3], J. Borcherding[1]

[1] University of Cologne Zoological Institute, General Ecology and Limnology, Research Station Grietherbusch, 46459 Rees-Grietherbusch, Germany
[2] Radboud University Nijmegen, Institute for Wetland and Water Research, Department of Animal Ecology and Ecophysiology, Toernooiveld 1, 6525 ED, The Netherlands
[3] Netherlands Centre for Biodiversity Naturalis, P.O. Box 9517, 2300 RA Leiden, The Netherlands
lisa.heermann@uni-koeln.de

## Abstract

High intra-cohort competition is known to initiate alternative resource use that may have important consequences for the population and even the biocoenosis. Alternative feeding strategies can lead to dramatic changes of individual growth within the population that, when accelerating within short periods, may subsequently stimulate cannibalism in putative predators. The present study examined differential feeding and intra-cohort cannibalism by young-of-the-year (YOY) perch (*Perca fluviatilis*) after hatching in three experimental ponds. As zooplankton biomass decreased, alternative food resources were added to the diet of YOY perch, suggesting that increased intra-specific competition forced fish to try alternative feeding strategies. Largest YOY perch fed on energetically richer resources (e.g., larval bream) and hence outgrew their smaller conspecifics, becoming large enough to enable cannibalism on these smaller conspecifics within around 60 days after hatching. Thus, the widening of initial size differences by feeding on bream or comparable food resources served as a stepping stone towards cannibalism. The dramatic spread of the age cohort in terms of size within a few weeks due to different feeding strategies was shown to be a stable pattern within the YOY perch population, as indicated by stable isotope analysis. The YOY perch population had not only split up in terms of size, but also in terms of trophic position with the large perch reaching higher trophic levels that may induce long-lasting effects on the population and community level.

# Schooling behavior of four characin species in an intermittent river in northeast Brazil

**L. R. Manna**[1], C. F. Rezende[2], R. Mazzoni[1]

[1] Universidade do Estado do Rio de Janeiro, Instituto de Biologia Roberto Alcantara Gomes / Departamento de Ecologia, Laboratório de Ecologia de Peixes. Rua São Francisco Xavier 524, Maracanã, CEP 20550-013, Rio de Janeiro, Brazil.
[2] Universidade Federal do Ceará, Centro de Ciências / Departamento de Biologia. C.P. 6021, CEP 60455-970, Fortaleza, Ceará, Brazil.
luisamanna@gmail.com

## Abstract

Within the group of fish, more than 50% of the species presents schooling behavior with synchronized and coordinated movements at some moment in their life stories (Shaw 1978; Parrish et al. 2002). Schools of characins are very abundant in Brazilian rivers and streams. In this study, we recorded schooling behavior of adults and juveniles of *Astyanax bimaculatus*, *Astyanax fasciatus*, *Serrapinus piaba* and *Compsura heterura* at Curu River, Ceará, in northeast Brazil. Underwater observations during snorkeling sessions were conducted in a 50m long stretch in seven different types of mesohabitat at day and night time using the "focal animal" and "*ad libitum*" samplings (Altmann, 1974), totaling 30 hours of records. The schooling behavior was registered 41 times in six of the seven observed mesohabitats. In 73,2% of observations, juveniles were foraging (investing on drift particles) and moving near surface, while adults were moving closer to the bottom. Furthermore, the adults were found surrounding the school and near the submerged marginal vegetation with less intense foraging activity. The piscivorous *Hoplias malabaricus* and *Crenicichla menezesi* were also observed near the schools hidden on the marginal vegetation and close to the bottom. Therefore, this schooling behavior with this distribution pattern, seem to be related to the predation risk and increasing food intake.

## References

ALTMANN, J. 1974. Observational study of behavior: sampling methods. *Behaviour*, 49: 227-265. PARRISH, J. K., VISCIDO, S. V. & GRÜNBAUM, D. 2002. Self-Organized Fish Schools: An Examination of Emergent Properties. *The Biological Bulletin*, 202: 296–305. SHAW, E. 1978. Schooling fishes. *American Scientist*, 66: 166–175

# Local adaptation in morphological characteristics of Japanese fluvial sculpin related to different environmental conditions in a single river system, eastern Japan

**T. Natsumeda**[1], T. Tsuruta[2], H. Takeshima[3], S. Awata[4], K. Iguchi[5]

1 Department of Animal-Environment System Science, Faculty of Risk and Crisis Management, Chiba Institute of Science, 3 Shiomi-cho, Choshi, 288-0025, Japan
2 Department of Human Life and Environment, Faculty of Human Environment, Osaka Sangyo University, 3-1-1 Nakagaito, Daito, Osaka 574-8530, Japan
3 Atmosphere and Ocean Research Institute, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, 277-8564, Japan
4 Sado Marine Biological Station, Faculty of Science, Niigata University, 87 Tassha, Sado, 952-2135, Japan
5 Freshwater Fisheries Research, National Research Institute of Fisheries Science, Fisheries Research Agency, 1088 Komaki, Ueda, 386-0031, Japan
natsutak@hotmail.com

## Abstract

Stream fish with low mobile ability are often restricted to narrow range of stream course, and their morphological characters seem to be affected substantially by environmental condition of habitats at which they live. We examined the relationships between environmental conditions, morphological characters, and food habits (life type: Takemon, 2005) of Japanese fluvial sculpin (*Cottus pollux*), a small benthic insectivorous fish with low mobility (Natsumeda, 2007), at seven tributaries of the same river system, eastern Japan. Principal component analysis showed that 27 morphological characteristics were divided into nine principle components, and 45.7 % of all variance was explained by first four principle components (PC1-PC4). Principle component score of PC1 (relative length of anal fin), PC3 (relative length of the second dorsal fin), and PC4 (relative height of body) differed significantly between tributaries. The score of PC1 and PC3 negatively correlated with water depths. The score of PC4 negatively correlated with current velocities, suggesting that they tend to have slender body height under environment with faster current velocities. The score of PC4 positively correlated with prey selectivity for swimmers (e.g. Baetidae); this score negatively correlated with selectivity for tube-builders (e.g. Chironomidae), implying their morphology-related prey selectivity for different life types. Our results suggest the possibility of local adaptation in morphological characters of Japanese fluvial sculpin even at tributary scale in the same river system, and this scale should be accepted as a minimum unit of conservation of the species.

**References**

NATSUMEDA, T. 2007. Movement patterns of Japanese fluvial sculpin in a headwater stream over two years. Transactions of the American Fisheries Society, 136: 1769-1777. TAKEMON, Y. 2005. Life-type concept and functional feeding groups of benthos communities as indicators of lotic ecosystem conditions. Japanese Journal of Ecology, 55:189-197.

# Daily life of a galaxiid fish: Insight into intra-specific competition effects.

**A. Akbaripasand**, M. Lokman, G. P. Closs

Department of Zoology, University of Otago, New Zealand
ab.akbary@gmail.com

## Abstract

Fish habitat selection is influenced by interactions between abiotic and biotic factors such as pool physical structure, food density and fish abundance. However, the role of food quality and social status has received little attention. We aim to answer the question, does the quantity and quality of food supply interact with social status and habitat structure to determine the abundance of drift-feeding fish in small streams. We examined this question in banded kokopu (*Galaxias fasciatus*), a drift-feeding fish native to New Zealand.

Our results showed that 1) both abiotic and biotic factors determined banded kokopu abundance and habitat selection, 2) Food abundance appeared to be more important than food energetic value in determining fish habitat selection, 3) Social status influenced individual growth suggesting that large dominant fish have a negative impact on the growth of small subordinate conspecifics through competition, 4) Fish movement was governed by social status, with less movement and high growth for dominant fish and the opposite pattern for subdominants and 5) Permanent relocation due to fierce intra-specific competition seemed to be best strategy to avoid intense within-pool competition for subordinate fish.

## References

AKBARIPASAND, A., NICHOL, E. C., P.LOKMAN, M. & CLOSS, G. P. (2011). Microhabitat use of a native New Zealand galaxiid fish, *Galaxias fasciatus*. *New Zealand Journal of Marine and Freshwater Research* 45, 135 - 144. HANSEN, E. A. & CLOSS, G. P. (2009). Long-term growth and movement in relation to food supply and social status in a stream fish. *Behavioral Ecology* 20, 616-623.

# Seasonal variations in the nutritional status of the European flounder *Platichthys flesus* in Minho estuary

**A. F. Nogueira** [1,2], E. Dias [1,3], A. T. Souza [1,3], A. Carvalho[2], J. Campos[1]

[1] CIMAR/CIIMAR– Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Rua dos Bragas 289, 4050-123, Portugal.
2 FCUP– Faculdade de Ciências da Universidade do Porto. Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
[3] ICBAS– Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Lg. Prof. Abel Salazar 2, 4099-003 Porto, Portugal

## Abstract

The flounder *Platichthys flesus* is a catadromous fish with a broad geographic distribution in Europe, with southern limit coinciding with Portugal. They feed and grow in estuaries and return to the sea during the winter to spawn (Summers, 1979). River Minho estuary is an important nursery area for this species, presenting high juvenile abundances (Cabral et al., 2007) which support a small scale fishery. Abiotic parameters can only be used to short extent as predictors for juvenile abundance (Freitas et al., 2009). Therefore, other factors might be more relevant in determining flounder recruitment to the area. Food availability may partially explain it by affecting the population nutritional status and hence the capacity of the population to survive during harsh conditions. Yet, no information exists on food conditions or on the nutritional status of the flounder population from Minho estuary. The present study aimed to evaluate the physical condition of juvenile flounder in this estuary, in terms of energetic content.

Overall, mean caloric content of flounder was 4835 (±28, se) cal.$g^{-1}$ DW and Fulton's condition factor was 0.82 (±0.01, se), with no significant difference between sexes. Some seasonal trends in flounder's condition were observed with maximum energetic content (5050 cal.$g^{-1}$ DW) in September and minimum (4634 cal.$g^{-1}$ DW) in May; while Fulton's condition was maximal in October (0.99) and minimal in February and May (0.69). Flounders from upstream locations within the estuary were more caloric than the ones from near the mouth of the river but the Fulton's condition index did not reflect this trend. A discussion is made on the usefulness of this morphological factor as an index of nutritional status relating in relation to the caloric content.

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# Long-term changes in the fish asssemblage structure and diversity of a shallow eutrophic reservoir (Lake Hídvégi, Hungary)

**Á. Ferincz**[1], N. Kováts[1], Á. Staszny[2], A. Weiperth[3], I. Tátrai[4], G. Paulovits[4]

[1] Department of Limnology, University of Pannonia; H-8200 Veszprém, Egyetem u. 10., Hungary
[2] Department of Aquaculture, Szent István University; H-2103 Gödöllő, Páter K. u. 1., Hungary
[3] Department of Animal Taxonomy and Animal Ecology; Eötvös Loránd University, H-1117 Budapest, Pázmány P. stny 1/c., Hungary
[4] Balaton Limnological Research Institute of HAS; H-8237 Tihany, Klebelsberg K. u. 3., Hungary
ferincz@almos.uni-pannon.hu

## Abstract

European reservoirs are considered to be well characterized from many point of view (Kubecka 1993, Gido et al. 2000). However, the description of long term sequence of events in the fish fauna is restricted and mostly limited to deep, oligomictic reservoirs (Riha et al. 2009). Lake Hídvégi is a shallow hypertrophic reservoir (average depth=1,14m), which was completed in 1985, in order to retain nutrients of River Zala before being transported to the eutrophic Lake Balaton (eg. Korponai et al. 2003, Tátrai et al. 2000). The changes of its fish fauna has been monitored in selected locations with standard method (electrofishing).

Species composition and assemblage structure changed significantly during the study period, between 1985 and 2009. Following the flooding, the rapid expansion of gibel carp (*Carassius gibelio* BLOCH, 1782*)* occurred, but after a short period this tendency turned. Surprisingly, based on the amongst-years variance of the relative abundances, most of the species was not affected dramatically by this invasion. By the end of the studied period, the native generalist roach (*Rutilus rutilus* L.1758*)* became the most abundant species, giving more than 50% of the stock. Analyzing functional guilds, we identified an increasing trend in omnivore abundance in parallel with the disappearance of planktivores. Comparison of rarefaction curves of each year indicated increasing tendency in diversity, but this trend was broken in the last examined year. Our results suggest that the fish assemblage structure can be considered as metastable, disturbance tolerant and is mostly composed by generalist cyprinid species.

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# Effects of temperature and food quality on age and size at maturity in Atlantic salmon *Salmo salar*

**B. Jonsson**[1], A. Finstad[2], N. Jonsson[1]

[1]Norwegian Institute for Nature Reseach, Gaustadalléen 21, N-0349 Oslo, Norway
[2]Norwegian Institute for Nature Research, Tungasletta 2, P.O.Box 5685 Sluppen, N-7485 Trondheim, Norway
bror.jonsson@nina.no

## Abstract

It has been hypothesized that the reaction norm between growth-rate and size at maturity in ectotherms depends on whether growth is affected by food or temperature. Increased temperature will decrease age and size at maturity, whereas increased lipid density will decrease age and increased size at maturity (the Berrigan & Charnov puzzle). We tested this experimentally for Atlantic salmon in sea water tanks by use of two temperatures and two diets. Growth rates were increased by increasing water temperature and/or ratio of lipids to proteins. Both treatments gave higher percentages of early mature and therefore smaller adults. Furthermore, food quality and temperature had synergistic effects on the deposition of energy reserves and on size at maturity in contrast to the proposed Berrigan-Charnov puzzle. The probability of Atlantic salmon attaining maturity for the first time during their second year in sea increased with growth rate during the preceding winter. High lipid diet and increased temperature during winter had an additive effect on the tendency to mature. Increased summer temperature exhibited no similar additional effect on age at maturity. Similar aged fish reared at elevated temperature and fed high lipid diet attained maturity at a larger size and exhibited higher mass-length-ratios than those reared at natural temperature and fed a low lipid diet, indicating that structural growth has priority over lipid deposits. There was a difference between sexes in that males could attain maturity one year younger than females when reared under similar environmental conditions. Males that matured during the first year in sea water were significantly smaller than similar aged immature males. Our finding is of relevance to the current global warming. Atlantic salmon will attain maturity younger and therefore smaller with continued climate warming when there is enough fat food. Females, however, will tend to mature older if the food quality is poor.

# Long term evolution of freshwater fish assemblages: effects of spring temperature and hydrology

C Boisneau

Tours University, CITERES UMR CNRS 6173, Parc de Grandmont, 37200 TOURS France
catherine.boisneau@univ-tours.fr

## Abstract

Since 1991, the University of Tours is monitoring hydrobiological datas for two stations, upstream and downstream, of the nuclear power station of Avoine into the Loire. The purpose of this study was to evaluate the long-term evolution of fish populations on the upper station, not impacted by the activity of water discharge, in conjunction with thermal and hydrological parameters related to the life cycles of the main fish species.

Fish were sampled by electrofishing, weighed and measured. Surveyed habitats were characterized by water depth, substrate and the presence or absence of plants. Despite the use of two different methods, the results were expressed as the number or biomass of fish per hour and, since 2001, by number or biomass of fish per $m^{-2}$.

The analysis shows a spatial dynamic of the habitats with a persistence over time of their relative proportions. The total number of species decreases despite arrival of exotic species. The disappearing species are of those of the eutrophic zone. Densities and biomasses increase exponentially, driven by species tolerant to water quality. The total biomass of fish and of invertivorous fish rates are inversely related to the flow level during June, the spawning period of the most abundant species, and positively correlated with thermal variables of June. The densities of major species are positively correlated with thermal variables of June. Fish communities are evolving in response to reduced trophic levels.

# Climate change in the high North - beneficial for Atlantic salmon but at the expense of Arctic charr?

**M. A. Svenning**[1], K. Sandem[2], M. Halvorsen[3], R. Borgstrøm[2]

[1]Norwegian institute for nature research, Department for Arctic Ecology (NINA-Tromsø), Fram Center, N-9296 Tromsø, Norway
[2]Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management, N-1432 Aas, Norway
[3]Morten Halvorsen, Museum Nord, N-8445 Melbu, Norway
martin.svenning@nina.no

## Abstract

Salmonids are affected by climate change across a hierarchy of coarse and fine spatial and temporal scales, and increasing temperature is suggested to be more beneficial for Atlantic salmon versus the more cold water adapted Arctic charr. In Finnmark, North-Norway, anadromous populations of charr and salmon coexist, however, catches of charr have decreased in some rivers during the last 10 years, while salmon landings have been stable or even increased, and that may in part be related to climate driven changes in the freshwater habitat. Thus, habitat use, relative numbers, and diet of sympatric stream living juveniles of salmon and charr were studied in the river Veidneselva, North-Norway, where they are the only fish species present. Sampling was conducted by electrofishing in more than 20 cross sections along the 17 kilometer long anadromous part of the river in 2000 and 2010. The strong dominance of charr in 2000, both in total number, and especially in the upper river areas, had disappeared in 2010, and salmon juveniles prominent in all types of habitats, irrespective of water depth and velocities. Although differences in diet were recorded within the species and length classes, a significant diet overlap between salmon and charr was still observed. A positive correlation between summer air temperature and annual individual juvenile growth rate was found for both species, but the growth response was significantly higher in salmon compared to charr. We therefore hypothesize that juvenile salmon in the northernmost areas may benefit from climate change at the expense of charr.

# Theme 2 - Threats to Systems and/or Species

*Invited speaker*

## Invasion biology and freshwater fish: research needs and opportunities

Emili García-Berthou

Institute of Aquatic Ecology, University of Girona, E-17071 Girona, Catalonia, Spain
http://invasiber.org/EGarcia/

**Abstract**

Freshwater fish are among the most imperiled taxa worldwide and invasive species play an important role in their decline. Freshwater ecosystems are enormously rich in biodiversity but also very affected by invasive species. Invasion biology has emerged in the last twenty years as the part of conservation biology devoted to understand and mitigate the impacts of invasive species. I will summarize the research needs that should be addressed to reduce the number of new invasions and to mitigate their impacts. I will also illustrate the research opportunities that invasive species afford to advance the understanding of ecological and evolutionary questions at unusually large spatial and temporal scales. Our research on the life history traits and impacts of eastern mosquitofish (*Gambusia holbrooki*) and European catfish (*Silurus glanis*) in the Iberian Peninsula will be used to exemplify these research needs and opportunities.

# Competition and predator-prey interactions between native and invasive juvenile fish in the Lower Rhine (Germany)

**S. Gertzen,** J. Borcherding

University of Cologne, Zoological Institute, General Ecology & Limnology, Ecological Research Station Grietherbusch, D-50674 Cologne, Germany
Svenja.Gertzen@gmx.de

## Abstract

Gobiidae originating from the Ponto-Caspian region have established high densities in the Lower Rhine (Germany) during recent years and regularly dominate the actual fish communities. Due to their still increasing abundances, invasive gobies are suspected to threaten the native fish fauna.

Sandy near-shore areas could be validated as the nursery habitat of invasive gobies as well as of some native fish species. This co-occurrence might lead to dietary competition between invasive species and the local fish fauna, and might further create new predator-prey relationships for piscivorous species.

Based on beach seinings from May to September at different day-times, and following gastrointestinal analyses of juveniles of two invasive gobiid species (round goby *Neogobius melanostomus* and monkey goby *N. fluviatilis*) and four native species (gudgeon *Gobio gobio*, Eurasian perch *Perca fluviatilis*, asp *Aspius aspius* and pikeperch *Sander lucioperca*) we aimed to analyze the status of gobies in the invaded community, as prey, competitor or predator.

Juvenile gobies fed primarily on Chironomidae and Crustacea and therefore highest dietary overlaps were found for gudgeon and perch, which fed also primarily on these resources. In contrast, the dominant prey category for asp was insects (mainly adult stages), whereas pikeperch preferred fish. Although all three piscivorous fish preyed upon gobies, the amount of preyed gobies was surprisingly low regarding their high densities in this habitat. Dietary competition and the actually sparse consumption by piscivores might further facilitate the invasion success and expansion of Ponto-Caspian gobies and thereby lead to negative impacts on the local fish community.

# The occurrence of gill-hooked Atlantic salmon (*Salmo salar* L.) in catch-and-release fishery on the Kola Peninsula, Russia.

**S. Prusov,** D. Kuzmin

Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 183038, 6 Knipovitch St., Murmansk, Russia.
prusov@pinro.ru

## Abstract

Studies conducted in different areas of anadromous Atlantic salmon (*Salmo salar* L.) range have demonstrated that salmon survive to spawn in most cases after being caught and released in recreational fishery with artificial lures. Post-release mortality is strongly linked to water temperature, exercise exhaustion, air exposure, time spent in fresh water and hook-induced damages. We assume that if the environmental conditions are good and fish are appropriately handled the capture rate of gill-hooked and badly bleeding salmon is likely to have the largest weight in post-release mortality. This study aims at estimating the rates of such captures in catch-and-release fisheries on the Kola Peninsula, Russian Federation.

Data were collected during catch-and-release fishing on the Ponoi river, Kharlovka river and Eastern Litsa river. 4231 salmon from catches of 690 recreational anglers were examined on the Ponoi river and 1007 salmon captured by 601 anglers were examined on the rivers Kharlovka and Eastern Litsa in 2003-2008. Mean rates of gill captures with bleedings in the study period constituted 5.4% for the rivers Kharlovka and Eastern Litsa and 6.9% for the Ponoi River, reaching in some years 8.8%. The frequency median for such captures stratified by fishing weeks never exceeded 10% with the upper quartile only occasionally higher than 10%. Gill-caught fish with angling induced severe bleeding are unlikely to survive after release. Experiments on such salmon with damaged gill blood vessels showed a very high mortality over a short time.

# Impact of centrarchid invasion on an endangered South African fish *Pseudobarbus afer* in headwater streams

**B. R. Ellender**[1], O. L. F. Weyl[2,3]

[1]Department of Ichthyology and Fisheries Science, Rhodes University, P.O. Box 94, Grahamstown, 6140 South Africa
[2]South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown, 6140 South Africa
[3]Centre for Invasion Biology, South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown, 6140 South Africa
bru.ellender@gmail.com

## Abstract

*Pseudobarbus afer* is a small endemic freshwater minnow that inhabits headwater streams in three small river systems in the Eastern Cape, South Africa. It is IUCN listed as endangered primarily due to the impacts of the alien predatory centrarchids *Micropterus salmoides* and *Micropterus dolomieu*. We assessed the distribution and relative abundance of this species in 6 headwater streams of the Swartkops River system using underwater video analysis, snorkel surveys and electrofishing and correlated this to habitat, stream size, flooding events and the presence of alien and native fishes. Stream size had no effect on *P. afer* occurrence or abundance, both of which were influenced mainly by the presence of alien centrarchids and upstream barriers. *Pseudobarbus afer* abundance was not affected by the presence of native predatory eels but was greatly reduced in stream reaches that were invaded by centrarchids. Flooding resulted in a distributional shift of *P. afer* and an increase of its abundance in invaded sections of the stream. These fish were however rapidly depleted in the centrarchid zone. The distribution of centrarchid fishes in the system appears stable and limited to larger streams below physical barriers and comprises 12% of the stream that is habitable by *P. afer*. The persistent threat of *M. salmoides* and *M. dolomieu* on *P. afer* stems primarily from recruitment from mainstream habitats, as neither species have self sustaining populations in any streams. The consequence of this and potential management interventions are discussed.

# Biological significance of thermal refugia to juvenile Atlantic salmon (*Salmo salar*) during periods of temperature stress

**E. Corey**[1], C. Breau[2], T. Linnansaari[1], R. Cunjak[1]

[1]Canadian Rivers Institute and Department of Biology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, Canada. E3B 5A3
[2]Fisheries and Oceans Canada; Gulf Fisheries Centre, 343 Université Avenue, Moncton, NB, E1C 9B6
emily.corey@unb.ca

## Abstract

Juvenile Atlantic salmon (*Salmo salar*) demonstrate a physiological stress response when water temperatures exceed 23ºC. Once temperatures approach the upper lethal limit (~28ºC), juvenile salmon manage their metabolism via behavioural thermoregulation. Territoriality is abandoned in favour of an aggregated response in areas of cooler water (thermal refugia). The objectives of this study were to *i)* determine environmental threshold conditions required for initiating behavioural thermoregulation of salmon parr, *ii)* examine how the incidence of temperature stress affects the distribution of juvenile salmon *in situ*. Passive Integrated Transponder (PIT) tags were utilized over two summers (2009/2010) to monitor the temperature-related movements of 635- 1+ and 2+ parr within the Miramichi River, Canada. In 2009, no juvenile salmon aggregations were observed despite maximum temperatures exceeding 24ºC for 7-consecutive days (max 26.1ºC). In 2010, 36.5% of the PIT-tagged juveniles were located prior to a thermal stressor event; 53.0% of these parr were subsequently re-sighted, within aggregations, when hourly temperatures remained >23ºC for 4-consecutive days (max 31.0ºC). Some parr traveled >10km to locate refugia during this period. Concurrent wide scale mortality was observed in all age-classes. Juvenile abundance in areas proximal to thermal refugia was 32.8% greater than in those areas lacking cool-water refugia. Preliminary analysis suggests that cumulative high-temperature exposure may stimulate aggregations. With future climate change scenarios predicting these temperature thresholds will be surpassed more frequently, it is important that the behavioural and physiological responses of parr be considered to ensure species conservation and sound management.

# The hour for generalists: fast recolonization after experimental fish removal in a Swiss lowland stream

**G. Thomas**, A. Peter

Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department Fish Ecology & Evolution, Seestr. 79, 6047 Kastanienbaum, Switzerland
gregor.thomas@eawag.ch

## Abstract

The successful colonization of restored habitat reaches or recolonization after disturbance events is an important process in rivers for species spread and persistence. So far, there is only little information available on recovery time in general and differences between species.

In a field- experiment we removed fish from three 250 m long stretches of a fourth/fifth order stream, a tributary to Lake Greifen (Canton of Zurich) in the Swiss lowlands. The study system provided 11 fish species in total, with 4 species dominating (brown trout, loach, chub, gudgeon). The three studied stretches were 1.2 km apart from each other and differed in morphological characteristics (width, depth) and in initial fish species composition. After removal of resident fishes the recolonization was monitored for 6 month.

One month after removal, fish abundance in two of the three reaches was already on a pre-removal level. Especially small individuals such as loach and 0+ trout showed a successful colonization in the two uppermost reaches. Small fish might have been dispersed by drift and benefit from reduced predation pressure in empty reaches.

Larger fish, such as chub and trout took longer to recover. After 6 month chub abundance was in all three sections higher than at the beginning of the experiment. Adult trout in contrast did not recover completely within half a year. Chub and gudgeon were able to establish in sections, where they had not been before.

In general species composition between the three stretches became more similar towards the end of the experiment, than they had been before fish removal. All three recolonized stretches were dominated by the four, most abundant species, rare species were not able to take their chance.

This study supports previous findings, that generalist species are efficient colonizers of empty reaches, which may reduce the likeliness of successful establishment of more specialized and rare species. In general recolonization occurs much faster than expected.

# Multiple stressors to smoltification: the effect of increased water temperature and an environmental contaminant on Atlantic salmon smolts

**M. G. L. Assunção**, L. Privitera, A. Moore

Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield road, NR33 0HT Lowestoft, UK
marta.assuncao@cefas.co.uk

## Abstract

As Atlantic salmon *(Salmo salar*) smolts migrate their transition from freshwater to seawater is preceded by a series of physiological and morphological changes triggered by environmental cues. Exposure to environmental contaminants at this life stage has been shown to influence their osmoregulatory function and affect their ability to physiologically adapt to saline conditions. With predicted increases in water temperature due to climate change, it is important to understand the combined effect of anthropogenic contaminants and temperature stress on salmon smolts fitness. In this study we investigated the effect of flow-through exposure to an environmental relevant concentration of a flame retardant (tributyl phosphate, 0.5µg/L) and increased water temperatures (ambient +2°C and ambient +5°C) on a set of physiological and morphometric parameters in Atlantic salmon smolts, before and after a 48 hour saltwater challenge. Using principal component analysis on all the parameters measured we obtained a first principal component linked with variables related to osmoregulation and a second principal component related to fish condition, in combination explaining 62% of the variance. For both principal components, the effect of different water temperatures did not depend on the level of flame retardant present. Overall, increased water temperatures had a more significant effect on both principal components before and after the saltwater challenge, when compared to the effect of exposure to the flame retardant.

# Concentrations of 18 elements in the tissues of five commercial Danubian fish species belonging to different trophic levels

**M. Lenhardt**[1], I. Jaric[2], Z. Visnjic-Jeftic[2], S. Skoric[2], Z. Gacic[2], M. Nikcevic[2], A. Hegedis[2]

[1]Institute for Biological Research University of Belgrade, Belgrade, Serbia
[2]Institute for Multidisciplinary Research University of Belgrade, Belgrade, Serbia
lenhardt@ibiss.bg.ac.rs

## Abstract

The goal of this study was to assess concentrations of 18 elements (Al, As, B, Ba, Cd, Co, Cr, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Se, Sr and Zn) in four tissues (liver, muscle, gills and gonads) of the five commercially exploited fish species (silver carp - *Hypophthalmichthys molitrix*, bream - *Abramis brama*, white bream - *Blicca bjoerkna*, common carp - *Cyprinus carpio* and European catfish - *Silurus glanis*) from the Danube River in Serbia, by the use of ICP-OES. Investigated section of the Danube River is located near Belgrade and receives large amounts of untreated or poorly treated communal and industrial waste waters. The main aim was to compare accumulation patterns of elements among fish species that belong to different trophic levels. Canonical Discriminant Analysis (CDA) showed a clear differentiation among silver carp, common carp and the other three species. Silver carp specimens were separated from the other four species mostly by high concentrations of Mn in gills, Cu and Mo in the liver, and Sr in gills. Common carp specimens were differentiated by high concentrations of Zn in gills, muscle and liver. Distribution of heavy metals among different tissues had a consistent pattern among the species. Concentrations of As, Cu and Mo were highest in liver, Al, B, Ba, Hg, Mn and Sr in gills, while Fe and Zn had the highest concentrations in both liver and gills.

# Oxidative stress biomarkers in Ave river fish

**S. Pereira,** A. L. Pinto, A. Fontaínhas-Fernandes, R. Cortes, S. M. Monteiro, A. M. Coimbra

Centre for the Research and Technology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes and Alto Douro, Apartado 1013, 5001-801 Vila Real, Portugal.
acoimbra@utad.pt

## Abstract

Oxidative stress in fish organs can be induced by several water contaminants. The oxidative damage may modify mitochondrial DNA, proteins and lipids, leading to mitochondrial bioenergetics failure and, consequently, to cell necrosis or apoptosis. Thus, the assessment of enzymes activities and of oxidative stress damage may be early-warning signs of pollutants exposure.

The aim of this study was to assess oxidative stress in liver of fish (*Squalius carolitertii*, *Luciobarbus bocagei* and *Pseudochondrostoma polylepis)* captured in seven locations of the Ave river basin, previous classified with different ecological status.

Lipid peroxidation, quantified by the thiobarbituric acid (TBARs) assay, showed that fish species have different sensibilities to water contaminants. In general, the values observed reflect the ecological status based on populations and physic-chemical parameters. However, liver lipid peroxidation values, in *L. bocagei*, were higher in a location classified with an ecological status of poor, when compared with the ones presented in fish captured in places classified as bad. *S. carolitertii* was the species that best reflected the contamination gradient previously established, as this was not evident in the other captured species.

Therefore, liver lipid peroxidation is a valid and useful early-warning biomarker of water quality decline, to assess different contamination grades.

# Invasive species in altered ecosystems: any effect of invasive fish in reservoirs?

**M. Clavero**[1], E. Aparicio[2,3], F. N. Godinho[4], V. Hermoso[5]

[1] Estación Biológica de Doñana – CSIC. Avd. Américo Vespucio s/n, 41092 Sevilla, Spain
[2] Institute of Aquatic Ecology, University of Girona, Girona, Catalonia, Spain
[3] United Research Services S.L., Barcelona, Catalonia, Spain
[4] Conselho Nacional da Água, Rua de O Século, 51, 2º 1200-433 Lisboa, Portugal
[5] Australian Rivers Institute, Griffith University, Nathan, Queensland 4111, Australia.
miguelito.clavero@gmail.com

## Abstract

It is known that invasive species are often able to thrive in altered systems, but it is not clear whether they exert negative effects on native biotas that might also occupy these systems. Here we use 247 surveys of fish communities in reservoirs across the Iberian Peninsula to describe their main characteristics and assess whether invasive fish have any noticeable effect on native species. 195 samples came from reservoirs in Mediterranean-climate areas and 52 were located in the Atlantic-climate area of northern Iberian Peninsula. Across the surveyed reservoirs we recorded the presence of 48 species. The most common species in reservoirs were the introduced common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*) and pumpkinseed (*Lepomis gibbosus*), but native barbels (*Luciobarbus* and *Barbus*) and nases (*Pseudochondrostoma* and *Parachondrostoma*) were present in more than half of the reservoirs. Reservoirs hosted on average more invasive species (mean 2.8; range 0-9) than native ones (mean 2.1; range 0-7). Invasive fish richness was positively related to reservoir area and human pressures and negatively to altitude. Native richness was higher in larger and deeper reservoirs and lower in older, more impacted reservoirs as well as in those with more piscivorous fish species. The negative influence of piscivorous fish was confirmed through structural equation modeling (i.e. controlling for other possible relationships) in Mediterranean reservoirs. The presence of introduced piscivourous thus seems to be an important factor excluding many native fish from reservoirs in the Iberian Peninsula.

# Acoustic telemetry of downstream migrating silver-phase European eels in the vicinity of three Irish hydropower stations

**T. Kieran McCarthy**, Jonathon Grennan

Ryan Institute and School of Natural Sciences, National University of Ireland Galway, University Road, Galway, Ireland.
tk.mccarthy@nuigalway.ie

## Abstract

The collapse of juvenile recruitment to European eel (*Anguilla anguilla*) populations over the last three decades is of great concern. Consequently, the European Union (Council Regulation 1100/2007) requires member states to facilitate escapement of potential spawners from river systems, so that a larger spawning stock may increase numbers of juveniles returning to continental waters. Various anthropogenic threats to migrating eels have been identified, including turbine passage mortality at hydropower stations (HPS). Therefore, as part of a study on spawner biomass escapement from two of the largest rivers in Ireland, the Rivers Erne and Shannon, migrating eels ($N$ = 315) were acoustically-tagged and released above three hydropower stations. This was done to monitor their movements and survival rates as they moved to estuarine areas downstream. Results indicated that mortalities at the hydropower stations varied, reflecting dam characteristics and optional spillway migration routes. Seasonal and between year differences in river discharge were shown to affect route selection and survival of eels. Female eel mortalities (cumulative and range) recorded at the three hydropower stations were: 7.9% (6.9–8.5%) at Cliff HPS and 8.3% (6.1–22%) at Cathaleen's Fall HPS on the River Erne, and 21.2% (17.9–25%) for Ardnacrusha HPS on the River Shannon. Mitigation measures currently employed at Irish hydropower stations involve upstream trapping of silver eels for safe release below dams. Development of alternative mitigation measures, such as deflection screens and controlled spillage during peak migration periods, is needed and telemetric analysis of eel migratory behavior is important in this respect.

# The effect of acidic releases from sulfate soils on riverine fish communities in Finland

**T. Vehanen**, A. Harjunpää, T.o Sutela

Finnish Game and Fisheries Research Institute, Oulu, Rakentajantie 3, P.O. Box 413, 90014 Oulun yliopisto, Finland)
teppo.vehanen@rktl.fi

## Abstract

Acid Sulfate Soils (ASS) are usually found in coastal areas as layers of former marine soils. The problems of ASS soils arise from their production of sulfuric acid and potential release of toxic metals once exposed to air. In Scandinavia the natural process of isostatic land rise has led to formation of ASS soils. Finland has some 100 000 - 200 000 hectares of ASS soils under cultivation, especially in the area of Southern Ostrobothnia. The acid and metal loads from these soils have lead to severe degradation of the biota in the rivers of the area. Here we present the results of the acidic releases on the fish community based on electrofishing of 32 rivers differently affected by acidic releases. Water quality affected by acidic releases had a large impact on the number of fish species present and fish community structure in the area. The rivers ranged from being totally fishless up to eight species present per site. Here we discuss the mechanisms behind the effects of acid releases and potential mitigation methods. Acid releases from ASS soils are usually related to climatic conditions, especially flooding after heavy rains. Climate change is expected to increase the occurrence of heavy rains, especially winter rains, in the future, thus increasing the risk of acid releases. Mitigation of acidic releases should include new technical solutions, changes in land use and releasing most problematic areas from agricultural land use.

# The effect of small-scale turbulence on feeding efficiency of perch (*Perca fluviatilis*)

**Z. Pekcan-Hekim**, L. Joensuu, J. Horppila

Department of Environmental Sciences, P.O. Box 65, University of Helsinki, Helsinki FI-00014, Finland
zeynep.pekcan-hekim@helsinki.fi

## Abstract

Understanding the influence of environmental factors on predator-prey interactions is crucial for understanding the structure of ecological communities. Climate change models predict increase in storm activity which could consequently affect turbulence in aquatic ecosystems. Additionally, turbidity is also predicted to increase with climate change and affect vision oriented predators in aquatic systems. Turbulence may enhance encounter rates for planktivorous predators and their prey, increasing feeding efficiency, while, turbidity diminishes the vision of fish decreasing the feeding efficiency of planktivorous fish. To test the interactive effect of turbulence and turbidity on fish feeding we conducted aquarium experiments. Experiments included perch (*Perca fluviatilis*) (5-6 cm) as predator and fourth instar phantom midge larvae (*Chaoborus flavicans)* as prey. Perch were placed in aquarium with 200 L of water and 200 *Chaoborus* larvae. Different levels of root-mean-square velocities levels ranging from 0.5 to 14.0 cm $s^{-1}$, and clay-turbidities of 0, 30 and 60 NTU, were used as treatments. Results from preliminary experiments suggest that low and intermediate levels of turbulence can benefit feeding of perch at intermediate turbidity levels. However, high turbulence and turbidity can have detrimental effects on perch feeding. Investigating how fish cope with increased turbulence will help us understand how changing climate might modify predator-prey interactions in lakes with changing water quality.

# Pacific salmon introductions in the North American Great Lakes: Effects on spawning streams

**D. J. Janetski**[1,2], D. T. Chaloner[1], A. H. Moerke[3], R. R. Rediske[2], J. P. O'Keefe[2], G. A. Lamberti[1]

[1]Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556
[2]Annis Water Resources Institute, Grand Valley State University, Muskegon, MI 49441
[3]Department of Biological Sciences, Lake Superior State University, Sault Ste. Marie, MI 49783
janetskd@gvsu.edu

## Abstract

Anadromous Pacific salmon (*Oncorhynchus* spp.) can have substantial ecological effects on stream ecosystems during spawning runs, including interactions with resident fish species, biological transport of contaminants, nutrient enrichment, and benthic disturbance. In introduced ranges, where environmental conditions often differ greatly from native ranges, little is known about the nature of these impacts. We conducted a two-year study of Pacific salmon in the North American Great Lakes, where salmon have been stocked since the 1960s, to assess the biological, chemical, and physical effects of salmon spawners on streams. During a salmon run in a Lake Michigan tributary, resident brook trout (*Salvelinus fontinalis*), moved predominantly upstream upon the arrival of spawners, often in excess of 200 m. Across 10 Great Lakes tributaries, pollutant concentrations (e.g., polychlorinated biphenyls [PCBs]) in stream-resident fish were strongly correlated with inputs from spawning salmon. In six tributaries, enrichment and disturbance effects were also observed and were unique from native ranges due to the differing environmental conditions of the Great Lakes. Dissolved nutrient responses to salmon runs were inconsistent and generally small compared to native ranges. In contrast, disturbance effects were large where salmon were abundant, sometimes reducing the abundance of benthic organisms by an order of magnitude. Overall, our results suggest that sediment disturbance, interspecific interactions, and pollutant dispersal are important considerations in assessing the overall ecological role of Pacific salmon in the Great Lakes. Furthermore, our findings offer insight into the context-dependency of interactions between anadromous fishes and their environment.

# Theme 3 - Conservation

*Invited speaker*

# Freshwater fish conservation – a still unresolved challenge

Maria João Collares-Pereira

Universidade de Lisboa, Faculdade de Ciências, Centro de Biologia Ambiental, Campo Grande, 1749-016 Lisboa, Portugal.
mjpereira@fc.ul.pt.

## Abstract

Fresh waters are threatened by a wide array of factors and anthropogenic impacts on fish species and communities are increasingly pervasive and severe. Recognizing the need for urgent action is not enough. Scientific knowledge on stream fish ecology has significantly advanced in the last decades but ecologists have to be more proactive and develop new conceptual frameworks that integrate science with societal values. Indeed as recently proposed, current and new conservation programs need to include the ecosystem services perspective and engage managers, policymakers, stakeholders and therefore all society. Research on ecosystem functioning and biodiversity patterns at the catchment level (based on reliable databases) are also paramount, as is monitoring the impact of conservation actions in use (*e.g*. protected areas, habitat restoration, stock enhancement). But, again, science-based messages have to be disseminated in a way that ensures the commitment of all the society if the objective is to be successful in conserving the biodiversity of fresh waters. In 2002 we presented a SWOT analysis[1] that will be used as the starting point for re-analyzing the situation. While reviewing the main aspects as perceived at that time, I will use some examples of endangered species from Mediterranean-type streams to address two specific issues: i) the need of multi-scale approaches incorporating multiple factors to depict both the role of historical and contemporary constraints; and ii) the importance of integrating genetic, phenotypic and environmental data and accurately identifying 'species' and intraspecific conservation units at distinct scales (and their interdependence) in conservation and management efforts.

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# Insights on the first five years of the ex-situ conservation of endangered freshwater fish

**C. Sousa-Santos**, J. Robalo, V. Almada

Eco-Ethology Research Unit, ISPA-IU
Rua Jardim do Tabaco, 34 – 1149 041 Lisboa, Portugal
csousasantos@gmail.com

## Abstract

The Mediterranean region, known to be one of the world's most important *hotspots* for biodiversity and endemism, is facing tremendous threats related with habitat degradation and global warming. The extinction risk is particularly high for non-migrating taxa that are unable to move to more favorable areas, such as the primary freshwater fish, that are confined to the rivers where they occur. More than 73% of the cyprinid fish species endemic to the Iberian Peninsula are considered to be "threatened", "vulnerable" or "critically endangered" and the effective size of these populations, most of them restricted to only a few distinct river basins, has been visibly decreasing in the last decade. In this context, we started in 2007 a pioneer project of *ex-situ* conservation of critically endangered endemic fish species, in order to preserve the genetic patrimony of populations in eminent risk of extinction until their habitats were restored and restocking with captive bred individuals may be accomplished. This was the first captive breeding program conducted in Portugal aiming to avoid the extinction of freshwater fish species. Stocks from seven populations in serious risk of extinction were successfully bred with an increment, in the first generation bred captivity, of 3.2 to 23.5 times the original number of spawners. Captive breeding programs are, however, mere instruments towards the preservation of highly endangered species and should not be considered *per se* but, instead, coupled with the implementation of measures for the rehabilitation of the natural habitats. Indeed, the ultimate goal of this kind of programs has to be the restocking of natural populations with offspring of a stock of breeders from the same population.

# Modelling stream carrying capacity for the conservation and management of salmonid populations

**D. Ayllón**[1], A. Almodóvar[1], G. G. Nicola[2], I. Parra[1], B. Elvira[1]

[1] Department of Zoology, Faculty of Biology, Complutense University of Madrid, E-28040 Madrid, Spain.
[2] Department of Environmental Sciences, University of Castilla-La Mancha, E-45071 Toledo, Spain.
daniel.ayllon@bio.ucm.es

## Abstract

Inherent in the carrying capacity notion is the basic idea of a maximum population a particular level of resources can support over a period of time. The carrying capacity provides a basis for evaluating the conservation status of a fish population and for assessing the changes in its dynamics resulting from anthropogenic impacts. Hence the stream carrying capacity (K) and its relationship with observed fish density (D/K ratio) could be useful metrics to employ when assessing the ecological status of Mediterranean trout streams. We propose a simple novel approach to model K dynamics for territorial salmonids, in which maximum abundance is limited by environmentally-induced fluctuating habitat conditions and regulated through territorial behaviour. We tested whether the model was capable of explaining the spatio-temporal fluctuations in brown trout *Salmo trutta* densities from twelve Mediterranean populations for a twelve-year period. We observed that density of different age-classes tracked K dynamics, but the eventual cohort performance was affected by both intercohort competition and intensity of intracohort competition experienced the previous year. This entails that restoration measures attempting to increase population abundance through stocking or increased cohort survival may reduce the performance of both the enhanced and competing cohorts. Further, high exploitation rates may lead populations occurring at low carrying capacities to extinction. Finally, D/K ratio seemed an accurate indicator of population conservation status since variations in the environmental and human degradation factors included in the models developed for the whole population and by age classes accounted for 68-81% of the D/K ratio variation.

# Relative importance of water temperature, intra and intercohort density dependence on the spatial variation of brown trout body size

**I. Parra**[1], A. Almodóvar[1], D. Ayllón[1], G. G. Nicola[2], B. Elvira[1]

[1]Department of Zoology, Faculty of Biology, Complutense University of Madrid, E-28040 Madrid, Spain.
[2]Department of Environmental Sciences, University of Castilla-La Mancha, E-45071 Toledo, Spain.
irenepm@bio.ucm.es

## Abstract

Fish body size is inherently linked to life history strategy and population dynamics. Brown trout *Salmo trutta* shows a high interpopulation variation in body size that results in wide spatial variations in fecundity and survival, with subsequent effects on population trajectories. This study looks at the relative influence of water temperature and density dependence on the spatial variation in body size of 126 brown trout cohorts from 12 Iberian rivers over a 12-year study period. Density in suitable habitat had a limiting role that influenced potential maximum growth of cohorts, and water temperature differentiated these cohorts in two groups of sites with high and low potential maximum growth. Water temperature had a positive cumulative effect on body size of all age classes. However, short-term exposure to extreme water temperature had deleterious effects on body size of age-0 trout. These results are especially relevant under ongoing global warming, since projected increases in temperature are bound to affect the future fitness of studied populations through growth disruptions. We observed also intra and intercohort density-dependent effects throughout the life span. Therefore, conservation and management measures aimed to increase cohort abundance and production, such as restocking, may actually impact the general performance of the enhanced and accompanying cohorts through the operation of density dependence. The present study supports that both density-dependent and density-independent processes are crucial for the understanding of population dynamics, and that their relative importance varies across scales of space and time.

# Viability analysis of the natural population of *Salmo salar* L. in the Allier catchment

**G. Dauphin**[1,2], E. Prévost[1,2]

[1] INRA, UMR 1224 Ecologie Comportementale et Biologie des Populations de Poissons, F-64310 Saint Pée sur Nivelle, France
[2] UPPA, UMR 1224 Ecologie Comportementale et Biologie des Populations de Poissons, F-64600 Anglet, France
guillaume.dauphin@gmail.com

## Abstract

Due to its conservation value, the Allier's salmon population has been monitored and several datasets such as fisheries catches, spawning nest counts, juvenile index of abundance and the number and life-stage of salmon stocked every year have been collected from 1975 to present. Synthesizing the information brought by these heterogeneous data sources in a formal statistical modeling framework is a difficult task. In order to reflect the natural process governing the population renewal it is also important to account for regulation mechanism such as density dependence as well as variability in the different transition parameters such as survival. Hierarchical Bayesian modelling (HBM) offers an efficient way to deal with such constraints while accounting for various forms of uncertainty.

The model built during this study and presented here brings together 35 years of heterogeneous data in a coherent framework while accounting for uncertainty. The results show a retrospective estimation of the past abundance of Atlantic salmon in three different spatial areas of the Allier River as well as the intergenerational renewal rate of the population. One of the main challenges of this modeling exercise was to incorporate the annual stocking data. The model provides estimates of the contribution of the different categories of salmon life-stage stocked (egg, fry and smolt) over the time series considered. These results provide useful information to the managers to apprehend the impact of the different restoration program over the last decades in the Allier River and make decision about the future programs.

# Responses in Atlantic salmon abundance, size and life history to major fishing regulations - a before-after study

E. Niemelä[1], B. Dempson[2], **M.-A. Svenning[3]**, J. Erkinaro[1], E. Hassinen[1], M. Länsman[1]

[1]Finnish Game and Fisheries Research Institute, Oulu Game and Fisheries Research,
Tutkijantie 2, FIN-90570, Oulu, Finland.
[2]Fisheries and Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1, Canada.
[3]Norwegian institute for nature research, Department for Arctic Ecology (NINA-Tromsø), Fram Center, N-9296 Tromsø, Norway
eero.niemelä@fmfi.no

## Abstract

We examined possible effects of major fishing regulations on Atlantic salmon populations in a large northern River Teno system over a period of 16 years before and 22 years after the management measures introduced in 1989–1990. After the ban on the coastal drift net fishery in 1989 and after fishing regulations in the River Teno in 1990, freshwater salmon catches increased for 1SW and 2SW maiden salmon and for repeat spawners but declined for 3SW and 4SW salmon, both in numbers and as relative proportions in the catches. The size of 1SW salmon was larger after the regulations, while in contrast, the size of 2SW was smaller also after the regulation indicating strong size-selection in the historical coastal drift net fishery. The size of 1–4SW salmon varied considerably over the 38 years period (1973-2010) in catches from all fishing gear types in the River Teno. The increase in 1SW fish size in the tributaries could be explained by the increase in the net mesh sizes used in the tributaries, but interestingly, the same phenomenon was true for a tributary where the mesh size remained the same over the whole study period. This indicates either a strong influence of the cessation of the size-selective marine drift net fishery or concurrent change in marine environment.

# Patterns of micro-habitat use and structures of free-ranging shoals of juvenile non-didadromous Galaxiid (*Galaxias anomalus*)

**A. Vivancos**, M. Paulin, G. P. Closs

University of Otago, Dunedin, New Zealand
gerry.closs@otago.ac.nz

**Abstract**

Non-diadromous Galaxiids are considered to be in gradual decline (Hitchmough, 2002) mainly because of human activity and introduced salmonids (McDowall, 2006). As juveniles, non-diadromous galaxiids undergo a pelagic stage where they gather in shoals in small backwaters and feed on drifting invertebrates (Jellyman et al., 2008). Within those shoals, fish position is ruled by a trade-off between the cost of swimming and prey capture success (Fausch, 1984). Free-ranging shoals of non-diadromous Galaxiids comprise dozens of individuals, behaving in what can be a very complex and apparently chaotic manner. Because of this complexity, the dynamics of such shoals are undescribed (Krause et al., 2000). However, the dynamics of these shoals underpins density-dependent regulation of populations, and are therefore crucial for understanding population biology and conservation. To investigate these patterns, we used an innovative tool, VidSync software (developed by Jason Neuswanger, University of Fairbanks) that uses in vivo stereo video footage to model, in three dimensions, individual movements within a shoal. This technique generates quantitative data that allowed a robust analysis of micro-habitat use and behavior at a very fine spatial and temporal scales. We chose to study small and large shoals of juvenile roundhead Galaxiids (*Galaxias anomalus*) at two sites. Key parameters, such as space use, distribution of fish positions, individual volume of functional habitat and feeding territory were very different in the two shoals suggesting that the structure and dynamics of shoals of drift-feeding fish are plastic and strongly context-dependent.

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# Movement and Spatial Distribution of Juvenile Lake Sturgeon in a Great Lakes Tributary

**C. R. Ruetz III**[1], A. C. Weiten[1], M. E.L. Altenritter[2], K. M. Smith[3]

[1]Annis Water Resources Institute, Grand Valley State University, 740 West Shoreline Drive, Muskegon, Michigan 49451, USA
[2]The University of Maine, School of Biology and Ecology, 5751 Murray Hall, Orono, Maine 04469, USA
[3]Michigan Department of Natural Resources, Fisheries Division, 621 North 10th Street, Plainwell, Michigan 49080, USA
ruetzc@gvsu.edu

## Abstract

Efforts to restore remnant populations of lake sturgeon *Acipenser fulvescens* in North America are hampered by the paucity of information on juvenile habitat requirements. We examined movements and spatial distribution of juvenile lake sturgeon in Muskegon Lake, Michigan, USA (a protected, drowned river mouth [DRM] lake that links the Muskegon River to Lake Michigan). We captured 68 juveniles representing multiple cohorts using gill nets. Twenty individuals were surgically implanted with ultrasonic transmitters and actively tracked during August-November 2008 and 2009 and from September 2010 to November 2011. Juvenile lake sturgeon were observed near (≤1.5 km) the confluence of the Muskegon River in Muskegon Lake during summer. In early fall, a seasonal shift occurred where juveniles moved to deeper waters, which coincided with fall overturn (i.e., loss of thermal stratification) and changes in dissolved oxygen (DO) concentrations in the lake. During summer, DO concentrations were often < 4 mg/L at depths > 7 m, and DO concentrations at locations of tagged lake sturgeon were > 7 mg/L in 94% of instances. Tracking over 24-hour periods in 2009 revealed no significant change in depth distribution or movement over four diel periods (dusk, night, dawn, and day). Our results suggest that: (1) Muskegon Lake serves as an important nursery habitat for juvenile lake sturgeon that hatched in the Muskegon River before they enter Lake Michigan, and (2) seasonal changes in DO concentration likely affect the distribution of juvenile lake sturgeon in DRM lakes.

# Native and introduced fish species richness in lacustrine Chilean Patagonia: inferences on species invasion from salmonid free lakes

**E. Habit**[1], J. Gonzalez[1], D. E. Ruzzante[2], S. J. Walde[2].

[1]Environmental Science Centre EULA, Universidad de Concepción, Chile.
[2]Department of Biology, Dalhousie University, Halifax, NS, Canada B3H 4J1.
email: ehabit@udec.cl

## Abstract

Latitudinal gradients are perhaps the best-known geographic patterns of species richness. The goal of this study was to document the links between habitat connectivity, dominance of introduced salmonids, and latitudinal gradients of species richness for freshwater fish in Chile. We were particularly interested in factors that explain the persistence of salmonid-free lakes in parts of Chilean Patagonia. In this study we use an extensive survey over a broad latitudinal range (39° to 54° S), to describe species richness and distributional patterns for native and introduced fish communities, making a special effort to locate salmonid free lakes. We tested for the importance of connectivity and physical factors in determining the patterns. Native and introduced species richness decreased with latitude and increased with lake size, and salmonid dominance showed a significant positive relationship with habitat connectivity. We found a total of 14 salmonid free lakes, all located in remote areas south of 45°S and upstream of major physical barriers. Salmonid free lakes tended to be single-species systems, but otherwise showed a broad range of characteristics. Temperature, as a correlate of latitude appears to be a key determinant of native and introduced species richness in Chilean lakes. We found no evidence of biotic resistance by native species to salmonid expansion, and although the original introductions were human-mediated, current patterns of exotic richness and salmonid dominance were not related to current human activity, as measured by land use. Rather, environmental factors, connectivity and temperature, limit salmonid expansion within Chilean freshwaters. FONDECYT 1080082.

# Conservation status of fish inhabiting lowland rivers assessed by beach seining

**L. Pekárik**[1], J. Koščo[2], L. Košuthová[3]

[1]Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia
[2]Faculty of Human and Natural Sciences, University of Prešov, Prešov, Slovakia
[3]Department of Breeding and Diseases of Game and Fish, University of Veterinary Medicine and Pharmacy, Košice, Slovakia
ladislav.pekarik@savba.sk

## Abstract

Lowland rivers are considered to be endangered biotopes. Therefore the current status of fish species occurring in lowland rivers is not sufficiently documented. Many standard fish sampling methods are not effective enough to record the middle part of main river channel. In the present study, we describe and compare the present status of threatened fish species occurring in lowland rivers of Central Europe using beach seining by small seine net over the whole diel period in the shallow near-shore habitats. The study was focused on two areas, Eastern Slovakia (Tisa, Bodrog and Latorica rivers) and Western Slovakia (Danube, Váh and Morava rivers) during the period 2007-2011. Based on obtained data, the conservation status of many main channel species was overestimated, in other words - the populations are more stable that it was presented. Significantly higher number of records of *Gymnocepahlus schaetser*, *Zingel zingel* or *Rutilus virgo* indicates that the absence of this species was caused by use of unsuitable method (electrofishing). Furthermore, based on our results from five years of monitoring, we can assess stable populations of target species. However, differences in species density between eastern and western region were found. On the other hand, *Pelecus cultratus* or *Acipenser* species were not recorded during this study, but anglers reported their presence.

The study was supported by the VEGA project no. 2/0080/11.

# *Ex situ* conservation of a unique bullhead *Cottus perifretum* population in the Demer River basin, Belgium

**I. Vught**[1], D. De Charleroy[1], C. Van Liefferinge[2], J. Coeck[1]

[1]Research Institute for Nature and Forest (INBO) - Dwersbos 28, 1630 Linkebeek - Belgium
[2]Agency for Nature and Forest (ANB) – Diestsepoort 6 bus 75, 3000 Leuven - Belgium
inne.vught@inbo.be

## Abstract

Bullhead is a small, bottom-dwelling cottid. It used to be common in Flanders (Belgium) but nowadays only very few, isolated populations remain. Consequently bullhead is listed as IUCN susceptible on the national Red List and fully protected. It is also listed in the EC Habitats Directive (92/43/EEC). Management should aim to conserve as many populations as possible to prevent further genetic loss.

Until 2003 bullhead (*Cottus perifretum*) was thought to be extinct from the Demer River basin in Flanders. That year a relict population, containing no less than 5 private allelles, was discovered in the Dorpbronbeek. This population is seriously endangered due to its small population size, small living area and recent habitat deterioration. Since *in situ* protection of the population proved to be difficult and insufficient, the Research Institute for Nature and Forest (INBO) and the Agency for Forest and Nature (ANB) immediately launched an *ex situ* conservation program. Bullhead were extracted from the relict population and used in an *ex situ* breeding program. Meanwhile the Zevenbronnenbeek was carefully selected from seven potential re-introduction locations within the Demer River basin based on its good water quality, suitable habitat and sufficient food availability.

In 2008 and 2009, 0+ bullhead were re-introduced in the Zevenbronnenbeek. The success of this re-introduction was yearly assessed by electric fishing. The results of 2009 looked promising (Vught *et al.*, 2011). New data from 2010 and 2011 on the abundance and population structure offer positive perspectives for the establishment of a healthy, self maintaining bullhead population.

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# Malformation of shockwave treated Medaka embryos due to a damaged yolk syncytium layer.

F. Stein

Biozentrum Grindel und Zoologisches Museum Hamburg
f.stein@zoologie.uni-hamburg.de

## Abstract

Low energetic shockwaves (energy flow density of max. 0.08 mJ/mm2) are used for extracorporeal shockwave therapy (ESWT) to treat patients with pain in soft tissues close to the bones and enthesiopathy. A similar application on embryos of Japanese Medaka (Oryzias latipes) cause focal lesions. A group of 378 embryos have been treated with 300 pulses. 55.6% of these embryos showed no effects (embryos with no effects = EnoE). In 44,4% of Medaka embryos effects were observed (embryos with effects = EwE). The EnoE developed normal, hatched successfully, became adult and reproduced successfully. The following morphological effects on EwE were observed: yolk lost (with slight and heavy expressions), pericardial edema, microphthalmia, opacity of the yolk and embryonic tissues and heavy tissue damage as well as the total destruction of the eggs including the embryos. None of the EwE hatched successfully. Due to the yolk lost the inner ultrafine structures of the yolk syncytium layer (YSL) were shifted and wrapped. The organelles structure was damaged. As a result the YSL was not able to digest the yolk mass and support the embryonic tissues with development signals and nutritional substances, which were given to the blood in yolk vessels. Due to deficiency of nutrition substances the embryonic tissues were undersupplied and were not able to finish their development successfully. As a result the development stagnated and the embryos died. It is highly probable that the same conditions can be expected where fish eggs are near under water detonation or heavy shocks, like dynamite fishing, clearing sank weapons by detonations or pile-driving activities.

# Host fish determination for Portuguese freshwater mussel species: A key factor for naiad conservation

**M. Lopes-Lima[1,2],** A. Teixeira[3], M. Hinzmann[1,2], S. Varandas[4], R. Sousa[5], R. Cortes[4], J. Machado[1,2]

[1]ICBAS-UP - Abel Salazar Biomedical Sciences Institute, University of Porto, Largo Prof. Abel Salazar nº2, 4099-003 Porto, Portugal
[2]CIMAR-LA/CIIMAR – Centre of Marine and Environmental Research, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[3]CIMO - Mountain Research Centre, School of Agriculture, Polytechnic Institute of Bragança, Portugal, Campus de Santa Apolónia - Apartado 1172, 5301-855 Bragança, Portugal
[4]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Universidade de Trás-os-Montes e Alto Douro, Universidade de Trás-os-Montes e Alto DouroQuinta de Prados, Apartado 1013, 5001-801 Vila Real Portugal.
[5]CBMA – Centre of Molecular and Environmental Biology, Department of Biology, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal.
lopeslima.ciimar@gmail.com

## Abstract

Freshwater mussels or naiads (Bivalvia, Unionoida) are among the most critically threatened faunistic groups worldwide. This decline is mainly provoked by habitat loss and fragmentation, habitat degradation, introduction of invasive species, among other biotic and abiotic alterations. In fact, these bivalves have a complex reproductive behavior where their larvae (glochidia) parasitize and depend on specific fish species as hosts for metamorphosis and upstream dispersion. For this reason, conservation of freshwater mussels is intertwined with the respective host fish and is of outmost importance to establish which fish species are suitable for each bivalve species. In the present work we successfully reproduce and determined the host fish species for *Anodonta anatina*, *Potomida Litorallis* and *Unio delphinus* from the Douro basin, Portugal. For this, glochidia were extracted from each species and placed in contact with distinct fish species that co-occur in the same basin. The fish species that successfully transformed glochidia in juveniles were then considered valid hosts. Interestingly, almost all effective hosts were native fish species (for *Anodonta anatina* just the invasive species *Onchorynchus mykiss* was a suitable host and *Gambusia hollbrooki* for *Unio delphinus*). Due to the increasing presence of invasive fish species and the construction of dams and barriers that reduce fish movements and dispersion, the conservational status of the freshwater mussel fauna in Portugal may suffer a great decline in near future.

# Usability of scale-morphometric methods for population biology studies of protected species

**Á. Staszny[1],** Á. Ferincz[2], T. Müller[1], A. Specziár[3], B. Urbányi[1], G. Paulovits[3], Z.t Csenki[1]

[1] Szent István University, Faculty of Agricultural and Environmental Sciences; Institute of Environmental & Landscape Management; Department of Aquaculture, Páter K. út 1. H-2100 Gödöllő, Hungary
[2] University of Pannonia, Department of Limnology, Egyetem u. 10. H-8201 Veszprém
[3] Hungarian Academy of Sciences, Centre for Ecological Research, Balaton Limnological Institute, Klebelsberg Kuno út 3. H-8237 Tihany
Staszny.Adam@mkk.szie.hu

## Abstract

The discrimination of fish populations based on their scale shape have been proved in several studies (Richards and Estevez 1997a, 1997b; Poulet *et al.* 2005; Ibañez *et al.* 2007; Staszny *et al.* 2009), being a good possibility for examination of protected species, as it provides information without permanent damage in the investigated specimen. However, the factors which play a role in the development of scale-shape, have not been studied widely (but see Ibañez *et al.* 2011). As normally in case of phenotypic characteristics, several effects may contribute to the development of the final look, such as purely genetic differences or environmental effects (phenotypic plasticity), or the mixture of these, even with opposite effects (countergradient variation) (Conover and Schultz 1995). Based on investigations of several factors, in laboratory and in natural conditions (genetic background effects on zebrafish, food availability impacts on zebrafish, sexual dimorphism in zebrafish and prussian carp, water temperature effects in common carp), it can be stated that both environmental parameters and genetic differences play a role in the development of scale shape. Environment has a more significant impact than genetic difference, so phenotypic plasticity has a greater role in scale shape formation. This method can be recommended in any case for testing protected species, because it does not provide less information about the populations studied, than the more traditional full-body studies, yet it is less invasive.

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# Theme 4 – Genetics

*Invited speaker*

## Beyond population genetics: new technologies offer new opportunities

Leif Asbjørn Vøllestad

Center for Ecological and Evolutionary Synthesis, Department of Biology, University of Oslo, POBox 1066 Blindern, N-0316 Oslo, Norway
avollest@bio.uio.no

**Abstract**

Freshwater fishes are of great economic, societal and cultural importance. They inhabit complex landscapes, both in terms of geography and jurisdictions, which makes management and conservation challenging. Classical population genetics has shown that populations are genetically structured, often at small spatial scales. Neutral genetic markers – such as microsatelittes – have been used extensively the last decades and great advances have been made in understanding processes such as gene flow, genetic drift and selection. Recent developments in state-of-the-art genomics have provided unique opportunities to accelerate biological research, and thus, population biology, tremendously. Indeed, the combination of profound ecological knowledge, "inexpensive" methods for massive analyses of single nucleotide polymorphisms (SNPs), and the possibility to do large-scale genome sequencing, will allow a deeper understanding of genotype-phenotype relationships in an eco-evolutionary setting. A critical step is, however, the huge amount of data generated. Considerable competence in robust statistical genetics and bioinformatics tools will be needed to be able to assemble and analyze this information. Given appropriate sampling protocols, and phenotypic information, it is possible to construct pedigrees for wild fish and assess quantitative genetics data. Even more interesting is the potential of identifying genes/genomic regions being under direct selection. One major challenge is to match the massive genetic information with relevant phenotypic information. Of particular interest is trying to understand the evolutionary background for and the mechanisms producing phenotypic plasticity.

# Cryptic *Gobio* species in Hungarian streams?

**P. Takács**[1], E. Csoma[2], Z. Pénzes[3], P. Bihari[3], T. Erős[1], A. Specziár[1], I. Szivák[1], P. Bíró[1]

[1]Balaton Limnological Institute, Centre for Ecological Research, Hungarian Academy of Sciences ,H-8237, Tihany, Klebelsberg Kuno u. 3., Hungary
[2]Department of Medical Microbiology, Medical and Health Science Centre, University of Debrecen, H-4032, Debrecen, Nagyerdei krt. 98., Hungary
[3]Biological Research Centre, Hungarian Academy of Sciences, H-6726, Szeged, Temesvári krt. 62., Hungary
takacs.peter@okologia.mta.hu

## Abstract

With the forefront of genetic analyses the taxonomy of many European fish taxa have been reevaluated in the last decade, including the stream dwelling *Gobio* genus. Recent genetic analyses proved the existence of two morphologically very similar species from the Carpathian region. The Carpathian gudgeon (*Gobio carpathicus*) was identified from the eastern, while the Danube gudgeon (*Gobio obtusirostris*) from the western (Transdanubian) region of the country. However, these studies examined on limited number of samples which originated from the verge of the region. Therefore, we still lack detailed information about the species identity, phlyogenetic relationships and genetic diversity of the *Gobio* species inhabiting the inner area of the Carpathian Basin. In this study 241 specimens from 27 sites were sampled and analyzed with two molecular methods, sequencing the mtDNA Control Region and Amplified Fragment Length Polymorphism. Results suggest an unambiguous east-west separation of the studied *Gobio* stocks. However, the haplotype of the Danube gudgeon could be identified only in the north-western region of Hungary, whereas the haplotype of the Carpathian gudgeon occured only at the northernmost sampling site, in the eastern part of the country. In the central and southern part of the Transdanubian region previously unknown haplotypes were found, and another different haplotype group appeared also at the eastern sites. These results indicate the presence of cryptic gudgeon lineages in the Carpathian Basin, Hungary.

## Changed to poster communication

# Genetic diversity in addition to ecological aspects to define Favourable Conservations Status, a case study on bullhead (*Cottus gobio*)

**C. Geeraerts**, J.Mergeay

Research Institute for Nature and Forest, Gaverstraat 4, B-9500 Geraardsbergen, Belgium
caroline.geeraerts@inbo.be

## Abstract

The EC Habitats Directive (92/43/EEC) requires measures to be taken to maintain or restore certain habitats and species that ensure their Favorable Conservation Status (FCS) across the European Community. Each member state is obliged to set up monitoring programs to estimate the conservation status of each species. Currently, the criteria for the FCS are defined by each member state independently, and are based on ecological or demographic traits only, with arguable threshold values. In contrast, genetic diversity, important for both the short- and long-term viability and future evolution of populations, is generally overlooked in the FCS (Laikre et al., 2010). We present a framework for comparing FCS using ecological criteria and genetic criteria in bullhead (*Cottus gobio*), applied on 25 wild populations in Belgium, and provide tentative results.

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# Population Genetics and Management of Pike (*Esox lucius*) in Ireland

**D. Pedreschi**[1], J. Caffrey[2], M. O'Grady[2], M. Kelly-Quinn[1], S. Mariani[1]

[1]University College Dublin, Belfield, Dublin 4, Ireland.
[2]Inland Fisheries Ireland, Swords Business Campus, Balheary Road, Swords, Co Dublin, Ireland.
debbi.pedreschi@ucdconnect.ie

**Abstract**

Throughout the northern hemisphere, northern pike *(Esox lucius)* is of particular socio-economic value for recreational and commercial fishing (Launey *et al.* 2006) and Ireland is no exception, where revenue from the angling industry is estimated at circa €50 million per annum. Pike have long been thought to be non-native to Ireland (Kennedy 1969, Went 1957), although a lack of direct evidence for this leads it to be a contentious issue between various stakeholder groups. It is not known how pike were originally introduced into Irish waterways, nor where they came from. Despite this, historical management of this species has been based upon this assumption, leading to controversial policies such as an intensive removal of pike during predator control operations, primarily in the 1950s and 60s, aimed at protecting native brown trout (*Salmo trutta)* populations (Mulcahy.& O'Rourke 1964).

In Ireland pike occurs in most freshwater systems, but until now no real attempt has been made to investigate relatedness and connectivity among populations. One previous Europe-wide study found one population from the River Shannon to be monomorphic at six microsatellite loci (Jacobsen *et al.* 2005). However, pike in other regions have been shown to exhibit genetic structuring, suggesting small founding local populations and natal-site and spawning site fidelity (Miller *et al.* 2001, Miller & Senanan 2003). Here we present the first Ireland-wide population genetic investigation using a suite of six polymorphic microsatellite markers and illustrate the nature of population connectivity in pike inhabiting Irish lakes, rivers and canals. This study provides the first piece of evidence which will better inform pike management in Ireland, and attempt to reconcile the various and often conflicting needs of an important socio-economic sector.

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# Freshwater Diversity Identification for Europe (FREDIE)

**M. Geiger**, J. Freyhof, F. Herder

Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany
m.geiger.zfmk@uni-bonn.de

## Abstract

FREDIE stands for 'Freshwater Diversity Identification for Europe' and is a nationally funded project bringing together DNA barcoding with taxonomic expertise for European freshwater fishes, mayflies and freshwater molluscs in order to develop an online available identification system. Although DNA barcoding offers the possibility to accelerate detection and monitoring of biodiversity, its quality and significance is strictly bound to availability and quality of underlying reference data. Within the FREDIE project, resources and expertise of three core institutes and a web of associated partners are combined to create a reliable and sustainable reference system for European freshwater organisms. Representatives of nearly all between Portugal and Ural living species of the three groups will be collected, identified by experts and sequenced to become barcode references. In cases where conventional barcode markers do not lead to unambiguous identifications a stratified identification system is planned. In addition to DNA sequence data we will provide respective voucher specimens and a DNA collection as permanent references available to the scientific community. Altogether, this strategy delivers beside the reference data and complementary collection vouchers molecular and morphological based estimations of species numbers of the three organism groups for Europe as well as new insights into their geographic structuring on a large scale. The project started May 2011 and we will present first data for about 95% of the freshwater fish species of the Mediterranean hotspot.

# European brook and river lampreys of the Iberian Peninsula: an overview of genetic and morphological variability

**C. S. Mateus**[1,2,3], M. J. Alves[3], B. R. Quintella [2,4], N. Mesquita[3], P. R. Almeida[1,2]

[1]Department of Biology, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[2]Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[3]Museu Nacional de História Natural e da Ciência, Center for Environmental Biology, Universidade de Lisboa, Rua da Escola Politécnica 56/58, 1250-102 Lisbon, Portugal.
[4]Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
csmateus@fc.ul.pt

## Abstract

The European river lamprey (*Lampetra fluviatilis* L., 1758) and the European brook lamprey (*Lampetra planeri* Bloch, 1784) are paired species, i.e. the larvae are morphologically similar but adults adopt different modes of life. In the so-called brook lampreys, sexual maturity is attained within a few months of metamorphosis, and as a result the adult feeding and migratory phase has been eliminated from the life cycle. The parasitic lampreys, after metamorphosis, moves downstream to feed in the estuaries or open sea (Zanandrea 1959). To date, several studies based essentially on allozyme and mitochondrial DNA (mtDNA) markers revealed a notorious lack of differentiation between the anadromous and resident form of this species pair, contrasting with the high levels of differentiation observed between populations of the resident form, *L. planeri* (e.g. Schreiber and Engelhorn 1998, Mateus et al. 2011). In the Iberian Peninsula this is particularly evident; our results from two mitochondrial genes indicated the existence of several highly divergent allopatric evolutionary lineages that evolved by fragmentation in the Iberian glacial refuge during the Ice Ages, suggesting speciation within the Iberian Peninsula (Mateus et al. 2011). Results from microsatellite loci analysis point in the same direction, separating populations rather than species. Finally, morphological differentiation between populations was also accessed. The results gathered so far provide new insight into the knowledge of the pattern of genetic and morphological variability and evolutionary processes that occur in this genus and will have major conservation implications to this threatened species pair.

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# PCR-RFLP method for the identification of four species of invasive gobies

J. Kohout[1,2], **L. Pekárik[1]**, A. Šedivá[1,2]

[1] Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia
[2] Institute of Animal Physiology and Genetics, Academy of Sciences of the Czech Republic, v.v.i., Liběchov, Czech Republic
kohout@iapg.cas.cz

## Abstract

Studying various aspects and consequences of biological invasions is of great importance in scientific and economic points of view. However, the identification of invaders, and especially their juveniles, could be substantially difficult if they are represented by several morphologically similar species. The aim of our work was to develop a rapid, cost-effective molecular method for identification of the four species of invasive gobies occurring in the central Danube basin, namely *Neogobius melanostomus*, *Neogobius fluviatilis*, *Ponticola kessleri* and *Babka gymnotrachelus*. First, the fragment of cytochrome oxidase I gene was amplified and sequenced for representative samples of the four species. The appropriate sequences of the four species available in GenBank were also used. Low intraspecific sequence variation was detected, whereas substantial interspecific differences were found. The fragment was digested with the BfaI enzyme, which showed unique restriction patterns for each of the species. The four patterns were clearly distinguishable from each other using the standard agarose gel electrophoresis. This method proved valuable for discriminating the four invasive gobies in the Danube basin as well as in other native and non-native areas of their distribution.

This contribution is the result of the project implementation: Development and application of the innovative diagnostic approach for the molecular identification of animals (ITMS: 26240220049) supported by the Research & Development Operational Programme funded by the ERDF.

# Towards the development of a demo-genetic model to improve conservation strategies in practice: the Mediterranean native brown trout as a case study

**J. Gil**[1], J. Labonne[2], A. Caudron[1]

[1]INRA UMR CARRTEL BP 511, 74203 Thonon Cedex, France
[2] INRA UMR ECOBIOP, 64310 St Pée-sur-Nivelle, France
jordi.gil@thonon.inra.fr

**Abstract**

During the last two decades the conservation of native salmonids populations has become a world-wide challenge for researchers and wildlife managers (Waples & Hendry 2008). However, effective conservation strategies appear difficult to implement in practice (Margules & Pressey 2000), especially due to the gap between academical findings supplied by scientists in ecological research and operational methods for environmental managers (Hart & Calhoun 2010). In the French Rhone drainage area, the Mediterranean native brown trout is threatened by stocking carried out by fishery managers using hatchery domestic trout from non-native Atlantic strain. The spatial distribution of the admixture between both native and non-native strains highlights contrasted situations. On one hand, many populations are highly admixed by non-native genes, whereas some pure or nearly pure Mediterranean populations with a high patrimonial interest still persist. Therefore, these results led to implement a collaborative work involving researchers and managers with both basic and applied goals. First, the study aims to better know the reproductive isolation process observed in natura between both Mediterranean native and Atlantic non-native strains. Second, we are developing a practical tool using a demo-genetic model to assess the demographic and genetic effects of conservation strategies on wild populations in order to help managers in their decision-making for implementing more effective actions. We propose to present the first development of the demo-genetic model using a neutral dynamics of the admixture in the Chevenne Creek and the ongoing PhD work on the pre- and post-zygotic isolation processes which will be included in the final version of the model.

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# Genetic structure of European grayling (*Thymallus thymallus* L.) populations in Switzerland and cross-boarder France: Implications for conservation and management

K. Winkler[1], S. Weiss[1], D. Grimardias[2], H. Persat[3], **F. Cattanéo[2]**

[1] Karl-Franzens University Graz, Institute of Zoology, Universitätsplatz 2, A-8010 Graz, Austria
[2] Hepia Geneva, University of Applied Sciences Western Switzerland, Technology, Architecture and Landscape, Ecology and Engineering of Freshwater Systems research group, route de Presinge 150, CH-1254, Jussy, Geneva, Switzerland
[3] Université Claude Bernard – Lyon I - UMR CNRS 5023 - Ecologie des Hydrosystèmes Fluviaux, Bât. Forel, F-69622 Villeurbanne Cedex, France
franck.cattaneo@hesge.ch

## Abstract

Native in Switzerland, European grayling has shown dramatic declines in population sizes in many rivers. The species is now recognized to be threatened. Causes of this decline probably are multifaceted. In an attempt to counteract this trend, fishery managers are increasing stocks by rearing, transporting, and stocking grayling with the aim of replenishing populations. While there are many potential problems with such efforts, there is a lack of basic information concerning the adaptive suitability of stocked material for site-specific conditions. Basic data on the phylogeographic as well as population genetic structure of the species are needed to help guide conservation strategies. We sampled 34 Swiss and cross-boarder French grayling populations to 1) gain insights into the lineage diversity that could result from four main hydrogeographic basins; 2) assess the population genetic structures with respect to important natural processes and potential anthropogenic disturbances; and 3) prioritise populations for conservation issues. Results revealed that, globally, the native biogeographical lineages are preserved. Microsatellite analysis at 12 loci showed highly variable (4.2-13.0) mean allele diversity across populations. Both haplotype and microsatellite analyses revealed a strong geographical structure of populations among and within basins, which may reveal potential impacts of habitat fragmentation. A substructure within some populations, together with other particular genetic characteristics, strongly suggested anthropogenetic (e.g. stocking with foreign material) causes. These results, complemented with detailed probabilistic analyses, enabled assignment of a conservation status for each population as well as sound recommendations for a national and cross-border management strategy.

# Theme 5 - Diadromous Fish

*Invited speaker*

## Which fate for diadromous fish in the European Streams of the future? Adaptability of species and adaptation of our practices

Eric Rochard

Irstea, Estuarine Ecosystems and Diadromous Fish research Unit, Cestas France

**Abstract**

From at least one century most of the studies have concluded that in European streams diadromous fish have been drastically impacted by anthropogenic pressures. To mitigate these impacts, some generations of fishways have been developed as well as few habitat restoration techniques and stocking protocols. However these tools have been used in limited cases and without assessment of their efficiency. Mismanagement practices and overfishing have also been recorded in most cases but without any implementation of best practices.

Today this gap between our knowledge and the present practices has not been filled. Conservation efforts have not been sufficient and in time and as a consequence most of these species are at risk of disappearing, even their IUCN status are not in accordance with their real status.

From on decade additional stressors, pollutants and climate change have also to be considered. Their effects on populations are not completely established but they clearly complicate the future of most diadromous species and mitigation tools are limited.

In this context of large scale pressures we expect that life traits of fish will change and lead to modifications in population dynamics and subsequently in the distribution of the species. From simulations we expect that these changes could be very important with drastic restriction for most species.

The scientific community may particularly help to achieve the conservation of these species achieve by a large cooperation i) to put more clearly this goal within the field of the conservation of the biodiversity including sociological and economical dimension; ii) to consider the present but also the future potential of the different basins according to climate change and regional pressures scenarios; iii) to assess and to review the efficiency of conservation measures at the species distribution scales.

# Is amphidromy a mechanism for enhancing the fecundity of small-bodied fish in coastal streams?

**G. P. Closs**[1], A. S. Hicks[2], P. G. Jellyman[3]

[1]Department of Zoology, University of Otago, Dunedin, New Zealand.
[2]Environment Southland, Invercargill, New Zealand.
[3]National Institute of Water & Atmospheric Research, Christchurch, New Zealand.
gerry.closs@otago.ac.nz

## Abstract

Amphidromy, a common diadromous life history strategy of fish across the Indo-Pacific region, involves freshwater spawning, larval transport to a marine habitat, a relatively short period of pelagic rearing, before juvenile migration back to and maturation in freshwater. The function of amphidromy has been debated, with larval dispersal being the most frequently invoked explanation. However, recent analyses, based on otolith microchemistry indicate regional retention rather than widespread dispersal of pelagic marine larvae of New Zealand species of Galaxias and Gobiomophus. This finding suggests that the primary function of amphidromy is something other than dispersal. Clues as to the primary function of amphidromy may be found be comparing the life cycles of amphidromous fish with closely related species that complete their entire life cycle in freshwater. We compared the size of eggs of over 30 pairs of amphidromous and closely related freshwater species, including representatives of cottids, galaxiiids, eleotrids and gobiod fishes. On average the egg size of the non-diadromous species was significantly larger, and the egg size of only one non-diadromous species was smaller than its amphidromous relative. The development of a large egg for a wholly freshwater life cycle comes at the cost of fecundity, but may be required to provision larvae for survival in the relatively challenging environment of small coastal streams. In contrast, amphidromous species can maintain a high level of fecundity by producing small pelagic larvae, but only if in relatively close proximity to productive, mostly marine, pelagic habitats.

# Larval drift of anadromous North Sea houting (*Coregonus oxyrinchus*) in the River IJssel, the Netherlands, and indications for spawning grounds

**J. Borcherding**[1], A. Breukelaar[2], H.V. Winter[3], U. König[1]

[1]University of Cologne, Zoological Institute, General Ecology & Limnology, Ecological Research Station Grietherbusch, D-50674 Cologne, Germany
[2]Rijkswaterstaat Waterdienst, NL-8200 AA Lelystad, The Netherlands
[3]IMARES, Inst. Marine Resources & Ecosystem Studies, Wageningen UR, NL-1970 AB IJmuiden, The Netherlands
Jost.Borcherding@uni-koeln.de

## Abstract

North Sea houting (NSH, *Coregonus oxyrinchus*) is an anadromous salmonid that historically was distributed in the whole Wadden Sea area extending from southern Jutland in Denmark to the Schelde delta in the Netherlands. The species has been considered extinct in the River Rhine since the 1940s. Shortly after the start of a re-introduction program in the Lower Rhine in 1996, first NSH were caught in Lake IJsselmeer (a part of the former Rhine delta), and natural reproduction was proven in 2006. Telemetry data of adult NSH (NEDAP TRAIL® system) suggested that the River IJssel, a lower branch of the Rhine, may serve as a spawning ground. To further investigate this, a drift net sampling for larvae was undertaken in the River IJssel, directly upstream from Kampen, where it discharges into Lake IJsselmeer. From the mid of March until the beginning of April 2010, 218 freshly hatched larvae of NSH were caught (maximum concentration 0.0032 larvae $m^{-3}$). The size of these larvae was in the same range as controls from a hatchery that were about 12 hours of age, indicating that the drifting larvae must have hatched in upstream areas of the River IJssel or tributaries. Calculations based on discharge revealed that roughly 500,000 freshly hatched NSH larvae could have passed within 19 days. Based on the number of drifting larvae, a rough estimation of the spawning population revealed about 1,000 spawners, highlighting the tremendous success of the re-introduction program of North Sea houting in the River Rhine.

# Home range and habitat use of 9 months old stocked European sturgeon (*Acipenser sturio*)

**M. L. Acolas**[1], C. Pichon[2], E. Rochard[1]

[1]Irstea, EPBX, Estuarine Ecosystems and Diadromous Fish Research Unit, 50 avenue de Verdun, 33612 Cestas, France
[2]Irstea, HBAN, 1 rue Pierre-Gilles de Gennes CS 10030, 92761 Antony France
marie-laure.acolas@irstea.fr

## Abstract

The last European sturgeon population comes from the Gironde basin. This species is classified as critically endangered and a stocking program was initiated since 2007 to sustain the natural population. The species knowledge is limited and behaviour of fish of less than 2 years old is unknown. In this context, an acoustic telemetry study was initiated in 2009 in order to assess individual home range and to analyse habitat use in the lower part of the Dordogne River and in the Gironde estuary. 48 fish (fork length: 31 cm) were tagged and released in April and their movements were monitored up to 38 days thanks to passive tracking. Fish trajectories were characterised using R software. Hydrographic distances, following the river, were estimated with Anaqualand 2.0 freeware and an individual linearity index was calculated for all fish. For 38 fish, the linearity index indicates a more or less straight downstream trajectory. For 10 fish, the linearity index traduces a sinuous movement and home range was calculated for those individuals using the Brownian Bridge Movement Model (BBMM). Home range 50% was between 3 and 32 $km^2$ according to the individuals. Thanks to GIS-based mapping of environmental variables (depth, sediment, benthic prey), characteristics of the habitat used were analysed.

# High importance of lacustrine habitats for production of Atlantic salmon (*Salmo salar*) smolts; a study of growth and densities of salmon parr in the watercourse, Roksdalsvassdraget, northern Norway

**R. Borgstrøm**[1], B. Benberg[1], I. S. Ingvaldsen[1], M. Halvorsen[2], Ø. K. Hanssen[3], M. A. Svenning[4]

[1]Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management, N-1432 Aas, Norway
[2]Morten Halvorsen, Museum Nord, N-8445 Melbu, Norway
[3]Ferskvannsbiologen, P.O. Box 127, N-8550 Lødingen, Norway
[4]Norwegian institute for nature research, Department for Arctic Ecology (NINA-Tromsø), Fram Center, N-9296 Tromsø, Norway
reidar.borgstrom@umb.no

## Abstract

A majority of studied Atlantic salmon (*Salmo salar*) populations in northern Norway utilize lacustrine habitats as nursery areas. However, the lacustrine contribution to total smolt production has not been estimated. To evaluate the production of Atlantic salmon presmolt in the streams versus the lakes, parr densities and parr growth were studied in the watercourse, Roksdalsvassdraget (69°03′N, 15°50′E) in Nordland county. Atlantic salmon juveniles inhabit three lakes and seven streams in this watercourse. In addition, brown trout (*Salmo trutta*), Arctic charr (*Salvelinus alpinus*), three spined stickleback (*Gasterosteus aculeatus*), European eel (*Anguilla anguilla*) and European flounder (*Platichthys flesus*) also occur. The number of presmolt (≥ 2+) in the streams was estimated by electrofishing, while the number of salmon presmolt in the lakes was estimated by gillnet catches of presmolt and information of gillnet catchability. Total estimated number of presmolt (≥ 2+) was ca 7000 in the streams and ca 7500 in the lakes, corresponding to a mean density of 10 and 4 presmolt per 100 $m^2$ in streams and lakes, respectively. With an assumed mortality of 30 % from presmolt to smolt, the annual smolt production may be approximately 10 000. Lacustrine salmon parr had better growth than stream-living parr. The study indicates that the lakes contribute significantly to the total production of Atlantic salmon smolt. The high salmon returns to several small, north Norwegian rivers may thus be explained by the relative large lacustrine smolt production, and should be emphasized when estimating the spawning target for these small watercourses.

# The impact of a brominated flame retardant on the physiology and behaviour of hatchery-reared Atlantic salmon (*Salmo salar* L.) smolts during the transition from freshwater to the marine environment.

**A. Moore**[1], C. Cotter[2], L. Privitera[1]

[1] CEFAS, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[2] ACMS, Marine Institute, Newport, Co. Mayo, Ireland
andy.moore@cefas.co.uk

## Abstract

Atlantic salmon smolts were exposed in a hatchery to environmental levels of a brominated flame retardant, tagged with miniature coded acoustic transmitters and released into freshwater at the peak of the smolt run. The subsequent movements of the smolts were monitored within the freshwater and immediate coastal zone using an array of acoustic receivers. Laboratory-based experiments also examined the impact of the flame retardant on physiological parameters associated with the parr-smolt transformation and saltwater survival.

Exposure of the salmon smolts to the flame retardant did not have a significant effect on any of the measured physiological parameters associated with the parr-smolt transformation when the fish were sampled in freshwater or after they had been placed in full strength seawater. However, 30% of the salmon smolts exposed to the flame retardant died within 18 hours of being transferred to seawater. There were no mortalities in the control group after 72 hours in seawater. The tagging study indicated that eight of the smolts exposed to the flame retardant died as they moved through the estuary and into the marine environment. The results of the study suggest that exposure of smolts to the flame retardant in freshwater may affect their ability to survive when they migrate into the marine environment. In conclusion, the study provides further evidence that the conditions experienced by juvenile salmon in freshwater may have a significant impact on their subsequent survival in the sea.

# Effects of short term tributyl phosphate exposure on silver eel downstream migration and physiology.

**L. Privitera**[1], K. Aarestrup [2], A. Moore [1]

[1]Cefas, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[2]DTU, National Institute of Aquatic Resources, Vejlsøvej 39, Silkeborg, 8600, Denmark.
Lucia.Privitera@cefas.co.uk

## Abstract

The European eel (*Anguilla anguilla*) populations have been declining rapidly since the late 1980's (Moriarty and Dekker, 1997) and despite limited management and restoration programmes, there has been little improvement in natural recruitment (Feunteun, 2002). In response to this decline, the EU "Eel Recovery" regulation, (Council Regulation 1100/2007) was implemented in 2007. To satisfy the EU Eel Recovery Plan, member states must develop Eel Management Plans which includes a requirement to indicate the proportion of eel of each life stage affected by contaminants, parasites and pathogens and the degree of infection/contamination. The major factors regulating eel populations are still unknown but pollution has been suggested to have a detrimental effect on eel health and potentially on their reproductive success and survival (Robinet and Feunteun, 2002).

The present study examined the impact of tributyl phosphate (TBP) on the behaviour of wild silver eels during their emigration from freshwater and into the coastal zone. Eels were tagged with miniature coded acoustic transmitters and exposed to an environmental concentration of TBP. Their subsequent movements were monitored as they migrated from freshwater and into the marine environment using strategically positioned acoustic receivers. In addition, the physiological status of separate groups of eels was measured to determine the impact of TBP exposure on osmoregulatory capability and survival of the fish once transferred into saltwater. Results from this study suggest that short term exposure to TBP did affect the eel physiology but not migratory behaviour.

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# Revisiting the question of interrupted summer growth in *Anguilla anguilla*

**I. Domingos** [1,2], J. L. Costa [1,2]

[1] Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
[2] Departamento de Biologia Animal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
idomingos@fc.ul.pt

## Abstract

Age reading remains a complicated task in anguillids mainly due to the recognized difficulty in interpreting otolith marks. In this study, the periodicity of growth increment formation was determined from the otoliths of eels sampled in central Portuguese river basins. Marginal increments on saggitae, measured monthly, were used to validate that periodicity and revealed that growth band deposition in freshwater reflects a bi-annual increment formation contrary to what happens in the brackishwater habitat. In freshwater, the first ring, corresponding to winter, was laid down between December and March whereas a second ring was laid down in summer between July and August. Unfavourable conditions such as high summer temperatures, typical of southern latitudes, can account for these results and affect growth similarly to what happens with low temperatures during winter, as shown by the seasonal and daily feeding intensity of eels. The implications of the present findings are discussed at the light of a future scenario of global warming and longer dry periods, expected for southern latitudes.

# Retrospective colonisation patterns of freshwater reaches of eel in Gironde catchment using multi elemental composition and strontium isotope ratio of otoliths.

**F. Daverat**[1]., A. Lochet[1], M. Eon[1], J. Martin[2], S. Berail[2], G. Bareille[2], C. Pecheyran[2]

1 EPBX Estuaries and Amphidromous fish research unit, IRSTEA, 50 av de Verdun 33612 CESTAS Cedex.
2 Laboratoire de Chimie Analytique Bio-inorganique et Environnement LCABIE, UMR CNRS 5034 Hélioparc Pau Pyrénées, 2 Avenue Pierre Angot, 64053 PAU Cedex 9, France
francoise.daverat@irstea.fr

## Abstract

The objective of the study was to retrieve the migration patterns of eels during their colonisation of the freshwater part of catchments. The present work used multi elemental otolith composition (Mn, Co, Zn, Rb, Cd, Sn, Ba, Sr, Pb and Li concentrations) coupled with strontium isotopes ratio otolith measures to investigate the movement patterns of eels migrating in the freshwater reaches of the Gironde catchment. One hundred eel samples were collected in 16 locations in the freshwater part of the Gironde river basin. The multi element composition of each otolith sample was measured with a femto-second laser coupled with a ICPMS along a life history transect between the core and the edge. In a second step, the strontium isotope ratio was measured along the same transect using a femto-second laser coupled with a multi collector ICPMS. Based on the hypothesis that the composition of edge of the otolith was representative of the habitat of capture, we investigated the possibility to use multi elemental composition and strontium isotopes rates to discriminate the different locations. To further validate the link between otolith composition and geographic position, a caging experiment was also set up for six months in three locations within the Gironde river basin. Two batches of eels were reared in cages during successive periods of three months. Results from the caging experiment and the analysis of edge composition of wild fish were used to interpret the individual movement patterns of the wild eels within the freshwater part of the catchment.

# Silver eel population dynamics in the River Shannon, Ireland.

**R. MacNamara**, T. K. McCarthy

Ryan Institute and School of Natural Sciences, National University of Ireland Galway, University Road, Galway, Ireland.
r.mcnamara1@gmail.com

## Abstract

The population structure and dynamics of seaward migrating silver-phase European eels (*Anguilla anguilla*) were studied at Killaloe eel weir on the lower River Shannon during 2008–2012. The river system (mean annual discharge 186 $m^3 \cdot s^{-1}$, catchment area 14 000 $km^2$), which is regulated for hydroelectricity generation, includes a series of lowland, mostly mesotrophic, lakes (cumulative area 390 $km^2$). These provide good feeding conditions for yellow-phase eel populations, though growth rates are relatively low due to prevailing temperature regimes. Downstream migration of silver-phase eels occur from August–March, with most (83%) movements at Killaloe occurring in October–December. Mark-recapture experiments and size frequency measurements enabled analysis of the variation in numbers, biomass and population structure of the migrating eels at Killaloe. Seasonal trends in both sex ratio and female size were observed. Fishery records and catch analyses for all other sites in the river system, together with results of the Killaloe eel weir study, show that current silver eel production varies from 61–74 t (1.6–1.9 $kg \cdot ha^{-1}$). The majority (*ca.* 65%) of these potential spawners are female. Long-term recruitment, mostly through stocking, and fishery records (1986–2012), were used to develop a model of silver eel production. This suggests that the decline in River Shannon silver eel production, observable in fishery records over the past three decades, will continue. Since 2009, all commercial eel fishing has ceased, and the current silver eel fishery is operated purely for conservation purposes, with all catches being released downstream of the hydropower dams.

# Stock structure of sea lamprey (*Petromyzon marinus*, L.) in Portugal exposed by heart fatty acid signature

**P. R. Almeida**[1,2], M. Machado[3], R. Ferreira[3,4], I. Alves-Pereira[3,4], C. S. Mateus[1,2,5], B. R. Quintella[2,6], M. J. Lança[3,7]

[1] Department of Biology, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[2] Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[3] Institute of Mediterranean Agrarian Sciences, University of Évora, dos Colegiais 2, 7000 Évora,
[4] Department of Chemistry, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[5]Museu Nacional de História Natural e da Ciência, Center for Environmental Biology, University of Lisbon, Rua da Escola Politécnica 56/58, 1250-102 Lisbon, Portugal.
[6] Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[7] Department of Animal Science, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
pmra@uevora.pt

**Abstract**

European populations of sea lamprey (*Petromyzon marinus* L.) have declined dramatically over the last 30 years and several authors have also pointed out a reduction in this species abundance in Portuguese rivers. Recent reports have suggested that fatty acid composition of phospholipids in some body tissues (e.g., heart tissue, brain, eggs) have a stable genetics basis, which make these tissues appropriate as stock identifiers. In this context, the purpose of this investigation was to analyze the stock structure of sea lampreys sampled in Portuguese river basins using heart tissue fatty acid signature. Adult sea lampreys were collected near the river mouth of eight Portuguese river basins (i.e. Minho, Lima, Cávado, Douro, Vouga, Mondego, Tagus and Guadiana) at the beginning of their spawning migration. The fatty acid profile of the heart tissue varied among individuals of the different river basins. A Multiple Discriminant Analysis (MDA) was employed to identify which fatty acid contributed most to these differences. Although in Tagus and Guadiana most of the individuals were correctly classified (100% and 94.7%, respectively), there are a few individuals of the other five watersheds that have profiles identical to those observed in these two river basins. The results are discussed in terms of fatty acid origin and hypothesis concerning the migratory behavior and the oceanic phase of the species' life cycle.

# Factors affecting the distribution of different early life history stages of twaite shad in the River Elbe, Germany

S. Oesmann

networks – Dipl. Biol. S. Oesmann GbR
Oelkersallee 60, 22769 Hamburg, Germany
info@oesmann.net

## Abstract

680 ring net hauls and relevant abiotic data sets where analysed to detect abiotic habitat preferences of eggs and larvae of twaite shad. The sampling was carried out at 32 sampling sites during spring and summer of the years 2008 and 2009 in the tidal part of the Elbe river, Germany. Twaite shad eggs were caught from the end of April until the end of June, larvae from the end of April until the mid of July.

Eggs were caught within a temperature interval ranging from 11.4 °C up to 19.2 °C, indicating maximum spawning intensity between 13 °C and 17 °C.

The distribution of larval twaite shad was mainly influenced by the factors temperature and salinity. The vertical distribution during day showed different patterns for different developmental stages. The abundances of free embryos larvae increased with increasing water depth.

Young larvae and older stages concentrated in the upper water layers during day. Longitudinal and lateral distributions of eggs and free embryos are assumed to depend from the position of the spawning sites and drift processes.

# Modeling the habitat suitability for spawning and larval shad in the Scheldt estuary

**M. Stevens**, A. Mouton, D. Buysse, T. V. D. Neucker, J. Coeck

Research Institute for Nature and Forest, Kliniekstraat 25, 1070 Brussels, Belgium
Maarten.Stevens@inbo.be

## Abstract

Diadromous fishes are important indicators of ecosystem health. Over the past century, however, most migratory species have disappeared from the river Scheldt due to human impacts. Recently, some species show signs of recovery and for twaite shad there are strong indications that they reproduce again in the Scheldt estuary. However, their spawning and nursery habitats are unknown and it is unclear whether the preconditions for a sustainable recovery are met.

Therefore, a habitat suitability model for spawning and larval shad was constructed based on a literature review. First the environmental variables that determine shad habitat suitability were selected (temperature, oxygen concentration, salinity, suspended solids, current velocity, tidal retention, depth and zooplankton concentration). These variables were then combined using fuzzy logic in order to determine the degree of suitability of a habitat. By integrating the variables in GIS the model was made spatially-explicit.

Early in the spawning season, the model predicts the presence of suitable spawning habitat in the upper freshwater part of the main stem of the estuary (Zeeschelde). In June, when the water temperature rises, suitable spawning habitat is also selected in the tidal tributaries of the Scheldt (River Nete). Suitable larval habitat is located mainly in the freshwater zone of the Zeeschelde and in the tidal River Rupel.

Based on the model results, restoration and management actions are suggested to safeguard the essential habitats for shad in the Scheldt. These include the further improvement of water quality and the protection and restoration of low dynamic habitats.

# Twaite shad migration and spawning – new insights from the Elbe estuary

**V. Magath**, R. Thiel

University of Hamburg, Biocenter Grindel and Zoological Museum, Martin-Luther-King-Platz 3, 20416 Hamburg, Germany
victoria.magath@uni-hamburg.de

## Abstract

Twaite shad *Alosa fallax* (Lacépède, 1803) is an anadromous species which has been included into Annexes II and V of the European Community Habitats Directive. To ensure the conservation of this species, the fundamental characteristics of its life strategy must be understood. Therefore, this study aims to determine aspects of its spawning migration, the spawning period as well as the location of the spawning areas in the Elbe estuary, Germany. Twaite shad was sampled at 11 sites in the Elbe estuary by monthly research fisheries in 2010. Additional samples were obtained from the cooling water intake of a power plant at the city of Brokdorf. Spawning period and spawning areas were identified by investigating the maturity stage and the gonadosomatic index (GSI).

Overall sex ratio was clearly shifted to the males. This was constant throughout the study period, but sex ratio differed spatially. Spawning took place from the end of April until the beginning of July at the most. Spawning areas were mainly situated in the upper parts of the study area with salinities below 1.0.

These results revealed differences in migration behaviour of males and females in the Elbe estuary. These new insights into spawning period and current spawning areas provide a basis in order to develop efficient protection measures for twaite shad in the future.

# Theme 6 - Aquatic Habitat Restoration and Mitigation Measures

*Invited speaker*

# Aquatic habitat restoration: a panacea or hindrance to fish conservation.

Ian G. Cowx

University of Hull International fisheries Institute, Hull HU6 7RX, UK
i.g.cowx@hull.ac.uk

## Abstract

Many freshwater fish species worldwide are under threat from overexploitation, water resource development schemes, habitat degradation, pollution and stock enhancement programmes. Unfortunately little is being done to maintain these species or enhance their populations, often because the fish and fisheries are considered of low economic value or do not attract the attention of the more charismatic megafauna. The primary actions undertaken in the past focus on protected areas, restricting fishing activities, restocking and imposing fiscal measures against polluters, and more recently habitation restoration, particularly are a result of obligations to support EU Water Framework Directive objectives or similar legislation elsewhere in the world. However, despite considerable investment in such practices, there is minimal evaluation of the effectiveness of such measures for maintaining or improving the conservation status of threatened fish species. This paper examines the position of habitat restoration as a tool in fish conservation management and will explore whether alternative and or complimentary measures are required to meet conservation objectives

# Improving the ecological continuity: consequences for an anadromous migratory fish, the Allis shad

**C Boisneau**[1], B Ruaux[1], P. Boisneau[2]

[1]Tours University, CITERES UMR CNRS 6173, Parc de Grandmont, 37200 TOURS France
[2]Association des Pêcheurs Professionnels Bassin Loire, La Bardoire 37150 CHISSEAUX
catherine.boisneau@univ-tours.fr

## Abstract

Allis shad is an anadromous migratory fish constituting a fishing resource for inland commercial fishermen in some big rivers in France. Its situation is strongly different among watersheds, decreasing in the Garonne - Dordogne, increasing in small coastal rivers in Britanny and in the Rhône River. In the medium part of the Loire watershed, a patrimonial fishing technique is used to collect these fishes. It is a passive lift net that can be used to study the anadromous migration of adults. Fishing effort and catch data, associated with sex ratio and age of fishes sampled on several fisheries are used to build an annual index of abundance of the cohorts. The temporal evolution of this index for two parts of the Loire, upstream and downstream of the Loire and Vienne rivers confluence, is analyzed and related with thermic, hydrological and ecological continuity variables.
Overall the entire sampling period, 1980-2004, the cohorts' abundances are not related to any hydrological or thermic variables. When considering ecological continuity improvement, ie before and after dam removing or fish passage improvement, Allis shad populations are functioning differently with an increase (threefold) of their abundance after improvement. On both river parts, before ecological continuity improvement, the abundances of the cohorts were related to water discharge above a high threshold, the percentile 90, which allowed spawners to join the spawning grounds. After ecological continuity improvement, adults can reach freely the spawning grounds and the abundance is now related to the hydrological variations.

# Effects of dam removal on watershed colonization by adult Sea lamprey *Petromyzon marinus* in a coastal river

**E. Lasnen**[1], M. R. Sabatié[2], N. Jeannot[2], J. Cucherousset[4,5]

[1] MNHN – UMR BOREA, CRESCO; 38 rue du Port Blanc, F-35800 Dinard, FRANCE
[2] UMR ESE, Agrocampus Ouest / INRA; 65 rue de Saint-Brieuc, CS 84215, F-35042 Rennes cedex, FRANCE
[3] INRA – U3E; Station de piégeage du Moulin des Princes, F-56620 Pont-Scorff, FRANCE
[4] CNRS, Université Paul Sabatier, ENFA – UMR5174EDB (Laboratoire Évolution & Diversité Biologique); 118 route de Narbonne, F-31062 Toulouse, France.
[5] Université de Toulouse, UMR5174 EDB ; F-31062 Toulouse, France.
emilien.lasne@mnhn.fr

## Abstract

Assessing the ecological effects of habitat restoration on wild populations is of crucial importance since habitat fragmentation is considered as one of the principal cause for biodiversity loss. Many freshwater fish populations have been fragmented worldwide by the construction of dams and this is notably true for many diadromous species that have heavily declined because of connectivity loss between their growing and spawning habitats caused by damming. To restore populations, dam removal has been conducted in some rivers, but the effects of such management actions have been rarely assessed to evaluate and support management actions. Here, we analyzed the spatial distribution and abundance of adult Sea Lamprey (*Petromyzon marinus*) along a coastal river of Brittany (France) from 1994 to 2011 to determine whether a dam removal that occurred in 2000 has significantly affected these population parameters. Specifically, nests were counted, mapped and implemented in a GIS database along a 32-km long sector. Our results demonstrated that the abundance of adult Sea Lampreys was higher after dam removal and that the distribution patterns of nests rapidly shifted upstream after habitat restoration. We also found that the spatial patterns of habitat colonization were context-dependent and affected by adult density, river discharge and dam removal. Overall, our results demonstrated that, within a relatively short period of time, dam removal had a positive effect of the population and further investigations are now needed to quantify the potential subsequent effects on juvenile recruitment and population functioning.

# The role of oxbow lakes on fish migration and reproduction in the River Emajõgi ecosystem (Estonia)

**M. Tambets1**[1], J. Tambets[1], M. Thalfeldt[1], E. Kärgenberg[2], F. Oekland[3], T. Saat[2]

[1]Eesti Loodushoiu Keskus (Wildlife Estonia), Veski 4, Tartu 51005, Estonia
[2]University of Tartu, 18 Ülikooli Street, Tartu, Estonia
[3]Norwegian Institute for Nature Research (NINA), P.O.Box 5685 Sluppen, N-7485 Trondheim, Norway
meelis.tambets@gmail.com

## Abstract

The Emajõgi River (length 100 km) connects lakes Peipsi (3555 km$^2$) and Võrtsjärv (270 km$^2$). There are 55 oxbow lakes in the upper course (70-100 km from river mouth) of the river. The total length (35 km) and surface area (70 ha) of oxbow lakes exceed those of the riverbed of this river section. Oxbow lakes have rich fish fauna and, together with alluvial meadows, provide excellent reproduction grounds for many fish species. The abundance of juvenile fish in oxbow lakes is very high.

Several fish species migrate to spawn in oxbow lakes from lakes Peipsi and Võrtsjärv, and other water bodies of the Emajõgi River system. We studied migrations of bream (*Abramis brama*) and asp (*Aspius aspius)* tagged with Carlin tags and acoustic transmitters. Over 10 000 specimens of bream and 30 adult asps were tagged, and 10-15% of fish were recaptured. Bream demonstrates extremely strong homing behavior returning to spawn, from year to year, into a particular oxbow lake. The asp demonstrated complicated migration pattern.

Oxygen deficiency often occurs in oxbow lakes in winter and sometimes also in summer, due to silting of lake mouth with sand and mud. Fish trapped in oxbow lakes may die. To restore and enhance the ecological potential of the Emajõgi River system, sediment was removed from mouths of 10 major oxbow lakes (LIFE07 NAT/EE/000120). Fish abundance in oxbow lakes increased following sediment removal.

# Behavioural response of the Iberian barbel (*Luciobarbus bocagei* Steindachner, 1864) in a pool and weir type fishway assessed with electromyogram telemetry

**C. M. Alexandre**[1,2,3], B. R. Quintella[1,4], C. S. Mateus[1,2,5], A. Silva[3], T. F. Ferreira[3], P. R. Almeida[1,2]

[1]Center of Oceanography, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[2]Biology Department, School of Sciences and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal
[3]Forestry Research Center, Institute of Agronomy, Technical University of Lisbon, Lisbon, Portugal
[4]Department of Animal Biology, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[5]Center for Environmental Biology, National Museum of Natural History, University of Lisbon, Rua da Escola Politécnica 58, 1250-102 Lisbon, Portugal
cmalexandre@fc.ul.pt

**Abstract**

Portuguese rivers are severely regulated by dams and weirs that, by deterring fish migration, contribute to the loss of species' stocks. Such decay promoted the development of fishways, which are becoming one of the most common measures for the restoration of connectivity in rivers (Clay, 1995). Their efficiency must be guaranteed by adjusting the design and hydraulic features of the facilities to the potential users (Katopodis, 2005). In this study we used an experimental pool-type fishway to study the swimming behaviour of a cyprinid potamodromous species, the Iberian barbel *Luciobarbus bocagei* Steindachner, 1864. In total, 44 barbels were used in the experiment, 22 of which tagged with EMG radio transmitters equipped with electrodes that register the muscle activity (Cooke et al., 2004). Untagged fish were used as control. A relationship was developed in a swimming tunnel for tagged fish whereby swimming speed could be estimated from the EMG telemetry signals and posteriorly compared with the barbels' swimming behaviour during the fishway passage. Tagged fishes exhibited a high passage success, and anaerobic burst swimming (Mateus et al., 2008) was only required to transpose the submerged orifices of the fishway. Barbels' swimming speed exhibited a positive relationship with some hydraulic variables within the fishway, namely the water velocity, turbulent kinetic energy, turbulence intensity and Reynolds shear stress, highlighting the importance of these parameters when designing fishways. Results suggest that EMG telemetry is a valuable tool to study barbels' swimming behaviour in pool-type fishways, where direct visual observations are frequently not possible. Data collected with this physiological biotelemetry technique may be used by biologists and engineers to modify existing fishways in order to improve attraction and passage efficiency.

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# Monitoring fine-scale movement and behavior of native and stocked trout populations (*Salmo trutta*) after habitat improvement in a headstream of northeastern Portugal

**A. A. T. Teixeira**[1], J. M. Oliveira[2], R. M.V. Cortes[2]

[1] CIMO- ESA-IPB- Mountain Research Centre, School of Agriculture, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 1172, 5301-855 Bragança, Portugal
[2]CITAB- Centre for the Research and Tecnhology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes e Alto Douro, Quinta dos Prados, 5000-911 Vila-Real, Portugal
amilt@ipb.pt

## Abstract

Passive integrated transponder (PIT) technology was used to monitor the fish movement and behaviour in the River Penacal, a salmonid headwater stream of northeastern Portugal. A total of 60 PIT tags (12 mm long x 2.1 mm diameter) were surgically implanted into native and stocked fish (13.5-17.5 cm; 18.2-60.0 g), considering a) 20 stocked trout, reared in traditional cement raceways; b) 20 stocked trout, previously acclimated to natural conditions and c) 20 native trout of different age classes (8.5-17.0 cm, 5.5-35.5 g) captured by electrofishing in the study site. Eight independent antennae, connected to a multi-point decoder (reader) unit, were randomly replaced every three days, in different microhabitats of a blocked reach (30m x 5m) during an observation period of 7 weeks, in July 2010. Fish habitat improvement was previously made, recurring to the incorporation of boulders and vegetation. The results confirmed this method as a suitable tool to assess the movement and habitat use of sympatric trout populations. About 95% of stocked and 85% of native PIT tagged trout were detected. Multivariate techniques confirmed different movements and habitat use among the three sympatric populations. Stocked trout, hatched-reared in traditional cement tanks, tended to occupy distinct microhabitats, located in the middle of the channel and without cover. Furthermore, these fishes displayed a greater mobility and a diel activity pattern different from both acclimated hatchery-reared and native trout populations, which displayed a better adaptation to the wild environment, using more frequently the refuge promoted by the habitat improvement.

# A comparison of Random Forest and Logistic Regression models to predict habitat suitability for fish

**P. Vezza**[1,2], P. Parasiewicz[3], O. Calles[4], M. Spairani[5] and C. Comoglio[1]

[1] Dipartimento di Ingegneria del Territorio, dell'Ambiente e delle Infrastrutture, Politecnico di Torino, 24, C.so Duca degli Abruzzi, Torino, Italy
[2] Instituto de Investigación para la Gestión Integrada de Zonas Costeras,, Universidad Politécnica de Valencia, 1, C/ Paranimf, Grao de Gandia, Valencia, Spain
[3] Rushing Rivers Institute, 592, Main Street, Amherst, Massachusetts, USA
[4] Department of Biology, Karlstad University, SE-651 88 Karlstad, Sweden
[5] Eaulogie s.r.l., 16, Via Federico Chabod, Aosta, Italy
paolo.vezza@polito.it

## Abstract

In the context of water resources planning and management, the prediction of fish presence related to the habitat characteristics is fundamental for the definition of environmental flows and habitat restoration measures. In particular, threatened and endemic fish species should be the targets of biodiversity safeguard and wildlife conservation actions. The recently developed meso-scale habitat models (i.e. MesoHABSIM) allow the use of multivariate statistical techniques to predict fish species distribution and to define habitat suitability criteria. In this research we compared Random Forest (RF) and Logistic Regressions (LR) analysis to predict the presence of bullhead (*Cottus gobio*) as a function of habitat conditions in 10 reference streams in Piedmont region (NW Italy). Along selected stream reaches, 100 mesohabitats were sampled for hydro-morphologic and biological parameters and RF and LR were used to select the most important habitat attributes for the fish presence across the region of interest. The preliminary results of this research are discussed, as well as possible future developments and applications, showing potentials and limitations of Random Forest in building habitat suitability models for fish.

# Contribution of wood to the provision of habitat for New Zealand's indigenous fish communities

B. R. Baillie[1,2]

[1]Scion, Private Bag 3020, Rotorua 3046, New Zealand
[2] The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand
brenda.baillie@scionresearch.com

## Abstract

Since humans arrived in New Zealand, indigenous forest cover has declined from approximately 85% to 24% of New Zealand's land area. Many streams have been deprived of their natural wood loadings. A field trial was established in three small forested streams to compare fish communities in pools where wood provided cover (wood pools), open pools (minimal or no wood cover) and riffles. A 200 m upstream reach was retained as a control section and wood was removed from a 200 m downstream section to measure the response of the stream channel and fish communities.

Wood pools contained most of the fish biomass, higher densities and biomass of banded kokopu (*Galaxias fasciatus*), and the weights of longfin eels (*Anguilla dieffenbachii*) were significantly higher in wood pools. Total species richness, density and biomass of bluegill bullies (*Gobiomorphus hubbsi*), torrentfish (*Cheimarrichthys fosteri*) and density of redfin bullies (*Gobiomorphus huttoni*) were highest in riffles. Differences in fish community composition were greatest between riffles and pools, whereas there was considerable overlap between the two pool types. Pool area declined following wood removal, increasing the area in riffles. Wood removal reduced the abundance of banded kokopu and large longfin eels in the treatment sections. At the reach scale there was a significant decline in the biomass of banded kokopu.

In this study, habitat provided by wood was important for two of the largest fish species in these fish communities. Wood has potential as a rehabilitation tool in streams in the absence of natural recruitment processes from forested riparian margins.

# Salmonid eradication for native fish rehabilitation: A sinister means to a critical cause?

L. Pham, **G. Closs**

Department of Zoology, University of Otago, Dunedin, New Zealand.
Lanpham3000@gmail.com

## Abstract

The native inhabitants of freshwater ecosystems have been detrimentally affected by introduced species globally. In the Southern Hemisphere, the Galaxiidae fish family have been severely impacted by the introduction of exotic salmonids. The distribution of many galaxiid species has been fragmented with salmonids occupying the lower reaches of streams, and galaxiids persisting in headwater refugia.

A major challenge facing conservation managers is how to safeguard the remaining populations of threatened native species. The piscicide rotenone has been widely used to eradicate or 'knock-back' invasive or unwanted fish species worldwide. However, there is little information regarding the impact on native fish being re-introduced to a stream after rotenone treatment. For the first time in New Zealand, rotenone was employed to eradicate brown trout (*Salmo trutta*) from two streams that also supported low numbers of banded kokopu (*Galaxias fasciatus*). Prior to poisoning attempts were made to capture all banded kokopu and hold them during the poinsoning operation. Following eradication of trout, banded kokopu were returned to the stream. We then measured banded kokopu mobility, weight, and condition over a 15 month period to record responses of the fish to both the absence of trout and depletion of aquatic invertebrate prey due to poisoning.

Management of salmonids by poisoning presents a challenge given the high fisheries value attributed to them by the public. This project also highlighted the difficulties conservation managers face in dealing with the public, government agencies, and the media when attempting eradication for the cause of native fish conservation.

# Complete Versus Partial Macrophyte Removal: The Impacts of Two Drain Management Strategies on Freshwater Fish in Lowland New Zealand Streams

**M. J. C. Greer**[1], S. K. Crow[2], A. S. Hicks[3], G. P. Closs[1]

[1]Department of Zoology, University of Otago, P.O Box 56, Dunedin, New Zealand
[2] National Institute of Water and Atmospheric Research, P.O Box 8602, Christchurch New Zealand
[3] Environment Southland, Private Bag 90116, Invercargill, New Zealand

## Abstract

Complete macrophyte removal to maintain drainage performance in lowland streams can have a negative effect on resident fish communities, but few studies have quantified this impact. Moreover, limited research has been carried out exploring alternative approaches for macrophyte removal that maintains drainage performance while minimising the impact on the resident fish community. The aims of this study were: (1) to determine how the current practice of removing almost 100 % of available macrophyte cover affects native fish populations in lowland New Zealand streams, and (2) to see if this impact can be reduced by limiting macrophyte removal to alternating 50 meter sections of the waterway.

Native fish populations were surveyed before and after experimental macrophyte removal for the following three treatments: 1-complete macrophyte removal. 2-macrophyte removal from alternating 50 m reaches, 3-control with no macrophyte removal. Radiotelemetry was used to monitor the behavioural response of individual giant kokopu (*Galaxias argenteus*) to the different treatments. The results of this study suggests that current drain management practices reduce catch per unit effort of fish by 60 %. Although limiting macrophyte removal to alternating 50 m sections did not minimise the community impacts of drain clearing, large giant kokopu did benefit from this strategy. All tagged giant kokopu remained in streams reaches partially cleared of macrophytes while in completely cleared reaches all individuals were displaced. These results demonstrate the threat current drain management practices pose to New Zealand native fish and highlight the value of trialling alternative methods of macrophyte removal.

# Efficiency and impacts of gillnets in small-scale fisheries of a large tropical river (Brazilian Amazon)

**R. A. M. Silvano**[1,2], G. Hallwass[1,2], A. A. Juras [2,3], P. F. Lopes[2,4]

[1]Dep. Ecologia and [2]PPG Ecologia UFRGS, CP 15007, 91501-970, Porto Alegre, RS, Brazil
[2]Fisheries and Food Institute (FIFO), Rua Oswaldo Cruz 277, Santos SP, Brazil
[3]Centrais Elétricas do Norte do Brasil S.A - Eletronorte - SCN Quadra 06 Conj. A, Blocos B e C, Entrada Norte 2, Asa Norte - Cep 70.716-901 - Brasília/DF, Brazil
[4]Depto. Botânica, Ecologia e Zoologia, Centro de Biociências, Universidade Federal do Rio Grande do Norte-Lagoa Nova, 59072-970, Natal, RN, Brazil
renato.silvano@ufrgs.br

## Abstract

We compared fishing efficiency and impact of gillnets of distinct mesh sizes, using fish sampling and fisheries data, in the Lower Tocantins River (Brazilian Amazon), to provide input to fish conservation and management. We sampled 3933 individuals of fish in 12 floodplain lakes using gillnets (6, 8, 10-12 and 14-16 cm between opposite knots), and we recorded 5.03 t of fish caught in 330 fish landings with gillnets of 6 cm, 8 cm, large (10 cm and larger), mixed, mixed large and mixed small. Indicators of gillnet efficiency were the catch per unit of effort (CPUE) of total fish sampled and caught by fishers (g of fish/ $km^2$ of gillnets * h fishing), CPUE of commercial fish sampled (> 1 % of the total biomass landed) and proportion of commercial fish biomass sampled. Indicators of impact (fish sampling) were number of non-commercial fish (by-catch) and proportion of fish below the length at first maturity (immature fish). Gillnets of 08 cm and large ones had higher CPUE in fish landings, while in fish samplings gillnets of 6 and 8 cm had higher CPUE (total and commercial fish only) and caught a higher proportion of commercial fish, gillnets of 10-12 cm showed a higher by-catch and gillnets of 6 cm caught more immature fish. Therefore, gillnets with 8 cm mesh size or similar could maximize catches and minimize impacts (by-catch and recruitment overfishing), improving fishers' yields and fish conservation in the studied river and in other similar tropical regions.

# Development of a fish behavioral barrier: Preliminary results on the effects of strobe light and air-bubble on different fish species

J. J. B. Jesus[1], R. M. V. Cortes[2], S. R. Natário[1], A. A. T. Teixeira[3], **J. S. Teixeira[1]**

[1]OriginAL Solutions, Estrada do Cando, Casa da Fraga, 5400-010 Chaves
[2]CITAB- Centre for the Research and Tecnhology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes e Alto Douro, Quinta dos Prados, 5000-911 Vila-Real, Portugal
[3] CIMO- ESA-IPB- Mountain Research Centre, School of Agriculture, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 1172, 5301-855 Bragança, Portugal
original.consulting@gmail.com

## Abstract

The responses of selected freshwater fish species (*Salmo trutta, Pseudochondrostoma duriense and Luciobarbus bocagei*) to strobe light, air bubbles or combined strobe light/ air-bubble interaction were investigated under laboratory conditions. All species tested exhibited avoidance behavior to strobe lights, namely for high strobe flash rate (600 flash/ minute). However strobe light was more efficient for brown trout and nase than for barbel. On the other hand, avoidance response for air-bubble showed low efficacy for trout and barbel species. Increased avoidance was more effective when strobe lights were combined with air bubbles. Results demonstrate the potential application of such behavioral barriers adapted to autochthonous freshwater species in order to allow fish movement to spawning areas, namely of threatened potamodromous species in streams affected by dams. These systems may provide conditions to increase the efficiency of fish passages and to avoid the mortality created by specific structures (channel turbines, pumping systems).

# POSTER COMMUNICATIONS

# Theme 1 - Ecosystem Functioning

# How rainfall and the hydrological regime affect fish reproduction in a Central Amazonian Reservoir, Brazil.

S. Amadio, R. N. Santos

Instituto Nacional de Pesquisas da Amazônia/Coordenação de Biodiversidade - Av. André Araújo 2936, Aleixo, Manaus, AM, Brasil.
amadio@inpa.gov.br

## Abstract

Balbina Reservoir was built on Uatumã River in 1987 in order to provide electricity to Manaus city (Amazonas, Brazil) and is the second largest reservoir in the Amazon region. The damming process in the river altered the environment as a whole, therefore this study aimed to evaluate the influence of local rainfall and hydrological regime on fish reproduction in the reservoir and river. Samples were taken from Balbina reservoir and Uatumã River bimonthly, from March 2005 to February 2007. Data on the precipitation and water level were provided by the Manaus Energia Company. Females at ripe, spawning and spawned reproductive stages were correlated with the rainfall and water level, using Spearman test. Water level ranged from 48.2 (February) to 50.5 m (June) in the reservoir and from 3.8 (August) to 4.2 m (February) in the river. The average rainfall in the area ranged from 52.9 mm during the dry season (August to October) to 380.8 mm during the rainy season (November to July). A total of 114 species were captured in the river and 46 in the reservoir; from these 52 (45.6%) and 24 (52.2%) were in reproduction respectively. Fishes from the river ($r = 0.64$, $p < 0.001$) and the reservoir ($r = 0.69$, $p < 0.001$) showed significant correlation between reproduction and precipitation, indicating that most fish species spawn during the rainy period however, reproduction could not be correlated to the water level, as it ranged very little due to the river damming($r = 0.22$, $p = 0.49$).

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# Seasonal variation of the water quality in ponds on nutritive potential and digestibility of tilapia *Oreochromis niloticus* in natural feeding condition (Mali, West Africa)

C. M. Blé[1], Y. L. Alla[1], O. A. Etchian[3], A. A. Adingra[1], S. Niamké[3], J. K. Diopoh[3], R. Arfi[4]

[1]Centre de Recherches Océanologiques, Département Aquaculture, BP V 18 Abidjan, Côte d'Ivoire.
[2]Université d'Abobo-Adjamé, Laboratoire de Biologie et de cytologie animale, 02 BP 801 Abidjan, Côte d'Ivoire
[3]Laboratoire de Biotechnologies, Filière Biochimie-Microbiologie, UFR Biosciences, Université de Cocody - Abidjan, 22 BP 582 Abidjan 22, Côte d'Ivoire.
[4]IRD (Institut de Recherche pour le Développement), LOPB, Centre d'Océanographie de Marseille, Faculté des Sciences de Luminy, 13009 Marseille, France.
blecel@hotmail.com

## Abstract

Effect of anthropogenic factors and seasonal variation on quality of *Oreochromis niloticus* diet in extensive aquaculture pond was investigated. The water nutrient concentrations mainly ammonium and orthophosphates presented significant seasonal variation ($p<0.05$). Total suspended solids, the main trophic source in pond, showed variable amounts between ponds during the same season. The chemical composition of this resource is characterized by a high proportion of mineral (89%). This is reflected in the poor quality of food ingested by fish. Indeed, the indigestible materials (fiber and minerals) represented 70% and 61% respectively of the ration ingested during the dry season and rainy season. Analysis of these results showed that anthropogenic factors including fertilizer application in change of environmental conditions and quality of fish food seems to be more important.

# Contribution of allochthonous carbon subsidies to the Minho estuary lower food web

E. Dias[1,2], P. Morais[2,3], A. M. Cotter[4], C. Antunes[2,5,6], J. C. Hoffman[4]

[1] ICBAS – Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Lg. Prof. Abel Salazar 2, 4099-003 Porto, Portugal
[2] CIMAR/CIIMAR- Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal
[3] ICCE- International Center for Coastal Ecohydrology, Palácio do Capitão-Mor, Horta das Figuras, EN 125, 8005-518 Faro, Portugal
[4] Mid-Continent Ecology Division, National Health and Environmental Effects Research Lab, US Environmental Protection Agency, 6201 Congdon Blvd, Duluth, MN 55804, USA
[5] Aquamuseu do Rio Minho, Parque do Castelinho s/n, 4920-290 Vila Nova de Cerveira, Portugal
[6] ESG - Escola Superior *Gallaecia*, Largo das Oliveiras s/n, 4920 Vila Nova de Cerveira, Portugal
esterdias@ciimar.up.pt

## Abstract

To study the contribution of autochthonous and allochthonous OM sources fuelling the lower food web in Minho River estuary (N-Portugal, Europe), we characterized the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope ratios of zooplankton and their potential OM sources, as well as the concentration and stable isotope ratios of dissolved inorganic carbon (DIC) and particulate OM (POM) along the estuarine salinity gradient, during a summer flow base.

The $\delta^{13}C_{DIC}$ values were lowest in the tidal freshwater (TFW) portion and higher toward the river mouth, following the expected conservative mixing. In the TFW portion, particulate organic carbon (POC) $\delta^{13}C_{POC}$ values (bottom: -28.5‰ to -25.5‰; surface: -29.3‰ to -26.3‰) and C:N (>10) of particulate samples indicated that terrestrial-derived sediment comprised a large portion of the bulk POM pool. In the polyhaline portion, $\delta^{13}C_{POC}$ values (bottom: -20.5‰ to -18.8‰; surface: -25.5‰ to -23.2‰) indicated that the bulk POM pool was generally derived from phytoplankton.

In the brackish estuary, zooplankton $\delta^{13}C$ values were similar to bottom $\delta^{13}C_{POC}$ values, suggesting that marine-derived OM provided a subsidy to the planktonic food web. In contrast, zooplankton $\delta^{13}C$ values in the TFW were similar to surface and bottom $\delta^{13}C_{POC}$ values, suggesting increasing importance of terrestrial- derived OM. Our stable isotope data suggest that the Minho River estuary has a high degree of connectivity along the estuarine salinity gradient and that both marine and freshwater inputs provide a food web subsidy. Therefore, any activity that disconnect the estuary from its adjacent systems (e.g. river, sea, land) may have profound impacts on the estuarine food web.

# Short- and long-term effects of water pollution in fish health: a case of study of Yuriria Lake

T. Espinal-Carrión, E. López-López

[1]Laboratorio de Ictiología y Limnología, Escuela Nacional de Ciencias Biológicas, IPN, Prol. de Carpio y Plan de Ayala s/n, Col. Sto. Tomás, Mexico, D.F., 11340, Mexico
eulopez@ipn.mx.

## Abstract

Fish exposure to mixture of pollutants faces several alterations in their health condition at several levels of organization: biochemical as well effects at population level. The aim of this work is to assess health condition in the silverside *Chirostoma jordani*, an endemic fish to the Mexican Central Plateau, living in Yuriria Lake and where is an important species in fisheries. Yuriria Lake is a water body that receives a mixture of pollutants from Río Lerma, one of the most polluted rivers in Mexico. Early warning biomarker (lipid peroxidation and antioxidant responses), and somatic indices and population structure by size classes were assessed. Water quality index was also assessed. Results showed that *Chirostoma jordani* faces a short-term effect which was evident by the increase in lipid peroxidation and the decrease in antioxidant enzymes activity that coincides with the dry season. At population level we detected a lack of the smallest size class that could be related with a prolonged drought period and a low water level in the lake. The highest levels of lipid peroxidation were associated with lower antioxidant activity and higher water quality index. Since, Yuriria Lake receives several xenobiotics that vary both spatially and temporally, during the dry season xenobiotics could be exerting severe effects in fish health. Long term effects could affect the whole population if the magnitude or duration of these stressors were increasing.

# Oocyte size and number: An invariant characteristic of life history in fishes

R. I. Rios [1], R. Garber[2], R. Mazzoni[3]

[1] Universidade Federal do Rio de Janeiro / Instituto de Biologia / Departamento de Ecologia. C.P. 68.020, Rio de Janeiro, RJ.
[2] RGARBER Estatística e Inovações, Rua Otacílio Novaes 172, Taquara, CEP 22.710-020, Rio de Janeiro, RJ, Brasil.
[3] Laboratório de Ecologia de Peixes, Departamento de Ecologia, Instituto de Biologia Roberto Alcantara Gomes, Universidade do Estado do Rio de Janeiro. Av. São Francisco Xavier 524, CEP 20.550-013, Rio de Janeiro, RJ, Brasil.
rir@biologia.ufrj.br

## Abstract

We consider resource allocation in reproduction, based on a trade-off between the number and size of oocytes and the effect of parental care on this trade-off (Wootton, 1998; Einum & Fleming, 2002). Regression analyses between relative fecundity (RF) and oocyte volume (OV) of 167 Osteichthyes species was done. To develop a predictive model to separate species with parental care (PC) from those without (NPC) a Discriminant Function Analysis (DF) was applied. The relationship RF-OV was: RF=a+bOV, where b=-1.064, a=1.93, $p<0.001$; $R2=0.971$. Regression slope did not differ from -1.0 (t test; $p=0.60$) thus; the product of RF and OV was approximately constant for the 167 species. The DF revealed that the 167 species could be classified into two groups according to the following model DF=0.0066RF-0.01844OV-0.91, where: DF>0 for NPC species and DF<0 for PC species. The hit rate analysis indicated that 95% of the species were correctly included in one of the two groups. Based in the present results we hypothesize that: (i) natural selection that acts in the determination of egg size allows less variability in NPC than in PC species, (ii) the product oocyte number-oocyte size can be considered an invariant relation for certain groups of bony fishes, (iii) small increases in egg size cause major reductions in fecundity thus reducing individual fitness. In such circumstances, genetic or/and epigenetic mechanisms that reduce phenotypic variation will be favored by natural selection. Genetic assimilation (or canalization-Gilbert & Epel,2009) would be the most parsimonious explanation for the existence of such pattern in fishes without parental care.

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# Feeding selectivity of nine fish species in an Atlantic Rainforest stream in southeastern Brazil

L. R. Manna[1], C. F. Rezende[2], M. M. Pereira[1], P. S. Marques [1], R. Mazzoni [1]

[1] Universidade do Estado do Rio de Janeiro, Instituto de Biologia Roberto Alcantara Gomes / Departamento de Ecologia, Laboratório de Ecologia de Peixes. Rua São Francisco Xavier 524, Maracanã, CEP 20550-013, Rio de Janeiro, Brazil.
[2] Universidade Federal do Ceará, Centro de Ciências / Departamento de Biologia. C.P. 6021, CEP 60455-970, Fortaleza, Ceará, Brazil.
luisamanna@gmail.com

## Abstract

The choice of food by fish species is directly related to the trophic resources density and can be influenced by spatial distribution of physical variables (Lawlor 1980a). In the present study, we analyzed the stomach contents of nine fish species in order to investigate the physical changes in the feeding strategy and compare the consumed items with those available in the environment. The feeding habits of 1970 specimens (*Astyanax taeniatus* – 651; *Characidium interruptum* – 24; *Characidium* sp. – 346; *Hypostomus punctatus* – 62; *Mimagoniates microlepis* – 174; *Parotocinclus maculicauda* – 117; *Phalloceros harpargos* – 103; *Pimelodella lateristriga* – 481; *Rhamdia quelen* – 12) were analyzed using the Alimentary Index (IAi) and the Lawlor (1980b) electivity index was used to compute feeding selectivity. The three study sites were classified by the presence or absence of canopy. At sites with canopy, *P. lateristriga, A. taeniatus* and *Characidium* sp. presented generalist diet with high values of selectivity for more items. *Rhamdia quelen* and *P. haspargos* were considered as specialist, consuming and selecting fewer items. At site with no canopy, *A. taeniatus*, *M. microlepis*, *P. lateristriga* and *C. interruptum* presented generalist diet, while *H. punctatus* and *P. maculicauda* were considered specialist. The species of the present study explored the resources according to their distribution along the river and presented the same feeding habits at different sites. The survey of the available resources, combined with the diet description is essential to understand the feeding strategies of each species and their trophic adaptabilities (Deus & Petrere-Junior 2003; Pinto & Uieda 2007).

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# The role of grazing behavior on the diet of a neotropical characin

P. S. Marques, M. Francis, R. Mazzoni

Universidade do Estado do Rio de Janeiro, Instituto de Biologia Roberto Alcantara Gomes / Departamento de Ecologia, Laboratório de Ecologia de Peixes. Rua São Francisco Xavier 524, Maracanã, CEP 20550-013, Rio de Janeiro, Brazil.
piata_bio@yahoo.com.br

## Abstract

Fish feeding behavior can play an important role on the study of fish's diet (Wooton, 1998; Stergiou & Karpouzi, 2002). Regarding this, the current study present the initial investigations on the relationship between feeding behavior and diet of *Bryconamericus microcephalus* (Miranda Ribeiro, 1908) (Family Characidae), from a coastal stream at Ilha Grande, Rio de Janeiro, Brazil. The study site was a stretch, 25m long, with open canopy and rocky bottom. Feeding behavior characterization was done through underwater observations from August to December 2011, following the "Focal Animal" and "*Ad. Libitum*" sampling methods (Altmann, 1974). A total of 6 hour of underwater observation was recorded at daylight. Grazing, answered for 27% of the feeding behavior. When displaying this behavior, fish vigorously scraps off periphyton from the rock surface by moving the teeth along the substrate in rapid succeeding strokes, which include a characteristic lateral body movement. Furthermore, in order to access fish's diet, we captured and dissected 27 individuals. Gut contents analysis was performed and the importance of each food item was accessed through an alimentary index (IAi) (Hahn *et al.,* 1997). According to IAi, periphyton was the most important food item in the diet (IAi=55%), followed by aquatic immature insects (IAi=10%). These preliminary data suggests that periphyton is actively consumed and it is not merely a "by-catch" item. Also, suggest that, despite its low displaying rates, grazing behavior was an effective feeding strategy which is capable of supplying more than 50% of fish's diet. Nevertheless, to ensure the observed pattern, further underwater observations are needed.

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# Reproductive strategy of main species in fisheries in Porto Colômbia Reservoir, Grande River, Southeastern from Brazil.

Y. S. Martins[1], R. E. S. Hojo[2], E. Rizzo[1], N. Bazzoli[2]

[1]Universidade Federal de Minas Gerais - Av. Antônio Carlos 6627, ICB O3 sala 164, 31270-901.
[2]Pontifícia Universidade Católica de Minas Gerais – Av. Dom José Gaspar 500, prédio 43, 30535-901.
bazzoli@pucminas.br

## Abstract

The present study aimed to classify reproductive strategy of main species caught in Porto Colômbia Reservoir, Grande River from Southeastern of Brazil. Based on frequency and variation of sexual rate (SR), gonadossomatic index (GSI), maturational gonadal stages (MGS), stomach repletion index (SRI), coelomic fat index (CFI), hepathosomatic index (HIS), Fulton's condition factor (K) and environmental factors, sampled fish species were qualitatively separated in three groups of reproductive strategy (Winemiller, 1989): equilibrium strategy: *Serrasalmus spilopleura*, *Loricaria lentiginosa* and *Satanoperca pappaterra* - These species presents fractioned spawning, long reproductive term, no reproductive migration and presents parental care. Opportunist strategy: *Schizodon nasutus*, *Metynnis maculatus*, *Pimelodus maculatus* and *Plagioscion squamosissimmus* - it also presents fractioned spawning and long reproductive term, making short or none reproductive migration and do not possesses parental care. Seasonal strategy - *Leporinus friderici* - This species presents total spawning, making short reproductive migrations and and do not possessing parental care. On the other hand multifactorial correspondence analysis (MCA) shows that two groups were formed (81.33% of total variance). One group was formed by *L. lentiginosa* and the other group was formed by all other species. These two grouping were formed mainly due "GSI" and "HSI" according to discrimination analysis (DA) (~ 92% of variance observed). This separation of *L. lentiginosa* from the other species could be explained by low fecundity, low "GSI" values and high egg size observed for this genus. This trade off is not observed for the other species in this study, agreeing with our results of "MCA".

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# Stream-dwelling Fishes From a Neotropical Rain Forest: Patterns of Distribution and Stability of the assemblages

R. Mazzoni[1], R. Iglesias-Rios[2]

[1] Universidade Federal do Rio de Janeiro / Instituto de Biologia / Departamento de Ecologia. C.P. 68020, Rio de Janeiro, RJ.
[2] Laboratório de Ecologia de Peixes, Departamento de Ecologia, Instituto de Biologia Roberto Alcantara Gomes, Universidade do Estado do Rio de Janeiro. Av. São Francisco Xavier 524, CEP 20550-013, Rio de Janeiro, RJ, Brasil.
mazzoni@uerj.br

## Abstract

Patterns of longitudinal changes in fish assemblages are common in rivers from the northern and southern hemispheres. These patterns have been attributed to two non-exclusive, alternative processes: (1) biotic zonation related to changes in habitat structure and the occurrence of barriers to dispersal of species (Vannote et al. 1980) and (2) addition and replacement of species related to habitat and biological characteristics (Mathews, 1998). We evaluated the composition of fish species along the longitudinal gradient of a Neotropical stream from a Rain Forest in Brazil. Environmental factors and biotic relationships, operating at different scales, responded for temporal variations in 15 years of study along 9 sites in Ubatiba stream. We found that environmental characteristics followed a spatial gradient along the stream. The rain proved to be an important factor and determined an unpredictable environment, due to torrential episodes that occur randomly throughout the year. Our temporal analysis indicated that assemblages are quite persistent with respect to species composition, but are very variable when considering specific densities. We observed that a waterfall limited fish movement to upstream areas and reduced diversity in this stream zone. Composition varied in space confirming the importance of environmental characteristics on species distribution. Despite the environmental requirements have shown to be important factors in the organization of assemblages, segregation of species with similar ecological requirements, was constant throughout the stream. Our future goal is to perform experiments to detect possible biotic and/or abiotic factors responsible for structuring the fish communities of Neotropical streams.

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# Population structure and length–weight relationships of six riverine fishes in southeastern Brazil

R. M. C.Melo[1], Y. S. Martins[1], D. M. F. Nunes[2], N. Bazzoli[2]

[1]Universidade Federal de Minas Gerais - Av. Antônio Carlos 6627, ICB O3 sala 164, 31270-901.
[2]Pontifícia Universidade Católica de Minas Gerais – Av. Dom José Gaspar 500, prédio 43, 30535-901.
rmagnocm@yahoo.com.br

## Abstract

The population structure and the length–weight relationship (LWR) provide important data for understanding the population dynamics of fish assemblages in river environments, and can help estimate weight or biomass in studies that utilizes nonlethal methods. The present study describes the sex ratio, sexual dimorphism in size and LWR of six fish species captured with gillnets of different mesh sizes, between April 2010 and February 2011, in the Paraopeba and Velhas Rivers, São Francisco River Basin. The data were obtained from 995 specimens belonging to Characidae and Loricariidae families. The species *Astyanax bimaculatus*, *Astyanax fasciatus* and *Astyanax scabripinnis* presented significantly more females than males, whereas *Hypostomus alatus* had significantly more males than females, contrasting with the characteristic sex ratio (1:1) of tropical fishes. Significant differences in the total length and body weight between males and females were observed only for *A. scabripinnis*, indicating sexual dimorphism in size for this species. The LWR was estimated for the males and females separately. Parameter *a* ranged from 0.005 in *A. bimaculatus* males to 0.083 in *A. bimaculatus* females, parameter *b* ranged from 2.74 in *A. fasciatus* males to 3.48 in *A. bimaculatus* males, and the determination coefficient ($r^2$) ranged from 0.781 in *A. scabripinnis* females to 0.983 in *H. alatus* females. Significant differences in the slope values (*b)* between males and females were not observed for species studied. All species showed negative allometric growth ($b < 3$), characterizing an increment of length greater than the increment of weight, excepting *A. bimaculatus* that had positive allometric growth.

# Contribution of autochthonous and allochthonous material on the diet of fish community of Mato Grosso stream, Rio de Janeiro, Brazil

M. Moraes[1], L. R. Manna[1], C. F. Rezende[2], R. Mazzoni[1]

[1] Departamento de Ecologia, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro – UERJ, Rua São Francisco Xavier, 524, Maracanã, CEP 20550-013, Rio de Janeiro, RJ, Brazil
[2] Departamento de Biologia, Centro de Ciências, Universidade Federal do Ceará – UFC, Campus do Pici, CEP 60455-970, Fortaleza, CE, Brazil
maira.eco@gmail.com

## Abstract

Spatial trophic changes are found for several species of fish in streams and a factor that can influence these variations is the presence and/or absence of vegetation cover (Pinto & Uieda, 2007). In areas with vegetation, fish diet is largely based on allochthonous material and in areas without vegetation on autochthonous material (Lowe- McConnell, 1987). In this sense, the objective of this work was to investigate the contribution of food items from different sources (allochthonous and autochthonous) in the diet of the fish community at Mato Grosso stream, Rio de Janeiro in Southeast Brazil. Samples were collected bimonthly from March 2006 to January 2007 using electrofishing and sieves at two sites differing in vegetation density (covered and uncovered site). Stomach content of each specimen was analyzed through volumetric method (%) and the difference in consumption of the species between sites was analyzed by chi-square test. Only *Astyanax taeniatus* presented significant difference between sites ($X^2$=87.715, p<0.005), consuming more allochthonous items at covered site and autochthonous items at uncovered site. The predominance of allochthonous preys was detected in the diet of *Mimagoniates microlepis* and autochthonous in *Pimelodella lateristriga* and *Characidium Interruptum* at the two study sites. These results demonstrate that either the contribution of allochthonous as autochthonous items is important for aquatic communities. Beside this, allochthonous material has a direct and indirect influence on the diet of species. Thus, deforestation of the areas around the streams may impact species especially those specialized in this type of food such as *M. microlepis*.

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# Trophic guilds of the fish community of Mato Grosso stream, Saquarema – Rio de Janeiro, Brazil

M. Moraes[1], L. R. Manna[1], C. F. Rezende[2], R. Mazzoni[1]

[1] Departamento de Ecologia, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro – UERJ, Rua São Francisco Xavier, 524, Maracanã, CEP 20550-013, Rio de Janeiro, RJ, Brazil
[2] Departamento de Biologia, Centro de Ciências, Universidade Federal do Ceará – UFC, Campus do Pici, CEP 60455-970, Fortaleza, CE, Brazil
maira.eco@gmail.com

## Abstract

Mato Grosso stream is located in the north-east of Rio de Janeiro and drains in the north-west area of Saquarema city. This stream is formed by riffles, runs and pools with several types of substrata, as rocks, gravel, sand and sites with and without vegetation cover. The aim of this study was to investigate the feeding habits of the fish community at Mato Grosso stream. Samples were collected bimonthly from March 2006 to January 2007, using electrofishing and sieves. In this stream there are 19 species (Miranda, 2009) of which 9 were studied in this work because only they had stomachs sufficient for analysis. Stomach content was analyzed through volumetric method (%). The species were classified into four trophic guilds: insectivorous, when species consumed mostly aquatic and terrestrial insects; *Mimagoniates microlepis*, *Characidium interruptum* and *Characidium vidalli* were included on this guild. Algivorous/detritivorous consumed algae and detritus; this guild included *Phalloceros harpagos*, *Parotocinclus maculicauda* and *Hypostomus punctatus*. Omnivorous consumed plant and animal material; this guild included *Astyanax taeniatus* and *Pimelodella lateristriga*. The carnivory guild was represented by *Rhamdia quelen* that fed mainly crustacean and fish. Then, we suggest that this trophic guild range reflects the high tophic plasticity of Atlantic Forest fishes. This could be explained by the wide diversity of food items (Abelha *et al*., 2001) and ability to use many resources by fishes (Lowe-McConnell, 1987).

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# Temporal changes in the ichthyofauna of the River Minho tidal freshwater wetlands, NW of the Iberian Peninsula

M. Mota[1], R. Sousa[1,2], A. Bio[1], M. J. Araújo[1,3], A. C. Braga[1,3], S. Costa-Dias[1], C. Antunes[1,4,5]

[1]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/UP). Rua dos Bragas, 289, 4050-123 Porto. PORTUGAL.
[2]Environmental and Molecular Biology Centre, University of Minho, Campus de Gualtar, 4710-057 Braga, PORTUGAL.
[3]ICBAS – Instituto of Biomedical Sciences Abel Salazar, University of Porto, Portugal.
[4]Aquamuseum of Minho River. Parque do Castelinho, 4920-290 Vila Nova de Cerveira. PORTUGAL
[5]Gallaecia University School. Largo das Oliveiras, 4920-275 Vila Nova de Cerveira. PORTUGAL
mmota@ciimar.up.pt

## Abstract

The ichthyofauna of the River Minho tidal freshwater wetlands was studied in a semi-enclosed area, between June 2007 and May 2010, to determine temporal patterns of abundance, biomass and species composition. Fish catches were standardized by the number of fyke nets and by the fishing effort, and correlated to river flow, water temperature and precipitation.

Six of the 21 fish species identified were non-indigenous species (NIS), representing 15% of the total captures (yet 43% of the biomass), 82% of overall captures, corresponded to freshwater species (62% of the biomass) (all the captured NIS are freshwater species) and 13% were catadromous (30% biomass). Fish assemblage showed seasonal patterns and a clear distinction between autumn/winter and spring/summer periods. There were significant differences between the autumn/winter seasons of 2007/8 and those of 2008/9, i.e. inter-annual variations, with the latter period characterized by particularly low catches (in number and biomass) yet high percentages of non-indigenous species. Higher water temperature had a significant negative effect on the observed number of species, but a positive effect on the number and biomass of NIS.

Many immature fish were captured, confirming the ecological importance of tidal freshwater wetlands as an essential nursery habitat. More attention has to be given to tidal freshwater wetlands and their structuring role on fish assemblages, as this information is vital for a sound management, conservation and restoration of estuarine areas.

# Ecological parameters of fish assemblages associated with habitat structure in two Neotropical rivers

R. M. C. Melo[1], D. M. F. Nunes[2], N. Bazzoli[2]

[1]Institute of Biological Sciences, Federal University of Minas Gerais, Av. Antônio Carlos 6627, P.O. Box 1686, 30161-970, Belo Horizonte, Minas Gerais, Brazil.
[2]Postgraduate Program on Zoology of Vertebrates, Pontifical Catholic University of Minas Gerais, Av. Dom José Gaspar 500, prédio 43, 30535-901, Belo Horizonte, Minas Gerais, Brazil
diegomnunes@hotmail.com

## Abstract

Knowledge of the relationship between the fish fauna and the associated habitats is fundamental to developing strategies of conservation and restoration of the aquatic environments. This study evaluated the quantitative composition of fish assemblages related to habitat structure in two rivers that drain the third largest urban agglomeration of Brazil. Fishes were captured, bimonthly between April 2010 and February 2011, using gillnets (15 m x 1.5 m with different mesh sizes), totaling 1440 m² of nets at each point sampled in the Paraopeba (P1, P2, P3) and Velhas Rivers (V1, V2, V3), São Francisco River basin. Data of habitat structure were also measured bimonthly in five random points in each sample point (longitudinal extension ± 250 m). In total were captured 1298 specimens and 32 species, representing 13.1% of known species in this basin. Of these species, 50% are Characiformes, 37.5% Siluriformes and 6.25% Gymnotiformes and Perciformes, and about 31% are endemic to the basin, 16% perform reproductive migration and 6% are exotic to the basin. The upstreamsample points presented higher species richness than the downstream, contrasting with the river continuum concept. Fish density and biomass was positively correlated with the presence of rapids, whereas diversity, evenness and dominance indexes of fish fauna showed that water volume positively influenced, although not significantly, these ecological parameters usually altered in impacted rivers. Canonical correspondence analysis showed that substrate, longitudinal mesohabitat and volume of the river were the structural characteristics of habitat that presented greater influence on quantitative distribution of the fish assemblages studied.

# Effects of temperature on the year-class strength of perch (*Perca fluviatilis* L.) in Estonian coastal waters.

U. Piirisalu[1,2], A. Albert[1], M. Barkala[1], R. Eschbaum[1], K. Hubel[1], K. Jürgens[1], M. Kesler[1], M. Rohtla[1], T. Saat[1], L. Saks[1,2], R. Svirgsden[1], I. Taal[1], A. Verliin[1], M. Vetemaa[1]

[1]Estonian Marine Institute, University of Tartu, Mäealuse 14, 12618 Tallinn, Estonia
[2]Department of Zoology, Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia
ulvi.piirisalu@ut.ee

## Abstract

One of the most important abiotic factors influencing the year-class strength of fish in temperate ecosystems is considered to be water temperature during the first year of life. Survival of eggs and larvae, summer growth, and also first winter survival are the key points to understanding recruitment. Various studies regarding relationships between year-class strength and water temperatures have been conducted on perch, one of the most important local commercial species in Northern parts of Baltic Sea region. In these kind of studies, authors have different conclusions on which period during the first year of life is the most influential to the formation of year-class strength. Here, we aim to detect which periods during the first year of the life of perch in Estonian coastal waters are responsible for determining the year-class strength. Perch year-class strength data collected from 1995-2010 were compared with water temperatures from the same period. Relationships with several biologically relevant temperature thresholds during different parts of the first year of life of perch were examined. Results suggest that no specific period during the first year of perch life can be singled out as the only key period determining year-class strength. Although the two most important factors appeared to be the warmth of summer and the smoothness of the rise in water temperatures in spring, the role of water temperatures is more likely to appear through a number of periods combined.

# Feeding habits and ecomorphology structure of two species of Characiforms of Rio Pereque-açú, Paraty, Rio de Janeiro, Brazil

T. Portella, R. Mazzoni

Laboratório de Ecologia de Peixes / Departamento de Ecologia / IBRAG / Universidade do Estado do Rio de Janeiro. Rua São Francisco Xavier, 524, CEP 20550-013, Rio de Janeiro, Brazil.
tulioportella@yahoo.com.br

## Abstract

We present the results of feeding habits and ecomorphology of two species of characiforms (*Hollandicthys multifasciatus* and *Bryconamericus microcephalus)* from streams that drain the area of Parque Nacional da Serra da Bocaina (PNSB) that is an important fragment of the Atlantic Forest biome. Samples were performed by electric fishing (Mazzoni et. all, 2000) and the captured fishes were fixed in 10% formalin and preserved in alcohol 70 ° GL. Specimens were identified at the Fish Ecology Laboratory/UERJ. Feeding habit, of both species, was determined by analysis of the stomach contents through the Volumetric Method (Vo) (Hyslop, 1980). Each food item was identified to the lowest taxonomic level according to (Merritt & Cummins, 1984; Perez, 1988) and then grouped into broader ecological categories: allochthonous or autochthonous arthropods, seeds / fruits, filamentous algae, plant fragment, organic matter, substrate / debris and others. Linear morphometric measures, such as body, head and mouth length, body depth and width, fins size, and others, were taken to characterize ecomorphological patterns through their transformation into ecomorphological indices (Gatz, 1978). We performed a Principal Component Analysis, based in seventeen ecomorphological indices, and obtained a clear morphological ordination/segregation of the studied species. Mouth and head sizes were the main characters responsible for the segregation of the species. Feeding habits corroborated the ecomorphological segregation and showed that both species are insectivorous feeders but *H. multifasciatus* fed mainly on the allochthonous items but *B. microcephalus* fed mainly on autochtonous ones.

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# Variations in egg characteristics of ruffe (*Gymnocephalus cernua* L.) inhabiting brackish and freshwater environments

R. Svirgsden, A. Albert, T. Saat

Estonian Marine Institute, University of Tartu, Mäealuse 14, 12618 Tallinn, Estonia
roland.svirgsden@ut.ee

## Abstract

Different environmental parameters force fishes to adapt to the environment where they live. One of these parameters is salinity, which directly influences the water osmotic pressure. In order to reproduce successfully, freshwater fish species inhabiting brackish environment must alter their reproductive characteristics, including egg properties. Ruffe *Gymnochephalus cernua* L. inhabits both freshwater lakes and larger rivers, but it is also abundant in the brackish coastal waters of Baltic Sea and is therefore a suitable model species for salinity studies. The aim of the current study was to analyse variations in different egg characteristics (diameter, wet and dry weight, energy content) between freshwater (Lakes Peipsi and Saadjärv, salinity < 0.1 ppt) and brackish water (Pärnu Bay, salinity 3.5-6 ppt) ruffe populations. Furthermore, we evaluated if those traits were affected by the female size and age. We found that there are significant discrepancies in egg characteristics. Diameters, wet and dry weights of ovulated eggs of the brackish water ruffe were considerably higher compared to the freshwater ruffe. Additionally, eggs of freshwater ruffe had a lower dry weight to total egg weight proportion despite of their smaller size. These variations in egg properties indicate significant modifications in reproductive strategies between freshwater and brackish water ruffe populations.

# Diet structure of smelt (*Osmerus eperlanus* L.) in brackish nearshore ecosystem

I. Taal[1], L. Saks[1,2], S. Nedolgova[2], A. Verliin[1], M. Kesler[1], K. Jürgens[1], R. Svirgsden[1], M. Vetemaa[1], T. Saat[1]

[1]Estonian Marine Institute, University of Tartu, Mäealuse 14, 12618 Tallinn, Estonia
[2]Department of Zoology, Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, 51014, Tartu, Estonia
imretaal@ut.ee

## Abstract

The seasonal diet composition and feeding activity of adult and sub-adult smelt *Osmerus eperlanus* in the coastal area of Gulf of Finland were studied by examining the stomach contents of 1444 fishes collected from April to December 2009. Crustaceans, mostly amphipods (*Gammarus* spp, *Corophium volutator*) and mysids (*Mysis* spp), followed by isopods (*Idotea* spp, *Saduria entomon*), cladocera (*Cercophagis pengoi*) and decapods (*Palaemon adspersus*)] were the most common prey. Piscivorous feeding was also evident, particularly in larger smelt during the summer months. Seven fish species were recorded in the stomach contents. Of these fish species three-spined stickleback (*Gasterosteus aculeatus*), nine-spined stickleback (*Pungitius pungitius*), sand goby (*Pomatoschistus minutus*) and common goby (*Pomatoschistus microps*) dominated. Baltic herring (*Clupea harengus*), common sand eel **(***Ammodytes tobianus*) and bullhead (*Cottus gobio*) were represented by single specimens in the data set. Smelt preyed also on molluscs (*Hydrobia* spp, *Radix ovata*, *Mytilus trossulus*, *Macoma balthica*), insects (*Corixa* spp), insect larvae (*Chaoborus* spp, *Chironomidae*, *Trichoptera*) as well as polychaete annelids (*Hediste diversicolor*).

# Theme 2 - Threats to Systems and/or Species

# Effects of flow regulation in the somatic condition and reproductive cycle of Iberian barbel (*Luciobarbus bocagei* Steindachner, 1864) and Iberian chub (*Squalius carolitertii* Doadrio, 1988) in a permanent Iberian river

C.M. Alexandre[1,2,3], T.F. Ferreira[3], P.R. Almeida[1,2]

[1]Center of Oceanography, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[2]Department of Biology, School of Sciences and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal
[3]Forestry Research Center, Institute of Agronomy, Technical University of Lisbon, Lisbon, Portugal
cmalexandre@fc.ul.pt

## Abstract

River regulation tends to modify flow patterns, causing a reduction of discharge variability and disturbing environmentally cued life cycles of fishes (Ward & Stanford, 1989). The objective of this study was to assess the changes in somatic condition (K) and reproductive cycle (GSI) of potamodromous Iberian barbel and resident Iberian chub, caused by the hydrological alteration promoted by Vilarinho das Furnas Dam on River Homem. From May 2010 to June 2011, three sites were sampled in River Homem and three in River Vez, a nearby non-disturbed river, selected as reference. Regarding GSI, male barbels exhibited a similar pattern between the two rivers. This did not happened with females, since in the regulated river they started gonad maturation with a 2-months delay. Chubs' GSI followed the same pattern for males and females in both rivers. Considering K, both species presented a clear pattern in the non-regulated river, with low values from summer to autumn and an increase in winter, followed by a new decrease in the beginning of the reproductive season. In the regulated river none of the species presented a clear pattern of somatic condition. With a few exceptions, overall K values for chubs were lower in the regulated river. Somatic condition of both species presented a positive correlation with monthly volume and the number of high flow days. Findings from this study are important to understand the derivation in biological patterns imposed by regulated rivers and to be used as guiding elements for flow requirements implementations.

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# Metal bioaccumulation in sea lamprey ammocoetes from Minho River (NW Iberian Peninsula)

M. J. Araújo[1], P. Reis[1], A. C. Braga[1], C. Antunes[1,2,3]

[1] Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/UP). Rua dos Bragas, 289, 4050-123 Porto. PORTUGAL
[2] Gallaecia University School. Largo das Oliveiras, 4920-275 Vila Nova de Cerveira. PORTUGAL
[3] Aquamuseum of Minho River. Parque do Castelinho, 4920-290 Vila Nova de Cerveira. PORTUGAL
major.a3@gmail.com

## Abstract

The ammocoetes of sea lamprey (*Petromyzon marinus*, Linnaeus 1758) are vulnerable to aquatic contamination due to filter feeding and dermal absorption as they live several years buried in freshwater sediments. The information available on this subject is scarce, so we aimed to correlate the metal levels bioaccumulated in ammocoetes from Minho River (NW Iberian Peninsula) with their age. The ammocoetes were captured by electrical fishing at spring and summer of 2009 and 2011 as a way to define 4 length classes that corresponded to 4 classes of age (below 3 years, 3+, 4+ 5+; n=168). The analysis of metals (Cd, Cr, Cu, Fe, Mn, Pb and Zn) in individuals of the three older classes (n=9) was performed by Atomic Absorption Spectrometry (AAS). Our findings showed significant correlations of Cd, Cu and Zn ($p<0.05$) and very significant correlations of Fe and Mn ($p<0.01$) with ammocoetes age. The Cr and Pb showed no significant correlations with age ($p>0.05$). The Fe levels are the highest of all metals which can result from the ubiquitous presence of this metal in the environment and the tolerance of ammocoetes to its accumulation (higher bioaccumulation factor). The ecological quality of freshwater habitats seems to be an important factor for ammocoetes conservation, because the duration of this phase, the type of habitat and feeding strategy appears to favor metal bioaccumulation, even in low contaminated areas.

# First record of *Anisakis simplex* (Nematoda, Anisakidae) in the sea lamprey (*Petromyzon marinus*)

M. Bao, M. E. Garci, J. M. Antonio, S. Pascual

Instituto de Investigaciones Marinas (CSIC). Eduardo Cabello 6, E-36208 Vigo, Spain.
miguelbaod@gmail.com

## Abstract

The sea lamprey (*Petromyzon marinus*) is an anadromous Agnatha which parasitizes marine mammals, sharks and teleosts during the marine phase of their life cycle (Wilkie et. al. 2004; Nichols & Tscherter 2011). They feed sucking mainly blood, other body fluids and products of tissue cytolysis (Farmer, 1980) from such hosts attaching them by a toothed circular sucking mouth (Igoe et. al. 2004).

In a routine fish inspection program for parasites carried out in our lab we dissected sea lampreys caught in the Ulla River, located off NW Spain (Galicia). The head and entire digestive tract of fish were examined for anisakid parasites following microscopic and PCR analysis. Cyst structures resembling parasitic forms were also analyzed by histological examination.

The diagnosis of the third-larval stage (L3) of the marine parasitic nematode *Anisakis simplex* in *Petromyzon marinus* is herein recorded for the first time. The plausible theory developed is that the sea lamprey might have acquired the larva when it was parasitized and feeding on the products of tissue cytolysis from an infected Atlantic salmon (or other infected teleost) carrying the sea lamprey.

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# Does *Anguillicoloides crassus* influence the metal accumulation of Minho River eels, *Anguilla anguilla*?

A. C. Braga[1], P. Reis[1], M. J. Araújo[1], C. Antunes[1,2,3]

[1]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/UP). Rua dos Bragas, 289, 4050-123 Porto. PORTUGAL
[2]Gallaecia University School. Largo das Oliveiras, 4920-275 Vila Nova de Cerveira. PORTUGAL
[3]Aquamuseum of Minho River. Parque do Castelinho, 4920-290 Vila Nova de Cerveira. PORTUGAL
catarinatrabalho@gmail.com

## Abstract

The European eel, *Anguilla anguilla* is a good bioindicator species due to its benthic habitat, predatory behavior and life cycle. This species is vulnerable to infections by the parasitical nematode *Anguillicoloides crassus* when at freshwater ecosystems. The parasite feeds on blood of the eel swim-bladder, causing damages in the walls and impairment of this organ. The objective of this work was to study if the state of infection (infected or un-infected) of the parasite affects the metal accumulation of eels, larger than 30 cm from different origins. The eels were captured at three sampling points in the international section of Minho River using fyke nets. The analysis of metals (Cd, Cr, Cu, Fe, Mn, Pb and Zn) in eels muscle and liver was performed by Atomic Absorption Spectrometry. In general for the muscle the metal concentrations were below the detection limit. The liver concentrations showed significant differences ($p<0.05$) between the state of infection at the two sampling points, since the infection prevalence in the third sampling point was 100%. The different origins seem to be more responsible for the differences of metal levels between the eels, than the state of infection. In conclusion the parasite appears to have impact in specific metal concentrations of eels liver, however, other factors should be considered regarding metal contamination on eel tissues.

# Reproductive-trait response of three cichlid species in a large Brazilian reservoir 15 years after a dam closure

M. A. L. Correia[1,2], E. P. Caramaschi[1]

[1]Fish Ecology Laboratory. Institute of Biology. Federal University of Rio de Janeiro (UFRJ). Brazil.
[2]National Counsel of Technological and Scientific Development (CNPq)
mayaraalc@yahoo.com.br

## Abstract

Evaluation of how related reproductive strategies generate similar responses in reproductive traits when organisms are confronted with environmental fluctuations is important to allow understanding of population-stability processes and predictions of species' responses to habitat changes. We characterized the changes in reproductive traits of three co-occurring cichlid species, and compared their reproductive investment after a disturbance. *Satanoperca jurupari*, *Geophagus surinamensis* and *Cichla piquiti* were successful in colonizing the large Serra da Mesa Reservoir on the Tocantins River. We hypothesized that 15 years after a dam construction, the three species would have the same reproductive investment, achieved by similar changes in traits. Biological data were obtained before the dam closure (Dec/1995) until the last monitoring (Oct/2010). Reservoir formation led to differences in the reproductive intensity of the three species, but over time their traits became similar. After 15 years, the species developed features of an equilibrium strategy, recognized by greater longevity, as evidenced by increasing length of individuals; and by increased investment in future reproduction, as evidenced by the decrease in reproductive activity along time. The changing environment led to similar changes in reproductive traits, which showed no differences in reproductive investment and body structure among the three species, thus confirming our hypothesis. The major differences found among the species were in *C. piquiti*, which currently has a smaller mean and maximum size, resulting from the pressure of sport fishing in the reservoir. Independently of the disturbance caused by the dam, fishing pressure may affect reproductive traits of *C. piquiti* over time.

# The ichthyofauna of the Elbe estuary: are there first effects of climate change?

D. Eick, V. Magath, R. Thiel

University of Hamburg, Biocenter Grindel and Zoological Museum, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany
Dennis.Eick@uni-hamburg.de

## Abstract

Several studies performed since the 1980s have shown that the Elbe estuary, located in northern Germany, is an important habitat for diverse marine, freshwater and diadromous fish species.

From April 2009 until October 2010 the most recent investigation of the fish fauna of the Elbe estuary was undertaken. During that study eleven stations along the estuary, between the cities of Cuxhaven and Hamburg were sampled. Each month, two flood and two ebb hauls were made at each station using a commercial stow net vessel. Altogether 703 hauls were performed.

A total of 61 fish species as well as cyprinid hybrids belonging to 25 families were recorded. Dominant species in the Elbe estuary regarding the frequency of occurrence were smelt (100%), ruffe (92.7%), flounder (87.7%), twaite shad (62.7%), European eel (54.1%) and three-spined stickleback (53.2%). The habitat function guilds were dominated by freshwater species. The geographical distribution categories of marine species indicated that lusitanian and boreal species occurred in equal parts. Only 3.2% of the species had an Atlantic distribution.

In comparison to the 1990s, an increase of lusitanian species was observed which could probably be attributed to effects of climate change. In future, increasing effects of climate change on the temperature regime, the sea level and the longitudinal location of the upper limit of brackish water are expected. They could have even more impact on species diversity and population structures of the whole fish assemblage of the Elbe estuary as well as on the estuarine food web and fish production.

# Assessing the risk of an emerging salmonid disease

I. Fontes, B. Okamura

[1] Department of Zoology, Natural History Museum, London, U.K.
i.fontes@nhm.ac.uk

## Abstract

Proliferative kidney disease (PKD) is an emerging disease that causes mortality of both wild and farmed salmonids across Europe and North America. The causative agent of PKD is the myxozoan parasite *Tetracapsuloides bryosalmonae* (Tb) which exploits the freshwater bryozoan *Fredericella sultana* as primary hosts. In bryozoans the parasite cycles between overt and covert infection stages, the former being constituted by sacs filled with spores infective to fish and the latter by single cells infecting the bryozoan body wall. Increases in temperature and nutrient levels promote both bryozoan growth and overt infection development suggesting environmental change promotes PKD outbreaks. This project focuses on the disease source (development of Tb in bryozoans) to assess the risk of PKD. Our objectives are to: 1) characterise bryozoan population dynamics and the dynamics of Tb within this host; 2) establish risk factors associated with Tb prevalence and burden in bryozoans and subsequent transmission to fish hosts; 3) use risk models developed from our epidemiological and field studies to create a protocol to sample bryozoans as a surrogate for sampling of wild fish in order to assess and monitor parasite levels and to produce a PKD risk map. Preliminary results on the temporal prevalence of overt/covert/uninfected bryozoan samples collected every 45 days from two rivers in southern England will be presented. A major aim of our research is to reduce direct sampling of valuable fish stocks by providing a tool to help conserve the health and diversity of wild fish populations.

# Reproductive parameters of the dourado Salminus franciscanus Lima & Britski, 2007 from Três Marias Hydroelectric Plant region in São Francisco River, Brazil

L. J. A. Freitas[1], Y. S. Martins[1], E. Rizzo[1], N. Bazzoli[2]

[1]Universidade Federal de Minas Gerais - Av. Antônio Carlos 6627, ICB O3 sala 164, 31270-901.
[2]Pontifícia Universidade Católica de Minas Gerais – Av. Dom José Gaspar 500, prédio 43, 30535-901.
ictio@icb.ufmg.br

## Abstract

Hydrological changes occur downstream from thermal and hydroelectric power plants and can affect fish reproduction, and then reducing fish stocks. The dourado *Salminus franciscanus*, migratory fish of high commercial value, depends on favorable areas to spawn and complete their reproductive cycle. This study aimed to analyze biological indicators and reproductive parameters of *S. franciscanus* in two stretches from São Francisco River, downstream from the Hydroelectric Plant in Três Marias: upstream (T1) and downstream (T2) of the mouth of the Abaeté River, a tributary on the left bank of the São Francisco River. Fish were captured over a reproductive cycle, and of each specimen length, body weight, gonadosomatic index (GSI) and the Fulton condition factor (K) were taken, afterword gonadal maturation stages were determined histologically. Biometric data and GSI of males and females were lower in T1, where temperatures and dissolved oxygen were lower. The gonad maturation began in September. The ripe stage was more frequent in December, and fish spawning season was especially between December and February, mainly in T2, where the fish found favorable conditions for reproduction. These results show the importance of the Abaeté River for the conservation of dourado *S. franciscanus* in the upper São Francisco River.

# Characterization and monitoring the biological invasion of *E. crassipes* in the Ave river

A. Matos[1,2], M. M. Santos[1,3,4], S. Morim[1]., A. Costa-Rei[1], A. I. Ferraz[2]

[1] Centro de Monitorização e Interpretação Ambiental de Vila do Conde, Av. Marquês Sá da Bandeira, 320; 4480-916 Vila do Conde
[2] Escola Superior Agrária do Instituto Politécnico de Viana do Castelo, Refóios do Lima; 4990-706 Ponte de Lima
[3] CIMAR/CIIMAR, Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Rua dos Bragas, 289; 4050-123 Porto
[4] Departamento de Biologia, Faculdade de Ciências da Universidade do Porto, Campo Alegre; 4169-007 Porto
santos@ciimar.up.pt

## Abstract

Water hyacinth (*E. crassipes*) is an aquatic floating plant, with a fibrous root system and glossy leaves (MARCHANTE et al, 2008). Their high growing rates, particularly in eutrophic conditions, and the absence of natural predators result in biological invasion episodes, causing environmental impacts such as blocking waterways and inducing changes in aquatic ecosystem as a consequence of oxygen depletion and the reduction of light penetration into the water, diminishing phytoplankton concentration thus affecting zooplankton-fish food chain (GISP, 2008). The present study aims to contribute to the characterization and monitoring *E. crassipes* invasion in Ave river nearby Vila do Conde, assisting the identification of effective control measures.

Monitoring took place twice in June, in 8 places along river margins. Biomass and water quality characterization included biomass estimation and physicochemical determination of nitrate, nitrite, phosphate, dissolved oxygen, pH, temperature and electrical conductivity.

River Ave water quality for multiple uses could be considered as excellent/good, except for phosphates, with concentrations > 1 mg/L, corresponding to water quality classification as very poor (SNIRH, 2011). Experimental results show poor correlation between water quality and *E. crassipe* growth. Although no significant changes were detected in water physicochemical characteristics, plants exhibited a substantial growth by the end of June. As the invasion occurred in specific places along the river, nearby physical barriers or with less water turbulence, it was possible to conclude that during the monitoring period, river physical characteristics had more influence promoting *E. crassipes* invasion than river water quality. Plant accumulation in specific margin areas is beneficial to ensure control measures efficacy.

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# Determination of metal concentrations on fish tissues to evaluate stress factors in a freshwater protected area (Paul de Arzila Natural Reserve, Portugal)

F. Morgado[1], A. M. Matos[1], E. F. Silva[2], C. Patinha[2], J. R. Gadelha[1], A. R. Figueiredo1, A. M. V. M. Soares[1]

[1]Biology Department, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.
[2]Geosciences Department, University of Aveiro,Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.
ritafigueiredo@ua.pt

## Abstract

Arzila Marsh is a freshwater wetland of international concern, included in the Natura 2000 network, located on the left margin of the Mondego River (Northwest Portugal). This wetland is also a Ramsar Convention Site and is included in the European Biogenetic Reserve Network. Monitoring the status of this ecosystem and stress factors that are affecting it, such as heavy metal contamination, has vital importance to the conservation of resident species since some of them are threatened and therefore protected by international laws. Quantification of heavy metals is an important aspect on any attempt for ecosystem conservation, as these are a source of environmental stress, and accumulate in several aquatic organisms (1,2). Metallic pollutants in Arzila Marsh reflect anthropogenic activities that occur near this ecosystem, due to nutrient and chemical discharge, especially from agriculture. Fish specimens (*Barbus bocagei*, *Chondrostoma macrolepidotus* and *Gobio gobio*) were collected in three sampling sites during January 2004, by electrofishing. These specimens were dissected. Gills, liver and muscle were extracted and digested to determine Al, Cr, Cu, Fe, Mn, Ni, Se and Zn concentrations by ICP-MS(inductively-coupled plasma mass spectrometry) (2). Results showed higher values of Al and Mn in gill, while higher values of Cr were registered in muscle. Cu, Fe, Ni, Se and Zn concentrations were higher in fish liver. Statistical analysis showed significant differences among species and fish tissues, but not among sampling sites.

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# Surface Water And Stream Sediment Contamination In A Protected Wetland (Arzila Marsh, Northwest Portugal)

F. Morgado[1], A. S. M. Matos[1], E. F. Silva [2], C. Patinha[2], A. Nogueira[1], A. R. Figueiredo[1], J. R. Gadelha[1], A. M. V. M. Soares [1]

[1]Biology Department, University of Aveiro, Campus Universitário de Santiago,3810-193 Aveiro, Portugal.
[2]Geosciences Department, University of Aveiro,Campus Universitário de Santiago 3810-193 Aveiro, Portugal.
ritafigueiredo@ua.pt

## Abstract

Surface water and stream sediment were sampled in a two-year period in a protected wetland (Arzila marsh, northwest Portugal). This protected wetland is a freshwater national and internationally protected, located on the left margin of the Mondego River. Since the last decade, it has been subjected to intense human disturbance essentially due to nutrient and chemical discharge from agriculture and urban areas (MANCINI et al. 2005). It is, though, of great concern the pollution status of this natural area. Physicochemical parameters (temperature, pH, conductivity and oxygen content) were measured *in situ*, and nutrient contents (nitrites, phosphates, nitrates and ammonia) were determined in the laboratory. Acid-preserved water samples and <170 µm fraction of dried sediment samples were analysed for heavy metal contents by ICP-AES (VAN RYSSEN et al. 1999). Data analysis was performed by One-Way ANOVA, followed by a canonical analysis for physicochemical parameters and heavy metals concentrations in water and sediments. Temperature and dissolved oxygen were the only physicochemical parameters which showed significant differences among seasons, while pH and nitrates showed significant differences among sampling sites. Cu amounts in water showed significant differences among seasons, unlike the other metals. In sediments, As, Cr, Cu, Fe, Ni and Zn revealed differences among sampling sites, but none showed differences among seasons.

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# Recent threats and habitat requirements of European mudminnow in Slovakia

L. Pekárik[1], J. Hajdú[2], L. Košuthová[3] , J. Koščo[4]

[1]Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia
[2]Administration of the Protected Landscape Area Dunajské luhy, State Nature Conservancy of the SR, Dunajská Streda, Slovakia
[3]Department of Breeding and Diseases of Game and Fish, University of Veterinary Medicine and Pharmacy, Košice, Slovakia
[4]Faculty of Human and Natural Sciences, University of Prešov, Prešov, Slovakia
ladislav.pekarik@savba.sk

## Abstract

Effective species conservation is highly dependent on the species requirements knowledge and on the major threats identification. European mudminnow (*Umbra krameri*) is endangered limnophilous species inhabiting small lowland waterbodies. In the past, its population decreased dramatically mainly due to habitat destruction. Recent populations are still threatened by many factors. In the present study, we describe habitat requirements of European mudminnow in Slovakia. Furthermore, we bring an overview about the major threats to this species occurrence and we evaluate some results of species habitat management. European mudminnow preferably occurs in irrigation canals followed by old oxbow lakes. The canal characteristics such as width, proportion of submerge and natant macrophytes cover and water velocity, suggested significant differences. The most suitable characteristics are average canal width 4.1 m, average macrophytes cover 39% for submerge macrophytes and 44% for natant macrophytes and low water velocity 0.05 m/s. European mudminnow is threatened by continuous habitat destructions and degradation, water pollution or recently by dry season during hot summers. Recent expansions of non-native fish species with similar habitat requirements, Amur sleeper (*Perccottus glenii*), black bullhead (*Ameiurus melas*), giebel carp (*Carassius gibelio*), pumkinseed (*Lepomis gibossus*) or topmouth gudgeon (*Pseudorasbora parva*) could cause serious threats as well.

# Gill histopathology and lipid peroxidation in Ave river fish

A. L. Pinto, S. Pereira, R. Cortes, A. Fontaínhas-Fernandes, A. M. Coimbra, S. M. Monteiro

Centre for the Research and Technology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes and Alto Douro, Apartado 1013, 5001-801 Vila Real, Portugal
smonteir@utad.pt

## Abstract

Ave river basin is located in the northwestern Portugal, a region with high demographic density, intensive agriculture and several industries, which effluents are continuously discharged to the watercourse (Pascoal & Cássio, 2004). To assess the effect of these pollutants on aquatic populations, a biomarker-based biomonitoring is a promising approach that may provide early-warning signals of pollutants exposure (Au, 2004). Fish gill is the first target of pollutants action. Gill histopathological changes are responsive to contaminants, constituting a potential biomarker (Au, 2004).

In this work, were assessed some biomarkers of exposure in gill of *Squalius carolitertii* and *Luciobarbus bocagei*, from Ave River. Samples were collected and processed for light microscopy and for lipid peroxidation analysis. The main histopathological changes observed were lamellar fusion, proliferation of gill epithelium, vasodilatation, aneurisms, edema, lifting and necrosis. Lesions prevalence showed that vasodilatation had higher incidence in polluted sites. In *L. bocagei*, prevalence of aneurisms also proved the existence of a pollution gradient among the different sites. A severity gradation scale showed, for both species, higher grades of lifting, lamellar fusion and proliferation of lamelar epithelium in polluted sites. In *S. carolitertii*, aneurisms also confirmed a gradient of severity consistent with the sites ecological status. However, edema and necrosis presented higher severity in places previously classified as poor than in places with bad ecological status. As well, lipid peroxidation showed a similar pattern. Thus, the sensitivity of necrosis and lipid peroxidation may reveal a worst ecological status than the previous classification, based on populations and physic-chemical parameters, proving the usefulness of these biomarkers as early-warning signs of water quality decline.

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# Population monitoring of an invasive fish species, black bullhead (*Ameiurus melas),* in Lake Sava (Belgrade, Serbia)

M. Pucar[1], A. Hegediš[1,2], M. Lenhardt[3], Z. Gačić[1], J. Krpo-Ćetković[2]

[1]Institute for Multidisciplinary Research, University of Belgrade, Kneza Višeslava 1, 11000 Belgrade, Serbia
[2]Faculty of Biology, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia
[3]"Siniša Stanković" Institute for Biological Research, University of Belgrade, Bulevar Despota Stefana 142, Belgrade, Serbia
mpucar@imsi.rs

## Abstract

Population monitoring of invasive alien fish species in Lake Sava (Belgrade, Serbia) started in May 2009, including one of the most invasive species in Serbia, the black bullhead, *Ameiurus melas* (Lenhardt et al. 2010)

Black bullhead samples were collected by fyke nets, positioned in three lines. Each line consists of five nets placed at 3 m, 10 m, 18 m, 25 m, and 35 m away from the shore, at depths of 1.5 m, 4 m, 5.5 m, 7.5 m, and 8 m, respectively.Distance between the lines were 15 m and samples were collected monthly.

Data collected so far were analysed using Mann-Whitney U test, which shows that there were significant differences between the catches in the nets positioned at 1.5 m depth (nearest to the shore) and at 4 m depth ($p=0.01$), while the catches in the nets nearest to the shore and nets at depths deeper than 4 m do not show significant differences. Based on these data, it can be assumed that black bullheads prefer the depth of 4 m where the vegetation zone of *Myriophyllum spicatum* is the thickest. Mann-Whitney U test ($p<0.05$) also shows that there is a difference in the number of fish caught seasonally (Cucherousset et al. 2006).The largest number of fish was caught during summer and the lowest during winter (Novomeska and Kovač, 2009). The size of the sampled specimens was 5.5-25 cm, and weight 1-235 g.

The results of this study predicted that the best period for mass removal would be in the summer, in the parts of the aquatic ecosystem rich in macrophytes.

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# The invasive bivalve *Corbicula fluminea* as a feeding resource for native species

C. Rodrigues[1], J. Campos[1], R. Sousa[1], S. Costa-Dias[1]

[1] CIMAR/CIIMAR – Centro Interdisciplinar de Investigação Marinha e Ambiental – Universidade do Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal
cristina_polonia@hotmail.com

## Abstract

The Asian clam *Corbicula fluminea* has become a major threat in Minho River (NW of the Iberian Peninsula) dominating the density, biomass (representing more than 90% of the total macrozoobenthic biomass) and secondary production of the estuary. After its introduction other benthic species seem to have declined.

Given those circumstances, this study is an attempt to clarify the potential role of *C. fluminea* as a feeding resource for native species. This is timimg because native predators did not evolved preying upon hard shelled molluscs like *C. fluminea* (i.e. the presence of *C. fluminea* in the gut of native fishes in the Minho River is not common with a few records of small individuals in flounder and trout being the exception). However, when subjected to extreme conditions (severe droughts or floods) massive die-offs of *C. fluminea* occur and soft parts of the clam may become available for higher trophic levels.

To determine if, in those conditions, the clam would be consumed, *Carcinus maenas*, *Crangon crangon* and *Platichthys flesus* captured in Minho Estuary were placed in aquaria and fed with a set of food, including *C. fluminea*.

Although rarely present in the guts of the fish inspected so far, experimental results show that 85% of *C. crangon* and 100% of *C. maenas* consume *C. fluminea*, when offered. Experimental results for *P. flesus* are incomplete at the moment, but the fact that small clams have been found in wild flounders' guts points to similar findings. Native species may adapt to changes in their diet and if an active live prey is not mandatory, massive die-offs migth be a unique feeding oportunity. The energy content of the Asian clam was estimated as 5245 (±2261) cal/g of soft tissues dry weight. Given that this invasive species may attain a mean biomass along the entire estuary of more than 160 g AFDW/$m^{-2}$ (with sites with more than 550 g AFDW/$m^{-2}$) the energy potentially available for native species deserves further attention.

# Effects of river channel straightening on trophic connections in fish assemblages from two Atlantic Forest coastal rivers (Rio de Janeiro, Brazil)

D. C. Rosa [1, 2], U. J.aramillo-Villa [1,2], É. P. Caramaschi [1,2,3]

[1]Laboratório de Ecologia de Peixes da UFRJ, Departamento de Ecologia, Instituto de Biologia, Cidade Universitária, CCS, Bloco A, Cx. Postal 68020, 21941-590 Rio de Janeiro, RJ, Brazil.
[2]Programa de Pós-Graduação em Ecologia da UFRJ
[3]erica.caramaschi@gmail.com

## Abstract

We analyzed the trophic relationships of fish communities in natural and straightened segments of two Brazilian coastal rivers in the state of Rio de Janeiro. For natural and straightened segments of Macaé and São João rivers gut contents of 128 and 312 individuals, respectively, were analyzed. For each section, we analyzed: 1) Species richness of items consumed, 2) Proportion of items consumed in each categories and origin, 3) Species richness of items, feeding strategy and change in trophic position for species common to natural and straightened segments; 4) Resource partitioning between species, 5) Properties of trophic webs. The richness of food items was high in natural segments, where the categories of items consumed by fish were equally distributed. In these segments, the percentage of allochthonous and autochthonous items were similar, whereas in straightened segments the percentages of autochthonous items were higher. The decrease in the amount of items consumed in straightened segments was observed for most species. Regarding the feeding strategy, *Astyanax* sp. presented differences between the natural section (specialist) and straightened section (generalist) only in Macaé River. *Awaous tajasica* and *Characidium* sp. changed the trophic position between natural and straightened segments of Macaé and São João rivers, respectively. The highest proportion of niche overlap was found in the straightened segments. Largest webs with the highest values of link densities were found in natural segments, however the values of connectance did not vary between segments. Riparian conditions comparatively preserved of São João River may be damping the straightening effect.

# Biological measures of fish communities of streams under different riparian conditions in Southeast Brazil

F. B. Santos[1], K. P. Carvalho[1], P. H. G. N. Martins[1], K. E. Esteves[2]

[1]Fisheries Institute, SP, Brazil. Av. Francisco Matarazzo, 455, CEP: 05001-900.
[2]Centro de Pesquisa e Desenvolvimento em Recursos Hídricos - Fisheries Institute, SP, Brazil. Av. Francisco Matarazzo, 455, CEP: 05001-900.
tata_bastos@yahoo.com.br

## Abstract

The development of tools to understand how tropical stream ecosystems respond to degradation is key for implementing management plans for stream conservation. The present study aimed to assess the usefulness of some biological measures of fish communities to assess the quality of streams under different riparian conditions, more specifically those located within sugarcane cultivation fields, which are widespread over the State of São Paulo. Three low order streams were selected for each riparian condition (Native Forest, Secondary Forest and Sugar-Cane). Fish were sampled over 50m stretches using a stationary electrofishing equipment (Honda EU 10i, 900W, 120V) during the dry (August/September) and rainy season (March) of 2011. A Habitat Index (HI) based on the level of degradation for each sampling site was calculated according to Callisto (2002). Despite significant differences of the HI between different riparian conditions (ANOVA, $P<0.05$), tested biological measures (density, biomass, dominance, trophic categories, position in the water column, tolerance) were not significantly different (ANOVA, $P>0.05$). Main differences were related to species composition as shown by a cluster analysis, which reflected the dominance of the intolerant characid *Bryconamericus iheringii* at the Native Forest sites, *Gymnotus carapo* and *Astyanax paranae* at the Secondary Forest and the tolerant Cyprinodontiform *Phalloceros* sp. at the Sugarcane sites.

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# The functional connection between hydrological characteristics and total fish catch on the Danube in Serbia

M. Smederevac-Lalić[1], A. Kalauzi[1], M. Lenhardt[2], S. Regner[1]

[1] Institute for Multidisciplinary Research, KnezaVišeslava 1, 11000 Belgrade, Serbia
[2] Institute for Biological Research, Bul. DespotaStefana 142, 11 000 Belgrade, Serbia
marijasmederevac@imsi.rs

## Abstract

Natural processes in the environment have a cyclical appearance, but in the past century anthropogenic factors have affected natural characteristics. Fluctuations in the amount and composition of fish catch, as well as the hydrological characteristics of the Danube are the result of a series of cumulative effects of natural and anthropogenic factors. Catch statistics have changed in the past 60 years, with some species disappearing and alien species appearing. Therefore, the aim of this study was to analyze existing data on long-term fluctuations in total catch of fish on the Danube in Serbia during 1948-2009 and to asses whether there is a functional connection between catch and water level and temperature.

A functional connection between hydrological characteristics, the water level of the Danube and fish catch was found for the period before dam construction and they were correlated ($r = 0.468$), with a significance level of $p = 0.012$. Besides local phenomena, the impacts of global climate, such as pressure fluctuations over the oceans and continents, appear deep in continental areas and affect the changes in local phenomena such as precipitation, river flow, water levels and fish catches. The Index of North Atlantic Oscillation (NAO) was significantly correlated with the temperature of the Danube.

Determination of the cycles and the regularities, as they appear, also presented in this study, may serve as a good base for making forecasts and producing a model that could help manage resources effectively.

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# Interplay between fish detritivory and pollutant biogeochemistry in the Río de la Plata Basin

E. D. Speranza[123], N. Cappelletti[12], L. M. Tatone[12], M. C. Migoya[1,2], J. C. Colombo[14]

[1]Laboratorio de Química Ambiental y Biogeoquímica, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata. Av. Calchaquí Km. 23.5, Florencio Varela (1888), Buenos Aires, Argentina.
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Av. Rivadavia 1917 C1033AAJ, CABA, Argentina
[3]Universidad Nacional Arturo Jauretche, Av San Martín 2002, Florencio Varela (1888), Buenos Aires, Argentina
[4]Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), 526 e/10 y 11, La Plata (1900), Buenos Aires, Argentina
laqab@intervar.com.ar

## Abstract

To evaluate the role of fish detritivory and migrations on pollutant biogeochemistry, biochemical composition (water, ash, lipids, proteins, carbohydrates, lipids classes, fatty acids), aliphatic hydrocarbons (ALI), polychlorinated biphenyls (PCBs), linear alkylbenzenes (LABs) and organochlorine pesticides (OClP) were determined in muscle of a dominant detritivorous fish (*Prochilodus lineatus*, Characiformes) and in settling particles collected along 1500km of the Rio de la Plata basin. In metropolitan Buenos Aires high vertical fluxes of sewage particles (20±14 g $cm^{-2}$ $yr^{-1}$) enriched in organic carbon (7.7±5.5%) and pollutants (ALI: 21±23 mg $cm^{-2}$ $yr^{-1}$; LABs: 0.42±0.62 mg $cm^{-2}$ $yr^{-1}$; PCBs: 1.6±1.8 µg $cm^{-2}$ $yr^{-1}$) were measured. This energy subsidy is profited by *P. lineatus*, which efficiently assimilate anthropogenic organic matter, gaining mass rapidly (condition index: 3.0±0.5) by lipid accumulation (24±13% fresh weight, fw) with a parallel coabsorption of hydrophobic pollutants (ALI: 121±62; LAB: 30±7.1; PCB: 12±3.1; OClP: 0.77±0.29 ug $g^{-1}$ fw) in low turnover lipid reserves. The high fish/settling material bioaccumulation factors of ALI (2.8±1.9) and PCB (147±68) reveal the ability of *P. lineatus* to biomagnify pollutants. Principal component analysis discriminated migrating Buenos Aires specimens in the Parana river from lean (lipids: 4.1±3.1 % fw) and barely polluted northern fish (ALI: 9.7±12; LAB: 2.1±5; PCBs: 0.52±0.83; OClP: 0.16±0.18 µg $g^{-1}$ fw), reflecting that migrations facilitate active pollutant transport. *P. lineatus* plays a key ecological role, assimilating significant amounts of organic matter and biomagnifying pollutants from urban discharges, which are exported to remote sites of the basin during migration and transferred to natural predators and human populations.

# Effects of extracorporeal shockwaves on embryonic development of *Oryzias latipes*

F. Stein

Biozentrum Grindel und Zoologisches Museum Hamburg
f.stein@zoologie.uni-hamburg.de

## Abstract

The extracorporeal shockwave therapy (ESWT) has been successfully used for treatment of patients with enthesiopathy since 1992. During the ESWT the acoustic impulse is focused to a spot of 4mm length and 1mm of diameter by an acoustic lens. Evidences of specific lesions inside the focal area due to low energy shockwaves are known since 1994. Damages of intracellular structures were demonstrated 2010 the first time. Direct after shockwave applications on Medaka embryos (Oryzias latipes) following primary morphological effects could be observed: Yolk lost (in slight and heavy expressions), pericardial edema, opacity of the yolk and embryonic tissues and also destruction of embryonic tissues up to a total destruction of the whole Medaka egg. During the following development secundary symptoms like microphthalmia, circulatory insufficiency, pericardial edema und and rough structured cloudiness of embryonic tissues could be observed. The most often observed secondary symptoms were combined with the primary main symptom yolk lost.

# Development of a fish index of biotic integrity (F-IBIP) for wadeable streams of Portugal

A. A. T. Teixeira[1], J. M. Oliveira[2], R. M. V. Cortes[2], M. T. Ferreira[3]

[1]CIMO- ESA-IPB- Mountain Research Centre, School of Agriculture, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 1172, 5301-855 Bragança, Portugal
[2]CITAB- Centre for the Research and Tecnhology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes e Alto Douro, Quinta dos Prados, 5000-911 Vila-Real, Portugal
[3]CEF- Forest Research Centre, Superior Institute of Agronomy, Technical University of Lisbon, Tapada da Ajuda, 1349–017 Lisbon, Portugal
amilt@ipb.pt

## Abstract

The fish index of biotic integrity (F-IBIP) was developed for the wadeable streams of Portugal in order to contribute for the application of Water Framework Directive and also for the management of freshwater fish resources. Based on a nationwide freshwater fish database, including more than 1000 fish sampling units collected during the last ten years, about 500 sites were selected, representing the diversity of natural conditions and human impacts in Portugal. Human disturbance was characterized using fifteen disturbance variables at catchment, segment and reach scales that were scored to the degree they deviated from minimally disturbed conditions. Multivariate technique analyses were used to identify different fish types, based on the minimally disturbed dataset and functional fish groups, and for the allocation of each sampling site to a specific type. Six fish types were found, representing the major fluvial geomorphological patterns in Portugal. Multiple discriminant analysis (MDA) demonstrated to be a robust tool, since 71 to 93% of sampling sites were correctly allocated. For each fish type different metrics, included in 6 functional attributes (*e.g.* feeding, reproduction, richness), were screened for precision, range, responsiveness to human pressure, correlation with natural gradients and redundancy. For each type 3 or 4 metrics were finally selected. F-IBIP showed to be an efficient method for the evaluation of biological quality and biotic integrity of Portuguese streams.

# How do two native fish species respond to the effluents from the sewage treatment plants in a Mediterranean river?

A. Maceda-Veiga[1], M. Monroy[1], E. Navarro[1], G. Viscor[2], A. Sostoa[1]

[1]Department of Animal Biology (Vertebrates) & Research Institute of Biodiversity, Faculty of Biology, University of Barcelona, E-08028 Barcelona, Spain.
[2]Department of Animal Physiology, Faculty of Biology, University of Barcelona, E-08028 Barcelona, Spain.
albertomaceda@gmail.com

## Abstract

Haematological (Haematocrit, haemoglobin concentrarion, erythrocyte and leucocyte profiles), genotoxicity (nuclear abnormalities in erythrocytes) and general morphometric (gross condition indices) parameters, and a histopathological evaluation of liver were assessed as general biomarkers of pollution in two feral cyprinid species (*Barbus meridionalis* and *Squalius laietanus*) exposed to the effluents from urban and industrial sewage treatment plants in Ripoll River (Catalonia, Spain). The physiological dysfunctions detected in the barbel were compatible with an inflammatory process and/or certain infection focus (neutrophilia, monocytosis, increased lumen of blood vessels, lymphocyte and histiocytes infiltration), and genotoxic damage (increase in erythrocyte nuclear abnormalities, erythropoetic inhibition, hepatic pyknotic nuclei). To contrast, the physiological response of chub corresponded to an adaptational response profile (increase erythropoetic rate, increase in the lumen of blood vessels and slightly monocytosis) to face with the deleterious effects of the xenobiotics present. Therefore, *B. meridionalis* seems more susceptible to the sewage effluent components than *S. laietanus.* The integration of various biomarker approaches may allow us to refine our knowledge about the physiological consequences that xenobiotics have on feral native fish species using the less invasive approach and these findings may contribute to refine the use of fish as bioindicators in the Mediterranean area.

# Growth of brown trout in headwater streams population

L. Závorka, O.Slavík, P. Horký

TGM – Water Research Institute, Podbabská 30, 160 62 Prague 6, Czech Republic
libor_zavorka@vuv.cz

## Abstract

Individual growth plays fundamental role in brown trout population dynamics (Elliott 1994, Lobon-Cervia 2007). In our study, growth of brown trout individuals from original populations of headwater streams was observed in the Vydra and Kremelna river basins, Sumava National Park, Czech Republic. The Sumava National Park is an important European biodiversity center, and one of the largest original natural areas in the Central Europe. Twenty localities were sampled by electrofishing twice in a season (May, October) during seven consecutive years (2005 - 2011). In total, 5195 individuals of the brown trout were caught, measured, marked (VIA and VIE tags; NMT, Inc.) and released over this period. Scale samples were taken from 750 of them. Fish growth was analyzed based on the scale reading, and verified by an increase in fish length of recaptured individuals. Average annual growth was 51 mm (range from 46 to 56 mm). Fish growth was unbalanced as individuals grew more in summer period from June to September, and juveniles grew faster than adults. For more precise description of individual growth pattern was estimated space structure of the population by synchrony in demographic parameters among twenty observed sampling sites (Koizumi et al. 2008). Growth was subsequently described in every synchronized population unit. Despite relatively low growth rate, typical in mountain steams populations, significant differences in individual body growth were found among estimated population units. We believe that considering of population spatial structure in the management of natural brown trout populations can enhance effectiveness of its protection.

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# Theme 3 - Conservation

# Morphological variations among populations of *Hemigrammuscoeruleus*(Characidae: Characiformes) in a Rio Negro tributary, Amazonas, Brazil

T. Barros, J. L. Gomes, H. Lazzarotto, É. Caramaschi

Laboratório de Ecologia de Peixes da UFRJ, Departamento de Ecologia, Instituto de Biologia, Cidade Universitária, CCS, Bloco A, Cx. Postal 68020, 21941-590 Rio de Janeiro, RJ, Brazil.
erica.caramaschi@gmail.com

## Abstract

The morphological variation among populations of *Hemigrammus coeruleus* Durbin, 1908 from four tributaries (Preto, Arara, Solimõeszinho and Pauini rivers) of Unini river basin, Rio Negro drainage, Amazonas, Brazil, were quantified by morphometric geometric analysis. Body size, quantified by centroid size, varied significantly ($p<0,001$) among populations. The largest body size was observed in the population of Pauini river, whereas the smaller individuals were measured in Preto river. The first axis of the canonical variable accounted for 44.06% of the variation, with this variable related mainly with body depth of the specimens, whereas the second axis accounted for 35.91% of the variation, concentrated mainly in the cephalic region. The population of Solimõeszinho separated from the other three in the main axis, whereas Arara and Pauini populations grouped together and Preto, whilst intermediary in the main axis, partially separated from the three other population in the second axis. Body shape among populations varied mainly in the position of maximum body depth and mouth orientation. The variation found in morphology did not relate with geographic distances between populations. It can be suggested that one of the factors contributing to separate the population from Solimõeszinho is the water colour (more particulate material carried by the current) and higher pH during the dry season, since differences between habitats might create selective pressures resulting in morphological divergences between conspecific populations.

# Spatial distribution of fish assemblage in large Neotropical reservoir: environmental ordination and profiles

S. G. C. Britto, A. C. Souto, A. P. V. Magnoni, H. Brandão, A.B. Nobile, J. Q. Souza, R. J. Silva, E. D. Carvalho

Laboratory of Fish Biology and Ecology, Institute of Biosciences, UNESP – Campus Botucatu, SP. Caixa Postal 510, Botucatu, SP, Brazil. CEP 18618-000. sgbritto@gmail.com

## Abstract

Human and economic growth has been demanding an increase of energy supply. In Brazil, this electrical energy supply is sustained principally by hydropower production, resulting in a set of impacts on the aquatic organisms, especially on the fish assemblages. In Neotropical regions these impoundments favor the predominance of generalist species and deplete the migratory ones, with possible local extinction (Woynarovich, 1991; Agostinho et al., 2003). The Paranapanema is an important river of Parana-Paraguay system and is heavily exploited for hydropower plants/impoundments. The Jurumirim reservoir is the first of a cascade of reservoirs on the axis of this river. Due to its geographical and environmental importance, this study aimed to investigate the fish assemblages of this reservoir. Gillnets were used, and four sampling were made along of one hydrological cycle in thirteen points, with three in reservoir, eight in tributaries and two in connected oxbow lagoons. Statistical analysis clearly showed that Jurumirim reservoir is spatially complex and presents fish community differences in relation to the studied environments (lotic and lentic stretches, lagoons, land use, etc.). The analysis also showed that despite impoundment effects on the fish assemblages, this reservoir has conditions to maintain threatened migratory species that are important to fisheries, and are strongly affected by others impoundments in this basin. Thus, this study can be used for public policy to order fisheries exploitation.

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# Control of exotic - a tool for conservation in sub-basins in the presence of confirmed *Anaecypris hispanica*

C. Carrapato, A. C. Cardoso

Instituto da Conservação da Natureza e da Biodiversidade, Departamento de Gestão das áreas Classificadas do Sul, Parque Natural do Vale do Guadiana, Rua D. Sancho II nº 15, 7750-350 Mértola, Portugal
carrapatomertola@gmail.com

## Abstract

In the last five years, the ICNB has conducted an experiment to control exotic fish species. This control was made on a pond with 700 meters long at Vascão river, a tributary of the Guadiana river with confirmed presence of *Anaecypris hispanica*.

The action was held one day a week for three months (August, September and October) over the five years, using trawl nets 25 meters long and two meters high and 15 mm mesh, and made three sieges through each day of capture.

The number of total captured exotic fishes was 9403 and has decreased of 161 to less than 30 for siege. To assess the impact of the measure in the control of exotic species in 2011, we used the method of successive catches, without replacement. We believe that this tool has a significant impact, since the method points to efficiency above 50%, with values of removal of individuals above 80%.

The results also indicate destabilization at the age structure of populations *Micropterus salmoides* and *Lepomis gibbosus*, in the last two years.

# Long term fish community monitoring program in the San Pedro River (Chile): temporal and spatial dynamic knowledge as key for conservation plans.

N. Colin, P. Piedra, Evelyn Habit

Aquatic Systems Research Unit, Environmental Science Center EULA-Chile, University of Concepcion, Concepción, Chile.
colin.nicole@gmail.com

**Abstract**

The San Pedro River is one of most diverse Chilean fluvial systems and has a minimal anthropic intervention and very low abundance of exotic species (< 5%). However, several hydropowers are planned for the watershed, which could alter the natural structure and dynamic of fish assemblages. Therefore, a monitoring program through time is essential to understand the natural dynamic of the fish fauna. Hence, we analyzed spatial and temporal community structure (2005-2011), in 13 sites along the river (40 km), using electrofishing as sampling method. In each site, we determined habitat types classified according to water quality and structure factors. Fish community is composed by 16 species, 14 natives and 2 exotics. Richness and diversity indices showed significant differences along the river (ANOVA, p=<0.001; p=<0.001) and among years (p=<0.001; p=N.S.). Multivariate analysis (NMDS) showed fish assemblages grouped by three different habitat types: pools, riffles and temporal pools ($R_{ANOSIM}$= 0.213; p=0.001). Also we found differences in diversity indices, fish composition and abundances among high and low flow season, which were associated with the presence of floodplains. Therefore, the San Pedro River fish community has a high spatio-temporal dynamic, where floodplains play an essential role for its natural dynamic, providing refuge, food and spawning areas. Maintenance of the natural regimen is then essential to conserve this fish fauna. Acknowledge to Colbun S.A. and Fondecyt 1110441.

# Optimization of field ecotoxicological biomonitoring experimental designs based on a priori multivariate analysis of multiple biomarkers

I. Cunha[1], A. Damasceno-Oliveira[2], C. Gravato[3], J. Santos[3], L. Guilhermino[3,4]

[1]CIIMAR/CIMAR-LA – Centro Interdisciplinar de Investigação Marinha e Ambiental, Laboratório de Estudos Moleculares e Celulares, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[2]CIIMAR/CIMAR-LA - Centro Interdisciplinar de Investigação Marinha e Ambiental, Laboratório de Ecofisiologia, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[3]CIIMAR/CIMAR-LA – Centro Interdisciplinar de Investigação Marinha e Ambiental, Laboratório de Ecotoxicologia e Ecologia, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[4]ICBAS - Instituto de Ciências Biomédicas Abel Salazar, Departamento de Estudos de Populações, Laboratório de Ecotoxicologia, Universidade do Porto, Largo Prof Abel Salazar 2, 4099-003 Porto, Portugal.
aol@ciimar.up.pt

## Abstract

Batteries of biomarkers are frequently used to assess health status of organism's populations providing important data for populations' management and environmental quality evaluation. Here we describe methodologies to 1) maximize the use of data through the imputation of missing values, 2) perform their quantitative interpretation, based on a simplified structure that integrates the various variables and, 3) produce discriminant functions that will allow the parsimonious classification of new samples, based on a reduced set of biomarkers. A database of biomarkers on yellow eels (*Anguilla anguilla*) from 3 Portuguese estuaries (Minho, Lima and Douro), differently impacted by contamination, was used. Stepwise Discriminant Analysis yielded the correct assignment of 92.7% of the cases using only 7 of the 13 biomarkers, for a similar result. These techniques may be particularly useful for planning biomonitoring programs covering large areas for long periods of time, contributing to reduce experimental effort and costs.

# Dynamics of fish assemblage in floating meadows from várzea (Amazonas, Brazil)

C. P. Deus[1], L. C. Ávila[2], C. M. Bührnheim[2]

[1]INPA/CBIO. Av. Andre Araújo 2936. Aleixo. Manaus-AM
[2]Universidade Federal do Amazonas – UFAM Av. General Rodrigo Octávio Jordão Ramos, 3000, Campus Universitário, Coroado I - Manaus/Amazonas
claudias@inpa.gov.br

**Abstract**

In the Amazon floodplain a large proportion of fish species use aquatic macrophytes as an area for feeding, reproduction, refuge, breeding and as a mean of dispersion. The intensity and variation of the water level considerably influenced the composition, richness and abundance of the species at certain localities. Analyzed data show the dynamic of the macrophyte fish assemblages from the Xiborena island between 2003 and 2007, with the aim of comprehending how the fish assemblages respond to the hydrological variations in temporal scales, within and between years. During these five years 40,302 individuals belonging to 197 species were captured, with the Characiformes accounting for 51.77% of the captures with 102 species. Total biomass was of 58.37 kg, being the Characiformes responsible for 61.89%. The most common species was *Moenkhausia lepidura* with 8,735 individuals and the species with higher biomass was *Schizodon fasciatus* (6.26 kg). There was a significant difference in species richness between the high water (179 spp.) and the low water periods (131 spp.), however the composition was not significantly different ($p= 0.16$). The total abundance values between high and low water periods indicated significant differences (15,740 and 24,562 individuals respectively) ($p= 0.0049$) (within year variation). The total biomass values in the low water period were higher (29.6 kg) when compared with the high water period (28.7 kg). Species turnover was high, species composition changed especially between 2004 and 2005. Related to stability the fish assemblages were highly variable in the Xiborena island (coefficient of variation = 78.01%). The assemblage persistence during the five years of study (measured by Kendall's W) corroborates this observation – the assemblage experienced variations among the years. Xiborena island fish assemblages are highly influenced by the flood pulse, which despite being a periodic event is also under influence of stochastic events (such as more pronounced dry or wet periods), affecting the fish assemblages in an unpredictable way.

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# Influence of macrohabitat preferences on the distribution of European brook and river lamprey larvae in the southern limit of the *Lampetra* genera distribution: implications for conservation and management

A. F. Ferreira [1], B. R. Quintella[1,2], C. Maia[3,4], C. S. Mateus[1,5,6], C. M. Alexandre[1,5], C. Capinha[7], P. R. Almeida[1,5]

[1]Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[2]Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[3]Planeta Vivo, Center of Environmental Investigation, Avenida da Liberdade, 4450-718 Leça da Palmeira, Portugal
[4]Eco-ethology Research Unit, ISPA, Rua Jardim do Tabaco, 1149-041 Lisboa, Portugal
[5]School of Science and Technology, Department of Biology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal
[6]Center for Environmental Biology, National Museum of Natural History, University of Lisbon, Rua da Escola Politécnica 58, 1250-102 Lisboa, Portugal
[7]Centre for Geographic Studys, University of Lisbon, Alameda da Universidade, 1600-214 Lisboa, Portugal
afferreira@fc.ul.pt

**Abstract**

The European river lamprey, *Lampetra fluviatilis* (L.), and the European brook lamprey, *Lampetra planeri* (Bloch, 1784), are considered highly threatened species in Portugal (Cabral et al., 2005). However, the lack of information about the ecology and distribution of these species poses difficulties to the identification of concrete actions directed to their conservation.

An extensive sampling campaign (402 sites), randomly distributed throughout the entire Continental Portuguese territory were defined, and *Lampetra* sp. ammocoetes presence/absence checked with electrofishing. This data were analyzed together with 11 macrohabitat predictors, obtained through Geographic Information Systems with Boosted Regression Trees (BRT). This is a form of logistic regression incorporating decision trees and a boosting algorithm that allowed both explanation and prediction of species distribution (Elith et al., 2008). The BRT model identified five environmental variables that predict the distribution of lampreys with a high level of accuracy. It was found that lampreys occur in low altitude river stretches, relatively close to the coast and with a substrate composed mainly by sand. Temperature and precipitation, two climatic variables indicative of water availability of rivers, were also identified as important predictors to explain *Lampetra* sp. occurrence.

A map with the probability of occurrence of *Lampetra* sp. in Portugal was generated with the model output, through which stretches of rivers were delimited with different priorities of conservation. Rivers classified with the higher level of conservation priority were identified as valid stretches to be proposed as Special Areas of Conservation, under the Natura 2000 Networking Programme.

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# Benthic macroinvertebrates and fish community patterns in a mosaic of floodplain habitats

E. Habit[1], C. Valdovinos[1], D. Camaño[1], N. Ortiz[1], J. Dosque[1], J. Salvo[1], F. Bretón[2], O. Link[2]

[1]Environmental Science Centre EULA, Universidad de Concepción, Chile.
[2] Civil Engineering Department, Universidad de Concepción, Chile
ehabit@udec.cl

## Abstract

Floodplains and riparian environments are extremely dynamic ecosystems which support high biodiversity. In them, fluvial processes occur at spatial and temporal scales ideal for understanding complex processes. In this work we are interested in knowing functional microhabitats for fish and macroinvertebrates community in the origin of the San Pedro River (Chile). We generated a detailed topographic map of a section of ca. 150 m long x 10 m wide using a GPS with differential correction, with a grid of more than 1000 points. Each point was identified by type of substrate, describing seven categories of physical habitats. Macroinvertebrate and fish sampling were qualitative, but stratified by habitats. During low flow and daytime we distinguish the following patterns: (a) habitats with substrate of terrestrial vegetation are occupied by *Hyalella*, Oligochaeta and juveniles of Galaxiids, (b) habitats of clay substrate are dominated by large individuals of *Aegla* and *Chilina* and have virtually no fish, except for schools of *G. maculatus* moving through the area, (c) habitats of boulders are dominated by Ephemeroptera, Diptera and *Percilia gillissi*, *Galaxias platei*, and *Percichtys trucha* (d) habitats of gravel are used primarily by *Aegla* and Ephemeroptera. Other environments do not show a clear structure of groups. Nocturnal underwater observations revealed a greater representation of species and size ranges of all species. Stomach contents of the 3 more abundant fish species reveal important dynamic between high and low flow seasons, with significant changes in the use of zooplankton. FONDECYT 1110441

# Connectivity and conservation of fish communities in coastal lakes

S. Hartz[1], T. Guimarães[1], E. Rocha[1], L. Artioli[2], C. Fialho[2], F. Becker[1]

[1] Departamento de Ecologia, Universidade Federal do Rio Grande do Sul, Caixa Postal 15007, CEP 91501970, Porto Alegre, RS, Brasil
[2] Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Caixa Postal 15007, CEP 91501970, Porto Alegre, RS, Brasil
sandra.hartz@ufrgs.br

## Abstract

Connectivity has an important influence on metacommunity composition (Olden et al, 2001). The modification of habitat connectivity could affect fish communities by the facilitation of species invasions combined with extirpation of the native species (Villéger et al., 2011). Here we evaluate the importance of connectivity and lake area in explaining fish assemblage composition in coastal lakes of southern Brazil, and discuss the potential effects of changing lake connectivity on fish conservation. The studied lakes encompass a range of different areas and connectivity, being subject to on-going landscape modification. We assessed fish assemblage composition in 31 lakes in the Tramandaí river system (50.14$^{o}$O; 29.98$^{o}$S). Using GIS tools, we measured connectivity in three ways: estuarine (CE), primary (CP) and historical connectivity. Fish data for each lake were obtained from field surveys and complemented with recent records from museum collections. Partial RDA analyses indicated that 16.8% of species composition variation is explained by connectivity measures. Freshwater species were negatively related to CE, which responded for 44% of explained variation in assemblage ordination. An endemic cichlid species was associated to historical connectivity. Connectivity measures were not related to invasive species, possibly because of a rapid invasion process and widespread distribution. The low importance of CP suggests that several species are widespread in the lake system and thus, that this metacommunity is structured by a mass effect (Leibold et al, 2004). Therefore, local antropogenic modification could affect the whole system (Mouillot, 2007), so that conservation of local assemblages should focus on habitat heterogeneity among lakes.

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# Monitoring Of Freshwater Fish Populations To Evaluate Conservation Of Native Species *Rutilus Macrolepidotus* In A Natura 2000 Protected Ecosystem (Paul De Arzila, Portugal)

F. Morgado[1], C. Dias[1], A. Baptista[2], A. R Figueiredo[1], J. R. Gadelha[1], A. M. V. M. Soares [1]

[1]CESAM & Biology Department, University of Aveiro,Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[2]Instituto da Conservação da Natureza, ICNB , Rua de Santa Marta, 55 1169 - 230 Lisboa
ritafigueiredo@ua.pt

## Abstract

Evaluating the conservation of native species follows the purpose of the Habitats Directive (Council Directive 92/42/EEC, May 21st 1992) implemented in Portugal by the Decree Law No.140/99. This Directive, which sets on the conservation of natural habitats and wild fauna and flora and being one of two European Directives concerning conservation of nature and wildlife, was adopted in 1992 as a European Union's response to the principles contained in the Berne Convention signed by all Member States. The Directive aims to protect some habitats and approximately 1000 listed species. Paul de Arzila is a freshwater wetland of international concern, included in the Natura 2000 network, located on the left margin of the Mondego River, Northwest Portugal. The conservation of the native fish *Rutilus macrolepidotus*, in Paul de Arzila, is included in the prevention of the extinction of native fish species, the arrest of the decline of its populations, the re-establishment of its populations and ensure the survival of its populations for future generations(1). This specie is classified and listed in Directive 92/43/EEC as Rare, Endemic, Localized, Threatened or Endangered. To this end suitable procedures(2) have to be undertaken so as to allow monitoring of fish populations and obtain data concerning fish populations' structure in this ecosystem in order to evaluate the current status of *Rutilus macrolepidotus* populations and fish fauna of those areas. Results described the spatial and temporal characterization of the patterns of distribution, abundance and biomass of freshwater fish community.

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# Monitoring The Impact On Freshwater Fish Populations Of The Restoration Of Degraded Waterways In A Natura 2000 Protected Ecosystem (Paul De Arzila, Portugal)

F. Morgado[1], C. Dias[1], A. Baptista[2], A. R. Figueiredo[1], J. R. Gadelha[1], A. M. V. M. Soares[1]

[1]CESAM & Biology Department, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[2]Instituto da Conservação da Natureza, ICNB, , Rua de Santa Marta, 55 1169 - 230 Lisboa
ritafigueiredo@ua.pt

## Abstract

Habitat degradation is the major cause of the decline of native fish since European settlement. Paul de Arzila is an interior freshwater wetland of international concern, included in the Natura 2000 network, located on the left margin of the Mondego River, Northwest Portugal. The restoration and preservation of habitats in this protected ecosystem was conducted by restoration of degraded waterways to be effective in the long term (1). For this, attention was given to issues as erosion control, fencing off streams, replanting indigenous vegetation and the removal and long term control of introduced plant species. Also, monitoring the status of this ecosystem and stress factors that affect freshwater fish populations after the restoration of degraded waterways, including spatial and temporal characterization of patterns of distribution in freshwater fish abundance, has vital importance to the conservation of resident species, some of them threatened by extinction. To this end, suitable procedures are being undertaken in order to monitor fish populations and to obtain data concerning fish populations' structure in this ecosystem (1,2). In-stream work was also undertaken, planned and executed so as to minimize any disturbance caused. The end work should be the re-establishment as far as practicable of original riparian environments. . The purposes follow the objectives of the Habitats Directive (Council Directive 92/43/EEC, May 21st 1992) on the conservation of natural habitats and of wild fauna and flora, implemented in Portugal by Decree-Law No. 140/99.

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# Impact on reproduction of forage fish in the São Francisco River, downstream from the Três Marias Dam, Southeastern Brazil

F. T. Normando[1], N. Bazzoli[1], K. B. Santiago[2]

[1] Postgraduate Department on Zoology of Vertebrates, Pontifical Catholic University of Minas Gerais, Av. Dom José Gaspar 500, prédio 43, 30535-901, Belo Horizonte, Minas Gerais, Brazil.
[2]Hydrobiology and Fish Hatchery Station of Três Marias, Caixa Postal 11, 39205-000, Três Marias, Minas Gerais, Brazil.
felipetalin@gmail.com

## Abstract

In areas downstream of hydroelectric dams, changes in hydrological regime and thermal disturbances are well known, which can cause impacts on reproductive biology of fish. To assess impact on forage fish reproduction at downstream of Três Marias hydroelectric plant, São Francisco River (Brazil), 606 individuals of forage fish species *Astyanax fasciatus* (n = 465) and *Astyanax bimaculatus* (n = 141) were captured bimonthly from November 2009 to October 2010. Samples were collected in two sections of the São Francisco River: section 1, immediately downstream from dam to first 34 km, section 2, after the confluence of the São Francisco with the Abaeté River (an important left bank affluent), at 34-54 km downstream from the dam. In section 2, there were higher values of water temperature, dissolved oxygen and turbidity over rainy season (September-February) compared to section 1. Water transparency was higher in section 1 than the other section. Fish captured in section 1, presented high occurrence of follicular atresia, and low frequency of spent males and spawned females. In section 1, females of both species have shown statistically lower values of total length, maximum gonadosomatic index and number of eggs than females in section 2. This study provides first evidence, analyzing reproductive parameters, that two species of forage fish, *A. fasciatus* and *A. bimaculatus*, present disruption of reproductive activity in the section immediately downstream of the Três Marias dam.

# Comparative analyses of initial development of *Salminus franciscanus* and *Pseudoplatystoma corruscans*, highest valued species in freshwater fisheries in São Fracisco River, Eastern from Brazil

D. M. F. Nunes[1], F. P. Arantes[1], Y. Sato[2], N. Bazzoli[1]

[1]Pontifical Catholic University of Minas Gerais, Av. Dom José Gaspar 500, prédio 43, 30535-901, Belo Horizonte, Minas Gerais, Brazil.
[2]Hydrobiology and Fish Hatchery Station of Três Marias, Caixa Postal 11, 39205-000, Três Marias, Minas Gerais, Brazil.
diegomnunes@hotmail.com

## Abstract

*Salminus franciscanus* and *Pseudoplatystoma corruscans* occurs in the São Francisco River Basin (SFR), Eastern Brazil, and these species are migratory fish of high commercial value and have their natural populations threatened by human activities. To study eggs and embryogenesis of these species, adult fish were collected in nature and subjected to induced reproduction by hypophysation. Oocytes of *S. franciscanus* are green, no adhesive, and possess a diameter of 741.1±107.6 µm, pellucid zone thickness of 7.3±1.4 µm, squamous follicular cells (4.2±0.9 µm heigh) in vitelogenic oocytes and, when hydrated, it presents a large perivitelline space. Oocytes of *P. corruscans* are yellow, no adhesive, possesses a diameter of 511.6±63.1 µm, thin pellucid zone with 1.2±0.4 µm thick, prismatic follicular cells with a height of 18.8±2.9 µm (in vitellogenic oocytes), gelatinous layer and small perivitelline space in spawned eggs. After fertilization, egg samples were analyzed from 10 to 10 minutes and photographed under a stereoscopic microscope. Egg segmentation originated blastomeres at animal pole on the mass of yolk (vegetative pole). At the blastocyst stage, the blastomeres are flattened, and through the movement of epibolia, it expanded over blastocyst edges culminating with the closing of the blastopore, about 7 hours (h) after fertilization for both species. Hatching occurred at 20h for *S. franciscanus* and 18h for *P. corruscans*. The results of this study provide basic information to improve technique of induced breeding, cultivation, and to promote conservation management actions of these important species of “SFR”.

# Temporal dynamics of the sea trout (*Salmo trutta trutta*) in the Minho River (NW of the Iberian Peninsula)

H. Ribeiro[1], M. J. Araújo[2], M. Mota[2,3], C. Braga[2], C. Antunes[2,3,4], R. Sousa[1,2]

[1] CBMA – Centre of Molecular and Environmental Biology, Department of Biology, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal.
[2] CIMAR-LA/CIIMAR – Centre of Marine and Environmental Research, University of Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[3] Aquamuseum of the Minho River, Parque do Castelinho, 4920-290 Vila Nova de Cerveira, Portugal.
[4] University School Gallaecia, Largo das Oliveiras 4920-275 Vila Nova de Cerveira, Portugal

## Abstract

Migrations are one of the most amazing characteristics of life on Earth and fishes are one of the faunal groups well recognized by their migratory behaviour. In the Minho River (NW of the Iberian Peninsula) six fish species present migratory behaviour, including the sea trout (*Salmo trutta trutta*) an anadromous fish from the Salmonidae family. Although being described as an important species in this river basin there is an almost complete lack of information regarding the basic ecological characteristics (e.g. abundance, biomass, life cycle, diet and spawning behaviour). Given this premise, this study aimed to increase the knowledge on basic aspects of the ecology of sea trout. In order to verify the temporal dynamics of this population, fyke nets were placed in a side arm of the River Minho from June 2007 to May 2012. Every week, fyke nets content was checked for the presence of sea trouts and the abiotic conditions were also recorded. The results showed that there are no significant differences over the years, but significant differences along the months were detected. The highest catches were taken in December and January while in July, August and September sea trout was absent from experimental fishing. Since this species is subject to various threats (e.g. presence of dams and other obstacles, deterioration of spawning grounds, poaching, pollution, presence of invasive species and climate change) the data obtained in this study could be important for future implementation of restoration measures that are essential for the conservation of this migratory fish species.

# Fish assemblage structure in Champotón River, Southestern of Mexico

J. E. Sedeño-Díaz[1,2], P. Trujillo-Jiménez[3], Eugenia López-López[1]

[1]Laboratorio de Ictiología y Limnología, Escuela Nacional de Ciencias Biológicas.- Prol. De Carpio y Plan de Ayala, Col. Santo Tomás, 11340, México D.F. México
[2]Programa Ambiental, Av. Wilfrido Massieu s/n. Esq. Av. Luis Enrique Erro. Col. Zacatenco, Mexico, DF, Mexico.
[3]Universidad Autónoma del Estado de Morelos, Av. Universidad 1001. Col. Chamilpa, Cuernavaca, Morelos CP 62209, Mexico.
jsedeno@ipn.mx

## Abstract

Río Champotón located in the humid tropics of Yucatán Peninsula in Southeastern Mexico is within the Usumacinta Province, the most diverse in fish fauna in Mexico. Is part of the Mesoamerican hotspot, with high endemism and exceptional habitat loss (Myers et al., 2000) and is an area recognized as poorly known for its biodiversity (CONABIO 2002). The spatial and seasonal variability of its freshwater fish fauna and their relation to physical habitat characteristics were studied. The Río Champotón fish fauna showed both spatial and seasonal distribution patterns. Specific richness was 27 freshwater fish species and was highest in the uppermost reaches during the rainy season. A distribution gradient of fish assemblage was observed in function of dominant substrate, stream velocity, and dissolved oxygen. Areas of nutrient enrichment (nitrate, ammonium, nitrite, orthophosphate, BOD) were detected along the watercourse, suggesting a trend toward eutrophication by effect of several human activities. *Astyanax aeneus* was the only fish species that was able to live in all freshwater course of Champotón river. All species in the freshwater region are native species, with the exception of *Oreochromis* sp. The information in this study highlights the fact that fish species living in the Río Champotón are sensitive to anthropogenic disturbance, since instances of local diversity depletion were observed.

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# Feeding of fish species in two interconnect ecosystems of a Neotropical River (preliminary data)

A. C. Souto[1], J. Lobón-Cerviá[2], E.D. Carvalho[1]

[1]Laboratory of Fish Biology and Ecology, Institute of Biosciences, UNESP – Campus Botucatu, SP. Caixa Postal 510, Botucatu, SP, Brazil. CEP 18618-000
[2]Museo Nacional de Ciencias Naturales, Madrid, Spain
carollsouto@hotmail.com

## Abstract

More than any other group of vertebrates, fishes differ on the type of food consumed (Nikolsky, 1963; Lowe-McConnell, 1999). Most of the species are able to exhibit a considerable feeding plasticity in their diet (Gerking, 1994; Zavala-Camin, 1996). The aim of this study was to compare the feeding ecology of fish assemblages in two interconnected ecosystems: a well preserved stretch of Paranapanema River, a large Neotropical River of Brazilian Southeastern and an adjacent lagoon, during the dry season. In the lagoon, 377 fish specimens were captured belonging to 16 species, and 196 specimens analyzed presented some stomach content. In the river, 240 specimens were captured belonging to 13 species, and 50 showed some stomach content. With the Alimentary Index (AI), we verified that the diet of the fish from the lagoon was composed by 31 food items, and the main resources were: aquatic insects, belonging to the Trichoptera, Ephemeroptera and Diptera orders, vegetal matter and fishes. In the river, the diet was composed by 15 food items, with vegetal matter and fishes as the main resources. The Detrended Correspondence Analysis (DCA) demonstrated that the common species to the two environments present similar feeding strategies. However, it can be noticed that a greater diversity of food items occurred in the lagoon, which can be due to their environmental characteristics and greater availability of resources. The ecological role of these aquatic ecosystems is evident, regarding conservation and biodiversity, as an important migratory route and as a recruitment area.

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# Biology of non-native largemouth bass *Micropterus salmoides* in Southern Africa

G. C. Taylor[1], P. Cowley[2], O.L.F. Weyl[2]

[1]Department of Ichthyology and Fisheries Science, Rhodes University, P.O. Box 94, Grahamstown, 6140 South Africa
[2]South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown, 6140 South Africa
g07t2509@campus.ru.ac.za

## Abstract

Largemouth bass *Micropterus salmoides*, listed as one of the 100 worst invasive biota, were introduced into South Africa in 1928. Spread to develop recreational angling opportunities, they have become established in larger rivers and impoundments throughout most of Southern Africa. They are invasive and have had demonstrable deleterious impacts on native fish and invertebrate communities. This paper contributes to understanding the biology and ecology of largemouth bass in invaded African ecosystems. We assessed diet and used validated age estimates obtained from sagittal otoliths to determine growth and maturity rates of 4 largemouth bass populations in temperate South Africa, and compared these with largemouth bass populations both in their native and non-native distributional range. Gut content analyses demonstrated that, like in native populations, fish made wide use of available vertebrate and invertebrate prey. Edge analysis and mark-recapture of chemically tagged wild fish was used to validate the annual deposition rate of growth increments on otoliths. While maturity was consistent with that of other populations, lifespan (13 years) was longer and growth rates slower than those reported from sub-tropical and tropical populations. These data supports common hypotheses that growth in this species is positively correlated with temperature. Results are discussed in relation to managing invasions by this fish species in southern Africa.

# Distribution and composition of freshwater fish communities in northeastern rivers (Douro basin, Portugal): Implications for mussel conservation strategies

S. Varandas[1], A. A. T. Teixeira[2], M. Lopes-Lima[3], R. M. V. Cortes[1], R. Sousa[3]

[1]CITAB-UTAD – Centre for Research and Technology of Agro-Environment and Biological Sciences, University of Trás-os-Montes and Alto Douro, Forestry Department, Apartado 1013, 5001-811 Vila Real, Portugal,
[2]CIMO- ESA-IPB – Mountain Research Centre, School of Agriculture, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 1172, 5301-854 Bragança, Portugal.
[3]CIMAR-LA/CIIMAR – Centre of Marine and Environmental Research, Laboratory of Ecotoxicology and Ecology, Rua dos Bragas 289, 4050-123 Porto, Portugal.
simonev@utad.pt

**Abstract**

Freshwater mussel populations (*Margaritifera margaritifera*, *Unio delphinus*, *Anodonta anatina* and *Potomida littoralis*) of three tributaries of the Douro basin are threatened by several factors (e.g. river regulation, pollution, habitat perturbation and the introduction of exotic species). It is known that host fish, manly autochthonous species, are essential for the life cycle and conservation of these naiad populations. Freshwater fish communities present in Tâmega, Tua and Sabor rivers are composed by autochthonous salmonid (*Salmo trutta*), cyprinid (*Squalius carolitertii, Squalius alburnoides, Pseudochondrostoma duriense, Achondrostoma oligolepis, Luciobarbus bocagei*) and cobitid (*Cobitis calderoni*) resident populations and an increasing number of exotic species (*e.g. Esox lucius, Micropterus salmoides, Lepomis gibbosus, Gambusia holbrooki, Gobio lozanoi, Carassius auratus, Cyprinus carpio, Sander lucioperca*). Diadromous species are limited to eel populations (*Anguilla anguilla*) and a low number has been detected only in the Tâmega river.

A good biological quality and biotic integrity can be found in many headwater streams of Tâmega, Tua and Sabor rivers. For instances, in the Rabaçal and Tuela streams (Tua basin), inside the Montesinho Natural Park, only autochthonous fish species are present and trout populations reach high densities supporting the most viable freshwater pearl mussel (*Margaritifera margaritifera*) populations of Portugal. However, other mussel populations (*U. delphinus*, *A. anatina* and *P. littoralis)* present in the lower part of the three rivers are severely threatened by river regulation (3 big dams are nowadays in construction), which will promote the disappearance of autochthonous host fish species and the dominance of exotic species.

# Predation risk assessment of black bass *Micropterus salmoides* on fish fauna of southern Portugal

D. Venade, M. Ilhéu

Department of Landscape, Environment and Planning, University of Évora, Apartado 94, 7002–554 Évora, Portugal.
diogovenade@gmail.com

## Abstract

The introduction of fish predators in new habitats has led to noticeable impacts around the world. Environmental conditions of intermittent Mediterranean type rivers favor the development of *M. salmoides*, being well established in all the southern Portuguese watersheds. The objective of this study is to assess the predation impact of *M. salmoides* on fish assemblages based on diet analysis and aquarium experiments.

*M. salmoides* showed a wide trophic range but with a pronounced predator character. The main trophic categories were aquatic macro-invertebrates (Ephemeroptera and Odonata larvae), fish and crayfish. The number of consumed prey was negatively correlated with fish length and animal consumption decrease with the increase on fish size. Fish prey was consumed mainly by medium size fish class (100-200 mm TL), representing 35% of diet. Non-native species (*Australoheros facetus Lepomis gibbosus* followed by *M. salmoides*) were the most frequently consumed fish preys, although native cyprinids (*Barbus spp* and *Squalius spp*) were also identified in the stomach contents (<5% of frequency). In aquarium experiments, the highest predation rate was observed for *L. gibbosus.* The predation efficiency was dependent on the prey species behavior and morphology.

The feeding strategy may be interpreted in term of cost-benefit analysis. In spite of fish prey value, the high cost involved in active predation may explain the high rate of insect larvae and crayfish consumption. The availability of small non-native fish, namely *L. gibbosus* and *A. facetum* with weaker swimming performance, compared with the native cyprinids may actually rescue native fauna from *M. salmoides* predation. Conservation and management programs involving invasive species control should be developed at the community level, integrating knowledge on the direct and indirect trophic species interactions.

# Theme 4 – Genetics

# Genetic demography of the endangered Iberian three-spined stickleback (*Gasterosteus aculeatus*) in Mediterranean streams

R. M. Araguas, O. Vidal, C. Pla, Núria Sanz

Laboratori d'Ictiologia Genètica, Universitat de Girona, Campus Montilivi, E-17071 Girona, Spain.
nuria.sanz@udg.edu.

## Abstract

The three-spined stickleback (*Gasterosteus aculeatus*) in the Iberian Peninsula is only distributed in freshwater habitats and has completely disappeared from most of its range, mainly as a consequence of habitat degradation and invasive fish introductions. In Portugal and Spain this species has been listed as endangered following IUCN (International Union for Conservation of Nature) criteria (Doadrio 2002; Cabral et al. 2005). The importance of genetic demography studies for conservation purposes lies in the influence of demographic parameters on effective population size (*Ne*) and, hence, on the long-term persistence of populations. We studied the genetic demography of three-spined stickleback in the Mediterranean, genotyping five microsatellites in five streams from the Northeastern Iberian Peninsula and in two temporal samples (2008-2009) from two captive stocks (Calonge and Ullals), created for conservation purposes. Our results indicated recent bottlenecks and small or even critical *Ne* mainly in captive stocks, but also in some of the native populations. Pedigree reconstruction showed large family sizes, associated with very high values of its variance, in some locations with small *Ne*. This was not observed in other locations, where low *Ne* should be related to other causes, as fragmentation and genetic drift. Due to its threatened situation and because they represent the populations living at the southern edge of its distribution, Northeastern Iberian stickleback should be considered of high conservation priority and urgent management measures should be designed.

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# Preliminary results of genetic diversity within sea trout population from intensively stocked southern Baltic river, based on microsatellite DNA analysis

R. Bernaś[1], A. Burzyński[2], P. Dębowski[1], R. Wenne[2]

[1] Department of Migratory Fishes in Gdańsk, Inland Fisheries Institute in Olsztyn - Poland
[2] Laboratory of Genetics of Marine Organisms, Institute of Oceanology Polish Academy of Science in Sopot - Poland
rber@infish.com.pl

## Abstract

Since dozens of years, sea trout and salmon fishery management in the Słupia river system has been based on mass stockings with smolts and fry. Their aim is to increase the number of specimens and, in the case of salmon, the restoration of an extinct population. As a result of these actions sea trout originated from natural and artificial spawning coexist in the Słupia River basin. All of these groups are in permanent interaction, with unknown gene flow intensity between them. Furthermore, the potential impact of stocking on sea trout genetic condition is also unclear. The preliminary analysis of sea trout genetic diversity was performed on 10 polymorphic microsatellite loci: 7 dinucleotide and 3 tetranucleotide. We investigated 216 sea trout specimens, from 5 groups: adults which originated from natural spawning (A), adults from smolts stocking (B), juveniles from a hatchery, F1 generation from group A and B (J), juveniles from the lower Słupia river (D) and wild parr from unstocked tributary (K). Initial results suggest that genetic polymorphism within sea trout from the studied groups is low but differences are statistically significant and show apparently high gene flow between groups. In particular, it seems that specimens from natural spawning have higher allelic richness and number of private alleles, contrary to group from hatchery.

# Genetic diversity and population structure of the sea lamprey across its distributional range

C. S. Mateus[1,2,3], M. J. Alves[3], B. R. Quintella [2,4], N. Mesquita[3], P. R. Almeida[1,2]

[1]Department of Biology, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[2]Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[3]Museu Nacional de História Natural e da Ciência, Center for Environmental Biology, University of Lisbon, Rua da Escola Politécnica 56/58, 1250-102 Lisbon, Portugal.
[4]Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
csmateus@fc.ul.pt

## Abstract

The sea lamprey (*Petromyzon marinus* L.) is parasitic and anadromous and is distributed at both sides of the North Atlantic. We assessed levels of genetic diversity and investigated patterns of population structure in several populations from Europe and North America, using microsatellite loci. So far, population structure analyses revealed a pattern in which populations from both sides of the North Atlantic comprise differentiated metapopulations. The observed pattern is congruent with previous mitochondrial DNA analysis, which revealed reduced population differentiation for *P. marinus* between Iberian populations but an absence of genetic exchange among sea lamprey populations spawning in the west and east Atlantic coasts (Rodríguez-Muñoz et al. 2004). These results should be considered in planning future policies aiming to manage sea lamprey populations across its range.

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# A comparison of population genetic patterns in economically important fishes of the Amazon basin: implications for management and conservation

M. C. F. Santos[1], V. Machado,[1] A. Leao[1], T. Silva[2], K. B. Passos[1], E. Galletti[1], D. Toffoli[1], O. Colatrelli[1], N. V. Meliciano[1], M. V. Amado[3], T. Hrbek[1], I. P. Farias[1]

[1]Laboratório de Evolução e Genética Animal/LEGAL, Universidade Federal do Amazonas/UFAM, Manaus, Amazonas, Brazil.
[2]Universidade Federal de Alagoas/UFAL, Alagoas – Pólo Penedo, Brazil;
[3]Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo, Unidade Vitória.
concyfreitas@yahoo.com.br

**Abstract**

The Amazon River system is home to the most diverse fish fauna of the planet which supports an important freshwater fishery generating more than US $200 million per year. The continued productivity of these resources, and their continued contribution to the socio-economic fabric of the region depends directly on sustainable fisheries practices, and genetic "health" of these resources. Using molecular genetic markers, it is possible to obtain information and elucidate key factors about the genetic structure, genetic diversity and population dynamics of Amazonian fishes. Our analyses reveal three main patterns in terms of distribution of genetic variability. Panmixia was observed in majority of economically important fishes such as *Colossoma macropomum*, *Prochilodus nigricans*, *Semaprochilodus insignis* and *Plagioscion squamosissimus*. The pattern of isolation by distance at basin-wide scale was observed mainly in the species *Arapaima gigas* and *Osteoglossum bicirrhossum*. All these species occur in large Amazonian rivers and their associated floodplains, with the seasonal dynamics of the Amazonian floodplain system facilitating the movement of organisms and subsequent gene exchange over large geographic distances. The pattern of structuring between different river basins was observed in species of cichlids such as *Symphysodon* spp, *Astronotus* spp *Pterophyllum* spp and *Mesonauta* spp, and in other small species that are exported as ornamental fishes. In a number of cases, observed divergences were compatible with the presence of Evolutionary Significant Units. The two principal patterns of structuring require different approaches to management and conservation. In the case of floodplain fishes, the impact of any management will have basin-wide implications, and thus management plans need to be designed with this goal in mind. In genetically structured species, management will need to be local and its impacts will be geographically restricted. The taxonomy of many of the genetically structure species will also need to be reevaluated. These results should be of interest to competent governmental organs, and will hopefully provide data for the implementation and improvement of strategies for monitoring, conservation and management of Amazonian fish fauna.

# FISHATLAS Project: population genetics as a tool for the conservation of endangered species

C. Sousa-Santos[1], J. Robalo[1], P. Branco[2], J. M. Santos[2], T. Ferreira[2], M. Sousa[3], R. Castilho[4], A. Ramos[4], I. Doadrio[5] V. Almada[1]

1 Eco-Ethology Research Unit, ISPA-IU, Rua Jardim do Tabaco, 34 – 1149 041 Lisboa, Portugal
2 Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal
3 Instituto para a Conservação da Natureza e Florestas, Rua de Santa Marta 55, 1169-230 Lisboa, Portugal
4 CCMAR, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal
5 Museo Nacional de Ciencias Naturales, CSIC, c/ José Gutiérrez Abascal 2, 28006 Madrid, Espanha
csousasantos@gmail.com

## Abstract

Several anthropogenic-induced threats are currently risking the survival of freshwater fish populations, especially in geographic areas where the effects of global warming are more intense. The risk of extinction is particularly high for primary freshwater fish species, since they are unable to migrate to more favorable regions. Since the majority of the target-species for this project was attributed with a conservation status, our aim is to contribute with valuable data on the biodiversity distribution patterns, the genetic structure and the demographic parameters of populations, and other central issues for scientists and managers concerned with the current risk of extinction threatening Iberian freshwater fish. To achieve this, we used an extensive coverage of the Portuguese hydrographical network (20 species from 80 river basins and sub-basins, comprising a total of around 6000 individuals sampled) and an innovative and well supported phylogeographic approach (by the concerted use of three molecular markers with different rates of evolution). At the end of the project, we believe that the obtained data may be used by the decision-makers and authorities not only in the present context of the management of the hydrological resources aiming to minimize the effects of climate changes, but also in the implementation of conservation and management plans aiming to preserve species and, specifically, to assign priorities in conservation policies when choices have to be made concerning which populations of each species must be preserved first, a decision that must take into account the maximization of standing genetic diversity.

# Are Madeira River rapids barriers for floodplain fishes of the Amazon basin? A multispecies comparative study and lessons for conservation

V. Machado[1], B. Soares[2], C. Doria[2], R. Pagotto[2], M. C. Santos[1], M. D. E. Lizarazo[1], I. Farias[1], T. Hrbek[1]

[1]Laboratório de Evolução e Genética Animal, Departamento de Biologia, Universidade Federal do Amazonas, Av. Rodrigo Otávio Jordão Ramos, 3000, 69077-000, Manaus, AM, Brasil
[2]Fundação Universidade Federal de Rondonia, Porto Velho, RO, Brasil

**Abstract**

The Madeira River comprises about 1.4 million km$^2$ and its basin area is about 20% of the Amazon basin. It is the largest tributary of the Amazon, and contributes about 15% of its annual discharge. The Madeira River in its upper section has 16 rapids in an approximately 360 km section between the cities of Porto Velho and Guajará Mirim. The largest of the rapids is the Teotonio located about 20 km above the Porto Velho, which constitute the greatest barrier to navigation in the river (Goulding *et al*, 2003). These rapids are also the largest geographical division in the Madeira River Valley, and many species of aquatic organisms are delimited by them. In order to test whether these rapids are or not a barrier to gene flow for species shared above and below the Teotonio rapids, we collected mitochondrial DNA data from several different fish species with different life histories. The species studied were grouped into migratory species (*Colossoma macropomum*, *Piaractus brachypomus* and *Prochilodus nigricans*), semi-migratory species (*Pellona castelnaeana* and *Triporteus angulatus*) and sedentary species (*Cichla pleizona* and *Astronotus crassipinnis*). Populations of individuals for each species were collected upstream and downstream of the rapids. The results showed a heterogeneous pattern of the effects of the rapids as barriers to gene flow. In all cases the rapids functioned as a barrier to gene flow to a greater or lesser extent, as observed in *Colossoma macropomum*, *Piaractus brachypomus* and *Prochilodus nigricans*. For other species the rapids are absolute barriers, isolating populations upstream and downstream, such as the species *Pellona castelnaeana* and *Triporteus angulatus*. Finally in the sedentary species (*Cichla pleizona* and *Astronotus crassipinnis*), the rapids are separating distinct lineages compatible with ESU classification. These results are important considering the construction of two hydroelectric plants in the region of these rapids, which definitely will change not only the evolutionary history of these species but of all semi-aquatic and aquatic organisms dependents on this river. The record of evolutionary patterns that we see now will be of fundamental importance to future plans for monitoring and mitigating the effects caused by construction of these hydroelectric plants in the upper Madeira River.

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# Theme 5 - Diadromous Fish

# Eel research and management on the Minho River

C. Antunes[1,2,3], C. Braga[1], M. J. Araújo[1], M. Mota[1]

[1]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/UP). Rua dos Bragas, 289, 4050-123 Porto
[2] Gallaecia High Education School. Largo das Oliveiras, 4920-275 Vila Nova de Cerveira
[3]Aquamuseu do Rio Minho. Parque do Castelinho, 4920-290 Vila Nova de Cerveira

## Abstract

The European eel, *Anguilla anguilla*, is present in all European watersheds but strongly limited by dams presence. Although European eels still seem to be common in many areas (mainly due to introduction), they are subject to several threats. Main threats include fisheries, stream migration blockages, loss of habitat, pollution, parasites and diseases, predatory birds as well as climatic changes of their environment especially during their larval marine migration. In the Atlantic, the most important glass eel fishery basins are Minho, the Asturian basins, the Basque river basins and the Guadalquivir. The Minho River forms the northern border between Portugal and Spain with a length of about 80 Km and it is the only Portuguese river where glass eel fishing is allowed. However, yellow and silver eel fishing was prohibited in 2011. Official statistics of Portugal and Spain concerning glass eel fisheries are underestimated. The eel management plan for Minho River was presented and approved by EU. Old and recent research data were organized and questions such as recruitment and glass eel mortality by fishing as well as silver eel escapement are discussed in this work. Yield of experimental fishing and real catches data provided by fishermen allow estimation the glass eel mortality by fishing. CPUE values for last season changed between 2.20 kg/boat and 32.65 kg/boat (11.36±7.60 kg/boat, mean±SD). In the Minho River tributaries eel biomass average of 22.69 Kg/ha was registered while average silver eel biomass percentage represented 24.33%. *Anguillicoloides crassus* prevalence varied between 23% and 100% in the international section of the river. Biological data monitoring are essential to comply with the management plan.

# A preliminary assessment of European eel (*Anguilla anguilla* Linnaeus, 1758) populations in rivers of Galicia (NW Spain).

F. Cobo[1,2], D. Nachón[1], S. Silva-Bautista[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], P. Gómez-Sande[1], C. Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago-Meijide[1]

[1]Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2]Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3]Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
fernando.cobo@usc.es

## Abstract

At present there is a need for reliable information on European eel *Anguilla anguilla* (Linnaeus, 1758) populations, as stocks are declining to critical levels. In order to establish the status of the stock, we performed samplings in 34 sections of 17 rivers of Galicia (NW Spain), during the summer of 2011. Electric fishing was conducted by wading where possible (21 locations) and data were expressed in terms of density (individuals/ha) and biomass (kg/ha). In the deepest points near the mouth of the rivers (13 locations) fyke-nets were used and values were expressed in CPUEs (individuals/hour/fyke-net and grams/hour/fyke-net). We obtained the percentage of silver eels, Fulton's condition factor and population structure. Density and biomass values showed high variation among sampling stations, with mean density values of 1880 ± 406 ind/ha (range: 149-5106) and mean biomass values of 42.8 ± 7.79 kg/ha (range: 6.4-91.9). The observed mean CPUEs were 0.11 ± 0.045 ind/h/fn (range: 0.02-0.54) and 12.6 ± 7.20 g/h/fn (range: 0.6-80.0). The biomass of silver eels showed also a high variation among rivers, with a mean biomass value of 9.97 ± 3.03 kg/ha (range: 0-41.88). The percentage of silver eels (kg) in the shallow areas of the rivers was 22.1 ± 4.37 % (range: 0.0-57.5), while in the deepest points the percentage of silver eels (kg) reached a mean value of 19.7 ± 6.72% (range: 0-58.43).

# The European eel (*Anguilla anguilla* Linnaeus, 1758) populations in coastal lagoons of NW Spain.

F. Cobo[1,2], S. Silva-Bautista[1], D. Nachón[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], P. Gómez-Sande[1], C. Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago-Meijide[1]

[1]Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2]Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3]Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
fernando.cobo@usc.es

## Abstract

The European eel *Anguilla anguilla* (Linnaeus, 1758) is a catadromous species with an European panmictic stock declining to critical levels. At present, an EU Regulation obliges all Member States to develop National Eel Management Plans, and there is a need for reliable information on eel populations. Coastal lagoons form an important part of the available habitat for eel in Europe, representing over 17,460 $km^2$. These areas support large eel stocks, and their potential production is very high, but in most cases habitat quality has progressively deteriorated owing to human impacts. We studied the conservation status of eel populations in 3 coastal lagoons of NW Spain. Fyke-nets were used to the catches and data were expressed in terms of CPUEs (individuals/hour/fyke-net and grams/hour/fyke-net). We studied the percentage of silver eels for determining the potential spawning stock, as well as the population structure and general biometric characteristics (length, weight and Fulton's condition factor). The mean values of CPUEs were 0.07 ± 0.024 ind/h/fn (range: 0.04-0.12) and 6.2 ± 1.80 g/h/fn (range: 3.6-9.7). The percentage of silver eels expressed in number of individuals and weight (kg) was 17.06 ± 13.12 % (range: 0.00-47.01) and 17.12 ± 14.99 % (range: 0.00-42.86) respectively. There is an important variation in the percentage of silver eels biomass (kg) registered in these coastal lagoons. However, the mean value (17.12 % of the total biomass) is high enough to consider the importance of monitoring these ecosystems for assessing their potential as reservoirs of migrants.

# Feeding ecology of *Anguilla anguilla* (L.) in freshwater systems of a large river basin in South-western Europe

J. L. Costa[1,2], I. Domingos[1,2], C. A. Assis[1,2], P. R. Almeida[1,3], F. Moreira[4], M. L. Chaves[1], E. Feunteun[5], M. J. Costa[1,2]

[1]Universidade de Lisboa, Faculdade de Ciências, Centro de Oceanografia, Campo Grande, 1749-016 Lisboa, Portugal
[2]Universidade de Lisboa, Faculdade de Ciências, Departamento de Biologia Animal, Campo Grande, 1749-016 Lisboa, Portugal
[3]Departamento de Biologia, Universidade de Évora, 7002-554 Évora, Portugal
[4]Centro de Ecologia Aplicada "Professor Baeta Neves", Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal
[5]Muséum National d'Histoire Naturelle, Station Marine, Av. Georges V, 35800 Dinard, France
jlcosta@fc.ul.pt

## Abstract

The feeding ecology of the European eel, *Anguilla anguilla* (L.), in freshwater systems of the Tagus river basin was studied through the analysis of specimens collected in the main river, including the tidal area and a small tributary. Eels, measuring from 63-706 mm in total length, fed on prey ranging from 1.0-122.0 mm in length. Dipterans, ephemeropterans and oligochaets were the most important prey. Spatial differences in feeding ecology of eels were related to the species density and environmental conditions, namely the longitudinal position of sampling sites in the basin, size of the water body, water current and latitude. The occurrence of seasonal variations in feeding ecology of eels might be explained by fluctuations in prey abundance related to temperature and freshwater flow. Food selection based on size, body robustness, concealment capacity and motility of prey, as well as and total length and head width of eels was also determined.

# New insights on the ecology of silver eels in Portugal

I. Domingos[1,2], J. L. Costa[1,2]

[1] Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
[2] Departamento de Biologia Animal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
idomingos@fc.ul.pt

## Abstract

The knowledge about the ecology of silver eels is crucial to implement the recovery measures included in the Portuguese Eel Management Plan, which has been approved by the EU Commission to comply with the needs set out in Regulation (EC) Nº 1100/2007. However, in Portugal little information is available on the characteristics of these reproductive specimens. In the present work unpublished data from 56 specimens captured in the Mondego and Tagus basins (central Portugal) between 1988 and 1990 were analysed and produced new insights on the biometry, sex, age, condition, and timing of metamorphosis and migration of silver eels in Portugal. These potential spawners were only observed between September and February with a peak of abundance between November and January. Their total length ranged from 274 mm to 426 mm (mean of 321 mm) and they presented an age between $2^+$ and $6^+$ (median of $4^+$) years. The condition of specimens varied between 0.11 and 0.24 (mean of 0.18) and males were largely dominant in the samples. Variations in these parameters in different months were analysed and the characteristics of Portuguese silver eels were compared with those from other regions considering the available literature.

# Sea lamprey fisheries in NW Iberian Peninsula: a comparison between two basins

M. Gonçalves[1], M. J. Araújo[2], Y. Stratoudakis[3], C. Antunes[2,4,5]

[1] Instituto Nacional dos Recursos Biológicos, Instituto Português de Investigação das Pescas e do Mar (INRB, I.P./IPIMAR), Av. General Norton de Matos 4, 4450-208 Matosinhos, Portugal.
[2] Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/UP). Rua dos Bragas, 289, 4050-123 Porto, Portugal.
[3] Instituto Nacional dos Recursos Biológicos, Instituto Português de Investigação das7 Pescas e do Mar (INRB, I.P./IPIMAR), Av. de Brasília s/n, 1449-006, Lisboa, Portugal.
[4] Aquamuseum of the Minho River, Parque do Castelinho. 4920-290 Vila Nova de Cerveira, Portugal.
[5] University School Gallaecia, Largo das Oliveiras, 4920-275 Vila Nova de Cerveira, Portugal.
mgoncalves@ipimar.pt

**Abstract**

Sea lamprey, *Petromyzon marinus* L., is a native anadromous species highly prized in the Iberian Peninsula and southern France. Pre-spawning fish enter estuaries from early winter until late spring and are targeted by dedicated fisheries. Here, we provide a comparative description of lamprey fisheries in two NW Iberian Peninsula basins: Cávado and Minho rivers. Fishing with trammel nets was performed in March and April 2002 at Cávado river and January to April 2011 at Cávado and Minho rivers, recording catches and effort, and sampling 1636 lampreys for total weight and length. CPUE analysis showed that sea lampreys were more abundant at Minho (4.9±0.54 sea lampreys/vessel/day) than at Cávado (1.9±0.26 sea lampreys/vessel/day in 2002 and 2.1±0.22 sea lampreys/vessel/day in 2011) and that the pattern of entrance in these two rivers was very similar, reaching a peak in the first fortnight of March. In Cávado, there were no differences between the two sampling years' relative abundance. Mean length and weight from Cávado was significantly higher in 2002 (89.7±0.19 cm and 1392.2±9.12 g) when compared to sea lampreys caught in the same months of 2011 (86.1±0.46 cm and 1217.9±19.49 g) and Minho (87.6±0.44 cm and 1318.7±19.96 g). Significant biometrical differences were also found between Minho (88.6±0.32 cm and 1326.0±13.41 g) and Cávado (85.8±0.38 cm and 1202.2±15.57 g) during 2011 (January to April). Due to its anguilliform morphology sea lampreys are expected to show negative allometric growth but in some fortnights the relative growth was isometric. The highest condition factor was obtained in the first fortnight of March 2002 and the second fortnight of February 2011 in Cávado, and in the second fortnight of March 2011 in Minho. This temporal and geographic variability may result from the exposure to different environmental conditions, diets and period of the adult parasitic phase.

# Morphological differentiation of Western Iberia sea lamprey stocks in relation to seabed topography

C. S. Mateus[1,2,3], B. R. Quintella [2,4], M. Lourenço[2], M. J. Lança[5,6], P. R. Almeida[1,2]

[1]Department of Biology, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[2]Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[3]Museu Nacional de História Natural e da Ciência, Center for Environmental Biology, Rua da Escola Politécnica 56/58, 1250-102 Lisbon, Portugal.
[4]Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[5]Department of Animal Science, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[6]Institute of Mediterranean Agrarian Sciences, University of Évora, dos Colegiais 2, 7000 Évora, Portugal.
csmateus@fc.ul.pt

## Abstract

Morphological characters of 224 adult sea lamprey *Petromyzon marinus* L. captured in eight Portuguese river basins (i.e., Minho, Lima Cávado, Douro, Vouga, Mondego, Tejo and Guadiana) were analysed to investigate the hypothesis of stock fragmentation promoted by geographical segregation during the oceanic parasitic phase of the life cycle. This study pointed out to the existence of three sea lamprey stocks (North/Central stock, the Tagus stock, and the Guadiana stock) possibly isolated in different abyssal plains of the oceanic area surrounding the western Iberia Peninsula continental shelf. Results indicate that morphometric traits are more useful than meristic ones to discriminate populations, and the cephalic region was identified as the most important body region to discriminate populations of sea lamprey spawners. Sexual dimorphism in morphometric characters was found, but not in meristics. The discriminant characters identified in this analysis may indicate that feeding areas hypothesized in this study are probably located at distinct bathymetries. The information gathered with this study is important to support management measures directed to recover the less healthy sea lamprey stocks of Western Iberian Peninsula.

# Contribution to the migratory fish species conservation in Minho River (Northwest Iberian Peninsula) - the Allis shad (*Alosa alosa* L.) case study

M. Mota[1,2,3], C. Antunes[2,3,4]

[1]ICBAS – Institute of Biomedical Sciences Abel Salazar, University of Porto, Largo Prof. Abel Salazar 2, 4099-003 Porto, Portugal.
[2]CIMAR/CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal.
[3]Aquamuseum of Minho River, Parque do Castelinho, 4920-290 Vila Nova de Cerveira, Portugal.
[4]ESG - Gallaecia High Education School. Largo das Oliveiras, 4920-275 Vila Nova de Cerveira
mmota@ciimar.up.pt

## Abstract

The Allis shad (*Alosa alosa*) has a great commercial importance in Europe. In Iberian Peninsula, more specifically in the international Minho River, this species it also assumes a preponderant cultural role. From middle of 20th century it was verified marked decline in spawner's number preceded by a reduction in available habitat area resulting from dam construction. This work contributed for the knowledge of the biology and ecology of the Minho River's Allis shad population. Several aspects were investigated, as spawner's age structure (by scales reading) and migration behaviour, reproductive biology (spawning periods and gonad development), hybridization with *Alosa fallax* (by morphological analysis), recognizing of juvenile's growth habitats and diet.

The achieved results provided guidelines for future management and species conservation. The recognition of spawning grounds and juvenile's growth habitats allowed identifying "sanctuary areas". The interdiction of sport fishing in these areas and of commercial fishing in critical areas as the river mouth and river areas with narrow margins may be the faster measure to achieve a better conservation status, providing greater opportunity for the recruitment success. The regulation of the flow of the first dam is essential for the survival and recruitment of Minho River's Allis shad population.

# Preliminary biological data on a population of twaite shad (*Alosa fallax* Lacépède, 1803) in NW Iberian Peninsula.

D. Nachón[1], S. Silva-Bautista[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], P. Gómez-Sande[1], C Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago[1], F. Cobo[1,2]

[1]Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2]Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3]Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
davidjose.nachon@usc.es

## Abstract

Populations of twaite shad (*Alosa fallax*) have severely declined across Europe. The protection of this species requires a detailed knowledge of its biology and ecology, as well as an assessment of its abundance. Therefore, there is a great need to get detailed information on the status of its populations in most of the distribution area. Twaite shad populations in Spain have been poorly studied compared with other European populations, and no data are available for the NW Iberian Peninsula populations. We intend to improve the knowledge on the biology and ecology of the river Ulla population (Galicia, NW Spain), giving for the first time data on individual characteristics. Specimens (n=89) were sampled between April and June 2011. Two typical trammel nets (40 m long, 70 mm and 100 mm loose inner layer mesh size respectively) were used. We selected two sampling stations in resting areas of the species, located at 20 km and 24 km from the sea. Preliminary data of reproducers are presented: total length, total weight, sex ratio, gonadosomatic index, hepatosomatic index, condition factor, gonadal condition factor and age structure. Males reach a mean length of 42.97 ± 0.70 cm (range: 33.7-52.4 cm) and a mean weight of 707.04 ± 35.37 g (range: 314-1250 g). For females the average of length was 49.25 ± 0.73 cm (range: 40.8-56.2 cm) and the mean weight was 1110.26 ± 54.42 g (range: 591-1625). Age ranged from 3 to 8 years.

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# Spawning characteristics and mating behaviour of twaite shad (*Alosa fallax* Lacépède, 1803) in the Ulla river (Northwestern Iberian Peninsula).

D. Nachón[1], S. Silva-Bautista[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], P. Gómez-Sande[1], C Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago[1], F. Cobo[1,2]

[1]Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2]Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3]Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
davidjose.nachon@usc.es

## Abstract

Knowledge on the life cycle of twaite shad presents important weakness as most of the available data come from studies conducted on close species: *Alosa alosa*, For example, concerning reproduction, identification of the spawning grounds is needed in order to develop proper conservation measures. Additionally, the study of some spawning characteristics (period of activity, temperature of water, etc.), mating behavior and iteropary complete the information on the reproduction of this species. Thus, the goal of this study was to identify the main spawning grounds and to document the spawning behavior of the twaite shad in the Ulla river. We have identified two spawning grounds. These are located in a stretch of the river at about 24 km to sea, at a distance of almost 800 meters from each other. One of them is a typical spawning ground, while the other is a forced spawning ground (downstream a small dam). Reproductive activity shows a modal peak from 03:00 a.m. to 4:00 a.m., with a range between 00:00 a.m. and 07:00 a.m. The rate of iteropatirity shows a maximum value of 59.55 %, and there are some individuals that reach four spawning events.

# Effects of temperature, salinity and feeding frequency on the development of Twaite Shad (*Alosa fallax*) larvae

T. Navarro[1], F. Ribeiro[2,3], C. Carrapato[4]

[1] Centro de Biologia Ambiental, Faculdade de Ciências da Universidade de Lisboa, 1749-016 Lisboa, Portugal
[2] Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, 1749-016 Lisboa, Portugal
[3] Museu Nacional de História Natural, Universidade de Lisboa, Rua da Escola Politécnica 58, 1269-102 Lisboa, Portugal
[4] Parque Natural do Vale do Guadiana, Instituto da Conservação da Natureza e da Biodiversidade, Centro Polivalente de Divulgação da Casa do Lanternim, Rua D. Sancho II nº 15, 7750-350 Mértola, Portugal
tiago.navarro.marques@gmail.com

## Abstract

The Twaite shad *Alosa fallax* (Lacépède, 1803) is an anadromous clupeid, widespread across the northeastern Atlantic coast, from northern Morocco to the Baltic Sea, and throughout the Mediterranean Sea. *Alosa fallax* is classified as vulnerable in most European countries, threatened mainly by limited connectivity to spawning grounds and changes in river hydrological dynamics, both caused by impoundment. The lack of knowledge about larvae physiology and ecology hampers the development of management and conservation measures.

This study evaluated the effects of water temperature, salinity and feeding frequency on larvae growth and mortality under controlled conditions. In the spring of 2011, gametes were extracted from spawning *A. fallax* in the Lower Guadiana River. Two sets of experiments were performed. First of all, larvae growth and mortality were assessed at six salinities (0g/L, 2,5g/L, 5g/L, 10g/L, 15g/L, 20g/L) and two feeding frequencies (1x/day, 3x/day) for ten days after first feeding. Salinities up to 15g/L were tolerated, with higher survival rates observed at 2,5g/L. At salinities equal or superior to 2,5g/L a single feeding per day of freshly hatched *Artemia* spp. *nauplii* was enough to sustain high growth rates, while at 0g/L higher feeding frequencies were required to maintain high growth rates due to *nauplii* lower survivability. Secondly, growth was compared between larvae reared at three different temperatures (20°C, 24°C, 28°C) for three months. Growth rates were higher at 24°C and 28°C, while at 20°C growth and survival rates were lower. Results are discussed in terms of conservation implications for this species.

# Infection of European eel by the parasite *Anguillicoloides crassus* in Portuguese continental systems

A. F. Neto[1], D. Passos[1], J. L. Costa[1,2], M. J. Costa[1,2], I. Domingos[1,2]

1Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
2Departamento de Biologia Animal, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
idomingos@fc.ul.pt

## Abstract

Infection of the European eel, *Anguilla anguilla*, by the swimbladder nematode *Anguillicoloides crassus* was investigated in four Portuguese continental systems: Aveiro and Óbidos lagoons and Tagus and Mira estuaries. A total of 296 yellow eels were examined, revealing a prevalence of 30% and an intensity of 3.1 lumen worms per swimbladder. Prevalence (P) values were higher in both estuarine systems studied: Tagus estuary (P= 42%) and Mira estuary (P = 55%) whereas the highest mean intensity (I) was found in Aveiro lagoon (I= 3.78 ±1.96). Considering the entire sample, a mean swimbladder degenerative index (SDI) of 1.30±1.24 was obtained. The proportion of Portuguese eels per SDI class revealed that 67% of the swimbladders were damaged. Although no nematodes were observed in Óbidos lagoon eels, moderate injuries were observed in the swimbladder of the 23% individuals captured. Severe injuries were only found in the other systems (8% of eels from Aveiro lagoon, 9% of eels from Tagus estuary and 11% of eels from Mira estuary). Whereas the type of system (lagoon/estuary) and salinity have an effect on *A. crassus* prevalence, SDI was only affected by the last variable. No significant model with the variables studied was found for intensity.

# Spatial and temporal variation in smolt age of Atlantic salmon in the subarctic River Teno system: temperature affected changes

E. Niemelä[1], B. Dempson[2], J. H. L'Abée-Lund[3], J. Erkinaro[1], M.-A. Svenning[4]

[1]Finnish Game and Fisheries Research Institute, Oulu Game and Fisheries Research, Tutkijantie 2, FIN-90570, Oulu, Finland.
[2]Fisheries and Oceans Canada, P.O. Box 5667, St. John's, NL A1C 5X1, Canada.
[3]Norwegian water resources and energy directorate Middelthunsgate 29, Postboks 5091 Majorstua, 0301 Oslo
[4]Norwegian institute for nature research, Department for Arctic Ecology (NINA-Tromsø), Fram Center, N-9296 Tromsø, Norway
martin.svenning@nina.no

## Abstract

In the River Teno system inhabit one of the largest and northern Atlantic salmon populations in its native distribution area. Smolt age of adult Atlantic salmon has been recorded in 13 discrete tributary populations in addition to the main river itself for more than 35 years. Most juveniles left the river after four years with a variation of 2-8 years, although a significant difference appeared among tributaries. A temporal increase in the incidence of five year old smolt was apparent in the salmon caught in the River Teno and some tributaries. This increase was connected with a corresponding decline in cumulative water temperature in early July experienced prior to smolt migration. There was a negative connection between smolt age and the sea age when Atlantic salmon attained sexual maturity. Cyclical fluctuations were apparent in smolt age of Atlantic salmon caught in the River Teno. Smolt age indices of different smolt cohort correlated significantly between different sea ages, indicating simultaneous variations in the smolt ages between 1SW and multi-sea-winter salmon.

# Diel changes in abundance and biomass of larval and juvenile twaite shad in the lower Elbe River

S. Oesmann

networks – Dipl. Biol. S. Oesmann GbR
Oelkersallee 60, 22769 Hamburg, Germany
info@oesmann.net

## Abstract

Two 24-hour fisheries were carried out at 2 sampling sites during May and June 2009 in the tidal freshwater region of the Elbe river, Germany.
The abundances of eggs and free embryos of twaite shad increased with increasing water depth. Young larvae and older stages concentrated in the upper water layers during day. The abundances of non yolk sac larvae and juveniles increased at night. During darkness the highest abundances were estimated in deeper water layers. This shift in abundance distribution patterns are discussed to be strongly influenced by light intensity.

# Trace elements accumulation in the sea lamprey along the major hydrographic basins of Portugal

S. Pedro[1], I. Caçador[1], B. Quintella[1,2], M. J. Lança[3,4], R. Ferreira[4,5], I. Alves-Pereira[4,5], P. R. Almeida[1,6]

[1]Center of Oceanography, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal.
[2]Department of Animal Biology, Faculty of Sciences of the University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
[3]Institute of Mediterranean Agrarian Sciences, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[4]Department of Animal Science, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[5]Department of Chemistry, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
[6]Department of Biology, School of Science and Technology, University of Évora, Largo dos Colegiais 2, 7000 Évora, Portugal.
ssfpedro@sapo.pt

## Abstract

The sea lamprey, *Petromyzon marinus* L., is an anadromous cyclostome that occurs in the main basins of Portugal. It is classified in the Portuguese Red List of Vertebrates as "Vulnerable" but, nonetheless, it is overfished in estuaries and freshwater during its reproductive migration, since it is considered a gastronomic delicacy. The sea lamprey is also explored in Spain and France. The contamination profile of this species is fairly unknown, in Portugal as in the rest of the world, as far as trace metals are concerned, with only a few studies on mercury and methyl-mercury accumulation in North America. Trace metals accumulation was analyzed by ICP-AES in 80 specimens from eight Portuguese river basins (sex ratio 1:1), in muscle and liver samples with the aim of: i) determine the safety of sea lamprey consumption regarding its heavy metals content; ii) analyze sex related differences between contamination profiles that may prevail from the differences in the lipid content of male and female spawners; and iii) investigate differences of dietary and/or geographic nature in trace metals accumulation, based on the team's previous works that show some evidences that the sea lampreys of the Western Iberia coast are, probably, using distinct oceanic regions and/or targeting different groups of hosts during the parasitic feeding phase of their life cycle.

# Migration patterns of Baltic Sea living burbot (*Lota lota* L.) as revealed by otolith microchemistry

M. Rohtla, M. Vetemaa, I. Taal, T. Saat

University of Tartu, Estonian Marine Institute, Mäealuse 14, Tallinn, 12618, Estonia
mehis.rohtla@ut.ee

## Abstract

Burbot (*Lota lota* L.) is considered to be the only gadoid species that lives exclusively in freshwaters. However, in some areas (*e.g.* the Baltic Sea) burbot has also adapted a brackish water life phase, where a part of population undertakes semianadromous spawning migrations to the lower reaches of rivers and brooks, but otherwise lives in the sea. As burbot is relatively unpopular target of commercial and recreational fisheries, our knowledge on the biology of coastal burbot populations is very scarce. In this study we used otolith strontium and calcium ratios (Sr:Ca) to validate the occurrence of semianadromous burbot populations and to investigate different life history traits. Specifically, we aimed to answer the following questions: 1) the importance of freshwater spawning for sea-living burbot, 2) age and length at first seaward migration and 3) frequency of freshwater spawning migrations. The specimens were collected from Matsalu Bay (n=30) and Saunja Bay (n=30) and analyzed for Sr:Ca from core to edge. This is the first non-observational burbot migratory study done with sea-living specimen and the first using otolith microchemistry.

# Disentangling the life cycle of sea lamprey (*Petromyzon marinus* Linnaeus, 1758): Duration and growth of the marine life stage.

S. Silva-Bautista[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], D. Nachón[1], P. Gómez-Sande[1], C. Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago-Meijide[1], F. Cobo[1,2]

[1] Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2] Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3] Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
sergio.silva@usc.es

## Abstract

After several years in freshwater, ammocoetes of sea lamprey (*Petromyzon marinus* Linnaeus, 1758) undergo a metamorphosis that allows young postmetamorphic individuals (PM) to migrate to the sea and start the hematophagous feeding. They remain at sea for an unknown period until they start the spawning migration. The literature information about this phase and its duration is very limited and inconsistent. We studied the sea lamprey downstream migration in the Ulla River and its estuary (NW Spain), where the *Liza aurata* (Risso, 1810) shoals provide an early and abundant food resource for the PM. Capture of these *Liza aurata* shoals allowed us to measure 223 PM between January and April 2011. The total length (± 1 mm) and weight (± 1 g) data were registered. Condition factor was calculated as [weight (g) x $10^6$]/ length $(mm)^3$. Hematophagous feeding in the estuary allowed the PM to increase exponentially their total length ($y = 142.76e^{0.1632x}$; $R^2 = 0.9685$) and weight ($y = 6.152e^{0.4718x}$; $R^2 = 0.9548$). Instantaneous growth rates observed were 0.755% $d^{-1}$ for total length and 2,647% $d^{-1}$ for weight. Our results show that the duration of the hematophagous feeding phase, which takes place mainly at the sea, spans from 8 to 10 months. Taking into account the date of completion of metamorphosis in this region (October-November) and the spawning season (May-July), the adult stage of sea lamprey (between metamorphosis and spawning) lasts 18 months.

# Downstream migration and hematophagous behaviour of newly metamorphosed sea lampreys (*Petromyzon marinus* Linnaeus, 1758)

S. Silva-Bautista[1], R. Vieira-Lanero[2], M. J. Servia[3], S. Barca-Bravo[1,2], J. Sánchez-Hernández[1], D. Nachón[1], P. Gómez-Sande[1], C. Morquecho[1], M. T. Couto-Mendoza[1], S. Rivas-Rodríguez[1], L. Lago-Meijide[1], F. Cobo[1,2]

[1]Universidad de Santiago de Compostela. Departamento de Zoología y Antropología Física, Campus Vida, 15782 Santiago de Compostela. Spain.
[2]Estación de Hidrobioloxía "Encoro do Con", Castroagudín s/n, 36617 Vilagarcía de Arousa, Pontevedra. Spain.
[3]Universidad de A Coruña. Departamento de Biología Animal, Biología Vegetal y Ecología. Facultad de Ciencias. Campus da Zapateira s/n. 15008 A Coruña. Spain.
sergio.silva@usc.es

## Abstract

The metamorphosis of sea lamprey (*Petromyzon marinus* Linnaeus, 1758) allows young postmetamorphic individuals (PM) to migrate to the sea and start the hematophagous feeding. The information about this phase is very limited, especially for European populations. We studied the downstream migration, the timing and location of first feeding and the prey species in the Ulla River and its estuary (NW Spain). In the river a total of 7027 PM were captured between 1997 and 2011 at three sites using a permanent trap and nets, and 72 metamorphic lampreys were captured by electrofishing in September 2010. Additionally, 190 *Salmo salar*, 69 *Salmo trutta*, and 89 *Alosa fallax*, were captured in the search for attached PM or wounds in 2011. Capture of *Liza aurata* shoals in the estuary showing attached PM allowed us to measure 343 lampreys between January and April from 2008 to 2011. The total length (± 1 mm) and weight (± 1 g) data were registered. Results show that downstream migration occurs between October and May with a peak in March. This migration stops for several months when PM reach the estuary, before moving to coastal waters starting in the month of April. Our results show also that part of the PM (10-30%) start the hematophagous feeding in the river, with a special preference for anadromous species probably because of their larger size. We also observed a preference for the region closer to the pectoral fins as a place for feeding.

# Climate induced change in life history strategy in High Arctic Svalbard charr

M.-A. Svenning[1], T. Lowen[2], J. Reist[2]

[1]Norwegian institute for nature research, Department for Arctic Ecology (NINA-Tromsø), Fram Center, N-9296 Tromsø, Norway
[2] Fisheries and Oceans Canada, 501 University Crescent, Winnipeg, MB, R3T 2N6, Canada.
martin.svenning@nina.no

## Abstract

The circumpolar Arctic charr, *Salvelinus alpinus*, is ideal for studying how environmental factors affect life history in fishes. Charr populations demonstrate a tremendous ecological plasticity and adaptations to harsh environments. Migratory behaviour, which is one aspect of the complex life history of the Arctic charr, is generally restricted to northern areas, in which anadromy is suggested to be more frequent in cold than in warm, temperate latitudes. Thus, it is thought that when conditions for feeding and growth in freshwater are unfavourable, the growth advantage to be gained by undertaking a seaward migration is maximized. Consequently, anadromy should be more advanced in charr inhabiting the cold and low-nutrient lake systems in High Arctic (as on Svalbard), than in those found in the southernmost parts of their distribution range. The recent global warming is expected to show a maximum increase at higher northern latitudes and on Svalbard, the mean temperature has increased significantly, especially the last decades. By use of otolith microchemistry we have shown that the frequency of migratory charr (older than 5 years) in a Svalbard lake system has changed from more than 80 % thirty years ago to less than 15 % the last five years, having serious influences of management of Svalbard Arctic. The results are discussed in relation to possible influences of climate change in arctic areas.

## REMISSIVE INDEX

# ABSTRACT TITLE INDEX

ciimar
Centro Interdisciplinar de Investigação Marinha e Ambiental
Rua dos Bragas, 289
4050-123 Porto
Portugal

Aquamuseu do rio minho
Parque do Castelinho
4920-290 V. N. Cerveira
Portugal

CERVEIRA vila das artes
Praça do Município
4920-284 V. N. Cerveira
Portugal

escola superior gallaecia
Largo das Oliveiras
4920-275 V. N. Cerveira
Portugal