

Abstract Book

Compiled by *Don MacKinlay*



International Congress on the Biology of Fish

3-7 August, 2014

Heriot-Watt University, Edinburgh

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Congress Organization

Local Host, Congress Organizer and Past President, AFS Physiology Section

Mark Hartl

Congress Chair and Programme Chair

Don MacKinlay

President, AFS Physiology Section and Plenary Session Chair

Brian Small

President-Elect, AFS Physiology Section and student Grants Chair

Mark Shrimpton

Secretary/Treasurer, Physiology Section

Matt Mesa

Symposium Organizers

5 th International Symposium on Burbot (<i>Lota lota</i>): <i>Martin Stapanian and Chris Myrick</i>
Air-breathing fish: in Nature and Aquaculture: <i>Sjannie Lefevre and Mark Bayley</i>
Application of physiology to improve fish culture: <i>Don MacKinlay and Alastair Lyndon</i>
Biology of the Hagfish: <i>Sue Edwards and Greg Goss</i>
Climate Change and Expanding Dead Zones: from the Tropics to the Poles, How will Fish Adapt? <i>Jay Nelson and Dal Val</i>
Conservation Physiology of Fish Migration: <i>Christian Tudorache</i>
Effects of Environmental Change on the Links between Physiology and Behaviour: <i>Neil Metcalfe and Shaun Killen</i>
Extra- and Intra-cellular Signalling: Conserved Responses Controlling Diverse Physiological Functions: <i>Steve Perry and Pung-Pung Hwang</i>
Fish Cell Cultures as a Tool for Fish Physiology Research: <i>Bruria Funkenstein, Niels Bols and Encarnacion Capilla</i>
Fish in a Toxic World: Biomarkers and Impacts of Exposure: <i>Mark Hartl, Tyson MacCormack and Lynn Weber</i>
Fish Reproductive Physiology and Biotechnology: <i>Luiz Renato de Franco</i>
FITFISH: <i>Arjan Palstra and Josep Planas</i>
General Contributed Papers: <i>Don MacKinlay</i>
Growth and Metabolism in Fishes: <i>Brian Small, Brian Peterson and Suraj Unniappan</i>
Intrinsic and Extrinsic Regulation of Fish Cardiovascular Function: <i>Kurt Gamperl, Holly Shiels and Ben Speers-Roesch</i>
Ion and Acid-Base Regulation in Fish: <i>Colin Brauner, Greg Goss and Steve McCormick</i>
Lampreys: Performance, Physiology, and Coping with Environmental Disturbances: <i>Matt Mesa, Stacia Sower and Margaret Docker</i>
Molecular and Physiological Mechanisms of the Fish Kidney: <i>Akiro Kato and J. Larry Renfro</i>
Parasites and Diseases of Fish: <i>Alastair Lyndon</i>
Physiological Perspectives of Fish Habitats: <i>Cory Suski and Steven Cooke</i>
Physiology of Elasmobranch Fishes: <i>Gary Anderson, Pat Wright and Suzie Currie</i>

Physiological Genomics: <i>Avner Cnaani and Elena Sarropoulou</i>
Plenary Session: <i>Brian Small</i>
Sensing the Environment: <i>Keith Tierney</i>
Stress in Fish: Mechanisms, Responses and Adaptations: <i>Lluis Tort and Matt Vijayan</i>
Swimming Physiology of Fish: <i>Arjan Palstra and Josep Planas</i>
Tropical Fish – A Biological Goldmine: <i>Dal Val, Vera Almeida-Val</i>
Winter Biology in Fish: The Dynamic World of Icy Rivers: <i>Jill Leonard and Eva Enders</i>
Zebrafish as Tools in Fish Physiology: <i>Alastair Lyndon and Ted Henry</i>

Schedule at a Glance

Sun Aug 3	Registration Opening Reception						
1400-1900							
Mon Aug 4	Room1	Room2	Room3	Room4	Room5	Room6	Room7
0930-1230	<i>Opening Ceremony & Plenary Session</i>						
1300-1500	Stress	Air Breathing	Reproduction	Cell Culture	Fish Culture	Burbot	Kidney
1520-1800	Stress	Air Breathing	Reproduction	Cell Culture	Fish Culture	Burbot	Zebrafish
1700-2100	<i>Poster Session</i>						
Tue Aug 5							
0830-1010	Stress	Environment	Tropical	Lamprey	Signalling	Habitat	
1030-1230	Stress	Environment	Tropical	Lamprey	Signalling	Habitat	
1300-1500	Stress	Environment	Tropical	Hagfish	Signalling	Migration	
1520-1800	Stress	Environment	Tropical	Hagfish	Signalling	Migration	
1700-2100	<i>Poster Session</i>						
Wed Aug 6							
0830-1010	Ion Regulation	Climate Change	Sensing	Elasmobranch	Growth	Toxicology	Swimming
1030-1230	Ion Regulation	Climate Change	Sensing	Elasmobranch	Growth	Toxicology	Swimming
1300-1500	Ion Regulation	Climate Change	Sensing	Elasmobranch	Growth	Toxicology	FITFISH
1520-1720	Ion Regulation	Climate Change	Sensing	Elasmobranch	Growth	Toxicology	FITFISH
1830-2200	<i>Congress Banquet Dinner at Gosford House</i>						
Thur Aug 7							
0830-1010	Ion Regulation	Genomics	Parasites Disease	Cardiovascular	Contributed	Winter	
1030-1230	Ion Regulation	Genomics		Cardiovascular	Contributed	Winter	
1300-1500	<i>Closing Session</i>						

Sponsors/Exhibitors

Heriot-Watt University

AFS Physiology Section

Loligo Systems

Society of Experimental Biology

Aquaculturedirectory.com

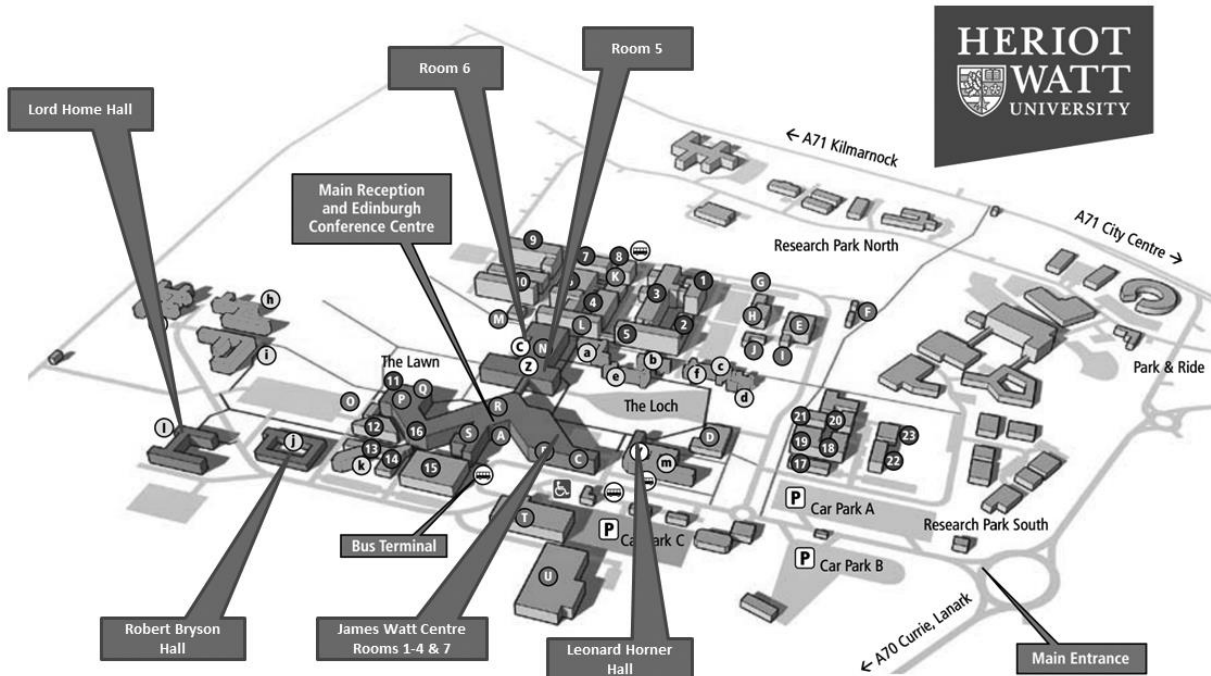
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Journal of Experimental Biology

Viewpoint

Cambridge University Press

Elsevier



Fish Biology Congress 2014 - Detailed Schedule

Sunday, August 3, 2014

1400-1900	Registration						
1830-2100	Opening Reception						
Monday, August 4, 2014							
09:00-12:30	PLENARY SESSION						
9:30	Welcome: Dr. Mark Hartl						
9:40	Official Opening						
9:50	Introduction to Plenary Session: Dr. Brian Small						
9:55	HOW WILL ANTARCTIC NOTOTHENIOID FISHES FARE AS THE SOUTHERN OCEAN WARMS? Dr. Kristin O'Brien						
10:25	UNDERSTANDING THE MECHANISMS OF TOXICITY OF ENVIRONMENTAL CHEMICALS TO FISH Dr. Eduarda Santos						
10:55	<i>Refreshment Break</i>						
11:15	DO T HELPER CELLS EXIST IN FISH? Dr. Chris Secombes						
11:45	AGNATHAN FISH AND THE EVOLUTION OF IONIC REGULATORY PHYSIOLOGY Dr. Susan Edwards						
12:15	Presentation of the Award of Excellence in Fish Physiology: Dr. Brian Small						
12:20	Award of Excellence Talk						
12:50	<i>Lunch Break</i>						
1350-1530	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Airbreathing Fish - in Nature and Aquaculture</i>	<i>Fish Reproductive Physiology and Biotechnology</i>	<i>Fish Cell Cultures as a Tool for Fish Physiology Research</i>	<i>Application of Physiology to Improve Fish Culture</i>	<i>5th International Symposium on Burbot</i>	<i>Molecular and Physiological Mechanisms of the Fish Kidney</i>
<i>Moderator</i>	<i>Matt Vijayan</i>	<i>Sjannie Lefevre</i>	<i>Luiz de Franca</i>	<i>Bruria Funkenstein</i>	<i>Alastair Lyndon</i>	<i>Martin Stapanian</i>	<i>Larry Renfro</i>
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7

13:50	INTRODUCTION TO THE STRESS SYMPOSIUM Vijayan, M.M., and Tort, L.	AIR BREATHING AND PHYSIOLOGICAL STRATEGIES DURING EMERSION IN GALAXIIDS Urbina, M.A. et al.	INTRODUCTION TO FISH REPRODUCTIVE PHYSIOLOGY AND BIOTECHNOLOGY SYMPOSIUM de Franca, Luiz and Berta Levavi-Silvan	COLLAGEN FORMING FISH CELL LINES AND THEIR USE IN FISH PHYSIOLOGY AND TOXICOLOGY Lee, L.E.J. et al.	APPLICATION OF PHYSIOLOGY TO IMPROVE FISH CULTURE Don MacKinlay	A DOUBLE-EDGED SWORD: USING BURBOT SWIMMING AND JUMPING PERFORMANCE DATA TO AID THE DESIGN OF BARRIERS TO MIGRATION AND FISH PASSAGE STRUCTURES Myrick, C.A. et al.	ION TRANSPORTERS IN THE KIDNEY OF EURYHALINE AND SEAWATER PUFFERFISHES Kato, A.
14:10	POSSIBLE INVOLVEMENT OF MINERALOCORTICOID SIGNALING PATHWAYS IN STRESS RESPONSE AND EMBRYOGENESIS IN RAINBOW TROUT. Kiilerich, P. et al.	AMPHIBIOUS ASTRONAUTS: GILL REMODELLING IN RESPONSE TO ALTERED BODY WEIGHT IN THE MANGROVE RIVULUS Turko, A.J. et al.	ASSESSMENT OF POSSIBLE HYBRIDIZATION IMPACT IN THE ANCESTRAL SEXUAL CASCADES Machado, M.P. et al.	ABC TRANSPORTERS IN ONCORHYNCHUS MYKISS PRIMARY GILL CELL CULTURE Kropf, C. et al.	ADAPTATION OF TWO MARINE SPECIES, GRAY MULLET (MUGIL CEPHALUS) AND WHITE GROUPEL (EPINEPHELUS AENEUS), TO CULTURE IN INLAND LOW SALINITY WATER Cnaani, A. et al.	CONSISTENT INDIVIDUAL DIFFERENCES IN BURBOT HOME RANGE, DISPERSAL, MOVEMENT AND SITE FIDELITY: EVIDENCE FOR PERSONALITY-DEPENDENT SPATIAL ECOLOGY Harrison, P.M. et al.	IMMUNOHISTOCHEMICAL LOCALIZATION OF MULTIPLE AQUAPORIN ISOFORMS IN EEL (ANGUILLA ROSTRATA) KIDNEY Cutler, C.P. et al.
14:30	SEROTONERGIC REGULATION OF THE HYPOTHALAMIC-PITUITARY-INTERRENAL AXIS VIA THE SEROTONIN 1A RECEPTOR IN THE GULF TOADFISH (OPSANUS BETA) Medeiros, L.R. et al.	TEMPERATURE SUSCEPTABILITY OF OXYGEN BINDING IN CATFISH HEMOGLOBIN Damsgaard, C. et al.	SOME CHARACTERISTICS AND FUNCTIONS OF SHBG, A NEWLY DISCOVERED SEX HORMONE BINDING GLOBULIN EXPRESSED IN GRANULOSA CELLS Marivin, E. et al.	ZEBRA FISH LIVER ZFL CELL LINE, AN IN-VITRO MODEL FOR THE ASSESSMENT OF TBT-INDUCED STEATOSIS IN FISH Porte, C. et al.	CAPACITY FOR EPA AND DHA SYNTHESIS IN ATLANTIC SALMON AT DIFFERENT LIFE STAGES Østbye, T-K. et al.	SEASONALITY IN DIEL MOVEMENTS AND HABITAT USE OF BURBOT IN A SUB-ARCTIC LAKE Cott, P.A. et al.	MECHANISMS AND CONTROL OF INORGANIC PHOSPHATE (Pi) TRANSPORT IN FISHES Renfro, J.L.
14:50	EFFECTS OF CORTISOL INPLANTS ON INNATE IMMUNE GENES AND CORTICOSTEROID RECEPTOR GENES IN RAINBOW TROUT Teles, M. et al.	BEING AN AIR BREATHER IN THE ARCTIC: HOW DOES ALASKA BLACKFISH SURVIVE HYPOXIA AND SUBMERGENCE? Lefevre, S. et al.	ANATOMICAL AND FUNCTIONAL NETWORKS IN THE TELEOST PITUITARY Levavi-Sivan, B. et al.	CELL-TYPE SPECIFIC ARYLHYDROCARBON RECEPTOR SIGNALING IN CULTURED LIVER AND IMMUNE CELLS OF RAINBOW TROUT Möller, A.M. et al.	DEVELOPING FRESHWATER NUTRITION IN TRIPLOID ATLANTIC SALMON (SALMO SALAR) AND THE IMPACT OF DIETARY PHOSPHOROUS Smedley, M.A. et al.	THE EFFICIENCY OF ELECTROFISHING FOR BURBOT UNDER EXPERIMENTAL CONDITIONS. De Charleroy, D. et al.	MOLECULAR-HISTOCHEMICAL INVESTIGATION OF CARTILAGINOUS FISH KIDNEY Hyodo, S. et al.

15:10	EFFECTS OF LHRH AND HCG ON CORTISOL PRODUCTION BY RAINBOW TROUT INTERRENAL TISSUE IN VITRO Barry, T.P. et al.	ONTOGENETIC TRANSITION FROM AQUATIC TO AMPHIBIOUS LIFE IN THE MUDSKIPPER, PERIOPHTHALMUS MODESTUS Yokouchi, K. et al.	RETINOIC ACID REQUIREMENTS IN THE REGULATION OF ZEBRAFISH SPERMATOGENESIS Crespo, D. et al.	THE PASSIVE AND FACILITATED TRANSPORT OF PHARMACEUTICALS BY A PRIMARY FISH GILL CELLS CULTURE MODEL Stott, L.C. et al.	SHORT- AND MEDIUM-TERM EFFECTS OF AN ANOREXIGENIC FACTOR ANTAGONIST AND ARGININE SUPPLEMENTATION ON CHOLECYSTOKININ, NEUROPEPTIDE Y AND LEPTIN GENE EXPRESSION, IGF-I SECRETION AND GROWTH PERFORMANCE IN RAINBOW TROUT (ONCORHYNCHUS MYKISS). Wood, J.D. et al.	DIET ANALYSIS OF BURBOT FROM EASTERN LAKE MICHIGAN: 1999-2012 Leonard, J.B.K. et al.	GENETIC ANALYSIS OF KIDNEY DEVELOPMENT USING THE ZEBRAFISH Wingert, R.A. et al.
15:30	Refreshment Break						
15:50 - 18:30	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Airbreathing Fish - in Nature and Aquaculture</i>	<i>Fish Reproductive Physiology and Biotechnology</i>	<i>Fish Cell Cultures as a Tool for Fish Physiology Research</i>	<i>Application of Physiology to Improve Fish Culture</i>	<i>5th International Symposium on Burbot</i>	<i>Zebrafish as Tools in Fish Physiology</i>
Moderator	Lluís Tort	Mark Bayley	Berta Levavi-Sivan	Bruria Funkenstein	Don MacKinlay	Chris Myrick	Ted Henry
Location	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7
15:50	EXPLORING PHYSIOLOGICAL FUNCTIONS OF THE PLEIOTROPIC MELANOCORTIN ALPHA-MSH IN ATLANTIC SALMON Gorissen, M. et al.	DO SOCIAL STATUS OR PREDATION THREAT INFLUENCE AIR-BREATHING BEHAVIOR OF A FACULTATIVE AIR BREATHER, PANAQUE MACCUS? Owens, C.E. et al.	GENE EXPRESSION PROFILING IN TESTIS OF PREPUBERTAL SALMON WITH DIFFERENT NUTRITIONAL STATUS Bogerd, J. et al.	THE ESTABLISHMENT AND USE OF A FIN CELL LINE FROM RAINBOW TROUT (ONCORHYNCHUS MYKISS) TO STUDY RHABDOVIRAL INFECTIONS IN VITRO Alvarez de Haro, N. et al.	QUANTIFICATION OF VARIATION OF METABOLIC ENZYMATIC ACTIVITIES IN LIVER OF BLUE TILAPIA Oreochromis aureus, IN RESPONSE TO LONG-TERM THERMAL ACCLIMATISATION Younis, E.M.	CHANGES IN SPATIAL DISTRIBUTION AND POPULATION SIZE STRUCTURE OF BURBOT IN RESPONSE TO INCREASED PREDATION BY A RECOVERED LAKE TROUT POPULATION IN LAKE SUPERIOR Gorman, O.T. et al.	LIGHT WAVELENGTH DIFFERENTIALLY AFFECTS THE ONTOGENY OF BEHAVIORAL RHYTHMS IN ZEBRAFISH LARVAE Di Rosa, V. et al.

16:10	THE ROLE OF OXIDATIVE STRESS IN THE MECHANISMS OF AMMONIA-INDUCED BRAIN SWELLING AND TOLERANCE IN THE GOLDFISH (CARASSIUS ARUATUS L.) Lisser, D.F.	O ₂ -CHEMORECEPTORS AND THE CONTROL OF CARDIORESPIRATORY RESPONSES TO HYPOXIA IN THE AFRICAN SHARPTOOTH CATFISH, CLARIAS GARIEPINUS, AN AIR-BREATHING FISH. Belão, T.C. et al.	ARTIFICIAL FERTILIZATION IN NILE TILAPIA OREOCHROMIS NILOTICUS USING CHILLED STORAGE MILT Piamsomboon, P. et al.	OMEGA-3 FATTY ACIDS INFLUENCE MITOCHONDRIAL FUNCTION AND INFLAMMATORY STATUS IN ATLANTIC SALMON IN VITRO DIFFERENTIATED PREADIPOCYTES Ruyter, B. et al.		POLYCHLORINATED BIPHENYL HOMOLOG DISTRIBUTIONS IN BURBOT FROM GREAT SLAVE LAKE AND LAKE ERIE Stapanian, M.A. et al.	THE EFFECTS OF MATERNAL CAROTENOID CONSUMPTION ON DEVELOPMENT IN ZEBRAFISH Eaton, L.E. et al.
16:30	KINETICS OF THE HEAT SHOCK RESPONSE IN LAKE WHITEFISH (COREGONUS CLUPEAFORMIS) Stefanovic, D.S. et al.	AERIAL RESPIRATION IN POLYPTERIDS Jew, C.J. et al.	SPERMATOGONIAL STEM CELL PHYSIOLOGY AND TRANSPLANTATION IN FISH França L.R. et al.	ROLES OF LEPTIN AND GHRELIN IN ADIPOGENESIS AND LIPID METABOLISM OF RAINBOW TROUT ADIPOCYTES IN VITRO Salmeron, C. et al.		THE EFFECTS OF WATER DEVELOPMENT ON THE GENETIC STRUCTURE OF NORTH AMERICAN BURBOT POPULATIONS Underwood, Z. E. et al.	ORIGIN AND DEVELOPMENT OF THE DOPAMINERGIC NEURONS INNERVATING THE PITUITARY IN ZEBRAFISH Fontaine, R. et al.
16:50	THE HEAT SHOCK RESPONSE AND THE DEVELOPMENT OF THERMOTOLERANCE IN EMBRYONIC LAKE WHITEFISH (COREGONUS CLUPEAFORMIS) Sessions, K.J. et al.	PH REGULATION DURING HYPERCAPNIA IN STRIPED CATFISH, PANGASIANODON HYPOPHthalmus Damsgaard, C. et al.	GENETIC MANIPULATION OF MALE GERMLINE STEM CELLS IN THE NILE TILAPIA (OREOCHROMIS NILOTICUS) Lacerda, S.M.S.N. et al.	IN VITRO EFFECTS OF L-LEUCINE, L-ARGININE AND L-GLUTAMINE ON ADIPOGENESIS AND LIPID METABOLISM IN RAINBOW TROUT (ONCORHYNCHUS MYKISS) Lutfi, E. et al.			IGFBP-1 AS A POTENTIAL MARKER OF ENVIRONMENTAL STRESS IN FISH Budige, V. et al.
17:10	COVARIATION BETWEEN BEHAVIOUR AND PHYSIOLOGICAL INDICATORS OF COPING STYLE IN ADULT AND LARVAL ZEBRAFISH (DANIO RERIO) Tudorache, C. et al.	AQUACULTURE OF AIR-BREATHING SPECIES IN VIET NAM Nguyen, T.P. et al.		MOLECULAR AND FUNCTIONAL CHARACTERIZATION OF NICOTINIC ACETYLCHOLINE RECEPTOR ALPHA 7 IN RAINBOW TROUT (ONCORHYNCHUS MYKISS) Torrealba, D. et al.			TEST THE WATER! EFFECTS OF A WATER DISINFECTION BYPRODUCT ON ZEBRAFISH (DANIO RERIO) EMBRYOS Bencsik, D. et al.
17:30				OPPOSING MUSCLE GROWTH PARADIGMS: A MODEL FOR UNDERSTANDING THE BALANCE BETWEEN ATROPHY AND HYPERTROPHY. Biga, P.R. et al.			

17:50				LONG-TERM SPONTANEOUSLY CONTRACTING 3D HEART AGGREGATE GENERATED IN VITRO FOR USE IN PHYSIOLOGICAL RESEARCH Grunow, B. et al.			
18:10				ISOLATION, CULTURE AND CHARACTERIZATION OF RAINBOW TROUT GRANULOSA CELLS Marivin, E. et al.			
18:30	<i>End of Session</i>						
18:45	<i>Poster Session I</i>						

Tuesday, August 5, 2014							
0830-1010	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Effects of Environmental Change on the Links Between Physiology and Behaviour</i>	<i>Tropical Fish - a Biological Goldmine</i>	<i>Lampreys - Performance, Physiology and Coping with Environmental Disturbances</i>	<i>Extra- and Intra-Cellular Signalling: Conserved Responses Controlling Diverse Physiological Functions</i>	<i>Physiological Perspectives of Fish Habitats</i>	
<i>Moderator</i>	<i>Matt Vijayan</i>	<i>Neil Metcalfe</i>	<i>Dal Val</i>	<i>Matt Mesa</i>	<i>Pung-Pung Hwang</i>	<i>Steve Cooke</i>	
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	
8:30	TOWARDS AN EVOLUTIONARY BACKGROUND FOR DEPRESSION: ATLANTIC SALMON AND DEPRESSIVE-LIKE STATES Vindas, M.A. et al.	THE ROLE OF INTRASPECIFIC PHYSIOLOGICAL DIVERSITY IN DETERMINING RESPONSES TO ENVIRONMENTAL PERTURBATIONS Clark, T.D. et al.	PERFORMANCE IN EXTREME ENVIRONMENTS: A CASE STUDY OF AN AFRICAN CYPRINID IN HYPOXIC SWAMPS Baltazar, C. et al.	THE IMPORTANCE OF LAMPREYS IN SCIENTIFIC RESEARCH Docker, M.F.	HYDROGEN SULPHIDE - AN ENDOGENOUS REGULATOR OF IONIC UPTAKE IN ZEBRAFISH Perry, S.F. et al.	PHYSIOLOGICAL PERSPECTIVES OF FISH HABITATS Suski, C.D. et al.	
8:50	A FISHY PERSPECTIVE ON CARRYOVER EFFECTS Cooke, S.J. et al.	ANIMAL PERSONALITY IS RELATED TO THERMAL PREFERENCE IN WILD-TYPE ZEBRAFISH DANIO	THERMAL TOLERANCE IN A WIDESPREAD AFRICAN CICHLID FISH: IMPLICATIONS FOR CLIMATE CHANGE IN	UPDATE ON THE DISCOVERY OF LAMPREY GONADOTROPIN(S) AND THEIR RECEPTORS Sower, S.A. et al.	THE ROLE OF HYDROGEN SULPHIDE IN THE CONTROL OF BREATHING IN HYPOXIC ZEBRAFISH (DANIO RERIO) Porteus, C.S. et al.	WATERSHED-SCALE LAND USE ACTIVITIES INFLUENCE THE PHYSIOLOGICAL CONDITION OF STREAM FISH Suski, C. D. et al.	

		RERIO (HAMILTON, 1822). Rey, S. et al.	EQUATORIAL WATERS McDonnell, L.H. et al.				
9:10	GLOBAL BIOTECHNOLOGICAL STRATEGIES FOR CHARACTERIZATION OF THE TRAIT ROBUSTNESS IN RAINBOW TROUT Verleih, M. et al.	PHYSIOLOGICAL AND BEHAVIORAL RESPONSES TO MULTIPLE ENVIRONMENTAL STRESSORS IN THE ENDANGERED DELTA SMELT, HYPOMESUS TRANSPACIFICUS Fangue, N.A. et al.	MYCOSPORINE-LIKE AMINO ACIDS PROVIDE A RAPID RESPONSE MECHANISM FOR UV PROTECTION IN REEF FISH Braun, C. et al.	THE EVOLUTION AND DEVELOPMENT OF PHOTORECEPTION IN LAMPREYS: IMPLICATIONS FOR BEHAVIOUR Collin, S. P. et al.	SIGNALING BY NITRIC OXIDE AND ITS METABOLITES Jensen, F.B.	VARIATION IN BODY COMPOSITION, GROWTH AND POPULATION STRUCTURE OF THE CENTRAL MUDMINNOW UMBRA LIMI IN RESPONSE TO WATERSHED LAND-USE Chapman, J.M. et al.	
9:30	COMPARISON OF ROBUSTNESS TRAITS IN TWO ISOGENIC LINES OF RAINBOW TROUT: USE OF A NEW APPROACH BASED ON MODELISATION OF BIOLOGICAL RESPONSES TO ACUTE STRESSORS Sadoul, B. et al.	BEHAVIOUR AND PHYSIOLOGY OF GILTHEAD SEABREAM (SPARUS AURATA) EARLY LIFE STAGES UNDER OCEAN WARMING AND ACIDIFICATION Pimentel, M.S. et al.	VACCINE AGAINST Streptococcus agalactiae IN Oreochromis niloticus PREPARED BY SONICATION Marcusso, P.F. et al.	EFFECTS OF A BLOOD DIET ON THE ACQUISITION OF SEA WATER TOLERANCE IN PARASITIC ANADROMOUS SEA LAMPREYS (PETROMYZON MARINUS). Wilkie, M.P. et al.	UNIQUE REGULATORY MECHANISMS FOR SULFATE SECRETION BY THE EEL KIDNEY Takei, Y. et al.	IS JUVENILE MIGRATION PHENOTYPE ESTABLISHED BY RECENT STIMULI OR MUCH EARLIER IN LIFE Schreck, C.B. et al.	
9:50	GROWTH AND PHYSIOLOGICAL RESPONSE OF JUVENILE TIDEWATER GOBY TO INTERSPECIFIC COMPETITION Chase, D.A. et al.	CROSSING-OVER THE LIMITS OF SEAHORSES: THE IMPACT OF OCEAN WARMING AND ACIDIFICATION ON A BONY-ARMoured POOR SWIMMER FISH Faleiro, F. et al.	DIFFERENTIAL MATING SUCCESS OF WRASSES AND EGG PREDATION RATES AT A MATING SITE IMPACTED BY DIVER FISH FEEDING Donaldson, T.J. et al.	RISK-MEDIATED HABITAT SELECTION BY SEA LAMPREY DURING THE REPRODUCTIVE MIGRATION Wagner, C.M. et al.	HIF-PROTEINS IN ZEBRAFISH DEVELOPMENT AND IN HYPOXIA Pelster, B. et al.	TACTICS TO PRODUCE WILD PHENOTYPES IN ARTIFICIALLY REARED SPRING CHINOOK SALMON Chitwood, R. et al.	
10:10	Refreshment Break						

1030-1230	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Effects of Environmental Change on the Links Between Physiology and Behaviour</i>	<i>Tropical Fish - a Biological Goldmine</i>	<i>Lampreys - Performance, Physiology and Coping with Environmental Disturbances</i>	<i>Extra- and Intra-Cellular Signalling: Conserved Responses Controlling Diverse Physiological Functions</i>	<i>Physiological Perspectives of Fish Habitats</i>	
<i>Moderator</i>	<i>Lluís Tort</i>	<i>Neil Metcalfe</i>	<i>Dal Val</i>	<i>Stacia Sower</i>	<i>Pung-Pung Hwang</i>	<i>Cory Suski</i>	
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	
10:30	DEVELOPMENTAL SOCIAL EXPERIENCE OF PARENTS AFFECTS BEHAVIOUR OF OFFSPRING IN ZEBRAFISH Tamilselvan, P. et al.	PHYSIOLOGICAL AND BEHAVIOURAL ASSESSMENT PROVIDES INSIGHT INTO THE RESPONSE AND LIKELY SURVIVAL OF PAGRUS AURATUS TO HYPOXIA Herbert, N.A. et al.	GUT TRANSPORT CHARACTERISTICS IN HERBIVOROUS AND CARNIVOROUS CHARACID FISH FROM ION POOR RIO NEGRO WATER Pelster, B. et al.	CONTRASTING POPULATION GENETIC STRUCTURE AMONG FRESHWATER-RESIDENT AND ANADROMOUS LAMPREYS; THE ROLE OF DEMOGRAPHIC HISTORY, DIFFERENTIAL SITE-FIDELITY, AND ANTHROPOGENIC INTENSIFICATION Bracken, F.S.A. et al.	EVIDENCE FOR A ROLE OF HEME OXYGENASE-1 IN THE CONTROL OF CARDIAC FUNCTION IN THE ZEBRAFISH LARVAE EXPOSED TO CHANGES IN WATER OXYGEN LEVELS Tzaneva, V. et al.	EVALUATION OF A HABITAT ENHANCEMENT IN COASTAL WETLANDS OF THE ST. LAWRENCE RIVER USING INDIVIDUAL HEALTH METRICS OF PUMPKINSEED (LEPOMIS GIBBOSUS) Ward, T.D. et al.	
10:50	MATERNAL STRESS AFFECTS CORTISOL DYNAMICS IN ZEBRAFISH Faught, E. et al.	ESTIMATING LINKS BETWEEN RESTING METABOLIC RATE AND BEHAVIOUR AT THE BETWEEN-INDIVIDUAL LEVEL. Adriaenssens B. et al.	INTEGRATING METABOLIC BIOCHEMISTRY AND FEEDING ECOLOGY: THE RELATIONSHIP BETWEEN DIETARY PREFERENCE AND GLUCOSE METABOLISM AMONG SERRASALMID FISHES (PIRANHAS AND PACUS) Speers-Roesch, B. et al.	LAMPREY CONSERVATION AND RESTORATION: SHARING KNOWLEDGE Noakes, D. L. G. et al.	HIF-1 MEDIATES ADAPTIVE METABOLISM SHIFT IN FISH BRAIN UNDER COLD EXPOSURE Tseng, Y.C. et al.	YEAR-ROUND 3-DIMENSIONAL SPATIAL AND TEMPORAL DISTRIBUTION OF TWO SYMPATRIC MORPHS OF ARCTIC CHARR (Salvelinus alpinus), FROM A REMOTE, LAND-LOCKED, ARCTIC POPULATION Rosten, C. M. et al.	
11:10	MATERNAL SOCIAL STATUS AFFECTS DEVELOPMENT OF THE STRESS RESPONSE IN ZEBRAFISH LARVAE Jeffrey, J.D. et al.	DECLINE OF THE WEATHERFISH (MISGURNUS FOSSILIS) IN THE NETHERLANDS IN RELATION TO CHANGES IN ENVIRONMENTAL FACTORS AND PHYSIOLOGY AND	THE USE OF CAT'S CLAW, Uncaria tomentosa, IN THE FEEDING OF TROPICAL FISH: GROWTH AND IMMUNE RESPONSE Yunis, A.J. et al.	IMPACT OF IRRIGATION DIVERSION SCREENS ON JUVENILE LAMPREYS IN THE COLUMBIA RIVER BASIN Mesa, M. G. et al.	MOLECULAR EQUIPMENT FOR CELL VOLUME-LINKED OSMOSENSING Watanabe, S. et al.	THE ROLE OF LIPIDS AND RHEOTAXIS OF JUVENILES IN THE FORMATION OF PHENOTYPIC GROUPS AND HETEROGENEITY OF ATLANTIC SALMON Murzina, S.A. et al.	

		BEHAVIOUR OF THE SPECIES Bruin, A. et al.					
11:30	INVESTIGATING THE EFFECTS OF ENVIRONMENTAL STRESSORS ON FISH WELFARE USING NON-INVASIVE MEASURES Edmonds, E.J. et al.	TO BOLDLY GULP: SEPARATING THE EFFECTS OF BOLDNESS AND METABOLIC RATE ON THE SURFACING BEHAVIOUR OF AN AIR-BREATHING FISH McKenzie, D.J. et al.	MICRORNAS REGULATE SKELETAL MUSCLE PHENOTYPE AND GROWTH IN PACU (Piaractus mesopotamicus). Duran, B.O.S. et al.	EFFECTIVENESS OF TECHNICAL FISH PASSES FOR UPSTREAM-MIGRATING EUROPEAN RIVER LAMPREY - ARE WE ANYWHERE NEARER UNDERSTANDING WHY THEY FUNCTION AS THEY DO? Lucas, M.C. et al.	PHYLOGENETIC AND MOLECULAR APPROACHES TO UNDERSTANDING CALCIUM-SENSING RECEPTOR FUNCTIONS IN FISHES Loretz, C.A. et al.	ADAPTABILITY TO DIFFERENT SALINITIES IN TWO SUBPOPULATIONS OF GADUS MORHUA FROM THE BALTIC SEA Kijewska, A. et al.	
11:50	SEEMINGLY CONTRADICTIONARY RESULTS REGARDING THE WELFARE OF FISH STUNNED USING DIFFERENT METHODS Gräns, A. et al.	LOCOMOTION IS REGULATED BY EXTERNAL TIDAL CHANGES IN THE BARRED MUDSKIPPER Ikegami T. et al.	PROTECTIVE EFFECTS OF RIO NEGRO WATER TO COPPER TOXICITY IN PACU, METYNNIS HYPSAUCHEN De Boeck, G. et al.	COMBINING TRADITIONAL KNOWLEDGE AND WESTERN SCIENCE TO FURTHER LAMPREY ECOLOGICAL RESEARCH AND CONSERVATION IN THE UMPQUA RIVER BASIN, OREGON, USA Coates, K.C. et al.	SENSING ACID/BASE VIA THE cAMP PATHWAY Tresguerres, M.		
12:10	USING ACCELEROMETER TAGS TO ESTIMATE POST-TAGGING BEHAVIOUR AND STRESS RESPONSE IN FISH Broell, F. et al.	PROSPECT OF ARCHERFISH RESEARCH: CHARTING THE DEVELOPMENT OF RESILIENCY IN CHANGING ENVIRONMENT Simon, K.D. et al.	MONITORING A RECENT PETROLEUM ASPHALT SPILL IN A HARBOR AREA IN RIO NEGRO (AMAZON) USING TIME-COURSE VARIATIONS OF BIOMARKERS OF TWO CICHLID SPECIES Sadauskas-Henrique, H. et al.		TROUT MINERALOCORTICOID RECEPTOR EXERTS IN VITRO A DOMINANT NEGATIVE ACTIVITY ON GLUCOCORTICOID RECEPTOR TRANSACTIVATION ACTIVITY. Prunet, P. et al.		
12:30	Lunch Break						

13:30 - 15:30	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Effects of Environmental Change on the Links Between Physiology and Behaviour</i>	<i>Tropical Fish - a Biological Goldmine</i>	<i>Biology of the Hagfishes</i>	<i>Extra- and Intra-Cellular Signalling: Conserved Responses Controlling Diverse Physiological Functions</i>	<i>Conservation Physiology of Fish Migration</i>
<i>Moderator</i>	<i>Lluís Tort</i>	<i>Shaun Killen</i>	<i>Vera Val</i>	<i>Sue Edwatts</i>	<i>Steve Perry</i>	<i>Christian Tudorache</i>
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
13:30	STRESS AND DISEASE SUSCEPTIBILITY OF WILD ADULT PACIFIC SALMON Teffer, A.K. et al.	THE ROLE OF DEVELOPMENTAL ENVIRONMENT IN SHAPING BEHAVIOUR AND PHYSIOLOGY Sloman, K.A.	THE IMPORTANCE OF SPATIAL SCALES TO ANALYSIS OF FISH DIVERSITY IN AMAZONIAN FLOODPLAIN LAKES, AND IMPLICATIONS FOR CONSERVATION Freitas, C.E.C. et al.	IMPORTANCE OF PUTTING BIOLOGICAL RESEARCH AT THE FOREFRONT OF HAGFISH FISHERIES DEVELOPMENT Grant, S.M.	BIASED SIGNALLING BY TWO ENDOGENOUS GnRH ISOFORMS IN GOLDFISH: INTEGRATION OF CLASS I PI3K-DEPENDENT SIGNAL TRANSDUCTION Pemberton, J.G. et al.	WHEN NETS GET IN THE WAY - THE STORY OF ENDANGERED COHO SALMON EN ROUTE TO SPAWNING GROUNDS Cooke, S.J. et al.
13:50	COMBINED EFFECT OF TEMPERATURE AND STARVATION ON THE APOPTOTIC PATHWAY AND ANTIOXIDANT DEFENSE OF MEAGRE (ARGYROSOMUS REGIUS) Soumalevris, A. et al.	CONTEXT-DEPENDENT LINKS BETWEEN INDIVIDUAL VARIATION IN METABOLISM AND SOMATIC GROWTH IN BROWN TROUT Auer, S.K et al.	SPATIAL HETEROGENEITY AND ORGANIZATION OF FISH ASSEMBLAGES IN AMAZONIAN FLOODPLAIN LAKES Siqueira-Souza, F.K. et al.	SEASONAL MIGRATION OF PACIFIC HAGFISH (EPTATRETUS STOUTI) OFF THE CENTRAL CALIFORNIA COAST Fox, D. A. et al.	THE LOST GILLS: AN ESSENTIAL ROLE OF PARATHYROID HORMONE IN DEVELOPING ZEBRAFISH Kwong, R.W.M. et al.	TEN YEARS OF LAB AND TELEMETRY STUDIES ON CANADA'S LARGEST SALMON RIVER FINDS EXCEPTIONALLY HIGH MORTALITY OF MIGRATING FEMALE SOCKEYE: ARE THEY RUNNING OUT OF GAS, STRESSED, SICK, OR DO THEY DIE OF BROKEN HEARTS? Hinch, S.G. et al.
14:10	EXOGENOUS GLUCOCORTICOID ON LEUKOCYTE RESPONSE OF TILAPIA DURING ACUTE INFLAMMATION Belo, M.A.A. et al.	DO DISPARITIES IN INDIVIDUAL THERMAL HABITAT USE EXPLAIN WITHIN-POPULATION VARIATIONS IN GROWTH RATES OF A COLD-WATER FISH? Guzzo, M.M. et al.	INTRA- AND INTER-ANNUAL CHANGES IN THE CONDITION FACTORS OF THREE CURIMATIDAE DETRITIVORES FROM AMAZONIAN FLOODPLAIN LAKES Correia, G.B. et al.	HAGFISH SLIME Fudge, D.S.	FUNCTIONAL REGULATION AND HORMONAL CONTROL OF CALCIUM UPTAKE IN ZEBRAFISH Hwang, P. P. et al.	CYPRINID FISH MOVEMENTS IN UPSTREAM FRAGMENTED STREAMS Branco, P. et al.

14:30	IS STRESS IN FARMED SALMON (SALMO SALAR) AN IMPORTANT FACTOR FOR SAPROLEGNIOSIS? Beckmann, M.J. et al.	THERMAL REGIME CHANGE AFFECTS LIFE HISTORY PARAMETERS IN A TROPICAL FRESHWATER FISH Reeve, A.J. et al.	MOLECULAR BASIS OF CHANGES IN PROPERTIES OF BLOOD IN PROTOPTERUS ANNECTENS DURING AESTIVATION Ong, L.Y.J. et al.	THE "EYE" AND PHOTORECEPTION IN HAGFISHES: INSIGHTS INTO THE EVOLUTION OF VISION Collin, S. P. et al.	Discussion following paper presentations.	MIGRATION OF THE WEATHERFISH (MISGURNUS FOSSILIS) BETWEEN DIFFERENT HABITATS IN TWO AGRICULTURAL DITCHES WITH DIFFERENT WATERLEVEL REGIMES Kranenborg, J. et al.	
14:50	GLUCOCORTICOID EFFECT OF DEXAMETHASONE ON SERUM BIOCHEMISTRY RESPONSE DURING INFECTIOUS AEROCISTITE. Belo, M.A.A. et al.	HOW DOES PREY QUALITY AFFECT LIFE-HISTORY TRAITS UNDER DIFFERENT TEMPERATURE REGIMES? Ross, S.D. et al.	TROPICAL CLIMATE CHANGE IMPAIRS SHARK EARLY ONTOGENY: DEVELOPMENTAL AND PHYSIOLOGICAL IMPLICATIONS Rosa, R. et al.	ANTIGEN RECEPTOR GENE ASSEMBLY IN HAGFISH Nagawa, F.		LARVAL DRIFT OF SELECTED NATIVE AND INVASIVE BENTHIC FISHES ALONG TWO DIFFERENT SHORE TYPES IN THE AUSTRIAN DANUBE Ramler, D. et al.	
15:10	METABOLIC EFFECTS AND LIVER DAMAGE OF MICROCYSTINS-CONTENT ON THE CRUDE EXTRACT OF CIANOBACTERIA, RADIOCYSTIS FERNANDOI, IN NEOTROPICAL FISH, HOPLIAS MALABARICUS Paulino, M.G. et al.	INTEGRATING INDIVIDUAL BEHAVIOR AND PHYSIOLOGY TO EXPLAIN ALTERNATIVE LIFE HISTORIES IN PARTIALLY MIGRATORY STEELHEAD AND RAINBOW TROUT (ONCORHYNCHUS MYKISS). Sloat, M.R. et al.		HYPOTHALAMIC-PITUITARY-GONADAL ENDOCRINE SYSTEM IN THE HAGFISH Nozaki, M.		JUVENILE GREEN STURGEON (ACIPENSER MEDIROSTRIS) BEHAVIOR NEAR WATER DIVERSIONS AND FISH GUIDANCE DEVICES: EXPERIMENTS IN LABORATORY SWIMMING FLUMES. Poletto, J.B. et al.	
15:30	Refreshment Break						
15:50 - 16:10	<i>Stress in Fish: Mechanisms, Responses and Adaptations</i>	<i>Effects of Environmental Change on the Links Between Physiology and Behaviour</i>	<i>Tropical Fish - a Biological Goldmine</i>	<i>Biology of the Hagfishes</i>	<i>Extra- and Intra-Cellular Signalling: Conserved Responses Controlling Diverse Physiological Functions</i>	<i>Conservation Physiology of Fish Migration</i>	
Moderator	Matt Vijayan	Shaun Killen	Vera Val	Sue Edwards	Steve Perry	Christian Tudorache	

Location	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
15:50	USE OF CARBON DIOXIDE AS A NON-PHYSICAL BARRIER TO FISH MOVEMENT Suski, C. D. et al.	MATURATION SHIFTS IN A TEMPERATE MARINE FISH STOCK CANNOT BE EXPLAINED BY WARMING TEMPERATURES ALONE Wright, P.J. et al.	OXYGEN TRANSFER IN THE AMAZONIAN FISH PROCHILODUS NIGRICANS Val, A.L. et al.	THE STEROID SIGNALLING PATHWAY IN HAGFISH Bury, N.R		RANGING AND MIGRATION OF LARGE SHARKS - ECOLOGICAL AND PHYSIOLOGICAL FACTORS Ormond, R.F.G. et al.
16:10	EFFECTS OF SELECTED POLLUTANTS ON THE GROWTH AND SURVIVAL OF CLARIAS GARIEPINUS (BURCHELL, 1822) Abidemi-Iromini, A.O. et al.		FUNCTIONAL ROLES OF AQUAPORINS IN THE GILLS OF THE CLIMBING PERCH, ANABAS TESTUDINEUS, DURING SEAWATER ACCLIMATION AND AMMONIA EXCRETION Chen, X.L. et al.	COMPARATIVE MORPHOLOGY OF PACIFIC HAGFISH IONOREGULATORY STRUCTURES Weinrauch, A.		QUANTIFICATION OF MASSIVE SEASONAL SHARK AGGREGATIONS Kajjura, S.M.
16:30			TROPICAL FISH EMBRYOS ON LAND: TERRESTRIAL EMBRYO DEPOSITION ENHANCES DEVELOPMENT IN THE AMPHIBIOUS FISH KRYPTOLEBIAS MARMORATUS Wright, P.A. et al.	SOLUBLE ADENYLYL CYCLASE IN HAGFISH GILLS Roa, J.N. et al.		
16:50			NITROGEN METABOLISM OF THE TAMBAQUI (Colossoma macropomum) Wood, C.M. et al.	EPITHELIAL TRANSPORT OF TRACE METALS IN PACIFIC HAGFISH Blewett, T.A. et al.		
17:10			Wood, C.M. et al. CONTINUED	EXTRABRANCHIAL HANDLING OF AMMONIA LOADING FOLLOWING HIGH EXTERNAL AMMONIA EXPOSURE IN THE PACIFIC HAGFISH (EPTATRETUS STOUTII) Clifford, A.M. et al.		

17:30				EXTREME AMMONIA TOLERANCE AND EVIDENCE OF ACTIVE AMMONIA EXCRETION BY THE PACIFIC HAGFISH Wilkie, M.P. et al.			
17:50	<i>End of Session</i>						
18:00	<i>Poster Session II</i>						

Wednesday, August 6, 2014							
0830-1010	<i>Ion and Acid-Base Regulation in Fish</i>	<i>Climate Change and Expanding Dead Zones: From the Tropics to the Poles, How Will Fish Adapt?</i>	<i>Sensing the Environment</i>	<i>Physiology of Elasmobranch Fishes</i>	<i>Growth and Metabolism in Fishes</i>	<i>Fish in a Toxic World: Biomarkers and Impacts of Exposure</i>	<i>Swimming Physiology of Fish</i>
<i>Moderator</i>	<i>Colin Brauner</i>	<i>Jay Nelson</i>	<i>Keith Tierney</i>	<i>Gary Anderson</i>	<i>Brian Small</i>	<i>Mark Hartl</i>	<i>Josep Planas</i>
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7
8:30	THE EVOLUTIONARY CONSEQUENCES OF STAYING IN FRESHWATER: SEAWATER PERFORMANCE, PHYSIOLOGY AND ENDOCRINOLOGY OF LANDLOCKED AND ANADROMOUS SALMON. McCormick, S.D. et al.	INTRODUCTION TO THE CLIMATE CHANGE AND FISH SYMPOSIUM Jay Nelson	KJELL B. DØVING (1936-2014): HIS LIFE AND SCIENTIFIC CONTRIBUTIONS Stabell, O.B.	Session start at 8.45 with 5 minute introduction.	RAINBOW TROUT HEPATOCYTES: A MODEL FOR RESOLVING THE GROWTH-PROMOTING AND LIPID CATABOLIC ACTIONS OF GROWTH HORMONE Sheridan, M.A.	EFFECT OF ETHOFUMESATE HERBICIDE ON ENERGY METABOLISM IN ROACH (RUTILUS RUTILUS) Maes, V. et al.	SWIMMING PHYSIOLOGY OF FISH Palstra, A.P., and Planas, J.V.
8:50	EFFECTS OF ANDROGENS AND CORTISOL ON GILL ION TRANSPORTERS AND OSMOREGULATORY CAPACITY IN ATLANTIC SALMON (SALMO SALAR) Nilsen, T.O. et al.	TEMPERATURE AND PH AFFECTS BLOOD OXYGEN AFFINITY OF SELECTED FISH SPECIES OF THE AMAZON Val, A.L. et al.	KJELL B. DØVING (1936-2014): HIS LIFE AND SCIENTIFIC CONTRIBUTIONS Stabell, O.B.	APPLYING SENSORY PHYSIOLOGY TO SHARK CONSERVATION Kajiura, S.M.	USING COMPARATIVE BIOLOGY TO UNDERSTAND GROWTH REGULATION IN TELEOSTS. Biga, P.R. et al.	COMBINED IMPACTS OF PERSISTENT ORGANIC POLLUTANTS AND GLOBAL WARMING ON THE CORAL REEF FISH SIGANUS GUTTATUS Baum, G.B. et al.	EVIDENCE FOR A MEDIATORY ROLE OF AMP-ACTIVATED PROTEIN KINASE ON THE METABOLIC EFFECTS OF SWIMMING-INDUCED CONTRACTILE ACTIVITY IN THE FISH SKELETAL MUSCLE Planas, J.V. et al.

9:10	MIGRATORY BEHAVIOUR AND PHYSIOLOGICAL STATUS OF OF POST-SPAWNERS OF ATLANTIC SALMON (SALMO SALAR L.) IN RIVER LÆRDALSELVA, NORWAY Kristensen, T. et al.	MODULATION OF LDH GENES AND SURVIVAL OF SPECIES OF AMAZONIAN FISH EXPOSED TO FUTURE CLIMATE CHANGE SCENARIOS Almeida-Val, V.M.F. et al.	FRIEND OR FOE? DOES SMELLING THE 'ENEMY' INFLUENCE WHERE JUVENILE REEF FISH CALL HOME? Coppock, A.G. et al.	EVOLUTION AND FUNCTION OF THE ELASMOBRANCH VISUAL SYSTEM Hart, N.S. et al.	GROWTH AND CONDITION OF TWO SMALL-SIZED CYPRINIDS IN A HYDROLOGICALLY-ALTERED MEDITERRANEAN STREAM Merciai, R. et al.	IMPACTS OF WEATHERED CRUDE OIL EXPOSURE ON THE EMBRYONIC DEVELOPMENT AND LARVAL FITNESS OF GULF KILLIFISH Brown, C.A. et al.	SWIM TRAINING OF ADULT ZEBRAFISH PROMOTES HYPERTROPHY AND VASCULARIZATION OF FAST SKELETAL MUSCLE FIBERS THROUGH ACTIVATION OF MYOGENIC AND ANGIOGENIC TRANSCRIPTIONAL PROGRAMS Rovira, M. et al.
9:30	MECHANISMS OF RESILIENCE TO ENVIRONMENTAL SALINITY IN KILLIFISH SPECIES Galvez, F.	PROTECTING HUMAN FOOD SECURITY AND BIODIVERSITY: CAN FISH ENERGETICS HELP TO PREDICT THE IMPACTS OF CLIMATE CHANGE ON TROPICAL FRESHWATER FISHES? Lapointe, D. et al.	OCEAN ACIDIFICATION IMPAIRS OLFACTORY SENSITIVITY DIRECTLY IN EUROPEAN SEA BASS (DICENTRARCHUS LABRAX) Porteus, C.S. et al.	HYDRODYNAMIC COMPLEXITY OF FLOW IN THE NASAL REGION OF A GUITARFISH Cox, J. et al.	REGULATION OF PITUITARY GROWTH HORMONE PRODUCTION BY GONADOTROPIN-INHIBITORY HORMONE IN GOLDFISH Habibi, H.R. et al.	EXPOSURE ROUTE PRODUCES DIFFERENT CARDIORESPIRATORY EFFECTS FOLLOWING ACUTE BENZO-A-PYRENE IN ADULT ZEBRAFISH (DANIO RERIO) Weber, L.P.	AEROBIC AND ANAEROBIC METABOLISM IN FISH: GAIT USE, MODELING AND TRADE-OFF Svendsen, J.C. et al.
9:50	INOSITOL METABOLISM AND OSMOREGULATION IN TWO EURYHALINE TELEOSTS, THE EUROPEAN EEL (ANGUILLA ANGUILLA) AND THE NILE TILAPIA (OREOCHROMIS NILOTICUS). Kalujnaia, S. et al.	FISH IN HOT WATER: HAS THE THERMAL PHYSIOLOGY OF NON-NATIVE SPANISH PUMPKINSEED (LEPOMIS GIBBOSUS) RESPONDED TO THE MILD CLIMATE OF ITS INTRODUCED RANGE? Rooke, A.C. et al.	NUCLEOBASE COMPOUNDS AS DIVERSE CHEMOSENSORY STIMULI ACROSS FISH SPECIES Shamchuk, A.L. et al.	NEUROANATOMICAL INSIGHTS INTO SENSORY ABILITIES AND BEHAVIOUR IN ELASMOBRANCHS Collin, S. P. et al.	NEFATIN-1 REGULATION OF GROWTH HORMONE SECRETION IN FISH Unniappan S. et al.	PARENTAL TROPHIC EXPOSURE TO POLYCYCLIC AROMATIC HYDROCARBONS EFFECTS ON METABOLIC AND SWIMMING PERFORMANCE IN DESCENDANTS OF ZEBRAFISH DANIO RERIO Lucas J. et al.	RECUPERATION OF ATLANTIC COD (GADUS MORHUA) FOLLOWING EXHAUSTIVE EXERCISE IN A SWIM TUNNEL – HOW CAN KNOWLEDGE OF SWIMMING PHYSIOLOGY IMPROVE FLESH QUALITY? Svalheim, R.A. et al.
10:10	Refreshment Break						
1030-1230	<i>Ion and Acid-Base Regulation in Fish</i>	<i>Climate Change and Expanding Dead Zones: From the Tropics to the Poles, How Will Fish Adapt?</i>	<i>Sensing the Environment</i>	<i>Physiology of Elasmobranch Fishes</i>	<i>Growth and Metabolism in Fishes</i>	<i>Fish in a Toxic World: Biomarkers and Impacts of Exposure</i>	<i>Swimming Physiology of Fish</i>
<i>Moderator</i>	<i>Colin Brauner</i>	<i>Jay Nelson</i>	<i>Keith Tierney</i>	<i>Pat Wright</i>	<i>Brian Small</i>	<i>Lynn Weber</i>	<i>Josep Planas</i>
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7

10:30	SEAWATER EXPERIENCE ENHANCES HYPO-OSMOTIC REGULATORY ABILITY IN MEDAKA Miyanishi, H. et al.	CARDIORESPIRATORY FUNCTION AND RED MUSCLE PERFORMANCE IN ARCTIC CHARR (<i>Salvelinus alpinus</i>) vs. ATLANTIC SALMON (<i>Salmo salar</i>) AT ELEVATED TEMPERATURES Gamperl, A.K. et al.	TRANSIENT RECEPTOR POTENTIAL CHANNELS (TRP) IN RAINBOW TROUT (<i>Oncorhynchus mykiss</i>): AN INTERFACE BETWEEN THERMAL SENSING AND MELATONIN SECRETION. Nisembaum, L.G. et al.	REPRODUCTIVE ENDOCRINOLOGY IN ELASMOBRANCHS: BASIC AND APPLIED SCIENCE Awruch, C.A. et al.	INTERACTIONS OF NITRIC OXIDE AND CALCIUM SIGNALLING PATHWAYS IN GROWTH HORMONE RELEASE FROM GOLDFISH PITUITARY CELLS Chang J.P. et al.	TREATMENT WITH THE SELECTIVE SEROTONIN REUPTAKE INHIBITOR, FLUOXETINE, INTERFERES WITH THE ABILITY OF TOADFISH TO RESPONSE TO ENVIRONMENTAL HYPOXIA McDonald, M.D. et al.	FORCED SWIMMING IN RAINBOW TROUT DOES NOT CONFER A BIOENERGETIC ADVANTAGE BUT REDUCES THE FRACTION OF PROTEIN OXIDIZED TO FUEL METABOLISM Skov, P.V. et al.
10:50	PROTECTIVE EFFECTS OF DISSOLVED ORGANIC CARBON (DOC) ON NA+ REGULATION AND NITROGENOUS WASTE EXCRETION IN DANIO RERIO EXPOSED TO LOW pH IN SOFT-WATER. Duarte, R.M. et al.	DO ANTARCTIC FISH LIKE IT HOT? WHAT ENERGY ALLOCATION CAN TELL US ABOUT DISTRIBUTION SHIFTS Sandersfeld, T. et al.	PRE-RETINAL DEVELOPMENT OF A NON-VISUAL SYSTEM IN ATLANTIC HALIBUT (<i>HIPPOGLOSSUS HIPPOGLOSSUS</i>) Eilertsen, M. et al.	THE EPIGONAL ORGAN AND MATURE POLE OF THE TESTIS IN THE RECREATIONALLY FISHED BLUE SHARK (<i>PRIONACE GLAUCA</i>): HISTOCHEMICO-FUNCTIONAL CORRELATES McClusky, L.M. et al.	NUTRIENT SENSING IN FISH: INVOLVEMENT IN THE REGULATION OF FOOD INTAKE AND ENERGY METABOLISM Soengas, J.L.	INHIBITION OF P-GLYCOPROTEIN IN THE BLOOD-BRAIN BARRIER OF TROUT ALTERS AVERMECTIN NEUROTOXICITY AND SWIMMING PERFORMANCE Kennedy, C.J. et al.	FORCED SUSTAINED SWIMMING EXERCISE AT OPTIMAL SPEED TO ENHANCE GROWTH PERFORMANCE OF YELLOWTAIL KINGFISH (<i>SERIOLA LALANDI</i>) Mes, D. et al.
11:10	CHARACTERIZATION OF SODIUM UPTAKE DURING DEVELOPING RAINBOW TROUT EMBRYOS Blair, S.D. et al.	FIT FOR THE FUTURE: MITOCHONDRIAL PLASTICITY FORMS THE BASIS FOR AEROBIC PERFORMANCE IN A CHANGING CLIMATE Mark, F. C.	DEVELOPMENT OF A VISUAL SYSTEM IN ATLANTIC COD Valen, R. et al.	IMMUNE FUNCTIONING IN CARTILAGINOUS FISHES Dooley, H.	CHARACTERISATION AND GENE EXPRESSION ANALYSIS OF CALPAINS, CATHEPSINS AND UBIQUITIN-PROTEASOME MEMBERS IN GILTHEAD SEA BREAM SKELETAL MUSCLE Salmeron, C. et al.	DEVELOPMENTAL EFFECTS OF A SYNTHETIC GLUCOCORTICOID DURING EMBRYOGENESIS IN ZEBRAFISH McNeil, P.L. et al.	IS THE SALMONID ADIPOSE FIN A MECHANOSENSORY ORGAN? Buckland-Nicks, J. et al.
11:30	CLONING OF SLC26A6, A PROPOSED CL-/HCO3-EXCHANGER IN RAINBOW TROUT, AND CHARACTERISATION OF CHLORIDE ACQUISITION IN FISH DURING EARLY RAINBOW TROUT DEVELOPMENT Clifford, A.M. et al.	LINKS BETWEEN METABOLIC TRAITS AND LATITUDINAL DISTRIBUTION ACROSS FISH SPECIES Nati J.J.H. et al.	CONE PHOTORECEPTOR DEATH & REGENERATION DURING ONTOGENY, AS MODELED IN ZEBRAFISH Allison, W.T.	ARE POLAR SEAS PARTICULARLY UNINVITING TO ELASMOBRANCHS? Treberg, J.R. et al.	TWO INSULIN-LIKE GROWTH FACTOR BINDING PROTEIN (IGFBP)-1 SUBTYPES AS NEGATIVE GROWTH INDICES IN SALMON Shimizu, M. et al.	GENERATIONAL EFFECTS OF BISPHENOL A ON SOMATOTROPIC AND STRESS AXES FUNCTION IN RAINBOW TROUT Vijayan, M.M. et al.	WHY ARE SCULPIN SUSCEPTIBLE TO THE EFFECTS OF ARTIFICIAL STRUCTURES?— PROPOSED METHOD OF IMPROVEMENT BASED ON THE SWIMMING BEHAVIOR Muraoka, K. et al.

11:50	CL- UPTAKE MECHANISM IN NCC- EXPRESSING IONOCYTES IN ZEBRAFISH Wang, Y.F. et al.	IMPACTS OF CO2-ACIDIFIED SEAWATER ON THE PHYSIOLOGICAL PERFORMANCE OF A JUVENILE ANTARCTIC FISH Todgham, A.E. et al.	SPECTRAL TUNING IN DEEP-SEA MYCTOPHIDS: A NOVEL AND UNIQUE VISUAL ADAPTATION de Busserolles, F. et al.	PHOSPHATE BALANCE IN THE CHOROID PLEXUS OF SHARKS S. ACANTHIAS AND M. CANIS: A ROLE FOR PiT TRANSPORTERS AND PTHRp IN A CENTRALLY REGULATED RENAL-GASTROINTESTINAL AXIS? Guerreiro, P.M. et al.	APPETITE GENE REGULATION IN GROWTH HORMONE TRANSGENIC COHO SALMON Kim, J.H. et al.	DROSPIRENONE EFFECTS IN HEPATIC METABOLISM AND GONADAL GENE EXPRESSION IN EUROPEAN SEA BASS (DICENTRARCHUS LABRAX) Blanco, M. et al.	ACCOMMODATING THE COST OF SWIMMING - THE APPLICABILITY OF EXERCISE-INDUCED GROWTH IN A NOVEL FINFISH AQUACULTURE SPECIES, THE HAPUKU (POLYPRION OXYGENEIOS) Khan, J.R. et al.
12:10	ACID-SENSING ION CHANNELS (ASICS) ARE INVOLVED IN EPITHELIAL SODIUM UPTAKE IN RAINBOW TROUT Dymowska, A.K. et al.	OCEAN ACIDIFICATION STIMULATES RESPIRATORY PLASTICITY IN THE ESTUARINE RED DRUM, SCIAENOPS OCELLATUS. Esbaugh, A.J. et al.		DEVELOPING A FIELD APPROACH FOR EXAMINING ELASMOBRANCH FEEDING ECOLOGY Semmens, J.M. et al.	CHARACTERIZATION OF SCAPHIRHYNCHUS STURGEON INSULIN-LIKE GROWTH FACTORS Small, B.C. et al.	HOW DO XENOBIOTICA BIOTRANSFORMATION RATES IN ANTARCTIC NOTOTHENIOID FISH COMPARE TO TEMPERATE SPECIES? Strobel, A. et al.	
12:30	Lunch Break						
1330-1530	<i>Ion and Acid-Base Regulation in Fish</i>	<i>Climate Change and Expanding Dead Zones: From the Tropics to the Poles, How Will Fish Adapt?</i>	<i>Sensing the Environment</i>	<i>Physiology of Elasmobranch Fishes</i>	<i>Growth and Metabolism in Fishes</i>	<i>Fish in a Toxic World: Biomarkers and Impacts of Exposure</i>	<i>FITFISH</i>
Moderator	<i>Greg Goss</i>	<i>Dal Val</i>	<i>Keith Tierney</i>	<i>Suzie Currie</i>	<i>Brian Small</i>	<i>Tyson MacCormack</i>	<i>Arjan Palstra</i>
Location	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7
13:30	POTASSIUM EXCRETION VIA ROMKA POTASSIUM CHANNEL EXPRESSED IN THE GILL IONOCYTES OF MOZAMBIQUE TILAPIA Furukawa, F. et al.	ADAPTATION TO OCEAN ACIDIFICATION OF A TEMPERATE FISH, DICENTRARCHUS LABRAX Crespel, A.	PASSIVE MONITORING OF ROUND GOBY ACOUSTIC ECOLOGY AND THE INFLUENCE OF ANTHROPOGENIC NOISE. Higgs, D.M. et al.	THE EFFECTS OF ECOLOGICAL OSMOTIC CHALLENGES ON THE METABOLISM OF AN ESTUARINE ASSEMBLAGE OF SHARKS Morash, A.J. et al.	NUTRIENT SENSING SYSTEMS ON REGULATION OF FOOD INTAKE AND GROWTH IN CHANNEL CATFISH Kobayashi, Y. et al.	DOES OCEAN ACIDIFICATION REDUCE COPPER-INDUCED DNA DAMAGE IN MARINE FISH AND CRUSTACEANS? Newbatt, S.J. et al.	COST ACTION FA1304: SWIMMING OF FISH AND IMPLICATIONS FOR MIGRATION AND AQUACULTURE (FITFISH) Palstra, A.P., and Planas, J.V.
13:50	EURYHALINE AND EURYTHERMIC FISH: REGULATION OF ION TRANSPORT IN THE COLD Marshall, W.S. et al.	HEART PERFORMANCE UNDERLIES HYPOXIA TOLERANCE IN EUROPEAN SEA BASS Ozolina, K. et al.	PROTECTION FROM CADMIUM-INDUCED OLFACTORY DYSFUNCTION BY SPECIFIC METALS IN RAINBOW TROUT (ONCORHYNCHUS MYKISS) Dew, W.A.	ROLES OF CHEMICAL AND MOLECULAR CHAPERONES WITH HYPO-OSMOTIC STRESS IN AN ESTUARINE ASSEMBLAGE OF ANCIENT FISHES Currie, S. et al.	TRACKING SEASONAL CHANGES IN CENTRAL GENE EXPRESSION OF APPETITE REGULATORS IN ANADROMOUS ARCTIC CHARR (SALVELINUS	INVESTIGATION INTO GENETIC DIVERSITY OF PERCH WITHIN THE CONTEXT OF NPP ACTIVITY Ragauskas A. et al.	SWIMMING-INDUCED MODULATION OF THE SKELETAL MUSCLE TRANSCRIPTOME IN RAINBOW TROUT Planas, J.V. et al.

			et al.		ALPINUS) Striberny, A. et al.		
14:10	IMMUNOLocalization of RHCg1, RHCg2, RHBg and NHE3B in the Gill Ionocytes of Rainbow Trout Hiroi, J.	INTRASPECIFIC VARIATION IN LOCOMOTOR EFFICIENCY, HYPOXIA TOLERANCE AND ECOLOGICAL PERFORMANCE IN EUROPEAN SEA BASS: IMPLICATIONS FOR AN INCREASINGLY HYPOXIC WORLD Nelson, J.A. et al.	INHERITED MAGNETIC OCEAN NAVIGATION IN JUVENILE PACIFIC SALMON Noakes, D.L.G. et al.	THE RESPONSES OF THE DOGFISH SHARK (SQUALUS ACANTHIAS SUCKLEYI) TO HIGH ENVIRONMENTAL AMMONIA Nawata, C.M. et al.	FASTING AND REFEEDING AFFECTS PLASMA LEPTIN IN RAINBOW TROUT Johansson, M. et al.	ZNO NANOPARTICLES DISRUPT THE PHYSIOLOGICAL STRESS RESPONSE IN WHITE SUCKER, CATOSTOMUS COMERSONII MacCormack, T.J. et al.	FOOD AVAILABILITY AND ENVIRONMENT ALTER SWIMMING CAPACITIES IN FRESHWATER FISH De Boeck, G. et al.
14:30	EFFECTS OF AMMONIA OR TERRESTRIAL EXPOSURE ON THE EXPRESSION OF RHESUS GLYCOPROTEINS IN THE GILLS OF THE CLIMBING PERCH, ANABAS TESTUDINEUS Chen, X.L. et al.	LOCALIZED EXTREME HYPOXIA AND PHENOTYPIC DIVERGENCE Chapman, L.J. et al.	OLFACTORY DISCRIMINATING ABILITY OF ADULT CHUM SALMON TOWARDS NATAL TRIBUTARY STREAMS Okubo, T. et al.	DOES AMMONIA TRIGGER VENTILATION IN ELASMOBRANCHS? De Boeck, G. et al.	OREXIN A ENHANCES FOOD INTAKE AND LOCOMOTOR ACTIVITY, AND EXERTS ANXIOTIC-LIKE ACTION Matsuda, K. et al.	THE EFFECT OF SALINITY ON THE MECHANISMS OF NI TOXICITY IN THE EURYHALINE ATLANTIC KILLIFISH Blewett T.A. et al.	THE MIGRATION BEHAVIOUR OF EUROPEAN SILVER EELS (ANGUILLA ANGUILLA) RELEASED IN OPEN OCEAN CONDITIONS Hanel, R. et al.
14:50	ZEBRAFISH (Danio rerio) AQUAPORIN 1a IS A MULTI-FUNCTIONAL WATER, CO2 AND NH3 CHANNEL Gilmour, K.M. et al.	BEHAVIORAL RESPONSES OF JUVENILE ESTUARINE FISHES TO DIEL-CYCLING HYPOXIA AND PH DIXON, R.L. et al.	THE MOLECULAR BASIS OF PARR-SMOLT TRANSFORMATION IN ATLANTIC SALMON (SALMO SALAR) Lorgen, M. et al.	THE ROLE OF RHESUS GLYCOPROTEINS IN AMMONIA BALANCE IN DOGFISH SHARK (SQUALUS ACANTHIAS) IN RESPONSE TO HYPO-OSMOTIC STRESS Wright, P.A. et al.	EFFECTS OF PHYTOESTROGENS ON EXPRESSION OF GENES REGULATING GROWTH-RELATED PROCESSES IN RAINBOW TROUT Cleveland, B.M. et al.	MOLECULAR MECHANISMS UNDERLYING CADMIUM-COPPER AND COPPER-LEAD INTERACTIONS IN GILLS OF ZEBRAFISH DANIO RERIO Komjarova, I. et al.	SWIMMING DEPTH OF ATLANTIC SALMON (Salmo salar L.) DURING SEA MIGRATION Sturlaugsson, J.

15:10	AQUAPORIN EXPRESSION IN THE JAPANESE MEDAKA (ORYZIAS LATIPES) IN FW AND SW: CHALLENGING THE PARADIGM OF INTESTINAL WATER TRANSPORT. Madsen, S.S. et al.	INTERACTIVE EFFECTS OF TEMPERATURE AND OVERNIGHT HYPOXIA ACCLIMATIONS ON THERMAL AND HYPOXIA TOLERANCE OF ARCTIC CHAR AND ATLANTIC SALMON; CONNECTION TO DIFFERENCES AT OXYGEN SUPPLY SYSTEM Anttila, K. et al.	INNATE AND LEARNED PREFERENCES FOR NATURAL STREAM VS. GROUND WATER IN SALMONIDS Dittman, A.H. et al.	A FUNCTIONAL SHIFT OF UREA-PRODUCING SITE FROM EXTRAEMBRYONIC YOLK SAC TO LIVER IN THE DEVELOPING EMBRYOS OF TWO OVIPAROUS CARTILAGINOUS FISHES Takagi, W. et al.	INCLUSION OF SOYBEAN MEAL IN ATLANTIC SALMON (SALMO SALAR L.) DIETS IS ASSOCIATED WITH THE PRODUCTION OF INFLAMMATORY MARKERS DETECTABLE IN FISH FECES Wacyk, J. et al.	MERCURY CONCENTRATIONS AND TRENDS IN AFRICAN INLAND WATERS Hanna, D.E.L. et al.	DIFFERENT POSSIBILITIES FOR TRACKING STURGEON MIGRATION AND HABITAT MAPPING IN THE DANUBE RIVER Lenhardt, M. et al.
15:30	Refreshment Break						
15:50 - 18:50	Ion and Acid-Base Regulation in Fish		Sensing the Environment	Physiology of Elasmobranch Fishes	Growth and Metabolism in Fishes	Fish in a Toxic World: Biomarkers and Impacts of Exposure	FITFISH
Moderator	Greg Goss		Keith Tierney	Gary Anderson	Brian Small	Tyson MacCormack	Arjan Palstra
Location	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	Room 7
15:50	DISCOVERY OF TRANSCRIPTION FACTORS FOR SEAWATER ACCLIMATION IN FISH INTESTINE VIA A TRANSCRIPTOMIC APPROACH Wong M.K.S. et al.		PROTECTION OF FISH OLFACTION AGAINST COPPER INDUCED IMPAIRMENT Azizishirazi, A. et al.	IDENTIFICATION AND EXPRESSION OF ELASMOBRANCH GLUCOSE TRANSPORTERS Deck, C.A. et al.	PHYSIOLOGICAL AND MOLECULAR CHANGES IN RAINBOW TROUT IN RESPONSE TO DIETARY SOURCES Overturf, K.	IMPACT OF METHYLMERCURY ON MIGRATORY BEHAVIOUR IN GLASS EEL (ANGUILLA ANGUILLA): AN EXPERIMENTAL STUDY Claveau, J. et al.	MODERATE PASSAGE EFFICACY, MIGRATORY DELAY AND PHENOTYPIC SELECTIVITY ASSOCIATED WITH A NATURE-LIKE FISHWAY: HOW IMPORTANT IS FISH SWIMMING PERFORMANCE? Svendsen, J.C. et al.
16:10	EXPRESSION PROFILING OF KEY ION TRANSPORTERS AND AQUAPORINS IN THE GILL AND ESOPHAGEAL-GASTROINTESTINAL TRACT OF EURYHALINE MOZAMBIQUE TILAPIA OREOCHROMIS MOSSAMBICUS IN FRESHWATER, SEAWATER AND HYPERSALINE WATER.			THE ROLE OF 1-ALPHA-HYDROXYCORTICOSTERONE IN THE ENDOCRINE STRESS RESPONSE OF ELASMOBRANCHS Lambert, F.N. et al.	ROLE OF LIPIDS IN POSTLARVAL DEVELOPMENT OF THE ARCTIC FISH LEPTOCLINUS MACULATUS DURING POLAR NIGHT IN SVALBARD Pekkoeva, S.N. et al.	MECHANISMS OF DEVELOPMENTAL TOXICITY IN ZEBRAFISH EXPOSED TO SELENIUM Janz, D.M. et al.	DOES REGIONAL STREAMFLOW VARIABILITY INFLUENCES SWIMMING PERFORMANCE OF FRESHWATER FISH? Quintella, B.R. et al.

	Lam, S.H. et al.						
16:30	NUTRIENT ABSORPTION IN THE ATLANTIC SALMON (SALMO SALAR L.) INTESTINE IS AFFECTED BY ENVIRONMENTAL SALINITY Sundh, H. et al.			BIOSYNTHESIS OF 1ALPHA-HYDROXYCORTICOSTERONE IN LEUCORAJA OCELLATA EVIDENCE TO SUGGEST A NOVEL STEROIDOGENIC ROUTE Wiens, J.K. et al.	THE EFFECT OF MODULATING RATION AND DIETARY LIPID ON GROWTH, SMOLTING, AND EARLY MALE MATURATION IN YEARLING UMATILLA RIVER FALL CHINOOK SALMON Larsen, D.L. et al.	DETERMINATION OF DIFFERENTIAL METAL AND METALLOIDS ACCUMULATION IN GILL, KIDNEY, HEPATOPANCREAS AND MUSCLE AND BIOMARKERS RESPONSE IN CENTROPOMUS PARALLELUS IN NEOTROPICAL ESTUARIES Souza, I.C. et al.	Discussion
16:50	INTESTINAL FLUID ABSORPTION BY MARINE TELEOSTS AFFECTS ACID-BASE BALANCE Grosell, M. et al.			ISOLATION OF A CYP11-LIKE MRNA FROM ELASMOBRANCH INTERRENAL TISSUE: THE KEY TO 1ALPHA-HYDROXYCORTICOSTERONE SYNTHESIS? Evans, A.N.	EFFECTS OF A PHYTOGENIC FEED ADDITIVE ON GROWTH AND SUSCEPTIBILITY OF CHANNEL CATFISH TO EDWARDSIELLA ICTALURI AND LEVELS OF MANNOSE AND RHAMNOSE BINDING LECTIN Peterson, B.C. et al.	LETHAL AND SUB LETHAL TOXICITY OF NITRATES AND PHOSPHATES IN THE ENDEMIC FISH SKIFFIA MULTIPUNCTATA AND GOODEA ATRIPINNIS Rueda-Jasso R.A. et al.	
17:10	GAS TRANSPORT, ACID-BASE AND ION REGULATION IN THE AIR-BREATHING FISH ANABAS TESTUDINEUS Bloch Peter, M.C.S. et al.				EFFECTS OF PROBIOTICS ON FISH LARVAL DEVELOPMENT Carnevali, O.		
17:30					SERUM BIOCHEMICAL CHANGES IN ALLOXAN-DIABETIC TILAPIA DURING INFECTIOUS AEROCISTITE Belo, M. A. A. et al.		

17:50					AEROBIC METABOLISM, GROWTH AND REPRODUCTION IN THE SHORT-LIVE NOTHOBRANCHIUS FURZERI: INFLUENCE OF AGEING AND TEMPERATURE Durolet M.v		
18:10	<i>End of Session</i>						
18:10 - 23:30	<i>Congress Banquet Dinner at Gosford House</i>						
Thursday, August 7, 2014							
0830-1010	<i>Ion and Acid-Base Regulation in Fish</i>	<i>Physiological Genomics</i>	<i>Parasites and Diseases of Fish</i>	<i>Intrinsic and Extrinsic Regulation of Fish Cardiovascular Function</i>	<i>General Contributed Papers</i>	<i>Winter Fish Biology: the Dynamic World of Icy Rivers</i>	
<i>Moderator</i>	<i>Steve McCormick</i>	<i>Avner Cnaani</i>	<i>Alastair Lyndon</i>	<i>Kurt Gamperl</i>	<i>Don MacKinlay</i>	<i>Jill Leonard</i>	
<i>Location</i>	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6	
8:30	Symposium will start at 8:50	INTRODUCTION TO THE PHYSIOLOGICAL GENOMICS SYMPOSIUM Elena Sarropoulou	AEROMONAS SALMONICIDA PROLIFERATION AND QUORUM SENSING IN RESPONSE TO MUCINS ISOLATED FROM ATLANTIC SALMON SKIN AND INTESTINE Padra, J.T. et al.	BENEFITS AND LIMITATIONS OF USING MAXIMUM HEART RATE TO ESTIMATE UPPER TEMPERATURE LIMITS OF FISH Anttila, K. et al.	A GRAPH BASED APPROACH TO ENHANCE FUNCTIONAL CONNECTIVITY OF FRAGMENTED SYSTEMS Branco, P. et al.	STABILITY OF SALMONID INCUBATION ENVIRONMENTS DURING WINTER IN SNOW-DOMINATED INTERIOR WATERSHEDS Shrimpton, J.M. et al.	
8:50	RESPIRATORY RESPONSES AND GUT CARBONATE PRODUCTION DURING HYPOXIA AND HYPERCARBIA IN THE EUROPEAN FLOUNDER (PLATICHTHYS FLESUS) Rogers, N.J. et al.	DEVELOPING SPECIES-SPECIFIC MARKERS IN TILAPIA BASED ON RESTRICTION ASSOCIATED DNA SEQUENCING (RAD-Seq) AND ADENOSINE DEAMINASE (ADA) Syaifudin M., et al.	AEROMONAS SALMONICIDA SSP. SALMONICIDA BINDS DIFFERENTIALLY TO MUCINS ISOLATED FROM SKIN AND INTESTINAL ORGANS OF ATLANTIC SALMON IN AN N-ACETYLNEURAMINI	CARDIAC OXYGEN LIMITATION DURING AN ACUTE TEMPERATURE CHALLENGE IN THE EUROPEAN PERCH, PERCA FLUVIATILIS: IMPLICATIONS OF THERMAL ACCLIMATION AND AMBIENT HYPEROXIA Ekström, A.B. et al.	PELAGIC LARVAL DURATION, SIZE AT SETTLEMENT AND COASTAL RECRUITMENT OF LIOPHRYS PHOLIS AS REVEALED FROM OTOLITH MICROSTRUCTURE Carvalho, M.G. et al.	MODELING OF ENVIRONMENTAL FLOW OPTIONS FOR OPTIMAL ATLANTIC SALMON (SALMO SALAR) EMBRYO SURVIVAL DURING WINTER IN A HYDROPEAKING RIVER Casas-Mulet R. et al.	

			C ACID DEPENDENT MANNER Lindén, S.K. et al.			
9:10	THE EFFECTS ON INTESTINAL PHYSIOLOGY BY THE GUANYLIN PEPTIDES OF GULF TOADFISH (OPSANUS BETA) EXPOSED TO HYPERSALINITY AND HYPERCAPNIA Ruhr, I.M. et al.	DIFFERENTIAL GENE EXPRESSION AND TRANSCRIPTOME CHARACTERIZATION IN EUROPEAN SEA BASS (DICENTRARCHUS LABRAX) LARVAL STAGES Kaitetzidou, E. et al.	DOES GROWING GREY SEAL POPULATION IN THE BALTIC IMPACT ON INCREASING THE PREVALENCE OF INFECTION WITH ANISAKID LARVAE IN COD? NadoIna, K. et al.	EFFECTS OF LOMA MORHUA (MICROSPORIDIA) INFECTION ON THE CARDIORESPIRATORY AND SWIMMING PERFORMANCE OF ATLANTIC COD GADUS MORHUA (L). Powell, M.D. et al.	OVARIAN MORPHOLOGY OF ASTYANAX ALTIPTARANAE (TELEOSTEI, CHARACIDAE): MACROSCOPIC, MICROSCOPIC, AND ULTRASTRUCTURAL CHARACTERS Cassel, M. et al.	THE EFFECT OF NEAR FREEZING TEMPERATURES ON DEVELOPMENT OF COHO SALMON DURING INCUBATION Tuor, K.M.F et al.
9:30	INFLUENCE OF HYPERCAPNIA ON INTESTINAL TRANSPORT AND CALCIUM CARBONATE FORMATION IN THE GULF TOADFISH (OPSANUS BETA) Heuer, R.M. et al.	PHYSIOLOGICAL RESPONSES TO HIGH WATER TEMPERATURE IN TWO THREATENED CALIFORNIA FISHES Jeffries, K.M. et al.	NON MAMMALIAN PATTERN RECOGNITION RECEPTOR FROM ROCK BREEM (OPLEGNATHUS FASCIATUS): GENOMIC CHARACTERIZATION AND TRANSCRIPTIONAL PROFILE UPON BACTERIAL AND VIRAL INDUCTIONS Thantrige, T.P. et al.	THE TEMPERATURE DEPENDENT CARDIAC REMODELING RESPONSE IN RAINBOW TROUT Keen, A.N. et al.	SEASONAL VARIATION IN BREEDING SUCCESS IN TWO-SPOTTED GOBIES de Jong, K. et al.	FACTORS CONTRIBUTING TO THE OVERWINTER SUCCESS OF YOUNG-OF-THE-YEAR BROOK TROUT (SALVELINUS FONTINALIS) Wagner, J.C. et al.
9:50	IMPACT OF FRESHWATER CHEMISTRY ON POST-FEEDING ACID-BASE REGULATION AND RESPIRATORY FUNCTION IN RAINBOW TROUT Urbina, M.A. et al.	TRANSCRIPTOMIC DIFFERENCES IN THE GILLS OF EURYHALINE MOZAMBIQUE TILAPIA OREOCHROMIS MOSSAMBICUS IN HYPO- AND HYPER-OSMOTIC STRESS. Lam, S.H. et al.		MORPHOLOGICAL CARDIAC REMODELING AND ANAEMIA IN MARINE FISHES. Powell, M.D. et al.	SEXY MALES IN MUDDY WATER? PHENOTYPIC DIVERGENCE IN AN AFRICAN CICHLID Gary, S.M. et al.	ACUTE AND CHRONIC ADJUSTMENTS OF INTRINSIC TISSUE METABOLIC RATE PLAY IMPORTANT ROLES IN THE INITIATION AND MAINTENANCE OF WINTER DORMANCY IN THE TEMPERATE WRASSE TAUTOGOLABRUS ADSPERSUS Speers-Roesch, B. et al.
10:10	Refreshment Break					

1030-1230	<i>Ion and Acid-Base Regulation in Fish</i>	<i>Physiological Genomics</i>		<i>Intrinsic and Extrinsic Regulation of Fish Cardiovascular Function</i>	<i>General Contributed Papers</i>	<i>Winter Fish Biology: the Dynamic World of Icy Rivers</i>
<i>Moderator</i>	<i>Steve McCormick</i>	<i>Elena Sarropoulou</i>		<i>Ben Speers-Roesch</i>	<i>Don MacKinlay</i>	<i>Jill Leonard</i>
<i>Location</i>	Room 1	Room 2		Room 4	Room 5	Room 6
10:30	RED CELL pH REGULATION DURING THE POST-FEEDING ALKALINE TIDE Wilson, R.W. et al.	TILAPIA'S SALINITY ADAPTATION – FROM COMPARATIVE TRANSCRIPTOME ANALYSIS TO NOVEL GENES CHARACTERIZATION Cnaani, A. et al.		ELECTRICAL ACTIVATION AND REPOLARIZATION SEQUENCE IN THE RAINBOW TROUT HEART Shiels, H. et al.	LAKE NIPISSING AND LAKE ONTARIO WALLEYE: SIMILARITIES AND DIFFERENCES IN PROVISION OF FATTY ACIDS TO OVA Wiegand, M.D. et al.	EFFECTS OF ICE COVER ON THE BEHAVIOUR AND GROWTH OF BROWN TROUT Watz, J. et al.
10:50	TRANSLOCATION OF VHA AND PENDRIN IN SHARK GILLS: A MECHANISM FOR ACID/BASE REGULATION Roa, J.N. et al.	META-ANALYSIS OF TISSUE TRANSCRIPTOMES IN STUDIES INVESTIGATING SUBSTITUTION OF DIETARY FISHMEAL WITH PLANT PROTEINS IN ATLANTIC SALMON De Santis, C. et al.		THE EFFECTS OF ACUTE ANOXIA ON THE SODIUM CURRENT OF ISOLATED VENTRICULAR MYOCYTES OF THE RAINBOW TROUT. Hardy, M.E.L. et al.	EVOLUTION OF MELATONIN BIOSYNTHESIS: A 500 MY-OLD STORY Magnanou, E. et al.	LINKING WINTER HABITAT VARIABLES TO FISH CONDITION IN ICE COVERED STREAMS Leonard, J.B.K. et al.
11:10	OSMOREGULATION AND ACID-BASE BALANCE IN WHITE STURGEON (ACIPENSER TRANSMONTANUS) DURING EXPOSURE TO ELEVATED SALINITY AND AQUATIC HYPERCARBIA Shaughnessy, C.A. et al.	CHARACTERIZATION OF THE PROTEINACEOUS MATRIX ASSOCIATED WITH INTESTINAL CALCIUM CARBONATE PRECIPITATES USING MASS SPECTROMETRY Schauer, K.L. et al.		NEFATIN-1 REGULATION OF CARDIOVASCULAR FUNCTIONS IN ZEBRAFISH Nair, N. et al.	LIGHT TO DARK: INVESTIGATING NOVEL PATHWAYS LINKING PHOTOPERIODIC CUES TO THE BRAIN-PITUITARY-GONAD AXIS IN ATLANTIC COD Doyle, A. et al.	NON-NATIVE PUMPKINSEED (LEPOMIS GIBBOSUS) INHABITING THE IBERIAN PENINSULA (SPAIN) HAVE LOST THEIR ANCESTRAL TOLERANCE TO NORTHERN NORTH AMERICAN WINTER CONDITIONS Rooke, A.C. et al.
11:30	GLOBAL CHANGE: CAN MINOR HYPERCAPNIA HAVE MAJOR CONSEQUENCES? Nilsson, G.E.	CHARACTERIZATION OF PEPTIDE TRANSPORTER SYSTEMS IN THE INTESTINE OF MOZAMBIQUE TILAPIA (OREOCHROMIS MOSSAMBICUS) Rozenberg, P. et al.				IMPACTS OF ICE FORMATION AND REGULATED FLOW ON JUVENILE ATLANTIC SALMON Alfredsen, K. et al.

11:50	CO2-INDUCED OCEAN ACIDIFICATION CAN INCREASE ANXIETY IN COASTAL CALIFORNIAN ROCKFISH, SEBASTES DIPLOPROA Hamilton, T. et al.	IDENTIFICATION OF GENE PATHWAYS INVOLVED IN DIFFERENTIAL GROWTH OF HYBRID STRIPED BASS USING TRANSCRIPTOMICS Fuller, S.A. et al.				
12:10	THE EFFECTS OF AQUATIC ACIDIFICATION ON GROWTH, DEVELOPMENT, AND OLFACTORY AND BEHAVIORAL RESPONSES OF EARLY LIFE STAGES OF PINK SALMON, ONCORHYNCHUS GORBUSCHA Brauner, C.J. et al.					
12:30	<i>Lunch Break</i>					
13:30 - 14:30	<i>Business Meeting & Closing Session</i>					
13:30	Student Travel Awards					
13:50	Best Paper Awards					
14:00	Physiology Section Business Meeting					
14:30	Next Congress Presentation					
14:45	Closing Remarks					
15:00	Adjourn					

List of Posters:

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5th International Symposium on Burbot (*Lota lota*)

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Airbreathing Fish - in Nature and Aquaculture

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ACCUMULATIONS OF CADMIUM IN SOME TISSUES, HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS IN OREOCHROMIS NILOTICUS, EXPOSED TO LONG TERM VARIOUS CONCENTRATION OF CADMIUM CHLORIDE

Abdel-Warith, A.A., Younis, E.M., Al-Asgah, N.A., and Allam, H.Y.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P35

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Abstract: *Oreochromis niloticus*, weighing 36.45 ± 1.12 g were divided into four groups first one unexposed fish and other three groups exposed to 10, 20 and 30% of LC50 cadmium chloride CdCl₂ to investigate the effects of exposure periods and concentrations of Cd on tissues and haematological and biochemical. Gill Cd accumulations was significantly increased in samples ranged between 7.64 ± 0.86 to $61.73 \pm 0.82 \mu\text{g/g}$ dry weight from lower concentration at 10 days to higher concentration at 30 days compared to control group $0.19 \pm 0.03 \mu\text{g/g}$ dry weight. In the same trend accumulation of Cd in liver and muscles observed significant increased by increasing time and doses. RBCs, Hb and Hct were reduced in fish exposed to Cd at all periods and they were lower than that of the control with significant differences. Plasma glucose concentration showed higher significant values increased. TP level of fish cadmium reflects significant reduction. TL of fish observed that increased cadmium concentrations led to significant increase in total lipids. Activities of AST and ALT were significant changes in plasma of *O. niloticus*.

EFFECTS OF SELECTED POLLUTANTS ON THE GROWTH AND SURVIVAL OF CLARIAS GARIEPINUS

Abidemi-Iromini, A.O., and Kusemiju, K.

Symposium: Stress in Fish **Type:** Oral **Order:** 31

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Abstract: Spent engine oil, NPK fertilizer (15:15:15) and sewage effluent pollutants on growth/survival of juvenile *Clarias gariepinus* catfish fed 5% body weight floating feed were investigated. Temperature (OC), pH and dissolved oxygen (mg/l), mortality and growth rate were monitored. 35% mortality occurred in NPK and 15% mortality in control tanks. Specimens in control and NPK tanks survived experimental period (70 days) with highest mean weight: control tank (51.9g) and length (9.6cm); NPK specimen had mean weight 35.0g and length 8.4cm. Condition factor 'K' in control tank and NPK tank were: 0.98 and 0.93. Food Conversion Ratio of control and NPK tanks were: 2.00 and 1.51. Food Conversion Efficiency in control and NPK tanks were: 50.11% and 66.35%. Specific growth rate in control tank was 1.47% per day, and NPK was 1.29% per day. No significant difference occurred in growth/survival rate of surviving specimens.

FOOD AND FEEDING HABITS OF TILAPIA ZILLII AND CHRYSICHTYS NIGRODIGITATUS IN OGUN RIVER

Adeosun, F.I.

Symposium: General Contributed Papers **Type:** Oral **Order:** 12

Contact: Adeosun Festus Idowu **E-mail:** adeosunfi@yahoo.com

Federal University of Agriculture Abeokuta. Ogun State Nigeria

Abstract: This paper provides information on the diets of *Tilapia zilli* and *Chrysichthys nigrodigitatus* in Ogun River. Fish species were procured from fishermen every fortnight using gill nets, cast nets and specimens were transported to the laboratory. 150 fish specimens of each species were examined and their stomach and gut contents were analyzed. Frequency of occurrence and numerical methods were employed in this study. In *T. zilli*, the result of the analysis showed that *Spirogyra* formed the main bulk of food consumed. *Nymphaea*, *Pithophora* and *Cornospogon* occurred frequently while *Pistia detritus* and plant remains featured less frequently while in *C. nigrodigitatus* the food organisms consisted of phytoplankton, crustaceans, molluscs, plant materials and fish parts. Variation in the frequency of occurrence of the various food items was observed. On the basis of food items found in the gut, *T. zilli* was classified as primary consumers.

ESTIMATING LINKS BETWEEN RESTING METABOLIC RATE AND BEHAVIOUR AT THE BETWEEN-INDIVIDUAL LEVEL

Adriaenssens, B. and Biro, P. A.

Symposium: Environmental Change **Type:** Oral **Order:** 7
Contact: Bart Adriaenssens **E-mail:** Bart.Adriaenssens@glasgow.ac.uk
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Abstract: Consistent individual differences in energy metabolism have been proposed to promote the occurrence of individual differences in behaviour, or animal personality. Metabolism and behaviour are however traits that also show considerable variation within individuals, both through time and in response to environmental factors. Scores of behaviour and metabolism could therefore show either labile correlations driven by short-time adjustments of both traits in concert, or more stable links caused by permanent environmental effects or genetic correlations (i.e. within- versus between-individual correlations). I will present data from repeated scores of resting metabolic rate (RMR) and behaviour in mosquitofish (*Gambusia holbrooki*). During my talk I will discuss (1) the consistency of both traits and (2) to which extent behaviour and RMR are consistently linked at the between-individual level. The results will be discussed in relation to existing hypotheses about the links between RMR and behavioural variation.

IMPACTS OF ICE FORMATION AND REGULATED FLOW ON JUVENILE ATLANTIC SALMON

Alfredsen, K. and Stickler, M.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 8
Contact: Knut Alfredsen **E-mail:** knut.alfredsen@ntnu.no
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Abstract: In the Norwegian high head hydropower system, regulated rivers can provide a winter environment that is completely different from a natural river. Release of water from deep reservoirs alter winter temperature and thereby the ice formation regime. Fish responses to the formation of ice have been studied in some rivers, but relatively few studies exist in rivers heavily influenced from hydropower production. This study builds on a 14-day radio telemetry study in the river Orkla in a period with very variable ice formation. Previously, Stickler et al. (2007) analysed behaviour of a group of permanently monitored fish collected during the same experiment. In this study we add analysed all fish tracked over the entire period with a focus on movements, diurnal patterns and ice induced behaviour. The results show behaviour that contrast previous findings in non-regulated rivers, particularly related to timing and length of movements. Results from this project are relevant for management and planning of winter operation of hydropower plants.

CONE PHOTORECEPTOR DEATH AND REGENERATION DURING ONTOGENY, AS MODELED IN ZEBRAFISH

Allison, W.T.

Symposium: Sensing the Environment **Type:** Oral **Order:** 10
Contact: W. Ted Allison **E-mail:** ted.allison@ualberta.ca
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Abstract: Like many fish, Salmonid retinas integrate ultraviolet sensitive (UV) cone photoreceptors as part of their colour vision. Salmonid UV cones are lost and regenerate from the retina associated with migratory events and thyroid hormone signaling. To best appreciate both ultimate and proximate mechanisms, we model these events by genetically engineering zebrafish. Conditional cell ablation constructs in transgenic fish have allowed us to specifically kill select cone photoreceptors, assess visual abilities, and assess cell-cell signaling during regeneration. We find that loss of UV cones led primarily to regeneration of cones, with a bias towards generating UV cones and restoring the cone mosaic. Further, the model speaks against an ultimate hypothesis of UV cone loss being associated with life in deeper waters, because death of UV cones did not induce generation of rod photoreceptors. Genetic analyses are revealing intrinsic signaling required for specifying cone subtypes during development and regeneration.

MODULATION OF LDH GENES AND SURVIVAL OF SPECIES OF AMAZONIAN FISH EXPOSED TO FUTURE CLIMATE CHANGE SCENARIOS

Almeida-Val, V.M.F., Fé, L.M.L., Campos, D.F., Dragan, F.G., Castro, N.S., Jesus, T.F., Paula-Silva, M.N., Coelho, M.A. and Val, A.L

Symposium: Climate Change **Type:** Oral **Order:** 2
Contact: Vera Maria Fonseca de Almeida e Val **E-mail:** veraval@inpa.gov.br
INPA, Av Andre Araujo 2936, Manaus, AM, ZIP 69067-375 Brazil

Abstract: Tropical fish present lower resistance to thermal variations compared to temperate fish. In the present work differential abilities of commercial and ornamental fishes of the Amazon to survive future climate change scenarios are analysed. Juveniles of tambaqui (*Colossoma macropomum*) and two congeneric ornamental fishes, cardinal tetra (*Paracheirodon axelrodi*) and green neon tetra (*P. simulans*), had their CTmin and CTmax determined and were exposed to simulated scenarios of climate changes (microcosmos). Thermal tolerance breadth for tambaqui was higher than tetra's. All three species exposed to microcosmos showed high dependence upon anaerobic metabolism, increasing LDH activities. Cardinal tetra presented significant increase of mortality over future climate change scenarios. LDH structure of fish living at extreme low temperatures is more thermo adaptable compared to tropical fish. Differences in LDH primary structure of Amazon fish seem related to differential ability to survive higher temperatures. (INPA; INCT ADAPTA – CNPq/FAPEAM; PIATAM - FINEP; FCT/CAPES)

THE ESTABLISHMENT AND USE OF A FIN CELL LINE FROM RAINBOW TROUT TO STUDY RHABDOVIRAL INFECTIONS IN VITRO

Alvarez de Haro, N., Fischer, U., and Villena, A.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 7
Contact: Neila Alvarez **E-mail:** neila.alvarez@unileon.es
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Abstract: Viral Haemorrhagic Septicaemia (VHS) is a disease of high economic impact and is notifiable according to EU and OIE. Here, we report the use of a rainbow trout fin cell line as a model to study the early infection with VHS virus (VHSV). This rhabdovirus, has been previously reported to use the fin base as the main portal of entry. Several cell lines were established from primary cultures of fin explants. One of them, (subcultured for more than 3 years so far) was used to study the early stages of VHSV infection, and antiviral cell defence. VHSV was used at

different MOI to infect cells for 24 and 48 hours. Viral replication was recorded by immunofluorescence and characterized by concomitant expression of immune-related genes using qRT-PCR. Main findings were up-regulation of Interferon type I and the anti-viral Mx protein, as well the chemokines IL-8, CK10 and CK12, which agree with the reported in vivo observations. Neila Álvarez held a predoctoral grant (BES-2009-027613) from the Spanish National Programme for Training Human Resources. This work was supported by Grant AGL2011-28921-C03-02 from the Spanish “Plan Nacional de I+D+I 2008-2011”.

BENEFITS AND LIMITATIONS OF USING MAXIMUM HEART RATE TO ESTIMATE UPPER TEMPERATURE LIMITS OF FISH

Anttila, K. and Farrell, A.P.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 1

Contact: Katja Anttila **E-mail:** katant@utu.fi

University of Turku, Department of Biology, Laboratory of Animal Physiology, FIN-20014 Turku Finland

Abstract: The mechanisms by which temperature, an ecological master factor, influences biogeographic distributions hold great interest. From salmonids to cyprinids and from polar fishes to eurythermal ones, acute warming increases maximum heart rate until a maximum rate is reached and then cardiac arrhythmia often follows. By overlying the thermal response of maximum heart rate on that for aerobic scope, transition temperatures for maximum heart rate such as the Arrhenius break point are closely associated with those for aerobic scope such as optimum and pejus temperatures. Thus, maximum heart rate can be used to explore the upper thermal limits of fishes with the benefits of (a) a more rapid assessment with fine temperature resolution than measuring aerobic scope, and (b) easily studying individual responses over a wide temperature range. However, great care is needed when studying thermal acclimation because the precise relationship between aerobic scope and maximum heart rate may change.

ASSOCIATION BETWEEN SWIMMING CAPACITY, CARDIAC PERFORMANCE AND THERMAL TOLERANCE IN ATLANTIC SALMON

Anttila, K., Jørgensen, S.M., Casselman, M.T., Timmerhaus, G., Krasnov, A., Farrell, A.P., and Takle, H.

Symposium: Swimming Physiology **Type:** Poster **Order:** P136

Contact: Katja Anttila **E-mail:** katant@utu.fi

University of Turku, Department of Biology, Laboratory of Animal Physiology, FIN-20014 Turku Finland

Abstract: In the present experiment we tested the hypothesis of linkage between the swimming capacity, cardiac performance and upper thermal tolerance in Atlantic salmon (*Salmo salar*). For the experiment 3200 smolts were screened for the swimming performance and divided to poor and good swimmers (critical swimming speeds $4-5.5$ body length s^{-1} and >7.5 body length s^{-1} , respectively). The poor swimmers had significantly lower Arrhenius Break Point temperature for maximum heart rate (fH_{max}), which is previously associated with optimum temperature, than good swimmers ($13.9 \pm 0.4^\circ C$ vs. $15.6 \pm 0.5^\circ C$). Furthermore, poor swimmers had a relatively smaller ventricular mass and thinner compact layer in ventricles. Thus, possibly as compensatory mechanism the poor swimmers had higher fH_{max} at warm temperatures than good swimmers. These morphological and heart rate differences persisted 15 weeks of rearing in brackish water. Therefore, it seems that early selection for swimming capacity could increase other capacities related to oxygen movement and thermal tolerance at the same time and this selection may represent a promising approach for salmon production.

INTERACTIVE EFFECTS OF TEMPERATURE AND OVERNIGHT HYPOXIA ACCLIMATIONS ON THERMAL AND HYPOXIA TOLERANCE OF ARCTIC CHAR AND ATLANTIC SALMON; CONNECTION TO DIFFERENCES AT OXYGEN SUPPLY SYSTEM
Anttila, K., Lewis M., Prokkola, J., Kanerva, M. and Nikinmaa, M.

Symposium: Climate Change **Type:** Oral **Order:** 16
Contact: Katja Anttila **E-mail:** katant@utu.fi

University of Turku, Department of Biology, Laboratory of Animal Physiology, FIN-20014 Turku Finland

Abstract: We studied the interactive effects of warming and overnight hypoxia on capacity of fish to tolerate these adverse conditions. An increase in acclimation temperature from 8°C to 15°C increased the critical thermal maximum (CT_{max}) of both char and salmon (by 1.3°C and 2.2°C, respectively). Hypoxia acclimation reduced the CT_{max} (by 0.2°C and 0.4°C, respectively). Both warm acclimation and overnight hypoxia more than doubled the hypoxia tolerance of salmon and also increased the tolerance of char by 25%. Salmon had 1.3°C higher CT_{max} than char but char tolerated much lower oxygen levels than salmon at a given temperature. These environmental influences were connected to the oxygen supply system of fish. The relative ventricle mass was higher in cold acclimated fish but the thickness of compact layer of ventricle increased with both warm and hypoxia acclimation. Char had significantly larger hearts and thicker compact layers than salmon. These changes could be correlated to the changes in hypoxia tolerance. The results show that encountering multiple stressors can have species-specific antagonist and synergic effects on the capacity of fish to tolerate the stressors.

THE EFFECT OF PROCESSED COPEPODS AS FOOD SOURCE ON FISH LARVAL PERFORMANCE
Arndt, C., Miest, J., Ueberschaer, B., and Sommer, U.

Symposium: Fish Culture **Type:** Poster **Order:** P5
Contact: Carmen Arndt **E-mail:** carndt@geomar.de

GEOMAR Helmholtz Centre for Ocean Research, Düsternbrooker Weg 20, 24105 Kiel Germany

Abstract: Fish larvae are very immature after hatching with undeveloped eyes, an immature immune system and no stomach. Sub-optimal nutrition is one aspect that leads to high mortalities among larvae during the first weeks of development. Copepods are the superior food for fish larvae than rotifers or *Artemia* because of their natural ingredients. However, their production in sufficient amounts is often not reliable. Therefore we made a storable product of copepods. In this study we offered the product via rotifers as a carrier to turbot larvae (*Scophthalmus maximus*) to see if the advantages of copepods also remain when fed as a processed product. Daily mortality was monitored and larvae were sampled at 11 and 24 dph to analyse growth, trypsin activity and expression of immune, growth, antioxidative and digestion-related genes. The results will be discussed in regard to optimization of larval rearing for aquaculture purposes.

MULTIPLEXING OF MICROSATELLITE MARKERS FOR PARENTAGE-BASED TAGGING OF HATCHERY BURBOT
Ashton, N.K., Campbell, M.R., Anders, P.J., Powell, M.S., and Cain, K.D.

Symposium: Burbot **Type:** Poster **Order:** P1
Contact: Neil Ashton **E-mail:** nk1ashton@yahoo.com
USA

Abstract: Concerned stakeholders in various nations are investigating stock enhancement or supplementation as one of several strategies to restore imperiled burbot (*Lota lota* L.) populations. In other intensively studied species, the use of genetic markers for parentage-based tagging (PBT) has become an important tool for evaluating the ecology of hatchery-wild fish interactions. Our objective was to determine if microsatellites previously developed for studies of burbot phylogeography could be multiplexed for effective PBT. A total of 14 microsatellite loci were multiplexed in four panels and tested for PBT efficacy in a hatchery population of burbot. An exclusion-based test involving 123

anonymous offspring and 51 known parent-pairs resulted in 97% of the progeny assigning to the correct parents. Due to modest genetic diversity in the broodstock population, a high false-assignment rate (19%) was observed when parental cross information was excluded from parentage analyses. The existing set of burbot microsatellites can be multiplexed into effective panels for PBT, however, we recommend the development of additional microsatellite or single nucleotide polymorphism markers to improve exclusionary power. Advancements in the field of burbot genetic markers could have broad implications for understanding the economy and ecology of future supplementation efforts.

CONTEXT-DEPENDENT LINKS BETWEEN INDIVIDUAL VARIATION IN METABOLISM AND SOMATIC GROWTH IN
BROWN TROUT

Auer, S.K., Salin, K., Rudolf, A. and Metcalfe, N.B.

Symposium: Environmental Change **Type:** Oral **Order:** 13
Contact: Sonya Auer **E-mail:** sonya.auer@glasgow.ac.uk
Graham Kerr Building, University of Glasgow, Glasgow G12 8QQ UK

Abstract: Metabolic rates can vary as much as 3-fold among individuals in a population, but why such variation persists is unclear given that they determine the energetic cost of living. Relationships between standard metabolic rate (SMR), growth and survival can vary with environmental conditions, suggesting that the fitness consequences of a given metabolic phenotype may be context-dependent. Less attention has focused on the link between aerobic scope (AS) and fitness under different environmental conditions, despite the importance of aerobic scope to an organism's total energetic capacity. We examined the effects of both SMR and AS on somatic growth rates of Brown Trout under different food levels in the laboratory. SMR and AS were uncorrelated across individuals. We found that the consequences for growth of an individual's SMR or AS differed across food levels, supporting the hypothesis of context-dependent links between individual variation in metabolism and fitness.

EFFECTS OF LAMBDA-CYHALOTHRIN IN DIGESTIVE ENZYMES ACTIVITIES OF THE NEOTROPICAL FISH MATRINXA
Avilez, I.M.; Venturini, F.P.; Moraes, F.D.; Soares, C.P.; Rossi, P.A.; Hackbarth, A.; De Almeida, L.A. Moraes, G.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P36
Contact: Gilberto Moraes **E-mail:** gil@ufscar.br
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SP, 13565-905 Brazil

Abstract: Lambda-cyhalothrin is highly toxic to non-target organisms such as fish. This compound is widely used to control insects and ectoparasites in fish farm. Toxicity is revealed by hematologic and metabolic changes, liver and nervous system damages, oxidative stress and genotoxicity. The aim of this study was to investigate the effects of lambda-cyhalothrin based insecticides (LBI) in digestive enzymes in gut of *B. amazonicus* exposed for 96h to 0.65 µg L⁻¹ (formulation tested was TrincaCaps® LBI). After exposure, it was observed an increase in trypsin activity (27.8%) and a decrease in chymotrypsin (16%). The inhibition of intestine chymotrypsin of matrinxã might decrease the digestion efficiency, decrease the growth rate and reduce survival rate. However, the increase in trypsin activity should be to maintain protein digestion in 96 hours.

REPRODUCTIVE ENDOCRINOLOGY IN ELASMOBRANCHS: BASIC AND APPLIED SCIENCE
Awruch, C.A., Waltrick, D.

Symposium: Elasmobranchs **Type:** Oral **Order:** 5

Contact: Cynthia Awruch **E-mail:** Cynthia.Awruch@utas.edu.au
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Abstract: The evolutionary success of Elasmobranchs is greatly attributed to their wide range of reproductive strategies controlled by different endocrine mechanisms. The diversity of reproductive strategies display by Elasmobranchs makes it difficult to generalise the control of gametogenesis and steroidogenesis. Novel information on the endocrine mechanisms controlling embryonic diapause, a temporary ceasing or retardation of development at any stage of embryogenesis, on the Australian sharpnose shark *Rhizoprionodon taylori* will be presented. In addition, the use of reproductive endocrinology as a non-lethal technique for management of Elasmobranch populations is becoming more popular, however up to date previous studies have linked reproductive hormones with external examination of the gonads from dead animals to validate the technique. Reproductive hormone levels were used as the only method to address reproduction on the seven gill shark *Notorynchus cepedianus*, which has significant potential to be used as a model in those cases where validation is not possible, e.g. threatened or endangered species, or species habiting marine protected areas.

PROTECTION OF FISH OLFACTION AGAINST COPPER INDUCED IMPAIRMENT
Azizishirazi, A., Dew, W. A., Bougas, B., Bernatchez, L., Pyle, G.

Symposium: Sensing the Environment **Type:** Oral **Order:** 19
Contact: Ali Azizishirazi **E-mail:** Aazizish@lakeheadu.ca
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Abstract: Mechanisms of copper-induced olfactory toxicity were studied in yellow perch exposed to 20 µg/l of copper for 24 hours. A novel, 1000-feature yellow perch microarray showed a total of 71 genes that were over/under transcribed in the Cu-exposed fish. RT-PCR confirmed the Cu-induced down regulation of genes of particular interest, including two sub-units of Na/K ATPase. Based on the role of Na/K ATPase in the olfactory neurons and the ability of increased dietary Na to protect Na/K ATPase against Cu, we then tested if dietary sodium uptake could compensate for Cu-impaired olfaction. Rainbow trout were fed for 7 d with food having normal or elevated concentrations of sodium. After a 24 h exposure to 10 µg/l of Cu, olfactory acuity was tested using electro-olfactography. Although fish fed with the normal diet had impaired olfaction, fish fed with the high Na diet had intact olfaction. These results suggest that elevated dietary Na can protect against Cu-induced olfactory function. However, subsequent feeding trials found no evidence to support that Cu-exposed fish preferentially chose high-Na food.

EFFECT OF PIKE PREDATION ON MIGRATING RIVER LAMPREY IN A SOUTHEASTERN BALTIC RIVER
Bagdonas K., and Nika N.

Symposium: Lampreys **Type:** Poster **Order:** P91
Contact: Kasparas Bagdonas **E-mail:** Kasparas.bagdonas@gmail.com
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Abstract: Economically important and protected migratory fish species are vulnerable to high predation risk during certain migration stages. Injuries attributed to northern pike (*Esox lucius*) were observed on migrating river lamprey (*Lampetra fluviatilis*) in Šventoji River, western Lithuania. Both direct and indirect effects of pike predation on lamprey were measured during a two-year investigation. Direct predation mortality of river lamprey was assessed by quantifying the proportion of lamprey in the diet of pike while the indirect effect of injuries was evaluated in an in situ experiment on chronic overwintering mortality. Results revealed only 12 % lamprey occurrence rate in the autumnal diet of pikes, moreover 63 % of pikes had empty stomachs. Meanwhile, an experimental group of injured lampreys had higher overwintering mortality than a control group. The investigation reveals that pike predation may

have substantial effect on river lamprey mortality through a combination of direct predation mortality and chronic physiological effects.

PERFORMANCE IN EXTREME ENVIRONMENTS: A CASE STUDY OF AN AFRICAN CYPRINID IN HYPOXIC SWAMPS

Baltazar, C., and Chapman, L.J.

Symposium: Tropical Fish **Type:** Oral **Order:** 1

Contact: Catherine Baltazar **E-mail:** cath.baltazar@gmail.com

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Abstract: East African papyrus swamps and their connected streams are characterized by a very steep gradient of dissolved oxygen ranging from extremely hypoxic swamp waters to well-oxygenated stream habitats. These connected ecotypes host morphologically and physiologically distinct phenotypes of the cyprinid fish *Barbus neumayeri*. One hypothesis explaining local adaptation in “leaky” systems is that phenotypes have a better fitness in their home habitat than in the alternative habitat. The goal of this study was to compare the performance of swamp- and stream-dwelling *B. neumayeri* in their home habitats, quantify dispersal rates between habitats, and evaluate potential effects of movement on fitness-related traits. A mark-recapture experiment was conducted over a 10-month period in Kibale National Park, Uganda. Results indicate lower condition and smaller average size in the swamp-dwelling fish. These findings are consistent with predictions based on physiological costs of hypoxic habitats. However, trade-offs associated with reproductive success or survival may offset challenges of life in low oxygen conditions.

CHANGES IN ERYTHROPOIETIN GENE EXPRESSION ARE FOLLOWED BY HEMATOLOGICAL CHANGES IN AMAZON OSCAR DURING HYPOXIA AND AFTER RECOVER

Baptista, R.B.; Val, A.L. and Almeida-Val, V.M.F.

Symposium: Tropical Fish **Type:** Poster **Order:** P141

Contact: Ramon Barros Baptista **E-mail:** ramon.barros@hotmail.com

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Abstract: Erythropoietin (Epo) is a glycoprotein hormone that control red blood cell production. EPO binds to receptors on erythrocytic precursor cells, multiplying and differentiating them into mature blood cells. Amazon fish, show remarkable hematological changes when exposed to extreme hypoxia. However, the relationship between such hematological changes and Epo gene expression has never been investigated in these animals. Here, we describe the relationship between the production of red cells during hypoxia in the Amazonian cichlid *Astronotus ocellatus*, and the expression of hepatic Epo gene. Ten fold increase of hepatic EPO gene under hypoxia, compared to control, is synchronized with increases in RBC, hematocrit, and glucose level. After reoxygenation Epo expression and RBC, hematocrit and glucose are reduced to levels near pre-exposure (normoxia). We suggest that the changes between EPO gene expression and red blood cells are interconnected and play an important role in keeping tissue oxygenation in *Astronotus* during hypoxia. (INPA; INCT ADAPTA–CNPq/FAPEAM)

COMPARATIVE VITELLOGENIN EXPRESSION IN TWO ALTERNATIVE FISH MODELS USING 17 α -ETHYNYLESTRADIOL

Baron, M., Dummett, C., Henry, T., and Jha, A.

Symposium: Zebrafish **Type:** Poster **Order:** P153

Contact: Matt Baron **E-mail:** matthew.baron@plymouth.ac.uk

School of Biological Sciences, 4th Floor Davy Building, Plymouth University, Drake Circus, Plymouth, Devon, PL4 8AA UK

Abstract: Few studies currently exist on the comparison between fish in vitro and in vivo systems and their relative sensitivities to chemical exposure. Here we report a study that compared the expression profiles of the vitellogenin gene (*vtg*) over time in a rainbow trout (*Oncorhynchus mykiss*) 3-D liver spheroid (in vitro) and zebrafish (*Danio rerio*) larvae (in vivo) model, after exposure to environmentally relevant levels of the endogenous estrogen 17 α -Ethinylestradiol (EE2). Optimisation of RNA extraction and reverse transcription techniques for both models was followed by exposure to EE2 (0.01 – 1 μ g L⁻¹) to determine NOEC and LOEC values. A time-course exposure was then used to profile *vtg* expression in each model using qPCR. Suitable housekeeping genes (i.e. 18S rRNA for spheroids and β -actin for the larvae) were also fully optimised and validated. The data presented here demonstrates the comparative sensitivity of the fish models to EE2 exposure.

THREE-DIMENSIONAL (3-D) HEPATIC FISH SPHEROIDS AS AN ALTERNATIVE IN VITRO MODEL FOR FISH
PHYSIOLOGICAL AND TOXICOLOGICAL RESEARCH

Baron, M., Purcell, W., Jackson, S., Owen, S., and Jha, A.

Symposium: Fish Cell Cultures **Type:** Poster **Order:** P30
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Abstract: The development and validation of reliable in vitro methods that offer an alternative to conventional in vivo studies is rapidly becoming an important tool to determine organ-specific physiological functions that can be used as markers to assess the toxicity of chemicals and contaminants in the aquatic environment. Here we describe a protocol for the routine formation of hepatic spheroids from rainbow trout and characterise their morphological and biochemical organ-functionality, with comparisons to immature suspension and 2-D monolayer cultures. Spheroids display significantly higher levels of glucose production and albumin synthesis compared to conventional culture systems, much like levels detected in 3-D organotypic models (liver slice / mammalian spheroids). Significantly lower levels of basal lactate dehydrogenase leakage suggest a high degree of membrane integrity within the spheroids, an important criterion for longevity in culture. Spheroids also maintain the morphological characteristics of in vivo liver tissue, particularly the histological architecture.

EFFECTS OF LHRH AND HCG ON CORTISOL PRODUCTION BY RAINBOW TROUT INTERRENAL TISSUE IN VITRO

Barry, T.P., and Kang, V.

Symposium: Stress in Fish **Type:** Oral **Order:** 5
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Abstract: We tested the hypothesis that luteinizing hormone releasing hormone (LHRH) and luteinizing hormone (LH) stimulate cortisol production in fish. Interrenal tissue from immature and sexually mature rainbow trout was cultured in vitro in the presence of various doses of LHRH, hCG (LH analog), 17 α ,20 α -dihydroxyprogesterone (17,20-P), and ACTH. 17,20-P and ACTH both increased cortisol production approximately 100-fold above control levels. LHRH and hCG both increased cortisol production approximately 10-fold above control levels. The effects LHRH, hCG and 17,20-P were greater in mature fish than immature fish. We conclude that reproductive hormones can regulate cortisol levels in spawning salmonid fish, and that physiological changes associated with gonadal maturation can alter the sensitivity of the interrenal to these factors. A model describing the key role of 17,20-P and other reproductive hormones in mediating the hypercortisolism associated with the death of semelparous Pacific salmon will be presented.

REPRODUCTIVE CYCLE, TRANSPORTATION AND INDUCED BREEDING OF THE AMAZONIAN CATFISH
HYPOPHTALMUS MARGINATUS: A BIOPROSPECTING STUDY OF FISH SPECIES WITH POTENTIAL FOR SUSTAINABLE
AQUACULTURE

*Batlouni, S.R., Hainfellner, P., Barbosa, L., De Souza, T.G., Kuradomi, R.Y., Figueiredo, D.G., Freitas, G.A.,
Queiroz, L.D., Nogueira, B.A., Maciel, C.R., Moraes-Valenti, P., Valenti, W.C.*

Symposium: Tropical Fish **Type:** Poster **Order:** P142

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University of Sao Paulo State (UNESP), Aquaculture Centre of UNESP (CAUNESP), Via de Acesso Prof. Paulo
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Abstract: In this study we took the first steps towards the domestication of *Hypophtalmus marginatus* (a planctophagous catfish), standardizing transportation and spermiation and obtaining advances in induced ovulation. We standardized in an unprecedented manner the transport of *Hypophtalmus marginatus* wild specimens from Tocantins River (Pará-Brazil) to captivity. Vitellogenesis and spawning occur respectively in October-November and December and females remain eight months in resting class (n = 291). All injected males (n=9) spermiated after induction with carp pituitary extract (EBHC) (0.5 and 6.0 mg/kg, 12 hours interval). Females ovulated only with the concomitant use of EBHC and prostagladin F (3 of 6 injected), but not when using only EBHC or mammalian gonadotropin releasing hormone analog with metoclopramide (one or two doses, various concentrations). The consolidation of the species for aquaculture purposes still depends on a better understanding of their reproductive biology and advances in the knowledge of its captive management. Acknowledgements: authors would like to thank the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP-2010/51271-6 (research grant) and FAPESP – 2011-18734-5 (scholarship)).

COMBINED IMPACTS OF PERSISTENT ORGANIC POLLUTANTS AND GLOBAL WARMING ON THE CORAL REEF FISH
SIGANUS GUTTATUS

Baum, G.B., Kegler, P. and Kunzmann, A.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 2

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Abstract: Worldwide, human populations are growing continuously at an enormous speed. As a result, a mixture of anthropogenic stressors can simultaneously affect marine organisms. For this project, the combined effects of two persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs) and linear alkylbenzene sulfonates (LAS), as well as their effect under a scenario of global warming respectively, was studied on the coral reef fish *Siganus guttatus* in Indonesia. Metabolic rates were measured and combined with other biochemical parameters (electron transport system activity, total protein and lipid content) to determine condition of *S. guttatus*. Preliminary results show a decreasing trend in overall fish condition such as increased standard metabolic rates at higher LAS concentrations and temperature (31 °C). Under combined stress of PAH and LAS together or in combination with increased temperature respectively, effects seem to multiply. This study sheds new light on the physiological impact of POP's in combination with global warming on coral reef fishes.

ESTABLISHMENT AND CHARACTERIZATION OF A PRIMARY CULTURE OF PITUITARY CELLS FROM MEDITERRANEAN
SEABASS

Baye, E., Paulin, C-H., Mathieu1, G., Falcón, J., and Besseau, L.

Symposium: Fish Cell Cultures **Type:** Poster **Order:** P31
Contact: Laurence BESSEAU **E-mail:** besseau@obs-banyuls.fr
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Abstract: The pituitary gland is a component of the neuroendocrine system at the interface between the nervous system and the rest of the body. It receives input from the brain and produces in turn a set of hormones involved in physiological functions as important as reproduction, growth, osmoregulation, feeding and immunity. The aim of this project was to establish and characterize a culture of Mediterranean sea bass (*D. labrax*) pituitary cells. For this purpose, pituitaries were dissociated (collagenase/trypsin solution) and the cells seeded in L15 culture medium supplemented with 10% fetal calf serum, using different substrates. We established conditions favorable to cell maintenance, proliferation and expression (immunocytochemistry, qPCR) of all the pituitary hormones as well as the secretion (western blot, ELISA) of some of them. This offers unique opportunities for in vitro investigations on the regulation of pituitary secretions, and the interaction and proliferation of pituitary cells. Project supported by the European Community under the FP7-ASSEMBLE project (grant agreement N° 227799-JRA) and by EMBRC-France/Investissement d'Avenir; E Baye was granted by EMBRC-France, C-H Paulin and G Mathieu by ASSEMBLE.

IS STRESS IN FARMED SALMON AN IMPORTANT FACTOR FOR SAPROLEGNIOSIS?

Beckmann, M.J., Secombes, C.J., van West, P.

Symposium: Stress in Fish **Type:** Oral **Order:** 25
Contact: Max Beckmann **E-mail:** R02MB12@abdn.ac.uk

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Abstract: Saprolegniosis is a major concern to fish farms leading to heavy losses due to infection by this filamentous oomycete pathogen. These infections are often observed after procedures likely to induce significant stress to the fish such as vaccination. In this study we have analysed the expression of a number of genes as putative stress markers, from fish at different stages of the vaccination process. These include steroidogenic acute regulatory protein (StAR) and cytochrome P450side-chain-cleavage, responsible for the regulation of steroidogenesis, the glucocorticoid receptor (GR) and heat shock proteins 90 and 70. First data shows significant activation of these stress markers as well as raised blood cortisol and glucose concentrations likely to affect susceptibility of salmon to Saprolegnia after vaccination. We aim to link stress marker gene expression to immune gene expression in future studies, with major changes in the latter seen during infection of salmon with Saprolegnia.

O₂-CHEMORECEPTORS AND THE CONTROL OF CARDIORESPIRATORY RESPONSES TO HYPOXIA IN THE AFRICAN SHARPTOOTH CATFISH, AN AIR-BREATHING FISH.

Belão, T.C., Florindo, L.H., Leite, C.A.C., Kalinin, A.L., and Rantin, F.T.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 7
Contact: F. Tadeu Rantin **E-mail:** ftrantin@gmail.com

Federal University of São Carlos, Department of Physiological Sciences, Via Washington Luiz, km 235 - 13565-905 São Carlos - SP Brazil

Abstract: The location, distribution and orientation of branchial O₂ chemoreceptors and their role on the control of the cardiorespiratory response to hypoxia in the air-breather *C. gariepinus* were analyzed. Fish were divided in two groups: Control (CG) with the four gill arches preserved and, denervated (DG), with the 1st gill arches excised. Both groups were submitted to graded hypoxia with and without access to air and the following variables were analyzed: Oxygen uptake - , breathing frequency - fR, ventilatory tidal volume - VT, gill ventilation - , oxygen extraction

from the inspired water – EO₂, and heart rate – fH (without access to air), and fR, fH and air-breathing frequency – fAB (with access to air) Internal and external injections of NaCN were administrated to confirm the receptors location and orientation. Externally oriented receptors distribute in all gill arches elicit the fH responses. Internally oriented receptors, restricted to the 1st gill arches, elicit the fR. The receptors modulating the fAB are internally oriented and present in the four gill arches.

SERUM BIOCHEMICAL CHANGES IN ALLOXAN-DIABETIC TILAPIA DURING INFECTIOUS AEROCISTITE
Belo, M. A. A.; Prado, E. J. R.; Moraes, A. C.; Foz, E. P.; Barbuio, R.; Faria, V. P.; Sebastião, F. A.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 23

Contact: Marco Antonio de Andrade Belo **E-mail:** maabelo@hotmail.com

Department of Veterinary Pathology, São Paulo State University, Jaboticabal, Zip code: 14884-900 Brazil

Abstract: Nile tilapia, *Oreochromis niloticus*, GIFT (± 532 g), masculinized, were divided into three groups of 21 animals each, treated or not with alloxan (both inoculated with *Aeromonas hydrophila* in the swim bladder) and a control group (inoculated with saline). Seven animals from each treatment were sampled at 6, 24 and 48 hours post-inoculation (HPI). Diabetic tilapia showed an increase ($P < 0.05$) about 10 times in glycemia (6 HPI). These findings were accompanied by transient increases in triglycerides and cholesterol in the initial phase of the infectious process. With 24 and 48 HPI blood glucose, triglycerides and cholesterol decreased and did not differ ($p > 0.05$) from the control animals. A significant increase ($P < 0.05$) in serum alkaline phosphatase activity in diabetic tilapia was observed in all study periods compared to both groups inoculated with *A. hydrophila* or saline.

EXOGENOUS GLUCOCORTICOID ON LEUKOCYTE RESPONSE OF TILAPIA DURING ACUTE INFLAMMATION
Belo, M.A.A., Prado, E.J.R., Moraes, A.C., Foz, E.P., Barbuio, R., Faria, V.P., Sebastião, F.A.

Symposium: Stress in Fish **Type:** Oral **Order:** 24

Contact: Marco Antonio de Andrade Belo **E-mail:** maabelo@hotmail.com

Department of Veterinary Pathology, São Paulo State University, Jaboticabal, Zip code: 14884-900 Brazil

Abstract: Nile tilapia, *Oreochromis niloticus*, GIFT (± 532 g), masculinized, were divided into three groups of 21 animals each treated or not with 2mg/kg of dexamethasone, intramuscular route (both inoculated with *Aeromonas hydrophila* in the swim bladder) and a control group (inoculated with saline). Seven animals from each treatment were sampled at 6, 24 and 48 hours post-inoculation (HPI). Tilapia treated with dexamethasone showed significant ($P < 0.05$) decrease in the number of neutrophils (6 HPI) and significant increase 48 HPI compared to infected tilapia. The number of monocytes revealed a significant decrease ($P < 0.05$) in animals treated with dexamethasone compared to inoculated fish (24 and 48 HPI). Lymphopenia ($P < 0.05$) was observed in fish treated with glucocorticoid (6, 24 and 48 HPI) compared to both groups inoculated with *A. hydrophila* or saline. Tilapias treated with dexamethasone presented low number of thrombocytes ($P < 0.05$) compared to saline control group (24 and 48 HPI) and to inoculated tilapia (24 HPI).

GLUCOCORTICOID EFFECT OF DEXAMETHASONE ON SERUM BIOCHEMISTRY RESPONSE DURING INFECTIOUS AEROCISTITE

Belo, M.A.A., Prado, E.J.R., Moraes, A.C., Foz, E.P., Barbuio, R., Faria, V.P., Sebastião, F.A.

Symposium: Stress in Fish **Type:** Oral **Order:** 26

Contact: Marco Antonio de Andrade Belo **E-mail:** maabelo@hotmail.com

Department of Veterinary Pathology, São Paulo State University, Jaboticabal, Zip code: 14884-900 Brazil

Abstract: Nile tilapia, *Oreochromis niloticus*, GIFT ($\pm 532\text{g}$), masculinized, were divided into three groups of 21 animals each treated or not with dexamethasone (both inoculated with *Aeromonas hydrophila* in the swim bladder) and a control group (inoculated with saline). Seven animals from each treatment were sampled at 6, 24 and 48 hours post-inoculation (HPI). Tilapia treated with dexamethasone showed no significant ($P > 0.05$) increase in blood glucose, triglycerides and cholesterol when compared to control animals in the most acute phase of the inflammatory process (6 HPI). With 24 and 48 HPI blood glucose, triglycerides and cholesterol increased significantly ($P < 0.05$) in animals treated with dexamethasone. The effect of dexamethasone on serum alkaline phosphatase activity was not observed. Fish treated with dexamethasone had higher amounts of total protein (24 HPI) and albumin (48 HPI) when compared to both groups inoculated with *A. hydrophila* or saline.

TEST THE WATER! EFFECTS OF A WATER DISINFECTION BYPRODUCT ON ZEBRAFISH EMBRYOS

Bencsik, D., Bakos, K., Fetter, E., Scholz, S., Kovács, R., Gazsi, Gy., Kövesi, J., Csepeli, A., Szende, B., Rác, G., Urbanyi, B., Csenki, Zs.**

Symposium: Zebrafish **Type:** Oral **Order:** 5

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Szent István University, Faculty of Agricultural and Environmental Sciences, Institute of Environmental and Landscape Management, Department of Aquaculture, Páter Károly St. 1., H-2100, Gödöllő Hungary

Abstract: Water is the fundamental life source that sustains all beings on Earth, and the driving force of the development of mankind. Perhaps due to the high degree of development and industrialization, drinking water of good quality and quantity becomes less and less accessible. Disinfection byproducts are poorly studied pollutants of drinking water. Based on literature, the number of compounds formed during drinking water treatment is estimated to be over 200. 4-ethylbenzaldehyde is one of these, detected in the drinking water of the Hungarian capital, Budapest. Effects of the substance have previously been examined on adult zebrafish (*Danio rerio*), however no information is available on its embryotoxic effects. The goal of this study was to determine the deformities/developmental disorders, lethal concentrations (LC) genotoxic effects and gene expression changes in the very early life stage of zebrafish.

ATLANTIC SALMON IMMUNE RESPONSE TO PARAMOEBIA PERURANS INFESTATION (AMOEBIC GILL DISEASE) AND INFLUENCE ON THE HOST PHYSIOLOGICAL STATUS

Benedicenti, Ottavia, Catherine Collins, Una McCarthy, Chris Secombes

Symposium: Parasites and Diseases **Type:** Poster **Order:** P101

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UK

Abstract: Amoebic gill disease (AGD) is an emerging disease in North European Atlantic salmon (*Salmo salar*) aquaculture caused by the amoeba *Paramoeba perurans*. Environmental conditions are known to affect the causative agent *P. perurans* but their effect on the host immune response is also important in understanding the role they play in disease emergence. Temperatures at non-optimal host ranges can induce stress in the fish. The role of temperature in modulating the immune response is one important factor to investigate 1) the role of the stress related to the neuroendocrine-immune system and 2) the interplay between these two systems. T-cell response gene expression analyses on fish infected with different AGD clones are under investigation to characterize the type of host immune response. Subsequent AGD challenges at a range of temperatures will be used to investigate the effect of this environmental parameter on the host immune response and on the host-parasite interaction in Atlantic salmon.

PHYSIOLOGICAL CHARACTERIZATION OF SMOLTIFICATION OF TWO FOREIGN STRAINS OF ATLANTIC SALMON
UNDER BELGIAN ENVIRONMENTAL CONDITIONS: IMPLICATION FOR RESTOCKING EFFORTS.

Bernard, B., Mandiki, S.N.M. and Kestemont, P.

Symposium: Fish Migration **Type:** Poster **Order:** P25

Contact: Bernard Benoit **E-mail:** benoit.bernard@unamur.be
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Abstract: Smoltification insures high survival rates at sea entry for migrating salmon juveniles. Some environmental factors controlling that process have been documented but less is reported on the impact of genetic pool or its interaction with environmental conditions. As smoltification is population specific, strain characteristics are of high importance for restocking programs, especially in rivers where fish populations already became extinct like in the river Meuse (Belgium). The present study aimed to compare Loire-Allier (France) and Cong (Ireland) strains under simulated Belgian conditions along the smoltification season using hormonal, osmotic and enzymatic indicators. Both strains showed similar hormonal secretion patterns over time but exhibited differences in variation range (i.e. IGF-1: 57,8 vs 47,2ng/ml; Na+K+ATPase: 10,2 vs 14,8 μ mol ADP.mg prot. $^{-1}$. h $^{-1}$). According to the most reliable indicators, smolting peak in Loire-Allier smolts occurred one week earlier than in Cong smolts. Implications for maximising yield of restocking efforts are then discussed.

THE COMBINED EFFECT OF DHA AND TAURINE ON GROWTH, SURVIVAL AND EYE DEVELOPMENT IN BLUEFIN TUNA
LARVAE

Besseau, L., Escande, M.-L., Nixon, O., Azouli, S., Koven, B., and Falcón, J.

Symposium: Fish Culture **Type:** Poster **Order:** P6

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Abstract: The larval rearing of blue fin tuna (BFT) is plagued by high mortality, particularly during first feeding. This may be due to poor eye development reducing the efficiency of prey capture leading to poorer growth and survival. Two nutrients, deficient in unenriched rotifers, that play a critical role in visual acuity are the essential fatty acid, docosahexaenoic acid (DHA; 22:6n-3) and the amino-sulfonic acid, taurine. This paper describes a series of studies that determined effective dietary DHA and taurine levels in first feeding BFT larvae in terms of retinal opsin level, rotifer ingestion rate, growth and survival. A significant DHA dose-dependent effect on larval rotifer ingestion and retinal photopigment opsin was shown. DHA enhanced visual acuity and rotifer consumption did not markedly influence larval growth or survival suggesting that taurine may be another limiting factor. We suggest that BFT first-feeding larvae require high dietary DHA to improve visual acuity and prey ingestion rate while moderate and low dietary taurine is necessary for enhanced survival and growth.

MATERNAL STRESS AND ELEVATED EMBRYO CORTISOL EXPOSURE AFFECTS LOCOMOTOR ACTIVITY IN LARVAL
ZEBRAFISH

Best, Carol and Mathilakath M. Vijayan

Symposium: Stress in Fish **Type:** Poster **Order:** P116

Contact: Carol Best **E-mail:** bestc@ucalgary.ca
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Abstract: Maternal stress and the attendant rise in cortisol levels in the embryos affect early developmental programming in zebrafish (*Danio rerio*). Glucocorticoid receptor (GR) knockdown along with transcriptome analysis suggested that early cortisol signalling affects a variety of pathways, including those critical for nervous and sensorimotor development. However, whether the changes in target genes are reflected in an altered sensorimotor activity has not been addressed before. We tested the hypothesis that elevated embryo cortisol levels alter the sensory and locomotor activity of zebrafish and this involves GR signalling. Fish locomotor activity was assessed using a high-throughput video analysis system. Our results highlight a role for elevated cortisol levels in the embryo, mimicking maternal stress, in impacting the locomotor activity in zebrafish. The increased locomotor activity in the dark, but not with light, suggest a role for cortisol in affecting sensorimotor development, leading to an altered behavioural phenotype.

SELENIUM ANTIOXIDATIVE PROTECTION IN ZEBRAFISH SUBJECTED TO DIETARY OXIDATIVE STRESS

Betancor, M.B., Almada-Pagán P.F., Sprague M., Hernández A., and Tocher D.R.

Symposium: Zebrafish **Type:** Poster **Order:** P154

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Abstract: Selenium (Se) is an essential micronutrient for vertebrates involved in antioxidant protection and thyroid hormone regulation among others. Se functions through its incorporation into proteins, and has as key role in selenoproteins (SEP). Long-chain polyunsaturated fatty acids, such as docosahexaenoic acid (DHA), are essential for fish although high dietary levels may lead to increased oxidative stress due to the high degree of unsaturation. The present study investigated the effect of Se supplementation on zebrafish oxidative status as well as SEP expression profile when subjected to a high DHA diet. Four groups of fish were fed for two months one of four experimental diets, containing high or low DHA, in combination with or without organic Se (7 ppm). Whole fish Se content reflected the dietary content. High dietary DHA increased oxidation, which was reduced by dietary Se. Results regarding SEP and Se-related gene expression will be discussed.

USING COMPARATIVE BIOLOGY TO UNDERSTAND GROWTH REGULATION IN TELEOSTS

Biga, P.R. and Froehlich, J.M.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 2

Contact: Peggy Biga **E-mail:** pegbiga@uab.edu

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Abstract: Due to the diversity of habitats that teleostei members inhabit, varying degrees of growth and metabolic phenotypes exist. However, most teleosts exhibit an indeterminate growth paradigm, with few exceptions identified to date. Additionally, teleosts are well known for their ability to maintain relatively normal homeostasis during times of fasting and/or starvation. However, recent evidence suggests that metabolic regulation appears to vary among teleosts depending on various environmental parameters and genetic background. We recently demonstrated that inbred strains of zebrafish exhibit differential responses to fasting, both physiologically and molecularly. Alternatively, zebrafish (*Danio rerio*) do appear to exhibit a robust response to fasting over a 35-day period, where a closely related species does not. Most interestingly, is these two closely related fish species exhibit different overall growth potentials that is likely due to differences in overall metabolic regulation capacity.

OPPOSING MUSCLE GROWTH PARADIGMS: A MODEL FOR UNDERSTANDING THE BALANCE BETWEEN ATROPHY AND HYPERTROPHY

Biga, P.R., Froehlich, J.M., and Seiliez, I.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 13

Contact: Peggy Biga **E-mail:** pegbiga@uab.edu

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Abstract: Closely related piscine species exhibiting differential growth potential serve as a unique platform to study the regulation of growth. The zebrafish (*Danio rerio*) has been used extensively as a model system for developmental studies but, unlike most teleost fish, it grows more determinately. A close relative, the giant danio (*Devario cf. aequipinnatus*), grows indeterminately, displaying both hyperplasia and hypertrophy in muscle as an adult. Muscle satellite cells in the determinate growth model express myogenic biomarkers consistent with mammals, while indeterminate growing danionins express high levels of Pax3 and little Myf5 and a higher proliferative capacity. These data support a more stem-like phenotype in indeterminately growing fish. Hormonal sensitivity and responsiveness vary between the growth paradigms, suggesting that the balance between atrophy and hypertrophy in adults is due to mechanisms regulating cell phenotype. Closely related species exhibiting opposing growth paradigms offer a unique platform to test various questions related to the regulation of growth potential.

CHARACTERIZATION OF SODIUM UPTAKE DURING DEVELOPING RAINBOW TROUT EMBRYOS

Blair, S.D., Boyle, D., Goss, G.G

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 8

Contact: Salvatore Blair **E-mail:** sdblair@ualberta.ca

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Abstract: Freshwater fish embryos are hypertonic to their external environments and must acquire ions to compensate diffusional losses. Developing embryos are known to regulate internal ion concentrations regardless of the external environment and elucidating the transporters involved is necessary for the overall understanding of this early process. In this study, the role of sodium uptake mechanisms were characterized in rainbow trout (*Oncorhynchus mykiss*) embryos in low and normal waters. Using a radioisotopic flux approach, and transporter-specific pharmacological inhibitors, sodium (^{22}Na) uptake was measured in whole embryos reared in normal (Edmonton City tapwater, $400\mu\text{M}$) and low ionic strength water ($60\mu\text{M}$). Significant sodium uptake inhibition was observed in both mediums signifying the utilization of multiple Na^+ uptake pathways. Transporter expression patterns in embryos were also monitored with IHC and qPCR over the course of development and correlated with physiological sodium uptake rates. Results shed light on the different modes of Na^+ transporter in developing trout embryos.

DROSPIRENONE EFFECTS IN HEPATIC METABOLISM AND GONADAL GENE EXPRESSION IN EUROPEAN SEA BASS

Blanco, M., Fernandes, D., Medina, P., Blázquez, M., and Porte, C.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 10

Contact: Maria Blanco **E-mail:** maria.blanco@cid.csic.es

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Abstract: The presence of progestagens in aquatic systems via waste-water effluents has significantly increased in the last decade. Drospirenone is one of the most widely used progestagens in contraceptive treatments and hormone replacement therapy. In a previous work, we reported drospirenone to inhibit CYP17 and CYP11 β activities in carp subcellular fraction at the low nM range. Nonetheless, no information is available about in vivo effects in fish. Thus, juvenile European sea bass (*Dicentrarchus labrax*) were exposed to different concentrations of drospirenone through

the food (0.01, 0.1, 1 and 10 mg/Kg) for up to 31 days in order to investigate in vivo toxicological effects. 7-Ethoxyresorufin-O-deethylase (EROD), 7-benzyloxy-4-trifluoromethyl-coumarin O-debenzyloxylase (BFCOD), UDP-glucuronyltransferase (UDPGT) and sulfotransferase activities were determined in liver. Gene expression levels of *cyp19a1a*, *cyp11 β* and *cyp17a1* in gonads were quantified using qRT-PCR. Plasma samples analysed by HPLC-MS/MS allowed the detection of drospirenone circulating in fish blood. However, no significant differences between control and exposed fish were detected for any of the analysed end-points, apart from higher expression of *cyp17a1* in exposed females in comparison to controls. This study evidences no alteration of the hepatic metabolism in juvenile sea bass exposed to drospirenone.

THE EFFECT OF SALINITY ON THE MECHANISMS OF NI TOXICITY IN THE EURYHALINE ATLANTIC KILLIFISH

Blewett T.A., Ransberry, V.E., McClelland, G.B., Wood, C.M

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 15

Contact: Tamzin Blewett **E-mail:** blewetta@mcmaster.ca
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Abstract: The mechanism by which nickel (Ni) causes toxicity to aquatic organisms is still subject to debate. This study investigated the effects of salinity on the mechanisms of Ni toxicity in the euryhaline killifish (*Fundulus heteroclitus*). Killifish were exposed to sub-lethal levels (5 mg L⁻¹) of waterborne Ni for 96 h in 0%, 10%, 30% and 100% seawater. Salinity had a protective effect against Ni accumulation only at the gill and kidney, while no effect of salinity was seen in other organs. Effects on tissue ion levels were negligible. However, catalase activity was decreased by Ni exposure in the gill in FW and 30% SW only and superoxide dismutase activity increased in the intestine following exposure to Ni at 100% SW. This work emphasizes that Ni is an oxidative stressor in fish and that salinity is not entirely protective against Ni accumulation or oxidative toxicity. (NSERC CRD, NiPERA)

EPITHELIAL TRANSPORT OF TRACE METALS IN PACIFIC HAGFISH

Blewett, T.A., Glover, C.N., Niyogi, S., Wood, C.M

Symposium: Hagfishes **Type:** Oral **Order:** 10

Contact: Tamzin Blewett **E-mail:** blewetta@mcmaster.ca
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Abstract: While recent evidence has shown that the skin rivals the gut as an uptake route for organic nutrients in hagfish, nothing is known regarding the absorption of trace metals in this group. In vivo and in vitro techniques with radioisotopes were therefore employed to examine the uptake of nickel and iron across gut and/or skin epithelia in Pacific hagfish. In vitro iron uptake per unit area was significantly higher across the skin than across the gut, and was dependent upon oxidation state in both epithelia. Cutaneous nickel uptake was biphasic, with saturation at low concentrations superseded by diffusion at higher levels. Supporting a role for the skin, nickel was absorbed directly from the water in vivo, albeit at rates an order of magnitude lower than those for amino acids. These data indicate a potential role for the skin of hagfish in the absorption of inorganic nutrients. (NSERC Discovery)

GENE EXPRESSION PROFILING IN TESTIS OF PREPUBERTAL SALMON WITH DIFFERENT NUTRITIONAL STATUS

Bogerd, J., Crespo, D., Montfort, J., Le Cam, A., Le Gac, F., Sambroni, E., Anderson, A., Taranger, G.L., Schulz, R.W.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 6

Contact: Luiz de Franca **E-mail:** lrfranca@icb.ufmg.br

Abstract: The molecular mechanisms regulating spermatogenesis in seasonally breeding species are still poorly understood. We investigated normal development and energy status-induced changes in testicular gene expression in early pubertal fish to study how growth and energy stores interfere with the brain-pituitary-testis axis to influence the decision to mature.

SERUM AMYLOID A AND ITS USE AS A BIOMARKER

Bohan, S., Dowling, D., and O'Hara, R.

Symposium: Stress in Fish **Type:** Poster **Order:** P117
Contact: Sandra Bohan **E-mail:** sandra.bohan@itcarlow.ie
Institute of Technology Carlow Ireland

Abstract: Serum Amyloid A (SAA) is a major acute phase protein which can be found in most vertebrates. SAA is divided into two forms; Acute phase Serum Amyloid A (A-SAA) and Constitutive phase Serum Amyloid A (C-SAA). Of these two forms only A-SAA increases in concentration in response to stress that includes inflammation or infection. This study aims to test the hypothesis, that A-SAA can be used as a biomarker for stress in fish as an indicator of environmental pollution. Initially, mRNA will be extracted from the liver, fatty tissue, heart, reproductive organs etc. of *Oncorhynchus mykiss* (Rainbow Trout). These samples will be used to determine where the largest A-SAA concentrations can be found and the study will then focus on these tissues. Quantitative PCR will be used to amplify the gene and estimate the gene expression levels in these tissues and from fish under different conditions.

STRONG EXPRESSION OF CREATINE-RELATED GENES IN THE SKELETAL MUSCLE OF RAINBOW TROUT INDICATES DIFFERENCES TO MAMMALS

Borchel, A., Verleih, M., Rebl, A., Kühn, C., and Goldammer, T.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P63
Contact: Andreas Borchel **E-mail:** borchel@fbn-dummerstorf.de
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Abstract: Creatine is an important metabolite that acts as a cellular energy buffer. In this study, we identified the rainbow trout cDNA sequences of GATM (glycine amidinotransferase) and GAMT (guanidinoacetate N-methyltransferase), both encoding enzymes involved in creatine-synthesis, as well as CKM (creatine kinase, muscle), encoding a creatine kinase. Furthermore, we analyzed their tissue-specific gene expression in kidney, liver, skeletal muscle and brain using quantitative real time PCR (qRT-PCR). GATM and GAMT as well as CKM were strongly expressed in the skeletal muscle. In contrast to that, creatine synthesis and usage in mammals have been shown to be spatially separated. Their GATM and GAMT are mainly active in the kidney and liver, respectively, but not in the muscle, while in rainbow trout GATM and GAMT gene expression was strikingly higher in the muscle (GATM >10x, kidney; GAMT >2x, liver). This indicates that creatine is not only used but also synthesized in the skeletal muscle of rainbow trout. (EFF grant: pilot project # VI-560/7308-4).

CAN PROBIOTICS MODULATE ZEBRAFISH BEHAVIOUR?

Borrelli, L., Fioretti, A., Leggieri, E., Dipineto, L., and Agnisola, C.

Symposium: Zebrafish **Type:** Poster **Order:** P155
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Abstract: A growing body of data supports the hypothesis that probiotics can exert psychotropic effects. Recently, it has been demonstrated that in mice the probiotic *Lactobacillus rhamnosus* impacts behavior and produces neuroactive substances such as GABA and serotonin, which act on the brain-gut axis. We tested the effects of *L. rhamnosus* on behavioural and swimming performance in zebrafish (*Danio rerio*), a well known model organism in translational neuroscience and behavioural research. Adult zebrafish were treated for 28 days with *L. rhamnosus*, and parameters were measured weekly. Spontaneous activity of fish was evaluated with a video-tracker software, while maximal swimming performance was individually evaluated in a swimming tunnel. Compared with control fishes, treated animals displayed an increase in growth rate and mean spontaneous swimming speed, as well as a change in the shoaling behavior. On the other end, no effect was observed in the maximal swimming speed in a sprint swimming protocol.

EFFECTS OF PARTIAL INSECT MEAL SUBSTITUTION OF FISH MEAL IN DIETS ON ENZYMATIC ACTIVITY IN DIFFERENT
FARMED TELEOST SPECIES

Bousdras, T., Feidantsis, K., Chatzifotis, S., Piccolo, G., Gai, F., Gasco, L. and Antonopoulou, E.

Symposium: Fish Culture **Type:** Poster **Order:** P7
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Laboratory of Animal Physiology, Department of Biology, Aristotle University of Thessaloniki, 54124,
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Abstract: The scientific and commercial interest of using insects as an alternative protein source to replace fish meal in fish diets is increasing. To that end, different growth trials have been conducted in three important farmed teleost species (*Dicentrarchus labrax*, *Sparus aurata* and *Oncorhynchus mykiss*). Herein, the enzymatic activity of metabolic (L-LDH, CS, MDH) and antioxidant (catalase, SOD, GR) enzymes in heart, white muscle, liver and intestine is presented. Generally, the enzymatic activities exhibited both distinct species specificity and tissue specificity. It appears that the insect meal based diets influenced less *O. mykiss* among the examined species, indicating that the water ecology may have an impact. Although all species are carnivorous, their trophic levels differ (3,3 for *S. aurata*; 3,8 for *D. labrax* and 4,4 for *O. mykiss* based on diet in natural habitats). Further studies on various protein translation levels such as mitogen-activated protein kinases are in progress.

CONTRASTING POPULATION GENETIC STRUCTURE AMONG FRESHWATER-RESIDENT AND ANADROMOUS
LAMPREYS; THE ROLE OF DEMOGRAPHIC HISTORY, DIFFERENTIAL SITE-FIDELITY, AND ANTHROPOGENIC
INTENSIFICATION

Bracken, F.S.A., Hoelzel, A.R., Hume, J.B., Lucas, M.C.

Symposium: Lampreys **Type:** Oral **Order:** 7
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Abstract: Loss of migratory ability remains a poorly understood aspect of evolutionary biology that may play an important role in promoting species radiation by both allopatric and sympatric mechanisms. Anadromy inherently offers an opportunity for the colonisation of freshwater environments, and the shift from an anadromous to a wholly-freshwater life-history has occurred in many families of fishes. Freshwater-resident forms have arisen repeatedly among lampreys (*Petromyzontidae*), and there has been much debate as to whether anadromous lampreys, and their derived freshwater-resident analogues, constitute distinct species or are divergent ecotypes of a

single polymorphic species. Samples of 543 European river lamprey *Lampetra fluviatilis* and European brook lamprey *L. planeri* from across 15 sites, primarily in the British Isles, were investigated for 829bp mtDNA sequence and 13 polymorphic microsatellite DNA loci. We found contrasting patterns of population structure for mtDNA and microsatellite DNA markers, such that low diversity and little structure were seen for all populations for mtDNA (consistent with a recent founder expansion event), whilst structure was determined by ecotype for nuclear markers. Strong differentiation was seen among freshwater-resident *L. planeri* populations and between *L. fluviatilis* and *L. planeri* in most cases, but little structure was evident among anadromous *L. fluviatilis* populations. We conclude that post-glacial colonisation founded multiple philopatric resident populations that became highly differentiated, a pattern that was likely intensified by anthropogenic barriers.

CYPRINID FISH MOVEMENTS IN UPSTREAM FRAGMENTED STREAMS

Branco, P., Amaral, S.D., Ferreira, M.T., and Santos, J.M.

Symposium: Fish Migration **Type:** Oral **Order:** 3

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Abstract: Fish migratory pattern is sometimes tainted by the presence of instream artificial barriers that hamper longitudinal connectivity. Is this pattern completely altered in upstream fragmented streams? To reply to this question a 6.5 km long stretch of river was monitored for movements during one year. Fish were tagged with Visible Implant Elastomer tags (VIE) and hydraulic parameters of each barrier were characterized every season. Results show that, although most of the barriers registered bad and poor permeability scores (ICF- River Connectivity Index) in all seasons, fish were able to negotiate them. But, contrarily to what was expected, fish preferred not to move. The traditional volitional downstream migration of young adults and the upstream spawning migration of the adults seem to be altered in upstream fragmented streams.

A GRAPH BASED APPROACH TO ENHANCE FUNCTIONAL CONNECTIVITY OF FRAGMENTED SYSTEMS

Branco, P., Segurado, P., Santos, J.M., and Ferreira, M.T.

Symposium: General Contributed Papers **Type:** Oral **Order:** 1

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Abstract: Freshwater systems are severely impacted by connectivity reduction due to the construction of dams and weirs. There is an increasing need for numerical tools that help decision-makers to plan restoration actions. This study provides a methodology for prioritizing the removal of barriers using spatial graphs and habitat suitability modeling. To exemplify the application of this procedure we used the lower Tagus river network and evaluated the impact of the dams (29 built between 1928 and 2004) on the river functional connectivity for two cyprinid fish species (*Luciobarbus bocagei* and *Squalius pyrenaicus*). Results show that dam construction on the Tagus was responsible for a 48.4– 54.4% reduction in connectivity. Actions to promote connectivity in 7 of the implanted dams would increase connectivity by 35.0 – 37.2%. This prioritization method makes it possible to quantify the impact of the removal or the placement of a new barrier in a river network.

MYCOSPORINE-LIKE AMINO ACIDS PROVIDE A RAPID RESPONSE MECHANISM FOR UV PROTECTION IN REEF FISH

Braun, C., Reef R., Siebeck, U.E.

Symposium: Tropical Fish **Type:** Oral **Order:** 3

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Abstract: Mycosporine-like Amino Acids (MAAs) are ultraviolet (UV) absorbing compounds commonly found in marine organisms. MAAs are continuously secreted into the external mucus of fish and are hypothesized to act as natural sunscreens by preventing UV radiation (UVR) induced DNA damage. To test this hypothesis, we analysed MAA levels and UV specific DNA damage in skin samples of two reef fish species exposed to a 1hr pulse of light either containing (treatment) or lacking UVR (control). Our results provide evidence for a protective role of MAAs as i) DNA damage was negatively correlated with MAA levels and ii) MAA levels significantly increased following UV exposure in one species (*Pomacentrus amboinensis*). This upregulation of MAA levels is the fastest reported in any organism. Quick modulation of sunscreen protection in response to changing UVR levels is expected to provide *P. amboinensis* with a selective advantage if UV levels continue to rise as predicted.

THE EFFECTS OF AQUATIC ACIDIFICATION ON GROWTH, DEVELOPMENT, AND OLFACTORY AND BEHAVIORAL RESPONSES OF EARLY LIFE STAGES OF PINK SALMON

Brauner, C.J., Ou, M., Lyall, E., Eom, J., Yun, S., Close, D., Gallup, J., and Hamilton, T.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 32

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Abstract: Projected increases in CO₂ will affect marine and freshwater (FW) systems, however, the latter has received little attention. Pink salmon are the most abundant of the Pacific salmon. They initially rear in FW but migrate to seawater (SW) at the smallest size of any salmonid (0.2g) before they are fully prepared for hypoosmoregulation. Thus, they may be very susceptible to environmental acidification. To investigate this, fish were exposed to 4 different pCO₂ scenarios (400, 1000, 2000 and a diurnal oscillating treatment (400-2000 uatm)) in FW, from eyed-embryos through to yolk-sac absorption (YSA). Control fish (400 uatm) were transferred to SW at YSA (when they would naturally migrate to SW), and exposed to 400 or 1600 for 3 weeks. In both FW and SW, there was a reduction in growth and maximal oxygen consumption rate at high CO₂. In FW, there was also a reduced ability to sense and respond to alarm cues, along with altered behavior at high CO₂.

GASTROINTESTINAL BLOOD FLOW AND DRINKING DYNAMICS IN RAINBOW TROUT TRANSITIONING INTO SEAWATER

Brijs, J., Olsson, C., Axelsson, M., and Sandblom, E.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P74

Contact: Jeroen Brijs **E-mail:** jeroen.brijs@bioenv.gu.se

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Abstract: The rainbow trout (*Oncorhynchus mykiss*) is a euryhaline teleost that can readily adjust physiologically from freshwater to seawater conditions. In seawater, drinking increases to compensate for water lost osmotically to the hyperosmotic environment through the gills and skin. In the gut, water is absorbed due to the osmotic gradient established by the active uptake of ions. Relatively little is understood about the gastrointestinal blood flow responses and potential metabolic costs associated with these osmoregulatory processes. Here we measured gastrointestinal blood flow and metabolic rate to explore these questions, with the hypothesis that gastrointestinal blood convection increases in hyperosmotic environments to transport absorbed ions and water, as well as supplying oxygen and nutrients to a more metabolically active gastrointestinal tract. Additionally, the dynamics of the 'immediate' drinking response was investigated using a novel approach measuring electrical activity in the

musculature of the esophagus. Preliminary results indicate that gastrointestinal perfusion increases in seawater. The underlying causes of this response will be further discussed.

USING ACCELEROMETER TAGS TO ESTIMATE POST-TAGGING BEHAVIOUR AND STRESS RESPONSE IN FISH

Broell, F., Burnell, C., Taggart, C.T., Taylor, A., Litvak, M. K.

Symposium: Stress in Fish **Type:** Oral **Order:** 21

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Abstract: Conventional and electronic tags play an important role in estimating fish movements and activity. However, external tags can adversely affect fish behaviour, swimming efficiency and elevate stress levels resulting from tagging procedures and tag load. We use tri-axial micro-accelerometers to assess immediate (acute) post-tagging behavioural response in shortnose sturgeon (*Acipenser brevirostrum*) in the wild and as well as longer-term (chronic) post-tagging response in captive Atlantic cod (*Gadus morhua*) tagged with differently-sized tags. First, we summarise the analytical techniques developed to determine stress-related behavioural response based on acceleration data. Using these techniques, we show that Atlantic cod present aberrant swimming behaviour (repetitive scouring) apparently associated with attempts to reduce tag load. We then demonstrate that elevated energy expenditure (maximum acceleration) during scouring is a function of tag load. Finally, we demonstrate that in the wild, immediate post-tagging behaviour is highly variable among individuals ranging from extended resting to elevated activity.

IMPACTS OF WEATHERED CRUDE OIL EXPOSURE ON THE EMBRYONIC DEVELOPMENT AND LARVAL FITNESS OF GULF KILLIFISH

Brown, C.A., Green, C.C., and Galvez, F

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 3

Contact: Charles A. Brown **E-mail:** cbrow87@tigers.lsu.edu

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Abstract: The Deepwater Horizon oil spill, which occurred off the Louisiana coast in the northern Gulf of Mexico, was the largest marine discharge of crude oil in history. Research has demonstrated that embryonic development is a sensitive life stage to teratogenic hydrocarbon exposure, resulting in bradycardia, cardiovascular developmental abnormalities, and reduced hatch. This study will assess the sensitivity and biological effects of developing killifish to embryonic exposure to water and sediments contaminated with southern Louisiana crude oil. Killifish embryos will be derived from six populations ranging from Texas to Florida along the northern Gulf of Mexico with different histories of environmental hydrocarbon exposure. Biological effects including impairment in cardiovascular form and function, hatching success, larval morphometrics, and mortality were monitored. Current studies are assessing the consequences of embryonic oil exposure on larval and juvenile fitness, including metabolic rate and hypoxia and salinity tolerance.

DECLINE OF THE WEATHERFISH IN THE NETHERLANDS IN RELATION TO CHANGES IN ENVIRONMENTAL FACTORS AND PHYSIOLOGY AND BEHAVIOUR OF THE SPECIES

Bruin, A. and Kranenbarg, J.

Symposium: Environmental Change **Type:** Oral **Order:** 8

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Abstract: The behaviour and physiology of resident floodplain species and the effect of the environment has received little study compared to the main stream migratory species. The weatherfish (*Misgurnus fossilis*) is a floodplain species highly adapted to living in densely vegetated and muddy waters like swamps, oxbows and pools. The river landscapes of the Netherlands have been cultivated since the 14th century. By building dikes, digging ditches and pumping off water, river floodplains were turned into agricultural land. The weatherfish seemed to be able to assimilate to these changes for a long time. The second half of the 20th century, however, saw a strong decline. In an effort to find the reasons for this decline we have analyzed the current and historical habitat of over 100 locations. We will discuss the occurrence of the weatherfish in the Netherlands through the centuries and the effect of changes in environment on its occurrence in relation to the physiology and behavior of the species.

IS THE SALMONID ADIPOSE FIN A MECHANOSENSORY ORGAN?

Buckland-Nicks, J., and Croll, R.P.

Symposium: Swimming Physiology **Type:** Oral **Order:** 8

Contact: John Buckland-Nicks **E-mail:** jbucklan@stfx.ca

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Abstract: Experiments showing that removal of the adipose fin of juvenile salmonids negatively affects swimming efficiency in turbulent water, suggested the possibility that the fin might serve a sensory function. Recent analysis of fin ultrastructure with electron microscopy and laser confocal microscopy has revealed a complex network of nerves interacting with astrocyte-like glial cells (ALCs). Several nerves enter the base of the fin and anastomose throughout its length forming specific patterns of terminal branching along the edge of the fin. Nerves are often linked to elements of structural collagen, as is typical of other vertebrate mechanoreceptors, providing support for the hypothesis that the adipose fin is functioning as a “precaudal flow sensor”. This research suggests that new methods of marking salmonids should be investigated, as millions of hatchery fish each year may be compromised by having their adipose fin removed prior to release.

ULTRASTRUCTURE OF THE SALMONID ADIPOSE FIN: EVIDENCE OF A COMPLEX NEURAL NETWORK

Buckland-Nicks, J., and Croll, R.P.

Symposium: General Contributed Papers **Type:** Poster **Order:** P54

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Canada

Abstract: The adipose fin of salmonids, although once widely regarded as vestigial and lacking innervation, has been shown to be important to the swimming efficiency of juvenile fish in turbulent water. Immunocytochemistry was combined with laser confocal microscopy to unveil a complex neural network forming specific patterns of terminal branches in three different regions of the outer edge. This elaborates on previous work done with electron microscopy that revealed the presence of silver-stained nerves interconnected with astrocyte-like cells, as well as myelinated and unmyelinated axons in nerves entering the fin. Fusiform actinotrichia in the subdermis provide structural support to the entire fin but also are linked to collagen cables that connect between the dermal collagen layers on opposite sides of the fin. Nerves are tied into this structural collagen suggesting that the adipose fin may be acting as a mechanosensory organ.

IGFBP-1 AS A POTENTIAL MARKER OF ENVIRONMENTAL STRESS IN FISH

Budige, V. and Lewitt, M.S.

Symposium: Zebrafish **Type:** Oral **Order:** 4

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Abstract: Insulin-like growth factors have diverse roles in growth and metabolism that are regulated by a family of IGF-binding proteins (IGFBPs). IGFBP-1 is an important inhibitor of IGF action. In mammals hepatic IGFBP-1 is inhibited by insulin, and stimulated by glucocorticoids and other stress-related factors. In zebrafish there are two IGFBP-1 genes and we have shown that expression of each is suppressed in vivo by feeding. We have developed a liver explant culture system to study the direct regulation of Igfbp1a and Igfbp1b in vitro. A 2-h exposure to a maximally effective concentration of dexamethasone stimulated Igfbp1a 44-fold ($p < 0.001$) and Igfbp1b 24-fold ($p < 0.001$), in the presence and absence of inhibition by insulin. A maximally inhibitory concentration of insulin was more effective at short incubation times (15min). Oestrogen stimulated IGFBP-1, particularly at long incubation times (24h). It is speculated that IGFBP-1 expression is a marker of environmental stress in fish.

THE STEROID SIGNALLING PATHWAY IN HAGFISH

Bury, N.R

Symposium: Hagfishes **Type:** Oral **Order:** 7

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Abstract: Hagfish and lamprey, representatives of early vertebrates, are grouped in one clade, and are thus equally related to jawed vertebrates. The hagfish, however, have undergone an extraordinary loss of vertebrate features making them appear more primitive. The evolution of a complex steroid hormone/receptor networks is unique in vertebrates. Within the steroid hormone family the corticoids are essential for glucose metabolism and ionoregulation in lamprey and jawed vertebrates, but their role in hagfish is enigmatic. The presentation will explore the evolution of the steroid receptors and their physiological role in the primitive fishes and question whether the glucocorticoid and mineralocorticoid properties of vertebrate corticosteroid receptors has been lost in hagfish.

CORTISOL TREATMENT MODULATES VASOTOCIN AND ISOTOCIN RECEPTORS EXPRESSION AFFECTING METABOLIC AND STRESS SYSTEMS OF GILTHEAD SEA BREAM

Cádiz, L., Román-Padilla, J., Martínez Rodríguez, G., Mancera, J.M., Martos-Sitcha, J.A.

Symposium: Stress in Fish **Type:** Poster **Order:** P118

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Abstract: Arginine vasotocin and isotocin are neurohypophyseal hormones involved in several physiological processes depending on the specific tissue in which their receptors are present. In teleosts, cortisol is a pleiotropic hormone, presenting different physiological roles (metabolism, stress, growth, osmoregulation, etc.). In this study, we assessed changes in vasotocin and isotocin receptors (AVTR and ITR, respectively) mRNA expression in liver and head-kidney of the gilthead sea bream (*Sparus aurata*) treated with cortisol. Specimens were injected intraperitoneally with slow release implants of coconut oil alone (control) or containing cortisol (50 $\mu\text{g}\cdot\text{g}^{-1}$ body

weight), and sampled at 12 hours, and 1, 3, and 10 days post-implantation. Our results suggest that enhancement of hepatic metabolic processes to provide energy to overcome stress could be mediated in part by AVTRs and ITR. Moreover, changes in mRNA expression of both receptors at head-kidney also suggest a role of these nonapeptides in feedback mechanism regulating cortisol synthesis/release.

EFFECTS OF PROBIOTICS ON FISH LARVAL DEVELOPMENT

Carnevali, O.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 22

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Abstract: Growth, metabolism and energy balance regulation is essential for correct development of organisms. A number of studies have shown that the administration of probiotic can positively modulate several biological processes during early stages of fish development. Probiotic administration is able to provoke intestinal microbiota changes, in turn affecting many biological processes such as food intake, lipid metabolism and muscle growth. In addition, a clear advancement of the bone deposition process together with a reduction of bone deformities were also demonstrated in different species. The multiple beneficial role of probiotic on fish larval development has been highlighted by morphological, histological and molecular methods in both marine and freshwater species. Although their role during larval stage has been, as said, highly demonstrated, the mechanisms through which the above mentioned processes are affected still need to be clarified. Our interest is focused on the possible pathways activated by microbiota changes during *D. rerio* development.

EFFECT OF A BPA-ENRICHED DIET ON SPARUS AURATA REPRODUCTION AND DETOXIFICATION

Carnevali, O., Nozzi, V., Dalla Valle, L., Traversi, I., Gioacchini, G., Benato, F., Colletti, E., Gallo, P., Di Marco Pisciotto, I., Mita, D.G., Hardiman, G., Mandich, A., Maradonna, F.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P37

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Abstract: In this study *Sparus aurata* juveniles were used for monitoring the effects of the administration of a BPA enriched diet on the reproductive and detoxification system of fish. Analysis of expression of genes involved in reproduction uncovered altered levels of vtg and Zp, indicating BPA estrogenic effect. Similarly, BPA up-regulated catd and era gene expression. The VtgA and vtgB isoforms are differently modulated by BPA. Cyp1a1, EROD activity and GST were significantly downregulated, confirming the ability of estrogenic compounds to inhibit the recovery process. The upregulation of CAT activity might be associated with the generation of ROS. All these results together confirm the estrogenic effect of BPA and its ability to impair reproduction and the detoxification process. All this information could be useful in developing diagnostic tools and in the generation of a database on the induction of key genes by different EDs. Supported by RICERCA FINALIZZATA 2009 "Food and environmental safety: the problem of the endocrine disruptors" to OC and AM

PELAGIC LARVAL DURATION, SIZE AT SETTLEMENT AND COASTAL RECRUITMENT OF LIPOPHRYNUS PHOLIS AS REVEALED FROM OTOLITH MICROSTRUCTURE

Carvalho, M.G., Moreira, A.S., Moreira, C., Queiroga, H., Santos, P.T., and Correia, A.T.

Symposium: General Contributed Papers **Type:** Oral **Order:** 2
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Abstract: *Lipophrys pholis* is a worldwide intertidal fish usually found in the Portuguese coastal shores. Spawning takes place from October/November to May in rocky beaches, after which demersal eggs hatch and larvae disperse to the coastal area. Individuals return within two or three months and settle in a particular set of rock tide pools, suggesting a homing behavior. Field data about the coastal recruitment and connectivity process are however limited for species. In this study 110 recruits ($TL \leq 30$ mm) were collected in April and May 2013 during the low tides periods in four rocky beaches along the occidental (Cabo do Mundo, Peniche and Vale do Homem) and south (Olhos de Água) Portuguese coasts. Some early life traits, such as pelagic larval duration (PLD) and size at settlement (SAS) were back-calculated from microstructure of otoliths. PLD estimated from micro-increments counts until the settlement mark showed a latitudinal reduction trend from North to South (73 ± 5 days; 64 ± 4 days; 57 ± 6 days and 58 ± 5 days, for Cabo do Mundo, Peniche, Vale do Homem e Olhos de Água, respectively). Furthermore PLD appears to be related in 30% with the regional seawater temperatures probably through the direct effect on the somatic growth. SAS did not show however any regional differences (15.1 ± 0.1 mm) suggesting to be a more conservative character within species. Back calculated spawning, hatching and settlement dates showed an uniform distribution through the lunar cycle. These new findings are discussed according to the current biological knowledge about the *L. pholis*.

MODELING OF ENVIRONMENTAL FLOW OPTIONS FOR OPTIMAL ATLANTIC SALMON EMBRYO SURVIVAL DURING WINTER IN A HYDROPEAKING RIVER

Casas-Mulet R., Alfredsen K., Saltveit S.J.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 2

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Abstract: Recent findings on causes of embryo mortality during winter suggests that long duration drawdowns during cold periods is the most likely cause of mortality in the ramping zone of hydropeaking rivers. With no water quality issues and very low inputs of fine sediments, exposure to dry conditions and sub-zero temperatures were the main factors explaining egg mortality. This paper presents a framework on which thresholds for optimal embryo survival are linked to physical habitat requirements at the meso-scale and integrated into alternative hydropower operations at the catchment scale. Several alternative hydropower options were evaluated in terms of economic and technical feasibility and their contribution to optimize embryo survival. Targeted alternative environmental flow releases during winter bottleneck periods can be more effective than general operational rules to comply with legislation. The development of well-informed and targeted mitigation strategies is important for future environmental hydropower management.

OVARIAN MORPHOLOGY OF *ASTYANAX ALTIPARANAE*: MACROSCOPIC, MICROSCOPIC, AND ULTRASTRUTURAL CHARACTERS

Cassel, M., and Borella, M.I.

Symposium: General Contributed Papers **Type:** Oral **Order:** 3

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Abstract: *Astyanax altiparanae* ovaries are of a cavity cystovarian kind with the germinal compartment in the form of lamellae. The oocyte develops into the following stages: oogonia arranged in nests, early oocytes individualized by follicular cells, establishment of follicular complex, previtellogenic growth, and vitellogenic growth. Maturation

is completed when the nucleus migrates toward the micropylar apparatus. Post-ovulatory complex and atresia were observed. In ultrastructure, the follicular cells presented flattened nucleus with loose chromatin and many elongated mitochondria. Theca cells have rounded nuclei with loose chromatin, few mitochondria, many vesicles, desmosomes and interdigitations. Initially, follicular cells have few organelles; however it presents many vesicles and prominent RER when the follicular complex is completely established. In this process there is also the thickening of the zona pellucida and a more pronounced formation of its canaliculi. There were blood capillaries between theca cells and the basement membrane, and immune cells surrounding the oocyte.

INTERACTIONS OF NITRIC OXIDE AND CALCIUM SIGNALLING PATHWAYS IN GROWTH HORMONE RELEASE FROM
GOLDFISH PITUITARY CELLS

Chang J.P., Sawisky G.R., and Uretsky A.D.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 6

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Abstract: We have shown that nitric oxide (NO) donors elicit Ca²⁺ signals in identified goldfish gonadotropes and NO and Ca²⁺ are two of the many intracellular pathways mediating the control of growth hormone (GH) secretion by neuroendocrine factors. In this study, we examined the relationships between NO and Ca²⁺-dependent intracellular mechanisms in GH secretion from primary cultures of dispersed goldfish pituitary cells using a combination of static incubation and column perfusion experiments and a pharmacological approach. Results suggest that NO-stimulated GH release is dependent on extracellular Ca²⁺ availability and intracellular Ca²⁺ stores possessing BHQ-inhibited CaATPases together with TMB-8- and caffeine-, but not ryanodine-sensitive, release channels. Camodulin kinase also participates in NO-induced GH release but caffeine-induced GH release is not upstream of NO. These findings also fit into the known properties of NO- and Ca²⁺-dependent signalling in gonadotropin-releasing hormone and dopamine stimulation of GH secretion. (Funded by NSERC and AHFMR.)

VARIATION IN BODY COMPOSITION, GROWTH AND POPULATION STRUCTURE OF THE CENTRAL MUDMINNOW IN
RESPONSE TO WATERSHED LAND-USE

Chapman, J.M., King, G.D., Filgueira, R., Suski, C.D., Cooke, S.J.

Symposium: Fish Habitats **Type:** Oral **Order:** 3

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Abstract: Changes in land-use within watersheds have been demonstrated to influence fish populations in stream ecosystems, yet the physiological mechanisms behind population-level changes remain elusive. In this study, GIS was used to characterize land-use in six tributaries of the St. Lawrence River. We then quantified seasonal energy dynamics, fish health indices and length at age of central mudminnow *Umbra limi* across the watersheds. These data were then compared to tributary fish community data to understand the relationship between *U. limi* energy stores, growth patterns and population age structure in response to changing watershed land-use.

LOCALIZED EXTREME HYPOXIA AND PHENOTYPIC DIVERGENCE

Chapman, L.J., and Martinez, M.

Symposium: Climate Change **Type:** Oral **Order:** 14

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Abstract: Aquatic hypoxia (low oxygen) provides a useful system for exploring ecological and evolutionary consequences of living under extreme conditions. It is also an environmental stressor of accelerating interest due to human activities that have increased the extent of hypoxic waters. The African cyprinid *Barbus neumayeri* exhibits strong patterns of phenotypic divergence between hypoxic swamps and normoxic streams in traits related to oxygen uptake (e.g., gill size), anaerobic capacity (e.g., LDH), life-history traits, and parasite occurrence, but also in traits indirectly affected by hypoxia (e.g., body shape). A combination of long-term acclimation and population genetics studies of *B. neumayeri* suggest the possibility of genetic differentiation between oxygen regimes over small spatial scales. Studies of adaptation to naturally occurring hypoxia could provide important insights into traits that may facilitate persistence and recovery in the face of globally increasing aquatic hypoxia.

GROWTH AND PHYSIOLOGICAL RESPONSE OF JUVENILE TIDEWATER GOBY TO INTERSPECIFIC COMPETITION

Chase, D.A., and Todgham, A.E.

Symposium: Stress in Fish **Type:** Oral **Order:** 15

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Abstract: Recovery of endangered fish species can be complicated by threats from introduced species. Intentional reintroduction to historic habitat has been used as a recovery tool; however, these fish face competition from fishes that have established in their native habitat since extirpation. This study sought to investigate the physiological response of tidewater goby (*Eucyclogobius newberryi*), an endangered fish species, when in the presence of threespine stickleback (*Gasterosteus aculeatus*), a native species, and rainwater killifish (*Lucania parva*), a non-native species. Juvenile fish were held in aquaria for 28 days under 50% and 75% feeding levels. Growth rates, survival, and indicators of stress (i.e. cortisol, glucose, and lactate) were assessed. Reduced feeding levels significantly affected survival, body condition, cortisol and glucose levels in gobies; however, this effect was similar across all species combinations. Findings indicate greater competitive impact from the native species, while the non-native killifish performed better than the goby under low food levels.

MORPHOLOGICAL AND HISTOCHEMICAL STUDY OF DIGESTIVE TRACT OF LEPORINUS ELONGATUS

Chedid, R.A., Faccioli, C.K., Mori, R.H., Amaral, A.C., Franceschini-Vicentini, I.B. and Vicentini, C.A.

Symposium: Tropical Fish **Type:** Poster **Order:** P143

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Abstract: This study characterized the morphology and histochemistry of the digestive tract of a Neotropical freshwater fish *Leporinus elongatus*. This specie presents a short and tubular esophagus with thick longitudinal folds. The esophageal epithelium is stratified squamous containing numerous goblet cells, which secrete acidic and neutral mucins for epithelial protection and lubrication. Stomach has "Y"-shaped constituted of cardiac, fundic and pyloric regions. The cardiac and fundic regions contain tubular gastric glands. Gastric epithelial cells present apical neutral mucins to prevent auto-digestion. The intestine consists of four regions: anterior with ten pyloric caeca, middle in "N"-shaped, long and straight posterior intestine and rectum. Intestinal epithelium is columnar containing enterocytes with PAS-positive brush border, goblet cells and rodlet cells. Goblet cells are numerous in anterior intestine secreting neutral and acidic mucins for epithelial lubrication and protection. In conclusion, these features are related to the feeding habits of *L. elongatus*, an omnivorous fish.

FUNCTIONAL ROLES OF AQUAPORINS IN THE GILLS OF THE CLIMBING PERCH DURING SEAWATER ACCLIMATION
AND AMMONIA EXCRETION

Chen, X.L., Hiong, K.C., Lam, S.H., Wong, W.P., Chew, S.F., Ip, Y.K.

Symposium: Tropical Fish **Type:** Oral **Order:** 18

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Abstract: The freshwater climbing perch, *Anabas testudineus*, is an obligate air-breathing teleost which can acclimate to seawater and actively excrete ammonia during emersion or ammonia exposure. Aquaporins are a superfamily of integral membrane proteins including the classical aquaporins, aquaglyceroporins and unorthodox aquaporins. They support a rapid but highly selective flux of water and/or small solutes across biological membranes. This study aimed to obtain the cDNA coding sequences of several aquaporin isoforms from the gills of *A. testudineus*, and to determine their branchial mRNA and protein expression in fish kept in fresh water (control), or exposed to seawater or 100 mM NH₄Cl in fresh water. The localization of these aquaporin isoforms in the branchial epithelium of *A. testudineus* was also determined using immunofluorescence microscopy. It was hoped that results obtained would shed light on the functional roles of different aquaporin isoforms in osmoregulation and/or active ammonia transport in *A. testudineus*.

EFFECTS OF AMMONIA OR TERRESTRIAL EXPOSURE ON THE EXPRESSION OF RHESUS GLYCOPROTEINS IN THE GILLS
OF THE CLIMBING PERCH

Chen, X.L., Zhang, B., Hiong, K.C., Lam, S.H., Wong, W.P., Chew, S.F., Ip, Y.K.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 15

Contact: Chen Xiu Ling **E-mail:** a0038172@nus.edu.sg

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Abstract: The freshwater climbing perch, *Anabas testudineus*, is an obligate air-breathing teleost which can actively excrete ammonia during emersion or when exposed to high concentrations of environmental ammonia. This study aimed to clone and sequence the rhesus glycoproteins (rhgp) from the gills of *A. testudineus* and to determine the effects of ammonia or terrestrial exposure on their branchial mRNA and protein expression. Four rhgp (rhag, rhbg, rhcg1 and rhcg2) were expressed in the gills of *A. testudineus*. Exposure to 100 mM of NH₄Cl or terrestrial condition led to significant increases in the mRNA expression of rhbg and rhcg1 in the gills of *A. testudineus*, suggesting their roles in active NH₄⁺ excretion. Efforts were also made to determine the cellular localization of the Rhgp isoforms in the gills of *A. testudineus* by immunofluorescence microscopy.

TACTICS TO PRODUCE WILD PHENOTYPES IN ARTIFICALLY REARED SPRING CHINOOK SALMON
Chitwood, R., Schreck, C.B., Billman, E.J., Unrein, J., Schroeder, R.K., Sharpe, C.S., Couture, R. and Noakes, D.L.G.

Symposium: Fish Habitats **Type:** Oral **Order:** 5

Contact: Rob Cchitwood **E-mail:** rob.chitwood@oregonstate.edu

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Abstract: Juvenile Chinook salmon display considerable variation in life history patterns associated with downstream movement. We explored the role of environmental variables that could cause fish to develop on

trajectories associated with these phenotypes. Given that our evaluations are based on laboratory-reared fish, we also assessed other fish quality variables for resemblance to wild fish. We found that temperature, density, tank substrate, low lipid diet, and feeding strategy could be manipulated to produce fish that fit certain movement patterns, particularly fall and spring run smolts. We also found that these variables were strongly associated with fish condition as judged from growth rates, fin condition, condition factor, coloration, frequency of precocity, and potentially body lipid content. Movement behavior of fish assessed in large artificial streams and in a separate study with telemetry of fish stocked in a river system supports the contention that these fish behave more like their wild counterparts than do typical hatchery fish.

EFFECTS OF DIETARY INCLUSION OF MICRO ALGAE (*CHLORELLA VULGARIS*) BY-PRODUCT ON GROWTH PERFORMANCE, BODY COMPOSITION AND ANTIOXIDANT ENZYME ACTIVITY OF OLIVE FLOUNDER

Choi, J., Park, H.G., and Lee S.M.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P64

Contact: Sang-Min Lee **E-mail:** smlee@gwnu.ac.kr

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Korea

Abstract: This study was carried out to investigate the effects of dietary inclusion of micro algae by-product (MAB) on growth, body composition and antioxidant enzyme activity of olive flounder (*Paralichthys olivaceus*). Five isonitrogenous and isocaloric diets were formulated to contain 0 (control), 5%, 10% and 15% MAB designated as MAB0, MAB5, MAB10 and MAB15, respectively. Weight gain of fish fed the MAB10 and MAB15 diets were higher than control. Catalase activity of blood in fish fed MAB10 and MAB15 were higher than those of control and MAB5. Antioxidant capacity of blood in fish fed MAB5 and MAB10 were higher than those of control and MAB15. DPPH radical scavenging activity of muscle in fish fed MAB15 was higher than control. The results of this study suggest that inclusion (10-15%) of microalgae by-product in diet could improve the growth and antioxidant activity of olive flounder.

METABOLIC ENZYMES ACTIVITY AND MUSCLE SPECIFIC GENES EXPRESSION IN RAINBOW TROUT IN RELATION TO AGE AND GROWTH RATE

Churova, M.V., Meshcheryakova, O.V., Aleksandrova, A.M., Nemova, N.N.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P65

Contact: Maria Churova **E-mail:** mchurova@yandex.ru

Institute of Biology of the Karelian Research Centre of the Russian Academy of Sciences, Pushkinskaya, 11,
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Abstract: Activity of aerobic and anaerobic enzymes (cytochrome c oxidase, COX, and lactate dehydrogenase, LDH), gene expression of myosin, MyoD, myogenin and myostatin were studied in muscle in rainbow trout of two ages (0+ and 1+) and were compared between slow- and fast-growing groups. The differences in parameters between age groups were established, such as the expression of myogenic regulatory factors (MyoD, myogenin) were higher in 0+ trout. The relationship between enzymes activity, myosin expression and growth rates were revealed. The activity of COX and LDH and myosin gene expression were higher in fast-growing fish. This research was supported by Grants of the Russian Federation President 1410.2014.4 and MK-3025.2014.4, the Russian Foundation for Basic Research (14-04-00473), the Federal Purposeful Program (contract No. 8050), Programs of RAS “Living Nature”, 2012–2014, and “Biological Resources” 2012–2014.

THE ROLE OF INTRASPECIFIC PHYSIOLOGICAL DIVERSITY IN DETERMINING RESPONSES TO ENVIRONMENTAL
PERTURBATIONS

Clark, T.D., Messmer, V., Pratchett, M.S., and Norin, T.

Symposium: Environmental Change **Type:** Oral **Order:** 1

Contact: Timothy Clark **E-mail:** timothy.clark.mail@gmail.com

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Abstract: The diversity and plasticity of phenotypes within a population are fundamental to driving resilience and acclimation potential. This presentation outlines how baseline differences in individual phenotypes can be predictive of subsequent responses to environmental perturbations. First, a study on the tropical barramundi (*Lates calcarifer*) shows that individuals with elevated metabolic attributes (standard metabolic rate [SMR], maximum metabolic rate [MMR] and aerobic scope [AS]) under control conditions (35 ppt salinity, 29°C, normoxia) show little change in SMR, MMR and AS in response to low salinity and high temperature, while MMR and AS are greatly depressed by hypoxia. The opposite patterns are observed in individual fish with relatively low metabolic attributes under control conditions. Second, a study on the coral trout (*Plectropomus leopardus*) shows that individuals with a propensity to exercise exhaustively (e.g., during catch-and-release fishing) will be under negative selection pressure as coral reefs continue to warm. These findings highlight the diversity of performance levels within populations, and provide some of the first insight into how individual phenotypes may be favoured under particular environmental conditions.

IMPACT OF METHYLMERCURY ON MIGRATORY BEHAVIOUR IN GLASS EEL: AN EXPERIMENTAL STUDY

*Claveau, J., Monperrus, M., Baudrimont, M., Gonzalez, P., Cavalheiro, J., Jarry, M., Bardonnat, A., Amouroux, D.,
Bolliet, V.*

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 18

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Abstract: In this study, we investigated the effect of methylmercury on glass eels propensity to migrate, mitochondrial activity and detoxification processes. Marine glass eels were sorted in an experimental flume in response to dusk. Migrante and non migrante glass eels were individually tagged and exposed to isotopically enriched 201 methylmercury. 40 glass eels were then sampled to study the effect of contamination on muscular fibres and the expression level of genes involved in detoxification processes and mitochondrial activity. To investigate the effect of contamination on glass eels behaviour, migrante and non migrante glass eels were sorted as explained above. Methylmercury uptake and demethylation product (201Hg(II)) were determined in all individuals by GC-ICPMS. Results showed a bioaccumulation of methylmercury by glass eels and a demethylation potential. Methylmercury exposure affected detoxification processes, mitochondrial activity, behaviour and revealed muscle and mitochondrial impairments. These effects varied between migrante and non migrante individuals.

EFFECTS OF PHYTOESTROGENS ON EXPRESSION OF GENES REGULATING GROWTH-RELATED PROCESSES IN
RAINBOW TROUT

Cleveland, B.M., and Manor, M.L.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 16

Contact: Beth Cleveland **E-mail:** beth.cleveland@ars.usda.gov

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Abstract: Phytoestrogens are plant-derived isoflavones that activate estrogen receptors. Phytoestrogen content of aquafeeds is increasing due to higher inclusion levels of soy and other legumes rich in these compounds. It is unknown whether phytoestrogens affect growth-related processes in a manner similar to the catabolic effects

estradiol. Rainbow trout were injected with estradiol and phytoestrogens genistein and daidzein, and regulation of growth- and proteolysis-related gene expression was determined after 24 hr. All compounds increased expression of estrogen receptor alpha-1 and vitellogenin in liver. Estradiol and a high dose of genistein (50 µg/g) produced similar gene expression responses, like down-regulation of the GH/IGF axis and up-regulation of igfbp2b. These treatments also increased expression of FA synthesis and β-oxidation genes in liver. In muscle, estradiol increased while a low dose of genistein (5 µg/g) decreased expression of fbxo32 (atrogen-1). These data suggest phytoestrogens produce dose-dependent effects on growth-related processes in rainbow trout.

EXTRABRANCHIAL HANDLING OF AMMONIA LOADING FOLLOWING HIGH EXTERNAL AMMONIA EXPOSURE IN THE PACIFIC HAGFISH

Clifford, A.M., and Goss, G.G.

Symposium: Hagfishes **Type:** Oral **Order:** 11

Contact: Alex Clifford **E-mail:** alex.clifford@ualberta.ca

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Abstract: In this study, we demonstrate differential ammonia handling by the anterior and posterior regions of the hagfish whereby a significant rate of ammonia flux occurs across the skin in the posterior section of the hagfish. Hagfish were exposed to elevated (20mmol/L) external ammonia (HEA) for 48hr and flux across the anterior and posterior segments were measured using specially designed flux chambers. Hagfish excreted ammonia at a rate of 147.2 µmol/kg/hr from the posterior (skin only) region which was ~20% of that observed in the anterior region (gill+skin). Additionally, hagfish acutely exposed to HEA in the posterior region displayed a 20-fold higher ammonia uptake rate compared to hagfish exposed to HEA in the anterior compartment. In situ measurement of ammonia skin flux rate was assessed using Ussing chambers. We demonstrate that excised skin from 48hr HEA exposed animals was able to flux ammonia at up to 3-fold higher rates than skin from non-HEA exposed animals thereby suggesting an ability to regulate ammonia flux across the skin.

CLONING OF SLC26A6, A PROPOSED CL-/HCO₃- EXCHANGER IN RAINBOW TROUT, AND CHARACTERISATION OF CHLORIDE ACQUISITION IN FISH DURING EARLY RAINBOW TROUT DEVELOPMENT

Clifford, A.M., Boyle D., Orr, E, Chamot, D and Goss, G.G.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 9

Contact: Alex Clifford **E-mail:** alex.clifford@ualberta.ca

University of Alberta, 116 St and 85 Ave, Edmonton, Alberta, T6G 2R3, Canada

Abstract: Freshwater fishes must continuously acquire ions, including Cl⁻, to counterbalance diffusive losses to a more dilute ambient environment. In this study, slc26a6, a prospective Cl⁻/HCO₃⁻ exchanger was identified in gills of rainbow trout (*Oncorhynchus mykiss*) and shown to be homologous to previously identified slc26a6 transcripts. Analysis of mRNA expression in tissues revealed a high abundance of the transcript in gills of freshwater trout which decreased 37-fold after acclimation of fish to 20‰ seawater (a high Cl⁻ environment). Expression of slc26a6 was also analysed during development of rainbow trout embryos and paired with a pharmacological characterisation of 36Cl⁻ acquisition. Although mRNA expression of slc26a6 exhibited little change, unidirectional 36Cl⁻ uptake in embryos exhibited a marked increase immediately post hatch. Chloride uptake was also shown to be sensitive to both anion exchange (DIDS) and carbonic anhydrase (acetazolamide) inhibitors supporting the role of a Cl⁻/HCO₃⁻ exchange protein in Cl⁻ uptake in trout embryos.

ADAPTATION OF TWO MARINE SPECIES, GRAY MULLET AND WHITE GROUPER, TO CULTURE IN INLAND LOW SALINITY WATER

Cnaani, A., Malamud, S., Perelberg, A., Smirnov, M., Slosman, T., and Harpaz, S.

Symposium: Fish Culture **Type:** Oral **Order:** 2

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Abstract: Gray mullet (*M. cephalus*) and white grouper (*E. aeneus*) are popular Mediterranean fish species, their domestication and culture in low-salinity water is gaining increasing interest. This study aimed to characterize the effect of water mineral content and composition on the survival, growth and physiology of gray mullet and white grouper, in order to evaluate the feasibility of their culture in various salinities. Gray mullet transferred from brackish to low-mineral water suffered an osmotic stress, as reflected in changes in gills structure, Na⁺/K⁺-ATPase activity, and blood mineral content. Comparison of acclimation protocols through sodium or calcium based solutions resulted in reduced osmotic stress and improved survival with the sodium based protocol. White groupers that were raised in range of salinities showed best growth in 1‰ salinity. Dietary salt supplementation improved growth in low salinities. Effect of water pH was evaluated and pH 8.2 found to be preferable over pH 7.8.

TILAPIA'S SALINITY ADAPTATION – FROM COMPARATIVE TRANSCRIPTOME ANALYSIS TO NOVEL GENES CHARACTERIZATION

Cnaani, A., Ronkin, D., Ben-Tal Cohen, E., Doron-Faigenboim, A., Seroussi, E.

Symposium: Physiological Genomics **Type:** Oral **Order:** 5

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Abstract: Tilapias (Family: Cichlidae) are a group of freshwater fishes, however, some of these species are tolerant to high salinities. Differences in salinity tolerance were observed in two tilapiine species, *Oreochromis mossambicus*, which is salinity tolerant and *O. niloticus*, which is more sensitive. Aiming to characterize the underlying mechanism differing their salinity tolerance we analyzed the intestinal transcriptomic response of those two species to salt- and freshwater acclimation. mRNA was sequenced using the Illumina Hi-Seq technique, gene expression and gene-ontology (GO) patterns were analyzed, and several genes were further characterized in additional organs. Our analyses indicate a different salinity dependent gene expression patterns between species and intestinal section. Overall, between 182 and 404 genes were significantly up-regulated in either fresh or salt water. The species comparison resulted with differential expression patterns of specific genes and GOs, including 70 genes with inversed salinity response, up-regulated in one species and down-regulated in the other species. From these genes we have focused on two potassium channels, KCNJ15 and KCNJ16, characterized their salinity-dependent gene expression and protein localization in various osmoregulatory organs.

COMBINING TRADITIONAL KNOWLEDGE AND WESTERN SCIENCE TO FURTHER LAMPREY ECOLOGICAL RESEARCH AND CONSERVATION IN THE UMPQUA RIVER BASIN, OREGON, USA

Coates, K.C., Dunham, Heck, M.P., J.B., Eagle-Smith, C.A., Kowalski, B.M., Siitari, K.J.

Symposium: Lampreys **Type:** Oral **Order:** 11

Contact: Kelly Coates **E-mail:** kcoates@cowcreek.com

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Abstract: The Cow Creek Band of the Umpqua Tribe of Indians Fisheries Program has been focusing on ecological research and conservation of Pacific lamprey (*Entosphenus tridentatus*) and western brook lamprey (*Lampetra richardsonii*) in the Umpqua Basin. Our approach to lamprey conservation incorporates traditional tribal knowledge

and western science in order to provide a comprehensive approach to conservation. We are examining the current ecology of lamprey within the basin through multiple research projects including; development of a lamprey distribution map and GIS database; annual targeted juvenile lamprey surveys within the basin and partnering with U.S. Geological Survey on a smallmouth bass predation on lamprey study. Information gained through traditional knowledge and current science will prepare us for future lamprey conservation work at a larger ecological scale.

THE "EYE" AND PHOTORECEPTION IN HAGFISHES: INSIGHTS INTO THE EVOLUTION OF VISION

Collin, S. P., Lamb, T. D., Davies, W. I. L., Hart, N. S. and Hunt, D. M.

Symposium: Hagfishes **Type:** Oral **Order:** 4

Contact: Shaun P. Collin **E-mail:** shaun.collin@uwa.edu.au

School of Animal Biology and the UWA Oceans Institute, The University of Western Australia, Crawley 6009,
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Abstract: Hagfish "eyes" are small, conical, completely lacking in any sign of a lens, an iris, a cornea or intra- or extraocular muscles, and buried beneath unpigmented translucent skin. The neural arrangement of the hagfish retina is strongly reminiscent of the pineal organ in non-mammalian vertebrates and therefore does not appear to subserve vision (image formation) but likely functions as a circadian organ, similar to the gnathostome pineal complex (which hagfish lack). However, little is known about how the "eyes" of hagfishes function and can inform us about the evolution of vision in gnathostomes. Here, we discuss the features of the photoreceptive system in the context of the evolution of the retina, dim light vision and predicting light-driven behaviours (if any). With further multidisciplinary research, it is hoped that we can uncover a more in depth understanding of the evolution of phototransduction and photokinetics of this important stage in vertebrate evolution.

THE EVOLUTION AND DEVELOPMENT OF PHOTORECEPTION IN LAMPREYS: IMPLICATIONS FOR BEHAVIOUR

Collin, S. P., Warrington, R., Davies, W. I. L., Hart, N. S., Potter, I. C., Gill, H. and Hunt, D. M.

Symposium: Lampreys **Type:** Oral **Order:** 3

Contact: Shaun P. Collin **E-mail:** shaun.collin@uwa.edu.au

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Abstract: Meeting the challenge of visually sampling an ancient aquatic landscape by the early vertebrates was crucial to their survival and would establish a retinal bauplan to be used by all subsequent vertebrate descendents. Image-forming eyes were under tremendous selection pressure and the ability to identify suitable prey and detect potential predators was thought to be one of the major drivers of speciation in the Early Cambrian. Using extant representatives of the earliest stage in vertebrate evolution (lampreys), we present predictions of the evolution and development of photoreception (image formation and irradiance detection) and show that these jawless fishes possess a large range of visual pigments potentially providing the capacity for colour discrimination. The diversity and function of visual pigments suggests intense selective pressures to optimize light capture and spectral tuning existed over 500 million years ago.

NEUROANATOMICAL INSIGHTS INTO SENSORY ABILITIES AND BEHAVIOUR IN ELASMOBRANCHS

Collin, S. P., Yopak, K. E., Atkinson, C. J. L., Schluessel, V. and Hart, N. S.

Symposium: Elasmobranchs **Type:** Oral **Order:** 4

Contact: Shaun P. Collin **E-mail:** shaun.collin@uwa.edu.au

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Abstract: As apex predators, cartilaginous fishes hold a unique position within a range of aquatic ecosystems, maintaining the fine balance between species' abundance and biodiversity. It is therefore important that we understand the impressive battery of sensory strategies that underlie many of their complex behaviours including finding prey, avoiding predators, navigating within their environment, forming reproductive aggregations and communication. This research focuses on a range of species in order to identify specific adaptations and the compromise between sensory resolution and sensitivity. For many species, we are able to quantitatively assess the summative convergence of sensory input and the relative importance of different sensory modalities at both peripheral and central levels of the nervous system. Data will be presented in the context of predictions of sensory capabilities and anatomical proxies for cognitive abilities and what further research is needed to explore these behaviourally.

A FISHY PERSPECTIVE ON CARRYOVER EFFECTS

Cooke, S.J., Midwood, J., O'Connor, C., Crossin, G., Larsen, M.H., Boel, M., Jepsen, N., and Aarestrup, K.

Symposium: Stress in Fish **Type:** Oral **Order:** 12

Contact: Steven Cooke **E-mail:** steven_cooke@carleton.ca
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Abstract: Carryover effects are a "hot topic" in animal ecology of late. They occur in any situation where an individual's previous history and experience explains a biologically relevant proportion of their current performance in a given situation. Much of the research to date on carryover effects in an ecological context has focused on migratory birds. Here we first provide an overview of the concept of carryover effects and its emergence in animal ecology as a new paradigm for thinking about the consequences of stress. We then summarize some of our recent work that explores the potential for carryover effects in fish with a focus on a wild population of sea trout in Denmark. We conclude considering how carryover effects may complicate conservation.

WHEN NETS GET IN THE WAY - THE STORY OF ENDANGERED COHO SALMON EN ROUTE TO SPAWNING GROUNDS

Cooke, S.J., Raby, G., Hinch, S.G., Farrell, A.P., Cook, K., Clark, T., Patterson, D.

Symposium: Fish Migration **Type:** Oral **Order:** 1

Contact: Steven Cooke **E-mail:** steven_cooke@carleton.ca
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Abstract: Endangered interior Fraser River (Canada) coho salmon are captured incidentally as bycatch while en route to spawning grounds. Although coho must be released, not all fish survive. Here we present findings arising from field studies associated with the commercial and aboriginal fishing sectors and experimental lab manipulations.

FRIEND OR FOE? DOES SMELLING THE 'ENEMY' INFLUENCE WHERE JUVENILE REEF FISH CALL HOME?

Coppock, A.G., Gardiner, N.M., Jones, G.P.

Symposium: Sensing the Environment **Type:** Oral **Order:** 3

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Abstract: Coral reef fish use olfaction to respond to a variety of chemical cues that allow them to garner critical information regarding their surroundings. The extent to which olfactory cues are utilised by juvenile reef fish in discerning amongst ‘friends’ or ‘foes’ when determining habitat at settlement, however, remains unclear. Here we test olfactory preferences for conspecifics and heterospecifics in newly settled juveniles of coral reef fishes. Juveniles of four gregarious, coral associated Pomacentrid species, which are commonly found co-habiting to varying degrees. *Dascyllus melanurus*, *Dascyllus reticulatus*, *Chrysiptera parasema* and *Pomacentrus moluccensis*, were subjected to a series of pairwise olfactory choice tests using two-channel choice flume. All four species demonstrated preferences towards the presence of conspecifics (*D. melanurus*: 63%, *D. reticulatus*: 61%, *C. parasema*: 65%, *P. moluccensis*: 56%). However, when tested against heterospecific species, significant avoidances were apparent. The strength of this avoidance was greatest towards *P. moluccensis*. While it is already known that conspecifics play a vital role in settlement site selection, the presence of heterospecifics may also be key determining the subsequent spatial distributions of juveniles across areas of coral reef.

INTRA- AND INTER-ANNUAL CHANGES IN THE CONDITION FACTORS OF THREE CURIMATIDAE DETRITIVORES FROM
AMAZONIAN FLOODPLAIN LAKES

Correia, G.B., Siqueira-Souza, F.K., Freitas, C.C.F.

Symposium: Tropical Fish **Type:** Oral **Order:** 14
Contact: Gisele Batista Correia **E-mail:** giselemika@gmail.com
Universidade Federal do Amazonas, Manaus, 69077-000 Brazil

Abstract: We tested the existence of intra- and inter-annual changes in the relative condition factors (kn) of three Curimatidae. We used weight and length data from fish that were caught in eight floodplain lakes of the Rio Solimões. These data were from experimental fisheries during each season of the hydrological cycle: flooding, flood, drying, and dry from 2004, 2005, and 2006. In general, there are similar patterns of intra-annual changes for these three species, with the highest estimates of kn during high water conditions. The lowest values were observed during the drying and dry seasons of 2005, when an extreme drought occurred in the Amazon basin. Higher values were observed during the same seasons in the year post-drought. We hypothesized that these patterns would be explained by the biological characteristics of these species and the effects of intra-annual hydrological changes, mainly the flood pulse effect, and by inter-annual climatic events, which are determined by global climate phenomena.

SEASONALITY IN DIEL MOVEMENTS AND HABITAT USE OF BURBOT IN A SUB-ARCTIC LAKE

Cott, P.A., Guzzo, M.M., Chapelsky, A.J., Milne, S.W., Blanchfield, P.J.

Symposium: Burbot **Type:** Oral **Order:** 3
Contact: Pete Cott **E-mail:** pcott@wlu.ca
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Abstract: Determining the habitat use and movements by fish is critical to our understanding of aquatic ecosystem function. We employed a high-resolution acoustic telemetry positioning system to track the movements and activity of 10 burbot (*Lota-lota*) over 2 years in a 420 ha sub-Arctic lake. Burbot underwent diel vertical migration, occupying deep water (10-20 m), with soft, low complexity substrates during daytime and ascended along the bottom to rocky, shallow water (>10 m) habitats at night. Increased activity rates during shallow water forays and littoral stable isotope values suggest active feeding events. Diel movement patterns held regardless of photoperiod. Because rate of vertical movement is governed by burbot's physoclastic swim bladders, the gas glands of which vary in size over the year, we also test for seasonal changes in diel ascent rate. The movements of burbot are more dynamic than previously believed, but are bound by light, temperature, and physiological constraints.

HYDRODYNAMIC COMPLEXITY OF FLOW IN THE NASAL REGION OF A GUITARFISH

Cox, J., M. Agbesi, D. Sykes, S. Naylor, K. Hay, L. Perkins, J. Maclaine, Z. Wang, and I. Gursul

Symposium: Elasmobranchs **Type:** Oral **Order:** 3

Contact: Jonathan Cox **E-mail:** j.p.l.cox@bath.ac.uk

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Abstract: We have scanned a guitarfish, *Rhinobatos lentiginosus*, using X-ray microcomputed tomography, and from this scan produced a virtual model of its head. From this virtual model we have fabricated a life-sized plastic model, and we have used this plastic model to investigate flow in the paired nasal regions of the guitarfish. First and foremost, we have shown that flow through the nasal region can be driven solely by an external flow (e.g. generated by swimming, or by a current). In other words, respiratory activity is not the only mechanism for driving flow through the nasal region. We have also shown that flow in the nasal region is complex, particularly in the vicinity of the nasal flaps, where there are several areas of recirculation, presumably assisting flow through the nasal region. Our results have significance for both olfaction in elasmobranchs and for the design of scent-tracking underwater vehicles.

THE ORIENTATION OF ZEBRAFISH: ROLES OF RHEOTAXIS AND MAGNETOTAXIS

Cresci, A., De Rosa, R., Agnisola, C.

Symposium: Sensing the Environment **Type:** Poster **Order:** P114

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Abstract: How animals can orient themselves, even in environments apparently lacking clear reference points, is still debated. Teleosts are present in all kinds of aquatic environment of the Earth and some species can cover distances of thousands of kilometers orienting themselves perfectly. Among the various factors that can be involved in the orientation of fishes, water currents and magnetic fields can play a key role. We studied the behavior linked to orientation in zebrafish (*Danio rerio*), a model organism in behavioral research, using a new swimming tunnel set up, which allowed us to study animal behavior in varying water flows and magnetic fields. We evaluated behavioral patterns of both schools and individual fishes with a video-track software. We found that magnetic fields in the range of 0-100 μ T affect the rheotaxis behavior of *Danio rerio*, suggesting that current and magnetic sensing interplay in zebrafish orientation.

ADAPTATION TO OCEAN ACIDIFICATION OF A TEMPERATE FISH, DICENTRARCHUS LABRAX

Crespel, A., Zambonino-Infante, J., Mazurais, D., Servili, A., and Claireaux, G.

Symposium: Climate Change **Type:** Oral **Order:** 11

Contact: Amelie Crespel **E-mail:** amelie.crespel@ifremer.fr

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Abstract: Carbon dioxide (CO₂) is accumulating in the atmosphere and, as it dissolves in the ocean, the water becomes more acidic, chemically altering marine ecosystems. Little is presently known about the capacity for fish populations to respond and adapt to such ocean acidification. In the present study we compared the larval development of European sea bass (*Dicentrarchus labrax*) reared under three capnic scenarios i.e., actual situation (PCO₂ = 400 μ atm), low acidification (intermediate predicted situation: PCO₂ = 800 μ atm) and high acidification

(harsher predicted situation: $PCO_2 = 1200 \mu\text{atm}$). From 2 to 45 days post hatching, no vital difference was observed among the fish reared under the three different conditions. However, some physiological indicators revealed an influence of acidification. Even though this influence did not adversely and significantly impact larval development, its long-term effect on juvenile performance remains to be assessed to have a more complete picture of the fish capacity to adapt.

RETINOIC ACID REQUIREMENTS IN THE REGULATION OF ZEBRAFISH SPERMATOGENESIS

Crespo, D., Bogerd J., Schulz R.W

Symposium: Reproductive Physiology **Type:** Oral **Order:** 5

Contact: Luiz de Franca **E-mail:** lfranca@icb.ufmg.br

Utrecht University Netherlands

Abstract: This study examines the possible involvement of retinoic acid (RA), the active form of the retinoids, in follicle-stimulating hormone (Fsh)-stimulated spermatogenesis in zebrafish.

ROLES OF CHEMICAL AND MOLECULAR CHAPERONES WITH HYPO-OSMOTIC STRESS IN AN ESTUARINE ASSEMBLAGE OF ANCIENT FISHES

Currie, S., MacLellan, R., Wright, P., MacCormack, T., Morash, A.J., and Semmens, J.M.

Symposium: Elasmobranchs **Type:** Oral **Order:** 19

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Abstract: Cartilaginous fishes, the phylogenetically oldest group of living jawed vertebrates, are divided into the holocephalans and elasmobranchs. We studied four species of elasmobranchs: spiny dogfish (*Squalus acanthias*), school (*Galeorhinus galeus*), gummy (*Mustelus antarcticus*) and seven-gill (*Notorynchus cepedianus*) sharks and one holocephalan, the elephant shark (*Callorhynchus milii*), captured from a Tasmanian estuary. We investigated their physiological response to an acute, ecologically-relevant 48 h hypo-osmotic stress, simulating a rain event. These sharks predominantly use urea and counteracting methylamines (e.g. TMAO, glycine betaine) to osmoconform to their environment. We hypothesized that each species would show variable tolerance to osmotic stress and this tolerance would be correlated with their movements within the estuary and with levels of blood chemical (e.g. methylamines) and molecular (e.g. heat shock proteins) chaperones. We further hypothesized a reciprocal relationship between these two chaperone systems. Haematology indicated variable osmotic stress tolerance in each species, likely linked to their ecological patterns. Chaperone relationships will be discussed when we analyse the data.

IMMUNOHISTOCHEMICAL LOCALIZATION OF MULTIPLE AQUAPORIN ISOFORMS IN EEL KIDNEY

Cutler, C.P., Gaines, A., Ogden D., Garrett, J., Powell, C., Harry, S., Fullerton, A. and Phelps, T.

Symposium: Fish Kidney **Type:** Oral **Order:** 2

Contact: Dr Christopher P. Cutler **E-mail:** ccutler@georgiasouthern.edu

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Abstract: Rabbit polyclonal antibodies have been made against eel aquaporin isoforms, AQP1, 1b, 3, 4, 4b, 8aa, 8ab and 10b. These aquaporin isoforms were localized to renal tubules, melano-macrophage-centers, blood vessels or connective tissue using immunohistochemistry and fluorescent and confocal microscopy. Co-localizations of AQP1

and AQP10b (AQPe) were performed with other aquaporin isoforms by labeling these antibodies directly with Dylight 550 and/or Dylight 633 (Pierce/Thermofisher). In marine eel kidney, AQP1 showed co-localization with some AQP1b (AQP1dup), AQP4 and AQP8ab expressing renal tubule segments, although other AQP1b, AQP4 and AQP8ab expressing renal tubule segments showed no AQP1 expression. AQP10b was expressed in connective tissue and basolateral membranes of renal tubule collecting duct cells. Collecting ducts also stained for AQP4 and AQP3, with possible low level expression of AQP1b and AQP8ab. In freshwater eels, apical renal tubule AQP3 expression was found in different tubule segments in comparison to AQP1.

CARNOSINE METABOLISM IN TELEOST FISH; IS THERE A POSSIBLE ROLE FOR HISTIDINE CONTAINING DIPEPTIDES (HCDS) IN OSMOREGULATION?

Dagens, C., Jin, J.Y., Kalujnaia, S. and Cramb, G.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P81

Contact: Claire Dagens **E-mail:** cad7@st-andrews.ac.uk

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Abstract: A single carnosine synthase (CARNS) gene and ESTs for at least two carnosine peptidases (CNDPs) and two carnosine methyl-transferases (METTLs) have been reported. CARNS expression is very low/undetectable in some species, and is not regulated by environmental salinity. In Atlantic salmon high levels of expression of CNDP1 and CNDP2a are found in the kidney, with much lower levels found in the gill, fin and skin, where a CNDP2b isoform predominates. FW/SW transfer resulted in the up-regulation of CNDP1 and down-regulation of CNDP2a in the kidney. In the skin the mRNA for CNDP1 and 2b are decreased following SW transfer, with little or no change in CNDP2a. The expression of two METTL isoforms (METTL2 and METTL6) are unaltered in the kidney and gill, but one or both are down-regulated in the skin and fin respectively, following SW transfer. Results suggest that HCDs may act as intracellular osmolytes to compensate for increases in extracellular osmolality resulting from SW migration.

PH REGULATION DURING HYPERCAPNIA IN STRIPED CATFISH

Damsgaard, C., Gam, L.T.H., Thinh, P.V., Huong, D.T.T., Wang, T., and Bayley, M.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 9

Contact: Christian Damsgaard **E-mail:** christian.damsgaard@biology.au.dk

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Abstract: Pangasiid catfish are important in aquaculture in South East Asia and are cultured in un-aerated ponds. We found these ponds to be severely hypercapnic throughout the growing season reaching PCO₂ levels of >30 mmHg. We studied blood acid-base regulation during exposure to realistic levels of hypercapnia in the air-breathing catfish *Pangasianodon hypophthalmus* to document the rate of HCO₃⁻ uptake and to assess its ability to regulate pH during hypercapnia. Using PCO₂ values measured in culture ponds in Vietnam, cannulated fish were exposed normoxic hypercapnia and blood was sampled over time. We show that *P. hypophthalmus* fully regulates pH within 48 hours of hypercapnia through HCO₃⁻ uptake in exchange for Cl⁻. These results are peculiar because nitrite uptake studies in *P. hypophthalmus* indicate a low branchial Cl⁻ permeability, and therefore a low regulatory capacity for pH during hypercapnia.

TEMPERATURE SUSCEPTABILITY OF OXYGEN BINDING IN CATFISH HEMOGLOBIN

Damsgaard, C., Huong, D.T.T., Wang, T., and Bayley, M.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 3
Contact: Christian Damsgaard **E-mail:** christian.damsgaard@biology.au.dk
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Abstract: The air-breathing and economically important tropical fish *Pangasianodon hypophthalmus* thrives in severely hypoxic (down to <3mmHg) and warm waters. To increase our understanding of its respiratory physiology, we characterized the oxygen-binding properties of isolated hemoglobin (Hb) and whole blood. *Pangasius* has a high blood O₂ affinity (P₅₀=9.2 mmHg) compared to similarly active fish species (trout P₅₀=24, salmon P₅₀=21, tuna P₅₀=16), but comparable to that of other, more sluggish air-breathing fish (P₅₀ 7-11 mmHg). The high oxygen affinity of *Pangasius* blood stems from low Cl⁻ sensitivity, rendering O₂ binding strongly temperature sensitive and reducing blood oxygen affinity at higher temperatures ($\Delta P_{50}/\Delta T=0.44\text{mmHg}/\text{oC}$). *Pangasius* has only one distinct iso-Hb and cannot therefore change isoform expression pattern at elevated temperatures. In addition the red cells appear to have very little response to adrenergic stimulation. O₂ transport and in vivo O₂ saturation in *Pangasius* therefore is unusually susceptible to increasing temperatures impacting in vivo O₂ saturation.

DOES AMMONIA TRIGGER VENTILATION IN ELASMOBRANCHS?
De Boeck, G. and Wood C.M.

Symposium: Elasmobranchs **Type:** Oral **Order:** 12
Contact: Gudrun De Boeck **E-mail:** gudrun.deboeck@uantwerpen.be
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Abstract: In teleosts and mammals, elevated levels of plasma ammonia cause central stimulation of respiration. So far, it is not known whether ammonia also serves as a respiratory stimulant in more primitive ureotelic fish e.g. elasmobranchs. We examined the ventilatory response of spiny dogfish, *Squalus acanthias* to elevated endogenous or environmental ammonia levels. Cannulated shark were injected with isotonic Na control or ammonia salts. (NH₄)₂SO₄ caused a strong increase in ventilation frequency and amplitude, while NaSO₄ did not. However, also PaCO₂ increased and pHa and plasma HCO₃⁻ decreased. NH₄HCO₃ caused a smaller increase in ventilation frequency and amplitude, together with a raise in PaCO₂ and plasma HCO₃⁻. Injection with NaHCO₃ which increased pHa and plasma HCO₃⁻ did not change ventilation. Exposure to high environmental ammonia initially did not induce changes in ventilation but as plasma ammonia increased ventilation amplitude (but not frequency) increased as well. We conclude that endogenous ammonia stimulates ventilation in spiny dogfish, while environmental ammonia only stimulates ventilation after ammonia diffuses into the bloodstream.

PROTECTIVE EFFECTS OF RIO NEGRO WATER TO COPPER TOXICITY IN PACU
De Boeck, G., Duarte, R.M, Wood, C.M., Almeida-Val, V.M. F. and Val, A.L.

Symposium: Tropical Fish **Type:** Oral **Order:** 10
Contact: Gudrun De Boeck **E-mail:** gudrun.deboeck@uantwerpen.be
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Abstract: Pacu were exposed to different Cu levels in Rio Negro water (0, 2, 4, 6, 8, 10 and 15 micromolar Cu) and acute effects were assessed during 6 hour flux periods. Threshold for toxicity seemed to be around 4 to 6 micromolar, as fish showed short lived (2 to 4 hour) increases in chloride losses, sodium losses and reduced ammonia excretion which all recovered. Plasma Na and ammonia levels remained relatively stable throughout all exposure levels, despite decreased Na/K ATPase activities. Proton ATPase activity was not affected. For a direct comparison, Pacu were also exposed to 4 micromolar Cu in INPA well water, which has a much lower DOC content. Toxic effects were similar, but more pronounced in INPA well water.

FOOD AVAILABILITY AND ENVIRONMENT ALTER SWIMMING CAPACITIES IN FRESHWATER FISH
De Boeck, G., Sinha, A.K., Liew, H.J. and Tudorache, C.

Symposium: FITFISH **Type:** Oral **Order:** 3
Contact: Gudrun De Boeck **E-mail:** gudrun.deboeck@uantwerpen.be
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Abstract: Environmental factors affect physiological processes in fish, including swimming capacity and behavior. When feeding occurs, it induces an additional competition between different homeostatic processes within an organism, e.g. those requiring oxygen. Physiological compensation strategies have been examined with a focus on metabolism and energy budgets, nitrogen waste and/or ammonia excretion efficiency and in swimming performance. Although feeding leads to increased metabolic demands and additional waste production which reduce swimming performance and compromise survival during environmental stress, it can also tone down ion loss and toxicant uptake due to reduced branchial ion transport. Species specific variations in sensitivities towards pollutants such as ammonia affect behavior and swimming performance in individual species differently, and thus alter predator-prey relationships and survival. Surprisingly, as feeding improves ammonia excretion, it can actually be beneficial during high ammonia exposure. Therefore, it is important to take feeding into account when studying environmental effects on swimming performance.

SPECTRAL TUNING IN DEEP-SEA MYCTOPHIDS: A NOVEL AND UNIQUE VISUAL ADAPTATION
de Busserolles, F., Hart, N.S., Hunt, D.M., Davies, W.I., Marshall, N.J., and Collin, S.P.

Symposium: Sensing the Environment **Type:** Oral **Order:** 11
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Abstract: Deep-sea fishes possess several adaptations to allow vision in this extreme environment, where light detection is pushed to its extreme limit. We have recently discovered that myctophids, one of the world's most abundant family of mesopelagic fishes, possess a novel visual specialisation; a sexually dimorphic retinal yellow pigment that is unique among vertebrates and may represent one of the secrets to the success of this family. This pigment is species-specific, varying in location, shape and size, and represents the first example of visual sexual dimorphism in any non-primate vertebrate. The pigment acts as a filter, maximally absorbing between 356 nm and 443 nm, and is present in species containing at least two rod visual pigments, one shifted toward longer wavelengths. We believe that this unique retinal filter serves to enhance contrast, thereby improving the detection of a more extensive range of bioluminescent and/or fluorescent emissions, and plays a role in food discrimination and/or sexual communication in the deep-sea.

THE EFFICIENCY OF ELECTROFISHING FOR BURBOT UNDER EXPERIMENTAL CONDITIONS
De Charleroy, D., Jansen, I., Vught, I., Auwerx, J., Quataert, P. and Coeck, J.

Symposium: Burbot **Type:** Oral **Order:** 4
Contact: Daniel De Charleroy **E-mail:** daniel.decharleroy@inbo.be
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Abstract: In Flanders, Belgium, a reintroduction program started in 2005, to rehabilitate Burbot, *Lota lota*, the only freshwater representative of the cod-family. It disappeared around 1970 from our river-systems. Captures of mature burbot are frequent in the restocked rivers, and 2 months old larvae are also observed in several cases. Recapture

numbers however of yoy fingerlings are very low. An experiment was set up to compare the efficiency and selectivity of electrofishing for burbot in comparison with other species, under experimental conditions in brook-like ponds. The results are surprising and show a very significant and distinct behaviour towards electrofishing. Burbot are more difficult to capture compared to the other fish species.

SEASONAL VARIATION IN BREEDING SUCCESS IN TWO-SPOTTED GOBIES

de Jong, K., Myhre, L.C., Wacker, S., Forsgren, E., and Amundsen, T.

Symposium: General Contributed Papers **Type:** Oral **Order:** 4

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Abstract: Many fish reproduce repeatedly during a reproductive season. In repeated breeders, the timing and duration of breeding will largely affect reproductive success. Seasonal variations in brood success will likely affect timing decisions, but have rarely been quantified in the wild in fish with paternal care. The two-spotted goby, a small marine fish, occurs in temperate regions characterized by strong environmental seasonality. Breeding males are abundant early in the season, whereas spawning-ready females are abundant late, indicating a sex difference in peak breeding time. We introduced artificial nests in the Gullmarfjord (Sweden) to document brood success. Early in the season breeding male density was higher and males were in better condition. Late in the season, broods were less often attended, less likely to hatch and the area of hatched eggs was smaller. We suggest that both sexes would benefit from breeding early, but that females may be more constrained in the onset of breeding.

META-ANALYSIS OF TISSUE TRANSCRIPTOMES IN STUDIES INVESTIGATING SUBSTITUTION OF DIETARY FISHMEAL WITH PLANT PROTEINS IN ATLANTIC SALMON

De Santis, C., Bartie, K., Crampton, V., Olsen, R.E., Tocher, D.R.

Symposium: Physiological Genomics **Type:** Oral **Order:** 6

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Abstract: As aquaculture continues to expand, so does the requirement for high-quality protein sources to replace fishmeal for feed production. Plant proteins have the best potential for the sustainable and economic substitution of marine proteins in fish feeds. However, plant proteins are not necessarily nutritionally ideal for all fish species. It is well established that, in carnivorous fish such as Atlantic salmon, plant proteins can negatively affect fish growth and health possibly due to antinutrients that often co-purify with the proteins themselves. It could be extremely advantageous to identify biomarkers with the ability to predict degraded growth and impaired health in response to dietary plant protein, particularly early in the life cycle of fish. The present study aimed to identify such markers by comparing tissue transcriptomic profiles obtained from independent nutritional trials. Further insights into expression patterns of key genes and their biological significance will be discussed.

PARTICULARITIES IN THE HORMONAL INDUCTION PROCESS IN WILD LEPORINUS FRIDERICI SPECIMENS, A SOUTH AMERICAN MIGRATORY FISH

De Souza, T.G., Kuradomi, R.Y., Hainfellner, P., Figueiredo, D.G., Lira, L.V.G., Barbosa, R.P., Freitas, G.A., Rodrigues, S., Porto-Foresti, F. and Batlouni, S.R.

Symposium: Tropical Fish **Type:** Poster **Order:** P144

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Abstract: Aiming to standardize an hormonally inducing protocol for obtaining *Leporinus friderici* viable embryos, in this study wild specimens were submitted to two treatments: Carp Pituitary Extract (CPE) (0.5 and 5.5 mg.Kg⁻¹, 12 hours interval) and ovopel [mammalian GnRH analogue (D-Ala⁶, Pro⁹-NET)-mGnRH + metoclopramide] (40 µg mGnRH_a and 20 mg metoclopramide, single dose). Although most females have ovulated, surprisingly viable embryos were not obtained with both protocols. After several attempts making changes in both treatments (concentrations, number of doses and intervals), we only obtained viable embryos using low doses of CPE (0.5 and 1.0 mg.Kg⁻¹, 6 hours interval), but as observed in other South American rheophilic species no *L. friderici* viable embryos were obtained with the use of synthetic hormones. We observed a failure during egg hydration process when ovopel was used indicating that more basic studies are needed to standardize the use of synthetic hormones in this species. Acknowledgements: FAPESP (2012/14901-7).

IDENTIFICATION AND EXPRESSION OF ELASMOBRANCH GLUCOSE TRANSPORTERS

Deck, C.A., LeMoine, C.M.R., and Walsh, P.J.

Symposium: Elasmobranchs **Type:** Oral **Order:** 16
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Abstract: Elasmobranchs consume extremely low-carb diets and their tissues have a general preference for ketone bodies as oxidative fuels, contributing to the dearth of information on glucose transporters in this group. Since rectal glands prefer glucose as a fuel, we aimed to determine which GLUTs are present and when/where they are expressed. We searched the little skate transcriptome and identified two putative GLUT sequences as phylogenetically similar to GLUT1 and GLUT4, and a third unknown GLUT-like transporter. The first two were cloned in the dogfish (*Squalus suckleyi*) to determine the expression across different tissues. The GLUT1 mRNA showed a ubiquitous expression and the GLUT4 mRNA was expressed highly in heart, gill, muscle, and brain, with lower levels in the liver and intestine, patterns that are consistent with those in other vertebrates. Potential changes in the expression of these two transporters following feeding and stress are also being investigated.

HIPPOCAMPUS REIDI AS A BIOINDICATOR OF CRUDE OIL EXPOSURE

Delunardo, F.A.C., Carvalho, L.R., Galão, M., Silva, B.F., Chippari-Gomes, A.R.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P38
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Abstract: The aim of this study was to explore the suitability of the seahorse *Hippocampus reidi* for assessing the effects of acute exposure to petroleum hydrocarbons. Fishes were exposed to three concentrations of crude oil (10, 20 and 30 mL / L) for 96 h, and the activity of the enzyme glutathione S-transferase (GST) was measured. Additionally, we carried out the alkaline comet assay and micronucleus (MN) test on *H. reidi* erythrocytes. Our results revealed a significant inhibition of GST activity in fish exposed to the higher concentration of crude oil compared to the corresponding control group. In contrast, the damage index (DI) values, and the frequencies of micronuclei obtained with the group exposed to a 30 mL / L concentration were significantly higher than control group. Therefore, these results indicate that genotoxicity assays are suitable for evaluating the genotoxicity of crude oil and *H. reidi* is a promising sentinel organism.

PROTECTION FROM CADMIUM-INDUCED OLFACTORY DYSFUNCTION BY SPECIFIC METALS IN RAINBOW TROUT

Dew, W.A., N. Veldhoen, A. Carew, C. Helbing, and G.G. Pyle

Symposium: Sensing the Environment **Type:** Oral **Order:** 13

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Abstract: Exposure to individual metals can impair the olfactory response of fish. Few studies, however, have investigated the effect of complex metal mixtures on olfaction. We utilized electro-olfactography to measure the effect of exposing rainbow trout (*Oncorhynchus mykiss*) to cadmium, copper, nickel, zinc, or a mixture of the four metals at or below the current Canadian guideline concentrations. After a 96 h exposure, cadmium caused a general impairment of the olfactory system, while copper, nickel, or zinc had no effect. Counter-intuitively, a mixture of all four metals induced no olfactory impairment. Binary mixture exposures demonstrated that nickel and zinc, but not copper, protected against cadmium-induced olfactory dysfunction. Sodium, magnesium, or calcium also confer protection from cadmium exposure. Work is ongoing to determine if metallothionein expression is driving this pattern of effect. By understanding how metal mixtures affect olfaction, we can better predict safe metal concentrations in waterways.

EFFECTS OF DIFFERENT LIGHT WAVELENGTHS ON THE ONTOGENY OF CLOCK GENE EXPRESSION IN ZEBRAFISH LARVAE

Di Rosa, V., Frigato, E., López-Olmeda, J.F., Sánchez-Vázquez, F.J., Bertolucci, C.

Symposium: Zebrafish **Type:** Poster **Order:** P156

Contact: Viviana Di Rosa **E-mail:** viviana.di@um.es

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Abstract: Zebrafish has been extensively used as a model for studies on both development and circadian rhythms. However, to date little is known on the ontogeny of the molecular clock and particularly the effect of light wavelengths. The aim of this work was to determine how light of different colors affect the ontogeny of molecular rhythmicity, that is the onset of rhythmicity of the following clock genes: *per1*, *per2*, *clock*, *bmal* and *dbp*. Zebrafish larvae were raised from 0 to 7 days post fertilization (dpf) under two different lighting regimes: light-dark cycle (12:12 LD) and constant darkness (DD). White (LDW), blue (LDB) and red (LDR) light were used for the LD cycles. The results revealed the presence of rhythmicity at 7 dpf for all clock genes in the larvae raised in LD cycle, but not in the larvae raised in DD. A rhythmic pattern from 0 dpf was found in some genes like *per1* and *per2*, with *per1* shifting the phase during development whereas other genes such as *bmal* needed several days to start oscillating.

LIGHT WAVELENGTH DIFFERENTIALLY AFFECTS THE ONTOGENY OF BEHAVIORAL RHYTHMS IN ZEBRAFISH LARVAE

Di Rosa, V., Frigato, E., Turcato, C., Cavallini, M., López-Olmeda, J.F., Bertolucci, C., Sánchez-Vázquez, F.J.

Symposium: Zebrafish **Type:** Oral **Order:** 1

Contact: Viviana Di Rosa **E-mail:** viviana.di@um.es

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Abstract: Zebrafish is commonly used as an animal model in research, especially regarding studies on development. In fish, previous studies highlighted the importance of lighting conditions on larval performance and survival, but its effects on other behavioral parameters such as locomotor activity are little explored. The aim of this research was to evaluate the influence of lighting conditions on the ontogeny of behavioural rhythmicity in zebrafish larvae. For this

purpose, 5 groups of zebrafish embryo/larvae were raised from 0 to 7 days post-fertilisation (dpf) under the following conditions: 4 groups maintained under light:dark (LD) cycles with light of different wavelengths: blue (LDB), red (LDR), violet (LDV) and white (full visible spectrum) (LDW), and one group raised under constant darkness (DD). Locomotor activity was video recorded and analyzed using specialized video tracking software. The results showed that lighting conditions influenced the onset of daily activity rhythms. Larvae were arrhythmic under DD. Conversely under LD cycles, the activity was rhythmic with different patterns under LDW, LDV and LDB respect to LDR. These findings emphasize the importance of lighting conditions and light composition during early fish development.

INNATE AND LEARNED PREFERENCES FOR NATURAL STREAM VS. GROUND WATER IN SALMONIDS

Dittman, A.H., Couture, R.B. Couture, O'Neil, J.P., May, D., and Noakes, N.L.G.

Symposium: Sensing the Environment **Type:** Oral **Order:** 18

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Abstract: Many hatchery practices increase the rate of straying by adult salmon returning from the ocean to spawn. Homing is governed by olfactory discrimination of home-stream water and exposure to this water during appropriate juvenile stages is critical for successful olfactory imprinting and homing. In most hatcheries, salmon are initially reared on ground water to control development rate (temperature) and limit exposure to pathogens. To explore whether exposure to surface water during embryonic periods is also important for successful imprinting in a hatchery setting, we conducted a series of experiments to examine innate preferences of emergent salmon for surface water vs. ground water and whether prior exposure to these water sources influences these preferences in a two-choice maze. Both steelhead and Chinook salmon demonstrated an innate preference for stream water over ground water. Initial incubation in ground water influenced these preference responses, however, suggesting that embryonic salmon learned olfactory cues.

BEHAVIORAL RESPONSES OF JUVENILE ESTUARINE FISHES TO DIEL-CYCLING HYPOXIA AND PH

Dixon, R.L., Greco, P.A., and Targett T.E.

Symposium: Climate Change **Type:** Oral **Order:** 15

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Abstract: Diel-cycling hypoxia and co-varying pH fluctuations can reduce the quality of shallow estuarine waters that serve as nurseries for juvenile fishes. Avoidance or compensatory behaviors allow fish to mitigate oxidative stress associated with low dissolved oxygen (DO). Aquatic surface respiration (ASR), or irrigating gills with the thin, air-saturated, surface layer is widespread among teleosts and provides a distinct advantage to fishes in hypoxic environments. 24-hour video observations were conducted under controlled laboratory conditions to determine behavioral responses of juvenile striped bass (*Morone saxatilis*), Atlantic silversides (*Menidia menidia*), striped killifish (*Fundulus majalis*), and mummichog (*Fundulus heteroclitus*) to different severities and combinations of diel-cycling DO (3-9 mg O₂ l⁻¹ or 1-11 mg O₂ l⁻¹) and pH (7.2-7.8 or 6.8-8.1) compared with responses at static normoxia (7.5 mg O₂ l⁻¹) and pH (7.5). The incidence of ASR, activity level, and position of each individual was recorded at pre-determined time intervals. ASR was observed in *M. menidia* and *F. majalis* between 1.31 and 1.49 mg O₂ l⁻¹ under the extreme DO range (1-11 mg O₂ l⁻¹), with both cycling and static pH. *M. saxatilis* reduced swimming activity and exhibited positive rheotaxis at corresponding DO levels. *F. heteroclitus* did not exhibit ASR in diel-cycling treatments but when DO was held constant at 1.0 mg O₂ l⁻¹, fish performed ASR after approximately 7 hours exposure. The occurrence of ASR is dependent upon species-specific hypoxia tolerance, and the temporal scale over which low oxygen occurs.

EXTRAORDINARY TOLERANCE TO NITRITE IN THE AIR BREATHING SWAMP EEL

Do, T.T.H, Nguyen, Q.T., Nguyen, K.H. and Bayley, M.

Symposium: Airbreathing Fish **Type:** Poster **Order:** P4

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Abstract: Air-breathing fish may be unusually resistant to the effects of elevated environmental nitrite ions because they can disassociate oxygen uptake and ion regulation at the branchial surfaces and because the only two species so far investigated (*Channa striata* and *Pangasionodon hypophthalmus*), have atypical responses and high tolerance. Here we investigated the effects of nitrite on another air breather, the swamp eel *Monopterus albus* and report both toxicity and hematological effects including methaemoglobin fraction, hematocrit, hemoglobin concentration, erythrocyte and lymphocyte counts. We found the swamp eel extraordinarily tolerant with a 96h LC50 of 31.3 mM NO₂⁻ in water with 0.3mM Cl⁻, and no mortality below 25mM. Methaemoglobin rose slowly and reached only 35.5% in fish exposed to 25mM. Red blood cell count, hematocrit and hemoglobin concentration were unchanged, even in the highest exposure concentration. Lymphocyte concentrations on the other hand rose significantly during exposure. This study provides further evidence that air-breathers respond differently to nitrite than water breathing fish.

THE IMPORTANCE OF LAMPREYS IN SCIENTIFIC RESEARCH

Docker, M.F.

Symposium: Lampreys **Type:** Oral **Order:** 1

Contact: Margaret Docker **E-mail:** Margaret.Docker@umanitoba.ca

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Abstract: Given their ‘lofty’ status at the base of the vertebrate family tree, lampreys have always received attention from at least a small group of scientists. Since the 1950s, considerable research has also been conducted in support of sea lamprey control in the Laurentian Great Lakes. Recently, however, lampreys have started getting more widespread attention. Research related to lamprey endocrinology (particularly the pivotal hypothalamic-pituitary axis and gonadotropin-releasing hormones) and the use of lampreys in evolutionary developmental (evo-devo) and biomedical studies have started to raise the profile of this group of ancient fishes. Lampreys are providing important and promising model systems in our quest to better understand the early evolutionary history of the vertebrates—particularly given the recent publication of the complete sea lamprey genome—and their increasing use in biomedical research is providing insights into treatment for people suffering from blood coagulation disorders, biliary atresia, hemochromatosis, and spinal cord injuries. This introduction to the Lampreys: Performance, Physiology and Coping with Environmental Disturbances symposium will provide a broad perspective of the growing scientific importance of this previously underappreciated group of fishes.

RNA INTERFERENCE TECHNOLOGY IN SEA LAMPREY: A PROOF-OF-CONCEPT

Docker, M.F., Heath, G., Childs, D., McCauley, D.W., and Whyard, S.

Symposium: Lampreys **Type:** Poster **Order:** P92

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Abstract: Gene knockdown or silencing (using morpholinos or RNA interference, RNAi) has been used to identify gene function in many eukaryotic organisms. In fishes, however, although morpholinos have been used routinely (including in sea lamprey), progress in RNAi research has been slow. In this study, we demonstrated that injection of six different short interfering, double-stranded RNAs (siRNAs) into lamprey embryos could reduce the targeted transcript levels by more than 50% and that gene knockdown could be achieved in larvae by feeding them siRNAs complexed with liposomes. With the recent publication of the sea lamprey genome, development of tools such as these may lead to a wealth of new knowledge of the genes and gene networks that control many aspects of lamprey biology. Furthermore, one of the siRNA treatments caused increased mortality of the larvae following a single feeding, suggesting that species-specific siRNAs could potentially be used to kill filter-feeding sea lamprey larvae in streams without adversely affecting non-target species.

GENE EXPRESSION DURING OVARIAN DIFFERENTIATION IN PARASITIC AND NON-PARASITIC LAMPREYS:
IMPLICATIONS FOR FECUNDITY AND LIFE HISTORY TYPES

Docker, M.F., Spice, E.K., and Whyard, S.

Symposium: Lampreys **Type:** Poster **Order:** P93

Contact: Margaret Docker **E-mail:** Margaret.Docker@umanitoba.ca

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Abstract: Fecundity differences between lamprey life history types (parasitic and non-parasitic) may first become evident at ovarian differentiation; non-parasitic species, which reproduce at small body sizes, may elaborate fewer oocytes even as larvae. However, nothing is known about the genetic basis of ovarian differentiation in lampreys. This study examined expression of eight target genes before, during, and after ovarian differentiation in parasitic chestnut lamprey *Ichthyomyzon castaneus* and non-parasitic northern brook lamprey *I. fossor*. Northern brook lamprey displayed higher expression of cytochrome c oxidase subunit III, whereas chestnut lamprey had higher expression of insulin-like growth factor 1 receptor; these genes may be involved in apoptosis and oocyte growth, respectively. Wilms' tumour suppressor protein 1 was expressed at a higher level in the undifferentiated (presumptive male) gonad, whereas 17-beta hydroxysteroid dehydrogenase and daz-associated protein 1 were expressed at higher levels in differentiated females. This study is the first to identify genes that may be involved in ovarian differentiation and fecundity in lampreys.

DIFFERENTIAL MATING SUCCESS OF WRASSES AND EGG PREDATION RATES AT A MATING SITE IMPACTED BY DIVER
FISH FEEDING

Donaldson, T.J., Staman, M.H. and Mesa, T.N.

Symposium: Tropical Fish **Type:** Oral **Order:** 5

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Abstract: Wrasses (Labridae) mate either in temporary resident spawning aggregations or in small groups at Finger Reef, Guam. This site is popular also with groups of divers and snorkelers that feed fishes. Fish feeding increases the density of most species and resident spawning aggregations form. Males that have greater mating success defend temporary mating territories adjacent to the outer reef slope where current exposure is good. Fish feeding also increases the densities of damselfishes and reef herring that prey upon wrasse eggs. This predation reduces the mating success of spawning fishes. Predation activity affects wrasse courtship success, too, because males often interrupt courtship activity to attack egg predators. Females often break-off courtship if egg predators are present. Thus, egg predation and interrupted courtship are costs to reproductive success that are probably much greater at fish feeding sites where aggregative spawning occurs compared to elsewhere on the reef.

IMMUNE FUNCTIONING IN CARTILAGINOUS FISHES

Dooley, H.

Symposium: Elasmobranchs **Type:** Oral **Order:** 7

Contact: Helen Dooley **E-mail:** h.dooley@abdn.ac.uk

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Abstract: Antibody-like proteins were first described in the serum of sharks almost 50 years ago however it was also believed that the adaptive immune response of elasmobranchs was rather basic and offered poor protection. Work being carried out by a number of research groups, including my own, is rapidly overturning this misconception; we are starting to characterise the immune genes of various species and have uncovered that cartilaginous fish have a diverse range of antibody isotypes and isoforms. Through in vivo studies we have also shown that they use these different antibodies to generate a robust multi-layered response, which confers long-term protection, following immunological challenge. We will overview the accumulated data and discuss the direction our research is taking to try to answer some of the outstanding questions about immune functioning in this key group.

LIGHT TO DARK: INVESTIGATING NOVEL PATHWAYS LINKING PHOTOPERIODIC CUES TO THE BRAIN-PITUITARY-GONAD AXIS IN ATLANTIC COD

Doyle, A., Cowan, M., Wright, P. J., Migaud, H. & Davie, A.

Symposium: General Contributed Papers **Type:** Oral **Order:** 8

Contact: Alice Doyle **E-mail:** alice.doyle@stir.ac.uk

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Abstract: In temperate climates, photoperiod has been identified as the strongest environmental cue for entraining the seasonal behaviours of mammals and birds, including seasonal reproduction. Over the last decade, several of the key drivers involved in the photoneuroendocrine cascade have been elucidated. *Eya3*, *TSH β* , and the deiodinases, have all been identified as key drivers of maturation in mammalian and avian seasonal breeders. However, little is yet known of their influence on maturation in fish. In this study, we analysed the photoperiodic regulation of the *Eya3*-*TSH β* -*Dio2* cascade in Atlantic cod exposed to either continuous light (reproductive inhibition) or simulated natural photoperiod (reproductive stimulation) from July to December. Monthly expression was analysed through qPCR, demonstrating a strong activation of pituitary *Eya3* under declining photoperiod. As this coincided with the onset of secondary gametogenesis, these results suggest that *Eya3* may play a stimulatory role in the photoneuroendocrine cascade of Atlantic cod.

H⁺-ATPASE INVOLVMENT IN NA⁺ REGULATION OF TWO AMAZON FISH SPECIES EXPOSED TO LOW PH IN NATURALLY ION-POOR AND HIGH DISSOLVED ORGANIC CARBON CONDITION

Duarte, R.M., and Val, A.L.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P82

Contact: Rafael Mendonça Duarte **E-mail:** mduarte.rafa@gmail.com

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Abstract: Amazon fish species from Rio Negro has been recognized to display specializations in branchial Na⁺ transport mechanisms to maintain their ionic balance at naturally acidic ion-poor waters. Our main aim was to evaluate the branchial Na⁺ regulation in *Nannostomus marginatus* (Lebasiinidae) and *Mesonauta insignis*

(Cichlidae) acutely exposed to low pH in natural blackwater conditions. In *N. marginatus*, an acidic-insensitive Na⁺ uptake system was seen in gills, that were associated to increases in H⁺-ATPase activity, while diffusive Na⁺ losses were significantly stimulated at pH 4.0. In contrast, *M. insignis* showed a strong control of paracellular Na⁺ losses; however, inhibition of both Na⁺ uptake and H⁺-ATPase activity were observed under low pH exposure. Our data confirm the presence of two basic mechanisms for Na⁺ regulation in a broader range of Amazon fish species. Perhaps most interestingly, H⁺-ATPase activity seems to be directly involved in the mechanisms for Na⁺ uptake in fish species inhabiting natural blackwater systems. (INPA; INCT ADAPTA – CNPQ/FAPEAM; Ciência sem Fronteiras)

PROTECTIVE EFFECTS OF DISSOLVED ORGANIC CARBON (DOC) ON NA⁺ REGULATION AND NITROGENOUS WASTE EXCRETION IN DANIO RERIO EXPOSED TO LOW pH IN SOFT-WATER

Duarte, R.M., Smith, D.S., Val, A.L., Wood, C.M

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 7

Contact: Rafael Mendonça Duarte **E-mail:** mduarte.rafa@gmail.com

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Abstract: The effect of DOC on freshwater organisms under acidic conditions is controversial. Negative and positive effects of DOC on survivorship, growth, ion-regulation and nitrogenous waste excretion have been reported. The extent of DOC effects depends on species, water composition and DOC source. We evaluated the role of two sources of DOC (Rio Negro and Luther Marsh) on Na⁺ regulation and N-excretion in zebrafish, acclimated to soft-water at neutral pH, and short-term (3h) exposed to either pH 7.0 or pH 4.0. The recovery to the pre-acclimation condition was also investigated. Both DOCs prevented the inhibition of Na⁺ uptake by low pH, with lesser effects on passive Na⁺ losses. In addition, DOC attenuated ammonia excretion at acidic conditions, particularly during the recovery period. Our data support the hypothesis that DOC helps fish to maintain Na⁺ balance and to thrive in acidic ion-poor water. (INPA; INCT ADAPTA – CNPQ/FAPEAM; Science Without Borders; McMaster University; Wilfrid Laurier University)

MICRORNAS REGULATE SKELETAL MUSCLE PHENOTYPE AND GROWTH IN PACU

Duran, B.O.S., Ferreira, A.V., Garcia, G.J.F., Moraes, L.N., Mareco, E.A., Salomão, R.A.S., Gutierrez de Paula, T., Carani, F.R., Santos, V.B., Carvalho, R.C., Dal-Pai-Silva, M.

Symposium: Tropical Fish **Type:** Oral **Order:** 9

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UNESP, Department of Morphology, Botucatu, São Paulo. Brazil

Abstract: The pacu (*Piaractus mesopotamicus*) is a Brazilian fish with high economic interest for pisciculture. The growth of skeletal muscle occurs by hyperplasia and hypertrophy, processes dependent on proliferation and differentiation of satellite cells. Many studies show that miRNAs regulate expression of target mRNAs, and that miR-1, miR-133a, miR-133b, miR-206 and miR-499 participate of muscle development, by inhibition of HDAC4, SRF, Pax7 and Sox6. The aim of our work was to evaluate the expression of miRNAs and their target mRNAs in muscle of pacu. We studied three development stages (larvae, juvenile and adult). Our results showed that miRNAs were differentially expressed between groups, and regulated the proliferation and differentiation of satellite cells, and the specification of phenotype in muscle fibers. This work provided the first miRNAs expression profile related to skeletal muscle in pacu and highlighted the important role of these molecules in muscle development.

AEROBIC METABOLISM, GROWTH AND REPRODUCTION IN THE SHORT-LIVE NOTHOBRANCHIUS FURZERI:
INFLUENCE OF AGING AND TEMPERATURE

Durollet M., A. Schouman, J. Lucas, C. Lefrançois

Symposium: Growth and Metabolism **Type:** Oral **Order:** 24

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Abstract: *Nothobranchius furzeri* is an annual fish with a rapid life cycle of about six months considered as a relevant model to study the impact of aging on the integrity of biological functions. The objective of our study was to highlight changes in aerobic metabolism, growth and reproduction effort during juvenile, adult and senescent stages in *N. furzeri*. Temperature is also known to influence these functions through its action at the cellular level. More specifically, a low temperature was demonstrated to slow down the mechanisms of senescence in *N. furzeri*. The target functions were studied in *N. furzeri* acclimated at two temperatures all along the life cycle, 26°C (optimal breeding temperature) and 22°C. The lowest temperature induced a shift of optimal age for metabolism and reproduction effort traduced by a soonest decrease in aerobic metabolic capacities, in eggs production and a slowdown in growth.

INFLUENCE OF TEMPERATURE IN THE AGE-RELATED CHANGES OF NOTHOBRANCHIUS FURZERI HEART

Durollet M., Becquet V., Murillo L., Huet V., Houque A., Lefrançois C., and Imbert Auvray N.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P75

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France

Abstract: The objective of our study was to explore the role of temperature, as an environmental regulator of the age-dependant changes in cardiac performances. Heart structure and functioning were studied in *Nothobranchius furzeri*, an annual fish with a short lifespan of about six months, bred at 26°C (optimal breeding temperature) and 22°C. Experiments were carried out at different ages: 7, 18, 30 and 36 weeks. We studied 1) calcium cycle during excitation-contraction coupling in freshly dissociates cells, 2) differential expression of genes involved in hypertrophy, hyperplasia, aerobic metabolism and oxidative stress using functional RT-qPCR and finally 3) citrate synthase activity as an index of mitochondrial oxidative capacity. Our results show an influence of temperature on heart aging from a structural and functional point of view.

ACID-SENSING ION CHANNELS (ASICS) ARE INVOLVED IN EPITHELIAL SODIUM UPTAKE IN RAINBOW TROUT

Dymowska, A.K., Schultz A.G., Blair, S.D., Chamost, D., and Goss, G.G.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 11

Contact: Agnieszka Dymowska **E-mail:** dymowska@ualberta.ca

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Abstract: The current model for Na⁺ uptake in rainbow trout gill proposes two mechanisms: NHE-Rh protein metabolon and/or epithelial Na⁺ channel coupled to H⁺-ATPase. However, while extensive evidence for NHE mediated Na⁺ uptake has been gathered, there is no molecular evidence for existence of an epithelial Na⁺ channel. We propose that in rainbow trout, acid-sensing ion channels (ASIC), members of the ENaC/DEG family, perform this function. We cloned ASIC gene homologues from the gill and demonstrated their expression in mitochondrion-rich cells. Moreover, using immunohistochemistry, we co-localized ASIC protein to the MRCs rich in NKA. We also report that in adult rainbow trout, ASIC specific inhibitors decreased Na⁺ uptake in a dose-dependent manner.

Our findings suggest that ASIC channels play a role in Na⁺ uptake in freshwater rainbow trout, and therefore we propose that they provide an alternative mechanism for Na⁺ uptake in freshwater.

THE ROLE OF ACID-SENSING ION CHANNELS (ASICs) IN EPITHELIAL SODIUM UPTAKE IN ADULT ZEBRAFISH

Dymowska, A.K., Schultz A.G., Boyle, D., and Goss, G.G.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P83

Contact: Agnieszka Dymowska **E-mail:** dymowska@ualberta.ca

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Abstract: Recently, we have demonstrated that ASICs play a role in Na⁺ uptake in freshwater rainbow trout. We investigated a potential involvement of this protein in Na⁺ transport in adult zebrafish, a commonly used model for freshwater fish ionoregulation. Using RT-PCR we found that ASICs 1,2 and 4 transcripts are present in the gills. Immunohistochemistry analysis with anti-ASIC4 antibody showed that while ASIC4 did not co-localize with NKA, it did co-localize with H⁺-ATPase. This suggests that ASIC4 protein is expressed in HR type of mitochondrion-rich cells. Various pharmacological ASICs inhibitors significantly reduced uptake of Na⁺ in adult zebrafish exposed to hard water, but did not cause the same response in individuals exposed to soft water. Our results suggest that zebrafish might employ different mechanisms for Na⁺ uptake at different ambient Na⁺ concentrations.

THE EFFECTS OF MATERNAL CAROTENOID CONSUMPTION ON DEVELOPMENT IN ZEBRAFISH

Eaton, L.E., Sloman, K.A., and Snellgrove, D.

Symposium: Zebrafish **Type:** Oral **Order:** 2

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Abstract: Zebrafish were fed diets of varying carotenoids for a 12 week period and subsequently bred. The embryos were then analysed for carotenoid content via HPLC to determine whether embryonic carotenoid deposition differed between maternal diet treatments. Carotenoids sequester oxygen and are believed to assist in continued aerobic respiration during periods of hypoxia by providing an endogenous source of molecular oxygen. Therefore, it was hypothesised that differences in maternal carotenoid consumption may impact embryonic oxygen consumption measured via respirometry. The effects of maternal carotenoid consumption on embryonic responses to an environmental stressor, hypoxia, were also investigated as the negative effects of hypoxia exposure during development are well documented.

INVESTIGATING THE EFFECTS OF ENVIRONMENTAL STRESSORS ON FISH WELFARE USING NON-INVASIVE MEASURES

Edmonds, E.J., Sloman, K., Henriquez, F., and Snellgrove, D.

Symposium: Stress in Fish **Type:** Oral **Order:** 19

Contact: Elizabeth Edmonds **E-mail:** elizabeth.edmonds@uws.ac.uk

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Abstract: There are a variety of methods used to measure the levels of stress and assess the welfare of a wide range of fish species. Although non-invasive measures of stress have been developed, the concentration of the stress hormone cortisol present within blood plasma is still the most popular measure of stress used. In this study, we investigated how environmental stressors affected the welfare of ornamental fish using a range of non-invasive

measures including behavioural responses. In particular, we also considered how the chemical composition of epidermal mucus varied in response to changes in diet and different stressors. The usefulness of these non-invasive measures in determining fish welfare is discussed.

AGNATHAN FISH AND THE EVOLUTION OF IONIC REGULATORY PHYSIOLOGY

Edwards S.L.

Symposium: Plenary **Type:** Oral **Order:** 4
Contact: Susan Edwards **E-mail:** edwardssl@appstate.edu
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Abstract: Modern extant agnathan fishes represent the evolutionary transition between invertebrates and vertebrate organisms. The current fossil record suggests that vertebrates originated in a marine environment, with some groups of agnathan fishes invading freshwater approximately 420 million years ago. This hypothesis is supported in that all vertebrates, with the exception of hagfishes, display plasma NaCl concentrations lower than that of seawater; presumably the result of freshwater invasion. To date, we have shown that these organisms do possess the ability regulate internal ionic and nitrogenous waste perturbations and that the excretion of excess ions and nitrogenous waste coincides with an up-regulation of ion transport genes and proteins in epithelial tissues similar to those seen in teleost fishes. The overarching aim of our research is that through the examination of ion regulation and nitrogenous waste excretion in agnathans we may answer questions as to how and when key physiological mechanisms have evolved.

PRE-RETINAL DEVELOPMENT OF A NON-VISUAL SYSTEM IN ATLANTIC HALIBUT

Eilertsen, M., Drivenes, Ø., Edvardsen, B.R., Lars O.E. Ebbesson, L.O.E. and Helvik, J.V.

Symposium: Sensing the Environment **Type:** Oral **Order:** 8
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Abstract: Non-visual photoreception is thought to be involved in a range of behavioural and physiological processes in teleost fishes, such as synchronisation of circadian and circannual rhythms, but also regulation of skin pigmentation, buoyancy in the water, hatching of eggs and phototaxis. Knowledge of the teleost photoreceptive system and the photopigments involved is far from complete. Especially, the function of the photoreceptive system at early stages of development, the neuronal integration of the photoreceptor cells and the role of different photopigments need to be elucidated. We have identified several non-visual photopigments in Atlantic halibut, melanopsins, vertebrate ancient opsin and exorhodopsin. Expression studies of these genes shows an advanced pattern of non-visual photoreceptor cells in several brain regions at the time of hatching, which emphasise the importance of direct brain photoreception in fish.

CARDIAC OXYGEN LIMITATION DURING AN ACUTE TEMPERATURE CHALLENGE IN THE EUROPEAN PERCH: IMPLICATIONS OF THERMAL ACCLIMATION AND AMBIENT HYPEROXIA

Ekström, A.B., B. Clark, T.D. Gräns, A. Jutfelt, J. Sandblom, E.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 2
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Abstract: Cardiac failure due to inadequate myocardial luminal oxygenation has been proposed to set the upper thermal tolerance limit in fish lacking coronary arteries. To test this idea, venous oxygen tension (PVO₂) and cardiovascular variables were recorded during a critical thermal maximum (CT_{max}) challenge in 17 and 24°C field acclimatized European perch (*Perca fluviatilis*). Although CT_{max} was 2.2°C higher in warm acclimatized perch, cardiac output and heart rate declined prior to CT_{max} at similar PVO₂. This suggests a common critical PVO₂ threshold was reached. Ambient hyperoxia (200%) in 17°C acclimatized fish increased PVO₂ across temperatures and elevated CT_{max} by 0.9°C whilst increasing cardiac output through an increase in stroke volume. Yet, heart rate still decreased before CT_{max}. We suggest that reduced myocardial luminal oxygen supply contribute to cardiac contractility failure in vivo, but the observed bradycardia prior to CT_{max} is likely caused by temperature per se rather than reduced oxygen availability.

RESPONSE OF FISH TO FREEZE-UP
Enders, E.C., and Bergeron, N.E.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 9
Contact: Eva Enders **E-mail:** eva.enders@dfo-mpo.gc.ca

Fisheries and Oceans Canada, Freshwater Institute, 501 University Crescent, Winnipeg, MB, R3T 2N6 Canada

Abstract: Throughout their lifetime, riverine fish face seasonal changes in the habitat conditions. Amongst these changes, those associated with the freeze-up period of cold region rivers are some of the most drastic ones. In response to these harsh dynamic conditions, fish adopt a number of physiological and behavioural responses mitigating some of the negative impacts associated to the freeze-up period. However, despite these adaptive mechanisms, this period is critical for the survival of fish and most likely plays an important limiting role in the production of freshwater species of cold-temperate region. We discuss how fish inhabiting cold region rivers respond to the changes in fluvial habitat during the freeze-up period and how human modifications of freeze-up conditions may impact the natural adaptation to freeze-up. Finally, the role of past and future technological developments for the characterization of fluvial habitat and tracking of fish movement, growth, and survival during winter are discussed.

HEMATOLOGY, BIOCHEMICAL PROFILE AND THYROID HORMONES OF FOUR SPECIES OF FRESHWATER STINGRAYS
Engracia de Moraes J.R.1,2, Brito F.M.1, Claudiano G.S.1, Yunis J.A.2,

Symposium: Tropical Fish **Type:** Poster **Order:** P145
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Via de Acesso Prof.Paulo Donato Castellane s/n 14884-900 - Jaboticabal, SP Brazil

Abstract: Potamotrygonidae is a family of freshwater stingray endemic of South America. We determined the hematological and serum biochemistry parameters of *Potamotrygon motoro* and *Potamotrygon falkneri* from Parana Basin and *Potamotrygon orbignyi* and *Potamotrygon scobina* from Amazon Basin. Blood was collected from 55 specimens of *Potamotrygon* sp., and these parameters were evaluated: red blood cell count, hematocrit percent, hemoglobin concentration, leucocytes count, trombocytes count, total protein concentration, albumin, uric acid, urea, creatinine, triglycerides, cholesterol, high density lipoprotein HDL, calcium, phosphorus, calcium/phosphorus relationship, creatine kinase CK, gamma-glutamyl transpeptidase GGT, Aspartate transaminase AST, Alanine transaminase ALT, globulin, albumin/globulin relationship, alkaline phosphatase AP, sodium, chloride, potassium, triiodothyronine T₃, and thyroxine T₄ hormones. The hematological indices were similar for all species, except for heterophils levels in *P. orbignyi* and *P. scobina* that were higher. Calcium, phosphorus, calcium/phosphorus relationship, sodium, potassium, chloride, AST, ALT, GGT, CK, albumin/globulin relationship, uric acid, creatinine, urea, triglycerides, HDL, T₃, T₄ levels had no significant difference between the species. These results suggest that there is low influence of habitat and feeding habits. AP, total protein, albumin, globulin, glucose, and total cholesterol had significant differences between the studied species. These results support the theory that stingrays

migrated from Atlantic Ocean, adapting to different conditions throughout the time and placed themselves geographically distant from each other.

LEVAMISOL AND DEXAMETHASONE IN CHRONIC INFLAMMATION BY FOREIGN BODY IN PIARACTUS
MESOPOTAMICUS

Engracia Moraes, Julieta Ruas de 1,2, Thalita Regina Petrillo1, Gustavo Claudiano da Silva1, Jefferson Yunis Aguinaga2, Flávio Ruas de Moraes1 1Department of Veterinary Pathology, School of Agrarian and Veterinary Sciences, Sao Paulo State University (U

Symposium: Tropical Fish **Type:** Poster **Order:** P146

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Abstract: The aim of this study was to investigate the effect of parenteral administration of dexamethasone and levamisole phosphate on the kinetics of accumulation of macrophages and formation of giant cells in glass cover slips implanted in subcutaneous tissue of pacu (*Piaractusmesopotamicus*) to simulate a stressful stimulus with immunosuppression and the possibility to compensate for it using an immunostimulant. 147 fish (CRD, N=7): NV = not treated, CL = control, L25 = levamisole (25 mg / kg), L 50 = levamisole (50 mg / kg), D2 = dexamethasone (2 mg / kg), D2 + L25 = dexamethasone (2 mg / kg + levamisole 25 mg / kg), D2 + L50 = dexamethasone (2 mg / kg + levamisole 50 mg / kg). implanted in animals with sterile glass cover slips at subcutaneous tissue and were administered intra-muscular drugs, according of each treatment. After two, seven and 15 days post-implantation (DPI), fish were anesthetized for blood collection and to remove the glass cover slips. The blood was used for hematological tests and the glass cover slips to assess the kinetics of accumulation of macrophages and formation of giant cells. Observed reduction in the number of erythrocytes and hemoglobin associated with increase of mean corpuscular volume, suggesting slight macrocytic anemia. Kinetic evaluation of cell accumulation on glass cover slip, the highest number of isolated macrophages occurred at seven days after implantation in all groups, associated with increased formation of polycariontes cells regardless of the number of cores. The dexamethasone (2.0 mg / kg) inhibited the accumulation of macrophages in the glass cover slip seven days after implantation. When the drugs were associated, this effect disappeared. The levamisole phosphate at concentration of 25 mg / kg, administered intramuscularly, has been shown acting on the hematological profile at 15th day. The combination of drugs did not interfere significantly in erythrocyte and leukocyte number in any of the treatments.

PRODUCTION OF Ig-Y SPECIFIC TO BACTERIAL ANTIGENS OF PHOTOBACTERIUM DAMSELAE IN THE PREVENTIVE
THERAPY OF RACHYCENTRON CANADUM EXPERIMENTALLY INFECTED

Engracia Moraes, Julieta Ruas de 1,2, Silas Fernandes Eto1, Gustavo Claudiano da Silva1, Dayanne Carla Fernandes1, Jefferson Yunis Aguinaga2, Thiago Fernandes Alves 2, Marina Tie Shimada 2, Rogério Salvador 3, Flávio Ruas de Moraes1 1Department of Veter

Symposium: Tropical Fish **Type:** Poster **Order:** P147

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Abstract: The use of IgY polyclonal antibodies presents a promising alternative to serum therapy and prophylaxis of microbial infections in humans, mammals and fish. Therefore, the aim of this study was the production and evaluation of immunoglobulin Y specified to *Photobacterium Damselae* in serum therapy of *Rachycentron canadum*. The study was divided into two experimental phases. In the first one, 10 laying hens Isa Brown (eight weeks of age) were inoculated intramuscularly with the bacterial antigen of *Photobacterium damsela*. Hens received doses booster each 15 days during 105 days. Serum samples and eggs were collected five days prior the booster doses. The

production and IgY antibody avidity were evaluated each 15 days by ELISA. The specificity was tested by Western Blot. The results showed an increase of titles and avidity of the antibodies in the serum and yolk on day 90. After obtaining the results of the first phase, antibodies were purified from the yolk at day 90. In the second phase, we tested the potential of these antibodies in the prophylaxis and therapy of *Rachycentron canadum* experimentally infected with *Photobacterium damsela*. The results collaborate for a new perspective in the prophylaxis and treatment of bacterial infections in fish, replacing the use of antibiotics in water and consequently increasing the microbial resistance.

OCEAN ACIDIFICATION STIMULATES RESPIRATORY PLASTICITY IN THE ESTUARINE RED DRUM
Esbaugh, A.J. and Nordi, W.

Symposium: Climate Change **Type:** Oral **Order:** 10

Contact: Andrew Esbaugh **E-mail:** a.esbaugh@austin.utexas.edu

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Abstract: Anthropogenic CO₂ release is causing unprecedented changes in the oceanic carbonate system. The estimated environmental changes are likely too rapid for many species to adapt through evolutionary processes; however, adaptive capacity of organisms may be enhanced by phenotypic plasticity. Ocean acidification causes an acid-base disturbance in fish with many downstream implications and previous work has provided theoretical evidence that respiratory plasticity could counteract these disturbances. The current study examined the effects of ocean acidification on red blood cell mediated CO₂ excretion and branchial CO₂ permeability in the red drum. Real-time PCR revealed significantly increased carbonic anhydrase and anion exchange expression in red blood cells after 24 h. Branchial diffusion distance was significantly reduced after 14 days of exposure, while the NH₃/CO₂ channels RhAG and RhCG1 expression doubled after 72 h. These results provide evidence that respiratory plasticity may help offset effects of ocean acidification on acid-base balance. Potential osmoregulatory trade-offs will also be discussed.

ISOLATION OF A CYP11-LIKE MRNA FROM ELASMOBRANCH INTERRENAL TISSUE: THE KEY TO 1ALPHA-HYDROXYCORTICOSTERONE SYNTHESIS?
Evans, A.N.

Symposium: Elasmobranchs **Type:** Oral **Order:** 20

Contact: Andrew Evans **E-mail:** andrew.n.evans@usm.edu

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Abstract: While the steroid hormone 1alpha-hydroxycorticosterone (1alpha-B) is thought to play a key role in elasmobranch physiology, enzymes involved in the final steps of 1alpha-B synthesis have not been described. We hypothesize that the putative elasmobranch cyp11b enzyme exhibits both 11beta- and 1alpha-hydroxylase activity, similar to the dual activity of mammalian CYP11B2. We have isolated a complete cyp11-like mRNA and >2000 bp of promoter sequence from Atlantic stingray interrenal tissue, and are currently examining the activity of the encoded protein using heterologous expression. This mRNA is only expressed in the interrenal, and BLAST analyses reveal moderate identity (35-55%) to only cyp11a and cyp11b genes. Phylogenetic analysis suggests that the stingray protein is more closely related to mammalian CYP11B1 and CYP11B2 than teleost cyp11b enzymes, which are more similar to cyp11a. Characterizing the activity and regulation of this potentially novel enzyme is critical for examining the synthesis and physiological actions of 1alpha-B.

ACTIVITIES OF CENTRAL ANTIOXIDANTS SUPEROXIDE DISMUTASE AND CATALASE, BUT NOT GLUTATHIONE-DEPENDENT ANTIOXIDANTS, ARE GENERALLY HIGHER IN RED-BLOODED THAN WHITE-BLOODED ANTARCTIC NOTOTHENIROID FISHES

Evans, E.R., Kuhn, D.E., and Crockett, E.L.

Symposium: General Contributed Papers **Type:** Poster **Order:** P55
Contact: Elizabeth Crockett **E-mail:** crockett@ohio.edu
Department of Biological Sciences, Ohio University, Athens, OH 45701 USA

Abstract: The Channichthyidae are largely Antarctic fishes, all of which lack hemoglobin. Loss of hemoglobin is associated with reduced oxidative damage to proteins. We hypothesized that white-blooded species do not require the more robust activities of antioxidants found in red-blooded species. Red-blooded species (*Notothenia coriiceps*, *Gobionotothen gibberifrons*) have higher total antioxidant capacities and enzymatic activities of superoxide dismutase (SOD) and catalase (CAT) in heart, skeletal muscle, and liver than white-blooded species (*Chaenocephalus aceratus*, *Chionodraco rastrospinosus*). However, white-blooded *Champscephalus gunnari* has comparable, if not higher, activities of SOD in liver and skeletal muscle compared with red-blooded fishes. While in most cases there are no significant differences among species in activities of glutathione-dependent enzymes, white-blooded *C. gunnari* has highest activities of glutathione peroxidase 1 in both muscles. Since *C. gunnari* is the least derived of the white-blooded species measured, this indicates a role for phylogeny in trends among antioxidant capacities. Supported by NSF ANT 1043576.

MORPHOMETRY OF THE MICROVILLI AND ALKALINE PHOSPHATASE ANALYSIS OF THE INTESTINE OF HEMISORUBIM PLATYRHYNCHOS

Faccioli, C.K., Chedid, R.A., Mori, R.H., Amaral, A.C., Franceschini-Vicentini, I.B. and Vicentini, C.A.

Symposium: Tropical Fish **Type:** Poster **Order:** P148
Contact: Claudemir Kuhn Faccioli **E-mail:** claudemirkf@fc.unesp.br
Department of Biological Sciences, Faculty of Sciences, São Paulo State University - UNESP, 14-01 Luiz Edmundo Carrijo Coube Ave., Bauru, SP 17033-360 Brazil

Abstract: This study measured the microvilli surface area ($MvSA = H\pi D + \pi R^2$, H-height, D-diameter, R-radius of microvilli) and analyzed the alkaline phosphatase in the intestine of carnivorous freshwater *Hemisorubim platyrhynchos* using transmission electron microscopy. This specie presents a short intestine and the microvilli are the key to increase the intestinal surface area, boosting absorption and forming a barrier against pathogens. MvSA was $0,275\mu m^2$ in anterior intestine and $0,223\mu m^2$ in posterior intestine, thus microvilli surface area is 23% bigger in the anterior than in posterior intestine. Alkaline phosphatase was present in microvilli throughout the intestine, but in the anterior intestine its activity was more intense. Alkaline phosphatase is found in cell membranes where active transport occurs and it acts in digestion and emulsification of food into chyme. In conclusion, the intensity of alkaline phosphatase and the MvSA indicated that the anterior intestine represents the site where occurs great absorption in *H. platyrhynchos*.

CROSSING-OVER THE LIMITS OF SEAHORSES: THE IMPACT OF OCEAN WARMING AND ACIDIFICATION ON A BONY-ARMOURED, POOR SWIMMER FISH

Faleiro, F., Santos, C., Aurélio, M.L., Baptista, M., Pimentel, M., Calado, R., Repolho, T., Rosa, R.

Symposium: Environmental Change **Type:** Oral **Order:** 5
Contact: Rui Rosa **E-mail:** rrosa@fc.ul.pt
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Abstract: Seahorses already face too many challenges in the wild, including habitat degradation and overexploitation. The question that arises is how will these already severely threatened fish endure additional stress from rapid climate change? Unlike most fishes, the poor swimming skills of seahorses, along with the ecological and biological constraints of their peculiar life style, place great weight on their physiological ability to face climate changes. In the present study, we evaluate, for the first time, the effects of ocean warming (+4 °C) and acidification ($\Delta\text{pH} = -0.5$) on the metabolism and behaviour patterns of adult temperate seahorses, *Hippocampus guttulatus*. Adult seahorses showed to be relatively well prepared to face the future changes in ocean temperature, but not the combined effect of warming and acidification. Seahorse metabolism increased normally with warming (Q10 values around 2), and behaviour and feeding were not affected. However, under hypercapnia (or the combined effect of warming and acidification), seahorses showed signs of metabolic depression, evidenced by a decline in oxygen consumption and ventilation rates, feeding intake, and activity levels. The attractive appearance and peculiar ecology of seahorses make them important flagship species for conservation actions and, thus, ideal species to draw attention to climate change issues.

PHYSIOLOGICAL AND BEHAVIORAL RESPONSES TO MULTIPLE ENVIRONMENTAL STRESSORS IN THE ENDANGERED
DELTA SMELT

Fangue, N.A., Komoroske, L., Hassenbein, M, Connon, R.E.

Symposium: Environmental Change **Type:** Oral **Order:** 3

Contact: Nann Fangue **E-mail:** nafangue@ucdavis.edu

UC Davis, Wildlife, Fish, and Conservation Biology Department, One Shields, Ave, 1088 Academic Surge, Davis,
CA 95616 USA

Abstract: The delta smelt (*Hypomesus transpacificus*) is an endemic fish in the Sacramento-San Joaquin Delta (SSJD) and is an important ecological indicator species. Delta smelt have rapidly declined in the past 30 years due to a variety of physiological and ecological stressors, and further impacts from climate change in the region are likely. We exposed delta smelt to ecologically-relevant combinations of temperature, salinity, and turbidity to assess variation in whole organism tolerances, feeding performance, and sublethal stress thresholds across delta smelt life stages, and linked these data to molecular mechanisms using functional gene expression profiles. These data highlight how physiological and behavioral studies that consider potentially interacting stressors are not only mechanistically revealing, but also inform ongoing modeling efforts to forecast the distribution and abundance of suitable habitat for endangered delta smelt under projected climate change scenarios in the SSJD.

THE ROLE OF THE CORTISOL STRESS AXIS IN REGULATING GONADAL FUNCTION

Faught, E, and Vijayan, M.M.

Symposium: Stress in Fish **Type:** Poster **Order:** P119

Contact: Erin Faught **E-mail:** lfaught@ucalgary.ca

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Abstract: While it is known that stress reduces reproductive capability in teleosts, the mechanism linking corticosteroid stress axis activation to gonadal dysfunction is not well understood. Hypothalamus-pituitary-interrenal (HPI) axis activation and the attendant rise in stress-associated neuroendocrine hormones, including adrenocorticotrophic hormone (ACTH) may lead to altered reproductive capacity. Indeed, recent studies have shown a high abundance of melanocortin 2 receptor (MC2R) transcripts in the gonads, as well as the ability of ACTH to suppress gonadotropin-induced estradiol secretion in zebrafish (*Danio rerio*) ovarian follicles. Therefore, using zebrafish as a model, we tested the hypothesis that ACTH has a direct effect on testicular steroidogenesis. Testes were exposed to either ACTH, 8-bromo-cAMP, or human chorionic gonadotropin for 3h and the cortisol production capacity ascertained. Results indicate that zebrafish testes synthesize cortisol in response to ACTH or 8-bromo-

cAMP stimulation. This study highlights an extra-adrenal role for ACTH in regulating cortisol levels during stress in fish.

MATERNAL STRESS AFFECTS CORTISOL DYNAMICS IN ZEBRAFISH

Faught, E., Best, C., and Vijayan, M.M.

Symposium: Stress in Fish **Type:** Oral **Order:** 17

Contact: Erin Faught **E-mail:** lfaught@ucalgary.ca

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Abstract: Maternally deposited cortisol is critical for early embryo development in zebrafish (*Danio rerio*). However, it is not yet known whether maternal stress translates to elevated embryo cortisol levels. We hypothesized that maternal stress results in reduced breeding success and higher embryo cortisol content. Stressor exposure consisted of a 5-day fasting, after which the fish were fed and bred for 10 days. Cortisol content was higher in the fasted mothers compared to the fed controls. There were no differences in cortisol levels in either ovarian tissue or in total embryos from each group. However, there was a clear temporal difference in the embryo cortisol content; the fasted group had higher levels towards the end of the 10 d breeding period. Embryo yield was also higher in the fasted group. Altogether, our results suggest that fasting increases fecundity in zebrafish, and provide insight into how maternal stress can affect embryo cortisol content in an asynchronous breeder.

SEASONAL VARIATIONS OF APOPTOSIS AND AUTOPHAGY IN THE LIVER OF THE GILTHEAD SEA BREAM

Feidantsis, K., Antonopoulou, A., and Michaelidis, B.

Symposium: Stress in Fish **Type:** Poster **Order:** P120

Contact: Konstantinos Feidantsis **E-mail:** kostas.feidantsis@gmail.com

Laboratory of Animal Physiology, Department of Biology, Aristotle University of Thessaloniki, 54124, Thessaloniki Greece

Abstract: . Tolerance to a changing climate regime and persistence in the natural environment depends on the limited capacity to acclimate to temperature shifts. In the present study we tried to identify the thermal limits by investigating the apoptotic and autophagic pathway in the liver of *Sparus aurata*, during one-year of acclimatization in the field. Thermal and oxidative impacts on cellular stress capacities were assessed by studying the levels of the apoptotic pathway proteins of the Bcl-2 family (Bcl-2, Bax and Bad), the levels of ubiquitin conjugates, as well as some autophagy indicator-proteins i.e. LC3B II/LC3B I ratio and SQSTM1/p62. The indicators of apoptosis exhibited higher levels mostly at increasing environmental temperatures during spring, while further temperature increase during summer did not result to additional increase (eurythermic status). Additionally, the higher LC3B II/LC3B I ratio and the decreased levels of SQSTM1/p62 during this period of increasing ambient temperature, indicated the autophagosomes activation.

EFFECTS OF OCEAN WARMING AND ACIDIFICATION ON THE EARLY DEVELOPMENT OF AN ANTARCTIC FISH,
GYMNODRACO ACUTICEPS

Flynn, E.E., and Todgham, A.E.

Symposium: Climate Change **Type:** Poster **Order:** P20

Contact: Erin Flynn **E-mail:** eflynn@mail.sfsu.edu

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Abstract: Predicting the response of marine fish to ocean climate change has important implications for fisheries and conservation, and recent work has suggested that early life stages of fishes may be the most vulnerable. To date very little research has focused on exposure during embryogenesis, particularly with the concurrent changes in temperature and pH predicted by the end of the century. The protracted embryogenesis (~11 months) of the Antarctic dragonfish, *Gymnodraco acuticeps*, provides the opportunity to examine the impacts of potential synergistic stressors on embryo physiology over a fine time scale. Using an integrative, experimental approach, our research examined the impacts of near-future warming (+ 2°C) and ocean acidification (650 and 1000 ppm CO₂) on metabolic processes during gastrulation to early segmentation. Increased temperature had a greater overall impact on survival and respiration than changes in CO₂ levels, suggesting that temperature may be the immediate driver of change at the organismal level.

ORIGIN AND DEVELOPMENT OF THE DOPAMINERGIC NEURONS INNERVATING THE PITUITARY IN ZEBRAFISH
Fontaine, R., Yamamoto, K., Affaticati, P., Bureau, C., Colin, I., Dufour, S., Vernier, P. and Pasqualini, C.

Symposium: Zebrafish **Type:** Oral **Order:** 3
Contact: Romain Fontaine **E-mail:** fontaine@inaf.cnrs-gif.fr
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Abstract: In many teleosts, the stimulatory control of the gonadotrope axis by GnRH is opposed by an inhibitory control by dopamine (DA). To get a deeper knowledge about the DA neurons involved in this control, and which have been poorly studied, we used zebrafish. We first localized, by retrograde tracing experiments, the DA cell bodies involved in this control in the most antero-ventral part of the preoptic area, and we called them preoptico-hypophyseal DA neurons (POHDA). We then characterized their tyrosine hydroxylase (th) gene expression, and show that they all express th1, and some of them co-express th2. The development of POHDA neurons was then studied, firstly examining the schedule of TH expression and their axonal arrival in the pituitary, secondly examining the expression patterns of several developmental genes. This study provides some new insights about the development of the DA system exerting an inhibitory action on the gonadotropin secretion.

SEASONAL MIGRATION OF PACIFIC HAGFISH OFF THE CENTRAL CALIFORNIA COAST
Fox, D. A., Stephens B. T., Nakamura, R.

Symposium: Hagfishes **Type:** Oral **Order:** 2
Contact: Dewayne Fox **E-mail:** dfox@desu.edu
Delaware State University, Department of Agriculture and Natural Resources, 1200 N. DuPont Highway, Dover,
DE, 19901 USA

Abstract: Pacific Hagfish (*Eptatretus stouti*) support lucrative fisheries throughout much of their range and have been extensively studied although our understanding of their life history and ecology is rather limited. Through a two year independent sampling program off the central California coast, we examined seasonal distribution and reproductive status of Pacific Hagfish in areas that had not been harvested. We collected 9,807 individuals at depths between 64-550m and noted significant differences in hagfish distribution by sex and season. Although both sexes could be found throughout our study area, mature females were more common in deeper waters (>91m) while mature males dominated inshore collections. Pacific Hagfish make directed inshore migrations during the winter/spring presumably for reproductive purposes before females move offshore in the late spring. As traditional fisheries decline, additional harvesters may look to enter the Pacific Hagfish fishery thus underscoring the need to collect baseline data to better inform management practices.

SPERMATOGONIAL STEM CELL PHYSIOLOGY AND TRANSPLANTATION IN FISH

França L.R., Costa, G.M.J., Lacerda S.M.S.N.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 8

Contact: Luiz de Franca **E-mail:** lrfranca@icb.ufmg.br
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Abstract: Spermatogonial stem cells (SSCs) are crucial for the establishment and maintenance of spermatogenesis in eukaryotes. In fish, some highly conserved vertebrate molecular markers (e.g. Gfra1 and Pou5f1/Oct4) are now available, representing important candidates for studies evaluating the regulation of SSCs and even functional investigations using SSCs transplantation. A technique already used to demonstrate that, different from mammals, fish germ stem cells (spermatogonia/oogonia) present high sexual plasticity that is determined by the somatic microenvironment, which is also very important for the preferential location and regulation of SSCs. A long-term in vitro culture system for SSCs is now established for some fish species, allowing the development of strategies to investigate key regulatory and functional aspects of germline stem cells (e.g. self-renewal and/or differentiation) or to amplify SSCs of rare, endangered, or commercially valuable species. This system also represents an important tool for transgenesis and the development of new biotechnologies in fish production.

INTRODUCTION TO FISH REPRODUCTIVE PHYSIOLOGY AND BIOTECHNOLOGY SYMPOSIUM

Franca, L. and B. Levavi-Sivan

Symposium: Reproductive Physiology **Type:** Oral **Order:** 1

Contact: Luiz de Franca **E-mail:** lrfranca@icb.ufmg.br
Utrecht University Netherlands

Abstract: Reproduction is among the major life processes that along with growth and metabolism, excretion, or immunity determine the physiology of fish. Hence, research into reproductive physiology is of great relevance not only for basic biology but also has important implications for applied research fields, in which biotechnological approaches in the context of finfish aquaculture or bio-conservation play increasingly important roles. This symposium will focus on advances in our understanding of the functioning of the main regulatory system controlling reproductive processes, the brain-pituitary-gonadal axis, at the cellular and molecular level. This includes external factors such as photoperiod, nutrition, or endocrine disruptors and toxicants, but also endogenous factors such as hormones and growth factors. Moreover, advances in sex determination and sex differentiation will fit into this symposium. Particularly in relation to the gonads, this symposium will encompass the fine regulation and interactions among germ and somatic cells, as well as the physiology/biology of germ stem cells and their microenvironment (niche). Finally, this symposium will include recent fish reproductive biotechnologies involving germ cells (xeno)transplantation as a tool to investigate gametogenesis, to preserve the germplasm of endangered species, to produce commercially valuable fish species using surrogated recipients, or to facilitate the generation of transgenic fish.

THE EFFECT OF TRIPLOIDY ON THE NEUROENDOCRINE RESPONSE TO STRESS IN ATLANTIC SALMON

Fraser, T., Vindas, M. A., Fjellidal, P.G., Winberg, S., Thornquist, P., Overli, O., Hansen, T., and Mayer, I.

Symposium: Stress in Fish **Type:** Poster **Order:** P121

Contact: Thomas Fraser **E-mail:** thomas.william.kenneth.fraser@nmbu.no
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Abstract: Sterile triploid salmon demonstrate differences in social behavior compared to diploid counterparts. Here we investigated serotonergic and dopaminergic activity, two neuroendocrine variables related to social behavior and coping styles in vertebrates. The telencephalon and brain stem of unstressed and stressed (30 min confinement)

diploid (control) and triploid salmon were analysed for serotonin, dopamine, and their metabolites. No ploidy effect was found in serotonergic or dopaminergic activity in unstressed fish. Stressed induced increased serotonergic activity in both brain regions, with triploids having a potentiated telencephalic response compared to diploids. Dopaminergic activity also increased following stress in the telencephalon of diploids, but not triploids. Based on the literature, the neuroendocrine profile of triploids is suggestive of greater behavioural inhibition following stress in comparison to diploids.

THE IMPORTANCE OF SPATIAL SCALES TO ANALYSIS OF FISH DIVERSITY IN AMAZONIAN FLOODPLAIN LAKES, AND IMPLICATIONS FOR CONSERVATION

Freitas, C.E.C., Siqueira-Souza, F.K., Florentino, A.C. and Hurd, L.E.

Symposium: Tropical Fish **Type:** Oral **Order:** 12

Contact: Carlos EC Freitas **E-mail:** cefreitas@ufam.edu.br

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Abstract: The Amazon Basin has the highest fish species diversity of any region in the world and we asked whether species diversity in this region is more a function of within-lake species richness (i.e., α diversity), or differences among lakes (β diversity). We collected fish in 10 floodplain lakes along the Solimões River, divided evenly between two lake types: those on islands in the river channel (island lakes), and those on the margins of the river (coastal lakes) during 2006. We partitioned fish diversity into three spatial scales: α = within each lake; β_1 = among lakes of the same type (coastal or island); and β_2 = between the two types of lakes, and compared their relative contributions to regional (γ) diversity. $\beta_1 + \beta_2$ contributed as much or more to γ diversity than did α . Although many of the 116 fish species were shared between lake types ($S = 72$), 32 species were found exclusively in coastal lakes and 12 species were found exclusively in island lakes. We suggest that it will be necessary to set areas larg

HAGFISH SLIME

Fudge, D.S.

Symposium: Hagfishes **Type:** Oral **Order:** 3

Contact: Douglas Fudge **E-mail:** dfudge@uoguelph.ca

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Abstract: Hagfishes are renowned for their ability to produce seemingly impossible volumes of fibrous slime, which functions as an effective deterrent against piscine predators. Here I will present answers to several questions about hagfish slime including: How do hagfishes make so much slime? Where is the slime made and by which cells? How is the slime deployed into seawater and how does it set up so quickly? What regulates unraveling of the fibrous component of the slime in seawater? What regulates the swelling and rupture of the numerous mucin vesicles that are released from the slime glands? Lastly, I will discuss how the specialized thread cells, which produce the silk-like fibres that permeate the slime and give it such unusual properties, are produced and organized within the cytoplasm of these cells.

INSULIN-LIKE GROWTH FACTOR 1 AS A POTENTIAL INDICATOR FOR AMINO ACID DEFICIENCIES IN THE YELLOWTAIL FISH

Fukada, H., Takahashi, N., Hosomi, N., Morioka, K., and Masumoto, T.

Symposium: Fish Culture **Type:** Poster **Order:** P8

Contact: Haruhisa Fukada **E-mail:** fukaharu@kochi-u.ac.jp
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Abstract: We believed that insulin-like growth factor 1 (Igf1) may be a useful indicator for amino acid deficiencies in the yellowtail, *Seriola quinqueradiata*. To evaluate Igf1 as marker for amino acid deficiencies, low fish-meal diets were made with 2 different fish meals. After 10 days of receiving each diet, fish were injected intramuscularly with several amino acid solutions, and igf1 mRNA expressions in their dorsal muscle were measured. We observed that igf1 mRNA expression increased when proline was injected in fish fed one diet and alanine and glutamine were injected in fish fed the other diet. Several diets supplemented with amino acids that were lacking in the basal 2 diets were prepared for 2 feeding trials. In 2 feeding trials, fish fed diets supplemented with those amino acids showed a higher growth performance than those fed the basal diets, suggesting that Igf1 is a useful indicator for amino acid deficiencies.

IDENTIFICATION OF GENE PATHWAYS INVOLVED IN DIFFERENTIAL GROWTH OF HYBRID STRIPED BASS USING
TRANSCRIPTOMICS

Fuller, S.A., and Beck, B.H.

Symposium: Physiological Genomics **Type:** Oral **Order:** 9

Contact: S. Adam Fuller **E-mail:** adam.fuller@ars.usda.gov

USDA ARS Stuttgart National Aquaculture Research Center, 2955 Highway 130E, PO Box 1050, Stuttgart, AR
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Abstract: Growth performance is the trait of primary importance to most hybrid striped bass producers, and improving growth is their number one goal. Recent genome projects have made large amounts of expressed sequence data available for numerous species of aquaculture importance, including striped bass. Utilizing genomic information is critical for identifying putative genes and cellular/molecular mechanisms which control the traits targeted in selection programs. In this study, we reared hybrid striped bass fingerlings from 47 families in replicate outdoor ponds and estimated parental effects and heritability of two growth-related traits to determine the genetic basis for selective improvement, and performed RNAseq on superior and inferior performing representatives to identify global expression differences. The top five differentially expressed genes between fast and slow growers are involved in the sterol synthesis pathway, regulate myoglobin, and calcium-related genes, all of which could play a role in muscle development. More detailed results will be discussed.

POTASSIUM EXCRETION VIA ROMKA POTASSIUM CHANNEL EXPRESSED IN THE GILL IONOCYTES OF MOZAMBIQUE
TILAPIA

Furukawa, F., Watanabe, S., Hiroi, J., Kaneko, T.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 12

Contact: Fumiya Furukawa **E-mail:** fumiya@marine.fs.a.u-tokyo.ac.jp

Institute of Cellular and Organismic Biology, Academia Sinica. R144 128, ICOB, Academia Rd. sec. 2, Nankang,
Taipei 11529 Taiwan

Abstract: Body fluid K⁺ homeostasis is important for survival of the animals. Thus, the mechanisms of K⁺ regulation are extensively studied in mammalian kidneys. However, this topic has been overlooked past decades in the field of fish biology, where Na⁺, Cl⁻, and acid-base regulation gathered predominant attention. Recently we investigated the possible K⁺ excretory pathway in seawater-acclimated Mozambique tilapia, and found that K⁺ was excreted via gill ionocytes. Also, we found that branchial mRNA expression of ROMKa, a homolog of human renal outer medullary K⁺ channel, was stimulated in response to high-K⁺ stress. ROMKa was expressed at the apical membrane of the ionocytes, and its central role in branchial K⁺ excretion was suggested. Furthermore, exposing freshwater-acclimated tilapia to high-K⁺ stress also resulted in ROMKa stimulation in the gill ionocytes. Finally,

ROMKa were localized to several ionocytes found in seawater or fresh water (Type- I, II, and IV) by triple-color immunofluorescence staining.

A METHOD FOR EPISODIC-LIKE MEMORY TESTING IN ZEBRAFISH

Gallup, J., Lucas, K., Mygglund, A., May, Z., Powell, R., Digweed, S., Schalomon, M., and Hamilton, T.J.

Symposium: Zebrafish **Type:** Poster **Order:** P157
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Abstract: Episodic memory in humans is often defined as memory of autobiographical events associated with what, where, and which occasion the memory occurred. Since conscious recall of previous events is quite difficult to test in other animals, tests of 'episodic-like' memory have been developed for mice, rats, and Yucatan minipigs. This type of memory remains uninvestigated in zebrafish (*Danio rerio*) even though they are becoming a popular model organism. To investigate the episodic-like memory capabilities of zebrafish we used a validated mammalian paradigm. When zebrafish were presented with a familiar object in a familiar context, and subsequently presented with the same object but in a novel location within the same context, they spend more time in the novel quadrant exploring the object. This evidence suggests that zebrafish display episodic-like memory as they remember what object they saw, where they saw the object, and on which occasion (specific context) it was presented.

MECHANISMS OF RESILIENCE TO ENVIRONMENTAL SALINITY IN KILLIFISH SPECIES

Galvez, F.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 4
Contact: Fernando Galvez **E-mail:** galvezf@lsu.edu
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Abstract: Salinity is arguably one of the most important barriers restricting the distribution of aquatic animals in the environment. Some species can change their phenotype to compensate for broad changes in environmental salinity, whereas other species have narrow salinity tolerance ranges. This presentation will describe the physiological responses and the genomic underpinnings of osmotic stress in natural populations of fish from the genus *Fundulus*. Utilizing a comparative and integrative approach, the mechanisms of acclimation to hypoosmotic and hyperosmotic challenges will be explored, describing differences in the compensatory responses to osmotic challenge between closely related fish taxa. The presentation will conclude with recent research investigating the role of polyamines in epithelial remodeling during osmotic stress, mechanisms of paracellular ion regulation ion transporting epithelia, and work to develop in vitro models to study ion transport in the gill epithelium of *Fundulus* species.

CARDIORESPIRATORY FUNCTION AND RED MUSCLE PERFORMANCE IN ARCTIC CHARR vs. ATLANTIC SALMON AT ELEVATED TEMPERATURES

Gamperl, A.K., Syme, D.A., Penney C.M., and Nash, G.W.

Symposium: Climate Change **Type:** Oral **Order:** 5
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Abstract: Climate change is expected to impact the growth, survival, and distribution of Arctic charr (*Salvelinus alpinus*), and result in competition with Atlantic salmon (*Salmo salar*) as this latter species moves northward. Given the importance of metabolic capacity, cardiac function and swimming performance to fish thermal biology and ecology we: 1) monitored cardiorespiratory parameters as adults of both species were exposed to a 20C h-1 temperature increase until their critical thermal maximum (CTMax); 2) examined the influence of acute increases in temperature on cardiac mitochondrial function; and 3) measured cardiac and red muscle contractile performance and efficiency when exposed to a range of temperatures after acclimation to 6 and 15oC. Collectively, these data provide several mechanistic (physiological) explanations for why Atlantic salmon will outcompete charr in a warming world, and further our understanding of how temperature affects muscle function in species with different thermal niches.

CARDIAC MYOGLOBIN DEFICIT HAS EVOLVED REPEATEDLY IN FISH

Garcia de la Serrana, D., Macqueen J.D and Johnston, I.A.

Symposium: Cardiovascular Function

Type: Poster

Order: P76

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Abstract: Myoglobin (Mb) is the classic vertebrate oxygen-binding protein expressed in aerobic striated muscles. It functions principally in oxygen delivery and provides muscle with its characteristic red colour. Certain members of Channichthyidae are the only fish widely believed to lack cardiac Mb expression, a trait that is often linked to the atypical circumstances of this family's Antarctic radiation. Here, we surveyed the teleost phylogeny, revealing that cardiac Mb deficit associated with pale heart colour has evolved repeatedly in diverse ecophysiological settings. We demonstrate that cardiac Mb deficit results from total pseudogenization in the stickleback *Gasterosteus aculeatus* and by massive reduction in mRNA level in two distant tropical species that retain a Mb protein subject to purifying selection. Our results suggest that near absence or loss of Mb-assisted oxygen delivery into heart muscle is a common facet of teleost biodiversity, even affecting lineages with notable oxygen demands. Mb deficit may impact how certain fish are able to deal with increased tissue oxygen demands arising during climate change.

SEXY MALES IN MUDDY WATER? PHENOTYPIC DIVERGENCE IN AN AFRICAN CICHLID

Gary, S.M., and Chapman, L.J.

Symposium: General Contributed Papers

Type: Oral

Order: 5

Contact: Suzanne Gray

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Abstract: In response to human-induced rapid environmental change (HIREC), species can shift their distribution, suffer extinction, or persist via adaptive change. Examples of the latter can be found among freshwater fishes, the most threatened vertebrates globally, showing population-level plastic and genetic adaptations to human-induced environmental extremes, such as low dissolved oxygen and high turbidity. Here, we investigate the phenotypic response of a wide-spread African cichlid, *Pseudocrenilabrus multicolor*, to turbidity – a globally pervasive environmental stressor. We used a combination of field surveys to capture natural phenotypic variation associated with development in complex, dynamic environments, and lab rearing studies to tease apart the effect of turbidity on phenotype. We found that high turbidity can induce color pattern and behavioral changes in addition to morphological change in sensory structures such as eyes and optic lobes of the brain. Such adaptations should allow individuals to cope with altered environmental conditions.

INTERACTIONS OF CORTISOL WITH NITRIC OXIDE SYNTHESIS IN RAINBOW TROUT

Gerber, L., Jensen, F.B., and Madsen, S.S.

Symposium: Stress in Fish **Type:** Poster **Order:** P122

Contact: Gerber Lucie **E-mail:** luciegerber@biology.sdu.dk

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Abstract: Fishes differ in their ability to cope with environmental stress. Nitric Oxide (NO) and cortisol are both physiological messenger molecules involved in stress response. We hypothesized that cortisol impacts on NO synthesis. The effects of cortisol injection on the expression of NO synthase (NOS) isoforms were investigated in gill, kidney, intestine and heart of freshwater (FW) and seawater (SW) acclimated rainbow trout, using QPCR. Cortisol induced a significant up-regulation of nNOS expression in kidney of FW fish, whereas cortisol induced a down-regulation of nNOS in kidney of SW fish and gill of FW fish. Cortisol injection also induced significant down-regulation of iNOS expression in kidney of SW fish. Corresponding changes in NO metabolites were measured by reductive chemiluminescence. The data highlight differential effects of cortisol on NOS expression in FW and SW trout and a tissue-dependent regulation. The results suggest crosstalk between NO synthesis and cortisol elevation in fish.

FISH FARMS AS A HABITAT FOR WILD FISH: HOW ARE ADULT ATLANTIC MACKEREL AND JUVENILE SAITHE AFFECTED?

Ghanawi, J., Telfer, T., McAdam, B.

Symposium: Fish Habitats **Type:** Poster **Order:** P106

Contact: Joly Ghanawi **E-mail:** jg57@stir.ac.uk

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Abstract: Artificial structures such as sea cage fish farms can aggregate wild fish with excess feed providing a novel source of food and possibly changing behaviour and physiology. We sampled migrating fish (Atlantic mackerel (*Scomber scombrus*)) and resident fish (juvenile saithe (*Pollachius virens*)) near and away from cages in a Scottish sea-loch to compare for differences in bioenergetic condition, stomach content, and fatty acid composition. Fish collected near cages exhibited higher condition, with quarter of stomachs collected near cages containing feed pellets. Fatty acid profiles of both species indicated differences between fish aggregating near and away from cages (elevated levels of linoleic acid and decreased omega-3/omega-6 ratios) with a stronger effect in the resident saithe compared with transient mackerel. Results indicate that sea cages act as artificial habitats for wild fish as they forage on commercial fish feed with consequences on physiology of both migrating and resident fish.

ZEBRAFISH AQUAPORIN 1a IS A MULTI-FUNCTIONAL WATER, CO₂ AND NH₃ CHANNEL

Gilmour, K.M., Talbot, K., Kwong, R.W. and Perry, S.F.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 16

Contact: Katie Gilmour **E-mail:** kgilmour@uottawa.ca

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Abstract: The objective of the present study was to determine whether zebrafish (*Danio rerio*) aquaporin 1a (AQP1a) plays a physiologically-relevant role in CO₂ and/or NH₃ excretion in vivo. Use of a translation-blocking morpholino oligonucleotide revealed that AQP1a knockdown significantly reduced rates of both CO₂ and NH₃ excretion in 4 days-post-fertilization zebrafish larvae. Elimination of red blood cell AQP1a using the haemolytic agent phenylhydrazine had no impact on CO₂ or NH₃ excretion, pointing to the AQP1a of yolk sac epithelium

ionocytes as the key site of AQP1a involvement in CO₂ and NH₃ excretion. When zebrafish larvae experiencing knockdown of Rh glycoproteins, which facilitate NH₃ as well as CO₂ excretion, were exposed to high external ammonia, AQP1a expression increased, suggesting that these multi-functional gas channels act in concert to facilitate CO₂ and NH₃ excretion. Collectively, the data support a physiologically-relevant role for AQP1a in CO₂ and NH₃ excretion in vivo in zebrafish.

LYMPHOCYTE SURVIVAL AND PROLIFERATION BY TUMOR NECROSIS FACTOR LIGAND FROM ROCK BREAM WITH ITS
MOLECULAR CHARACTERIZATION AND EXPRESSION ANALYSIS

Godahewa, G.I., Wickramaarachchi, W.D.N., Wan, Q. and Lee, J.

Symposium: Stress in Fish **Type:** Oral **Order:** 29

Contact: G. I. Godahewa **E-mail:** imarshana@gmail.com

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Abstract: Tumor necrosis factor (TNF) members' play a vital role in the regulation of inflammation by stimulates the downstream signaling pathways. B-cell activating factor (BAFF) is a cytokine, belongs to the TNF ligand superfamily 13B. As a cytokine, BAFF play an important role in the survival, proliferation, differentiation of B cells/lymphocytes while enhancing immune responses. 2108bp full-length Rb-BAFF cDNA possessed 264aa (29kDa) protein. TNF, MORN and UBQ domains were discovered. Possible receptor and polypeptide binding sites were identified. Pairwise comparison showed 83.0% identities and 86.7% similarities with *Epinephelus awoara*. It has close evolutionary relation with *Epinephelus awoara*. Rb-BAFF was predominantly expressed in kidney, head kidney and spleen. As a response of spleen tissue challenge, Rb-BAFF mRNA was significantly expressed at 24h post challenge in lipopolysaccharide and Poly IC. Upon rock bream iridovirus and *Streptococcus iniae*, Rb-BAFF was gradually increased up to 6 h and 12 h respectively. Moreover, rRb-BAFF has encountered the increase of rock bream lymphocyte survival and proliferation with 10µg/mL for 48 h incubation period. It can be suggested that Rb-BAFF might be involved in immune regulation of rock.

EXPLORING PHYSIOLOGICAL FUNCTIONS OF THE PLEIOTROPIC MELANOCORTIN ALPHA-MSH IN ATLANTIC SALMON

Gorissen, M., Nilsen, T-O., Bye-Ingebrigtsen, E., Handeland, S.O., Helvik, J.V., Stefansson, S.O., Flik, G., Ebbesson, L.O.E.

Symposium: Stress in Fish **Type:** Oral **Order:** 6

Contact: Lars Ebbesson **E-mail:** smoltbrain@me.com

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Abstract: Melanocortins and their receptors are involved in a variety of processes including color adaptation, stress, feed intake and reproduction. Alpha-MSH is one melanocortin derived from a precursor peptide encoded by the POMC gene. In order to better understand the nature of a-MSH in salmon, we conducted a series of experiments investigating changes in circulating levels, using an a-MSH RIA, during 1) parr-smolt transformation (smoltification), 2) day and night in parr and smolts, 3) in postsmolts, diurnal changes under continuous constant light (LL), full spectrum light: total darkness:12:12 (LD) and LD under different narrow wavelength spectra during the dark period, and 4) effects of chronic and acute stress during smoltification. The results demonstrate a dynamic range of responses with development and environmental situations and provide a basis for new functional studies on MSH in salmon biology.

CHANGES IN SPATIAL DISTRIBUTION AND POPULATION SIZE STRUCTURE OF BURBOT IN RESPONSE TO INCREASED PREDATION BY A RECOVERED LAKE TROUT POPULATION IN LAKE SUPERIOR

Gorman, O.T., Stapanian, M.A., Sitar, S.P.

Symposium: Burbot **Type:** Oral **Order:** 6
Contact: Owen Gorman **E-mail:** otgorman@usgs.gov

U.S. Geological Survey, Lake Superior Biological Station, 2800 Lake Shore Drive East, Ashland, Wisconsin 54806
USA

Abstract: We examined data for Burbot *Lota lota* captured in bottom trawl surveys at inshore (5-15 m depths), nearshore (15-80 m), and offshore (80-300 m) sites in Lake Superior during 1978-2013. Mean age and length at capture increased with depth, and mean length and age increased with time. The trend of increasing Burbot mean size coincided with the recovery of the Lake Trout *Salvelinus namaycush*, which preys on Burbot. Over the time series, mean length of Lake Trout and Burbot consumed by Lake Trout increased over the time series. These results are consistent with a hypothesis of increased predation mortality on Burbot by Lake Trout over the time series has resulted in changed age-size structure and depth distribution of Burbot. This interpretation is consistent with a pattern of young Burbot moving from shallow, nearshore nursery habitats and being subjected to a “gauntlet” of predation as they enter deep, offshore habitats.

SEEMINGLY CONTRADICTIONARY RESULTS REGARDING THE WELFARE OF FISH STUNNED USING DIFFERENT METHODS

Gräns, A., Niklasson, L., Sundell, K., Sandblom, E., Kiessling, A.,

Symposium: Stress in Fish **Type:** Oral **Order:** 20
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Gothenburg, 405 30 Sweden

Abstract: Stunning fish with CO₂ is still the dominating method used in Swedish aquaculture. In an on-site study the behaviours and plasma levels of cortisol and ions as well as blood haematological variables were compared for Arctic char (*Salvelinus alpinus*) stunned with CO₂ or electric exposure. CO₂ exposure triggered aversive struggling and escape responses for several minutes before the fish was immobilized, whereas in fish exposed to an electric current immobilization was instant. On average, it took 5 min for the fish to recover from electrical stunning, whereas fish stunned with CO₂ failed to recover. Despite this, the electrically stunned fish had more than double the plasma levels of cortisol compared to fish stunned with CO₂. This result is surprising considering that the behavioural stress reactions were much more pronounced following CO₂ exposure. Several possible explanations for these seemingly contradictory results will be presented and discussed.

IMPORTANCE OF PUTTING BIOLOGICAL RESEARCH AT THE FOREFRONT OF HAGFISH FISHERIES DEVELOPMENT

Grant, S.M.

Symposium: Hagfishes **Type:** Oral **Order:** 1
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Abstract: In the Newfoundland and Labrador region of Canada, recently developed Atlantic hagfish (*Myxine glutinosa*) fisheries underwent a detailed biological analysis at the forefront of fishery development. This presentation highlights several key findings including analysis of female maturity schedule (i.e., size at first attainment, 50%, and 100% maturity) and subsequent gear selectivity studies to avoid over harvesting of juveniles. In addition, over 11,000 animals captured in baited pots were dissected establishing: 1) hermaphrodites are rare, 0.2-0.3%, 2) males and females first mature at similar length and attain similar maximum length, 3) reduction in

maturity schedule with a reduction in the average size of individuals in a population, 4) no loss of eggs to atresia once eggs attain a length of 15 mm, 5) potential fecundity and relative potential fecundity (No. eggs/100 g) of eggs ≥ 15 mm are positively correlated with body length with the latter exhibiting the strongest relationships, 6) eggs in final stage of maturation are at least 20.0 mm long and 8.0 mm in diameter, 7) egg size in final stage of maturation is independent of female body length, 8) there is no evidence of synchronization of the initiation of the reproductive cycle in primiparous females or evidence of a synchronized spawning event/season, 9) recently hatch juveniles are up to 100 mm TL and possibly larger, 10) smallest juveniles are concentrated within 300-400 m depth strata suggestive of nursery grounds/adult migration to spawn grounds, 11) evidence of an increase in reproductive output over a four-year period of intensive fishing pressure evidenced by an increase in fecundity and reduction in the duration of the resting period between reproductive cycles.

INTESTINAL FLUID ABSORPTION BY MARINE TELEOSTS AFFECTS ACID-BASE BALANCE

Grosell, M., Heuer, R.M., Ruhr, I., Schauer, K.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 22

Contact: Martin Grosell **E-mail:** mgrosell@rsmas.miami.edu
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Abstract: Marine fish maintain an internal osmotic pressure of ~ 300 mOsm and are forced to ingest seawater to compensate for diffusive water loss. Imbibed seawater is desalinated in the water-impermeable esophagus, resulting in intestinal fluids hyperosmotic to the blood plasma. Hypertonic fluid absorption by the intestinal epithelium is driven by Na⁺ and Cl⁻ absorption, for most species, with $\sim 50\%$ of Cl⁻ absorption being attributable to anion exchange resulting in up to 100 mM luminal bicarbonate. Thus, water absorption is linked to substantial intestinal base excretion equivalent to a net acid gain, an acid gain which is cleared by the gills. Intestinal base secretion responds to physiological and environmental factors but does not appear to contribute to dynamic regulation of acid-base status. The strides made in the past decade in understanding the role of intestinal acid-base transport in osmoregulation and acid-base balance will be reviewed to provide context for recent discoveries.

COMPARISON OF RATES AND ENERGETIC COSTS OF PROTEIN SYNTHESIS BETWEEN RED-BLOODED AND WHITE-BLOODED ANTARCTIC FISHES

Grove, T.J., Lewis, J.M., and O'Brien, K.M.

Symposium: General Contributed Papers **Type:** Poster **Order:** P56

Contact: Theresa J. Grove **E-mail:** tjgrove@valdosta.edu
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Abstract: Icefishes (Family Channichthyidae) within the suborder Notothenioidei are a unique group of fishes found primarily in the Southern Ocean. All icefishes have lost the expression of hemoglobin (Hb), and six of the 16 species lack myoglobin (Mb) expression in their heart ventricle. As iron-centered proteins, Hb and Mb promote the formation of reactive oxygen species (ROS) that damage biological macromolecules, leading to the question: Does the loss of Hb and Mb provide a physiological benefit to icefishes compared to red-blood notothenioids? While hearts and oxidative skeletal muscles of icefishes have lower levels of oxidized proteins compared to red-blooded notothenioids, rates of protein synthesis in hearts and the fraction of oxygen consumption devoted to protein synthesis in isolated hepatocytes and cardiomyocytes from *Notothenia coriiceps* (+Hb/+Mb), *Pseudochaenichthys georgianus* (-Hb/+Mb), and *Chaenocephalus aceratus* (-Hb/-Mb) are not significantly different. It is possible that levels of oxidized proteins in red-blooded notothenioids are not high enough to warrant increased rates of protein turnover. Supported by NSF ANT 1043781

LONG-TERM SPONTANEOUSLY CONTRACTING 3D HEART AGGREGATE GENERATED IN VITRO FOR USE IN
PHYSIOLOGICAL RESEARCH

Grunow, B., Mohament, L., Shiels, H.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 14

Contact: Bianka Grunow **E-mail:** bianka.grunow@manchester.ac.uk

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Abstract: We have previously reported the development of a fast and cost-effective heart model system in vitro established from diverse fish species, like e.g. trout, sturgeon, murena, zebrafish and salmon. The generation of up to five spontaneously contracting cell aggregates (SCC) from one fish larva without differentiation medium or electrical stimulation was possible. SCCs could be kept in culture for up to 6 month while retaining their functionality and displaying contraction rates similar to the fish heart. Immunochemical, molecular and electron microscopic analysis exposed fully developed cardiomyocytes with typical sarcomere structures throughout the cells and proteins like α -Actin, Troponin I, myosin and actin and gap junctions proteins (e.g. β -Catenin, N-Cadherin, 1&2-Desmoplakin). Also, the presence of a pacemaker centre could be proved with ICC against anti-HCN4 and anti-Connexin45, showing the SCCs to be an autonomous functional syncytium. Electrophysiological studies on the SCCs revealed the presence and functionality of the L-type calcium channel, ATP-potassium channel and hERG potassium channel. After the addition of common ion channel blockers significant changes were measured in the contraction frequencies and APD90s. Also a high regeneration potential of the SCCs is present as it could be shown in ZF ventricle. SCCs could be divided into two pieces and within two weeks a fully regeneration and stable functionality in both isolated pieces could be observed. In conclusion our analysis supports the development of this model as a high-throughput test system in fish and human cardiac research with the potential to complement and reduce animal testing.

PHOSPHATE BALANCE IN THE CHOROID PLEXUS OF SHARKS *S. ACANTHIAS* AND *M. CANIS*: A ROLE FOR PiT
TRANSPORTERS AND PTHrP IN A CENTRALLY REGULATED RENAL-GASTROINTESTINAL AXIS?

Guerreiro, P.M., Bataille, A.M., Parker, S. and Renfro, J.L.

Symposium: Elasmobranchs **Type:** Oral **Order:** 14

Contact: Pedro M Guerreiro **E-mail:** pmgg@ualg.pt

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Abstract: Inorganic phosphate (Pi) availability in water is scarce and the food is the only available source for fish. Despite its paramount importance, there is little information on overall phosphate endocrine or sensing mechanisms controlling balance via intestinal and renal transporters. This study aimed to characterize the possible role of the choroid plexus (CP) in determining CSF [Pi]. The shark sheet-like IVth CP was mounted in Ussing chambers. Under short-circuited conditions ^{33}Pi fluxes revealed potent active CSF-to-blood transport with biochemical properties consistent with PiT Na⁺-dependent transporters (SLC20 family). RT-PCR revealed PiT1 and PiT2, but no NaPiII (SLC34 family) gene expression in CP. Immunohistochemistry localized PiT2 in the CP apical microvillar membranes while PiT1 occurred primarily in vascular endothelial cells. Active removal of Pi may adjust the CSF buffering capacity by maintaining a high sensitivity to small shifts in CO₂/HCO₃⁻. Studies showed changes in [Pi]CSF may have dramatic effects on renal Pi excretion and Pi appetite in rats. Shark CP expresses both PTHrP and its receptor, endocrine players in Ca/Pi balance. Could choroidal epithelial PiT2 be part of a central Pi-sensing/regulatory pathway?

IT'S GETTING WARM AND WATERY! THE STRESS ENDOCRINE AXIS OF *NOTOTHENIA ROSSII* AND *N. CORIICEPS* IN
RESPONSE TO ENVIRONMENTAL CHALLENGES

Guerreiro, P.M., Becker, A.G., Louro, B., Couto, E., Silva, S. and Canario, A.V.M.

Symposium: Climate Change **Type:** Poster **Order:** P21
Contact: Pedro M Guerreiro **E-mail:** pmgg@ualg.pt

Centre of Marine Sciences, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

Abstract: The stability of the Antarctic Ocean is threatened by recent and predicted effects of climate change, modifying an habitat where fish evolved for about 30 million years. How will the stress endocrine axis of Antarctic fishes cope with such changes? We exposed *Notothenia coriiceps* and *N. rossii* to changes in water temperature or/and salinity to evaluate the response of several physiological processes, including the stress axis. Fish were transferred to experimental tanks and acclimated from natural temperatures (0-2°C) to 4-8°C and from 32‰ to 20-10‰. The roles of the stress endocrine axis in changing conditions were tested using GR/MR blockers (mifepristone, spironolactone) and agonists (dexamethasone, cortisol), and inhibiting cortisol release (using metyrapone). No significant mortality or changes in behaviour between were observed. Initial data shows cortisol and expression of metabolic-related genes were upregulated and modulated by manipulation of GR/MR. Fish in altered conditions were less responsive to handling than those in natural temperature and salinity. These results suggest that Antarctic fish are reactive to environmental change, but that their ability to accommodate rapid or adaptive responses may be compromised.

RENAL FUNCTION IN THE ANTARCTIC NOTOTHENIA ROSSII EXPOSED TO DILUTED SEAWATER AND ELEVATED TEMPERATURE

Guerreiro, P.M., Louro, B., Cruz, B., Wilson, J.M. and Canario, A.V.M.

Symposium: Fish Kidney **Type:** Poster **Order:** P99

Contact: Pedro M Guerreiro **E-mail:** pmgg@ualg.pt

Centre of Marine Sciences, Universidade do Algarve, 8005-139 Faro Portugal

Abstract: Antarctic fishes evolved in a stable environment for roughly 30 million years, currently displaying a number of peculiar structural features, including aglomerular kidneys, suggested as an adaptation to prevent the loss of water and anti-freeze proteins. Recent climate changes and forecast models indicate the temperature increase in coastal areas of maritime Antarctica may lead to melting and freshening of shallow enclosed waters. We exposed *Notothenia rossii* to rapid but gradual changes from 0-2°C to 4-8°C and from 32‰ to 20-10‰, over a period of up to 10 days. Plasma and urine electrolytes and renal and branchial Na⁺/K⁺-ATPase were determined, and tissues were collected for immunohistochemistry and gene expression. The rise in temperature induced a dependent decrease in plasma osmolality and Na⁺/K⁺-ATPase activity, while low salinity reduced both plasma and urine osmolality, with fish showing a marked increase in urine production. Results indicate these fish possess important mechanisms for water elimination despite their aglomerular kidneys.

THE ROLE OF ENDOTHELIN-1 IN ACUTE REGULATION OF H⁺ SECRETION UPON ACID CHALLENGE IN ZEBRAFISH

Guh, Y.J., Wang, J.H., Lin, L.Y., and Hwang, P.P.

Symposium: Cellular Signalling **Type:** Oral **Order:** 15

Contact: Ying-Jey Guh **E-mail:** yingjeyguh@gmail.com

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Abstract: Endothelin-1 (EDN1) is a regulator for the transepithelial H⁺ secretion in mammals; however, its role in fish is unclear. Using loss- and gain-of-function approaches, our previous study in zebrafish demonstrated EDN1 controls the H⁺-ATPase-dependent acid secretion in the H⁺-ATPase-rich ionocytes probably through post-translational regulation, implying the role of EDN1 signaling in the acute regulation of body fluid acid-base balance. To support this hypothesis, we further examined the changes in the acid secretion function and the related genes expression in zebrafish during acute transfer to pH-4 freshwater. H⁺ secretion in the embryonic skin was stimulated

at 6 h after the transfer, but no concomitant changes were observed in the expression of H⁺-ATPase and other acid-regulatory transporters. EDN1 expression, preceding the stimulation of H⁺ secretion, was increased at 4 h after the treatment. Taken together, EDN1 signaling may control fish acid-base regulation mechanism to cope with acute pH changes in environment.

PHYSIOLOGICAL RESPONSE AND STRESS-RELATED GENE EXPRESSION FROM RED DRUM REARED IN FRESHWATER CONDITIONS

Gullian, M., and Zapata, O.

Symposium: Fish Habitats **Type:** Oral **Order:** 10

Contact: Mariel Gullian **E-mail:** mgullian@marista.edu.mx

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Abstract: The effect of long-term freshwater acclimation on the blood and plasma ion composition of Red Drum *Sciaenops ocellatus* was investigated with the goal of elucidating the necessity of ion remediation. Four replicates (n = 50) of freshwater-acclimated (FW) fish (1.6 ± 0.2 g) were raised in 25-m³ tanks supported by 140,000 L of recirculating water. Four replicates (n = 50) of seawater (SW) fish groups were placed in 40-m³ offshore cages at 32–35 psu. Blood was collected from 100 fish (FW = 578 ± 50 g; SW = 686 ± 45 g) of each group (FW, SW) after 8 months of rearing. During the grow-out phase, the survival of FW and SW fish was 57.5% and 92.2%, respectively. The water ion composition (mainly the Ca²⁺/K⁺ [43%] and Ca²⁺/Mg²⁺ ratios [1%]) explained 56.6% of the plasmatic ion variability in the fish groups. Freshwater exposure produced significant reductions in osmolality and in several plasma indicators (Na⁺, Cl⁻, and Mg²⁺); the K⁺ levels from FW fish were the most compromised parameter. The water Ca²⁺/Na⁺ ratio had a greater influence (44%) on the plasma chemistry parameters, mainly glucose and creatinine. Freshwater-acclimated fish had a higher percentage of hematocrit, hemoglobin, and red blood cells than SW fish, but the water quality explained only 12.5% of the blood parameter variability between the FW and SW groups. The results support the conclusion that Red Drum tolerates salinity variations and can adopt a relatively stable condition for short periods; however, the data suggest that Red Drum have only a limited ability to withstand a hyposmotic environment for long periods due to their limited ability in maintaining K⁺ concentrations without external supplementation. Freshwater environments with high Ca²⁺/Na⁺, Ca²⁺/K⁺, and Ca²⁺/Mg²⁺ ratios appear to be a chronic stress factor that should be considered in future experiments.

DOES STRESS DURING EMBRYOGENESIS AFFECT THE DEVELOPMENT AND INTEGRITY OF THE HPI- AND SOMATOTROPIC AXES IN ATLANTIC SALMON?

Gustavsen, L.A.S., Johnsen, H.K., Tveiten, H., Johnsen, H. and Jørgensen, E.H.

Symposium: Stress in Fish **Type:** Poster **Order:** P123

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Abstract: The development of functional endocrine axes occurs during embryogenesis and this development may be perturbed by environmental influences (i.e. stressors) via epigenetic programming (EP). In Norwegian farming salmon eggs are exposed to a “shocking” procedure at the eyed egg stage, to get rid of weak embryos, but nothing is known about possible consequences of this praxis for fish robustness later in life. In the present study groups of salmon eggs and fry were exposed to a various number of cold shocks (0oC) and air exposures during the period from eyed egg stage to start feeding. In comparison with untreated embryos/fry the stress treatment downregulated the expression of all analyzed gens within the HPI-axis in start-feeding fry (880 Do post-fertilization). To reveal possible permanent EP effects we have investigated their smolt development and –quality, including the integrity of their HPI- and somatotropic axes. Results will be presented at the meeting.

WITHIN-POPULATION VARIATION IN ACTIVITY RATES AND HABITAT SELECTION OF A COLD-WATER STENOTHERM:
BIOENERGETIC IMPLICATIONS

Guzzo, M.M., Cott, P.A., Chapelsky, A.J., Callaghan, D.T., Blanchfield, P.J.

Symposium: Fish Habitats **Type:** Poster **Order:** P107
Contact: Matthew Guzzo **E-mail:** guzzom@myumanitoba.ca
Biological Sciences, University of Manitoba Canada

Abstract: Within-population variations in fish behaviour have been well described in the ecological literature. Much of this research has focused on the shy-bold continuum and its effects on growth and survival. One phenotypic trait often used to evaluate boldness is activity level. Difference in activity level can vary significantly within single populations and can have major implications on growth rate divergence among individuals, driven by differences in food acquisition and metabolic costs. We use a high-resolution telemetry positioning system and depth and activity sensing transmitters to examine variation in activity levels of lake trout (*Salvelinus namaycush*) in a sub-Arctic lake. Our study lake contains pelagic and littoral prey-fish, freshwater shrimp, and a simple benthic invertebrate community, providing a range of prey choices for lake trout. We present observed individual variation in activity and relate these differences to depth, and spatial habitat occupancy. Finally, we present theoretical bioenergetic implications of the different behavioural patterns.

DO DISPARITIES IN INDIVIDUAL THERMAL HABITAT USE EXPLAIN WITHIN-POPULATION VARIATIONS IN GROWTH
RATES OF A COLD-WATER FISH?

Guzzo, M.M., Rennie, M.D., Blanchfield, P.J.

Symposium: Environmental Change **Type:** Oral **Order:** 14
Contact: Matthew Guzzo **E-mail:** guzzom@myumanitoba.ca
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Abstract: The growth of fishes depends on their ability to overcome metabolic costs through energy acquisition. Intra-population variability in growth and behaviour are well documented; however, few studies have linked empirical data on individual fish growth and behaviour over multiple years. Understanding the interplay between individual behaviour and growth will help elucidate mechanisms leading to life-history divergences observed within populations and enhance our ability to predict how fish populations will adapt to stressors. Lake trout (*Salvelinus namaycush*) are a model species to examine behavioural divergence, as they require cold, well-oxygenated habitat. In small lakes that contain only nearshore prey-fish, thermal stratification forces trout into colder, deeper water, away from most profitable prey. Employing 13 years of telemetry data from a small lake, we found consistent individual variation in thermal occupancy and activity by telemetry-tagged trout. Using annual mark-recapture data, we quantify growth of tagged trout to evaluate how individual behaviour patterns influence growth.

REGULATION OF PITUITARY GROWTH HORMONE PRODUCTION BY GONADOTROPIN-INHIBITORY HORMONE IN
GOLDFISH

Habibi, H.R., Moussavi, M., Wlasichuk, M., Chang, J.P., .

Symposium: Growth and Metabolism **Type:** Oral **Order:** 4
Contact: Hamid R. Habibi **E-mail:** habibi@ucalgary.ca
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Abstract: Gonadotropin-inhibitory hormone (GnIH) is known for its partial control of reproductive axis in fish and other vertebrates. In comparison, the role of GnIH in the control of pituitary growth hormone (GH) production is

less well characterized. In this study, we investigated the effects of goldfish GnIH (gGnIH) on basal and GnRH-induced GH secretion and mRNA expression in goldfish. Results indicate that 1) responses to the two native forms of GnRH in goldfish (sGnRH and cGnRH-II) and their interactions with gGnIH are different; and 2) gGnIH exerts its action directly at the level of pituitary, and by influencing other neuroendocrine factors involved in GH regulation. These findings provide novel information on the complex stimulatory and inhibitory effects of gGnIH on basal and GnRH-stimulated GH production, and a framework for better understanding the role of gGnIH in integrated control of growth and reproduction in goldfish and other vertebrates. Funded by NSERC.

CO₂-INDUCED OCEAN ACIDIFICATION CAN INCREASE ANXIETY IN COASTAL CALIFORNIAN ROCKFISH
Hamilton, T., Holcombe, A., and Tresguerres, M

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 31

Contact: Trevor Hamilton **E-mail:** HamiltonT9@macewan.ca

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Abstract: In the next century the level of atmospheric carbon dioxide (CO₂) is projected to drastically increase, which may have a great impact on marine life. Previous research indicates that CO₂-induced ocean acidification (OA) alters the olfactory ability in fish by altering the reversal potential of GABAA receptors. Since the GABAA receptor plays a major role in anxiety in most animals we examined the potential effect of CO₂-induced OA (~1125 µatm) on anxiety in juvenile Californian rockfish (*Sebastes diploproa*) using two behavioural tests and pharmacological manipulation of GABA_A receptors. Rockfish exposed to OA exhibited higher levels of anxiety in the light/dark test compared to controls (~483 µatm CO₂), and the administration of gabazine, a GABAA_A antagonist eliminated this difference. Additionally, the administration of a GABAA_A agonist, muscimol, had opposing effects in the OA-exposed fish compared to the control fish, providing further evidence for an altered Cl⁻ flux through GABAA receptors.

THE MIGRATION BEHAVIOUR OF EUROPEAN SILVER EELS RELEASED IN OPEN OCEAN CONDITIONS
Hanel, R., Westerberg, H., Aarestrup, K., Wysujack, K.

Symposium: FITFISH **Type:** Oral **Order:** 4

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Abstract: Despite some recent progress, there are still large knowledge gaps concerning the long-distance oceanic migration of European eel *Anguilla anguilla*. To achieve a better understanding of migration routes and behaviour, 28 large female eels equipped with pop-up satellite transmitters were released at three different locations in the eastern Atlantic Ocean and the Sargasso Sea. Eels released in the Sargasso Sea used greater depths and a broader temperature range than individuals released closer to the European continent. At least 2 eels were clearly preyed upon. The transmitters ascended in a considerable range of directions from the release points. While the results of this study did not allow conclusions about the exact location of European eel spawning sites, they increased our understanding of behavioural characteristics of this enigmatic species.

MERCURY CONCENTRATIONS AND TRENDS IN AFRICAN INLAND WATERS
Hanna, D.E.L., Solomon, C.T., Poste, A.E. and Chapman, L.J.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 17

Contact: Dalal Hanna **E-mail:** dalal.e.hanna@gmail.com

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Abstract: Mercury (Hg), a potent neurotoxin, is a contaminant of great concern for the African fisheries sector because of its potential negative effects on fish stocks and marketability, as well human health. We compiled published data on Hg contamination in African freshwater organisms to describe broad patterns and to identify data gaps. We retrieved 30 studies evaluating Hg concentrations across 65 different locations. Across all locations, the mean total Hg concentration was 140.731 ng/g, falling below the WHO/FAO's recommended guideline of 500 ng/g for fish. Nonetheless, it is impossible to rule out the potential negative effects of Hg contamination in Africa, as there are several hundred waterbodies for which data were not available, and the impacts of chronic exposure to low levels of Hg are still not fully understood. Using mixed models, we also found that trends of biomagnification and bioaccumulation of Hg are important throughout African freshwater organisms.

THE EFFECTS OF ACUTE ANOXIA ON THE SODIUM CURRENT OF ISOLATED VENTRICULAR MYOCYTES OF THE RAINBOW TROUT.

Hardy, M.E.L., Galli, G.L.J., Shiels, H.A.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 7

Contact: Matt Hardy **E-mail:** matthew.hardy@manchester.ac.uk

Faculty of Life Sciences, University of Manchester, 2.30 Core Technology Facility, 46 Grafton Street, Manchester. M13 9NT. UK

Abstract: The rainbow trout (*Oncorhynchus mykiss*) is known to have disrupted cardiac function in response to anoxia, but the cellular mechanisms underlying this damage are not known. In the present study, we have examined the effects of acute anoxia on the cardiac sodium current of isolated ventricular trout myocytes. Sodium currents were measured using the whole cell patch clamp configuration during perfusion with a low sodium-based Tyrode's solution. Normoxia was mimicked by bubbling the perfusate with 100% oxygen; anoxia was mimicked by using 2 mM sodium cyanide to inhibit Complex IV of the mitochondrial electron transport chain and bubbling the perfusate with 100% nitrogen. Results showed that anoxia increased the peak amplitude of the cardiac sodium current. Further study is required to fully evaluate the effects of anoxia on other cardiac ionic currents to understand the consequences of oxygen deprivation on the electrical activity of the heart in this species.

CONSISTENT INDIVIDUAL DIFFERENCES IN BURBOT HOME RANGE, DISPERSAL, MOVEMENT AND SITE FIDELITY: EVIDENCE FOR PERSONALITY-DEPENDENT SPATIAL ECOLOGY

Harrison, P.M., Gutowsky, L.F.G., Martins, E.G., Patterson, D.A., Cooke, S.J. and Power, M.

Symposium: Burbot **Type:** Oral **Order:** 2

Contact: Philip M Harrison **E-mail:** pharriso@uwaterloo.ca

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Abstract: Heterogeneity in burbot spatial ecology is common. However, to date, no authors have investigated whether these between-individual differences in behaviour are consistent across time and between contexts and thus represent personality-dependent behaviours. In this study, we explore between-individual differences in home range, vertical activity, movement, dispersal, and site fidelity of 44 burbot *Lota lota* over 2 years, using a telemetry, in a reservoir in British Columbia, Canada. We test whether burbot spatial behaviours meet personality-dependent criteria of repeatability and cross contextual consistency, and test for correlations between traits indicative of a behavioural syndrome. Our results document consistent personality-dependent spatial ecology with individuals ranging from 'resident' with small home ranges, high site fidelity and minimal movement, to 'mobile' with large home ranges, little site fidelity and high movement rates. Our findings will likely have implications for the selection of individuals for burbot reintroduction programs and the design of protected areas. Furthermore conservation of the

type of space-use diversity we observed, will likely be important for the future resilience of burbot populations to environmental change.

EVOLUTION AND FUNCTION OF THE ELASMOBRANCH VISUAL SYSTEM

Hart, N.S., Hunt, D.M., Collin S.P.

Symposium: Elasmobranchs **Type:** Oral **Order:** 2

Contact: Nathan Hart **E-mail:** nathan.hart@uwa.edu.au

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Abstract: Traditionally, the elasmobranch visual system was considered to be poorly developed relative to other aquatic animals and have a lesser role in driving behaviours than other senses such as olfaction. However, recent studies have shown that the elasmobranch visual system is far more complex and diverse than anticipated. Notable findings include the discovery that many species of ray have well developed colour vision, while sharks are completely colour blind, and that the relative sizes of both the eyes and the visual centres of the brain vary according to habitat and behaviour. Here, we present our most recent findings on the function and evolution of the elasmobranch visual system and show how this fundamental knowledge is helping to further our understanding of elasmobranch behavioural ecology as well as develop novel ways to avoid shark-human conflict.

DYNAMIC CHANGES IN SCOPE FOR HEART RATE AND CARDIAC AUTONOMIC TONES DURING THERMAL ACCLIMATION IN TROUT

Hellgren, K. Ekström, A. Gräns, A. Sandblom, E.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P77

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Abstract: Fish, like all ectotherms, respond to acute warming by increased heart rate that may result in a decreased scope for heart rate (the difference between resting and maximal values). If given time to acclimate these acute effects are usually buffered by processes that reduce resting heart rate and restore the scope for heart rate. However, the time course and interaction of the underlying mechanisms for this are poorly understood. To determine resting heart rate, scope for heart rate and cardiac autonomic tones, groups of trout (*Oncorhynchus mykiss*) were instrumented with ECG electrodes and an abdominal catheter for drug administration. The acclimation process was followed from an initial acclimation temperature of 9°C, through an acute transfer to 16°C, and recurrently for another 38 days. The interaction between changes in extrinsic cardiac autonomic tones and intrinsic pacemaker rate to reset cardiac scope during thermal acclimation in fish will be presented and discussed.

PHYSIOLOGICAL AND BEHAVIOURAL ASSESSMENT PROVIDES INSIGHT INTO THE RESPONSE AND LIKELY SURVIVAL OF PAGRUS AURATUS TO HYPOXIA

Herbert, N.A., Cook, D.G., Iftikar, F.I., Baker, D.W. and Hickey, A.J.R.

Symposium: Environmental Change **Type:** Oral **Order:** 6

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Abstract: One of New Zealand's most important stock of seabream, *Pagrus auratus* (Sparidae), is potentially under threat from hypoxia as a result of urban and land use change in and around the Auckland area. The response and likely survival of this species was therefore addressed through a range of physiological and behavioural assessments. At 18°C *P. auratus* avoids low PO₂ (2.9 kPa) just below their critical oxygen tension limit (P_{crit} = 5.3 kPa) indicating that avoidance is triggered when aerobic scope (AS) is zero and anaerobic metabolism is unavoidable. This was confirmed in two ways: 1) the physiology and avoidance behaviour of fish made anaemic by phenylhydrazine treatment was adjusted more readily at higher PO₂ (i.e. they were more sensitive to hypoxia) but these fish avoided low PO₂ in the same way as normocytic fish when their P_{crit} threshold was surpassed. 2) High levels of plasma lactate were observed in both anaemic and normocytic fish at the point of avoidance. Exposing *P. auratus* to a 6 week period of moderate hypoxia (10.2-12.1 kPa PO₂) did not adjust P_{crit} or AS but hypoxia-acclimated fish showed increased tolerance to hypoxia by behaviourally avoiding lower PO₂ levels (3.3 vs. 5.3 kPa) without greater perturbations to lactate or glucose. This behavioural change was associated with improved O₂ uptake efficiency by heart mitochondria but an unexpected decrease in blood O₂ carrying capacity and an increase in whole-blood P₅₀ was observed. These changes potentially suggest a prioritization of O₂ delivery and O₂ utilisation over O₂ uptake during long-term hypoxia and appears to convey a slight survival benefit. Overall, however, *P. auratus* may not fare well under hypoxic conditions because it is not especially hypoxia tolerant and it only attempts to avoid hypoxia when its critical O₂ limit has been surpassed.

INFLUENCE OF HYPERCAPNIA ON INTESTINAL TRANSPORT AND CALCIUM CARBONATE FORMATION IN THE GULF TOADFISH

Heuer, R.M., Munley, K.M., Narsinghani, N., and Grosell, M.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 25

Contact: Rachael Heuer **E-mail:** rheuer@rsmas.miami.edu

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Abstract: Gulf toadfish were exposed to CO₂ levels ranging from 0.25 to 2% to examine changes in intestinal transport and intestinal carbonate precipitate formation rate and cation composition. As expected, HCO₃⁻ in plasma increased with CO₂, and at the highest level (2%), a ~5 fold increase in plasma HCO₃⁻ (mM) translated to a greater than 2 fold increase in rectal fluid [HCO₃⁻] and a similar decrease in rectal [Cl⁻], suggesting intestinal anion exchange is impacted by hypercapnia. Consistent with this observation is increased CaCO₃ production at high CO₂ levels. Reduced Mg²⁺ (mM) in rectal fluid with increasing CO₂ suggested a change in carbonate composition, an observation that was supported by increased Mg mol% from carbonates imaged using SEM and analyzed by EDS (energy-dispersive x-ray spectroscopy). CO₂ impacts on other ions, drinking rate, carbonate residence time, and dissolution will also be presented. Understanding impacts of hypercapnia on intestinal function will strengthen predictions of CaCO₃ fate upon release.

PASSIVE MONITORING OF ROUND GOBY ACOUSTIC ECOLOGY AND THE INFLUENCE OF ANTHROPOGENIC NOISE

Higgs, D.M. and Humphrey, S.R.

Symposium: Sensing the Environment **Type:** Oral **Order:** 12

Contact: Dennis Higgs **E-mail:** dhiggs@uwindsor.ca

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Abstract: To assess the interaction between noise and acoustic ecology, we deployed multiple datalogger hydrophones to fully characterize the acoustic behaviour of round goby (*Neogobius melanostomus*), a locally invasive species. We also correlated goby calling rates with anthropogenic noise levels as a direct test of the hypothesized role of noise on natural acoustic behaviour of fish. Round goby showed a clear diel patterning of calling behaviour, with the highest activity during nighttime hours and ceasing at midday; supporting the importance

of acoustic, versus visual, signalling for mate attraction and also allowing us to pinpoint spawning areas for possible remediation. We are currently examining the relation between noise level and calling rate to directly test the role of anthropogenic noise on calling patterns and to ascertain the relative roles of different noise types. This approach will allow a direct test of the importance of noise and the plasticity of fish acoustics to deal with differing background levels.

TEN YEARS OF LAB AND TELEMTRY STUDIES ON CANADA'S LARGEST SALMON RIVER FINDS EXCEPTIONALLY HIGH MORTALITY OF MIGRATING FEMALE SOCKEYE: ARE THEY RUNNING OUT OF GAS, STRESSED, SICK, OR DO THEY DIE OF BROKEN HEARTS?

Hinch, S.G., Eliason, E.J., Farrell, A.P., Cooke, S. J., and Patterson, D.A.

Symposium: Fish Migration **Type:** Oral **Order:** 2

Contact: Scott Hinch **E-mail:** scott.hinch@ubc.ca

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Abstract: I review key findings from our past 10 years of research involving the study of behaviour, physiology and survival of up-river migrating adult sockeye salmon. Using physiological and conventional telemetry and experiments in laboratory flumes and tanks, we discovered that when faced with challenging conditions (e.g. high or turbulent flows, high temperatures, confinement) towards the end of their migratory period females suffer 2-5X higher mortality than males. The causes of this phenomenon could be multiplicative as females must allocate large energy levels to gonads and do not eat so could exhaust reserves, they maintain high levels of circulating plasma cortisol which enhances physiological stress responses including making them more immunocompromised and less resistant to pathogens, and they have relatively poorer cardiac performance under fast swimming speeds. Any of these issues could accelerate natural mortality rates when migratory conditions become arduous. I review the evidence for these causes and discuss the broader implications of this phenomenon.

IMMUNOLOCALIZATION OF RHC1, RHC2, RHBG AND NHE3B IN THE GILL IONOCYTES OF RAINBOW TROUT

Hiroi, J.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 14

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Abstract: Branchial ionocytes of rainbow trout are classifiable into NHE3b positive and negative ionocytes, which are comparable to PNA positive and negative ionocytes, respectively. In this study, localization patterns of three Rh glycoproteins, Rhcg1, Rhcg2 and RhbG were examined with homologous antibodies raised against each of the three Rh proteins. Rhcg1 immunoreactivity was restricted to the apical membrane of NHE3b positive ionocytes: the immunoreactivity of Rhcg1 and NHE3b was completely colocalized. Rhcg2 was found at the apical membrane of respiratory pavement cells, and Rhcg2 and Rhcg1 were never colocalized in the same cells. RhbG was detectable at the basolateral membrane of pavement cells and NHE3b positive ionocytes. These localization patterns were conserved among freshwater, seawater, deionized water and acidic water groups.

EFFECT OF ACIDIC ENVIRONMENT ON MECHANOTRANSDUCER CHANNEL-MEDIATED CA²⁺ ENTRY IN ZEBRAFISH NEUROMAST HAIR CELLS

Hornig, J.L., and Lin, L.Y.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P84
Contact: J. L. Horng **E-mail:** jlhorng@tmu.edu.tw
department of anatomy, Taipei medical university, Taipei Taiwan

Abstract: Zebrafish lateral-line hair cells are an *in vivo* model for studying hair cell development, function, and ototoxicity. In this study, a noninvasive electrophysiological method, the scanning ion-electrode technique (SIET), was applied to detect function of MET channels in intact zebrafish embryos. Using a Ca²⁺-selective microelectrode to deflect hair bundles and simultaneously record the Ca²⁺ flux, the inward Ca²⁺ flux was detected at stereocilia of hair cells in 2~4-days post-fertilization embryos. Ca²⁺ influx was blocked by MET channel blockers (BAPTA, La³⁺, Gd³⁺, and curare). Furthermore, pH5 water acclimation for 48-96 hpf reduced function of MET channel but not hair cell development suggesting that MET channel is sensitive to acidic pH. Prolonged pH5 water acclimation for 0-96 hpf reduced function of MET channel and hair cell development. This study demonstrated MET channel-mediated Ca²⁺ entry at hair cells by SIET and damage of acidic environment on hair cell function and development.

APPETITE-REGULATING HORMONES IN THE YELLOWTAIL: cDNA CLONING AND RESPONSE TO NUTRITIONAL CONDITIONS

Hosomi, N., Takahashi, N., Masumoto, Y., Fukada, H.

Symposium: Fish Culture **Type:** Poster **Order:** P9
Contact: Haruhisa Fukada **E-mail:** b13m6f49@s.kochi-u.ac.jp
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Abstract: The yellowtail, *Seriola quinqueradiata*, is one of the most commonly used fish in aquaculture in Japan. However, little is known about the appetite hormones of the yellowtail. Therefore, we cloned the following 3 appetite hormones: neuropeptide Y (Npy), melanin-concentrating hormone (Mch), and cholecystokinin (Cck). We observed that only npy mRNA expression in the hypothalamus responded to fasting in a 2-week fasting experiment. mch mRNA expression in the hypothalamus was relatively higher in fasted fish than in control fish, and cck mRNA expression in all the tested brain regions did not change with fasting. In a 1-day fasting experiment, mRNA expressions of the 3 hormones in the hypothalamus were similar to those observed in the 2-week experiment. The mRNA expressions of appetite hormones in the hypothalamus may reflect the appetite of yellowtail. We are currently performing further studies on the responses of the appetite hormones to nutrients.

FUNCTIONAL REGULATION AND HORMONAL CONTROL OF CALCIUM UPTAKE IN ZEBRAFISH

Hwang, P. P., Lin, C. H., Lafont A. G., and Tseng D. Y.

Symposium: Cellular Signalling **Type:** Oral **Order:** 17
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Abstract: Fish have to maintain their body fluid calcium homeostasis for normal cell activities to cope with calcium-fluctuating aquatic environment. Many hormones were proposed to control the calcium homeostasis; however, detailed molecular pathways were largely unclear. Recent studies on zebrafish provided some advances in this issue. Specific group of ionocytes expressing apical ECaC and basolateral PMCA2/NCX1b carry out the major function of calcium uptake, and the expression of only ECaC, ionocyte number and thus the calcium uptake are enhanced in response to a low- calcium environment. Hypercalcemic hormones of cortisol (glucocorticoid receptor), vitamin D (the receptor VDRa) and parathyroid (PTH-1) and the hypocalcemic calcitonin (the receptor CTR) and stanniocalcin (STC-1) respectively enhance and suppress calcium uptake function by differentially regulating ECaC expression. Systematically, calcium sensing receptor has time-dependent effects on the expressions of STC- and PTH-1, thereby providing a possible STC-1/PTH-1 counterbalancing mechanism toward body fluid calcium homeostasis.

MOLECULAR-HISTOCHEMICAL INVESTIGATION OF CARTILAGINOUS FISH KIDNEY

Hyodo, S., Hasegawa, K., Takagi, W., and Kakumura, K.

Symposium: Fish Kidney **Type:** Oral **Order:** 4

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Abstract: For adaptation to high-salinity marine environments, cartilaginous fishes (sharks, skates, rays and chimaeras) adopt a unique urea-based osmoregulation strategy. Their kidneys reabsorb nearly all filtered urea from the primary urine, and this is an essential component of urea retention in their body fluid. The cartilaginous fish kidney is composed of the extraordinarily elaborate nephron system, e.g., the four-loop configuration of each nephron, and the sac-like peritubular sheath in the bundle zone. These anatomical characteristics have been considered to be important for urea reabsorption, however a mechanism for urea reabsorption is still largely unknown. To address this problem, we focused on elephant fish (*Callorhynchus milii*) for which a genome database is available, and conducted molecular mapping of membrane transporters along the different segments of the nephron. A possible model for urea reabsorption is discussed based on the anatomical features of nephron segments, and on the results of molecular mapping.

LOCOMOTION IS REGULATED BY EXTERNAL TIDAL CHANGES IN THE BARRED MUDSKIPPER

Ikegami T., Oyama Y., Takemura A.

Symposium: Environmental Change **Type:** Oral **Order:** 10

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Abstract: The barred mudskipper, *Periophthalmus argentilineatus*, is an intertidal amphibian fish in tropical and subtropical regions. This species is active on the surface of mudflats during low tides. Rising tides allow it to migrate from the mudflat to the land, and is inactive during high tides. This study was aimed to investigate the eco-physiological mechanism of locomotion in this species. Locomotion was monitored under conditions of light and darkness (LD12:12), constant darkness (DD), reversed LD (DL12:12), and constant light (LL). There was arrhythmicity in locomotion under any conditions. When melatonin release from the cultured pineal organ was examined under LD, DD, and LL, day-low and night-high variation was observed under LD, but not under DD and LL. In addition, melatonin injection failed to alter locomotion. In contrast, when locomotion was monitored under artificial tidal changes, it showed tidal-synchronized rhythms. It is suggested that the locomotion of this species is tidally controlled.

INVESTIGATION OF INSHORE HAGFISH ADAPTIVE IMMUNE RESPONSE FOCUSED ON IMMUNE RELATED GENE AND VARIABLE LYMPHOCYTE RECEPTORS (VLRS)

Im, S.P., J.S. Lee, S.W. Kim, Y.L. Kim, Y.G. Kim, H.B. Jang, S.W. Nho, I.S. Cha, S.B. Park, J.E. Yu, J.M. Lazarte, T.Q. Nhu and T.S. Jung

Symposium: Hagfishes **Type:** Poster **Order:** P18

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Abstract: Inshore hagfish (*Eptatretus burger*), a jawless fish, is known to have variable lymphocyte receptors (VLRs) namely VLR-A, -B and -C. Among these receptors, VLR-B shares common characteristics with mammalian B cell receptors specifically called, immunoglobulin. In the mammalian system, immune stimulation triggers changes from B cell to plasma cell which, in effect, will induce the secretion of immunoglobulins. In lymphoblast formation, several genes are known to regulate its transformation, proliferation and differentiation into plasmacytes. Some of these regulator genes are Ikaros, CD45 and Spi. Here we checked on the expression of the regulator genes (Ikaros, CD45 and Spi) in both short and long term periods. We also examined the gene expression levels of VLR-A, -B and -C and evaluated the VLR-B expression level through ELISA. Results showed that the gene expression level of Ikaros was up-regulated in short term period but was down-regulated in the long term period. In the case of CD45, there was no significant difference that was observed in the short term period; however, an up-regulation of the gene was observed in the long term period. In the case of Spi, there was no significant difference was observed in both short and long term periods. Checking the gene expression level of the three VLRs, the three genes showed up-regulation patterns in short term period. VLR-A and VLR-C showed similar gene expression level at day 0 in long term period, while only VLR-B showed a consistent up-regulation pattern in the long term period. Hence, these data implicate that VLR-A and VLR-C, which are T-lymphocyte-like cells in mammals, are involved in the initial stage of the immune response of the fish. On the other hand, VLR-B, which is known as a B-lymphocyte-like cell in mammals, is involved in the latter stage of immune response and has a high similarity with the adaptive immune response observed in the mammalian immune system.

COMPARISON OF SEASONAL PROFILES OF GILL Na^+ , K^+ -ATPASE BETWEEN MASU SALMON IN SOUTHERN AND NORTHERN JAPAN

Inatani, Y., Nakajima, T., Ineno, T., Shimura, H., Uchida, K., and Shimizu, M.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P85

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Abstract: Masu salmon in Hokkaido (north Japan) are anadromous migrating to the ocean in their second spring. They acquire seawater adaptability during smoltification in freshwater by activating gill Na^+ , K^+ -ATPase (NKA). On the other hand, masu salmon in Miyazaki (south Japan) are believed to be non-anadromous due to high seawater temperatures in that area. We compared profiles of gill NKA activity and NKA α subunit mRNA levels during smoltification period of masu salmon in both regions. The northern population showed peaks of gill NKA activity and mRNA levels of $\alpha 1b$, a seawater-type isoform, from March to May. In contrast, no such increases were observed in the southern population. These results suggest that the southern population of masu salmon may not develop seawater adaptability in spring. However, the possibility that relatively high rearing water temperature (17°C) prevented fish from increasing gill NKA activity needs to be considered.

MATURATION IN COD AND OTOLITH ZONE FORMATION

Irgens, C., Folkvord, A., and Kjesbu, O.S.

Symposium: General Contributed Papers **Type:** Poster **Order:** P57

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Abstract: Knowledge of growth, age and size at the onset of maturation is important for fish stock assessment. So-called spawning checks or “spawning zones” in cod otoliths, first described by Rollefson (1933), have subsequently been used to determine age at maturation and to construct maturity ogives for individual cohorts of Northeast Arctic cod (NEAC). Spawning checks in otoliths may be especially useful in studies of change in age-at-maturation in relation to climate change and exploitation due to the access to large historical otolith archives (e.g. at the Institute

of Marine Research, Norway). However, spawning checks in gadoid otoliths have not yet rigorously been validated, and it also remains to be documented the exact timing of spawning check formation relative to the actual time of spawning. This poster will present the results from an experimental pilot study of multiple marked NEAC to validate potential spawning checks in relation to the actual observed spawning behaviour. A more exact timing of spawning related otolith growth could be determined since the otoliths were stained prior and post spawning.

THE SMELL OF DEATH: OLFATORY CONDITIONING OF COMMON CARPS FOR CADAVER DETECTION

Jamandre, B.W., Ferrari, F., and Poncin, P.

Symposium: Sensing the Environment **Type:** Oral **Order:** 6

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Abstract: Whether due to crime, accident and/or natural disaster, the recovery of deceased victims is without doubt very important. However, it is not uncommon of the difficulties of locating the remains of the victim most especially in aquatic or submerged environments. For this reason, we conducted an original research that aims to design and evaluate an olfactory conditioning and testing protocol that allows monitoring of behavioral and physiological responses in common carps for detecting cadavers. The primary step to achieve this is to understand the basic mechanisms of olfactory learning in carps to tap them as biosensors in forensic sciences. Carps were conditioned using a positive reinforcement conditioning paradigm in an olfactometer apparatus, associating cadaver scent (for ethical reasons, porcine carcass were used) (conditioned stimulus – CS) with worms and food (unconditioned stimuli – US). Initial conditionings lasted for 7 days comprising of two conditioning trials per day. After which, the carps were presented the CS without the reinforcements to test whether they can trace the cadaver scent. Results show that for only as few as 14 conditioning trials, majority of carps were able to trace the correct chamber where the CS was placed. In comparison, non-conditioned carps ignored the CS and showed repulsive behaviors and reactions. This preliminary study reveals that *C. carpio* are capable to acquire and learn the skill of tracing cadaver scent quickly by classical conditioning method.

MECHANISMS OF DEVELOPMENTAL TOXICITY IN ZEBRAFISH EXPOSED TO SELENIUM

Janz, D.M., and Thomas, J.K.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 19

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Abstract: The essential trace element selenium (Se) is extremely toxic to oviparous fish species at exposures only slightly above essentiality, causing a range of early life stage toxicities. Biotransformation of selenomethionine (SeMet) incorporated into egg yolk proteins during oogenesis has been hypothesized to result in oxidative stress during early larval development, and thus may be linked mechanistically to larval deformities. To further investigate this hypothesis, zebrafish embryos were exposed to SeMet via in ovo maternal transfer or yolk microinjection. Dose-dependent increases in embryo mortality and deformities were observed during yolk resorption (i.e., between 4-6 days post-fertilization [dpf]) using both exposure routes. Significant up-regulation of nuclear factor erythroid 2-related factor 2 (nrf2a and nrf2b) and Pi class glutathione S-transferase (gstp1 and gstp2) mRNA levels were observed in 2-4 dpf embryos, indicating induction of genes related to increased pro-oxidants. Significant down-regulation of methionine adenosyltransferase 1A (mat1a) mRNA levels was also observed at 3 dpf, suggesting alteration of methylation-related processes. These and other results provide mechanistic insight into the complexity of early life stage selenium toxicities in fishes.

MATERNAL SOCIAL STATUS AFFECTS DEVELOPMENT OF THE STRESS RESPONSE IN ZEBRAFISH LARVAE

Jeffrey, J.D., Gilmour, K.M.

Symposium: Stress in Fish **Type:** Oral **Order:** 18

Contact: Jennifer Jeffrey **E-mail:** jenjeffrey@gmail.com

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Abstract: Social stress results in chronically elevated levels of cortisol, the main glucocorticoid stress hormone in fish, in subordinate individuals. The objective of the present study was to evaluate the effect of maternal social status/stress on development of the stress response in zebrafish (*Danio rerio*). Eggs from female zebrafish paired for 48 h were fertilized in vitro and sampled up to 6 days post-fertilization (dpf). Although social status did not affect maternal cortisol contribution to offspring, dominant females contributed significantly more glucocorticoid receptor (GR) and cytochrome P450 side chain cleavage enzyme (P450scc) mRNA to offspring. At 2 dpf, larvae from dominant females exhibited significantly lower baseline cortisol levels. In addition, at 6 dpf, maternal subordination attenuated the stress response of their offspring. Together, these results suggest that maternal social status affects mRNA levels of key genes involved in embryogenesis (GR and P450scc), cortisol levels during a key point of development (hatching) and the cortisol response to stress, which if maintained, may affect future stress-coping style.

PHYSIOLOGICAL RESPONSES TO HIGH WATER TEMPERATURE IN TWO THREATENED CALIFORNIA FISHES

Jeffries, K.M., Bjelde, B.E., Komoroske, L.M., Sommer, T., Fanguie, N.A., and Connon, R.E.

Symposium: Physiological Genomics **Type:** Oral **Order:** 3

Contact: Ken Jeffries **E-mail:** kenmjeffries@gmail.com

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Abstract: Many native fishes in the San Francisco Bay Estuary system, California, USA, have been in decline. Two species of concern in this system are the critically endangered delta smelt (*Hypomesus transpacificus*) and the threatened longfin smelt (*Spirinchus thaleichthys*). Current efforts to protect these species affect the water supply for 25 million people and a multi-billion dollar agriculture industry. However, little is known about the molecular mechanisms involved in thermal tolerance and whether these species can cope with projected increases in water temperature. We determined the CTMax of 50 day old fish which was 27.5°C and 25°C for delta smelt and longfin smelt, respectively. We then acutely exposed fish to environmentally-relevant temperatures of 14°C and 20°C to assess metabolic rate and cellular responses to the temperature treatments. This project uses RNA-seq and qPCR approaches combined with respirometry to identify physiological responses associated with temperature for these ecologically-relevant species.

EFFECTS OF GRADUAL TRANSFER TO SEA WATER ON GROWTH RATE AND FOOD CONVERSION RATIO IN FRESHWATER TILAPIA ZILLII

Jenjan, H.B., Salman, N.A., and EITUMMEY, F.F

Symposium: Stress in Fish **Type:** Poster **Order:** P124

Contact: Hussein B. Jenjan **E-mail:** hjenjan@yahoo.com

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Abstract: The effects of gradual transfer to sea water (37.00 g/l) on growth and food conversion ratio in freshwater *Tilapia zillii* was investigated. The fish were transferred from fresh water to sea water (37.00 g/l) through a continuous salinity increase (9.2, 18.5, 27.00 g/l salinity). Fish were kept over 40 day (10 days in each salinity media

to monitor the effects of salinity on growth rate And feeding activities. Adaptation to 9.2 and 18.5 g/l salinity caused nonsignificant decrease in growth performance. On the other hand specific growth rate (SGR) exhibited significant reduction following transfer into 27.00 and 37.00 g/l salinity media. Energy expenditure for osmoregulatory purposes might cause such reduction. Food conversion ratio (FCR) value showed elevation when fish were adapted to increased salinity media than the control group. The increment reached statistical significance in the 27.00 and 37.00 g/l salinity only, indicating improved effect to feeding activity.

SIGNALING BY NITRIC OXIDE AND ITS METABOLITES

Jensen, F.B.

Symposium: Cellular Signalling **Type:** Oral **Order:** 3

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Abstract: Nitric oxide (NO) is a ubiquitous signaling molecule with multiple physiological functions. NO is produced by NO synthases (NOS) and exerts its functions through nitrosylation of heme groups or S-nitrosation of cysteines. Other NO metabolites include nitrite and nitrate. Some of the metabolites functions as reservoirs of NO activity that become activated under hypoxic conditions. Thus, endogenous nitrite can be reduced to NO by deoxygenated myoglobin or hemoglobin under hypoxia and take over NO production from NOS (that is compromised by oxygen lack). The talk overviews NO homeostasis in fish, with focus on NO production via NOS isozymes and nitrite reduction, and the switch between these production pathways upon changes in oxygen availability. Particular attention is paid to the role of NO and its metabolites in adapting species to oxygen-limiting conditions and in providing cytoprotection during anoxia/reoxygenation events. The importance of nitrite shuttling between external and internal compartments is advocated.

INFLUENCE OF CORTISOL AND DEXAMETHASONE ON HYPOTHALAMIC-PITUITARY-INTERRENAL AXIS REGULATION IN GILTHEAD SEA BREAM JUVENILES

Jerez, I., Ruiz-Jarabo, I., and Mancera, J. M.

Symposium: Stress in Fish **Type:** Poster **Order:** P125

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Abstract: Under a stress situation, the hypothalamic-pituitary-interrenal (HPI) axis is stimulated releasing as end product cortisol to blood, being its synthesis and release controlled at different levels. Hypothalamic corticotropin releasing hormone (CRH) stimulates ACTH synthesis and release from adenohypophyseal corticotropic cells, and this hormone induces cortisol synthesis and releases from interrenal cells of the head kidney. In addition, many other factors control this pathway, such as CRH binding protein (CRH-BP), being also postulated that thyrotropin-releasing hormone (TRH) is involved. The aim of this study was to assess the effect of cortisol and dexamethasone (a synthetic glucocorticoid that binds cortisol receptors), after 35 days of orally administration, on expression levels of the main genes (CRH, TRH and ACTH) related to regulation of this axis in gilthead sea bream (*Sparus aurata*). Our results showed differences in the expression of these genes and plasma cortisol levels, suggesting that both compounds modified regulation of the HPI axis at different levels.

EFFECTS OF 3,5,3'-TRIIODOTHYRONINE, PROPYLTHIOURACIL, CORTISOL AND DEXAMETHASONE ON GILL NA⁺/K⁺-ATPASE AND H⁺-ATPASE ACTIVITIES IN GILTHEAD SEA BREAM JUVENILES

Jerez, I., Ruiz-Jarabo, I., and Mancera, J. M.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P86

Contact: Ismael Jerez Cepa **E-mail:** ismael.jerezcepa@alum.uca.es

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Abstract: Gill is a crucial osmoregulatory organ for the acclimation of teleosts to different environmental salinities. Ionic exchange in this tissue is carried on by several pumps, channels and transporters, with special relevance on the Na⁺/K⁺ and the H⁺-ATPase. These ATPases have been described to be affected by changes in the thyroid and interrenal systems. We assessed the effect of different compounds related to both thyroid and interrenal axes in *Sparus aurata* after an osmotic shock. Thus, we administered for 38 days the following compounds: i) 3,5,3'-triiodothyronine (T3), ii) propylthiouracil (PTU), an antithyroid compound which inhibits the synthesis of thyroid hormones; iii) cortisol, and iv) dexamethasone, a synthetic glucocorticoid that binds cortisol receptors. During the first 35 days, specimens were maintained at 40 ppt salinity and, after this period, a hyposmotic shock was induced transferring them to low environmental salinity (7 ppt) for the last 3 days. Our results showed variations in both ATPase activities induced by the different compounds and related to hyposmotic transfer.

UNDER THE HEAT: TRANSCRIPTOMICS OF TWO IBERIAN CYPRINIDS

Jesus, T. F., Almeida-Val, V. M.F., Coelho, M.M.

Symposium: Climate Change **Type:** Poster **Order:** P22

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Abstract: Climate change is threatening biodiversity worldwide, with increasing occurrence of extreme events such as droughts caused by events of high temperature coupled with a decrease in rainfall. Ectotherms, such as fish, tend to be particularly exposed to harsh temperatures, since their metabolism depend on the environment. In the northern and southwestern parts of the Iberian Peninsula we recognize two distinct types of river regimes, where two species inhabit exclusively, *S. carolitertii* and *S. torgalensis*. It is expected that each species will be differently impacted by climate change, since southern rivers are more prone to extreme events. In this study we submitted individuals from both species to an increase in temperature, from 18°C to 30°C, and collected 3 organs to perform RNA-seq under a control and a test situation. Differentially expressed genes identified between the libraries correspond to important functional categories for thermal stress responses. A set of these genes will be used as target for further research on related topics.

AERIAL RESPIRATION IN POLYPTERIDS

Jew, C.J. and Hicks, J.W.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 8

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Abstract: Polypterid genera, *Erpetoichthys* and *Polypterus*, can both satisfy O₂ demand breathing air, however, only *Erpetoichthys* is amphibious. To investigate whether respiratory capacity was limiting in the evolution of amphibiousness, we measured O₂ consumption, CO₂ production, and respiratory partitioning (pulmonary and cutaneous) in both genera in air. Pulmonary respiration accounted for 78% and 59% of total VO₂ and VCO₂ in *Erpetoichthys* and 50% and 31% in *Polypterus*. Differences in respiratory partitioning of O₂ and CO₂ resulted in reduced pulmonary respiratory exchange ratios (RER) and elevated cutaneous RERs in *Erpetoichthys* (0.7-lungs, 1.8-

skin) and Polypterus (0.5-lungs, 1.1-skin). Erpetoichthys showed an elevated ability for pulmonary CO₂ excretion relative to Polypterus, which instead used a larger component of cutaneous excretion. Regardless, the total RERs of both genera (0.7-0.9) indicated Erpetoichthys and Polypterus did not differ in overall CO₂ aerial respiratory capacity. In polypterid, gas exchange ability likely was not limiting in the evolution of amphibiousness.

NEUROKININ B-RELATED PEPTIDE SUPPRESSES THE EXPRESSIONS OF GNRH I, KISS 2, TAC 3 AND VTG GENES IN MATURE FEMALE NILE TILAPIA

Jin, Y.H., Park, J.W., Kim, J.H., Kim, H.K., Kim, W.S. and Kwon, J.Y.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P48

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Abstract: Neurokinin B (NKB) has a potential role in controlling mammalian reproduction. Teleosts possess not only NKB but NKB-related peptide (NKBRP), but their roles are not as clear as in mammals. In this study, synthetic NKB and NKBRP were injected into mature female tilapia intraperitoneally to investigate its effect on the reproductive axis. After the injection, several important reproduction-related genes were analyzed using qRT-PCR. Plasma levels of E₂ and 11-KT were measured by ELISA. Both NKB and NKBRP had no effect on the plasma level of sex steroids. However, NKBRP induced declines of expression level of GnRH I, Kiss2, tac3, and VTG mRNAs while NKB seemed to have no distinct effect except for resulting in the decrease of VTG mRNA. These results indicate that the roles of NKB and NKBRP in this fish may be associated with reproductive processes although their exact functions are not clear at the moment.

FASTING AND REFEEDING AFFECTS PLASMA LEPTIN IN RAINBOW TROUT

Johansson, M., Einarsdottir, I.E., and Björnsson, B.Th.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 14

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Abstract: Leptin has been found to have an anorexigenic effect in fish, indicating a role in regulation of growth and energy homeostasis. The study aimed to elucidate the relationship between leptin and food intake after a four-week period of fasting in rainbow trout. Utilizing a salmonid leptin radioimmunoassay, the study confirmed earlier findings that plasma leptin levels rise in fasting rainbow trout. Following the fasting period, the rainbow trout were clearly in a state of anorexia, with only a minority of the fish starting to feed during the first hours of refeeding. Even after 72h, some individuals had yet to start feeding. Non-feeding individuals had high plasma leptin levels, while in those feeding, the leptin levels decreased rapidly in correlation with food reaching the gastrointestinal tract. The data indicate that the leptin-induced anorexic state is broken after feeding commences and not by sensory responses to the presence of food.

DIFFERENTIAL GENE EXPRESSION AND TRANSCRIPTOME CHARACTERIZATION IN EUROPEAN SEA BASS LARVAL STAGES

Kaitetzidou, E., Xiang, J., Antonopoulou, E., Tsigenopoulos, C., Sarropoulou, E.

Symposium: Physiological Genomics **Type:** Oral **Order:** 2

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Abstract: Larval stages are the most critical period in the production of marine fish. Key developmental events occur early in development and are influenced by external parameters like stress, temperature, salinity and photoperiodism. Any failure in these processes may cause malformations, developmental delays, poor growth, and massive mortalities. Knowledge of the genes of developmental processes and their regulating mechanism will permit a focused molecular approach for understanding the development from egg throughout juvenile stages. The new sequencing and analysis methods allow transcriptome and small RNA screens with the scope of detecting differential expression for any species of interest. In this study, we have investigated the transcriptome of the European sea bass (*Dicentrarchus labrax*) comprising large and small RNA transcripts during seven early developmental stages (from morula to hatching) applying Illumina technology. The European sea bass (*Dicentrarchus labrax*) belongs to the species of high economic importance for the European and Mediterranean aquaculture.

APPLYING SENSORY PHYSIOLOGY TO SHARK CONSERVATION

Kajiura, S.M.

Symposium: Elasmobranchs **Type:** Oral **Order:** 1

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Abstract: Global shark populations are being unsustainably exploited and a large proportion of these mortalities is attributed to sharks caught as unwanted, incidental bycatch. To conserve healthy shark populations in the face of rising fishing pressure, it is critical to develop and implement bycatch mitigation techniques. I describe a cost-effective method to dramatically reduce shark catch in longline fisheries. Juxtaposing Zinc and Graphite in seawater produces a galvanic electric field sufficiently strong to repel sharks from baited hooks. Shark catch on Zinc/Graphite treated hooks was reduced by 80% compared to procedural controls and by 85% compared to untreated hooks. This technique is particularly appealing because it selectively acts upon the elasmobranch electrosensory system, which is not present in commercially targeted teleost species. Thus, sharks are repelled without reducing the catch rates of the target species. If widely adopted, this technique could potentially save millions of sharks each year and simultaneously increase the efficiency and profitability of commercial fishermen.

QUANTIFICATION OF MASSIVE SEASONAL SHARK AGGREGATIONS

Kajiura, S.M.

Symposium: Fish Migration **Type:** Oral **Order:** 8

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Abstract: South Florida witnesses an enormous migration of marine apex predators each year as massive aggregations of blacktip sharks (*Carcharhinus limbatus*) overwinter in nearshore waters. The narrow shelf and close proximity of the Gulf Stream Current to the Palm Beach County (PBC) shoreline constrain tens of thousands of sharks to the shallow, coastal environment. This natural bottleneck provides a unique opportunity to estimate abundance. Over a sixteen month period, a biweekly aerial survey was flown along the length of PBC and the number of sharks was directly counted. Shark abundance peaked in the winter (January-March) and declined to nearly zero in the summer months and was inversely correlated with water temperature. These baseline abundance data can be compared to future studies to determine if shark population size is changing and if sharks are restricting their southward migration as global water temperatures increase.

INOSITOL METABOLISM AND OSMOREGULATION IN TWO EURYHALINE TELEOSTS, THE EUROPEAN EEL AND THE NILE TILAPIA

Kalujnaia, S., Gellatly S., Hazon, N. and Cramb, G.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 5

Contact: Gordon Cramb **E-mail:** gc@st-andrews.ac.uk

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Abstract: Inositol can accumulate in cells either by increasing the activity of the sodium-linked myo-inositol transporter (SMIT) or by enhanced de novo synthesis. Myo-inositol phosphate (MIP) synthase and inositol monophosphatase (IMPA) are the two enzymes required for the de novo synthesis of inositol from glucose 6-phosphate. Although single MIP synthase and SMIT genes appear to be expressed in teleosts, up to five IMPA isoforms (IMPAs1.1, 1.2, 1.3, 1.4 and 2) can be found which exhibit differential tissue expression. One of the isoforms (IMPA1.1), which exhibits near ubiquitous tissue expression, is salinity-sensitive with mRNA and protein expression increasing up to 20-fold following acclimation of fish to SW environments. Following SW-acclimation, the genes for IMPA isoforms, MIP synthase and SMIT exhibit both teleost- and tissue-specific expression profiles, however in both the eel and tilapia the IMPA1.1 is potentially the main regulator of inositol biosynthesis when fish are in SW.

FLOW AND WATER TEMPERATURE SIMULATION WITH FUTURE SCENARIOS FOR WATERDHEDED ECOSYSTEM MANAGEMENT IN THE KUSHIRO RIVER, JAPAN

Kameyama, S., Yamagata, Y., Nohara, S., Sato, M. and Terui, S.

Symposium: Sensing the Environment **Type:** Poster **Order:** P115

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Abstract: The primary causes of water temperature rising is not only climate change but also land-use alteration by human activities. The Kushiro River watershed is representative nature restoration site in Japan. From ecological aspect however, the seasonal dynamics of water temperature has not been monitored in the before-after assessment. So, we focused on the water temperature simulation by using watershed hydrological model. Then, we adopted future land-use scenario in 2050 as initial condition to this model. The objectives of our study are following two. 1) We set up some future scenarios (in 2050) to this watershed and developed simulation model to forecast the water temperature change. 2) To evaluate the impact of land-use change on water temperature and the aquatic ecosystem. As the result of this approach, we calculated the water temperature change though the year. Then we discussed the actual plans that we should start with local stake holders.

CHANGES IN PHYSIOLOGICAL GROWTH PARAMETERS DURING DOWNSTREAM AND COASTAL MIGRATION IN CHUM SALMON OF EASTERN HOKKAIDO, JAPAN

Kaneko, N., Taniyama, N., Inatani, Y., Nagano, Y., Miyakoshi, Y., Fujiwara, M., Torao, M., and Shimizu, M.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P67

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Abstract: Early marine phase is a critical period for survival of juvenile chum salmon (*Oncorhynchus keta*) as growth-dependent mortalities likely occur during this phase. Monitoring growth is therefore important to estimate their survival. We measured muscle RNA/DNA ratio and circulating insulin-like growth factor (IGF)-I, as candidates of growth indices, in juvenile chum salmon caught in river, estuary, port and inshore of the eastern Hokkaido, Japan from spring to summer. In mid-June, muscle RNA/DNA ratio and plasma IGF-I levels were highest in coastal fish. Fish caught in the estuary were smallest and had the lowest RNA/DNA ratio and IGF-I values. There were positive significant correlations between growth indices and body size, while IGF-I had a higher correlation coefficient ($r = 0.76$) than did RNA/DNA ratio ($r = 0.40$). Findings of the present study warrant further validation of these parameters as growth indices of juvenile chum salmon.

ION TRANSPORTERS IN THE KIDNEY OF EURYHALINE AND SEAWATER PUFFERFISHES

Kato, A.

Symposium: Fish Kidney **Type:** Oral **Order:** 1
Contact: Akira Kato **E-mail:** akirkato@bio.titech.ac.jp
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Abstract: The kidney plays an essential role in body-fluid homeostasis in freshwater (FW) and seawater (SW) teleosts. FW teleosts excrete excess water by producing large amount of hypotonic urine, whereas marine teleosts conserve water and excrete divalent ions in a small amount of urine. To clarify the mechanisms of ion transport in renal tubular cells, we analyzed the expression, localization, and activity of ion transporters in the kidney of a euryhaline pufferfish (river puffer, *Takifugu obscurus*) and a marine pufferfish (tiger puffer, *Takifugu rubripes*). Our studies have suggested that: (i) apical $n\text{Na}^+/\text{Ca}^{2+}$ exchanger NCX2 (Slc8a2), $\text{Cl}^-/\text{SO}_4^{2-}$ exchangers (Slc26a6 paralogs), and borate channel (Slc4a11) mediate tubular secretion of Ca^{2+} , SO_4^{2-} , and borate, respectively, in SW; (ii) vesicular (Slc41a1) and lateral (CNNM3) Mg^{2+} transporters are involved in tubular secretion of Mg^{2+} in SW; (iii) an apical Na^+-Cl^- cotransporter NCC (Slc12a3) mediates urine dilution in FW, and (iv) an apical $\text{Na}^+-\text{K}^+-2\text{Cl}^-$ cotransporter NKCC2 (Slc12a1) is involved in NaCl reabsorption for urine volume reduction in SW.

THE TEMPERATURE DEPENDENT CARDIAC REMODELING RESPONSE IN RAINBOW TROUT

Keen, A.N., and Shiels, H.A.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 4
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Abstract: Rainbow trout (*Oncorhynchus mykiss*) are an ectothermic species that inhabit temperate waters and, therefore, experience large seasonal temperature fluctuation that directly alters their physiology. To maintain optimal function the heart has to remodel with temperature changing in size, form and function. Fish were acclimated to 3 temperatures; cold (5 °C), control (10 °C) and warm (18 °C). Diastolic pressure volume curves were generated, by controlled filling of the heart, for of each chamber of the heart in each group. Cardiac compliance tended to be higher in the warm acclimated group suggesting that each chamber was stiffer with cold acclimation; however, significance was only found in the outflow tract (OFT; $p > 0.05$). These results correlated with histological examination, with there generally being a higher density of collagen found in the cold acclimated tissue than the warm. The only tissue to show evidence of elastin was the OFT and the density was higher in the warm acclimated tissue. The material properties of the tissue were tested by AFM with preliminary data suggesting the same story as in the other experiments and that atrial tissue is the least compliant, followed by the spongy myocardium, then the compact myocardium, with the OFT tissue showing the highest degree of compliance in all groups. Finally, FTIR spectra were generated for each of the tissues. Preliminary data indicates an increase in protein in the ventricle, a decrease in protein in the OFT and protein levels in the atrium remaining constant after cold acclimation. Principal component analysis revealed that the main variance between the tissue was in the amide

I and amide II absorption wavelengths, which contain the bending vibrations the for protein backbone. Interestingly, we did not see the characteristic changes in heart morphology that have previously been reported with cardiac remodelling in rainbow trout. However, the fact that we have still seen a number of differences between the tissues suggests that higher resolution changes occur before gross morphological ones. In conclusion, there appears to be a number of inconsistencies with the scope of the cardiac remodelling response of rainbow trout to chronic temperature change. However, the passive properties of the heart are capable of remodelling in numerous ways ranging from whole heart morphology to underlying biochemistry.

BEHAVIOURAL EFFECTS OF SEROTONIN RE-UP TAKE INHIBITORS ON THE THREE-SPINE STICKLEBACK

Kellner, M., Porseryd, T., Olsén, H.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P39

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Abstract: Selective Serotonin Re-uptake Inhibitors (SSRI) are a group of antidepressant pharmaceuticals which exert their effect by blocking the Re-uptake of serotonin into the pre-synaptic nerve ending. SSRI are also lipophilic and degradation in conventional sewage treatment plants is poor. SSRI levels have been found to have a profound impact on both physiological and behavioural variables in fish, ranging from changes in estradiol levels and reproduction disturbances to more subtle behavioural disturbances like failure to react to a conspecific alarm substance, fish being more inclined to dwelling near the surface or becoming less aggressive. We use the three-spine stickleback (*Gasterosteus aculeatus*) as study animal, a species with a very broad range of behaviours. The species is common in various aquatic environments, including polluted areas. After exposure to low concentrations of citalopram, known as the most specific SSRI on the market, changes of ecological relevant behaviours such as stress behaviour and foraging were recorded. These behavioural changes observed in the three-spine stickleback could have a profound ecological impact if the effects are manifested under field conditions.

INHIBITION OF P-GLYCOPROTEIN IN THE BLOOD-BRAIN BARRIER OF TROUT ALTERS AVERMECTIN NEUROTOXICITY AND SWIMMING PERFORMANCE

Kennedy, C.J., K.B. Tierney and M. Mittlestadt

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 7

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Abstract: The contribution of the transporter P-glycoprotein (P-gp) to the blood brain barrier (BBB) in trout was examined using the P-gp substrates and CNS neurotoxins ivermectin [IVM] and emamectin benzoate [EB]. Swimming performance was examined in fish injected i.p. with 0.01-1.0 and 1-50 mg/kg of IVM or EB, respectively, either alone or in combination with cyclosporin A (CsA: a P-gp substrate) at 1 mg/kg. IVM affected the performance at lower concentrations than EB and when fish were exposed to IVM or EB in the presence of CsA, alterations to swimming were increased, suggesting that affects on P-gp activity by CsA increased chemical penetration into the CNS. Differences were seen in the effect of co-administration of CsA on swimming-related toxicity; EB toxicity increased more than IVM toxicity. These results provide evidence for a role of P-gp in the BBB of fish, and suggest that this protein protects fish from environmental neurotoxins.

ACCOMMODATING THE COST OF SWIMMING - THE APPLICABILITY OF EXERCISE-INDUCED GROWTH IN A NOVEL FINFISH AQUACULTURE SPECIES, THE HAPUKU

Khan, J.R., Trembath, C., Pether, S., Bruce, M., Walker, S.P., Herbert, N.A.

Symposium: Swimming Physiology **Type:** Oral **Order:** 10
Contact: Javed Khan **E-mail:** jkha022@aucklanduni.ac.nz
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Abstract: Induced-swimming can improve the growth and feed conversion efficiency of finfish aquaculture species, such as salmonids and *Seriola* sp., but some species, such as Atlantic cod, show no or a negative productivity response to exercise. As a possible explanation for these species-specific differences, a recent hypothesis proposed that the applicability of exercise training, as well as the exercise regime for optimal growth gain (ER opt growth), was dependant on the size of available aerobic metabolic scope (AMS). This study aimed to test this hypothesis by measuring the growth and swimming metabolism of hapuku, *Polyprion oxygeneios*, exposed to different exercise regimes and reconciling the metabolic costs of swimming and growth (i.e. specific dynamic action, SDA) against AMS. Two 8-week growth trials were conducted with ERs of 0.0, 0.25, 0.5, 0.75, 1 and 1.5 body lengths per second (BL s⁻¹). Fish on a relatively high growth trajectory showed a small but positive growth response to exercise but only in the range of 0.5 to 0.75 BL s⁻¹ compared to static water controls. Slightly larger fish on a slower growth trajectory, however, showed no evidence of exercise-induced growth. Long-term exposure to water flow at 0.75 and 1.5 BL s⁻¹ also yielded little difference in the swimming metabolism of fish relative to static water controls. Reconciling the SDA of hapuku with the metabolic costs of swimming showed that hapuku AMS is sufficient to support growth and swimming at all ERs. The current data shows that exercise-induced growth is independent of AMS in this species and therefore possibly varies as a function of species, life stage and/or inherent growth trajectories.

TOXIC EFFECTS OF PHENOLIC METABOLITE 6-OH-BDE 85 ON ZEBRAFISH EMBRYOS

Kheirallah, N., and El-Sayed Ali, T.

Symposium: Zebrafish **Type:** Poster **Order:** P158
Contact: Nessrin Kheirallah **E-mail:** nessrin_kheirallah@yahoo.com
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Abstract: The hydroxylated polybrominated diphenyl ethers (OH-PBDEs) are important metabolites formed by in vivo metabolism of brominated diphenyl ethers and a natural product produced by marine organisms such as algae, so such ethers are ubiquitous in the environment. 6-OH-BDE 85 is a type of such metabolites. In order to monitor both general toxicity as well as teratogenicity of this compound, embryos of zebrafish were exposed to gradual concentrations (0.03, 0.1, 0.3, 1 and 2.5 μM) of 6-OH-BD137. After 24, 48, 72 and 96 hrs of exposure, general morphology and teratogenic effects were recorded. Both the general morphology score and the teratogenicity score were analyzed. Results showed that the doses 1 and 2.5 μM were lethal when examined at 24 hs post fertilization (hpf) while the dose 0.3 μM caused developmental retardation and deformation at 48 hpf and global death at 96 hpf. This study shows that such metabolites should be included in the ecotoxicological studies for a proper risk assessment and more attention should be given to this class of chemicals in the aquatic environment.

POSSIBLE INVOLVEMENT OF MINERALOCORTICOID SIGNALING PATHWAYS IN STRESS RESPONSE AND EMBRYOGENESIS IN RAINBOW TROUT

Kiilerich, P., Valotaire, C., Goardon, L., Prunet, P.

Symposium: Stress in Fish **Type:** Oral **Order:** 2
Contact: Patrick Prunet **E-mail:** patrick.prunet@rennes.inra.fr
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Abstract: The role of the mineralocorticoid signaling pathways and its ligand 11-deoxycorticosterone (DOC) is still enigmatic with no conclusive demonstration of osmoregulatory roles. Here we will present recent data on the involvement of the MR/DOC signaling axis in stress and in embryonic development in rainbow trout. In juvenile fish, a chronic confinement stress exposure led to a significant increase in plasma DOC levels. That sustained up-regulation is associated with a negative feed-back on MR expression at the level of pituitary but not in the other tissues (hypothalamus, interrenal). This regulation was confirmed by immuno-localization of MR protein in the CNS. A few studies have also indicated a possible role for DOC in development. Thus, the onset of DOC synthesis and endogenous corticosteroid receptor gene expression were investigated from fertilization to the swim-up stage. Altogether, these data suggest that stress response and early development are governed by mineralocorticoid signaling pathway in trout.

ADAPTABILITY TO DIFFERENT SALINITIES IN TWO SUBPOPULATIONS OF GADUS MORHUA FROM THE BALTIC SEA
Kijewska, A., Kalamarz-Kubiak, H., and Wenne, R.

Symposium: Fish Habitats **Type:** Oral **Order:** 11

Contact: Agnieszka Kijewska **E-mail:** agnes@iopan.gda.pl

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Abstract: The aim of the study was to determine whether the expression of Na/K-ATPase α , and hsp70 genes, and plasma cortisol concentration can be used as parameters for determination of the adaptability to different salinities in populations of cod from east and west Baltic Sea. East subpopulation of cod living in low salinity (8PSU) waters was compared to the subpopulation from west Baltic living in higher salinity (over 18PSU). After acclimation, both populations were adapted to gradually reduced (to 3 PSU) and elevated salinities (to 33 PSU). Hsp70 expression assay was up-regulated only in west subpopulation acclimated to tested salinities. Plasma level of cortisol was increased in each tested group of cod. The pattern of expression of Na/K-ATPase α was different in both cod's subpopulations as well as in different salinities. The applied parameters indicate the adaptive differences between two examined subpopulations from the Baltic Sea.

GENETIC DIFFERENTIATION OF GADUS MORHUA ACCORDING TO SALINITY GRADIENT
Kijewska, A., Poćwierz-Kotus, A., and Wenne, R.

Symposium: Fish Habitats **Type:** Poster **Order:** P108

Contact: Agnieszka Kijewska **E-mail:** agnes@iopan.gda.pl

Institute of Oceanology, Polish Academy of Sciences, Dept. of Genetics and Marine Biotechnology, Powstańców
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Abstract: The Baltic is a semi-enclosed sea characterized by decreasing salinity in the eastern and northern direction. Eastern Baltic cod living in extremely low salinity waters face the prospect of future climate change causing an increased flow of freshwater to the Baltic. SNPs correlated with salinity gradient were used to test if there is any difference between distribution of alleles depend on geographical localization. SNPs were tested in samples collected along the west-northeast transect in the Baltic Sea. Results indicated a clear distinctness of the west population from the east populations. Three cod samples representing east and west population were also genotyped using a cod derived SNP-array. Clustering analysis and principal coordinates analysis clearly confirmed the difference between eastern and western samples. Thus, salinity is probably one of the main factors affecting the population structure of cod in the Baltic Sea.

SEXUAL HARASSMENT DRIVES INCREASED SWIMMING EFFICIENCY IN FEMALE GUPPIES

Killen, S.S., Darden, S.K., Salin, K., Metcalfe, N.B., and Croft, D.P.

Symposium: Swimming Physiology **Type:** Poster **Order:** P140

Contact: Shaun Killen **E-mail:** shaun.killen@glasgow.ac.uk
United Kingdom

Abstract: Differing fitness strategies between males and females can generate sexual conflict within species and varying selective pressures for each sex. We examined whether conflict over the frequency of mating between male and female guppies can induce changes in the swimming performance and aerobic capacity of females as they work to escape harassment by males. Female guppies were reared with either high or low levels of male harassment. Females exposed to high levels of harassment did not display a higher maximal sustained swimming speed or aerobic scope when compared to females receiving low levels of harassment. However, highly harassed females used less oxygen to swim at a given speed and consequently have a lower cost of transport. It is possible that frequent chasing may generate a training effect, whereby female guppies develop increased mitochondrial efficiency. Alternatively, females experiencing harassment may be more practiced at swimming quickly and simply be better swimmers.

ADAPTATION FOR ACTIVITY PREDICTS INTERSPECIFIC VARIATION IN THE METABOLIC RATES OF FISHES

Killen, S.S., Glazier, D.S., Clark, T.D., Atkinson, D., Willener, A.S.T., and Halsey, L.G.

Symposium: General Contributed Papers **Type:** Poster **Order:** P62

Contact: Shaun Killen **E-mail:** shaun.killen@glasgow.ac.uk
United Kingdom

Abstract: Although resting and active metabolic rates vary widely among species, little is known about the morphological and ecological factors that generate and maintain this variability. We examined interspecific correlations between resting and active metabolic rates in teleost fishes, and tested for associations between metabolic rates and morphological (liver and brain size, gill surface area, muscle composition) and ecological (trophic level, lifestyle) factors related to activity level. Resting and active metabolic rates are strongly correlated across species, reflecting a functional link whereby morphological features required for increased activity also increase resting metabolic rate. This limitation – that species cannot typically increase the capacity for activity without acquiring additional resting costs – could be a key constraint driving interspecific variation in metabolic rates and aerobic scope in response to broad-scale ecological pressures.

APPETITE GENE REGULATION IN GROWTH HORMONE TRANSGENIC COHO SALMON

Kim, J.H., and Devlin, R.H.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 7

Contact: Jinyoung Kim **E-mail:** jhkim1972@gmail.com
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Abstract: The regulation of food intake and energy balance are key factors influencing growth in vertebrates, and involve complex neuronal and metabolic signals. Growth hormone (GH) transgenic fish can possess highly stimulated growth and elevated appetites and feeding motivation, and hence provide a useful model to analyze the relationship between metabolism, growth, and feeding behaviour. To investigate changes in brain gene expression associated with elevated growth, three sized-matched genotypes of coho salmon were examined: 1) non-transgenic wild-type, 2) fast-growing GH transgenic on full ration, and 3) GH transgenic ration restricted to match growth to that of wild type. mRNA for AgRP1, AgRP2, NPY, MC4R, MCH, SST1A, CART, POMC, CCK, GH and IGF-1 were examined in hypothalamus, preoptic area, and pituitary from each genotype before feeding, and at 1h and 4h

post feeding. Significant modifications in mRNA levels have been detected in all tissues which may play a role in appetite regulation.

STRESS AND SKIN IMMUNOLOGY IN TURBOT

Klein, V., and Miest, J.

Symposium: Stress in Fish **Type:** Poster **Order:** P126

Contact: Joanna Miest **E-mail:** jmiest@geomar.de

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Abstract: Stress is known to influence the immune system and can, depending on the intensity and duration of the stress event, have both stimulating and inhibiting effects. In mammals stress is known to influence the skin (e.g. development of stress related disorders, effect on the innate and adaptive immune response in the skin). Especially in fish, which literally swim in pathogens, the skin poses as one of the major barriers to invading pathogens. However the effect of stress on skin has been little researched in fish so far even though this knowledge could lead to new treatment and prevention methods. Hence we investigated the effect stress, mimicked via cortisol implants, has on skin immunity in juvenile turbot (*Scophthalmus maximus*). Results of immune and skin related gene expression will be put into context of physical skin barrier function and mucosal immune factors.

NUTRIENT SENSING SYSTEMS ON REGULATION OF FOOD INTAKE AND GROWTH IN CHANNEL CATFISH

Kobayashi, Y., Peterson, B.C., Waldbieser, G.C

Symposium: Growth and Metabolism **Type:** Oral **Order:** 12

Contact: Yass Kobayashi **E-mail:** y_kobayashi@fhsu.edu

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Abstract: In channel catfish, genetic selection toward increased growth leads to hyperphagia and increased peritoneal fat accumulation without significantly affecting the muscle growth. It is plausible that selection towards increased growth alters the muscle's ability to sense, acquire, and metabolize nutrients and that nutrient usage is diverted from the muscle to fat. Recently, we investigated muscle expression of uncoupling protein 2 (UCP2) in channel catfish. Two distinct UCP2 (UCP2a and 2b) were identified in channel catfish, and expression of UCP2b mRNA was readily detectable in skeletal muscle. During a 21 week feeding study, catfish that grew faster tended to have lower levels of UCP2b mRNA on day 60 but not on days 0 or 150 of the study, suggesting that increased growth appears to be independent of UCP2b expression. Currently, we are investigating the role of other nutrient sensing systems on regulation of muscle nutrient metabolism and growth in channel catfish.

MOLECULAR MECHANISMS UNDERLYING CADMIUM-COPPER AND COPPER-LEAD INTERACTIONS IN GILLS OF ZEBRAFISH

Komjarova, I., and Bury, N.R.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 16

Contact: Irina Komjarova **E-mail:** irina.komjarova@kcl.ac.uk

King's College London, Department of Biochemistry, Metal Metabolism Group, 150 Stamford Street, London, SE1 9NH UK

Abstract: This study investigates accumulation of essential (Cu) and toxic (Cd, Pb) metals in zebrafish *Danio rerio* gills during mixed-metal exposure using stable isotopes and molecular approaches. Zebrafish were exposed to

¹⁰⁶Cd, ²⁰⁴Pb and ⁶⁵Cu as single metals and their mixtures in the medium hard OECD water at environmentally relevant concentrations. The metal burdens of zebrafish gills were followed in time for 48h to obtain metal uptake rates. The transcript levels of genes involved in transport of Cu (CTR1, ATP7a), divalent metals (DMT1), Zn (ZIP8), Ca (ECaC), and Na (NHE-2) determined by quantitative RT-PCR technique were compared between the treatments at 24 and 48h of exposure. Then, the obtained metal uptake profiles were compared with changes in gene expression levels. The results showed presence of common uptake pathways that may explain alteration of the metal uptake rates in combined exposures.

MIGRATION OF THE WEATHERFISH BETWEEN DIFFERENT HABITATS IN TWO AGRICULTURAL DITCHES WITH DIFFERENT WATERLEVEL REGIMES

Kranenborg, J. and Bruin, A.

Symposium: Fish Migration **Type:** Oral **Order:** 4

Contact: Jan Kranenborg **E-mail:** j.kranenborg@ravon.nl

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Abstract: The weatherfish (*Misgurnus fossilis*) is a floodplain species highly adapted to living in densely vegetated and muddy waters. The river landscapes of the Netherlands have been cultivated since the 14th century. By building dikes, digging ditches and pumping off water, river floodplains were turned into agricultural land. For a long time the weatherfish seemed to be able to assimilate to these changes. The second half of the 20th century, however, saw a strong decline. Changes in water management and water levels probably have played a major role in this decline. To learn more about the migration behaviour of the species in relation to changes in water level and the availability of habitats we studied two agricultural ditches with different water regimes from March 2012 until July 2013. We marked weatherfish with passive integrated transponders and located them every 1-2 weeks. Migration patterns differed between the two locations. We will discuss the effect of changes in water level in relation to the species physiology and behaviour and suggest management solutions for waters with existing populations.

MIGRATORY BEHAVIOUR AND PHYSIOLOGICAL STATUS OF OF POST-SPAWNERS OF ATLANTIC SALMON IN RIVER LÆRDALSELVA, NORWAY

Kristensen, T., Urke, H.A., Ulvund, J.B., Takle, H., Farrell, A., Rosseland, B.O., Ebbesson, L.O.E. and Nilsen, T.O.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 3

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Abstract: Post-spawning survival of Atlantic salmon in River Lærdalselva has historically been very high, and visual countings during the spawning season (oct-nov) and post-spawning (apr) from 196X to 197X revealed minimum winter survival rates in the range of 70-90% (Rosseland, 1980). Mark-recapture studies from the same time-period revealed substantial survival and returns. The potential contribution of secondary spawners may be underestimated by river catches (Halttunen et al., 2009), and little is known about migratory behaviour and physiological adaptations to a second sea migration in in post-spawning survivors. We caught 36 post spawners (90 cm ±12 SD) in early April 2013. Twenty-five fish were tagged with acoustic tags depth transmitters, gill biopsied for NKA activity and gene expression measurements, and released for migration studies. The remaining 11 fish were retained and repeatedly gill biopsied for NKA activity and gene expression at regular intervals for 8 weeks. Approximately 20% of the tagged fish migrated in April, prior to increased water discharge. The remaining tagged fish migrated during a large increase in water discharge in early May, concurrent with the initiation of smolt migration. Migratory speed in the fjord system was high, with no apparent mortality, and will be discussed in relation to physiological changes in post-spawners during the spring.

ABC TRANSPORTERS IN ONCORHYNCHUS MYKISS PRIMARY GILL CELL CULTURE

Kropf, C., Fent, K., Segner, H.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 2

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Abstract: The fish gill is a structurally complex organ and integrates many physiological functions, such as ion and acid-base regulation, nitrogenous waste excretion, and gas exchange. Branchial cells initiate an important point of primary contact with waterborne toxicants and act as a major route of uptake and a potential excretion route. The role of xenobiotic transporters in gill tissue as well as in primary gill cell cultures has not yet been elucidated. Primary gill cells cultured on solid and permeable support have been evaluated as a model to measure transport activities using classical ABC transporter substrates and inhibitors. The mRNA profiles determined and correlated to the functional assays, and the response to ABC transporter inducers tested. The results indicate a general low expression of ABC transporters mRNA in primary gill cell culture as well as a change in transcripts levels over culturing time, which demonstrates the effect of primary gill cell culture age on experimental outcomes.

ANTIOXIDANT CAPACITIES ARE NOT MATCHED TO LEVELS OF NON-HEME IRON IN SELECTED TISSUES OF WHITE- AND RED-BLOODED ANTARCTIC FISHES

Kuhn, D.E., and Crockett, E.L.

Symposium: General Contributed Papers **Type:** Poster **Order:** P58

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Abstract: Heme-containing proteins and sources of non-heme iron have the potential to generate damaging radicals. We tested the hypothesis that antioxidant capacities in tissues of hemoglobin-containing (red-blooded) and hemoglobin-lacking (white-blooded) Antarctic fishes are matched to contents of non-heme iron and ferritin, the latter a protein involved in sequestration of iron. While levels of ferritin and non-heme iron are, for the most part, 2-4 times higher in muscle tissues and liver of red- than white-blooded species, activities of central antioxidants, superoxide dismutase and catalase normalized to non-heme iron, are on average 3-fold higher in tissues of white-blooded species compared with those species with hemoglobin. Similarly, activities of glutathione-dependent antioxidants and amounts of ascorbate, normalized to non-heme iron, are 2-6 times higher in white-blooded than red-blooded fishes. These results indicate that white-blooded fishes require extra antioxidant protection relative to their non-heme iron contents compared to red-blooded notothenioid fishes. Supported by NSF ANT 1043576.

THE ROLE OF TRANSCRIPTION FACTOR GLIAL CELL MISSING 2 (GCM2) IN CA²⁺ BALANCE IN ZEBRAFISH LARVAE

Kumai, Y., Kwong, R.W.M. and Perry, S.F.

Symposium: Cellular Signalling **Type:** Oral **Order:** 14

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Abstract: The present study investigated the role of the transcription factor, glial cell missing 2 (gcm2) in Ca²⁺ regulation in zebrafish larvae. Translational gene knockdown of gcm2 decreased Ca²⁺ uptake and the density of ionocytes expressing the epithelial Ca²⁺ channel (zeca), and disrupted overall Ca²⁺ balance. Acclimation to either low Ca²⁺ (25 μM [Ca²⁺]) acidic water (pH ~ 4.0) significantly increased the mRNA expression of gcm2. When measured in control water following acclimation to these conditions, Ca²⁺ uptake was significantly elevated.

However, in fish experiencing *gcm2* knockdown, no such stimulation of Ca²⁺ uptake was observed. Over-expression of *gcm2* mRNA resulted in a significant increase in Ca²⁺ uptake and in the numbers of zecac-expressing ionocytes. These observations reveal a critical role for *gcm2* in Ca²⁺ homeostasis in zebrafish larvae.

RE-STRIPPING AND SEMINAL CHARACTERISTICS OF PACU DURING THE BREEDING SEASON

Kuradomi, R.Y., De Souza, T.G., Foresti, F., Schulz, R.W., Bogerd, J., Honji, R.M., Moreira, R.G., Squassoni, G.H., Furlan, L.R., Maschio, L.R., Almeida, E.A., and Batlouni, S.R.

Symposium: Tropical Fish **Type:** Poster **Order:** P149

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Centro de Aquicultura (CAUNESP), Universidade Estadual Paulista, (UNESP) / Via de Acesso Prof. Paulo Donato Castellane, s/n; Jaboticabal - SP, 14884-900 Brazil

Abstract: In this study we analyzed the semen characteristics of hormonally induced pacu in November (n=7), December (n=5), February (n=4) and from re-stripped males (first stripped in November and re-stripped in the December) (n=4). Sperm density, ionic composition, pH, osmolality were similar among groups. The semen volume, seminal plasma protein concentration and incidence of morphological anomalous sperm increased over time. On the other hand, some parameters associated to good quality semen, such as sperm motility and viability and DNA integrity decreased. Moreover, we observed a positive association between motility, viability and DNA integrity of sperm with elevation of 11-Ketotestosterone, but not with *fsbh* and *lhb* mRNA levels in the pituitary. Semen obtained early (November) or from re-stripped males showed better characteristics than those collected on other occasions. In conclusion, collecting semen from pacu at the end of breeding season should be avoided while stripping early and then re-stripping later on seems an interesting approach for this species that may be used for diverse aquaculture purposes. Acknowledgments: processo FAPESP 2010/00825-1 and 2010/05286-1; CAPES: processo BEX 8501/11-4.

THE LOST GILLS: AN ESSENTIAL ROLE OF PARATHYROID HORMONE IN DEVELOPING ZEBRAFISH

Kwong, R.W.M., and Perry, S.F.

Symposium: Cellular Signalling **Type:** Oral **Order:** 16

Contact: Raymond Kwong **E-mail:** wkwong@uottawa.ca

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Abstract: Parathyroid hormone (PTH) is thought to be important in regulating calcium homeostasis and skeletogenesis in vertebrate; however, little is known about the molecular mechanisms by which PTH regulates ion transport and development. Using developing zebrafish (*Danio rerio*) as a model organism, we demonstrated that translational gene knockdown of PTH1 by an antisense morpholino significantly reduced the density of ionocytes, including H⁺-ATPase-rich and Na⁺/K⁺-ATPase-rich cells. Density of p63 (an epidermal stem cell marker)-positive cells was also decreased in the PTH1 morphants. Surprisingly, we also observed that formation of branchial arches was prevented in fish experiencing PTH1 knockdown. Real-time PCR analysis suggested that mRNA expression of a cell-fate transcription factor *gcm2* was decreased in the morphants. Co-injection of *gcm2* cRNA and PTH1 morpholino could partially rescue the phenotypes of PTH1 morphants. Overall, these findings suggest that PTH1 is essential for ionocyte differentiation and gill development, probably via its interaction with *gcm2*.

GENETIC MANIPULATION OF MALE GERMLINE STEM CELLS IN THE NILE TILAPIA

Lacerda, S.M.S.N., Tonelli, F.M.P., Costa, G.M.J., Resende R.R., França, L.R.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 9
Contact: Luiz de Franca **E-mail:** lrfranca@icb.ufmg.br
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Abstract: Due to their ability to transmit the genetic information to the subsequent generation, spermatogonial stem cells (SSCs) are unique cells in the adult organism. Therefore, their genetic modification provide a great opportunity to study the biology of their complex processes, enabling the generation of transgenic animals in a wide range of species, including fish. Recently, we have developed a competent SSC culture system and an efficient methodology for SSCs transplantation in Nile tilapia. Also, the ability of lentiviral vectors to transduce SSCs in vitro, by inserting a reporter gene, is now being investigated. As it results in long-term integration and expression of the transgene, using long-term fluorescence analysis and DNA sequencing we observed that, similar to mammals, viral transduction may represent an efficient method to introduce genes into fish male germline. We have currently obtained stable genetically modified SSCs in tilapias and are now evaluating the functionality of this approach.

OCEAN ACIDIFICATION: BEHAVIOURAL DISTURBANCE IN GASTEROSTEUS ACULEATUS IS RESOTORED BY GABA-A RECEPTOR ANTAGONIST

Lai, F., Jutfelt, F., and Nilsson, G.E.

Symposium: Climate Change **Type:** Poster **Order:** P23
Contact: Floriana Lai **E-mail:** floriana.lai@ibv.uio.no
Department of Bioscience University of Oslo P.O. Box 1066 Blindern N-0316 Oslo Norway

Abstract: The general increase in carbon dioxide levels in the atmosphere and consequently the changes in the ocean chemistry could have important consequences to the marine life. Several studies have identified drastic effects of near-future CO₂ levels on the sensory system and behaviour of coral reef fish. The neural mechanism responsible of these abnormalities has been found to involve the main inhibitory receptor in the brain, the GABAA receptor. In acidified water, fish regulatory changes of HCO₃⁻ and Cl⁻ ions across the neural membrane could render some GABAA receptors excitatory rather than inhibitory thereby affecting fish behavior. Here we investigated the involvement of the GABAA receptor in the three spined stickleback (*Gasterosteus aculeatus*), a temperate species that was recently found to be sensitive to high-CO₂ exposure (~1000 µatm). We show that loss of behavioural lateralization can be rapidly counteracted by GABAA receptor antagonist treatment, indicating that elevated CO₂ interferes with GABAA receptor function.

MECHANISMS OF REPRODUCTIVE TOXICITY FOLLOWING EXPOSURE TO BISPHENOL A IN ZEBRAFISH

Laing, L.V., Viana, J., Trunkfield, L., Uren Webster, T.M., Mill, J., and Santos, E. M.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P49
Contact: Lauren Laing **E-mail:** ll292@exeter.ac.uk
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Abstract: Bisphenol A (BPA) is a high production chemical present in epoxy resins and polycarbonate plastics. This chemical is ubiquitous in the environment resulting in widespread exposure of aquatic organisms. Previous evidence demonstrated that BPA induces oestrogenic effects associated with adverse effects on reproduction in fish and mammals, and the potential for epigenetic effects has also been suggested. We aimed to investigate the reproductive effects of BPA in fish, and document the potential (epi)genetic mechanisms mediating these effects. We conducted a 15 day exposure of breeding zebrafish to 0.01, 0.1 and 1mg/L BPA. 1mg/L BPA significantly reduced fertilisation, increased the Hepatosomatic Index of males and appeared to increase egg production. We are now conducting transcription profiling for known oestrogen responsive genes and steroidogenic enzymes, as well as

DNA methylation analysis of the promoters of selected genes in order to investigate potential mechanisms resulting in the physiological effects we have observed.

FISH CELL LINES: AN IN-VITRO TOOL FOR AQUATIC TOXICOLOGICAL STUDIES

Lakra, W. S., Rathore, G., and Goswami, M.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 6

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Abstract: Fish cell lines can be employed as biological alternative to the use of whole animals and are critical component of experiments involving physiological responses of host to external stimuli. In last few years, we have developed cell lines from *Labeo rohita*, *Cyprinus carpio*, *Chitala chitala*, *Tor tor*, *Schizothorax richardsonii* and *Puntius chelynoides*. Most of these cells were able to grow at temperatures between 25°C and 32°C in L-15 medium. Cells showed fibroblastic morphology, high plating efficiency and diploid chromosome number. One of the cell line (RF) developed from *L. rohita*, was used as an in vitro tool for monitoring of heavy metal cytotoxicity in the aquatic environment through various endpoint assays including maximum tolerated dose determination, MTT assay, neutral red uptake assay and Coomassie brilliant blue assay. Our results illustrate the utility of fish cell line as an in vitro model for aquatic toxicological studies.

TRANSCRIPTOMIC DIFFERENCES IN THE GILLS OF EURYHALINE MOZAMBIQUE TILAPIA IN HYPO- AND HYPER-OSMOTIC STRESS.

Lam, S.H., Lui, E.Y., Li, Z., Cai, S., Sung W.K., Mathavan, S., Lam, T.J., and Ip, Y.K.

Symposium: Physiological Genomics **Type:** Oral **Order:** 4

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Abstract: The euryhaline *Oreochromis mossambicus* is an interesting model for investigating iono-osmoregulation because of its remarkable ability to tolerate extreme environmental salinity fluctuation. The gills are important iono-osmoregulatory organ, however, most studies have focused mainly on several key molecules or parameters hence yielding limited perspective of the versatile iono-osmoregulation in this euryhaline fish. In this study, we employed next-generation sequencing technology to capture transcriptome-wide differences in the gills of the freshwater- and seawater-acclimated Mozambique tilapia. We identified over 5000 transcripts with high homology (E-value <1.0E-50) to human genes that were differentially expressed and were significantly associated with over 50 canonical signaling pathways that are operating in at least 23 biological processes. Additionally, over 100 transcripts encoding putative inorganic ion transporters/channels were identified. We have also validated the expression profiles of selected genes in tilapia acclimated to freshwater, seawater and hypersaline water. This study has provided an unprecedented transcriptome-wide perspective of iono-osmoregulation in gills since such investigations were initiated more than 80 years ago.

EXPRESSION PROFILING OF KEY ION TRANSPORTERS AND AQUAPORINS IN THE GILL AND ESOPHAGEAL-GASTROINTESTINAL TRACT OF EURYHALINE MOZAMBIQUE TILAPIA IN FRESHWATER, SEAWATER AND HYPERSALINE WATER.

Lam, S.H., Lui, E.Y., Li, Z., Wilson, J.M.W., Ip, Y.K., Lin, Q., and Lam, T.J.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 19

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Abstract: The remarkable ability of euryhaline Mozambique tilapia to tolerate extreme salinity fluctuation makes it an excellent model for investigating iono-osmoregulation and euryhalinity. Using next-generation sequencing, we identified above five-thousand human homologs which were significantly associated with over fifty canonical signaling pathways operating in at least twenty-three biological processes that were differentially regulated in gills or gut of freshwater- and seawater-acclimated tilapia. Expression of selected key ion-transporters and several aquaporin isoforms were quantified using real-time PCR in the gills and esophageal-gastrointestinal tract of tilapia acclimated in freshwater, seawater and hypersaline water. Among the tissues investigated, gill and posterior intestine were found to be highly responsive to salinity changes, followed by anterior and middle intestine. The findings were partly corroborated by immuno-localization of selected transport proteins. The ability of the tilapia to significantly up-regulate intestinal key ion transporters and specific aquaporin isoforms especially in the posterior intestine is likely crucial for its survival in extreme hypersalinity. This study has provided unprecedented transcriptomic view and new insights into the gene responsiveness and tissues under iono-osmoregulatory stress in the tilapia.

THE ROLE OF 1-ALPHA-HYDROXYCORTICOSTERONE IN THE ENDOCRINE STRESS RESPONSE OF ELASMOBRANCHS

Lambert, F.N., Treberg J.R., and Evans, A.N.

Symposium: Elasmobranchs **Type:** Oral **Order:** 17

Contact: Faith Lambert **E-mail:** faith.lambert@eagles.usm.edu

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Abstract: The corticosteroid 1-alpha-hydroxycorticosterone (1-alpha-OH-B) is unique to the elasmobranch fishes, where it is thought to serve a dual function as both mineralocorticoid and glucocorticoid. However, the role of 1-alpha-OH-B in the endocrine stress response, particularly its role as a glucocorticoid, has yet to be directly examined. In this experiment, male Atlantic stingrays (*Dasyatis sabina*) were exposed to air for thirty minutes to induce primary and secondary stress responses. Blood samples were taken at 0, 15, and 30 minutes, with a recovery sample at 48 hours. During air exposure, blood lactate, PCO₂, and acidosis significantly increased, indicating a strong secondary stress response. At 48 hours these parameters were fully recovered to basal levels. Our results include the first specific measurement of circulating 1-alpha-OH-B during stress, providing critical insight concerning the glucocorticoid role of 1-alpha-OH-B as well as the relative importance of glucose vs. beta-hydroxybutyrate as oxidative fuels in the elasmobranch fishes.

DEVELOPMENT OF A 3 DIMENSIONAL IN VITRO MODEL USING GASTROINTESTINAL TRACT CELLS (RTGUTGC) OF RAINBOW TROUT FOR ECOTOXICOLOGICAL STUDIES

Langan, L.M, Owen, S.F, Jackson, S.K, Purcell, W.M and Jha, A.N

Symposium: Fish Cell Cultures **Type:** Poster **Order:** P32

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Abstract: Monolayer cell cultures have been widely used for biological studies. These cells however lose many of their physiological attributes important for organ function. In this context, spheroid or 3 dimensional (3D) cultures are viewed as a bridge between the standard monolayer culture system and in vivo models, as they better mimic the

physiological conditions. This study aimed to develop and characterise spheroids from cells of the gastrointestinal tract (GI) origin. RTgutGC, an established cell line from rainbow trout (*Oncorhynchus mykiss*) was used to establish spheroids in 96 well plates by a gyratory-mediated method. Spheroid formation was divided into two phases: immature (1-7 days) and mature (>7 days). Confocal and electron studies of the spheroids showed some of the typical characteristics of the intestinal cells including presence of 'finger like' projections morphologically similar to micro villi. Preliminary findings suggest that the spheroids developed from the established cell line (RTgutGC) morphologically resemble tissue/cells in vivo. This is an important step forward in developing an alternative in vitro tool for fish ecotoxicological studies.

PROTECTING HUMAN FOOD SECURITY AND BIODIVERSITY: CAN FISH ENERGETICS HELP TO PREDICT THE IMPACTS OF CLIMATE CHANGE ON TROPICAL FRESHWATER FISHES?

Lapointe, D., Cooperman, M.S., Clark, T.D., Chapman, L. J., Farrell, A.P., Kaufman, L., Hannah, L., Val, A.L., Ferreira, M.S., Balirwa, J.S., Mbabazi, D., Mwanja, M., Limhong, C., and Cooke, S.J.

Symposium: Climate Change **Type:** Oral **Order:** 3

Contact: Dominique Lapointe **E-mail:** dominique.lapointe@carleton.ca

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Abstract: Following Janzen's hypothesis, research has demonstrated that organisms from thermally stable environments tend to be thermal specialists, and that for some of them, optimal metabolic performance is achieved at temperatures near their upper tolerance limits. Therefore, fish of tropical environments may be exceptionally sensitive to even small changes in temperature anticipated from global climate change. Despite that threat, the thermal biology of tropical freshwater fishes has received little attention, albeit they represent an important source of protein and income for many local communities. Hence, this project aims to assess whether the thermal sensitivity of fish metabolism and energetics can be used to forecast the vulnerability of key tropical freshwater fishes to climate change. Experiments are conducted at three locations (Brazil, Uganda, and Cambodia), where we quantify the metabolic capacities of two species acclimated for 3 weeks to three water temperature treatments. The project addresses a time sensitive conservation problem, with a goal to contribute to the protection of culturally and socio-economically important fish species in the tropics.

A SYSTEMATIC NEXT-GENERATION ANALYSIS OF THE IMPACT OF GENOME DUPLICATION ON THE PHYSIOLOGICAL EVOLUTION OF SALMONID FISH

Lappin, F.M., Martin, S.A.M., Macqueen, D.J.

Symposium: Physiological Genomics **Type:** Poster **Order:** P104

Contact: Fiona Lappin **E-mail:** r01fl13@abdn.ac.uk

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Abstract: Whole genome duplication (WGD) involves the doubling of an organism's ploidy level. As entire gene pathways are doubled, there is subsequent potential for new functions to arise and be selected on during evolution. An ancestral WGD to all salmonid fish occurred ~90Ma and an extensive set of the gene duplicates (paralogs) created have been retained during evolution. We are systematically examining the molecular evolution of salmonid paralogs from a broad range of functional pathways, including those regulating growth, immunity and smoltification. Our approach is exploiting sequence-capture enrichment and Illumina HiSeq to acquire thousands of paralogous coding sequences in fifteen salmonid species spanning the family tree. We plan to systematically reconstruct historic natural selective pressures acting on duplicated salmonid pathways using state-of-the-art comparative phylogenetic methods based on the non-synonymous to synonymous substitution rate. Our study system will allow us to test the hypothesis that WGD facilitated the physiological evolution of anadromy – an iconic and defining salmonid trait.

THE EFFECT OF MODULATING RATION AND DIETARY LIPID ON GROWTH, SMOLTING, AND EARLY MALE MATURATION IN YEARLING UMATILLA RIVER FALL CHINOOK SALMON

Larsen, D.L., Harstad, D.L., Spangenberg, D.K., Clarke, L., Beckman, B.R.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 20

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Abstract: In the Columbia and Snake River basins of the Pacific Northwest United States a significant number of fall Chinook salmon hatchery programs use yearling, as opposed to sub-yearling, rearing regimes for smolt production. This strategy produces large smolts capable of avoiding predation, but mounting evidence suggests that these programs experience high rates of early male maturation (age-1 microjacks, age-2 minijacks, age-3 jacks) as opposed to age-4 and -5 fish. High rates of early male maturation are symptomatic of an imbalance in the life-history composition of a population, may have negative ecological impacts, reduce the number of full size adults and are a waste of program resources. Several studies have confirmed that age of maturation in Chinook salmon is influenced by dietary lipid and autumn growth rate. Here we report early results from the first two release years of a four year production scale 2x2 factorial experiment being conducted with Umatilla River fall Chinook salmon at Bonneville Hatchery, OR examining the effect of High (18%) and Low (12%) lipid diet and High (7 days/wk) and Low (4 days/wk) ration on growth, smolting, demographics and smolt-to-adult returns (SARs). Treatments were differentially coded-wire and PIT tagged for subsequent post release evaluation. We monitored bi-monthly length, weight, K, body lipid, gill Na⁺/K⁺-ATPase activity (smolt index), and final microjack and minijack rates via measurement of plasma 11-ketotestosterone levels. The treatments successfully altered growth rate, and body lipid levels. Based on gill ATPase activity all treatments, except LoFat-LoRation, smolted in the first fall and then again in the spring with spring levels being highest in the LoFat-LoRation and lowest in the HiFat-HiRation. Early male maturation rates (microjacks + minijacks) ranged from 60-70% of all males in HiFat-HiRation and HiFat-LoRation, 53% in the LoFat-HiRation and 36% in the LoFat-LoRation. Taken together, these data suggest that reducing autumn size and lipid level had a significant impact on optimizing smolt development and decreasing early male maturation at a reduced feed cost. However, this outcome came at the expense of smolt size and future adult return data will confirm which rearing strategy may be optimum for improving SARs in this and other yearling fall Chinook salmon hatchery programs.

COLLAGEN FORMING FISH CELL LINES AND THEIR USE IN FISH PHYSIOLOGY AND TOXICOLOGY

Lee, L.E.J., Spiteri, K.W.J., Mak, A.S.M., Vo, N.T.K., Alexander, J.A.N., Saran, M.K., and Bols, N.C.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 1

Contact: Lucy Lee **E-mail:** lucy.lee@ufv.ca

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Abstract: Collagen is the most abundant protein in vertebrates including fish. It is a major structural protein, whose synthesis and deposition is regulated by hormones and diet, and is modulated by disease and physico-chemical factors. Despite its pivotal role in structural integrity, growth, and wound healing, comparatively little is known about fish collagen synthesis, regulation, and role in fish health. In vitro models have been crucial for human and higher vertebrates to study collagen synthesis and secretion, yet very few models have been developed for fish. Like humans and other primates, teleosts require Ascorbic acid (AA) in their diet for collagen synthesis as they lack gulonolactone oxydase, a critical enzyme for AA synthesis. This study provides an overview on the use of novel fish cell lines to study collagen, as models to evaluate physico-chemical factors regulating synthesis, secretion and deposition of collagen, wound healing, disease progression, toxicity studies and nutraceutical effects.

EFFECTS OF DIETARY INCLUSION OF SOLID CULTURE FERMENTED SOYBEAN MEAL WITH PHAFFIA RHODOZYMA ON THE MUSCLE PIGMENTATION AND ANTIOXIDANT ENZYME ACTIVITY OF JUVENILE RAINBOW TROUT

Lee, S.Y., Choi, J., Chang, K.H., Cho, S.J., Seo H.J., and Lee, S.M.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P68

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Abstract: A feeding trial was conducted to investigate dietary inclusion of fermented soybean meal (FSM) with *Phaffia rhodozyma* for the muscle pigmentation of rainbow trout. Seven diets were formulated to contain 0, 50, 75 and 100 ppm astaxanthin adding by different levels of FSM or carophyll pink (DSM). Growth performance and feed utilization of fish were not affected by dietary FSM or DSM levels. The muscle redness of fish fed the A50DSM, A75FSM, A75DSM, A100FSM, A100DSM were higher than control diet. Total carotenoid content in the muscle of fish fed the A50DSM diet was higher than control diet. The astaxanthin contents in the muscle of fish fed the A50DSM, A75DSM and A100DSM diets were higher than control diet. The results suggest that a diet contained 50 ppm astaxanthin formulated with 10% FSM could be useful for muscle pigmentation of juvenile rainbow trout.

BEING AN AIR BREATHER IN THE ARCTIC: HOW DOES ALASKA BLACKFISH SURVIVE HYPOXIA AND SUBMERGENCE?

Lefevre, S., Stecyk, J.A.W., Damsgaard, C., Pascale, D.R., Nilsson, G.E.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 4

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Abstract: The Alaska blackfish (*Dallia pectoralis*) is the only air-breathing fish in the Arctic. Consequently, a thick layer of ice during winter months effectively precludes air breathing. Here we evaluated the dependence on air breathing under different environmental conditions. Oxygen uptake ($\dot{M}O_2$) from air and water was measured for 5°C- and 15°C-acclimated fish in normoxia and hypoxia, with and without air access. Alaska blackfish relied more on air breathing when facing hypoxia than high temperature. When exposed to hypoxia without air access, $\dot{M}O_{2rest}$ decreased by 30% at both 5°C and 15°C, and fish lost equilibrium after 6 and 3 h, respectively. The critical PO_2 (P_{crit}) was high (5 kPa) and independent of acclimation temperature, indicating an ability to maintain P_{crit} despite an 88% higher $\dot{M}O_{2rest}$ at 15°C. Compensatory changes of gill morphology or haemoglobin oxygen affinity did not contribute to the temperature independence of P_{crit} . This study suggests that the Alaska blackfish must avoid severe hypoxia unless it has access to air.

DIFFERENT POSSIBILITIES FOR TRACKING STURGEON MIGRATION AND HABITAT MAPPING IN THE DANUBE RIVER

Lenhardt, M., Jaric, I., Skoric, S., Smederevac-Lalic, M., Cvijanovic, G., Djikanovic, V., Visnjic-Jeftic, Z., Hegedis, A., Mickovic, B., Nikcevic, M., Jovicic, K., Jacimovic, M. and Gacic, Z.

Symposium: FITFISH **Type:** Oral **Order:** 6

Contact: Mirjana Lenhardt **E-mail:** lenhardt@ibiss.bg.ac.rs

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Abstract: Out of six sturgeon species which originally inhabited the Danube River, European sturgeon (*Acipenser sturio*) is considered as already extinct, ship sturgeon (*A. nudiiventris*) is on the brink of extinction, while beluga (*Huso huso*), Russian sturgeon (*A. gueldenstaedtii*) and stellate sturgeon (*A. stellatus*) became critically endangered

due to overfishing and dam building, which interrupted their migration routes. The downstream dam is situated on 863 river km, and the upstream dam on 943 river km, with no fish passes provided. More effort is needed to track sturgeons' behaviour at the downstream dam, as well as to characterize spawning, wintering and nursering habitats. In this work, detailed comparative analysis of available methods for such investigations was conducted, and of their potential advantages and disadvantages. Analysis included radio and acoustic transmitters, data storage tags, pop-up satellite tags and PIT tags, as well as the use of Adaptive Resolution Imaging Sonar (ARIS).

LINKING WINTER HABITAT VARIABLES TO FISH CONDITION IN ICE COVERED STREAMS

Leonard, J.B.K, Gagnon, C., Guth, R., Haavisto, J., Wagner, J.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 6

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Abstract: Characterizing localized fish habitat and linking it to biologically relevant indicators of fish success is particularly challenging during the winter in regions where ice covers streams. We have developed techniques for evaluating ice and substrate variability in small streams and linked these variables to fish overwinter condition change. This approach has allowed us to quantitatively characterize patterns in winter stream habitat variability that relate to habitat stability and fish condition in several species. Our data support the contention that constant ice cover and constant open water both represent stable winter conditions while dynamic ice represents unstable conditions which may be more challenging to fish. We suggest that streams, or reaches, may be vulnerable to shifting stability classification due to climate change and that characterization of winter habitat variability may allow managers to identify streams within a local area that are more vulnerable to climate change impacts.

DIET ANALYSIS OF BURBOT FROM EASTERN LAKE MICHIGAN: 1999-2012

Leonard, J.B.K. and Hares, C.J.

Symposium: Burbot **Type:** Oral **Order:** 5

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Abstract: The Lake Michigan fish community has undergone many changes due to introduction of non-native species, but the time course of impact on the food web in the lake is not well understood. Burbot (*Lota lota*) is neglected in most management plans, despite their status as a top level, native-predator in the Great Lakes. We used burbot diet samples from eastern Lake Michigan to evaluate temporal alterations (1999-2012) in diet with particular attention to non-native vs. native prey. The collective contribution of sculpin, alewife, and ninespine stickleback to burbot diet decreased from ~80% before 2006 to ~15% in 2012. Round goby contribution to burbot diet increased from ~0% before 2006 to >60% in 2012, implying a dramatic diet shift for burbot in just six years. This diet shift suggests a change from pelagic/benthic to benthic foraging, and a change in prey consumption from alewife/cottid sculpin to invasive round goby.

ANATOMICAL AND FUNCTIONAL NETWORKS IN THE TELEOST PITUITARY

Levavi-Sivan, B. and M. Golan

Symposium: Reproductive Physiology **Type:** Oral **Order:** 4

Contact: Berta Levavi-Sivan **E-mail:** berta.sivan@mail.huji.ac.il

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Abstract: Tilapia have become one of the most important fish in world aquaculture, as well as important model fish. We produced transgenic tilapia lines in which the gonadotroph cells are labeled in order to study their population dynamics, anatomy and function in the context of the reproductive axis. 3-D imaging of labeled gonadotrophs using advanced imaging techniques, reveals that these cells have unique distributions and form large-scale homotypic networks. Functional coupling through gap junctions was found to mediate the response to GnRH in LH, but not FSH cells. We were also able to label folliculostellate cells in the teleost pituitary. These cells form a structural and functional network within the PI and PPD and are closely associated with FSH cells, but not with LH cells. Our findings provide novel tools for the study of gonadotroph function and shine new light on the intricate relationships between cells of the teleost pituitary.

THE EFFECTS OF PHOTOPERIOD, TEMPERATURE ACCLIMATION AND HEAT SHOCK ON GENE EXPRESSION IN SALMONIDS

Lewis M., Anttila K., Kanerva M., Prokkola J., Nikinmaa M.

Symposium: Stress in Fish **Type:** Poster **Order:** P127

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Abstract: Increasing water temperature is a major environmental concern, particularly along northern latitudes where temperature, circadian and seasonal light variations are pronounced. Photoperiod influences various life history traits of temperate fish, and these rhythmic responses are often adjusted by temperature. Temperature is seldom used as a variable in estimating the rates of different control steps in gene expression, i.e. transcription, translation and mRNA and protein stability. Therefore, we have studied the effect of photoperiod and temperature on the transcription-translation relationship in two salmonid species (salmon and arctic charr). Fish were acclimated for 4 weeks to 8 and 14 °C. The transcription and translation of HSP70 was evaluated at the beginning, middle and end of the light cycle, since the HSP gene is both transcriptionally and translationally induced by heat shock, given to the animals prior to sampling. RT-PCR and western blotting were used to quantify inducible HSP70 gene transcription and translation, respectively.

SIMILAR RESPONSES TO HYPOXIA IN TWO AIR-BREATHING ANABANTOID FISHES WITH DIFFERENT GILL MORPHOLOGY

Lin, H.C., Lin, S.S., and Wang, M.C.

Symposium: Airbreathing Fish **Type:** Poster **Order:** P3

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Abstract: To balance the O₂ and metabolism demands, organisms may change from aerobic to anaerobic respiration by utilizing glycogen as the emergency fuel in glycogenolysis, and the function of sodium-potassium adenosine triphosphatase (Na⁺/K⁺-ATPase, NKA) may be depressed to preserve energy consumption. From our previous study on the morphological and biochemical variations in the gills of 12 aquatic air-breathing anabantoid fish, it is known that *Macropodus opercularis*, compared to *Helostoma temminckii*, has an apparent gill modification for blood transport in the 4th gill. The purpose of the present study was to compare the responses to hypoxia in these two species. Our results indicated that they responded similarly, including an increase in air-breathing frequency and no decline in blood glucose, gill lactate and NKA activity. It is likely that glycogenolysis is taken place in glycogen-rich cells and glucose transferred to the nearby mitochondria-rich cells in gills.

AEROMONAS SALMONICIDA BINDS DIFFERENTIALLY TO MUCINS ISOLATED FROM SKIN AND INTESTINAL ORGANS
OF ATLANTIC SALMON IN AN N-ACETYLNEURAMINIC ACID DEPENDENT MANNER

Lindén, S.K., Padra, J.T., Sundh, H., Jin, C., Karlsson, N.G., and Sundell, K.

Symposium: Parasites and Diseases **Type:** Oral **Order:** 2

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Abstract: *Aeromonas salmonicida* infection, furunculosis disease, cause morbidity and mortality in salmonid aquaculture. The first line of defense the pathogen encounters is the mucus layer, which is predominantly comprised by mucins. We isolated and characterized mucins from the skin and intestinal tract of healthy salmonids and studied the binding of *A. salmonicida*. In the skin, the density and glycan chain length of the mucins were lower than in the intestinal tract mucins. *A. salmonicida* bound to the mucins isolated from the intestinal tract to a greater extent than to the skin mucins, in an N-acetylneuraminic acid dependent manner. Thus, sialylated structures are important for *A. salmonicida* binding, suggesting a pivotal role of sialylation in the mucosal defense. The marked difference in sialylation level as well as *A. salmonicida* binding between the skin and intestinal tract, suggests inter-organ differences in the host-pathogen interaction and in the mucin defense against *A. salmonicida*.

THE ROLE OF OXIDATIVE STRESS IN THE MECHANISMS OF AMMONIA-INDUCED BRAIN SWELLING AND TOLERANCE
IN THE GOLDFISH

Lisser, D.F.

Symposium: Stress in Fish **Type:** Oral **Order:** 7

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Abstract: Toxic build-ups of ammonia lead to swelling of astrocytes, which can cause potentially fatal brain swelling in mammals, but such swelling is reversible in the anoxia- and ammonia-tolerant goldfish. The present study tested the hypothesis that the higher antioxidant capacity of goldfish explained its greater ammonia tolerance compared to ammonia-sensitive rainbow trout (*Oncorhynchus mykiss*). Exposure to high external ammonia (HEA) resulted in pronounced 20- to 50-fold increases in plasma ammonia 48h in the trout and goldfish. Lipid peroxidation was significantly reduced in the liver relative to control values following 24h HEA exposure in goldfish, and activities of hepatic and muscle antioxidants (glutathione peroxidase, GPX; glutathione reductase) remained unchanged. However, the basal activity of hepatic GPX was significantly higher in goldfish than trout, suggesting that maintenance of high basal levels of antioxidant enzymes may be necessary for tolerance to ammonia. To confirm these findings, biomarkers of oxidative stress and activities of various antioxidant enzymes (GPX; GR; catalase, CAT) will be analyzed in the brain of goldfish and rainbow trout.

ROLE OF IONOCYTES IN MEDAKA LARVAE SUBJECTED TO ENVIRONMENTAL HYPERCAPNIA

Liu, S.T., Chen, P.Y., Horng, J.L., Lin, L.Y.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P87

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Abstract: Ionocytes in fish gill and skin play a critical role in acid-base regulation. In previous studies, the coupling of Na⁺/H⁺ exchanger (NHE3) and rhesus glycoprotein (Rhcg1) in ionocytes of medaka (*Oryzias latipes*) was

suggested to secrete acid equivalents (H^+/NH_4^+) and was up-regulated in fish subjected to low pH water. However, it is unclear how the ionocytes response to acidosis caused by environmental hypercapnia. In this study, a scanning ion-selective electrode technique (SIET) was applied to measure H^+ and NH_4^+ secretion by individual ionocytes in skin of medaka larvae exposed to 1% CO_2 for 5 days. The hypercapnia treatment increased H^+ secretion but decreased secretion by the yolk-sac skin, suggesting that the ionocyte does not favor NH_4^+ for acid secretion under hypercapnia. The hypercapnia-induced H^+ secretion was suppressed by the NHE inhibitor. Interestingly, hypercapnia treatment also caused alkalization of the apical surface of ionocytes. The alkalization was reduced by acetazolamide, an inhibitor of carbonic anhydrase (CA). Two type of CA, ca2 and ca15, were found in the ionocytes with in situ hybridization. Real-time PCR showed that the mRNA levels of nhe3, rhcg1 and ca15 but not ca2 of gills were induced by the hypercapnia. This study suggests that NHE3, Rhcg1 and the membrane-bound CA15 are critical for acid secretion by ionocytes in response to hypercapnia.

EXPRESSION OF BK POTASSIUM CHANNELS IN GILLS OF SALMO SALAR DURING SMOLTIFICATION

Loncoman, C., Gutierrez, L., Strobel, P., Oyarzun, R., Conejeros, I., Alarcon, P., Contreras, C. and Morera, F.J.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P88

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Abstract: Instrumental to smoltification process is the ability of smolt gills to gradually become capable of active salt secretion. The mechanism of NaCl secretion requires a thermodynamic prerequisite to work under conditions of high extracellular salinity in seawater, which is the recycling of extracellular potassium, most likely through potassium channels. However, the identities of potassium channels required for NaCl secretion in seawater are still unknown for *Salmo salar* and only recently have begun to be studied in other teleosts. In the present study, we show the expression of mRNA from a high conductance voltage- and calcium-activated potassium (BK) channel in gills of *Salmo salar* and we explore if mRNA expression of BK channel is modified during the progression of smoltification. The detection and changes in mRNA expression were made in conjunction with the enzymatic activity of Na^+/K^+ ATPase, the current “molecular marker” of smoltification widely used by the Chilean salmon industry.

PHYLOGENETIC AND MOLECULAR APPROACHES TO UNDERSTANDING CALCIUM-SENSING RECEPTOR FUNCTIONS IN FISHES

Loretz, C.A., and Herberger, A.L.

Symposium: Cellular Signalling **Type:** Oral **Order:** 9

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Abstract: The extracellular calcium-sensing receptor (CaSR) is a key detector of ionic calcium in vertebrates. Represented in all vertebrate classes, the CaSRs are a highly-conserved family of proteins closely related phylogenetically to pheromone, odorant, taste and vomeronasal receptors of the GPCR superfamily. CaSRs are widely expressed in tissues with various roles in calcium homeostasis. In mammals, these roles have been well studied in health and disease, but in fishes, until recently, little has been known. By comparative protein homology modeling, group-specific differences in structure distinguish CaSRs of cartilaginous fishes, bony fishes and tetrapods. Using functional expression of cloned fish receptor, ligand sensitivity and downstream transductional signaling have been compared with those of mammal receptor and related to protein structure differences. The tissue distribution of CaSR in fishes suggests roles in detecting both extracellular (but internal) and external calcium concentrations. And, recently, CaSR knockdown in zebrafish has revealed the specific importance of this receptor in normal development.

THE MOLECULAR BASIS OF PARR-SMOLT TRANSFORMATION IN ATLANTIC SALMON

Lorgen, M., Casadei, E., Birnie, M., Hazlerigg, D.G. and Martin, S.A.M.

Symposium: Sensing the Environment **Type:** Oral **Order:** 17

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Abstract: Atlantic salmon are well known for undertaking extensive anadromous migrations. Before seaward migration, freshwater juveniles (parr) must become seawater adapted smolts. This transition is called parr smolt transformation (PST). PST is triggered by photoperiod. In seasonal birds and mammals, a conserved pathway of active thyroid hormone (T3) regulation via the action of photoperiodically regulated deiodinase (DIO) genes has been shown to regulate seasonal responses. It is unknown if the same pathway is present in teleost fishes. We characterized the DIO genes in *S. salar*, identifying 6 in total: DIO1, DIO2A, DIO2B, DIO3A1, DIO3A2 and DIO3B. As DIO2 genes activate thyroid activity, we examined DIO2 mRNA expression under changing photoperiod across PST in gill and brain using qPCR. We found a highly significant increase in DIO2B under long day (LD) photoperiod in both gill and brain, while DIO2A increased significantly on transfer to seawater in gill only. In silico promoter analysis of the DIO2 paralogues suggests transcriptional regulation differences. The results suggest evolution of differential function following the salmonid specific whole genome duplication event.

NEURO-ENDOCRINE CONTROL OF THE SALINITY ADAPTABILITY IN FISH – A STUDY OF FISH CAUDAL NEUROSECRETORY SYSTEM

Lu, W., Mccrohan, C. and Balment, R.

Symposium: Cellular Signalling **Type:** Oral **Order:** 13

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Abstract: The caudal neurosecretory system (CNSS) is a part of stress response system, a neuroendocrine structure unique to fish. Large peptide-synthesizing neurons, Dahlgren cells, located in the terminal segments of the spinal cord, project to a neurohaemal organ, the urophysis, from which neuropeptides are released into the circulation. CNSS is the major site of expression and secretion of CRF, UI and UII. These peptides are differentially expressed with co-localisation of up to two in a single cell. Dahlgren cells display a range of electrical firing patterns, including characteristic bursting activity, which is dependent on L-type Ca²⁺ and Ca-activated K⁺ channels. Electrophysiological and mRNA expression studies have examined changes in response to altered physiological demands. Bursting activity is more robust and more Dahlgren cells are recruited in seawater compared to freshwater adapted fish and this is mirrored by a reduction in mRNA expression for L-type Ca²⁺ and Ca-activated K⁺ channels. Acute seawater/freshwater transfer experiments support a role for CNSS in adaptation to changing environmental salinity. We hypothesise that the Dahlgren cell population is reprogrammed during salinity adaptation, and this is seen as changes in gene expression profile and electrical activity.

DO AEROBIC METABOLIC CAPACITIES REGULATE GROWTH AND REPRODUCTION PERFORMANCES IN THE SHORT LIVE NOTOBRANCHUS FURZERI?

Lucas J., M. Durollet, Schouman A., L. Kayser, C. Lefrançois

Symposium: Growth and Metabolism **Type:** Poster **Order:** P69

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Abstract: Assessing fitness is a fundamental component for understanding population dynamics since it is related to reproductive success and survival. In fish, fitness is mainly evaluated through different proxies, such as aerobic metabolic scope (AMS), growth and other physiological performances (e.g. locomotion and cardiovascular functions). However, relationship between fitness and these variables remains unclear, because of the long lifespan of most of the fish species and the consequent difficulty in assessing all along their life cycle these variables, as well as the reproductive effort. *Nothobranchius furzeri* is an annual species characterized by a 3 to 6 months lifespan. The objective of this study is to explore the relationship between AMS, food intake, growth and reproductive effort in mature fish and senescent *N. furzeri* acclimated to an optimal (26°C) and a limiting (22°C) temperature. Preliminary results in adults will be presented and individual relationships between the variables measured will be discussed.

PARENTAL TROPHIC EXPOSURE TO POLYCYCLIC AROMATIC HYDROCARBONS EFFECTS ON METABOLIC AND SWIMMING PERFORMANCE IN DESCENDANTS OF ZEBRAFISH

Lucas J., Percelay I., Nouhaud M., Rosset L.-C., Lefrançois C.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 5

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Abstract: Found as complex mixtures in environment, PAHs effects depend of their concentration, their origins (i.e. petrogenic and pyrolytic), their chemicals properties, the way of contamination and the lifestage considered. In aquatic ecosystem, fish eggs could be directly affected by PAHs via contact with contaminated sediment and/or water, as well as through parental transfer. The aim of our study was to investigate the effects of parental trophic exposure to pyrolytic and petrogenic PAHs in zebrafish *Danio rerio*. Zebrafish parents were exposed to environmental-relevant concentrations of PAHs from the first meal (i.e. 5 day post fertilization, dpf) to the age of reproduction. Parental effect was evaluated through the assessment of aerobic metabolic scope, cardiac frequency and locomotor performance at larval and juvenile stages of the descendance. Reproduction impairments did not permit the study of petrogenic descendants. While no effects were observed on pyrolytic parents, our results suggest that this type of PAHs induced tachycardia in 5 dpf-larvae and reduced aerobic metabolic scope in 2-months juveniles. On the contrary, locomotor performance, assessed through critical swimming speed, was not affected.

EFFECTIVENESS OF TECHNICAL FISH PASSES FOR UPSTREAM-MIGRATING EUROPEAN RIVER LAMPREY - ARE WE ANYWHERE NEARER UNDERSTANDING WHY THEY FUNCTION AS THEY DO?

Lucas, M.C., Foulds, W.L., Tummers, J.S., Silva, S., Jang, M.-H. and O'Brien, P.

Symposium: Lampreys **Type:** Oral **Order:** 10

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Abstract: A key element to conservation of threatened migratory lampreys is provision of upstream passage at barriers, yet the efficacy and suitability of fishway types for lampreys are poorly known. Lampreys have relatively poor sustained and burst swimming performance and while some species are good climbers, the European river lamprey *Lampetra fluviatilis*, is not one of these. Using Passive Integrated Transponder (PIT) telemetry, this study evaluated the efficacy of pool-weir, plain Denil baffle, Larinier super-active baffle, bristle elver pass fishways for river lamprey. In Britain, the Larinier, is the main 'multi-species' fishway type. For lamprey that entered fishways, 0%, 0.3%, 0% and 5% passage efficiencies were recorded for Denil, Larinier, elver, and pool-weir fishways, respectively. In studies at the Larinier and elver passes at one weir, five of 31 (16%) lamprey tagged with acoustic tags as well as PITs, passed directly over the Crump weir, rather than through the multispecies fishway. Flow-

velocity measurements within the Larinier pass indicate that, at least during lower flows, water velocities were substantially lower than recorded burst swimming capability, suggesting that passage failure may have a behavioural element. The pool and weir pass, and elver pass, exhibited poor attraction efficiency (43%, 11% respectively) compared to the Denil and Larinier (92%, 91% respectively), probably as a result of ineffective attraction flow direction at the pool and weir (emerging perpendicular to main flow) and low attraction flow at the elver pass. Many lamprey detected at the fishway entrances were recorded within 24h of release and returned mostly during high flow events on up to 12 separate dates over a period of 4-5 months. Under study conditions, these fishways were unsuitable for river lamprey. If river lamprey are to be passed effectively, research and implementation needs to concentrate on providing fish passes with hydraulic conditions that are amenable to their passage.

EFFECT OF PROBIOTIC BACILLUS POLYFERMENTICUS AGAINST STREPTOCOCCUS AGALACTIAE AND GROWTH PROMOTION OF TILAPIA

Lukkana, M., and Wongtavatchai, J.

Symposium: Parasites and Diseases **Type:** Poster **Order:** P102

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Abstract: In vitro antibacterial activity of *Bacillus polyfermenticus* (BP) against tilapia Streptococcal pathogen was evaluated using the agar dilution method and co-incubation method. Both in vitro tests conformed the inhibitory effect of BP on the growth of *Streptococcus agalactiae*. Tilapia fry (0.04 gm body weight) were challenged with a 6 hour immersion bath of 103 CFU/mL *S. agalactiae* (infective dose 20%) following a 28 day feeding BP supplemented diet to test their disease resistance. Growth performance observed in tilapia fry and broodstocks all support the growth promotion potency of the supplemented diet, however, BP supplemented diet failed to prevent the disease in tilapia fry immersion infected with *S. agalactiae*. The present study demonstrated growth promoting and the in vitro inhibitory potency of BP against *S. agalactiae*, whereas, disease resistance was not achieved in tilapia fry.

IN VITRO EFFECTS OF L-LEUCINE, L-ARGININE AND L-GLUTAMINE ON ADIPOGENESIS AND LIPID METABOLISM IN RAINBOW TROUT

Lutfi, E., Urpi, A., Velez E.J., Gutierrez J., Capilla, E., Navarro, I.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 10

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Abstract: Some nutritional effects on adipocyte development and lipid metabolism regulation appear to be mediated by the dietary amino acid profile. In order to investigate how individual amino acids are involved in lipid metabolism and adipogenesis in fish, we examined the effects of L-leucine, L-arginine and L-glutamine on lipid mobilization and cell proliferation/differentiation in rainbow trout cultured adipocytes. All treatments produced a significant increase in cell proliferation. Nevertheless, only L-leucine showed a clear lipolytic effect and anti-differentiation action decreasing lipid accumulation at different culture stages. Gene expression and western blot analyses are being also performed to further elucidate the effects of these amino acids in the main lipid metabolism and cell proliferation/differentiation markers and their signaling pathways. These findings indicate the importance of amino acids during adipogenesis and lipid mobilization, contributing to improve our knowledge on their regulatory role in rainbow trout adipocyte metabolism. Supported by EU (LIFECYCLE FP7-222719), MICINN (AGL2011-24961).

INTER-SPECIFIC DIFFERENCES IN FISH CARDIOPHYSIOLOGY REVEALED USING ECHOCARDIOGRAPHY

Ma, K. G. L., Gamperl, A. K., Rodnick, K. J., Syme, D. A., and Weber, L. P.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P78

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Abstract: Doppler and B-mode ultrasonography, and electrocardiography, were used to examine cardiac hemodynamic function in three fish species with markedly different heart morphologies [northern pike (*Esox lucius*), white sturgeon (*Acipenser transmontanus*) and rainbow trout (*Oncorhynchus mykiss*); weight ranges between ~ 100-250 g] under light anaesthesia at 12°C. *Visa-a-fronte* filling of the atrium (i.e. due to ventricular contraction) was observed, and the diameter of the atrio-ventricular (AV) and ventriculo-bulbar (BV) valves was very similar, in all three species. In contrast, there were several clear differences in ventricular filling and ejection. Biphasic ventricular filling (due to both central venous pressure and atrial contraction) was recorded in 75% of sturgeon and 89% of trout, whereas the former was rarely observed in pike. In addition, while peak blood velocity through the AV valve was highest in pike (~ 55 vs. 20-25 cm s⁻¹ in sturgeon and trout), it was the sturgeon that differed with respect to ventricular ejection (~ 20 vs. 70–75 cm s⁻¹ in the other species).

ZNO NANOPARTICLES DISRUPT THE PHYSIOLOGICAL STRESS RESPONSE IN WHITE SUCKER

MacCormack, T.J., Bessemer, R.A., Robertson, A.B., Butler, K.M.A., Tunnah, L., Currie, S., and Dieni, C.A.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 14

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Abstract: Engineered nanomaterials (ENMs) trigger oxidative stress in the cardiovascular system but their physiological impact in fish is unclear. To address this, we studied the effects of environmentally relevant ZnO ENMs (nZnO) on white sucker, *Catostomus commersonii*, using electrocardiography, intermittent flow respirometry, and biochemical and molecular analyses. nZnO exposure triggered an oxidative stress response in multiple tissues and increased Na⁺/K⁺-ATPase activity and heat shock protein expression in gill. This was accompanied by a decrease in heart rate and no change in resting metabolic rate. Our results suggest that ENMs simultaneously initiate a direct biochemical stress response and a physiological hypoxia response via interactions with gill chemoreceptors. The resulting decrease in cardiac scope and increase in tissue energy demand could substantially reduce aerobic scope and impact survival in challenging environments. Studies are underway to address these questions and to clarify the risks associated with aquatic ENM exposure.

ASSESSMENT OF POSSIBLE HYBRIDIZATION IMPACT IN THE ANCESTRAL SEXUAL CASCADES

Machado, M.P., Matos, I., Pinho, J., Schartl, M. and Coelho, M.M.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 2

Contact: Miguel Machado **E-mail:** miguelpmachado@hotmail.com

Universidade de Lisboa, Faculdade de Ciências, DBA / Edifício C2, sala 2.3.12 / Campo Grande / 1749-016 Lisboa Portugal

Abstract: Mechanisms of sex determination are unexpectedly diverse and change rapidly during evolution. Presumably, sex-determining systems change when some factor destabilizes it, leading to the evolution of a new one. Since hybridization can bring abrupt changes in the sexual development genes, a higher variability may be found when considering sex determination in hybrid fishes. Iberian Peninsula rivers host an hybridogenetic

allopolyploid complex, the *Squalius alburnoides* complex, which presents a diploid all-male lineage and triploid lineages that sex biased towards female. *S. alburnoides* forms and the maternal species *Squalius pyrenaicus* interbreed with each other which may lead to recurrent situations of ploidy and genomic shocks. A whole transcriptome characterization of organs involved in sexual processes from adult males and female nuclear non-hybrid forms was implemented in order to identify genes that could be potentially involved in *S. alburnoides* sexual development, and to verify whether hybridization brings disturbance to the system.

TRANSCRIPTOME CHARACTERIZATION OF TISSUES INVOLVED IN SEXUAL MECHANISMS COULD SUGGESTS A
DISTINCT PATTERN OF SEX PLAYERS

Machado, M.P., Pinho, J., Matos, I., Grosso, A.R., Inácio, A, Schartl, M. and Coelho, M.M.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P50

Contact: Miguel Machado **E-mail:** miguelpmachado@hotmail.com

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Abstract: Sex determination is one of the most widespread ontogenetic processes and was expected to be highly stable during evolution. However, the opposite scenario is also be found, especially among fish. Moreover, gonadal fate decision is not final, but has to be actively maintained throughout life. *Squalius pyrenaicus* is a suitable model to study the sexual development of species living in variable environment. Through deep-sequencing, an extensive characterization of the adult female and male transcriptomes of this species was performed by RNA-seq and SSH-seq, using gonad, brain and liver. Our results suggest that *S. pyrenaicus* species undergoes an unexpected gene expression pattern, with several sex related genes presenting an opposite gender expression than the one described in literature for most of the fish species.

INTRODUCTION TO APPLICATION OF PHYSIOLOGY IN FISH CULTURE

MacKinlay, D.D.

Symposium: Fish Culture **Type:** Oral **Order:** 1

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Abstract: Fish are cultured throughout the world for conservation, restoration, harvest, recreation, food and ornamental markets, and scientific research. There are many practical ways that the many tools available in physiological research have been applied to increase the growth, survival and quality of fish during culture and, for stocked fish, survival after release. The talks in this Symposium include research on ion regulation, fatty acid synthesis, nutritional supplements, growth performance and thermal regulation, and their implications for improvements to fish culture. There are many more kinds of physiological research (from behavior to bioenergetics, from endocrine to exercise, from hepatic to histological, from reproductive to respiratory and from sensory to stress) that have the potential to enhance all of the aspects of fish culture (from adult capture and holding to egg-takes and incubation to growth and survival to rearing and release) to obtain the best possible product for fish farmers, fisheries agencies and their clients and stakeholders.

TUBULAR LOCALIZATION AND EXPRESSION DYNAMICS OF AQUAPORINS IN THE KIDNEY OF ATLANTIC SALMON

Madsen, S.S. and Engelund, M.B.

Symposium: Fish Kidney **Type:** Poster **Order:** P100

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Abstract: Aquaporins are well known facilitators of transcellular water movement in mammalian kidneys but in the teleost kidney not much is known about the molecular pathway of water transport. In this study we mapped the localization pattern of three aquaporins (Aqp) (Aqp1aa, Aqp1ab and Aqp8b) and two aquaglyceroporins (Aqp3a and Aqp10b) in the kidney of freshwater- and seawater-acclimated Atlantic salmon at both parr and smolt stage. All Aqps were most abundant in the proximal tubules and there was no clear effect of salinity on localization pattern. Aqp1aa and Aqp3a were found apically but extended throughout the epithelial cells. Aqp10b was found apically and along the lateral membrane. Aqp8b was mainly basolateral and Aqp1ab was found in subapical intracellular compartments. Aquaporin levels changed dramatically in response to both SW and sham transfer at the mRNA level but not the protein level, which remained constant for nearly all paralogs.

AQUAPORIN EXPRESSION IN THE JAPANESE MEDAKA IN FW AND SW: CHALLENGING THE PARADIGM OF
INTESTINAL WATER TRANSPORT.

Madsen, S.S., Bujak, J., and Tipsmark, C.K.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 17

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Abstract: The salinity dependent expression dynamics of 7 aquaporin paralogs (aqp1a, -3a, -7, -8ab, -10a, -10b and -11a) were investigated in several tissues of euryhaline Japanese medaka (*Oryzias latipes*). Most paralogs had a broad tissue distribution and several were affected by salinity in both osmoregulatory and non-osmoregulatory tissues. Surprisingly, in the intestine there was a strong decline in aqp1a, -7, -8ab and -10a upon SW-acclimation. Using custom made antibodies, Aqp1a, -8ab and -10a were localized apically in enterocytes of FW fish but strongly decreased, vanished or moved to sub apical regions, when fish were acclimated to SW. Further, 6 Na⁺,K⁺-ATPase α -subunit isoform transcripts were analyzed in the intestine but none showed a consistent response to salinity. In contrast, mRNA of the Na⁺,K⁺,2Cl⁻-cotransporter type-2 strongly increased in the intestine in SW compared to FW fish. The data are surprising and challenges the paradigm of transepithelial intestinal water absorption in SW fishes.

EFFECT OF ETHOFUMESATE HERBICIDE ON ENERGY METABOLISM IN ROACH

Maes, V., Vettier, A., Dedourge-Geffard, O., Geffard, A., Palluel, O., Sanchez, W., Paris-Palacios, S., Betoulle, S., David, E.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 1

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Abstract: Studying the energy metabolism constitutes an appropriate approach to detect physiological disturbances of organisms linked to their exposure to pollutants. In this study, juvenile roach were exposed to three concentrations of ethofumesate, a benzofuran herbicide, during seven days, at 10°C, in order to determine the effect of ethofumesate on the energy metabolism in roach at different (biochemical, molecular and cellular) regulation levels. Among biological processes involved in cellular energy synthesis, we focused on glycolysis and respiratory chain pathways. Glycolysis fluxes, gene expression, electron transport system, anti-oxidant responses and mitochondria ultrastructure were analyzed in muscle sampled after 0, 1 and 7 days of roach exposure. Effect of ethofumesate was mainly observable on glycolysis pathway, with a significant decrease of expression of hexokinase gene in contaminated fish compared to control. We can hypothesize that gene expression of hexokinase was

regulated to avoid any disturbance in glycolytic flux. This study provides potential new biomarkers related to the energy metabolism in fish.

EVOLUTION OF MELATONIN BIOSYNTHESIS: A 500 MY-OLD STORY

Magnanou, E., Cazaméa-Catalan, D., Besseau, L., Coon, S.L., Fuentès, M., Paulin, C.H., Jørgensen, E., Wolf, Y.I., Kooning, E.V., Hyodo, S., Klein, D.C., Falcon, J.

Symposium: General Contributed Papers **Type:** Oral **Order:** 7

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Abstract: Melatonin is the vertebrate hormone of the night: circulating levels are markedly higher at night than during day. This increase is driven by increases in acetylation of serotonin in the pineal gland by arylalkylamine-N-acetyltransferase (AANAT), the penultimate enzyme in the synthesis of melatonin. AANAT is also found in the retina where melatonin plays a paracrine role. Here, we focused on the evolution of AANAT in early vertebrates and tested the putative role of whole genome duplications (WGD) on their diversification, using cloning, syntenic analysis and functional assays. We found that pineal and retinal AANAT from Agnates and Chondrichthyes are compositionally, biochemically, and kinetically similar to AANATs found in bony vertebrates (VT-AANAT), while it is absent in Cephalochordates and other forms of life. VT-AANAT evolved from a duplication of the non-vertebrate gene form of AANAT after the Cephalochordate-Vertebrate split. Its emergence involved a dramatic acceleration of evolution that accompanied neofunctionalization. The appearance of new VT-AANAT forms in Actinopterygians and Teleosts are concomitant with known WGD. We discuss the resulting AANAT subfunctionalization and secondary losses.

VACCINE AGAINST STREPTOCOCCUS AGALACTIAE IN OREOCHROMIS NILOTICUS PREPARED BY SONICATION

Marcusso, P.F., Eto, S.F., Yunis, J., Claudiano, G.S., Fernandes, D.C., Neto, F.M.A., Petrillo, T.R., Salvador, R., Moraes, J.R.E., and Moraes, F.R..

Symposium: Tropical Fish **Type:** Oral **Order:** 4

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Via de Acesso Prof. Paulo Donato Castellane s/n - Jaboaticabal/SP - CEP 14884-900 Brazil

Abstract: The aim of this study was to evaluate the efficiency of a *S. agalactiae* vaccine inactivated by sonication. It was evaluated the humoral and cellular response in 425 Nile tilapias (200 ± 25g). To identify which fraction of the bacteria (soluble or insoluble) were more efficient, fish were distributed into four groups (n=20) and injected with: G1 (PBS), G2 (PBS+ Freund's incomplete adjuvant [IFA]), G3 (soluble fraction + IFA) and, G4 (insoluble fraction + IFA). After 21 days, fish were challenged with a homologous strain of the bacteria (LC50), resulting in a survival rate was 0, 16.7, 50, and 100%, respectively. Therefore, the insoluble fraction was used to evaluate the humoral response by direct agglutination in microplate. For this, 63 fish were distributed in G5 (PBS) and G6 (insoluble fraction + IFA). Blood samples were taken at 0, 7, 14, 21, 28, 35, 42, 60 and, 90 days after inoculation. The highest levels of titres were at 60 and 90 days. However, titres appeared from day 21. Globulins levels were high at 35, 60 and 90 days. Total number of lymphocytes was high between 14 and 90 days. To assess the cellular response induced by vaccination, fish (n=21) were distributed into 3 groups and injected in the swim bladder: G7 (PBS), G8 (PBS + IFA), and G9 (insoluble fraction + IFA). Inflammatory exudates were collected at 6, 24 and 48 hours after inoculation. Cellular accumulation was higher at 24 hours in G9, predominantly macrophages and granulocytes. We concluded that vaccination with the insoluble antigen of *S. agalactiae* provides adequate protection to tilapias infected with this bacterium.

CHARACTERIZATION OF THE TRANSCRIPTOME OF FAST AND SLOW MUSCLE FIBRES IN THE PACU

Mareco, E., Garcia de la Serrana, D., Johnston I.A., Dal-Pai-Silva, M.

Symposium: Physiological Genomics **Type:** Poster **Order:** P105

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Abstract: Fish myotomal muscle is composed of anatomically segregated fibre types (slow, intermediate and fast) with distinct metabolic phenotypes. Pacu (*Piaractus mesopotamicus*) is a member of the Characiform family native to the South America and is a target of aquaculture industry. The main limitations for the development of a selective breeding program for this species are the lack of genetic information. The primary objectives of the present study were 1) to use NGS to increase the genetic resources available for Pacu, 2) to exploit the anatomical separation of fibre types to compare the transcriptomes of Slow and Fast muscles. We sequenced fast and slow skeletal muscle (n=5) using a HiSeq 2000. Yielded a total of 390,706,230 pair-end reads for fast and 374,952,267 pair-end reads for slow muscle. The average contig length obtained was 1,334bp (N50=2,772bp) with 232,637 annotated sequences. Over 15,000 different genes were present in the transcriptome and for over 8,000 complete sequences.

SOME CHARACTERISTICS AND FUNCTIONS OF SHBGB, A NEWLY DISCOVERED SEX HORMONE BINDING GLOBULIN EXPRESSED IN GRANULOSA CELLS

Marivin, E., Courteille, A., Bodinier, P., Mourot, B., Guiguen, Y., Bobe, J., and Fostier, A.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 3

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Abstract: A new sex hormone binding globulin (Shbgb) has recently been identified in salmonids but the function of this protein needs to be elucidated. Biological properties of Shbgb and its possible functions will be presented. Shbgb is not synthesized in liver like Shbga but specifically in granulosa cells. In silico analysis of gene protein sequences shows a similar structure between Shbga and Shbgb. However, the corresponding recombinant proteins do not have the same steroid binding characteristics. Shbgb shows a more strict binding affinity for estradiol and testosterone than Shbga and thus Shbgb does not bind androstenedione but testosterone. Accordingly, shbgb could differently compete for androstenedione and testosterone against the aromatase localized in granulosa cells and could modulate the estradiol synthesis from these two potential substrates. The potential effect of Shbgb on estradiol metabolism will also be discussed. Besides, the effect of gonadotropins, estradiol, testosterone, insulin, and Igf1 on Shbgb expression in granulosa cells will be presented.

ISOLATION, CULTURE AND CHARACTERIZATION OF RAINBOW TROUT GRANULOSA CELLS

Marivin, E., Mourot, B., Courteille, A., Rime, H., Bobe, J., Fostier, A.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 15

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Abstract: Detailed protocols for isolation of rainbow trout granulosa cells with a proper cell characterization are not available. Here, vitellogenic ovarian follicles were isolated with tweezers under binocular. Follicular layers were then digested with collagenase. After an overnight incubation with calcium free Hank's medium complemented with bovine serum albumin, GC were collected by filtration. When necessary, a Percoll® filtration could be performed to

remove blood cells. GC could be cultured for several weeks in a complete trout medium added with 5-10% steroid free Ultrosor® in gelatin-coated culture plates. GC are round cells of 20 µm diameter with a granular cytoplasm, which tend to aggregate. They give a positive signal in immunohistochemistry using a specific anti-aromatase antibody. GC are responsive to gonadotropins after several days and keep their steroidogenic properties followed by measurement of estradiol and 17,20β-dihydroxy-4-prenen-3-one release. Conditions for acid nucleic transfection of GC will be also discussed.

FIT FOR THE FUTURE: MITOCHONDRIAL PLASTICITY FORMS THE BASIS FOR AEROBIC PERFORMANCE IN A CHANGING CLIMATE

Mark, F. C.

Symposium: Climate Change **Type:** Oral **Order:** 7

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Abstract: Ocean acidification goes hand in hand with ocean warming and increasingly threatens life in the world's oceans. Due to their well-developed capacities for ion- and pH-regulation, fish have generally been regarded as reasonably tolerant towards ocean acidification. Yet, there is a growing body of evidence that also fish and especially their early life stages, have to rearrange their aerobic metabolic pathways to meet the challenges of ocean acidification and warming, including energetic trade-offs. This puts their mitochondria into the focus of interest, which have to provide aerobic energy in sour times of increased temperatures and PCO₂. I will present examples of how these challenges are met in mitochondrial acclimation of various life stages of cold temperate fish species. Maternal effects also become visible at the mitochondrial level and can additionally serve to use the full range of genotypic and phenotypic plasticity in physiological acclimation to a changing ocean.

EURYHALINE AND EURYTHERMIC FISH: REGULATION OF ION TRANSPORT IN THE COLD

Marshall, W.S., Barnes, K.R., Buhariwalla, H.E.C., Osmond, E.M., Robertson, G. and Cozzi, R.R.F.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 13

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Abstract: Opercular epithelia from mummichogs (*Fundulus heteroclitus*) acclimated to cold (5°C) and warm (20°C) seawater were isolated in vitro to measure Cl⁻ secretion as short-circuit current (SCC). Variation from 30°C to 0.2°C in aerobic conditions revealed a sharp break in Arrhenius plots of SCC at 8°C, below which SCC decreased markedly (Q₁₀=6.90 for warm; 4.23 for cold acclimated tissues), suggesting a phase change in mitochondrial inner membrane. In anaerobic conditions, chloride transport continued at a lower rate, and SCC decrease below 8°C was less pronounced (Q₁₀=2.95 for warm; 3.08 for cold), suggesting a shift in transporter function in plasma membrane. In warm-acclimated fish, regulation of SCC by hypotonic shock and hormones was blocked by cold temperatures, whereas cold-acclimated fish could still regulate Cl⁻ secretion. Fatty acid analysis revealed lower saturated and higher monounsaturated fats, indicating homeoviscous adaptation in the cold in defense of ion transport regulation. Supported by NSERC.

EFFECTS OF MICROCYSTIN-LR ON CARDIORESPIRATORY PARAMETERS OF TRAIÁRA DURING AQUATIC HYPOXIA.

Martins, N.D., Yunes, J.S., Rantin, F.T., Kalinin, A.L.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P40

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Abstract: Microcystins (MCs) are toxins commonly found in nature, highly toxic and widely dispersed in aquatic environments. The aim of this study was evaluate the effects of MCs on the cardiorespiratory responses of *Hoplias malabaricus*. Were used 14 specimens of traíra (Wt=155±5,5g) divided into: control group (Control, n=7)– intraperitoneal injection of 0.5 ml of 0.9% saline; Group exposed to MC-LR, (Mcis, n=7)–injection of saline plus lyophilized extract containing MC-LR(100µg/kg⁻¹ body weight). Parameters evaluated by flow-through respirometry during aquatic hypoxia were: metabolic rate(VO₂-mL O₂.kg⁻¹.h⁻¹), gill ventilation(VG-mL H₂O.kg⁻¹.min⁻¹), respiratory frequency(fR-breaths.min⁻¹), ventilatory tidal volume(VT-mL H₂O.kg⁻¹.breath⁻¹), O₂ extraction(EO₂-%) and heart rate (fH-bpm). There was no significant difference between VO₂ of the groups. The VG values of Mcis group were higher than the Control ones in almost all O₂ tensions analyzed. The fR groups, did not differ significantly. The VT values of Mcis were higher than the control in the most of the O₂ tensions. The EO₂ values of Mcis group were lower in all O₂ tensions. The fH showed no difference between groups.

OREXIN A ENHANCES FOOD INTAKE AND LOCOMOTOR ACTIVITY, AND EXERTS ANXIOTIC-LIKE ACTION

Matsuda, K., Shibata, H., and Nakamachi, T.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 15

Contact: Kouhei Matsuda **E-mail:** kmatsuda@sci.u-toyama.ac.jp

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Abstract: In mammals, orexin and its receptor system are involved in the regulation of food intake, locomotion and psychomotor activities. With regard to non-mammalian vertebrates, there has also been intensive study aimed at the identification and functional characterization of orexin and its receptor, and recent investigations of the role of orexin have revealed that it exerts behavioral effects in teleost fish. Goldfish is an excellent teleost fish model, and in this species it has been demonstrated that orexin increases food consumption as an orexigenic factor and enhances locomotor activity, as well as being involved in the regulation of active and rest status (circadian rhythmicity), as is the case in mammals. Recently, orexin has also been shown to induce anxiety-like behavior in this species. This presentation reviews current knowledge of orexin derived from studies of teleost fish, as representative non-mammals, focusing particularly on the role of the orexin system.

KINETICS OF DNA DAMAGE AND REPAIR IN FISH, USING THE ZEBRAFISH AS A MODEL

McCabe, C.A., Theodorakis, C.W., Henry, B.T., Hartl, M.G.J.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P47

Contact: Mark Hartl **E-mail:** m.hartl@hw.ac.uk

Centre for Marine Biodiversity & Biotechnology, School of Life Sciences, Heriot-Watt University UK

Abstract: The objective of the study was to investigate the kinetics of DNA repair in fish, using the zebrafish (*Danio rerio*) as a model. The repair kinetics were assessed by disappearance of DNA damage. DNA damage was induced by exposing larval zebrafish to ultraviolet light (UV-C) (0.33 mW/cm²) and assessed using the comet assay technique. Single strand breaks (SSBs) were reflected as an increase of % DNA content in the comet tail. DNA damage-specific enzymes created SSBs at different types of bases, including oxidised base damage and formation of pyrimidine dimers. Thus, using these enzymes can be used to assess relative number of damaged bases. It was found that DNA damage was induced by exposure to UV irradiation and the amount of damage decreased in proportion to recovery time period. Most DNA damage was observed to be repaired after a 1- hour period. Future studies will

analyse the RNA of exposed larvae to determine the kinetics of repair-gene expression. Further studies will investigate the DNA damage and expression of repair genes in fish exposed to photoactivated TiO₂ nanoparticles.

THE EPIGONAL ORGAN AND MATURE POLE OF THE TESTIS IN THE RECREATIONALLY FISHED BLUE SHARK:
HISTOCHEMICO-FUNCTIONAL CORRELATES
McClusky, L.M. and Sulikowski, J.

Symposium: Elasmobranchs **Type:** Oral **Order:** 6

Contact: Leon McClusky **E-mail:** leonmc@hin.no

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Abstract: The immune system's exact role in normal spermatogenesis is poorly understood. The attachment of the lymphomyeloid epigonal organ specifically to the shark testis's mature pole is a curious finding. Moreover, the tissue remains unremarkable and functionally unchanged despite cestode parasites embedded into its surface in wild-caught Prionace. We show here that epigonal leukocytes shed their granule-laden cytoplasm into the cyst resorption zone (RZ, the region separating the spermatogenic tissue from the epigonal organ) as they begin to migrate into the RZ. Using the immunoreactivity of the transcription factor PCNA as marker, it is shown that the granule-lacking leukocytes infiltrated exclusively spermatozoal cysts leftover after the wave of wide-spread multinuclear cell death (MNC) in summer-breeding males in a seasonally dependent manner. By contrast, Prionace caught two months later show fully recovered testes containing numerous completely intact spermatozoal cysts. Findings suggest the presence in Prionace of a seasonally activated clearance mechanism at the mature pole which manifests as an autoimmune response to unwanted spermatozoa.

THE PHYSIOLOGY OF ANADROMY
McCormick, S.D.

Symposium: Plenary **Type:** Oral **Order:** 5

Contact: Stephen D. McCormick **E-mail:** mccormick@umext.umass.edu

USGS, Conte Anadromous Fish Research Center, One Migratory Way, PO Box 796, Turners Falls, MA 01376 USA

Abstract: All anadromous species must make the transition from freshwater to seawater at least once in their lifetime. Salmon undergo morphological, physiological and behavioral changes that are preparatory and adaptive for seawater entry and are collectively known as the parr-smolt transformation. Smolt development is regulated by environmental factors such as photoperiod and temperature and mediated by the neuroendocrine system. The development of salinity tolerance is the most well-studied developmental change that occurs during smolting. The three main ion transporters involved in salt secretion, Na/K-ATPase, Na/K/2Cl cotransporter and CFTR are up-regulated in smolts in freshwater prior to exposure to seawater. Recent studies indicate that the seawater-specific α isoform of Na/K-ATPase, NKA α 1b, is up-regulated during smolt development. Measurement of the freshwater and seawater isoforms of gill NKA allows for detection of the differential impacts of acidification on freshwater and seawater osmoregulation. The regulation of these isoforms is the target of selection, as differences in their abundance have been seen between anadromous and landlocked populations. There are clear evolutionary differences in the timing of smolt development within the salmonid lineage. Since all anadromous species appear unable to survive in seawater early in ontogeny, there are developmental increases in salinity tolerance in all anadromous species. The diversity of physiological strategies for seawater entry in other anadromous species such as lamprey, shad and striped bass will be presented along with hypotheses for the selective pressures that have resulted in these strategies.

THE EVOLUTIONARY CONSEQUENCES OF STAYING IN FRESHWATER: SEAWATER PERFORMANCE, PHYSIOLOGY AND ENDOCRINOLOGY OF LANDLOCKED AND ANADROMOUS SALMON.

McCormick, S.D., Regish, A.M., O'Dea, M.F. and Bernier, N.J.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 1

Contact: Stephen D. McCormick **E-mail:** mccormick@umext.umass.edu

USGS, Conte Anadromous Fish Research Center, One Migratory Way, PO Box 796, Turners Falls, MA 01376 USA

Abstract: Landlocked populations of anadromous fish have evolved frequently in some species, but the effects of this altered life history on traits associated with survival in seawater have not been well established. Landlocked Atlantic salmon usually maintain migration from streams to lakes, similar in timing to the seaward migration of anadromous strains. Thus, there is relaxed selection on traits associated with ocean entry but not on other life history changes such as downstream migration and imprinting. In this study anadromous and landlocked Atlantic salmon were reared under identical conditions after fertilization and examined for differences in seawater performance and its underlying physiological and endocrine control during the time of spring downstream migration. We found that salinity tolerance as judged by plasma chloride after direct transfer to 35 ppt increased in both strains in spring but was highest for the anadromous strain. Survival and growth in the first two weeks of seawater exposure was also greater for the anadromous strain. Gill Na⁺/K⁺-ATPase (NKA) activity and plasma cortisol levels were greater in the anadromous strain, whereas plasma thyroxine levels were similar in the two strains. The anadromous strain had higher levels of pituitary ACTH (POMC) mRNA and brain levels of CRH and Urotensin II mRNA at the peak of smolt development. The results provide evidence that the stimulation of the hypothalamic-pituitary adrenal axis leads to increased salinity tolerance during smolt development, and that these traits are decreased in landlocked Atlantic salmon.

TREATMENT WITH THE SELECTIVE SEROTONIN REUPTAKE INHIBITOR, FLUOXETINE, INTERFERES WITH THE ABILITY OF TOADFISH TO RESPONSE TO ENVIRONMENTAL HYPOXIA

McDonald, M.D., Marin, S., Panlilio, J.M.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 6

Contact: Danielle McDonald **E-mail:** dmcdonald@rsmas.miami.edu

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Abstract: Fluoxetine, the active compound in the antidepressant, Prozac™, is found in measurable quantities in surface and ground waters. Fluoxetine treatment has been shown to result in an increase in extracellular concentrations of the neurotransmitter, serotonin (5-HT). Given the role of 5-HT in the response of fish to environmental hypoxia, we hypothesized that fluoxetine treatment would inhibit or attenuate the hypoxia response. Gulf toadfish (*Opsanus beta*) were treated intraperitoneally with 0 (control), 10 or 25 µg.g⁻¹ fluoxetine. In response to hypoxia, control fish experienced a typical reduction in heart rate (fH), an increase in ventilatory amplitude (VAMP) and a reduction in caudal arterial blood pressure (PCA). Treatment with fluoxetine resulted in a dose-dependent attenuation of PCA; the VAMP and fH responses also showed fluoxetine sensitivity. Our data shows that fluoxetine treatment results in a decreased capacity to respond to hypoxia and suggests that waterborne fluoxetine exposure may have a negative impact on fish survival when faced with the additional challenge of environmental hypoxia.

THERMAL TOLERANCE IN A WIDESPREAD AFRICAN CICHLID FISH: IMPLICATIONS FOR CLIMATE CHANGE IN EQUATORIAL WATERS

McDonnell, L.H. and Chapman, L.J.

Symposium: Tropical Fish **Type:** Oral **Order:** 2

Contact: Laura McDonnell **E-mail:** laura.mcdonnell@mail.mcgill.ca

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Abstract: Rising water temperature associated with climate change is increasingly recognized as a stressor for aquatic organisms, particularly for tropical ectotherms that are predicted to have narrow thermal windows relative to temperate ectotherms. Despite this, few studies have focused on the physiological response of tropical freshwater fish to thermal increase, limiting the emergence of general patterns. This study quantified the aerobic performance of the widespread African cichlid fish *Pseudocrenilabrus multicolor victoriae* in response to short-term acclimation to four temperature treatments (26, 28, 30 and 32°C), with the highest temperature 1.0°C above the average maximum temperature in their habitat over a 3-year period. Physiological trials were completed in an intermittent flow respirometer to measure standard metabolic rate (SMR) and critical oxygen tension (P_{crit}). *P. multicolor* acclimated to 32°C had a higher SMR and a higher P_{crit} than those from the other groups. The higher P_{crit} is indicative of lower tolerance to hypoxic stress. These results suggest that high habitat temperatures in *P. multicolor* may induce metabolic costs that could limit aerobic performance.

TO BOLDLY GULP: SEPARATING THE EFFECTS OF BOLDNESS AND METABOLIC RATE ON THE SURFACING
BEHAVIOUR OF AN AIR-BREATHING FISH

McKenzie, D.J., Belão, T.C, Killen, S.S., Blasco, F.R., Zeraik, V., Rantin, F.T.

Symposium: Environmental Change **Type:** Oral **Order:** 9

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Abstract: Facultative air-breathing fishes are interesting models to investigate how individual variation in physiology and personality might drive risk-taking to acquire an essential resource, oxygen. In particular, whether metabolic oxygen demand and boldness can exert effects independently and how their influences might depend upon prevailing environmental conditions, notably aquatic hypoxia. The african catfish *Clarias gariepinus* is a facultative air breather, in aquatic normoxia it can maintain standard metabolic rate (SMR) by gill ventilation alone. It does, however, spontaneously gulp oxygen-rich air, despite the fact that this brings significant risk of predation. In hypoxia, it must gulp air to meet SMR. Using techniques of bimodal respirometry we found that, in normoxia, the proportion of metabolic rate derived from air breathing was not dependent on the individual SMR of 29 juvenile catfish. It was, however, dependent on individual boldness, assessed as time to resume air breathing after a simulated attack, or tendency to boldness in an open field test. In aquatic hypoxia, dependence of air breathing on boldness disappeared; the proportion of oxygen taken from air was directly dependent upon individual SMR. This indicates that boldness and energy metabolism exert independent effects on risk-taking to gulp air. Personality influences the risky behaviour when physiological drive to secure oxygen is relaxed but, when air breathing becomes essential to sustain SMR, physiology dominates.

MONITORING FISH HEALTH IN CANADIAN AREAS OF CONCERN USING METHODS DEVELOPED FOR CANADIAN
ENVIRONMENTAL EFFECTS MONITORING PROGRAMS

McMaster, M.E., Tetreault, G.T., Bennett, C.J., BARRETT, T., and MUNKITTRICK, K.R.

Symposium: Parasites and Diseases **Type:** Oral **Order:** 4

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Abstract: Environment Canada has undertaken studies in Canadian Areas of Concern (AOCs) to determine the current state of fish and wildlife health. Overall fish health is being evaluated using methods developed for Environmental Effects Monitoring (EEM) Programs for the pulp and paper and metal mining industries in Canada. This includes evaluating age structure, energy utilization and energy storage in two resident fish species at AOC and

appropriate reference locations. The EEM program is cyclical in nature, first identifying effects, then confirming those effects followed by determination of the extent and magnitude of those effects. Through our AOC fish studies, we have initial studies on two species of fish followed by confirmation studies on one of the two species. The presentation will examine the data from ten of Canada's Areas of Concern with recommendations based on critical effects sizes identified for use by the pulp and paper EEM program.

DEVELOPMENTAL EFFECTS OF A SYNTHETIC GLUCOCORTICOID DURING EMBRYOGENESIS IN ZEBRAFISH

McNeil, P.L., Sloman, K.A., Thacker, R., Morrison, C.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 8

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Abstract: The majority of toxicological studies which have assessed the environmental impact of pharmaceuticals within the aquatic environment have largely overlooked synthetic glucocorticoids, such as prednisolone. Prednisolone is one of the most commonly prescribed synthetic glucocorticoids in the UK and is frequently detected within the aquatic environment. This study investigated the effects of prednisolone on zebrafish embryogenesis in response to three environmentally relevant concentrations. Traditional toxicological endpoints (hatching, mortality & size) were assessed in addition to various physiological parameters (heart rate, O₂ consumption, muscle integrity & craniofacial morphogenesis). Activity and swimming were also assessed. Although prednisolone did not significantly affect embryo mortality or size, a significant increase in heart rate, O₂ consumption and hatch rate was shown. No effect was found on muscle integrity; however craniofacial development was significantly altered. Prednisolone also significantly altered behaviour. Therefore, exposure to prednisolone resulted in significant physiological and behavioural changes during zebrafish embryogenesis.

MOLECULAR MECHANISMS FOR ALTERED SKELETAL RESPONSE TO DIET IN TRIPLOID ATLANTIC SALMON

McStay, E., Kokkinias, P., Smedley, M.A., Taylor, J.T., Migaud, H.

Symposium: Fish Culture **Type:** Poster **Order:** P10

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Abstract: To determine potential mechanisms for altered skeletal response to dietary phosphorous in triploid Atlantic salmon it is necessary to investigate pathways directly associated with dietary phosphorous homeostasis within the skeleton. Dietary phosphorous is known to be a key nutrient risk factor for malformation. Incidence of which is higher in triploids. Yet molecular mechanisms underpinning this and the impact of triploidy on gene expression are largely unknown. To this end the gene coding Fibroblast growth factor 23 (FGF23), a key protein in phosphorous homeostasis secreted from osteocytes in the bone, was identified and characterized in Atlantic salmon. mRNA Expression for key phosphorous homeostasis genes, including Fgf23 was subsequently analyzed by qPCR in vertebrae of diploid and triploid Atlantic salmon exposed to high and low phosphorous diets. An understanding of "triploid-specific" molecular mechanisms of phosphorous homeostasis within the skeleton may help in the resolution of negative culture traits and successful triploid production.

SEROTONERGIC REGULATION OF THE HYPOTHALAMIC-PITUITARY-INTERRENAL AXIS VIA THE SEROTONIN 1A RECEPTOR IN THE GULF TOADFISH

Medeiros, L.R., Cartalano, M.C., and McDonald, M.D.

Symposium: Stress in Fish **Type:** Oral **Order:** 3

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Abstract: Stimulation of the toadfish 5-HT_{1A} receptor with 8-OH-DPAT results in a significant elevation in plasma cortisol. Conversely, chronically elevated plasma cortisol has been shown to decrease brain 5-HT_{1A} receptor mRNA and protein levels via the GR. Experiments confirmed that the release of CRF and ACTH can be stimulated with 8-OH-DPAT, a response that is also attenuated by crowding stress. Moreover, treatment with the GR blocker RU486 relieved this attenuation. In vitro kidney experiments suggest that chronically elevated plasma cortisol attenuates ACTH- and 5-HT-stimulated cortisol secretion from the interrenal cells of toadfish, a response that is not reversed by RU486 treatment. Thus, while it appears that the GR is responsible for mediating the negative feedback of cortisol on centrally located 5-HT_{1A} receptors, it does not appear to be responsible for mediating attenuation of cortisol secretion from the interrenal cells. Combined, these results explain in part a disconnect between brain 5-HT_{1A} levels and cortisol secretion.

TIMING OF STRESS, NOT MAGNITUDE, IS AN IMPORTANT FACTOR IN DETERMINING EGG VIABILITY OF FARMED
FEMALE RAINBOW TROUT

Medeiros, L.R., Elliott, M., and Nagler, J.J.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P51

Contact: Lea R. Medeiros **E-mail:** lmedeiros@uidaho.edu

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Abstract: Rainbow trout (*Oncorhynchus mykiss*) production is hindered by sub-fertility problems that affect embryonic survival and thus overall production. The objective of this project was to determine if cortisol was responsible for mediating sub-fertility and also if the timing of the elevation in plasma cortisol was important. Cortisol-implanted fish experienced a significant increase in circulating levels of cortisol compared to sham-implanted fish and plasma cortisol remained elevated relative to controls for the 4-week period between implant insertions. No significant difference was found between the cortisol- and sham-implanted treatments; however, there is a significant correlation between viability and the timing of the treatment relative to the reproductive cycle. Fish treated immediately post-spawn experienced a higher incidence of sub-fertility than those treated 4 – 8 or 8 – 12 months post-spawning. These results imply that it is the timing, and not necessarily the magnitude, of the stress that is important in determining embryo viability.

GROWTH AND CONDITION OF TWO SMALL-SIZED CYPRINIDS IN A HYDROLOGICALLY-ALTERED MEDITERRANEAN
STREAM

Merciai, R., Bae, M.J., Sabater, S., Srean, P., Garcia-Berthou E.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 3

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Abstract: Hydrological alterations affect most Mediterranean watercourses. Growth and condition (weight-length relationship) of two fish species of conservation interest (*Barbus meridionalis* and *Squalius laietanus*) were analyzed in 12 sites along the Tordera (NE Spain), a small-sized river strongly impacted by water abstraction, and 3 sites in a tributary (Arbucies stream). A total of 860 *B. meridionalis* and 406 *S. laietanus* scale samples were collected between May 2012 and October 2013. The influences of environmental and intrinsic factors on fish growth and condition were analysed by mixed-effects linear models and analysis of covariance, respectively. A strong effect of

fish age on annual size increments was found in both species, as well as significant site × age × year of growth interaction. Condition and growth rates were highest in the middle reaches, which have a permanent flow regime but also receive nutrient inputs from urban areas, whereas they were lower in upper and the lowermost reaches, where waterflow is temporary due to water abstraction.

FORCED SUSTAINED SWIMMING EXERCISE AT OPTIMAL SPEED TO ENHANCE GROWTH PERFORMANCE OF
YELLOWTAIL KINGFISH

Mes, D., Kloet, K., Blonk, R.J.W., Palstra, A.P.

Symposium: Swimming Physiology **Type:** Oral **Order:** 7

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Abstract: Juvenile yellowtail kingfish were either forced to perform sustained swimming exercise at an optimal speed of 2.46 body-lengths per second ('swimmers') or allowed to perform spontaneous activity at low water flow ('resters') in a 3,600 L oval-shaped flume with flow created by an impeller driven by an electric motor. At the start of the experiment, ten fish were sampled as controls (346±6mm, 504±27g). After 18 days, swimmers (n=23; 385±4mm, 735±23g) showed a 92% greater increase in body-length and 46% greater increase in body-weight as compared to resters (n=23; 367±5mm, 661±32g). As both groups were fed equal portions, the feed conversion ratio (FCR) for swimmers was 1.21 and lower than 1.74 for resters. Using Doppler ultrasound imaging, we found a 31% higher blood flow in the ventral aorta of swimmers vs. resters (respect. 44±3 ml/min vs. 34±3 ml/min, under anaesthesia). This study shows that growth performance can be rapidly improved by optimal swimming, even without larger feed investments.

IMPACT OF IRRIGATION DIVERSION SCREENS ON JUVENILE LAMPREYS IN THE COLUMBIA RIVER BASIN

Mesa, M. G., Christiansen, H. E., Weiland, L. K., and Rose, B. P.

Symposium: Lampreys **Type:** Oral **Order:** 9

Contact: Matt Mesa **E-mail:** mmesa@usgs.gov

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Abstract: Pacific lamprey (*Entosphenus tridentatus*) populations in the Columbia River basin have declined in recent years and understanding lamprey passage at irrigation diversions is a high priority issue. For this reason, we tested the effectiveness of five common fish screen materials (perforated plate, Intralox, vertical bar, and 12 and 14 gauge wire cloth) to protect lamprey ammocoetes (ranging from 28–153 mm in length) at simulated water diversions in two recirculating flumes. In tests using a small flume where screen panels were placed perpendicular to the flow with no sweeping velocity, the perforated plate screen prevented entrainment of 85% of the fish, protected fish larger than 46 mm, and offered the best overall protection of all the screen types tested. The Intralox and vertical bar screens protected 74% and 67% of the fish and prevented fish larger than 58 and 55 mm from becoming entrained. The 12 and 14 gauge wire cloth screens prevented fish larger than 90 and 78 mm from becoming entrained and offered the lowest overall protection, preventing only 34% and 38% of all fish from entrainment. In recent tests using a much larger flume with large screen panels and sweeping velocities, the perforated plate and Intralox screens performed similarly to the results described above. When approach velocities were halved on the perforated plate screen (from 12 to 6 cm/s), more lampreys were able to move away from the screen and protection was improved. More testing is currently ongoing. Our results should contribute to the development of operational and design criteria for fish screens to protect juvenile lampreys.

IMMUNOMODULATION IN TURBOT LARVAE AND ITS EFFECT ON SURVIVAL AND IMMUNITY

Miest, J.J., and Arndt, C.

Symposium: Fish Culture **Type:** Poster **Order:** P11

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Abstract: Immunomodulation has been shown to increase survival and immunity in juvenile and adult fish. Hence the integration of substances such as β -glucan into the feed is already common in order to reduce stress and mortalities in fish farms. However little is known about the effects immunomodulating substances can have on the most crucial and vulnerable life stage: the larvae. In nature larval survival of some fish species can be as low as 1 %. One aim of aquaculture research is therefore to enhance this survival in order to increase production. In this study we administered a β -glucan containing feed additive to turbot larvae (*Scophthalmus maximus*) via life feed (*Brachionus* sp., Rotifers). Daily mortality was monitored and larvae were sampled at 11 dph and 24 dph to analyse immune gene expression and lysozyme activity. The results will be discussed in regard to optimization of larval rearing for aquaculture purposes.

SEAWATER EXPERIENCE ENHANCES HYPO-OSMOTIC REGULATORY ABILITY IN MEDAKA

Miyanishi, H., Inokuchi, M., Nobata, S., Kaneko, T.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 6

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Abstract: Medaka *Oryzias latipes* is a euryhaline species that usually inhabits freshwater (FW) but is also adaptable to full-strength seawater (SW). We examined in this study how SW experience affected hypo-osmotic regulatory ability in medaka. For the preparation of SW-experienced fish, FW medaka were acclimated to SW after pre-acclimation in 1/2 SW, and the SW-acclimated fish were transferred back to FW. The SW-experienced fish and control FW fish (SW-unexperienced fish) were transferred directly to SW. Whereas control FW fish could not survive direct transfer to SW, 1/4 of SW-experienced fish were successfully adapted to SW. Blood osmolality of SW-experienced fish was lower than that of control FW fish after direct transfer to SW. In SW-experienced medaka, the ability to excrete NaCl in gill ionocytes was enhanced in comparison with control FW fish. These results indicate that SW experience enhances hypo-osmotic regulatory ability, suggesting epigenetic mechanisms involved in seawater adaptation.

BEHAVIOURAL FEVER OF ZEBRAFISH LARVAE DURING A DSRNA-INDUCED ANTI-VIRAL IMMUNE RESPONSE

Moiche, V., Rey, S., Boltana, S., Teles, M., and MacKenzie, S.

Symposium: Zebrafish **Type:** Poster **Order:** P159

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Abstract: Behavioural fever has been reported in different species of ectotherms in response to exogenous pyrogens. This response depends on different intrinsic and environmental factors as well as developmental stage. For this study, zebrafish larvae (18-20 dpf) were initially placed in a thermal gradient, which allowed them to select their preferred temperature. In order to guarantee 'freedom of choice', a novel aquaria based on a vertical gradient column system was custom built. This tank allowed non-invasive observation of ZF group vertical distribution under isothermal (at 28 °C) and thermal gradient conditions (range 28-32°C). Similar to previous studies in ZF adults, ZF

larvae produce a behavioural fever response to dsRNA challenge, in this case by modifying their distribution in the thermal column. The thermal response is coupled to increased antiviral mRNA expression. Our results confirm the onset of behavioural fever in zebrafish larvae coupled to the immune response at approx. 3 wpf.

CELL-TYPE SPECIFIC ARYLHYDROCARBON RECEPTOR SIGNALING IN CULTURED LIVER AND IMMUNE CELLS OF RAINBOW TROUT

Möller, A.M., Spirotis, M. and Segner, H.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 4

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Abstract: The cytosolic transcription factor aryl hydrocarbon receptor (AhR) senses small chemical molecules including important environmental contaminants, such as dioxins, polychlorinated biphenyls and polyaromatic hydrocarbons. Upon activation, the AhR induces via the dioxin-response element to gene transcriptional changes, which are cell-specific and associate with cell-specific toxicity. Hallmarks of AhR-mediated toxicity in vertebrates are hepatotoxicity and immunosuppression. Here, we demonstrate the use of primary cultures of rainbow trout immune and liver cells to examine cell-specific differences in global gene expression mediated by AhR activation. Immune cells were isolated from head kidney and spleen by mechanical disaggregation, and hepatocytes were isolated from the liver by collagenase perfusion. The cells were cultivated as monolayers in serum-free media and were exposed to equipotent concentrations of the AhR ligand, benzo(a)pyrene (BaP). Global gene expression analysis revealed that, in total, 672 genes were regulated in liver cells, 134 in head kidney cells and 408 in spleen cells. Among the genes that were commonly upregulated in liver, head kidney and spleen, were CYP1A1, CYP1A3 and sulfotransferase. GO-term enrichment analysis of the regulated genes revealed an organ-specific response, with main focuses on transcription and biosynthetic metabolism in the liver, protein metabolism and immune response in head kidney cells and response activities and homeostatic processes in spleen cells.

ALTERNAGIN-C, A DISINTEGRIN-LIKE PROTEIN FROM RHINOCEROPHIS ALTERNATUS SNAKE VENOM, INDUCES BOTH POSITIVE INOTROPIC AND CHRONOTROPIC EFFECTS ON FISH MYOCARDIAL CONTRACTILITY

Monteiro, D.A., Selistre-de-Araujo, H.S., Kalinin, A.L., Rantin, F.T.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P79

Contact: Diana Amaral Monteiro **E-mail:** dianaamonteiro@yahoo.com.br

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Abstract: We evaluated the effects of the alternagin-C (ALT-C: 0.5 mg/kg, via intra-arterial), a disintegrin-like protein purified from the venom of the snake, *Rhinocerophis alternatus*, on in vitro assays for myocardial contractility of traíra, *Hoplias malabaricus*. The ALT-C increased cardiac performance promoting: 1) increases in the contraction force and contraction and relaxation rates, and decreasing in the values of time to the peak tension and time to half- and 90% relaxation; 2) improvements in the cardiac pumping capacity and maximal electrical stimulation, shifting the optimum frequency curve upward and to the right; 3) abolishment of the negative force-frequency relationship typical of the teleost myocardium, indicating a higher efficiency of the calcium removal mechanisms. The changes ALT-C-induced may lead to improvement in the cardiac output regulation, which may be essential during hypoxic conditions, indicating its potential to be used in the therapies for cardiovascular diseases. Financial support: FAPESP (Proc. 12/10993-4).

GENOTOXIC EFFECTS OF CYPERMETHRIN INSECTICIDE IN A NEOTROPICAL FISH MATRINXA
Moraes, F.D., Pesenti, E., Venturini, F.P., Rossi, P.A., Avilez, I.M., Cestari, M.M., Moraes, G.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P41

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Abstract: Cypermethrin is an insecticide used in crops and fish farming. The aim of this study was investigating the genotoxic potential of cypermethrin (Galgotrin®) in *Brycon amazonicus*. The fish were exposed to 0 (control), 7.2 µg L⁻¹ (B), 14.4 µg L⁻¹ (C) and 21.6 µg L⁻¹ (D) of cypermethrin for 96h. The frequency of micronucleus (MN) and nuclear alterations (NA) as blebbed, lobed, vacuolated, notched nuclei and binucleated cell were analyzed in erythrocytes. Some intoxication signals were observed. The data were evaluated by Kruskal-Wallis test and Student-Newman-Keuls pos-test ($p < 0.05$; $n = 15$). The MN and NA media (\pm standard error) frequency of control, B, C and D groups were 0.8 ± 0.2 , 2.7 ± 0.5 , 2.3 ± 0.3 and $1.6 \pm 0.3\%$, respectively. The MN and NA frequency increased significantly in B and C related to control ($p < 0.05$). The exposed fish presented slow swimming and opercular opening. The results indicate that cypermethrin based-insecticide is genotoxic to fish. The genotoxicity mechanism could be related to oxidative stress or direct effect of cypermethrin in DNA. Financial support: Sao Paulo Research Foundation process 13/14192-9

THE EFFECTS OF ECOLOGICAL OSMOTIC CHALLENGES ON THE METABOLISM OF AN ESTUARINE ASSEMBLAGE OF SHARKS

Morash, A.J., Currie, S., Frappell, P.B., Semmens, J.

Symposium: Elasmobranchs **Type:** Oral **Order:** 13

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Abstract: We studied 3 species of elasmobranchs: school (*Galeorhinus galeus*), gummy (*Mustelus antarcticus*) and seven-gill (*Notorynchus cepedianus*) sharks and 1 holocephalan, the elephant shark (*Callorhynchus milii*) all of which can be found in estuarine areas of Tasmania. Tracking data indicates distinct movements of the different species into and out of the estuaries in response to changing salinity. We hypothesized that species present during large rain events (hyposaline) or after long hot/dry periods (hypersaline) would be able to metabolically acclimate and/or quickly recover during these events when compared to the species that move to normosaline waters. We acutely exposed each species to hypo- and hypersaline treatments and measured metabolic rate, haematological parameters and tissue enzymes before, during and after exposure. Results indicate that each species responded uniquely to the exposures by suppressing metabolism or altering blood parameters important for oxygen transport. Furthermore, several species were able to recover faster than others when returned to normosaline water. This ecologically relevant data helps to predict the use of the estuaries as nurseries and feeding grounds by various species during climatic changes and how this will affect these species into the future.

CYTOTOXIC EFFECTS OF METHYLMERCURY AND ARSENIC IN THE GILTHEAD SEABREAM CELL LINE SAF-1

Morcillo, P., Esteban, M.A., Cuesta, A.

Symposium: Fish Cell Cultures **Type:** Poster **Order:** P33

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Fish Innate Immune System Group, Department of Cell Biology and Histology, Faculty of Biology, Regional Campus of International Excellence "Campus Mare Nostrum", University of Murcia, 30100 Murcia Spain

Abstract: For evaluation of the toxicity of aquatic pollutants, fish cell lines are a potential alternative to fish bioassays. In this study, cells of the fibroblast SAF-1 cell line from gilthead seabream (*Sparus aurata*) were exposed to methylmercury (MeHg) and arsenic trioxide (As) and the cytotoxicity and the production of reactive oxygen species (ROS) were examined. The two heavy metals produced a dose dependent reduction in the fraction of viable cells as determined by the neutral red assay. MeHg showed higher toxicity for SAF-1 cells (EC₅₀=0.01 mM) than As (EC₅₀=0.082 mM). Moreover, the production of ROS, determined by dihydrorhodamine 123 and flow cytometry, by SAF-1 exposed to the EC₀ and EC₅₀ dosages was in both cases significantly increased (P<0.005). Furthermore, toxicity produced SAF-1 cell death by apoptosis as demonstrated by scanning electron microscopy (formation of blebs) and gene expression (up-regulation of the pro-apoptotic bax and down-regulation of the anti-apoptotic bcl2 genes). This report provides comparative tools to evaluate the potential inputs of contamination on marine waters and fish using the SAF-1 cell line. Acknowledgements. This work was co-funded by Ministerio de Economía y Competitividad (AGL2010-20801-C02-02) and FEDER.

ISOLATION AND IDENTIFICATION OF LACTOBACILLUS FROM PERCH INTESTINE IN ARAS DAM, IRAN BY PCR METHOD

Mortazavi Tabrizi, S.J., Anvarian, M., and Hamzei, S.

Symposium: Parasites and Diseases **Type:** Oral **Order:** 8

Contact: Seyyed Javid Mortazavi Tabrizi **E-mail:** J.mortazavi@iaut.ac.ir

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Abstract: Lactobacilli bacteria are gram positive, without spore, catalase-negative and filamentous bacteria that mainly ferment different Carbohydrates into lactate and acetate. During this research about 50 perch (*Perca fluviatilis*) hunted from Aras Dam, Iran, randomly. The samples were transported to the Microbiology Laboratory of Veterinary Medicine Faculty of Tabriz under sterile conditions and in the vicinity of ice, and after dissection according to sterile Method; 1 gram of stool was sampled from the anterior part of intestine and cultured in MRS Agar plates. After phenotypic and biochemical identity of Bacteria, for distinction of lactobacillus species molecular characterization, 16SrDNA gene was amplified and PCR products were sequenced. Results of sequencing about 3 isolated bacteria indicated that this species has been lactobacillus fermentum and the founding's corresponding to produce results from biochemical tests and determine cutting pattern for this species.

Na⁺, K⁺, AND AMMONIA NET FLUXES OF TWO AMAZONIAN FISH SPECIES NATIVE TO RIO NEGRO (CUIEIRAS AFFLUENT) CHALLENGED BY ACUTE LOW pH EXPOSURE

Mota, S. B., Duarte, R. M. S., Sadauskas-Henrique, H., Almeida-Val, V. M. F.

Symposium: Tropical Fish **Type:** Poster **Order:** P150

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Abstract: Amazon fish from blackwaters are physiologically challenged to maintain their ionic homeostasis under extremely ion-poor conditions, associated with low pH and high contents of dissolved organic carbon. Here, we evaluate the effects of serial acute (1h) exposure to low pH (5.2; 4.5; 4.0 and 3.5) on net fluxes of Na⁺, K⁺ and ammonia in *Mesonauta festivus* and *Moenkhausia lepidura* in natural Rio Negro water. The threshold for Na⁺ Jnet was pH 4.0 to the cichlid *M. festivus* and pH 3.5 to the characid *M. lepidura*, whereas for K⁺ Jnet we observed a reversal pattern. Ammonia excretion was strongly stimulated by pH 4.5 and 4.0 in *M. festivus*, while in *M. lepidura* increased ammonia Jnet was observed in all tested pHs. Thus, we suggest that differential tolerance to low pH among these species are related to the degree of stimulation of ionic and nitrogenous waste losses. (INPA; INCT ADAPTA – CNPQ/FAPEAM)

THE EPIDERMAL GROWTH FACTOR FAMILY IN THE OVARY OF EUROPEAN SEA BASS: LH AND FSH ACTIONS
Muñoz, I., Rocha, A., Mazón, M.J., Zanuy, S., Gómez, A.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P52

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Abstract: The involvement of the epidermal growth factor (EGF) family in the local control of follicular growth and oocyte maturation is well documented in mammals. Several studies in zebrafish suggest that Egf could act as paracrine signals from the oocyte to regulate the function of the surrounding somatic follicle cells. In the European sea bass (*Dicentrarchus labrax*), a model marine perciform, the characterization of these paracrine factors has not been performed yet. The expression patterns of the Egf family ligands and Egf receptors (Egfra and Egfrb) in different tissues of sea bass were studied. All of them were detected in gonads, suggesting a role of this family in the control of gametogenesis in sea bass. Quantification of the expression of the Egf-like ligands and their receptors in the ovary of adult sea bass during a whole reproductive cycle showed different profiles for these genes. However, in all cases, except for Egf, maximum levels of expression are found in maturing-ovulating animals. Fish ovarian development and gametogenesis are primarily controlled by hypophyseal gonadotropins (Fsh and Lh). We wanted to further investigate if these hormones regulate egf or egfr expression in vitro. For that purpose, stimulations of sea bass ovary culture with recombinant sea bass single-chain Fsh or Lh were carried out. Gonadotropins did not modulate either Egf or Egfr expression. In view of our results, we think that gonadotropins could exert their actions over Egf and Egfr via another mechanisms than transcriptional control. Supported by GV (proyecto GV/2013/124), MICINN (AGL2011-28890).

WHY ARE SCULPIN SUSCEPTIBLE TO THE EFFECTS OF ARTIFICIAL STRUCTURES?– PROPOSED METHOD OF IMPROVEMENT BASED ON THE SWIMMING BEHAVIOR
Muraoka, K., Nakanishi, S., Kayaba, Y.

Symposium: Swimming Physiology **Type:** Oral **Order:** 9

Contact: Keiko Muraoka **E-mail:** muraoka@pwri.go.jp

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Abstract: Sculpin (*Cottus pollux*) is a weak swimmer. Our experimental study shows that only a 15-cm drop prevents their migration, even though their maximum swimming speed is not particularly slow. We propose a method to improve their migration based on two patterns of swimming behavior observed around artificial structures. One swimming pattern is to almost slide or creep along the bottom, splaying their pectoral fin. The other is moving in a kind of arc, before squaring their ventral fin. It is assumed that water depth and flow velocity are related to these swimming patterns. The latter pattern prevents their migration on high velocity flow, because they cannot control their migration due to upper pressure on the belly. From these results, it is considered necessary to reduce the flow velocities near the bottom for sculpin migration. Also, a high-density refuge will help avoid their failure to migrate. The combination of various roughnesses effectively improves their migration.

EFFECT OF FISH MEAL COMPONENT ON GENE EXPRESSION LEVELS OF CHOLECYSTOKININ AND PANCREATIC DIGESTIVE ENZYMES IN YELLOWTAIL
Murashita, K., Takahashi, N., Hosomi, N., Yamamoto, Y., and Fukada H.

Symposium: Fish Culture **Type:** Poster **Order:** P12

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Abstract: In vertebrates, it is well known that cholecystokinin (Cck) stimulates the pancreatic digestive enzymes secretion. We have reported that fish meal (FM) increased cck and trypsin gene expression in yellowtail *Seriola quinqueradiata*, whereas plant proteins did not increase the gene expression. This indicates FM strongly stimulates the digestive enzymes secretion/synthesis in yellowtail. In this study, we focused on the components of FM; the FM was divided into water-soluble (WS) and water-insoluble (IS) fractions. Administration of the WS fraction to yellowtail increased the gene expression of trypsin, lipase, cck and cck receptor (cck-1r) but not those of fish administered the IS fraction, suggesting the enzyme stimulation factor should exist in the WS fraction. Chemical analyses revealed that the main component of the WS fraction seemed to be very small peptides and/or free amino acids. We are trying to identify the enzyme stimulation factor using *in vivo* and *in vitro* techniques.

THE ROLE OF LIPIDS AND RHEOTAXIS OF JUVENILES IN THE FORMATION OF PHENOTYPIC GROUPS AND HETEROGENEITY OF ATLANTIC SALMON

Murzina, S.A., Nefedova, Z.A., Veselov, A.E., Ripatti, P.O., Nemova, N.N., Pavlov, D.S.

Symposium: Fish Habitats **Type:** Oral **Order:** 9

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Abstract: Lipid composition is a biochemical indicator of the status and health of juveniles while rheotactic behavior affects the spatial patterns of fish settlement, thus both reflect processes as the intra-population differentiation of the young salmon. The research presented the lipid status and rheotaxis of the fry of salmon that inhabited different biotopes of the Varzuga River (the Kola Peninsula). The stable differences in the rheotactic parameters of the groups of salmon that formed immediately after the fish from the same spawning nests settled indicate the effect of the heterogeneity in the lipid composition of the embryos on the development of differences in these rheotactic parameters. The existence of phenotypic groups plays a significant role in the further differentiation of the young salmon, growth, the timing of migration. Acknowledgements: The President of the Russian Federation Grant NSH 1410.2014.4; RFBR № 14-04-0047-a; Program of RAS "Living Nature"; FCP № 8050.

A DOUBLE-EDGED SWORD: USING BURBOT SWIMMING AND JUMPING PERFORMANCE DATA TO AID THE DESIGN OF BARRIERS TO MIGRATION AND FISH PASSAGE STRUCTURES

Myrick, C.A., and Gardunio, E.I.

Symposium: Burbot **Type:** Oral **Order:** 1

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Abstract: Most burbot (*Lota lota*) populations are native, but those in the Green River system in the western United States are invasive. The invasive burbot threaten native fish species, so efforts are underway to physically exclude burbot from stream and river segments with instream barriers. In their native habitats, burbot populations are sometimes impacted by the longitudinal fragmentation of streams and rivers. We used a three-tiered approach to measure the swimming and jumping performance of wild-caught burbot under laboratory conditions to produce data that could be used to design barriers to burbot movement, or to develop effective fish passage structures. From a barrier standpoint, vertical drops of $\geq 100\%$ TL and plunge pool depths of $\geq 30\%$ TL of the largest burbot in a system should prevent them from successfully jumping over the obstacles. Similarly, velocity barriers with

minimum velocities of ≥ 3.2 body lengths per second for the largest burbot in the system should restrict upstream passage. We will also discuss how the same data set can be applied to fish passage development for burbot.

DOES GROWING GREY SEAL POPULATION IN THE BALTIC IMPACT ON INCREASING THE PREVALENCE OF INFECTION WITH ANISAKID LARVAE IN COD?

Nadolna, K., Podolska, M.

Symposium: Parasites and Diseases **Type:** Oral **Order:** 3

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Abstract: Cod *Gadus morhua* from the southern Baltic was examined in 2011-2013 for the presence of anisakid parasites. Zoonotic species of *Contracaecum*, *Anisakis*, *Pseudoterranova*, were found in the liver of cod. In 2011 the mean prevalence of infection was 12% and increased rapidly in subsequent years. Results have been compared with previous studies (1987-1994). Generalized linear models (GLMs) were applied to analyse the prevalence of infection with *Anisakis* sp. and *Contracaecum* sp. relative to biological and spatial parameters. Effects of the sampling region and year were significant in GLMs. The prevalence of infection correlated negatively with body condition factor of fish. Currently even small, young cod (20 cm long) are infected, which may be the result of greater availability of infected food. As the grey seal serve as a final host for *C. osculatum*; therefore, an increasing seal population size may impact the dispersion of this nematode in the Baltic.

ANTIGEN RECEPTOR GENE ASSEMBLY IN HAGFISH

Nagawa, F.

Symposium: Hagfishes **Type:** Oral **Order:** 5

Contact: Fumikiyo Nagawa **E-mail:** snagawa@mail.ecc.u-tokyo.ac.jp

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Abstract: Variable lymphocyte receptors (VLRs) are the antigen receptors in jawless vertebrates, such as lamprey and hagfish. A functional VLR gene, which consists of several leucine-rich repeats, is generated by the assembly of variable germline LRR gene segments that encode LRRs. In lamprey, stepwise assembly of the gene segments occurs by replacement of the intervening non-coding DNA between the 5' and 3' constant regions by a process involving "copy choice". Basically only one VLR gene is assembled in a lymphocyte through allelic exclusion and feedback inhibition. The mechanism of hagfish VLR gene-assembly is not clear at present because of insufficient information on the germline LRR gene segments. Here, we have sequenced several hundred hagfish germline LRR segments using sequence capture and high-throughput 454 sequencing, and also analyzed many partially assembled VLR genes. The implications of these data along with a possible mechanism of hagfish VLR gene assembly will be discussed.

NEFATIN-1 REGULATION OF CARDIOVASCULAR FUNCTIONS IN ZEBRAFISH

Nair, N., Gerger, C., Weber, L., Unniappan, S.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 8

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Abstract: Nesfatin-1 is a multifunctional, naturally occurring peptide in vertebrates. We hypothesized that nesfatin-1 is a modulator of cardiovascular functions in zebrafish. Here we characterized the endogenous nesfatin-1 and its effects on zebrafish cardiovascular physiology. Zebrafish cardiomyocytes express nesfatin-1-like immunoreactivity. Ultrasound imaging of zebrafish heart at 15 minutes post-intraperitoneal injection of nesfatin-1 showed a dose-dependent inhibition of end-diastolic and end-systolic volumes, while a significant increase in end-diastolic volume was found at the lowest dosage. However, these combined effects did not alter the stroke volume. Heart rate and cardiac output were also significantly decreased in zebrafish that received nesfatin-1. Nesfatin-1 caused a significant increase in the expression of Atp2a2a mRNA encoding the calcium-handling pump, SERCA2a, while no alterations were found in the expression of calcium handling protein RyR1b encoding mRNA. Our data supports the hypothesis that nesfatin-1 is a modulator of zebrafish cardiovascular physiology.

LINKS BETWEEN METABOLIC TRAITS AND LATITUDINAL DISTRIBUTION ACROSS FISH SPECIES

Nati J.J.H., Johnson P., Lindstrom J., Killen S.S.

Symposium: Climate Change **Type:** Oral **Order:** 8

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Abstract: A range of biotic and abiotic factors may affect the geographical distribution of species. For example, recent work has shown that latitude range in ectothermic species might be governed by thermal tolerance limits. Still unknown, however, are the proximate physiological mechanisms that allow certain species to have wider thermal limits and possibly a broader geographic range. Here we examined how metabolic and life-history traits might affect latitudinal range and position in fish. Our comparative analysis of the existing data from literature revealed a positive correlation between aerobic scope and latitude range across 65 fish species and species with higher baseline metabolic rate were found at higher latitudinal positions. These findings suggest that geographical distribution and capacity to colonise new habitats of fishes is tightly linked with their metabolic physiology. In this regard, we are currently investigating how the physiological traits of invasive fish species may differ from of native fish species.

THE RESPONSES OF THE DOGFISH SHARK TO HIGH ENVIRONMENTAL AMMONIA

Nawata, C.M., Walsh, P.J., and Wood, C.M.

Symposium: Elasmobranchs **Type:** Oral **Order:** 10

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Abstract: Marine elasmobranchs are ureotelic and exhibit very low gill permeability to both urea and ammonia. When dogfish sharks were exposed to high environmental ammonia (HEA -1200 $\mu\text{mol L}^{-1}$, pH 7.7), they initially took up ammonia but were able to re-establish excretion by 36-48 h, reducing blood total ammonia levels below environmental concentrations, and exhibiting only a slight blood acid-base disturbance. A blood-to-water PNH_3 gradient in favour of excretion was maintained throughout, and a marked increase in transepithelial potential re-established the outwardly directed electrochemical gradient for NH_4^+ . Urea-N excretion was greatly elevated, suggesting conversion of ammonia taken up from the environment into urea by the ornithine-urea cycle. The mRNA expressions of Rhbg in the gill and Rhag in the red blood cells were both down-regulated, suggesting a barrier function. Rhp2 expression did not change. Ammonia infusion experiments and mRNA measurements of other transporters cast additional light on these responses (NSERC Discovery).

DEVELOPMENT OF MUSCLES TISSUE OF LARVAE TROUT FROM VRLIKA RIVER, CROATIA

Nejedli, S., Kozaric, Z., Tlak Gajger, I., Nejedli, D.

Symposium: General Contributed Papers **Type:** Poster **Order:** P59

Contact: Srebrenka Nejedli **E-mail:** snejedli@vef.hr

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Abstract: Investigations were carried out on trout larvae (*Salmothymus obtrusirostris*, Heckel 185) age of 10-56 days caught from Vrlika river (Croatia). Larvae were taken every two days and fixed in 10% buffered formalin. The fixed material was embedded in paraffin and serially longitudinally cut in the 10 micrometers thick sections and were stained with hematoxylin and eosin, Toidin blue, PAS and Ancian blue methods to show the tissue structure. Development of the larvae were analysed, primarily the development of muscle tissue. The number of myosepts on the 10 larvae were measured in the period of 10-18, 20-28, 30-38 and 40-48 days. In these periods average number of myosepts increased and it was on 10-18 days 42.82, 22-30 days 49.78, 30-38 days 53.57 and 40-48 days 57.04 myosepts.

INTRASPECIFIC VARIATION IN LOCOMOTOR EFFICIENCY, HYPOXIA TOLERANCE AND ECOLOGICAL PERFORMANCE IN EUROPEAN SEA BASS: IMPLICATIONS FOR AN INCREASINGLY HYPOXIC WORLD

Nelson, J.A., Claireaux, G. and Mark, F. C.

Symposium: Climate Change **Type:** Oral **Order:** 13

Contact: Jay Nelson **E-mail:** jnelson@towson.edu

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Abstract: Future success of estuarine fishes will depend on their ability to execute life processes with less oxygen due to anthropogenic activities. Studying intraspecific variation of marine fish physiology and its relation to hypoxia tolerance could provide clues as to fish success in a more hypoxic ocean. We investigated individual variation and repeatability of hypoxia tolerance and its relationship to physiology in European sea bass. We measured maximum anaerobic speed at exhaustion (UCAT), gait transition speed between aerobic and anaerobic swimming, swimming efficiency, routine metabolic rate, post-UCAT metabolic rate, aerobic scope and body morphology. Fish were also released into artificial estuaries for five months at densities that ensured competition for natural forage but were not exposed to predation. Metabolic rate after the UCAT test was inversely related to hypoxia tolerance and was predictive of an animal surviving the estuaries. Early death in the estuaries was characterized by a late transition from aerobic to anaerobic swimming mode and low anaerobic swimming capacity.

DOES OCEAN ACIDIFICATION REDUCE COPPER-INDUCED DNA DAMAGE IN MARINE FISH AND CRUSTACEANS?

Newbatt, S.J., Ford, C., Lewis, C.A., Sanders, M.B., Tyler, C.R., Hutchinson, T.H., Wilson, R.W.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 12

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Abstract: Elevated environmental CO₂ (ocean acidification) reduces seawater pH, in turn altering copper speciation towards increased bioavailability and potential toxicity. However, here we suggest that the physiological response to elevated environmental CO₂ changes blood chemistry such that internalised copper becomes less toxic. We studied shore crabs (*Carcinus maenas*) and European sea bass (*Dicentrarchus labrax*). Water-breathing animals acutely subjected to elevated environmental CO₂ experience a corresponding extracellular acidosis. Fish and crustaceans

regulate this disturbance by accumulating bicarbonate ions (HCO_3^-) in the blood. Preliminary data from in vivo studies on shore crabs and in vitro studies on sea bass suggest that this internal accumulation of HCO_3^- ions may provide a hitherto undocumented protective effect against the cellular oxidative-damage caused by internalised copper. This protection is hypothesised to result from the complexation of copper species with HCO_3^- ions in the blood, decreasing the potential for cell entry and oxidative damage. Theoretically, the same mechanism should apply to all strong acid-base regulators, including finfish and other crustaceans.

AQUACULTURE OF AIR-BREATHING SPECIES IN VIET NAM

Nguyen, T.P., Do, T.T.H, Wang, T. and Bayley, M.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 10

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Abstract: Vietnam ranks third in global aquaculture production (FAO, 2012) with a total of 3.2 million tons, of which fish contributed with more than 2.2 million tons (Fisheries Directorate, 2014). Most is produced in the Mekong delta region where the dominating freshwater species are air-breathing and include catfish (*Pangasianodon hypophthalmus* and *Pangasius bocourti*), snake head (*Channa striata*), and swamp eel (*Monopterus albus*); with mud skipper (*Pseudapocryptes elongatus*) in the brackishwater. On a global scale, the production of air-breathing species now represent 8% of the global cultured fish production and therefore exceed the total global production of salmonids. Air-breathing probably evolved in response to hypoxia and these fish are well adapted to conditions considered poor for water breathing fish. The separation of ion regulatory and oxygen uptake functions at branchial surfaces seems also to have conveyed enhanced tolerance to common toxins and the freshwater species of the Mekong delta all seem tolerant to brackish water. Data on these issues will be presented and research needs for the continued development of air-breathing fish culture highlighted.

PATTERNS IN SEA TROUT FRY PHYSIOLOGICAL STATUS AT EMERGENCE FROM NATURAL REDDS

Nika, N., Virbickas, T. and Kontautas, A.

Symposium: Fish Habitats **Type:** Poster **Order:** P109

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Abstract: Salmonid fish fry emergence patterns from the redd gravel have high importance on their subsequent establishment of feeding territory, dispersal and survival potential. A detailed two-year study on *Salmo trutta* emergence timing, distribution and physiological status was carried out in a small lowland stream Blendziava in western Lithuania by trapping emerging fry from natural redds. Standard morphological and biochemical RNA:DNA ratio approaches were used to evaluate fry physiological status at the emergence. Emergence from individual redds in both years followed near normal distribution, usually with several peak days in a whole long emergence period. Peak emergers were characterized by the optimal body physiological condition with the greatest body length and weight, while still having some buffer yolk reserves left. Meantime, the late emergers had depleted yolk reserves (less than 1%) and this was reflected in decrease of wet weight and Fulton's condition index. At this stage fry are potentially vulnerable to starving if emergence is impeded even for a short time. Such delicate patterns in physiological condition changes for the last emerging fry was soundly represented by RNA:DNA ratio of muscle samples, what was not always detected by inert traditional morphological measures.

EFFECTS OF ANDROGENS AND CORTISOL ON GILL ION TRANSPORTERS AND OSMOREGULATORY CAPACITY IN
ATLANTIC SALMON

*Nilsen, T.O., Andersson, E., Sundh, H., Taranger, G.L., Schulz, R.W., Sundell, K., Norberg, B., Ebbesson, L.O.E.,
Handeland, S.O., Stefansson, S.O.*

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 2

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Abstract: Sex steroids have been reported to compromise ion homeostasis in teleosts, yet there is limited and somewhat contradictory knowledge about the mechanisms through which androgens impact osmoregulatory capacity in salmonids. Immature Atlantic salmon post-smolts in sea water (SW) were injected with 11-ketoandrostenedione (OA; 25 µg/g BW), cortisol (F; 25 µg/g BW), F+OA (25 µg/g BW) and sham control (CON). After 8 days treatment, androgen treated post-smolts demonstrates a striking transcriptional increase in FW-type of ion transporters in SW acclimated fish, concurrent with no apparent ion perturbations, or down regulation of SW gill ion-transporters. Cortisol-treated post-smolts displayed increased gill ion transporters, with an additive effect in F+OA treated fish in seawater. Moreover, decreased transcript levels of SW type gill ion transporters followed cortisol treatment while combining cortisol and androgen induced severe osmoregulatory stress and mortalities in seawater; no mortality occurred when only cortisol was administered. Our findings suggest that androgens remodel gill epithelia for FW entry rather than leading to osmoregulatory dysfunction in SW. Moreover, maturing salmon kept in SW may be sensitive to stress since combinations of elevated androgens and cortisol levels have detrimental effects on ion homeostasis and fish welfare.

GLOBAL CHANGE: CAN MINOR HYPERCAPNIA HAVE MAJOR CONSEQUENCES?

Nilsson, G.E.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 30

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Abstract: Over the last years it has become evident that sustained exposure to the projected elevation of oceanic pCO₂, from today's 400 µatm to 800 - 1000 µatm, can alter the behavior of fish. The initial studies involved damselfishes on the Great Barrier Reef, but similar effects have now been seen in temperate fishes (from North Atlantic and Californian coasts). Thus, a mere doubling of ambient pCO₂, which until recently was considered unlikely to have any physiological consequences, clearly has the ability to alter brain functions. These functions include those involved in olfactory preferences, activity, boldness, anxiety, lateralization of movement, hearing, vision, and learning. These impairments can be rapidly reversed by treatment with a moderate dose of an antagonist of the neuronal GABA-A receptor – which is the only major neurotransmitter receptor / ion channel with conductance for Cl⁻ and HCO₃⁻. These are the same two ions that can be expected to be altered by exposure to high CO₂. I will discuss some scenarios leading to changes in neuronal Cl⁻ and HCO₃⁻ gradients that could alter GABA-A receptor function.

INITIAL CHARACTERIZATION OF IMMUNORELEVANT GENES AS PREREQUISITE FOR STRESS ANALYSES IN
AQUACULTURED MARAENA WHITEFISH

Nipkow, M., Altmann, S., Bochert, R., Goldammer, T.

Symposium: Stress in Fish **Type:** Poster **Order:** P128

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Abstract: Natural stocks of the anadromous salmonid maraena whitefish (*Coregonus maraena*) are running low in the Southern Baltic Sea. Since stock compensating efforts are not sufficient to meet the demand a new attempt is the establishment of a highly productive and robust whitefish population for local aquaculture. Therefore, molecular biological approaches support the development of a robust breeding strain. For this purpose, we isolated and characterized respective cDNA sequences of the following pivotal immune genes IL6 (Interleukin 6), IL8 (interleukin 8), IL12 (interleukin 12), SAA (serum amyloid A), IL1b (interleukin 1b), ERK1 (extracellular signal regulated kinase 1), ERK2 (extracellular signal regulated kinase 2) and TNF (tumor necrosis factor). Furthermore, we measured the spleen-specific expression of the aforementioned genes in whitefish grown in two different aquaculture systems by quantitative Real-Time PCR (qRT-PCR). Regarding the trait robustness, our aim is to examine possible differences in the immune response between the two housing conditions – one derived from a closed circular system with UV-purified, tempered, brackish water (around 20 °C), and the other from an open-flow system with untreated brackish water (from 18 to 2 °C). EFF VI-560/730-32614

TRANSIENT RECEPTOR POTENTIAL CHANNELS (TRP) IN RAINBOW TROUT): AN INTERFACE BETWEEN THERMAL SENSING AND MELATONIN SECRETION.

Nisembaum, L.G., Besseau, L., Paulin, C-H., Charpantier, A., Loentgen, G., Martin, P., Magnanou, E., Fuentès, M., Delgado, M.J., Falcón, J.

Symposium: Sensing the Environment **Type:** Oral **Order:** 7

Contact: Laura Nisembaum **E-mail:** nisembaum@obs-banyuls.fr

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Abstract: Photoperiod determines the duration of the nocturnal melatonin production. In turn, this time-keeping hormone contributes to coordinating daily and annual rhythms of metabolism, physiology and behavior. Temperature is also important because it regulates the amplitude of the nocturnal melatonin surge in non-mammalian vertebrates. However, the mechanisms underlying this thermal regulation remain unknown. Because members of the transient receptor potential channel (TRP) family mediate temperature sensing in mammals we investigated whether TRP might be involved in the control of melatonin secretion in trout. Here we report the cloning, qualitative and quantitative distribution of TRPV1 and TRPV4 in rainbow trout. These receptors displayed a wide distribution; the highest expression levels were found in the kidney and intestine (TRPV1 and TRPV4) as well as pineal gland and heart (TRPV4). In the pineal gland, (1) expression was localized in photoreceptor cells; (2) *in vitro* pharmacological investigations indicated a TRP-dependent modulation of melatonin secretion in the dark. These results are a first step in the elucidation of thermal sensing in fish.

LAMPREY CONSERVATION AND RESTORATION: SHARING KNOWLEDGE

Noakes, D. L. G., Clemens, B. J, and van de Wetering, S. J.

Symposium: Lampreys **Type:** Oral **Order:** 8

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Abstract: There are increasing concerns for the management of Pacific coast lampreys. We identified emerging linkages in biology, research and management with a workshop representing tribal fish commissions, independent contractors, federal agencies, watershed councils, universities, and state agencies from Canada and the USA. We addressed Pacific lampreys as important cultural and ecological species including: 1) indicators of ecosystem health, 2) key regional restoration and conservation initiatives, 3) expert perspectives, 4) collaborations to address key questions, and 5) subsequent meetings to fill information gaps. A documentary film highlighted tribal concerns about lampreys. We recognized five key areas: 1) evolution and dispersal, 2) ocean biology, 3) freshwater biology,

4) ecosystem services, and 5) passage. An initial Pacific Lamprey Recovery Plan was developed and will be submitted for publication.

INHERITED MAGNETIC OCEAN NAVIGATION IN JUVENILE PACIFIC SALMON

Noakes, D. L. G., Putman, N. F., Scanlan, M. M., Billman, E. J., O'Neil, J. P., Couture, R. B., Quinn, T. P., Lohmann, K. J., Klimley, A. P., and Meinke, A. M.

Symposium: Sensing the Environment **Type:** Oral **Order:** 14

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Abstract: We tested the hypothesis that Pacific salmon are guided by the field intensity and inclination angle of the earth's magnetic field. We rear and test the fish under both local, undisturbed geomagnetic conditions and under specified magnetic intensity and inclination conditions representing different geographic locations. Juvenile Chinook salmon and steelhead exposed to magnetic fields characterizing the northern and southern latitudinal extremes of their oceanic range orient in opposite directions, in each case towards their marine feeding grounds. Fish use both the magnetic intensity and inclination angle to assess their location; orientation is random when magnetic coordinates are contradictory (i.e., northern intensity paired with southern inclination and vice versa). Fish tested had no migratory experience, suggesting that their magnetic map sense is inherited. Steelhead reared or tested in a spatially non-uniform and widely varying magnetic field failed to distinguish between the same experimental fields and were not significantly oriented.

IS THE FATE OF PACIFIC LAMPREY WRITTEN IN THE CLOUD?

Noakes, D. L. G., Unrein, J. R., Fedewa, E., Gonzalez, R., Rincón Diaz, M. P., and Nicole Duplaix, N.

Symposium: Lampreys **Type:** Poster **Order:** P94

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Abstract: Recovery of Pacific Lamprey, *Entosphenus tridentatus*, (PLA) in the Columbia River Basin requires effective communication and cooperation among researchers, managers, policy makers, stakeholders and the general public. We used a free cloud-based program, SpiderScribe, to create a decision tree timeline for data gathering and development of projects, implementation of studies and monitoring programs and project evaluation and adaptation. We target four main issues: knowledge gaps and public perception, habitat loss and degradation, water quality and contaminants, and passage barriers. SpiderScribe can organize ideas generated in meetings and workshops so many people can work remotely to edit and accessing the most recent work. It is an educational tool, to describe what we know about lamprey biology and habitat needs as well as what remains to be studied.

INTESTINE, LIVER AND MUSCLE CELULAR ACTIVITY AND DEVELOPMENT OF JUVENILE DOURADO FED WITH LYOPHILIZED BOVINE COLOSTRUM

Nordi, W.M.; Moretti, D.B.; da Cruz, T.M. P.; Cyrino, J.E.P.; Machado-Neto, R.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P70

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Abstract: Lyophilized bovine colostrum (LBC), as a partial protein source and insulin-like growth factor I (IGF-I), may constitute an innovative ingredient in fish feeding. Concentrations of serum IGF-I, and intestine, liver and muscle total protein (TP), DNA, RNA, reliable indicators of growth rates and feeding regime changes, was evaluated in dourado (*Salminus brasiliensis*) (10.84 ± 0.182 g; 13.27 ± 0.351 cm, n=15) fed with diet 0%, 10% and 20% inclusion of LBC, at 30 and 60 days. Serum IGF-I concentration increased ($P < 0.05$) between 30 and 60 days. Intestine TP, DNA, RNA and the ratios of these variables were not influenced ($P > 0.05$) by diets or periods. Liver DNA increased markedly between 30 and 60 days, in 20% LBC group ($P < 0.05$). Muscle RNA and RNA/DNA decreased until 60 days, while TP/RNA increased during this period. Increased muscle RNA content indicates predominance of fish growth by hypertrophy. Since the LBC did not a negative influence in cellular activities, can be a promising alternative source of protein and IGF-I in dourado feeding.

HYPOTHALAMIC-PITUITARY-GONADAL ENDOCRINE SYSTEM IN THE HAGFISH

Nozaki, M.

Symposium: Hagfishes **Type:** Oral **Order:** 6

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Abstract: Not only the pituitary gland but also all major adenohipophysial hormones and their receptors are considered to be vertebrate novelties. Since hagfishes represent the most primitive vertebrate, they are of particular importance in understanding the evolution of the hypothalamic-pituitary-gonadal axis related to reproduction. In contrast to gnathostomes that have two gonadotropins (GTHs: LH and FSH), only one GTH has been identified in the hagfish. Immunohistochemical and functional studies confirmed that this hagfish GTH was significantly correlated with the developmental stages of the gonads and showed the presence of a steroid (estradiol) feedback system at the hypothalamic-pituitary levels of the hagfish. Moreover, a PQRamide peptide was identified in the hagfish hypothalamus, and was shown to stimulate the expression of GTH α mRNA in the hagfish pituitary. These findings provide evidence that there are neuroendocrine-pituitary hormones that share common structures and functional features compared to later evolved vertebrates.

HOW WILL ANTARCTIC NOTOTHENIROID FISHES FARE AS THE SOUTHERN OCEAN WARMS?

O'Brien, K.M.

Symposium: Plenary **Type:** Oral **Order:** 1

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Abstract: Antarctic notothenioid fishes are among the most stenothermic organisms on earth with an upper insipient lethal temperature of $\sim 6^{\circ}\text{C}$. Members of the notothenioid family, Channichthyidae (icefishes), lacking hemoglobin, are even less tolerant of elevations in temperature than red-blooded notothenioids. The physiological and biochemical basis of thermal tolerance in Antarctic fishes is largely unknown. Oxygen delivery likely does not limit critical thermal maxima (CTMax), as supplemental oxygen does not extend CTMax in either red-or white-blooded notothenioids. Results from our studies suggest that decrements in cardiac function caused by mitochondrial dysfunction and oxidative damage, or loss of neuronal function may be contributing factors. Antarctic fishes have a modest capacity to acclimate to warmer temperatures. Aerobic metabolic capacity of the red-blooded notothenioid *Notothenia coriiceps* does not change following acclimation to 4°C for three weeks. Supported by a grant from the NSF (ANT 0741301).

PROTEOMIC STUDIES ON THE SARCOPLASMIC PROTEIN COMPONENTS IN THE MUSCLES OF DEEP-SEA FISH SPECIES
Ochiai, Y.

Symposium: Fish Habitats **Type:** Poster **Order:** P110

Contact: Yoshihiro Ochiai **E-mail:** aochiai@tokai-u.jp

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Abstract: In order to understand the adaptation mechanism of fish to deep sea, attempts were made to characterize the compositions of sarcoplasmic proteins from the deep-sea species. Twenty fish species from the Pacific side of Japanese coast were used in the study. Electrophoretic analyses using SDS-PAGE and two dimensional were performed on the extracts from the dorsal part of white muscles with 20 mM neutral phosphate buffer. It was revealed that the electrophoretic patterns were quite species-specific, especially in the lower molecular weight ranges, and those from closely related species (i.e., Macrouridae) from different habitat depths showed significant differences. The stoichiometric analysis of protein components also lead to the same conclusion. The results obtained suggest that adaptation to high hydraulic pressure has been realized by protein expression levels., although it is possible minute replacements of amino acid residues hardly be detected by conventional electrophoretic conditions are also involved in the adaptation.

RESOLVING FISH HAEMOGLOBIN: SIMULTANEOUS PH AND SPECTROPHOTOMETRIC RECORDINGS IN BLOOD
MICROVOLUMES ADVANCE OXYGEN BINDING MEASUREMENTS.

Oellermann, M, Pörtner, H.O., and Mark, F.C.

Symposium: Climate Change **Type:** Poster **Order:** P24

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Abstract: Oxygen transport measurements have been widely used to explain evolutionary adaptation and performance in fishes. Simultaneous measurements of blood pH and oxygen saturation are essential to understand oxygen transport as it occurs in vivo, but has been challenging to monitor with existing methods, particularly in minute blood volumes. We equipped a gas diffusion chamber with a broad-range fibre-optic spectrophotometer and a micro-pH optode and successfully recorded changes of pigment oxygenation and pH in only 15 µl of whole fish blood at 0°C. Highly resolved spectra ranging from 280 – 900 nm captured the complex absorbance features of Antarctic fish haemoglobin in response to changing oxygen and carbon dioxide partial pressures. After consideration of photobleaching and intrinsic fluorescence, pH optodes recorded pH shifts of 0.03 pH units. With this modified diffusion chamber experimental biologists are able to accurately characterize oxygen binding with minimal sample consumption and manipulation under diverse experimental settings.

COMPOSITION AND DYNAMICS OF SOME NUTRIENT LEVELS IN JABI DAM, LOWER USUMA DAM AND
GWAGWALADA RIVER IN NIGERIA

Ojutiku, R.O, Kolo, R.J, Mbanaso, C.A

Symposium: Environmental Change **Type:** Poster **Order:** P26

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Abstract: Jabi dam, Lower Usuma dam and Gwagwalada river in the Federal Capital Territory were studied for a period of eighteen months (June 2005 – January 2007) to determine their nutrient composition and dynamics. Samples were collected from these water bodies on monthly basis. The concentration of some nutrient parameters such as Phosphate-phosphorus (PO₄-P), Nitrate-Nitrogen (NO₄-N), Total Dissolved Solids (TDS), Calcium (Ca),

Potassium (K) and Sodium (Na) were assessed and determined. The results obtained were statistically analysed to show any relationship amongst them. The mean values for NO₄-N, Ca and K were not significantly different ($P > 0.05$) between the three water bodies. While the mean value for PO₄-P were significantly different ($P < 0.05$), with Jabi dam having the highest mean value of 11.61 mg/l, followed by Gwagwalada river, 9.96 mg/l and Lower Usuma dam had least mean value of 2.46 mg/l. Jabi dam, Lower Usuma dam and Gwagwalada river had mean TDS of 95.0 mg/l, 88.5 mg/l and 104.5 mg/l respectively, Gwagwalada river being significantly different ($P < 0.05$) from Jabi and Lower Usuma dams. Similarly, Jabi dam, Lower Usuma dam and Gwagwalada river had mean Sodium values of 2.42 mg/l, 2.85 mg/l and 3.73 mg/l respectively, Gwagwalada river being also significantly different ($P < 0.05$) from Jabi and Lower Usuma dams. PO₄-P and NO₄-N showed no significant ($P > 0.05$) monthly variations in the three water bodies. However, TDS, Ca, K, and Na showed significant ($P < 0.05$) monthly variations in the three water bodies. TDS, Ca, K, and Na had all their wet season mean values higher than their dry season mean values in all the three water bodies studied, while PO₄-P and NO₄-N had their wet season mean values lower than the dry season mean values in the three water bodies. The study revealed that the nutrient parameters measured were slightly lower than the World Health Organization (WHO) recommended values for aquatic life.

Keywords: Jabi dam, Lower Usuma dam, Gwagwalada river, Nutrients levels and variations.

OLFACTORY DISCRIMINATING ABILITY OF ADULT CHUM SALMON TOWARDS NATAL TRIBUTARY STREAMS

Okubo, T., Chen, E.Y., and Ueda, H.

Symposium: Sensing the Environment **Type:** Oral **Order:** 16

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Abstract: Chum salmon (*Oncorhynchus keta*) possess the unique ability to locate their natal tributary streams from the main stem within a watershed. Electrophysiological discriminating abilities were studied using adult mature male chum salmon that homed to the Chitose River, which is a major tributary in the Ishikari River watershed. Dissolved free amino acid compositions (DFAAC) were also analyzed by HPLC. Electro-olfactogram (EOG) response levels were compared the Chitose River water (CRW), the Ishikari River water (ISW), and the Toyohira River water (TRW), which is another tributary in the Ishikari River watershed. The EOG response of fish exposed to CRW and ISW was significantly greater than that of fish exposed to TRW. Significant differences were detected for 11 DFAAC between CRW and ISW and for 2 DFAAC between ISW and TRW. These results suggest that adult chum can discriminate their natal tributary streams from the main stem despite large differences in DFAAC.

OXIDATIVE DEFENSE IN THE MUSCLE OF PROTOPTERUS ANNECTENS DURING AESTIVATION

Ong, L.Y.J., Chng, Y.R., Hiong, K.C., Ching, B.Y., Chen, X.L., Wong, W.P., Chew, S. F., and Ip, Y. K.

Symposium: Tropical Fish **Type:** Poster **Order:** P151

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Abstract: Lungfishes hold an important position concerning water-land transition during evolution, and extant African lungfishes can undergo long periods of aestivation on land during drought. This study aimed to determine the mRNA and protein expression of copper/zinc superoxide dismutase, manganese superoxide dismutase, catalase, glutathione peroxidases 1 and 4 in the muscle of the African lungfish, *Protopterus annectens*, during the induction, maintenance and arousal phases of aestivation in air. Results indicate that the expression of these genes were down-regulated in the muscle during the maintenance phase of aestivation, indicating that there could be a suppression of the production of various oxidative elements in the muscle of *P. annectens* during aestivation.

MOLECULAR BASIS OF CHANGES IN PROPERTIES OF BLOOD IN PROTOPTERUS ANNECTENS DURING AESTIVATION
Ong, L.Y.J., Chng, Y.R., Hiong, K.C., Chung, S.T.C., Tan, X.R., Wong, W.P., Chew, S. F., and Ip, Y. K.

Symposium: Tropical Fish **Type:** Oral **Order:** 15

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Abstract: Lungfishes hold an important position concerning water-land transition during evolution, and extant African lungfishes can undergo long periods of aestivation on land during drought. This study aimed to obtain the coding cDNA sequences of haemoglobin isoforms, two pro-coagulant genes (coagulation factor II and fibrinogen gamma chain) and two anti-coagulant genes (plasminogen and serin peptidase, clade C, member 1) from the liver of the African lungfish, *Protopterus annectens*, and to determine their mRNA expression in various organs/tissues of fish during the induction, maintenance and arousal phases of aestivation in air. Results showed that aestivation led to changes in the mRNA expression of some haemoglobin isoforms, indicating possible changes in respiratory properties of hemoglobin during aestivation. Furthermore, the two pro-coagulant genes were down-regulated in the liver during the maintenance phase of aestivation presumably to promote anti-clotting, while the two anti-coagulant genes were down-regulated upon arousal probably to restore the blood clotting capacity.

RANGING AND MIGRATION OF LARGE SHARKS - ECOLOGICAL AND PHYSIOLOGICAL FACTORS

Ormond, R.F.G., Gore, M.A., Rowat, D. and Lea, J.S.E.

Symposium: Fish Migration **Type:** Oral **Order:** 7

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Abstract: We have used Pop-Up satellite tags, SPOT satellite tags, and acoustic tags to study the ranging and migratory behaviour of basking, whale, tiger, oceanic white-tip, silky, grey reef, Caribbean reef and black-tip reef sharks, in the Atlantic and Indian Oceans. Our data show that while the smallest species (black-tip reef shark) is reluctant to cross even a shallow 750 metre gap between reefs, large basking shark, whale shark and tiger shark will undertake trans-oceanic migrations. Considerable variation in ranging and migratory behaviour is evident both within and between species, with some individuals apparently adopting complex multi-leg annual migrations. We propose these differences reflect a) the availability elsewhere of richer food sources, b) the low additional energetic cost of migration, c) the effects of body size on a shark's ability to survive periods without feeding and d) the effects of body size on the risk of predation.

CAPACITY FOR EPA AND DHA SYNTHESIS IN ATLANTIC SALMON AT DIFFERENT LIFE STAGES

Østbye, T-K., Ruyter, B., Sonesson, A, Kjør, M., Baranski, M., Bakke, H, Thomassen, M., Sigholt, T., Berge, G.M.

Symposium: Fish Culture **Type:** Oral **Order:** 3

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Abstract: The aquaculture industry is challenged by reduced availability of fish oil, and thereby the omega-3 fatty acids EPA/DHA, for feed production. Atlantic salmon is able to convert 18:3n-3 from plant origin to EPA/DHA. This conversion is higher in the freshwater stage prior to smoltification, than at later life stages in seawater. The

mechanisms regulating these changes in capacity for EPA/DHA synthesis during and after smoltification are not clear. We have investigated if the capacity for EPA/DHA production can be kept at a higher level if salmon is held a prolonged period in freshwater before transfer to saltwater. In addition, we have tested if there are differences EPA/DHA production between salmon families selected by differences in gene expression of delta 6 desaturase. We show that the capacity for EPA and DHA synthesis in Atlantic salmon is influenced both by life stage, dietary fatty acid composition and genetic background.

PHYSIOLOGICAL AND MOLECULAR CHANGES IN RAINBOW TROUT IN RESPONSE TO DIETARY SOURCES

Overturf, K.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 18

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Abstract: Feed formulations for trout have evolved significantly over the last several decades. The use of fishmeal and fish oil as the main protein and energy sources have been the standard in commercial feeds. Currently, reductions in the level of fishmeal and fish oil are becoming more common with levels of these ingredients dependent on economics and desired growth rates. Feed formulations are still calculated according digestibility and concentrations that were necessary when fish meal and fish oil were the primary energy sources in the feed. These calculations don't take into account on dietary component interactions, effect of absorption rates and strain differences. To develop diets that completely meet the energy and nutritional requirements for rapid and efficient growth in rainbow trout requires a greater understanding of the nutrient, metabolic, and physiological interactions that take place between the feed and the animal. We have demonstrated that diets which contain differential levels of protein and oil and differences in amino acid availability will have profound effects on the growth rate, metabolic processing, muscle regulation, and body composition of the trout fed these diets. And that effect will be further confounded when feeds are compared between fish selected for growth and/or utilization of different dietary components. This information can then be used to gain a better understanding of these metabolic systems and their interactions and for the generation of models for predicting optimal energy formulations.

DO SOCIAL STATUS OR PREDATION THREAT INFLUENCE AIR-BREATHING BEHAVIOR OF A FACULTATIVE AIR BREATHER, PANAQUE MACCUS?

Owens, C.E., Fisher, M.E. and Nelson, J.A.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 6

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Abstract: This study tested whether dominance hierarchies in a facultative air-breathing fish are either related to metabolic rate and/or influence surfacing during hypoxia. Surfacing of individuals within two groups of four animals with pre-determined dominance hierarchies was recorded during multiple exposures to hypoxia (10% air saturation). Air breathing behavior was repeatable; the dominant individuals surfaced at higher oxygen tensions and had the highest surfacing frequency, while the lowest ranked individuals displayed the opposite trend. Fish were also exposed to hypoxia individually with variable access to cover and in the presence of a static or mobile avian predator decoy. The presence of a predator significantly influenced the time animals spent near the surface during hypoxia. Animal size and metabolic rate will also be considered in interpreting these results. Our results highlight how social status and perceived risk can affect air-breathing behavior and the importance of considering both behavioral and physiological responses to hypoxia.

HEART PERFORMANCE UNDERLIES HYPOXIA TOLERANCE IN EUROPEAN SEA BASS

Ozolina, K., Joyce, W., Mauduit, F., Ollivier, H., Claireaux, G., Shiels, H.A.

Symposium: Climate Change **Type:** Oral **Order:** 12
Contact: Karlina Ozolina **E-mail:** karlina.ozolina@postgrad.manchester.ac.uk
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Abstract: Aquatic hypoxia is a pervasive problem in coastal environments. Although intraspecific variation in hypoxia tolerance is well documented in fish, the factors underlying this variation remain unclear. The present study examined heart performance in European sea bass with temporally repeatable hypoxia tolerance validated over one and a half years. Sea bass were divided into hypoxia challenge test (HCT) 'winners' and 'losers', before cardiac performance was investigated using isometric myocardial strip preparations. In hypoxia, but not fully oxygenated conditions, HCT winners produced more force, with higher rates of contraction and relaxation, than HCT losers. Sarcoplasmic reticulum inhibition had no significant effect on force of contraction, rate of contraction or rate of relaxation in either winners or losers. Our study suggests hypoxia tolerant fish have hearts that perform better under hypoxic conditions than less tolerant counterparts. As the occurrence of aquatic hypoxia grows, the cardiovascular system may be a major target for natural selection.

AEROMONAS SALMONICIDA PROLIFERATION AND QUORUM SENSING IN RESPONSE TO MUCINS ISOLATED FROM ATLANTIC SALMON SKIN AND INTESTINE

Padra, J.T., Sundh, H., Sundell, K., and Lindén, S.K.

Symposium: Parasites and Diseases **Type:** Oral **Order:** 1
Contact: Janos Tamas Padra **E-mail:** janos.tamas.padra@gu.se
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Abstract: All mucosal surfaces are covered by a mucus gel, and *A. salmonicida* (cause furunculosis disease) bind to the mucins which are the main component of this gel. We purified mucins from skin, pyloric caeca, proximal and distal intestine of healthy salmon and studied *A. salmonicida* proliferation and quorum sensing in their presence. Intestinal mucins enhanced *A. salmonicida* growth, whereas skin mucins had no effect. The mucins from all sites were highly sialylated, and enzymatic desialylation enhanced proliferation further. Mucins from all sites decreased the production of quorum sensing (QS) signal molecules. Thus, it appears that although mucins of the intestinal tract stimulated *A. salmonicida* growth, presumably reflecting that the pathogen senses the right target niche, the sialylated mucin glycans seems to act as a defense mechanism and limits the growth response. Mucin inhibition of QS may be an additional host defense mechanism.

COST ACTION FA1304: SWIMMING OF FISH AND IMPLICATIONS FOR MIGRATION AND AQUACULTURE (FITFISH)

Palstra, A.P., and Planas, J.V.

Symposium: FITFISH **Type:** Oral **Order:** 1
Contact: Arjan Palstra **E-mail:** arjan.palstra@wur.nl
The Institute for Marine Resources and Ecosystem Studies (IMARES), Wageningen University & Research Centre, Korringaweg 5, 4401 NT Yerseke The Netherlands

Abstract: The study of swimming of fish is essential for our understanding of the interplay between migration, growth and reproduction in wild fish but also has considerable interest for fish in aquaculture. The main objective of the COST Action FITFISH is to develop a research network in which fish swimming in the wild and in aquaculture is studied for the first time under a multidisciplinary perspective. FITFISH will provide the ground for technological

breakthroughs (e.g. more accurate monitoring of migrant fish; design of exercise-“friendly” fish farming facilities), for establishing swimming as an essential factor determining welfare and for demonstrating that swimming can benefit quality production. FITFISH will add value to independent, nationally funded research activities by providing the means to exchange information, promote industrial activities and influence policies at a European level in a new common forum. Activities in FITFISH also include the training and exchange of early stage researchers in the area. For more information: http://www.cost.eu/domains_actions/fa/Actions/FA1304.

SWIMMING PHYSIOLOGY OF FISH

Palstra, A.P., and Planas, J.V.

Symposium: Swimming Physiology **Type:** Oral **Order:** 1

Contact: Arjan Palstra **E-mail:** arjan.palstra@wur.nl

The Institute for Marine Resources and Ecosystem Studies (IMARES), Wageningen University and Research Centre, Korringaweg 5, 4401 NT Yerseke Netherlands

Abstract: Swimming is an important aspect of the life history of fish in the aquatic environment. However, the physiological effects of swimming on growth, metabolism, reproduction and immunity are not fully understood in fish. Improved knowledge on the swimming physiology of fish and its application to fisheries science and aquaculture (i.e. farming a fitter fish) is currently needed in the face of global environmental changes, high fishing pressures, increased aquaculture production as well as increased concern on fish welfare. For this purpose, the FitFish satellite workshop (www.ub.edu/fitfish2010/) and the first and second symposium on the Swimming Physiology of Fish were organized as part of the 9th and 10th International Congress of Fish Biology (Barcelona, 2010 and Madison, 2012). The present symposium intends to continue efforts to bring together scientists covering various aspects of the swimming physiology of fish and present the most up-to-date information on this relevant topic.

METABOLIC EFFECTS AND LIVER DAMAGE OF MICROCYSTINS-CONTENT ON THE CRUDE EXTRACT OF CIANOBACTERIA, RADIOCYSTIS FERNANDOI, IN NEOTROPICAL FISH, HOPLIAS MALABARICUS

*Paulino, M.G., Rossi, P.A., Venturini, F.P., Tavares, D., Sousa, N.E.S., Sakuragui, M.M., Moraes, G., Terezan, A.P.,
Fernandes, J.B., Giani, A., Fernandes, M.N.*

Symposium: Stress in Fish **Type:** Oral **Order:** 27

Contact: Marcelo Paulino **E-mail:** mclpaulino@yahoo.com.br

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Abstract: Microcystins (MC) are potent hepatotoxins found on cyanobacteria. The toxicological effects of microcystins from *Radiocystis fernandoi* were verified in the structure of *Hoplias malabaricus* liver and energetic metabolism, after 12 and 96h. The fish were exposed via intraperitoneal injection with 100 µg MC kg⁻¹ (total MC from crude extract per body weight). After both experimental spans, plasma, liver and white muscle were sampled for biochemical analyses. The results indicate damages in the hepatocytes structure, confirmed by the increase in plasmatic alanine aminotransferase (ALT) and in direct bilirubin content in the 96h exposed group. The fish metabolism was affected by MC exposure, with depletion of hepatic glycogen in both experimental groups. In conclusion, MC cause stress and liver structural change in *H. malabaricus*, increasing energy demand and varying metabolic function which may affect the whole ecosystem through trophic bioaccumulation. Financial support: FAPESP, CNPq (INCT-TA), CEMIG

ROLE OF LIPIDS IN POSTLARVAL DEVELOPMENT OF THE ARCTIC FISH LEPTOCLINUS MACULATUS DURING POLAR NIGHT IN SVALBARD

Pekkoeva, S.N., Murzina, S.A., Falk-Petersen, S., Nefedova, Z.A., Ripatti, P.O., Nemova N.N.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 19
Contact: Svetlana Pekkoeva **E-mail:** pek-svetlana@mail.ru
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Abstract: *Leptoclinus maculatus* (daubed shanny) is widely distributed and ecologically important in polar ecosystems. The fish has a complex life cycle that maintained sustainable presence and adaptation to the Arctic environment. Postlarvae being pelagic (adults are bottom) have an unusual part of their body called "lipid sac". It accumulates mainly storage lipids originating from zooplankton. The lipid sac is an evolutionary adaptation enabling postlarvae to grow and develop as a pelagic larvae up-to 3 years. Muscles perform the lipid profile in relation to physiology and ecology in winter. The research is aimed to study the role of lipids in postlarval development of the daubed shanny during polar night in Svalbard with special attention to adaptive strategies. The research was supported by The President of the Russian Federation Grant NSh 1410.2014.4; Program of RAS "Living nature"; The Presidium of RAS 'Searching fundamental research for development of the Russian Arctic', "Ecological and biochemical characteristics of sustainability of aquatic organisms in the Russian Arctic in the Era of climate change" project (2014-2016); «Timing of ecological processes in Spitsbergen fjords» project.

HIF-PROTEINS IN ZEBRAFISH DEVELOPMENT AND IN HYPOXIA

Pelster, B. and Köblitz, L.

Symposium: Cellular Signalling **Type:** Oral **Order:** 6
Contact: Bernd Pelster **E-mail:** bernd.pelster@uibk.ac.at
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Abstract: In zebrafish three different isoforms of the hypoxia inducible transcription factor, Hif-1 α , Hif-2 α and Hif-3 α have been identified. Using Western blot analysis the expression of these three isoforms was assessed during the first 9 days of development. All three isoforms were expressed between 1 and 9 dpf. While Hif-1 α was present at a constant low level throughout development, the expression of Hif-2 α and of Hif-3 α increased after hatching and was significantly higher in later developmental stages compared to the embryonic stages. Hypoxia (PO₂ = 5 kPa) resulted in a stabilization of Hif-1 α , while no increase in the level of the other two Hif-proteins was observed. Immunohistochemical evidence supports the conclusion that the different isoforms serve a different function in development.

GUT TRANSPORT CHARACTERISTICS IN HERBIVOROUS AND CARNIVOROUS CHARACID FISH FROM ION POOR RIO NEGRO WATER

Pelster, B., Wood, C.M., Val, A. and Val, V.

Symposium: Tropical Fish **Type:** Oral **Order:** 6
Contact: Bernd Pelster **E-mail:** bernd.pelster@uibk.ac.at
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Abstract: Three closely related characids, Tambaqui (omnivore), Black Piranha (carnivore) and Pacu (herbivore), all Serrasalminidae, inhabit the ion-poor, acidic Rio Negro. We compared O₂-consumption and N-excretion rates in vivo, and sodium, chloride, glucose and ammonia transport characteristics of gut sac preparations in vitro. Pacu had the lowest N/O₂ ratio, suggesting N-limitation. In all species, sodium, chloride, glucose, and ammonia were taken up at high rates from the intestine, resulting in an isosmotic fluid flux. The area-specific uptake rates of anterior, middle and posterior sections were similar in all three species. However, due to the much higher gut length to fork length

ratio, the overall transport capacity of the gut of the herbivorous Pacu by far exceeded the transport capacity of their carnivorous and omnivorous relatives, thus compensating for the lower digestibility of the plant diet. (INCT ADAPTA – CNPq/FAPEAM; Ciência sem Fronteiras).

GNRH-SELECTIVE SIGNAL TRANSDUCTION NETWORKS AND PITUITARY CELL FUNCTION: UNDERSTANDING THE INTRACELLULAR COMPLEXITY OF MULTIFACTORIAL NEUROENDOCRINE CONTROL

Pemberton, J.G., Orr, M.E., Stafford, J.L., and Chang, J.P.

Symposium: Cellular Signalling **Type:** Poster **Order:** P29

Contact: Joshua G. Pemberton **E-mail:** jp28@ualberta.ca

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Abstract: In goldfish (*Carassius auratus*), two endogenous gonadotropin-releasing hormones, GnRH2 and GnRH3, both stimulate luteinizing hormone (LH) and growth hormone (GH) secretion via multiple signal transduction cascades. GnRH-activated cascades include isozymes of phosphoinositide 3-kinase, protein kinase C, mitogen-activated protein kinase, and selective utilization of Ca²⁺-dependent intracellular signalling mechanisms. In this study, we examined the interactions between these intracellular signalling pathways in the acute and long-term control of LH and GH release using primary cultures of dispersed goldfish pituitary cells. Results indicate that distinct signal transduction modules differentially control basal and GnRH-stimulated hormone release in a time-, pituitary cell type-, and GnRH isoform-selective manner. Interestingly, basal and agonist-induced changes in total LH and GH availability are often dissociated from mRNA expression. These findings reveal the complexity of GnRH-stimulated signalling networks and add to our understanding of GnRH isoform-selective signal transduction. (Supported by NSERC, AIHS, and the Killam Trusts)

BIASED SIGNALLING BY TWO ENDOGENOUS GNRH ISOFORMS IN GOLDFISH: INTEGRATION OF CLASS I PI3K-DEPENDENT SIGNAL TRANSDUCTION

Pemberton, J.G., Stafford, J.L., and Chang, J.P.

Symposium: Cellular Signalling **Type:** Oral **Order:** 12

Contact: Joshua G. Pemberton **E-mail:** jp28@ualberta.ca

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Abstract: Among its many functions, gonadotropin-releasing hormone (GnRH) has been shown to stimulate luteinizing hormone (LH) and growth hormone (GH) release through direct actions on gonadotropes and somatotropes, respectively. The presence of multiple GnRH isoforms in the brain is a common feature among chordates and goldfish pituitary cells are exposed to two native GnRH isoforms, GnRH2 (chicken-II) and GnRH3 (salmon), that both activate the same population of cell-surface G protein-coupled receptors (GnRHRs). Our ongoing research examines how GnRH2- and GnRH3-selective signal transduction mechanisms participate in the differential control of hormone release using primary cultures of dispersed goldfish pituitary cells. In particular, we provide the first evidence for the involvement of class I phosphoinositide 3-kinase (PI3K) isozymes in the control of GnRH actions, supporting the hypothesis that GnRH2 and GnRH3 binding to GnRHRs can bias the activation of PI3K-dependent signalling in gonadotropes and somatotropes. (Supported by NSERC, AIHS, and the Killam Trusts)

CLOVE OIL AS ANAESTHETIC FOR LAMBARI: ATTENUATION OF STRESS RESPONSES

Pereira-da-Silva, E.M., Oliveira, R.H.F., and Beraldo, C.M.

Symposium: Stress in Fish **Type:** Poster **Order:** P129

Contact: Elyara Maria Pereira-da-Silva **E-mail:** elyara@usp.br

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Abstract: To assess the potential of clove oil in mitigating stress in lambari (*Astyanax altiparanae*), native species in Brazil, juveniles females of similar weight (8.9 ± 1.8 g) were submitted or not to stress (5 min air exposure) with or without prior deep anesthesia (50 mg.L⁻¹). The levels of blood glucose, cortisol, hematocrit, hepatosomatic index (HSI) and the concentrations of liver and white muscle glycogen were compared. Glucose increased in all treatments suggesting handling effects. Fish that were stressed without the prior anesthesia presented an increase in cortisol levels (146.6 %) and reduction of muscle glycogen (40.1 %). We observed a similar increase in hematocrit after anesthesia (7.5 %) and the stress (8.4 %), responses that were also attenuated by prior anesthesia. No changes in IHS or liver glycogen were observed. It was concluded that the anesthetic clove oil attenuates the stress responses in lambari, contributing to improve welfare and the production.

HYDROGEN SULPHIDE - AN ENDOGENOUS REGULATOR OF IONIC UPTAKE IN ZEBRAFISH

Perry, S.F., Porteus, C., Kumai, Y., and Kwong, R.W.M.

Symposium: Cellular Signalling **Type:** Oral **Order:** 1

Contact: Steve F. Perry **E-mail:** sfperry@uottawa.ca

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Abstract: Hydrogen sulphide (H₂S) is a gaseous signaling molecule implicated in chemoreception and cardiorespiratory control. This talk will focus on the role of H₂S in regulating Na⁺ and Ca²⁺ uptake in larval zebrafish. Treatment of larvae with waterborne H₂S donors rapidly reduced Na⁺ uptake. Exposure of larvae to water enriched with NaCl caused a pronounced reduction in Na⁺ uptake which was prevented by pharmacological inhibition of cystathionine- β -synthase (CBS) or cystathionine- β -lyase (CSE), enzymes involved in the endogenous synthesis of H₂S. Furthermore, knockdown of CSE or CBS increased the basal rate of Na⁺ uptake. The results of additional knockdown experiments and measurements of acid excretion suggest that Na⁺ uptake via NHE3b, but not NCC, is inhibited by H₂S. In contrast, H₂S appears to be a potent stimulator of Ca²⁺ uptake. Immunohistochemistry demonstrated that several ionocyte sub-types express CSE. These data suggests a physiologically relevant role of H₂S in regulating Na⁺ and Ca²⁺ uptake. (word limit: 150)

GAS TRANSPORT, ACID-BASE AND ION REGULATION IN THE AIR-BREATHING FISH ANABAS TESTUDINEUS

Peter, M.C.S. and V.S. Peter

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 21

Contact: M. Subhash Peter **E-mail:** subhashpeter@yahoo.com

Centre for Evolutionary and Integrative Biology, University of Kerala, Kariavattom, Thiruvananthapuram-695 581, Kerala India

Abstract: A vibrant physiologic plasticity exists in air-breathing fish to accommodate the environmental oscillations, though the integrative mechanism of this plasticity is not yet fully understood. We examined the integrative role of gas transport, acid-base and ion regulation in an obligate air-breathing fish (*Anabas testudineus* Bloch) challenged with hypoxia, acid/base disruption or hyperosmotic condition. We measured the O₂ and CO₂ transport status, acid-base equivalents and ion transporter activities and expression in this fish. Carbonic anhydrase (CA) activity, a key player in gas and acid/base transport and the activity and expression of the transporters Na⁺, K⁺ ATPase (NKA) and H⁺ATPase (HA) in osmoregulatory epithelia were quantified. Analyses of the response pattern of these transporters indicate an organ-specific acid/base and osmotic compensation. Evidence is thus presented that an integrative control of gas transport, acid/base and ion regulation exists in this air-breathing fish that establishes a physiologic plasticity (Supported by a DST Project grant).

EFFECTS OF A PHYTOGENIC FEED ADDITIVE ON GROWTH AND SUSCEPTIBILITY OF CHANNEL CATFISH TO EDWARDSIELLA ICTALURI AND LEVELS OF MANNOSE AND RHAMNOSE BINDING LECTIN
Peterson, B.C., Peatman, E., Ourth, D.D., Beltran, R., Santos, G.A., and Waldbieser, G.C.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 21
Contact: Brian Peterson **E-mail:** brian.peterson@ars.usda.gov
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Abstract: A study was conducted to investigate the effect of essential oils (EO) on growth and disease susceptibility to *Edwardsiella ictaluri*. Weight gain and food conversion ratio were similar. After exposing fish to virulent *E. ictaluri*, survival was higher (69.5 vs 48.4%) in fish fed EO ($P < 0.05$). In the EO fish, plasma mannose binding lectin (MBL) levels were similar to non-challenged fish but higher than control fed fish one day after challenge ($P < 0.001$). On d 14, MBL mRNA levels were upregulated 15-fold in fish fed EO compared to control and non-challenged fish ($P < 0.001$). Intestine rhamnose binding lectin 1 (RBL1) mRNA levels were upregulated 6.6 and 3.2-fold in fish fed EO ($P < 0.05$) on days 7 and 14, respectively. The results demonstrate that essential oils improve survival of channel catfish challenged with *E. ictaluri*. The mechanisms through which essential oils improve survival may involve MBL and RBL1.

MOLECULAR CHARACTERISATION AND TOOL GENERATION TO STUDY THE IMMUNE RESPONSE IN SMALL-SPOTTED CATSHARK

Pettinello, R., Alnabulsi, A., Cash, B. G., Crouch, K., Dooley, H.

Symposium: Elasmobranchs **Type:** Poster **Order:** P112
Contact: Rita Pettinello **E-mail:** r01rp13@abdn.ac.uk

School Of Biological Sciences, University Of Aberdeen, Zoology Building, Tillydrone Avenue, Aberdeen, AB24 2TZ UK

Abstract: Cartilaginous fish are the most phylogenetically distant taxon relative to mammals to possess an adaptive immune system based upon immunoglobulins (Igs), T cell receptors (TCRs) and major histocompatibility complex (MHC). Previous studies have shown that sharks produce a robust and long-lived response following immunisation; however, we have little knowledge of where, and how, the cells of the immune system interact in order to generate this response. Using small-spotted catshark as our model we have begun to clone a selection of molecules that are displayed upon the surface of B and T lymphocytes, the archetypical cells of the adaptive immune system, or dendritic cells (DCs), a key cell type connecting the innate and adaptive immune systems. Once cloned we can raise monoclonal antibodies against these molecules enabling us to visualise the tissue distribution of lymphocytes and DCs in naive catsharks then study their interaction during an adaptive immune response.

MECHANISMS OF BRAIN SWELLING IN THE RAINBOW TROUT AND IN THE GOLDFISH
Pham-Ho, P., Lister, Z., and Wilkie M.P.

Symposium: Stress in Fish **Type:** Poster **Order:** P130
Contact: Phillip Pham-Ho **E-mail:** hoxp6910@mylaurier.ca
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Abstract: In fishes, increased internal ammonia results from high external ammonia (HEA) exposure, vigorous exercise or following feeding. At toxic levels, ammonia could cause increased brain water content and swelling by

the over-excitation of N-methyl-D-aspartate receptors (NMDARr) on neurons through the generation of reactive oxygen species (ROS). To test this hypothesis, rainbow trout and goldfish were administered the NMDAR antagonist, MK801, to determine if brain water accumulation was reduced during HEA exposure. Exposure of goldfish to 5mmol/L of NH₄Cl led to 12% increases in brain water content, but swelling was significantly reduced in the MK801 treated goldfish exposed to HEA. Acclimation to low temperatures, which should slow ROS generation, also prevented brain swelling. However, treatment with the glutamine synthetase antagonist, methionine sulfoximine, did not prevent ammonia-induced increases in brain water content. We suggest that over-activation of the NMDAR is a key event leading to brain swelling in goldfish and trout.

EFFECTS OF ANAESTHESIA WITH BENZOCAINE, MS-222 OR AQUI-S ON BLOOD GASES AND HAEMATOLOGICAL PARAMETERS IN STRIPPED CATFISH

Phuong, L.M., Huong, D.T.T., Wang, T., and Bayley, M.

Symposium: Airbreathing Fish **Type:** Poster **Order:** P2

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Abstract: Fish anaesthesia is used to minimize handling stress and damage during harvesting, transportation, and during surgical procedures. Through depression of cardiovascular and respiratory functions it causes significant changes in blood gases and pH. Here, we present the effects of Benzocaine, MS-222, and Aqui-S (Clove oil) on blood gases and haematological parameters of commercial sized (~1kg) stripped catfish (*Pangasianodon hypophthalmus*) and the time course of recovery. Blood was taken by blind catheterization of dorsal aorta during anaesthesia, and regularly during the following 72 h recovery in aerated water. All anaesthetics caused rapid increases in pCO₂ and lactate resulting in a sharp increase in pHe closely mirrored by pHi, as well as a marked rise in hematocrit, associated with increased RBC counts not altered RBC volume and elevated cortisol and glucose. All anaesthetics showed similar efficacy and blood parameters were normalized within 24 to 48h.

ARTIFICIAL FERTILIZATION IN NILE TILAPIA USING CHILLED STORAGE MILT

Piamsomboon, P. and Wongtavatchai, J.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 7

Contact: Patharapol Piamsomboon **E-mail:** ake11122@hotmail.com

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Abstract: Fertilization of Nile tilapia *Oreochromis niloticus* eggs was achieved successfully using chilled milt. Eggs and milt were obtained from healthy tilapia brooders (age 1-2 yr, weight > 200 g). Freshly collected milt was washed with 0.85% NSS and preserved in Freshwater fish saline (FFS) containing penicillin and streptomycin. Adequate sperm quality (>60% motility and viability) was presented in the preserved milt kept at 4 oC, for 8 hours. The preserved milt was then applied onto the fresh, hand collected eggs. Fertilized eggs were incubated in semi-closed water system at 30 ±1°C. The development of embryo from the artificial fertilization eggs was found comparable to the naturally fertilized eggs. Artificial fertilization procedures examined in this study are beneficial to the transportation of genetic materials and breeding selection in tilapia aquaculture.

INVESTIGATION OF FARM MANAGEMENT FACTORS ASSOCIATED WITH WHITE SPOT DISEASE IN PACIFIC WHITE SHRIMP

Piamsomboon, P., Inchaisri, C., and Wongtavatchai, J.

Symposium: Parasites and Diseases **Type:** Poster **Order:** P103
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Abstract: The present study identified risk factors associated with the occurrence of WSD outbreaks in intensive shrimp farming area in Chanthaburi province, Thailand. Farm managements and locations were analyzed as risk factor in two different models. Data were obtained from 157 farms using structured questionnaires and handheld GPS device for the locations. Generalized estimating equation was used to create the multivariable models. Water resources, continuous culture, use of chlorine compounds for disinfection and distance from farm to coastline or main road were found to be risk factors of WSD. Contrary, application of lime during the dried-pond period and probiotics feed additives were found to be preventive factors. Two significant clusters of 8.56 and 4.58 km of locations model and two non-significant clusters of 10.61 and 4.28 km of farm management model were detected using mean predicted values (SatScan™ software). However, the evidence of overlapping clusters generated from each model may suggest the relationship of the probability between the 2 models.

BEHAVIOURAL AND METABOLIC RESPONSES OF THE DOLPHINFISH TO OCEAN ACIDIFICATION

Pimentel, M.S., Pegado, M., Repolho, T., Rosa, R.

Symposium: Environmental Change **Type:** Poster **Order:** P27

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Laboratório Marítimo da Guia, Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Av. Nossa Senhora do Cabo, 939, 2750-374 Cascais Portugal

Abstract: Atmospheric CO₂ concentration is expected to rise to 730–1,020 μatm by the end of this century. The consequent changes in the ocean's chemistry (e.g., lower pH and availability of the carbonate ions) are expected to pose particular problems for marine organisms, especially in the more vulnerable early life stages. The aim of this study was to investigate how the future predictions of ocean acidification may compromise the metabolism and swimming capabilities of the recently hatched larvae of the tropical dolphinfish (*Coryphaena hippurus*). Here, we show that the future environmental hypercapnia (Δ pH 0.5; pCO₂~1,600 μatm) significantly ($p < 0.05$) reduced oxygen consumption rate up to 17 %. Moreover, the swimming duration and orientation frequency also decreased with increasing pCO₂ (50 and 62.5 %, respectively). We argue that these hypercapnia-driven metabolic and locomotory challenges may potentially influence recruitment, dispersal success, and the population dynamics of this circumtropical oceanic top predator.

BEHAVIOUR AND PHYSIOLOGY OF GILTHEAD SEABREAM EARLY LIFE STAGES UNDER OCEAN WARMING AND ACIDIFICATION

Pimentel, M.S., Diniz, M., Faria, A.M., Gonçalves, E.J., Machado, J., Rosa, R.

Symposium: Environmental Change **Type:** Oral **Order:** 4

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Laboratório Marítimo da Guia, Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Av. Nossa Senhora do Cabo, 939, 2750-374 Cascais Portugal

Abstract: Early life stages of many marine organisms are being challenged by rising seawater temperature and CO₂ concentrations, but it is poorly known how such stages will endure under the combined effects of future ocean acidification and warming. Here we show that future predictions of ocean warming (+4°C) and acidification (Δ pH=0.5units) may compromise the early ontogeny of a commercially-important fish, *Sparus aurata*. High pCO₂

and warmer temperatures significantly decreased hatching success, larval survival, growth and metabolic rates. Higher percentage of larvae malformations were observed in increased CO₂ conditions. Furthermore, larvae behaviour was also affected under the future environmental conditions. Swimming duration, vertical orientation frequency and capture rate decreased significantly. These findings highlight the particular sensitivity of fish early life stages to these climate change-related variables and the above-mentioned physiological and behavioural challenges may influence the adult-fish ecology, distribution and abundance of this species.

SWIMMING-INDUCED MODULATION OF THE SKELETAL MUSCLE TRANSCRIPTOME IN RAINBOW TROUT

Planas, J.V., Magnoni, L.J., and Palstra, A.P.

Symposium: FITFISH **Type:** Oral **Order:** 2

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Abstract: Swimming is an integral part of the behavior of many species of fish and is accomplished through the contractile activity of skeletal muscle. In turn, swimming-induced contractile activity modulates the skeletal muscle phenotype. In salmonid fish, swimming under sustainable speeds may promote somatic growth by a complex interaction of factors including increased feed intake, feed conversion and nutrient utilization rates, as well as contraction-induced adaptive mechanisms at the molecular and cellular levels in skeletal muscle. In this talk, I will discuss recent data from my laboratory on the transcriptomic response of skeletal muscle to swimming-induced activity in rainbow trout (*Oncorhynchus mykiss*) using microarray analysis and RNAseq.

EVIDENCE FOR A MEDIATORY ROLE OF AMP-ACTIVATED PROTEIN KINASE ON THE METABOLIC EFFECTS OF SWIMMING-INDUCED CONTRACTILE ACTIVITY IN THE FISH SKELETAL MUSCLE

Planas, J.V., Palstra, A.P., and Magnoni, L.M.

Symposium: Swimming Physiology **Type:** Oral **Order:** 2

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Abstract: AMP-dependent protein kinase (AMPK) is a phylogenetically conserved enzyme that senses changes in the AMP/ATP ratio in cells and, consequently, acts as a “metabolic master switch” mediating the cellular adaptation to environmental or nutritional stress factors. In mammals, AMPK is activated in skeletal muscle by exercise, resulting in increased GLUT4-mediated glucose uptake and utilization. However, little is known regarding the potential mediatory role of AMPK on the metabolic effects of swimming in fish. Our group has recently begun to investigate the metabolic role of AMPK and its regulation by contractile activity in skeletal muscle in fish. Our results indicate that AMPK stimulates the uptake and utilization of glucose in fish skeletal muscle cells by specifically up-regulating the GLUT4-dependent glucose transport machinery as well as the mRNA levels of genes involved in glucose utilization. Importantly, we have obtained evidence for the stimulatory effect of muscle contractile activity, either induced in vivo by swimming or in vitro by electrical stimulation of trout myotubes, on AMPK activity. Therefore, AMPK appears to be an important metabolic sensor in fish skeletal muscle.

CAN MARINE FISHERY BY-PRODUCTS REDUCE STRESS RESPONSE IN CULTURED ATLANTIC SALMON?

Plante, S., Béland, B., Lamarre, S., and McNiven, M.

Symposium: Stress in Fish **Type:** Poster **Order:** P131

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Abstract: Worldwide demand for aquaculture fish is growing each year and so is the need for fishmeal to sustain this demand. Consequently, the availability of this key ingredient is decreasing while its price is inflating. Several alternatives to fishmeal have been sought during the last decades. Recent reports suggest that marine by-products contain several physiologically stimulating and prophylactic bio-molecules that can be used as fish feed additives. Our group is currently involved in a five-year research project on the valorisation of Atlantic Canada's marine by-products. One of the aims of this project was to prepare fish feeds that include novel marine by-products, such as gonads or liver, and test their effects on the stress resistance in Atlantic salmon. After a 10 weeks feeding trial, juvenile salmon were challenged to a thermal tolerance stress test and their stress response was measured. We will present our methodology and preliminary results.

JUVENILE GREEN STURGEON BEHAVIOR NEAR WATER DIVERSIONS AND FISH GUIDANCE DEVICES: EXPERIMENTS IN LABORATORY SWIMMING FLUMES.

Poletto, J.B., Cocherell, D.E., Mussen, T.D, Cech, J.J., Klimley, A.P., and Fanguie, N.A.

Symposium: Fish Migration **Type:** Oral **Order:** 6

Contact: Jamilynn B. Poletto **E-mail:** jbpoletto@ucdavis.edu

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Abstract: Water projects designed to extract water for local urban, industrial, and agricultural use contribute to the fragmentation and degradation of suitable habitat for native fishes in rivers and estuaries worldwide. The number of water diversions located throughout the Sacramento-San Joaquin watershed in California exceeds 3,300, and interactions with diversions during juvenile outmigrations have been implicated in population declines of the threatened anadromous green sturgeon (*Acipenser medirostris*). Despite this, little is known about the behavior of this species near water diversions. We quantified the behavior of juvenile green sturgeon near a simulated water diversion structure under various hydraulic conditions, including entrainment rates into the diversion, swimming performance near the structure, and the efficacy of several deterrents to prevent interactions. Our results are informative in developing effective management strategies to mitigate the impacts of water diversions on sturgeon populations, and suggest that effective restoration strategies that balance agricultural needs with conservation programs are possible.

ZEBRA FISH LIVER ZFL CELL LINE, AN IN-VITRO MODEL FOR THE ASSESSMENT OF TBT-INDUCED STEATOSIS IN FISH

Porte, C., Dimastrogiovanni, G., Jauregui, O., Blumberg, B.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 3

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Abstract: A number of studies have pointed out the existence of chemicals, termed obesogens, which inappropriately regulate lipid metabolism and promote adipogenesis. Among them, tributyltin (TBT) is known to induce adipocyte differentiation and to increase lipid accumulation and induce hepatic steatosis in mice. However, despite TBT being a well known environmental pollutant, information regarding its obesogenic effects and/or disruption of lipid metabolism in fish is lacking. This work investigates the suitability of the ZFL cell line as an in-vitro model to study the effect of environmentally relevant concentrations of TBT on cellular lipids. ZFL cells were exposed to 10, 25, 50 & 100 nM TBT for 96 h in basal medium or in medium supplemented with a mixture of lipids.

Nile Red, a lipid specific fluorescent dye, was used to estimate intracellular lipid accumulation, which increased up to 2.5 fold in cells exposed to 100 nM TBT when culture medium was supplemented with lipids. Cellular lipids were further characterized by ultra-high performance liquid chromatography coupled with mass spectrometry (UHPLC-MS). A total of 72 lipid species including phosphatidylcholines (PC), PC-plasmalogen, lyso-PC, diacylglycerols, triacylglycerols and cholesterol esters were identified. A relative increase (2-fold) in membrane lipids (PC, plasmalogen PC and lyso PC) was detected in TBT-exposed cells. However, if basal medium was supplemented with lipids, TBT-exposed cells showed a 20-fold increase in triacylglycerols, with no alteration at all of membrane lipids. The work highlights the ability of TBT to alter ZFL cell lipidome and to induce steatosis in lipid supplemented culture medium. The model can be successfully applied to other environmental contaminants suspected to interfere with cellular lipids.

THE ROLE OF HYDROGEN SULPHIDE IN THE CONTROL OF BREATHING IN HYPOXIC ZEBRAFISH

Porteus, C.S., Abdallah, S.J., Pollack, J., Kumai, Y, Kwong, R.W.M., Yew, H.M., Milsom, W.K., and Perry, S.F.

Symposium: Cellular Signalling **Type:** Oral **Order:** 2

Contact: Cosima Porteus **E-mail:** c.s.porteus@exeter.ac.uk

Geoffrey Pope Building, Biosciences, College of Life & Environmental Sciences, University of Exeter, Exeter, EX4 4QD UK

Abstract: The current study investigated the role of hydrogen sulphide (H₂S) in oxygen sensing and the hypoxic ventilatory response (HVR) of adult and larval zebrafish. Both adults and larvae exhibited a dose-dependent increase in ventilation to sodium sulphide, a H₂S donor. The two major biosynthetic enzymes of H₂S are cystathionine beta-synthase (CBS) and cystathionine gamma-lyase (CSE). Adult zebrafish displayed a blunted HVR when pre-exposed to inhibitors of CBS and CSE. In larvae, knockdown of either CBS or CSE using morpholinos abolished the HVR. Immunohistochemistry of neuroepithelial cells (NECs, the putative oxygen sensing cells of fish) revealed the presence of both CBS and CSE in adults, while the NECs of larvae only expressed CSE. Finally, dissociated NECs significantly increased internal calcium concentration in the presence of sodium sulphide. Combined, these results indicate that H₂S in NECs is involved in oxygen sensing and that it plays an important role in the HVR.

OCEAN ACIDIFICATION IMPAIRS OLFACTORY SENSITIVITY DIRECTLY IN EUROPEAN SEA BASS

Porteus, C.S., Hubbard, P. C., and Wilson, R.W.

Symposium: Sensing the Environment **Type:** Oral **Order:** 4

Contact: Cosima Porteus **E-mail:** c.s.porteus@exeter.ac.uk

Geoffrey Pope Building, Biosciences, College of Life & Environmental Sciences, University of Exeter, Exeter, EX4 4QD UK

Abstract: Coral reef fish exposed to ocean acidification (OA) predicted for year 2100 respond inappropriately to olfactory cues, vital for their survival. A brain mechanism has been proposed based on GABAA receptor dysfunction, but other potential causes and OA effects on temperate species remain largely unknown. We hypothesized that OA has a direct effect on the olfactory sensitivity of fish and measured the response of the olfactory system of sea bass to various odorants in control (~500 ppm) and OA (1000 ppm) conditions. The responses to some amino acids, bile acids, conspecific bile, and alarm cue were reduced in OA conditions. Additionally, the detection threshold of some odorants increased by 2 to 4 fold in OA. Thus, OA reduces the olfactory sensitivity of bass directly and this is due, at least in part, to a reduction in odorant-receptor affinity at lower pH, providing a new mechanism for this impairment.

EFFECTS OF LOMA MORHUA (MICROSPORIDIA) INFECTION ON THE CARDIORESPIRATORY AND SWIMMING
PERFORMANCE OF ATLANTIC COD
Powell, M.D. and Gamperl, A.K.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 3
Contact: Mark Powell **E-mail:** mark.powell@niva.no
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Abstract: The microsporidian *Loma morhua* infects Atlantic cod (*Gadus morhua*) and results in the formation of gill and cardiac xenomas. Given the importance of these organs to metabolic capacity and thermal tolerance, the cardiorespiratory performance of cod with a naturally acquired infection of *Loma* was measured during an acute temperature increase (2°C h⁻¹) from 10°C to the fish's critical thermal maximum (CT_{Max}; 21.0 ± 0.3°C). Additionally, oxygen consumption and swimming performance were measured during two successive critical swimming speed (U_{crit}) tests at 10°C. Results show that while *Loma* infection had a negative impact on cod cardiac function at warm temperatures, and on metabolic capacity in both the CT_{Max} and U_{crit} tests (i.e. a reduction of 30-40%), the Atlantic cod largely compensates for these cardiorespiratory limitations. e.g. CT_{Max} and U_{crit} were comparable to those reported by Gollock et al. (2006) (22.2 ± 0.2°C) and Petersen and Gamperl (2010) (both studies ~ 1.7 bl s⁻¹), respectively.

MORPHOLOGICAL CARDIAC REMODELING AND ANAEMIA IN MARINE FISHES
Powell, M.D., Burke, M., Stone D. and Harris, J.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 5
Contact: Mark Powell **E-mail:** mark.powell@niva.no
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Abstract: Anaemia occurs as a pathological consequence in fish and has been modelled using phenylhydrazine where a progressive and sustained functional haemolytic anaemia can be achieved. In a number of marine species namely Atlantic cod (*Gadus morhua*), Atlantic salmon (*Salmo salar*), Atlantic halibut (*Hippoglossus hippoglossus*) and the yellowtail kingfish (*Seriola lalandi*) experimental haemolytic anaemia resulted in morphological cardiac remodeling. In most species examined, there were minimal changes in blood biochemistry. Anaemic Atlantic cod demonstrated reduced resting oxygen consumption compared to controls and, limited capacity to increase oxygen consumption during a bout of exhaustive exercise. Anaemic yellowtail kingfish showed a small reduction in cardiac output but increased heart rate when subjected to an acute temperature increase of 2°C h⁻¹ as well as cardiac hypertrophy. Increased relative cardiac mass, particularly of the ventricle, along with changes in ventricle shape are likely compensatory morphological changes enhancing cardiac efficiency and potentially cardiac output to offset anaemic hypoxaemia.

TROUT MINERALOCORTICOID RECEPTOR EXERTS IN VITRO A DOMINANT NEGATIVE ACTIVITY ON GLUCOCORTICOID
RECEPTOR TRANSACTIVATION ACTIVITY

Prunet, P., Kiilerich, P., Triqueneaux, G., Trayer, V., Terrien, X., Lombès, M.

Symposium: Cellular Signalling **Type:** Oral **Order:** 11
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Abstract: In rainbow trout, two glucocorticoid receptors (rtGR1, rtGR2) and one mineralocorticoid receptor (rtMR) has been characterized and co-localized in the same epithelial cells in osmoregulatory tissues. This leads us to question whether GR-MR may interact through heterodimerization as previously described in mammals. Analysis of the transactivation properties of rtGR1 or rtGR2 in presence of rtMR was carried out in COS-7 cells. Expression

of rtMR in presence of rtGR1 or rtGR2 significantly decreases the cortisol-induced transactivation activity of rtGR1. When using other GRE-containing promoters, similar inhibitory effects of MR are observed. These data suggest existence of MR-GR interactions which were further studied using new mutated rtMR constructs containing different point mutations in the DNA-binding domain. Overall, our results suggest that the inhibitory effect of MR on GR activity is related to reduction of GR-self-synergy and involves N-terminal sequences of the MR. Biological relevance of such in vitro studies will be discussed.

DOES REGIONAL STREAMFLOW VARIABILITY INFLUENCES SWIMMING PERFORMANCE OF FRESHWATER FISH?

Quintella, B.R., Alexandre, C.M. and Almeida, P.R.

Symposium: FITFISH **Type:** Oral **Order:** 8

Contact: Bernardo Quintella **E-mail:** bsquintella@fc.ul.pt

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Abstract: Regional streamflow variability is responsible for considerable habitat variations to which fish respond through specific life-history strategies and morphological adaptations. We compared the swimming performance and eco-morphology of two Iberian barbel (*Luciobarbus bocagei*) populations from permanent and temporary rivers. The permanent river was characterized by higher water persistence and a more turbulent environment, contrasting with the stable environment that is present in the temporary ecosystem during most of the time. Barbels inhabiting the permanent river had a higher critical swimming speed (U_{crit}) and a more fusiform body shape, lower body condition and longer and higher pectoral and dorsal fins, when compared with the population from the temporary watercourse. These results reflect an environmental-induced response to reduce hydrodynamic resistance and energy expenditure during locomotion and can be used as valuable information for environmental managers to understand and improve the regional specificity of common river restoration measures, such as the construction and arrangement of fishways and the adequacy of instream flow manipulations.

PASSAGE EFFICIENCY AND BEHAVIOUR OF SEA LAMPREY SPAWNERS IN A VERTICAL-SLOT FISHWAY

Quintella, B.R., Mateus, C.S., Alexandre, C.M., Cardoso, G.R., Ferreira, A.F., Pereira, E.D. and Almeida, P.R.

Symposium: Lampreys **Type:** Poster **Order:** P95

Contact: Bernardo Quintella **E-mail:** bsquintella@fc.ul.pt

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Abstract: Dams and weirs are known to have major impacts on migratory fish such as the sea lamprey *Petromyzon marinus*, but these deleterious effects can be mitigated by the construction of efficient fishways. The Açude-Ponte weir at Coimbra represented the upstream limit of sea lamprey's distribution in River Mondego until 2011, when a vertical-slot fishway was installed. Since then, several methodologies including visual counts and bio-telemetry techniques were used to monitor its efficiency. A total of 221 adult lampreys were tagged with PIT tags to assess the efficiency of the fishway. From 28 lampreys tagged with conventional radio transmitters and released downstream of the weir, eight (ca. 30%) successfully surpassed the fishway, reaching the upstream spawning areas in the main river stretch and tributaries. Data obtained from three lampreys tagged with EMG transmitters give a first glance of the fine-scale behavior and muscular effort required during fishway negotiation. Finally, visual counts identified the upstream passage of nearly 8,000 lampreys during the 2013 spawning season. A statistical model developed with this data clearly shows that the weir discharges significantly influence the migratory behavior in the vicinity of the fishway, limiting its efficiency during high discharge periods.

INVESTIGATION INTO GENETIC DIVERSITY OF PERCH WITHIN THE CONTEXT OF NPP ACTIVITY

Ragauskas A., Butkauskas D., and Sruoga A.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 13
Contact: Adomas Ragauskas **E-mail:** adomas.ragauskas@gmail.com
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Abstract: The development and exploitation of Nuclear Power Plants (NPPs) have great impact on aquatic ecosystems. Seeking to establish a tool for monitoring of a long-term anthropogenic effect on the population genetic structure of fishes it is necessary to create a molecular database of the model fish species. The aim of the study was to assess genetic variability of mtDNA D-loop region of 262 perch specimens caught in various locations in Lithuania and Latvia in order to find out whether the genetic diversity of perch population inhabiting Ignalina NPP cooler is different from the genetic diversity of other studied perch populations. Currently accumulated data indicate that perch population inhabiting cooler of Ignalina NPP possesses unique genetic diversity compared to all other studied populations: out of 37 haplotypes found in Lithuanian and Latvian perch populations four unique haplotypes were detected exclusively in Ignalina NPP cooler.

LARVAL DRIFT OF SELECTED NATIVE AND INVASIVE BENTHIC FISHES ALONG TWO DIFFERENT SHORE TYPES IN THE AUSTRIAN DANUBE

Ramler, D., Ahmelt, H., and Keckeis, H.

Symposium: Fish Migration **Type:** Oral **Order:** 5
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Abstract: The drift of early development stages is an important event in the lifecycle of many riverine fish species. It is a key element of dispersal and ensures that larvae reach suitable nursery habitats that provide food and shelter. Drifting is highly stage- and species specific and therefore requires detailed analyses on the lowest possible taxonomic level. This study explored the effects of two opposed shoreline-situations (near-natural vs. artificial) on the larval and juvenile drift of two selected families of high ecological importance (Percidae and Gobiidae). Composition and size structure, as well as seasonal and diurnal patterns are described for percids and gobiids on genus level. Conformities and deviations to existing literature specifications are given. In addition, the implications of river modifications on early life stages of fish, but also the possibilities of shore rehabilitation measures and its effect on larval dispersal, are discussed.

CONSTRUCTING A MULTI-SPECIES TRANSCRIPTOME RESOURCE FOR CHONDRICHTHYES TO ENABLE EVOLUTIONARY AND FUNCTIONAL STUDIES

Redmond, A.K., Crouch, K., Dooley, H.

Symposium: Elasmobranchs **Type:** Poster **Order:** P113
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Abstract: The recently completed elephant shark genome sequence has created a wealth of opportunity for enquiry into vertebrate evolution and shark biology. Despite this, the genetic content of a phylogenetic group may be misrepresented when using a single taxon to infer evolutionary history. We have compiled a database which contains new assemblies and annotations for all previously available RNA-seq data for Chondrichthyes, as well as

new RNA-seq spleen data from four phylogenetically diverse elasmobranch species. We analysed our dataset for the presence of the transcription factors, cytokines and cytokine receptors of the mammalian CD4+ T helper cell lineage, a key component of the adaptive immune system, in order to demonstrate its utility. Phylogenetic analyses verified the presence of an IL-6R homolog, reported to be missing from the elephant shark genome assembly, and several ZBTB7 family transcription factors, which may control CD4/CD8 lineage commitment. These findings validate our database as a useful research tool for shark biology specifically and vertebrate evolution in general.

THERMAL REGIME CHANGE AFFECTS LIFE HISTORY PARAMETERS IN A TROPICAL FRESHWATER FISH

Reeve, A.J., Ojanguren, A.F. and Magurran, A.E.

Symposium: Environmental Change **Type:** Oral **Order:** 15

Contact: Al Reeve **E-mail:** ajr20@st-andrews.ac.uk

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Abstract: How a species responds to shifts in its thermal environment will determine their success when released into a new habitat or if the climate changes. To identify how novel conditions alters life history we created two ecologically-realistic temperature regimes and, using a fully-crossed design, grew two successive generations of guppies (*Poecilia reticulata*) until maturity recording each fish's standard length (SL) on a weekly basis. We modelled the growth parameters of individual fish using Von Bertalanffy's growth equation and demonstrated clear differences in growth trajectories between the thermal regimes. To explore the link between the shape of the growth curves and life history we measured fecundity and offspring size as well as male reproductive behaviour, colouration and sperm characteristics. These results identify some of the phenotypic responses made by fish within and between generations during the early stages of environmental change.

EVALUATION OF THE TRANSCRIPTIONAL ACTIVITY OF A CONJUGATED ESTROGEN (β -ESTRADIOL-6 (O-CARBOXYMETHYL) OXIME: BSA) ON AN ESTROGEN-SENSITIVE BIOMARKER ZEBRAFISH LINE

Reining, M., Bakos, K., Marcell, I., Csepeli, A., Csenki, Zs., Urbanyi, B., Kovacs, B., Patocs, A.

Symposium: Zebrafish **Type:** Poster **Order:** P160

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Abstract: Synthetic substances containing estrogens are present all around (active substances in drugs, environmental estrogens). The majority of these chemicals release estradiol that acts in a classical mode through (nuclear and cytoplasmic) estrogen receptors modifying the expression of estrogen sensitive genes. However, recently it has been found that estrogenic substances might also initiate a rapid but unspecific signal from membrane bound receptors. Our work first aimed to test whether a BSA-conjugated-estrogen might act similarly to free estradiols. A BSA conjugated estrogen (β -estradiol-6 (O-carboxymethyl) oxime: BSA) was tested on an estrogen sensitive biomarker zebrafish line (vtg:mCherry). The BSA-conjugated estradiol and equimolar 17β -estradiol were administered to vtg:mCherry fish and fluorescence was assessed by fluorescent microscopy. Compared to the 17β -estradiol the BSA-conjugated estradiol provoked a much weaker signal, suggesting that the classical estrogen receptor mediated signaling pathway may not be activated by this compound.

MECHANISMS AND CONTROL OF INORGANIC PHOSPHATE (Pi) TRANSPORT IN FISHES

Renfro, J.L.

Symposium: Fish Kidney **Type:** Oral **Order:** 3
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Abstract: Pi is a vital nutrient for growth, metabolic activity, acid-base and calcium balance. In fishes the sole determinant of Pi input is dietary, and output is controlled by the kidneys. The uptake by intestine involves isoforms of the NaPiII family (Slc34) of transporters and is very responsive to dietary phosphorous content. Renal Pi transporters also include isoforms of NaPiII that have been implicated in reabsorption of filtered Pi as well as renal tubule secretion. Approximately 20 different hormones, especially parathyroid hormone related peptide and Stanniocalcin, as well as extracellular [Pi] and pH have been shown to alter nephron reabsorption and secretion. In addition, the [Pi] of the cerebrospinal fluid (CSF) may have a role in control of renal Pi transport, and our recent studies of shark brain choroid plexus show that it actively removes Pi from CSF thus opening new possible pathways for Pi homeostasis in the fishes.

ANIMAL PERSONALITY IS RELATED TO THERMAL PREFERENCE IN WILD-TYPE ZEBRAFISH
Rey, S., Digka, N., Mackenzie, S.

Symposium: Environmental Change **Type:** Oral **Order:** 2
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Abstract: It has been widely supported that individual animals express different strategies to cope with environmental challenge. Furthermore in ectothermic species such as fish, individuals must use behavioral thermoregulation mechanisms in order to optimize physiological performance. In the present study, thermal preference was tested in groups of zebrafish screened for proactive and reactive animal personalities. Both proactive and reactive individual adult zebrafish (*Danio rerio*) were identified in a wild-type population of healthy, similar aged and sized, individuals. Three replicate groups of proactive, reactive and non-screened controls (naïve individuals) were used for the needs of the experiments. The frequency distribution of the animals was recorded in a custom-built multi chamber tank under both constant temperature and a continuous thermal gradient profile (ranging from 21°C to 35°C) allowing the temperature preference of each group to be recorded over a 24h time period. Proactive and reactive animal personalities expressed significantly different thermal preferences within the temperature gradient. General activity and exploration behavior within the first hour were also measured. Our results show that proactive fish, generally characterized as more aggressive, risk-takers and prone to routine formation, have a preference for higher temperature environments. Reactive fish which are shy, less risk-prone and more flexible, favor medium-colder temperatures. These results are of significant importance in relation to understanding the adaptive meaning of animal personality within a population. This is the first report of thermopreferendum in zebrafish where individual animal personality coupled to freedom of choice has been applied to understand variation in individual thermal preference within a population

OSTEOBLASTOGENESIS IN GILTHEAD SEA BREEM: TRANSCRIPTIONAL CHARACTERIZATION AND TEMPERATURE EFFECTS

Riera, N., Andres, M., Salmeron, C., Velez, E.J., Takahashi, L.S., Gutierrez, J., Navarro, I., Capilla, E.

Symposium: Fish Cell Cultures **Type:** Poster **Order:** P34
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Abstract: To better understand the process of osteoblastogenesis in gilthead sea bream, we determined the expression of bone formation-related genes in primary cultured osteoblasts during differentiation and extracellular matrix (ECM) mineralization. A structural ECM component, Fibronectin Ia, was induced at the beginning of the

culture (day 5) and then decreased progressively up to day 20, whereas key regulators of mineral deposition like Osteopontin or Matrix Gla-Protein, rose continuously during culture development, together with increased mineralization. Subsequently, differentiated osteoblasts (day 13) were used to study the effects of different incubation temperatures, 18°C, 23°C (control) and 28°C, on the mRNA levels of these genes. Preliminary results indicated that a decrease in temperature down-regulated the expression of most of the osteogenic genes analyzed. This in vitro system is suitable for the study of fish osteoblast biology, as well as the factors that might influence the in vivo appearance of skeletal malformations. Supported by MICINN (AGL2010-17324).

SOLUBLE ADENYLYL CYCLASE IN HAGFISH GILLS

Roa, J.N., and Tresguerres, M.

Symposium: Hagfishes **Type:** Oral **Order:** 9

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Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Drive (0202), La Jolla, California, 92093 USA

Abstract: Soluble adenylyl cyclase (sAC) has been shown to act as a sensor of blood acid/base (A/B) status in mammals and sharks. Additionally, sAC-related proteins are present in cyanobacteria and sAC orthologs are found in most animal phyla, leading to the suggestion that sAC is an evolutionarily conserved A/B sensor. Here, we report evidence that sAC is present and functional in hagfish gills. Antibodies against dogfish shark-sAC cross-reacted with a ~110 KDa protein band in gill homogenates, which matches dogfish sAC size. Immunofluorescence revealed that a sAC-like protein is present throughout the cytoplasm of most hagfish gill epithelial cells. Finally, hagfish gill homogenates demonstrated bicarbonate-stimulated and KH7-sensitive cAMP production, which are hallmarks of sAC activity. Future experiments will attempt to clone the hagfish sAC gene, and establish its physiological role(s). Due to the basal position of hagfishes in the vertebrate lineage, these results can provide important insights on the evolution of A/B sensing and regulation.

TRANSLOCATION OF VHA AND PENDRIN IN SHARK GILLS: A MECHANISM FOR ACID/BASE REGULATION

Roa, J.N., and Tresguerres, M.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 28

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Abstract: We immunolocalized the anion-exchanger pendrin to base-secreting V-H⁺-ATPase (VHA)-rich cells in gills from leopard shark *Triakis semifasciata*. In starved sharks, VHA signal was mostly cytoplasmic and pendrin was present at the apical pole. However, in fed sharks VHA and pendrin translocated to the basolateral and apical cell membrane, respectively. This is the first study to show translocation of pendrin to the apical membrane, where it likely mediates bicarbonate secretion to compensate blood alkalosis. In addition, the bicarbonate-sensitive acid/base sensor soluble adenylyl cyclase (sAC) was highly abundant in both base-secreting and Na⁺/K⁺-ATPase-rich acid secreting cells. Enzymatic assays revealed bicarbonate-stimulated and KH7-sensitive cAMP production in gill homogenates, indicative of sAC activity. Finally, we found that both acid- and base-secreting cells express high amounts of transmembrane adenylyl cyclases (tmACs). We propose a model whereby blood/acid base status is sensed by the combined action of sAC and G-Protein Coupled Receptors/tmAC.

BIOCHEMICAL EFFECTS OF ACUTE EXPOSURE TO THE ANTIBIOTIC ERYTHROMYCIN IN RAINBOW TROUT

Rodrigues, S., Antunes, S.C., Carvalho, M.G., Correia, A.T.C., and Nunes, B.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P42

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Abstract: Antibiotics are continuously dispersed into the environment as a result of human and veterinary uses. Residues of antibiotics have been found in aquatic environments, but their effects on fish have not been thoroughly studied. This work assessed the sub-lethal effects of the antibiotic erythromycin on rainbow trout (*Oncorhynchus mykiss*). Fish were exposed during 96h to erythromycin in concentrations of 0.001, 0.010, 0.100, 1.000 and 10.00 mg/L. The toxicological assessment of effects focused on oxidative stress parameters: glutathione reductase (GRed), catalase (CAT), glutathione S-transferases (GSTs) and lipid peroxidation (TBARS assay) in liver and gills; and acetylcholinesterase (AChE) in muscle and eyes. The obtained results indicate that the exposure to erythromycin induced alterations on the antioxidant homeostasis of exposed organisms, including lipid peroxidation (TBARS concentration increase in gills and decrease in liver) and on the cellular redox status (GSTs, GRed and CAT activities were significantly altered) in *O. mykiss*.

DIFFERENCES IN DIETARY LIPIDS PROFILE DURING EARLY LARVAL DEVELOPMENT AFFECT THE INCIDENCE OF SKELETAL DEFORMITIES IN SOLEA SENEGALENSIS

Rodriguez-Rua, A., Roman-Padilla, J., Fernandez-Diaz, C. and Hachero-Cruzado, I.

Symposium: Fish Culture **Type:** Poster **Order:** P13

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Abstract: In this study, we evaluated the effect of three diets, two with high triacylglycerol (TAG) levels (consisting of rotifers enriched with microalgae *Isochrysis galbana* (ISO) and a Fish Oil emulsion (FO)) and other with a low TAG level (using Marine Lecithin emulsion (ML)) on skeletogenesis of *Solea senegalensis* larvae. For this purpose, we fed larvae from hatching until day 9 with each three experimental diets in triplicate. Subsequently, rotifers were replaced by *Artemia metanauplii* enriched with T-ISO from 10 to 30 days after hatching in all experimental conditions. Dietary treatment affected growth and survival. A significant effect on the total number of vertebrae was found, mainly associated to larvae fed ML diet. Although the incidence of vertebral deformities was similar, different trends in the cranial region were observed. Larvae fed FO diet increased more than 2-fold the number of individuals with incomplete eye migration. Our results suggest that changes in dietary lipids profile during the early larval development have an effect in *S. senegalensis* skeletogenesis, modifying the total number of vertebrae and the incidence of individuals with incomplete eye migration.

RESPIRATORY RESPONSES AND GUT CARBONATE PRODUCTION DURING HYPOXIA AND HYPERCARBIA IN THE EUROPEAN FLOUNDER

Rogers, N.J., and Wilson, R.W.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 23

Contact: Nick Rogers **E-mail:** njr210@exeter.ac.uk

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Abstract: The intestinal precipitation and excretion of CaCO₃ by marine teleosts forms a key part of their osmoregulatory strategy but also makes a significant global contribution to the marine inorganic carbon cycle. Understanding how environmental factors such as hypoxia and hypercarbia affect fish carbonate production is therefore important to accurately model this process in the oceans of the past, present and future. In the European

flounder (*Platichthys flesus*) hypoxia (50 % air saturation) increased CaCO₃ excretion rate by 2.4-fold while hypercarbia (3000 ppm) caused a 1.5-fold increase. When combined, these two treatments acted synergistically, increasing CaCO₃ excretion rate by 4.3-fold. Further data suggest these effects were primarily caused by elevated gill ventilation volumes and compensatory increases in drinking rate. Blood pH regulation during hypercarbia further promotes carbonate precipitation by enhanced supply of HCO₃⁻ to the gut. This directly links fish respiratory, osmoregulatory and acid-base physiology with the marine inorganic carbon cycle.

DIET LIPID PROFILE MODULATES EXPRESSION OF GENES RELATED WITH PHOSPHOLIPIDS METABOLISM AND LIPOPROTEIN SYNTHESIS IN SOLEA SENEGALENSIS LARVAE

Roman-Padilla, J., Rodriguez-Rua, A., Manchado, M., Ponce, M., Fernandez-Diaz, C., and Hachero-Cruzado, I.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P71

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Abstract: In this work, we evaluated the effect of three diets, two with high triacylglycerol (TAG) levels (consisting of rotifers enriched with microalgae *Isochrysis galbana* (T-ISO) and a Fish Oil emulsion (FO)) and other with a low TAG level (using Marine Lecithin emulsion (ML)) on expression profile of *Solea senegalensis* early larvae. For this purpose, we fed larvae from hatching until day 9 with each three experimental diets in triplicate. Although T-ISO and FO diet had similar TAG content, fatty acid composition of T-ISO diet was significantly different. Histological analysis showed significant differences in the pattern of lipid accumulation of T-ISO larvae. Genes related with phospholipids metabolism including *pss*, *cdp-dag*, *cdp-cho* and *gpat3* were down-regulated in larvae fed T-ISO diet. Moreover, a coordinated regulation of genes related with lipoproteins synthesis (*apob*, *apoe*, *apoa4* and *apoc2*) was found in both diets containing high TAG levels. Our results suggest that diet TAG play a key role in larvae lipid transport, and fish larvae can modulate phospholipids synthesis pathway during the developmental stages.

NON-NATIVE PUMPKINSEED INHABITING THE IBERIAN PENINSULA HAVE LOST THEIR ANCESTRAL TOLERANCE TO NORTHERN NORTH AMERICAN WINTER CONDITIONS

Rooke, A.C., and Fox, M.G.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 7

Contact: Anna C Rooke **E-mail:** annarooke@trentu.ca
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Abstract: We use non-native pumpkinseed introduced into Spanish water-bodies almost 100 years ago, to determine how the winter physiology of wild warmwater fish may respond to relatively rapid changes in winter climate. Non-native Iberian, and native Canadian pumpkinseed, raised in a common environment in central Ontario Canada, were used to assess for tolerance to winter conditions typical of the northern native range. Adult survival in outdoor ponds was higher in Canadian populations (68% and 78%) than Iberian populations (31% and 49%). Juvenile Iberian pumpkinseed experienced higher mortality earlier in the winter period than Canadian populations under simulated winter conditions in the lab. Lipid content of Iberian juveniles decreased on average by 49% during the first half of the winter, while that of Canadian populations decreased by only 12-20%. These results suggest that relatively short exposure to warm climates can result in adaptive change in the winter physiology of wild fish populations.

FISH IN HOT WATER: HAS THE THERMAL PHYSIOLOGY OF NON-NATIVE SPANISH PUMPKINSEED RESPONDED TO THE MILD CLIMATE OF ITS INTRODUCED RANGE?

Rooke, A.C., Burness, G., and Fox, M.G.

Symposium: Climate Change **Type:** Oral **Order:** 4
Contact: Anna C Rooke **E-mail:** annarooke@trentu.ca
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Abstract: Temperature-related metabolic adaptations have the potential to mitigate energetic stressors associated with changes in thermal environment, however it is unknown if thermal physiology in wild populations can respond to the relatively rapid changes in thermal conditions expected as a result of climate change. We used non-native pumpkinseed (*Lepomis gibbosus*) introduced into the mild climate of Spain ~ 100 years ago, to assess for rapid adaptation of thermal physiology in wild populations. Spanish pumpkinseed experience warmer, longer summers and warmer, shorter winters compared with native Canadian populations. We assessed resting metabolic rate and upper critical thermal tolerance at a wide range of acclimation temperatures (5 - 35 °C) in pumpkinseed from two non-native Spanish, and two native Canadian populations. We predicted that Spanish pumpkinseed will have a lower metabolic rate at high temperatures, whereas Canadian pumpkinseed will have a lower metabolic rate at low temperatures. Differences at high or low temperatures could indicate the relative importance of summer and winter selective pressures on thermal physiology in wild populations.

TROPICAL CLIMATE CHANGE IMPAIRS SHARK EARLY ONTOGENY: DEVELOPMENTAL AND PHYSIOLOGICAL IMPLICATIONS

Rosa, R., Baptista, M., Pimentel, M.S., Lopes, V.M., Pegado, M.R., Trübenbach, K., Campos, D., Almeida-Val, V., Coelho, M.M., Repolho, T., Calado, R.

Symposium: Tropical Fish **Type:** Oral **Order:** 16
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Abstract: Sharks are one of the most threatened groups of marine animals worldwide, mostly due to overfishing and habitat degradation/loss. Although these cartilaginous fish have evolved to fill many ecological niches across a wide range of habitats, they have limited capability to rapidly adapt to human-induced changes in their environments. So far, ocean acidification was not considered as a direct climate-related threat to sharks. Here we show, for the first time, that a long-term acclimation process of a tropical shark (*Chiloscyllium punctatum*) to the projected scenarios of ocean acidification ($\Delta\text{pH}=0.5$) and warming (+4 °C) for 2100 elicited significant impairments on shark condition, growth, physiology (metabolic and ventilation rates; respiratory, digestive and antioxidant enzyme activities) and survival. Moreover, our findings show that ecophysiological experiences and resulting phenotypes of developing embryos under hypercapnia and warming are carried-over to later shark life stages. Carry-over effects have never been described for this group of animals and may play a critical role in the reduction of shark fitness under climate change. This study reveals the need of experimentally-based risk assessments of sharks to climate change, so that managers and policy-makers can proactively target the most endangered species.

HOW DOES PREY QUALITY AFFECT LIFE-HISTORY TRAITS UNDER DIFFERENT TEMPERATURE REGIMES?

Ross, S.D., Holt, R., van Deurs, M., Andersen, N.G., Nielsen, J.R. and Jørgensen, C.

Symposium: Environmental Change **Type:** Oral **Order:** 16
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Abstract: In the western Baltic Sea, whiting (*Merlangius merlangius*) in the western part mainly prey on high lipid fish, while in the eastern part polychaetes and small crustaceans of lower nutritional value are important. Despite

these dietary differences, the condition of the fish is the same irrespective of area, suggesting that behavioural adaptations and differences in life history strategies may compensate for the lower nutritional value of the prey. How does food quality affect trade-offs in behaviour and energy allocation schemes? When is it more advantageous to prey on easily digestible, but less lipid rich prey, opposed to lipid rich prey that is digested at a slower rate? And do differences in temperature alter the emergent behavioural and energy allocation patterns? These questions will be addressed using a mechanistic model that predicts temperature- and food quality- induced adaptations for life histories and behaviour of Baltic Sea whiting.

YEAR-ROUND 3-DIMENSIONAL SPATIAL AND TEMPORAL DISTRIBUTION OF TWO SYMPATRIC MORPHS OF ARCTIC CHARR, FROM A REMOTE, LAND- LOCKED, ARCTIC POPULATION

Rosten, C. M., Hawley, K. L., Christensen, G., Lucas, M. C.

Symposium: Fish Habitats **Type:** Oral **Order:** 8

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Abstract: Limited fish ecology research has been conducted in Arctic freshwater in winter. This study utilised a passive, telemetry positioning system to map the year-round, 3-dimensional spatial distribution of 28 acoustically tagged Arctic charr, from a remote, Arctic, land-locked population. An array of 19 receivers was deployed, resulting in near-complete coverage of the study lake (surface area; 0.72 km², max depth; 34 m) over a 12 month period (September 2009–2010). Morphological variation within the tagged sample identified two sympatric ecophenotypes; Robust and Delicate, exhibiting clearly defined resource partitioning in terms of year-round habitat use (fish depth, fish distance from lake bed) and activity (home range area) (ANOVA, 1 df, $p < 0.05$). A significant diel pattern of fish speed was observed during the months of polar night; December and January (GLM: hour x morph, fish ID random effect; $n = 1,056$, $df = 23$, $F = 1.58$, $p < 0.05$), but not during the months of polar day; May – July (GLM: hour x morph, fish ID random effect; $n = 1,353$, $df = 23$, $F = 0.68$, $p > 0.05$). Under ice during the winter, both morphotypes maintained the same mean depth of 12 metres, albeit in different lake habitats (Delicate occupied more offshore waters than Robust), thus both morphotypes were exposed to the same ambient water temperature. The findings reveal that year-round ecology of fish in Arctic freshwater systems can be complex, with behaviour under ice more variable than previously perceived, and fine-scale spatial partitioning occurring in distinct ecotypes. The study shows the utility of autonomous telemetry methods for gathering behavioural ecology data in poorly accessible and inhospitable environments.

EFFECTS OF PITUITARY INJECTIONS ON SEXUAL MATURATION IN THREE-SPINED STICKLEBACKS UNDER DIFFERENT PHYSIOLOGICAL CONDITIONS

Roufidou, C., and Borg, B.

Symposium: Reproductive Physiology **Type:** Poster **Order:** P53

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Abstract: Both male sticklebacks under short photoperiod and post-breeding males have low levels of androgens and low FSH-beta, LH-beta and sGnRH mRNA levels. However, the former will mature if exposed to long photoperiod, whereas the refractory post-breeding fish will not. This may be related to differences in responsiveness to gonadotropins. Males kept under short photoperiod and post-breeding males under long photoperiod were injected with ¼ stickleback pituitary daily for ten days. The kidney somatic indices (KSI: kidney weight/body weight x 100) were measured. The breeding male stickleback kidney hypertrophies under androgen stimulation and secretes spiggin, which is used in nest building. The KSI for the pituitary injected and control males in short photoperiod was $1.40 \pm 0.12\%$ and $0.67 \pm 0.05\%$ respectively ($p < 0.0001$), whereas pituitary injected and control post-breeding

males had similar KSIs; $0.93 \pm 0.08\%$ and $0.98 \pm 0.12\%$ ($p=0.75$). Thus, the responsiveness to pituitary injections differed. One possibility is that they may differ in gonadal GTHs receptors.

TRANSCRIPTOME PROFILING OF THE ADULT ZEBRAFISH HEART UNDER EXERCISE

Rovira, M., Burgerhout, E. Palstra, A.P., and Planas, J.V.

Symposium: Swimming Physiology **Type:** Poster **Order:** P137

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Abstract: Cardiovascular research using the zebrafish (*Danio rerio*) as model species has made important contributions to cardiac cell specification, regeneration and function over the last decade. However, the response of the adult zebrafish heart to exercise, known in mammals to elicit important adaptations in this tissue, has not been evaluated to date. Our group is investigating the physiological effects of swimming in adult zebrafish and recently established a swim-training protocol under sustained exercise conditions (i.e. optimal swimming speed) (Palstra et al. *PLoS One*, 5:e14483, 2010). Under these conditions, we subjected adult zebrafish to 20 days of swim-training and analyzed the transcriptomic response in the zebrafish heart by microarray analysis. We identified more than seven hundred differentially expressed genes involved in processes such as cell cycle and proliferation, extracellular matrix and cytoskeleton, muscle contraction, growth factors/signalling pathways and metabolism. These results provide insights into the molecular adaptive mechanisms taking place in the zebrafish heart in response to swimming-induced activity.

SWIM TRAINING OF ADULT ZEBRAFISH PROMOTES HYPERTROPHY AND VASCULARIZATION OF FAST SKELETAL MUSCLE FIBERS THROUGH ACTIVATION OF MYOGENIC AND ANGIOGENIC TRANSCRIPTIONAL PROGRAMS

Rovira, M., Palstra, A.P., and Planas, J.V.

Symposium: Swimming Physiology **Type:** Oral **Order:** 3

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Abstract: In zebrafish, as in other teleost species, swimming-induced contractile activity under sustained conditions potentiates somatic growth. In the present study, we aimed at investigating the cellular and molecular adaptive mechanisms that take place in the fast skeletal muscle of adult zebrafish in response to swimming. By performing microarray analysis we have identified over four thousand significantly differentially expressed genes in skeletal muscle that are involved in different processes such as muscle growth and development, muscle contraction, angiogenesis, metabolism and immune-related genes. Moreover, swim training increased fibre size (i.e. hypertrophy) and vascularization in fast muscle. These results show that exercise produces meaningful changes in the fast muscle transcriptome and suggest that fibre hypertrophy may be responsible for the growth-promoting effects of exercise accompanied by a switch to a more oxidative capacity of white muscle fibres to fuel the energy demands imposed by swimming. These findings provide insight into the cellular and molecular adaptive mechanisms underlying the swimming-induced potentiation of growth.

CHARACTERIZATION OF PEPTIDE TRANSPORTER SYSTEMS IN THE INTESTINE OF MOZAMBIQUE TILAPIA

Rozenberg, P., Nitzan, T., Seroussi, E., Harpaz, S., Cnaani, A.

Symposium: Physiological Genomics **Type:** Oral **Order:** 8
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Abstract: Peptide transporters (PepT) are membrane carriers which mediates the absorption of di- and tri- peptide from the intestinal lumen into the enterocytes. Tilapia's transcriptomic analysis indicated three PepT genes that are affected by environmental salinity changes. In order to characterize the influence of salinity and feeding on the PepT systems in Mozambique tilapia, we sampled fish reared in fresh and sea water, at three time points after feeding (6, 24, 72 h), representing different digestive stages. Quantitative gene expressions of PepT1a, PepT1b, and PepT2, were measured in the anterior, middle, and posterior intestine. Antibodies for these three genes were developed, and used in western-blot and immunohistochemistry analyses for protein expression and localization. Sequencing and phylogenetic analysis showed clustering with mRNA variants from other teleosts. We found differential expression and localization of these genes along the intestine, which correlated with the different digestive stages. The PepT1 genes are typical of the proximal section with the highest expression at the early time point, while PepT2 is typical of the distal section with higher expression at a later time point. An opposite effect of salinity on gene expression was found along the intestinal sections.

LETHAL AND SUB LETHAL TOXICITY OF NITRATES AND PHOSPHATES IN THE ENDEMIC FISH SKIFFIA
MULTIPUNCTATA AND GOODEA ATRIPINNIS

Rueda-Jasso R.A., DeLos Santos-Bailón A. and Campos-Mendoza A.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 22
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Abstract: The Goodeinae sub-family is a representative group of the high diversity of the Mexican freshwater fish. They are endemic to the Mexican Central Plateau, viviparous and more than half of the group's species are endangered because of the high levels of pollution and deterioration of the water bodies they inhabit. This paper determined the effect on the endemic fishes *Skiffia multipunctata* and *Goodea atripinnis* by lethal and sub-lethal concentrations of nitrates and phosphates to establish their respective tolerance intervals. Five and six concentrations of nitrites and phosphates were tested, (n=30). The LC50 was obtained following the OECD procedures. The exposure to both toxic compounds caused respiratory and swimming alterations and the presence of wounds and mortality. Both toxics also caused severe alterations at gill level (hyperplasia, hypertrophy and lamellar fusion) at smaller concentrations than those marked as limits in the Official Mexican Norm (for conservation of wild aquatic fauna).

THE EFFECTS ON INTESTINAL PHYSIOLOGY BY THE GUANYLIN PEPTIDES OF GULF TOADFISH EXPOSED TO
HYPER-SALINITY AND HYPERCAPNIA

Ruhr, I.M., Heuer, R.M., Mager, E.M., Takei, Y., Grosell, M.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 24
Contact: Ilan Ruhr **E-mail:** iruhr@rsmas.miami.edu
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Abstract: The homologous peptides guanylin, uroguanylin, and renoguanylin (RGN) affect osmoregulation in the posterior intestine of the Gulf toadfish by reversing short-circuit current. Stimulation by RGN of the posterior intestine leads to net Cl⁻ and fluid secretion, and inhibits HCO₃⁻ secretion. This secretory response coincides with the presence of basolateral NKCC1 and apical CFTR staining in the posterior intestine. These observations contradict the established osmoregulatory function of the marine teleost intestine in fluid absorption. However, fluid

secretion by the posterior intestine may facilitate the release of CaCO₃ precipitates. To test this hypothesis, fish were exposed to hypersalinity (60 ppt) and will be exposed to hypercapnia (1% CO₂), two treatments known to increase intestinal CaCO₃ production. Exposure to 60 ppt resulted in elevated mRNA expression in the posterior intestine of NKCC1, CFTR, and the guanylin peptides' receptor, and resulted in a greater secretory response to RGN by this tissue, possibly in support of the above hypothesis.

OMEGA-3 FATTY ACIDS INFLUENCE MITOCHONDRIAL FUNCTION AND INFLAMMATORY STATUS IN ATLANTIC SALMON IN VITRO DIFFERENTIATED PREADIPOCYTES

Ruyter, B., Østbye, T. K., Torgersen, J., Krasnov, A. and Todorčević, M.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 8

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Abstract: White adipose tissue in Atlantic salmon is considered an active endocrine and secretory organ with multiple regulatory functions in metabolic processes. In course of their in vitro development, adipocytes express several adipokine- and immune-related genes. In order to gain knowledge on how different fatty acids influence inflammatory response and immune functions in adipocytes, we have performed an in vitro trial with Atlantic salmon preadipocytes. Preadipocytes in culture incubated with the classical immune inducer lipopolysaccharide (LPS) showed high responsiveness. Gene expression analyses revealed LPS induced expression of a large number of immune-related genes, even at an early stage of development. The conservation of immune activity in salmon white adipocyte precursor cells thus provides more evidence for the immune role of white adipose tissue in fish. We further observed that the omega-3 fatty acids 20:5 n-3 and 22:6 n-3 protects the mitochondria from LPS induced damage and have an anti-inflammatory effect.

PALEOCHANNEL TARUMÃ-MIRIM AND CUIEIRAS: A RECENT GEOLOGICAL BARRIER CAUSING DIFFERENTIATION IN APISTOGRAMMA SP. POPULATIONS

Sá Leitão, C.S., Santos, C.H.A., Vilarinho, G.C.C., Castro, N.S., Paula-Silva, M.N., M.M.G.C.N., Val, A.L., Almeida-Val, V.M.F.

Symposium: Tropical Fish **Type:** Poster **Order:** P152

Contact: Carolina Sousa de Sá Leitão **E-mail:** kcaufs@gmail.com
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Abstract: A paleochannel evidences that Cuieiras and Tarumã-Mirim Rivers separated between 104 and 105 years ago. Here, we show the influence of this recent geological event on the populations' genetic structure of *Apistogramma gephyra* and *Apistogramma pulchra*. Samples of both species were sequenced for 16S, COI and RAG. DNASp, MEGA v4.1 and Arlequin softwares were used to analyze the results. Genetic distances within and between groups were 0.02±0.00 and 0.19±0.03 for *A. gephyra*, and 0.05±0.01 and 0.15±0.05 for *A. pulchra* for Cuieiras and Tarumã-Mirim populations, respectively. Nucleotide diversities were 0.061 (*A. gephyra*) and 0.095 (*A. pulchra*). Genetic differentiation (F_{ST}) was 0.263 (*A. gephyra* Cuieiras vs *A. gephyra* Tarumã) and 0.231 (*A. pulchra* Cuieiras vs *A. pulchra* Tarumã). Neighbor-joining method resulted in distinct separation of analyzed *Apistogramma* populations. We suggest that the paleochannel is causing genetic divergence between populations of *Apistogramma* sp. (INPA; INCT ADAPTA - CNPq/FAPEAM); Universal (FAPEAM); CAPES/FCT)

MONITORING A RECENT PETROLEUM ASPHALT SPILL IN A HARBOR AREA IN RIO NEGRO (AMAZON) USING TIME-COURSE VARIATIONS OF BIOMARKERS OF TWO CICHLID SPECIES

Sadauskas-Henrique, H., Mota, S.B., Campos, D., Kochhann, D., Val, A.L. and Almeida-Val, V.M.F.

Symposium: Tropical Fish **Type:** Oral **Order:** 11
Contact: Helen Sadauskas Henrique **E-mail:** helensadauskas@yahoo.com.br
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Abstract: Contamination of freshwater systems with petroleum compounds has increased in the last decades due the extraction, transport and processing. Variations of water quality, associated with Amazon flood pulses, can strength the toxicity of the petroleum hydrocarbons to the resident ichthyofauna. Here, we analyzed biotransformation and antioxidant enzymes, PAH metabolites in bile and DNA damage in erythrocytes as potential biomarkers in two Amazon cichlid species to monitor recently contaminated harbor area in Rio Negro/AM. These biomarkers presented a time-dependent response, paralleled by an increase in EROD, a hepatic phase I biotransformation enzyme. PAH metabolites also increased in the bile of both species, characterizing a mid- to long-time exposure to the contaminant. Increased DNA damage in erythrocytes was present in both species after 15 days. These results suggest that multiple biomarkers provide an appropriate tool for assessing the quality of waters of the Amazon. (INPA; INCT ADAPTA – CNPq/FAPEAM; CAPES; PIATAM - FINEP)

COMPARISON OF ROBUSTNESS TRAITS IN TWO ISOGENIC LINES OF RAINBOW TROUT: USE OF A NEW APPROACH BASED ON MODELISATION OF BIOLOGICAL RESPONSES TO ACUTE STRESSORS

Sadoul, B., Leguen, I., Colson, V., Friggens, N.C., Prunet, P.

Symposium: Stress in Fish **Type:** Oral **Order:** 14
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Abstract: Robustness is a complex trait difficult to phenotype. In the present study, two features of robustness were assessed in rainbow trout: sensitivity and resilience to an acute stressor. Thus, robustness was approached by analyzing dynamics of various physiological and behavioral responses to an acute stressor. For that purpose, oxygen consumption, cortisol release rate but also group dispersion and group activity of two isogenic lines of juvenile rainbow trout were followed before and after a four hours confinement challenge. Temporal patterns produced by this experiment were analyzed using a new approach based on modelisation. The two isogenic lines were found to be highly divergent only in their corticosteroid reactivity, whereas no correlation was observed between physiological and behavioral sensitivity or resilience in these lines. However, multivariate analysis of these data showed two separate and independent fish group coping strategies in both lines, consisting in either modifying group behavior traits or physiological traits.

ROLES OF LEPTIN AND GHRELIN IN ADIPOGENESIS AND LIPID METABOLISM OF RAINBOW TROUT ADIPOCYTES IN VITRO

Salmeron, C., Johansson, M., Asaad, M., Angotzi, A.R., Ronnestad, I., Jonsson, E., Bjornsson, B.Th., Gutierrez, J., Capilla, E., Navarro, I.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 9
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Abstract: We examined the effects of leptin and ghrelin, two well-known regulators of energy homeostasis, on adipogenesis and expression of lipid metabolism-related genes in rainbow trout adipocytes. Leptin expression and secretion increased from the preadipocyte to mature adipocyte stage. Both ghrelin and its functional receptor were identified, but neither leptin nor ghrelin influenced adipogenesis. In isolated adipocytes, both hormones stimulated

glycerol release, although the expression of lipolysis markers was unchanged. Leptin significantly suppressed fatty acid transporter-1 expression, suggesting it has an anti-lipogenic role, whereas ghrelin significantly up-regulated the expression of lipoprotein lipase, fatty acid synthase and peroxisome proliferator-activated receptor-beta, indicating increased lipid synthesis and deposition. Overall, these data indicate that leptin and ghrelin have opposite roles regulating lipid metabolism in rainbow trout. However, their mechanisms of action need to be further explored to better understand the modulation of adiposity, an important quality trait for aquacultured salmonids. Supported by LIFE CYCLE (EU-FP7 222719).

CHARACTERISATION AND GENE EXPRESSION ANALYSIS OF CALPAINS, CATHEPSINS AND UBIQUITIN-PROTEASOME MEMBERS IN GILTHEAD SEA BREAM SKELETAL MUSCLE

Salmeron, C., Navarro, I., Johnston, I.A., Gutierrez, J., Capilla, E.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 9

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Abstract: The proteolytic enzymes involved in muscle protein turnover in fish are also responsible for post-mortem flesh softening and are therefore potential determinants of product quality. We have identified in gilthead sea bream fast skeletal muscle several genes of the calpain, cathepsin, and ubiquitin-proteasome systems. Transcripts expression was analysed at three life-history stages, during fasting/re-feeding and after feeding four experimental diets with different carbohydrate-to-protein ratios. Most of the genes studied were significantly down-regulated from fingerlings to juveniles/adults, and with re-feeding, suggesting a decrease in muscle proteolysis in both contexts. Moreover, increased dietary carbohydrate content enhanced muscle texture, which showed a significant negative correlation with sacapn1 and sacapns1a expression. These data demonstrate that feeding regimes can modulate proteolytic genes expression, providing a potential method of influencing post-mortem fillet tenderisation, and indicate the potential use of some calpains as molecular markers of flesh quality in gilthead sea bream. Supported by LIFE CYCLE (EU-FP7 222719).

PROTEOMIC PROFILE OF SKIN MUCUS OF GILTHEAD SEA BREAM AS NON-INVASIVE WELFARE INDICATOR

Sanahuja, I., Millán-Cubillo, A.F., Sánchez, S., de Oliveira, E., Odena, M.A., Díaz, R., Blasco, J., Fernández-Borrás, J., Ibarz, A.

Symposium: Fish Culture **Type:** Poster **Order:** P14

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Abstract: Skin mucus is not only the first physical barrier in teleosts to prevent on the physical and chemical attacks but it contains multiple components related to metabolism, environmental influences and nutritional status. The aims of this study are to identify mucus proteins of a marine teleost and their potential use as welfare indicators. The corresponding proteome maps were obtained by 2D-electrophoresis, and over 1000 spots were matched using ImageMaster-2D. The 100 most abundant proteins were further analysed by LC-MS/MS and identified by database retrieval. "Top ten" spots in abundance were protective (C1q-complex, two Transferrin isoforms, two HSP70 isoforms), structural components (Keratin-Type1, α -Actin, Profilin) and metabolic enzymes (GAPDH, DCDT). Both tissue of origin and function (from Gene Ontology) of the identified proteins will be the basis for discussing if the skin mucus proteins could be used as non-invasive method to determine the animal status and, in extension, of their culture conditions.

METABOLIC REORGANISATION OF GILTHEAD SEA BREEM LIVER DURING THERMAL FLUCTUATIONS: DIETARY ENERGY EFFECTS ON COLD GROWTH ARREST AND RECOVERY CAPACITY

Sánchez, S., Eroldoğan, O.T., Özşahinoğlu, I., Mumoğullarında, P., Sanahuja, I., Millán-Cubillo, A.F., Guerreiro, P.G., Fontanillas, R., Blasco, J., Fernández-Borràs, J., Ibarz, A.

Symposium: Fish Culture **Type:** Poster **Order:** P15

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Abstract: Gilthead sea bream exposed to suboptimal temperatures during winter shows arrest growth, with metabolic depression and fasting. Three groups (in triplicate) of juveniles (145 g b.w.) were submitted to controlled thermal variations: 35 days at 22°C (Pre-Cold), 50 days at 14°C (Cold) and 30 days at 22°C (Recovery). Two groups were fed with diets differing in energy (D14: with 14% lipid, D18: 18% lipid), and the third received D18 plus protective agents (D18W). The effects of temperature challenges on the metabolic oxidative pathways and protective processes were assayed through the activities of key liver enzymes. Thermal coefficient (Q₁₀) of all enzymes concluded a lack of adaptation to cold, irrespective of the diet. The differences found between 7 (“early”) and at the end of the recovery period (“late”) indicated that dietary energy content and protectors influence liver metabolism. Thus, optimization of recovery from winter challenge will require a feeding scheme with protective diets.

DO ANTARCTIC FISH LIKE IT HOT? WHAT ENERGY ALLOCATION CAN TELL US ABOUT DISTRIBUTION SHIFTS

Sandersfeld, T., W. Davison, M. Lamare, C. Richter and R. Knust

Symposium: Climate Change **Type:** Oral **Order:** 6

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Abstract: Despite evidence for distribution shifts of single species and ecosystem changes as a reaction to global warming, little is known about the underlying processes. As a consequence of warming waters in the Southern Ocean, shifts in species distribution are expected with sub-Antarctic species migrating southward to high-Antarctic waters, while species from temperate regions might intrude sub-Antarctic areas. Species distribution and abundance are driven by reproduction and growth. Growth and reproduction depend upon surplus energy being available after baseline costs of maintenance have been met. However, interdependencies of temperature and energy budgets of single species have rarely been investigated. This study assesses the impact of temperature on energy budgets of Antarctic fish from different thermal habitats. Results show that increasing temperatures can enhance feeding efficiency and growth. However, temperatures exceeding a species-specific threshold have destructive effects on energy utilization and are likely to affect distribution patterns. In conclusion, energy budget studies are a crucial tool to understand species distribution limits and adaptations in response to a changing environment.

UNDERSTANDING THE MECHANISMS OF TOXICITY OF ENVIRONMENTAL CHEMICALS TO FISH

Santos, E.M, Uren Webster T.M., Fitzgerald, J. Huang, I.C.

Symposium: Plenary **Type:** Oral **Order:** 2

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Abstract: The aquatic environment acts as a sink to a large range of anthropogenic chemicals with the potential to cause toxicity to aquatic organisms. In order to better understand and predict the consequences of exposure to these

chemicals, it is fundamental that their mechanisms of toxicity are documented. For fish, comprehensive datasets characterising the global mechanisms of toxicity of environmental chemicals are generally limited to a small number of model species for which genomic resources exist. There is a need to broaden the scope of mechanistic studies to other species of ecological importance in order to better protect aquatic systems. We have investigated the effects of a range of chemicals in model (zebrafish, three-spined stickleback) and non-model (brown trout) fish species in order to enhance our understanding of the consequences of exposures to fish populations inhabiting contaminated environments. The chemicals investigated included oestrogenic chemicals, pesticides and metals, and the results suggest both overlapping and unique pathways of toxicity. We have also investigated the potential for wild fish populations to have differential susceptibility to environmental chemicals. We identified a population of brown trout from the River Hayle, Cornwall (U.K.), with remarkable tolerance to metals, and characterised molecular pathways associated with this tolerance. We also investigated the potential for alterations in environmental factors to affect the susceptibility of fish to chemical contaminants. We identified very significant changes in the toxicity of copper and dinoseb to zebrafish embryos when exposures occur under reduced oxygen concentrations. Together, these datasets enable us to better understand some of the complex interactions modulating chemical toxicity to fish populations in their natural environment.

CHARACTERIZATION OF THE PROTEINACEOUS MATRIX ASSOCIATED WITH INTESTINAL CALCIUM CARBONATE
PRECIPITATES USING MASS SPECTROMETRY

Schauer, K.L. and Grosell, M.

Symposium: Physiological Genomics **Type:** Oral **Order:** 7

Contact: Kevin Schauer **E-mail:** kschauer@rsmas.miami.edu

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Abstract: The precipitation of calcium carbonate in the intestines of marine fish plays a pivotal role in their whole body osmoregulatory strategy. To begin elucidating the mechanisms behind this relatively uncharacterized example of biomineralization, the protein constituents of carbonate precipitates collected from the intestines of gulf toadfish (*Opsanus beta*) were analyzed. Raw precipitates were collected directly from the intestine and submitted to a number of stringent purification steps to remove potential contaminants. Inorganic carbonate was then removed by the addition of concentrated EDTA, leaving only the organic matrix. SDS-PAGE analysis reveals a number of proteins consistently associated with this matrix. A recently assembled transcriptome for *O. beta* allowed for identification of these proteins using mass spectrometry-based shotgun proteomics. Nearly 100 proteins were identified in this matrix using this technique. Interestingly, over 10% of the proteins identified contained probable calcium-binding domains, suggesting they may play a role in the biomineralization process.

MECHANISMS OF SLIME THREAD PRODUCTION IN THE HAGFISH GLAND THREAD CELL

Schorno, S., Fudge, D.S., and Heyland, A.

Symposium: Hagfishes **Type:** Poster **Order:** P19

Contact: Sarah Schorno **E-mail:** sschorno@uoguelph.ca

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Abstract: Hagfishes are known for their unique defensive slime, which they use to ward off gill breathing predators. Gland thread cells (GTCs) are one of the major cell types within hagfish slime glands and the silk-like protein threads they produce increase the strength of the slime and could be a useful model for producing environmentally sustainable protein fibres. However, the mechanisms of how the thread elongates and becomes so elaborately coiled within gland thread cells remains poorly understood. Additionally, the time required for a GTC to fully mature and the glands to refill are unknown. Regarding thread skein formation, we propose that the nucleus acts as a template and rotates to form loops of thread, with loose intermediate filaments twisted together near the apical tip of the

nucleus, and motor proteins driving the unidirectional rotation of the nucleus and the twisting of intermediate filaments into a coherent thread.

INFLUENCE OF TEMPERATURE AND AGING ON PERFORMANCES IN NOTHOBRANCHIUS FURZERI

Schouman A, Durollet M, Lucas J, Lefrançois C

Symposium: Growth and Metabolism **Type:** Poster **Order:** P72

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Abstract: Variability in performances is commonly found within a same species. This variability is determined by the genome, but also by intrinsic factors, such as age or sex of individuals, as well as environmental factors, such as temperature. It has been for instance demonstrated in several species that fish metabolism and growth varied with temperature, showing a maximum at an optimal temperature. The objective of this study was to investigate physiological performance (e.g. swimming, specific dynamic action) as a function of both intrinsic and environmental factors, the age and the temperature. The target species is *Nothobranchius furzerei*, a teleost species whose lifespan in nature does not exceed 6 months. Performances were studied at 18 and 36 weeks, representative of the adult and senescent stages, respectively. Fish were bred in couples at two temperatures (22 and 26°C). Preliminary results regarding adults are presented and discussed in relation with this species short lifespan.

IS JUVENILE MIGRATION PHENOTYPE ESTABLISHED BY RECENT STIMULI OR MUCH EARLIER IN LIFE

Schreck, C.B., Billman, E.J. Unrein, J., Chitwood, R., Whitman, L.D., Schroeder, R.K., Sharpe, C.S., Kimmel, C., and Noakes, D.L.G.

Symposium: Fish Habitats **Type:** Oral **Order:** 4

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Abstract: Juvenile Chinook salmon *Oncorhynchus tshawytscha* in the Upper Willamette River, Oregon, USA display considerable variation in downstream-movement life history tactics. Fish reared in circular tanks self-sort into surface- and bottom-oriented groups starting just after per os feeding begins. Morphometric analysis suggests that the surface phenotype is similar in shape to wild fall migrants and parr from downstream sites. The benthic phenotype fish are similar to wild spring migrants and fish collected concurrently up-river. Bone structure analysis of the head suggests that these differences rest with the jaw. Plasma sodium, gill Na/K ATPase and boldness analyses also revealed early effects of rearing conditions. We suggest that downstream movement of juveniles soon after emergence is associated with differentiation in the expression of life history variation. This contention is also supported by movement studies in large artificial streams and in a small tributary stream.

IDENTIFICATION OF PHEROMONE RECEPTOR ANTAGONISTS FOR INVASIVE SEA LAMPREY CONTROL

Scott, A.M., Huertas, M., Liu, N., Gunturu, S., Raschka, S., Kuhn, L.A., and Li, W.

Symposium: Lampreys **Type:** Poster **Order:** P96

Contact: Anne Scott **E-mail:** scottan7@msu.edu

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Abstract: The sea lamprey (*Petromyzon marinus*) is an invasive parasite in the Great Lakes that relies on male sex pheromones to attract ovulatory females for spawning. We hypothesized that antagonists similar to the sex pheromone 3-keto petromyzonol sulfate (3kPZS) will bind to its cognate pheromone receptor, inhibit 3kPZS olfactory detection, and disrupt behavioral responses of female sea lamprey. Candidate antagonists were identified by computationally screening millions of commercially available compounds as analogs of 3kPZS that match a set of key chemical functional groups and docked well into the receptor structure. Afterwards, electro-olfactograms were conducted to determine the reduction of 3kPZS by putative antagonist. Finally, the identified blockers of 3kPZS olfaction were tested in a bifurcated maze bioassay to determine their ability to block behavioral responses to 3kPZS. This integrative approach resulted in the identification of several antagonists, including a natural molecule that nullifies pheromone reception in vivo at picomolar concentration. This research was supported by the Great Lakes Fishery Commission.

MITOCHONDRIAL RESPONSES OF CRUCIAN CARP CARDIOMYOCYTES TO CHEMICAL ANOXIA

Scott, M.A., Stensløkken, K.O., and Nilsson, G.E.

Symposium: General Contributed Papers **Type:** Poster **Order:** P60

Contact: Mark Scott **E-mail:** m.a.scott@ibv.uio.no
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Abstract: Crucian carp inhabit oxygen-depleted lakes for months during the winter and effectively maintain normal cardiac function in anoxia. This is in contrast to other known anoxia tolerant animals, such as some species of freshwater turtle (*Trachemys* and *Chrysemys*), that drastically metabolically depress cardiac activity. This begs the question how crucian carp are able to maintain cardiac mitochondrial activity in anoxia for long periods of time when no other animal can? Using fluorescence microscopy, enzymatically isolated crucian carp cardiomyocytes loaded with the mitochondrial membrane-potential sensitive dye Tetramethylrhodamine methyl ester (TMRM) were exposed to treatments of cyanide or iodoacetate for 6 hours. Cyanide disrupts the electron transport chain and iodoacetate stops glycolysis. By 1 hour, iodoacetate-exposed cells had shown a significantly decreased TMRM intensity, whereas the cyanide-exposed cells showed no effect even after 6 hours. This suggests that the crucian carp is maintaining mitochondrial membrane potential despite a stalled electron transport chain and that it is using glycolysis to fuel it.

DO T HELPER CELLS EXIST IN FISH?

Secombes, C.J., Yoon, S., Mitra, S., Zou, J., and Bird, S.

Symposium: Plenary **Type:** Oral **Order:** 3

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Abstract: In tetrapods the immune response is regulated by intercellular mediators termed cytokines. Cytokines released from a subpopulation of lymphocytes called T helper (Th) cells drive specific immunity in different directions dependent upon the pathogen encountered. Analysis of the cytokine repertoire in fish has revealed many homologous genes, or genes that likely have a shared ancestry. This talk will outline what we know about such cytokines in fish, and will then explore the evidence that at least in bony fish, these cytokines may be released from a population of cells with Th function.

DEVELOPING A FIELD APPROACH FOR EXAMINING ELASMOBRANCH FEEDING ECOLOGY

Semmens, J.M., Barnett, A., Fitzpatrick, R., Kock, A., McAllister, J., Payne, N.L., Sims, D.,

Symposium: Elasmobranchs **Type:** Oral **Order:** 9

Contact: Jayson Semmens **E-mail:** jayson.semmens@utas.edu.au

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Abstract: Understanding the energetic requirements of organisms in the wild is fundamental to ecosystem ecology, as the energetic benefits and costs associated with their activities will heavily influence life-history strategies and trophic relationships. Inherent difficulties studying marine predatory behaviour in the wild have hindered our understanding of the energetic requirements and associated trophic relationships of apex predators. In the case of predatory sharks, approaches that provide energetic data are urgently needed, as many of these species are highly vulnerable to overexploitation. Accelerometry has emerged as a powerful tool for estimating energy expenditure in a range of animals, but has only recently been used to estimate field metabolic rate in aquatic taxa. Accelerometry is also emerging as a key tool for identifying feeding events and measuring prey encounter rates in aquatic animals. Here, we use an accelerometry approach to examine feeding ecology in a variety of elasmobranchs, including white sharks (*Carcharodon carcharias*).

THE HEAT SHOCK RESPONSE AND THE DEVELOPMENT OF THERMOTOLERANCE IN EMBRYONIC LAKE WHITEFISH

Sessions, K.J., Boreham, D.R., Somers, C.M., Wilson, J.Y., Manzon, R.G.

Symposium: Stress in Fish **Type:** Oral **Order:** 9

Contact: Katherine Sessions **E-mail:** katherinejs@live.com

University of Regina, Regina, S4S 0A2 Canada

Abstract: Lake Whitefish (LWF) embryos develop at 3-6°C and thus may be sensitive to thermal stress. The aim of our research is to determine if mild transient heat shocks (HS) have detrimental or hormetic (beneficial) effects on LWF embryos. It is plausible that mild HS will increase cellular resistance and lower embryo susceptibility to subsequent stressors. Embryos were exposed to one of three transient HS regimes (delta3°C every 3 and 6 days and delta6°C every 6 days). Subsequent exposure to a one hour HS of delta15°C elevated HSP70 mRNA levels in the both 3°C transient groups but not the 6°C group. A four hour HS of delta15°C elevated HSP70 mRNA in all transient groups. In contrast, HSP70 mRNA did not increase following a delta12°C HS in any group. Our data indicated LWF embryos are resilient to thermal stress and a mild transient HS does alter the HS response to more severe stressors.

THE EFFECTS OF LIGHT INTENSITY AND 17A-METHYL TESTOSTERONE OF COLORATION IN SCATOPHAGUS ARGUS

Shahidiannamaghi, M., Jamily, S., Fatemi, S.M.,

Symposium: Tropical Fish **Type:** Oral **Order:** 21

Contact: Mojtaba Shahidiannamaghi **E-mail:** m.shahidian@yahoo.com

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Abstract: 17 α -methyl testosterone is among androgens, which plays a role in sexual cycle and is used for increasing growth and changing secondary attributes. In this research, the effect of three different doses of this hormone (300, 400 and 1000 mg/kg/kg) coupled with the control (without hormone) on secondary sexual characteristics (Hue and value) of *Scatophagus argus*. The results of this research indicated that there is a strong relationship between the physiological condition of fish with the skin color and secondary sexual characteristics of this fish and by increase of dose the glitter in the fish's tint is increased. Tint, the bottom of body in fish samples with doses of 0, 300 and 400 ml/kg had no significant difference ($P > 0.05$), while in a dose of 1000 ml/kg of the allotment it had significant difference ($P < 0.05$) and the maximum tint was observed in samples with 1000 ml dosage. This result indicated the tendency to increase red tint, while in all investigated doses, significant difference in the rate of tint between tailfin

and body fin ($P < 0.05$). On the other side, the factor of tint in the tailfin of fish had significant difference too ($P < 0.05$) and indicates a decreasing procedure toward red tint. The effect of light intensity at three different luxury (100000, 50000, 100 Lux) at a constant 12-hour lighting control treatment within 24 hours of the day with them for 45 days continuously assessed. The results showed that the thickness of the tissue between the treatments were significant differences in levels of light intensity ($P < 0.01$). These results suggest that increasing the amount of light, the melanin layer thickness increases. Simultaneous study of both light and hormone combined with tissue thickness will not cause a significant difference ($P < 0.05$).

NUCLEOBASE COMPOUNDS AS DIVERSE CHEMOSENSORY STIMULI ACROSS FISH SPECIES

Shamchuk, A.L., Blunt, B., and Tierney, K.B.

Symposium: Sensing the Environment **Type:** Oral **Order:** 5

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Abstract: Although nucleotides have already been identified as chemosensory stimuli for fish, it is unknown which structural components of a nucleotide (purine, sugar or phosphates) are necessary to stimulate the olfactory tissue. Furthermore, differences in purine ring functional groups may influence the type of receptor bound and subsequent behavioural responses. Our preliminary electro-olfactogram studies on goldfish revealed that both nucleosides and purine ring structures alone effectively stimulate olfactory epithelium. Behaviourally, our data showed that only select 10-5M nucleosides and nucleobases provoked activity changes in juvenile rainbow trout, and both embryonic and adult zebrafish. To handle the high degree of individual variation observed in our embryonic behavioural studies, we created a threshold-based method that sorted individuals into one of twenty-four distinct stimulus-evoked phenotypes. To this end, we have explored whether the variable behavioural responses to different nucleobase compounds are dependent on the species, developmental stage, or nature of each fish.

OSMOREGULATION AND ACID-BASE BALANCE IN WHITE STURGEON DURING EXPOSURE TO ELEVATED SALINITY AND AQUATIC HYPERCARBIA

Shaughnessy, C.A., Baker, D.W., Brauner, C.J., Morgan, J.D., and Bystriansky, J.S.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 29
Contact: Ciaran A Shaughnessy **E-mail:** ciaran.a.shaughnessy@gmail.com
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Abstract: The gill epithelium is the primary site of both acid-base balance and ion regulation in fish; many transporters involved with acid-base compensation, too, require the movement of salinity-relevant ions. The present study examines the physiological effects of elevated dissolved CO₂ (an acid-base disturbance) on osmoregulation during salinity acclimation in the white sturgeon (*Acipenser transmontanus*). Blood pH (pHe), plasma [HCO₃⁻], [Na⁺], [Cl⁻], and osmolarity, white muscle water content, and gill Na/K⁺-ATPase (NKA) activity were examined over a 10-day hypercarbic seawater acclimation. Exposure to hypercarbia induced severe extracellular acidosis (from pH 7.65 to pH 7.2). Hypercarbic seawater-exposed sturgeon showed increases in plasma [ion] over those of normocarbic seawater controls, corresponding to even greater increases gill NKA activity. pHe recovery in the hypercarbic seawater-exposed sturgeon appeared to be negatively associated with osmotic recovery in this group. These findings suggest the mechanisms of osmoregulation and acid-base balance interact, and may be antagonistic in nature.

RAINBOW TROUT HEPATOCYTES: A MODEL FOR RESOLVING THE GROWTH-PROMOTING AND LIPID CATABOLIC ACTIONS OF GROWTH HORMONE

Sheridan, M.A.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 1

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Abstract: Growth hormone (GH) regulates two disparate metabolic processes: growth promotion (anabolic) and breakdown of stored lipid (catabolic). In trout hepatocytes, which are a principal site IGF-1 production and lipid storage, GH stimulated IGF-1 production in cells from fed fish but not in cells from 4-week fasted fish, whereas GH stimulated lipolysis in cells from fasted fish and not in cells from fed fish. During feeding, GH activates the JAK-STAT, PI3K-Akt, and ERK signaling systems, but during fasting GH activates the PLC/PKC and ERK pathways. Serum from fed fish rescued IGF-1 production in cells from fasted fish and serum from fasted fish induced lipolysis in cells from fed fish. Insulin, which is deficient in fasting fish, also can rescue IGF-1 production in cells from fasted fish concomitant with activation of JAK-STAT, PI3K-Akt, and ERK. These findings indicate that the response of GH results from the differential linkage of GH to signaling pathways and that nutritional state and INS abundance modulates GH-signal pathway-response linkage.

ELECTRICAL ACTIVATION AND REPOLARIZATION SEQUENCE IN THE RAINBOW TROUT HEART

Shiels, H., Bernus O., White E.

Symposium: Cardiovascular Function **Type:** Oral **Order:** 6

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Abstract: During the evolution of the vertebrate heart, the main modulator of cardiac output has shifted from stroke volume to heart rate. Fish such as rainbow trout vary stroke volume to a large extent to modulate cardiac output. This may impact mechanoelectric feedback of the heart. We investigated electrical activity of the isolated rainbow trout heart by optical mapping. Results show excitation progressing from the AV junction with a base to apex excitation profile. No transmural differences in ventricular action potential (i.e. between spongy and compact layers) were observed. Adrenaline increased ventricular action potential duration and resulted in electrical alternans at fast stimulation frequencies. Results will be discussed in relation to mechano-sensitivity of electrical activity in the fish heart.

TWO INSULIN-LIKE GROWTH FACTOR BINDING PROTEIN (IGFBP)-1 SUBTYPES AS NEGATIVE GROWTH INDICES IN SALMON

Shimizu, M., Kawaguchi, K., Fukuda, M., Kaneko, N., and Nakano, Y.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 10

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Abstract: Circulating insulin-like growth factor (IGF)-I is a positive growth index in several teleosts, but its availability for growth is regulated by IGF-binding proteins (IGFBPs). In salmon plasma/serum, two subtypes of IGFBP-1 have been identified. Since IGFBP-1a and -b levels are generally high under catabolic conditions such as fasting and stress, they are candidates of negative growth indices. The present study examined responses of IGFBP-1 subtypes and IGF-I to fasting and refeeding in masu salmon (*Oncorhynchus masou*) and correlated them with growth rate. Circulating protein and liver mRNA levels of IGFBP-1a and -1b were increased by fasting for 4-5 weeks and returned to the basal levels 2 weeks after refeeding. These parameters were negatively correlated with

individual growth rate, whereas IGF-I showed a positive relationship. These results suggest that two IGFBP-1 subtypes can be used as negative growth indices in salmon and may stabilize/improve the assessment of fish growth by IGF-I.

STABILITY OF SALMONID INCUBATION ENVIRONMENTS DURING WINTER IN SNOW-DOMINATED INTERIOR WATERSHEDS

Shrimpton, J.M., Williamson, C.J., McRae, C.J., Warren, K.D., and Zimmerman, J.T.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 1

Contact: Mark Shrimpton **E-mail:** shrimptm@unbc.ca

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Abstract: Locations where salmonids spawn in interior snow-dominated watersheds experience large changes in air and surface water conditions over winter. Intragravel environment has not been well characterized, but changes may be deleterious to larval development and survival. We measured physical characteristics of the intragravel habitat for bull trout and coho salmon redds in the fall when fish spawn and throughout the incubation period over winter. Significant changes in intragravel temperature were measured over time, but little difference was found between used and unused sites. Although used sites were generally colder than unused, the used sites experienced more stable temperatures than unused sites. Measures of intragravel permeability and water flow, however, did not change over the winter months for redds of both species, but did differ significantly between used and unused sites. Incubation conditions for used sites, therefore, exhibited more stable temperatures and intragravel flow than unused sites for both bull trout and coho salmon redds; both are likely to be important for maximizing survival of larval fish.

OSMOREGULATORY POTENTIAL OF THE CICHLID AUSTRALOHEROS FACETUS, AN INVASIVE SPECIES IN SOUTHERN PORTUGAL STREAMS

Silva, F.B.V., Saraiva, J.L., Canario, A.V.M., and Guerreiro, P.M.

Symposium: Fish Habitats **Type:** Poster **Order:** P111

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Abstract: The South American cichlid *Australoheros facetus* (chanchito) is invasive in streams of southern Portugal, where environmental conditions, very different from the species' native habitat, show broad seasonal variations in temperature, oxygen and hydrological regime, and flash floods that can displace fish assemblages downstream. It is however not clear whether chanchito can withstand the salinities of estuaries. We evaluated the physiological potential for intrusion in brackish waters by determining branchial and renal Na⁺/K⁺-ATPase activity, plasma electrolytes, osmolality and circulating cortisol. Fish (N≥6/group) were kept at 0 (control) or gradually acclimated to 5 or 15psu. No mortality or change in feeding was observed. Gill, but not kidney Na⁺/K⁺-ATPase activity, plasma osmolality and cortisol levels were significantly elevated in the highest salinity and all positively correlated, suggesting fish can live in brackish waters, allocating resources for osmoregulation. Studies on long-term adaptation, growth and reproduction are needed to assess whether chanchito could settle in new locations, bringing ecological implications on the native estuarine fauna.

PROSPECT OF ARCHERFISH RESEARCH: CHARTING THE DEVELOPMENT OF RESILIENCY IN CHANGING ENVIRONMENT

Simon, K.D., De, M., and Mazlan, A.G.

Symposium: Environmental Change **Type:** Oral **Order:** 11

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Abstract: The sympatric archerfishes *Toxotes chatareus* and *Toxotes jaculatrix*, along with all members of the family Toxotidae, spit water at targeted aerial insects as a means to acquire food. They inhabit mangrove estuaries, which are a critically important habitat as a breeding and nursery grounds for fishes as well as the full life cycle of species like archerfish. In the past five decades mangroves have been polluted through sewage outfall and their unfavourable smell and high density of mosquitoes has made them prime locations for land reclamation and throughout Southeast Asia most of this coastal waterline has been converted into a multistory residential areas, hotels or even commercial spots. It is interesting to note that, these sympatric species survive well in Malaysian mangrove estuaries. The generic nomenclature of this species has been described nearly 250 years ago. The earliest biological description on feeding reported that this species mostly consumed plant materials and insects. In Malaysian waters or perhaps throughout the other part of tropical estuaries, detail biological study related with the resiliency of this species is yet to be done. Our research for the past five years has focused on the understanding of the basic biology of archerfishes in hoping to explore the potentiality of resiliency development. The results have unveiled the fascinating ontogenetic diet shifting from insects and aquatic plants to carnivory feeding behaviour. Our findings also reported that archerfish has prolonged digestion and absorption time which may reflect the high degree of resiliency for living in limited food resource environment. The reproductive strategy of these amazing fishes representing that they are synchronous total spawners and their fecundity ranged from 20, 000 to 150, 000 eggs for each individual. Spawning occurs in both species between the months of November and December during rainy season. The calculated values of condition factors (one and above) revealed the wellbeingness of archerfishes in Malaysian estuaries. Our extensive information on the basic biology of two archerfish species will be useful in understanding the resiliency strategy of this fascinating fishes, their functional roles in sustaining their living in such a harsh estuarine environment.

CYP19 BASED SEX DETERMINATION IN SOME AQUACULTURE FISH SPECIES FOR MONOSEX PRODUCTION

Singh, Atul K.

Symposium: Reproductive Physiology **Type:** Oral **Order:** 11

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Abstract: In a large majority of teleost fish, genetic component in sex differentiation is not known to strongly demonstrate sex determining gene. Of the techniques available to mass-produce a sterile or monosex population, the hormonal induction of sex reversal is the most widely practiced. This paper presents the synthesis of works done on sex reversal using 17α methyltestosterone (17α MT), 17β estradiol, non-steroidal aromatase inhibitors (AIs) and oestrogen receptor agonist, tamoxifen in commercially important aquaculture species mossambique tilapia *Oreochromis mossambicus*, Nile tilapia *Oreochromis niloticus*, common carp *Cyprinus carpio*, mahseer *Tor putitora* and African catfish *Clarias gariepinus*. Results delineated a significant deviation in sex ratio leading to high level of masculinization in different aquaculture species with treatments of AIs. At the same time when aromatase level was determined we found elevated level of aromatase in females while depressed level in males suggesting that aromatase play important role in sex determination these fish species.

SPATIAL HETEROGENEITY AND ORGANIZATION OF FISH ASSEMBLAGES IN AMAZONIAN FLOODPLAIN LAKES

Siqueira-Souza, F.K., Freitas, C.E.C., Lawrence, H.E., Petrere Jr. Miguel

Symposium: Tropical Fish **Type:** Oral **Order:** 13

Contact: Flávia Kelly Siqueira de Souza **E-mail:** flaviasouza@ufam.edu.br
Federal University of Amazonas, Dept. Fisheries Sciences, Av. Gen. Rodrigo Otávio, 3000, 69077-000, Manaus-
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Abstract: Floodplain lakes of the Amazon River Basin contain some of the highest fish species diversity on earth. We sampled fish species in three types of floodplain lakes: coastal, mainland, and island, with gillnets during the flooding and receding seasons in 2011, from different habitats: macrophyte banks, open water and flooded forest. We Collected 167 species and 18,783 individuals, and measured species diversity. Cluster analysis, ANOVA, and ANOSIM revealed differences among lake types and habitats within lakes, but did not reveal marked differences in the species composition for scales: season, lake type, and habitat type. Species richness was similar for all three lakes and between hydrologic seasons, but each lake had a substantial number of unique species. We discuss features of biology and hydrology that may explain some of these effects, and conclude that in order to adequately represent fish diversity in Amazonian floodplain lakes all three scales must be included in the sampling program.

FORCED SWIMMING IN RAINBOW TROUT DOES NOT CONFER A BIOENERGETIC ADVANTAGE BUT REDUCES THE
FRACTION OF PROTEIN OXIDIZED TO FUEL METABOLISM

Skov, P.V., Lund, I., and Pargana, A.M.

Symposium: Swimming Physiology **Type:** Oral **Order:** 6

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Abstract: The effects of moderate exercise on the bioenergetics of rainbow trout was assessed during a 15 week growth experiment, in which fish were reared at three different current speeds: 1 BL s⁻¹, 0.5 BL s⁻¹ and still water (≈ 0 BL s⁻¹) using a restricted feeding regime. Specific growth rates (SGR) and feed conversion ratios (FCR) were calculated every three weeks. Tank based routine metabolic rates (RMR) were measured hourly, while measurements of total ammonia nitrogen (TAN) excretion at 3 hour intervals were used to calculate nitrogen quotients (NQ). Following the growth experiment, individual respirometry was used to determine standard metabolic rate (SMR). Energetic budgets revealed higher energy expenditure with increasing current speed, resulting in slower growth. The group exposed to 1 BL s⁻¹ current speed had significantly higher RMR, lower SGR and FCR than the other groups. The results show that, under the tested circumstances, water current negatively affects growth despite seemingly inducing a decrease in SMR. Most likely, a limited dietary energy supply was insufficient for covering additional costs of swimming while supporting enhanced growth.

EFFECT OF FOOD DEPRIVATION AND REFEEDING ON VASOTOCIN AND ISTOCIN RECEPTOR GENES EXPRESSION IN
THE GILTHEAD SEA BREAM

Skrzynska A.K., Martos-Sitcha J.A., Martínez-Rodríguez G., Mancera J.M.

Symposium: Stress in Fish **Type:** Poster **Order:** P132

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Abstract: The present study describes the influence of the starvation and re-feeding processes on the vasotocinergic and isotocinergic systems in *Sparus aurata*. mRNA expression levels for vasotocin (AVT) and isotocin (IT) receptor genes were assessed in a time-course response study in immature gilthead sea bream (*Sparus aurata*) maintained under food deprivation during 14 days as well as after one week of re-feeding. Changes in plasma cortisol and metabolites levels, as well as hepatosomatic index, indicate a clear stress situation and metabolic mobilization in fasted and re-fed specimens. At hypothalamic level, mRNA expression of both AVTR V1a2-type and V2-type

peaked in the first 7 days in those specimens exposed to starving, decreasing onwards till the end of the experiment. In liver, AVTR V1a2-type expression levels were similar between re-feeding and food-deprived groups. Metabolic indicators assessed shown that sea breams maintained under re-feeding conditions recovery its values near to those found in the control group. Our results suggest a clear interaction between stress and vasotocinergic/isotocinergic systems during the early phase of adaptation to food deprivation and re-feeding process

INTEGRATING INDIVIDUAL BEHAVIOR AND PHYSIOLOGY TO EXPLAIN ALTERNATIVE LIFE HISTORIES IN PARTIALLY
MIGRATORY STEELHEAD AND RAINBOW TROUT

Sloat, M.R., and Reeves, G.H.

Symposium: Environmental Change **Type:** Oral **Order:** 17

Contact: Matthew R Sloat **E-mail:** matthew.sloat@oregonstate.edu

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Abstract: Steelhead and rainbow trout are common names for marine-migratory (anadromous) and freshwater-resident forms of *Oncorhynchus mykiss*, a partially migratory salmonid fish. Expression of these alternative life histories is a plastic response to individual patterns of energy acquisition, assimilation, and allocation during juvenile life stages. In a series of experiments in laboratory streams, we determined the influence of individual variation in energy metabolism on behavior, growth, and life-history expression in *O. mykiss*. Standard metabolic rate (SMR) was a strong predictor of agonistic behavior, dominance, and feeding territory acquisition by juvenile fish during the transition from dependence on maternal provisioning of egg-yolk reserves to independent feeding. Subsequent rearing experiments determined that individuals with higher SMR had a higher probability of expressing anadromy and a lower probability of maturing as freshwater residents. In addition to SMR, we observed a significant influence of sex, rearing temperature, and individual growth trajectories on life histories. Partially migratory populations of *O. mykiss* maintain an exceptionally diverse portfolio of life-history strategies. Results from this work lend insight into a suite of behavioral and physiological processes influencing individual life histories.

THE ROLE OF DEVELOPMENTAL ENVIRONMENT IN SHAPING BEHAVIOUR AND PHYSIOLOGY

Sloman, K.A.

Symposium: Environmental Change **Type:** Oral **Order:** 12

Contact: Kath Sloman **E-mail:** katherine.sloman@uws.ac.uk

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Abstract: Abiotic changes in developmental environment are well known to affect the physiology and behaviour of individuals but the role of the biotic environment, such as social interaction and maternal stress, is less researched. Here I will discuss the effects of both the social environment experienced during development and maternal stress in shaping behaviour and physiology in a variety of fish species. In particular, I will focus on how changes in the developmental environment shape future behaviours such as aggression, exploration and anxiety. Understanding the influence of such factors on behaviour and physiology is vitally important if we are to predict the effects of changes to the developmental environment.

CHARACTERIZATION OF SCAPHIRHYNCHUS STURGEON INSULIN-LIKE GROWTH FACTORS

Small, B.C., and Fenn, C.M.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 11

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Abstract: It is hypothesized that growth hormone (GH) mediates the anabolic actions of insulin-like growth factor (IGF)-I and -II in sturgeon. Using Shovelnose Sturgeon *Scaphirhynchus platorhynchus*, the objectives of this research were to identify the acute and chronic effects of exogenous recombinant bovine GH (rbGH) on IGF-I and -II gene expression and whole animal growth and nutrient partitioning. In the first experiment, fish were injected with one of five rbGH concentrations (0, 30, 60, 120, 240 µg/g BW) and sampled at five time points (6, 12, 24, 36, 48-h). Hepatic IGF-I expression was higher than muscle expression. IGF-II was not expressed in muscle. rbGH significantly increased IGF expression in both tissues by 48 hours post injection. In the second experiment, bi-weekly rbGH administration for 6 weeks resulted in increased length and weight gain and whole body protein concentration. This research provides further insight in to the regulation and evolution of the vertebrate somatotrophic axis.

DEVELOPING FRESHWATER NUTRITION IN TRIPLOID ATLANTIC SALMON AND THE IMPACT OF DIETARY PHOSPHOROUS

Smedley, M.A., Taylor, J.T., Clarkson, M., Bozolla, P., McStay, E., Leeming, D., Campbell, P., Migaud, H.

Symposium: Fish Culture **Type:** Oral **Order:** 4

Contact: Herve Migaud **E-mail:** herve.migaud@stir.ac.uk

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Abstract: In order for triploid Atlantic salmon to commercially implemented, adequate nutrition needs to be defined to support faster growth potential and mitigate the higher occurrence of skeletal malformations. We fed both diploid and triploid salmon three levels of dietary phosphorous from known standard to boosted levels throughout the entire freshwater lifecycle. Samples were taken for whole body and bone properties including x-ray, vertebral strength, mineral composition, flesh quality analysis and gene expression. We found that where triploids performed better with higher levels of dietary phosphorous growth was comparatively impeded in diploids suggesting a higher dietary need in triploids. Additionally occurrence and severity of skeletal malformations in triploids was successfully mitigated in the groups fed higher levels of dietary phosphorous to diploids fed a standard feed level. This research is an important step forward in triploid nutrition development, which will be key in its industrial success.

CHRONOTROPIC NEUROCARDIOLOGY OF THE ZEBRAFISH

Smith, F.M., Stoyek, M.R., and Croll, R.P.

Symposium: Cardiovascular Function **Type:** Poster **Order:** P80

Contact: Frank M Smith **E-mail:** fsmith@dal.ca

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Abstract: The intracardiac nervous system (ICNS) is the final common pathway for neural control of vertebrate cardiac function, but the local circuitry controlling any specific function has not been established. We have investigated the neuroanatomy and physiology of pacemaker control by the ICNS in the heart of adult zebrafish, a representative teleost. A mean of 197±23 (SE; n=8) neuronal somata was found within the heart, predominantly in a plexus surrounding the sinoatrial valves. Putative pacemaker cells were identified in the bases of these valves using antibodies against HCN4 channel protein and by intracellular recording. Intrinsic plexus neurons expressing choline acetyltransferase, nitric oxide synthetase and vasoactive intestinal polypeptide innervated pacemaker cells. Extrinsic axons targeting these cells expressed tyrosine hydroxylase. Electrical stimulation of cardiac vagosympathetic nerves evoked frequency-dependent bradycardia followed by tachycardia. Parasympathetic blockade (atropine) prevented bradycardia while sympathetic blockade (timolol) prevented tachycardia. These results clarify the intracardiac neural substrate for chronotropic control.

NUTRIENT SENSING IN FISH: INVOLVEMENT IN THE REGULATION OF FOOD INTAKE AND ENERGY METABOLISM
Soengas, J.L.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 8

Contact: Jose L. Soengas **E-mail:** jsoengas@uvigo.es

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Abstract: Nutrient sensing mechanisms have been characterized in fish in recent years. Glucosensing capacity is present in central (hypothalamus and hindbrain) and peripheral (liver, Brockmann bodies and intestine) tissues of rainbow trout whereas fatty acid (FA) sensors seem to be present in hypothalamus, liver and BB in the same species. Central gluco- and FA-sensing capacity seems to be related to food intake regulation through changes in the expression of anorexigenic and orexigenic neuropeptides. Nutrient sensing in BB appears to be direct and related to hormone release. In liver nutrient sensing is related to metabolic homeostasis, and in some cases (FA) can be the consequence of previous hypothalamic sensing. A picture of the main results obtained to date in these studies, as well as perspectives for future research in the field will be provided.

LOW SALINITY ENVIRONMENT ENHANCES THE ABILITY OF INTESTINAL AMINO ACID ABSORPTION IN MOZAMBIQUE
TILAPIA

Soma, S., Kaneko, T., Watanabe, S.

Symposium: Growth and Metabolism **Type:** Poster **Order:** P73

Contact: Satoshi Soma **E-mail:** soma@marine.fs.a.u-tokyo.ac.jp

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Abstract: Elucidation of intestinal amino acid absorption is important for better understanding of fish growth. To clarify the precise mechanism, we focused on 10 amino acid transporters (ATs) in Mozambique tilapia. Quantitative PCR analysis showed that most ATs were highly expressed in the anterior intestine, and in situ hybridization clarified specific expression of most ATs in the intestinal epithelial cells. These results suggest that amino acid absorption occurs mainly in the anterior intestine through ATs. Furthermore, the expression levels of ATs in the anterior intestine were generally higher in freshwater-adapted fishes than in seawater-adapted ones. An intestinal sac experiment showed that amino acid absorption was suppressed under luminal low Na⁺ condition. Taken together, amino acid absorbing ability in the anterior intestine is stimulated in freshwater by up-regulation of ATs to compensate for inefficient absorption in low Na⁺ condition.

COMBINED EFFECT OF TEMPERATURE AND STARVATION ON THE APOPTOTIC PATHWAY AND ANTIOXIDANT
DEFENSE OF MEAGRE

Soumavevris, A., Feidantsis, K., Chatzifotis, S., and Antonopoulou, E.

Symposium: Stress in Fish **Type:** Oral **Order:** 23

Contact: Alexandros Soumavevris **E-mail:** alexsoumavevris@hotmail.com

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Abstract: In natural habitats or under aquaculture conditions fish undergo temperature shifts and starvation events that may challenge the overall organism homeostasis. In this study we investigated the apoptotic pathways and the antioxidant defense of meagre (which at the initial sampling had an average body weight of 138g and a 20% weight

loss was observed at the end of the experimental trial) under the effect of simultaneous temperature increase (17, 20, 23 and 26°C) and food restriction for 3 months. Bcl-2, Bax and ubiquitin conjugates levels, as well as activity levels of superoxide dismutase, catalase and glutathione reductase were examined in the liver and muscle of meagre. These molecular markers showed elevated levels indicating cellular stress response under the concomitant effect of food restriction and temperature, especially above 23°C, probably due to reactive oxygen species generation. Food deprivation as well as temperature increase can lead to oxidative stress caused by hypoxia.

DETERMINATION OF DIFFERENTIAL METAL AND METALLOIDS ACCUMULATION IN GILL, KIDNEY, HEPATOPANCREAS AND MUSCLE AND BIOMARKERS RESPONSE IN CENTROPOMUS PARALLELUS IN NEOTROPICAL ESTUARIES
Souza, I.C., Morozesk, M., Sakuragui, M., Tavares, D., Monferrán, M.V., Wunderlin, D.A., Fernandes, M.N.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 21

Contact: Iara da Costa Souza **E-mail:** iara.csoza@gmail.com

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Abstract: We report levels of metals and metalloids (B, Al, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Ag, Cd, Hg and Pb) in muscle, hepatopancreas, kidney and gill tissues as well as their influence in biochemical biomarkers of exposure and effect in the native fish *Centropomus parallelus* from two neotropical estuaries affected by different anthropogenic factors. Metal analysis was performed with inductively-coupled plasma-optic emission spectroscopy (ICP-OES). Biomarkers measured were catalase, superoxide dismutase, glutathione-S-transferase, reduced glutathione, Na⁺/K⁺-ATPase, H⁺-ATPase, metallothionein, acetylcholinesterase, lipid hydroperoxides and oxidatively modified proteins. Multivariate statistics were used to indicate both spatial and temporal changes in metal composition of fish tissues and correlate with health status of inhabitant fish, showing the biggest levels of metal accumulation on gills and expressive biochemical alterations in Vitória Bay by reduced glutathione, Na⁺/K⁺-ATPase, H⁺-ATPase, metallothionein, acetylcholinesterase, lipid hydroperoxides and oxidatively modified proteins. Financial support: IINCT-TA and CNPq.

UPDATE ON THE DISCOVERY OF LAMPREY GONADOTROPIN(S) AND THEIR RECEPTORS

Sower, S.A., Kosugi, T., Decatur, W.A., Gargan, J., Freamat, M., Ul-Hasan, S., Hausken, K., Wilmot, M., Marquis, T., Hall, J.A., Nozaki, M., Hollander, L., Shpilman, M., and Levavi-Sivan, B.

Symposium: Lampreys **Type:** Oral **Order:** 2

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Abstract: Glycoprotein hormones, follicle-stimulating hormone (FSH), luteinizing hormone (LH), and thyroid-stimulating hormone (TSH) consist of the common α subunit (GpA1) and unique β subunits (GpB1, 2, 3) while thyrostimulin consists of GpA2 and GpB5. Here we report the identification and characterization of a functional novel glycoprotein lamprey hormone, GpH, that consists of IGpA2 and GpH β in the sea lamprey *Petromyzon marinus*. LGpA2 and GpH β were shown to form a heterodimer and were expressed in the pituitary using immunohistochemistry and in situ hybridization. A recombinant lamprey GpH activated the lamprey glycoprotein hormone receptor-1 as measured by increased cAMP/luciferase activity. These data are the first to demonstrate a functional unique glycoprotein heterodimer that is not found in any other vertebrate. In lampreys, an extant Agnathan, the organization of the HPG axis is similar with gnathostomes in its most fundamental features but with a simplified structure, overlapping with the pituitary-thyroid axis and involving a single glycoprotein hormone interacting with potentially two receptors.

ACUTE AND CHRONIC ADJUSTMENTS OF INTRINSIC TISSUE METABOLIC RATE PLAY IMPORTANT ROLES IN THE INITIATION AND MAINTENANCE OF WINTER DORMANCY IN THE TEMPERATE WRASSE

Speers-Roesch, B., and Driedzic, W.R.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 5

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Abstract: In order to survive winter, many temperate fishes enter a dormant state characterized by inactivity, low metabolic rate, and non-feeding. The physiological mechanisms underlying winter dormancy remain poorly understood, including the level of biological organization at which it is initiated and maintained and whether an active metabolic rate depression is involved. To address this knowledge gap, we are studying cunner (*Tautoglabrus adspersus*), which at low temperatures show a rapid, large depression of whole-animal metabolic rate. To ascertain the potential involvement of intrinsic tissue metabolic rate depression as well as its time scale and tissue-specificity, we measured the in vitro thermal sensitivity of metabolic rate of heart, gill, liver, and intestine slices from active (9°C) and 4- and 10-week dormant (1°C) cunner. We found two distinct, time-dependent tissue metabolic rate responses: an acute, cold-induced decrease in metabolic rate that exceeded expected Q₁₀ effects in liver, heart and gill; and a chronic, gradual decrease of metabolic rate in gill and intestine that may reflect a response to fasting rather than low temperature per se. Together, these acute and chronic adjustments of intrinsic tissue metabolic rate could account for as much as 70% of the whole-animal metabolic rate depression during dormancy.

INTEGRATING METABOLIC BIOCHEMISTRY AND FEEDING ECOLOGY: THE RELATIONSHIP BETWEEN DIETARY PREFERENCE AND GLUCOSE METABOLISM AMONG SERRASALMID FISHES (PIRANHAS AND PACUS)

Speers-Roesch, B., Val, A.L., Val, V.M.F., and Driedzic, W.R.

Symposium: Tropical Fish **Type:** Oral **Order:** 7

Contact: Ben Speers-Roesch **E-mail:** bspeersr@gmail.com

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Abstract: The piranhas and pacus (Serrasalminidae) are a large family of neotropical freshwater fishes with diverse dietary preferences, from the herbivorous or frugivorous pacus to the omnivorous or carnivorous piranhas. This group presents a good comparative model to explore the biochemical correlates of dietary preference. For example, debate exists about the importance in fishes of glucose metabolism and specifically de novo glucose synthesis (gluconeogenesis), including the effects of diet. We hypothesized that carnivory in piranhas would be associated with an enhanced gluconeogenic capacity compared with the herbivorous pacu, because of lower dietary glucose intake in the former group. We measured activities of key enzymes of gluconeogenesis, the opposing reactions of glycolysis, and aerobic metabolism in liver (a major site of gluconeogenesis) and heart (a site of glucose use) of two *Serrasalmus* piranha species and three pacu species (*Metynnis* and *Myleus* spp.). We found little support for our hypothesis. However, our analyses suggest that the gluconeogenic pathway in serrasalmids may be important for supplying substrates for glycogen synthesis in carnivores or lipid synthesis in herbivores. (NSERC Discovery; INPA; INCT ADAPTA-CNPQ/FAPEAM).

KJELL B. DØVING (1936-2014): HIS LIFE AND SCIENTIFIC CONTRIBUTIONS

Stabell, O.B.

Symposium: Sensing the Environment **Type:** Oral **Order:** 1

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Abstract: Professor Kjell B. Døving died on February 7th, ending the era of an enthusiastic contributor to fish science. This memory talk gives an overview of his academic life, with particular focus on olfactory research, and on KBD as a creator of an encouraging social milieu for recruits in the field. The functional properties of the olfactory system in fish represented the starting point and final focus for KBD as a scientist. As a student he used burbot as a model system, partly because of their long and distinct subdivided olfactory tracts. The results obtained later led to a major discovery on the expression of olfactory controlled behaviour. During recent years, he used crucian carp to further explore that field. Olfactory controlled fish migration was another field of interest. The discovery of bile salts as highly potent odorants, and their potential use as pheromones in salmonid homing, will forever be associated with his name.

POLYCHLORINATED BIPHENYL HOMOLOG DISTRIBUTIONS IN BURBOT FROM GREAT SLAVE LAKE AND LAKE ERIE
Stapanian, M.A., Madenjian, C.P., Cott, P.A., Rediske, R.R., and O'Keefe, J.P.

Symposium: Burbot **Type:** Oral **Order:** 7
Contact: Martin A. Stapanian **E-mail:** mstapanian@usgs.gov
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Abstract: The proportion of total polychlorinated biphenyls (PCBs) for 12 homologs found in whole-body samples of burbot (*Lota lota*) from Great Slave Lake were compared with those from burbot from Lake Erie. Total PCB concentrations in Great Slave Lake burbot were about 60 times lower than concentrations in Lake Erie burbot. Burbot captured in Great Slave Lake generally contained a higher proportion of the lower-chlorinated (2-4 chlorines) homologs than did burbot captured in Lake Erie, and the reverse occurred for the more highly chlorinated (7-9 chlorines) homologs. Hexachloro congeners dominated the proportions of total PCB in burbot from both lakes, and this proportion was higher in burbot from Great Slave Lake. Proportions were higher in Lake Erie for pentachloro congeners, which was the second most abundant homolog in both lakes. Our results generally supported a prediction of greater proportions of lower-chlorinated PCB congeners in organisms in remote areas. However, the geographic trends in homolog distribution identified in previous studies may actually be more complex.

INVESTIGATION INTO GENETIC VARIABILITY OF PARASITIC AND NON-PARASITIC LAMPREYS INHABITING RIVERS IN LITHUANIA

Staponkus, R., Butkauskas, D., Kesminas, V., Sruoga, A.

Symposium: Lampreys **Type:** Poster **Order:** P97
Contact: Robertas Staponkus **E-mail:** robertas.staponkus@gmail.com
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Abstract: Phylogenetic analysis of river lamprey *Lampetra fluviatilis* and brook lamprey *Lampetra planeri* collected in 9 locations in Lithuania was estimated using the mtDNA control region I. Overall 21 haplotypes unequally distributed among 5 drainages were identified based on established data set consisting of 63 sequences. Phylogenetic analysis revealed one highly differentiated lineage that was clearly separated from the majority of closely related specimens. This lineage consisted of two haplotypes shared by few individuals from two drainages corresponding to the same region. It showed genetic divergence of $5.7\% \pm 1.9\%$ ($\pm SE$) ($p < 0.01$) from the rest D-loop sequences belonging to *L. fluviatilis* and *L. planeri* individuals and expressed a greater similarity with Ukrainian lamprey *Eudontomyzon mariae* than *Lampetra* genus. It could be guessed that a part of the non-parasitic lamprey population inhabiting western North Lithuania rivers harbours forms of mtDNA considered as belonging to an undescribed species sharing common ancestry with *E. mariae*.

KINETICS OF THE HEAT SHOCK RESPONSE IN LAKE WHITEFISH
Stefanovic, D.S., Boreham, D.R., Somers, C.M., Wilson, J.Y., and Manzon, R.G.

Symposium: Stress in Fish **Type:** Oral **Order:** 8
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Abstract: Lake Whitefish (LWF) is a cold water species that spawn in late fall such that embryos develop ~4C. Here we investigated thermal stress by characterizing the kinetics of the heat shock response (HSR) throughout LWF development. We show that Hsp70 mRNA levels are elevated following an 11C heat shock (HS), but not 5C or 8C HS, suggesting embryos are resistant to thermal stress. Moreover, no increase in other inducible Hsps (Hsp90 alpha and Hsp47) was observed following any HS. Once triggered the HSR was long lasting with Hsp70 mRNA levels remaining elevated 8 hours post-HS. Juvenile LWF show increases in all inducible Hsps at temperatures that were 6C and 9C above seasonal temperature (14C). Constitutive Hsps (Hsp90 beta and Hsc70) mRNA levels were relatively stable in all HSR experiments. These data will help better understand the impact of thermal shifts associated with changing environments and industrial thermal pollution on this and other cold water fishes.

THE PASSIVE AND FACILITATED TRANSPORT OF PHARMACEUTICALS BY A PRIMARY FISH GILL CELLS CULTURE MODEL

Stott, L.C., Schnell, S., Hogstrand, C., Owen, S.F. & Bury, N.R.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 5
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Abstract: Large numbers of freshwater fish are used in regulatory bioconcentration factor (BCF) tests to assess the bioconcentrative properties of xenobiotics such as pharmaceuticals. The gills of fish are the principle site of xenobiotic uptake. The current study aims to validate the use of an in vitro rainbow trout primary gill cell system in order to replace, refine and reduce the numbers of fish used in regulatory testing. Primary gill cells are cultured on permeable supports in a two-compartment model that can tolerate apical freshwater, thus mimicking the intact water-gill interface. The in vitro transport of seven pharmaceuticals across the gill revealed that for some, facilitated transport plays a key role especially at low, environmentally relevant concentrations. This transport may be via specific SLC and ABC proteins and we provide evidence of 'first pass' metabolism at the gill via certain CYP enzymes. Our data correlate with predictive models and in vivo values and may be used in BCF model calculations, thereby demonstrating the applicability of this system as a tool to assess the physiological effect of pharmaceuticals in fish.

TRACKING SEASONAL CHANGES IN CENTRAL GENE EXPRESSION OF APPETITE REGULATORS IN ANADROMOUS ARCTIC CHARR

Striberny, A., Jobling, M., Ravuri, C.S., Jørgensen E.H.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 13
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Abstract: The life of anadromous Arctic charr is characterized by anorexia and emaciation during overwintering in fresh water and gluttonous feeding when resident in seawater during a few weeks in summer. The maintenance of these habits in captivity, when supplied continually with food, indicates existence of endogenous regulation of food

intake. Gene expression data of 12 appetite regulators are presented for the hypothalamus, mesencephalon and telencephalon of voluntarily anorexic charr sampled in May and January, and hyperphagic charr sampled in July. The expression of anorexic Leptin A1, Leptin receptor, and Melanocortin receptor - 4 was higher in the hypothalamus of hyperphagic charr than in anorexic charr, whereas the expression pattern was reversed in the mesencephalon and telencephalon. When hyperphagic charr were subjected to feed deprivation for one week during summer no effects on hypothalamic gene expression of appetite regulators were detected.

HOW DO XENOBIOTICA BIOTRANSFORMATION RATES IN ANTARCTIC NOTOTHENIOID FISH COMPARE TO
TEMPERATE SPECIES?

Strobel, A., Holm, P., Segner, H.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 15

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Abstract: Chemical contamination of the Antarctic environment, in particular by halogenated aromatic hydrocarbons (HAHs), is increasing, and Antarctic fishes accumulate the xenobiotics. The physiology of Antarctic notothenioid fish departs in many aspects from temperate fish. Due to their physiological adaptation and constraints, we hypothesize that Antarctic notothenioids possess limited biotransformation capacities to cope with rising contaminant levels. In order to determine the potential toxicity of HAHs for Antarctic fish, we analyzed species differing in trophic position and physiology (red-blooded: *Notothenia rossii*, *Gobionotothen gibberifrons*, white-blooded: *Chaenocephalus aceratus* & *Champscephalus gunnari*), and compared them to trout (*Oncorhynchus mykiss*). We measured activities of biotransformation enzymes (e.g. EROD, GST) from 0 to 12°C, as well as actual rates of xenobiotic metabolism in vitro in liver S9 fractions. Our data revealed that the enzymatic biotransformation capacities of Antarctic fish are only half as efficient as our model temperate fish. Furthermore, the metabolic biotransformation rates of contaminants are highest in trout and lowest in ice fish. Thus, the findings of our study suggest that the evolutionary adaptation of Antarctic fish makes them more susceptible to the effects of anthropogenic pollution than temperate fish, with the hemoglobinless icefish being the most vulnerable species.

SWIMMING DEPTH OF ATLANTIC SALMON DURING SEA MIGRATION

Sturlaugsson, J.

Symposium: FITFISH **Type:** Oral **Order:** 5

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Abstract: This study obtained in 2005 the first continuous data series on swimming depth of Atlantic salmon kelts and smolts for the whole sea migration and in addition data on corresponding water temperature. Information on same parameters were sampled again in 2006 for salmon kelts, but then salinity was also measured giving the first profile of that kind for Atlantic salmon roundtrip in sea. The data on the swimming depth of the salmon and the environmental parameters measured were collected by use of data storage tags. The swimming depth during the round trip of the salmon from the estuary to the feeding grounds in the oceanic areas and back into the estuary again is revealed in relation to the migration phases and the observed environmental parameters. The Atlantic salmon is highly pelagic during the sea migration but show significant diurnal vertical migration.

NUTRIENT ABSORPTION IN THE ATLANTIC SALMON INTESTINE IS AFFECTED BY ENVIRONMENTAL SALINITY

Sundh, H., Nilsen, T.O., Jönsson, E., Stefansson, S.O. and Sundell, K.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 20
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Abstract: Na⁺/K⁺-ATPases (NKA) located in the basolateral membrane of the intestinal absorptive cells (enterocytes) are the main driving force for both ion-coupled intestinal fluid transport and nutrient absorption in Atlantic salmon in seawater. It is hypothesized that a decreased need for osmoregulation in brackish water may be beneficial for the nutrient uptake and thereby the growth of the fish. Atlantic salmon post-smolts were acclimated to freshwater (FW), 12, 22 and 34 ppt seawater (SW) for several months. The intestinal nutrient transport (L-lysine and D-glucose) was measured in Ussing chambers and separate fish were used for intestinal mRNA expression of selected ion and nutrient transporters. No differences were found in mRNA levels of the NKA- α 1c, NKCC2 co-transporter or SGLT-1 in relation to salinity, whereas the specific high-affinity low capacity Na⁺-coupled nutrient transport was significantly higher in FW and 22 ppt as compared to the 34 ppt group. The results suggest an allocation of the electrochemical gradient towards ion driven fluid transport in full strength SW.

USE OF CARBON DIOXIDE AS A NON-PHYSICAL BARRIER TO FISH MOVEMENT
Suski, C. D., Dennis, C. E. III, Adhikari, S.

Symposium: Stress in Fish **Type:** Oral **Order:** 28
Contact: Cory Suski **E-mail:** suski@illinois.edu
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Abstract: Invasive Asian carp, one of the most abundant fishes in many rivers in the Midwestern United States, are currently contained within the Mississippi River basin by electrified barriers. Development of novel barriers would provide additional means to prevent Asian carp from spreading. In particular, barriers effective against small fish would be beneficial as electricity loses effectiveness with small fish. This presentation summarizes three studies that quantify the effectiveness of CO₂ to act as a non-physical barrier. Small fish were exposed to elevated CO₂ to define concentrations that cause avoidance, as well as stress-related gene expression. The capacity for physiological acclimation following extended exposure to CO₂ was also explored. Results demonstrate that 100-200 mg/L CO₂ will induce the upregulation of stress-related gene pathways, and cause small fish to avoid an area. Extended exposure to CO₂ will induce changes to physiology and performance. Together, CO₂ has potential as a barrier to prevent the spread of Asian carp.

WATERSHED-SCALE LAND USE ACTIVITIES INFLUENCE THE PHYSIOLOGICAL CONDITION OF STREAM FISH
Suski, C. D., King, G. D., Chapman, J. and Cooke, S. J.

Symposium: Fish Habitats **Type:** Oral **Order:** 2
Contact: Cory Suski **E-mail:** suski@illinois.edu
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Abstract: Human activities that alter land use, such as urbanization and increased agriculture can negatively impact habitat for fishes. Habitat choices have physiological consequences for fish, and sub-optimal habitats can lead to increased energy expenditure, chronic stress or increased energetic costs, that can cause negative outcomes for both individual fish, and fish populations. The use of sub-lethal physiological tools can provide novel insights into how both land use and habitat types impact individual fish. The objective of this study was to relate variation in land use at the watershed scale to the physiological properties of resident fishes. For this, we used both an extensive, as well as an intensive, approach, coupling field observations, standardized stress sampling, and physiological sampling across a range of land uses. Results demonstrate the value of natural areas in facilitating the physiological condition of resident fishes. Results are further discussed in the context of habitat restoration.

PHYSIOLOGICAL PERSPECTIVES OF FISH HABITATS

Suski, C.D., and Cooke, S.J.

Symposium: Fish Habitats **Type:** Oral **Order:** 1

Contact: Cory Suski **E-mail:** suski@illinois.edu

University of Illinois, NRES, 1102 S Goodwin Ave, Urbana, IL, 61801 USA

Abstract: This presentation will provide an overview and introduction to the symposium the influence of variation in habitat quality on the condition (physiology, health, energetics, fitness) of wild marine and freshwater fish. Huey's seminal paper (1991; Am Nat) on the physiological consequences of habitat selection stimulated much thought about how organismal condition was influenced by various aspects of the landscape. Fish, perhaps more than any other taxa, have been well studied in terms of habitat use and selection with much research on physiology and environmental relations in a laboratory context. Less common are efforts explore physiological and energetic consequences of habitat selection in the wild. Doing so would provide important linkages between organisms and their environment, which presumably underlie performance metrics such as fitness. Recent years have seen the development of several new concepts and ideas that explain how organisms use various habitats, and the consequences of doing so.

RECUPERATION OF ATLANTIC COD FOLLOWING EXHAUSTIVE EXERCISE IN A SWIM TUNNEL – HOW CAN KNOWLEDGE OF SWIMMING PHYSIOLOGY IMPROVE FLESH QUALITY?

Svalheim, R.A., Karlsson, A., Olsen, S.H., Johnsen, H.K., Aas-Hansen, Oe.

Symposium: Swimming Physiology **Type:** Oral **Order:** 5

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Abstract: During trawling operations, fish may swim to exhaustion before being captured. The aim of this study was to investigate role of exhaustive swimming on the physiology and flesh quality in Atlantic cod. A total of 95 cod (64 ± 6cm) were swum to exhaustion in a swim tunnel (1400L fish chamber), followed by recuperation for 0,2,4,6 or 10 hours, before being euthanized. Residual blood in fillets and development of rigor mortis were selected as quality parameters Fish killed immediately after swimming entered rigor mortis significantly faster than those that were allowed to recuperate. There were also higher levels of blood lactate and lower levels of blood glucose in this group, compared to the other groups. Residual blood in the muscles increased during the first 4 hours of recuperation and then declined during the next 6 hours. We conclude that swimming to exhaustion reduces flesh quality, but the negative effects can be prevented by allowing the fish to recuperate after capture.

AEROBIC AND ANAEROBIC METABOLISM IN FISH: GAIT USE, MODELING AND TRADE-OFF

Svendsen, J.C., Tirsgaard, B., and Steffensen, J.F

Symposium: Swimming Physiology **Type:** Oral **Order:** 4

Contact: Jon C. Svendsen **E-mail:** jos@aqu.dtu.dk

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Abstract: The influence of anaerobic metabolism remains poorly understood in fish energetics. Approaching prolonged swimming speeds, anaerobic metabolism may contribute significantly to the total metabolic cost of swimming (i.e. both aerobic and anaerobic metabolic costs). Using gilthead seabream (*Sparus aurata*), this study

tested three hypotheses: 1) gait transition from steady to unsteady swimming is associated with anaerobic metabolism evidenced as excess post exercise oxygen consumption (EPOC); 2) the hydrodynamics-based power function provides a better model for the total metabolic cost of swimming than the exponential function; and 3) there is a trade-off between the maximum sustained swimming speed (U_{sus} ; i.e. no contribution of anaerobic metabolism) and minimum cost of transport (COT_{min}). Using intermittent flow respirometry and video analysis, fish were exposed to increasing swimming speeds and consecutive measures of EPOC to examine aerobic and anaerobic contributions up to the critical swimming speed (U_{crit}). Data revealed that anaerobic metabolism may cover more than 50% of the total metabolic cost of swimming at speeds approaching U_{crit} . Results will be discussed.

MODERATE PASSAGE EFFICACY, MIGRATORY DELAY AND PHENOTYPIC SELECTIVITY ASSOCIATED WITH A NATURE-LIKE FISHWAY: HOW IMPORTANT IS FISH SWIMMING PERFORMANCE?

Svendsen, J.C., Wilson, J.M., and Aarestrup, K.

Symposium: FITFISH **Type:** Oral **Order:** 7

Contact: Jon C. Svendsen **E-mail:** jos@aqua.dtu.dk

Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Rua dos Bragas 289, 4050-123 Porto Portugal

Abstract: Effects of artificial barriers in riverine ecosystems can be mitigated using fishways that re-establish habitat connectivity, however, the efficacy of many installed fishways remains poorly documented. This is especially the case with the nature-like fishway, which is increasingly installed in streams and rivers to promote habitat connectivity. The objective of this study is to examine the efficacy of a nature-like fishway and test if the fishway causes migratory delay and is phenotypically selective. To this end, swim-through PIT antennas were installed downstream and upstream of a nature-like fishway and the migratory behaviour of mature brown trout (*Salmo trutta*) was mapped. The results revealed moderate passage efficacy and a short term migratory delay caused by the fishway. Moreover, the fishway was phenotypically selective as indicated by a positive correlation between fish length and the probability of passage. The costs of constructing fishways are discussed in relation to fish swimming performance and behaviour.

DEVELOPING SPECIES-SPECIFIC MARKERS IN TILAPIA BASED ON RESTRICTION ASSOCIATED DNA SEQUENCING (RAD-Seq) AND ADENOSINE DEAMINASE (ADA)

Syaifudin M., Taggart J.B., Bekaert M., Penman D.J., and McAndrew B.J.

Symposium: Physiological Genomics **Type:** Oral **Order:** 1

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Abstract: Identification of tilapia species, hybrids and introgressed populations is of importance in aquaculture and in wild populations where introductions have occurred. Many species are similar morphologically. Mitochondrial DNA markers can distinguish between species, but are of very limited use in analysing hybrids. We set out to identify species-diagnostic nuclear DNA markers (single nucleotide polymorphisms, SNP) using two approaches: (i) sequencing of the coding regions of the *ada* gene (which codes for an isozyme that has been used for species identification); and (ii) a next-generation sequencing technique (restriction-associated DNA sequencing, RAD-seq). The first approach was partially successful, generating SNP markers that distinguished some species pairs, while the second generated hundreds of SNPs with alleles unique to each species in the initial run. We are now extending the RAD-seq approach to more species and multiple populations, aiming to develop a robust and cost-effective technique.

A FUNCTIONAL SHIFT OF UREA-PRODUCING SITE FROM EXTRAEMBRYONIC YOLK SAC TO LIVER IN THE DEVELOPING EMBRYOS OF TWO OVIPAROUS CARTILAGINOUS FISHES

Takagi, W., Kajimura, M., Tanaka, H., Bell, J.D. and Hyodo, S.

Symposium: Elasmobranchs **Type:** Oral **Order:** 11

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Abstract: For adaptation to high-osmolality marine environment, cartilaginous fish retain a high systemic concentration of urea. Although the composition of embryonic body fluid was similar to that in adult fish, urea-producing organ has not been identified in developing embryo. Therefore, we investigated the mRNA expression profiles of ornithine urea cycle (OUC) enzymes in two oviparous species. The expression of OUC enzyme genes was detected in the embryonic body, and remarkably increased to hatching, presumably due to the liver growth. The mRNA expression was also found in extraembryonic yolk sac membrane (YSM). The mRNA level of rate-limiting carbamoyl phosphate synthetase III was much higher in the YSM than that in the embryonic body during early stages of development. Our results demonstrate that the YSM makes an important contribution to the ureosmotic strategy of oviparous embryos, and that a functional shift of urea-producing site from YSM to embryonic liver occurs during the development.

IMPROVEMENT OF INSULIN RESISTANCE BY PLANT MATERIALS IN FISH

Takase, K. and I. Kakuta

Symposium: Growth and Metabolism **Type:** Poster **Order:** P66

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Abstract: Although most fish are characterized by a limited efficiency to use carbohydrate, the exact mechanism of the poor utilization of carbohydrate by fish is still unclear. The purpose of this study was to determine the effects of several natural materials on insulin resistance in fish. Natural materials were administered orally to goldfish, rainbow trout and red sea bream. After 3 weeks, the rate of 2-deoxy-D-glucose (2DG) uptake in the trunk white muscle was measured. Moreover, it was in fixed quantity by a western blot method about on the activities of Akt, PI3 kinase, AMP kinase in muscle cells and the level of GLUT4 on the cell surface. Oral administration of a wild plant mineral mixture, red ginseng and inositol from rice bran ameliorated insulin resistance by enhancing glucose utilization in trunk muscle of these fish. This time we will report about the ameliorating mechanism in detail.

UNIQUE REGULATORY MECHANISMS FOR SULFATE SECRETION BY THE EEL KIDNEY

Takei, Y., and Watanabe, T.

Symposium: Cellular Signalling **Type:** Oral **Order:** 4

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Abstract: Eels are unique in sulfate regulation among teleosts as they maintain plasma sulfate concentration 6 folds higher in sulfate-deficient FW than in sulfate-excess SW. This is achieved by drastic changes in renal sulfate regulation; from active absorption by apical Slc13a1 and basolateral Slc26a1 to active secretion by apical Slc26a6s and basolateral Slc26a1 within a few days after SW transfer. Three Slc26a6 subtypes are localized in different segments of renal proximal tubule of SW eels. The switching of absorptive Slc13a1 to secretory Slc26a6s after SW transfer is triggered by environmental Cl⁻, not SO₄²⁻, but a small amount of Na⁺ is also necessary. As an inhibitor

of Na⁺-Cl⁻ cotransporter (NCC) in environmental SW blocked the switching and intra-arterial injection of choline-Cl, not Na-gluconate, induced switching, environmental Cl⁻ ions were taken up by the gill NCC upon encountering SW and signal proximal tubular cells to switch the SO4²⁻ transporters to secretory types.

DEVELOPMENTAL SOCIAL EXPERIENCE OF PARENTS AFFECTS BEHAVIOUR OF OFFSPRING IN ZEBRAFISH
Tamilselvan, P., and Sloman, K.

Symposium: Stress in Fish **Type:** Oral **Order:** 16
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Abstract: Early life experiences are important in explaining individual differences in behaviour. In social animals, the developmental social environment can mediate behaviour later in life. It was hypothesised that zebrafish raised in social isolation would display differences in behaviour later in life and any alterations in behaviour might be passed to subsequent offspring. Individuals were raised in three diverse social environments: social isolation, groups of 30 and of 100. Fish were tested for anxiety, activity and aggression. Fish raised in isolation and groups of 30 were more anxious than fish raised in groups of 100. Fish raised in isolation were less aggressive than fish raised in groups of 30 and 100. Offspring of isolated fish were found to be less aggressive than offspring from social groups. Thus, the present study shows that the social environment experienced by zebrafish affects their behaviour, an effect which is also passed on to their offspring

STRESS AND DISEASE SUSCEPTIBILITY OF WILD ADULT PACIFIC SALMON
Teffer, A.K., Miller, K.M., Jeffries, K.M., Patterson, D.A., Farrell, A.P., Cooke, S.J., Juanes, F., Hinch, S.G.

Symposium: Stress in Fish **Type:** Oral **Order:** 22
Contact: Amy Teffer **E-mail:** ateffe@uvic.ca
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Abstract: There are inherent challenges to understanding disease processes in wild fish populations, accounting for multiple environmental stressors and complex life histories, such as that of Pacific salmon (*Oncorhynchus* spp.). Declining Pacific salmon productivity has coincided with rising river temperatures and fishing pressure during spawning migration with increasing instances of en route mortality. Novel tools are needed to quantify the role of stressors in infectious disease development, potentially accelerating proliferation of microbes and decreasing host resiliency. Laboratory holding studies using wild-caught adult salmon were conducted to apply controlled high temperature and fisheries capture stress, with repeated non-lethal biopsy sampling throughout the migration period. High-throughput qPCR was used to simultaneously quantify relative loads of up to 45 microbes associated with salmon disease and the relative expression of host immune- and stress-related genes. This approach has produced a trajectory of disease-associated processes of wild adult salmon and the modulatory role of relevant stressors.

EFFECTS OF CORTISOL INPLANTS ON INNATE IMMUNE GENES AND CORTICOSTEROID RECEPTOR GENES IN RAINBOW TROUT
Teles, M., Fierro-Castro, C., Tridico, R., Cortes, R., Tort, L.

Symposium: Stress in Fish **Type:** Oral **Order:** 4
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Abstract: In the present work we injected rainbow trout with slow-release cortisol implants emulating acute and chronic stress. The mRNA levels of liver lysozyme and complement, C3, factor H and factor B and the transcriptional levels of the CRs in several organs of trout after 10 days of cortisol implantation were measured. The results revealed a latter down-regulatory effect of cortisol on the activity of both ACH50 and lysozyme, in agreement with previous findings in stressed fish. In the liver, the mRNA levels of lysozyme, factor B and factor H significantly decreased in the recovery period. These changes in mRNA abundances correlate with plasma data, since both lysozyme and complement activities decreased. Overall, the results support the relevant role of cortisol in modulating key components of the innate immune response, and the expression of their related genes. We also show that even during the recovery period we still found changes in the transcriptional levels of the CRs in gills, spleen and gonads.

NON MAMMALIAN PATTERN RECOGNITION RECEPTOR FROM ROCK BREAM: GENOMIC CHARACTERIZATION AND TRANSCRIPTIONAL PROFILE UPON BACTERIAL AND VIRAL INDUCTIONS

Thanthrige, T.P., D.A.S. Elvitigala, H.B. Jeong, S. Kang, J. Lee and B.S. Lim

Symposium: Parasites and Diseases **Type:** Oral **Order:** 7

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Abstract: TLR21, a non-mammalian type pattern recognition receptor, almost restricted to the fish species even though those can be identified rarely in avians and amphibians. Herein, this study was carried out to identify and characterize TLR21 from rock bream (*Oplegnathus fasciatus*) designated as RbTLR21, at transcriptional and genomic level. The complete coding sequence of RbTLR21 was 2919 bp in length which encodes a protein consisting 973 amino acids. The anticipated protein structure resembled a typical TLR domain architecture. Phylogenetic analysis revealed that, RbTLR21 shows a close evolutionary relationship with zebrafish ortholog. Genomic structure of RbTLR21 was consisted of single exon. The RbTLR 21 was ubiquitously expressed in all the tissues and predominantly expressed in spleen, liver and blood. Moreover, upon the stimulation with *Edwardsiella tarda*, *Streptococcus iniae* and Rock bream iridovirus, the RbTLR21 transcript level was up-regulated in spleen tissues, indicating that RbTLR21 may involve in host innate immune responses.

THE EFFECT OF ENVIRONMENTAL STRESSORS ON THE ENERGETICS AND KINEMATICS OF FISH SWIMMING

Thomas, A.L., Ozolina, K., Samson, E. Nudds, R., Shiels, H.A.

Symposium: Swimming Physiology **Type:** Poster **Order:** P138

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Abstract: Brown trout are a species native to UK and European waterways. Recognized for their importance both socially and economically they are threatened through changes to their specific habitat brought about by accelerated climate change. Traditionally studies have described the effects of a single stressor on the mechanics and energetics of fish performance, but few have examined the interacting effects of multiple stressors in synchrony. In this study, swimming kinematics and energetics of brown trout (*Salmo trutta*) were measured at three temperatures (14, 18 and 22°C), two dissolved oxygen levels (normoxic and 70% air saturation) and at slow, and fast steady-state swimming speeds. In addition, terminal blood and tissue sampling was used to determine glucocorticoid response. The trout increased metabolic rate with both swimming speed and temperature. Changes in tail beat frequency and amplitude also occurred, demonstrating a link between swimming kinematics and changes in oxygen consumption. The observed changes in swimming kinematics are likely an indirect consequence of effects on muscle physiology. The ability to maintain efficient locomotion under the pressure of changing environmental conditions, demonstrates

a high degree of kinematic plasticity. This facet may prove advantageous, allowing trout to exist at the environmental extremes predicted for the near future.

THE ENVIRONMENTAL INFLUENCE ON REPRODUCTIVE PERFORMANCE OF AMPHIPRION SEBAE, WITH SPECIAL REFERENCE TO PHOTOPERIOD AND TEMPERATURE

Thomas, D., Prakash, C., Sreekanth, G.B., and Gopakumar, G.

Symposium: Environmental Change **Type:** Oral **Order:** 20

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Abstract: Marine ornamental fishes are primarily collected from wild for commercial trade. Developing standardized breeding and rearing practices will help to reduce the pressure on the wild populations. The environmental manipulations influence the breeding performance of these fishes significantly. In this context, an experimental study was conducted to determine the environmental regulation of spawning performance in sebae anemone fish, *Amphiprion sebae* using photoperiod and temperature manipulations to offset ideal breeding conditions. The functional breeding pairs were acclimatized and maintained under different photoperiod, temperature and their combination regimes. Different reproductive parameters like, spawning interval, number of eggs per spawning and hatching rate were found to significantly different among the treatments. The photoperiod experiment, treatment 18L:06D presented the shortest spawning interval (10.833 ± 0.477 days) while the highest number of eggs (1211) and hatching rate (90.6 ± 1.57) were demonstrated by the treatment 16L:08D. In the temperature experiment, the spawning interval (7.666 ± 0.333 days) was lowest at 340C while the number of eggs (934) and hatching rate (80.660 ± 3.529) were highest at 300C. Combination of photoperiod and temperature had found a significant effect on reproductive performance. The lowest spawning interval (7.333 ± 0.881 days) was exhibited by the combination treatment 18L:06D and 340C. However, the higher number of eggs (1455) and hatching rate (94.000 ± 2.081) were observed under the treatment 16L:08D and 300C, which were superior in comparison with treatments in isolation. These findings can suggest that photoperiod and temperature manipulation can be used as a tool to alter the reproductive performances in *A. sebae* and can help to obtain better reproductive performance in captivity.

IMPACTS OF CO₂-ACIDIFIED SEAWATER ON THE PHYSIOLOGICAL PERFORMANCE OF A JUVENILE ANTARCTIC FISH

Todgham, A.E., Bjelde, B.E. and Miller, N.A.

Symposium: Climate Change **Type:** Oral **Order:** 9

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Abstract: High latitude seas are predicted to experience the impacts of CO₂-acidified seawater (ocean acidification, OA) within the next 40 years; however, organisms within these oceans may be some of the most vulnerable to environmental change, having evolved under stable conditions for millions of years. Early life stages are of particular concern as they are thought to be more sensitive to changes in climate-related variables than adults. Our research investigated the impacts of OA on the juvenile Antarctic fish, *Trematomus bernacchii* and integrated metabolic responses, growth and development, and cardiac performance to broadly understand the physiological plasticity of early life history stages of fishes developing under elevated CO₂ (410ppm, 650ppm, 1050ppm CO₂). Despite early shifts in energy metabolism in response to elevated CO₂, juvenile fish demonstrated a capacity to acclimate over a 4-wk period resulting in no differences in condition factor, oxygen consumption and heart rate between treatments.

REPLACEMENT OF FISHMEAL WITH PLANT FEEDSTUFFS IN THE DIET OF RED DRUM: EFFECTS ON PRODUCTION CHARACTERISTICS AND TOLERANCE TO AQUACULTURE-RELATED STRESSORS

Tomasso, J.R., Moxley, J.D., Rossi, A., Buentello, C., Pohlenz, C., Gatlin, D.M.

Symposium: Fish Culture **Type:** Poster **Order:** P16

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Abstract: The continued expansion of intensive aquaculture activities requires that substitutes for fishmeal-based protein be identified. In this study, we evaluated partial (50% and 75%) replacement of fishmeal in red drum, *Sciaenops ocellatus*, diets with soy protein concentrate (S) and barley protein concentrate (B). Growth, feed efficiency, survival, tolerance to low temperature, and tolerance to handling in warm, hypersaline water were evaluated. Only the diet with a 50% replacement of fishmeal with S yielded results comparable to fish fed a non-substituted fish meal diet. However, the low-temperature studies were complicated by differences in mean fish weight among the groups. The results of this study indicate S may be partially substituted for fish meal in red drum diets.

MOLECULAR AND FUNCTIONAL CHARACTERIZATION OF NICOTINIC ACETYLCHOLINE RECEPTOR ALPHA 7 IN RAINBOW TROUT

Torrealba, D., MacKenzie, S., and Roher, N.

Symposium: Fish Cell Cultures **Type:** Oral **Order:** 11

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Abstract: Nicotinic acetylcholine receptor alpha 7 subunit (alpha7nAChR) is present in different cells of the immune system such as macrophages and lymphocytes and is essential for controlling inflammation in mammals. In order to characterize the alpha7nAChR and to study its functional involvement in the control of the inflammatory response in fish, we have obtained the coding sequence of the trout alpha7nACh receptor and we have described the response of macrophages to acetylcholine (ACh) and lipopolysaccharide (LPS). The protein sequence of the receptor is highly conserved between fish and mammals and the binding of fluorescent alpha-bungarotoxin (alpha-BTX) suggests that trout macrophages have a functional alpha7nAChR. After ACh and LPS treatment we did not observe differences in gene expression of pro-inflammatory and anti-inflammatory cytokines in macrophages. In addition, we did not observe an increase in the phagocytic activity of macrophages stimulated with ACh, unlike is described in mammals.

ARE POLAR SEAS PARTICULARLY UNINVITING TO ELASMOBRANCHS?

Treberg, J.R., Atchison, S., Reist, J., Brandt, C., Anderson, W.G., Speers-Roesch, B.

Symposium: Elasmobranchs **Type:** Oral **Order:** 8

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Abstract: Similar to the pattern seen with increasing depth, the diversity of elasmobranchs declines disproportionately, compared to teleosts, with increasing latitude. This is most extreme when comparing high latitude polar seas to warmer or lower latitude environments. The elasmobranchs found in polar seas are typically members of taxa that are common in the deep sea, suggesting these waters may share common unfavourable features to elasmobranch fishes. Physiologically, elasmobranchs display numerous distinctions from teleosts. With a focus

on aspects of osmoregulation and energy metabolism, here we compare the biological traits of elasmobranch species that permanently reside in polar waters, such as the Arctic skate *Amblyraja hyperborea*, to those of other polar fishes. Drawing comparisons between polar and deep-sea taxa, we assess if these chronically cold environments pose physiological challenges specific to elasmobranchs.

SENSING ACID/BASE VIA THE cAMP PATHWAY

Tresguerres, M.

Symposium: Cellular Signalling **Type:** Oral **Order:** 10

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Abstract: All organisms regularly experience variations in the levels of carbon dioxide, protons (~pH) and bicarbonate ions in their intra- and extra-cellular fluids. For example, feeding may induce blood alkalosis, exercising and environmental hypercapnia may induce acidosis, and photosynthesis and calcification may induce acidosis or alkalosis (depending on the fluid compartment considered). To maintain homeostasis, acid/base (A/B) stress must be readily compensated. Additionally, carbon dioxide, pH and bicarbonate levels are known to regulate many other biological functions not directly related to A/B regulation. Thus, all organisms must be able to sense A/B conditions. The cyclic AMP pathway can mediate multiple physiological responses through PKA-dependent phosphorylation, EPAC proteins, and channel gating. This presentation will discuss the potential roles of soluble adenylyl cyclase and transmembrane adenylyl cyclases in sensing carbon dioxide, pH and bicarbonate and triggering physiological responses in diverse organisms.

GONAD DEVELOPMENT AND HISTOLOGY IN BAGRUS BAYAD CULTURED IN OUTDOOR EARTHEN POND

Tsadu, S.M., Lamai, S.L., Yisa, T.A. and Ibrahim, S.U.

Symposium: General Contributed Papers **Type:** Poster **Order:** P61

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Abstract: Abstract *Bagrus bayad* (Daget) are found in Nigerian freshwaters in Rivers Niger, Benue, Kaduna and Lake Chad. This feral species were observed to have high growth rate and other aquaculture qualities. 200 live juveniles (100 males and 100 females) were maintained in 5m² outdoor earthen pond for 12 months. The objective was to study some aspects of their biology particularly the gonad development and histology, growth and survival with the aim of introducing the species into aquaculture. The fish were checked regularly at 4 weeks intervals for gonad development and maturity stages. One male and one female were dissected each time and gonads used for histological studies. Gonad developmental stages were classified according to description by Bruton (1979). Cross sections through the ovaries and testis showed gonads in stages II, III, IV and V. Photomicrographs of all the stages observed were made and described. Growth and development continued in the fish under culture and it was concluded that *Bagrus bayad* could be introduced into aquaculture. Key Words: *Bagrus bayad*, gonad, histology, aquaculture

ZEBRAFISH IS ALSO A SENSITIVE ANIMAL MODEL TO ASSESS THE SEWAGE DISCHARGE AND OTHER POTENTIAL WATER POLLUTION

Tsai, Shu-Chuan

Symposium: Zebrafish **Type:** Poster **Order:** P161
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Abstract: To monitor the sewage discharge and other potential water pollution, there formulate different biology acute toxicity tests in the Laws and Regulations by the Taiwan Environmental Protection Administration. There are accustomed to using three kind fishes including stone moroko, carp and medaka. Zebrafish is another sensitive animal model to assess the drugs toxicity and environmental risks. In this study, we used 1.5 ± 0.1 cm small fish to monitor the campus experimental and life sewage of Central Taiwan University of Science and Technology (CTUST). In 96 hrs acute toxicity test the lethal rate, histopathologic sections of gill, acetylcholine esterase (AChE) activity and metallothionein (MT) concentrations were detected. In 30 days chronic toxicity test the lethal rate and condition factor (CF) were calculated. in 96 hr acute toxicity test, the lethal rate was 100% in experimental and life wastewater but 10% lower than sewage disposal treatments. In Gill histological sections, experimental wastewater groups showed secondary lamella degeneration and RBC cluster, life wastewater group showed swollen bases of secondary lamella and sewage discharge groups were not significantly different with control. AChE activity of the sewage discharge groups (Life sewage (Lo) 78.63 U/mg; Experimenta sewage (Eo): 60.77 U/mg) was higher than the experimental (31.73U/mg) and life wastewater (47.51U/mg) groups. MT concentrations of the sewage discharge groups (Lo: 339.73ng/m; Eo:375.76 ng/m) was lower than the experimental (623.29 ng/mg) and life wastewater (599.11 ng/mg) groups. In chronic toxicity test, the lethal rate of the sewage discharge groups (Lo: 45.55%; Eo: 43.33%) was lower than the experimental (60.00%) and life wastewater (53.33%) groups. Condition factors of control (1.39) was higher than the waste water treatment groups (Li: 1.24; Lo: 1.32; Ei: 1.27; Eo: 1.33). The influences of sewage discharge in zebrafish could recovered after transferred to dechlorinated water.. In summary, the waste water treatment systems of CTUST could effectively decrease most acute toxicity of wastewater, but the remained trace waste still inhibited the growth rate, oocyte yield and hatching rate in chronic toxicity. This study also showed that zebrafish is potential animal model to monitor the water quality.

HIF-1 MEDIATES ADAPTIVE METABOLISM SHIFT IN FISH BRAIN UNDER COLD EXPOSURE

Tseng, Y.C., Chen, R.D., Liu, S.T., Lee, J.R., and Hwang, P.P.

Symposium: Cellular Signalling **Type:** Oral **Order:** 7

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Abstract: Metabolism of ectothermic organisms is affected by ambient temperature changes whereas intrinsic brain is a highly energy consuming organ. To date little is known on signaling aspects regarding the metabolic homeostasis in fish brain under cold exposure. The hypoxia-inducible factor (HIF) expressions in zebrafish brains was increased by about 50 % under 18°C cold exposure, while the protein carbonyls concentration was increased by 38 %. Meanwhile the glutathione content as well as the ratio of glutathione disulfide to glutathione remained constant. In addition, cold exposure not only increases the glucose transporter and monocarboxylate transporter expressions in zebrafish brain, but also activates uncoupling protein and peroxisome proliferator-activated receptor axis that may involve to prevent oxidative damage. The observed of HIF increment by mild ROS accumulation under cold exposure provides an adaptive signal to induce a metabolic shift from mitochondrial respiration to carbohydrates utilization for maintaining regular metabolic homeostasis in fish brains.

PHYSIOLOGICAL AND BIOCHEMICAL ASPECTS OF PARTIAL REPLACEMENT OF FISH MEAL WITH PLANT PROTEIN SOURCES IN COMBINATION WITH DIETARY VITAMIN C IN MEAGRE

Tsertou, M.I., Feidantsis, K., Chatzifotis, S., Pavlidis, M., Katharios, P. and Antonopoulou, E.

Symposium: Fish Culture **Type:** Poster **Order:** P17

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Abstract: The use of alternative protein sources such as plant protein, is one of the priorities for aquaculture sustainability. Partial (25%) replacement of fish meal by plant proteins (soybean and corn gluten) was examined in meagre (*Argyrosomus regius*), with average weight 25 ± 0.23 gr, during a 3-month feeding trial. Additionally, the effect of dietary supplementation of ascorbic acid (2g/kg) on general physiology of meagre was studied. Growth performance, various plasma metabolites, antioxidant enzymatic activities and expression levels of heat-shock protein family as well as apoptotic and anti-apoptotic proteins were studied in muscle, liver, kidney and intestine of fish. Fish fed with the fish meal diet showed higher growth performance. No significant changes were observed in hematological indicators among the fish meal and vitamin C diets, while antioxidant enzymatic activities and diverse protein levels exhibited distinct tissue specificity.

COVARIATION BETWEEN BEHAVIOUR AND PHYSIOLOGICAL INDICATORS OF COPING STYLE IN ADULT AND LARVAL ZEBRAFISH

Tudorache, C., Schaaf, J.M., Slabbekoorn H.

Symposium: Stress in Fish **Type:** Oral **Order:** 10
Contact: Christian Tudorache **E-mail:** c.tudorache@biology.leidenuniv.nl
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Abstract: Many vertebrates exhibit individual variation in physiological and behavioral response to stress. In adult and larval zebrafish (*Danio rerio*) netting stress leads to behaviorally and physiologically distinct reactions in different coping styles: in adult fish, reactive individuals display i) increased basal cortisol concentrations after being repeatedly stressed, ii) higher cortisol secretion over time and iii) a slower recovery of cortisol concentration towards basal levels after acute netting stress, than proactive fish. The physiological response to netting stress is similar in larvae. Additionally, swimming kinematics before and after netting stress differ with coping styles, with generally higher swimming activity but lower recovery rates in reactive individuals. This study shows for the first time in zebrafish as an upcoming model system for stress research, that different coping styles are associated with different physiological and behavioural responses over time, especially during the recovery from stress, and that coping styles can explain otherwise unaccounted variation in physiological stress responses. A better understanding of the expression of coping styles is of great value for medical applications, animal welfare issues and conservation physiology.

THE EFFECT OF NEAR FREEZING TEMPERATURES ON DEVELOPMENT OF COHO SALMON DURING INCUBATION

Tuor, K.M.F and Shrimpton, J.M

Symposium: Winter Fish Biology **Type:** Oral **Order:** 3
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Canada

Abstract: Coho salmon (*Oncorhynchus kisutch*) have an extensive freshwater distribution, but the range of conditions during incubation is not well known – particularly for northern and interior populations. Temperature directly affects development of embryonic and larval coho. Our objectives were to determine the range of temperatures larval coho experience throughout incubation and what adaptations may be required for survival in cold temperatures. Intragravel temperatures were examined throughout the incubation period for ten watersheds in British Columbia where coho are known to spawn. Incubation temperatures within two interior systems were found to drop to near freezing temperatures during winter. Development at such cold temperatures represents an

impressive physiological capacity, but not all populations experience temperatures near freezing. To determine if selection for cold temperature tolerance during incubation has altered development among different populations, we are presently measuring development rate, oxygen consumption, and survival. Analysis will assess differences between cold-adapted and warm-adapted populations reared at different temperatures.

AMPHIBIOUS ASTRONAUTS: GILL REMODELLING IN RESPONSE TO ALTERED BODY WEIGHT IN THE MANGROVE RIVULUS

Turko, A.J, Croll, R.P., Fudge, D.S., Kültz, D., Smith, F.M, and Wright, P.A.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 2

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Abstract: Mammals respond to changes in body weight (e.g. during spaceflight), but because aquatic fishes are effectively weightless, they are thought to be unresponsive to changes in weight. No studies have considered amphibious fishes, which tolerate increased weight during emersion. We hypothesized that differences in effective body weight alter gill structural support in the amphibious fish *Kryptolebias marmoratus*. Fish were acclimated for 7d to water (1g), air (1g), or simulated microgravity (0.06g) in air. Gill arches from air exposed fish were ~40% stiffer than gill arches of fish in water, while gill arches in microgravity acclimated fish were not stiffened. Polarized light and transmission electron microscopy showed dense packing of collagen fibers in air exposed fish (1g), which may be responsible for increasing stiffness. This is the first report of weight-induced musculoskeletal remodelling in a fish, suggesting that the ability to respond to changes in body weight is necessary for occupying terrestrial habitats.

EVIDENCE FOR A ROLE OF HEME OXYGENASE-1 IN THE CONTROL OF CARDIAC FUNCTION IN THE ZEBRAFISH LARVAE EXPOSED TO CHANGES IN WATER OXYGEN LEVELS

Tzaneva, V., and Perry, S.F.

Symposium: Cellular Signalling **Type:** Oral **Order:** 5

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Abstract: Cardiomyocytes respond to hypoxic stress by activating compensatory genes such as heme oxygenase-1 (HO-1). HO-1 is inducible under hypoxic conditions and is responsible for the breakdown of heme into carbon monoxide, iron, and bilirubin. In this study we investigate the effects of HO-1 on control of cardiac function in the zebrafish larvae when exposed to low O₂ levels. Acute hypoxia exposure (30 min, PwO₂ = 30 mmHg) caused a significant increase in HO-1 activity in control but not HO-1 morphant (HO-1 knockdown) zebrafish larvae 4 days post fertilization (dpf). The heart rate of control larvae (4 dpf) significantly increased during hypoxia exposure from a baseline of 144.1±3.9 beats per minute (BPM) to 155±5.7 BPM. Hypoxia did not cause a significant increase in heart rate in HO-1 morphants. HO-1 morphants exposed to low O₂ levels, however, had a significantly higher heart stroke volume (0.378±0.06 nl) than their control conspecifics (0.15±0.05 nl).

EFFECT OF CONFINEMENT ON THE STATUS OF PHYSIOLOGICAL STRESS RESPONSE OF ADVANCED FRY OF ROHU FISH

Ullah, I., Zuberi, A., Kusar, N., and Khan, K.U.

Symposium: Stress in Fish **Type:** Oral **Order:** 30

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Abstract: The effect of confinement on the status of cortisol and AChE, in advanced fry of *Labeo rohita*, during live hauling for twelve hours was determined. Fry of *L. rohita* average weight 2.45 ± 0.25 g were packed in polyethylene bags under pressurized oxygen, at a stocking density of 70 ± 1.52 g L⁻¹. Before packing water temperature was 20°C, oxygen 5.9 mg L⁻¹, pH 8.5 mg L⁻¹ and total ammonia < 0.5 mg L⁻¹. The whole-body and water borne cortisol concentration increased significantly ($P < 0.001$) at 2 hrs and then start decreasing. The second peak of water borne and whole body cortisol concentration was observed at 8 and 10 hrs of confinement while cortisol release rate continuously decreased significantly ($P < 0.05$) after 2 hrs. The level of AChE activity showed negative relation with increase in confinement duration. These results suggest that at this temperature and stocking density *L. rohita* fry can tolerate about 8-10 hrs of confinement.

THE EFFECTS OF WATER DEVELOPMENT ON THE GENETIC STRUCTURE OF NORTH AMERICAN BURBOT POPULATIONS

Underwood, Z. E., Mandeville, E. G., and Walters, A. W.

Symposium: Burbot **Type:** Oral **Order:** 8

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Abstract: Burbot (*Lota lota*), a member of the cod family, are a unique freshwater fish species of ecological, recreational, and cultural importance throughout their Holarctic distribution. In the state of Wyoming, USA, burbot are native to the Wind/Bighorn River drainage where they are a popular sport fish and an apex native predator in the region. Regional declines in abundance and demographic shifts have been observed, spurring increased research and conservation efforts. One main factor attributed to these declines is water development for agricultural purposes. We examined the genetic structure of burbot populations within natural and human-made water bodies throughout the watershed using next-generation DNA sequencing and a Bayesian modeling approach. Genetically divergent groups were observed within both the natural and human-made waters, and mixing of genetically distinct groups within certain human-made waters suggest regional source-sink interactions are occurring. Our findings will aid fisheries managers in the conservation of burbot within this region, and within other regions affected by water development.

NESFATIN-1 REGULATION OF GROWTH HORMONE SECRETION IN FISH

Unniappan S., Gonzalez, R., Pham V., Pemberton J., Chang JP

Symposium: Growth and Metabolism **Type:** Oral **Order:** 5

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Abstract: Nesfatin-1 is a naturally occurring, multifunctional peptide in vertebrates. We hypothesized that nesfatin-1 is a modulator of growth hormone (GH) secretion in goldfish. Our objective was to determine the effects of nesfatin-1 on GH secretion. Fluorescence immunohistochemistry did not find nesfatin-1 in the proximal pars distalis of goldfish pituitary where GH-producing somatotropes are located. Intracerebroventricular injection of synthetic nesfatin-1 caused a significant reduction in the hypothalamic expression of mRNAs encoding gonadotropin releasing hormone and pituitary adenylate cyclase activating polypeptide, two potent GH stimulatory hormones in goldfish. Both pituitary GH mRNA expression and serum GH levels were also significantly decreased in these fish treated with nesfatin-1. Nesfatin-1 also caused a marked suppression in GH release in vitro from a mixed population

of dispersed pituitary cells. In conclusion, our data supports an inhibitory role for nesfatin-1 on GH secretion in goldfish. Funded by NSERC of Canada.

IMPACT OF FRESHWATER CHEMISTRY ON POST-FEEDING ACID-BASE REGULATION AND RESPIRATORY FUNCTION IN RAINBOW TROUT

Urbina, M.A. and Wilson R.W.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 26

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Abstract: Feeding causes an alkaline tide in fish (a rise in blood pH and [HCO₃⁻]), recovery from which involves regulatory processes at the gill, intestine and kidney. Environmental chemistry is known to influence acid-base ion fluxes via the gills (e.g. freshwater Cl⁻ and HCO₃⁻ directly control Cl⁻/HCO₃⁻ exchange, and Ca²⁺ affects gill ionic permeability). We therefore hypothesised that the abundance of these ions in freshwater would affect recovery from the alkaline tide and its physiological consequences (e.g. gas exchange). In adult rainbow trout at 15 °C and voluntarily feeding on a 3% ration, environmental [Cl⁻] (0.05, 0.5 and 5 mM) was the most effective at modulating bicarbonate, ammonia, urea, and net acid-base fluxes; high Cl⁻ increased the peak rate of net base excretion by 10-fold (from 1.5-3h), the cumulative flux by 2-fold (over 96h), and reduced its post-prandial recovery time by 4-fold. Physiological (e.g. gas exchange) and ecological consequences are being explored.

AIR BREATHING AND PHYSIOLOGICAL STRATEGIES DURING EMERSION IN GALAXIIDIS

Urbina, M.A., Walsh, P.J., Meredith, A.S., Glover, C.N. and Forster, M.E.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 1

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Abstract: All members of the family Galaxiidae are small and scaleless, characteristics advantageous for cutaneous respiration. We have explored the energy metabolism, nitrogen waste handling and cutaneous gas exchange in aquatic and aerial settings in three galaxiid species that differ in their aerial tolerance. *Galaxias maculatus* emerses for periods of a few hours to escape severe aquatic hypoxia, while the two mudfish studied, *Neochanna burrowsius* and *Neochanna apoda* remain burrowed for months during droughts. Our results showed that all species performed cutaneous gas exchange. In mudfish, the contribution of gill and skin to total oxygen uptake was similar in water and air, but differed in *G. maculatus*. Only urea levels increased in plasma and muscle during emersion. Our results determined that a low metabolic rate and a decrease in the reliance on proteins for energy metabolism are the main strategies used for galaxiids to prolong survival in the absence of water.

OXYGEN TRANSFER IN THE AMAZONIAN FISH PROCHILODUS NIGRICANS

Val, A.L., Gomes, K.R.M. and Almeida-Val, V.M.F

Symposium: Tropical Fish **Type:** Oral **Order:** 17

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INPA, Av Andre Araujo 2936, Manaus, AM, ZIP 69067-375 Brazil

Abstract: *Prochilodus nigricans* is an Amazonian fish that endure extreme variations of dissolved oxygen within a day in the wide variety of habitats in its migratory way. We have shown that *Prochilodus* overcomes seasonal and diurnal changes in dissolved oxygen by adjusting erythrocyte ATP and GTP, modulators of Hb-O₂ affinity. *Prochilodus* does not exhibit any apparent morphological alterations to improve oxygen uptake, depending on rapid adjustments of blood properties. To investigate this aspect, functional properties of hemolysate, pHe, pHi, plasma lactate and erythrocyte levels of ATP and GTP of *Prochilodus* were analyzed over a period of six hours under hypoxia and subsequent recovery in normoxia. GTP, but not ATP, was reduced after three hours under hypoxia. All other analyzed blood parameters exhibited a time-course change in animals under hypoxia and returned to normoxic levels. Clearly, *Prochilodus* is able to adjust blood properties to endure environmental constraints regards oxygen availability. (INPA; INCT ADAPTA – CNPq/FAPEAM)

TEMPERATURE AND PH AFFECTS BLOOD OXYGEN AFFINITY OF SELECTED FISH SPECIES OF THE AMAZON

Val, A.L.; Paula-Silva, M.N.; Almeida-Val, V.M.F and Wood, C.M.

Symposium: Climate Change **Type:** Oral **Order:** 1
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Abstract: Global warming has been related to lower dissolved oxygen and water pH that represents a challenge for tropical fish. In the Amazon, these changes can push fishes to the limit of their adaptive capacity as they evolved in a thermo-stable environment, inhabit hypoxic environments and, in many cases, have to withstand acidic/ion-poor waters, as is the case of the fish of the Rio Negro. Blood-O₂ affinities of characids, cichlids and few species from other groups, collected in the Rio Negro, Anavilhanas Islands, near ICMBio base, were assayed at pHs 7.0, 7.4 and 7.8 at 31 (highest temperature average over the last eight years), 33 and 35°C. A significant increase of P₅₀ (decreased blood-O₂ affinity) with temperature was observed for six out of seven species analyzed. This is in agreement with the characids but contrasts with the catfish from the same river system previously analyzed. (INPA; INCT ADAPTA – CNPq/FAPEAM; Ciência sem Fronteiras)

DEVELOPMENT OF A VISUAL SYSTEM IN ATLANTIC COD

Valen, R., Edvardsen, R.B., Drivenes, O., Soviknes, A.M. and Helvik, J. V.

Symposium: Sensing the Environment **Type:** Oral **Order:** 9
Contact: Ragnhild Valen **E-mail:** ragnhild.valen@bio.uib.no
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Abstract: Teleosts show a great variety in visual opsin complement, due to both gene duplication and gene loss. The repertoire ranges from monochromatic (scotopic vision) rod opsin only retinas seen in many deep-sea species to tetrachromatic vision in some pelagic species. We have investigated the opsin repertoire of Atlantic cod (*G. morhua*) and found that cod lacks LWS (red sensitive) and SWS1 (UV sensitive) genes while the RH2 (green sensitive) has three paralogues. We also show that there is an ontogenetic change in the array of cone opsins expressed related to onset of metamorphosis. We provide the first molecular evidence for color vision driven by only two families of cone opsins due to gene loss in a teleost.

EFFECT OF TWO PISCIRICKETTIA SALMONIS TYPES ON THE FISH SPECIES ONCORHYNCHUS MYKISS AND ELEGINOPS MACLUVINUS

Vargas-Chacoff, L., Oyarzún, R., Valdivia, S., Saldoval, R., Bertrán, C. and Yáñez, A.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P89
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Abstract: Fish are sensitive to different stressor agents such as temperature, salinity, crowding, handling and pathogens such as bacteria or virus, which produce several responses in the immunological system, metabolism, and behaviour. The aim of this study was to evaluate the effect of two *Piscirickettsia salmonis* types injected in juveniles of *Oncorhynchus mykiss* and *Eleginops maclovinus*. Three groups of each species were injected, two groups injected with the ATCC VR-1361 or Austral-005 (antibiotic resistant and highly pathogenic) type strains of *P. salmonis*. The concentration injected for both strains types was 10^9 cells/ g bw; the control group was injected with PBS. After 21 days of infection, samples of serum, plasma, liver and muscle were obtained from fish. Serum Immunoglobulin type M (IgM) and plasma cortisol levels presented highest values in fish injected with *P. salmonis* Austral 005 in both species of fish. Plasma glucose, lactate, triglycerides, osmolality, proteins, and total amino acids presented different responses according to fish species and bacteria type. Similar variations were observed in enzymatic activities, where carbohydrates, lipids and amino acid metabolism presented different responses according to fish species and bacteria type in liver and muscle. The results indicated that effect of two types of bacteria on *O. mykiss* and *E. maclovinus* specimens induced immunological and stress responses, and evoked deep changes in the metabolite stores in all tissues tested, indicating a mobilization of energy substrates in response to the infection with different *P. salmonis* strain types. Acknowledgments: This study was financed by FONDECYT Projects 1110235, Dirección de Investigación (DID) from the Universidad Austral de Chile and FONDAP-INCAR, N°15110027.

KARYOTYPIC DIVERSITY BETWEEN RAINBOW TROUT AND SNOW TROUT

Vasave, S., Saxena, A. and Srivastav, S.K

Symposium: General Contributed Papers **Type:** Oral **Order:** 9
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Abstract: The Cytogenetic studies were carried out in two important coldwater fishes, Rainbow trout (*Oncorhynchus mykiss*) and Snow trout (*Schizothorax richardsonii*), by Giemsa staining. The diploid chromosome number ($2n$) in Rainbow trout (*Oncorhynchus mykiss*) the modal diploid number was found to be $2n = 60$. The karyotype formula obtained consist of 38 metacentric (M), 6 submetacentric (Sm) and 16 telocentric chromosomes ($24M + 20 Sm + 16 T$). The fundamental arm number was derived to be 208 (FN = 208) and in Snow trout (*Schizothorax richardsonii*), the modal diploid number was found to be $2n = 96$. The karyotype formula obtained consist of 18 metacentric (M), 16 submetacentric (Sm) and 12 subtelo-centric and 50 telocentric chromosomes ($18 M + 28 Sm + 50 T$). The fundamental arm number was derived to be 284 (FN = 284). This is the attempt to compare the wild snow trout obtained from Himalayan stream and farm raised Rainbow trout in these species using conventional staining.

SUSTAINED EXERCISE: MUSCLE GROWTH POTENTIAL IN GILTHEAD SEA BREAM

Velez, E.J., Azizi, S., Millan-Cubillo, A.F., Lutfi, E., Navarro, I., Ibarz, A., Fernandez-Borras, J., Blasco, J., Capilla, E., Gutierrez, J.

Symposium: Swimming Physiology **Type:** Poster **Order:** P139
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Abstract: Swimming activity primarily accelerates growth in fish by increasing protein synthesis and energy efficiency. The aim of this work was to characterize the effects of five weeks of moderate sustained activity in gene and protein expression of myogenic regulatory factors, proliferation markers, proteolytic enzymes, as well as AKT

and TOR signalling pathways activation in muscle of gilthead sea bream juveniles. Western blot results showed an increase in proliferation markers expression and TOR phosphorylation with exercise. Moreover, real-time PCR data showed that exercise increased the gene expression of proteases in the epaxial anterior region, whereas enhanced proliferation markers expression in the epaxial caudal area compared with control fish; thus, suggesting a different response of both muscle regions during swimming adaptation. In summary, the present study contributes to improve knowledge on gilthead sea bream myogenesis in order to optimize muscle growth and quality in this species. Supported by MICINN (AGL2012-39768); XRAq; 2009SGR-00402.

EFFECTS OF A PYRETHROID INSECTICIDE ON THE ANTIOXIDANT METABOLISM OF THE FRESHWATER FISH BRYCON
AMAZONICUS

Venturini, F.P., de Moraes, F.D., Rossi, P.A., Avilez, I.M., Moraes, G.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P43

Contact: Francine Perri Venturini **E-mail:** francineventurini@gmail.com

Federal University of Sao Carlos Rod. Washington Luiz Km 235, São Carlos, SP, Brazil. CEP 13565-905 Brazil

Abstract: Pyrethroids, used worldwide, are highly toxic to fish. In this study, the antioxidant response of Brycon amazonicus exposed to lambda-cyhalothrin (LCH) and recovery was evaluated. Fish (n=12) were exposed to 0.65 µgL⁻¹ of LCH for 96h and allowed to recover for 7 days. Catalase (CAT) and glucose-6-phosphate dehydrogenase (G6PDH) were assayed in liver, kidney and gill. Superoxide dismutase (SOD) and glutathione peroxidase (GPx) were in liver. After exposure, hepatic SOD, CAT and GPx lessened 37, 35 and 32%, respectively. After recovery, SOD activity remained lessened 19%, while GPx augmented 141%. After exposure, gills' G6PDH decreased 40%, and CAT increased 33% after recovery. In kidney, CAT diminished 30% and GPx augmented 71% after exposure, while CAT increased 39% and G6PDH decreased 49% after recovery. These responses show the complex interactions among the metabolic steps of the antioxidant metabolism and its specificity to the animal species and xenobiotic.

ALTERATIONS ON BIOCHEMICAL PARAMETERS OF RAINBOW TROUT AFTER A PYRETHROID SINGLE-PULSE
EXPOSURE FOLLOWED BY REPEATED SWIMMING

Venturini, F.P., Osachoff, H.L., Moraes, G., Kennedy, C.J.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P44

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Abstract: Pesticides, such as lambda-cyhalothrin (LCH), can reach aquatic environments leading to adverse effects on non-target organisms. That effects are heavily due to nerve functions disturbances affecting vg., the swimming performance. Thus, we have evaluated the LCH effects in three repeated burst swimming trials with rainbow trout (*Oncorhynchus mykiss*). Moreover, effects on biochemical parameters (muscular glycogen; plasma L-lactate, glucose, cortisol, protein and Cl⁻) were examined. Plasma protein content did not show any difference at any experimental periods. Plasma cortisol increased while muscular glycogen decreased after the swim trials. Albeit, these parameters did not depict any difference in exposed fish. Plasma L-lactate, glucose and Cl⁻ were responsive to LCH exposure. Even after recovery for 24h, these levels in exposed fish remained higher than in control fish. Our findings suggest that rainbow trout energy metabolism and osmoregulation were affected by LCH, highlighting the importance of evaluating sub-lethal doses as integrative toxicological parameters.

ETHANOL TOXICITY IN ZEBRAFISH DEPENDS ON TIME OF DAY

Vera, L.M., Bello, C., Sánchez-Vázquez, F.J.

Symposium: Zebrafish **Type:** Poster **Order:** P162
Contact: Luisa M. Vera **E-mail:** luisa.veraandujar@stir.ac.uk
Institute of Aquaculture, Pathfoot Building, University of Stirling, FK9 4LA, Stirling. UK

Abstract: Ethanol is the most commonly abused drug but little information is available on daily rhythmicity of its deleterious effects. In this study we investigated the daily rhythm of ethanol toxicity in zebrafish larvae and adult individuals, which were exposed to ethanol at different times. The acute lethal toxicity of ethanol (4%) in larvae showed a daily rhythm, with higher mortality rates being observed at the beginning of the light phase. In adult zebrafish, a sublethal concentration of ethanol (1%) had a higher impact on locomotor activity during the light phase too, inhibiting swimming activity after 1-4 min of exposure. Furthermore, daily differences were observed in gene expression levels of hepatic alcohol detoxifying enzymes, which were higher when zebrafish were exposed to ethanol during the dark phase. These findings highlight the significance of considering the time of day when researching alcohol toxicology, pointing out that morning exposure to alcohol is worst.

STRESS RESPONSE IN GILTHEAD SEA BREAM IS TIME-OF-DAY DEPENDENT

Vera, L.M., Montoya, A., Pujante, I.M., Pérez-Sánchez, J., Calduch-Giner, JA, Mancera, J.M., Moliner, J., Sánchez-Vázquez, F.J.

Symposium: Stress in Fish **Type:** Poster **Order:** P133
Contact: Luisa M. Vera **E-mail:** luisa.veraandujar@stir.ac.uk
Institute of Aquaculture, Pathfoot Building, University of Stirling, FK9 4LA, Stirling. UK

Abstract: The aim of the present research was to investigate the existence of time-dependent differences in the stress response in gilthead sea bream. To this end, we studied the effect of 30 s air exposure at different times of the day and night on physiological stress indicators (cortisol and glucose), as well as hypothalamic expression of genes encoding hormones of HPI axis (crh and crhbp) and mitochondrial oxidative stress biomarkers (coxIV, prdx3, prdx5 and ucp1). Our results indicate that stress response shows daily rhythmicity in gilthead sea bream, although the phase of the rhythm differs among stress indicators (neuroendocrine and mitochondrial oxidative markers). Hence, while plasma cortisol in the stressed fish peaked in the middle of the dark phase, coxIV, prdx3 and prdx5 expression was higher during the light phase, suggesting that different timing mechanisms may be involved in the control of specific stress response.

CHARACTERIZATION OF THE APOPTOTIC CASPASE CASCADE IN RAINBOW TROUT

Verleih, M., Borchel, A., Rebl, A., Brunner, R.M., Köllner, B., Kühn, C., and Goldammer, T.

Symposium: Stress in Fish **Type:** Poster **Order:** P134
Contact: Tom Goldammer **E-mail:** tomgoldammer@fhn-dummerstorf.de
Leibniz Institute for Farm Animal Biology (FBN), Institute Genome Biology, Fish Genetics Unit, Wilhelm-Stahl-Allee 2, Dummerstorf, D-18196 Germany

Abstract: Apoptosis is an evolutionary conserved and dynamic process that controls developmental processes and the homeostasis of organisms. Result of the programmed cell death is the target-orientated degradation and phagocytosis of unnecessary or irreversibly damaged cells (about 50 billion/day). We use farmed rainbow trout (*Oncorhynchus mykiss*) to uncover unknown features within the apoptosis pathway in general, since the study of this process under intensively alternated environmental conditions is more promising with a teleost model compared to mammals. Our analyses will contribute to the generation of a molecular test tool for stress detection of fish in aquaculture. Caspases (CASP) represent key molecules of apoptosis. The structure of several caspase genes is unknown in rainbow trout. Moreover, knowledge about function and dynamics in gene expression is limited for

numerous caspase and further apoptose pathway related genes in stress situations and during embryonic and juvenile developmental stages. Using global transcriptome analyses, we present information about missing links within the apoptotic caspase cascade in rainbow trout. (ESF grant AU11040)

GLOBAL BIOTECHNOLOGICAL STRATEGIES FOR CHARACTERIZATION OF THE TRAIT ROBUSTNESS IN RAINBOW TROUT

Verleih, M., Relb, A., Brunner, R.M., Köbis, J., Borchel, A., Korytář, T., Krasnov, A., Kühn, C., Goldammer, T.

Symposium: Stress in Fish **Type:** Oral **Order:** 13

Contact: Marieke Verleih **E-mail:** verleih@fbn-dummerstorf.de

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Abstract: Aim of rainbow trout aquaculture is the sustainable production of healthy, fast growing fish with excellent file quality to ensure progressive gains. Our research contributes to this goal by focusing on the analysis of the trait robustness. In general, this complex trait describes the productive adaptation potential of fish towards local environmental aquaculture conditions. We uncover and describe trait-linked differences by the biotechnological comparison of rainbow trout strains selected for survival (local model strain BORN) and for growth (import commercial strain). Therefore, we perform phenotypic, immunological, and global transcriptome studies in healthy and moderately stressed fish. The experiments include typical stress parameters, such as pathogen impact (*A. salmonicida*), temperature fluctuations, and stocking rate differences. First results reveal significant strain specificity after most analyses (survival and growth, innate and adaptive immunity), and suggest different stress coping strategies. Furthermore, data indicate that in semi-open or open aquaculture, farming of locally adapted breeding strains is sustainable and in accordance with animal welfare. EFF pilot project VI-560/7308-4.

GENERATIONAL EFFECTS OF BISPHENOL A ON SOMATOTROPIC AND STRESS AXES FUNCTION IN RAINBOW TROUT

Vijayan, M.M., and Birceanu, O.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 9

Contact: Matt Vijayan **E-mail:** matt.vijayan@ucalgary.ca

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Abstract: Studies have shown that lipophilic contaminants are maternally transferred to developing offspring. However, the impact these contaminants have on development and long-term fish performances are not well understood. We tested the hypothesis that bisphenol A (BPA) accumulation in eggs, mimicking maternal transfer, will lead to disruption in the developmental programming of growth and stress axes functioning in rainbow trout (*Oncorhynchus mykiss*), and that these changes are passed on to the next generation. Oocytes accumulated 0, 0.8, 4.4 or 41.3 ng BPA egg⁻¹ and they were fertilized and maintained in BPA-free environment for F1 and F2 generations. BPA exposure reduced specific growth rate, disrupted transcript levels of genes involved in somatotrophic axis function and altered cortisol stress axis development and function in the F1 and F2 generations. The results demonstrate that ancestral exposure to BPA disrupts growth and stress performances in rainbow trout, leading to the proposal that epigenetic changes are involved.

TOWARDS AN EVOLUTIONARY BACKGROUND FOR DEPRESSION: ATLANTIC SALMON AND DEPRESSIVE-LIKE STATES

Vindas, M.A., Folkedal, O., Höglund, E., Gorissen, M., Flik, G., Braastad, B.O., Kristiansen, T.S., Øverli, Ø.

Symposium: Stress in Fish **Type:** Oral **Order:** 11

Contact: Marco Vindas **E-mail:** marcoav@ibv.uio.no

University of Oslo, Department of Biosciences, Blinderveien 6, NO-0316 Oslo Norway

Abstract: Learned helplessness is characterized by behavioural inhibition, deficits in coping and dysregulated neurobiological signalling. We sampled farmed Atlantic salmon twice at basal levels and acute stress conditions in order to analyse cortisol and serotonergic activity. Chronically elevated serotonergic activity was associated with inability to react further to a novel acute stressor in small subordinate individuals, along with a behavioural output reminiscent of learned helplessness. These small fish also had elevated plasma cortisol concentrations at basal levels and reacted to acute stress with increased cortisol levels. The ability to increase circulating cortisol levels without an accompanying increase in 5-HT neurotransmission likely makes the animal susceptible to negative effects of cortisol on brain function. The behavioural inhibition syndrome typical to depressive-like states may serve as an adaptive strategy which vulnerable individuals employ to decrease their exposure to unpredictable / uncontrollable challenges.

FRUSTRATIVE REWARD OMISSION INCREASES AGGRESSIVE BEHAVIOUR OF INFERIOR FIGHTERS

Vindas, M.A., Johansen, I.B., Vela-Avitua, S., Nørstrud, K.S., Aalgaard, M., Braastad, B.O., Höglund, E., Øverli, Ø.

Symposium: Stress in Fish **Type:** Poster **Order:** P135

Contact: Marco Vindas **E-mail:** marcoav@ibv.uio.no

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Abstract: In dominance contests individuals adjust their behaviour relative to resource value and own resource holding potential (RHP). Normally, smaller individuals have inferior fighting abilities compared to larger conspecifics. Affective and cognitive processes can alter contest dynamics. We investigated effects of omission of expected reward (OER) on individuals possessing a 36-40 % difference in RHP fighting for social dominance. Small control individuals displayed submissive behaviour and virtually no aggression. Small OER individuals were more aggressive, and 2 out of 11 became socially dominant. Increased aggression in small OER individuals was accompanied by increased serotonin levels in the dorsomedial pallium (proposed amygdala homologue), but no changes in limbic dopamine neurochemistry were observed in OER individuals. The behavioural and physiological response to OER in fish indicates that frustration is an evolutionarily conserved affective state. Moreover, our results indicate that aggressive motivation to reward unpredictability affects low RHP individuals strongest.

INCLUSION OF SOYBEAN MEAL IN ATLANTIC SALMON DIETS IS ASSOCIATED WITH THE PRODUCTION OF INFLAMMATORY MARKERS DETECTABLE IN FISH FECES

Wacyk, J., González, S. and Mercado, L.

Symposium: Growth and Metabolism **Type:** Oral **Order:** 17

Contact: Jurij Wacyk **E-mail:** jwacyk@u.uchile.cl

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Abstract: High inclusion of soybean meal in salmon diets is associated with reductions in nutrient digestibility and inflammatory responses in the digestive tract. In order to better understand the effects of plant protein use in carnivorous fish diets, the objective of the present study was to evaluate the effects of soybean meal inclusion in salmon diets over inflammatory markers in fish feces and if this was associated with differences in nutrient transporter gene expression in the proximal intestine. Three hundred and sixty *Salmo salar* juveniles (average weight 50 g) were randomly distributed among 6 tanks (150 L). The diets used were: control (fish meal) and experimental (30% soybean meal). Fecal samples of fish fed diets with soybean meal presented significantly higher levels of TNF- α than fish fed the control diets. While, no differences were observed for fecal levels of IL-8, another inflammatory marker. Gene expression data is being generated.

RISK-MEDIATED HABITAT SELECTION BY SEA LAMPREY DURING THE REPRODUCTIVE MIGRATION

Wagner, C.M., Luhring, T., Bals, J., Meckley, T., Nair, M.

Symposium: Lampreys **Type:** Oral **Order:** 6

Contact: Michael Wagner **E-mail:** mwagner@msu.edu

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Abstract: A basal vertebrate, the sea lamprey represents a model organism for integration of sensory and neurological mechanisms that ultimately regulate the acquisition and use of chemical information. To date, development of that model has focused almost entirely on attractant pheromones (odors of positive valence). Because animal decision-making involves active trade-offs between risks and opportunities, revelation of the full biological significance of chemical information requires the integration of countervailing signals (positive and negative) considered over natural scales. Through a large series of laboratory and field experiments we reveal the role of chemical risk information (a conspecific alarm cue) in mediating movements at two critical junctures during the reproductive migration: (1) when selecting a spawning watershed, where positive and negative signals overlap (conflicting information), and (2) when selecting a spawning stream at river confluences, where opposing signals contrast but are spatially distinct. We conclude a primary role of the alarm cue is to reveal recently degraded larval-rearing habitat. This conclusion stands in contrast to the general anticipation that alarm cues mediate predator-prey interactions alone.

FACTORS CONTRIBUTING TO THE OVERWINTER SUCCESS OF YOUNG-OF-THE-YEAR BROOK TROUT

Wagner, J.C. and Leonard J.B.K.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 4

Contact: Joseph Wagner **E-mail:** joswagne@nmu.edu

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Abstract: Winter can be an especially difficult season to endure for many fishes inhabiting streams at northern latitudes. However, our understanding of this critical time period is limited due to the logistics associated with winter field work. This study aimed to quantify winter stream conditions and evaluate their effect on the overwinter success of young-of-the-year brook trout (*Salvelinus fontinalis*). Single pass electrofishing surveys were conducted before and after the winter season. Fish were implanted with VI Alpha tags and the overwinter change in condition was determined using Fulton's condition factor (K). In-stream habitat features were examined and high-resolution ice condition data were generated using novel techniques. Results showed a significant difference in the overwinter condition change between streams (ANOVA, $p=0.004$). It was also demonstrated that ice conditions can vary tremendously, even within a small geographic region. Key habitat characteristics in ice covered streams were identified and possible implications were explored.

EFFECTS OF SEX PHEROMONES ON CIRCADIAN ELEMENTS OF LOCOMOTOR RHYTHMS IN THE SEA LAMPREY

Walaszczyk, E.J., Johnson, N.S., Steibel, J.P., Bussy, U., Li, K., Chung-Davidson, Y.-W., and Li, W.

Symposium: Lampreys **Type:** Poster **Order:** P98

Contact: Erin Walaszczyk **E-mail:** walaszcz@msu.edu

293 Farm Lane Room 158 Giltner Hall, Michigan State University, East Lansing, MI, 48824 USA

Abstract: As adult female sea lamprey undergo sexual maturation (ovulation), their activity pattern switches from nocturnal to arrhythmic. In nature, these females are exposed to sex pheromone compounds released by mature

males. Because the pineal complex regulates locomotor rhythmicity and sexual maturation in lampreys, we speculated that this organ interacts with pheromone detection to govern locomotion patterns. We elucidated the activity patterns of adult females across maturation and after pheromone exposure in field and laboratory studies. To examine the effects of pheromones on pineal neural circuitry, we measured molecular markers, neurotransmitters, and clock gene mRNA expression levels in the pineal complex, the brain, and the retina using RT-QPCR and LC-MS/MS. Our results demonstrated that pheromones reduce total activity in pre-ovulated and ovulated females and suppress the nocturnal locomotor rhythm in ovulated females. In addition, these pheromones affected the pineal gland neural circuitry and the expression of several clock genes in several tissues examined. This study was supported by the Great Lakes Fisheries Commission and NIGMS grant 1R24GM083982.

CL- UPTAKE MECHANISM IN NCC-EXPRESSING IONOCYTES IN ZEBRAFISH

Wang, Y.F., Yang, J.J., Tseng, Y. C., Chen, R. D., and Hwang, P. P.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 10

Contact: Wang Yi-Fang **E-mail:** wienwald@gmail.com

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Abstract: Cl⁻, the most abundant anion in animal body fluids, is well regulated in fish inhabiting aquatic environment with fluctuating Cl⁻ levels. Previous molecular physiological studies identified Na⁺-Cl⁻ cotransporter (NCC)-expressing cells as the major ionocytes carrying out Cl⁻ uptake function in fish. Recently in zebrafish, we cloned 12 members of clc chloride channels and among them only clc-2c was colocalized with NCC in the same ionocytes in the gill/skin by double in situ hybridization/immunocytochemistry. Acclimation to a low Cl⁻ environment stimulated the mRNA expression of both clc-2c and ncc (zslc12a10.2). Loss-of-function of clc-2c, similar to that of ncc, resulted in a significant decrease in Cl⁻ contents in zebrafish embryos. clc-2c knockdown stimulated ncc expression and ncc knockdown enhanced the expression of clc-2c, suggesting mutual compensation between the 2 transporters. Taken altogether, apical NCC and basolateral ClC-2C may collaborate to achieve the transepithelial Cl⁻ uptake mechanism in fish.

EVALUATION OF A HABITAT ENHANCEMENT IN COASTAL WETLANDS OF THE ST. LAWRENCE RIVER USING
INDIVIDUAL HEALTH METRICS OF PUMPKINSEED

Ward, T.D., Chapman, J.C., King, G.D., Midwood, J.D., Suski, C.D., Cooke, S.J.

Symposium: Fish Habitats **Type:** Oral **Order:** 7

Contact: Taylor Ward **E-mail:** taylor_ward@carleton.ca

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Abstract: The concept of contingency in restoration ecology contends that land use legacies, management actions and landscape setting all impinge on the successional trajectory of restored ecosystems; however the relative influence of each factor remains unclear. In this study we use the individual physiological health status of a ubiquitous model fish species (*Lepomis gibbosus*) to evaluate the success of a habitat enhancement initiative in the coastal wetlands of the St. Lawrence River. The use of individual health metrics (blood glucose, hematocrit, organosomatic indices and energy density) as an indicator of habitat condition represents a novel approach to characterizing restoration success.

MOLECULAR EQUIPMENT FOR CELL VOLUME-LINKED OSMOSENSING

Watanabe, S., Seale, A.P., Inokuchi, M., Grau, E.G., and Kaneko, T.

Symposium: Cellular Signalling **Type:** Oral **Order:** 8
Contact: Soichi Watanabe **E-mail:** watanabe@marine.fs.a.u-tokyo.ac.jp
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Abstract: For teleost fishes, osmoregulation is a fundamental function to survive. All osmoregulatory activities should be optimized according to the internal osmotic status, and it stands to reason that osmosensing is essential for proper osmoregulation. PRL is a hyperosmoregulatory hormone in teleosts, and its release from PRL cells can be altered by extracellular osmolality changes. This response requires cell volume changes and extracellular Ca²⁺. We have investigated molecular mechanisms for osmosensing in PRL cells, and revealed that AQP3 water channel contributes to the sensitivity of PRL-cell's osmosensing. We have also shown that TRPV4 stretch-activated Ca²⁺ channel is the triggering molecule for osmosensitive PRL release. The existence of the molecular equipment for osmosensing in PRL cells indicates that cell-autonomous PRL release regulation is the physiologically-functional system for osmoregulation control in teleosts. Additionally, extensive expression of these molecules implies that other osmoregulatory organs can also regulate their own activities by cell volume-linked osmosensing.

EFFECTS OF ICE COVER ON THE BEHAVIOUR AND GROWTH OF BROWN TROUT
Watz, J., Bergman, E., Piccolo J., and Greenberg L.

Symposium: Winter Fish Biology **Type:** Oral **Order:** 10
Contact: Johan Watz **E-mail:** johan.watz@kau.se
Karlstad University, Biology, SE-651 88 Karlstad Sweden

Abstract: During winter, predation risk from endothermic predators is high for juvenile salmonids, and as a result they become nocturnally active, with low foraging efficiency. Because surface ice may offer protection from endothermic predators, salmonids should react by increasing their daytime foraging activity and spend less energy on anti-predator behaviours, which may have consequences for growth. These predictions were tested in laboratory and field experiments using brown trout. In a laboratory flume, trout had lower ventilation rates and higher foraging activity in the presence of surface ice than in its absence. In a boreal forest stream, we suspended plastic sheeting over five 30-m-long stretches of the stream, and found that trout that had spent winter under this simulated ice cover grew better than trout in control stretches. We suggest that surface ice may play an important role in the overwinter survival rates of stream fish at high latitudes or altitudes.

EXPOSURE ROUTE PRODUCES DIFFERENT CARDIORESPIRATORY EFFECTS FOLLOWING ACUTE BENZO-A-PYRENE IN
ADULT ZEBRAFISH
Weber, L.P.

Symposium: Fish in a Toxic World **Type:** Oral **Order:** 4
Contact: Lynn Weber **E-mail:** lynn.weber@usask.ca
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Abstract: Recent evidence suggests polycyclic aromatic hydrocarbons (PAHs) may cause cardiorespiratory toxicity in larval fish. We examined whether PAHs also affect cardiorespiratory function in adult fish and whether exposure route affects this using the prototypical PAH, benzo[a]pyrene (BaP). Adult zebrafish were injected (i.p.) twice with increasing concentrations of BaP or exposed aqueously. After 48 hr, oxygen consumption (n=10 fish/treatment) or echocardiography (n=12 fish/treatment) were measured. Oxygen consumption (MO₂) was increased dose-dependently by injected BaP, particularly at higher swimming speeds. In contrast, aqueous BaP increased MO₂ at only basal conditions. Cardiac output and heart rate were significantly decreased in BaP-exposed fish with both exposure routes. However, BaP-injection caused cardiac arrhythmias and significant increases in CYP1A and SERCA2 cardiac expression, proteins associated with detoxification and cardiac calcium handling, respectively. In

contrast, BaP injection caused primarily suppression of cardiac contractility. Thus, although acute BaP exposure consistently impaired cardiorespiratory function in adult zebrafish, the primary mechanism differed with exposure route.

COMPARATIVE MORPHOLOGY OF PACIFIC HAGFISH IONOREGULATORY STRUCTURES
Weinrauch, A., and Goss, G.

Symposium: Hagfishes **Type:** Oral **Order:** 8
Contact: Alyssa Weinrauch **E-mail:** weinrauc@ualberta.ca
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Abstract: Hagfish present an opportunity to examine early evolution of vertebrates due to their basal phylogenetic position. Recently, anterior and posterior differences in acid/base regulation have been highlighted in Pacific hagfish (*Eptatretus stoutii*); however, a comprehensive analysis of tissue morphology for comparison with physiological studies has not previously been conducted. Light, scanning and transmission electron micrographs of important ionoregulatory tissues (the skin, intestine and gill) are highlighted here. The skin (75-125 µm) demonstrates a capacity for ion and nutrient transport. My results indicate the presence of specialized cells that fuse with the irregular surface. The intestine partitions all mucous cells in the foregut, utilizing the hindgut for absorption and digestion. Specialized cells containing acidophilic zymogen granules are present through the hindgut. Additionally, microplacae-decorated ciliated columnar cells line the gut although specialized pores are interspersed. Gill filaments are comprised of secondary and tertiary lamellae containing 40-60 lamellar folds while microplacae enhance surface area. However, the specific SEM identifiable MR cell architecture for other teleosts is absent in hagfishes.

LAKE NIPISSING AND LAKE ONTARIO WALLEYE: SIMILARITIES AND DIFFERENCES IN PROVISION OF FATTY ACIDS TO OVA

Wiegand, M.D., Johnston, T.A., Szmadyła, R.L., Porteus, L.R., Moles, M.D., and Leggett, W.C.

Symposium: General Contributed Papers **Type:** Oral **Order:** 6
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Abstract: Walleye (*Sander vitreus*) in Lakes Nipissing and Ontario produce ova with similar mass and fatty acid profiles, but pre-spawning Nipissing walleye have lower GSI (and thus fecundity) and HSI. We investigated whether provisioning of eggs with adequate essential polyunsaturated fatty acid (EFA) reserves in Nipissing walleye was at the expense of somatic tissue EFA proportions, or if ova composition was preserved by limiting GSI. We also compared pre-spawning somatic tissues between the sexes. There was no difference between populations in 20:4(n-6) (ARA) or 22:6(n-3) (DHA) percentages in either muscle or visceral fat, but muscle of females had lower DHA percentages than male muscle. Liver ARA and DHA percentages were greater in females than in males, likely reflecting vitellogenin production. Subsequently, we found that ratios of 20:5(n-3) (EPA) to ARA decreased in both ova and visceral fat after invasion of Lake Nipissing by the spiny water flea, *Bythotrephes longimanus*.

BIOSYNTHESIS OF 1ALPHA-HYDROXYCORTICOSTERONE IN LEUCORAJA OCELLATA EVIDENCE TO SUGGEST A NOVEL STEROIDOGENIC ROUTE

Wiens, J.K., Brassinga, A.K.C., and Anderson, W.G.

Symposium: Elasmobranchs **Type:** Oral **Order:** 18
Contact: Julia Wiens **E-mail:** wiensj34@myumanitoba.ca

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Abstract: Elasmobranch fish provide a challenging model for studies in comparative physiology and endocrinology for a number of reasons. Despite substantial effort the complete biosynthetic pathway for 1 α -hydroxycorticosterone in elasmobranch fish remains to be determined. Previous studies have demonstrated the presence of ureolytic bacteria in the liver of a number of different species including the little skate, *Leucoraja erinacea*, and bacterial modification of steroids is not an uncommon phenomenon in vertebrates. In the present study we demonstrate the presence of ureolytic bacteria in homogenates of renal and inter-renal tissue in the winter skate, *Leucoraja ocellata*. Six strains of bacterial isolates taken from, renal/inter-renal tissue or liver of the winter skate were incubated with known amounts of potential precursors to 1 α -hydroxycorticosterone. Only a single strain incorporated a steroid intermediate. This strain was from the genus *Rhodococcus* and the intermediate was 11-deoxycorticosterone. Data presented will propose a novel alternative pathway for the biosynthesis of 1 α -hydroxycorticosterone.

EXTREME AMMONIA TOLERANCE AND EVIDENCE OF ACTIVE AMMONIA EXCRETION BY THE PACIFIC HAGFISH
Wilkie, M.P., Clifford, A.M., and Goss, G.G.

Symposium: Hagfishes **Type:** Oral **Order:** 12

Contact: Michael Wilkie **E-mail:** mwilkie@wlu.ca

Department of Biology, Wilfrid Laurier University, Waterloo, Ontario, N2L 3C5 Canada

Abstract: The Pacific hagfish (*Eptatretus stoutii*) feeds on intermittent food falls of carrion (e.g. fish, large cetaceans) during which time it may experience extremely high ammonia while burrowing into the decomposing carcasses. We demonstrated that Pacific hagfish can withstand exposure to 20 mmol/L total ammonia (T_{amm}=NH₃+NH₄⁺) for 48h, during which time ammonia excretion (J_{amm}) was transiently inhibited, resulting in 100-fold increases in plasma [T_{amm}] to 5,000 μ mol/L. This increase in plasma T_{amm} resulted from NH₃ influx down massive inwardly directed PNH₃ gradients, which also led to a short-lived metabolic alkalosis. Plasma [T_{amm}] stabilized after 24-48 h by reducing NH₃ diffusing capacity (DNH₃) across the body surface, which lowered NH₃ influx, and by resumption of J_{amm} against inwardly directed PNH₃ and NH₄⁺ electrochemical gradients. We conclude that restoration of J_{amm} by the Pacific hagfish during ammonia exposure involves secondary active transport of NH₄⁺, possibly mediated by Na⁺/NH₄⁺ (H⁺) exchange.

EFFECTS OF A BLOOD DIET ON THE ACQUISITION OF SEA WATER TOLERANCE IN PARASITIC ANADROMOUS SEA LAMPREYS

Wilkie, M.P., Besaw, J., Medeiros, T., Hlina, B, and Pham-Ho, P.

Symposium: Lampreys **Type:** Oral **Order:** 4

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Abstract: Anadromous sea lampreys spend most of their life in fresh water (FW) as filter-feeding larvae prior to metamorphosing into juvenile lampreys that migrate to sea, where they feed on the blood of fishes. Because the non-trophic period of metamorphosis leads to depleted internal energy stores, we tested the hypothesis that feeding improves the capacity of juvenile lampreys to ionoregulate in sea water (SW). Accordingly, juvenile sea lampreys were allowed to feed on trout in brackish water (BW; 3.3 ppt) before being gradually acclimated to full-strength SW (33 ppt). In BW, feeding was accompanied by 50% greater rates of branchial Na⁺/K⁺-ATPase (NKA) activity compared to non-feeders. However, non-fed lamprey readily acclimated to SW, despite lower initial NKA activities. Moreover, there were no differences in plasma Cl⁻ concentration amongst the 2 groups. While feeding may enhance gill-mediated ionoregulation capacity in BW, initial results suggest it may not be essential for the acquisition of SW tolerance.

RED CELL pH REGULATION DURING THE POST-FEEDING ALKALINE TIDE

Wilson, R.W., Smith, C.R. and Urbina, M.A.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 27

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Abstract: The feeding-induced alkaline tide (initial rapid rise, then slower recovery of blood pH) is probably the most common acid-base disturbance fish experience, but the least studied. The alkaline tide may aid oxygen uptake at the gills (via a Bohr shift increasing haemoglobin's affinity for oxygen), but may be maladaptive for tissue oxygen delivery during metabolically demanding digestive processes. We therefore investigated whether freshwater rainbow trout regulate erythrocyte pH to maintain appropriate haemoglobin-oxygen binding characteristics following a voluntary meal. Erythrocytes experienced half the alkalosis of plasma (0.1 v. 0.2. pH units) at 2-h post feed, which followed the intracellular/extracellular relationship observed when bicarbonate was added to blood in vitro. However, erythrocyte pHi recovered by 6 h, whereas whole blood pH took >24 h to recover. Haemoglobin-oxygen saturation rose by 25% then recovered in synchrony with erythrocyte pHi. The mechanisms for regulating erythrocyte pH and oxygen delivery after feeding are being explored.

GENETIC ANALYSIS OF KIDNEY DEVELOPMENT USING THE ZEBRAFISH

Wingert, R.A., Bounds, R., Cihlar, J., Fox, A., McKernan, M. and Gerlach, G.F.

Symposium: Fish Kidney **Type:** Oral **Order:** 5

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Abstract: The kidney performs essential physiological roles. Nephrons, the basic structural and functional renal unit, are epithelial tubes with discrete regions: a blood filter comprised of podocytes, proximal and distal tubule segments of transporting epithelia that modify the filtrate, and a duct. The pathways that pattern nephron segments along the proximo-distal axis remain poorly understood. Zebrafish are a highly relevant genetic model for nephrology research because nephron segments are conserved with mammals, including humans. We performed a novel genetic screen to identify nephrogenesis genes using zebrafish and identified 45 prospective alleles associated with renal defects. Taken together, our collection will provide a useful resource to delineate the genes that direct nephrogenesis pathways, and may provide new models to study human congenital kidney defects.

DISCOVERY OF TRANSCRIPTION FACTORS FOR SEAWATER ACCLIMATION IN FISH INTESTINE VIA A
TRANSCRIPTOMIC APPROACH

Wong M.K.S., Ozaki H., Suzuki Y., Iwasaki W., Takei Y.

Symposium: Ion and Acid-Base Regulation **Type:** Oral **Order:** 18

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Abstract: Teleost intestine exerts multiple functions including osmoregulation. Seawater teleosts drink copiously and the imbibed water is absorbed via a sodium potassium chloride co-transport system. Signaling factors for

seawater acclimation are not known in the intestine and therefore, we use a transcriptomic approach to investigate the transcription factors in the intestine of medaka under a time-course (0h, 1h, 3h, 1d, and 7d) seawater transfer. Illumina Hi-Seq Sequencing was used to provide a deep coverage of identified genes and RNA-seq was performed to quantify the expression levels of all annotated genes. Over 50 transiently upregulated transcription factors were obtained at 1h and/or 3h seawater transfer. By quantitative PCR, we confirmed 5 transcription factors specific to seawater challenge, which will be further examined by knockdown experiments. Our results pioneer the knowledge of novel transcription factors that may have broad effects on various osmoregulatory organs.

NITROGEN METABOLISM OF THE TAMBAQUI

Wood, C.M., Netto, J.G. De S., Wilson, J., Almeida-Val, V., and Val, A.L

Symposium: Tropical Fish **Type:** Oral **Order:** 19

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Abstract: The characiform tambaqui (Serrasalminae) is immensely important in aquaculture and fisheries in tropical South America, but its nitrogen metabolism has been little studied. The fish is ammonotelic, excreting < 15% urea-N. Although highly tolerant to low pH, ion -poor water, and hypoxia, it is not highly resistant to ammonia toxicity. When exposed to sublethal ammonia (2.5 mmol L⁻¹, pH 7.0), ammonia excretion (M_{amm}) is restored to greater than baseline levels after 10h, but there is no increase in urea-N excretion (M_{urea-N}). M_{amm} peaks at 4-6h post-feeding, reaches stable levels within 24h during 8d of fasting, decreases during acute hypoxia (25% saturation), increases greatly during acute temperature increases (28-33-38°C), but does not change during increasing levels of aerobic exercise. M_{urea-N} exhibits very different patterns. Protein oxidation supports a surprisingly high 60-80% of aerobic metabolism at rest, and this drops markedly during exercise (INCT ADAPTA – CNPq/FAPEAM; Ciência sem Fronteiras).

SHORT- AND MEDIUM-TERM EFFECTS OF AN ANOREXIGENIC FACTOR ANTAGONIST AND ARGININE SUPPLEMENTATION ON CHOLECYSTOKININ, NEUROPEPTIDE Y AND LEPTIN GENE EXPRESSION, IGF-I SECRETION AND GROWTH PERFORMANCE IN RAINBOW TROUT

Wood, J.D., Alvarez, M., Olivares, G., Wacyk, J.

Symposium: Fish Culture **Type:** Oral **Order:** 5

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Abstract: Groups of rainbow trout were fed a control diet, arginine-supplemented diet or a diet containing the cholecystokinin antagonist proglumide and a fourth group fasted for 28 days. Fish fed the antagonist diet had the highest feed intake, highest SGR and highest IGF-I levels. Highest FCE was for the control group (1.03) followed by the antagonist fed group (1.06). Overall neuropeptide Y gene expression was on average 10.5% higher in fish fed the antagonist diet compared with the arginine-supplemented diet. No significant differences were found in cholecystokinin expression between fed groups. Leptin expression was lowest in fasted fish but not significantly. The study shows that proglumide treatment can modify the appetite/satiety balance in rainbow trout. This is the first time that beneficial effects on growth performance and IGF-I levels have been observed using an anorexigenic hormone antagonist in a salmonid.

TROPICAL FISH EMBRYOS ON LAND: TERRESTRIAL EMBRYO DEPOSITION ENHANCES DEVELOPMENT IN THE
AMPHIBIOUS FISH *KRYPTOLEBIAS MARMORATUS*

Wright, P., M. Wells and A. Turko

Symposium: Tropical Fish **Type:** Oral **Order:** 20

Contact: Patricia Wright **E-mail:** patwrith@uoguelph

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Abstract: Few teleost fishes incubate embryos out of water, but the oxygen-rich terrestrial environment could provide advantages for early growth and development. We used the amphibious mangrove rivulus, *Kryptolebias marmoratus* to test the hypothesis that embryonic oxygen uptake is limited in aquatic environments relative to air. Adult mangrove rivulus released 2-fold more embryos in terrestrial vs aquatic environments and terrestrially-reared embryos had accelerated developmental rates. Surprisingly, terrestrially-reared embryos consumed less oxygen and possessed larger yolk reserves. Water-reared embryos moved more compared to air-reared embryos at 7 days post release, likely contributing to higher rates of oxygen uptake. The embryonic rearing environment did not affect adult growth, reproduction or survival in air. These results suggest that exposure to an oxygen-rich terrestrial environment is less energetically costly than development in water with no obvious long-term consequences.

THE ROLE OF RHESUS GLYCOPROTEINS IN AMMONIA BALANCE IN DOGFISH SHARK IN RESPONSE TO HYPO-
OSMOTIC STRESS

Wright, P.A., Lawrence, M.J., Currie, S., MacLellan, R., Wood, C., and Edwards, S.

Symposium: Elasmobranchs **Type:** Oral **Order:** 15

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Abstract: Marine elasmobranchs synthesize and retain urea to counterbalance the osmotic stress of seawater. Ammonia excretion is very low in marine elasmobranchs, as ammonia is scavenged to make urea. Do Rh proteins regulate ammonia permeability in elasmobranchs? We tested the hypothesis that Rhcg is critical for ammonia retention or excretion and expression is regulated to maintain ammonia homeostasis with changing external salinity in dogfish sharks. Plasma urea and osmolarity significantly decreased with hypo-osmotic stress (70% SW), but plasma ammonia and ion levels were unchanged. As well, skeletal muscle urea levels but not ammonia levels were significantly reduced (-34%). Using the Rhcg hagfish-specific antibody, we found apical staining in gill interlamellar filament cells and renal tubule cells. The Na⁺H⁺ exchanger (NHE2) co-localized with Rhcg in renal cells. This is the first report of Rhcg localization in elasmobranch tissues. The possible role of Rhcg in ammonia transport in elasmobranchs will be discussed.

MATURATION SHIFTS IN A TEMPERATE MARINE FISH STOCK CANNOT BE EXPLAINED BY WARMING TEMPERATURES
ALONE

Wright, P.J., Tobin, D., Palmer, SCF, Marshall, CT

Symposium: Environmental Change **Type:** Oral **Order:** 18

Contact: Peter Wright **E-mail:** P.J.Wright@marlab.ac.uk

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Abstract: Downward shifts in maturation reaction norms have occurred at a time of high exploitation and increasing sea temperatures. A prediction of expected maturation change due to environment could help to disentangle possible genetic and environmental influences. Changes in FSH expression in haddock (*Melanogrammus aeglefinus*) indicate that this species commits to maturation by the autumn equinox prior to spawning. Temperature trials during the summer found that this factor explained most variation in maturation commitment. The relevance of this to the field

was explored using a stochastic, individual-based simulation model of growth and maturity, incorporating the experimentally determined temperature-dependent maturation threshold. Although the model explained some of the high-frequency variation, the interaction between the observed warming trend and maturation was insufficient to account for the magnitude of the long-term increase in proportion mature. An increasing departure between predicted and observed proportion mature over recent decades suggests a long-term decline in the maturation – state threshold, possibly reflective of some genetic change.

OXIDATIVE DEFENSE OF SMTB AND MT2, AND OTHER ANTI-OXIDATIVE RESPONSES IN THE GILLS AND BRAIN
TISSUES UPON CADMIUM EXPOSURE ON ZEBRAFISH
Wu S.M., Shu L.S. and Liu J.H.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P45
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Abstract: Fish were exposed with 0 and 1.78 μM Cd. On gills, the ROS was not significantly change, but the LPO levels were significantly increased at 1- and 6- h upon Cd exposure. The SOD and GPx were significant up-regulated upon 1- and 3- h of Cd exposure, respectively, the CAT were not change, GPx were recovered as control level upon 6 h of Cd exposure. On brain, the ROS were significantly increased from 1 to 6 h upon Cd exposure. On the contrary, LPO levels were significantly higher than control only at 6 h of Cd exposure. The SOD showed significantly higher than control at 3 h of Cd exposure, but the CAT and GPx were significantly increased at 1-3 h of Cd exposure. Include brain and gills, their mt-2 and smt-B gene expressions were increased significantly only at 3 h, and recovered at 6 h upon Cd exposure. We accorded the changes of anti-oxidative responses, and suggested the mt-2 and smt-B, both play a function on the anti-oxidation responses upon cadmium exposure.

THE PSEUDOBRENCHS OF EURYHALINE SILVER MOONY AND MOZAMBIQUE TILAPIA WITH SALINITY-DEPENDENT
MORPHOLOGY AND ION TRANSPORTERS EXPRESSION
Yang, S.H., Kang, C.K., Yen, L.C., and Lee, T.H.

Symposium: Ion and Acid-Base Regulation **Type:** Poster **Order:** P90
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Department of Life Sciences, National Chung Hsing University, Taichung 402 Taiwan

Abstract: In the euryhaline silver moony (*Monodactylus argenteus*), the pseudobranch belongs to the lamellae semi-free type: one row of filaments on the opercular membrane and fusion occurs on the buccal edge. The pseudobranchial epithelium of the moony contains two types of Na^+ , K^+ -ATPase (NKA) rich cells: chloride cells (CCs) and pseudobranch type cells (PSCs). While the pseudobranch of Mozambique tilapia (*Oreochromis mossambicus*) belongs to the embedded type containing only the PSCs. Our results revealed that numbers and sizes of CCs, NKA expression, and ion transporters for Cl^- secretion increased in the pseudobranchs of SW-acclimated silver moony, indicating the potential roles of the pseudobranchs containing CCs for hypo-osmoregulation. On the other hand, increase in numbers and sizes of PSCs in the FW-acclimated moony and Na^+ , H^+ exchanger expression of FW-acclimated tilapia demonstrated that PSCs might function in ion-uptake as well as acid secretion.

ONTOGENETIC TRANSITION FROM AQUATIC TO AMPHIBIOUS LIFE IN THE MUDSKIPPER
Yokouchi, K.

Symposium: Airbreathing Fish **Type:** Oral **Order:** 5

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Abstract: This study aimed to observe behavioral, morphological and biochemical changes during transition from aquatic to amphibious life in the mudskipper, *Periophthalmus modestus*. Transition from pelagic to demersal living occurred 30 days after hatching (stage I), which was followed by exploring water's edge in 1.5 days afterwards (stage II). Oriented movement on land started in further 3 days (stage 3), and finally the fish started feeding on land in 12 days (stage IV). Body morphology transformation during transition included rostral to ventral movement of the mouth, lateral to dorsal movement of the eyes, and development of a muscular stem of the pectoral fin. Whole-body content of triiodothyronine increased with time, while thyroxin peaked at stages III and IV. Confinement of larvae in normoxic water till 70 days after hatching did not affect survival, timing of shifting to benthic mode of life or gross anatomy.

CLONING OF SEX RELATED GENES AND THE DIMORPHIC EXPRESSION ANALYSIS IN OLIVE FLOUNDER

You, F., Wen, A.Y., Wang, L.J., Weng, S.D., Zou Y.X., Wu Z.H., Zhang P.J.

Symposium: Reproductive Physiology

Type: Oral

Order: 10

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Abstract: Some genes including *dmrt1*, *dmrt4*, *sox9*, *dax1*, *Ftz-f1*, *wnt4* and *lhx1* were cloned from olive flounder. Expression analysis showed these genes and *cyp19a* are sex-related. Among them, *dmrt1*, *dmrt4*, *sox9* and *lhx1a* were male-biased genes while others were female-biased genes, similar to the result of transcriptome analysis. Notably, *dmrt1* expression was 70 times higher in testis than in ovary ($P < 0.05$), and mRNA was detected clearly in spermatocytes and Sertoli cells. *Cyp19a* expression level was 40 times higher in ovary than in testis ($P < 0.01$), and mRNA was detected clearly in follicular cells in ovary. The CpG methylation levels of *dmrt1*, *cyp19a* and *dmrt4* were consistent with their expression levels in gonads. However, *sox9* and *dax1* promoter CpGs in testis and ovary were totally demethylated, inconsistent with their differential expression patterns. These genes showed different expression patterns during gonad differentiation period and gonad five developmental stages. It is implied that these genes could play important roles during the two periods.

QUANTIFICATION OF VARIATION OF METABOLIC ENZYMATIC ACTIVITIES IN LIVER OF BLUE TILAPIA IN RESPONSE TO LONG-TERM THERMAL ACCLIMATISATION

Younis, E.M.

Symposium: Fish Culture

Type: Oral

Order: 6

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Abstract: The effects of rearing temperature on white muscle and hepatic Phosphofructokinase (PFK), Pyruvate kinase (PK), Lactate dehydrogenase (LDH), Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) were examined in fingerlings of blue tilapia, *O. aureus*. The experiment was conducted for 14 weeks at temperatures of 18, 22, 26, 30 and 34 °C. The activity of the glycolytic enzymes PFK, PK and LDH in white muscle increased significantly with the increase in water temperature. A reverse trend was observed for these enzymes in the liver, except for LDH, which behaved in the same manner as in white muscle. Cytosolic AST and ALT activity increased in both white muscle and liver in response to warm thermal acclimatisation, while a reduction in mitochondrial AST and ALT activity was noticed at high temperatures in comparison with those at a lower temperature.

HISTOPATHOLOGICAL ALTERATIONS IN THE LIVER AND INTESTINE OF THE NILE TILAPIA EXPOSED TO LONG-TERM
SUBLETHAL CONCENTRATIONS OF CADMIUM CHLORIDE

Younis, E.M.; Abdel- Warith, A.A.; AL-Asgah, N.A.; Ebaid,H.

Symposium: Fish in a Toxic World **Type:** Poster **Order:** P46

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Abstract: Fingerlings of Nile tilapia *Oreochromis niloticus* were exposed to 2.68, 3.36 and 5.04 mg/L of cadmium chloride (CdCl₂), which represent 10, 20 and 30% of previously determined 96-h LC₅₀ for the same fish species. The experiment was conducted for 20 days, before sections of the liver and intestine of treated fish were investigated. The hepatic tissues of fish exposed to 10 % LC₅₀ showed markedly increased vacuolations into hepatocytes. In addition, the cytoplasm was characterized by coarse granules and vacuoles. Abundant erythrocytic infiltration was clearly observed in hepatocytes of fish exposed to 20% LC₅₀. The intestinal tissues from fish exposed to all doses showed proliferated and greatly increased goblet cells, the longitudinal muscularis was disturbed, and there was an increase in degenerated nuclei and apoptosis in crypts of the sub-mucosal layer. Moreover, an increase in the inflammatory cells and dilated blood vessels was observed in the group treated with 30% LC₅₀. The histopathological alterations varied between slight, moderate and severe structural changes.

THE USE OF CAT'S CLAW IN THE FEEDING OF TROPICAL FISH: GROWTH AND IMMUNE RESPONSE

Yunis, A.J., Claudiano, S.G., Silas, E.F., Fernandes, M.P., Fernandes, T., Manrique, W., Fernandes, D.C., Ruas de Moraes, F., Engracia de Moraes, J.

Symposium: Tropical Fish **Type:** Oral **Order:** 8

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Via de Acesso Prof.Paulo Donato Castellane s/n 14884-900 - Jaboticabal, SP Brazil

Abstract: This study aimed to evaluate the effect of the toxicity of *U. tomentosa* in fish and its effect on growth performance and immune response in tilapia. The quantification of the active compounds of the plant was carried out by chromatography. The aqueous extract was considered practically nontoxic to *Hyphessobrycon eques* (LC₅₀ = 18.16 g/L). To determine the best period of feeding, it was analyzed the cellular component and haematological parameters in aerocistite in tilapia and it was found that the maximum accumulation of cellular and best hematologic results occurred after three weeks. To evaluate the effect of this plant on immune activity and growth performance of Nile tilapia, we used 450 fish (81.3 ± 4.5g) randomly distributed at 25 fish per 1500-L tank and fed diet containing 0.0, 75, 150, 300 and 450 mg/kg diet for 3 weeks. After the 3-week experimental period, fish of each treatment were challenged by inactivated *Streptococcus agalactiae*. Samples were taken at 6, 24 and 48 hours. We found a dose-dependent response of blood leukocytes after 6 hours post-inoculation. However, the highest levels were at 24 hours. Further, splenic melanomacrophage centers were significant higher in size and number in treated groups. Furthermore, a significant increase of IgM expression in spleen was detected at 24 hours in supplemented fish with 300 and 450 mg/Kg diet. There were no histopathological lesions in any treatment in gills, intestine, spleen and liver. We found an unexpected increase of weight gain that would be explained, partially, due to increase of intestinal villus size. We concluded that *Uncaria tomentosa* added to Nile tilapia diet, particularly 300 mg/kg feed for 3 weeks, activates non-specific immunity, growth as well as specific immune response. Additionally, histopathological results suggest that the plant could be used orally without undesirable side effects.

LITHIUM CHLORIDE EXPOSURE AFFECT CAUDAL FIN REGENERATION IN *CORYDORAS AENEUS*: AN
ULTRASTRUCTURAL STUDY

Symposium: Environmental Change **Type:** Poster **Order:** P28

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Abstract: In the present study we examined the effects of lithium chloride on the *Corydoras aeneus* caudal fin regeneration. After caudal fin amputation, the fish were exposed 3 hours daily to 35 mM lithium chloride for 9 days. The effects of lithium chloride treatment were evaluated by analyzing the caudal fin ultrastructure at 3, 6 and 9 days after amputation. Comparison of normal and LiCl treated fish, clearly shows that regeneration of amputated caudal fins was inhibited or delayed after lithium treatment. By the third day after amputation (dpa) in the LiCl treated fish loss of cell attachment and appearance of expanded intercellular spaces were observed between epidermal cells. Moreover, in LiCl treated fish many blastemal cells showed cytoplasmic vacuolation. At six dpa, no lepidotrichial matrix was observed in LiCl treated fish. Instead, many apoptotic cells and cells exhibited a micronucleus-like structure were seen in the blastema.

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12th
International
Congress on the
Biology of Fishes

June 12-16, 2016
Texas State University
San Marcos, Texas USA



San Marcos is located in the “Heart of Texas”, 50 km southwest of Austin and 80 km northeast of San Antonio. It is home of Texas State University, a comprehensive, public university with an enrollment of 35,000 students.

The conference will be held on the campus in the Lyndon Baines Johnson Student Center. Dormitory rooms will be available nearby, and hotel rooms will be available in town. Social activities will include a welcome reception at the Witliff Gallery on campus and a traditional Texas BBQ on Spring Lake, the headwaters of the San Marcos River.

The Austin airport (AUS) provides easy connections to most US gateway airports, and has daily nonstop flights to and from London and Mexico City. The San Antonio airport (SAT) also offers flights from many of the US gateway airports, Guadalajara, and Mexico City.

The conference will operate a van service for attendees. Vans may be reserved for trips to and from the airports, Austin, and San Antonio. A fee will be charged to cover expenses. Shuttling to and from hotels, the BBQ, and field trips will be free to registered attendees.

Things to see and do while in the “Heart of Texas:

- **Float the San Marcos River - a crystal-clear, constant 21 C, spring-fed river that passes through the campus**
- **Visit San Antonio – The River Walk, The Alamo, San Antonio Zoo, The Mission Trail, Fiesta Texas & Seaworld**
- **Visit Austin – The University of Texas, Barton Springs, Lady Bird Johnson Wildflower Center, Congress Avenue bat flights**
- **Take in the nightlife on the San Marcos Square**

Conference field trips:

- **San Marcos Aquatic Resources Center – A US Fish & Wildlife Service facility dedicated to research and conservation of endangered species**
- **AE Wood State Fish Hatchery – A state-of-the-art fish hatchery operated in San Marcos by the Texas Parks & Wildlife Department**

The Physiology Section of the American Fisheries Society

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- Past Congress Proceedings

- 2014 – Edinburgh, Scotland
- 2012 – Madison, Wisconsin
- 2010 – Barcelona, Spain
- 2008 – Portland, Oregon
- 2006 – St. John's, Newfoundland
- 2004 – Manaus, Brazil
- 2002 – Vancouver, British Columbia
- 2000 – Aberdeen, Scotland
- 1998 – Baltimore, USA
- 1996 – San Francisco, California
- 1994 – Vancouver, British Columbia