ECOLOGICAL AND EVOLUTIONARY ETHOLOGY OF FISHES

EEEF 2012

Final Program

University of Windsor, Canada

June 17 to 21, 2012

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Contents

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Access to visitors is available from June 15 to June 24th

There are QR (Quick Response) codes posted during the sessions. Simply scan the icons with your smartphone or tablet to download the program book or schedule.

All Abstracts are posted on the conference website: www.uwindsor.ca/eeef

Conference Organizing Groups

Scientific Committee:
Lynda D. Corkum (host)
Dennis Higgs

Local Organizing Committee:
Lynda D. Corkum (co-chair)
Dennis Higgs (co-chair)
Alyson Lafromboise (program: oral presentations, abstracts)
Jeffrey Zeyl (program: poster presentations)
Jennifer Smith (contributors, T-shirts)
William (Bill) Glass (student raffle & travel grants)
Kristina Wantola (student raffle & travel grants)
Lisa Isabella-Valenzi (local restaurants)
Cory Ochs (Registration)
Samantha Baker (Registration)

Fish Print Making Activity:
David Bechler

Fishing on the River:
Bill Glass

Campus IT support for Abstract Submission and Registration:
Shiladitya (Shil) Chakrabarti

Internet Access:
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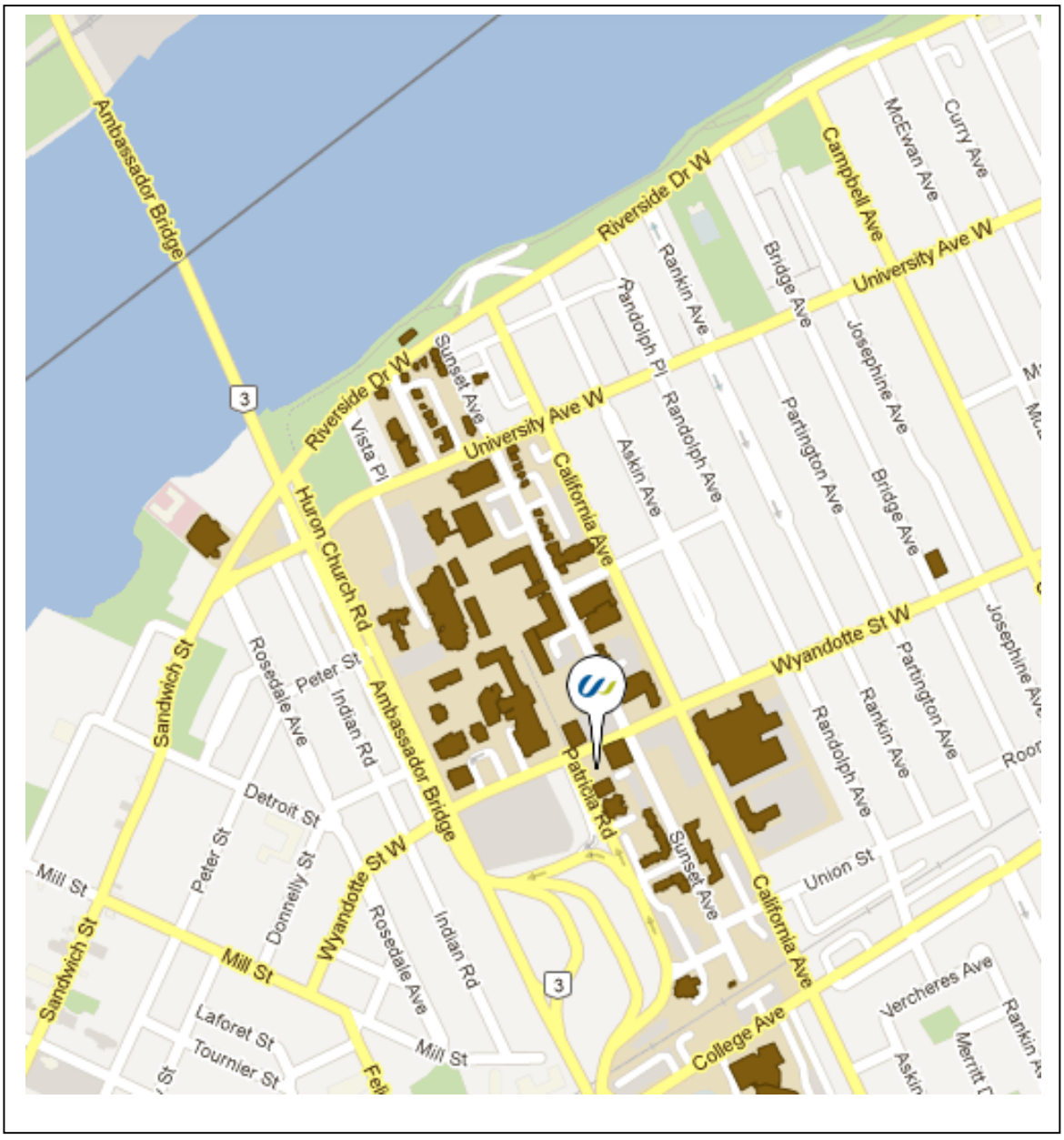
ECOLOGICAL AND EVOLUTIONARY ETHOLOGY OF FISHES 2012

University of Windsor – General Location



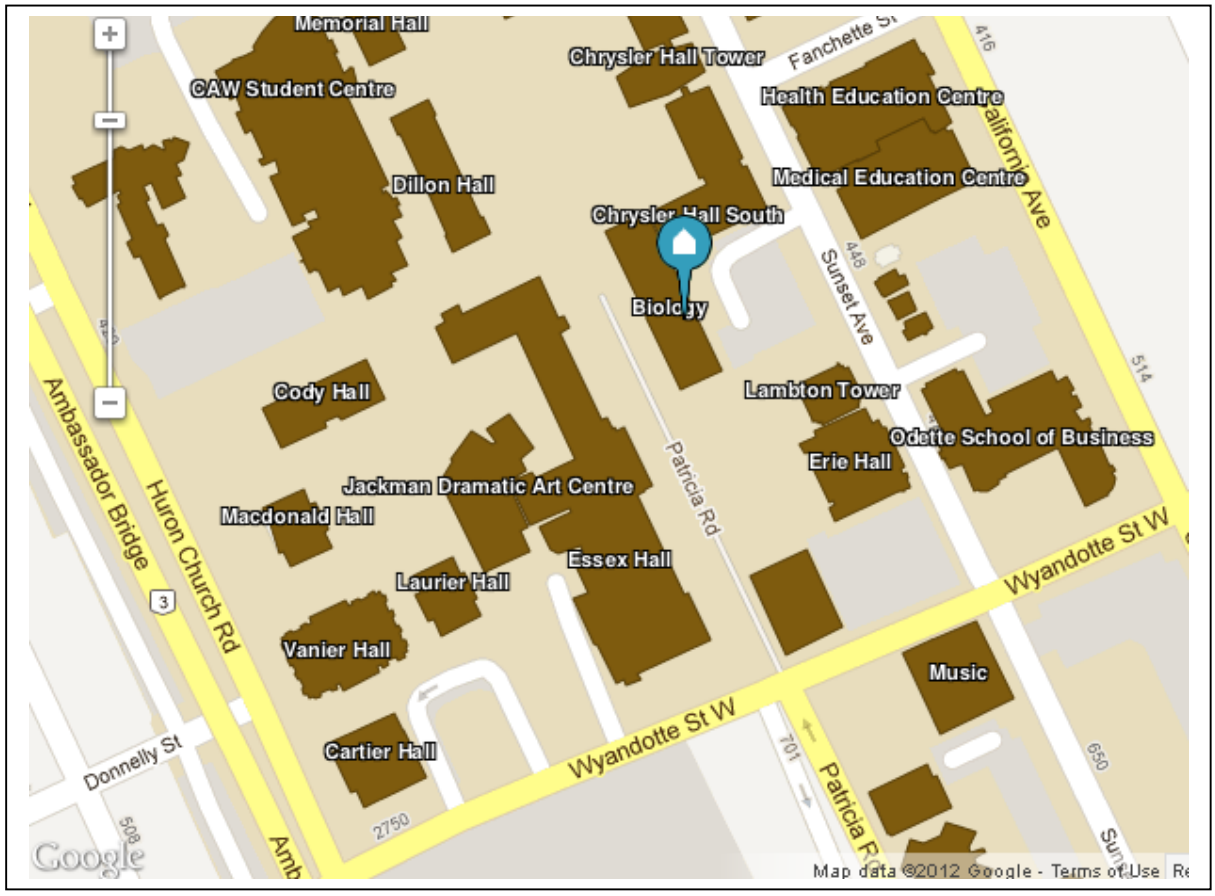
The NOLDUS Ethovision Training Workshop

Location: Department of Biological Sciences, Room 122

University of Windsor

401 Sunset Avenue

Date/Time: June 17th 1:00 to 5:00 p.m.



The VEMCO Fish Tracking Workshop

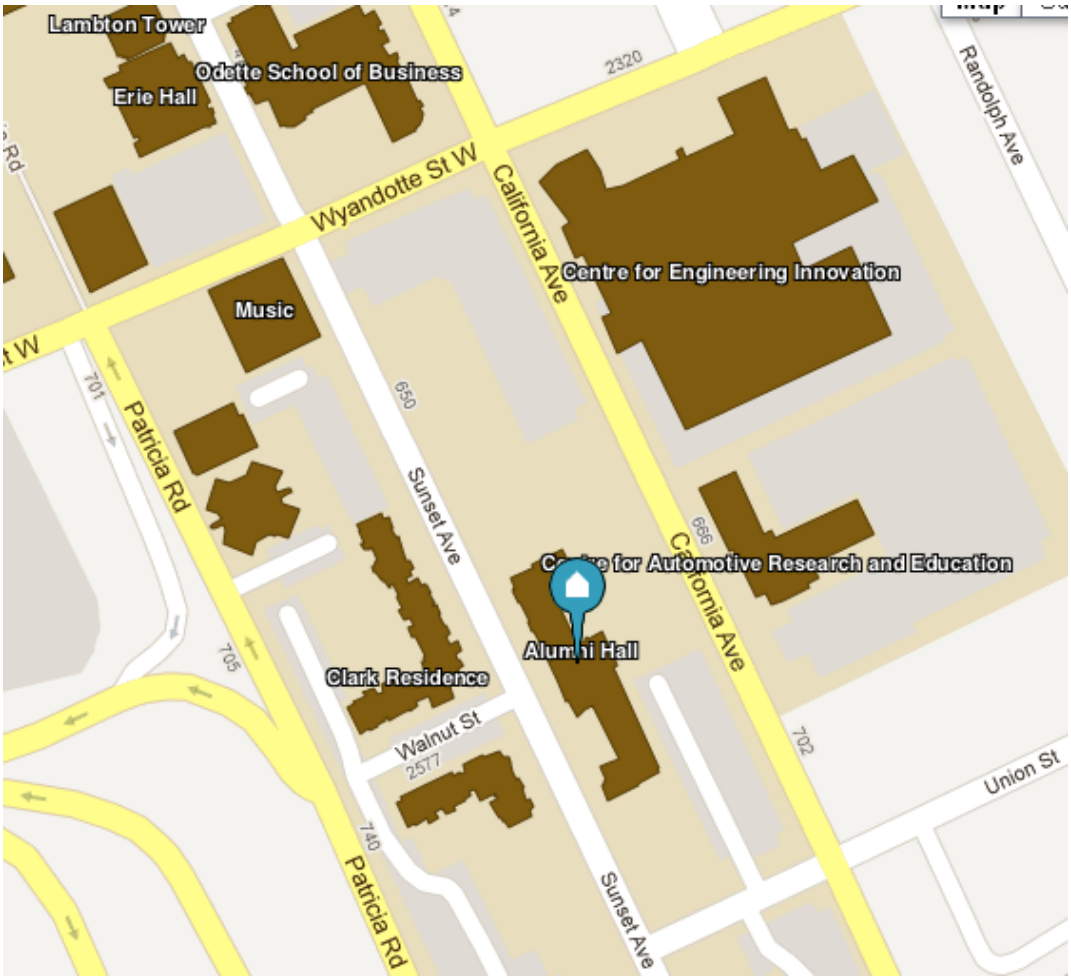
Location: GLIER (Great Lakes Institute for Environmental Research)

2990 Riverside Dr. W. just west of the Ambassador Bridge

Date/Time: June 17th 1:00 to 5:00 p.m.

Welcome Mixer

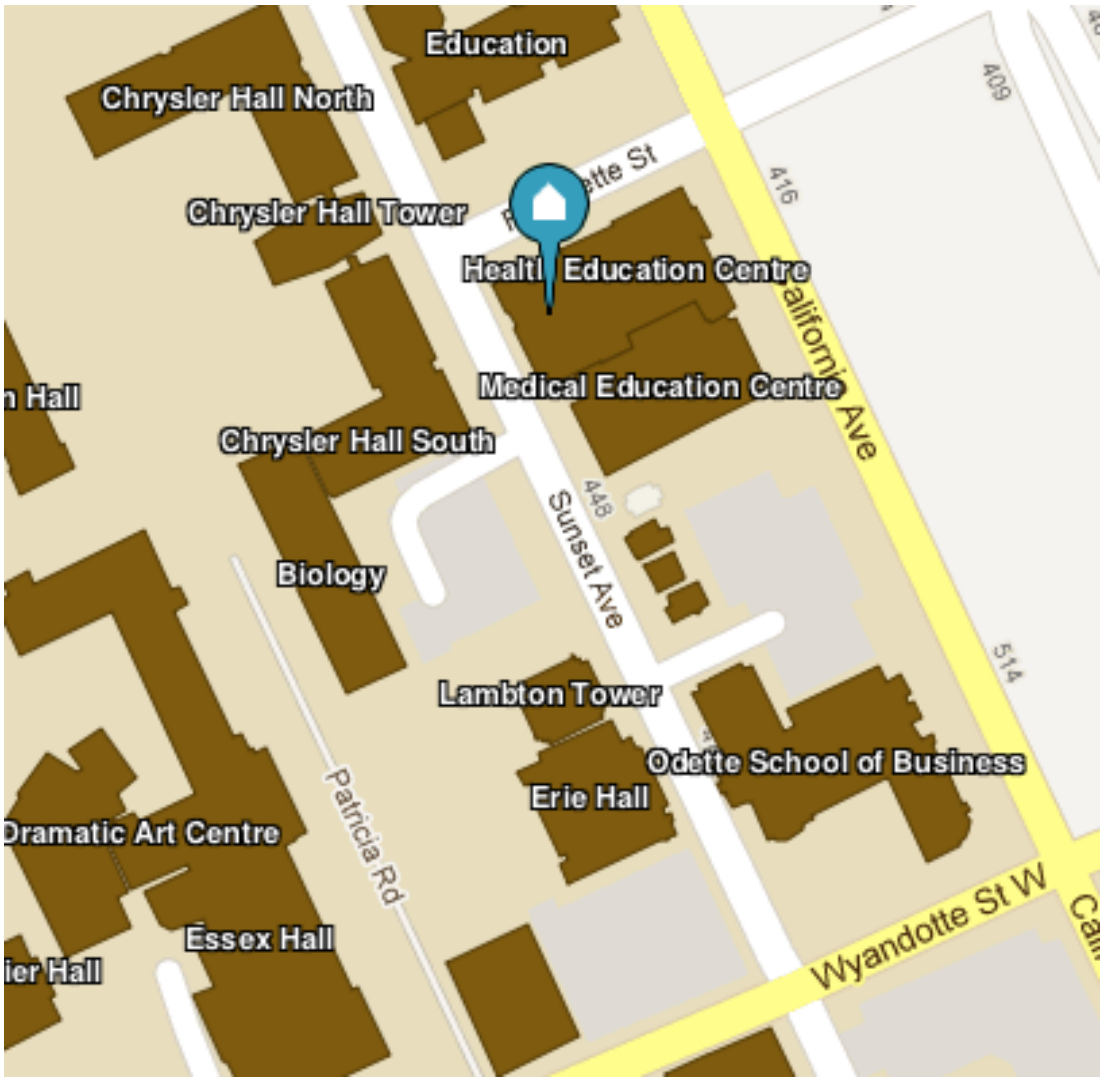
Location: McPherson Lounge, Alumni Hall
2990 Riverside Dr. W. just west of the Ambassador Bridge
Date/Time: June 17th 7:00 to 9:00 p.m.



EEEF Conference Sessions
Location: Toldo Health Education Centre,
Monday to Wednesday, Room 104; Thursday, Room 203

Date June 18th to 21st, 2012

Start Time: 09:00 h



EEEF 2012
OVERVIEW OF EVENTS

Time	Sunday June 17th
1:00-5:00	**NOLDUS User/Product** Biology Bldg room 122
1:00-5:00	**VEMCO Fish Tracking** GLIER (2990 Riverside Dr. W. just west of the Ambassador Bridge)

Time	Sunday June 17th
7:00-9:00 p.m.	**Welcome Social & Registration** Bar & Light food McPherson lounge, Alumni Hall

Conference Presentations	
Oral	**Toldo HEC Bldg: Monday- Wed, room 104; Thursday, room 203**
Posters	**CAW Student Bldg; Commons (main floor) Tuesday 5:30 to 7:30 p.m.**

Activities	
Tues 7:45-9:00 p.m.	**Fish Print Making with Dave Belcher, Biology Building Room 29**
Wed 7:00 p.m.	**Fishing on the Detroit River with Bill Glass**

Summary of Oral Presentations

Time	Monday June 18th
9:00 – 9:15	**Introductions**
Session Chairs:	***Drs. Dennis Higgs & Craig Radford***
9:15-10:00	**Dr. Weiming Li** Pheromones, Sensory Ecology & Behaviour of Fishes
10:00-10:20	Coombs
10:20-:10:40	Radford
10:40-11:00	**HEALTH BREAK**
11:00-11:15	Laframboise
11:15-11:30	Rous*
11:30-11:50	Siebeck
11:50-1:30	**LUNCH (on your own)**
1:30-1:50	Soares
1:50:-2:05.	Barkley*
2:05-2:20	Green*
2:20-2:40	Zielinski
2:40-3:00	Bassett
3:00-3:15	Isabella-Valenzi*
3:15-3:30	Smith*
3:30-3:45	**HEALTH BREAK**
3:45-4:00	Wantola*
4:00-4:20	Tierney
4:20-4:40	Higgs
4:40-4:55	Havel*
4:55-5:10	Caiger*
6:00-8:00 p.m. BANQUET: Riverfront Club of the Riverside Inn, 333 Riverside Drive West Speaker: Dr. Charles Krueger, GLFC	

Time	Tuesday June 19th	Wednesday June 20th	Thursday June 21st
Session Chairs	***Lynda Corkum***	***Sigal Balshine***	***Yolanda Morbey***
9:00-9:45	**Dr. Ellen Marsden Invasive Fishes**	**Dr. Robert Hecky Global Freshwater Fishes …**	**Dr. Trevor Pitcher Genetic Quality & Conservation of Fishes**
9:45-10:00	Marentette	Steele*	Kuntz*
10:00-10:15	Pettitt-Wade*	Wright*	Robinson*
10:15-10:30	Balshine	Zhu	Lehnert*
10:30-10:45	**HEALTH BREAK**		Johnson*
Session Chairs	***Scott Hinch***	***David Noakes***	
10:45-11:00	Lapointe	Beaudry*	Houde*
11:00-11:15	Yavno*	Glass*	Bowden *
11:15–11:30	Serrao*	MacPherson*	**HEALTH BREAK**
11:30-11:45	Haug*	Fraser	Heath
11:45-noon	Abrahams	Hunt	Noakes
Noon-1:30	**LUNCH (on own at local restaurants)**		**STUDENT AWARDS**
Session chairs	***Julie Marentette***	***Ann Cleveland***	
1:30-1:45	McCallum*	Cogliati*	*= Student presentation and eligible for award.
1:45-2:00	Smyth*	Rodgers*	
2:00-2:15	Breck	Morbey	
2:15-2:30	Challice*	Bernhardt*	
2:30-2:45	Christiansen*	Lapointe	
2:45-3:00	Cleveland	Magellan	
3:00-3:15	**HEALTH BREAK**		
Session chairs	***Nick Lapointe***	***Maria Abate***	
3:15-3:30	Peklova*	DeBruyne*	
3:30-3:45	Perez	Farwell*	
3:45-4:00	Sopinka*	Manny	
4:00-4:15	Hinch	Noakes	
EVENING EVENTS	**Poster session & Mixer: vendors, raffle, 5:30-7:30 p.m. CAW Student Centre**	**Fishing on the River** for interested anglers (BYO rods, lures & license) 7:00 pm	
	Fish Print Making w/ David Bechler 7:45-9 pm, Rm 29 Biology Bldg Room 29	**Student Pub Night**	

Summary of Poster Presentations

(Tuesday, June 19th, 5:30 to 7:30 p.m., CAW Commons; * = student presentation)

*Bak-Coleman, J. et al. Are rheotactic behaviors enhanced in schooling fish?

Bechler D. and L. Vedas. Log packing behaviors in the mangrove rivulus, *Kryptolebias marmoratus*.

Belanger, R.M. et al. Methyltestosterone-induce changes in olfaction and androgen receptor expression in the olfactory organs of zebrafish (*Danio rerio*).

*Black, C.A. and T.E. Pitcher. Effects of hybridization on the reintroduction of Atlantic salmon (*Salmo salar*).

*Cheng, J. et al. Evaluation of the spatial criteria used in the conservation risk assessments of freshwater taxa.

Ciborowski, J.J.H. et al. A comparison of analytical methods to derive fish assemblage bioindicators of environmental condition relative to anthropogenic stress at great lakes coastal margins.

Dittman, A. et al. Olfactory imprinting in chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) embryos.

*Grande, G. et al. Male round goby reproductive status determination by non-invasive measures.

*Lindstedt, E.R. and I.M. Hamilton. Predation risk and behavioral consistency in western mosquitofish (*Gambusia affinis*).

*Mokdad, A. et al. Variation in eye size reflects predation risk and resource availability in the guppy (*Poecilia reticulata*).

*Mouland, J. and C.C. Wilson. Genetic restoration of Aurora Trout: results from captive and wild trials.

Noakes, D.L.G. et al. Can steelhead 'ocean mortality' be explained by survival in lower rivers and estuaries?

*Ochs, C.L. et al. Investigating the potential of using odour-based trapping strategies to reduce invasive round goby (*Neogobius melanostomus*) populations: viability of mitigating behavioural disturbance of non-target species.

*Salter, J.S. Jr. and D.L. Bechler. Factors controlling the selection of vegetated blackwater habitats by fish.

*Takahasi, H. and M.E. Abate. Cellular responses to stressor of fish health.

*Unitis, M. et al. Use of coastal wetland types by juvenile fishes.

*Wiper, M.L. and D.M. Higgs. Genetic and sex effects on brain morphology in chinook salmon (*Oncorhynchus tshawytscha*).

ECOLOGICAL AND EVOLUTIONARY ETHOLOGY OF FISHES 2012 PROGRAM

SUNDAY JUNE 17TH

1:00-5:00 p.m.	NOLDUS User/Product	Biology Building Room 122
1:00-5:00 p.m.	VEMCO Fish Tracking	GLIER, Room 250 (1st floor)
7:00-9:00 p.m.	Welcome Mixer	McPherson Lounge, Alumni Hall

MONDAY JUNE 18TH

PLENARY & CONTRIBUTED TALKS – TOLDO HEALTH EDUCATION CENTRE, RM 104

9:00-9:15 Introductions and Welcome
Dr. Lynda Corkum; Dr. Marlys Koschinsky (Dean of Science)

Pheromones, Sensory Ecology and the Behaviour of Fishes
Session Chairs: Drs. Dennis Higgs & Craig Radford

9:15-10:00 Dr. Weiming Li (Plenary Speaker)
Biosynthesis, function and evolution of a male mating pheromone in the sea lamprey

10:00-10:20 Coombs, S (Invited)
Fish-inspired flow-sensing technologies and applications: the interface between sensory biology and engineering

10:20-10:40 Radford, CA (Invited)
Rethinking fish hearing: new insights into how hearing is evaluated

10:40-11:00 HEALTH BREAK

11:00-11:15 Laframboise, AJ
The scent of steroids: continuing evidence for reproductive pheromones in the round goby

11:15-11:30 Rous, AM
The behavioural basis of trapping an invasive species: lessons learned from the sea lamprey

11:30-11:50 Siebeck, UE (Invited)
Visual ecology of settlement-stage reef fish

11:50-1:30 LUNCH – on your own at local restaurants

1:30-1:50 Soares, D (invited)
Unique mechanosensory adaptation to extreme environments in cavefish

1:50-2:05 Barkley, AN
Acoustic communication and courtship displays in the electric yellow cichlid (Labidochromis caeruleus)

2:05-2:20 Green, W
The olfactory bulb of the sea lamprey: odour processing and implications for olfactory-mediated movements

2:20-2:40 Zielinski, BS (Invited)
The neurobiology that links olfaction to locomotion in the sea lamprey, Petromyzon marinus

2:40-3:00 Basset, D (Invited)
Does turbidity provide an invasion pathway for exotic fish?

3:00-3:15 Isabella-Valenzi, L
Attraction of round gobies, Neogobius melanostomus, to conspecific calls
3:15-3:30 Smith, J
Responses of female round gobies (Neogobius melanostomus) to isolates containing steroids released by reproductive males

3:30-3:45 HEALTH BREAK

3:45-4:00 Wantola, K
Fanning behavior and communication in the round goby (Neogobius melanostomus), an invasive fish
4:00-4:20 Tierney, KB (Invited)
Sensing synthetic dangers underwater
4:20-4:40 Higgs, DM (Invited)
The contribution of lateral line to "hearing" in fish
4:40-4:55 Havel, LN
Larval red drum (Sciaenops ocellatus) change their behavior in response to acoustic stimulus
4:55-5:10 Caiger, P
A proposed mechanism for the observed ontogenetic improvement in the hearing ability of hapuka (Polyprion oxygeneios)

6:00-8:00 BANQUET – Riverfront Club of the Riverside Inn
Guest speaker – Dr. Charles Krueger, GLFC

TUESDAY JUNE 19TH

PLENARY & CONTRIBUTED TALKS – TOLDO HEALTH EDUCATION CENTRE, RM 104

Invasive Fishes
Session Chair: Lynda Corkum

9:00-9:45 Dr. Ellen Marsden (Plenary Speaker)
Non-indigenous fishes

9:45-10:00 Marentette, JR
Sex differences in activity, exploration and prey responses of the invasive round goby (Neogobius melanostomus)
10:10-10:15 Pettitt-Wade, H
An ecological and evolutionary approach to the study of two non-indigenous goby in the Great Lakes
10:15-10:30 Balshine, S
Characteristics of round goby populations at invasion fronts

10:30-10:45 HEALTH BREAK

Session Chair: Scott Hinch

10:45-11:00 Lapointe, N
Ecology of a recently introduced population of northern snakehead (Channa argus) in the Potomac River, Virginia
11:00-11:15 Yavno, S
Morphological responses to trophic levels in native and non-native fish
11:15-11:30 Serrao, N

Using DNA barcoding to create a reference library for snakeheads to aid detection in environmental DNA

11:30-11:45 Haug, E
Antipredator behavior and survival of invasive African jewel cichlid (Hemichromis letourneuxi) in the presence of piscivorous fish native to peninsular Florida

- END OF THE INVASIVE FISHES SESSION -
- GENERAL SESSION -

11:45-12:00 Abrahams, MV
The environmental impact of predictability: the effect of sea cages on the distribution of marine fishes in the North Atlantic

12:00-1:30 LUNCH – on your own at local restaurants

Session Chair (General session): Julie Marentette

1:30-1:45 McCallum, E
Field contamination in the invasive round goby: effects on associative learning

1:45-2:00 Smyth, ERB
Unintended consequences and trade-offs of fish passage

2:00-2:15 Breck, JE
Using life history theory and a 3D temperature model to predict climate change effects on fish age at maturity for Great Lakes salmonids

2:15-2:30 Challice, A
Habitat occupancy by lake whitefish (Coregonus clupeaformis) includes an ecotone in the profundal zone of two Canadian Shield lakes

2:30-2:45 Christiansen, HM
Have we underestimated the age of the world's largest predatory fish?

2:45-3:00 Cleveland, A
Who is minding the anemone? Gender and species comparisons of territorial behavior in two sympatric anemonefish species (Amphiprion clarkia and A. perideraion)

3:00-3:15 HEALTH BREAK

Session Chair (General session): Nicolas Lapointe

3:15-3:30 Peklova, I
Depth and temperature preferences of the deep-water flatfish, Greenland halibut (Reinhardtius hippoglossoides), in Cumberland Sound, Canadian Arctic

3:30-3:45 Perez, KO
Influence of maternally derived and dietary fatty acids on ecological performance of larval red drum (Sciaenops ocellatus)

3:45-4:00 Sopinka, N
Stressed out salmon: effects of parental stress on sockeye salmon offspring

4:00-4:15 Hinch, SG
Physiological drivers of adult salmon migration timing, speed and success

5:30-7:30 POSTER SESSION & MIXER – vendors, raffle & cash bar; CAW Student Center Commons area

7:45-9:00 Fish Print Making with David Bechler; Biology Building, Room 29

WEDNESDAY JUNE 20TH

PLENARY & CONTRIBUTED TALKS – TOLDO HEALTH EDUCATION CENTRE, RM 104

Global Freshwater Fishes and Ecosystem Health
Session Chair: Sigal Balshine

9:00-9:45 Dr. Robert Hecky (Plenary Speaker)
I can see clearly now: Insights from stable isotopic analyses to ecological and evolutionary dynamics of haplochromines in the African Great Lakes

9:45-10:00 Steele, S
The effect of habitat quality on benthic macroinvertebrate communities and colonization in newly formed channels

10:00-10:15 Wright, CW
The impact of habitat selection, habitat structure and stream order on species diversity at bridge sites

10:15-10:30 Zhu, X
Monitoring and assessing environmental and cumulative impacts on Great Slave Lake fishery productivity and the fish community association

10:30-10:45 HEALTH BREAK

Session Chair: David Noakes

10:45-11:00 Beaudry, M
Oxidative stress and growth in alligator gar (Atractosteus spatula) exposed to environmentally relevant concentrations of the aquatic herbicide, diquat

- END GLOBAL FRESHWATER FISHES & ECOSYSTEM HEALTH SESSIONS –
- GENERAL SESSION –

11:00-11:15 Glass, W
Novel molecular phylogeny of the Lepisosteidae and identification of specimens of unknown origin

11:15-11:30 MacPherson, B
Comparison of phylogenies constructed from CYTB, COI and whole mitochondrial genome sequences to determine which is most effective in distinguishing true tuna species from related species

11:30-11:45 Fraser, DF
Niche construction through predation: an experimental study of a predatory reversal in a streamfish

11:45-12:00 Hunt, J
Evolution of parental care in convict cichlids: division of labor, offspring survival and horizontal transmission of microbes

12:00-1:30 LUNCH – on your own at local restaurants

Session Chair (General session): Ann Cleveland

1:30-1:45 Cogliati, KM
Father of mine…where did you go? High degree of paternity loss in a species with alternative reproductive tactics

1:45-2:00 Rodgers, C

Effects of androgens on parental care behavior in male bluegill sunfish

2:00-2:15 Morbey, YE
Climate change and reproductive decisions in a long-lived salmonid: do lake trout invest more in reproduction when spring foraging opportunities are prolonged

2:15-2:30 Bernhardt, L
The impact of color on egg laying rates and outcrossing of Kryptolebias marmoratus

2:30-2:45 Lapointe, N
Annual depth and temperature selection by warm and coolwater fishes in Toronto Harbour

2:45-3:00 Magellan, K
Migration as a function of airbreathing in a newly discovered Galaxiid fish

3:00-3:15 HEALTH BREAK

Session Chair (General session): Maria Abate

3:15-3:30 DeBruyne, RL
Using ichthyoplankton surveys to assess fish habitat in the St. Clair-Detroit River corridor

3:30-3:45 Farwell, M
Links between polychlorinated biphenyls, endocrine function, and sperm traits in Chinook salmon (Oncorhynchus tshawytscha) from Lake Ontario

3:45-4:00 Manny, B
Restoring fish spawning habitat in the Great Lakes connecting channels

4:00-4:15 Noakes, D
Effects of temperature on sexual development in steelhead trout (Oncorhynchus mykiss): an unseen threat from climate change

7:00 FISHING ON THE RIVER – for interested anglers; provide your own rods, lures and license

Student Pub Night

THURSDAY JUNE 21st

PLENARY & CONTRIBUTED TALKS – TOLDO HEALTH EDUCATION CENTRE, RM 203

Genetic Quality and the Conservation of Fishes
Session Chair: Yolanda Morbey

9:00-9:45 Dr. Trevor Pitcher (Plenary Speaker)
Genetic quality and the conservation of fishes

9:45-10:00 Kuntz, S
Population differentiation of Ontario lake trout (Salvelinus namaycush) using the major histocompatibility complex class II beata gene

10:00-10:15 Robinson, TN
Local adaptation to pathogens and variation in the major histocompatibility genes of arctic charr (Salvelinus alpinus) across a latitudinal gradient

10:15-10:30 Lehnert, SJ
Farmed and wild Chinook salmon (Oncorhynchus tshawytscha) competing in semi-natural spawning channels

10:30-10:45 Johnson, K
The effects of inbreeding on sperm quality in lake trout

10:45-11:00 Houde, AL
Candidate selection for restoring extirpated populations

11:00-11:15 Bowden, B
Outmigration and thermal ecology of adult walleye from the Tittabawassee River

11:15-11:30 HEALTH BREAK

11:30-11:45 Heath, DD
Inbreeding depression in Chinook salmon: growth and survival variation among offspring from hermaphrodite self-crossed and out-crossed mating

11:45-12:00 Noakes, DLG
Born to be wild: can we produce artificially reared fish with a wild phenotype?

12:00 PRESENTATION OF STUDENT AWARDS

CLOSING COMMENTS: David Noakes

Oral Presentation Abstracts

MONDAY, JUNE 18TH

BIOSYNTHESIS, FUNCTION AND EVOLUTION OF A MALE MATING PHEROMONE IN THE SEA LAMPREY.

Li, W[1], K. Li[1], C. Brant[1], M. Siefkes[2], E. Walaszczyk[1], H. Wang[1], T. Buchinger[1], N. Johnson[3], and Y. Chung-Davidson[1]
1 Department of Fisheries & Wildlife, Michigan State University, East Lansing, MI 48824, U.S.A.
2 Great Lakes Fishery Commission, Ann Arbor, MI, U.S.A.
3 United States Geological Survey, Great Lakes Science Center, Hammond Bay Biological Station, Millersburg, MI, U.S.A.

Fish pheromones are chemical cues that modify behavioral, physiological or developmental processes of individuals of the same species. Previous studies have shown that sexually mature male sea lampreys (*Petromyzon marinus*) release mating pheromones that coordinate reproduction with ovulated females during their terminal life stage. Male sea lampreys, after becoming spermiated, actively release a bile acid, 7α,12α,24-trihydroxy-5α-cholan-3-one-24-sulfate (3kPZS), across their gills through specialized glandular cells. Ovulated female sea lampreys respond to synthesized 3kPZS at concentrations as low as 10-13M by swimming directly upstream to the source. Recently, we have integrated multi-disciplinary approaches to examine the diversity of molecular structures and functions of this male pheromones system. Biochemical and molecular analyses indicated that 3kPZS is mainly synthesized in the liver and modified at the gills before secretion into the water. Chemical fractionation, coupled with behavioral assays, demonstrated that compounds with structures similar to 3kPZS likely unction as minor components of the male mating pheromone. Physiological and chemical analyses showed that the male pheromone modifies the reproductive neuroendocrine system and progress of sexual maturation in both male and female sea lampreys. Furthermore, our results documented that male pheromone exposure suppresses the nocturnal locomotor rhythm in ovulatory females and affects melatonin production as well as the expression of several clock genes in the pineal complex and the brain. Comparative studies suggested that 3kPZS signaling is likely a conserved system among petromyzonid species. Our studies on lamprey pheromones have mainly been supported by the Great Lakes Fisheries Commission, the National Science Foundation, and the National Institute of General Medical Sciences.

FISH-INSPIRED FLOW-SENSING TECHNOLOGIES AND APPLICATIONS: THE INTERFACE BETWEEN SENSORY BIOLOGY AND ENGINEERING

Coombs, S.
Department of Biological Sciences and JP Scott Center for Neuroscience, Mind and Behavior, Bowling Green State University, Bowling Green, OH (e-mail: scoombs@bgsu.edu)

As a spatially-distributed system of flow sensors, the lateral line system has evolved over millions of years to meet the varied flow-sensing needs of some 30,000 species of fish living in different freshwater and marine environments. This talk will introduce some of the fish-inspired flow-sensing technologies and engineering applications that are currently being explored in collaborations between sensory biologists and engineers. Design features for flow-sensing technologies have been inspired from several different levels of lateral line organization, including (1) the structural features of individual lateral line sensors, (2) the spatial distribution, orientation and number of sensors on the body surface and (3) encoding and processing of flow information by the nervous system. Likewise, applications of flow-sensing technologies to the control of underwater autonomous vehicles (AUVs) have been inspired by how fish use flow in a variety of behavioral contexts, such as (1) collision avoidance in the dark by blind cavefish, (2) localization of moving targets by nocturnal fish, (3) rapid transmission of threat information

among schooling fish and (4) the ability of fish to harness flow energy. While fish behavior and the lateral line sensory system provide bio-inspirations for engineered systems, the engineering field likewise provides control theory, engineered flow sensors, and flow-sensing platforms (AUVs) for testing hypotheses about the neural mechanisms of flow-guided behaviors in fish.

RETHINKING FISH HEARING: NEW INSIGHTS INTO HOW HEARING IS EVALUATED

Radford, C.A.[1], J.C. Montgomery[1], P. Caiger[1], and D.M. Higgs[2]
1 Leigh Marine Laboratory, University of Auckland, PO Box 349, Warkworth, 0941, New Zealand
2 Department of Biological Sciences, University of Windsor, Windsor ON Canada

The auditory evoked potential technique has been used for the past 15 years to evaluate the hearing ability of fish, with the resulting audiograms presented in terms of sound pressure (dB re 1µPa) and the particle motion (dB re 1ms-2) component has been largely ignored. More recently, researchers have started to present audiograms in terms of particle acceleration, which has been measured in one of two ways; one, measuring the difference between two hydrophones (Euler Equation); and two using accelerometers. Here we compared the particle acceleration and pressure auditory thresholds of three species of fish with differing hearing specialisations, Goldfish (*Carassius auratus*; weberian osciles), bigeye (*Pempheris adspersus*; otolaterophysic connection) and the common triplefin (*Fosterygion lapillum*; no swimbladder), with three different methods of determining particle accelerations (Euler Equation, Accelerometers, Shaker Table). In terms of particle acceleration all three fish species had similar hearing thresholds, as opposed to pressure thresholds where the goldfish was the most sensitive followed by the bigeye and the triplefin was the least sensitive. The accelerometer technique provided significantly more sensitive particle acceleration hearing thresholds compared to the shaker table and Euler equation. It is suggested here that all fish have a similar ability to detect the particle motion component of the sound field and it's their ability to impart the pressure component of the sound field to the inner ear via ancillary hearing structures that provides the differences in hearing ability. Furthermore, researchers need to be careful in how they present and measure the stimulus of interest when determining the hearing ability of fish.

THE SCENT OF STEROIDS: CONTINUING EVIDENCE FOR REPRODUCTIVE PHEROMONES IN THE ROUND GOBY

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There is no established strategy for controlling the spread of the invasive round goby (*Neogobius melanostomus*) in the Great Lakes. This small benthic fish is a voracious predator of native fish eggs, a vector for disease and a competitor for prime spawning habitat. Reproductive males (RMs) establish nests which they guard aggressively until a gravid female enters and deposits eggs. The RM will continue to guard the nest and care for the eggs until they hatch. RMs may release pheromones to attract females to their nests, a strategy that provides a useful target for bio control. Reproductive pheromones may be used in critical areas to trap and remove round gobies, freeing up those areas for use by native species as well as possibly slowing population growth. RMs synthesize and release several novel androgens including: 3α-hydroxy-5β-androstane-11,17-dione (11-oxo-etiocholanolone; 11-O-ETIO), 3α-hydroxy-5β-androstane-11,17-dione 3-sulfate (11-oxoetiocholanolone-3-sulfate; 11-O-ETIO-3-s) and 3α,17β-dihydroxy-5b-androstan-11-one 17-sulfate. We used electro-olfactogram (EOG) – a recording of evoked field potentials from the olfactory epithelium – to investigate the olfactory properties of these novel androgens. Both 11-O-ETIO and 11-O-ETIO-3-s evoked EOG responses in the round goby, but not in goldfish, indicating that these steroid odors may be specific to the round goby. In addition, the round goby can discriminate between 11-O-ETIO, 11-O-ETIO-3-s and etiocholanolone (ETIO). Pharmacological inhibition studies found that in the round goby olfactory system, steroids are transduced via two second messenger cascades (cAMP and IP3)

while general teleost odors taurocholic acid and L-alanine use only cAMP or IP3, respectively. We suggest that 11-O-ETIO and 11-O-ETIO-3-s are potential round goby reproductive pheromones, given their olfactory properties and should be further considered as part of a multi-sensory round goby trapping control strategy.

THE BEHAVIOURAL BASIS OF TRAPPING AN INVASIVE SPECIES: LESSONS LEARNED FROM THE SEA LAMPREY.

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We tested whether large-scale manipulations of discharge influenced the behaviour of spawning-run sea lamprey *(Petromyzon marinus*), an invasive species in the Laurentian Great Lakes, in a manner that increased their susceptibility to trapping near the Clergue Generating Station on the St. Marys River. Invasive animals are becoming the focus of management concern in many ecosystems across the globe. Trapping is a potentially valuable form of control. For sea lamprey, increased trap success in large rivers is desired to meet the management objectives of a binational control program. One hundred and sixteen sea lamprey were tagged with passive integrated transponder tags and released downstream of the generating station. Antennas at two traps monitored when sea lamprey approached, and left or entered, a trap. Multi-state Markov (MSM) models were used to test how transition rates between being unavailable and available to be trapped, and between entering and leaving a trap, differed with night-to-night manipulations of discharge through the power plant. Sea lamprey altered their behaviour in response to discharge, but the changes did not result in increased trapping success. Sea lamprey were approximately two times more likely to approach a trap when discharge was high than when it was low, but they were approximately five times more likely to leave the trap rather than enter. This study found that overall trapping success was approximately twenty percent. Overall trapping success was also no higher on nights with high discharge than nights with low discharge. Our study demonstrates that the behavioural responses of sea lamprey to changes in discharge are complex and additional stimuli are likely needed to encourage sea lamprey to enter a trap.

VISUAL ECOLOGY OF SETTLEMENT-STAGE REEF FISH.

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Most reef fish species spend some time during their early development in the pelagic environment before returning to and settling on a reef. Up until just two decades ago, the overall consensus was that larval dispersal is largely driven by physical processes. Since then we have started to realise that this is not the case and that the swimming as well as sensory abilities of settlement-stage larvae are much better than previously assumed. We know now that settlement stage reef fish are able to orient in an environment, which lacks any visual landmarks. It is still largely unknown how they achieve this, what kind of cues they use to find a reef, and with that, a suitable habitat for settlement. Here, we analyse the light environment as well as the visual system and visual behaviour of settlement stage reef fish in attempt to narrow down the types of visual cues available to them. Behavioural experiments testing the potential use of polarisation cues for orientation and testing the use of brightness cues for settlement habitat selection will be presented and discussed.

UNIQUE MECHANOSENSORY ADAPTATION TO EXTREME ENVIRONMENTS IN CAVEFISH.

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Extant cavefishes can be viewed as replicate experiments in adaptation to an extreme environment. Various surface dwelling fishes have independently invaded caves throughout evolutionary time. Thus, the existence of independently derived cave forms provides a unique opportunity to examine parallel evolution and convergence because cavefish species belong to a diverse palette of families. All cavefish ancestors had to outmaneuver and adapt to the harsh constraints imposed by the extreme environment of caves and their perpetual darkness. As a result a suite of specific troglobitic phenotypes have independently emerged. Here we studied the cavefish Astroblepid pholeter which is endemic to a single
cave on Ecuador (Jumandy 77˚47'33"W 0˚52'30"S). Our results show that this fish species is of special interest because it appears to be the first teleost to have no neuromasts. We were not able to detect the presence of neuromasts using neither DASPEI, nor scanning electron micrography, nor serial thin sectioning of the skin. Instead, we found that A. pholeter dorsal skin is covered with novel putative sensory organs that are unique in morphology, respond electorphysiologically to mechanosensory stimuli and influence rheotaxic behavior.

ACOUSTIC COMMUNICATION AND COURTSHIP DISPLAYS IN THE ELECTRIC YELLOW CICHLID (*LABIDOCHROMIS CAERULEUS*)

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The family Cichlidae presents an attractive model for the examination of selective drivers behind diversification due to its relatively recent radiation and high species diversity. While much effort has been expended on determining the role of visual signaling in this radiation, due to the large amount of colour variation in this group, much less attention has been paid to other forms of reproductive communication. In the current study we examined acoustic communication in one species of Lake Malawi cichlid, *Labidochromis caeruleus*, to test the amount of individual variation in male call output and the effect of female differences on male calls. Seven male *L. caeruleus* were exposed to one of three females and their interactions were recorded using a hydrophone and video camera. Calls were only produced during courtship behaviour and at least 3 different types of calls were recorded. We analysed call duration, pulses per call, length of pulse, pulse repetition rate per second, and peak frequency in all trials and found differences between males in these basic call parameters. Female effects are still being analysed. While analyses are still ongoing, it seems clear that there are inter-individual differences in male call structure in this species with the potential for signaling male quality to female conspecifics. Comparisons to previous work also suggests strong species-specificity in acoustic parameters for *L. caeruleus*. It is clear that *L. caeruleus* reproductive displays have a strong acoustic component and this modality is likely a prime determinant of reproductive decisions and mate choice.

THE OLFACTORY BULB OF THE SEA LAMPREY: ODOUR PROCESSING AND IMPLICATIONS FOR OLFACTORY-MEDIATED MOVEMENTS.

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The peripheral olfactory organ of the sea lamprey is comprised of the main olfactory epithelium and an accessory olfactory organ. Olfactory information from the main epithelium and accessory organ transits through an anatomically unique medial region of the olfactory bulb to command neurons in the hindbrain driving locomotor behaviours. Non-medial regions of the olfactory bulb receive olfactory information exclusively from the main olfactory epithelium and primary output neurons project to forebrain structures where sensory information is further integrated. In this study we used an ex-vivo nose-brain preparation to investigate the neural responses of the medial and non-medial subsystems of the olfactory bulb to a variety of odours, including lamprey sex pheromones and migratory pheromones, using local field potential and multi-unit recordings. Response profiles of local field potentials were monophasic or multiphasic in shape and were consistent within a given recording location, independent of odour category. The amplitude, response latency, and half-width of field potential responses were examined for each odour in both the medial and non-medial regions of the olfactory bulb. In addition, changes in spike frequency were examined for multiunit recordings revealing both excitatory and inhibitory responses to amino acids, sex pheromones, and migratory pheromones depending on the recording location within the olfactory bulb. Taken together these responses suggest that olfactory information is chemotopically organized in the lamprey olfactory bulb and that the medial olfactory bulb region is responsive to basic amino acids, lamprey sex pheromones and migratory pheromones and has the ability to evoke locomotor responses related to feeding, migration, and spawning. Funding provided by the Great Lakes Fishery Commission and NSERC.

THE NEUROBIOLOGY THAT LINKS OLFACTION TO LOCOMOTION IN THE SEA LAMPREY, *PETROMYZON MARINUS*.

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Aquatic vertebrates such as lampreys utilize chemical senses during movements associated with predation, migration and spawning. We have identified a neural substrate that allows for the transformation of an olfactory input into a locomotor output. Olfactory sensory input is transmitted to projection neurons (PNs) located in the medial region of the olfactory bulb. These project to the posterior tuberculum in the ventral diencephalon, where signals are directed to the mesencephalic locomotor region to reach reticulospinal cells in the lower brainstem (the command neurons for locomotion). Activation along this olfactory-motor pathway generates swimming behaviour. Sensory neurons located in the accessory olfactory organ project axons only into the medial region of the olfactory bulb containing the PNs for this olfactory-locomotor substrate; although infrequent olfactory sensory neurons in the main olfactory epithelium also project into this medial bulbar territory. Amino acid, bile acid and pheromone odorants elicit local field potentials as well as multi-unit responses in this medial region. The dendrites and somata of these medial PNs are confined to glomerular neuropil, and are not observed in any of the deeper layers. The organization and responsiveness of this olfactory –locomotor substrate suggests that it is unique compared to the rest of the olfactory

system, in terms of input, output, neuroanatomy and chemical responsiveness.
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DOES TURBIDITY PROVIDE AN INVASION PATHWAY FOR EXOTIC FISH?
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Worldwide, freshwater ecosystems are becoming increasingly turbid due to human activities. It is within these ecosystems that the largest number of exotic fish invasions, and native fish extinctions, occur. In the United States these invasions result in annual economic costs of $5.4 billion a year. In this study we propose that increased turbidity leads to a change in the sensory performance of fish, with non-visual invasive species becoming more competitive than visual native species leading to changes in fish communities. In order to establish this hypothesis fish trapping was conducted along a highly marked turbidity gradient within the Waikato River, in New Zealand. Our results show that *Gambusia affinis*, an invasive species, dominated fish numbers on the turbid side of the river, while Inanga, *Galaxius maculatus*, a native species, was found in higher numbers along the clear side. Behavioural experiments were then conducted to establish feeding capabilities of these species across a range of turbidity levels. The neuroanatomy of freshwater fish was also investigated to show whether exotic species tend to have enlarged non-visual sensory centres in the brain compared with 'at risk' native species. This study indicates that turbidity may provide an invasion pathway for exotic fish, leading to declines in native fish populations. The results produced from this work will provide vital information on those habitats most at risk from invasion, those species most likely to invade such habitats, and those native species that are most under threat from these invasions. It will also provide the biological underpinning for a paradigm shift in control of freshwater fish invasives from direct control to habitat remediation.

ATTRACTION OF ROUND GOBIES, *NEOGOBIUS MELANOSTOMUS*, TO CONSPECIFIC CALLS.
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Male round gobies (*Neogobius melanostomus*) emit calls and female gobies respond to these calls with high specificity, but the context in which these calls are used remains unclear. It has been suggested that these calls serve a reproductive function but both males and females respond to acoustic cues and different types of calls have been recorded. The goal of the current study was to examine differential attraction between reproductive morphologies to a range of conspecific call types. We use playback experiments in the lab to determine the response of gobies of both sexes to recordings of two conspecific calls, a grunt and a drum, in relation to reproductive status of responding fish. For the grunt, reproductive females displayed a significantly higher response for first approach than nonreproductive males and number of approaches than reproductive males and nonreproductive females, but not for the duration of time spent at the playing speaker, while for the drum call, reproductive females were found to never approach the playing speaker and spent significantly less time at the sound source as a result. In contrast to the female responses, nonreproductive and sneaker males displayed a strong preference to the drumming call. Overall these results support that the grunt could be a mate attraction call while the drum may be used by nonreproductive and sneaker males for eavesdropping. By determining the relationship between reproductive state and auditory responsiveness to conspecific calls, we are further elucidating the function of acoustic communication in the round goby. These results are currently being explored as a potential tactic in selective trapping of gobies to reduce their impact on freshwater ecosystems in the future.

RESPONSES OF FEMALE ROUND GOBIES (*NEOGOBIUS MELANOSTOMUS*) TO ISOLATES CONTAINING STEROIDS RELEASED BY REPRODUCTIVE MALES

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There is a growing concern over the expansion and increasing abundance of the round goby (*Neogobius melanostomus*) in the Laurentian Great Lakes and surrounding water ways. Recent behavioural studies suggest that reproductive males attract females to nesting sites using putative steroidal pheromones. Following stimulation of the hypothalamic-gonadal axis, males release unconjugated and conjugated forms of 3α-hydroxy-5β-androstane-11,17-dione (11-O-ETIO). The released conjugates of 11-O-ETIO include those sulphated or glucuronated at either the 3 or 17 position (4 conjugates in total). In this study, we analysed behavioural responses of reproductive and non-reproductive female round gobies to conditioned water and to fractions, each containing an isolated steroid (either free, 3s, 17s,3g or 17g). It was found that both reproductive and non-reproductive females increased swimming activity in response to conditioned water extracts when compared with responses to control water, providing further evidence in support of inter-sexual pheromones in N. melanostomus. We also began to investigate the possibility of monitoring behavioural responses to isolate the particular steroid(s) necessary in attracting females to nest sites. It was found that non-reproductive females increased swimming activity in response to fractions containing 11-oxo-ETIO-3s when compared with their responses to negative control water. These results suggest that conjugated isolates from reproductive male urine may have the potential to attract females to nesting sites. Further research must be conducted to determine the behavioural responses of reproductive females to each of the steroid isolates.

FANNING BEHAVIOUR AND COMMUNICATION IN THE ROUND GOBY (*NEOGOBIUS MELANOSTOMUS*), AN INVASIVE FISH

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Pheromones are important olfactory signals used by animals to communicate with both conspecifics and heterospecifics. There is an important trade-off between dispersal over long distances and concentration of the signal. Some species overcome this problem by using specialized organs to facilitate the dispersal of pheromones. Since male fish begin to fan their fins before spawning occurs, the fins are likely used to facilitate pheromone dispersal. The round goby is an invasive fish species in the Great Lakes. Current measures of reproductive status (gonadosomatic index, 11-ketotestosterone levels) can be unreliable and require the fish to be sacrificed. Nest guarding male gobies fan with their pectoral and caudal fins before spawning occurs, suggesting that fanning could be used as an indicator of reproductive status. Male gobies release sex pheromones to attract females to the nest likely through fanning (pumping) water out of the nest over a distance of 35 cm. The objective of this study was to determine if male fanning is associated with male reproductive and/or other morphological traits. Using video recordings of male fanning behaviour, rates were calculated and related to various characteristics of the male. A significant positive relationship was found between pectoral fanning rate and GSI however there was no relationship between caudal fanning and GSI or fanning and 11-ketotestosterone levels. A negative relationship between tail length and caudal fanning rate was also found. Surprisingly, no relationship was found between GSI and 11-ketotestosterone. The ability to manipulate breeding in round gobies by dispersal of released pheromones might lure females to traps and away from areas where they negatively interact with native species. If we are able to better identify reproductive males (i.e. males that release sex attractants), it would enhance our ability to control this species in designated areas where round gobies negatively affect native fishes.

SENSING SYNTHETIC DANGERS UNDERWATER.

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For many fishes, one of the most important sensory inputs is that of smell, i.e. olfaction. Through relatively exposed olfactory neurons, fish gather information essential to feeding, migrating, mating and avoiding predators. Recently we have endeavoured to test the axiom that fish, as with other organisms, will use olfaction to avoid harmful substances. Since many of the harmful substances being introduced into the aquatic environment are synthetic compounds based on naturally occurring molecules that fish can detect, we hypothesized that they would be able to detect some synthetic compounds. Through physiological studies measuring olfactory neuron responses directly, we confirmed that this was the case. This still begged the question: will a synthetic contaminant smell 'off' or more like its attractive natural analogue? We attempted to answer this question by giving fish the choice to move into or away from different realistic contaminant mixtures. We found that some mixtures, such as municipal grey water, do evoke behavioral avoidance while others, such as herbicide mixtures, actually evoke attraction. Data suggests that the attraction responses can be attributed to compounds with structural similarity to plant hormones and amino acids. Our overarching goal is to model how the different spatial and temporal inputs of synthetic contaminants into aquatic habitats will modulate the movement of fishes in a changing environment.

THE CONTRIBUTION OF THE LATERAL LINE TO "HEARING" IN FISH.

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In fish, sound stimuli are an important signaling modality for both long- and short-distance communication. In the underwater environment, sound propagates as both a pressure wave and as particle displacement, with particle displacement dominating close to the source (the nearfield). At the receptor level, both the ear and the neuromast hair cells act as displacement detectors and both are potentially stimulated by sound sources in the nearfield. A now common way to test "hearing" in fish involves auditory evoked potentials (AEP), with recordings made from electrodes implanted near the auditory brainstem and neural responses to sound stimuli are recorded. These AEP recordings are typically conducted in enclosed acoustic environments with the fish well within the particle motion area of the sound field, especially for lower frequencies. We tested the contribution of neuromast hair cells to AEP by first testing intact goldfish (*Carassius auratus*), then ablating their neuromasts with 0.05% (w/v) streptomycin sulfate — to disable superficial and canal neuromasts — and retesting the same goldfish. We did a similar experiment with other goldfish but physically ablated superficial neuromasts only. At 100 and 200 Hz, there was a 10-15 dB increase in threshold (in both pressure and acceleration units) after streptomycin treatment but no significant difference at higher frequencies. There was no difference in threshold in control fish or in fish that only had superficial neuromasts removed, indicating that the differential responses were driven by canal neuromast responses Taken together these results indicate that AEP results at lower frequencies should be interpreted as multimodal responses, rather than "hearing". The results also suggest that in natural situations, because fish calls are predominately low frequencies, both the ear and lateral line likely play an integrative role in detecting and responding to many types of "acoustic" stimuli.

LARVAL RED DRUM (SCIAENOPS OCELLATUS) CHANGE THEIR BEHAVIOR IN RESPONSE TO ACOUSTIC STIMULUS.

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Seagrass meadows provide important nursery grounds for many estuarine fishes and invertebrates. These habitats afford both food and refuge, but another potential advantage of seagrass habitats is their unique acoustic properties. The free gas contained within the plant tissue and the bubbles produced during photosynthesis form an acoustically compressible substrate, which alters the estuarine soundscape. It is hypothesized that larval fishes that use seagrass meadows as nursery habitat preferentially settle within the seagrass beds because of the reduction in sound within. In laboratory trials, we examined the behavioral response of larval red drum (*Sciaenops ocellatus*) over a range of sizes to a 500-Hz pure sine tone at four separate amplitude treatments and white noise in the frequency band of 0.1 to 1.0 kHz. These five acoustic treatments represented amplitudes the larvae experience while in the pelagic and demersal environments of the Gulf of Mexico, where they occur naturally. Each larva was tested in a paired comparison: without introduced sound (control) and with one of the five acoustic treatments. After removing the effect of fish size on swimming speed, individuals covered less distance (swam more slowly) during the sound treatment compared to the control (quiet period). The increase in swimming speed associated with quieter environments could translate into differences in foraging efficiency and predator encounter rates depending on the habitat in which a larva settles, consequently affecting chances of survival.

A PROPOSED MECHANISM FOR THE OBSERVED ONTOGENETIC IMPROVEMENT IN THE HEARING ABILITY OF HAPUKA (*POLYPRION OXYGENEIOS*).

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The majority of reef fishes have a biphasic life cycle, including a pelagic or dispersal phase where they undergo feeding, ontogenetic development and growth in the open ocean. The duration of this pelagic stage usually lasts an order of days to weeks before settlement onto reefs; however, the grouper *Polyprion oxygeneios* (hapuka) is unusual in that it spends up to four years in the pelagic environment before settlement. Using the auditory evoked potential (AEP) technique, hearing thresholds were determined in four age-classes of hapuka, from late-stage larvae to one year old juveniles,. The youngest age-class had poor hearing abilities, with the lowest thresholds of 132 dB re 1 µPa, and a narrow auditory bandwidth (100-800 Hz). Hearing thresholds improved significantly throughout the remainder of their first year, with decreases in thresholds across the entire frequency range up to 27 dB re 1µPa, along with an increase in auditory bandwidth (up to 1000 Hz). Dissections and magnetic resonance image (MRI) scans were used to investigate structural mechansisms that may account for this ontogenetic improvement in hearing. These showed that rostral extensions of the swim bladder begin to develop early in the juvenile stage. This extension wraps either side of the fused vertebrae, immediatley caudal to the otic capsule. However, at no age-class of the fish we investigated did the swim bladder connect to the otic capsule. It is suggested here that this indirect connection between the swim bladder and the otic capusle could impart pressure sensitivity directly to the inner ear and account for the increase in sensitivity seen during development.

TUESDAY, JUNE 19TH

NON-INDIGENOUS FISHES

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The transfer of fish species outside their native range, with the intent to establish self-sustaining populations, is a time-honored tradition dating back a few thousand years. Similar to crop plants, horticultural plants, and domesticated mammals, fishes are an important component of our food, culture, and recreation. In recent decades, the cultural imperative to reconfigure natural systems to serve humans has been slowly replaced with understanding the value of native species and the importance of ecological stability. Significant progress has been made in reducing vectors of exotic fish introductions. State and federal agencies, on the whole, no longer view stocking of new exotic species as a desirable management activity; ballast water regulations are in place in the Great Lakes and elsewhere; bait fish regulations are being implemented in many states; the aquaculture industry is under scrutiny, and attention is being focused on the aquarium industry as a source of new exotic species. But fish introductions, usually accompanied by other exotic taxa, have radically altered many aquatic communities. Are the changes we have wrought on fish communities irrevocable, repairable, or perhaps even desirable? Human population growth has led to progressive habitat alterations which, in many areas, are unlikely to be reversed. Food scarcity places increasing demands on aquatic habitats to produce a harvestable biomass of a limited number of fish species. Water scarcity is reducing fish habitats, while also promoting the construction of canals that allow exotic species to invade new watersheds. Recreational fishers often prefer exotic species to local native fishes. Educating the public, and governments, about the cost of maintaining ecosystem services damaged by exotic species is a priority. The harsh admission that some aquatic systems are, like farmland, irreversibly transformed by exotic aquatic species may also be needed

SEX DIFFERENCES IN ACTIVITY, EXPLORATION AND PREY RESPONSES OF THE INVASIVE ROUND GOBY (NEOGOBIUS MELANOSTOMUS).

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Sex-specific patterns in movement (e.g., foraging and dispersal) are driven by different trade-offs in the benefits of finding new resources, versus costs such as increased predation risk. Behavioural differences between sexes or among individuals, measured in the laboratory, can predict longer-term movements of individuals and population dynamics in the field, which is particularly important for invasion biology. Here, we examined differences in activity, exploration, foraging, and responses to predation risk between male and female round goby, a small benthic fish invasive in both North America and northwestern Europe. In the lab, males were more active, more likely to discover and forage from a food source, and showed greater activity in the presence of simulated predation risk than females. In the field, while females had longer field residence times than males over the long term, few other differences were observed between male and female movement and recapture rates, as an estimate of survival. We present these results in the context of population dynamics both in established round goby populations, and in regions where these fish continue to invade.

AN ECOLOGICAL AND EVOLUTIONARY APPROACH TO THE STUDY OF TWO NON-INDIGENOUS GOBY IN THE GREAT LAKES.

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The spread of non-indigenous species is predicted to increase as human populations grow, and climates change. There is potential for rapid evolution following invasion from non-indigenous species. Thus invasion and subsequent spread of non-indigenous species to novel environments provides an opportunity to study evolutionary events in relatively short time scales. These events can provide insight into the interacting evolutionary and ecological processes associated with invasion success. The aim of this study was to investigate the influence of ecological niche and diet on the post-established survival and success of two non-indigenous fish: round goby (successful; *Neogobius melanostomus*) and tubenose goby (less successful; *Proterorhinus semilunaris*). Ecological metrics were matched to genetic diversity in each individual. The study was part of an integrated nation-wide initiative directed towards improving knowledge on the factors that govern the spread and potential risk of aquatic invasive species (AIS) in the Great Lakes (Canadian Aquatic Invasive Species Network, CAISN). Stable isotopes (δ13N and δ13C) (IRMS), mercury (DMA-80 analyzer) and gut contents were used as tracers of ecological niche width. Zebra mussels (*Dreissena polymorpha*) provided a baseline for stable isotope values. We hypothesized that more successful goby have a broader diet and ecological niche width. This could in part be due to a link between environmental plasticity, diet and ecological niche, but ultimately indicates the ability of these traits to improve reproductive success. The findings of this study have the potential to better our understanding of the link between ecological and evolutionary processes in driving the success of species in a rapidly changing world. Preliminary results from 2011 collections and sampling projected for 2012 will be presented for the Great Lakes, native Eurasian and invaded European water bodies.

CHARACTERISTICS OF ROUND GOBY POPULATIONS AT INVASION FRONTS

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The role of aggression as a factor promoting invasiveness remains hotly debated. Previous research suggests that larger, more aggressive or bold individuals are more likely to disperse, and thus such individuals may be overrepresented on the invasion front. In contrast, it has also been argued that individuals at the invasion front represent the least competitive individuals in the population, those that are competitively excluded from established areas, and therefore are small, shy, submissive, and exhibit reduced aggression and sociability. In this study, we explore these predictions by quantifying body morphology and the levels of intra-specific aggression in the round goby, *Neogobius melanostomus*, an invasive fish that continues to spread rapidly through the Laurentian Great Lakes region in North America. Male round goby were collected from invasion fronts and from areas with an established population. In the behavioural trials, we size-matched fish from each collection site and then staged resource contests between them. Invasion front fish were not more active or bold prior to the contest and used the same types of aggressive displays as fish from established areas. Invasion front fish won 65% the contests, and tended to perform more aggressive acts overall. Our results also showed that body size asymmetry was an overriding determinant of competitive outcomes but that individual variation in aggressiveness could also be a contributing factor determining the

composition of round goby invasion fronts throughout the Laurentian Great Lakes and its tributaries.

ECOLOGY OF A RECENTLY INTRODUCED POPULATION OF NORTHERN SNAKEHEAD (CHANNA ARGUS) IN THE POTOMAC RIVER, VIRGINIA.

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A population of northern snakehead (*Channa argus*) was recently established in the Potomac River catchment. This large, piscivorous, air-breathing fish may pose substantial risk to native fishes. To understand the natural history of this invader, we studied its dispersal ability, habitat use, feeding habits, diet, spawning, and growth. We implanted 49 fish with radio transmitters in October 2006, and tracked them through summer 2007. Habitat and measures of water quality were recorded at northern snakehead and paired random locations. We captured northern snakehead for gut-content analysis from May to August 2007 and 2008. Additionally, we captured co-occuring North American species to determine diet overlap, including largemouth bass (*Micropterus salmoides*), longnose gar (*Lepisosteus osseus*), American eel (*Anguilla rostrata*), and yellow perch (*Perca flavescens*). Nests were monitored, taking larval samples daily. Larval growth was measured, and adult growth was measured through recapture of tagged fish. Approximately 1/3 of tagged northern snakehead dispersed (some over 40 km) just prior to the start of the spawning season in May, whereas the majority remained in relatively restricted home ranges (<4 km2). Northern snakehead preferred shallow (<1.5 m) habitats with thick cover. Northern snakehead fed during daylight, almost exclusively on fishes, and diet overlap was biologically significant only with largemouth bass. Indications of spawning were observed from May to September, and guarded nests were found in thick Hydrilla verticillata. Control efforts would be most effective if focused on the pre-spawning and spawning periods, in shallow habitat with plenty of cover.

MORPHOLOGICAL RESPONSES TO TROPHIC LEVELS IN NATIVE AND NON-NATIVE FISH

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Non-indigenous species that exhibit a high degree of morphological plasticity are more likely to successfully spread through novel environments. The pumpkinseed (Lepomis gibbosus) is a North American centrarchid, first introduced to Europe over a century ago, and has since been reported in over 28 countries. In the Iberian Peninsula, the species is particularly invasive and is quickly spreading through Spain and Portugal's network of reservoirs and tributaries. We hypothesized that morphological traits in pumpkinseed that are functionally significant for feeding and locomotion, will differ by habitat (river or lake) and population origin (native or non-native). We reared F1 juveniles from two Spanish and two Ontario populations for 80 days in enclosures (1 m x 1 m x 0.5 m) that restricted fish to either the littoral or pelagic zone of an artificial pond, while permitting the passage of invertebrates and water. While differences in phenotypic plasticity between North American and European populations appeared to be minimal, fish held under pelagic conditions exhibited significantly longer dorsal and ventral caudal peduncle lengths, and wider caudal fin bases, regardless of geographic origin. Pelagic conditions induced narrower bodies in lacustrine population and wider bodies in fluvial population, and more anteriorly located dorsal and pelvic fins in all populations. Non-native pumpkinseeds continued to exhibit longer median fins and wider bodies, which is consistent with the findings of previous morphological comparisons. Native and non-native pumpkinseeds

held under pelagic conditions appear to exhibit similar morphological changes geared towards enhancing their ability to cruise through open-water habitat. Measurements pertaining to internal feeding structures (e.g. jaw size, distance between gill rakers) are forthcoming, and may help to clarify whether non-native pumpkinseed are better able to adapt their feeding morphology in response to novel food resources.

USING DNA BARCODING TO CREATE A REFERENCE LIBRARY FOR SNAKEHEADS TO AID DETECTION IN ENVIRONMENTAL DNA.

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Snakeheads represent a diverse group of opportunistic predators endemic to Asia and Africa that have entered North America through the ornamental fish trade. They have been released into Florida, Hawaii, and Maryland waters establishing invasive populations that pose a threat to indigenous freshwater biodiversity. Understanding pathways of invasion requires access to accurate species identification, which can be challenging because snakehead taxonomy is not well understood. DNA barcoding has gained attention as a powerful tool for identifying diverse fishes and has the benefit of being suitable for the identification of all life stages. The aims of this study are to 1) build a library of mitochondrial 5' COI DNA barcodes derived from expert identified reference specimens in order to 2) determine the identity of invasive species found in North America using barcoding, and 3) exploit species-specific patterns of sequence variation in the barcode library to develop Taqman assays needed to 4) detect invasive Channa species from the environmental DNA (eDNA) they shed into water using real-time PCR.
Ninety-three tissue samples representing twenty-one Channidae species were sourced, including the three invasive species from North America. Total genomic DNA was extracted, PCR amplified and bi-directionally sequenced according to standard Fish Barcode of Life protocols. Sequence and specimen meta-data was archived and aligned with other published data using the Barcode of Life Data Systems (www.BOLDSystems.org), yielding a combined data set of 184 specimens representing 24 species. Results from genetic distance-based analyses demonstrate that DNA barcodes can be used to diagnose snakehead species. High intra-specific variation was observed among C. gachua, C. striata and C. marulius suggesting cryptic diversity presence. Invasive snakeheads in Lake Wylie, North Carolina, reported as C. argus were actually identified as C. maculata using barcodes.
Probe design for remote detection of varied snakehead species from eDNA using qPCR will be discussed.

ANTIPREDATOR BEHAVIOR AND SURVIVAL OF INVASIVE AFRICAN JEWEL CICHLID (*HEMICHROMIS LETOURNEUXI*) IN THE PRESENCE OF PISCIVOROUS FISH NATIVE TO PENINSULAR FLORIDA

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One of the most influential factors on the life history of many aquatic animals, such as teleost fishes, is the risk presented by predators. Despite the large number of non-native fish introductions in peninsular Florida, its freshwater systems have proven highly resistant to small-bodied, (< 150 mm in length) non-native, ornamental species, with one major exception: African jewelfish *Hemichromis letourneuxi*. This may be due to these systems' predator/prey dynamics. Small-bodied fish generally cannot employ one of the most successful methods for avoiding predation, large body size, because they do not grow large enough to be invulnerable to gape-limited predators. To explore possible explanations for this single exception, we evaluated two non-native, freshwater, ornamental fishes' vulnerability to two species of common, native predatory fish in a series of laboratory experiments. The non-native

ornamental species, which functioned as potential prey in our system, were the African jewelfish, and the morphologically similar kenyi cichlid *Maylandia lombardoi*, both of which are found in the aquarium trade. The native predators were largemouth bass *Micropterus salmoides*, a large-bodied predator, and eastern mosquitofish *Gambusia holbrooki*, a small-bodied but aggressive competitor and predator. We exposed sets of ten prey fish to three predator treatments (n = 4) including each predator alone (either 1 bass or 75 mosquitofish) and both predators together. Behaviors and habitat use were defined in advance and evaluated based on video recordings of the fish in experimental systems during the trials. We then examined the possible relationships between prey survival and behavior in the various experimental treatments, as well as in a series of short-term, observation tank trials.

GENERAL SUBMISSIONS

THE ENVIRONMENTAL IMPACT OF PREDICTABILITY: THE EFFECT OF SEA CAGES ON THE DISTRIBUTION OF MARINE FISHES IN THE NORTH ATLANTIC.

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The distribution of resources in most environments is highly unpredictable, especially at small time and spatial scales. However, aquaculture sites are an exception to this. Feeding barges will travel to the same locations and deliver a predetermined amount of food every day. They are not variable in space since their locations are fixed for years, and they do not vary significantly through time beyond changes in daily rations to compensate for increases in biomass within the sea cage. Earlier work has demonstrated that surplus food will tend to cause concentrations of fish in the immediate vicinity of the sea cages. However, we sought to determine whether the predictability of resources associated with sea cages and the subsequent stable distribution of surrounding fish could be the basis for a localized ecosystem that would generate elevated abundances of fish well beyond the immediate location of the sea cage. To test this hypothesis, we conducted a series of hydroacoustic surveys in 8 bays that contained sea cages relative to 5 sites that were preapproved for aquaculture (i.e., contained the same physical characteristics as aquaculture sites) but were not yet developed. We conducted our survey over a four day period in September 2011, and measured the overall distribution of biological targets within the bay, as well as detailed measures of targets in the immediate vicinity of sea cages. Our results demonstrate that sea cages do have a significant impact on the distribution of marine fish at a variety of scales and we discuss the implications of these results that are both positive and negative for wild fish populations.

FIELD CONTAMINATION IN THE INVASIVE ROUND GOBY: EFFECTS ON ASSOCIATIVE LEARNING.

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An organism's ability to learn and associate particular locations with predation risk or reliable food can increase its survival. However, exposure to contaminants may impair these cognitive behaviours. To analyze the effects of field contamination on associative learning capabilities, we collected and tested 48 adult round goby (*Neogobius melanostomus*) from two sites within Hamilton Harbour (Ontario, Canada). We used fish from a known site of historical contamination at Sherman Inlet close to Randal Reef (N=24), as well as fish from a site of much lower contamination, La Salle Park (N=24). We tested the ability of fish from these two locals to associate a particular area in a test tank with a positive stimulus (a food reward). The testing tank was divided into three compartments, each with a different substrate type. Initial preference for tank chamber was assessed, followed by three training days during which the

least preferred substrate type was associated with the food reward, and culminated in a final assessment of area/substrate choice without a food reward. Following the experiment, the whole brain and forebrain masses were measured. We predicted that round goby from sites of lower contamination would perform better on this association task and have heavier brain masses. The results were somewhat supportive of our predictions, and will be discussed from a behavioural and neuroanatomical perspective to shed light on the impact of real world exposures to contaminants on learning and decision-making.

UNINTENDED CONSEQUENCES AND TRADE-OFFS OF FISH PASSAGE.

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We review evidence for unintended consequences and trade-offs associated with the passage of fishes. Provisioning of fish passageways at dams and dam removals are being carried out increasingly as resource managers seek ways to reduce fragmentation of migratory fish populations and restore biodiversity and nature-like ecosystem services in tributaries altered by dams. The benefits of provisioning upstream passage are highlighted widely. Possible unwanted consequences and trade-offs of upstream passage are coming to light, but remain poorly examined and underappreciated. Unintended consequences arise when passage of native and desirable introduced fishes is delayed, undone (fallback), results in patterns of movement and habitat use that reduce Darwinian fitness (e.g. ecological traps), or highly selective taxonomically and numerically. Trade-offs arise when passage decisions intended to benefit native species interfere with management decisions intended to control the unwanted spread of non-native fishes and aquatic invertebrates, or genes, diseases, and contaminants carried by hatchery and wild fishes. These consequences and trade-offs will vary in importance from system to system and can result in large economical and environmental costs. Decisions about how to manage fish passage therefore involve substantial risks, and could benefit from use of a formal, structured process that allows transparent, objective, and, where possible, quantitative evaluation of these risks. Such a process can also facilitate the design of an adaptive framework that provides valuable insights into future decisions.

USING LIFE HISTORY THEORY AND A 3D TEMPERATURE MODEL TO PREDICT CLIMATE CHANGE EFFECTS ON FISH AGE AT MATURITY FOR GREAT LAKES SALMONIDS

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Climate change is expected to result in changes in fish population growth and life history traits such as age at maturation. We use life history theory to quantify age at maturity and consider three fitness functions: intrinsic rate of population increase (r), net reproductive rate (R0), and

Fisher's reproductive value (Vx). For each fitness function we quantify effects of climate change on optimal age of first reproduction for semelparous and iteroparous females in different Great Lakes. We use IPCC scenarios of climate change, a 3-dimensional model of lake temperature, and bioenergetics models to predict climate impacts on individual fish growth. For the range of predicted individual growth rates, we calculate the resulting optimal age of maturation for semelparous Chinook salmon and iteroparous steelhead living in the Great Lakes. We describe the sensitivity of age of maturity to growth, size-specific survival, and reproduction parameters. We show that age of maturity is especially sensitive to juvenile survivorship. Our analysis shows that maximizing r and Vx result in the same optimal age at maturity; maximizing R0 results in a different optimal age at maturity than for r and Vx, except when populations are stable. For R0, predicted age at maturity was most sensitive to changes in juvenile growth and survival, whereas for Vx, predicted age at maturity was most sensitive to changes in the length exponent describing fecundity and juvenile survival. We predict that under climate change scenarios of warmer lake temperatures, Chinook salmon and steelhead will increase individual growth rate and mature earlier than at present, resulting in increased population growth rates. Future work will determine fish maturation response to fishing.

HABITAT OCCUPANCY BY LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*) INCLUDES AN ECOTONE IN THE PROFUNDAL ZONE OF TWO CANADIAN SHIELD LAKES.

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Temperature and dissolved oxygen preferences have traditionally defined habitat for lake whitefish (Coregonus clupeaformis). These parameters produce volumetric estimates of habitat largely in the hypolimnion without regard to spatial structure. The purpose of this study was to determine if structure was important in defining lake whitefish habitat. We estimated habitat occupancy patterns for lake whitefish using a multi-pass survey approach based on randomly-stratified gillnets in two lakes (Lake Opeongo and Smoke Lake). Multi-pass surveys permit separation of detection from occupancy as a function of habitat covariates. Essentially, sites where whitefish appear absent (zero catches) can be modeled for occupancy based on covariates. Habitat covariates, including temperature, light, depth, and substrate habitat via acoustic classification were modeled at two different spatial scales, the scale of the net employed and a presumed movement scale. Both scales demonstrated the importance of depth and proximity to a previously underappreciated ecotone in the profundal zone. Based on model selection, both depth and a substrate ecotone (the gradient between softness-hardness) best described occupancy of lake whitefish in Lake Opeongo. Lake whitefish occupied deeper water in Smoke Lake and did not show an adherence to the substrate ecotone. Diurnal behaviour appeared to be important in the detection process with morning activity leading to greater detection than afternoon activity. This multi-pass approach demonstrated spatial structure in lake whitefish habitat selection. It also revealed the importance of a little known but key habitat feature – the E2 ecotone. This feature aligns with internal wave structure of the thermocline and appears where the thermocline contacts the lake substrate. The role of this ecotone as fish habitat was unrecognized prior to this study but may have important implications for other benthivorous fish in Canadian Shield lakes.

HAVE WE UNDERESTIMATED THE AGE OF THE WORLD'S LARGEST PREDATORY FISH?

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Incorrect age estimates have previously led to mismanagement of fisheries with devastating consequences. For the white shark (*Carcharodon carcharias*), current age estimates derived using standard X-radiography (X-ray) are inconclusive and have not been validated. We used two methods to attempt to verify and validate the X-ray determined ages. Firstly, we used femtosecond laser ablation inductively coupled plasma mass spectrometry (fs-LA-ICP-MS) to determine the calcium (Ca) concentrations across the vertebral centra of 58 South African white sharks. A statistically unbiased estimate of the number of Ca peaks (i.e. age) was derived using a modified standard peak-finding algorithm and compared to traditional X-ray reader counts. Secondly, we used bomb radiocarbon analysis of 8 samples from four individuals in an attempt to validate the age estimates. Ages determined by X-ray analysis were the youngest of the three methods, with the fastest growth rates and earliest ages at maturity. The Ca peak age estimates were the oldest and had the slowest growth rates with the oldest ages at maturity, while the results from the bomb radiocarbon analysis indicated ages and growth rates were between these two methods. While age estimates obtained from the validation and verification techniques did not agree, both methods indicated that ages determined by X-ray analysis were underestimated. As white sharks are listed as vulnerable on the International Union for Conservation of Nature's Red List and on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora based on current X-ray determined age estimates it is likely that these designations will need to be reevaluated based on older age estimates.

WHO IS MINDING THE ANEMONE? GENDER AND SPECIES COMPARISONS OF TERRITORIAL BEHAVIOR IN TWO SYMPATRIC ANEMONEFISH SPECIES (*AMPHIPRION CLARKII* AND *A. PERIDERAION*)

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Recent studies have characterized social structure and dominance hierarchies in anemonefish species; anemonefish groups typically consist of a breeding pair and several subordinate juveniles. Social rank within groups is strictly controlled with the dominant female exerting top-down effects on rank and size of other group members. However, group composition, fidelity within a group, and group size may be more nuanced than what has been described thus far. We made behavioral comparisons between male and female *Amphiprion clarkii* and male and female *A. perideraion* in order to assess differences in the amount of time individuals spent with their host anemones (*Heteractis crispa*). We observed individuals of each anemonefish species for 10-min intervals from 0600-1800 to characterize 1) the amount of time individuals spent within 25 cm of their anemone, 2) the duration of each visit to an anemone, and 3) the number of anemones an individual fish regularly visited. We found significant differences in each parameter, both between sexes and between species. Overall, male and female *A. clarkii* are associated with significantly more anemones than are male or female *A. perideraion*; additionally both male and female *A. clarkii* spend significantly more time away from their anemones than do *A. perideraion*, and visits to host anemones are significantly shorter for *A. clarkii*. Within species, females visited more anemones, spent less time within anemone tentacle crowns, and traveled much greater distances than males to visit additional anemones. Research has indicated that nutrient transfer from resident fish to host anemone occurs when the partners are in close proximity, which may suggest that A. perideraion, with its "homebody behavior" may make a better partner in this mutualistic symbiosis.

DEPTH AND TEMPERATURE PREFERENCES OF THE DEEP-WATER FLATFISH, GREENLAND HALIBUT (*REINHARDTIUS HIPPOGLOSSOIDES*), IN CUMBERLAND SOUND, CANADIAN ARCTIC.

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Arctic marine fish have been under growing pressure from commercial fisheries, yet very little is known about the movement of these fish. Greenland Halibut (*Reinhardtius hippoglossoides*) is a benthic flatfish that occupy deep, cold waters and its distribution ranges to above the Arctic circle. These fish have become an important commercial resource, however its role in arctic food web is yet to be fully understood. Satellite telemetry has been shown as a particularly useful tool to track the movement of marine fauna. Subsequently, as a part of Ocean Tracking Network initiative, nine pop-off archival transmitting tags were deployed on Greenland Halibut in Cumberland Sound, Baffin Island in August 2010 for 70, 100, and 300 days, to provide better understanding of short and long term (seasonal) movements, behavioural patterns and preferred depth and temperature. All tags reported back, popping up within 27 km from the tagging site. In general, Greenland Halibut ranged between 400-1400 m and preferred deep waters >900 m especially during the open water period of the year, showing strong site fidelity to a deep water region located in the central part of the Sound. Two fish that carried tags thorough the winter both occupied shallower depths on average during ice cover season (799 ± 120 m) as oppose to open water season (1041 ± 112 m). This may be indicative of seasonal movement into shallower grounds for ice covered period, where it is indeed usually caught by fishermen in the winter but not during the summer months. Detailed time-depth records showed variability in activity levels, however these were not related to diel cycles and were not indicative of extensive pelagic behaviour. Inconsistent activity levels suggest opportunistic foraging behaviour or predator avoidance behaviour.

INFLUENCE OF MATERNALLY DERIVED AND DIETARY FATTY ACIDS ON ECOLOGICAL PERFORMANCE OF LARVAL RED DRUM (*SCIAENOPS OCELLATUS*).

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Dietary intake of certain essential fatty acids, particularly arachidonic acid (ARA) and docosahexaenoic acid (DHA) by fish larvae is known to benefit their growth, development, and survival. Additionally, correlations have been reported between concentrations of ARA and DHA in eggs and the anti-predator behavior of larvae three weeks after hatching, with the suggestion of irreversible effects caused by fatty acid deficiencies in eggs. We evaluated the combined effects of varying the supply of these fatty acids in eggs and in the larval diet on larval routine swimming and anti-predator behaviors. First, we determined the natural levels of these essential fatty acids by collecting wild red drum eggs from the tidal inlet at Port Aransas, Texas, in 2009, 2010 and 2011. Mean ARA levels in wild eggs were higher than typical levels in captive spawned red drum eggs (7.2 vs. 5.0 mg g-1 dry weight), whereas mean DHA levels were lower in wild eggs than in typical captive spawned eggs (23.7 vs. 38.5 mg g-1 dry weight). We then conducted a supplementation experiment and a depletion experiment using captive red drum broodstock with the goal of reaching wild levels of ARA and DHA in the eggs. Larvae were fed either non-enriched *Artemia* sp. nauplii or *Artemia* nauplii at one of two levels of enrichment (1x, 2x), and performance was measured after three weeks. Fish that had been fed the 2x enrichment diet consistently reacted to the predatory stimulus sooner and overall at a higher frequency, than fish in the other diet treatments. Knowing these causes of variation in larval performance may increase our understanding of mechanisms behind fish survivorship and recruitment, and suggests that corrective measures could improve the efficacy of stock-enhancement programs.

STRESSED OUT SALMON: EFFECTS OF PARENTAL STRESS ON SOCKEYE SALMON OFFSPRING

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Stress experienced by parents can have detrimental effects on offspring, the next generation of a population. Migrating Pacific salmon now experience a growing number and intensity of environmental and anthropogenic stressors. Enduring these stressors is necessary in order for individuals to reach spawning grounds and reproduce. However, exposure of migrating adults to such stressors may have resonating effects on offspring, and may also contribute to the persistent decline in wild stocks of sockeye salmon (*Oncorhynchus nerka*). Such effects have yet to be fully elucidated in sockeye, thus, we examined the transgenerational effects of stress in a coastal population of sockeye that migrate along a Fraser River tributary in British Columbia. Parent fish were intercepted 6 weeks prior to peak spawning and exposed to a physical stressor throughout the final stages of reproductive maturation. Additionally, eggs from mature females caught on spawning grounds were exposed to varying levels of cortisol during fertilization to mimic stressor-induced increases in maternal deposition of cortisol to eggs. Egg quality, embryo survival and fry swim performance were assessed for offspring sired from stressed and undisturbed parents, and eggs exposed to cortisol. Compared to undisturbed fish, females exposed to the chronic stressor had smaller eggs. Both stressed and undisturbed females had smaller eggs compared to wild spawners. Survival and offspring swim capacity results will be discussed from an ecological perspective and will be related to the biological conservation of sockeye salmon.

PHYSIOLOGICAL DRIVERS OF ADULT SALMON MIGRATION TIMING, SPEED AND SUCCESS

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Salmonid migrations represent one of the most complex and intriguing biological phenomena in the animal kingdom. We summarize advances that have been made in understanding the timing, speed and success of migrations of wild adult Pacific salmon through the integration of broad-scale telemetry systems with disciplines including physiology, behaviour, functional genomics, and experimental biology. We overview intervention experiments and telemetry field approaches used to examine these issues for adult Fraser River sockeye salmon and explore hypotheses about recent changes in salmon behaviour and mortality. Since 1995, one of the largest groups of Pacific salmon, Late-run Fraser sockeye have begun adult freshwater migrations 2-6 weeks earlier than normal and associated with this changed behaviour is extreme mortality (up to 95% in some years) of early migrants. We have found that reproductively advanced fish travel faster during coastal migrations and are less likely to hold in the estuary prior to starting their freshwater spawning migration. Osmoregulatory changes begin 800 km from natal freshwater and fish that are more 'freshwater prepared' migrate faster through coastal waters. These faster speeds may be a response to our laboratory finding that elevated levels of reproductive hormones reduces saltwater tolerance in ocean migrants. We have found that early migrating Late runs appear to be reproductively motivated for freshwater entry but are not physiologically prepared for freshwater entry. These results indicate that the genesis of the early migration phenomenon is not an adult coastal migration issue but must be

related to physiological events during ocean residency or earlier in their life history, and may be linked to a novel virus.

WEDNESDAY, JUNE 20TH

GLOBAL FRESHWATER FISHES AND ECOSYSTEM HEALTH

I CAN SEE CLEARLY NOW: INSIGHTS FROM STABLE ISOTOPIC ANALYSES TO ECOLOGICAL AND EVOLUTIONARY DYNAMICS OF HAPLOCHROMINES IN THE AFRICAN GREAT LAKES.

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The Great Lakes of Africa, Victoria, Malawi and Tanganyika, each host endemic species flocks which together account for a disproportionate share of the global diversity of freshwater fish. This diversity is overwhelmingly contained in one family, the Cichlidae, particularly within the subfamily Pseudocrenilabrinae which has several tribes in the African Great Lakes (commonly and collectively referred to as haplochromines). Haplochromines have undergone spectacular evolutionary radiation in each lake. This extensive and apparently rapid diversification has fascinated evolutionary biologists while confounding fisheries management which attempts to maintain this diversity. In each endemic flock, trophic selection pressures have been invoked to explain the evolution of functional morphologies, especially in the cranial and jaw structures, as well as evident differences in behavior allowing utilization of different habitats. Stable isotope analysis of these species-rich communities, provides clear evidence that morphologically distinct species have significantly disparate diets or feed in distinct habitats. Species-rich communities with high population densities are able to maintain isotopic distinction even among closely related species. Despite this distinction, isotopic analysis of pelagic and littoral benthic communities in Lake Tanganyika demonstrate a significant dependence of the littoral communities on pelagic food sources, except among the obligate benthic algal grazers. Cichlids are highly visual and loss of water transparency can obliterate selective feeding and breeding. Closely related sibling species can become distinct or indistinct in their isotopic composition as environmental conditions change. Increasing water transparency along a turbidity gradient in Lake Victoria allowed sibling species to become more selective in prey, feeding habitat and mate selection as waters clarify. Similarly comparison of modern haplochromine species with historic specimens from museum collections from Lake Victoria demonstrate modification of prey selection in response to changes in turbidity and light penetration as a result of the eutrophication of the lake. Evolution of species-rich haplochromine communities is most explosive and rapid in the littoral where clear water interfaces with habitat complexity to allow these fishes to exploit a broad range of trophic opportunities as well as enabling sexual selection. Maintaining clear waters is the first line of protection for the remarkable diversity of the African Great Lakes and all their trophic and behavioral innovations.

THE EFFECT OF HABITAT QUALITY ON BENTHIC MACROINVERTEBRATE COMMUNITIES AND COLONIZATION IN NEWLY FORMED CHANNELS

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Sustaining biodiversity has become an important consideration in current and future impacts on the environment, with restoration of cold water habitat developing as an important tool in the conservation of native aquatic biodiversity in Ontario. Biomonitoring surveys using benthic

macroinvertebrate communities as indicators of ecosystem health were conducted in this study to assess the impact of restoration on community structuring in heavily altered streams. Ontario Benthic Biomonitoring Network (OBBN) protocol was used to collect benthic samples from three newly watered channels designed to improve cold water habitat: a historical reach in Marden Creek (Guelph) reclaimed to bypass a tailing pond; a segment in Marden Creek (Guelph) in the process of channelization after the removal of a dam; and a new channel segment constructed to bypass a small lake and link upstream segments of Second Creek (Terra Cotta) with natural downstream reaches. These conditions not only allowed for the assessment of restoration methods, but for a study of the successional patterns and rates of colonization events of benthic macroinvertebrates in temperate streams. Benthic communities from five test sites within the new channels were compared to reference conditions in their respective watersheds using species diversity and community similarity indices. Early results have shown seasonal variability in community similarity between reference and test conditions that may be due to differences in resource availability and habitat structure. Shifts toward less sensitive taxa within and downstream of the restoration site in summer months suggest community structure is influenced by several factors including hydrology and habitat quality. Further analysis is needed to determine which variables within the environment are influencing the differences in patterns seen between test sites. Current efforts are focused on examining successional patterns of benthic macroinvertebrates in different sites and what parameters of each site are controlling initial colonization success of dominant taxa.

THE IMPACT OF HABITAT SELECTION, HABITAT STRUCTURE AND STREAM ORDER ON SPECIES DIVERSITY AT BRIDGE SITES

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Habitat selection or preference is an important behavioral component in fish in that it can influence survival, reproduction, foraging success, and assemblage structure. Here we report on variations in habitat structure at bridge sites on 1st through 4th order streams as it relates to fish assemblage structure and as a refuge for repopulating streams after periods of drought. The diminution or cessation of flow in a stream can lead to the extinction of populations of aquatic organisms over various reaches of a stream, yet can also provide an excellent opportunity for the assessment of bridge sites as potential refuges for assemblages of fishes. Surviving populations of various species of fish then provide the potential for repopulation along reaches of stream where population extinction has occurred. This study was carried out during a severe drought in South Georgia, USA. Data collected indicates that lower order stream bridge sites have greater potential to act as refuges than do higher order streams. Specifically, lower order streams possessed greater fish diversity at bridge sites compared to up and downstream assemblages while assemblage diversity at bridge sites on higher order streams was not as great compared to up and downstream assemblages and in some cases was even lower. In addition, lower order steam bridge sites often possessed greater complexity in habitat structure compared to bridge sites on higher order streams, which may have contributed to the greater differences in assemblage structure at bridge sites compared to up and downstream assemblages.

MONITORING AND ASSESSING ENVIRONMENTAL AND CUMULATIVE IMPACTS ON GREAT SLAVE LAKE FISHERY PRODUCTIVITY AND THE FISH COMMUNITY ASSOCIATION.

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Since the mid-1940s, Great Slave Lake has supported the largest freshwater fishery in the Northwest Territories, Canada. The annual commercial harvest for Lake Whitefish and Lake

Trout combined changed from over 4200 tonnes in 1948-1949 to less than 500 tonnes since 2006. Fishery production and fish communities in Great Slave Lake are virtually unstudied and thus represent a high-priority gap for monitoring and assessing cumulative impacts on aquatic living resources in the relatively oligotrophic ecosystems. A standardized multi-mesh gillnet sampling program was implemented during July-August, 2011, targeted to 1) develop a large lake sampling protocol in the NWT, 2) test the sampling efficiency of the multi-mesh gillnet, and 3) examine the feasibility of monitoring and assessing framework in the Canadian North. ANOVA showed statistically differences in length and weight of Lake Whitefish as well as major environmental variables between areas and depth strata. With respect to fish community attributes, the dominant species, Ciscoes and Lake Whitefish, contributed to >90% cumulative percentages of the fish community, were identified. Between areas IW and IE, the species-specific relative abundance (NPUE) were similar, but differed somewhat in biomass-based composition (BPUE), impacted by benthic Longnose Sucker, in particular. Multivariate analyses showed that depth strata and dissolved oxygen levels significantly influenced the species-specific biomass distribution in the benthic environment, while temperature strongly dictated spatial distribution of the cold-water fish community in the upper water columns. There may be some other abiotic variables or biological components that need to be integrated into future monitoring, but these preliminary results highlight the significance of monitoring environmental and cumulative impacts mixed with aquatic climate changes and anthropogenic activities. Within this framework, multidisciplinary factors may be monitored and assessed to ensure the sustainability of fishery production, diversity of the fish communities, and integrity of the boreal freshwater ecosystem.

OXIDATIVE STRESS AND GROWTH IN ALLIGATOR GAR (*ATRACTOSTEUS SPATULA*) EXPOSED TO ENVIRONMENTALLY RELEVANT CONCENTRATIONS OF THE AQUATIC HERBICIDE, DIQUAT.

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In Canada the threatened Spotted gar, *Lepisosteus oculatus*, inhabits just three bays of Lake Erie. One of these populations in Rondeau Bay has been exposed to annual applications of the aquatic herbicide, diquat (1,1'-ethylene-2,2'-dipyridylium), which can increase proliferation of oxygen free radicals and potentially impair growth. In summer 2010, a treated area of Rondeau Bay contained 40 · g · L-1 diquat 3 hours post-treatment, declining to 4 · g · L-1 after 24 hours. Cultured Alligator gar (*Atractosteus spatula*) were used as a surrogate Lepisosteid species to examine dose-response relationships between diquat exposure, growth and oxidative stress parameters. Juveniles (8.5g) were exposed to nominal concentrations of 0 (reference), 50, 200 or 400 · g · L-1 diquat in a static-renewal system for 7 days, followed by 6-weeks of depuration in untreated water. Neither diquat, nor its metabolites, were detected in liver, even among fish sampled immediately after the 7 day exposure. Growth rates of body mass (g · day-1), total length (cm · day-1) and liver mass (g · day 1) were not affected. Indicators of oxidative stress (tocopherol, retinoids) were not different among the treatment groups. While isoprostane concentrations were affected in the low and high diquat treatment groups, no consistent dose-response relationships were evident. Results from this experiment indicate that low, and transient, diquat concentrations in Rondeau Bay may be too low to have deleterious effects on resident Lepisosteans.

GENERAL SUBMISSIONS

NOVEL MOLECULAR PHYLOGENY OF THE LEPISOSTEIDAE AND IDENTIFICATION OF SPECIMENS OF UNKNOWN ORIGIN.

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Phylogeography, the study of the evolutionary relationships among populations or species across geographic space, allows for the inference of past events such as dispersal, colonization and isolation. In this study, we have created a phylogeny based on the mitochondrial Cytochrome Oxidase 1 (CO1) gene and the mitochondrial Cytochrome B gene for the family Lepisosteidae. CO1 and Cytochrome B sequences were generated by sequencing mitochondrial DNA for several individuals from four North American Lepisosteus species and from published sequences available for the other three species on GenBank. Multiple haplotypes of CO1 were seen for the Florida Gar (Lepisosteus platyrhincus), while only a single haplotype was found for its closest relative, the Spotted Gar (Lepisoteus oculatus). The topology of the phylogentic tree resembles that created by Grande (2010) based on morphometric characters, showing two distinct genera. The molecular based tree, however, has Shortnose Gar (Lepisosteus platostomous) closely related to Longnose Gar (Lepisosteus osseus), while Grande (2010) places the Longnose Gar closer to the clade containing Spotted and Florida Gar. Our phylogeny, the first molecular-based phylogeny for this family of large piscivorous fishes, indicates an interesting pattern of post-glacial colonization and expansion among species found within temperate zones as well as island colonization and subsequent speciation in sub-tropical and tropical regions. The analyses permit the identification of several specimens obtained through the aquarium trade and one specimen from a live food-fish market to the species level.

COMPARISON OF PHYLOGENIES CONSTRUCTED FROM CYTB, COI AND WHOLE MITOCHONDRIAL GENOME SEQUENCES TO DETERMINE WHICH IS MOST EFFECTIVE IN DISTINGUISHING TRUE TUNA SPECIES FROM RELATED SPECIES.

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The use of mitochondrial DNA gene sequences to reconstruct phylogenies is widespread; however those phylogenies are commonly based on relatively few genes. We compared phylogenies of true tunas and related species based on commonly used gene sequences (CO1, CytB) with those constructed from whole mitochondrial genome sequences to determine the most effective approach for phylogenetic resolution of species-level relationships. Sequences for six species of true tuna (*T. alalunga, T. thynnus, T. obesus, T. tonggol, T. maccoyii, T. orientalis*) and for four related species (*A. rochei, A. thazard, E. alletteratus, K. pelamis*) were obtained from NCBI-GenBank. We generated phylogenetic trees via a suite of methods (Neighbour-Joining, Maximum Likelihood, Minimum Evolution, Maximum Parsimony). Trees for CytB failed to distinguish true tuna species from the related species compared with trees for COI and whole genome sequences which adequately resolved these groups. This indicates that COI barcoding is effective in distinguishing true tuna species from related species, as are phylogenies based on whole mitochondrial genome sequences. However, a curious result for COI and the whole mitochondrial genome sequences is that the Maximum Parsimony trees failed to resolve true tuna species from related species. This result may not point to a deficiency with using mitochondrial DNA sequences to construct phylogenies but instead suggests that the assumption of parsimony in nature is not always met. From an applied perspective, our analysis highlights the potential for species misidentification in the food industry.

NICHE CONSTRUCTION THROUGH PREDATION: AN EXPERIMENTAL STUDY OF A PREDATORY REVERSAL IN A STREAM FISH

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Niche construction may follow species introductions when the introduced taxon alters the selection pressures in its new environment. Plants have been the focus of this process with relatively little attention to animals. We investigated the role of niche construction in the success of an introduction of guppies, *Poecilia reticulata,* into reaches that had contained only the killifish, *Rivulus hartii,* a known intraguild predator of guppies. We used a combination of laboratory and mesocosm experiments and field introductions in Trinidad to evaluate the predator-prey relationship between the guppy and *Rivulus.* Here we show that guppies can reverse the predator-prey relationship by preying on juvenile *Rivulus*. Laboratory studies found that mature guppies can consume hatchling *Rivulus*, and experimental stream studies found that guppies always reduced the number of *Rivulus* surviving from eggs. Growth trials also found significant resource competition between Rivulus and guppies of similar size, with *Rivulus* being the superior competitor. A field experiment, in which guppies were introduced into previously guppy-free stream sections, resulted in a reduction in abundance of immature size classes of *Rivulus* relative to no-guppy, control reaches. Together, these results indicate that guppies, by rarifying the ambient *Rivulus* population, lessen both predation on themselves and competition from similarly-sized *Rivulus*, thereby "buying time" to establish in a novel environment. We hypothesize that predation by newly introduced guppies constitutes ecological niche construction, a process, which over time, improves the realized niche of the guppy, while deteriorating the niche of *Rivulus*, and leading to selection for life history traits of both taxa.

EVOLUTION OF PARENTAL CARE IN CONVICT CICHLIDS: DIVISION OF LABOR, OFFSPRING SURVIVAL AND HORIZONTAL TRANSMISSION OF MICROBES.

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Parental care, an evolutionarily foundational form of sociality, often involves prolongered parent-offspring contact. Fishes enhance offspring survival by aerating and guarding embryos, but may also benefit offspring through horizontal transmission of beneficial microbes. This phenomenon, well-documented in birds and mammals, remains largely unexamined in fishes, but could promote the evolution of parental care. Wild convict cichlids (*Amatitlania nigrofasciata*) provide biparental care for up to six weeks and exhibit marked division of labor. We investigated whether parental specialization persisted under simplified experimental conditions, and quantified parent-offspring contact and offspring survival to four days post-hatching. We divided newly spawned broods, rearing half with parents and the other in the same aquarium, but sequestered from parental contact. To identify bacteria associated with parents and offspring, we collected samples of embryos, slime-coats of parents, and fry that did and did not receive parental care. We extracted bacterial DNA, isolated and amplified 16s rDNA using PCR, and visually differentiated among taxa using denaturing gradient gel electrophoresis (DGGE). Stained gels (SYBR Green) were photographed with UV transillumination. We compared percent survival of offspring that did and did not receive parental care (one-tailed paired-sample t-test); male and female parental behaviors (Wilcoxin sign-rank tests); and bacterial compositions of parents, offspring and aquarium water (Gel2K). We created a hierarchical cluster for each family (n = 11) using nearest-neighbor and Jaccard distance, and tested the likelihood that groupings were non-random (Chi-square Goodness-of-fit test). Percent survival was higher with parental contact, and male and female behavior differed in ways similar to parents observed in wild populations. Fry that received care bore more bacterial taxa compared to their no-care siblings, but microflora did not cluster with either parent. Though we lack definitive evidence from this study, we conclude that parent-offspring transmission of bacteria is not only possible, but likely.

FATHER OF MINE… WHERE DID YOU GO? HIGH DEGREE OF PATERNITY LOSS IN A SPECIES WITH ALTERNATIVE REPRODUCTIVE TACTICS.

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In many mating systems, males adopt alternative reproductive tactics to maximize reproductive success. Common alternative tactics are guarding versus cuckolding. In fishes, guarding males commonly invest more energy into courting females, defending nests, and providing paternal care. Cuckolding males steal fertilizations by simply releasing their sperm in the nest of a guarding male. The existence of these two tactics have been extremely well documented in the plainfin midshipman fish (*Porichthys notatus*), however, the relative reproductive success of the guarding male remains unknown. In this study, we used molecular genetic markers to determine the level of paternity assigned to the guarding males and in turn, the relative rate of cuckoldry in a population of plainfin midshipman from Southwestern British Columbia. Furthermore, we explored how paternity rates in the field varied with male phenotype and across the breeding season. We collected and genotyped fin tissues from 38 supposed fathers and 20-50 putative offspring from their nests. Our results, based on six microsatellite primers, revealed the lowest documented rates of paternity in a species with obligate paternal care. Although paternity remained consistently lower than previous studies based on other species, paternity did increase as the breeding season progressed. Male body size did not significantly predict paternity. Our findings provide an important contribution for understanding the ultimate factors underlying alternative reproductive tactics in this species, and highlight the importance of investigating reproductive success across the entire breeding season.

EFFECTS OF ANDROGENS ON PARENTAL CARE BEHAVIOUR IN MALE BLUEGILL SUNFISH.

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Research suggests that during parental care, nurturing behaviour trades-off with defensive behaviour and that this trade-off is likely mediated by androgens. This trade-off has been studied predominantly in species with biparental care, where potential detrimental effects of elevated androgens on parental care behaviours can be, and often are, compensated for by changes in behaviour of the unmanipulated parent. However, for species where only one parent provides care, and thus deficits in care cannot be compensated for, manipulation of androgen levels may more clearly demonstrate whether such a proposed trade-off between nurturing and defensive behaviour exists. Here, we manipulated androgen 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 testosterone, 11-ketotestosterone or flutamide, an androgen receptor blocker. The males were then observed over the course of several days and tested for their nurturing behaviour (fanning of the eggs, removal of dead eggs or eggs with fungus) and their aggressiveness towards a brood predator. We found that males implanted with 11-ketotestosterone displayed 64% more aggressive behaviours and 71% fewer nurturing behaviours than control groups. In contrast, males implanted with flutamide displayed 7% fewer aggressive behaviours and 126% more nurturing behaviours than controls. Meanwhile, males with experimentally elevated testosterone levels showed higher aggression, but there was no apparent reduction in nurturing behaviour. Taken together, these results suggest that even in a uniparental care system, aggression and nurturing behaviours do trade-off during parental care and this trade-off is likely mediated by androgens. We conclude by discussing the potential mechanism that mediates such a trade-off.

THE IMPACT OF COLOR ON EGG LAYING RATES AND OUTCROSSING OF *KRYPTOLEBIAS MARMORATUS.*

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Kryptolebias marmoratus participates in a reproductive system involving androdioecy in which populations are composed of hermaphrodites and males where self-fertilization or outcrossing can occur. As result of self-fertilization, it is possible to develop nearly 100% homozygous strains or reestablish heterozygosity via outcrossing between a hermaphrodite and a male. Because these fish are widely used in many aspects of research, the need for eggs is great. This research examines background color and its relationship to movement patterns, egg laying and outcrossing. Prior to beginning this research, lag time, a measure of boldness, was conducted on untested strains to determine position on a shy/bold continuum. From this, five strains (R2, HON 7, SSRHL, SLC8E, and VOL) were selected to cover differing geographical origins and levels of shyness and boldness. All five strains have been tested for activity and movements as a function of color preference. Movement rates parallel the shy/bold order previously established as well as geographic regions. Color preference tests showed black was most preferred and white least preferred. Egg production as a function of black and white backgrounds revealed a daily cyclical pattern of egg laying with sudden bursts of egg laying upon changing background color. Preliminary genetic analyses using a highly variable microsatellite marker has not demonstrated an increased level of outcrossing beyond that reported in previous studies.

ANNUAL DEPTH AND TEMPERATURE SELECTION BY WARM AND COOLWATER FISHES IN TORONTO HARBOUR.

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Coastal wetlands represent important habitats for warmwater fishes in the Laurentian Great Lakes. Restoration efforts here seek to improve habitat conditions for key native species, but are often focused on spawning and nursery habitats. Differences in habitat selection across seasons are poorly understood, particularly for winter. Our objective was to track seasonal depth and temperature selection by key freshwater fish species in Toronto Harbour, a heavily modified coastal embayment where extensive restoration efforts are ongoing. We used acoustic telemetry to monitor habitat selection for two top predators, largemouth bass (*Micropterus salmoides*) and northern pike (*Esox lucius*), and for common carp (*Cyprinus Carpio*), a nonative species comprising >50% of the harbour's fish biomass. All species demonstrated shifts in depth selection with changes in temperature. Bass depths were relatively constant in summer (~1 m) and winter (~2 m), but were more variable in spring and fall. Bass explored deeper waters in fall, when depth selection was most variable. Carp also occupied shallow depths in summer but, in contrast to other species, were found in deepest depths in fall and early winter, then moved shallower mid-winter. Pike were found in the deepest waters in winter (~5 m) and displayed highly variable depth selection in spring and fall. Results will inform habitat creation efforts and timing windows for spring construction activities.

MIGRATION AS A FUNCTION OF AIRBREATHING IN A NEWLY DISCOVERED GALAXIID FISH.

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Amphibious air-breathing fish utilize atmospheric oxygen during periods of aerial exposure and may be able to survive without surface water. One such fish is the newly discovered *Galaxias* 'nebula' from South Africa. Previous work has established that *G.* 'nebula' shows behavioural adaptations, and undergoes progressive physiological changes, in response to emersion. However, little is known about the function of airbreathing. In this study I investigated one potential function, migration, in a series of experiments using specially constructed raceways. In two experiments in which fish were provided with alternative pools, up to 50% of individuals voluntarily left their home pool suggesting airbreathing has functions other than simply survival. In addition, of the fish that moved, 47% reached the alternative pool and a further 7% were found on a straight line between the two pools, suggesting these fish have the ability to detect and locate alternative water sources. However, neither fish density nor the relative size of individuals significantly affected the potential for movement or the distance moved suggesting factors such as aggressive defence of a home territory do not play a role in this species. A third experiment demonstrated that medium sized fish spend significantly more time moving towards water and perform more leaps in the direction of water than either smaller or larger individuals. As these medium sized fish are assumed to be older juveniles or young adults that may be more likely to disperse than older or younger fish, a migration function for airbreathing in this species is feasible. This may be a factor in the distribution of this fish, which has the largest range of the South African galaxiids, and may also increase their survival potential under increasing threat from introduced alien species and habitat destruction.

USING ICHTHYOPLANKTON SURVEYS TO ASSESS FISH HABITAT IN THE ST. CLAIR-DETROIT RIVER CORRIDOR.

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Historically, 32 fish species spawned within the St. Clair-Detroit River (SCDR) corridor; however increased habitat loss due to dredging, industrialization, and urbanization throughout the corridor resulted in substantial losses of functional spawning and nursery habitat. As a result, the fisheries production in the corridor decreased. Recent habitat restoration initiatives have replaced spawning substrates at some locations in the SCDR and several native species have responded positively. Species returning to spawn or exhibiting increased spawning activity in the SCDR include lake sturgeon, lake whitefish, walleye, and yellow perch. We examined larval fish drift data from 2006-2011 and evaluated trends and patterns of larval drift in the main channels of the SCDR corridor that demonstrate increases in native fish production. Overall composition was variable across months, reflecting the number of species (38 species classifications identified in the 6 years) using the corridor. The St. Clair River had substantially fewer larvae and showed different temporal patterns in species composition compared to the Detroit River sites during 2010-2011. Samples from both rivers demonstrated downstream drift from Lake Huron to Lake Erie. The composition and magnitude of larval fishes collected from the SCDR during our study (2006-2011) differed dramatically from previous collections made during 1977-78 and 1983-84 in that the contemporary study shows more evidence of successful native fish spawning and production in the Corridor and the early collections contained more Lake Huron transients. Overall, ichthyoplankton surveys in this Great Lakes connecting channel revealed unique insight about the level of habitat use by larval fishes in the corridor as well as transients drifting between Lakes Huron and Erie.

LINKS BETWEEN POLYCHLORINATED BIPHENYLS, ENDOCRINE FUNCTION, AND SPERM TRAITS IN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) FROM LAKE ONTARIO.

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Environmental contamination has been associated with declines in reproductive success across several taxa. These declines have been linked to underlying changes in mating behavior, genetic quality, metabolic function, endocrine function, and gamete development. Chinook salmon (*Oncorhynchus tshawytscha*) exhibit a semelparous reproductive life-history strategy, a strategy that has received little attention with respect to environmental contaminants. In land-locked populations, such as those in Lake Ontario, adult hooknose Chinook salmon take part in an upstream migration from the lake, arriving in their natal streams to spawn and subsequently die. This migration is a critical period for gamete development and maturation to maximize reproductive success during their only opportunity to spawn throughout their life. A byproduct of this migration and development of reproductive traits is the high degree of energy loss and mobilization of fat stores. From a toxicological perspective, hydrophobic contaminants in the fat stores of the migrating fish will, in theory, magnify and could have negative effects on endocrine function and gamete development. We used a population of Chinook salmon from Lake Ontario to investigate whether polychlorinated biphenyl (PCB) exposure is linked to declines in reproductive hormone concentrations and ultimately sperm quality metrics linked to fertilization success. Preliminary results suggest significant negative relationships between sum PCB concentrations and 11-ketotestosterone but not sperm quality metrics, suggesting any potential links between sum PCB concentrations and reproductive success are not associated with sperm quality. Our research is one of few studies examining mechanistic relationships between environmental contaminants on sperm quality and endocrine function using wild individuals.

RESTORING FISH SPAWNING HABITAT IN THE GREAT LAKES CONNECTING CHANNELS

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The international rivers connecting lakes Huron and Erie have been greatly altered over the last 150 years, resulting in beneficial use impairments. Much of the Detroit and St. Clair River channels have been blasted, dredged and straightened to accommodate large freighters. This process removed or covered rocky areas that once were fish spawning grounds. Despite these habitat losses, the connecting channels remain the largest free flowing rivers in the Great Lakes basin and some fish continue to migrate into these rivers to spawn, including lake sturgeon which is threatened in Ontario, Michigan and other Great Lakes states. Over the past 10 years, a broad coalition of organizations has constructed two rock-rubble, fish spawning reefs near Belle Isle and Fighting Island in the Detroit River. Extensive sampling of adult fish using the reefs, fish egg deposition and larval fish dispersal revealed that fish use of the constructed spawning habitat was almost immediate. Fourteen species of native fish, including lake sturgeon, lake whitefish and walleye, have spawned on the new reefs. These positive results have helped project partners secure funding to construct additional fish spawning reefs in the St. Clair River. Differences between the two existing reef projects have been examined, including fish preferences for different rock substrates and the impact of water velocity on fish use of the spawning habitat. Post construction assessments have led to several reef placement and design innovations that are being incorporated into upcoming fish habitat construction projects. One on-going challenge is to help residents in southeast Michigan understand the habitat degradation and remarkable diversity that lies beneath the water surface of the connecting

channels. Michigan Sea Grant has found that the recovery of lake sturgeon in these channels is a powerful story that helps people connect with the rich aquatic life in the Great Lakes.

EFFECTS OF TEMPERATURE ON SEXUAL DEVELOPMENT IN STEELHEAD TROUT (ONCORHYNCHUS MYKISS): AN UNSEEN THREAT FROM CLIMATE CHANGE.

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Steelhead trout (*Oncorhynchus mykiss*), like many other teleosts, are gonochores so their sex is genetically determined. We studied the effect of rearing temperature on development and sexual differentiation of steelhead trout. We tested the effects of source of fish (hatchery vs wild parents), individual males and females (single pair matings), rearing temperature (ambient, chilled, heated) and age (ontogeny) on sexual differentiation. We tested the hypothesis that differences in water temperature during embryonic development will significantly alter gene expression by changing growth rate, and sexual differentiation of individual fish. We predicted that temperatures above or below ambient conditions typical for the species during development will up- or down-regulate aromatase activity, and hence produce individuals whose phenotypic sex is changed from their genotypic sex. Our results agree with our predictions. At elevated temperatures genotypic females are more likely to develop as phenotypic males and at chilled temperatures genotypic males are more likely to develop as phenotypic females. Also, the somatic growth and differentiation of individual fish are differentially affected by rearing temperature. Theoretical models predict that climate warming will increasingly tend to masculinize salmon and steelhead, and drive the Y chromosome and male genotype to extinction.

THURSDAY, JUNE 21ST

GENETIC QUALITY AND THE CONSERVATION OF FISHES

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Each year millions of fish are caught and used for conservation breeding programs that attempt to augment natural populations that are threatened with extinction. These programs typically mate individuals haphazardly and as such they overlook the importance of genetic quality (comprising both good and compatible genes) arising from sexual selection to offspring fitness and ultimately to ensuring population health. Here, I will review the literature and draw on my lab's data from studies of Chinook salmon (*Oncorhynchus tshawytscha*) and Atlantic salmon (*Salmo salar*) to discuss (1) what is genetic quality in the context of natural and sexual selection, (2) what are the recognition mechanisms for genetic quality, (3) how to assay genetic quality using quantitative genetic tools, (4) what are the current strategies used in conservation breeding programs and (5) how to potentially improve conservation breeding programs through the incorporation of knowledge gleaned from sexual selection occurring in wild populations. Overall, I will argue that instead of the current paradigm of maintaining as much genetic diversity as possible, we need a more comprehensive approach combining both genetic diversity and genetic quality to effectively enhance targeted species and populations (via captive breeding, supportive breeding and translocations programs) in order to mitigate enduring wild-population declines.

POPULATION DIFFERENTIATION OF ONTARIO LAKE TROUT (SALVELINUS NAMAYCUSH) USING THE MAJOR HISTOCOMPATIBILITY COMPLEX CLASS II BETA GENE.

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The lake trout (Salvelinus namaycush) is a coldwater salmonid with an extensive native distribution across formerly glaciated regions of North America. Lake trout are known to be a glacial 'relict' species and evolved as a result of glaciation events during the Pleistocene era. Prior genetic studies of lake trout have used multiple neutral genetic marker systems including allozymes, microsatellites and mitochondrial DNA (mtDNA) to distinguish multiple glacial refugia and phylogeographic lineages within North America. The aim of this project is to differentiate lake trout populations within Ontario using a non-neutral marker, the major histocompatibility (MH) class II beta gene. MH genes are the most highly polymorphic nuclear genes known and class II genes present extracellular pathogens to helper T cells as part of the immune response system. Native, mixed ancestry and hatchery lake trout populations across Ontario will be characterized for MH diversity and allelic states to assess their diversity and divergence. From this, a geographic map of MH structure and diversity will be generated and compared to previous studies that relied on neutral markers. The introgression of MH class II beta alleles within the mixed-ancestry populations and the significance of adaptive genetic diversity within and among populations from different histories will also be investigated.

Local Adaptation to Pathogens and Variation in the Major Histocompatibility Genes of Arctic charr (Salvelinus alpinus) across a Latitudinal Gradient

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Arctic charr occupy a diverse range of ecosystems across a large latitudinal gradient with the Canadian Arctic and sub-Arctic. Differences between the ecosystems provide the opportunity for the development of biological differences among population to arise, due to local adaptation. Selection at the immune level can occur rapidly, through local adaptation to pathogens such as bacterial communities and parasite loads that differ between ecosystems. We use variation in the Class II Major Histocompatability (MH) genes, which are responsible for mounting an immune response to combat these pathogens as a measure of local adaptation through immunogenetic selection in order to test the hypothesis that variation in the level of diversity in MH genotypes among groups of arctic charr is associated with differences in pathogen load across a latitudinal gradient. Correlations between the MH genotypes and both the intensity of the bacterial community and the parasite load were measured to determine if higher levels of variation observed in the MH genes were correlated with increased selection pressure due to pathogen exposure. In order to differentiate the effects of differences in the level of genetic diversity overall from pathogen-mediated selection, genotypes of fish from each site were analyzed using eighteen polymorphic microsatellite loci (which are relatively neutral) and compared to the patterns of overall genetic variation observed in the MH genotypes (which are under selection). Our results provide valuable insight into the relationship between local pathogen-mediated adaptation and immunogenetic selection in different populations of Arctic charr. These results enable a better understanding of evolutionary processes through which populations could adapt to novel changes in their environment. They will also provide baseline data for use in determining how specific Arctic charr populations may respond to future changes in climate.

FARMED AND WILD CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA) COMPETING IN SEMI-NATURAL SPAWNING CHANNELS.

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The domestication of salmonids often leads to genetic changes at the population level. As farmed populations diverge from their wild counterparts, a serious concern for conservation is the potential impacts that escaped salmon can have on the wild population if hybridization between wild and farmed salmon occurs. Hybridization can result in outbreeding depression through the disruption of locally adapted gene complexes thus having negative impacts on the fitness of the wild salmon population. However, the hybridization of wild and escaped farm salmon will depend on various factors, including the ability of the farmed fish to escape and survive, and then successfully compete for mates on spawning grounds. As a result of domestication, we would predict that farmed salmon would experience a reduction in reproductive success relative to wild salmon. Using semi-natural spawning channels, we compared the relative reproductive success of wild and farmed male Chinook salmon (*Oncorhynchus tshawytscha*) competing for mates. We determined offspring parentage using microsatellite genetic markers to examine the relative fertilization and reproductive success of wild and farmed males. We compared parentage at the egg and fry stage to examine the change in paternity proportions that occurs between these stages, as well as how sexual selection drives egg fertilization success and how natural selection operates on offspring survival to the fry stage. We assessed the risk posed by escaped farmed salmon on the wild salmon population, with respect to spawning interactions. The outcome of these reproductive interactions can provide valuable information for the conservation of this salmon species.

THE EFFECTS OF INBREEDING ON SPERM QUALITY IN LAKE TROUT.

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The effects of inbreeding on fitness-related traits such as survival and reproductive success have been well documented in both wild and captive populations. More recently however, inbreeding has been shown to affect fitness in cryptic ways, including negative effects on sperm quality. The majority of research investigating the consequences of inbreeding on sperm quality has focused on mammals, yet not much has been done on other taxa. Our research focuses on the effects of inbreeding on sperm quality in a captively bred fish species: the Lake trout, *Salvelinus namaycush*. In 2003, in-vitro fertilization techniques were used to create males with four levels of inbreeding (unrelated, maternal half sibs, paternal half sibs, and full sibs). In 2009, 2010 and 2011, we collected sperm from sexually matured males of the population. We then used video recordings of activated sperm and a computer-assisted sperm analysis (CASA) system, to measure sperm velocity, motility, linearity, longevity, and density for each male. Results show no significant effect of inbreeding on sperm traits throughout three years. These results may be attributed to a possible purging event, lack of selective pressure in a captive environment or lack of an effect of inbreeding depression on male reproduction. Overall, our study provides evidence that not all inbreeding leads to inbreeding depression in fitness-related traits.

CANDIDATE SELECTION FOR RESTORING EXTIRPATED POPULATIONS

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Globally, native biodiversity has declined because of human impacts resulting in the extirpation (local extinction) of several populations. Recent habitat revitalization efforts may have restored the environment to a state suitable for population reintroduction. An important question in conservation biology is how to identify appropriate candidate populations for the restoration of extirpated populations. Candidate selection is generally done to match the genetic similarity (genetic matching) between the candidate and extirpated populations. However, a genetic match may no longer be suitable if the environment has changed substantially in ways that did not lead to the initial extirpation, or the environment is projected to change substantially due to global climate change. Another approach for candidate selection is to match the local environments (environment matching) between the candidate and extirpated populations. While genetic matching and environment matching are not mutually exclusive concepts, it is predicted that populations that are an environment match (to the new or projected conditions) may have a higher likelihood of restoration than populations that are a genetic match. Here, we present the theories and supporting case studies of genetic and environment matching. We will discuss the use of genetic markers for identifying populations for genetic and environment matching and discuss the identification of important environment features for environment matching. We highlight that there should be more studies comparing the performance of candidate populations, identifying appropriate genetic markers, and identifying important environment features for environment matching.

OUTMIGRATION AND THERMAL ECOLOGY OF ADULT WALLEYE FROM THE TITTABAWASSEE RIVER.

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Walleye (*Sander Vitreus*) is an important commercial and recreational fish in Saginaw Bay, Lake Huron. Walleye spawning in the Tittabawassee River, tributary to Saginaw Bay, represent the largest spawning stock of walleye in Lake Huron. Understanding walleye movement and thermal ecology will help better define the scope and timing of movement of segments of this stock. This study will determine the association of sex, size and age on walleye movement and thermal habitat after they spawn. The Great Lakes Acoustic Telemetry Observing System is

being used to track 200 walleye from the Tittabawassee River. Walleye were tagged between March 28 and April 4 2011 through coelomic implantation of acoustic transmitters equipped with temperature loggers. Specific objectives are to determine the timing of outmigration from both the river and Saginaw Bay relative to fish sex, age and size. In addition, data from temperature loggers recovered from tagged fish will enable us to evaluate the thermal experience of fish relative to sex. This presentation will provide information about the first year of outmigration telemetry data as well as an overview of findings related to thermal biology of walleye.

INBREEDING DEPRESSION IN CHINOOK SALMON: GROWTH AND SURVIVAL VARIATION AMONG OFFSPRING FROM HERMAPHRODITE SELF-CROSSED AND OUT-CROSSED MATING

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There is theoretical and empirical evidence that inbreeding is maladaptive and can lead to detrimental effects at the level of the organism and population. Since inbreeding acts to decrease heterozygosity and increase genetic load, the effects of inbreeding fundamentally erode population viability. In Pacific salmon, recurring population bottlenecks and philopatry should lead to high levels of inbreeding, but also purging of recessive deleterious alleles. Curiously, efforts to measure inbreeding depression in salmon show few or no effects. We thus expected inbreeding depression to be subtle in our study species, Chinook salmon (Oncorhynchus tshawytscha). We explored inbreeding depression in Chinook salmon using extreme levels of inbreeding: we bred self-crossed families using hermaphrodite salmon generated by hormonal manipulation of the developing embryos. We used the male and female gametes from each of two viable hermaphrodite salmon ("H") and four normal ("N") male and female salmon to create three types of crosses: 1) self-crosses (HxH), 2) normal by hermaphrodite reciprocal crosses (NxH and HxN), and 3) normal crosses (NxN). We compared survival and body size over a 2 year period between the HxH and NxN offspring to detect possible inbreeding depression effects. For traits where we found a difference, we further compared the reciprocal crosses (HxN & NxH) with the HxH offspring to evaluate the potential for hermaphrodite gamete quality affect performance. We found very pronounced inbreeding depression effects on both survival and growth; however, those effects were mostly observed later in the seawater life stages. Although the level of inbreeding used in this study was very high, it is comparable to levels expected for small isolated salmon populations. Our results highlight the need to consider inbreeding effects for conservation and management purposes. Our data also shed light on the evolutionary nature of inbreeding depression and the mechanisms of deleterious allele purging.

BORN TO BE WILD: CAN WE PRODUCE ARTIFICIALLY REARED FISH WITH A WILD PHENOTYPE?

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We must understand how migration and survival relate to the conditions juvenile spring

Chinook salmon (Oncorhynchus tshawytscha) experience during their downstream passage through hydroelectric projects to evaluate passage improvement efforts. Hatchery-origin fish must be used to accommodate the large sample sizes required for robust tagging studies. However, differences in morphology, behavior, and physiology between hatchery-origin and wild juveniles could confound estimates of dam passage efficiencies and survival of naturally reared salmonids. We are using existing data on the growth rates, phenotypic variation and the environmental conditions that naturally reared spring Chinook experience in the Upper Willamette Basin to develop appropriate rearing tactics for producing hatchery-origin juveniles that more closely resemble the migratory phenotypes and fitness of their wild counterparts. We are testing predictions from our initial hypotheses by evaluating the effects of temperature, rearing density, spatial relationships, diet formulation, food delivery, substrate type, and habitat complexity on the development of hatchery spring Chinook. We are assessing their body condition, growth and development as well as the behavioral traits associated with migratory activity. We are testing predictions from 12 hypotheses with 46 different groups of fish replicated among 20 treatments, including fish designated for release, at the Fish Performance and Genetics Laboratory and the Oregon Hatchery Research Center with two brood years of Chinook. The former facility is also rearing 1,000's of fish to be made available for telemetry studies with fish scheduled to be released in the spring and fall of this and next year as yearlings. In addition, rearing options will be made available for 100's of thousands of fish being raised at Willamette Hatchery scheduled for release this spring as sub-yearlings Our study will determine the feasibility of producing wild spring Chinook surrogates for use in field studies that require large numbers of fish for this ESA-listed species.

POSTER ABSTRACTS

Session 1: Pheromones, Sensory Ecology & Behaviour of Fishes

ARE RHEOTACTIC BEHAVIORS ENHANCED IN SCHOOLING FISH?

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When placed in flow, many species of fish tend to exhibit an upstream orientation (positive rheotaxis), a behavior well-documented in solitary and groups of non-schooling fish. To investigate the rheotactic behavior of schooling fish in flow, the giant danio (D. aequipinnatus), a strongly-schooling, rheophilic species, was tested in groups of 1, 2, and 8 individuals at 7 flow speeds ranging from 0-1 BL/s (3 cm/s). Groups of 8 fish exhibited significant positive rheotaxis ($p < .05$) whereas groups of 2 and solitary fish failed to do so, indicating that social isolation alone cannot account for these differences. While school cohesion has been shown to deteriorate in the absence of vision, rheotaxis is highly multisensory and persists in total darkness. It was therefore possible to disrupt school cohesion by testing in the dark without disrupting rheotaxis. For this experiment, schools of 8 fish and solitary fish were tested in no-flow, slow-flow (< 1 BL/s or 2.8 cm/s) and fast-flow (2 BL/s or 7 cm/s), in both the light and the dark. Significant differences in rheotaxis between solitary fish and groups of 8 were only seen in the slow-flow condition in the light. These results suggest that enhanced rheotaxis in groups of 8 depends on visually enabled school cohesion, which results in a lower threshold for rheotaxis compared to solitary fish. Finally, to rule out the possibility that solitary fish simply take longer to acclimate to flow conditions, solitary fish were placed in the slow flow condition (that producing the maximum group effect) for an hour and compared against a no-flow control. No significant increase in upstream orientation was observed over the duration of the experiment. Overall, this study provides insights into the way in which schools of fish may enhance detection and behavioral response to flow.

METHYLTESTOSTERONE-INDUCED CHANGES IN OLFACTION AND ANDROGEN RECEPTOR EXPRESSION IN THE OLFACTORY ORGANS OF ZEBRAFISH (*DANIO RERIO*).

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Steroid-induced central neural effects that influence olfactory sensitivity, sex partner preferences, and chemoinvestigative behaviours are well known in vertebrates. However, with the data currently available, it is difficult to speculate on which specific component(s) of the neural pathway that processes olfactory signals are targeted for differentiation by steroid hormones in the developing nervous system. We used juvenile of a cyprinid fish, the zebrafish (*Danio rerio*) to investigate the effects of 17□-methyltestosterone (MT; 10-8 M) or ethanol vehicle (control) on both electro-olfactogram (EOG) recording and behavioural assays in order to determine if androgens enhance pheromone detection and male sex behaviours. MT treatment increased both the magnitudes and sensitivities of EOG response to F2 prostaglandins, which function as female sex pheromones in cyprinid fishes. Further, MT-treated juvenile zebrafish performed more courtship behaviors (nuzzling and quivering) with a PGF2□ –treated stimulus fish than did control juveniles, showing that MT induced a functional response to pheromonal prostaglandin. Lastly, to assess the olfactory targets of androgens, thus linking androgen treatment with changes in olfaction, we examined androgen receptor transcription levels as an indicator of protein expression in the olfactory bulb and olfactory epithelium using RNA extraction, quantification and reverse transcriptase PCR. Overall, the results of these experiments indicate that androgen treatment induces increases in olfactory responsiveness to pheromonal prostaglandins and may also lead to increases in androgen receptor expression in the olfactory bulb and epithelium.

OLFACTORY IMPRINTING IN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) AND STEELHEAD (*O. MYKISS*) EMBRYOS.

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Adult Pacific salmon use chemical cues to return to selected locations in freshwater rivers or streams to spawn, from chemical imprinting as juvenile smolts. If they would imprint on the chemical features of their water during earlier embryonic development, the procedure of artificially imprinting hatchery salmon will be much more feasible from a technical and management perspective. We tested Chinook salmon and steelhead trout reared in one of three water sources: Fall Creek, Carnes Creek, or well water. Carnes Creek is a first-order tributary to Fall Creek, well water comes from an underground source. We tested all fish against all possible water sources, in pair-wise combinations, with 30 trials for each (to control for water position - two arms of the Y- maze), in groups (10 fish) for each trial. Each fish was tested once, as soon as possible after yolk depletion. Fish were tested in Plexiglas Y-maze tanks in the dark to minimize any visual cues. Fish from each treatment were placed in the downstream end of the maze and allowed to acclimate for 5 minutes. Then fish were allowed to swim freely within the maze for a 30-minute trial. At the end of each trial, we recorded the location of each fish and designated odor choice as the odor arm with the most fish at the end of the trial. Preference for an odor was assessed by chi-square contingency analysis using each trial as a data point. All fish preferred Fall Creek or Carnes Creek water compared to well water, regardless of their rearing water, suggesting an intrinsic attraction of "surface" water, compared to well water. Fish responded equally to Fall Creek or Carnes Creek water, suggesting they have similar chemical signals. We discuss the implications for rearing water sources and imprinting for hatchery and wild salmon.

PREDATION RISK AND BEHAVIORAL CONSISTENCY IN WESTERN MOSQUITOFISH (*GAMBUSIA AFFINIS*).

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Predation is a ubiquitous and strong evolutionary pressure and many studies have demonstrated distinct individual responses that may result from exposure to predation. Because making mistakes in high predation environments is especially costly, selection may favor individual consistency of behavioral traits that have high fitness "success". Here, we tested behavioral repeatability across different predation contexts and predicted that individuals in high risk environments would behave more consistently (that is, exhibit similar behavioral trait values over time) than would individuals in low risk environments. We tested whether the consistency of several behavioral traits (sociality, exploration and boldness) varied with respect to the perceived predation risk of an environment in Western mosquitofish (*Gambusia affinis*) by comparing the repeatability of behavior for fish observed in tanks that were densely and sparsely planted with artificial plants. Preliminary data indicates that fish perceived their risk of predation to be higher in sparsely planted tanks. Here we will present how the repeatability of these behavioral traits varies with respect to differences in predation regime.

INVESTIGATING THE POTENTIAL OF USING ODOUR-BASED TRAPPING STRATEGIES TO REDUCE INVASIVE ROUND GOBY (*NEOGOBIUS MELANOSTOMUS*) POPULATIONS: VIABILITY OF MITIGATING BEHAVIOURAL DISTURBANCE OF NON-TARGET SPECIES.

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The olfactory system of fishes facilitates innate chemosensory communication and influences reproductive, migratory, predator avoidance and feeding behaviours. Aside from environmental cues, such as amino acids and bile acids that can serve as feeding cues, fishes are attuned to chemical cues released by both conspecifics and heterospecifics. Pheromone trapping is an increasingly viable strategy to reduce invasive fish populations, largely due to the pheromones' function of evoking behavioural responses among conspecifics. Prior to attempting such population control techniques, the pheromones must be identified and their possible influence on non-target species addressed. The round goby (*Neogobius melanostomus*) is a species invasive to the Great Lakes region. Steroids released by reproductive male round gobies (3□-hydroxy-5□-androstane-11,17-dione (11-O-ETIO) and 3□-hydroxy-5□-androstane-11,17-dione 3-sulfate (11-O-ETIO-3-s)) evoke olfactory sensory responses among conspecifics and have been identified as putative pheromones. We investigated whether the olfactory system of alternative perciform species sharing the same ecosystem as round gobies in the Great Lakes region respond to the putative pheromones. Rock bass (*Ambloplites rupestris*), bluegill sunfish (*Lepomis macrochirus*), pumpkinseed sunfish (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), and yellow perch (*Perca flavescens*) were targets of an electro-olfactogram experiment designed to record changes in the summed generator potential within the exposed olfactory epithelium in response to odours. The olfactory epithelium was exposed to water until odours representing amino acids, bile acids, putative round goby pheromones, and control solutions were introduced. We found that although fishes within this order responded to amino acids and bile acids, only round gobies responded to the putative pheromones. This study provides support for a pheromone trapping trial to be conducted in the field without adversely affecting the olfactory activity of non-target fish populations in the area.

Session 2: Invasive fishes

MALE ROUND GOBY REPRODUCTIVE STATUS DETERMINATION BY NON-INVASIVE MEASURES.

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To date, attempts to confidently determine the reproductive status of a male round goby (*Neogobius melanostomus*), an invasive fish species, have typically involved dissection to determine the gonadsomatic index (GSI). The GSI (gonad mass/somatic mass x 100%) is a common measure of reproductive status in fishes. Although reproductive (parental) males are typically black, not all black males are reproductive. We measured several morphological traits, including surface area of each fin (first & second dorsal , right pectoral, fused pelvic , anal and caudal) head width, and total length as well as GSI from male round goby collected from Kingsville and Erieau, Ontario in summer 2011. Using discriminate function analysis (DFA), we determine which of the suite of measures best delineated two groups of males defined by GSI (GSI of reproductive males were > 1; and, GSI of non-reproductive males were <1). Results of the DFA showed that the surface are of the first dorsal fin best delineated the two groups of males. The surface area of this fin was significantly larger for reproductive than non-reproductive males for any given measure of total length (ANCOVA, $P<0.001$). This easily measured variable (surface area of the first dorsal fin) to total body length is a good predictor of reproductive status in round goby males. The ability to easily identify reproductive males from field collections will facilitate numerous breeding experiments used to develop management techniques for this invasive species.

Session 3: Global Freshwater Fishes and Ecosystem Health

FACTORS CONTROLLING THE SELECTION OF VEGETATED BLACKWATER HABITATS BY FISH.

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Habitat selection plays a pivotal role in the life and successful reproduction of an individual, and must provide suitable resources such as protection from predators, food and reproductive sites. Spatial parameters provided by the vegetation may also play a critical factor in that vegetation type and density could limit fish size and subsequently species composition. In this study, we report on the physical, chemical, and biological structure of twenty shoreline vegetated plots located in predominantly blackwater habitats found in South Georgia (USA) and how the traits associated with these plots influence fish assemblage composition. Preliminary and ongoing analyses indicate the geographic location (river basin), vegetation types and physical traits such as depth, water volume, and anthropomorphic impacts may play critical roles in fish assemblage structure and habitat selection.

SESSION 4: Genetic Quality and Conservation of Fishes

EFFECTS OF HYBRIDIZATION ON THE REINTRODUCTION OF ATLANTIC SALMON (*SALMO SALAR*).

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Atlantic salmon (*Salmo salar*) has historically been one of the most important salmonids in Lake Ontario for its role in commercial and sport fisheries and as a top predator. Although Atlantic salmon played a key role in Lake Ontario they were extirpated, partly owing to habitat loss due to human activities. Over the last two decades efforts have gone into revitalizing the lake's

habitat and studies suggest that the Lake Ontario basin is now in appropriate condition for Atlantic salmon reintroduction. Three strains (LaHave, Sebago, and Lac St. Jean) of Atlantic salmon have been approved for reintroduction into Lake Ontario. However, little is known about the viability of hybrids from crosses created between strains. Hybrids can exhibit hybrid vigour or hybrid breakdown resulting from the effects of new genes being introduced into a population. We collected gametes from eight females and eight males (4 of each sex from each strain) and performed a full-factorial breeding design producing 64 families consisting of non-hybrid and hybrid offspring. Survival metrics were measured to assess whether hybrid vigour or breakdown occurs. Results will be discussed in relation to these two outcomes.

GENETIC RESTORATION OF AURORA TROUT: RESULTS FROM CAPTIVE AND WILD TRIALS.

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Genetic restoration through translocation has been used to reverse inbreeding depression across a range of endangered taxa with varying degrees of success. Although uncontrolled trials entail some risk, using experimental breeding crosses in controlled environments can test the feasibility of genetic restoration for enhancing fitness in populations or species of conservation concern without risking outbreeding depression and irreversible genetic loss. Aurora trout (Salvelinus fontinalis timagamiensis) were extirpated from their native lakes in northeastern Ontario 50 years ago by acid rain. All contemporary aurora trout are descended from nine founding individuals collected in 1958, followed by multiple generations of hatchery rearing. With so few founders and unavoidable inbreeding in the early captive generations, inbreeding depression has been identified as a significant risk to their long term survival. We investigated the effectiveness of genetic restoration in aurora trout by monitoring the survival, comparative fitness, and maintenance of the aurora phenotype in two generations of crosses between aurora trout and brook trout. As well as tracking the comparative life history of first- and second-generation crosses under controlled hatchery conditions, aurora trout and two backcross types were marked and stocked into two inland lakes to assess their comparative survival and ecological fitness. Results from both the hatchery and wild trials showed significantly greater survival and performance of introgressed (backcross) aurora trout over pure aurora trout, with highly variable retention of the aurora trout phenotype. These results suggest that backcrossing provides an opportunity to restore the fitness of aurora trout without compromising their phenotypic and evolutionary distinctiveness.

CELLULAR RESPONSES TO STRESSORS OF FISH HEALTH.

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Fish health can be affected by a number of physical or biological environmental stressors. The overall level of environmental stress is exacerbated by anthropogenic factors (e.g., pollutants) in the wild or purely as a function of captive breeding programs (e.g., crowding, diet). Fish physiological responses to poor environments include inflammation and disease and changes in development, morphology, and growth. Elucidating the cellular responses to environmental stressors may provide a better means to assess how fish species tolerate a broad range of environmental insults. For example, post-stress cellular activities include changes in cell cycle, induction of apoptosis, oxidative stress, and an immune response. Much of the information connecting environmental and physiological stress in fish to its underlying cellular responses is fragmented within the literature or specifically focused on biomedical applications. In this study, we mined the literature and genomic databases to identify fish gene expression responses that resulted from experimental treatments which broadly represent poor environmental conditions. Our study ultimately explores the connections of gene expression patterns to known cellular functions in the context of how fish may respond to major factors that diminish the quality of their environment.

GENETIC AND SEX EFFECTS ON BRAIN MORPHOLOGY IN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*).

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The environmental rearing conditions of fish can have a significant impact on their brain morphology, both on the brain as a whole and of its individual regions. Very little research, however, has looked at genetic effects on brain morphology of fish yet genetics has the potential to affect brain morphology as much as environmental rearing conditions. For example, in medaka (Oryzias latipes) fish of different genetic strains show significantly different brain morphologies. The current study sought to further explore the area of genetic as well as sex effects on brain morphology of Chinook salmon (Oncorhynchus tshawytscha). Two genetic strains from "high performance" and "low performance" genetic lines were created and maintained by Yellow Island Aquaculture Limited. To test whether possible genetic and sex effects exist, brains from male and female adult Chinook salmon of both the high and low genetic lines were collected from mature fish and fixed in formalin. Digital photographs of each brain were taken and length, width and height measurements were collected to examine relative and absolute area and volume of each brain and of the olfactory bulb, telencephalon, optic tectum and cerebellum. Between sexes, males had a higher brain:body weight ratio, indicating a higher investment in brain size in males. Between genetic lines, low performance strains had a higher brain:body weight ratio, indicating more investment in brain mass in the low performance strains and a differential trade-off between body growth and brain growth in these two performance strains. There were no differences between individual brain areas, suggesting tradeoffs are systemic rather than due to differential allocation of brain function. Taken together these results show unintended effects of aquaculture programs emphasizing fast somatic growth and may have important implications for conservation hatcheries that may raise fish for eventual release.

Session 5: General submissions

LOG PACKING BEHAVIORS IN THE MANGROVE RIVULUS, *KRYPTOLEBIAS MARMORATUS*.

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Taylor, Turner and Davis first described log packing in *Kryptolebias marmoratus* in 2008, a behavior in which the mangrove rivulus moves into cavities and chambers inside logs and occupies them for extended time periods. Luke and Bechler subsequently provided a detailed description of behavioral interactions involving *K. marmoratus* dyads in an open water situation. This study, using an artificial log with chambers and passageways, examined the behaviors that occur when individuals enter, occupy and then leave a log as water levels fluctuate in an observation tank containing the artificial log. A total of 21 individual behaviors were observed and were composed of: (1) eleven neutral behaviors, (2) five aggressive behaviors, and (3) five submissive behaviors. All neutral behaviors involved single fish that were either entering or leaving the log or adjusting position within the log. Agonistic behaviors (aggressive and submissive) involved two or more fish with the majority of the behaviors involving various means by which one fish moved via different mechanisms in order to secure a position in the log or avoid contact with another fish. A primary factor contributing to the diversity of behaviors was the presence or absence of water which required that fish move and interact with each other in different ways depending on the hydrologic conditions present at the time.

EVALUATION OF THE SPATIAL CRITERIA USED IN THE CONSERVATION RISK ASSESSMENTS OF FRESHWATER TAXA.

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The spatial criteria used by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) are adopted from the IUCN Red List procedure, including the measures of Extent of Occurrence (EO), Area of Occupancy (AO) and numbers of locations. Originally recommended for large terrestrial vertebrates, these criteria and their threshold values have been questioned for their applicability on species living in linear habitats, such as stream species. Using the standard method, EO may include broad areas of terrestrial habitat that are unsuitable for freshwater species. For AO, COSEWIC recommends using of 2km x 2km grids whereas most streams in Canada are 100m or less in width, which may result in overestimation of AO. The lack of explicit methods to identify locations also results in greater uncertainty for some species. We compiled the COSEWIC assessments for all listed freshwater fish (131) and mollusk taxa (22) and confirmed the frequent use of these spatial parameters in determining conservation status of freshwater taxa. Also, for 10 freshwater fish taxa, the reported AO were greater than the EO, conflicting with the definitions of these two parameters. In order to evaluate the suitability of these spatial criteria on freshwater taxa, we use two approaches. First, the COSEWIC status of freshwater taxa is compared to an alternative, independent conservation status determined using the approach based on 7 forms of rarity. Second, we calculate AO with a more biologically relevant approach by measuring the area of stream segments that the taxa occupy and compare them with the COSEWIC reported AO. We discuss our findings and their implications with regards to the currently applied criteria used by COSEWIC and IUCN and whether the current methods are providing suitable assessments of risk.

A COMPARISON OF ANALYTICAL METHODS TO DERIVE FISH ASSEMBLAGE BIOINDICATORS OF ENVIRONMENTAL CONDITION RELATIVE TO ANTHROPOGENIC STRESS AT GREAT LAKES COASTAL MARGINS.

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Increasing reliance on bioassessment to infer biological condition has led to diverse approaches to ecological indicator development. However, few studies have compared their sensitivity or classification accuracy. We used data from fish fyke net catches at over 120 locations spanning a composite gradient of anthropogenic stress (agricultural, population and pollution measures) at US Great Lakes coastal margins. The fidelity, sensitivity and discriminatory ability of 4 analytical methods to develop fish-based bioindicators were assessed. The fish vs. disturbance data were used to construct 1) probability-based indicators of ecological condition (Howe et al. *Ecological Indicators* 2007); 2) composite measures using taxa whose relatives abundances change at environmental thresholds (derived from Threshold Indicator Taxa Analysis, Baker & King, *Methods in Ecology & Evolution* 2010); 3) composite measures using taxa identified from weighted-average transfer functions (Reavie et al. *Journal of Great Lakes Research* 2006); 4) novel extension of the BEAST multivariate approach (Reynoldson et al. *Australian Journal of*

Ecology 1995) - the Reference-Degraded Continuum. All methods identified the same taxa as contributing most weight to the indices' discrim¬inatory abilities, indicating methods' capacity to detect species-specific indicators of equivalent-to-reference and degraded locations. They also detected group-specific thresholds at approxi¬mately the same point along the stressor gradient, albeit with differing degrees of precision. Better discriminatory functions could be derived for sites in the less disturbed northern ecoprovince than in the more highly developed southern ecoprovince, likely because even minimally disturbed southern sites are subject to significant anthropogenic activities. The results also confirmed our expectation of a latitudinal influence on fish community composition. Assemblages diagnostic of relatively degraded conditions in the coldest, most oligotrophic ecozone, were identified as typifying reference conditions in warmer, more eutrophic ecozones. Thus, anthropogenic influences on coastal margin environmental attributes may anticipate the natural effects of climate change in the Great Lakes.

VARIATION IN EYE SIZE REFLECTS PREDATION RISK AND RESOURCE AVAILABILITY IN THE GUPPY (*POECILIA RETICULATA*).

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Guppies (*Poecilia reticulata*) have become a model species for the study of environmentally induced plasticity in life history traits. Lens and eye size are particularly important factors contributing to the sensitivity and resolution of vision in fish. As lens size increases, spherical aberration decreases. As eye size (and so retinal surface area) increases, visual sensitivity increases. In the current study, we investigate possible environmental influences, particularly predation levels and forest canopy cover, on lens and eye size between four pairs of Trinidadian populations. Four populations experience high predation by strongly piscivorous fish and four experience relatively low predation by gape-limited fish. High predation regimes tend to have lower canopy cover and have more food availability than low predation areas. After controlling for body size, we found that low predation populations have an overall larger eye size whereas lens size did not significantly differ between predation regimes. This preliminary data indicates that because body size is restricted by food availability in low predation areas, adults with higher visual sensitivity are better adapted to respond and escape predation which entails higher fitness.

CAN STEELHEAD 'OCEAN MORTALITY' BE EXPLAINED BY SURVIVAL IN LOWER RIVERS AND ESTUARIES?

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4 Oregon Department of Fish and Wildlife, Fish Research, 28655 Highway 34, Corvallis, OR 97333 USA.
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Pacific salmon under go dramatic physiological and behavioral changes when they move from their natal freshwater habitats to the marine environment. That downstream migration is associated with considerable benefits and costs that shape the life history of individuals. We studied mortality for steelhead, Oncorhynchus mykiss, smolts in Oregon coastal rivers. Survival to the ocean is currently estimated using data from smolt traps located well upstream of the estuary. More critically, the features that determine mortality or survival of individual fish are not known, data are summarized at the population level. We used acoustic telemetry and detailed physiological sampling of individual smolts to determine their downstream movements and survival. We tagged and tracked steelhead smolts in two different Oregon coastal rivers over 2 years. Our data suggest: 1) wild steelhead smolts spend little time in the estuary, 2) typically only 40 - 50% of wild smolts reaching the estuary actually enter the ocean, 3) most mortality occurs in the lower estuary, and 4) smolts tagged during the peak of the run appear to have relatively consistent survival rates. Our data strengthen life cycle models used in recovery plans by providing missing data on mortality locations and mortality rates in the riverine and estuarine portions of smolt migration. Our data enhance monitoring plans for estimating survival of migrants to the ocean, as well as life history models. Our results can be used to refine predictive life history models for Pacific salmon, related to the physiological and other characters of individual fish.

USE OF COASTAL WETLAND TYPES BY JUVENILE FISHES.

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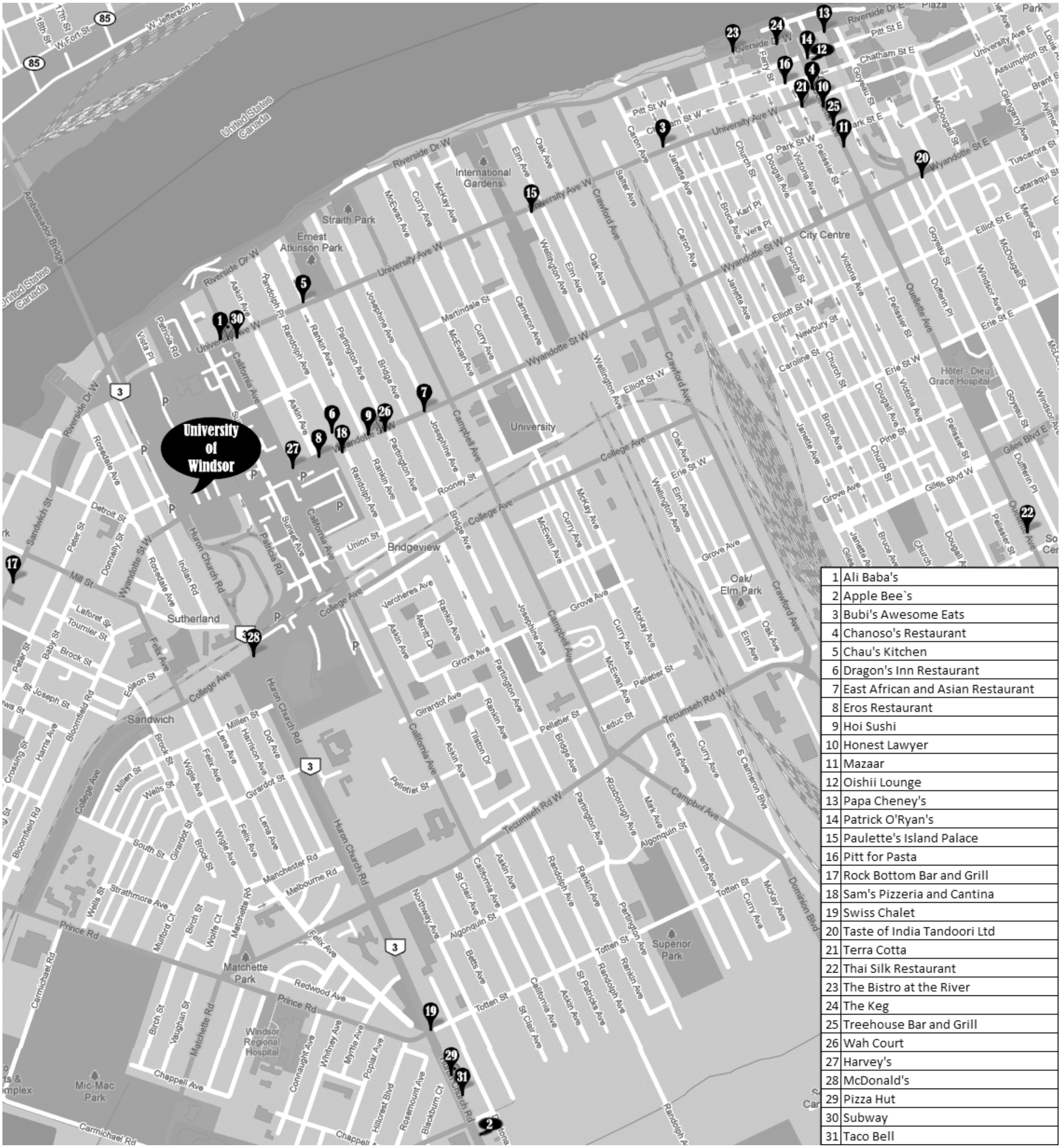
Great Lake coastal wetlands are commonly known to be an integral part of many fish species life histories, however, the importance of different wetland types to fish production has not received adequate attention. Of particular interest is the relative abundance and diversity of gamefish YOY across major wetland types. The objective of this study was to determine the differences in YOY abundance, diversity, and evenness in fringing, protected, and riverine Great Lake coastal wetlands. Thirty-five sites were sampled using Great Lakes Coastal Wetland Consortium accepted trap netting protocols. Sites were sampled during the summer (June to mid August) of 2011. Primarily, data consisted of mean number of YOY species and their relative abundance per net. Fetch was also calculated for each site sampled to determine the effect of wave energy on larval fish assemblages. We used analysis of variance and regression approaches to assess differences in YOY species diversity, relative abundance, and evenness among wetland types. Preliminary analyses suggest that riverine wetlands have the highest diversity and abundance of fish YOY, which also corresponds to sites with lower wave energy. Overall, our study provides information on the differential importance of wetland type for fish production. This information may prove useful when prioritizing wetlands for conservation.

	Restaurants	Type of Food	Cost/per person	Location	Phone
1	Ali Baba's	Middle Eastern	$11-25	2440 University Ave. W.	(519) 255-2222
2	Apple Bee`s	Burgers, quesdillas, steak; vegetarian options	$11-25	2187 Huron Church Road	(519) 972-3000
3	Bubi's Awesome Eats	Burgers, mixed grill	$11-25	620 University Ave. W	(519) 252-2001
4	Chanoso's Restaurant	Create your own stir fry/vegetarian options	$11-25	255 Ouellette Ave.	(519) 254-8530
5	Chau's Kitchen	Chinese	$11-25	2106 Univeristy Ave. W	(519) 255-7646
6	Dragon's Inn Restaurant	Chinese	$11-25	2240 Wyandotte St. W.	(519) 258-7613
7	East African and Asian Restaurant	East African and Asian	$11-25	1806 Wyandotte St. W	(519) 971-8763
8	Eros Restaurant	Pan-asian	$7-15	2270 Wyandotte St. W	(519) 977-1104
9	Hoi Sushi	Sushi; all you can eat	$11-25	2080 Wyandotte St. W	(519) 258-3888
10	Honest Lawyer	Pub grub/fusion	$11-25	300 Ouellette Ave.	(519) 977-0599
11	Mazaar	Lebanese, vegetarian options	$14-25	372 Ouelette Ave.	(519) 976-9696
12	Oishii Lounge	Sushi, sashimi, raw and cooked options	$11-25	255 Ouelette Ave.	(519) 971-9916
13	Papa Cheney's	Burgers, fries, pitas, etc	$11-25	63 Riverside Dr. E.	(519) 258-1334
14	Patrick O'Ryan's	Irish Pub	$11-25	25 Pitt St. E	(519) 977-5722
15	Paulette's Island Palace	Traditional Caribbean	$11-25	1175 Univeristy St. W	(519) 977-7462
16	Pitt for Pasta	Italian	$11-25	122A Chatham St. W.	(519) 254-4545
17	Rock Bottom Bar and Grill	Sandwiches, burgers, chicken fingers	$11-25	3236 Sandwich St.	(519) 258-7553
18	Sam's Pizzeria and Cantina	Pizza, pasta, panzerotti	$11-25	2215 Wyandotte St. W.	(519) 800-0579
19	Swiss Chalet	Homestyle cooking, chicken, burgers, ribs, etc	$11-25	1690 Huron Church Rd.	(519) 973-4686
20	Taste of India Tandoori Ltd	Indian	$11-25	155 Wyandotte St. E.	(519) 253-1414
21	Terra Cotta	Wood-fired pizza	$11-25	318 Pelissier Street	(519) 971-0223
22	Thai Silk Restaurant	Thai	$11-25	1368 Ouelette Ave.	(519) 971-7788
23	The Bistro at the River	Western European	$11-25	78 Riverside Dr. W.	(519) 971-0100
24	The Keg	Steakhouse	$11-25	1 Riverside Drive W. #101	(519) 254-1646
25	Treehouse Bar and Grill	Pub grub	$11-25	351 Ouelette Ave.	(519) 525-6626
26	Wah Court	Cantonese	$11-25	2037 Wyandotte St. W	(519) 254-1388

	Fast Food	Type of Food	Cost/per person	Location	Phone
27	Harvey's	Burgers and fries	$6-10	2380 Wyandotte Street West	(519) 973-7844
28	McDonald's	Burgers and fries	$6-10	883 Huron Church Road	(519) 258-3531
29	Pizza Hut	Pizza	$6-10	1770 Huron Church Road	(519) 310-1010
30	Subway	Submarine sandwiches	$6-10	2424 University Ave. W	(519) 971-9777
31	Taco Bell	Tacos	$6-10	1790 Huron Church Road	(519) 977-0662



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