Ecology and Evolutionary Ethology of Fishes Conference

Montreal, Quebec

June 17-20, 2018

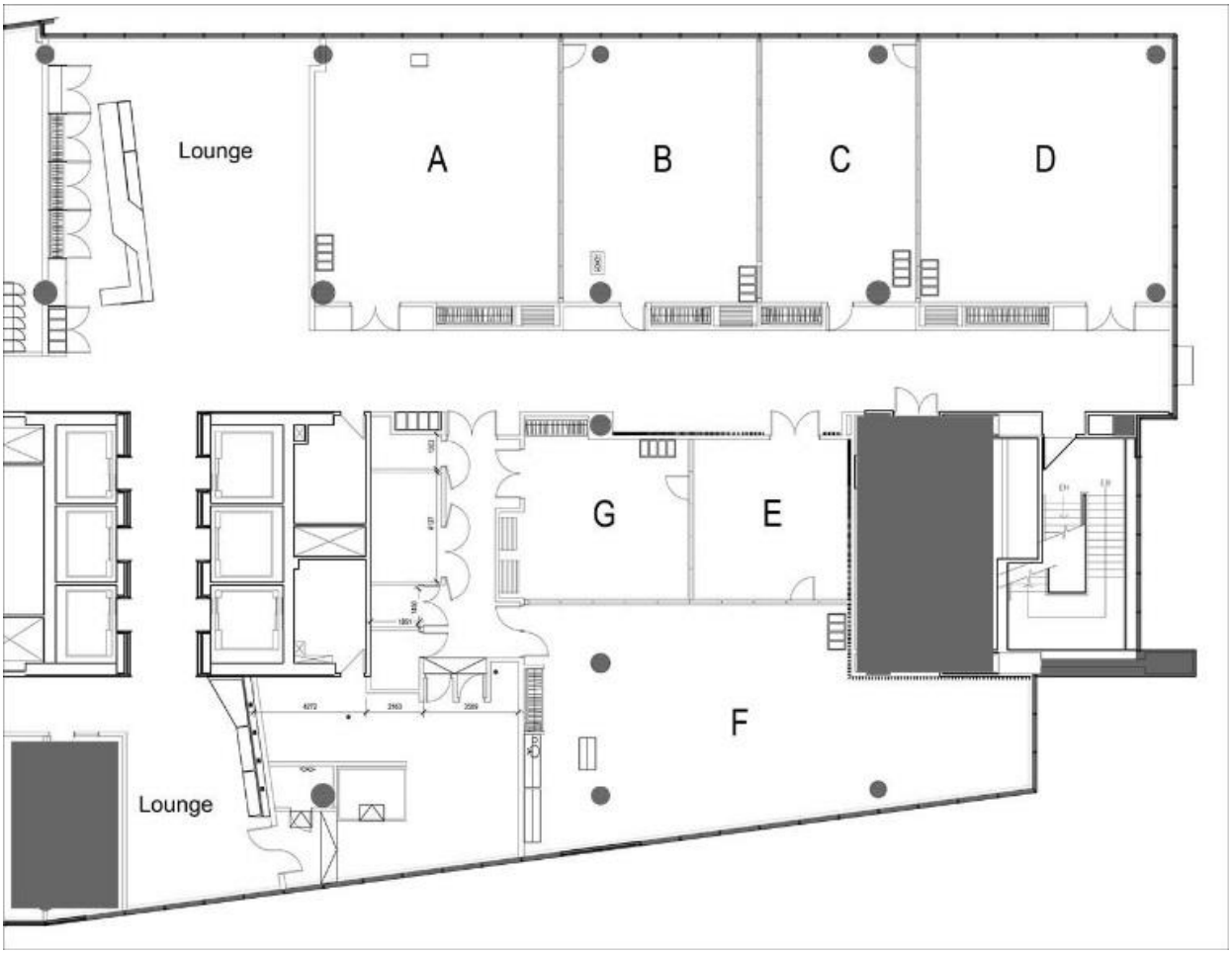
2018 Organizing Committee

Bryan Neff	Western University
Pedro Peres-Neto	Concordia University
Dylan Fraser	Concordia University
James Grant	Concordia University

Conference Venue

John Molson Building
1600 Boulevard de Maisonneuve O
Montréal, QC H3H 1J5

Conference facility map (9th floor)



Where to eat

Coffee/Breakfast

Tim Hortons	Starbucks

Fast Food

A&W Canada	Thai Express	McDonalds

Restaurants (Walking distance)

Chateau Kabab	La Pizzella	Devi
L'Acadamie (BYOB)	Bis (Fine dining)	Europea (Fine dining)
Brutopia (Brew pub)	Copper Branch (Vegan)	Panthere Verte (Vegan)

*Rue Crescent has many more restaurants with terraces for fine-weather dining

Classic Montreal Foods (Taxi recommended)

Poutine – Labanquise, 994 Rue Rachel E (expect to wait in line at peak times)

Montreal Smoked Meat – Schwartz's Deli, 3895 St Laurent Blvd

Conference Schedule

Sunday, June 17, 2018	
	First floor atrium
17:00-20:00	Registration
	Room EFG
17:00-20:00	Welcome reception

Monday, June 18, 2018		
7:45-9:00	Coffee available (Room EFG)	
	First floor atrium	
8:00-9:00	Registration	
	Room AB ***Keynote presentations***	
8:45-9:00	Opening remarks	
9:00-9:45	Lauren Chapman *Hot fish in a warming world: effects of dual stressors on energetics and performance of African equatorial fishes*	
9:45-10:30	Jeff Hutchings *Adaptive significance of life-history variability in landlocked Atlantic salmon*	
10:30-11:00	Coffee break (Room EFG)	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
11:00-11:20	Grant, James *Social inertia in stream salmonid territories: implications for population dynamics and restoration*	Taniguchi, Yoshinori *A comparison of freshwater recreational fisheries management in the USA and Japan*
11:20-11:40	Therrien, Christian *Effects of stream habitat structure on foraging in Atlantic salmon (Salmo salar)*	Hasegawa, Koh *Wild masu salmon is outcompeted by hatchery masu salmon rather than nonnative brown trout*
11:40-12:00	Bouchard, Colin *Heterogeneity of space use tactics in salmon parr along breeding season in relation to the individual maturity level*	Steingrímsson, Stefan *Territoriality and population density in stream-dwelling salmonids*
12:00-13:30	Lunch	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
13:30-13:50	Lake, Colin *Restoration of Atlantic salmon to Lake Ontario*	Allen, Emily *The effects of body size and previous experience on sexual selection in Japanese medaka (Oryzias latipes)*

13:50-14:10	Chiavelli, Rich *Restoration challenges, efforts, and progress for Atlantic salmon in New York Lake Ontario waters*	Potter, Sophie *With friends like these, who needs enemies? Phenotype-dependent social environment choice in the male Trinidadian guppy (Poecilia reticulata)*
14:10-14:30	Piironen, Jorma *Efforts to rescue critically endangered Finnish landlocked salmon (Salmo salar m. sebago)*	Cogliati, Karen *Sticking together? Motivation to be near conspecifics for juvenile Chinook salmon reared in three different environments*
14:50-15:10	Barlaup, Bjørn *The recovery of a landlocked Atlantic salmon population in Southern Norway - 50 years with multiple stressors and mitigation efforts*	Mirza, Reehan *A molecular viewpoint on the phylogenetic conservation of injury-released alarm cues in Ostariophysans*
15:10-15:40	Coffee break (Room EFG)	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
15:40-16:00	Sirois, Pascal *Management of the landlocked Atlantic salmon fishery in Lac Saint-Jean: A paradigm shift*	Neff, Bryan *Effects of hormone manipulation on parental care behaviours in bluegill sunfish*
16:00-16:20	Ardren, William *Restoring river runs of landlocked Atlantic salmon*	Robinson, Beren *Effects of adult niche diversification on juvenile performance in polyphenic pumpkinseed sunfish (Lepomis gibbosus)*
16:20-16:40	Bergman, Eva *Conservation of landlocked salmon and trout in a regulated river – a holistic approach*	Jarvis, Will *Testing for phenotype-habitat matching in a phenotypically diverse sunfish population*
16:40-17:00	Greenberg, Larry *Post-spawning survival and downstream passage of landlocked Atlantic salmon the regulated river Klarälven*	O'Dea, Rose *Effects of developmental temperature on phenotypes and their variability: a meta-analysis of fish data*
17:00-17:20	Clarke, Keith *The Ouananiche of Malelpeg Lake: a synopsis of studies conducted since the development of the Granite Canal hydroelectric project*	Pitcher, Trevor *Major histocompatibility complex variation among alternative reproductive tactics of Chinook salmon*
17:20 -17:40	Smitka, Jerry *Overview of Atlantic salmon smolt size, winter temperatures and relative adult returns from Great Lakes and Lake Champlain hatcheries, spring 2017*	
18:00-20:00	Poster reception (First floor atrium)	

Tuesday, June 19, 2018		
7:45-9:00	Coffee available (Room EFG)	
8:00-8:45	**Room CD** Ardren & Greenberg *Discussion about publishing proceedings of the Atlantic salmon symposium in a special journal issue*	
	Room AB ***Keynote presentations***	
9:00-9:45	Alison Bell *Transgenerational and behavioral plasticity at the molecular level in sticklebacks*	
9:45-10:30	Sigal Balshine *Understanding cannibalism, competition, and care: lessons from a singing toadfish*	
10:30-11:00	Coffee break (Room EFG)	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
11:00-11:20	Zathey, Nicole *Effects of strain and rearing temperatures on swim performance and thermal preferences of Atlantic salmon (Salmo salar)*	Haley, Anne *Nuptial colouration and breeding behaviour of an endemic 'white' stickleback*
11:20-11:40	Goerig, Elsa *Sprinting performance of Atlantic salmon*	Axelrod, Caleb *Brain, behaviour, and adaptive divergence*
11:40-11:50	Muir, Carlie *Developmental plasticity of cardiac function and thermal performance in Atlantic salmon*	Gosselin, Benjamin *Artificially increased underwater noise changes yellow perch feeding activity in winter conditions*
11:50-12:00	Prevost, Ashlee *Reproductive success of landlocked Atlantic salmon in two Lake Champlain tributaries*	Guéveneux-Julien, Cynthia *Habitat quality models: using video-cameras to better plan fish habitat conservation*
12:00-13:30	Lunch	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
13:30-13:50	Sundt-Hansen, Line *Investigating population abundance and habitat requirements of the river-resident Atlantic salmon (Salmo salar) småblank*	Gamble, Madilyn *Sexual conflict in salmon life history patterns*

13:50-14:10	Scanlan, Michelle *Where do landlocked Atlantic salmon think they are? A magnetic map sense in a non-anadromous population*	McDonnell, Laura *Elevated temperature affects the physiology and behaviour of the Endangered Pugnose shiner*
14:10-14:30	Minkoff, David *Homing and imprinting cues for landlocked Atlantic salmon*	Reyes, Daniel *Effects of temperature variation on vertebral number and body shape in Astyanax mexicanus (Teleostei: Characidae)*
14:50-15:10	Castro-Santos, Theodore *Understanding effort: consequences of delayed movement for both upstream and downstream passage of Atlantic salmon at barriers*	Holub, Rachel *The influence of individual differences in behavior on trapping efficiency of invasive Sea Lamprey (Petromyzon marinus)*
15:10-15:40	Coffee break (Room EFG)	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***General session***
15:40-16:00	Kortet, Raine *Morphology, swimming performance and foraging in semi-wild and hatchery-reared landlocked salmon juveniles*	Gossieaux, Philippine *Impacts of stocking on effective population size in Brook charr*
16:00-16:20	Bordeleau, Xavier *Consequences of hatchery practices on the physiology, migratory behaviour and survival of wild-origin, hatchery-spawned Atlantic salmon kelts released back to their natal river*	Crawford, Steve *Maori, local and science knowledge systems in the ecology and management of Aotearoa/New Zealand white pointers (Carcharodon carcharias)*
16:20-16:40	McLennan, Darryl *Juvenile Atlantic salmon telomere length varies with environmental quality*	Vanalderweireldt, Lucie *Migratory contingents of striped bass (Morone saxatilis) in the St. Lawrence River: should I stay or should I go?*
16:40-17:00	Fleming, Ian *Maternal effects of migration on sympatric offspring of resident and anadromous Atlantic salmon*	Hashemzadeh, Iraj *Phylogenomics of the Brown trout (Salmo trutta L.) complex*
17:00-17:30		EEEF business meeting *All are welcome*
17:30-20:00	Banquet (Room EFG)	

Wednesday, June 20, 2018		
7:45-9:00	Coffee available (Room EFG)	
	Room AB ***Atlantic salmon symposium***	**Room CD** ***Eco-evolutionary dynamics symposium***
9:00-9:20	Noakes, David *What does the salmon nose know?*	Hendry, Andrew *Eco-evolutionary dynamics in hyper-variable environments: stickleback in bar-built estuaries*
9:20-9:40	Weir, Laura *Habitat quality and nest location as predictors of Atlantic salmon (Salmo salar) density*	Derry, Alison *Eco-evolutionary implications of the co-evolution of adult body mass and excretion rate between genetically size-divergent brook trout populations*
9:40-10:00	Correa, Cristian *Unraveling life history variation and connectivity among of salmonids' southern cousins in Patagonia*	Auer, Sonya *Nutrients from salmon parents alter selection pressures on their offspring*
10:00-10:20	Muñoz, Nico *Biofilm impacts and riparian consumption of non-native Chinook salmon in Patagonia, southern Chile*	Wood, Zachary *Predator presence suppresses a trait-driven trophic cascade in western mosquitofish (Gambusia affinis)*
10:20-10:50	Coffee break (Room EFG)	
	Room AB ***General session***	**Room CD** ***General session***
10:50-11:10	Robertsen, Grethe *Effects of climate on competitive interactions between Arctic char and brown trout*	Church, Kathleen *A meta-analysis of the effects of habitat complexity and territoriality on behaviour*
11:10-11:30	Pepino, Marc *Do thermal barriers in summer enhance winter foraging opportunities in lacustrine brook charr?*	Brown, Grant *Neophobia as a response to uncertainty of risk: lessons from prey fishes*
11:30-11:50	Mannion, Krystal *Effect of food availability on diel activity in stream-dwelling Arctic charr (Salvelinus alpinus)*	Reader, Simon *Early-life influences on guppy brain and behaviour: Population comparisons and developmental manipulations*
11:50-12:00	EEEF Award Presentation (Room AB)	

Poster presentations

General Session	
Abate, Maria	Does the chorion limit precocious activity in pre-hatch zebrafish (*Danio rerio*)?
Fitschen-Brown, Meredith	Factors effecting variation in female mate-preference between two male reproductive tactics in the swordtail fish, *Xiphophorus multilineatus*
Fraser, Doug	A role for strong intraguild predator relationships in affecting the success of invasions
Goldman, Jack	Functional concentration of disturbance cues influence conspecific and heterospecific responses by Trinidadian guppies and convict cichlids
Hashemzadeh, Iraj	The Blind Iran Cave Barbs: a probable case of ancient sympatric speciation
Knapp, Rosemary	Evolution of parental care and modes of reproduction in bony fishes
Mazeroll, Anthony	The Amazon Research Center for Ornamental Fishes
Steingrímsson, Stefan	Foraging and social behaviour of cave-dwelling Arctic charr in the Lake Mývatn area, northern Iceland
Tucker, Fred	Boldness and anxiety-like behavior in melanic and non-melanic hybrid swordtails

Atlantic Salmon Symposium	
Bremset, Gunnbjørn	An extremist among salmonids: Habitat use of landlocked salmon (småblank) in a Norwegian river
Hatanpää, Aurora	Spawning behaviour of landlocked salmon (*Salmo salar* m. sebago) after trapping and transportation
Johnston, Patricia	Implementation of a landlocked salmon population in the Romaine 4 reservoir

Keynote presentations

Dr. Lauren Chapman
McGill University

Hot Fish in a Warming World: Effects of Dual Stressors on Energetics and Performance of African Equatorial Fishes

Tropical fishes may be more sensitive to climate warming than temperate species because they experience small annual temperature fluctuations and seem to live relatively close to their maximum thermal tolerance. Here, I present results of a series of acclimation and rearing experiments that explore effects of temperature on energetics, behavior, and performance (e.g. aerobic scope, swim performance) of two East African fishes: the Egyptian mouth-brooder (*Pseudocrenilabrus multicolor*) and the Nile perch (*Lates niloticus*). Our results demonstrate that aerobic performance can be maximal at temperatures near the limit of ecological relevance, and for Nile perch, longer exposure time results in higher thermal tolerance and a decrease in metabolic costs of elevated temperature. In addition to direct effects of thermal stress on fish performance, climate warming is likely to interact with other stressors, in particular, aquatic hypoxia, because oxygen solubility decreases with rising temperature while ectothermic metabolism increases. To explore the interaction between hypoxia and temperature, F1 offspring of P. multicolor were reared in four treatments (low or high oxygen; cool or hot temperature). We observed developmental plasticity in morphological traits (e.g., gill size), behaviour, energetics, and performance; and development under hypoxia modulated negative effects of acute thermal stress on swim performance.

Dr. Jeff Hutchings
Dalhousie University

Adaptive significance of life-history variability in landlocked Atlantic salmon

Population viability depends on life histories that generate consistently positive rates of per capita growth ($r > 0$). For many Atlantic salmon, the fitness benefits of anadromy (large size: 45-120cm; rapid growth: 30-40cm yr-1; high fecundity: 103 eggs) exceed the primary cost (high mortality: ~95% yr-1). In some systems (Newfoundland), the fitness of non-anadromous, or 'landlocked', salmon (males and females) equals that of sea-run salmon, resulting in their co-existence. Where migration to and from sea is prevented, landlocked salmon tend to exhibit one of two life-history types. Large landlocked salmon (>35-50cm) are

associated with large lakes that sustain abundant small fish, e.g., smelt or vendace; they are able to co-exist with multiple species at multiple trophic levels. By contrast, small landlocked salmon mature at small sizes (<15-20cm), produce few eggs, and live brief lives. Their life history seems possible only in waters of low fish species diversity and (likely) no predators. Recovery of depleted landlocked populations are likely inhibited by Allee effects and, in some cases, low r. Using optimality modelling, I hope to identify the life-history boundary conditions that constrain population viability and serve to limit the distribution of landlocked Atlantic salmon throughout its native range.

Dr. Alison Bell
University of Illinois, Urbana-Champaign

Transgenerational and behavioral plasticity at the molecular level in sticklebacks

In this talk I will present two case studies of behavioral plasticity at the molecular level in threespined sticklebacks, a species famous for their behavioral repertoire. In the first case study, I will show that transgenerational and developmental plasticity in response to cues of predation risk produce comparable and nonadditive responses at the phenotypic and molecular level. For example, offspring with both personally-acquired and paternally-acquired cues of predation risk resembled offspring that received cues from a single source. A similar pattern was detected at the molecular level: there was a core set of genes that were differentially expressed in the brains of offspring, regardless of whether risk was experienced by their father, themselves or both. This transcriptional response is consistent with a molecular switch that is activated in response to an environmental cue, regardless of whether the environment is experienced by parents, their offspring or both. The second half of the talk will focus on short-term behavioral plasticity in response to social interactions. I will present results showing rapid and dramatic epigenomic plasticity in response to a brief territorial challenge in male sticklebacks. I will show how we are integrating time course brain gene expression data with a transcriptional regulatory network, and linking changes in gene expression to changes in chromatin accessibility. Together, these two case studies illustrate how examining behavioral plasticity at the molecular level provides insights into the proximate causes and evolution of behavior.

Dr. Sigal Balshine
McMaster University

Understanding Cannibalism, Competition, and Care: lessons from a singing toadfish

Cannibalism of young is a common, yet seemingly paradoxical, phenomenon observed across a wide variety of taxa. Behavioural ecologists have been particularly interested in understanding this behaviour within the context of parental care, because of the high putative costs of terminating offspring that have already received investment. Using a series of field and lab experiments with the plainfin midshipman fish (*Porichthys notatus*), my students and I have investigated why offspring cannibalism occurs. We show that plainfin midshipman males endure an extremely long (3 - 4 months) and taxing parental care period, but that (surprisingly) males with the lowest energy reserves are least likely to engage in offspring cannibalism. The highest rates of offspring cannibalism are associated with low nest paternity and periods of intense male-male competition. The plainfin midshipman has many unusual courtship behaviours and parental care tactics, including using sound to win over females. Competition is rife, with many males taking over nests from other males and many sneaker males in the population who steal fertilizations from caring males. I will describe our recent research progress on studying competition, cannibalism and care in this fascinating singing toadfish. I will also highlight how fish behaviour can be linked to population dynamics, and foodweb dynamics.

Oral presentations

The effects of body size and previous experience on sexual selection in Japanese medaka (*Oryzias latipes*)

Allen, Emily R[1]*; Weir, Laura K[2]

[1]Saint Mary's University; [2]Saint Mary's University

Many factors can interact to contribute to male mating success, including body size, behaviour and sperm traits. Both behavioural and sperm characteristics can be altered depending upon a male's previous mating experience. In Japanese medaka (*Oryzias latipes*), males mate with many females each day and larger males mate more frequently than small males. Fertilization success decreases with successive matings, and thus females should prefer males who have not recently mated because higher sperm counts are positively correlated with egg fertilization success. However, females may also be more receptive to males who have recently mated because mate-copying removes the need to assess a particular male. In a factorial experiment, we examined the interactive effect of size and previous experience on mating behaviour and success. Each trial included a large and small male who differed in their previous experience. Experienced males had the opportunity to court and mate with ten females prior to the focal observations. Females mated with large males in 15 of 20 trials, and 13 of 20 males that successfully spawned had previous experience. Rates of courtship and aggression were positively related to mating success. Therefore, previous experience has an influence on courtship and spawning success.

Restoring river runs of landlocked Atlantic salmon

Ardren, William R[1]*; Harbicht, Andrew[2]; McCormick, Stephen[3]; Fraser, Dylan[2]

[1]U.S. Fish and Wildlife Service, Essex Junction; [2]Concordia University; [3]U.S. Geological Survey, Turners Falls

Landlocked Atlantic salmon (*Salmo salar*) were extirpated from Lake Champlain in the early 1800s. Sea lamprey control and stocking yearling smolts, provide for a popular salmon fishery in the lake. However, spawning runs of salmon to rivers have remained low. From 2010 to 2017, we conducted an adaptive management experiment focused on increasing river-runs of salmon to enhance in river fisheries and restore natural populations. Goals of the program were to: (1) identify indicators of smolting to optimize timing of stocking to periods when fish are likely to imprint on rivers and (2) evaluate alternative hatchery rearing and stocking methods. Gill Na+/K+ ATPase activity during the spring was identified as an indicator of smolting for landlocked salmon but activity levels were much lower than observed in anadromous populations. We observed a 4 fold

increase in smolt-to-adult survival and reduced stray rates for smolts reared in river water with an ambient temperature profile compared to smolts reared on well water with an increased temperature profile. Earlier release dates, March vs May, decreased smolt-to-adult survival rates by 88%. Our results demonstrate potential for rapid increases in river-runs using hatchery smolts combined with targeted research and adaptive management.

Nutrients from salmon parents alter selection pressures on their offspring

Auer, Sonya K[1]*; Anderson, Graeme J[1]; McKelvey, Simon[2]; Bassar, Ronald D[3]; McLennan, Darryl[1]; Armstrong, John D[4]; Nislow, Keith H[5]; Downie, Helen K[4]; McKelvey, Lynn[2]; Morgan, Thomas AJ[4]; Salin, Karine[1]; Orrell, Danielle L_1; Gauthey, Alice[6]; Reid, Thomas C[1]; Metcalfe, Neil B[1]

[1]Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow; [2]Cromarty Firth Fishery Trust; [3]Williams College; [4]Marine Scotland – Science, Freshwater Fisheries Laboratory; [5]USDA Forest Service Northern Research Station, Amherst; [6]Université Pierre et Marie Curie, Paris

Organisms can modify their surrounding environment, but whether these changes are large enough to feed back and alter their evolutionary trajectories is not well understood, particularly in wild populations. Here we show that nutrient pulses from decomposing Atlantic salmon (*Salmo salar*) parents alter selection pressures on their offspring with important consequences for their phenotypic and genetic diversity. We found a strong survival advantage to larger eggs and faster juvenile metabolic rates in streams lacking carcasses but not in streams containing this parental nutrient input. Differences in selection intensities led to significant phenotypic divergence in these two traits among stream types. Stronger selection in streams with low parental nutrient input also decreased the number of surviving families compared to streams with high parental nutrient levels. Observed effects of parent-derived nutrients on selection pressures provide experimental evidence for key components of eco-evolutionary feedbacks in wild populations.

Brain, behaviour, and adaptive divergence

Axelrod, Caleb*; Robinson, Beren W; Laberge, Frederic

University of Guelph

Changes in behaviour that initiate niche shifts are thought to promote adaptive divergence when shifts in ecology change selection on secondary traits. If cognitive abilities and behavioural characteristics are rooted in the substrate of neural tissue in the brain, then we may expect brain morphology will also be related to habitat use in diverging populations. Consistent differences in brain morphology have evolved between fish species adapted to different habitat types, but this relationship may be confounded

with additional species differences unrelated to ecological diversification. This species confound can be removed by testing for relationships between brain morphology and habitat use among ecologically divergent populations within a species. Pumpkinseed sunfish (*Lepomis gibbosus*) can diverge into shallow inshore littoral and deep offshore pelagic ecotypes that coexist in the same lake. We compared the gross brain morphology quantified from digitized photographs of dissected brains of wild fish sampled from littoral and pelagic sites from a single polyphenic population. Grass brain morphology varied between ecotypes. This result is consistent with the hypothesis of rapid consequential behavioral differentiation between diverging populations, and the hypothesis that behavioural and cognitive characteristics related to habitat use are rooted in the neural substrate of the brain.

The recovery of a landlocked Atlantic salmon population in Southern Norway - 50 years with multiple stressors and mitigation efforts

Barlaup, Bjørn T[1]; Skoglund, H[1]; Pulg, U[1]; Kaste Ø[2]

[1]Uni Research Environment, LFI (Laboratory of freshwater ecology and inland fisheries);
[2]Norwegian Institute for Water Research-NIVA

The Bleke salmon is a native landlocked salmon found in Southern Norway. Here, they migrate from lotic spawning and nursery habitats to lake Byglandsfjorden (45 km^2) where they feed on zooplankton until they mature between 20-30 cm. Historically, fishing during the spawning run was an important local tradition. However, this came to an end as the stock collapsed and almost went extinct in the late 1960s from the combined effects of acidification and hydropower development. Since 1979, salmon fry originating from a very small brood stock, have been released into the lake, but by the 1990s, there were still few signs of natural recruitment. The last 20 years have seen decreases in acidification that improved water chemical conditions for salmon. To mitigate the effects from hydropower, supplemental gravel has been added to increase spawning habitat, restrictions on water level fluctuations have been implemented since 2009 to prevent desiccation of spawning grounds, fishways have been installed, and measures to reduce effects of gas supersaturation have been suggested. At present, natural recruits are on the rise and fish stocking has been terminated to promote a self-sustained population. Long-term monitoring, public awareness, and knowledge-based environmental management have been important to the ongoing efforts to restore the Bleke salmon population.

Conservation of landlocked salmon and trout in a regulated river – a holistic approach

Bergman, Eva[1]*; Calles, Olle[1]; Greenberg, Larry[1]; Hagelin, Anna[1,2]; Norrgård, Johnny[3]; Nyqvist, Daniel[1,4]; Piccolo, John J[1]

[1]Karlstad University, Sweden; [2]County Administrative Board of Västra Götaland, Sweden; [3]Gammelkroppa Lax AB, Sweden; [4]Institute of Marine Research in Bergen, Norway

Populations of migratory salmon and trout have worldwide shown a decline due to human activities. Over the years numerous measures have been undertaken to maintain these populations, and conservation of migratory salmonids requires understanding of their ecology at multiple scales, combined with assessing anthropogenic impacts. The regulated River Klarälven and Lake Vänern host endemic populations of landlocked Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*). The historically high abundances of the salmonids in the River Klarälven in the early 1800s have decreased dramatically, reaching all-time lows after the completion of nine Swedish hydroelectric power stations in the 1960s. After an extensive stocking program and transportation of spawners past eight hydroelectric plants, catches from commercial, maintenance and sport fishing have again increased. Recently, increases in the proportion of wild salmon returning to the river have generated interest in establishment of wild salmon inhabiting the entire river, including upstream of the Norwegian border where they historically occurred. How well are we equipped to meet these new goals, taking into account our limited knowledge of the species' different life stages, coordination between different actors involved in the conservation processes, and our skills to communicate and understand everybody's role in this conservation process?

Consequences of hatchery practices on the physiology, migratory behaviour and survival of wild-origin, hatchery-spawned Atlantic salmon kelts released back to their natal river

Bordeleau, Xavier[1]*; Hatcher, Bruce G[2]; Denny, Shelley[3]; Fast, Mark D[4]; Whoriskey, Fred G[5]; Patterson, David A[6]; Crossin, Glenn T[1]

[1]Dalhousie University; [2]Cape Breton University; [3]Unama'ki Institute of Natural Resources; [4]University of Prince Edward Island; [5]Ocean Tracking Network University; [6]Fisheries and Oceans Canada

Broodstock collection programs are a widely used management practice within the Atlantic salmon's native range, in both anadromous and landlocked populations. However, wild salmon captured as part of these programs experience multiple stressors in hatcheries, and the potential consequences of such practices on the physiology, migratory behaviour, and long-term survival of post-spawners (termed kelts) upon their return back to the wild have received minimal attention. We addressed these knowledge gaps by physiologically sampling and acoustically tracking 30 hatchery-spawned and 31 wild-spawned kelts released back to their river of origin (Middle and Baddeck rivers, NS, Canada). Individuals were followed for up to two years through their downstream river

migration, estuarine residence, ocean entry, and subsequent return as repeat-spawners. Compared to wild-spawned counterparts, hatchery-spawned kelts had significantly higher stress levels and potentially altered immune states, and exhibited earlier freshwater-exit and elevated estuarine mortality. Furthermore, survival to repeat-spawning was 0% and 6.5% for hatchery-spawned and wild-spawned kelts, respectively. Given that female repeat-spawners are generally large and have high fecundity, our findings suggest that a reduction in iteroparity as a result of hatchery practices could have population-level consequences. These repercussions should be considered in current conservation and management practices for iteroparous salmonid species.

Heterogeneity of space use tactics in salmon parr along breeding season in relation to the individual maturity level

Bouchard, Colin*; Rives, Jacques: Lange, Frédéric; Tentelier, Cédric

UMR ECOBIOP, INRA, University of Pau & Pays Adour

Maturity leads to a changeover of focal resources, switching from trophic to breeding habitats and food to potential mates. Given this change of focal resources and their spatio-temporal distributions, maturity may affect space use. Body condition may also impact space use when individuals compete for resources. Aims of this study were to link space use to the maturity level and body condition of Atlantic salmon parr. We monitored the daily positions of 40 one-year parr by radio-tracking them throughout the spawning season, in a 2.5km river section where nests were mapped. Mature individuals covered both a longer upstream (1.4 vs 0.5 km) and total distance than immature (3.2 vs 1.3 km). Longer mature individuals, but not those in better condition, moved further upstream. Finally, the ability of mature individuals to resettle increased their probability to encounter a nest. This study is the first documenting space use of mature parr at a broader scale than the direct vicinity of nests. These results suggest mature parr have a potentially higher impact than expected on genetic diversity and life history diversity. Such data are also helpful to estimate the energy costs associated with movement of mature parr, besides costs of gonad maturation.

Neophobia as a response to uncertainty of risk: lessons from prey fishes

Brown, Grant E*

Concordia University

Due to the unforgiving nature of predation, prey animals are continually faced with the conflicting demands of predator avoidance and a suite of other fitness-related activities (i.e. nonconsumptive effects of predation). The reliable assessment of local predation risks should allow prey to optimize behavioural decisions and reduce the impacts of NCEs.

However, predation risks can be spatially and temporally variable, leading to uncertainty in local risks. Such uncertainty is argued to dramatically increase the costs of decision-making among prey populations. Recently, we have argued that neophobia (the 'fear' of novel stimuli) is a phenotypically plastic response to unpredictable predation risk. Our results to date suggest that induced neophobia may function as a generalized response to uncertainty. In support of this hypothesis, I will highlight our recent laboratory and field studies that: 1) link the intensity of ambient predation risk to the strength and retention of neophobic responses and 2) disentangle the role of variability, predictability and diversity of risks in shaping neophobia. Given the combined effects of anthropogenic habitat degradation, invasive species and climate change, understanding how prey respond to ecological uncertainty is critical question for ecologists.

Understanding Effort: Consequences of delayed movement for both upstream and downstream passage of Atlantic salmon at barriers

Castro-Santos, T*; Nyqvist, D; Harbicht, A

USGS-Leetown Science Center

Fish passage is about more than simply passing fish. The goal is to provide connectivity between habitats, and delays incurred during passage can have long-term consequences for individual fitness as well as key processes at the population level. In a pair of studies performed in tributaries to Lake Champlain we quantified passage performance of landlocked Atlantic salmon, both during a downstream smolt migration and an upstream spawning migration. In both cases the barriers were passable, but overall passage was reduced by the extended delays incurred by salmon as they tried to pass. By quantifying the effort expended attempting to pass these barriers we gain insights into biological and environmental factors that limit motivation, and how these combine with structural features to govern passage success.

Restoration challenges, efforts, and progress for Atlantic salmon in New York Lake Ontario waters

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The USGS Tunison Laboratory of Aquatic Science and the NYS Department of Environmental Conservation (NYSDEC) have collaborated on an effort to test the feasibility of restoring Atlantic Salmon as a component of the fish community in New York waters of Lake Ontario. The Salmon River in the Eastern basin has provided the best opportunity for stocking, adult collection, and provides suitable habitat for natural reproduction and early life stage success. Indicators of success include an increase of

adult returns since first observed in 1998 as a result of yearly stocking by the state in the Salmon River. Conducted surveys show additional recreational opportunities in tributaries and Lake Ontario. Successful natural reproduction not seen in over a century was first recorded in 2009 and four additional years since then. Tunison began Collection of eggs from returning adults captured in the Salmon River that adapted to Lake Ontario conditions in 2014 and progeny of these fish have been annually stocked as part of their yearly production of 70,000 fingerlings and 20 to 30,000 smolts. I will further review the progress of the efforts, discuss challenges, and outline future plans for potential restoration of Atlantic salmon.

A meta-analysis of the effects of habitat complexity and territoriality on behaviour

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Concordia University

The addition of habitat complexity is frequently used to increase the population density of territorial species and to reduce aggression among captive animals. However, it is unknown if territorial species are generally uniquely affected by complexity. We conducted a meta-analysis to compare the behaviour of territorial and non-territorial taxa in complex and open habitats to determine the effects of habitat complexity on 1) territory size, 2) density, 3) aggression, 4) foraging, 5) activity, 6) shyness, 7) exploration, 8) sociality and 9) survival. Overall, habitat complexity significantly affected all measures except sociality. Territorial and non-territorial species tended to respond differently to complexity. Territorial species showed lower aggression, foraging, and activity in complex habitats, while non-territorial species showed the opposite pattern in complex habitats. Survival of territorial species remained unaffected by complexity, while in contrast, non-territorial species suffered less mortality in complex habitats, thereby suggesting that they experience less risk of predation in open habitats. For territorial species, the effects of habitat complexity on density and activity were strong and highly predictable, with consistent increases in density and decreases in activity. This meta-analysis demonstrates that territorial animals respond differently to habitat complexity, likely due to their strong reliance on visual cues.

The Ouananiche of Malelpeg Lake: a synopsis of studies conducted since the development of the Granite Canal hydroelectric project

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Maelpeg Lake is a large hydroelectric reservoir (32600 ha) located in central Newfoundland that is home to a productive landlocked Atlantic Salmon (ouananiche) population. Salmon in this system can live for up to eight (8) years and attain a maximum forth length of greater than 450 mm. In the early 2000's new generating capacity was installed at the upstream end of Maelpeg Lake, this development resulted in the destruction of the primary spawning area in the lake. As part of the offset for these habitat losses a 1.6 km fish habitat channel, subsequently named Compensation Creek, was constructed. In the interim a series of studies on the fish populations of the area have been conducted. These studies have included observations on adult salmon movement, salmon spawning behavior as well as observations on general habitat use and evolution of fish utilization of Compensation Creek. Adult salmon rapidly utilized the new habitat provided in Compensation Creek and over the long term almost half the salmon tagged in the reservoir used the creek during spawning. Fish from all parts of the reservoir appear to be able to find the relatively small creek with adults only using the creek for a short duration and then returning to the lake after spawning. The creek provides habitat for younger age classes (< 3 years) with densities similar to natural steams. The relative rapid use of the new habitat may be related to the low fish species diversity in found in Newfoundland which can result in a plasticity of life history strategies and habitat usage patterns.

Sticking together? Motivation to be near conspecifics for juvenile Chinook salmon reared in three different environments

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[1]Oregon State University; [2]Oregon Hatchery Research Center

Wild and hatchery salmonids experience significantly different environments during juvenile development. Typically, hatchery fish are reared at high density compared to natural-origin (wild) conspecifics. Hatcheries release thousands of juvenile smolts into rivers to swim downstream to the ocean. Here, we tested whether natural-origin and hatchery juvenile Chinook salmon differed in their motivation to be near conspecifics. Additionally, we tested a third group of juvenile Chinook salmon raised using altered rearing protocols to produce wild-like phenotypes, called "wild fish surrogates". We predicted that hatchery fish would be most motivated to be near conspecifics compared to natural-origin and wild fish surrogates when individually tested. Fish were tested in an arena where we placed unfamiliar conspecifics in a compartment at the opposite end of a start box, or left the compartment empty as a control. For each fish, we evaluated the time it took to exit the start box into an aversive zone, the time it took to traverse the aversive zone, and the time spent in the preference zone. These results will shed light on the effects of rearing environment on social behaviour. Understanding the social and

motivational differences between hatchery and natural-origin fish may help guide conservation hatcheries and other programs.

Unraveling life history variation and connectivity among of salmonids' southern cousins in Patagonia

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Universidad Austral de Chile

Among the freshwater and diadromous Patagonian ichthyofauna south of 37°S, probably the little known genus Aplochiton was dominant (Galaxiidae). Tales still resonate among old fishermen about plentiful catches, peculiar translucent flesh, delicate taste, and complete absence of scales. Currently, however, Aplochiton are rare at best, and their main threat are invasive salmonids. The goal of this study is to uncover life history variation within and among Aplochiton species, and describe coastal and inland pattern of population structure. Preliminary results of surveys and elemental analyses of otolith transects suggested great variation in life-history types involving residency in freshwater (land-locking), ontogenetic incursions to the sea (catadromy/amphidromy), or both. Population genetic analyses (SNPs) revealed the greatest differentiation in landlocked populations, as expected. However, all coastal populations, even of a seemingly freshwater species, seemed to cluster together at the smallest spatial scale (<50 Km), suggesting local marine dispersal and low phylopatry. At a meso-scale (<350 Km) only populations of clearly diadromous species clustered together, whereas at the largest scale (>700 Km) all Aplochiton species were highly structured. Like salmonids, the southern cousins of the genus Aplochiton share complex and variable life histories whose knowledge is pivotal for setting sensitive conservation targets and management objectives.

Maternal effects of migration on sympatric offspring of resident and anadromous Atlantic salmon

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Many coastal rivers in Newfoundland contain sympatric anadromous and non-anadromous (i.e. resident) phenotypes of Atlantic salmon. The coexistence of these sympatric phenotypes may be affected by differences in early offspring performance as a result of maternal effects (e.g., marine versus freshwater derived nutrients in the eggs). To examine this, paternal half sib families were created by crossing pairs of unique anadromous and resident females with single males. Lipid profiles measured throughout

development (egg to emergent fry) revealed no significant differences in total lipids between the two offspring types, however anadromous offspring had higher amounts of long chain fatty acids (EPA, DHA) and ratios of ω3:ω6 fatty acids, which may influence early development. Results also showed that resident mothers had larger eggs and their offspring were larger at emergence. Pair-wise dominance trials between newly emerged offspring revealed no significant difference in positioning relative to a defensible food source. Similarly, growth and survival of the newly emerged offspring, tested over a four week period in stream channels and across three treatments (2 allopatry, sympatry) differed little. Thus despite apparent differences in maternal contributions, there were no indications under the experimental conditions examined that these strongly influenced offspring performance after emergence.

Sexual conflict in salmon life history patterns

Gamble, Madilyn*

Dartmouth College

Sexual conflict occurs when selection on a single trait acts in different directions in males and females. In salmonids, sexual conflict exists around age at maturity. For females, size is tightly correlated with fecundity and egg size – thus larger (usually older) females have higher reproductive fitness. For males, however, reproductive success is less related to size. Males may mature smaller and younger than females and still sire offspring. Indeed, males of many anadromous salmonids may exhibit a "sneaker" tactic in which they mature at a fraction of the size of the largest males and sneak copulations with females by waiting unnoticed in her nest until he can release sperm as she releases her eggs. On the other hand, anadromous males may exhibit satellite or dominant tactics on the spawning grounds depending on their size relative to competitors. Despite this divergence in life history patterns between the sexes and the importance of life history to management and conservation, research on salmon life history often ignores the influence of sexual conflict, and studies on life history traits seldom look for differences between the sexes. My research explores how life history relationships differ between the sexes across salmon populations and species.

Sprinting performance of Atlantic salmon

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Natural and anthropogenic riverine features such as waterfalls, culverts or fishways may impede or delay fish movements, with associated consequences on fitness. The ability to cope with challenging hydraulic conditions is closely related to species' behavior and

swimming capacity. Thus, knowledge of maximum swimming capacity and endurance is of primary interest to fish passage issues. Here we present data of adult salmons volitionally swimming in a 35 m experimental flume, under flow velocity ranging from 0.25 to 4 m s-1. Salmons migrating upstream in the Connecticut River were captured at Holyoke dam. They were tagged with passive integrated transponders (PIT-tags), and released in a large staging area downstream of the flume. PIT antennas spaced along the flume recorded distance of ascent as well as instantaneous and average swim speeds for each individual attempt. A high-speed camera also recorded the lateral and ventral view of swimming fish. The relationship between swim speed and fatigue time for prolonged and sprint swimming modes was quantified, as well as some kinematics parameters during sprinting. The results will be useful for predictions of fish passage at barriers and fishway design, as well as for addressing fundamental questions pertaining to the limits to swimming performance.

Artificially increased underwater noise changes yellow perch feeding activity in winter conditions

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Fish are constantly exposed to underwater sounds. Noise generated by human activities creates increasingly fragmented and varying soundscapes. Increases in noise intensity could influence fish feeding behaviour through noise avoidance effects leading to changes in habitat use. From a predator's perspective, capture rate may increase due to distracted preys or through cognitive processes increasing arousal. Alternatively, noise can reduce the intensity, duration and frequency of feeding activities due to stress. In the present study, we aimed to test whether the yellow perch (*Perca flavescens*) feeding activity was modified by an increase in ambient noise levels. To this end, we performed a playback experiment under the ice sheet of a frozen lake, where we artificially raised noise levels while recording feeding activity. Our results show that increase in ambient noise levels does not cause avoidance or changes in the number of captured prey. However we found that noise treatment increases the yellow perch feeding efficiency (the probability that an attack ends into a capture). Thus, noise exposure could increase a predator's alertness through cognitive processes rendering it more efficient.

Impacts of stocking on effective population size in Brook charr

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[1]Université de Sherbrooke; [2]Université Laval; [3]Université du Québec à Chicoutimi

Effective population size (Ne) is a measure of the genetic size of a population and a crucial parameter for wildlife population management since it is strongly related to retention of genetic diversity in time and/or to inbreeding levels. Many exploited fish populations are stocked with the purpose of increasing population sizes to sustain important fishing pressures. However, supplementation with hatchery-reared fish could at the same time increase population census size and decrease Ne (i.e. Ryman-Laikre effect). Our study aims at characterizing how stocking impacts Ne in supplemented populations of Brook charr (Salvelinus fontinalis) in Québec and at assessing how this relationship varies with the intensity of stocking (e.g. number of stocking events, number of fish stocked/ha). Using 54 populations, we found that stocked lakes have significantly lower Ne than unstocked lakes but found no additional effect of stocking intensity on Ne of stocked lakes. Our results suggest that supplementation per se has a negative impact on Ne but that more intense stocking does not necessarily translate into lower Ne. Also, we found no effect of the number of years since last stocking on Ne, suggesting that stopping supplementation has little further consequences on change in Ne in stocked lakes.

Social inertia in stream salmonid territories: implications for population dynamics and restoration

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[1]Concordia University; [2]Saint Mary's University; [3]Holar University College

Most pristine salmonid populations experience some kind of density-dependent population regulation via survival, growth rate, or dispersal. In contrast, salmonid populations requiring restoration are typically considered to be at low density. At high density, local population density will be set by territory size and the degree to which it changes in response to changes in key environmental variables: population density, food abundance, habitat complexity, predation hazard, and the synchrony of arrival of competitors. In a series of laboratory, field and meta-analytic studies, we show that territory size changes as predicted by optimal territory size models, but the magnitude of these changes is relatively modest. This social inertia implies that territory size will play an important role in population regulation. At low densities, however, density dependent individual growth rate and dispersal continue to play an important role in dynamics of the population. Hence, we characterize the "salmonid life history" as being inherently prone to density-dependent effects.

Post-spawning survival and downstream passage of landlocked Atlantic salmon the regulated river Klarälven

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Karlstad University

Repeat salmonid spawners may make large contributions to total recruitment and long term population stability. Despite their potential importance, little is known about this life stage for landlocked populations. Here, we studied post-spawning behaviour and survival of landlocked Atlantic salmon in relation to downstream dam passage in the River Klarälven, Sweden from 2011-14. Eight hydropower stations separate the feeding grounds in Lake Vänern from the spawning grounds in the river, and no measures to facilitate downstream migration are present. Nearly half of the salmon survived spawning and initiated downstream migration. Females and small fish had higher post-spawning survival than males and large fish. During years with high spill, 84% of the fish passed the first dam, mostly via upward-opening spill gates after a median delay of 25 min. During a year of low spill, 41% of the fish passed the dam, mostly through the turbines, where mortality was high. In addition, most fish approached the turbine intake near the surface. For all years combined, only 2% of the tagged fish successfully passed all eight hydropower stations to reach Lake Vänern. This result underscores the need for remedial measures to increase survival of downstream migrating kelts.

Eco-evolutionary implications of the co-evolution of adult body mass and excretion rate between genetically size-divergent brook trout populations

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We tested if there was a difference in mass-specific excretion rate between two genetically size-divergent brook trout populations that can be accounted for by genetic/maternal factors. We conducted laboratory-based common garden experimentation using F1 generation fish, with five to seven families per population at two ages. We found that genetic/maternal differences in excretion rate on a per gram basis co-evolve with genetic divergence in adult body mass between the populations. However, this co-evolution has also resulted in no net difference in excretion rate between populations when differences in adult body mass were accounted for. Uncertainty in census estimates and variation in body mass distributions created substantial variation in extrapolated whole-population excretion estimates. No other studies to our knowledge have tested for genetic/maternal divergence in excretion rate between genetically size-divergent fish populations. Genetically-based population divergence in body mass, energy allocation in reproduction, and mass-specific excretion rate in the brook trout was likely a result of selection associated with differences in the availability of overwintering habitat between streams. Our study has eco-evolutionary implications for the effects of basal metabolic rate on body size, reproductive investment, and fitness in the context of size-selective harvesting and nutrient cycling in aquatic ecosystems.

Habitat quality models: using video-cameras to better plan fish habitat conservation

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University of Montreal

Overfishing, pollution, habitat alteration and destruction have all had great impacts on freshwater fish ecosystems. Over the years, multiple tools were developed, aiming to mitigate these impacts and help restore fish populations that were damaged. Habitat Quality Models (HQM) are such tools. They are used to identify critical habitats for species by linking environmental factors to habitat quality. Nevertheless, few problems remain with HQM, especially when they are used for roaming species with complex behavior like fish. Indeed, HQM for fish are usually built on data collected "punctually" (at one point in time). However, this type of data might lead to misinterpretation of a fish's habitat selection if it was sampled during transition to a patch of higher quality. That is why we suggest a sampling technique that is increasingly used, thanks to technological advances, and that would allow observation of fish over time: submerged video-cameras. This technique would allow us to build HQM better suited for fish by providing behavioral data. We hypothesize that, compared to HQM derived from another visual sampling technique, our models will provide better insights on habitat quality for fish and a better tool for conservation planning.

Nuptial colouration and breeding behaviour of an endemic 'white' stickleback

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Saint Mary's University

The white Threespine Stickleback, an ecotype endemic to Nova Scotia, breeds sympatrically with the common marine Threespine Stickleback (*Gasterosteus aculeatus*) in brackish water. During the breeding season, 'white' males display bright white colouration and lack parental care, which differs from the typical nuptial colouration and extensive parental care shown by the 'common' males. Previous studies indicate that genetic and behavioural differences exist between ecotypes, however the mechanisms by which white Threespine Stickleback achieve nuptial colouration is unknown. To understand the cellular basis of nuptial colouration, we quantified melanophores in the skin of both breeding and non-breeding white and common ecotypes. Breeding white males had fewer melanophores than common and non-breeding males. In addition, we identified behavioural correlates of rapid colour change by observing and photographing breeding males in the field. Preliminary results from field observations corroborate earlier findings that 'white' males are more active than 'common' males. Our field results also suggest considerable plasticity in the degree of white colouration during the 5-minute observation periods. Together, results from the melanophore and field studies suggest

that nuptial colouration is influenced by breeding state and can also rapidly change in association with specific male behaviours.

Wild masu salmon is outcompeted by hatchery masu salmon rather than nonnative brown trout

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Hokkaido National Fisheries Research Institute

Artificially grown native species are released into natural environments to increase biological resources or recover endangered populations. They have enhanced survivability and may outcompete wild conspecifics as native invaders. In addition, it is likely that the competitive effects of native invaders on native species are more intense than those of nonnative invaders. To test these hypotheses, an enclosure experiment was conducted using young-of-the-year wild and hatchery (grown large to increase survival after stocking) native masu salmon *Oncorhynchus masou* and nonnative brown trout *Salmo trutta* (smaller than wild masu salmon). The competitive effects were evaluated by stomach fullness and growth of wild masu salmon. The magnitude relationships of stomach fullness and growth between the experimental treatments showed the same patterns suggesting that competition for foraging habitat reached the growth. Wild masu salmon had negative effects of hatchery conspecifics, and the effects were larger than those of brown trout. These results were caused by competitive dominance from a body size difference. In conclusion, the results support the hypothesis that artificially enlarged hatchery masu salmon function as native invaders and its negative effects on wild masu salmon were larger than those of a nonnative invader.

Phylogenomics of the Brown trout (*Salmo trutta* L.) complex

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Brown Trout is the most widespread salmonid species distributed in Eurasia and the North Africa. Many cases of inter-basin transfers of Brown Trout had been conducted during the past decades. In addition, numerous morphological species had been described in this complex. In order to clarify the distribution of non-native Brown Trout and to assess the taxonomic and phylogenetic status of different taxa, described within the Brown Trout complex, we analysed specimens from 85 localities all over its natural distribution using genomic data. The data reveals admixture of the Atlantic Trout in all

non-Atlantic major basins. Our results reveals that *Salmo marmoratus*, *Salmo platycephalus*, *Salmo pellegrini*, *Salmo cettii*, *Salmo labrax*, *Salmo lumi*, *Salmo carpio*, *Salmo caspius*, *Salmo ciscaucasicus*, and *Salmo oxianus* each have their genomic signature. It is inferred that the origin of *S. marmoratus* and *S. platycephalus* involved hybridization events that occurred after the divergence of the Atlantic and the Mediterranean lineages. The Ponto-Caspian populations are closely related and they, probably, were in contact during the past few thousand years. The molecular clock calibration we used shows that radiation of most of the Mediterranean taxa has occurred after the last ice age probably due to the post-glacial warming.

Eco-evolutionary dynamics in hyper-variable environments: stickleback in bar-built estuaries.

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McGill University

The eco-evolutionary consequences of temporal variation in selection remain hotly debated. We explored these consequences by studying threespine stickleback in a set of bar-built estuaries along the central California coast. In most years, heavy rains induce water flow strong enough to break through isolating sand bars, connecting streams to the ocean. New sand bars typically re-form within a few weeks or months, thereby re-isolating populations within the estuaries. These breaching events cause severe and often extremely rapid changes in abiotic and biotic conditions; and should therefore represent an intensely variable selective environment in both space and time. This selection lead to important adaptive and ecological consequences. I will describe work on this system that seeks such insights from the combined analysis of neutral and adaptive population genetic structure, adaptive traits, ecological stoichiometry, and whole-genome within-generation selection.

The influence of individual differences in behavior on trapping efficiency of invasive sea lamprey (*Petromyzon marinus*)

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University of Guelph

Scientists are being pressed for methods to counter the unwanted effects of invasive species. The Sea Lamprey is an invasive species in the Laurentian Great Lakes. This species has been the target of a binational control program, which includes trapping, since the 1950s. Bias in trap catches could undermine control efforts. We tested if individual differences in time to enter a novel environment (exploration) and proportion of time moving (activity) in standardized tests were related to individual probabilities of trap

encounter and entrance in the St. Marys River. Individuals were PIT tagged, measured for behaviour, and released in the river. PIT antenna and trap checks quantified encounter and entrance events. Although we found repeatability in the lab for exploration and activity within individuals, we found no evidence that more exploratory, active individuals are more likely to encounter and enter traps than less exploratory, inactive individuals. Concerns for how individual differences in behaviour could reduce trapping efficiency remain unsupported.

Testing for phenotype-habitat matching in a phenotypically diverse sunfish population

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University of Guelph

It is important to understand how animals in spatially structured populations select their local habitat because it will influence individual performance and fitness, and consequently the opportunity for local adaption. We tested the hypothesis that individuals select local habitats based on their phenotypic match to optimize performance. We predicted that individuals that move between habitats will have traits more like the population in their destination habitat than their source habitat. We evaluated habitat selection mechanisms between years with a mark-recapture study of a polyphenic population of pumpkinseed sunfish (Centrarchidae: *Lepomis gibbosus*) composed of ecologically divergent types that occupy alternate lake habitats. 1000 adult sunfish were marked in both lake habitats in summer 2016 and 46 were recaptured in summer 2017. Understanding habitat selection is important both evolutionarily and ecologically because it can influence local adaptation through effects on gene flow and population dynamics through effects on foraging and density.

What does the salmon nose know?

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Olfactory learning of anadromous salmonid fishes is accepted as a textbook example for imprinting, and the basis for the philopatric behaviour of adults to spawn in the same location as their parents. The accepted model is that adult salmonids recognize the chemical nature of their home stream, based upon exposure to that unique chemical composition as juveniles. This model underpins a management tool, whereby juveniles are held in designated acclimation areas prior to seaward migration, thereby promoting their subsequent return, as adults, to these locations. Nonetheless, straying of hatchery-

origin adults to areas other than these acclimation sites remains a problem. We are studying the straying behaviour of hatchery-origin Chinook salmon (*Oncorhynchus tshawytscha*) by investigating details of olfactory learning, odorant responses and homing by spawning adults. We will describe experiments testing our hypothesis of sequential imprinting during ontogeny of Chinook salmon and how our findings are being applied to reduce straying of hatchery-origin fish.

Morphology, swimming performance and foraging in semi-wild and hatchery-reared landlocked salmon juveniles

Kortet, Raine[1]*; Hatanpää, Aurora[1]; Huuskonen, Hannu[1]; Kekäläinen, Jukka[1]; Hyvärinen, Pekka[2]; Vitelletti, Maria Letizia[1]; Piironen, Jorma[3]

[1]University of Eastern Finland; [2]Natural Resources Institute Finland, Paltamo; [3]Natural Resources Institute Finland, Joensuu

The Saimaa landlocked salmon in Finland is a critically endangered ecomorph due to the historical damming of rivers. Recently, efforts have been taken to restore some of the earlier reproduction areas to return the natural life cycle. However, as the population has been reared in hatcheries over many generations it is crucial to know whether domestication has affected the population's fitness-related traits and to assess how the developmental environment affects salmon's phenotype. In the present experiment, we studied the role of the early developmental environment in trait formation by comparing juveniles (0+ years) from three backgrounds: 1) semi-wild fish electrofished from the River Ala-Koitajoki (stocked there as alevins), 2) fish grown in standard hatchery rearing conditions and 3) fish grown in enriched hatchery rearing conditions. We studied their morphology, critical swimming speed and capability of feeding on natural prey. Our preliminary analyses indicate background-dependent variation in all the studied traits. Semi-wild fish consumed more natural prey items, had higher critical swimming speed and differed in their fin morphology, when compared to hatchery reared fish. Thus, the developmental environment seems to produce differences in key traits that are potentially linked to survival in the wild.

Restoration of Atlantic salmon to Lake Ontario

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Originating as a small stocking program in 1987, the Lake Ontario Atlantic Salmon Restoration Program has developed into a significant partnership combining the efforts of the Ministry of Natural Resources and Forestry (MNRF), the Ontario Federation of Anglers

and Hunters (OFAH), and many corporate and community partners. Since 2006, significant progress has been made through enhancements in fish production, community involvement, research and assessment, and habitat enhancement. However, progress toward some program benchmarks has not kept pace. Specifically, the program has failed to generate sufficient numbers of returning adult fish to achieve program goals. In 2015, the program steering committee developed a revised five-year plan (2016-2020) with new priorities and performance measures designed to accelerate restoration with emphasis on improving adult returns. This talk focuses on the new phase of the restoration program, including changes in stocking and fish culture practices, and various methods of assessing returning adults in tributaries with mixed-species migratory runs of other salmonids.

Effect of food availability on diel activity in stream-dwelling Arctic charr (*Salvelinus alpinus*)

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[1]Hólar University College; [2]HAS University of Applied Sciences

This project examines how intraspecific competition may shape diel activity of juvenile Arctic charr (*Salvelinus alpinus*). In a field experiment, 64 fish were tagged and assorted into 8 enclosures exposed to either high or low food availability, with a 47.7% reduction of mean drift density (prey/m³) between treatments. All fish were monitored for six 24hr cycles, over two weeks, during which diel activity and environmental conditions were recorded. Individuals were then tested for behavioral variation (i.e. boldness) in laboratory test arenas (open field, shelter emergence, and sociability). Results indicate a 64% activity average (range=25-100%), with higher activity rates in the high food (mean=69%) than the low food treatment (mean =60%). Activity was higher during the night (low and high food means = 72% and 78%), than during the day (low and high food means = 53% and 63%). Fish growth did not differ significantly between the high (SGR = 0.27%/day) and the low (SGR = 0.09%/day) food treatment, but more active fish grew faster than less active ones. Importantly, our fish did not increase their activity to compensate for reduced food, contradicting previous studies. Lastly, we examine whether diel activity and growth relate to phenotypic differences among individuals.

Elevated temperature affects the physiology and behaviour of the endangered pugnose shiner

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Climate change has altered environments globally, especially freshwaters, that are already among the most threatened ecosystems on the planet. Protection of freshwater taxa demands an understanding of environmental thresholds that can be used to define critical habitat and mitigate threats. We measured sub-lethal behavioural and physiological thresholds in the Endangered Pugnose shiner (*Notropis anogenus*) to assess its ability to cope with elevated water temperature. Pugnose shiner is a small freshwater cyprinid fish, distributed amongst specific, small habitats within the Great Lakes, and is listed as Endangered by Canada's Species at Risk Act. In a lab study, fish were acclimated for two weeks to six temperature treatments, encompassing their natural spring/summer thermal averages and extremes. We detected significant differences in Pugnose's standard metabolic rate (SMR), as well as behavioural (agitation temperature) and physiological (critical thermal maximum) thresholds across temperatures. SMR increased sharply under elevated water temperatures, which may pose challenges if Pugnose are faced simultaneously with other stressors affecting oxygen availability or uptake. Their thermal stress window was lowest at intermediate acclimation temperatures. These results help define this species' thermal window and highlight the importance of incorporating behavioural thresholds with physiological ones in determining how fish may cope in changing environments.

Juvenile Atlantic salmon telomere length varies with environmental quality

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Habitat quality may affect the physiological state of the organisms that live within it. However, individual physiological state is often difficult to quantify. We report here on an experimental field study that links environmental quality to the length of the telomeres (the protective caps at the end of chromosomes, whose rate of shortening is a biomarker of physiological stress). Eggs from the same families of wild Atlantic salmon were distributed at the same density across 10 oligotrophic Scottish streams. Five streams were fertilised with simulated adult salmon carcasses, while the other five streams acted as low nutrient controls. This fertilisation led to a higher abundance of macroinvertebrates, fed on by the young salmon. Telomere length was negatively correlated with growth rate. Moreover, both an increase in local density and the absence of the preferred substrate type (large stones) caused greater shortening of telomeres in the low than in the high nutrient streams. Since cellular senescence is triggered when telomeres reach a critically short length, this suggests that a lower quality environment (in terms of both the preferred food supply and physical structure) causes faster cellular senescence in wild juvenile salmon.

Homing and imprinting cues for landlocked Atlantic salmon

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Indigenous populations of Atlantic salmon (*Salmo salar*) in Lake Champlain were extirpated by 1838. Re-introduction efforts from 1973-present include annual stocking from hatcheries to support a recreational fishing industry, yet the number of wild spawning (river-run) salmon remains low. Current management plans emphasize the need to restore self-sustaining populations, however the reasons for the dearth of river-run salmon remain uncertain. Our research focuses on the timing and mechanisms of S. salar imprinting and homing, with potential implications for hatchery protocols for rearing salmon targeted for restoration. The focus of our studies includes: 1. Investigation of the relative concentrations and temporal stability of dissolved, free amino acids (DFAA) in salmon stream sites in Vermont, New York and Maine during known period of downstream (Spring) and spawning (Autumn) migrations to determine if DFAAs can be candidate odors for imprinting on natal stream chemistry. 2. Developing a weekly time-series of relative concentrations of thyroxine (T4) hormone during different stages of development to establish the time windows of thyroxin surges in Atlantic salmon that may correspond with odor imprinting periods hypothesized to occur both in parr-smolt and hatchling-emergence stages of development.

A molecular viewpoint on the phylogenetic conservation of injury-released alarm cues in Ostariophysans

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In this study, we examined the cross-species response of Ostariophysans from a molecular viewpoint. Previous studies have found that Ostariophysans respond with antipredator behaviour to injury-released alarm cues from other Ostariophysans suggesting that the structure of the chemicals are similar. Recently, we have found using High Performance Liquid Chromatography (HPLC) that fright responses in minnows are caused by only a portion of the skin. In our first experiment, we verified the cross-species response of fathead minnows to the injury-released alarm cues of fathead minnow, redbelly dace, glowlight tetras and a control of swordtails. In our second experiment, we used HPLC to collect the same peaks from the whole skin extract from fathead minnows, redbelly dace, glowlight tetras and swordtails. Fatheads exhibited a fright response to skin extracts from fathead minnows, redbelly dace and glowlight tetras, but not swordtails. When examining the fractions collected from HPLC, fatheads exhibited a fright response

to the same HPLC peaks from fathead minnows, redbelly dace and glowlight tetras, but not swordtails. Our results indicate that the chemicals that cause fright responses in fathead minnows are similar in structure and this is a step forward in identifying what chemicals comprise Ostariophysan injury-released alarm cues.

Developmental plasticity of cardiac function and thermal performance in Atlantic salmon

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Elevated water temperatures impose increased oxygen demands on the cardiorespiratory system of salmonids, and these demands are primarily met via increased heart rates. When temperatures exceed the upper limits of a fish's thermal window, it results in cardiac failure and ultimately death, leaving salmon vulnerable to high environmental temperatures. Previous work suggests that phenotypic plasticity in cardiac development helps shape thermal performance in salmon, such that the heart develops to function optimally at temperatures reflecting those experienced during embryogenesis. In this study, Atlantic salmon were raised from fertilization in present-day (+0ºC) or projected future (+4ºC) temperature conditions. At the parr stage, we measured maximum heart rate and atrioventricular blood flow velocity at increasing temperatures using a Doppler flow velocity system. We found that higher temperatures during development led to higher optimal temperatures, as calculated by both heart rate and cardiac output. Higher temperatures during development were also associated with the ability to maintain normal cardiac function at higher temperatures, without experiencing cardiac arrhythmias. In addition, higher developmental temperatures led to higher maximum heart rates. These results support the hypothesis that the thermal environment experienced during development can alter thermal performance later in life, possibly through plasticity in cardiac development. I conclude by discussing these data within the context of Atlantic salmon conservation in Lake Ontario.

Biofilm impacts and riparian consumption of non-native Chinook salmon in Patagonia, southern Chile

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Non-native species that change the movement and availability of resources are likely to impact invaded food web through bottom-up effects. Over the past three decades,

Chinook salmon (*Oncorhynchus tshawytscha*) have been colonizing the Patagonian streams of southern South America. In their native habitat, Pacific salmon can fertilize stream ecosystems with marine-derived nutrients due to their anadromous and semelparous life cycle. In this study, we examined the bottom-up impacts of Chinook salmon in Patagonia by 1) assessing whether Chinook salmon affect the biomass of the biofilm community in multiple streams, and 2) qualitatively describing the animal consumers of Chinook carcasses. Using a Before-After-Control-Impact (BACI) design, we found that senescent Chinook salmon were associated with increased biofilm biomass (i.e. [algal chlorophyll a]), consistent with a nutrient subsidy effect. Furthermore, our qualitative surveys revealed consistent and widespread consumption of Chinook carcasses, including consumers such as the culpeo fox (*Lycalopex culpaeus*), non-native mink (*Neovison vison*), blow flies (Calliphoridae) and the native passerine *Chucao tapaculo*, which gleaned over carcasses for fly larvae. These findings indicate that Chinook salmon are likely to have a variety of bottom-up effects in the relatively pristine ecosystems of Patagonia.

Effects of hormone manipulation on parental care behaviours in bluegill sunfish

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Androgens and prolactin have been implicated as potential hormonal mediators of parental care behaviours in vertebrates. Specifically, positive associations are predicted between androgen levels and defensive behaviours, and between prolactin levels and nurturing behaviours. Whether or not these hormones mediate these two types of behaviours, or if a trade-off exists between them, have been studied by behavioral endocrinologists for years, but rarely in fishes. Here, we manipulated androgen and prolactin levels in bluegill sunfish (*Lepomis macrochirus*), a species where males provide sole parental care for the young. At the onset of the care period, males were implanted with 11-ketotestosterone (a major teleost androgen), the androgen receptor antagonist flutamide, prolactin, the prolactin antagonist bromocriptine, or a control implant. Males were then observed over several days and tested for their aggressiveness towards an experimentally-presented brood predator and for nurturing behavior (fanning of the eggs, removal of dead or fungal-infected eggs). As predicted, males implanted with 11-ketotestosterone displayed significantly more aggressive behaviours and males implanted with prolactin displayed significantly more nurturing behaviours. Taken together, these results show that parental care behaviours are mediated by both androgens and prolactin, although the evidence for a trade-off between aggressive and nurturing behaviours was less conclusive.

Effects of developmental temperature on phenotypes and their variability: a meta-analysis of fish data

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Developmental plasticity describes how the same embryos will develop into different adults if they develop in different environments. Fish species are particularly sensitive to the thermal environment of embryogenesis. Most research on the effect of developmental temperature in fishes focuses on average phenotypic effects. However, population dynamics are also affected by phenotypic variability. Here we perform a systematic meta-analysis of phenotypic data from over 6000 fish originating from 84 experimental egg groups, to test whether fish reared in temperatures that are warmer or cooler than normal exhibit greater phenotypic variability. We also tested for differences in phenotypic means. Developmental temperature had larger and more consistent affects on phenotypic variability than on average phenotypes. We found overall greater variability for fish reared at abnormal temperatures, for both cool and warm treatments. Temperature differences that were larger in magnitude produced larger differences in variability. Surprisingly we found no or very small differences on phenotypic means. Together our results suggest that developmental plasticity can widen the phenotypic breadth of a fish population while maintaining the average phenotype.

Do thermal barriers in summer enhance winter foraging opportunities in lacustrine brook charr?

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Elevated temperatures in the epilimnion of dimictic lakes during summer could substantially reduce the use of rich feeding areas in the littoral zone by cold-stenothermic fish like brook charr, *Salvelinus fontinalis*. Although brook charr could cope with this thermal constraint through thermoregulatory behaviours, we hypothesize that limitations on accessibility to the littoral zone during summer would enhance foraging opportunities during winter. We used acoustic telemetry in a dimictic Canadian Shield lake to track individuals equipped with internal transmitters that provide data on body temperature, depth, and positioning every minute. We found that habitat use is primarily constrained by temperature during summer: the individuals concentrate near the central part of the lake (i.e., the pelagic zone) or undertake short excursions to the littoral zone. In winter, most of the individuals shift to littoral areas that were unexploited during summer. Our results suggest that thermal barriers create resource waves (i.e., ephemeral foraging opportunities that change over space and time) that lacustrine brook charr are able to track across seasons.

Efforts to rescue critically endangered Finnish landlocked salmon (*Salmo salar* m. sebago)

Piironen, Jorma

Natural Resources Institute Finland (Luke)

Landlocked salmon in Finland is critically endangered. It has not been able to reproduce naturally for decades. All known spawning grounds and nursery habitats were lost due to construction of hydropower stations between the 1950's to 1970's. Consequently, salmon in Lake Pielinen vanished and Lake Saimaa population collapsed, thus suffering from low genetic diversity and increased risk for inbreeding. Presently, the landlocked salmon is totally dependent on fish farming and juvenile stocking. Efforts to restore habitats and enhance natural reproduction in the former salmon rivers began in 2013, after the Supreme Administrative Court judgement to increase water flow from 2 to 5 m3/s into River Ala-Koitajoki. Accordingly, suitability of restored habitats has been tested by stocking alevins and 1-year-old juveniles and by transporting salmon spawners caught below the Kuurna, the lowest hydropower station in the River Pielisjoki. The spawners have accepted new habitats and reproduced successfully. However, high winter mortality and predation (pike, burbot, zander) decrease the number of juveniles and smolts. Corresponding habitat restoration efforts, supportive stocking and spawner transporting above hydropower dams are in progress also in the Lieksanjoki and Pielisjoki Rivers. In addition, pilot crossings to introduce new genes from other salmon populations have recently been started.

Major histocompatibility complex variation among alternative reproductive tactics of Chinook salmon

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To investigate genetic diversity in Lake Ontario Chinook salmon, we genotyped males representing two alternative reproductive tactics, jacks (small sneaker males) and hooknoses (large guarding males). We genotyped fish from the population at neutral (microsatellites) and functional (MHC II ß1) markers. Estimates of genetic diversity, including number of alleles, allelic richness and heterozygosity, were greatest for jacks compared to both hooknoses and females at the MHC. Females showed the lowest levels of genetic diversity, where only 50% of the females were heterozygous. Pairwise genetic divergence was calculated between the groups. Jacks and females were significantly genetically divergent, whereas all other pairwise comparisons were not genetically divergent. Genetic diversity estimates from neutral markers were similar among groups, with the exception of number of alleles, likely due to differences in number of individuals

genotyped. There was no significant genetic divergence between jacks, hooknoses and females. These results suggest that there are genetic differences between alternative reproductive tactics that ought to be taken into account when examining the genetic make-up of the Lake Ontario population of Chinook salmon.

With friends like these, who needs enemies? Phenotype-dependent social environment choice in the male Trinidadian guppy (*Poecilia reticulata*)

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Same-sex social associations incur individual fitness consequences which can be affected by social and environmental conditions. We tested male Trinidadian guppies from three different populations (of varying predation levels) to see if they preferred more or less attractive shoalmates in the presence and absence of females, and found that they showed no preference with females present, but a clear preference for more attractive shoalmates when females were absent. We then tested whether ambient predation risk (indicated by the presence of a chemical alarm cue) would affect their apparent preference for larger, colourful and therefore conspicuous shoalmates. Focal males from high and low predation risk populations were tested, and the previous preference for more attractive shoalmates was again seen when the alarm cue was absent. However, when it was present, drab focal males from the high predation population instead preferred to shoal with conspecifics phenotypically similar to themselves. This suggests that in this case, it is more important to minimise the oddity effect and therefore risk of predation.

Reproductive success of landlocked Atlantic salmon in two Lake Champlain tributaries

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Reintroduction programs are implemented to regenerate self-sustaining Atlantic salmon populations by stocking hatchery reared juveniles of varying life stages in freshwater systems. These types of reintroduction programs are annually conducted in the Lake Champlain (LC) watershed to restore its landlocked Atlantic salmon population. While a significant number of surviving adults return annually to spawn in LC tributaries, little is known about their reproductive success (RS) as well as the genetic makeup of surviving offspring. We investigated the RS of salmon returning to the Winooski River, VT in 2015 and the Boquet River, NY in 2016. This was achieved by combining full drainage surveys and a DNA parentage analysis; tissue samples collected from returning adults and their wild produced young-of-the-year offspring were genotyped at nine highly polymorphic

microsatellite loci. The parentage results suggest that few adults produced offspring in both rivers, and that RS was variable among adults within rivers. A total of 14-15 of 124 and 3-5 of 81 returning parents produced offspring in the Winooski and Boquet Rivers, respectively. While these data demonstrate that adults were successful in reproducing in both systems, a larger number of effective breeders would need to produce offspring in subsequent years to avoid short term issues associated with low genetic diversity and inbreeding. This study is one of the first to quantify and document natural RS of reintroduced salmon in the LC basin, and provides relevant data for assessing salmon recolonization and reestablishment potential in other systems.

Early-life influences on guppy brain and behaviour: Population comparisons and developmental manipulations

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Experience in early life can be a powerful influence on adult brain and behaviour. Early-life stress, for example, may 'adaptively program' individuals, better preparing them for future adversity, or may have pathological effects, leaving them less well prepared for adversity. We used a combination of field population comparisons and developmental manipulations of Trinidadian guppies *Poecilia reticulata* to focus on the role of the predatory and social environment in shaping adult phenotypes. We find evidence for developmental plasticity in a number of traits: reliance on social information and social learning, hormonal stress responses, and relative brain volume. Interestingly, many of these effects were sex specific, with early-life conditions only having an effect in males (e.g. brain volume) or in females (e.g. stress response). Thus developmental plasticity is extensive in the traits we examined. I will discuss the implications of these findings for broader questions of cognitive evolution.

Effects of temperature variation on vertebral number and body shape in *Astyanax mexicanus* (Teleostei: Characidae)

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Environmental changes can modify the phenotypic characteristics of populations, which in turn can influence their evolutionary trajectories. Temperature is a particularly important environmental variable that is known to have significant impacts on the phenotype. Here, we raised specimens of the freshwater fish *Astyanax mexicanus* to examine how temperature variation influenced vertebral number and body shape. Specimens were also subjected to two water turbulence regimes. Vertebral number was

counted from x-rays and body shape variation was analyzed using geometric morphometrics. Temperature significantly impacted mean total vertebral number. Fish reared at lower temperatures had more precaudal vertebrae while fish reared at higher temperatures had more caudal vertebrae. Vertebral fusions, were most frequent at the extreme temperature treatments. Temperature significantly impacted body shape as well, with fish reared at 20˚C being particularly divergent in body shape. Water turbulence variation also impacted body shape in a generally predictable manner, with specimens reared in high turbulence environments being more streamlined and having extended dorsal and anal fin bases. Variation in environmental variables thus resulted in significant changes in morphological traits known to impact fish fitness, indicating that *A. mexicanus* has the capacity to exhibit adaptive plasticity when challenged by environmental change.

Effects of climate on competitive interactions between Arctic char and brown trout

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Arctic char (*Salvelinus alpinus*) and brown trout (*Salmo trutta*) coexist along a wide climatic gradient. In studies of natural populations, it has been shown that their coexistence depends on climatic parameters, such as ice-cover dynamics and lake productivity: char often outcompete trout in cold lakes with long ice-covered periods and low productivity, whereas trout exclude char from warm and productive lakes. This observed pattern may be connected with previously described species-specific differences in physiological traits, such as energy efficiency. In this experimental study we manipulate light conditions and water temperatures to assess how inter-specific variation in behaviours, such as feeding rate and aggressiveness, is influenced by climatic parameters. By increasing our understanding of interactions between char and trout under different environmental conditions, this study can facilitate better predictions of their abundance in the face of global climate change.

Effects of adult niche diversification on juvenile performance in polyphenic pumpkinseed sunfish (*Lepomis gibbosus*)

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Habitat shifts are thought to account for rapid diversification in the fishes of postglacial lakes, particularly across the littoral – pelagic axis. Habitat shifts reflect ‘ecological opportunity’ that by avoiding a detrimental species interaction can generate diversifying

selection driving adaptive diversification. However, most research, by focusing on adults, has ignored the consequences of habitat shifts to early life stages. Diversification is more likely when multiple life stages benefit from using a new habitat (through access to resources, increased survival or reduced reproductive interference), and less likely when some life stages face costs that may void benefits to other stages. In this context, observed adaptive divergence implies that the effects of habitat shifts on other life stages are not too costly. As far as we now this prediction has not been empirically verified. We illustrate how divergence into the pelagic habitat positively influences juvenile performance in ways that can facilitate trophic divergence of sunfish ecotypes that coexist in different lake habitats. It is not widely considered within the ecological theory of adaptive radiation how the benefits of ecological opportunity for one life stage may be enhanced or offset (an 'ecological catastrophe') by effects on other life stages.

Where do landlocked Atlantic salmon think they are? A magnetic map sense in a non-anadromous population

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Animals must be able to determine their positions and regulate behavioural responses in space and time. "Magnetic displacement" experiments demonstrated that anadromous salmonids and other long-distance migrants orient using positional information from the Earth's magnetic field. We evaluated if a magnetic "map sense" exists in populations that do not undertake oceanic migrations. We examined the magnetic orientation responses of juvenile Atlantic salmon originally from a landlocked population in Maine, USA transferred approximately 60 years ago to a lake in central Oregon, USA. Magnetic displacements represented locations at the boundaries of oceanic ranges for Pacific salmon (introduced range) and in the North Atlantic (ancestral range). Despite a life-history that has precluded ocean migration for decades, these juvenile Atlantic salmon can detect and orient appropriately to geomagnetic cues. A "magnetic map" is involved in the behaviour of both landlocked and anadromous salmon as a shared ancestral character of the Family Salmonidae. This also illustrates flexibility in the magnetic navigational system of salmonids, particularly the influence of early rearing conditions on the geographic coordination of this orientation ability.

Management of the landlocked Atlantic salmon fishery in Lac Saint-Jean: A paradigm shift

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The recreational fishery of landlocked Atlantic salmon (*Salmo salar*) in Lac Saint-Jean is renowned in North America since the end of the 19th century. In this presentation, we will show how the fishery management shifted from an anadromous-salmon-based approach to an ecosystem-based management. Spawning runs of the Mistassini River population have been monitored yearly since 1975. During decades, managers tried to increase spawners abundance assuming that the limiting factor was smolt production in rivers. This assumption was based on the management of anadromous Atlantic salmon populations in Eastern Canada. However, scientific research showed a close interrelation between landlocked Atlantic salmon production and the abundance of its preferred prey, juvenile rainbow smelt. This observation brought to light that the bottleneck of landlocked Atlantic salmon production was not in rivers but in the lake. Since then, management of the recreational fishery shifted to an ecosystem-based approach taking into account population dynamics of both the sportfish and the forage fish.

Overview of Atlantic salmon smolt size, winter temperatures and relative adult returns from Great Lakes and Lake Champlain hatcheries, spring 2017

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Plantings of Atlantic salmon smolts since the inception of Ontario's Atlantic salmon program in 2006 have produced few confirmed adult returns to Ontario streams. A systematic review of smolt size and winter water temperatures at six hatcheries in the Great Lakes and Lake Champlain suggests that hatcheries that use an ambient temperature water supply (0.5 – 4oC) during the winter months prior to stocking have a noticeably better long term survival to maturity than those hatcheries that used groundwater (9-10oC) as the water supply. Within the reviewed ambient water supply hatcheries group (Ed Weed, Mich. DNR, LSSU, Adirondack), it is abundantly clear that hatcheries that stocked at 8oC and used matched temperature stocking had better success then at other stocking temperatures. This success was apparently amplified when imprinting was assured. Two Michigan hatcheries (DNR, LSSU) that use an ambient water supply during the winter months and matching temperatures (8oC) at stocking have been very successful with a return per cohort estimated of 7-10% to the fishery. Two hatcheries stocking at lower temperatures, Normandale (Ontario) and the USGS Tunison Lab hatcheries that use groundwater have apparently seen poor returns. It is our contention, based on review and discussion with other jurisdictions in comparison to Ontario's approach that there are inconsistencies across the board with respect to culture, stocking methodologies and knowledge that may be impairing or limiting our collective efforts for Atlantic salmon management and restoration. Recommendations to

improve Ontario Atlantic salmon adult returns include: 1. Transition to a colder winter water supply. 2.Initiate matched temperature stocking to the stream and lake. 3. Initiate imprinting pond trials. Recommendations to all Great Lakes and Lake Champlain agencies. 1. Establish an independent audit team to synthesize knowledge and provide stocking management and hatchery recommendations to all agencies. 2. Collectively prepare a culture manual specific for Great Lakes and Lake Champlain and stocking manual for landlocked Atlantic salmon for both restoration and sports fishing. 3. Better inform staff on the comparative differences between the biology and behaviour of Atlantic salmon and trout.

Territoriality and population density in stream-dwelling salmonids

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Territorial behaviour plays a major role for the population ecology of stream-dwelling salmonids, and is affected by a range of ecological variables, such as body size, food availability and population density. In this study, we collected data on several components of territorial behaviour in young-of-the-year (YOY) salmonids from over 20 published studies and examined how these were associated with population density. In short, various aspects of territorial behaviour were strongly associated with population density. First, as expected, territory size decreases with increasing population density. Second, at low population density, YOY salmonids use a higher number of foraging stations within their territories, i.e. they use multiple central-place territories. Third, as population density increases, territorial fish attack intruders more frequently and from a shorter distance. Finally, a clear difference in territorial behaviour emerged between experimental laboratory studies (high density) and observational field studies (low density). Although individual studies have demonstrated the effect of population density on territoriality (and vice versa), this review examines these associations across a wider range in population density and ecological conditions than previously possible. We will discuss how these findings contribute to our understanding of the way territoriality shapes the population ecology of stream salmonids.

Investigating population abundance and habitat requirements of the river-resident Atlantic salmon (*Salmo salar*) småblank

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The landlocked Atlantic salmon ("småblank") is a endemic to the river Namsen in Mid-Norway and is the only European Atlantic salmon population accomplishing its whole life cycle in a river. Anthropogenic impacts have reduced and fragmented available habitat for this landlocked salmon, often as a result of hydropower power reservoirs and weirs. Despite this being a unique endemic population, little knowledge exists of the biology and life history of the småblank. In this study, we investigated the population abundance, habitat use and population structure of the landlocked salmon. The småblank population is thin and fragmented and the River Namsen includes remote and inaccessible areas and unpredictable weather conditions. To investigate population life history and abundance we combined several methods such as electrofishing boat, handheld electrofishing equipment (near shore), observations by snorkling, gill nets, telemetry and genetical analysis. Our preliminary results suggest that the population abundance of småblank has indeed been reduced the past decades, although some tributaries to River Namsen has self- sustaining populations. The main factor for the decrease in population density is likely the loss of suitable habitat.

A comparison of freshwater recreational fisheries management in the USA and Japan

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Inland recreational fisheries are compared in the USA and Japan. Freshwater fishery management in the USA is done by professional biologists with academic training in fisheries biology. In Japan, on the other hand, fishery unions are responsible for the fishery management but seldom have the financial resources to employ professional biologists. Habitat improvement is a major management activity in the USA whereas stocking is the dominant management activity in Japan. The USA and Japan also differ in the prevalence of catch-and-release angling, types of harvest regulations, and use of fish stocking. Despite differences in management regimes, both countries face similar challenges in recruiting new anglers in the face of the declining interest in nature activities in today's youth and meeting the conflicting mandates to provide sport fishing opportunities while conserving native species.

Effects of stream habitat structure on foraging in Atlantic salmon (*Salmo salar*)

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Stream restoration programs frequently focus on increasing habitat complexity and the availability of shelters for small fishes. However, the consequences of shelter availability on the foraging behavior and growth of important native species such as Atlantic salmon

(*Salmo salar*) are not well-understood. Atlantic salmon were extirpated from Lake Ontario and since their extirpation, restoration attempts have focused on evaluating the suitability the LaHave and Sebago strains. How these two strains respond to an increase in shelter availability in Lake Ontario's tributaries may be an important factor that can influence their juvenile performance during restoration attempts. To address these knowledge gaps, I measured the feeding and activity of juvenile Atlantic salmon from the two populations while they were held in net pens erected in a Lake Ontario tributary that differed in their level of shelter. Fish from both strains foraged more and had greater activity when shelter was abundant. However these differences in foraging behavior did not have a noticeable effect on growth rate or the amount of food consumed. Overall, the results suggest that high shelter availability is beneficial for Atlantic salmon with no differences between strains. I will discuss how our data might help direct recovery efforts for Atlantic salmon.

Migratory contingents of striped bass (*Morone saxatilis*) in the St. Lawrence River: should I stay or should I go?

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Migratory contingents are groups of individuals belonging to the same population that adopt different migratory patterns. They have been identified in numerous Striped Bass (*Morone saxatilis*) populations along the North American east coast. In the St. Lawrence River (Canada), the Striped Bass population was extirpated by the mid-1960, due to cumulative effects of habitat destruction and overfishing. A re-introduction program started in 2002 and it is now recognized that the population self-reproduced during the last decade. Recently, three migratory contingents have been identified at the juvenile stage: freshwater residents, oligohaline migrants, and mesohaline migrants. However, little is known about factors promoting freshwater residency vs. downstream movements. In this study, we compared feeding success, growth and morphological features of Striped Bass juveniles from three migratory contingents. In September 2014, juveniles were sampled with a beach seine and then, dissected for gut content and otolith microstructure analyses. In addition, to determine individual migratory history, we estimated the concentration of trace elements along otolith transects with a LA-ICP-MS. Freshwater residents exhibited higher feeding success and the fastest-growth compared to migrants. We hypothesized that migration activity is induced by lower feeding and growing conditions, leading to the research of new foraging opportunities.

Habitat quality and nest location as predictors of Atlantic salmon (*Salmo salar*) density

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The distribution of juvenile fish within their environment depends on a variety of factors including habitat quality, conspecific density, and hatch location. Young-of-the-year Atlantic salmon (*Salmo salar*) disperse both passively with water current following emergence from their gravel nests, and actively, in some cases over relatively long distances. Our current knowledge of dispersal of Atlantic salmon is based mainly on measurements from artificial nests; the focus of the current work is to estimate dispersal distance from natural nests and to determine how proximity to nests and habitat quality interact to influence the density and size distribution of fry. To this end, we conducted nest surveys covering the length of Catamaran Brook, New Brunswick during the autumn mating season. The following summer, densities and sizes of young-of-the-year were estimated from electrofishing surveys. In addition, a subset of nests and fry were sampled for genetic analyses to link offspring to their nest of origin. Our results indicate that the best predictor of density is habitat type. Genetic data indicate that newly emerged salmon disperse an average of 1.2km from their nests. Taken together, these results suggest that that distribution of territorial young-of-the-year is strongly influenced by active dispersal to preferred feeding sites.

Predator presence suppresses a trait-driven trophic cascade in western mosquitofish (*Gambusia affinis*)

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Eco-evolutionary trophic cascades, in which evolution at one trophic level drives community change at proximate and distant trophic levels, have been documented in a growing number of systems and contexts. Here we investigated cascading effects of antipredator evolution in western mosquitofish (*Gambusia affinis*). Antipredator evolution can potentially drive trophic cascades through two mechanisms: functional trait differences and density (i.e. survival) differences. We aimed to assess the relative strength of these mechanisms. To this end, we introduced mosquitofish from alternate predation backgrounds into replicated pond mesocosms. We varied predator (largemouth bass, *Micropterus salmoides*) presence and replaced consumed mosquitofish in some mesocosms to separate trait, density, and predator context contributions to cascading community change. Interestingly, community divergence driven by mosquitofish background was almost entirely limited to mesocosms without bass, in which low-

predation mosquitofish led to a huge bottom-up boost in producers and zooplankton. These results suggest that cascading effects of mosquitofish background are largely trait-driven, and that considering predator context is essential in assessing and predicting trait-driven trophic cascades.

Effects of strain and rearing temperatures on swim performance and thermal preferences of Atlantic salmon (*Salmo salar*)

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Atlantic salmon were once abundant in Lake Ontario but were extirpated by 1900. In Ontario, recent stocking efforts have released three strains of Atlantic salmon into Lake Ontario, but a self-sustaining population has not yet been established. One factor that may be limiting the success of these stocking efforts is a poor match between the thermal performance of the stocked Atlantic salmon and the thermal environment of Lake Ontario and its tributaries. Our research examines critical swim speed (aerobic) and burst swim speed (anaerobic) to quantify differences in thermal performance curves among three different strains and at different rearing temperatures. These thermal performance measures are complemented by assessments of temperature preference. Together these data will contribute to Atlantic salmon management by identifying the strains and rearing conditions best-suited for reintroduction into the thermal environment of Lake Ontario.

Poster presentations

Does the chorion limit precocious activity in pre-hatch zebrafish (*Danio rerio*)?

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Whether or not the chorion limits movement in pre-hatch zebrafish was tested by manually dechorionating embryos (8 dpf) with watchmaker forceps. Embryos that were handled but not pierced with forceps had intact chorions and served as the control. Both groups (n = 44) were incubated in egg water media in glass petri plates; and at 24 hpf the number of tail flicks/minute were counted using a dissecting microscope. Unpaired t-test results (P < 0.0001) show that naked embryos exhibited three times more tail flicks than the control. A second experiment tested whether dechorionated embryos exhibited greater activity compared to those with chorions beyond 24 hpf. Both dechorionated and control embryos (8 dpf) were placed in each of two glass 9-well plates. The embryos were video-recorded on 1 and 2 dpf while being incubated during the daytime in egg water supplied by peristaltic pumps (0.6 ml/min). Paired t-test results (P < 0.025) show that the average number tail flicks/minute was greater for naked embryos on both days and indicate pre-hatch zebrafish are capable of persistent precocious activity. Whether or not the limit on movement by the protective chorion results in tradeoffs on developmental rate or other traits remains to be determined.

An extremist among salmonids: Habitat use of landlocked salmon (småblank) in a Norwegian river

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Factors effecting variation in female mate-preference between two male reproductive tactics in the swordtail fish, *Xiphophorus multilineatus*

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Female mate preference can be a powerful indicator of male reproductive success and variation in the strength of female preference can drive evolutionary patterns within and among populations. Therefore, understanding how phenotypic and environmental traits alter the strength and direction of female mate preference can elucidate the mechanisms

that drive the maintenance of multiple mating strategies within populations. A previous study showed that smaller females had a weaker preference for males that court (courter) compared to small males that use a sneak-chase behavior (sneaker), in *Xiphophorus multilineatus*. We investigated the hypothesis that a female's lineage (courter versus sneaker) influenced the strength of this mate preference, controlling for her size. Furthermore, we tested the hypothesis that the weaker preference in smaller females is due to increased stress levels by measuring both cortisol levels and blood glucose. Our results suggest future studies to examine the adaptive variation in female mate preferences, as well as the role of this variation in maintaining alternative male reproductive tactics.

Functional concentration of disturbance cues influence conspecific and heterospecific responses by Trinidadian guppies and convict cichlids

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Concordia University

Prey are under immense pressure to make context specific, behavioural decisions, and rely on public information to help reduce the costs associated with making inappropriate decisions. Chemical cues are widely used by aquatic vertebrates to gather information about surrounding local conditions and facilitate subsequent actions. There are at least two types of chemosensory cues that have garnered attention in fish: damage-released alarm cues and disturbance cues. Previous studies on chemosensory assessment of risk have largely focused on damaged-released alarm cues, with disturbance cues receiving less attention. Disturbance cues are argued to function as early warning signals released in urine of aquatic vertebrates that warn conspecific and heterospecific prey guild members of potential risk. We conducted laboratory studies to (1) determine whether Trinidadian guppies produce and respond to disturbance cues, (2) whether functional concentration elicits a greater response and (3) whether the cross-species response (Brown et al 2012) is specialist enough to observe an effect of functional concentration. Our results suggest that Trinidadian guppies produce disturbance cues as exposure to conspecific cues elicited a response and increasing donor group size influenced responses by conspecifics, suggesting an effect of functional concentration. However, we predict an effect of functional concentration on heterospecifc responses to conspecific disturbance cues.

The Blind Iran Cave Barbs: a probable case of ancient sympatric speciation

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The subterranean habitats with their isolated and resource limited nature behave as substrates for ecological divergence and speciation via differential selective pressures. In these habitats resource limitation, forces the subterranean animals to adapt to different ecological niches and diverge morphologically to use all existing resources while decreasing competition. The Blind Iran Cave Barb species *Garra typhlops* and *Garra lorestanensis,* appear to speciated in a subterranean habitat via sympatric speciation. To test this hypothesis we used morphological and mtDNA data along with a panel of 11,257 genome-wide SNPs. The Cave barb species differ in the presence/absence of the mental disc and they show a relatively deep mitochondrial sequence divergence along with a shallow genomic divergence. The cave barbs meet nearly all general criteria of the sympatric speciation, including sympatric existence and sister phylogenetic relationship. Based on the demographic analysis the case of Iran cave barb species fits to an isolation by migration model. Regarding the results we propose that the most parsimonious scenario for the case of Iran Cave Barb speciation is sympatric speciation.

Spawning behaviour of landlocked salmon (*Salmo salar* m. sebago) after trapping and transportation

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[1]University of Eastern Finland; [2]Natural Resources Institute Finland (Luke)

Natural breeding of landlocked salmon in Finland ceased in 1950's to 1970's due to damming rivers making landlocked salmon dependent on hatchery supported fish releases. The River Ala-Koitajoki was originally important breeding ground to landlocked salmon. In 1955 minimum water flow dropped from over 70 down to 2 m3/s. Restoration efforts and enhancing natural reproduction were initiated 2013, after the water flow was increased from 2 to 5 m3/s. Here, we explored how the introduced spawners behave after transporting and whether the restored habitats provide suitable spawning environment. The River Ala-Koitajoki is located above dammed Pielisjoki River. Wild-grown spawners were captured below the lowest dam in the River Pielisjoki. Hatchery reared spawners were used for comparison. In total, 180 spawners were tagged with radio transmitters before transporting them into River Ala-Koitajoki during the first week of October in years 2013-2017. Monitoring results indicated that almost all transported spawners accepted the river and found suitable spawning grounds. Spawning redds were located by snorkeling on the basis of the transmitter signals. Despite of the low water

flow, the transported spawners succeeded to reproduce. The eggs survived over winter and wild juveniles were found in all areas where spawning took place.

Implementation of a landlocked salmon population in the Romaine 4 reservoir

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Hydro-Quebec is currently building a 1,550-MW hydroelectric project, in Havre St-Pierre (Quebec, Canada), the Romaine Complex. One of the obligations set out in the permits issued by the provincial and federal authorities is the implementation a landlocked salmon population in the Romaine 4 reservoir. The realization of the development plan, that began in 2015 and will extend to 2035, has several constraints and challenges. The poster will present the steps of the implementation of the plan, as creating a spawning pool with spawners and smolts captured in lakes and rivers of the watershed; proceed to artificial fertilization and stocking broodstock in selected streams of the reservoir; evaluation of habitat quality in the system for all life stages and obstacles to migration; development of new spawning habitats. One of the challenges encountered is the lack of information on the biology of landlocked salmon in northern areas, where its usual prey fish, the rainbow smelt, is absent. Monitoring studies, as spawning ground follow-up (spawners presence, eggs deposition), parr density in streams and smolts estimation, are planned to ensure that the landlocked salmon population will develop properly and adapt to the conditions of the Romaine-4 reservoir.

Evolution of parental care and modes of reproduction in bony fishes

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University of Oklahoma

Bony fishes exhibit a great diversity of parental care behaviors and modes of reproduction. The evolution of most modes of parental care is not particularly well understood and deserves more attention in light of recent revisions to our understanding of teleost evolution. We used the recently revised phylogenetic hypothesis from the Euteleost Tree of Life project (EToL; Broughton et al. and Betancur-R et al. 2013) to quantify the number of times each mode of parental care has evolved and to identify transitions between paternal and maternal care and parental care types. Parental care is known from 95 bony fish families. Transitions between care giver and/or type of care have occurred within at least 24 families. Paternal care and nest guarding are the most frequent modes of parental care. Similar to earlier studies, we find that no care seems to be the likely ancestral condition and for the evolution of particular modes of care more specifically. We identified 77 transitions in our analyses. The improved resolution of bony fish phylogeny provided by the EToL tree, especially among the Percomorpharia, will

allow us to explore potential physiological and behavioral factors that allow or constrain the evolution of various modes of parental care.

The Amazon Research Center for Ornamental Fishes

Mazeroll, Anthony

Amazon Research Center for Ornamental Fishes, Iquitos, Peru

Peru has an incredible number of diverse ecosystems. Over 85% of the 900 freshwater fish species of Peru are found within the Amazon basin, and 30% are endemic Peru. The Amazon River systems are being threatened by loss of habitat, introduction of exotic species for food purposes; drought; and most importantly over fishing. It has been assumed that the ornamental fish trade was potentially one of the few sustainable resources in the Amazon Basin. Two studies on the sustainable use of ornamental fishes in Peru concluded: (1) two aquarium species collected from the Rio Nanay (high fishing pressure) may be in fact endangered in their natural habitat because of over fishing and destructive fishing techniques, (2) the areas of high fishing pressure (Rio Nanay) had a significant reduction in the abundances of all fishes, species diversity, and fish biomass as compared to those areas with medium or low fishing pressure. Thus, the Amazon Research Center for Ornamental Fishes was established in Iquitos, Peru with the mission to provide education and support research that will facilitate the development of sustainable ornamental fish aquaculture in the Peruvian Amazon resulting in sound conservation practices and improved economic development for the local fisherman.

Foraging and social behaviour of cave-dwelling Arctic charr in the Lake Mývatn area, northern Iceland

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Foraging mode, the behavioural tactics adopted by animals when searching for and attacking prey, yield important insights into how animals vary in the use and exploitation of their local habitats. In this study, we examined the foraging mode, feeding behaviour and aggression for 55 Arctic charr (fork length = 5.0-17.0 cm) in four lava caves in the Lake Mývatn area. As expected from fish in lentic waters, the cave-dwelling Arctic charr were highly mobile during prey search (median=80.1% of the time) and prior to prey attack (median=73.0%). Majority of foraging attempts were directed towards the water surface (mean=73.0%), but to a lesser degree towards benthic prey (mean=16.4%) or prey in the water column (mean = 10.6%). Substantial variability was detected among individuals, as many fish directed their foraging efforts toward prey in only one of the three sub-habitats. Finally, aggression toward, and received from, another fish, typically increased

and decreased with body size, respectively, suggesting the existence of a size-related dominance hierarchy within each cave. This study yields an important first step in understanding how behaviour contributes to the survival and local adaption of small benthic Arctic charr in unique habitats such as lava caves.

Boldness and anxiety-like behavior in melanic and non-melanic hybrid swordtails

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Ohio University

Invasive species are often generalists, with the phenotypic variation necessary to be successful in a new environment. *Xiphophorus helleri* x *maculatus* is an invasive hybrid propagated in the pet trade that has been introduced on every continent except Antarctica. A variety of color morphotypes have emerged as a result of highly selective breeding in the pet trade. The selective breeding for coloration may also select for behavioral phenotypes that could benefit these swordtails when establishing an invasive population. I chose to examine variation in melanin pigmentation as it relates to boldness and anxiety-like behavior, as these behaviors have been found to be associated with invasive success, and melanin has been previously linked to other behaviors (i.e. aggressive behavior in the mosquitofish, *Gambusia affinis*). In addition, I examined whether these two behaviors are distinct (uncorrelated) or part of a continuum (bold-shy behavioral syndrome). My results will help determine if there is variation in these behaviors due to the artificial selection for a variety of color morphs in pet-trade fish that could be leading to the success of this invasive hybrid.

A role for strong intraguild predator relationships in affecting the success of invasions

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Strong intraguild predator relationships (IGPs) can be important in affecting the efficacy of biotic resistance in preventing establishment by non-resident species. We evaluated a bi-directional IGP relationship in a fish invasion in which the species, guppies and mosquitofish, eat each other's young. We first established the size-dependence of the predator-prey relationships in aquarium trials. The interaction was highly asymmetrical with mosquitofish more frequently eating the guppy. We then tested for the effects of each IG predator on recruitment by the other in mesocosms. Regardless of the order of introduction, mosquitofish always eliminated guppy recruitment over the 10-week course of the experiment, establishing the asymmetrical strength of the IGP relationship. Using aquaria, we conducted behavioral observations of the interactions between the two species. The dominant species in the field trials, mosquitofish, debilitated guppies by fin-

nipping, supporting a role for partial predation in this system. These findings suggest that the otherwise globally invasive guppy, may fail in establishing when the resident community contains a strong IG predator. Further, they support theoretical predictions that bi-directional IGPs should be unstable, and demonstrate a need to consider them, specifically their strength, in predicting establishment and subsequent spread by an introduced species.

Résumés Français

Rester ensemble? La motivation pour rester près de ses semblables chez les juvéniles de Saumon Chinook élevés dans trois environnements différents

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Les salmonidés sauvages et d'élevages sont confrontés à des environnements très différents durant leur développement précoce. Typiquement, les poissons d'élevages sont élevés à haute densité en comparaison des poissons sauvages de la même espèce. Les écloseries relâchent chaque année des milliers de smolts en rivière pour leur migration vers l'océan. Dans cette étude, nous avons testé si l'origine des juvéniles de saumon Chinook (sauvage ou d'élevage) a un impact sur leur association avec des congénères. Nous avons aussi testé un troisième groupe de juvéniles Chinook élevés dans un environnement produisant des phénotypes similaires à ceux de poissons sauvages désignés sous le nom de « pseudo poissons sauvages ». En condition de test individuel, nous prévoyons que les poissons d´élevage ont une motivation plus élevée que les poissons sauvages à être près de congénères. Les poissons ont été testés dans une arène dans laquelle nous avons placé un congénère non-familier dans un compartiment situé à l´opposé de la zone de départ, ou laissé ce même compartiment vide à titre de témoin.Pour chaque poisson, nous avons évalué le temps de sortie de la zone de départ, et le temps passé dans la zone de préférence. Ces résultats révèlent des effets de l'environnement sur le comportement social. Mieux comprendre les différences de motivation et de comportements sociaux entre des poissons sauvages et des poissons d'élevages peut aider à l'élaboration de programmes de conservation destinés aux écloseries et autres acteurs de la filière.

Que sait le nez du saumon?

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L'apprentissage olfactif chez les salmonidés est considéré comme un cas d´ école pour illustrer la notion d´empreinte et le mécanisme de base par lequel les adultes retournent pondre sur leur site de naissance (comportement philopatrique). L´explication largement accepté est que les saumons adultes sont capables de reconnaitre l'odeur précise de leur rivière natale grâce à sa composition chimique. Cette empreinte olfactive est réalisée lors du développement au stade de juvénile. Ce mécanisme constitue un outil de gestion des

populations: les juvéniles de saumons d'élevage sont acclimatés en eau douce dans des sections de rivière prédéfinies, avant leur migration vers l'océan, de façon à promouvoir leur retour au stade adulte dans ces mêmes zones. Cependant, une certaine proportion des poissons réintroduits ne reviennent pas sur ces aires prédéfinies mais sur des rivières ou bassin avoisinants. Nous étudions ce phénomène chez le saumon Chinook (Oncorhynchus tshawytscha) en décortiquant l'apprentissage olfactif, les réponses aux odeurs, et le retour des adultes sur leur site natal. Nous présentons les expériences qui testent notre hypothèse d'empreinte séquentielle pendant l'ontogénie chez des saumons Chinook, et montrons comment nos résultats peuvent être utilisés pour réduire le nombre d'individus ne retournant pas à leur rivière natale.

Où les saumons pensent-ils être ? L'existence d'un sens magnétique dans une population confinée de saumon Altantique

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Les animaux doivent pouvoir déterminer leur position dans l'environnement pour ajuster leurs réponses comportementales dans le temps et l'espace. Des expériences de manipulation du champ magnétique ont démontré que les salmonidés anadromes et autres grands migrateurs s'orientent grâce à une perception du champ magnétique terrestre. Dans cette étude, nous avons testé l'existence d´un sens magnétique dans une population ne migrant pas vers l'océan. Nous avons examiné l'orientation en réponse à des champs magnétiques chez des juvéniles de saumon Atlantique originaires d'une population confinée au milieu continental dans le Maine, USA, et transférée il y a une soixantaine d'années dans un lac du centre de l'Oregon, USA. Ces saumons ont été soumis à différents champs magnétiques, similaires aux valeurs rencontrées à la limite de répartition géographique des saumons du Pacifique (après son introduction) et des valeurs correspondantes à celles de l'aire de répartition géographique ancestrale du saumon Atlantique. Malgré l´absence de migration océanique depuis des dizaines d'années, ces juvéniles de saumon Atlantique peuvent détecter et utiliser les signaux géomagnétiques pour s´orienter. Une « carte magnétique » est impliquée dans le comportement des populations confinées et des populations anadromes de saumon, un caractère ancestral de la famille des Salmonidae. Ces résultats illustrent aussi la flexibilité du système de navigation magnétique des salmonidés, particulièrement l'influence des conditions environnementales à des stades précoces de développement sur l'orientation spatiale..