PROGRAMME AND ABSTRACT BOOK

MORPHOLOGY MEETS PHYSIOLOGY: A TRIBUTE TO PIERRE LAURENT
30 JUNE – 1 JULY 2017
UNIVERSITY OF GOTHENBURG, SWEDEN

MORPHOLOGY MEETS PHYSIOLOGY: A TRIBUTE TO PIERRE LAURENT

SOCIETY FOR EXPERIMENTAL BIOLOGY

MORPHOLOGY MEETS PHYSIOLOGY: A TRIBUTE TO PIERRE LAURENT

ORGANISED BY:
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HAROLD BERGMAN
UNIVERSITY OF WYOMING, UNITED STATES
MARTIN GROSELL
UNIVERSITY OF MIAMI, UNITED STATES

MEETING SPONSORED BY:

DELEGATE INFORMATION

BADGES

Participants are required to wear name badges at all times for proof of registration, security purposes and catering identification.

Name badges will contain a barcode which will be scanned on entry each day to record attendance at meeting for SEB administrative purposes only.

CATERING

Lunch and refreshments during the satellite meeting are included in your registration fee and will be served in the breakout area.

CONFERENCE DINNER

The conference dinner cruise on M/S S:t Erik will be departing from the Lilla Bommens Quay (Address: 411 04, Gothenburg) at 18:30 so please meet at the Quay at **18:15**. The dinner will include a Swedish buffet, drinks and entertainment and will return to the Quay at 21:30.

CERTIFICATE OF ATTENDANCE

Delegates requiring a certificate of attendance should visit the SEB registration desk on their departure.

VENUE

Botanical Building
University of Gothenburg
Carl Skottsbergs gata 22B
413 19 Göteborg, Sweden

The scientific sessions will be taking place in the Auditorium on the ground floor. The poster session will be taking place in the breakout area.

LIABILITY

Neither the Society for Experimental Biology nor the University of Gothenburg will accept responsibility for damage or injury to persons or property during the meeting. Participants are advised to arrange their own personal health and travel insurance.

PHOTOGRAPHY

No photographs are to be taken of the speakers and their slides during the meeting.

**Please note: The SEB will be taking photos during the event for promotional purposes. If you have any concerns, please visit the SEB registration desk.*

POSTER SESSION

The poster session will be taking place in the breakout area between 17:30 – 19:00 on Friday 30 June. Poster presenters are invited to hang their poster on their arrival (Velcro will be provided) and are asked to remove their posters by 17:00 on Saturday 1 July. Any posters left behind will be disposed of.

REGISTRATION

The registration desk will be open during the hours of the meeting and a SEB staff member will be on hand during the refreshment and lunch breaks should you require any assistance.

TWITTER

We're looking to increase the conversation at the meeting using Twitter so please get tweeting!
Follow the conversation **#SEBGILLS**
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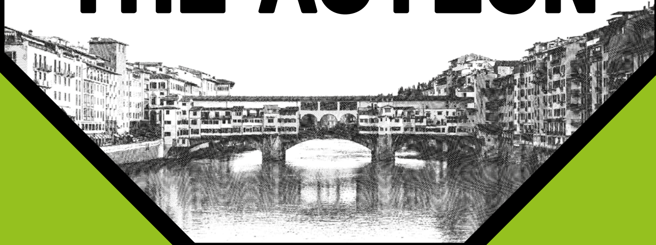

SESSION TOPICS WILL INCLUDE:

SCIENCE ACROSS BOUNDARIES – ANIMAL, PLANT AND CELL BIOLOGY

METABOLIC DIVERSITY
(ANIMAL, PLANT AND CELL BIOLOGY)

STRESS: FROM CELLULAR MECHANISMS TO ORGANISMAL RESPONSES AND CONSERVATION
(ANIMAL AND CELL BIOLOGY)

- PUMPING IONS AS A RESPONSE TO STRESS FROM AQUATIC HABITAT TRANSITIONS: CELLULAR AND MOLECULAR MECHANISMS RELATED TO EVOLUTIONARY CHANGES
- THE ROLE OF THE MITOCHONDRIA IN ENVIRONMENTAL ADAPTATION AND DISEASE
- ADVANCES IN NON-INVASIVE MONITORING OF STRESS IN THE FIELD AND LABORATORY: APPLICATIONS FOR CONSERVATION

GENERAL CELL AND PLANT BIOLOGY
(CELL AND PLANT BIOLOGY)

ANIMAL BIOLOGY

BIOMECHANICS

- BIOMECHANICS AND CLIMATE CHANGE
- OPEN BIOMECHANICS

PROXIMATE AND ULTIMATE DRIVERS OF BEHAVIOUR

- GENERALITY OF THE 'PACE-OF-LIFE SYNDROME'
- INTRASPECIFIC VARIATION IN RESPONSES TO STRESS: WHY INDIVIDUALS MATTER?
- THE ROLE OF INDIVIDUAL VARIATION IN THE BEHAVIOUR OF ANIMAL GROUPS

THERMOBIOLOGY

- CARDIO-RESPIRATORY ADAPTATIONS TO ENVIRONMENTAL CHANGE
- MITOCHONDRIA IN CHANGING CLIMATES: BIOSENSORS AND MEDIATORS OF ANIMAL RESILIENCE
- OCEAN WARMING AND ACIDIFICATION: WHAT UNDERLYING MECHANISMS CAN REVEAL ABOUT IMPACTS OF MULTIPLE STRESSORS

OTHER ANIMAL BIOLOGY SESSIONS

- OPEN ANIMAL BIOLOGY

PLANT BIOLOGY

- CLIMATE CHANGE IMPACT ON URBAN AND NATURAL FORESTS
- ENHANCING PLANT PHOTOSYNTHESIS WITH BIOPHYSICAL CO_2 CONCENTRATING MECHANISMS
- EPIGENETIC MEMORY AND ENVIRONMENTAL ADAPTATION
- FROM GENOME TO GENOMES
- MORPHOGENESIS IN NON-FLOWERING PLANTS
- PLANT BIOTECHNOLOGY FOR HEALTH AND NUTRITION
- PLANT TEMPERATURE PERCEPTION AND RESPONSES
- SHAPING ROOT ARCHITECTURE – FROM NUTRIENT SENSING AND TROPISMS TO SYSTEMIC SIGNALS AND DECISION MAKING

CELL BIOLOGY

- FUNCTIONAL ORGANISATION OF THE NUCLEAR PERIPHERY
- GREEN MICROBES
- SEQUENCING FROM LAB TO FIELD AND THE POST GENOMIC ERA
- SYSTEMS ANALYSES OF MULTICELLULARITY COMPLEXITY
- QUANTITATIVE SYNTHETIC BIOLOGY

SEB+

- BIOLOGY EDUCATION AND CLASS SIZE: CHALLENGES, OPPORTUNITIES AND STRATEGIES FOR SCALING TEACHING
- CAREER DEVELOPMENT WORKSHOPS FOR YOUNG RESEARCHERS
- DIVERSITY DINNER
- EMBRACING YOUR ETHICAL REVIEW BODY - A WIN-WIN SITUATION
- MEET THE ACADEMICS

PROGRAMME

FRIDAY 30 JUNE

08:15 REGISTRATION

08:45
Opening remarks
Chris Wood
University of British Columbia, Canada
Harold Bergman
University of Wyoming, United States

CHAIR: CHRIS WOOD

09:00
PLENARY LECTURE
Steve Perry
University of Ottawa, Canada
The morphology-physiology interface at the gill
AS17.1

09:40
Jonathan Wilson
Wilfrid Laurier University, Canada
Pierre and the pavement cell as an ionocyte
AS17.2

10:05
Junya Hiroi
St. Marianna University School of Medicine, Japan
Immunohistochemistry of ion and ammonia transporting cells in teleost fish
AS17.3

10:30 REFRESHMENT BREAK/POSTERS

CHAIR: HAROLD BERGMAN

11:00
Tobias Wang
Aarhus University, Denmark
The Asian swamp eel (*Monopterus albus*): A peculiar air-breathing fish from South East Asia with numerous strange adaptations
AS17.4

11:25
Gudrun De Boeck
University of Antwerp, Belgium
When ecotoxicology meets morphology: lessons learned from Pierre Laurent
AS17.5

11:50
John Steffensen
University of Copenhagen, Denmark
Morphology versus swimming physiology
AS17.6

12:15
Cosima Porteus
University of Exeter, United Kingdom
Gill neuroepithelial cells: a history and a look ahead
AS17.7

12:40 LUNCH/POSTERS

PROGRAMME

CHAIR: DANIELLE MCDONALD

14:00
Greg Goss
University of Alberta, Canada
Integrating gill morphology and ion transport – the long road to molecular identification of gill Na^+ transporters
AS17.8

14:25
Kathleen Gilmour
University of Ottawa, Canada
Localization of carbonic anhydrase isoforms in the fish gill: consequences for physiological function
AS17.9

14:50
Jehan-Hervé Lignot
University of Montpellier, France
The effects of acute transfer to freshwater on ion transporters of the pharyngeal cavity in European seabass (*Dicentrarchus labrax*)
AS17.10

15:15
M C Subhash Peter
University of Kerala, India
Understanding the cortisol-driven integrative Na^+ transport in osmoregulatory epithelia of air-breathing fish
AS17.11

15:30
Alyssa Weinrauch
University of Alberta, Canada
Characterisation of post-prandially induced changes in whole animal physiology and hindgut morphology of the Pacific hagfish (*Eptatretus stoutii*)
AS17.12

15:45 REFRESHMENT BREAK/POSTERS

CHAIR: DAVID RANDALL

16:15
Sandra Fehsenfeld
University of British Columbia, Canada
Goldfish renal tubules and acid-base regulation – more than meets the eye
AS17.13

16:30
William Marshall
St Francis Xavier University, Canada
Morphology and function of the paracellular pathway in salt-secreting cell complexes of euryhaline fish exposed to hypersaline conditions: Regulation by accessory cells
AS17.14

16:45
Mikkel Thomsen
Aarhus University, Denmark
The lactate ventilatory response – New clothes for an old friend
AS17.15

17:00
Robert Shadwick
University of British Columbia, Canada
Using morphology to infer physiology of large whales
AS17.16

17:30 END OF DAY 1

17:30 – 19.00
Poster session and drinks
Chair: Jonathan Wilson

PROGRAMME

SATURDAY 1 JULY

08:45 REGISTRATION

CHAIR: JONATHAN WILSON

09:00
Danielle McDonald
RSMAS University of Miami, United States
Urea pulsing in toadfish: physiology, morphology, and the contributions of Pierre Laurent
AS17.17

09:25
Martin Tresguerres
Scripps Institution of Oceanography, United States
Cell biology meets physiology: novel cellular mechanisms involving sAC and V-type H^+ ATPase in aquatic animals
AS17.18

09:50
Colin Brauner
University of British Columbia, Canada
Ontogeny and paleophysiology of the chordate gill
AS17.19

10:15
Warren Burggren
University of North Texas, United States
Cardio-respiratory physiological phenotypic plasticity in developing airbreathing anabantid fishes (*Betta splendens* and *Trichopodus trichopterus*)
AS17.20

10:30 REFRESHMENT BREAK/POSTERS

CHAIR: DAVID RANDALL

11:00
Ora Johannsson
University of British Columbia, Canada
It takes a team to study a fish: Air-breathing in the Lake Magadi tilapia, *Alcolapia grahami*
AS17.21

11:15
Milica Mandic
University of Ottawa, Canada
Control of the hypoxic ventilatory response in larval zebrafish (*Danio rerio*) via hypoxia-inducible factor 1α
AS17.22

11:30
John Buckland-Nicks
St Francis Xavier University, Canada
The adipose fin as a precaudal flow sensor
AS17.23

11:45
Göran Nilsson
University of Oslo, Norway
Rapid and adaptive structural changes in fish gills
AS17.24

12:10 LUNCH/POSTERS

PROGRAMME

CHAIR: HAROLD BERGMAN

13:30
Michael Wilkie
Wilfrid Laurier University, Canada
Exploiting basic knowledge of the gill to reveal how fishes cope with natural and anthropogenic stressors in aquatic ecosystems
AS17.25

13:55
Lauren Chapman
McGill University, Canada
Phenotypic plasticity in cichlid gills in response to hypoxia and elevated water temperature
AS17.26

14:20
Jodie L Rummer
James Cook University, Australia
Phenotypic plasticity at the gills of coral reef fishes and links to altered performance in response to anthropogenic stress
AS17.39

14:45
Nicholas Carey
Hopkins Marine Station Stanford University, United States
The filter-feeding anatomy of the anchovy *Engraulis mordax*: changes to swimming kinematics under increased hydrodynamic drag
AS17.28

15:00 REFRESHMENT BREAK/POSTERS

CHAIR: CHRIS WOOD

15:30
Le My Phuong
Aarhus University, Denmark
Gill plasticity in the air-breathing striped catfish *Pangasianodon hypophthalmus*
AS17.29

15:45
Catherine Lorin-Nebel
Montpellier University, France
How do European sea bass *Dicentrarchus labrax* cope with freshwater environments?
AS17.30

16:00
David J McKenzie
CNRS Montpellier, France
Swimming versus air-breathing in fishes
AS17.31

16:25
Concluding remarks
David Randall and Claudine Chevalier

17:00 CLOSE OF MEETING

18:15 – 21.30
Conference Dinner Cruise on M/s S:t Erik
Departure meeting point: Lilla Bommens Quay, 411 04, Gothenburg
Meet at Quay Lilla Bommens by 18:15 for departure at 18:30

POSTER SESSION FRIDAY 30 JUNE

Pazit Con
The Hebrew University, Israel
Expression and localization of peptide transporters (PepTs) during Mozambique tilapia (*Oreochromis mossambicus*) larval development
AS17.33

Tamzin Blewett
University of Alberta, Canada
Understanding the mechanisms of toxicity from hydraulic fracturing flowback and produced waters on aquatic biota
AS17.34

Junho Eom
University of British Columbia, Canada
The mechanism of ventilation in the Pacific Hagfish (*Eptatretus stoutii*)
AS17.35

Marina Giacomin
The University of British Columbia, Canada
Salinity acclimation and hypoxia tolerance in the killifish Fundulus heteroclitus
AS17.37

Alex M Zimmer
University of Ottawa, Canada
Breathing with your fins? Exploring the role of an unexpected structure in ventilatory function in larval fish
AS17.38

MORPHOLOGY MEETS PHYSIOLOGY – A TRIBUTE TO PIERRE LAURENT

AS17.1 THE MORPHOLOGY-PHYSIOLOGY INTERFACE AT THE GILL

FRIDAY 30 JUNE 2017 **09:00**

STEVE F PERRY (UNIVERSITY OF OTTAWA, CANADA)

@ SFPERRY@UOTTAWA.CA

Pierre Laurent pioneered the use of morphological methods to study the physiology of the fish gill. His technical prowess coupled with unparalleled creativity placed him at the vanguard of several physiological sub-disciplines including osmoregulation, chemoreception, cardiorespiratory control mechanisms, gas transfer and acid-base balance. Laurent's elegant immunocytochemical studies on trout gill provided the first description of piscine neuroepithelial cells (NECs). Based on the morphological response (degranulation) of the NECs to hypoxia, it was suggested that these cells could function as O_2 chemoreceptors, a "before its time" idea that was confirmed more than 20 years later and which is currently the subject of intensive investigation. Laurent's "structure and function" approach to studying osmoregulation led to the concept of gill remodelling as a mechanism to regulate the function of ion-transporting cells (ionocytes) and hence rates of ionic uptake. Moreover, his observations of cellular ultrastructural changes in response to acid-base challenges led to the notion of ionocyte diversity and a "morphological model" for acid-base regulation in fish. Pierre Laurent's studies were massive in their scope, ranging from a possible chemosensory role of his beloved pseudobranch to pulsatile urea excretion in Gulf toadfish. Despite their diversity, these studies shared a common theme - the use of morphology to elucidate fundamental principles of physiology.

AS17.2 PIERRE AND THE PAVEMENT CELL AS AN IONOCYTE

FRIDAY 30 JUNE 2017 **09:40**

JONATHAN M WILSON (WILFRID LAURIER UNIVERSITY, CANADA), AYDEN MALEKJAHANI (WILFRID LAURIER UNIVERSITY, CANADA), JUSTINE DOHERTY (WILFRID LAURIER UNIVERSITY, CANADA)

@ JMWILSON@WLU.CA

The gill is the primary organ for both ion regulation and gas exchange in fishes with the lamellae ideally suited for gas exchange with their high blood flow, thin pseudostratified epithelium and large surface area, while the gill filament epithelium contains large, mitochondrion-rich (MRC) ionocytes for active ion regulation. These ionocytes have high levels of the basolateral sodium pump, Na^+/K^+ -ATPase (NKA), which creates the sodium-motive force for many of the ion and acid-base regulatory processes in the gill. However, it has been proposed that the flattened respiratory or "pavement" cells covering the lamellae may also have a significant role in ion regulation given that they cover over 90% of the gill surface; however, NKA is generally not detectable. In this study we have addressed the potential role of the lamellar pavement cells in ion regulation by using immunofluorescence microscopy to localize NKA to the basolateral membrane of these cells using more sensitive detection methods than those needed for detection in mitochondrion-rich ionocytes. We examine a wide range of representative fishes including cyclostomes (hagfish and lamprey), chondrichthyans (sharks, skates, rays and holocephali), a lungfish (sarcopterygian) and a number of ray finned fishes (bichir, sturgeon, teleosts). We observed lamellar pavement cell NKA staining in many of the species that we examined although at predictably much lower levels of expression than MRCs. This study thus helps establish that pavement cells have the potential to function as ionocytes in the fish gill.

AS17.3 IMMUNOHISTOCHEMISTRY OF ION AND AMMONIA TRANSPORTING CELLS IN TELEOST FISH

FRIDAY 30 JUNE 2017 10:05

JUNYA HIROI (ST. MARIANNA UNIVERSITY SCHOOL OF MEDICINE, JAPAN)

@ J-HIROI@MARIANNA-U.AC.JP

Immunofluorescence microscopy is a powerful tool for studying fish gill morphology and physiology: it allows us to simultaneously visualize the localization patterns of multiple membrane proteins in the cells, but its optical resolution has been limited to approximately half of the wavelength of the captured light. I employed "super-resolution" immunofluorescence imaging, in which a conventional confocal microscope equipped with high-efficiency GaAsP detectors was set at a smaller pinhole size (0.6 Airy unit), and a deconvolution technique was used to restore the blurred images. This method was performed to localize Rhcg1, Rhcg2, Rhbg, and NHE3b, which are responsible for ion and ammonia transport, in the gills of rainbow trout and Atlantic salmon. Rhcg1 immunoreactivity was restricted to the apical membrane of ionocytes which also showed apical NHE3b immunoreactivity. 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 both Rhcg1-positive ionocytes and Rhcg2-positive pavement cells. Under lower magnification observations, the immunoreactivity of Rhcg1 and NHE3b looked likely to be colocalized at the apical membrane of the ionocytes, but the higher-resolution imaging revealed that NHE3b was diffused and located rather subapically in freshwater-acclimated fish, whereas that NHE3b was concentrated at the apical membrane, being more colocalized with Rhcg1, following transfer to deionized water or acidic water. These morphological changes would imply that ammonia-dependent sodium uptake by the Rh-NHE metabolon is more active in low-sodium and low-pH environments.

AS17.4 THE ASIAN SWAMP EEL *(MONOPTERUS ALBUS)*: A PECULIAR AIR-BREATHING FISH FROM SOUTH EAST ASIA WITH NUMEROUS STRANGE ADAPTATIONS

FRIDAY 30 JUNE 2017 11:00

TOBIAS WANG (AARHUS UNIVERSITY, DENMARK), THINH PHAN (CANTHO UNIVERSITY, VIETNAM), MIKKEL THY THOMSEN (AARHUS UNIVERSITY, DENMARK), DO THI THANH HOUNG (CANTHO UNIVERSITY, VIETNAM), MARK BAYLEY (AARHUS UNIVERSITY, DENMARK)

@ TOBIAS.WANG@BIOS.AU.DK

The Asian swamp eel is a most peculiar fish. It thrives in freshwater, including rice fields, across South East Asia, but tolerates low salinities. *Monopterus albus* has the rather distinctive capacity of retreating into burrows in the flood plain mud, where it reproduces during the tropical dry season. Its gills are almost vestigial and *Monopterus albus* relies on a vascularized buccal cavity for air-breathing, whose apparent low surface area can cover the low metabolic rate by virtue of a very high blood oxygen affinity and high haematocrit. The cardiovascular system is highly specialised with a large shunt vessel allowing venous systemic blood to bypass the gills. The regulation of this shunt remains enigmatic, but inflation of the buccal cavity with air is associated with a marked tachycardia and an elevation of cardiac output driven by autonomic innervation of the heart and the vasculature.

Despite its diminutive gills, *Monopterus albus* is capable of full acid-base compensation to profound respiratory acidosis by elevating plasma [HCO_{3^-}] to levels well above 30 mM. Somewhat surprisingly, this metabolic compensation to severe hypercapnia is also possible during air-exposure and it seems that the kidneys play an important role. Air-exposure per se does not affect arterial PCO_2, but increased temperature leads to a progressive rise in arterial PCO_2, such that pH is reduced with no changes in plasma [HCO_{3^-}]. As such, *Monopterus albus* displays the classical alpha-stat response of air-breathing vertebrates, but although ventilation is sensitive to aquatic hypercarbia, there is no direct indication of central chemoreception.

AS17.5 WHEN ECOTOXICOLOGY MEETS MORPHOLOGY: LESSONS LEARNED FROM PIERRE LAURENT

FRIDAY 30 JUNE 2017 **11:25**

GUDRUN DE BOECK (UNIVERSITY OF ANTWERP, BELGIUM), VICTORIA MATEY (SAN DIEGO STATE UNIVERSITY, UNITED STATES), VERA M F ALMEIDA-VAL (INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA, BRAZIL), ADALBERTO L VAL (INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA, BRAZIL), RONNY BLUST (UNIVERSITY OF ANTWERP, BELGIUM), CHRIS M WOOD (UNIVERSITY OF BRITISH COLUMBIA, CANADA)

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Ecophysiology and ecotoxicology look at cellular and organismal responses to environmental changes, often in a quest for biomarkers. Frequently, these studies are focussed either on molecular and biochemical responses, or on morphological damage. However, the interplay between physiological and morphological processes can be important and informative. As a PhD student, my first papers focussed on respirometry, ionoregulation and excretion. My initial contact with morphological studies was unusual as during my PhD, we looked at physiological processes not only through ^{31}P-Nuclear Magnetic Resonance Spectroscopy, but also through ^{1}H-Nuclear Magnetic Resonance Imagine. My first 'classical' light microscopy studies only took place during my postdoctoral years, looking at effects of metals on gill lamellae both in Antwerp, and at McMaster where I had the honour to meet Prof. Pierre Laurent. This inspired me to continue looking for the link between toxicology-physiology-morphology, and we started inter-species comparisons realising that huge differences in gill responses occurred. For example in gibel carp secondary lamellae seemed to be embedded in an interlamellar cell mass under metal exposure, similar to the gill remodelling seen in crucian carp under normoxic conditions, presumably using this adaptive trait to reduce ion losses. Later, during some Brazilian research visits to the INPA in Manaus, morphological studies helped to explain our observations of ionoregulatory responses to hypoxia in Oscars, showing surprising differences between fed and fasted fish. I'm happy to say that the legacy continues with my students, who started looking at gill responses under ammonia exposure, including effects of food availability.

AS17.6 MORPHOLOGY VERSUS SWIMMING PHYSIOLOGY

FRIDAY 30 JUNE 2017 **11:50**

JOHN F STEFFENSEN (UNIVERSITY OF COPENHAGEN, DENMARK)

@ JFSTEFFENSEN@BIO.KU.DK

The morphology and swimming behaviour of different fish, e.g. Picasso fish, parrotfish, surf perch and sunfish, will be described, as well as the swimming energetics of some selected species.

In addition, it will be discussed whether the current swim tunnel respirometers are appropriate for swimming all species, or new designs and swimming protocols are more relevant for some species.

AS17.7 GILL NEUROEPITHELIAL CELLS: A HISTORY AND A LOOK AHEAD

FRIDAY 30 JUNE 2017 **12:15**

COSIMA S PORTEUS (UNIVERSITY OF EXETER, UNITED KINGDOM)

@ C.S.PORTEUS@EXETER.AC.UK

In the early 1980s, Pierre Laurent's research group was the first to describe the neuroepithelial cells (NECs) in fish. Using a variety of histology and histochemistry techniques in a variety of fishes, they found that these cells were mitochondrion rich, contained dense cored vesicles, were innervated, contained serotonin and were found in close proximity to blood vessels. More importantly, they showed that when fish are exposed to hypoxia for 30 minutes the number of dense cored vesicles decreased in NECs, indicating these cells respond to hypoxia by releasing neurotransmitters. Since then, Mike Jonz has provided electrophysiological evidence showing that zebrafish NECs respond to hypoxia by depolarizing. He also showed that the number and density of zebrafish NECs increased when fish are exposed to chronic hypoxia, and used immunohistochemistry to further characterize these cells, including their development. More recent studies have focused on determining if neurotransmitters other than serotonin are involved in the hypoxic response. Unlike the oxygen sensing cells

of mammals, NECs do not contain catecholamines and acetylcholine, although acetylcholine has been found in other cells in gill filaments. Since their discovery, NECs have been hypothesized to be homologous to glomus cells and/or pulmonary neuroendocrine cells due to shared characteristics to both of these. I will be discussing recent findings from the field that shed light on this debate.

AS17.8 INTEGRATING GILL MORPHOLOGY AND ION TRANSPORT – THE LONG ROAD TO MOLECULAR IDENTIFICATION OF GILL NA^+ TRANSPORTERS

FRIDAY 30 JUNE 2017 **14:00**

GREG G GOSS (UNIVERSITY OF ALBERTA, CANADA)

GREG.GOSS@UALBERTA.CA

The role of the gill in freshwater fish ion transport function has been intensively investigated for decades with the specific cellular mechanisms and locations of these transporters on the chloride cells/mitochondrion-rich cells/ionocytes/PNA^+/PNA^- cells of the gill providing a rich topic for research and debate. Importantly, the original observations made in collaboration with Pierre Laurent demonstrated rapid (within 6 h) morphological adjustments could be found in the fish gill and that these adjustments directly coincided with acute adjustments of ion (Na^+, Cl^-, Ca^{2+}) transport rate. These seminal experiments pointed to multiple levels of the control of cellular ion transport function and over time, these observations have proven foundational in our current fish gill models separating ion transport function into multiple cellular ionocyte subtypes. More recently, significant success at identifying the potential molecular mechanisms of Na^+ transport (Na^+/H^+ exchangers, acid-sensing ion channels and Na^+ Cl^- cotransporters) and Cl^- transport (Slc26a3, Slc26a6, Na^+/Cl^- cotransporters) has opened new avenues for discussions with localization, regulation and function in different cellular subtypes the topics of debate. This talk will focus on the currently proposed mechanisms for Na^+ transport: Na^+/H^+ exchangers (NHEs), acid-sensing ion channels (ASICS) and Na^+ Cl^- cotransporters (NCCs) and discuss the roles they may play in freshwater fish gill Na^+ transport.

AS17.9 LOCALIZATION OF CARBONIC ANHYDRASE ISOFORMS IN THE FISH GILL: CONSEQUENCES FOR PHYSIOLOGICAL FUNCTION

FRIDAY 30 JUNE 2017 **14:25**

KATHLEEN GILMOUR
(UNIVERSITY OF OTTAWA, CANADA)

KGILMOUR@UOTTAWA.CA

Long before molecular approaches allowed the diversity of carbonic anhydrase (CA) isoforms to be recognized, Pierre Laurent used immunohistochemistry to identify different CA isoforms in the branchial epithelium and red blood cells of rainbow trout. Two additional observations arose from this work; first, that the branchial CA isoform was present in the cytoplasm of epithelial cells but absent from the blood space, and second, that branchial CA tended to be distributed in the apical rather than basolateral region of epithelial cells. Later work (by others) confirmed the functional significance of these perceptive observations. For example, the absence of CA activity from the blood space in the gill was found to result in apparent diffusion limitations on CO_2 excretion, which is reliant on red blood cell CA. More recently, studies have been exploring the distribution of branchial CA across ionocyte types as well as the regulation of branchial CA in response to acid-base disturbances. Similarly, the apical localization of branchial CA is taking on new meaning in the context of metabolons that rely on the coordinated localization and activity of proteins to facilitate ion transport. Thus, Pierre Laurent's work on CA in relation to gill morphology has informed our understanding of the physiological function of CA in the fish gill.cribing protein activation and diffusion in the cytosol.

AS17.10 THE EFFECTS OF ACUTE TRANSFER TO FRESHWATER ON ION TRANSPORTERS OF THE PHARYNGEAL CAVITY IN EUROPEAN SEABASS *(DICENTRARCHUS LABRAX)*

FRIDAY 30 JUNE 2017 **14:50**

JEHAN-HERVÉ LIGNOT (UNIVERSITY OF MONTPELLIER, FRANCE), GERSENDE MAUGARS (UNIVERSITY OF MONTPELLIER, FRANCE), VIVIANE BOULO (IFREMER, FRANCE)

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Gene expression of key ion transporters (the Na^+/K^+ -ATPase NKA, the Na^+, K^+ - 2Cl- cotransporter NKCC1 and CFTR) in the gills, opercular inner epithelium and pseudobranch of European seabass juveniles (*Dicentrarchus labrax*) were studied after acute transfer up to 4 days from seawater (SW) to freshwater (FW). The functional remodelling of these organs was also studied. Handling stress (SW to SW transfer) rapidly induced a transcript level decrease for the three ion transporters in the gills and operculum. NKA and CFTR relative expression level were stable, but in the pseudobranch, NKCC1 transcript levels increased (up to 2.4-fold). Transfer to FW induced even more organ-specific responses. In the gills, a 1.8-fold increase for NKA transcript levels occurs within 4 days post transfer with also a general decrease for CFTR and NKCC1. In the operculum, transcript levels are only slightly modified. In the pseudobranch, there is a transient NKCC1 increase followed by 0.6-fold decrease and 0.8-fold CFTR decrease. FW transfer also induced a density decrease for the opercular ionocytes and goblet cells. Therefore, gills and operculum display similar trends in SW-fish but have different responses in FW-transferred fish. Also, the pseudobranch presents contrasting response both in SW and in FW, most probably due to the high density of a cell type that is morphologically and functionally different compared to the typical gill-type ionocyte. This pseudobranch-type ionocyte could be involved in blood acid-base regulation masking a minor osmotic regulatory capacity of this organ compared to the gills.

AS17.11 UNDERSTANDING THE CORTISOL-DRIVEN INTEGRATIVE NA^+ TRANSPORT IN OSMOREGULATORY EPITHELIA OF AIR-BREATHING FISH

FRIDAY 30 JUNE 2017 **15:15**

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Osmoregulatory epithelia of air-breathing fish possess varied ion transporting cells, which act as target for many hormones including cortisol. Cortisol as stress hormone, shows osmotic and ion regulatory actions in fish. Further, it shows interaction with thyroid hormones (TH) and modifies the pattern of stress response in fish. It is not certain how cortisol integrates with THs and regulates Na^+ transport in fish. We, therefore, focused on Na^+/K^+ - ATPase (NKA), the key transporter that maintains Na^+ and K^+ gradients across plasma membrane. The direct action of THs on NKA functions was then tested on gills, kidney and intestine of air-breathing fish kept either in stressed or non-stressed condition. Molecular analyses utilizing qRT-PCR techniques showed differential regulation of nkaα isoforms (α1a, α1b and α1c) mRNA expression in these ion transporting cells, indicating an integrative role of cortisol in Na^+ signaling. Immunocytochemical localization of NKA showed that cortisol could modify the distribution pattern of its immunoreactivity in the osmoregulatory epithelia of fish. Likewise, NKA protein abundance in these tissues showed spatial and temporal responses to cortisol challenge. Collectively, evidence is presented that cortisol integrates Na^+ transporter functions in fish tissues (supported by grants from iCEIB, UGC-SAP DRS II, Govt of Kerala and UoK).

AS17.12 CHARACTERIZATION OF POST-PRANDIALLY INDUCED CHANGES IN WHOLE ANIMAL PHYSIOLOGY AND HINDGUT MORPHOLOGY OF THE PACIFIC HAGFISH *(EPTATRETUS STOUTII)*

FRIDAY 30 JUNE 2017 **15:30**

ALYSSA WEINRAUCH (UNIVERSITY OF ALBERTA, CANADA), ALEXANDER CLIFFORD (UNIVERSITY OF ALBERTA, CANADA), GREG GOSS (UNIVERSITY OF ALBERTA, CANADA)

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Scavenging hagfish are thought to utilize immersive feeding behaviours in decaying carcasses. This unique microcosm presents several potential environmental challenges that have been characterized in recent years, including hypercapnia, hypoxia and high environmental ammonia. The effects of feeding on digestive hagfish physiology, however, have never before been examined. Thus, this study sought to elucidate physiological changes induced after feeding by measuring metabolic oxygen consumption, ammonia excretion patterns and acid-base status, while also evaluating the potential for morphological remodeling of the hindgut in these intermittent feeders. Basal metabolic oxygen consumption (641.5 µmol kg^{-1} h^{-1}) was significantly increased to 1868 µmol kg^{-1} h^{-1} 8h following feeding, resulting in a peak metabolic factorial scope of 2.92. An accompanying 11-fold increase in base excretion (2981.99 µmol kg^{-1} h^{-1}) occurred at this time, with no observed accompanying changes in blood acid-base status (alkaline tide). Ammonia excretion increased from 17.3 µmol g^{-1} h^{-1} to 277.8 µmol g^{-1} h^{-1} by 36 h. Pronounced physiological changes occurring at 8h post-feeding were complemented with significant changes in hindgut morphology. Specifically, mucosal thickness increased from 97.4 µm in fasted hagfish, to 117 µm and 111 µm in 8h and 36h post-fed hagfish, respectively. Additionally, microvilli length increased significantly from 0.51 µm in fasted hagfish to 1.30 µm 8h following feeding. By 36h, the microvillar length returned to fasting levels at 0.55 µm. This study provides evidence for both physiological and morphological changes induced by feeding and offer insights into early diverging vertebrate life history.

AS17.13 GOLDFISH RENAL TUBULES AND ACID-BASE REGULATION - MORE THAN MEETS THE EYE

FRIDAY 30 JUNE 2017 **16:15**

SANDRA FEHSENFELD (UNIVERSITY OF BRITISH COLUMBIA, CANADA), DENNIS KOLOSOV (MCMASTER UNIVERSITY, CANADA), MICHAEL J O'DONNELL (MCMASTER UNIVERSITY, CANADA), CHRIS M WOOD (UNIVERSITY OF BRITISH COLUMBIA, CANADA)

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Although the important role of the teleost gill for acid-base regulation has been firmly established, less attention has been given to the teleost kidney. Although seemingly "chaotic" in its morphological organization, renal tubules of goldfish (*Carassius auratus*) exhibit distinct zonation similar to the mammalian kidney. Microdissection of intact tubules enabled us to characterise the differential expression patterns and changes in mRNA levels for key epithelial transporters involved in acid-base regulation along the renal tubule of fed and fasted goldfish. Specifically, elevated mRNA levels of carbonic anhydrase II (CAII), V-type-H^+-ATPase (HAT), Na^+/H^+-exchanger-3 (NHE3) and Rhesus-protein-cg1a (Rhcg1a) in the distal tubule indicated the potentially increased importance of this section in dealing with the acid and ammonia load caused by feeding. Employing the Scanning Ion-selective Electrode Technique (SIET) together with transporter-specific inhibitors to record H^+ flux across the epithelium of isolated goldfish kidney tubules, SIET data suggested a role for all investigated transporters (CAII, HAT, bicarbonate transporters Cl^-/HCO_3^--exchanger and Na^+/HCO_3^--cotransporter, NHE3, Na^+/K^+-ATPase, Rhcg1a) in renal acid-base regulation. Overall, NHE3 may play a more important role in direct proton transport than HAT. Preliminary observations also suggest that although lacking the Loop of Henle, the goldfish kidney possesses a structure comparable to the juxtaglomerular apparatus of the mammalian kidney. Linking renal tubule morphology to potential function in an evolutionary predecessor of the mammalian kidney will allow us to develop a more detailed comparative model for renal acid-base regulation that may provide additional evolutionary insight into the kidney function of vertebrates (NSERC Discovery).

AS17.14 MORPHOLOGY AND FUNCTION OF THE PARACELLULAR PATHWAY IN SALT-SECRETING CELL COMPLEXES OF EURYHALINE FISH EXPOSED TO HYPERSALINE CONDITIONS: REGULATION BY ACCESSORY CELLS

FRIDAY 30 JUNE 2017 16:30

WILLIAM S MARSHALL (ST FRANCIS XAVIER UNIVERSITY, CANADA), REGINA RF COZZI (ST FRANCIS XAVIER UNIVERSITY, CANADA), MELANIE SPIEKER (ALBERT-LUDWIGS-UNIVERSITÄT FREIBURG, GERMANY), LAUREN CLAUS (ST FRANCIS XAVIER UNIVERSITY, CANADA), GEORGE N ROBERTSON (ST FRANCIS XAVIER UNIVERSITY, CANADA)

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Salt-secreting epithelia secrete Na^+ passively down an electrochemical gradient via a paracellular pathway between ionocytes and accessory cells (Sardet et al. 1979). We assessed how this pathway is modified to allow Na^+ secretion in hypersaline environments. *Mummichogs* (*Fundulus heteroclitus*) acclimated to hypersaline (2SW, 64 ‰) for 30 days developed invasive projections of accessory cells with increased area of tight junction, detected by punctate distribution of CFTR immunofluorescence and TEM of opercular epithelia (OE), a gill-like tissue rich in ionocytes. By immunocytochemistry, accessory cells and ionocytes had with-no-lysine kinase (WNK1), detected by antiWNK1pT58, a conserved site, stronger in accessory cells of SW and 2SW opercular epithelia (OE), whereas accessory cells lacked p38MAPK, compared to ionocytes. Isolated OE bathed in SW on the mucosal side had transepithelial potential (Vt) of +40.1+/-0.9 mV (n=24), sufficient for passive Na^+ secretion (Nernst equilibrium voltage ≡ ENa = +24.11 mV). OE from fish acclimated to 2SW bathed in 2SW had significantly higher Vt of +45.1+/-1.2 mV (n=24), sufficient for passive Na^+ secretion (ENa = +40.74 mV), but with lower driving force. Estimates of shunt conductance from epithelial conductance (Gt) vs. short-circuit current (Isc) plots (extrapolation to zero Isc) suggested an overall reduction in total epithelial shunt conductance in 2SW acclimated fish. In contrast, the morphological elaboration of tight junctions, an increase in accessory cell-ionocyte contact points, implies an increase in local paracellular conductance, that would compensate for the diminished net driving force for Na^+ and allow salt secretion even in extreme salinities.

AS17.15 THE LACTATE VENTILATORY RESPONSE – NEW CLOTHES FOR AN OLD FRIEND

FRIDAY 30 JUNE 2017 16:45

MIKKEL T THOMSEN (AARHUS UNIVERSITY, DENMARK), TOBIAS WANG (AARHUS UNIVERSITY, DENMARK), GÖRAN E NILSSON (OSLO UNIVERSITY, NORWAY), SJANNIE LEFEVRE (OSLO UNIVERSITY, NORWAY), WILLIAM K MILSOM (UNIVERSITY OF BRITISH COLUMBIA, CANADA), MARK BAYLEY (AARHUS UNIVERSITY, DENMARK)

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For decades after its discovery, the lactate ion was regarded as merely an end-product of anaerobic metabolism with no important regulatory functions. As with many other metabolites, lactate is now known to be important in a number of physiological responses, one of which is the stimulation of an olfactory receptor located in the mouse carotid body, involved in initiating a hypoxic ventilatory response. Driven by this discovery in mammals, we undertook a comparative investigation on the presence of a similar response in *Teleostei*. In double cannulated fish, we recorded ventilation following Na-lactate injections to avoid confounding disturbances of arterial pH on lactate elevation. We studied two phylogenetically distant teleosts, a catfish (*Pangasianodon hypophthalmus*) and a salmonid (*Oncorhynchus mykiss*), and found that both exhibit a strong ventilatory response to lactate concentrations well within the physiological range. This stimulation of ventilation is reduced, but not eliminated, following denervation of the 1st gill arch. Furthermore, by measuring mRNA expression levels we established that a gene homologous to that involved in lactate sensing in mice is expressed on the gills of *O. mykiss*, with a higher expression level on the first gill arch - the same location thought to be responsible for a large part of oxygen sensing. Collectively, these findings suggest that the stimulation of the hypoxic ventilatory response by the lactate ion is conserved amongst vertebrates. Currently, we are recording electrophysiological responses to lactate in perfused gill arches to directly link stimulation of putative lactate receptors with the hypoxic ventilatory response.

AS17.16 USING MORPHOLOGY TO INFER PHYSIOLOGY OF LARGE WHALES

FRIDAY 30 JUNE 2017 17:00

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The study of physiology in large whales is hindered by the logistical problem of conducting invasive experiments. Consequently many basic aspects of physiology related to their large body size and aquatic lifestyle remain unknown. We use morphology and tissue mechanical properties to infer physiological function in living whales, and examples will be presented related to mechanics of lunge feeding and pressure effects on the circulatory system in rapid and deep diving. We described a structure located within the mandibular symphysis of rorqual whales that we propose is a mechanoreceptor. A variety of morphological evidence was used to infer that this organ coordinates control of mouth opening and closing during lunge feeding, an important innovation that supports extreme body size. In fin whales we found the walls of thoracic arteries are highly reinforced with collagen, making then virtually non-compliant under normal physiological pressures. Based on the structure and tissue mechanical properties we propose that this unique arterial design protects against large and transient variations in arterial transmural pressures arising from rapid depth-induced ambient pressure changes. In the absence of direct measurements we developed a mathematical model to test this hypothesis. Other aspects of whale physiology we are investigating via morphology are: the role of muscle in controlling the expansion of the ventral cavity pouch during engulfment, predictions of hydrodynamic drag from numerical analysis of body shapes, lung function in deep diving whales, and specializations for rapidly swallowing large amounts of krill.

AS17.17 MODELLING MECHANICAL STRESSES IN EPITHELIA

SATURDAY 1 JULY 2017 09:00

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The first time I really got to know Pierre was when I was a graduate student at McMaster University on a research trip to RSMAS, the University of Miami. It must have been 1998 or 1999. We were characterizing the urea excretion mechanism of the Gulf toadfish, *Opsanus* beta, which allows for the pulsatile excretion of urea across its gill. Pierre was continuing work on a project with Chris Wood and Pat Walsh investigating potential morphological changes in the gill during a pulsatile urea excretion in the Gulf toadfish, *Opsanus beta*. The first part of his work was published with Yuxiang Wang, Steve Perry, Katie Gilmour and Claudine Chevalier in Cell and Tissue Research in 2001. I remember Pierre on that first trip, and during the many subsequent trips either to Miami or to McMaster University in Canada: his charm, the twinkle in his eye, his commitment to his work and being so very French. It was Pierre that suggested, on our last research trip together in Miami with Chris and Pat in 2002, it might be serotonin (5-HT, 5-hydroxytryptamine) that activates pulsatile urea excretion in toadfish; a hypothesis that was proven correct and on which work is based still today.

AS17.18 CELL BIOLOGY MEETS PHYSIOLOGY: NOVEL CELLULAR MECHANISMS INVOLVING SAC AND V-TYPE H+ ATPASE IN AQUATIC ANIMALS

SATURDAY 1 JULY 2017 09:25

MARTIN TRESGUERRES (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES), JINAE N ROA (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES), KATIE L BAROTT (UNIVERSITY OF PENNSYLVANIA, UNITED STATES), DANIEL YEE (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES), MARK HILDEBRAND (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES), CRISTINA SALMERÓN-SALVADOR (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES), MEGAN E BARRON (SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNITED STATES)

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The soluble adenylyl cyclase (sAC) is an cAMP-producing enzyme that is stimulated by bicarbonate. In certain cellular contexts, sAC can act as sensor of carbon dioxide, pH and bicarbonate levels (collectively referred as Acid/Base; or A/B). Because cAMP can regulate the activities of target proteins by post-translational modifications, sAC is poised to play important roles in maintaining cell A/B homeostasis. The V-type H^+ ATPase (VHA) is a multi-subunit enzyme that hydrolyzes ATP to 'pump' H^+ across the cell plasma membrane and several endomembranes. Depending on its sub-cellular localization, VHA can mediate intra- or extra-cellular pH regulation, or organelle acidification for diverse purposes. Both sAC and VHA are evolutionarily conserved in eukaryotes; furthermore, sAC modulates VHA function in diverse organisms and cell types. Some of the examples I will discuss in this talk include acid/base sensing and regulation of blood pH in shark gill cells, intracellular pH regulation and symbiosome acidification for photosynthesis in coral cells, and vesicle and vacuole acidification for silicification and nutrient storage in diatoms.

AS17.19 ONTOGENY AND PALEOPHYSIOLOGY OF THE CHORDATE GILL

SATURDAY 1 JULY 2017 09:50

COLIN J BRAUNER (UNIVERSITY OF BRITISH COLUMBIA, CANADA), MICHAEL A SACKVILLE (UNIVERSITY OF BRITISH COLUMBIA, CANADA)

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The gill played a key role in the adaptive radiation of early chordates by supplanting the skin as the dominant site for oxygen uptake. This shift to the gill relaxed constraints associated with oxygen uptake at the skin, allowing chordates to increase body size, dermal thickness and activity. The adult vertebrate gill is multifunctional, playing a dominant role in gas exchange, ionoregulation, acid-base balance and ammonia excretion. In rainbow trout, direct physiological measurements indicate that the initial function of the gill during development is primarily ionoregulatory and only secondarily respiratory. Developing larval teleosts experience similar increases in body size and dermal thickness to those that characterize early chordate evolution and thus, it is intriguing to consider that the early chordate gill may have also became critical for ion flux before oxygen uptake. We use larval lampreys as a representative system to test how increasing organism size might have affected gill function in early chordates. We directly and simultaneously measure the flux of O_2, CO_2, ammonia and sodium at the gill and skin of whole larvae, *in vivo*, over a range of body sizes (0.02-2.00g). We find that sodium flux is dominated by the gill at much smaller body sizes than gas flux, even when challenged by hypoxia and temperature. Our results suggest that ion regulation rather than gas exchange might have been the primary function of the early chordate gill, questioning long-standing views of chordate gill origins and constraints shaping early chordate evolution.

AS17.20 CARDIO-RESPIRATORY PHYSIOLOGICAL PHENOTYPIC PLASTICITY IN DEVELOPING AIRBREATHING ANABANTID FISHES (*BETTA SPLENDENS* AND *TRICHOPODUS TRICHOPTERUS*)

SATURDAY 1 JULY 2017 10:15

WARREN W BURGGREN (UNIVERSITY OF NORTH TEXAS, UNITED STATES), FERNANDO MENDEZ-SANCHEZ (AUTONOMOUS UNIVERSITY OF THE STATE OF MEXICO, MEXICO)

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The physiological transition of larval air breathing fishes from aquatic to aerial respiration, and how hypoxia influences this process, is poorly understood. Consequently, developmental phenotypic plasticity of cardiorespiratory physiology was determined in two taxonomically closely related air-breathing anabantid fishes (*Betta splendens* and *Trichopodus trichopterus*) occupying different freshwater habitats. Larvae were exposed to chronic nocturnal hypoxia (12 h at 17 kPa or 14 kPa) with diurnal normoxia, representing actual environmental conditions, from hatching through 35 days post-fertilization. Opercular and heart rates measured in normoxia were not affected by rearing in chronic intermittent hypoxic. However, routine oxygen consumption (~4 µmol O_2/g/h in normoxia in *Betta*), was significantly elevated by chronic nocturnal hypoxic exposure at 17 kPa but not by more severe (14kPa) hypoxia. Routine oxygen consumption in *Trichopodus* (6-7 µmol O_2/g/h), significantly higher than in *Betta*, was unaffected by any level of chronic hypoxic exposure. P_{Crit}, the PO_2 at which begins to decrease as ambient PO_2 falls, was measured at 35 dpf and decreased with increasing hypoxia in *Betta*, indicating a greater hypoxic tolerance. However, P_{Crit} in *Trichopodus* increased as rearing conditions grew more hypoxic, suggesting that hypoxic acclimation led to lowered hypoxic resistance. Species-specific differences in physiological developmental plasticity thus emerge between the relatively closely related *Betta* and *Trichopodus*. Hypoxic conditioning increased hypoxic tolerance in *Betta*, which inhabits temporary ponds with nocturnal hypoxia. *Trichopodus*, on the other hand, which inhabits more permanent oxygenated bodies of water, showed few responses to hypoxia, reflecting a lower degree of developmental phenotypic plasticity.

AS17.21 IT TAKES A TEAM TO STUDY A FISH: AIR-BREATHING IN THE LAKE MAGADI TILAPIA, *ALCOLAPIA GRAHAMI*

SATURDAY 1 JULY 2017 11:00

ORA E JOHANNSSON (UNIVERSITY OF BRITISH COLUMBIA, CANADA), HAROLD L BERGMAN (UNIVERSITY OF WYOMING, UNITED STATES), CHRIS M WOOD (UNIVERSITY OF BRITISH COLUMBIA, CANADA), PIERRE LAURENT ((DECEASED), FRANCE), DORCAS G KAVEMBE (SOUTH EASTERN KENYA UNIVERSITY, KENYA), ADALTO BIANCHINI (UNIVERSIDADE FEDERAL DO RIO GRANDE, BRAZIL), CLAUDINE CHEVALIER (MCMASTER UNIVERSITY, CANADA), KEVIN V BRIX (ECOTOX, UNITED STATES), LUCAS F BIANCHINI (UNIVERSIDADE FEDERAL DO RIO GRANDE, BRAZIL), GUDRUN DE BOECK (UNIVERSITEIT ANTWERPEN, BELGIUM), JOHN N MAINA (UNIVERSITY OF JOHANNESBURG, SOUTH AFRICA), MICHAEL B PAPAH (UNIVERSITY OF DELAWARE, UNITED STATES), KISIPAN M LETURA (EGERTON UNIVERSITY, KENYA), RODI O OJOO (UNIVERSITY OF NAIROBI, KENYA)

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The Lake Magadi tilapia, *Alcolapia grahami*, inhabits one of the more extreme environments in the world for fish with high temperatures, alkalinity and sunlight. Lake Magadi is covered with trona and the fish live in small lagoons around the edges of the lake. Observation of the fish revealed that they would break from underwater activities and rush to join groups of fish (pods) which were air-breathing and after a while return to normal activities. The pods increased in size and extend throughout the day reaching a peak in early-afternoon. Air breathing properties were quantified from video footage. Temperature, oxygen and concentrations of reactive oxygen (H_2O_2) were monitored in four lagoons. H_2O_2 concentrations were amongst the highest observed in the world and sufficient to cause oxidative stress. The peak periods of air breathing corresponded with the peaks in H_2O_2 concentration. We hypothesized that H_2O_2 could be irritating the gills and contributing to the need to air breathe. Pierre Laurent and Claudine Chevalier examined the gills for damage and discovered the first instance of a cichlid fish which produced an inter-lamellar cell mass. We came back three years later to test the H_2O_2 hypothesis. Unfortunately, H_2O_2 on its own did not induce air-breathing. Other hypotheses now need to be examined.

AS17.22 CONTROL OF THE HYPOXIC VENTILATORY RESPONSE IN LARVAL ZEBRAFISH (DANIO RERIO) VIA HYPOXIA-INDUCIBLE FACTOR 1α

SATURDAY 1 JULY 2017 11:15

MILICA MANDIC (UNIVERSITY OF OTTAWA, CANADA), VELISLAVA TZANEVA (UNIVERSITY OF OTTAWA, CANADA), STEVE F PERRY (UNIVERSITY OF OTTAWA, CANADA)

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The hypoxic ventilatory response (HVR) is a key first line of defense in fish exposed to environmental hypoxia. Many mechanisms have been proposed for the control of the HVR, including the induction of hypoxia-inducible factor 1 α (HIF1 α), a transcription factor that alters the transcription patterns of many hypoxia-inducible genes. In cyprinids, there are two paralogs of HIF1α (HIF1α -aa and HIF1α -ab), although little is known about the specific roles or potential sub-functionalization of the paralogs in response to hypoxia. In this study, we examined HVR, measured as ventilation frequency (f_V), in wild-type, HIF1α -aa and HIF1α -ab knockout lines in larval zebrafish (Danio rerio). In wild-type zebrafish, f_V increased across developmental time (4 days post fertilization [dpf], 7dpf, 10 dpf and 15 dpf) in response to hypoxia (30 mmHg). However, hypoxic f_V was transient during early development and only at 10 dpf was f_V sustained throughout hypoxia exposure. In contrast, in HIF1α -ab knockout zebrafish there was no increase in hypoxic f_V at 4 dpf, and as the larvae developed the magnitude of HVR increased but to a lesser degree than in wild-type larvae, until 15 dpf at which point there was no difference between the two groups. There was no effect of HIF1α -aa knockout on hypoxic f_V, suggesting that there is sub-functionalization of HIF1α paralogs, with HIF1α -ab playing a role in HVR during the early stages of zebrafish development. Currently, we are testing if the mechanism of HIF1α -ab control of HVR is via nitric oxide, a known stimulatory gaseous neurotransmitter in larval zebrafish.

AS17.23 THE ADIPOSE FIN AS A PRECAUDAL FLOW SENSOR

SATURDAY 1 JULY 2017 11:30

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Swimming in teleost fishes, such as trout (Salmoniformes) and catfishes (Otophysi), was for many years considered to occur without any input from the adipose fin, which was widely regarded as vestigial and non-functional. Prediction of a function as a precaudal flow sensor came from experiments that showed that amputation of the adipose fin in trout resulted in significant reduction in swimming efficiency, particularly in turbulent water. Morphological studies of trout adipose fins using electron microscopy and immunocytochemistry confirmed that they are passive structures, lacking muscles but are highly innervated and supported by a complex network of actinotrichia and collagen fibres, implying a sensory function. In some catfishes, movement of the fin is possible, as paired muscles attached to an endoskeleton, insert on the base of the fin. Recent electrophysiological studies on the catfish, *Corydoras aeneus*, confirmed sensitive mechanosensation in the fin, providing support for the precaudal flow sensor hypothesis. A possible exception to this trend is the lanternfish (Myctophiformes), which has an adipose fin but lives in the still waters of the mesopelagic. New data suggest that the lanternfish adipose has an endoskeleton with paired muscles and may function like that of the catfish. Adipose fins have evolved repeatedly in the history of teleosts suggesting not only that they are adaptive but that differences in structure between groups indicate functions may vary. The mechanosensory nature of the adipose fin may provide for novel ways to sense the environment of these fishes both near the water's surface and in the deeps.

AS17.24 RAPID AND ADAPTIVE STRUCTURAL CHANGES IN FISH GILLS

SATURDAY 1 JULY 2017 11:45

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The discovery of a near total transformation of the gill morphology of crucian carp and goldfish (two cyprinids of the genus *Carassius*) in response to hypoxia or elevated temperature, appears to have increased the awareness that gill structure, and particularly lamellar area, can be quite plastic and undergo rapid change. Consequently, more and more cases of gill transformation are being described. When the *Carassius* species are in cold and well-oxygenated water the lamellae are completely embedded in an interlamellar cell mass (ILCM), which may function to reduce osmoregulatory costs and protect against pathogens, toxicants and structural damage. The ILCM regresses when oxygen demand increases in warm or hypoxic water, resulting in protruding lamellae and a larger respiratory surface area. It is now evident that gill remodeling is phylogenetically widespread as it has been found in a wide range of teleosts, including several cyprinids, killifish, eel, a pangasiid catfish, salmonids and anabantoids. It may not only occur in hypoxia or at high temperatures but also in response to challenges such as low water pH or strenuous exercise. Moreover, it is not restricted to teleosts, having been reported to occur in a stingray exposed to hypoxia.

AS17.25 EXPLOITING BASIC KNOWLEDGE OF THE GILL TO REVEAL HOW FISHES COPE WITH NATURAL AND ANTHROPOGENIC STRESSORS IN AQUATIC ECOSYSTEMS

SATURDAY 1 JULY 2017 13:30

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The insight and novel research of Pierre Laurent led to a greater understanding of how gill-mediated physiological processes were linked to changes in gill morphology and ultrastructure, greatly improving our understanding of how fishes respond to and cope with natural and/or anthropogenic stressors. Here, I outline how his work has provided researchers with a framework to study how lampricides, pesticides used to control invasive sea lampreys (Petromyzon marinus) in the Great Lakes of North America, exert their toxic effects. Sea lampreys invaded the Great Lakes in the early 20th century, and by mid-century blood-sucking parasitic juvenile lampreys had decimated native fish populations. Lamprey populations are now controlled using 3-trifluoromethyl-4-nitrophenol (TFM), which is applied to nursery streams containing larval lampreys. Although it specifically targets lampreys, TFM can adversely affect sensitive non-target fishes including threatened lake sturgeon (Acipenser fulvescens). Our work has shown that TFM interferes with mitochondrial ATP production by uncoupling oxidative phosphorylation, which could also compromise ATP-dependent ion and acid-base regulation by the gills. Using radio-labeled TFM (14C-TFM) and Na^+ ($24Na^+$), respirometry, and enzyme assays and immunohistochemisty (V-ATPase, NKA), we have shown that non-lethal concentrations of TFM only transiently affect gill structure and function in lampreys and non-target fishes, despite interfering with ATP production. However, the magnitude of disturbances is highly dependent upon water quality and TFM dose. This improved understanding of how TFM affects gill function and structure has enabled us to better predict how TFM impacts non-target fish populations, and how to develop safer protocols of lampricide application.

AS17.26 PHENOTYPIC PLASTICITY IN CICHLID GILLS IN RESPONSE TO HYPOXIA AND ELEVATED WATER TEMPERATURE

SATURDAY 1 JULY 2017 **13:55**

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Hypoxia (low dissolved oxygen, DO) is a serious manifestation of anthropogenic stress to inland waters that can affect fitness and performance in fishes. In a series of studies on African cichlids, we addressed consequences of life-long exposure to hypoxia on morphological and physiological traits. Lab-rearing experiments on the cichlid *Pseudocrenilabrus multicolor victoriae* showed a strong element of developmental plasticity in gill size and shape. F1 offspring reared under hypoxia developed larger gills (filament length, surface area) than full sibs reared under normoxia, as well as deeper bodies and larger heads that may accommodate the gill proliferation. Similar results were observed in two other species of African cichlids. When the rearing DO was switched (normoxia to hypoxia or hypoxia to normoxia) during development, *P. multicolor* showed evidence of phenotypic tracking i.e. gill size tracked the temporal shift in DO. Such developmental flexibility may be important for persistence in heterogeneous, changing, and/or novel DO environments. However, hypoxia is likely to interact with other environmental stressors including climate change. Rising water temperature may exacerbate impacts of hypoxia on fishes, because oxygen solubility decreases with rising temperature while fish metabolism increases. Conversely, hypoxia may exacerbate thermal stress by limiting aerobic performance at higher temperatures. We reared F1 offspring of *P. multicolor* in a full factorial split-brood design with four treatments (low or high DO; cool or hot temperature). Independent and interactive effects of hypoxia and elevated temperature were evident in both morphological (gill size) and physiological (e.g. aerobic scope, critical oxygen tension) traits.

AS17.39 PHENOTYPIC PLASTICITY AT THE GILLS OF CORAL REEF FISHES AND LINKS TO ALTERED PERFORMANCE IN RESPONSE TO ANTHROPOGENIC STRESS

FRIDAY 30 JUNE 2017

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Coral reefs experience some of the greatest anthropogenic impacts of all marine ecosystems. Worldwide, 30% of reefs already face severe damage, with 60% loss predicted by 2030. In 2016 and 2017, the Great Barrier Reef suffered unprecedented back-to-back mass coral-bleaching events due to high temperatures. Additionally, changes in land use (e.g. agriculture, mining, infrastructure) are increasing sediment loads and causing dramatic declines in water quality. Elevated temperatures and poor water quality can create O_2-limiting, high energy-requiring scenarios for coral reef fishes. Preliminary data on several species suggest that larvae hatch with fully-developed gills, perhaps emphasizing O_2 requirements/limitations early in ontogeny. However, as adults, near-equatorial populations of reef fishes are limited in their capacity to morphologically remodel their gills, unlike their temperate-water counterparts that do so to enhance gas exchange and maintain osmotic/ion balance. This aligns with the collapse in aerobic metabolic scope at the same elevated temperatures. When reef fishes are exposed to elevated sediment loads/turbidity, gill diffusion distance increases by >50%, surface area decreases, mucous production increases, and the gill microbiome shifts toward pathogen-related haplotypes. For some, this comes with an increase in standard and decrease in maximum metabolic rates, consequently decreasing aerobic scope, thus linking changes at the gill with whole-animal performance. These results are important in gaining an overarching understanding of how reef fishes are affected by severe and frequent changes to water quality in terms of their O_2 transport system to which flow-on effects are at the level of performance, fitness, population dynamics, and ecosystem health.

AS17.28 THE FILTER-FEEDING ANATOMY OF THE ANCHOVY ENGRAULIS MORDAX: CHANGES TO SWIMMING KINEMATICS UNDER INCREASED HYDRODYNAMIC DRAG

SATURDAY 1 JULY 2017 **14:45**

NICHOLAS CAREY (HOPKINS MARINE STATION STANFORD UNIVERSITY, UNITED STATES), JEAN POTVIN (SAINT LOUIS UNIVERSITY, UNITED STATES), JULIA D SIGWART (QUEEN'S UNIVERSITY BELFAST, UNITED KINGDOM), JEREMY A GOLDBOGEN (HOPKINS MARINE STATION STANFORD UNIVERSITY, UNITED STATES)

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The Northern anchovy *Engraulis mordax* is an iconic forage fish in the eastern Pacific where it schools in large aggregations. It supports a host of predator populations, including cetaceans, pinnipeds, sea birds, and large predatory fish, and is also an important commercial stock in the region. *Engraulis mordax* feed on a range of zooplankton and small pelagic invertebrates, but switch between feeding modes depending on prey size. For larger prey, they capture them raptorially, but for small prey they ram filter feed, passing large volumes of water over a filtering apparatus which when deployed is around three times the width of the head. Swimming with the filtering apparatus deployed is energetically costly, as we show through substantial changes to swimming kinematics captured via high-speed video recordings. We also present 3D models of the filter feeding anatomy, and use these to model the hydrodynamic drag during ram filter feeding. Our data clarify the hydrodynamic consequences of this foraging specialisation, where anchovies abandon highly streamlined, low drag, mouth closed swimming, for high drag, energetically costly filter feeding.

AS17.29 GILL PLASTICITY IN THE AIR-BREATHING STRIPED CATFISH *PANGASIANODON HYPOPHTHALMUS*

SATURDAY 1 JULY 2017 **15:30**

LE MY PHUONG (AARHUS UNIVERSITY, DENMARK), DO THI THANH HUONG (CAN THO UNIVERSITY, VIETNAM), JENS RANDEL NYENGAARD (AARHUS UNIVERSITY, DENMARK), MARK BAYLEY (AARHUS UNIVERSITY, DENMARK)

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The ability of fish to alter their gill structures as a result of changing respiratory or osmoregulatory demands, or by a transition of fish respiratory modes, has been shown in numerous species. The facultative air-breathing Pangasianodon hypophthalmus, encounters a variety of environmental challenges during its migration of more than 2000 km along the Mekong river, from its upstream spawning grounds in Laos to its downstream growth habitat in the Mekong delta region. Recently, this species has been shown to have highly plastic branchial surfaces. Using vertical uniform random section based stereological methods; the respiratory surface areas (SA) and water-blood diffusion distance of P. hypophthalmus swim bladder and gills were quantified during development from approximately 5g to 2000g. In addition, the effects of varying the oxygen demand of the fish on branchial surfaces, were assessed by altering environmental temperature, PO_2, and swimming speed. Both branchial SA and swim bladder SA scaled with mass as expected from inter-species comparisons, except that there was a temporary reduction in branchial SA at 25g. With respect to oxygen demand, the branchial SA was found to be highly variable. Thus the weight specific SA was comparable to trout in high temperature and hypoxic environments, but almost completely eliminated in normoxic low temperature animals, as a result of the growth of extensive inter lamella cell mass (ILCM). All treatments that increased ventilatory effort including environmental hypoxia, water temperature or swimming speed, caused a dramatic increase in SA by loss of ILCM.

AS17.30 HOW DO EUROPEAN SEA BASS *DICENTRARCHUS LABRAX* COPE WITH FRESHWATER ENVIRONMENTS?

SATURDAY 1 JULY 2017 15:45

CATHERINE LORIN-NEBEL (MONTPELLIER UNIVERSITY, FRANCE), EVA BLONDEAU-BIDET (MONTPELLIER UNIVERSITY, FRANCE), WALIULLAH MASROOR (MONTPELLIER UNIVERSITY, FRANCE), GERSENDE MAUGARS (MONTPELLIER UNIVERSITY, FRANCE)

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The European sea bass *Dicentrarchus labrax* is a euryhaline species that lives in the sea and undertakes seasonal migrations in lagoons or estuaries. These habitats are characterized by high salinity fluctuations and often low salinities. Sea bass have thus to efficiently osmoregulate and to be able to switch between hypo-and hyperosmoregulation. Sea bass juveniles and adults have been acclimated to SW or FW and their blood and osmoregulatory tissues have been analyzed. Two genes encoding for alpha 1 subunit isoforms (NKAα1a and NKAα1b) have been identified in the sea bass genome and compared through phylogeny. Expression patterns clearly showed that NKAα1a is the main NKAα1 isoform expressed in sea bass osmoregulatory tissues, whatever the considered salinity. Long-term freshwater challenge affects NKAα1 expression patterns, notably in the gills with increased NKAα1a and decreased NKAα1b expression levels. Screening of other key ion transporters and channels involved in ion transport in sea bass gills (NBC1, NCC, NKCC1 isoforms, NHE isoforms, VHA, …) clearly shows that the Na^+/Cl^- cotransporter (NCC) and Na^+/H^+-3 exchanger (NHE3) are key components of FW acclimation. Branchial gene expressions and microscopic observations suggest the presence of NHE3- and NCC-type mitochondrion-rich cells that may have different functions in osmoregulation, acid-base regulation and nitrogen excretion. No epithelial Na^+ channel (ENaC) has been identified in the sea bass genome.

AS17.31 SWIMMING VERSUS AIR-BREATHING IN FISHES

SATURDAY 1 JULY 2017 16:00

DAVID J MCKENZIE (CNRS MONTPELLIER, FRANCE), FELIPE R BLASCO (UFSCAR, BRAZIL), SHAUN S KILLEN (GLASGOW, UNITED KINGDOM), THIAGO C BELÃO (UFSCAR, BRAZIL), ANDREW J ESBAUGH (UTAU, UNITED STATES), SJANNIE LEFEVRE (OSLO, NORWAY), F. TADEU RANTIN (UFSCAR, BRAZIL)

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One of Pierre Laurent's most influential studies was Dunel-Erb et al. (1982), which described neuro-epithelial cells in primary lamellae of fish gills and proposed that they were peripheral tissue oxygen sensors. Alongside other seminal studies from around that time, this stimulated much research into gill chemoreceptors and respiratory control in fishes. In fishes with bimodal respiration it is now established that surfacing, to gulp air, is a reflex response driven by stimulation of gill oxygen chemoreceptors. This underlies the profound increases in air-breathing in aquatic hypoxia. In all bimodal fishes studied to date, physical activity (swimming) also causes large increases in air-breathing frequency. Interestingly, facultative air-breathers will gulp air when swimming even when they can achieve the same performance by gill ventilation alone. This seems paradoxical because air-breathing puts fishes at risk of predation, and constant surfacing should also reduce the efficiency of swimming. The response may be a 'hard-wired' reflex that the fishes cannot avoid, which would indicate a strong role for oxygen chemoreception in driving air-breathing behaviours in fishes. That said, there is evidence that the intensity with which bimodal fishes gulp air can be driven by factors other than oxygen supply or demand, such as their 'personality' or aggressive interactions amongst conspecifics. It is not yet clear what role peripheral oxygen chemoreceptors play in these air-breathing responses.

POSTER SESSION FRIDAY 30 JUNE

AS17.33 EXPRESSION AND LOCALIZATION OF PEPTIDE TRANSPORTERS (PepTs) DURING MOZAMBIQUE TILAPIA *(OREOCHROMIS MOSSAMBICUS)* LARVAL DEVELOPMENT

FRIDAY 30 JUNE 2017

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Protein utilization is a major physiological process in fish, supplying amino acids for energetic requirements and tissue growth. While there are many studies on protein utilization in adult fish, less is known on utilization in larvae. During larval development, before exogenous feeding begins, the yolk sac is the only protein reservoir for these fundamental processes. Peptide transporter (PepT) is a trans-membranal protein that mediates intestinal absorption of di- and tri-peptide into the enterocytes, with a major role in protein utilization. In fish, there are two variants of the high capacity/low affinity isoform, PepT1a and PepT1b, and one variant of the low capacity/high affinity isoform, PepT2. We have shown that all three variants are expressed in adult Mozambique tilapia intestine and are localized in a physiological-complimentary manner. Aiming to investigate the role of these transporters in yolk-protein utilization during the larval development, we conducted a 19 days experiment in which we tracked the relative expression of the three PepT variants during the larval development. Costume made antibodies were used for visualization and localization of PepTs within the developing organs. All three transporters were expressed at 4-19 days post fertilization. The expression pattern of the three variants along this period of development imply complementary relationships, with a decrease in PepT2 expression in parallel to increase expression of the PepT1 variants. Immunolocalization of the PepTs in the developing larvae place them on the apical membrane of epithelial cells in the primordial intestine. The results will be presented within the context of embryonic development.

AS17.34 UNDERSTANDING THE MECHANISMS OF TOXICITY FROM HYDRAULIC FRACTURING FLOWBACK AND PRODUCED WATERS ON AQUATIC BIOTA

FRIDAY 30 JUNE 2017

TAMZIN BLEWETT (UNIVERSITY OF ALBERTA, CANADA), ALYSSA WEINRAUCH (UNIVERSITY OF ALBERTA, CANADA), PERRINE DELOMPRÉ (UNIVERSITY OF ALBERTA, CANADA), GREG GOSS (UNIVERSITY OF ALBERTA, CANADA)

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Hydraulic fracturing fluids are complex mixtures containing high concentrations of salts (up to 330,000 ppm), organic, and metal contaminants. However, little data exist on the potential mechanisms of toxicity of these flowback and produced wastewaters (FPW) on aquatic biota. Juvenile rainbow trout were exposed to either control, FPW (2.5 or 7.5%), FPW that had been treated with activated charcoal (AC), or a custom salt-matched control (SW; replicating only the salt content of FPW) for 48 hours. Gill histology revealed decreases in interlamellar cell mass (ILCM) and mean lamellar length in all treatments (FPW, AC and SW) compared to control, indicative of hyperosmotic stress. Liver CYP1A1 activity was significantly elevated by 7.5-fold in the FPW 7.5% treatment only, indicative of an induction of Phase I metabolism. Branchial superoxide dismutase activity significantly decreased in all treatments with the lowest activity occurring in the 7.5% FPW group. Catalase activity increased in liver with the highest values noted in fish exposed to 7.5% FPW. No changes were observed with respect to glutathione-S-transferase, while

increased lipid peroxidation was only observed in both FPW treatments (2.5, 7.5%). These data suggest a characteristic signature of FPW impact which may help in risk assessment and biomonitoring of FPW spills.

AS17.35 THE MECHANISM OF VENTILATION IN THE PACIFIC HAGFISH *(EPTATRETUS STOUTII)*

FRIDAY 30 JUNE 2017

JUNHO EOM (UNIVERSITY OF BRITISH COLUMBIA, CANADA), CHRISTOPHER M WOOD (UNIVERSITY OF BRITISH COLUMBIA, CANADA)

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Ventilatory flow in the hagfish is usually attributed to the pumping action of the velum which inhales water through the dorsal nostril and propels it posteriorly to the gill pouches. However exact details remain incompletely understood. We used recordings of pressure and impedance to measure changes in ventilation from the nostril, velum, and 12th gill pouch, and employed ammonia as a stimulant to alter ventilation. In resting animals at 12°C, velum movement (frequency: 0.46 ± 0.14 sec^{-1}) was correlated with pressure frequency at the nostril (pressure amplitude: 0.11 ± 0.05 cm H_2O) whereas both pressure frequency (0.28 ± 0.01 sec^{-1}) and amplitude at the 12th gill pouch (0.05 ± 0.02 cm H_2O) were much lower. After ammonia injection to the venous sinus, both the velum frequency (0.63 ± 0.20 sec^{-1}) and the pressure frequency at the 12th gill pouch (0.30 ± 0.03 sec-1) increased but remained very different from one another. Pressure amplitude increased greatly both at the nostril (1.75 ± 0.78 cm H_2O) and the 12th gill pouch (0.44 ± 0.23 cm H_2O). Heart rate increased from 0.23 ± 0.04 sec^{-1} to 0.49 ± 0.17 sec^{-1}. The results suggest a two-phase water-pumping system in the pacific hagfish (NSERC Discovery).

AS17.37 SALINITY ACCLIMATION AND HYPOXIA TOLERANCE IN THE KILLIFISH FUNDULUS HETEROCLITUS

FRIDAY 30 JUNE 2017

MARINA GIACOMIN (THE UNIVERSITY OF BRITISH COLUMBIA, CANADA), PATRICIA SCHULTE (THE UNIVERSITY OF BRITISH COLUMBIA, CANADA), CHRIS M WOOD (THE UNIVERSITY OF BRITISH COLUMBIA, CANADA)

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A large surface area and thin diffusion distances are characteristics of the fish gill that maximize gas exchange, but consequently also promote diffusion of ions across the gill epithelium. Due to this nature of the fish gill and the osmorespiratory compromise, when fish are exposed to hypoxia and need to increase the oxygen uptake capacity at the gills, physiological trade-offs in ion regulation can arise. Salinity acclimation can play a role in hypoxia tolerance, which in Fundulus heteroclitus, assessed through loss of equilibrium (LOE) tests, is reduced at acclimation salinities below 11 ppt (the isosmotic point), but not at salinities above this point, when measured at the acclimation salinity. Acute transfer to isosmotic salinity did not affect hypoxia tolerance. Additionally, oxygen regulation patterns can range from a high degree of regulation (at 11 ppt) to nearly direct conformation in freshwater acclimated fish. We hypothesized that the basis of this differential hypoxia tolerance seen in F. heteroclitus acclimated to different salinities lies in the surface area and distance for oxygen diffusion at the gills. In order to evaluate this idea, F. heteroclitus were acclimated to 0, 11 and 35 ppt water for 4 weeks, and the gills were fixed for measurements of surface area and diffusion distance. We predicted that surface area and diffusion distance would be inversely correlated, and that lower surface area and thicker diffusion distance that would favour ion retention would compromise oxygen uptake and therefore hypoxia tolerance (NSERC Discovery).

AS17.38 BREATHING WITH YOUR FINS? EXPLORING THE ROLE OF AN UNEXPECTED STRUCTURE IN VENTILATORY FUNCTION IN LARVAL FISH

FRIDAY 30 JUNE 2017

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Immediately following hatch, larval fish lack a developed gill and the skin comprises the majority of total surface area. This morphology imposes a constraint whereby without a functional gill, the skin acts as the dominant site of gas exchange in early life. Despite this fact, few studies have addressed how cutaneous oxygen uptake is enhanced in response to an increase in demand. For instance, how is oxygen transfer increased in response to hypoxia or increased metabolic rate? One current hypothesis is that the pectoral fins of larvae ventilate the skin, promoting transcutaneous oxygen transfer. In fact, previous work in our lab and others has demonstrated that fin movements of larval zebrafish (*Danio rerio*) increase in response to hypoxia. However, no study to date has examined the physiological significance of this response and whether fin movements directly promote cutaneous oxygen uptake. We will address these questions using larval zebrafish and rainbow trout (*Oncorhynchus mykiss*). Fin movements in response to hypoxia and exhaustive exercise (chasing) will be assessed in both species to understand whether increased fin movements is potentially a general response of larval fish. We will then surgically remove the pectoral fins of larvae of both species and assess oxygen consumption at rest, in hypoxia, and following exercise, critical oxygen tension (P_{crit}), and markers of anaerobic metabolism such as whole-body lactate levels. The overall goal is to address the hypothesis that the pectoral fins of larval fish serve a respiratory role when the skin is the dominant site of oxygen uptake.

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