

## **Abstracts of Oral Papers not published in the Supplement**

### **Stocking hatchery-reared brown trout in different densities into a wild population – a comparison of growth and movement**

In spring 2001 and 2002 a small stream was stocked with tagged hatchery-reared yearling brown trout (*Salmo trutta*), in order to study their influence on the resident brown trout population. The stream was separated into six sections: two sections without stocking, two sections where stocking doubled the trout population and two sections where the fish population was quadrupled. The working hypothesis was that due to food limitation (competition) growth of the wild fish will be negatively influenced by stocking, and wild fish will be displaced by the (possibly more aggressive) hatchery fish. Surprisingly, growth rate of wild and stocked fish of the same age was similar and independent of stocking density. Two main reasons may be responsible for this finding: only a low percentage of the stocked fish remained in the stream, and food was not limited during summer. Only 12–19% of the stocked fish were recaptured after six months, in contrast to 40–70% of one-year old and up to 100% of older wild trout. The wild fish were not displaced by hatchery-reared fish: During summer the wild fish remained more or less stationary, whereas most of the stocked trout had left their release site. The results indicate that in a natural stream stocking of hatchery reared brown trout does not influence negatively growth and movement of the wild fish independent of stocking density.

Baer, J. (*Fisheries Research Station of Baden-Württemberg, Untere Seestraße 81, 88085 Langenargen, Germany*).

### **Swimming activity of seabass: comparing patterns obtained in natural environment and in re-circulating tanks under high density**

Seabass (*Dicentrarchus labrax*) swimming activity was compared between natural environments and aquaculture facilities. Behaviour under natural conditions was assessed in a saltmarsh pond (250 m<sup>2</sup>, 18 × 14 × 0.8 m) using acoustic telemetry. From several surveys, we documented the diel activity rhythm and demonstrated group effects on swimming patterns and amplitudes by comparing activity of solitary fish with that of a fish living in a group of 60. Consequences of weather variability were also analysed and revealed a high sensitivity of fish to atmospheric conditions for both swimming and demand-feeding behaviour. Behaviour in fish tanks was also studied using acoustic telemetry, as part of the EUREKA EU1 960 'Aqua-Maki 2' project investigating aspects of fish culture in re-circulating tanks under high density. A re-circulating hexagonal tank (5.4 × 5.4 m, 1.8 m depth, 48 m<sup>3</sup>) was equipped with positioning and demand-feeding systems, oxygen and temperature probes. Initial density was 50 kg m<sup>3</sup> in March and rose to 90 kg m<sup>3</sup> at the end of the experiment in May. During this period, the movements of nine fish were continuously recorded for 24 h each, reaching a total of six 24 h episode at eight days interval. Swimming activity was analysed in terms of activity rhythms and space occupation specially around feeding events. The two data set and main results will be presented and compared to assess seabass behavioural plasticity and sensitivity to husbandry conditions.

Bégout Anras, M.-L.<sup>1</sup>, Lagardère, J. P.<sup>1</sup> & Covès, D.<sup>2</sup> (<sup>1</sup>*Centre de Recherche sur les Ecosystèmes Marins et Aquacoles, CNRS/IFREMER, BP 5, F-17137 L'Hourmeau, France;* <sup>2</sup>*Station Expérimentale d'Aquaculture, IFREMER, Chemin de Maguelone, F-34250 Palavas, France*).

### **Genetic quality of domesticated African tilapia populations**

Anecdotal and empirical evidence exists for substantial (up to 40%) declines in growth among *Oreochromis* populations domesticated in both large and small-scale fish farms in Africa. These declines are at least partly attributable to poor genetic management, including inadvertent selection, inbreeding, bottle-necks and founder effects. Due to restricted cash flow and investment capital, genetic management and selective breeding for the improvement of domesticated populations are difficult for small-scale farmers, but feasible on larger-scale farms. In managing domesticated gene pools, feral populations can serve as a broodstock reservoir, making the use of indigenous species advantageous. A development model of large-scale hatcheries producing selected lines of sex-reversed, indigenous tilapia for sale to smaller-scale farmers is proposed as a solution to the problems of poor genetic management in African aquaculture.

Brummett, R. E. & Ponzoni, R. (*WorldFish Centre, BP 2008, Yaoundé, Cameroon*).

### **Polyculture production of juvenile fishes for survival in nature**

Production of seed for stock enhancement projects requires consideration of the behavioural quality of the animals to be released in the wild. Our approach to improving behavioural quality of hatchery fish is to raise them in polyculture with the plants or animals that fish normally utilize as shelter in nature. Results suggest that such 'naturalized' systems provide a broad improvement in behaviour as both predator avoidance and feeding skills were improved relative to control hatchery fish. In addition fish in a naturalized system grew better and were more tolerant of stress than were fish reared by traditional hatchery methods. We hypothesize that the spatial heterogeneity of our 'naturalized' systems provided training in both hiding and seeking and that these activities improved feed conversion and stress tolerance.

Burke, J. S., Morris, J. & Kenworthy, J. (*NOAA, National Ocean Service, Center for Coastal Fisheries and Habitat Research, 101 Pivers Island Road, Beaufort, NC 28516-9722, U.S.A.*).

### **Experimental investigation of the success of stocked, domestic brown trout and their effects on wild brown trout in upland and lowland rivers**

The stocking of adult, domestic brown trout (DBT) (*Salmo trutta* L.) to supplement angling catches is a common practice. There is increasing concern, however, over the effects of such stockings on indigenous wild brown trout (WBT) populations. This paper describes an experimental field trial to explore the success of stocked DBT and their effects on WBT growth and abundance. DBT adults were stocked into upland rain-fed and lowland spring-fed streams. Three stocking treatments and a control were replicated six times for each of the two stream categories. In spring, baseline adult (defined as >200 mm LF) WBT densities were increased by 25, 50 and 100% using equal quantities of two different strains of DBT from two large suppliers. All DBT were measured, weighed and tagged before being stocked. The stocking procedure approximated to current stocking practice. A total of 48 500 m experimental sites were used. The abundance of WBT was estimated at each survey site in the summer prior to stocking via electrofishing and the depletion method. All WBT captured were measured and weighed.

In addition, all WBT >100 mm were tagged. Habitat was assessed using the HABSCORE model. Post-treatment monitoring was undertaken in the summer following stocking. Data will be presented regarding the effects of the stocking treatments on the growth and abundance of WBT as well as the strain-dependent performance of DBT across all sites and on a river type-specific basis. The suitability of using HABSCORE to formulate appropriate stocking densities will be discussed.

Chatterji, R. K.<sup>1</sup>, Stubbing, D. N.<sup>1</sup>, Bark, A. W.<sup>2</sup> & Williams, W. P.<sup>2</sup> (<sup>1</sup>*The Game Conservancy Trust, Fordingbridge, Hampshire SP6 1EF, U.K.*; <sup>2</sup>*Department of Life Sciences, King's College, Franklin-Wilkins Building, 150 Stamford Street, London SE1 9NN, U.K.*).

### **Stock enhancement and conservation culture of sturgeons: problems and prospects**

Stock enhancement is the main source of *Acipenser gueldenstaedtii* and *A. stellatus* recruitment in the Sea of Azov, where up to 30 million juveniles have been released in recent years. The hatchery production strategy aimed solely to produce and release the largest possible number of juveniles, utilizing only the most mature broodfish of the spring spawning run. Although monitoring of age, mass and physiological conditions of the broodstock during the period of hatchery breeding did not show significant changes, the spawning run was dramatically shortened from several months to just 15 days, and includes only fish with advanced gonadal maturity. Conservation of the Azov Sea species and their unique spawning ecotypes is currently supported by the Federal Living Gene Bank, which maintains over 9000 adults of eight endangered species. This paper summarizes the results of comparative analysis of biological characteristics such as growth, age of the first sexual maturation, relative fecundity, and morphological and physiological indices in wild and cultured specimens of different species and intraspecific groups of sturgeons. We conclude that there is a need for developing better hatchery technologies to maintain diversity of the stocks, through breeding protocols that maximize the genetic diversity of offspring based on evaluation of parentage and relatedness in farmed stocks by micro-satellite loci.

Chebanov, M. S., Galich, E. V., Chmir, Y. N. (*Federal Centre for Genetics and Selection in Aquaculture, 12 Oktyabrskaya Str, Krasnodar 350063, Russia*).

### **Effect of domestication on ide *Leuciscus idus* L. reproductive parameters**

Ide *Leuciscus idus* L. is a riverine cyprinid commonly produced as a subsidiary species in polyculture with common carp in Poland. In many cases production of restocking material is based on farm-reared broodstock. The aim of the paper is to study possible domestication effects on female reproductive parameters in ide following long-term pond cultivation. Three groups of fish were analysed: group (1) consisted of fish cultivated in carp ponds for three generations; group (2) consisted of fish caught as wild one-year-olds in rivers and kept in ponds until sexual maturation (first pond-reared generation) and group (3) consisted of wild ide females caught at spawning sites just before natural spawning. All fish originated from the Vistula River in central Poland. Fish were stimulated with Hungarian synthetic hormone analogue (Ovopel). Body length and mass, individual fecundity and egg size were measured during spawning, and egg survival was assessed at the eyed ova stage.

Ciesla, M. & Wojda, R. (*Department of Ichthyobiology and Fisheries, Warsaw Agricultural University, ul. Ciszewskiego 8, PL-02-786 Warszawa, Poland*).

### **Differences in the energetic cost of swimming in turbulent flow between wild, farmed and domesticated juvenile Atlantic salmon *Salmo salar***

Domestication has been shown to have an effect on morphology and behaviour of Atlantic salmon (*Salmo salar*). We compared swimming costs of three groups of juvenile Atlantic salmon subject to different levels of domestication: (1) wild fish; (2) first generation farmed fish origination from wild genitors; and (2) seventh generation farmed fish originating from Norwegian aquaculture stocks. We assessed swimming costs under two types of turbulent flow (one mean flow velocity of 23 cm s<sup>-1</sup> and two standard deviations of flow velocity of 5 and 8 cm s<sup>-1</sup>). Respirometry experiments were conducted with fish in a mass range of 5–15 g wet at a water temperature of 15° C. Our results confirm (1) that net swimming costs are affected by different levels of turbulence such that, for a given mean flow velocity, fish spent 1.5-times more energy as turbulence increased, (2) that domesticated fish differed in their morphology (having deeper bodies and smaller fins) and in their net swimming costs (being up to 30.3% higher than for wild fish) and (3) that swimming cost models developed for farmed fish may be also be applied to wild fish in turbulent environments.

Enders, E. C.<sup>1</sup>, Boisclair, D.<sup>1</sup> & Roy, A. G.<sup>2</sup> (<sup>1</sup>*Département de sciences biologiques, Université de Montréal, C.P. 6128 Succursale Centre ville, Montréal, Québec, H3C 3J7, Canada;* <sup>2</sup>*Département de géographie, Université de Montréal, C.P. 6128 Succursale Centre ville, Montréal, Québec, H3C 3J7, Canada*).

### **Reproductive ecology of cultured fish in the wild**

Fish show a tremendous diversity in patterns of reproductive investment and in associated breeding systems (*i.e.* parental care and sexual selection, including the number of mates obtained by both sexes and the manner in which they are obtained through competition for mates and resources, courtship, and mate choice). These patterns play an integral role in shaping the evolution of populations and their dynamics, and thus changes in these patterns necessarily affect population viability. Artificial culture of fish in hatcheries, net-pens and gene banks almost invariably disrupts the natural breeding system and alters fitness-related traits. The implications, both genetic and ecological, of the intentional and unintentional release of these fish for wild populations are largely dependent on what occurs during breeding and its subsequent effects on offspring performance. Our findings and those of others have indicated that gene flow from cultured to wild populations is frequently impeded by altered breeding behaviour and biased by sex and life history strategy. Moreover, breeding affects subsequent offspring performance through not only genetic (*e.g.*, disruption of co-adapted gene complexes, MHC non-assortative mating), but also non-genetic maternal effects (*e.g.*, breeding time and location, egg size). While significant advances have been made in the last decade, our understanding of the reproductive ecology of cultured fish in the wild remains somewhat in its infancy. Such study continues to be integral in enlightening our management of cultured fishes in the wild, and more broadly for increasing our understanding of fish breeding systems and thus population dynamics.

Fleming, I. A. (*Ocean Sciences Centre, Memorial University of Newfoundland, St John's, NL A1C 5S7, Canada*).

### **Maladaptation and phenotypic mismatch in cultured Atlantic salmon used for stocking**

Compared to wild populations, cultured Atlantic salmon often sustain higher mortality rates and lower adult return rates when stocked as juveniles into natural streams. The ultimate causes for such differences in fitness, however, are not clear. Here we tested if

relaxed levels of natural selection and improved survival in the hatchery environment could account for the observed degree of maladaptation among stocked fish. To do this, we assessed the degree of phenotypic mismatch between wild and cultured fish in three populations over five consecutive years. Significant differences were found in several phenotypic traits that are likely to have fitness implications. Thus, if the objective is to mimic wild individuals for restoration purposes, current hatchery practices aimed at maximising juvenile survival and enhancing growth may need to be revised.

García de Leániz, C.<sup>1</sup>, Consuegra, S.<sup>2</sup> & Serdio, A.<sup>1</sup> (<sup>1</sup>*Centro Ictiológico de Arredondo, 39813 Arredondo, Cantabria, Spain;* <sup>2</sup>*Zoological Society of London, Institute of Zoology, Regent's Park, London, U.K.*).

### **Why do salmonid antipredator responses weaken in hatchery rearing?**

The Arctic charr of Lake Saimaa are the most endangered fish population in Finland, and reintroduction programs have been unsuccessful. Low success of reintroduction programs has drawn attention to behavioural properties of hatchery-reared fish. Mortality due to predation often is a principal cause of failure. Antipredator behaviour may degenerate rapidly under hatchery conditions due to (i) reduced genetic variation in antipredator behaviour and/or (ii) selection that would favour bold and fast growing individuals and disfavour predator awareness supposedly associated with slow growth. To test the relative importance of these two factors we first analysed the amount of variation in innate antipredator responses between and within families of hatchery-bred Arctic charr of the Lake Saimaa stock. We then tested whether fast growing individuals would show reduced responses to chemical cues from their natural predators compared to their slow growing counterparts. Based on the results we propose procedures for maintaining and improving antipredator skills of hatchery-reared salmonids.

Hirvonen, H. & Laakkonen, M. V. M. (*Integrative Ecology Unit, Department of Biological and Environmental Sciences, University of Helsinki, P. O. Box 65, FI-00014 Helsinki, Finland*).

### **Long-term studies on genetic interaction between wild and ranched cod *Gadus morhua* by use of a genetic marked strain**

Releases of farmed fish, whether accidental from commercial aquaculture facilities or intentional as part of stock enhancement/ranching activities, are considered to pose a risk to native gene pools. Stock enhancement studies of Atlantic cod, *Gadus morhua*, based on artificially produced juveniles, were initiated in 1984 in western Norway, and genetic aspects were incorporated. In order to investigate potential interbreeding between released and wild cod, a genetically marked cod strain was developed, being homozygotic for a rare allele (*GPI-1\*30*) expressed in white muscle tissue. In the period from 1990 to 1994, juveniles from the genetic marked strain were released in large quantities in three locations (Masfjord, Øygarden, Heimarkspollen), giving a significant increase of the marker allele in the local wild cod populations. Recently, studies have been conducted in the same areas to estimate the extent of interbreeding between the wild and released cod. The results, however, revealed no permanent increase of the frequency of the marker allele and/or *GPI-1\*30* heterozygotes as would be expected from interbreeding. The recent data are compared with comprehensive genetic data of the cod populations in the areas before the actual releases, covering the full period from 1994 to 2003. The present results are also discussed in relation to fishing pressure on coastal cod, migration information and reproductive success of released, genetically marked cod.

Jørstad, K. E.<sup>1,3</sup>, Nævdal, G.<sup>2</sup>, Karlsen, Ø.<sup>1</sup>, Torkildsen, S.<sup>2</sup>, Paulsen, O. I.<sup>1</sup> & Otterå, H.<sup>1</sup> (<sup>1</sup>*Institute of Marine Research, Department of Aquaculture, Bergen, Norway*; <sup>2</sup>*University of Bergen, Department of Fishery and Marine Biology, Bergen, Norway*; <sup>3</sup>*Corresponding author: POB 1870 Nordnes, 5817 Bergen, Norway*).

### **Comparison of maturation timing, egg size and fecundity between hatchery lines of chinook salmon and their wild donor stocks**

Increasing concern has been expressed about the genetic effects of cultured salmonid fishes on natural populations. Avoidance of extreme negative outcomes was one reason for the establishment of a genetic management policy for the State of Alaska. However, domestication within the hatchery may still cause divergence from the wild donor population. This divergence could potentially lead to adverse impacts on wild stocks through straying and introgression. This study examines potential domestication in two Alaskan chinook salmon stocks. The Little Port Walter (LPW) Hatchery Chickamin River stock resulted from a small collection of wild broodstock in 1976. The LPW Unuk stock was founded with a larger number of individuals in 1976 and has had subsequent infusion of wild gametes. These lines have been maintained at LPW through ocean ranching of tagged smolts. Comparisons are made between the hatchery lines, progeny of wild chinook collected from the Chickamin and Unuk Rivers, and hybrids between the hatchery and wild groups. Mature ocean-ranched female chinook salmon returning to the facility were periodically graded for ripeness and spawned. Body size and meristic measurements were collected from these mature spawners. Maturation timing, fecundity, and individual egg size of these fourth generation hatchery fish are compared with that of offspring of wild fish from the same donor stock. Stock of origin is confirmed for all spawners and offspring using microsatellite DNA analysis.

Joyce, J. E., Wertheimer, A. C., Gray, A. & Thrower, F. (*National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Highway Juneau, Alaska 99801, U.S.A.*).

### **Consequences to fitness-related traits of hybridization between farmed and wild Atlantic salmon, *Salmo salar***

Introgression between wild and farmed Atlantic salmon *Salmo salar* has been hypothesized to influence the persistence of wild populations, particularly those at heightened risk of extinction. Based on pure and hybrid crosses involving one farmed and two wild populations (Tusket River and Stewiacke River, an endangered population) in a common-garden environment, we examined the consequences of introgression to survival, growth, and disease resistance in the first year of life. Introgression with farmed salmon had either no effect (Stewiacke) or a negative effect (Tusket) on survival. Importantly, the among-family variance in survival (a negative correlate of population persistence) was higher for the hybrids than it was among the pure crosses. There was also evidence of genetic differences in growth rate and disease susceptibility. Introgression with their farmed counterparts is unlikely to have a positive effect on the fitness of wild Atlantic salmon. The degree to which genetic interactions between farmed and wild salmon threaten the latter's persistence almost certainly depends on the degree to which individuals are adapted to their local environment, on the genetic differentiation between farmed and wild individuals, and on the relative proportions of farmed and wild salmon during spawning.

Lawlor, J. L. & Hutchings, J. A. (*Department of Biology, Dalhousie University, Halifax, Nova Scotia B3H 4J1, Canada*).

### **Comparative analysis of morphometric characters of juvenile sterlet *Acipenser ruthenus* L. from natural population and aquaculture**

A comparative analysis was performed on sixteen morphometric characters, in three different juvenile sterlet *Acipenser ruthenus* L. populations. Specimens were collected from a wild population in the Serbian part of the Danube River ( $n=46$ ), from aquaculture stocks in the Czech Republic originating from Russia ( $n=40$ ), and aquaculture stocks in the Slovak Republic originating from Slovakian part of the Danube River ( $n=28$ ). Average values for total length were  $29.9 \pm 3.9$  cm,  $29.1 \pm 3.7$  cm and  $27.3 \pm 7.7$  cm for Serbia, Czech Republic and Slovak Republic, respectively. Populations were compared using *t*-test and sequential Bonferroni correction for multiple comparisons was applied in order to determine significant differences between them. Results of analysis showed that all three populations differed in prebarbel length, interocular distance and maximum head width. Although all these characters are head-related, head length itself was very uniform among all populations. The natural population from the Serbian part of the Danube River differed from the populations reared in aquaculture in seven morphometric characters. The two populations reared in aquaculture consistently showed lower morphological variability than the wild population, even though they had different genetic backgrounds (Russia and Slovakia). Future genetic studies will show if this tendency is caused by a reduction in genetic variability.

Lenhardt, M.<sup>1</sup>, Prokes, M.<sup>2</sup>, Jaric, I. Z.<sup>3</sup>, Barus, V.<sup>2</sup>, Kolarevic, J.<sup>3</sup>, Krupka, I.<sup>4</sup>, Cvijanovic, G.<sup>3</sup>, Cakic, P.<sup>1</sup> & Gacic, Z.<sup>3</sup> (<sup>1</sup>*Institute for Biological Research, 29 Novembra 142, 11000 Belgrade, Serbia and Montenegro*; <sup>2</sup>*Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic, Kvetna 8, 603 65 Brno, Czech Republic*; <sup>3</sup>*Centre for Multidisciplinary Studies, Kneza Viseslava 1, 11000 Belgrade, Serbia and Montenegro*; <sup>4</sup>*Majernikova 10, 841 05 Bratislava, Slovak Republic*).

### **Population dynamics of fisheries stock enhancement**

The population dynamics of fisheries stock enhancement, and its potential for generating benefits over and above those obtainable from optimal exploitation of wild stocks alone are poorly understood and highly controversial. I extend the dynamic pool theory of fishing to stock enhancement by unpacking recruitment, incorporating regulation in the recruited stock, and accounting for biological differences between wild and hatchery fish. I then analyse the dynamics of stock enhancement and its potential role in fisheries management, using the candidate stock of North Sea sole as an example. Enhancement through release of recruits or advanced juveniles is predicted to increase total yield and stock abundance, but reduce abundance of the naturally recruited stock component through compensatory responses or overfishing. Release of genetically maladapted fish reduces the effectiveness of enhancement, and is most detrimental overall if fitness of hatchery fish is only moderately compromised. As a temporary measure for rebuilding of depleted stocks, enhancement can not substitute for effort limitation, and is advantageous as an auxiliary measure only if the population has been reduced to a very low proportion of its unexploited biomass. Quantitative analysis of population dynamics is central to the responsible use of stock enhancement in fisheries management, and the necessary tools are available.

Lorenzen, K. (*Department of Environmental Science and Technology, Imperial College, Prince Consort Road, London SW7 2BP, U.K.*).

### **Domestication, comparative biology and interactions of wild and cultured fish: convenor's synthesis**

Aquaculture is expanding rapidly and many fish species are brought into cultivation, entering a process of domestication with consequences for their morphology, physiology,

ecology and evolution. In some species the abundance of cultured populations matches or exceeds that of wild stocks, and interactions between cultured and wild fish can pose significant conservation challenges. At the same time, captive breeding and re-introduction play an important role in the conservation of some of the world's most endangered fishes. Drawing on contributions from the FSBI Symposium and the wider literature, we synthesize current knowledge of the process and extent of fish domestication, interactions between cultured and wild fish, and the use of cultured fish in fisheries enhancement and restoration. We provide a perspective on the role of biological issues within the wider context of aquaculture development and aquatic conservation biology, and conclude with a discussion of promising avenues for further research.

Lorenzen, K.<sup>1</sup>, Beveridge, M.<sup>2</sup> & Mangel, M.<sup>3</sup> (<sup>1</sup>*Environmental Science & Technology, Imperial College, London SW7 2BP, U.K.*; <sup>2</sup>*FRS Freshwater Laboratory, Pitlochry, Perth PH16 5LB, U.K.*; <sup>3</sup>*Applied Mathematics and Statistics, University of California, Santa Cruz 95060, U.S.A.*)

### **Reared perch v. wild perch – first results about organoleptical and technological quality**

The Eurasian perch, *Perca fluviatilis* L., has good potential as a candidate for inland aquaculture diversification in Europe. To aid the development of this new product, we define a quality reference based on attributes of wild perch, and compare the quality of perch reared in three different culture systems: (1) extensive (pond), (2) semi-extensive (tank) and (3) intensive (re-circulation system). In order to define a precise quality reference, it is necessary to characterize the spatial and seasonal variability in quality attributes of wild fish. To do so, wild perch were harvested every three months for a full biological cycle from two different natural systems (Lake Geneva in France and the River Rhine in the Netherlands). Two components of quality were taken into account: organoleptical (colour of skin and fillets (L\*C\*H° system; 12 variables), seven morphological measurements) and six technological components (viscero, hepato and gonadosomatic index, perivisceral fat index, fillet yield and condition factor K2). Using Principal Component Analysis, we show that within-season variability is high, particularly for Rhine perch. Perch from the Rhine have a compact body and caudal fin, and possess a longer mouth and head than perch from Lake Geneva. Reared fish possess wild-like characteristics except for technological variables. Fish from extensive and semi-extensive systems show similar attributes, while fish from intensive rearing systems show a higher viscerosomatic and perivisceral fat index.

Mairesse, G., Thomas, M., Gardeur, J.-N. & Brun-Bellut, J. (*Laboratoire de Sciences Animales, INPL-INRA-UHP Nancy 1, 34, rue Sainte Catherine, F-54000 Nancy, France*).

### **Disease interaction between farmed and wild fish populations**

This paper reviews the literature on disease interaction between wild and farmed fish and recommends strategies to reduce the disease risks to both populations. Most, if not all, diseases of farmed fish originate in wild populations. The close contact between farmed and wild fish readily leads to pathogen exchange. Aquaculture creates conditions (e.g. high stocking levels) conducive to pathogen transmission and disease; hence pathogens can overspill back, resulting in high levels of challenge to wild populations. This is exemplified by sea lice infections in farmed Atlantic salmon. Stocking with hatchery reared fish or aquaculture escapees can affect disease dynamics in wild populations. Whirling disease has been spread to many wild rainbow trout populations in the US with the release of hatchery reared stock. The greatest impact of aquaculture on disease in wild populations has resulted from the movement of fish for cultivation. Examples of exotic disease introduction following movement of live fish for aquaculture with serious



consequences for wild populations are reviewed. The salmon parasite, *Gyrodactylus salaris*, has destroyed wild salmon populations in 44 Norwegian rivers. Crayfish plague has wiped out European crayfish over much of Europe. Eels numbers have declined in Europe and infection with the swimbladder nematode *Anguillicola crassus* has in part been blamed. The impact of disease in farmed fish on wild populations can be mitigated. Risk analysis methods need to be refined and applied to live fish movement and new aquacultural developments. Appropriate biosecurity strategies, based on risk assessments, should be developed to reduce pathogen exchange and mitigate the consequences.

Peeler, E. J.<sup>1</sup> & Murray, A. G.<sup>2</sup> (<sup>1</sup>*Centre for Environment, Fisheries and Aquaculture Science, Barrack Road, The Nothe, Weymouth, DT4 7QN, U.K.*; <sup>2</sup>*Fisheries Research Services, P. O. Box 101, 357 Victoria Road, Aberdeen, AB11 9DB, U.K.*).

#### **A comparative study of the performance of family groups of Atlantic salmon reared in tanks and released in a river**

A study was conducted in the Dale River as a part of a stock enhancement programme. The aim was to compare growth and the incidence of precocious maturation between offspring from precocious and large maturing males, and to study genotype-environment interactions. River and hatchery performance was compared for 5 × 2 maternal half-sib family groups, which were stocked as 0+ juveniles or maintained in the hatchery throughout. To identify the offspring, the broodfish were characterized by DNA-fingerprinting (eight microsatellite markers). Smolt size of 1+ hatchery-reared smolt and fish caught in a smolt trap, and the size and incidence of precocious maturation among 1+ hatchery-reared parr and 1+ and 2+ parr caught in the river are compared between the families.

Skilbrei, O. T. & Wennevik, V. (*Institute of Marine Research, P. O. Box 1870, N-5024 Bergen-Nordnes, Norway*).

#### **Life-history traits of the common pandora *Pagellus erythrinus* L., interpreted using information from aquaculture experiments**

The common pandora *Pagellus erythrinus* is considered a promising species for Mediterranean aquaculture, due to its high market price and good reproduction in captive conditions. The aim of this paper is to clarify aspects of reproduction and growth in the common pandora, using data from both aquaculture studies and experimental fishing. Spawning time and behaviour, frequency of egg deposition, larval performance, growth of juveniles and adults and morphometric characteristics were studied in fish originating from a broodstock acclimatised to captivity since 1997. At the same time observations on length structure and other morphometric measures, age and patterns of sexual maturity were gathered from ten trawl-surveys between 1996 and 2002. The surveys were carried out in late spring and early autumn in the Central-Southern Tyrrhenian Sea, area where the breeders had been captured. Wild fish growth patterns were estimated using length frequency distribution analysis and age-based methods. The study showed that several micro-cohorts enter in the fishery over an extended period, and growth is faster than previously reported.

Spedicato, M. T., Carbonara, P. & Lembo, G. (*COISPA Tecnologia and Ricerca, Experimental Station for the Study of Marine Resources, Via dei Trulli 18-20, 70045 Bari-Torre a Mare, Italy*).

### **Ecological model of interactions between escaped and wild Atlantic salmon *Salmo salar***

Atlantic salmon in Maine were once abundant but have become depleted, and are listed as endangered under the federal Endangered Species Act. Historically, salmon numbers in Maine may have been as high as 100 000 adults, but habitat loss, pollution and overfishing have contributed to the decline of the species. In 2000, only 110 adults returned to spawn in Maine rivers. Maine produces *c.* 15 000 metric tons/year of aquacultured Atlantic salmon from a total of nearly 600 coastal net pens. Escapees from these pens may interact with the wild salmon. The dynamics of salmon populations under such conditions are poorly understood. In order to illuminate the role aquaculture may play in such a system, we have developed a model for simulating population trajectories for both wild salmon and competing populations derived from aquaculture escapes. The model simulates a small population of wild salmon based in a stream/estuary system, into which an aquaculture facility is losing fish to escapes. Biological parameters in the model were estimated as much as possible from data in the USFWS report on Maine salmon. We used the model to investigate the consequences of a variety of ecological interactions between the wild and cultured fish including competitive, genetic and disease effects. Initial results indicate that many of these effects allow the aquaculture-derived population to supplant the wild fish, but that wild populations may still persist under some conditions.

Stephens, A.<sup>1</sup> & Cooper, A. B.<sup>2</sup> (<sup>1</sup>*Ocean Sciences Ph.D. Program, Mangel Lab, Applied Math and Statistics, University of California Santa Cruz, Santa Cruz, CA 95060, U.S.A.*; <sup>2</sup>*College of Life Sciences and Agriculture, University of New Hampshire, Taylor Hall, Durham, NH 03824, U.S.A.*).

### **Why do some fish do it younger than others? learning from experiments**

Reproductive traits of fish such as age at first maturation or fecundity are not fixed: there is growing evidence that they change through time under the influence of various environmental factors, including fishing. Because these parameters are important in determining population dynamics, a better understanding of these changes is important to fisheries stock assessment. However, field studies are often inconclusive with respect to the ultimate causes of a given change. Although numerous experimental studies have been assessed the influence of environmental factors such as temperature on the reproduction in fish, these generally focus on single factors and do not consider the effects of the origin and individual history of experimental fish. There is scope for the development of ecological experiments to investigate the effects of interacting environmental factors on reproduction at the individual and population levels. This presentation will review experiments that could be used to predict environmental influences in the wild and the limits to such extrapolations. Finally, we will present a set of experiments designed to study maturation reaction norms in fish, *i.e.* the size at first reproduction as a function of age. We will investigate the effects of genotypes and environmental effects (feeding and temperature) on growth, age at maturity and subsequent spawning performances in reared cohorts.

Suquet, M.<sup>1</sup>, Rochet, M.-J.<sup>2</sup> & Gaignon, J. L.<sup>1</sup> (<sup>1</sup>*Laboratoire Adaptation – Reproduction – Nutrition, IFREMER, BP 70, 29280 Plouzané, France*; <sup>2</sup>*Laboratoire MAERHA, IFREMER, B.P. 21105, 44311 Nantes Cedex 03, France*).

### **Population genetics, conservation and evolution in salmonids and other widely cultured fishes: some perspectives over six decades**

This paper explores my shifting understandings of interactions primarily between salmonid fish culture and fish conservation during the latter half of the 20th century.

The idea that conspecific natural and cultured fish were largely interchangeable among phenotypically similar populations began to change with the advent of molecular genetic markers. With the gradual clarification of major geographic lineages beginning in the 1970s came awareness that translocations among anadromous lineages were generally destined for failure; in contrast, gene flow more readily occurred among non-anadromous lineages and sometimes, species. Concurrently, data were accumulating that adaptations to their respective environments distinguished cultured and wild populations within a lineage. Reduced obstacles to gene flow at this level often resulted in homogenizations among wild and cultured fish in areas where widespread hatchery releases occurred; conversely, adaptive radiations in vacant habitats sometimes occurred over a few decades from single source hatchery releases. Current ideas relating to salmonid interbreeding, population substructure and culture germinated from these observations. Among lineages, resistance to gene flow is much greater between anadromous than purely freshwater populations or species. Ease of within-lineage gene flow in both groups is problematical with regard to cultured and wild populations because large-scale supplementation programs erode local adaptations and fine-scale population substructures. A potential ability to regenerate natural substructure upon relaxation of supplementation is offset by uncertainties of time scales and intrinsic capabilities homogenized populations. However these losses can be minimized by a management that separates harvest and reproduction of wild and cultured subpopulations. Some generality of this strategy to other fishes is supported by losses of local adaptations and outbreeding depression in black basses following population admixtures that parallel those observed in salmonids.

Utter, F. (*School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195 U.S.A.*).

#### **Efficiency of allele frequency-based bayesian programmes for detecting hybridization between farmed and wild salmon**

Large escapes of cultured salmon from net-pens have become inevitable disasters linked to the growth of aquaculture in coastal areas. Hybridization between farmed and wild salmon has been witnessed; but the extent of eventual genetic introgression is controversial as selection against hybrids can maintain distinct gene pools. Individual assignment tests based on genetic data have been widely used in fisheries, due to the importance of accurate population assignment for a variety of purposes including distinction between individuals of native and stocked origin. However the ability of these Bayesian programs to detect hybrids and subsequent generations between closely related populations has been little investigated. Here we present results regarding the efficiency of two new computer programs, structure and New Hybrids in detecting hybridization between farmed and wild salmon from the river Teno (Northern Europe) based on genetic data obtained from 17 microsatellite loci.

Vähä, J.-P. K. & Primmer, C. R. (*Department of Ecology and Systematics, P. O. Box 65, University of Helsinki, FI-00014 Helsinki, Finland*).

#### **Compensatory releases reduce genetic differentiation among Atlantic salmon populations in the Baltic Sea: evidence from the River Ume-Vindelälven**

About 90% of salmon smolts in the Baltic Sea derive from hatchery enhancement programmes designed to compensate for loss of catches and genetic resources due to the damming of salmon rivers. The potential threat of genetic homogenization from extensive hatchery releases, however, has not been thoroughly investigated. We provide evidence that straying from deliberate releases poses a threat to indigenous populations by identifying the origin of 127 fin-clipped (hatchery) salmon caught in the River Ume-

Vindelälven during 1997 to 2000, using mtDNA and six microsatellite loci. The analysis of eight potential donor stocks revealed that compensatory releases from the R. Ångerman and R. Luleälven hatcheries have resulted in a significant amount of straying to the river Ume-Vindelälven (at least 10 and 12 migrants per year). As predicted to due to increased migration, the analysis of temporal samples from the wild population of R. Vindelälven showed a decreasing trend in genetic differentiation estimates (measured as  $F_{st}$ ) relative to hatchery the hatchery strains of R. Ångermanälven and R. Luleälven. Our results suggest that gene flow from compensatory releases poses a serious threat to the genetic makeup of the existing wild populations in the Baltic.

Vasemägi, A. (*Swedish University of Agricultural Sciences, Department of Aquaculture, S-901 83 Umeå, Sweden*).

### **Domestication and absolute ownership of fish in the English common law**

The English common law has, for the purpose of describing the rights of ownership of animals, divided them into two classes, those the subject of absolute ownership and those the subject of a limited property right. In this system, fish have long been regarded as the subject of a limited property right, one dependent on possession.

The principles underlying those concepts follow the Roman law concepts applicable to the proprietorship of animals and adopted in much of Europe. Those principles were further developed and adapted over many centuries in England, but more significantly in the common law countries outside of England, over the last century. They are principles that have a limited relationship to domestication. Drawing on the recent decisions outside of England it is possible to refashion the commonly presented tests as to the absolute ownership of animals. Based on those decisions, it may be asserted, that a person may absolutely own an animal that is a member of a population of animals that have had a long association with humans, or are exploited by a community in a recognized manner, other than by hunting. When applied to fish, particularly those from stock enhancement, sea ranching and aquaculture escapes, those principles raise a number of questions. Does the aquaculturist remain the owner of the fish that have escaped? Is it possible to retain ownership of stock enhancements and sea ranched fish? In some cases they may also raise an issue as to the liability for those fish at large.

Walrut, B. P. (*43 Wright Street, Adelaide, SA 5000, Australia*).

## Abstracts of Posters not published in the Supplement

### Variable number of tandem repeats in the growth hormone gene of *Sparus aurata*: association with growth and effect on gene transcription

The GH gene of *Sparus aurata* (saGH) contains variable number of tandem repeats (VNTR). The hyper-variable minisatellites in the first and third introns segregate in a Mendelian manner and exhibit numerous alleles. Analysis by PCR and sequencing of the two introns in several wild Sparidae species revealed comparable minisatellites with some variations. 'Zoo blot' with the first intron unit as a probe showed this sequence to be characteristic of several families from the Perciformes order. Unexpectedly, a similar minisatellite was found in the first intron of the GH gene in flounder, which belongs to a different order. Transfection of constructs containing a reporter gene and first intron of different length to four cell lines resulted in an inhibitory effect of the longer intron relative to the short intron. A (CA)<sub>n</sub> microsatellite (saGHpCA) is found in the GH promoter. A similar repeat at the same location is present in GH promoters of several other fish species. High variability (11 alleles) of the saGHpCA was found in a hatchery population. Full-sib family genotyping showed a Mendelian inheritance of these alleles. A significant association was found between allele distribution and body mass in large and average size fishes from a hatchery population. The intron minisatellites may serve as markers for hybrid population and parental assignment. Its presence in families and orders of the higher teleosts may help solving classification uncertainties. Their conservation and inhibitory effect suggest a biological role. The saGHpCA is correlated with growth and may be a good candidate for predicting growth performance.

Almuly, R.<sup>1</sup>, Poleg-Danin, Y.<sup>2</sup>, Kashi, Y.<sup>2</sup>, Gorshkov, S.<sup>3</sup>, Gorshkova, G.<sup>3</sup>, Dyman, A.<sup>1</sup>, Cavari, B.<sup>1</sup>, Rapoport, B.<sup>1</sup>, Soller, M.<sup>4</sup> & Funkenstein, B.<sup>1</sup> (<sup>1</sup>National Institute of Oceanography, Israel Oceanographic & Limnological Research, Haifa, Israel; <sup>2</sup>Department of Food Engineering and Biotechnology, The Technion, Haifa, Israel; <sup>3</sup>National Center of Mariculture, Israel Oceanographic & Limnological Research, Eilat, Israel; <sup>4</sup>Department of Genetics, The Alexander Silberman Life Sciences Institute, The Hebrew University of Jerusalem, Jerusalem, Israel).

### Escapees of potentially invasive fishes from an ornamental aquaculture facility: the case of topmouth gudgeon *Pseudorasbora parva*

Accidental escapees from aquacultural facilities are an ongoing problem facing scientists, conservationists, policy makers and naturalists throughout the world. The topmouth gudgeon *Pseudorasbora parva*, a small cyprinid native to Southeast Asia, was introduced to Romanian waters in 1960 via the aquaculture trade and has since spread throughout Europe. It first appeared in England in an ornamental fish farm near Romsey in Hampshire. The aim of the present study was to quantify the dispersal of this potentially highly invasive species from an ornamental fish farm into the wild. In order to measure the dispersal of escapees, intensive electrofishing surveys were carried out between June and September 2003 in the catchment downstream of the fish farm. The distribution of topmouth gudgeon in the catchment was found to be limited and patchy.

The presence of small individuals suggests that the species has successfully established itself in the wild, but this remains to be confirmed. The results were examined in light of invasion theory principles of biological resistance and ecological fitness.

Beyer, K.<sup>1,2,3</sup> (<sup>1</sup>*Centre for Ecology and Hydrology, Winfrith Technology Centre, Dorchester, Dorset, DT2 8ZD, U.K.*; <sup>2</sup>*University of Hull, Cottingham Road, Hull, HU6 7RX, U.K.*; <sup>3</sup>*Centre for Environment Fisheries and Aquaculture Science, The Nothe, Barrack Road, Weymouth, Dorset, DT4 8UB, U.K.*).

### **Changes of nase *Chondrostoma nasus* L. occurrence in the Wislok River, southern Poland, after stocking with pond reared juveniles**

Nase *Chondrostoma nasus* L., once one of the most common fish species in the upper reaches of central European rivers, is now considered endangered throughout its natural range. Since 2000 the Department of Ichthyobiology and Fisheries, Warsaw Agricultural University, has co-operated with the Polish Anglers Association in Krosno to study the effects of river restocking with pond-farmed nase juveniles. The experiment is carried out on Wislok River, where nase was very twenty years ago but has now completely disappeared. Selected parts of the river are stocked with tagged, one-summer and 1 year-old juveniles. Changes in nase occurrence, and their growth and foraging behaviour have been analysed.

Ciesla, M.<sup>1</sup>, Sliwinski, J.<sup>1</sup>, Konieczny, P.<sup>2</sup> & Litynski, R.<sup>1</sup> (<sup>1</sup>*Department of Ichthyobiology and Fisheries, Warsaw Agricultural University, ul. Ciszewskiego 8, PL-02-786 Warszawa, Poland*; <sup>2</sup>*Polish Anglers Association in Krosno, ul. Jasna 26a, PL-38-404 Krosno, Poland*).

### **Influence of rearing method on ide *Leuciscus idus* L. juvenile survival under pike and pikeperch predation**

The influence of rearing methods on ide *Leuciscus idus* L. juvenile survival under pike and pikeperch predation was investigated. Survival of two groups of ide was compared: group (1) consisted of juveniles reared in tanks under fully controlled conditions, while group (2) consisted of pond-reared juveniles. Both groups were obtained from the same parents, separated at the larval stage in early spring and cultured in the different environments until late autumn. Juveniles from both groups were placed in tanks with pike or pikeperch, and their survival compared after one, three and six days of exposure to the predators.

Ciesla, M.<sup>1</sup> & Kaczkowski, Z.<sup>2</sup> (<sup>1</sup>*Department of Ichthyobiology and Fisheries, Warsaw Agricultural University, ul. Ciszewskiego 8, PL-02-786 Warszawa, Poland*; <sup>2</sup>*Department of Applied Ecology, University of Lodz, ul. Banacha 12/16, PL-90-237 Łódź, Poland*).

### **Laboratory simulation of the effects of environmental salinity on wild-caught juveniles of European sea bass *Dicentrarchus labrax* and gilthead seabream *Sparus aurata***

Gilthead seabream *Sparus aurata* and European sea bass *Dicentrarchus labrax*, are two important species in Mediterranean aquaculture. In the wild, their juveniles occur in brackish areas such as lagoons and river deltas. Even though the juveniles seem to favour brackish environments, low salinity incurs an energy cost for osmoregulation. This paper presents the results of a series of laboratory experiments exploring the effects of salinity

on growth, feeding, food conversion, survival and maintenance energy requirements of wild-caught juveniles. The fish were kept in the laboratory, divided in groups of 20 in small tanks of 50 l each, and supplied with biologically filtered seawater of four salinity levels (8, 18, 28‰ and natural seawater) and fixed temperature ( $20 \pm 1.4^\circ\text{C}$ ). The fish were fed pelleted feed throughout the experiment. Both species showed great similarity in their responses to lower salinities. Satiation time for both species increased with decreasing salinity, while maintenance requirements (required daily ration and energy) increased as with increasing salinity. Growth and feed conversion is highest for salinities around 28‰ and lower for salinities above and below. Both species share common physiological features, and intermediate salinities are optimal for their performance in nature and in captivity.

Conides, A. J.<sup>1</sup>, Glamuzina, B.<sup>2</sup> & Papaconstantinou, C.<sup>1</sup> (<sup>1</sup>*Hellenic Centre for Marine Research, Agios Kosmas, Hellinikon, 16610 Athens, Greece;* <sup>2</sup>*Aquaculture Department, University of Dubrovnik, Cira Carica 4, 20000 Dubrovnik, Croatia*).

#### **Photoperiod and temperature effects on gametogenesis in winter flounder *Pseudopleuronectes americanus***

The winter flounder is an in-shore flatfish living in shallow waters on the east coast of North America from Labrador to Georgia. In the St Lawrence estuary, the reproductive season is May and June. Our objective was to test the effects of winter-spring photoperiod and temperature conditions on the timing of sexual maturation in both males and females. Groups (16 animals each) of winter flounder breeders were maintained from mid-January to mid-May under five different experimental conditions: (1) natural photoperiod and temperature conditions; (2) natural photoperiod,  $6^\circ\text{C}$ ; (3) 15L:9D, natural temperature conditions; (4) 15L:9D,  $6^\circ\text{C}$ ; (5) accelerated photoperiod increase from winter to spring conditions,  $6^\circ\text{C}$ . Natural photoperiod and temperature conditions correspond to a gradual increase in light period from 8L:16D (January) to 15L:9D (May) and in temperature from  $-1^\circ\text{C}$  (January to April) to  $6^\circ\text{C}$  (May). GSI and condition factor did not differ among the treatments ( $P > 0.05$ ). In males, milt production occurred simultaneously in the different treatments and histological examination did not indicate any significant effect of either photoperiod or temperature on testes development. In females, seven stages of oocyte development were observed. Both the number of oocytes at the cortical alveoli stage and number of atretic oocytes increased at  $6^\circ\text{C}$  (warm temperature conditions). Overall, neither photoperiod nor temperature modified the reproductive period. Warm winter-spring temperature conditions, however, may decrease egg numbers and egg quality.

Duchemin, M. B.<sup>1,2</sup>, Audet, C.<sup>1</sup> & Lambert, Y.<sup>3</sup> (<sup>1</sup>*ISMER, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski, Québec G5L 3A1, Canada;* <sup>2</sup>*Present address: LEMAR, Institut Universitaire Européen de la Mer, Place Nicolas Copernic, Technopôle Brest-Iroise, 29280 Plouzané, France;* <sup>3</sup>*Ministère des Pêches et des Océans, Institut Maurice-Lamontagne, C.P. 1000, Mont-Joli, Québec G5H 3Z4, Canada*).

#### **Physiological and behavioural differences of hatchery and wild-reared steelhead *Oncorhynchus mykiss* smolts of the same genetic origin**

In many parts of the world release of hatchery-reared smolts has long been used to mitigate for the deleterious effects of habitat loss and overfishing on salmonid populations. Of increasing concern is whether this may cause harm by spreading non-native

stocks and potentially releasing incompetent smolts. The objective of this study was to determine if smolt physiology and behavior of juveniles produced from a recently founded native broodstock differ from their wild (naturally-reared) counterparts. In the fall of 2002 and 2003 juvenile wild steelhead were captured, PIT tagged, and returned ( $n = 1360$  in 2002 and  $n = 2708$  in 2003) to Abernathy Creek. In winter of 2003 and 2004 hatchery-reared fish were PIT tagged and later released ( $n = 1100$  in 2003 and  $n = 1400$  in 2004) into Abernathy Creek. Gill biopsies were collected from wild and hatchery fish throughout the rearing and out-migration season. The timing and speed of outmigration was assessed using two stationary PIT tag antennas (92–97% efficient). Hatchery migrants in 2003 were larger, had significantly lower gill  $\text{Na}^+$ ,  $\text{K}^+$  -ATPase activities, and migrated slower than wild fish. Results from the 2004 migratory season will also be presented. This study shows that hatchery rearing can result in smolts which are physiologically and behaviourally different from genetically similar wild fish. Whether these differences are critical enough to affect the rate of adult returns will be determined in future years.

Gale, W. L., Hill, M. S. & Zydlewski, G. B. (*US Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Creek Road, Longview, WA 98632, U.S.A.*).

#### **Comparative evaluation of sturgeon larvae and juveniles reared under control of seasonal propagation of the wild and domestic breeders**

Sturgeon populations (*Acipenser gueldenstaedtii* and *A. stellatus*) in the Sea of Azov basin are maintained largely through stock enhancement. A monitoring is in operation for biological characteristics of juveniles, including body length and mass, physiological-biochemical indices, teratology, thermal stability, salt resistance, oxygen deficiency resistance and melanophore adaptive response as indicators of physiological fitness, and neuro-pharmacological testing with a sedative (MS-222). Behavioural experiments include the assessment of background movement and reactivity to the effect of low/high frequency sounds and light of long/short duration. Juveniles obtained from breeders in which the reproductive cycle had been delayed for up to 90 days did not show significantly different levels of morphological anomalies compared to juveniles obtained with conventional reproductive techniques. The most frequent defects are observed in pectoral fins (up to 20 per cent) and olfactory organs (up to 10 per cent). Fingerlings showed an adequate and timely adaptive reaction of melanophores towards dark and light background. The experiment demonstrated that sturgeon fingerlings produced under controlled conditions are euryhaline and robust to thermal and oxygen stress. Some differences in biological attributes were noted between juveniles obtained from wild and domesticated breeders of *A. gueldenstaedtii* and *A. stellatus*.

Galich, E. V. & Chebanov, M. S. (*Federal Centre for Genetics and Selection in Aquaculture, 12 Oktyabrskaya Str., Krasnodar 350063, Russia*).

#### **Gene expression patterns in Atlantic salmon *Salmo salar*: gene expression during osmoregulation in intestine tissue**

Ireland has the world's largest stocks of wild Atlantic salmon. A better understanding of gene expression will benefit conservation of wild stock as well as salmon aquaculture. We describe the PRTL project designed to advance the fundamental understanding of the genome of Atlantic Salmon *Salmo salar*. The major objective is to create the first comprehensive database of gene expression and functional information using cDNA libraries and Microarray technology. One key area of interest to salmon biology is osmoregulation, which is critical to the ability of salmon to adapt in seawater. Tissues implicated in this process are the gills, intestine and skin.



To initiate studies, SSH (suppression subtractive hybridization) libraries were constructed from intestine RNA extracted from smolts sampled in January and May. A number of potentially interesting clones have been identified, among those a heat shock protein, hsp90 in the reverse library. Others SSH libraries from various tissues (pituitary, hypothalamus, brain, gill, intestine, head kidney and spleen) have also been constructed and will be used to construct a 5000 clone microarray slide. This slide will then be used to elucidate gene expression profiles in various tissues. Further sample collection has been carried out to answer questions regarding biological differences between one- year and two-year old parr and wild and hatchery smolt.

Hubert, S.<sup>1</sup>, O’Keeffe, A. M.<sup>1</sup>, Cotter, D.<sup>2</sup>, Wilkins, N. P.<sup>3</sup> & Cairns, M. T.<sup>1</sup>  
(<sup>1</sup>National Diagnostics Centre, NUI, Galway, Ireland; <sup>2</sup>Marine Institute, Funnace, Newport, Ireland; <sup>3</sup>Department of Zoology, NUI, Galway, Ireland).

### **Feasibility of a project for active restocking of the sea adjacent the salt pans of Tarquinia (Italy)**

The depletion of fish stocks in the Mediterranean suggests that restocking may be a useful approach for restoring fisheries. In this paper we consider the potential for using derelict salt pans at Tarquinia (50 miles north of Rome) to rear fish for restocking in adjacent coastal areas. We discuss candidate species for stock enhancement, ways of minimizing stress in the capture of broodstock, genetic monitoring of wild catches, various aspects of operational restocking (release stage of larvae or juveniles, *etc*) and suggest approaches for evaluating results. Finally, we provide an economic and financial analysis of investment costs and likely benefits for different scenarios, and guidelines for a restocking policy that may be implemented by public authorities.

Ingle, E. & Venzi, L. (*Dipartimento di Ecologia e Sviluppo Economico Sostenibile (DECOS), Universita’ della Tuscia, Via S. Giovanni de Lellis #1, 01100 Viterbo, Italy*).

### **DNA Polymorphism of Percidae population structure in the Kuibyshev water reservoir of Russia**

The pike perches *Stizostedion lucioperca* and *S. volgense*, river perch *Perca fluviatilis* and ruffe *Gymnocephalus cernuus* are important components of the fish fauna of the Kuibyshev reservoir in Russia. We analysed genetic variation within and among populations of these species. Two microsatellite DNA from walleye *S. vitreum* were used as primers of this study. Each of the DNA markers resolved 6–10 alleles with locus *Svi4* and *Svi6* and size range of 102–169 base pairs (bp). PCR was performed with the selected primers, with temperature cycles followed a denaturing profile for 30 s at 94° C. A final 10 min elongation step was resumed at 72° C after 35 cycles. *Stizostedion volgense* showed the highest bp of 100 to 3000, differing by sex, age and maturity level. The populations of *P. fluviatilis* have variable DNA polymorphism within the range 90–1000 base pairs. We also detected a new band in the fingerprints. The degree of neutral genetic variation detected indicates that effective population sizes of the study species are large.

Islam, A.<sup>1,2</sup>, Gorshkov, O. V.<sup>1</sup>, Chernov, V. M.<sup>1</sup> & Kuznetsov, V. A.<sup>2</sup> (<sup>1</sup>Kazan Institute of Biophysics and Biochemistry, Russian Academy of Science, 420111 Kazan, Russia; <sup>2</sup>Kazan State University, 420008 Kazan, Russia).

### **The importance of aquaculture to nase *Chondrostoma nasus* conservation in Poland**

Nase *Chondrostoma nasus* L. is one of the most threatened reophilic fish species in Poland. At present it has almost disappeared from the northern and central parts of its range while in the south its abundance has decreased. Protection of the species through closed seasons, catch and size limits has not been sufficient, and active enhancement through stocking is now applied. Developing the technology of hormonally induced spawning and adapting carp pond culture techniques for the rearing of nase enabled substantial enhancement efforts. According to Polish Anglers Association, stocking has increased from 50 000 of hatchlings in 1994 to 840 000 of hatchlings, 568 000 summer and 900 000 autumn juveniles, and 1720 two year-old fish in 2002. At present the problems to be solved urgently are preserving the genetic diversity of cultured and wild populations, and evaluating stocking effectiveness.

Kaczkowski, Z.<sup>1</sup>, Ciesla, M.<sup>2</sup> & Zalewski, M.<sup>3</sup> (<sup>1</sup>*Department of Applied Ecology, University of Lodz, ul. Banacha 12/16, 90-237 Łódź, Poland;* <sup>2</sup>*Institute of Ichthyobiology and Fisheries Warsaw Agricultural University, ul. Ciszewskiego 8, 02-786 Warszawa, Poland;* <sup>3</sup>*International Centre of Ecology Polish Academy of Science, ul. M. Konopnickiej 1, Dziekanów Lesny, 05-092 Lomianki, Poland*).

### **State and role of active conservation of barbel *Barbus barbus* in Poland**

Barbel *Barbus barbus* is a highly valued target of recreational fisheries. Due to environmental degradation and growing angler pressure, its abundance has decreased in many rivers. In response to this, active protection strategies are being developed by scientists and the Polish Anglers Association. Methods of breeding in captivity have been developed for restocking purposes. Production and release have increased from 19 600 summer fry and 692 adult fish in 1998 to 7000 summer and 32 000 autumn juveniles, and 3150 two year-old fish in 2002. The preservation of genetic diversity is a major challenge in these enhancement programmes.

Kaczkowski, Z.<sup>1</sup> & Mirosław, C.<sup>2</sup> (<sup>1</sup>*Department of Applied Ecology, University of Lodz, ul. Banacha 12/16, 90-237 Łódź, Poland;* <sup>2</sup>*Institute of Ichthyobiology and Fisheries, Warsaw Agricultural University, ul. Ciszewskiego 8, 02-786 Warszawa, Poland*).

### **Disruption of the melatonin rhythm in wild and farmed fish: a consequence of prolonged thyroxine administration and calcium depletion**

Recent studies suggest that the pineal gland and its major product melatonin (N-acetyl-5-methoxytryptamine: Mel) play a role in integration of various neural and endocrine functions. Observations indicate that Mel as a signal of photoperiod regulates a number of biological phenomena, including reproduction, day/night activity and many other physiological events associated with daily or seasonal rhythms in vertebrates, including fish. Mel has also been found to be a highly effective preventive antioxidant and free radical scavenger, protecting organism from oxidative damage. In all species examined, plasma melatonin concentration shows a diurnal rhythm, with the highest levels during the night. Our studies are focused on the cues affecting Mel synthesis capacity in wild and farmed fish. The Mel rhythm in fish can be disrupted by fluctuations in surrounding calcium concentration or by prolonged thyroxine (T4) exposure. Physiological depletion of plasma ionized calcium may limit the capacity of Mel night production in two fish species, farmed rainbow trout and wild flounder. Prolonged (2 week) exposure to high level of exogenous thyroxine (T4) results in reduced night-time plasma Mel levels, and may thus inhibit the melatonin-related time-keeping system in juvenile salmon. Disruption of the daily Mel rhythm implies a reduced ability of organisms to

respond properly to environmental signals, and may be a useful indicator of disturbance in physiological functions.

Kulczykowska, E., Sokolowska, E., Gozdowska, M. & Kalamarz, H. (*Institute of Oceanology PAS, Powstańców Warszawy 55 Str., 81-712 Sopot, Poland*).

### **Gonadal maturation in the blackspot seabream *Pagellus bogaraveo*: a comparison between a farmed and a wild broodstock**

The blackspot seabream *Pagellus bogaraveo* (Brünnich, 1768) has been regarded as a possible alternative to traditionally cultured Mediterranean species such as seabream and seabass, due to its high market value and good adaptation to captivity. Broodstock establishment and management represent the first step towards reliable production of eggs and fry, which is required to develop aquaculture of this new species. Two different broodstocks were tested for gonadal maturation and spawning, one constituting of wild fish caught as juveniles and reared in tanks until sexual maturity (4 years), and one assembled from wild adult fish caught during or just before the reproductive season. All fish were maintained under the same rearing conditions and fed the same diet. Gonadal stripping and biopsies were performed weekly to monitor maturation in both males and females. Ovarian samples were staged for maturity on the basis of follicular diameter and migration of germinal vesicle. Sperm samples were tested for density (number of spermatozoa ml<sup>-1</sup>) and motility. The fish reared in captivity reached ovarian maturity during the breeding season of the wild stock. Eggs were obtained by stripping from both farmed and wild specimens, but appeared degenerated as a result of being retained too long in the ovarian cavity due to the absence of spontaneous spawning. Spermiation was prolonged in the farmed fish, but appeared to be blocked in the wild breeders after first sampling. However, the sperm was very viscous and the motile spermatozoa did not exceed 10%.

Micale, V., Maricchiolo, G. & Genovese, L. (*Consiglio Nazionale delle Ricerche – Istituto per l'Ambiente Marino Costiero, sezione di Messina Spianata S.Raineri 86, 98122 Messina, Italy*).

### **The ontogeny of the alimentary tract of larval pandora, *Pagellus erythrinus* L.**

The ontogenesis of the alimentary tract and its associated structures (liver, pancreas, gall bladder) was studied in common pandora *Pagellus erythrinus* L., a promising species for diversification in Mediterranean aquaculture. Mass production of pandora has been limited so far by high larval and juvenile mortalities, which appear to be related to nutritional deficiencies. The development of the larval digestive system was studied histologically from hatching (0 DAH) until day 50 (50 DAH) in reared specimens, obtained by natural spawning from a broodstock adapted to captivity. At first feeding (3–4 DAH) both the mouth and anus had opened and the digestive tract was differentiated in four portions: buccopharynx, oesophagus, incipient stomach and intestine. The pancreas, liver and gall bladder were also differentiated at this stage. Soon after the commencement of exogenous feeding (5–6 DAH), the anterior intestinal epithelium showed large vacuoles indicating the capacity for absorption of lipids, whereas acidophilic supranuclear inclusions indicating protein absorption were observed in the posterior intestinal epithelium. Both the bile and main pancreatic ducts had opened in the anterior intestine, just after the pyloric sphincter, at this stage. Intestinal coiling was apparent since 4 DAH, while mucosal folding began at 10 DAH. Scattered mucous cells occurred in the oral cavity and the intestine, while they were largely diffused in the oesophagus. Gastric glands and pyloric caeca were firstly observed at 28 DAH and appeared well developed by 41 DAH, indicating the transition from larval to juvenile stage and the acquisition of an adult mode of digestion.

Micale, V.<sup>1</sup>, Garaffo, M.<sup>2</sup>, Genovese, L.<sup>1</sup>, Spedicato, M. T.<sup>3</sup> & Muglia, U.<sup>4</sup> (<sup>1</sup>*Consiglio Nazionale delle Ricerche, Istituto per l'Ambiente Marino Costiero, sezione di Messina spianata S. Raineri 86, 98122 Messina, Italy;* <sup>2</sup>*Dipartimento di Sanità Pubblica Veterinaria, Facoltà di Medicina Veterinaria, Università di Messina – Polo Universitario Annunziata, 98168 Messina, Italy;* <sup>3</sup>*COISPA Tecnologia & Ricerca, Via dei Trulli 18, 70045 Bari -Torre a mare, Italy;* <sup>4</sup>*Dipartimento di Morfologia, Biochimica, Fisiologia e Produzioni Animali – Facoltà di Medicina Veterinaria, Università di Messina – Polo Universitario Annunziata, 98168 Messina, Italy).*

### **Influence of dry diets on reproductive performance and egg lipid composition during the first spawning season of captive pollack**

Four-year-old pollack *Pollachius pollachius* L., previously fed on dry pellets since their juvenile stage, were divided into three experimental groups two months prior their first spawning season. They were fed a commercial broodstock pellet enriched with 6% added oils, either: (1) capelin oil (control), (2) capelin oil plus arachidonic acid, or (3) DHA rich tuna oil. Spawning performance was determined in each group and egg lipids were analysed. During the vitellogenic period, the estradiol levels in plasma increased with oocyte enlargement, indicating that captivity and pelleted feed did not affect reproductive capacity. Females from each group spawned spontaneously between February and May. Egg production per kg of female was highest in the control group. Fertilization rate was highest (39%) in the group fed on diet enhanced in DHA. Lipid content in eggs reached 16% of dry mass, containing mainly phospholipids (75%). Egg fatty acid profiles showed few differences between dietary treatments. There was no significant difference in the concentration of Docosahexaenoic acid (22:6n-3) between groups. Arachidonic acid (20:4n-6) was lower in neutral and polar lipids of eggs from the control group than in the other groups. Tuna oil diet induced the highest DHA/EPA ratio in eggs and seemed to provide sufficient arachidonic acid for pollack broodstock. Egg fatty acid profiles are compared with 6 year-old pollack broodstock fed on fish, and with other cultured and wild fish species.

Omnes, M. H., Recek, S., Barone, H., Le Delliou, H., Schmitz, A., Mutelet, A., Suquet, M. & Robin, J. H. (*IFREMER, Laboratoire Adaptation, Reproduction et Nutrition des poissons marins, BP. 70, 29280, Plouzané, France*).

### **Distribution of genetic variation in farmed and natural stocks of european eel**

European eel (*Anguilla anguilla*; Teleostei) is a valuable commercial species. However, over the past 25 years, the population of European eel has been declining to such a degree that major concerns have been raised for its long-term conservation. Since little information is available on the life-cycle and genetic structure of European eel, it has been difficult to evaluate the existence of any population substructuring. Molecular genetic methods contribute to a better knowledge of the demography and population structure in marine fish. In addition, management strategies and conservation goals must consider information on genetic substructuring as well as on life history patterns.

The aim of the study is to provide more detailed knowledge on the genetic variability, demography and population substructuring of European eel by analysing and comparing natural and farmed individuals. Natural eel samples have been obtained in two geographical sites (Netherlands, France) including temporal samples in a short-scale (within years) and a long-scale (between years). Simultaneously, farmed glass eels have been

grown in two separate batches during one year. Batches have been monitored and genetic samples have been obtained during the year.

A combination of selection-sensitive (allozymes) and selection-neutral markers (microsatellites) has been used in the study since selection seems to play an important role in the determination of the quality of future eel spawners. Results suggest a positive correlation between growth and genetic variability since individuals attaining a large length and mass present significant higher heterozygosities.

Pujolar, J. M., Maes, G. E. & Volekaert, F. A. M. (*Laboratory of Aquatic Ecology, Katholieke Universiteit Leuven, B3000 Leuven, Belgium*).

### **Muscle development in cultured blackspot seabream *Pagellus bogaraveo*: preliminary histochemical and immunohistochemical data on the fibre types**

We studied muscle ontogeny and fibre type characteristics in the blackspot seabream, a new species for commercial aquaculture. Myosin ATPase and SDH histochemistry and immunohistochemistry were tested at different ontogenetic stages, using a panel of antibodies to myosin isoforms and parvalbumin. In general, deep white muscle was parvalbumin-positive, and superficial 'red' muscle was parvalbumin-negative at all ages examined. At 6 days of age (transition from endogenous to exogenous feeding) three layers of muscle fibres were observed with different antimyosin reactivities: superficial monolayer, presumptive slow red (present only as a small group of fibres adjacent to the lateral line nerve), and presumptive fast-white (forming the bulk of the muscle). The superficial monolayer and presumptive slow fibres were positive for SDH. At 60 days of age (transition from live to artificial feeding) an additional fibre type was identified: a typical 'pink' or intermediate layer. In juveniles, the axial muscle consisted mainly of fast white fibres covered by a slow-red layer and between them a pink layer. Surprisingly, the red layer could be resolved into two distinct types by myosin immunostaining. Red fibres were also present along the horizontal septum, near the notochord. Both red and white muscle layers showed a mosaic appearance, which was confirmed by ATPase reaction. The work was financed by British Council, CRUP, and FCT (PhD Grant SFRH-BD-14068-2003).

Rowlerson, A. M.<sup>1</sup>, Silva, P.<sup>2</sup>, Rocha, E.<sup>2,3</sup>, Olmedo, M.<sup>4</sup> & Valente, L. M. P.<sup>2,3</sup> (<sup>1</sup>*School of Biomedical Sciences, King's College, University of London, Guy's Campus, London SE1 1UL, U.K.*; <sup>2</sup>*ICBAS – Institute of Biomedical Sciences Abel Salazar, University of Porto, Largo Prof Abel Salazar, No. 2, 4099-003 Porto, Portugal*; <sup>3</sup>*CIIMAR – Center for Marine and Environmental Research, R. dos Bragas, 289 Porto, Portugal*; <sup>4</sup>*Instituto Español de Oceanografía, Cabo Estay, Vigo, Spain*).

### **Influence of dietary protein level on growth performance and body composition of juvenile blackspot seabream, *Pagellus bogaraveo* (Brunnich, 1768)**

Blackspot seabream *Pagellus bogaraveo* is a potential candidate species for southern European aquaculture. A 12-week feeding trial was then conducted to evaluate the effect of dietary protein level on growth performance, body composition and feed use efficiency of blackspot seabream juveniles (22.7 g each). Five isolipidic diets (12.5%) with graded levels of protein (20, 30, 40, 50 and 60%) were hand-distributed, twice a day, to duplicate groups of fish (120 fish per tank), until satiation. Growth (DGC), survival and feed utilization (FCR) were recorded through monthly sampling. Growth performance was significantly affected by dietary protein level ( $P < 0.05$ ), and fish fed at the 50% protein level exhibited the highest

final body mass. Feed conversion ratio decreased with increasing levels of dietary protein, fish fed 60% protein being the most efficient. No significant differences were found in whole body composition among treatments ( $P > 0.05$ ). Financed by FCT (Project POCTI/CVT/39239/2001, PhD Grant SFRH-BD-14068-2003)

Silva, P.<sup>1</sup>, Andrade, C. A. P.<sup>2</sup>, Timóteo Viriato, M. F. A.<sup>2</sup>, Rocha, E.<sup>3</sup> & Valente L.M.P.<sup>1,3</sup> (<sup>1</sup>ICBAS – Institute of Biomedical Sciences Abel Salazar, University of Porto, Portugal; <sup>2</sup>Direcção Regional de Pescas, Centro de Maricultura da Calheta, Madeira, Portugal; <sup>3</sup>CIIMAR – Centre for Marine and Environmental Research, R. dos Bragas, 289 Porto, Portugal).

### The calpastatin/calpain system in trout *Salmo trutta trutta* muscle

Many recent reports suggest that the calpastatin/calpain system plays a role in cellular growth and differentiation. Defects of the calpastatin/calpain system have been linked to cellular dysfunctions, apoptosis, myocardial infarct, and dystrophies. The calpastatin/calpain system has also been implicated in post-mortem tenderization of skeletal muscle through degradation of key myofibrillar and associated proteins, a process of key importance to meat quality. In the present study we investigate the presence and activity of the calpastatin/calpain system in trout muscle samples, collected at 0, 3, 18 and 28 h post-mortem, by immunohistochemistry method. Calpastatin is a specific endogenous enzyme of cytosol, modulating the ubiquitous calpains. Calpastatin was found in samples obtained *in vivo* and immediately post-mortem, but its concentration declined rapidly in samples obtained 3, 18 and 28 h post-mortem. The ubiquitous m e m-calpains, which are localized on Z line proteins and activated by intracellular  $Ca^{2+}$  increase, showed a rapid decline within 3 h post-mortem. By contrast p94 calpain, which is specific to skeletal muscle, showed a slow decrease post-mortem which was independent of intracellular  $Ca^{2+}$  increase. Our results suggest that the mechanism of activation and activity of the calpastatin/calpain system in trout is similar to that described in mammals.

Varricchio, E.<sup>1</sup>, Rubino, T.<sup>1</sup>, Paino, S.<sup>1</sup>, Di Lascio, T.<sup>1</sup>, Paciello, O.<sup>2</sup> & Langella, M.<sup>1</sup> (<sup>1</sup>Department of Animal Production Sciences, University of Basilicata, Potenza, Italy; <sup>2</sup>Department of Pathology and Animal Health, University of Naples “Federico II”, Naples, Italy).

### Hatching time as an indicator of environmental incompatibility and outbreeding depression in intraspecific salmon hybrids

We analysed hatching times of hybrids between two spatially separated pink salmon *Oncorhynchus gorbusha* populations. We repeated the experiment in independent even- and odd-year broodlines. In 1996 and in 1997, we made F1 hybrids from Auke Creek (Juneau, Alaska) females and Pillar Creek (Kodiak, 1000 km away) males and F1 controls from Auke Creek parents. Families were reared and released at Auke Creek. F2 hybrids, controls, and backcrosses were made from F1 returns in 1998 and 1999. In 2001, we made F1 hybrids at Pillar Creek with native females and Auke Creek males. Pillar Creek ancestry prolonged development: At Auke Creek, hybrid families (half Pillar Creek ancestry) developed more slowly (more Accumulated Temperature Units between fertilization and hatch;  $P < 0.0001$ ) than did controls (only Auke Creek ancestry). At Pillar Creek, families with only Pillar Creek ancestry developed more slowly than did hybrids with half Auke Creek ancestry. Development times of backcrosses were intermediate between those of hybrids and controls. The variation in development times

between Auke Creek and Pillar Creek pink salmon has a genetic component that probably results from local adaptation and illustrates a mechanism that can lead to outbreeding depression in intercrosses between salmon populations (*e.g.*, occurring between wild and translocated stocks).

Wang, I. A., Smoker, W. W., Gilk, S. E., Oxman, D. S. & Gharrett, A. J. (*University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, 11120 Glacier Highway, Juneau, AK 99801, U.S.A.*).