General Schedule of Events for the 42nd Annual Larval Fish Conference  
June 24-28th, 2018,  
Victoria, BC, Canada

Venue: Delta Ocean Pointe Resort, 100 Harbour Rd, Victoria, BC.

With the exception of the Larval Fish Identification Workshop, all conference events will take place at the Delta Ocean Pointe.

The Registration Desk will be located in the Harbour Room on Sunday evening beginning at 18:00, and outside the Arbutus room thereafter on Monday to Thursday.

The Poster Session (Monday evening) and the Awards Reception (Wednesday evening) will both be held in the Harbour room.

Oral Presentations and the ELHS Business Meeting will be held in Arbutus A room.

Jun 23 (Saturday): Larval Fish Identification Workshop (University of Victoria)  
Jun 24 (Sunday): Early Career Mentoring Session (13:00-16:00)  
Registration and Opening Gathering (18:00-21:00)  
Jun 25 (Monday): Oral Presentations (08:30-17:00)  
Poster Session (18:00-21:00)  
Jun 26 (Tuesday): Oral Presentations (08:30-16:45)  
ELH Section Business Meeting (16:45-18:00)  
Jun 27 (Wednesday): Oral Presentations (08:30-17:00)  
Reception and Student Award (18:00-21:00)  
Jun 28 (Thursday): Oral Presentations (08:30-17:00)
General Instructions

With the exception of the keynote address, oral presentations are scheduled for 15 minutes (12 minutes for presentation + 3 minutes for questions). Because we wanted to avoid concurrent sessions, the session chairs will have to strictly enforce these time limits.

Presenters must prepare their talks in either PowerPoint (.ppt or .pptx) or PDF (.pdf) format. Talks will be run on laptops with Windows OS, with internet, sound and video (VLC) capabilities. Please ensure that unusual fonts, and any videos or sound files are embedded in the PowerPoint file (or transferred onto the presentation laptop). To save time between presentations, presenters will not be permitted to use their own laptop. Please therefore make sure that your talk gets uploaded to the conference laptop (in the Arbutus Room) prior to your session.

The poster session will be held Monday evening. The poster boards be available all day Monday. Posters must be no larger than 4’x4’ in overall size.

Student talks have been concentrated into sessions from Monday to midday Wednesday to allow the judges time to make their decisions prior to the awards reception on Wednesday evening. As a result, all theme sessions have presentations scattered in blocks throughout the four days of the meeting.

Acknowledgments

We would like to thank all the volunteers who assisted through the various stages of making this conference a reality.

Special thanks to Stu Ludsin (Co-director of the Aquatic Ecology Laboratory, The Ohio State University) for volunteering to serve as Mentor for the Early Career Scientist Event and to Alison Deary (NOAA, Alaska Fisheries Science Center) and Marta Moyano (University of Hamburg) for coordinating the event. We appreciate the efforts of Peter Konstantinidis (Oregon State University, Dept. of Fisheries and Wildlife), Alison Deary, Moira Galbraith (Fisheries and Oceans Canada, Institute of Oceans Sciences) and Jessica Qualley (University of Victoria) for organizing the Larval Fish Identification Workshop.

Jessica Holden (University of Victoria) kindly provided her inspiration to create the meeting’s logo.

Financial support was provided by Fisheries and Oceans Canada (Newfoundland and Labrador), the Pacific Salmon Foundation, and the Biology Department and the Faculty of Science of the University of Victoria. The Early Life History Section and the Executive Committee provided valuable assistance in financing the organization of the conference.

We hope you enjoy the conference and the city of Victoria (Tourism Victoria).

John Dower  
University of Victoria  
E-mail: lfc2018@gmail.com

Francis Juanes  
University of Victoria

Pierre Pepin  
Fisheries and Oceans Canada  
Website: http://lfc-2018.com/
Keynote Address – Janet Duffy-Anderson

Biographical Sketch – Dr. Janet Duffy-Anderson is the Program Manager for the NOAA/Alaska Fisheries Science Center’s Recruitment Processes Program and co-lead for the Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI) Program. Janet earned a BS from Lafayette College, a PhD from the University of Delaware, and she conducted postdoctoral work at Rutgers University and the University of Washington. In 2001, Janet was hired by NOAA to link early life history ecology to fisheries recruitment dynamics and ecosystem functioning. For over two decades, Janet has been interested in the development of mechanistic approaches to understanding how climate and ecosystem shifts mediate recruitment in Alaskan waters, with a focus on those events that affect fish during the vulnerable first year of life. Janet studies the biology and ecology of the egg, larval, and juvenile stages of marine and estuarine fishes, the interactions of these life stages with prevailing atmospheric, oceanographic, and biological processes, and the implications for population variability, trophic shifts, and ecosystem change. Janet applies these results to the development of indicators that can be used in assessments, forecasting, and Ecosystem Based Fishery Management. She is interested in processes from organism to ecosystem level.

The Contribution of Fish Early Life Studies to Ecosystem Based Fishery Management

Foundational early life ecology research focused on understanding factors affecting survival and subsequent cohort strength of single species populations. As process-based ecology has advanced, so too has the need to respond to the modern challenges of multiple, aggregated stressors and the ecosystem-wide, cascading changes manifested by them. This new reality requires broadening our approach to fish early life research and re-framing pre-recruit ecology in the context of the whole system. The implementation of Ecosystem Based Fishery Management (EBFM) formalizes a holistic ecosystem approach to fishery science, allowing researchers to address fundamental fisheries questions while considering other ecosystem elements that can influence recruitment outcomes. The same is true for fish early life history science; research on larval and juvenile fishes, conducted as a part of cross-trophic, whole ecosystem investigations, can be used to not only advance understanding of recruitment dynamics in target species but also to project reverberated effects on the ecosystem as a whole, including interacting processes, multispecies effects, shifts in ecosystem structure, and ecological trade-offs. Indeed, mechanistic understanding of ELH ecology is the cornerstone to modeling efforts that are central to comprehensive Integrated Ecosystem Assessments. Moreover, early life information can be invaluable to management efforts including providing process-based understanding, informing management strategies, and forecasting change. This presentation will use examples of first year of life research conducted as part of integrated ecosystem studies at the National Oceanic and Atmospheric Administration's Alaska Fisheries Science Center, to demonstrate how fish early life history information has been used to implement EBFM and how it can be used to develop thresholds for adaptive management strategies.
## Monday at a glance

<table>
<thead>
<tr>
<th>Session</th>
<th>Time</th>
<th>Monday</th>
<th>Title</th>
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<tbody>
<tr>
<td>Opening Session</td>
<td>08:30</td>
<td>John Dower</td>
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<td>09:15</td>
<td>Duffy-Anderson</td>
<td>The Contribution of Fish Early Life Studies to Ecosystem Based Fishery Management</td>
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<td>Pierre Pepin</td>
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<tr>
<td>Life after death</td>
<td>10:30</td>
<td>Duguid*</td>
<td>A case study of fine scale habitat use by first ocean year Chinook Salmon: implications for growth and predation exposure</td>
<td>Pierre Pepin</td>
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<td></td>
<td>10:45</td>
<td>Mikhey*</td>
<td>Die or migrate: A case study on brown trout juveniles</td>
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<td>11:00</td>
<td>MacRobert*</td>
<td>Spatial risk: Influence of piscivorous fish on selection of nursery habitat by age-0 juvenile cod</td>
<td>Hannes Baumann</td>
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<td></td>
<td>11:15</td>
<td>Miller</td>
<td>Spatial and temporal variation in recruitment of amphidromous gobies on the island of Hawaii</td>
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<td></td>
<td>11:30</td>
<td>Prigle*</td>
<td>Sex-specific growth and mortality patterns in juvenile Atlantic silversides (Menidia menidia) from Connecticut waters</td>
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<td></td>
<td>11:45</td>
<td>Moll*</td>
<td>Contribution of an inshore nursery area to the Atlantic herring (Clupea harengus) population in the Western Baltic Sea</td>
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<td>Lunch</td>
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<tr>
<td>Emerging Threats</td>
<td>13:30</td>
<td>Flannery*</td>
<td>Effect of short- and long-term exposure to low pH and dissolved oxygen on swimming performance of juvenile rockfish</td>
<td>Hannes Baumann</td>
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<td></td>
<td>13:45</td>
<td>Murray*</td>
<td>Early life stages of the northern sand lance Ammodytes dubius show high sensitivity to acidification and warming in a CO2 x temperature factorial experiment</td>
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<td>14:00</td>
<td>Brodeur</td>
<td>Larval fish as a predictor of available prey fields for juvenile salmon: successes, failures, and new approaches for salmon management</td>
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<td>14:15</td>
<td>Hajovsky*</td>
<td>The occurrence of microplastics in the diet of juvenile fish in South Texas coastal bays</td>
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<td>14:30</td>
<td>Kotterba</td>
<td>Spawning behavior of Atlantic herring (Clupea harengus) and its dependence on littoral macrophytes</td>
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<td>14:45</td>
<td>von Nordheim*</td>
<td>Survival of Atlantic Herring Eggs on Baltic Sea Spawning Beds</td>
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<td>15:30</td>
<td>Dehnert*</td>
<td>Effects of low, subchronic exposure of 2,4-dichlorophenoxyacetic acid (2,4-D) and commercial 2,4-D formulations on early life stages of fathead minnows (Pimephales promelas)</td>
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<tr>
<td>Growth-Survival Paradigm</td>
<td>15:45</td>
<td>Robert</td>
<td>Life in the fast lane: revisiting the fast growth - high survival paradigm during early life of fishes</td>
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<td>16:00</td>
<td>Hincliffe*</td>
<td>Using mortality and growth rate relationships of larval fish to assess the role of frontal eddies at offshore nursery grounds</td>
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<td>16:15</td>
<td>Giebels*</td>
<td>Influence of fine-scale plankton patchiness on larval fish growth in the straits of Florida</td>
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<td>16:30</td>
<td>Van Slijndeweld*</td>
<td>Feeding, growth and mortality of young-of-the-year Striped Bass: a comparison among habitats in the St. Lawrence Estuary</td>
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<td>16:45</td>
<td>Axler*</td>
<td>Variability in ichthyoplankton distributions and growth across river plumes in the northern Gulf of Mexico</td>
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*Asterisks denote student presentations*
## Tuesday at a glance

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<tr>
<th>Section</th>
<th>Time</th>
<th>Tuesday</th>
<th>Title</th>
<th>Chair</th>
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<tbody>
<tr>
<td><strong>Contribution papers</strong></td>
<td>8:30</td>
<td>Bromschwig*</td>
<td>Feeding ecology and food web structure of ichthyoplankton at a coastal Gulf of Mexico inlet</td>
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<td>8:45</td>
<td>Caralan</td>
<td>Larval fish strategies in front of stratification in coastal areas</td>
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<td>9:00</td>
<td>Teletche</td>
<td>Assessment of the knowledge acquired on the early life stages of temperate freshwater fish species: comparisons between European and North American fauna</td>
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<td>9:15</td>
<td>Novaes Flarini*</td>
<td>Foraging of juvenile northern anchovy under light backgrounds of different polarization characteristics</td>
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<td></td>
<td>9:30</td>
<td>DeBruyne</td>
<td>If you build it, will they come? Restoring lophophotic spawning habitat in the Laurentian Great Lakes connecting channel</td>
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<td>9:45</td>
<td>Bjorkesedt</td>
<td>Connecting currents, clines, counts, and the coast: the importance of hydrographic structure for understanding early life history and recruitment of rockfishes.</td>
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<td>Health Break</td>
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<td>10:30</td>
<td>Burns*</td>
<td>Maternal diet affects egg DNA content and reproductive energy allocation strategy of southern flounder, Paralichthys lethostigma, within a spawning season</td>
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<td>10:45</td>
<td>Fuman</td>
<td>Finding the needle in the haystack: Using lipidomics to explore possible causes of metabolic programming in red drum larvae</td>
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<td>11:00</td>
<td>Prada*</td>
<td>Drifting and swimming response of Asian carp eggs and larvae to different flow conditions in a laboratory flume experiment</td>
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<td>11:15</td>
<td>Dauden Bengoa*</td>
<td>Myctophid larval fish assemblages linked to oceanographic conditions in the deep water region of the southern Gulf of Mexico</td>
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<tr>
<td><strong>Growth-Survival paradigm</strong></td>
<td>11:30</td>
<td>Bornman*</td>
<td>Comparison of predator-prey interactions and body condition (RNA:DNA) in late-stage larvae of Glicristella aestuaria (Family Clupeidae) in mangrove and non-mangrove estuaries of warm-temperate South Africa</td>
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<td>11:45</td>
<td>Mavri</td>
<td>Trophic niche overlap in native and alien clupeiform larvae in the eastern Mediterranean</td>
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<td>13:30</td>
<td>Smit*</td>
<td>Preliminary insights on the knock-on effects of harmful algal blooms on dominant larval fish species in a warm temperate estuary, South Africa</td>
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<tr>
<td><strong>Fisheries oceanography</strong></td>
<td>13:45</td>
<td>Geist</td>
<td>The hurricane Harvey freshwater plume and its effect on the ichthyoplankton community - introduction to the RAPID plankton project and historical data from the affected area</td>
<td>Janet Duffy, Anderson</td>
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<td>14:00</td>
<td>Corso*</td>
<td>A time-series analysis of the larval fish assemblage of the Western Antarctic Peninsula</td>
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<td>14:15</td>
<td>Namik*</td>
<td>Interannual variation of mesopelagic larval fish assemblages in the southeast Brazilian Bight</td>
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<td>14:30</td>
<td>Sowick*</td>
<td>Fine-scale horizontal and vertical distribution of larval fishes, their prey, and their predators in the tidally modulated Columbia River Plume</td>
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<td>14:45</td>
<td>Paris</td>
<td>Environmental effects on larval fish ontogenetic vertical migration</td>
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<td>Health Break</td>
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<td>15:30</td>
<td>Almeida*</td>
<td>Do winter conditions alter the timing of larval walleye (&lt;i&gt;Dendroaspis variegata&lt;/i&gt;) and zooplankton prey production in Lake Erie?</td>
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<td>15:45</td>
<td>Ray*</td>
<td>Ocean acidification may lead to smaller ooliths in newly-settled winter flounder (Pseudopleuronectes americanus)</td>
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<td><strong>Life after death</strong></td>
<td>16:00</td>
<td>Geissinger*</td>
<td>Overwinter survival and movement of juvenile Atlantic cod (Gadus morhua) in nearshore coastal Newfoundland</td>
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<td>16:15</td>
<td>Xhamaasi*</td>
<td>Relationship between larval growth and survival of Atlantic mackerel (Scomber scombrus) derived from juveniles ingested by the northern gannet</td>
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<td>16:30</td>
<td>Pascoe*</td>
<td>Quantifying condition in Young-of-Year Pacific herring using six metrics</td>
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*Asterisks denote student presentations*
### Wednesday at a glance

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<th>Session</th>
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<th>Title</th>
<th>Chair</th>
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<tbody>
<tr>
<td>Application of ichthyoplankton data</td>
<td>8:30</td>
<td>Integrated Ecosystem Research Programs and their necessity to elucidate the early life history dynamics of ecological species: An example from the Arctic</td>
<td>Pierre Pepin</td>
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<td>8:45</td>
<td>Guysh* Larval fish diversity distribution within a coastal marine reserve. What light traps and plankton nets reveal</td>
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<td></td>
<td>9:00</td>
<td>Koslow Temporal patterns in fish communities, their coherence and response to ocean forcing along the west coast of North America based on analysis of ichthyoplankton time series</td>
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<td></td>
<td>9:15</td>
<td>Wang* The spatial-temporal patterns of ichthyoplankton in the upper mainstream of the Yangtze River: influences of upstream dam cascade discharge and downstream impoundment of the Three Gorges Reservoir</td>
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<td>9:30</td>
<td>Berensteina* Better together: biophysical simulations support schooling behavior of fish/ larvae throughout ontogeny</td>
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<td>9:45</td>
<td>Choi* Discovery of eggs from four species of Ophiichthysidae and Congridae (Anguilliformes) in the northern East China Sea based on DNA barcoding</td>
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<td>10:00</td>
<td>Break</td>
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<tr>
<td>Life after death</td>
<td>10:30</td>
<td>Hernandez Linking Juvenile fish to Habitat to Recruitment: Development of a Holoplagic Sargassum index for Gray Triggerfish Management in the northern Gulf of Mexico</td>
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<td>10:45</td>
<td>Majors Differential persistence favors habitat preferences at settlement that determine the distribution of a coral reef fish</td>
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<td>11:00</td>
<td>Nash Advances in our understanding of juvenile fish ecology: A challenging area for field sampling and experimentation</td>
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<td>11:15</td>
<td>Strydom Counting the costs of bias in fish ecology? Lessons learned from studying larvae and juveniles in temperate South African estuaries</td>
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<td>11:30</td>
<td>Jordan River herring juvenile population dynamics in coastal ecosystem</td>
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<td>11:45</td>
<td>Inda-Diaz Fish larvae assemblages along an intertropical front</td>
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<td>Lunch</td>
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<tr>
<td>Fisheries oceanography</td>
<td>13:30</td>
<td>Moyano Exploring the link between metabolism and growth in marine fish larvae</td>
<td>Dominique Robert</td>
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<td>13:45</td>
<td>Polte Potential effects of phenology shifts on herring (Clupea harengus) recruitment in the Western Baltic Sea</td>
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<td>14:00</td>
<td>Shoji Possible contribution of submarine groundwater on coastal fisheries production: increase in feeding and growth of juvenile marbled flounder Pseudopleuronectes yokohamae in a cage experiment</td>
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<td>14:15</td>
<td>Sanchez-Velasco Larval fish habitats and deoxygenation in the Pacific off Mexico</td>
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<td>Emerging Threats</td>
<td>14:30</td>
<td>Sswat Performance of herring larvae under ocean acidification in an ecosystem approach</td>
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<td>14:45</td>
<td>Wesler The impact of ocean acidification on larval yellowfin tuna (Thunnus albacares) development</td>
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<tr>
<td>Growth-Survival Paradigm</td>
<td>15:30</td>
<td>Greer Distribution of larval fishes, zolatious zooplankton, and prey in the vicinity of a convergence-induced thin layer in the northern Gulf of Mexico</td>
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<td>15:45</td>
<td>Robison Predation strategies of larval fish capturing evasive copepod prey</td>
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<td>16:00</td>
<td>Bouchard Investigating the relationship between foraging strategy and feeding success using polar cod larvae</td>
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<td>16:15</td>
<td>Deary Diet and bioenergetics of early stage Sakiseth, Xeniophilia fimbria, collected from the western Gulf of Alaska in 2017</td>
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<td>16:30</td>
<td>Zavala Morphospace and niche partitioning in larvae of two sympatric Diogenichthys species</td>
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<td>16:45</td>
<td>Tuttle Escape of Copepods from Approaching Larval Fish: Theory and Observation</td>
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<td>Environmental Biology of Kootenai River Burbot, Lota lota, Early Life Stages</td>
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<td>Use of Algae and Clay in Rearing Larval Sablefish (Anoplopoma fimbria)</td>
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<td>The Best Approach for Predicting Egg Development Time from Temperature is both Context and Species-Dependent</td>
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<td>The expression of agrpt, a hypothalamic appetite-stimulating neuropeptide, reveals hydrodynamic-induced starvation in a larval fish</td>
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<td>Assessment of the larval fish community in the solitary islands canyon off southeast Australia and its potential role in cross shelf movement of larvae</td>
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<td>Eric Bolkstedt</td>
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<td>Leis Variation in Behavior of Larval Fishes As Bet Hedging</td>
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<td>Webb How Coral Reef Fish Larvae Find A Home?: Insights From Sensory Organ Ontogeny</td>
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<td>Fisheries oceanography</td>
<td>Killawii On Larval Aggregation and Chinae Restaurants</td>
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<td>Copeman Impacts of temperature and food availability on the condition of larval Arctic cod (Boreogadus saida) and walleye pollack (Gadus chalcogrammus)</td>
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<td>Hurst Ocean acidification effects on growth and behavior of Pacific cod larvae</td>
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<td>Ludsin Understanding and predicting climate change impacts on Yellow Perch recruitment in Lake Erie</td>
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<td>Murphy Left high and dry: the importance of getting off the beach for capelin survival</td>
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<td>Marancik Comparing Adult and Larval Hake Distribution Patterns to Determine Stock Structure in the Northeast US Atlantic Shelf Ecosystem</td>
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<td>Marruk Fishery threats the spawning aggregations of Mottled Gaspere (Myctoperco rubra) in northeastern Mediterranean</td>
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<td>Application of ichthyoplankton data</td>
<td>Asth Comparison of the distributions and concentrations of larval, young-of-the-year, and adult flatfishes off the central Oregon coast</td>
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<tr>
<td>15:45</td>
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<td>Chambers Experimental methodologies optimized for examining the scope of responses in early life stages of marine fishes due to multiple stressors, variable environments, and climate change</td>
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<td>White Bring the noise: the influence of larval recruitment variability on the adaptive management of marine protected areas</td>
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<td>Nielsen Analyses of multispecies ichthyoplankton data along the US west coast as indicators of ecosystem changes</td>
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<td>Growing up in a plastic ocean - the impact of microplastic uptake in juvenile seabream</td>
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<td>Reproductive tactics of southern hake Merluccius australis in the Chilean Patagonia</td>
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<td>Characterizing the Response of the Winter-Spring Ichthyoplankton Community to Environmental Change</td>
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<td>Hsieh</td>
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<td>Bouska</td>
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<td>How do anchovy and sardine eggs and larval abundance and distribution vary within the same spawning period?</td>
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<td>Serranidae larvae from the Southeastern Brazilian Bight</td>
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<td>Inda-Diaz</td>
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<td>Bahia Víccaino as a transitional area for fish larvae communities in the Southern California Current</td>
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<td>Molecular markers: an auxiliary tool to morphological identification of fish larvae from the Gulf of Mexico</td>
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<td>Larval orientation behavior begins shortly after hatching in a coral reef fish</td>
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<td>Paralarval cephalopods of the Northeast US: the larval fish of the invertebrate world</td>
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<td>Effect of temperature and the growth of blackthroat seapearch juveniles (Doederleinia berycoides) under laboratory conditions</td>
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*Asterisks denote student posters*
ORAL PRESENTATIONS

Do winter conditions alter the timing of larval walleye (*Sander vitreus*) and zooplankton prey production in Lake Erie?

L Zoe Almeida¹*, Amara Huddleston¹, James Hood¹, Stuart Ludsin¹, Elizabeth Marschall¹

¹Ohio State University

Marine and freshwater fish adapted to spawn according to spring environmental cues (e.g., temperature, light) may experience phenological mismatch with their prey, owing to climate-driven shifts in the timing of spring onset. These shifts may cause a temporal mismatch between the production of larval fish and their zooplankton prey if different cues initiate their production. We examined the potential for this mismatch in Lake Erie walleye (*Sander vitreus*) by comparing zooplankton community composition and diet selectivity of larval walleye in the spring, following contrasting winters (long, cold vs. short, warm) during two periods (1990s, 2010s). While preliminary comparisons between recent mild (2012, 2016) and severe (2014, 2015) winters showed no consistent differences in the timing of match between walleye larvae and their prey, we did find a potential difference in prey availability between time periods unrelated to winter severity. During 2011-2013, small walleye larvae (≤ 11 mm) selected for cyclopoids and larger walleye larvae selected for small cladocerans. These taxonomic groups had 1 to 2 orders of magnitude lower biomass during 2011-2016 than during 1994-1999. As both time periods included cold and warm winters, winter severity may not be the sole driver of the match between the production of larval walleye and their zooplankton prey, and in turn, larval foraging. Further analyses will tease apart the influence of year-to-year variation in winter severity and decadal changes in zooplankton communities on the potential match/mismatch of larval walleye and their prey in Lake Erie. In addition, we will discuss the implications of our findings to understanding walleye growth and recruitment dynamics.

Comparison of the distributions and concentrations of larval, young-of-the-year, and adult flatfishes off the central Oregon coast

Toby Auth¹, Anthony Phillips², Matthew Yergey¹, Waldo Wakefield²

¹Pacific States Marine Fisheries Commission, ²NOAA

Fish early-life history stages may be sensitive indicators of environmental conditions and of future recruitment potential in adult fish stocks within the California Current ecosystem. Limited research has been conducted on young-of-the-year (YOY) flatfishes off Oregon since the pioneering work during the late 1970s and early 1980s. In the present study, we collected YOY and adult groundfish samples using a benthic beam trawl from six stations (3-15 nm offshore) along and near the historically-sampled Newport Hydrographic (NH) line (44.67°N) monthly in 2012-15, and analyzed them for seasonal and spatial patterns. Ichthyoplankton was also analyzed from bongo samples collected from comparable stations along the NH line. We compared the ichthyoplankton concentrations and distributions to those found in the beam trawl with suitable lag periods to examine larval supply to the demersal environment. From a preliminary total catch of 8,600 fish from the beam trawls in July 2012-June 2013, 84% comprised the following flatfish taxa: *Parophrys vetulus* (38%; English sole), *Isosetta isolepis* (20%; Butter sole), *Citharichthys* spp. (17%; Sanddabs), and *Lyopsetta exilis* (9%; Slender sole). Seasonal settlement signals were observed for three of the species (*P. vetulus*: spring/early summer; *I. isolepis*: summer; and *L. exilis*: late summer/fall), while no seasonal signal was observed for *Citharichthys* spp. The larval data revealed periods of peak concentration for all four of the examined taxa (*P. vetulus*: winter; *I. isolepis*: late winter; *L. exilis*: late spring/early summer; and *Citharichthys* spp.: winter and summer). Cross-shelf settlement signals were also observed (*P. vetulus* and *I. isolepis*: near shore; *Citharichthys* spp. and *L. exilis*: further offshore), while larvae of all four taxa were more concentrated near shore than further offshore. We will present complete results from the 2012-15 data once the sample processing is complete.
Variability in ichthyoplankton distributions and growth across river plumes in the northern Gulf of Mexico

Kelia Axler¹, Su Sponaugle¹, Frank Hernandez, Jr.², Christian Briseño-Avena¹, Robert Cowen¹
¹Oregon State University, ²University of Southern Mississippi

River plumes discharging into the coastal waters of the northern Gulf of Mexico are important physical and biological drivers of the survival of the early life stages of many marine fishes. In this study, multiple salinity gradients produced by the outflow of the Mobile Bay, Alabama estuary were targeted with a multinet sampler (BIONESS) for depth-discrete sampling of ichthyoplankton to capture the effects of plume dynamics during the high-flow month of April 2016. Each net tow was classified as having sampled one of two distinct water masses based on known salinity values: either “plume” (<25 psu) or “nonplume” (>30 psu). Mean density of larval fishes (no./100 m³) and community composition did not differ between plume and nonplume waters, but significantly more eggs were found in plume waters. Size frequency distributions of larval broad-striped anchovy (Anchoa hepsetus), an abundant nearshore forage fish species in the northern Gulf, indicated that larger individuals (>16 mm) were present in nonplume waters but absent from plume waters. Sagittal otolith microstructure analysis revealed that mean recent growth was significantly lower in A. hepsetus collected from plume water masses than those from nonplume waters. Preliminary data for another abundant nearshore species, larval sand seatrout (Cynoscion arenarius), showed a similar size variation between water masses with larger individuals present in nonplume waters but absent in plume waters. These results suggest that plume waters may be an unfavorable environment for certain fish larvae and will be studied further to examine trophodynamic connections. Specifically, net-collected zooplankton counts and high resolution in situ imagery enable fine-scale examination of the predator and prey fields in each water mass, while diet composition and gut fullness of A. hepsetus and C. arenarius reveal how short-term feeding success correlates with the observed growth variation.

Better together: biophysical simulations support schooling behavior of fish larvae throughout ontogeny

Igal Berenshtein¹*, Claire Paris¹, Moshe Kiflawi²
¹Rosenstiel School of Marine and Atmospheric Science, University of Miami, ²Interuniversity institute for marine sciences and Ben Gurion University

Schooling is very common in adult and juvenile fish, but was rarely studied during the larval stage. Recent otolith micro-chemistry studies of coral reef fish have demonstrated that cohorts of larvae can move through similar paths and settle within a few meters one from another. However, little is known about the processes involved in the formation and maintenance of these cohorts. Here we use a biophysical modeling approach to examine whether local hydrodynamics, various individual behaviors, or larval schooling can explain cohesive patterns observed for Neopomacentrus miryae in the Gulf of Aqaba/Eilat (Red Sea), and whether schooling is feasible in terms of initial encounter probability. We then examine the consequences of schooling behavior on larval settlement success and connectivity. Our results indicate that: (1) schooling behavior is necessary for generating cohesive dispersal patterns; (2) initial larval encounter of newly-hatched passive larvae is plausible, depending on initial larval densities and patchiness; and (3) schooling behavior increases the rate of larval settlement while decreasing the percentage of realized connections. Together with mounting evidence of cohesive dispersal, this numerical study demonstrates that larval schooling behavior throughout the pelagic phase is to be expected, and provides insights on its effect on settlement success and connectivity patterns. Future research is needed to understand the mechanisms of fission-fusion dynamics of larval cohorts and their effect on dispersal. Our findings should be considered in future efforts of larval dispersal models, specifically in the context of marine connectivity and the planning of marine protected area networks.
Connecting currents, -clines, counts, and the coast: the importance of hydrographic structure for understanding early life history and recruitment of rockfishes.

Eric Bjorkstedt¹
¹NOAA Fisheries

Hydrographic fronts have shown to influence the ecology of marine systems by enhancing productivity, often in conjunction with elevated biomass density, and structuring transport of plankton. In the coastal upwelling system of the California Current, fronts have the characteristics of being dynamic, mobile structures, yet also exhibiting broadly consistent structure in their spatial distribution. Published studies have shown correlations between the prevalence of fronts and indices of larval supply to benthic populations that support a hypothesis that fronts play a significant role in structuring the distribution and transport of planktonic or micronektonic early life history stages of coastal species. As a step towards better connecting spatial patterns along the coast to ocean dynamics, I review and analyze data from several field surveys to examine how fronts (and related hydrographic structure) influence the distribution of early life history stages of rockfish (Sebastes spp.) ranging from larval through pelagic juvenile stages. These results support the hypothesized connection between fronts and population structure, provide a basis for understanding the implications of discrepancies in spatial overlap of sampling grids and hydrographic structure for abundance indices derived from survey observations, and highlight the need for targeted sampling to better address questions about the role fronts play in the ecology of early life history stages.

Comparison of predator-prey interactions and body condition (RNA:DNA) in late-stage larvae of Gilchristella aestuaria (Family Clupeidae) in mangrove and non-mangrove estuaries of warm-temperate South Africa

Eugin Bornman¹*, Nadine Srydom¹, Catriona Clemmesen², Tris Wooldridge¹
¹Nelson Mandela University, ²Helmholtz Centre for Ocean Research (GEOMAR)

A paradigm exists that mangrove estuaries are ideal fish nursery areas as they increase growth and survival of juvenile fishes by providing enhanced food availability and protection. However, most studies have focused on tropical mangroves with a few studies extending into the warm temperate areas where mangroves reach the limit of their distribution. Work to date has given conflicting results. This study aimed to assess whether mangrove presence renders an advantage to the larvae of an important estuarine resident fish species, Gilchristella aestuaria, by comparing the food patch quality in warm temperate mangrove and non-mangrove estuaries on the south-east coast of South Africa. This study found that mangrove presence positively related to postflexion larval densities when coupled with abiotic (e.g. temperature and turbidity) and biotic factors (e.g. predator-prey interactions). Results indicate that mangrove habitats acted as sediment sinks, slightly reducing the turbidity of these estuaries which resulted in postflexion larvae actively selecting larger, more nutritious prey, which in turn, significantly increased their individual instantaneous growth rates (0.11 ± 0.21 Gi) when compared to postflexion larvae in non-mangrove estuaries (0.09 ± 0.12 Gi). Understanding the spatial and temporal dynamics, predator-prey interactions as well as the growth and survival of G. aestuaria is particularly important as they are key zooplanktivores that are prey to other species in estuarine food webs.
Investigating the relationships between foraging strategy and feeding success using polar cod larvae

Caroline Bouchard¹, Ariane Aspirault², Dominique Robert², Louis Fortier³
¹Greenland Institute of Natural Resources, ²Université du Québec à Rimouski, ³Université Laval

The larval foraging strategy of some fish species is characterized by spatiotemporal variability that can be related to prey field. For instance, Atlantic cod (Gadus morhua) and snapper (Chrysophrys auratus) larvae feed selectively when their preferred prey is abundant in the environment, and opportunistically when the preferred prey is rare. For these species, high feeding success is linked to strong prey selectivity. By contrast, high feeding success has been linked to opportunistic feeding in larval radiated shanny (Ulvaria subbifurcata). Here, we use polar cod (Boreogadus saida) to investigate the relationships between foraging strategy and feeding success. Ingested prey were identified to the lowest possible taxonomical level and measured in 1797 larvae and juveniles 4.5 to 55.6 mm standard length collected from 1993 to 2014 in four arctic seas. Prey carbon was estimated using taxon-specific allometric equations. Feeding success was defined as the ratio of ingested carbon to larval weight. Individual trophic-niche breadth (i.e. range of sizes of ingested prey) was defined as the standard deviation of log-transformed prey sizes, with narrow trophic niche indicative of a specialized diet and broad trophic niche of opportunistic feeding. Larvae < 17 mm had narrower trophic niche and higher feeding success in the Beaufort Sea than in northern Baffin Bay and the Greenland Sea, suggesting that superior feeding conditions in the Beaufort Sea (likely linked to the Mackenzie River plume) allowed polar cod larvae to feed more selectively on preferred prey than their congeners in the two other regions. Interestingly, across all regions, larvae < 15 mm (n = 1069) optimally fed at intermediate trophic-niche breadth, a pattern rarely observed in trophodynamics studies.

Larval fish as a predictor of available prey fields for juvenile salmon: successes, failures, and new approaches for salmon management

Richard Brodeur¹, Toby Auth², Elizabeth Daly¹, Brian Burke¹, Cheryl Morgan³
¹NOAA Fisheries, ²Pacific States Marine Fisheries Commission, ³Oregon State University

Summer diets of juvenile coho and Chinook salmon are primarily made up of late-larval and early-juvenile winter-spawning taxa such as rockfishes, sand lance, sculpins, and smelts. Plankton and large trawl nets under-sample these salmon prey in the marine environment, so we investigated whether estimates of larval fish abundance or biomass in the winter and early spring could be used to create an index of food available to young salmon later in the summer. We examined winter (January-March) ichthyoplankton biomass estimates from the Newport Oregon Hydrographic line (NH, 44° 39′ N) from 1997-2016 as a potential indicator of future feeding conditions for young salmon in the marine environment. The relationship between this biomass estimate and salmon survival was relatively strong until recent years when phenological and distributional shifts in spawning of some species occurred due to unusually warm ocean conditions. New indices were derived based on the community composition that provided better predictions for Chinook salmon marine survival. We also explored using these indices for different stocks of salmon and also for other species such as steelhead. In addition, we examined a new index based on larval fish biomass collected during May and June as a predictor for subyearling fall Chinook salmon survival which migrate to sea in summer, much later than the spring Chinook previously investigated. Larval fishes have been shown to be a good indicator of ocean conditions and we believe they can be a useful and cost-effective performance indicator of future fish trophic dynamics for juvenile salmon, and can provide an early warning of major shifts in the availability of food resources and subsequent effects on survival and returns of adult salmon.
Feeding ecology and food web structure of ichthyoplankton at a coastal Gulf of Mexico inlet

Michelle Bromschwig¹*, Polly Hajovsky¹, Simon Geist¹
¹Texas A&M University - Corpus Christi

The availability of food in terms of quantity and quality is an important factor regulating survival of early life stages of fishes, as it determines the rate of development of bodily function and somatic growth. Understanding food web interactions during the larval stage is thus an important component of predicting success of larval recruitment to adult fish populations. Coastal inlets pose a potential bottleneck for larval stages of Gulf of Mexico (GoM) fish species that utilize estuarine bays as juvenile nurseries. The trophic relationships among larval fish were investigated for larvae passing through a south Texas coastal inlet connecting the GoM to Corpus Christi Bay, Texas, during the fall spawning season 2017. We hypothesize that prey supply and diversity will change within a spawning season, which will affect the (1) diet composition of fish larvae, and (2) overall structure of the ichthyoplankton food web. Atlantic croaker (Micropogonias undulatus) was selected as a model species for (1), since it was an abundant species and contained the highest percentage of full guts from collected samples. Diet composition of Atlantic croaker was determined to the lowest taxonomic level possible via stomach content analysis. Food web structure for (2) was assessed using δ13C and δ15N stable isotope analysis of all larval fish species collected.

Maternal diet affects egg DHA content and reproductive energy allocation strategy of southern flounder, Paralichthys lethostigma, within a spawning season

Corinne Burns¹*, Lee Fuiman²
¹Université du Québec à Rimouski - ISMER, ²University of Texas Marine Science Institute

Southern flounder, Paralichthys lethostigma, migrate annually from estuarine to offshore environments in order to spawn. Females likely consume different quantities, proportions and species of prey in the offshore environment than in the estuary, resulting in a change in maternal fatty acid consumption over time, but the effects of dietary changes on egg composition are unknown. Groups of southern flounder were fed a common diet prior to the experiment, switched to a high DHA diet, low DHA diet, or no change (control) diet after the first spawn, and spawned weekly over an 8-week experimental period. Results suggest that southern flounder are mixed breeders and quickly transfer DHA from the diet into the eggs, but also utilize stored DHA to supplement eggs when DHA in the maternal diet is low. Females fed a high DHA diet produced eggs with a significantly higher proportion of DHA than the week 0 mean after 3 weeks on the experimental diet. Females fed a low DHA diet produced eggs with decreasing DHA through 5 weeks, but this trend reversed after week 6 for the remainder of the experiment. The amount of DHA in liver and white muscle tissue from females fed a low DHA diet was significantly less than in control tissues. These results show that the proportion of DHA in southern flounder eggs can change within one spawning season if there is a change in diet at the beginning of the spawning season. Changes in egg DHA within a spawning season could be important to southern flounder survival and recruitment if egg DHA is related to larval quality.
Larval fish strategies in front of stratification in coastal areas

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Day and night vertical patterns of larval distribution were studied fortnightly at a nearshore Mediterranean larval fish assemblage (40m depth), during the spring-summer transition, at two depth strata (above and below thermocline) using bongo-40 nets. The water column was strongly stratified from June on with the thermocline around 20m depth. A total of 12284 larvae (belonging to 48 taxa included in 30 families) were collected. Most larvae belonged to coastal species. Although intra-annual variations in larval density were found (higher larval abundances in May), total larval abundance was always higher during nighttime and above the thermocline. All larvae were measured and taxa divided into pre- and post-flexion groups to disentangle possible differences in how stages deal with stratification. A Self Organizing Map (SOM) was used to extract common patterns of taxa and stages and to analyze relationship between these taxa with environmental variables. The environmental variables explored included module of the current, temperature and wave height as well as biological variables such as micro- and meso-zooplankton biomass and chlorophyll-a. SOM analysis allowed to classify the proportion of larval fish abundance in nine patterns according to its presence during night/day time and above/below thermocline. The predominant pattern coincided with most of the day-below-thermocline hauls. The pattern located in the opposite side of the neural network, occurred during night-below-thermocline hauls at the end of the study period including high percentages of post-flexion larvae and high values of water temperature. Since SOM introduces non-linear correlations in the analysis, the patterns provide new insights on the effect of environmental variables on larval fish vertical distribution and abundances in the area, showing the efficacy of SOM to identify relationships between variables in complex data sets.

Experimental methodologies optimized for examining the scope of responses in early life-stages of marine fishes due to multiple stressors, variable environments, and climate change

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Studies of biological effects of fish early life-stages (ELS) to variable environments, including those associated with a changing climate, will benefit by progressions from descriptive to predictive, and from qualitative to quantitative characterizations of these environmentally induced biotic responses. We describe experimental systems for generating broad-spectrum, high-frequency, and variable environmental factors useful for characterizing biotic plasticity by small-bodied marine organisms. The first apparatus is a thermal gradient block that can generate several dozen different constant thermal regimes for evaluating temperature effects on key ELS responses. The second apparatus uses a novel means of generating a large number of CO₂ environments useful for studying ELS responses to future ocean acidification. The third apparatus, analogous to the CO₂ one, provides a large number of different dissolve oxygen environments. All systems can simulate high-frequency temporal variability including (e.g., daily, tidal), and all have been tested using ELS responses of the estuarine forage fish Atlantic silverside (Menidia menidia). Regarding thermal regimes, embryonic period duration (EPD) decreased as a power function with warming temperature, size at hatch decreased linearly with warming temperatures, and survival to hatch decreased at temperature extremes. Elevated CO₂ resulted in decreased EPD, hatch size was maximal at intermediate CO₂ levels, and both survival and hatch size decreased with increasing variability in CO₂. Lower DO resulted in lower survival, longer EPD, and hatching at smaller sizes; a pattern that was apparent when hypoxia was combined with other stressors (e.g., increasing CO₂). Importantly, accurately characterizing these biological responses is not feasible using experimental designs with few treatment levels and, in many cases, the underlying response shapes would not be unmasked by such designs.
Discovery of eggs from four species of Ophichthidae and Congridae (Anguilliformes) in the northern East China Sea based on DNA barcoding

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Eggs of four species of Anguilliformes were first discovered by genetic identification in the northern East China Sea, where leptocephali and adults have been observed. The species were Ophisurus macrorhynchos and Echelus uropterus belonging to Ophichthidae, and Ariosoma major and Gnathophis heterognathos belonging to Congridae. The eggs were identified using three molecular genetic markers (mitochondrial 12S rRNA, 16S rRNA, and COI), sequences obtained from local adult specimens, and geographic distribution data. Developmental stages of all eggs were in the early or middle. For all species except A. major, the eggs were found near the range of small leptocephali, which indicates these species spawn near the East China Sea.

Impacts of temperature and food availability on the condition of larval Arctic cod (Boreogadus saida) and walleye pollock (Gadus chalcogrammus)

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The Arctic marine environment is rapidly changing with rising sea surface temperatures, declining sea ice habitat and projected increases in boreal species invasions. The success of resident Arctic fish will depend on both their thermal tolerance and their ability to cope with changing trophic interactions. Larval fish energetic condition is closely associated with mortality rates and therefore provides an indicator of overall well-being or fitness. In this study, we experimentally determined larval morphometric and lipid-based condition in an Arctic gadid (Arctic cod, Boreogadus saida) and a boreal gadid (walleye pollock, Gadus chalcogrammus) in response to different temperatures and food rations. Our results suggest that larval condition is highly sensitive to both factors but varies in a species- and ontogenetic-dependent manner. Results indicated that condition metrics based on length-weight relationships were not as sensitive as those based on lipid storage. Further, condition metrics changed with ontogeny and were best used within a developmental stage rather than across developmental stages. As expected, larval condition in first feeding Arctic cod was higher at colder temperatures (2 to 5 °C) than in the boreal gadid (5 to 12 °C). However, at more developed larval stages the peak condition for Arctic cod was at warmer temperatures (7 °C), while walleye pollock had the same thermal optimum as during earlier stages. Arctic cod were more sensitive to food ration at first feeding than walleye pollock, however; at later larval stages both species had a negative condition response to low food ration, especially at elevated temperatures (5 vs 7 °C). The lower thermal tolerance of Arctic cod, coupled with a higher sensitivity to food availability indicates that Arctic cod are particularly vulnerable to on-going environmental change.
A time-series analysis of the larval fish assemblage of the Western Antarctic Peninsula

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The Western Antarctic Peninsula (WAP) is one of the most rapidly warming regions on Earth, and where resulting reduction in sea ice is affecting the pelagic ecosystem. Intensive commercial fishing during the 1970s/1980s and changes in predator dynamics pose additional threats to the stability of the regional fish fauna. However, the potential long-term effects of these ecosystem changes on the abundance of endemic fishes along the WAP is unknown. In this study, we examine a 25-year time series of larval fishes collected in austral summer as part of the ongoing Palmer Antarctica Long-Term Ecological Research program (Palmer LTER) plankton sampling. Larval fish specimens are identified to the lowest taxonomic level possible, at minimum family, and archived at the Virginia Institute of Marine Science (VIMS) Nunnally Ichthyology Collection. We investigate changes in abundance and distribution of 12 families in relation to a variety of physical (e.g., sea surface temperature, sea ice extent, climate oscillations) and biological (e.g., phytoplankton chlorophyll a, zooplankton and penguin abundance) factors. We also investigate temporal and spatial patterns of the keystone species Pleuragramma antarcticum, which is a reliably identifiable species and the only pelagic fish in this community. Preliminary results indicate a decline of P. antarcticum larvae in the northern, sub-Antarctic region of the WAP, where there is a positive correlation between P. antarcticum and sea ice extent. Considerable interannual variation in abundance of individual families is likely related to environmental conditions, which can be used to predict future changes. The results of this analysis are important for understanding and managing fisheries in the Southern Ocean, as climate change impacts the pelagic food web of the region.

Myctophid larval fish assemblages linked to oceanographic conditions in the deep water region of the southern Gulf of Mexico

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In the Gulf of Mexico (GoM), larval fish assemblages have been linked to platform vs oceanic habitats, regions of riverine influence, and mesoscale structures such as cyclonic and anticyclonic eddies released from the Loop Current. Myctophids are one of the mesopelagic fish families with higher biomass and broader worldwide distribution, playing an important role in the trophic structure of oceanic communities. However, studies focused on their larval ecology and distribution within the GoM are limited. We evaluated whether myctophid larval assemblages are linked to oceanographic conditions, surface transport or a reflection of local spawning populations in the southern GoM’s deepwater region. On August-September 2015, 55 zooplankton samples were collected using standard bongo net tows. The stations extended throughout Mexico’s Exclusive Economic Zone (19°N-25°N), including the Yucatan Channel. On average, 24.6% of the standardized larval fish abundance was myctophids, and they were present at all stations. Of four assemblages identified with a Bray-Curtis dissimilarity analysis, the dominant in the GoM was found in stations of the Bay of Campeche (BC) and in the north-central gulf. The high percentage of pre-flexion larvae coupled with differences in hydrographic parameters and predominant surface circulation between BC and the north-central gulf, indicate that local spawning populations contribute to the formation of the assemblage more than environmental conditions in surface waters or transport processes. Stations in the north of the Yucatan peninsula that were located within the region of influence of the Loop Current shared an assemblage, which may reflect biogeographic differences in the species composition of myctophids between the northern Caribbean and western GoM. These results highlight the importance of local spawning and surface transport, and provide insight into biogeographic patterns during the early life stages of mesopelagic fishes in the GoM.
Diet and bioenergetics of early stage sablefish, *Anoplopoma fimbria*, collected from the western Gulf of Alaska in 2017

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Sablefish (*Anoplopoma fimbria*) support a lucrative fishery in the Gulf of Alaska but numbers have declined despite a regulated fishery. Recruitment in *A. fimbria* is poorly understood due to its unusual early life history. Unlike many other deep-water fishes, egg development and the first few weeks of life occur at depth (200–400 m) before an extreme vertical migration, which initiates a prolonged neustonic phase. Once in the neuston, *A. fimbria* larvae and early juveniles can grow as fast as 3 mm/day. Accordingly, food resources of sufficient quality and quantity must be located to support this extraordinary growth rate. However, one facet of the ecology of *A. fimbria* that is relatively understudied is the foraging ecology in the early stages. In this study, we examined the diet of *A. fimbria* collected during a 2017 ecosystem survey in the western Gulf of Alaska (wGOA). The goals of this study are (1) to provide current diet information for this commercially important fishery resource, (2) assess if dietary differences exist among *A. fimbria* collected from different areas of the wGOA, (3) compare this study to historical diet studies conducted in regions outside of Alaska, and (4) examine the link between diet and bioenergetic condition, using a fatty acid analysis. Due to the delayed development of robust feeding structures, we do not expect this species to be selectively foraging. Individuals in the best condition are likely consuming more prey relative to those in poorer condition, regardless of nutritional quality of the prey. The diet data presented here contribute to the ecosystem information that is currently needed for the Gulf of Alaska to successfully understand the impact of environmental factors on the growth and survival *A. fimbria* and develop new management tools to successfully manage this lucrative stock.

Integrated Ecosystem Research Programs and their necessity to elucidate the early life history dynamics of ecological species: An example from the Arctic

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The Arctic waters surrounding northern Alaska (Chukchi and Beaufort seas) are experiencing some of the most extreme reductions in sea ice cover and thickness ever recorded, which has climatic ramifications extending far beyond the Arctic ecosystems. However, little is known about the Arctic, particularly the fishes that inhabit this ice-driven ecosystem. Arctic Cod (*Boreogadus saida*) is the most abundant fish in the Arctic and is an ecologically important forage fish species for sea birds, marine mammals, and other economically important fishes such as salmonids. Although Arctic Cod are not commercially exploited in the Arctic waters of the United States, they have been well-studied in the Russian Arctic, where they are commercially exploited. Ecosystem-based fisheries management (EBFM), which is a holistic approach to managing fishery stocks, considers the impact of fisheries on other components of the ecosystem such as other organisms, the habitat, and the socioeconomics. As an ecologically important species, research into the early life history and ecology of Arctic Cod is necessary in an EBFM framework to sustainably manage the marine mammals and salmonids that rely on Arctic Cod for sustenance, as well as to minimize the impacts from oil and gas development on Arctic Cod Essential Fish Habitat. The Arctic Integrated Ecosystem Research Program (IERP) is an example of an interdisciplinary, multi-institution research project studying the physical and biological processes of the northern Bering, Chukchi, and Beaufort seas. The Arctic IERP is providing data that, until now, has been unavailable. For example, sampling in late spring 2017 provides us with the earliest recorded data of Arctic Cod distribution, abundance, and trophic position. These data complement samples collected in the fall 2017. The data collected during the Arctic IERP provides the foundational data needed to enact EBFM plans in the Arctic and construct life history models for Arctic Cod.
If you build it, will they come? Restoring lithophilic spawning habitat in the Laurentian Great Lakes connecting channel

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Historically, lake sturgeon (Acipenser fulvescens) were abundant in the Laurentian Great Lakes connecting channel, the St. Clair - Detroit River System (SCDRS). However, by 1925 the removal of river bottom substrates greatly reduced spawning habitat and contributed to the decline of lake sturgeon populations in these rivers. To restore functional fish spawning habitat, several reefs (0.1-1.6 ha) have been constructed throughout the SCDRS. Here we examine the adaptive management process used and pre- and post-construction physical and biological monitoring efforts for egg deposition and larvae at these reefs to determine if lake sturgeon, and other species, use the reef for spawning. Eggs were sampled using egg mats and larvae were sampled during nocturnal drift with benthic D-frame nets and depth-stratified conical nets deployed upstream and downstream of the reef. No eggs were collected at reference sample sites prior to construction; however, lake sturgeon eggs were collected on the new reefs material immediately after construction. Examination of larval drift collections downstream of the reef show successful incubation and hatch of the eggs deposited on the reef, indicating that the reef is providing functional spawning habitat for lake sturgeon. Thorough pre- and post-monitoring provides information critical to the adaptive management approach to restoration and to aid the recovery of lake sturgeon in the SCDRS.

Effects of low, subchronic exposure of 2,4-dichlorophenoxyacetic acid (2,4-D) and commercial 2,4-D formulations on early life stages of fathead minnows (Pimephales promelas)

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Aquatic herbicides are commonly used to control a wide variety of algae and plants, while having the potential to contaminate and affect non-target organisms. However, the impacts of low-level 2,4-dichlorophenoxyacetic acid (2,4-D) herbicide exposure on larval fish development, endocrine systems, and survival are not well understood. We conducted a series of experiments to determine the effects of low concentrations (0.05, 0.50 and 2.00 ppm) of two commercial amine salt herbicide formulations of 2,4-D [Weedestroy®AM40 (WAM40) and DMA®4IVM (DMA4)] and pure 2,4-D on the development, endocrine cortisol stress response, and survival of larval fathead minnows (Pimephales promelas). Larval survival (30 dph) was decreased following exposure of eggs and larvae to pure 2,4-D (0.50 ppm; p ≤ 0.001), as well as to WAM40 (0.50 and 2.00 ppm; p ≤ 0.001) and DMA4 (0.50 and 2.00 ppm p ≤ 0.001, p ≤ 0.001). We recorded no differences in baseline cortisol concentrations among the four treatment groups (p > 0.05). We observed an inverse dose response for peak cortisol concentrations: 0 ppm (control), 78 ng/g, 0.05 ppm, 32 ng/g (p < 0.001), 0.50 ppm, 54 ng/g (p < 0.01) and 2.00 ppm, 64 ng/g (p > 0.05). We observed no difference in the amount of time to return to baseline cortisol concentrations (p > 0.05). Present data narrowed the critical window of exposure for effects on survival to the period between fertilization to 14 dph. Morphological development was not negatively altered by any of the compounds tested. However, the commercial formulations increased larval total length and mass at 2.00 ppm. The production of cortisol was inhibited at low environmentally relevant concentrations. Taken together, the results indicate that the use of 2,4-D herbicides for weed control in aquatic ecosystems at current recommended concentrations (< 2 ppm whole lake; < 4 ppm spot treatment) could present risks to fathead minnow larval survival, recruitment, and fitness.
A case study of fine scale habitat use by first ocean year Chinook salmon: implications for growth and predation exposure

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Coastal epipelagic habitats occupied by juvenile Chinook salmon are structured at fine scales by tidal currents, wind, and topography. How juvenile salmon distribution interacts with this structure may have implications for diet, growth, and exposure to predation. We have developed two adjacent (~ 4 km apart) sites in the Southern Gulf Islands (Strait of Georgia, Canada) with differing oceanography as a case study of juvenile Chinook salmon habitat use in late summer and fall of their first ocean year. We characterized the physical and biological oceanography of these sites with a combination of temperature profiles, zooplankton sampling, and hydroacoustic surveys. Using a flexible, low cost, small vessel based approach (microtrolling), we investigated distribution, diet and growth of juvenile Chinook salmon between July and October. We also employed acoustic telemetry to directly measure Chinook salmon movements within and around our study area. Our results suggest that individual juvenile Chinook salmon, even of the same age and stock, behave differently. Differing patterns of habitat use could be related to trade-offs between growth and predation exposure. Predation and failure to reach a critical size prior to winter are two leading hypotheses to explain depressed marine survival of Salish Sea Chinook Salmon. Our work suggests that fine scale processes should be taken into account when evaluating these hypotheses.

Larval fish swimming behavior alters dispersal patterns from marine protected areas in the North-Western Mediterranean Sea

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Most demersal fishes undergo a dispersal phase as larvae, which strongly influences the connectivity among adult populations and, consequently, their genetic structure and replenishment opportunities. Because this phase is difficult to observe directly, it is frequently simulated through numerical models, most of which consider larvae as passive or only vertically migrating. However, in several locations, including the Mediterranean Sea, several larval fish species have been shown to swim fast and orient. Here we use a Lagrangian model to study connectivity patterns among three Mediterranean Marine Protected Areas (MPAs) and compare simulations in which virtual larvae are passive to simulations in which oriented swimming is implemented. The parameterization of behavior is based on empirical data for two groups of species of the economically and ecologically important family Sparidae: species with small larvae (i.e., 9-11 mm), displaying a maximum swimming speed of 6 cm s⁻¹ and a pelagic larval duration of 13-19 days (e.g., Diplodus annularis L., Oblada melanura L.) and species with large larvae (i.e., 14-16 cm), displaying a maximum swimming speed of 10 cm s⁻¹ and a PLD of 28-38 days (e.g., Spondyliosoma cantharus L.). Including larval behavior in the model (i) increased the overall proportion of successful settlers, (ii) enhanced self-recruitment within the MPAs, but also (iii) increased the intensity, and (iv) widened the export of eggs and larvae (recruitment subsidy) from the MPAs; overall, it significantly changed connectivity patterns. These results highlight the need to gather the observational data that are required to correctly parameterize connectivity models and efficiently manage marine resources.
Effect of short- and long-term exposure to low pH and dissolved oxygen on swimming performance of juvenile rockfish

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It has been hypothesized that temperate fish in coastal upwelling regions might be more resilient to ocean acidification and hypoxia, having evolved under natural exposure to low pH and dissolved oxygen (DO) during upwelling events. Yet, how these fish are affected by natural variability in pH and DO over short time scales remains poorly understood, as do the effects of longer term trends in pH and DO driven by climate change. We conducted two sets of experiments to examine whether long-term (two month) exposure to reduced pH and DO affected critical swimming speed $U_{\text{crit}}$ of juvenile rockfish. In the first experiment, pH and DO were manipulated independently over a gradient (pH: 7.8, 7.5, 7.3; DO: 6.0, 4.0, 2.0 mg/L). In the second experiment, intermediate levels of pH and DO were examined in a 2x2 crossed design. Results indicate that $U_{\text{crit}}$ declines under prolonged exposure to reduced pH or DO, but that the effect of DO is stronger and dominates the response of fish exposed to both stressors concurrently. We also conducted experiments to examine whether changes in pH and DO related to upwelling events might have short-term effects on swimming capabilities of juvenile rockfish. These experiments assessed $U_{\text{crit}}$ for juvenile rockfish exposed to reduced pH, DO, or both stressors concurrently for periods of 1 to 24 hours. Results from these experiments were less conclusive. In the first experiment, it appeared that declines in $U_{\text{crit}}$ developed over the course of a few hours, but the second experiment indicated that much of this decline might be related to how long the fish were confined in treatment. Independent of exposure length, these experiments suggest that reduced DO had a stronger effect than pH in reducing $U_{\text{crit}}$ of juvenile rockfish, and dominated the effect of concurrent exposure to DO and pH stressors.

Finding the needle in the haystack: Using lipidomics to explore possible causes of metabolic programming in red drum larvae

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Previous work in our laboratory has shown that ecologically important performance of red drum (Sciaenops ocellatus) larvae is correlated with levels of the fatty acid docosahexaenoic acid (DHA) in larval tissues. The diet of red drum broodstock can be manipulated to change the amount of DHA in the egg which affects the ability of larvae to acquire and/or retain DHA in their body tissues when the larval diet is contains high levels of DHA. This relationship is similar to a condition observed in mammals and referred to as metabolic (or nutritional) programming. In order to better understand the mechanisms of metabolic programming in red drum, manipulated broodstock diets to produce eggs containing DHA concentrations ranging from 25 to 55 mg g⁻¹ DHA. Eggs were reared under common garden conditions and larvae were sampled at 17 and 21 days posthatching (dph). The experiment was conducted independently on two sets of broodstock. Lipid profiles of eggs were measured using gas chromatography and high-resolution/accurate mass (HR/AM) ultra-high pressure liquid chromatography-mass spectrometry (UHPLC-MS), which measured 369 constituents. These variables were explored for relationships with DHA content of larvae at 17 and 21 dph. Sixty three egg constituents were significantly correlated with DHA content of larvae at 17 dph; 56 egg constituents were correlated in 21-dph larvae. Jointly, 18 egg constituents were correlated with DHA content of larvae. Based on the limited data set, these results suggest that particular phosphatidylcholines, triglycerides, and cholesterol esters in eggs may play a role in metabolic programming, but the analysis would benefit from additional experiments.
Overwinter survival and movement of juvenile Atlantic cod (Gadus morhua) in nearshore coastal Newfoundland

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Atlantic cod (Gadus morhua) typically experience high mortality rates during their first year of life. In subarctic Newfoundland, cod settle into coastal habitats in several recruitment pulses throughout summer and fall, resulting in a broad length-frequency distribution prior to their first winter. The first winter likely represents a critical period in cod survival, ultimately determining cohort strength. We evaluated size-structured overwinter survival and movement of juvenile Atlantic cod using mark-recapture techniques. Juvenile cod were marked with fluorescent dyes, Calcein and alizarin red-S, on two separate occasions in October 2016. Fluorescent dyes lay down a colour on the otolith, thus potentially producing two distinct marks in each fish. Fish were captured in May 2017 from the release site and two neighboring coves to determine overwinter movement and survival. Data were analyzed using RMark package, an interface to program MARK. Recaptured fish showed size-structured survival, with 10.5% of marked fish recovered. Marked fish were also identified in a neighboring cove approximately 1.2 km from the release site. Recapture rate was higher than expected. Recaptures in the neighboring cove show evidence of dispersion after winter, signifying the importance of usable habitat throughout Newman Sound, Newfoundland.

The Hurricane Harvey freshwater plume and its effect on the ichthyoplankton community - Introduction to the RAPID Plankton project and historical data from the affected area

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Extreme weather events like hurricanes have tremendous consequences for the impacted areas, including changes in the community structure. In late summer 2017, Hurricane Harvey hit the Texas coast and delivered record-breaking amounts of rainfall to the area around Houston. In addition to the vast amount of destruction on land, it created a large freshwater plume in the adjacent Gulf of Mexico (GoM) waters off the city of Galveston. This plume occurred during September and October, a time of the year which usually sees very little precipitation. A large amount of nutrients also entered the GoM, stimulating late-season primary production in the affected area. We embarked to study if and how the ichthyoplankton community was affected, with particular focus on species with peak reproductive seasons in late summer and fall, such as several members of the family Sciaenidae. This study is part of the collaborative NSF RAPID project titled "Response of plankton assemblages and trophodynamics to a historic, hurricane-induced floodwater plume in a subtropical, pelagic environment". This project investigates the responses of phytoplankton, zooplankton, ichthyoplankton, and the planktonic food web to the plume. Here we present data on ichthyoplankton community composition, taxonomic richness, and diversity in the affected area off Galveston, Texas, prior to the event. For that, we analyzed data collected by NOAA's Southeast Area Monitoring and Assessment Program (SEAMAP) Fall Ichthyoplankton monitoring cruises from 2002-2016. During those surveys, larval fish were sampled through the water column up to a depth of 200 m with a 61 cm bongo net (335 μm mesh) and near the surface using a neuston net (950 μm mesh). These results will provide the baseline against which samples taken 3 weeks, 2, 4 and 7 months after Hurricane Harvey will be compared.
Influence of fine-scale plankton patchiness on larval fish growth in the Straits of Florida

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Fine- (meters) to mesoscale (kilometers) physical processes introduce spatial variability to the pelagic environment, with this "patchiness" being ecologically important across most trophic levels. Dense aggregations of prey may be key for survivorship, increasing larvae-prey encounter rates and enhancing foraging success, which translates to faster growth rates. Yet, examining the spatial distributions of larval fish prey and predators has been challenging because traditional net sampling provides only broad resolution information over large spatial scales. Recent advances in fine-scale sampling technologies now enable the application of in situ measurements to look beyond average scenarios, providing the opportunity to investigate how spatial variability in plankton aggregations influences higher trophic levels. We integrated fine-scale net tows (10's m) with in situ imaging to disentangle predator-prey interactions influencing larval fish growth in the Straits of Florida (SOF). Samples were collected in June 2014 and 2015 in regions of the SOF with varying degrees of prey and predator patchiness. Otolith-derived recent growth was analyzed for four ecologically important larval fish species (the reef fishes Xyrichtys novacula and Thalassoma bifasciatum, and the tunas Thunnus atlanticus and Katsuwanus pelamis), and compared along a regional gradient of plankton patchiness. This integration enabled us to relate larval fish growth to in situ spatial distributions of planktonic prey and predators to answer fundamental ecological questions regarding biological consequences of prey patchiness on larval fish growth.

Distribution of larval fishes, gelatinous zooplankton, and prey in the vicinity of a convergence-induced thin layer in the northern Gulf of Mexico

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Thin layers are dense aggregations of phytoplankton or zooplankton that are hotspots for trophic transfer. High-resolution sampling technologies (e.g., acoustics and imaging) are revealing the ubiquity of these features in coastal oceans, but the mechanisms of formation and resulting biological responses relevant to early stage fishes are still poorly characterized. We used a towed plankton imaging system, along with discrete net and bottle samples, to measure the biological and physical properties of a thin layer in the northern Gulf of Mexico (nGOM) near the 20 m isobath. The < 1 m thick layer had a distinct "arc" shape, spanning 2.5 km between 8 and 4 m below the surface (in the north to south dimension), and was primarily composed of Odontella sp. diatoms. The mesozooplankton community was dominated by doliolids (maximum ~30,000 ind. m⁻³) whose peak abundances tended to track the depth of the thin layer. Larval fishes and copepods were most abundant above the thin layer, becoming increasingly vertically compressed as the thin layer rose toward the surface. Copepod, doliolid, and chaetognath concentrations peaked just south of the thin layer near the surface, but larval fishes were not abundant in this area. Hydromedusae were concentrated just north of the layer ~8 m below the surface. A high-resolution physical oceanographic model indicated that the thin layer was generated by a northward-propagating surface convergence. These conditions occur regularly during the stratified summer season in the nGOM, suggesting that the formation of these layers could be an important mechanism for larvae acquiring anomalously high concentrations of food. The spatial relationships of the larvae to potential predators may be more complicated, with their positioning in response to this convergence influenced by their fine-scale vertical distribution, buoyancy/swimming ability, and possibly competition or predation by other zooplankton.
Larval fish diversity distribution within a coastal marine reserve: What light traps and plankton nets reveal

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The coastal regions of Jamaica provide habitats that are critical for the survival of the early life stages of reef fish. In the marine managed area of Discovery Bay also known as a Special Fishery Conservation Area (SFCA), an understanding of the diversity and distribution of the early life history stages of fish is limited. We therefore investigated the species richness and composition of larval fish by comparing the effectiveness of two types of sampling gear: light trap and plankton net. Using both gear types, we were able to account for approximately 75% of the species present within the bay which comprised of forty two families and forty four species of predominantly reef-associated species of varied sizes. The light traps caught larger but less diverse individuals compared to the plankton net; while the plankton net caught more individuals compared to the light trap. The catch from both gear types were dominated by the families Clupeidae, Pomacentridae, Labrisomidae and Gobiidae while families such as Lutjanidae, Haemulidae and Serranidae, which are considered commercially important, were scarcely caught. We found that gear selectivity, biological and physical factors may have influenced the diversity, size and composition of larval fish caught throughout the study period. A time series analysis detected a seasonal pattern, (using temperature and photoperiod as variables) in larval fish abundance in the sample area with the peak abundance occurring during summer months. Although small temperature increases might favour larval development, the vulnerability of spawning events and growth of early life stages of fish to temperature changes as associated with the effects of climate change, should not be overlooked. The crucial role that larval fish play in the sustainability of our fisheries and the potential impact of climate change and overfishing highlights the importance of incorporating larval fish assessments in the ecological monitoring of marine reserves.

The occurrence of microplastics in the diet of juvenile fish in South Texas coastal bays

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Plastic pollution and the negative consequences of plastics entering marine food webs has gained public attention in recent years. Small pieces of plastic, microplastic (<500 µm), have been found globally in aquatic systems, such as oceans, bays, lakes and rivers. Corpus Christi Bay is a major bay in South Texas, surrounded by a large amount of petroleum-based industries and several cities. One of these cities is Corpus Christi, the 8th largest city in Texas and home to the 6th busiest port in the US. This produces various types of potential microplastic pollution sources. At the same time Corpus Christi Bay is an important juvenile nursery area for several fish species such as redfish (Sciaenops ocellatus), spotted seatrout (Cynoscion nebulosus), Atlantic croaker (Micropogonias undulatus) and anchovies (Anchoa spp). However, a baseline study of microplastic pollution in the water column, ingestion by early juvenile fish and effect on nutritional condition is lacking. Here, we (1) quantified microplastics in the surface water and (2) examined the diet of selected species representing different foraging types. The following hypotheses were tested: (a) microplastic pollution stemming from residential areas will be most abundant, (b) water column filter feeders (Anchoa spp.) will have higher amounts of plastic in their digestive tract than bottom feeders (M. undulatus). Preliminary results show that microplastic pollution is apparent in Corpus Christi Bay and that it is taken up by juvenile fish. In surface water samples microplastic fibers were the most abundant type. Blue colored fibers were the most abundant color and was found in 6% of our M. undulatus stomachs. Waste water treatment plants are the prime suspect to be the source as it is assumed that the majority of these fibers stem from shedding of clothes and enter the bay through. As a next step, the type of plastics found in water and stomachs will be determined by a micro Fourier Transform Infra-red system.
Linking juvenile fish habitat to recruitment: Development of a holopelagic Sargassum index for gray triggerfish management in the northern Gulf of Mexico

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Floating Sargassum habitats are presumed nursery areas for several commercially and recreationally targeted fish species in the northern Gulf of Mexico, including Gray Triggerfish. In spite of its importance, little is known about the environmental and climatic factors that drive variability in Sargassum biomass and distribution, and the role this variability plays in the recruitment of associated fishes. Gray Triggerfish is a federally managed species with a relatively unique life cycle. Larvae emerge from demersal eggs and are planktonic until they "settle" in offshore Sargassum habitats before returning to demersal habitats as larger juveniles. Here, we address the following question: does a "good" Sargassum year equate to "good" Gray Triggerfish recruitment. Using a time series of Sargassum observations (2006-2017) from neuston net samples collected during NOAA Southeast Area Monitoring and Assessment Program (SEAMAP) surveys, we developed yearly and seasonal Sargassum habitat indices using a delta-lognormal model. The habitat indices were then compared to a recruitment index created for Gray Triggerfish in Gulf of Mexico stock assessments to determine the relationship between yearly/seasonal amounts of Sargassum habitat and stock size of Gray Triggerfish. Preliminary results suggest that the Sargassum habitat indices derived from observations during spring and fall surveys correlate well with the abundance of Gray Triggerfish juveniles observed the following summer, albeit only for years when Sargassum biomass was relatively high. Future research will include developing additional Sargassum indices based on remote sensing observations, and testing the efficacy of remote sensing and field-derived habitat indices for inclusion in stock assessments of other managed species associated with Sargassum.

Using mortality and growth rate relationships of larval fish to assess the role of frontal eddies as off-shore nursery grounds

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Sub-mesoscale oceanic eddies which form on the frontal edge of western boundary currents, may act as important off-shore nursery grounds for larvae of coastal fish species. Entrainment of coastal waters pre-conditioned with plankton into frontal eddies may sustain larval cohorts by facilitating increased growth however, previous studies have failed to consider competing effects of growth and mortality simultaneously. We propose an alternative hypothesis that frontal eddies support larvae with a variety of growth rates by entraining cohorts into offshore habitats with low predator abundance and reduced mortality. The size distribution of coastal larval fish commonly shows an increased proportion of larger larvae off-shore, and this trend may be explained by reduced mortality rates. A similar trend is evident in the mortality and growth of zooplankton as suggested by the slope of the biomass size spectrum. Using historic larval samples of 3 commercially important forage fish species from the East Australian Current, growth and mortality metrics are being considered in conjunction with biological and physiochemical oceanic characteristics to establish a biomechanical link between cohort development and their environment, and asses the role of frontal eddies as off-shore nursery grounds. Initial investigations of larval Sardinops and Trachurus catch curves from a 2010 voyage indicate reduced mortality rates in off-shore eddies compared to on-shelf spawning grounds. However, similar variation in mortality is not evident in less abundant Scomber samples of the same voyage, which may reflect difficulties with small sample size and large error explicit in this approach. Findings thus far support the premise that reduced predation plays a mechanistic role in allowing frontal eddies to sustain larval cohorts, highlighting the need to better understand how variation in larval fish mortality and growth determine recruitment success.
The expression of agrp1, a hypothalamic appetite-stimulating neuropeptide, reveals hydrodynamic-induced starvation in a larval fish

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Larval fish suffer dramatic mortality in the days following transition to autonomous feeding, with over 90% of larvae being eliminated within a period of a few weeks. Recent work has shown that the hydrodynamic environment experienced by recently-hatched larvae impedes their feeding rates even under high prey densities. Here, we tested whether these low feeding rates result in acute starvation during this "critical period" in Sparus aurata throughout early larval development (8-23 days post-hatching). We screened three candidate genes agrp1, npy, and hsp70, whose expression was previously shown to respond to starvation in fish. Of the three genes, agrp1 was identified as a suitable indicator for starvation. Localization of agrp1 mRNA by whole-mount in-situ hybridization confirmed that, in S. aurata larvae, agrp1 is expressed only in the hypothalamus. Quantification of agrp1 mRNA using Real-time PCR revealed that the expression of this gene is elevated in starved compared to fed larvae. Manipulating the water viscosity to simulate the hydrodynamic conditions during the onset of the critical period led to increased agrp1 expression. These findings suggest that the hydrodynamic constraints on larval feeding lead to the starvation of small larvae, providing a mechanistic explanation for the 'safe harbour' hypothesis.

Ocean acidification effects on growth and behavior of Pacific cod larvae

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High latitude seas support a number of commercially important fisheries and are predicted to be most immediately impacted by ongoing ocean acidification. However, the responses to these changes by most fishery species, including Pacific cod (Gadus macrocephalus), remain unknown. Elevated CO₂ levels are expected to have a range of impacts, broadly categorized as "direct" (physiological), "indirect" (foodweb), and "interactive" (usually through sensory and behavioral responses). In one experiment, we examined the effects of elevated CO₂ on growth rates of larval Pacific cod over the first 9 weeks of life under two different feeding treatments. Fish at elevated CO₂ levels (1700 µATM) were smaller and had lower lipid levels at 2 weeks of age than fish at ambient CO₂ levels. The differences among CO₂ treatments were not observed among older fish. These results contrast with previous observations on co-occurring larval walleye pollock. In a separate experiment, the phototaxis responses of Pacific cod larvae under ambient and elevated CO₂ levels were examined. Fish at elevated CO₂ levels exhibited a stronger phototaxis response than fish at ambient CO₂ levels, but this effect was only seen in 4-week old larvae. At 8-weeks of age, phototaxis was weaker and not affected by CO₂ level. These experiments suggest a stage-specific sensitivity of Pacific cod to both the direct and interactive effects of ocean acidification. Further understanding of these effects will be required to predict the impacts on fishery production.
Fish larvae assemblages along an intertropical river plume front

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The lifecycle of most teleost fishes includes a planktonic phase, when larvae vulnerability is highest. Several studies suggest that physical-biological coupling, particularly at mesoscale, affects spawning and larval survivor. Thus, structures such river plume fronts dynamics influence ichthyoplankton dispersion and retention to suitable zones for development and survivor. Different larvae species of different affinities converge in this hydrographic structure, as part of different assemblages. The aim of this study was to describe the community structure of larval fish along a transect from the shallow shore zone to the oceanic zone during 2017 winter. The study area is located in the Intertropical Zone of the Mexican Eastern Tropical Pacific, which is a highly river runoffs. The section goes through a perpendicular section from the low steep shelf, a semi-enclosed basin, a seamount, and finally the deep-sea oceanic zone. CTD casts and surface and vertical zooplankton tows were realized. A strong surface thermohaline front was detected farther than expected (~30km from the coast). A spatial gap between surface and 0-200m zooplankton biomass larval fish abundance was found, with higher values of both variables in the stratified coastal side of the front. The coastal side was stronger stratified, while the oceanic one two fish larvae assemblages were found each side of the front, with mainly oceanic species in the deep side of the front, and coastal species in the shallower side. River plume fronts in the coastal zones of tropical seas are important structures in larval fish development and survivor, further seasonal studies should be realized in order to detect the effect of the intertropical marine systems variability in larval fish community.

Larviculture of Kootenai River burbot, Lota lota

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Burbot (Lota lota) is a challenging species for aquaculturists due to its unique early life stage morphology, physiology, environmental biology, and behavior. The Kootenai Tribe of Idaho operates a large-scale conservation aquaculture program to produce burbot for general population restoration; for laboratory studies of early life environmental requirements / tolerances; and for experimental releases of early life stages to investigate the environmental biology in the altered river habitat. The success of larviculture is a major determinant of annual hatchery production. The complicated and unique combination of early life history traits will be illustrated and described. How aquaculturists have accommodated the early life stages resulting in successful hatchery rearing will be discussed.
Fish larvae associations off the west coast of the Baja California peninsula during climate anomalies of 2014 and 2015

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During 2013 to 2016, a series of climatic events developed in the northern hemisphere of the Pacific Ocean that affected the dynamics of the California Current System (SCC). The oceanic region off the western coast of the Baja California Peninsula (WCBCP) was affected in 2015-2016 by one of the most intense El Niño events recorded (comparable with those of 1982-1983 and 1997-1998), which was preceded by the warm water mass that originated in the Gulf of Alaska in 2013, and by a short-lived El Niño event in 2014. Although the effect of those processes on different faunal groups from the north and center of the SCC has been studied, there is still discussion about the effect they had on the southern portion. This work provides evidence of the influence of environmental variables on the distribution of fish larvae associations of the WCBCP during the summers of 2014 and 2015. Based on techniques of classification and ordination using environmental and ichthyoplanktonic data, four associations related to values of high larval abundance of mesopelagic species were found during 2014, where the species richness was contributed by demersal populations in a community dominated by tropical-subtropical species. In 2015 there were five associations related to low values of abundance and species richness in a community that registered an increase of coastal species with a wide faunal affinity.

River herring juvenile population dynamics in coastal ecosystems

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River herring (collectively alewife Alosa pseudoharengus and blueback herring Alosa aestivalis), influence ecosystem and nutrient dynamics as predators of zooplankton and prey for a suite of piscivorous species. Anadromous river herring populations have undergone long-term declines, interfering with ecological processes at landscape scales. Freshwater productivity and ocean processes remain poorly understood, and this inhibits identifying the correct prescriptions towards recovery. I will describe the results of multiple lake surveys, paired (alewife present/absent) lake and laboratory experiments, and modeling efforts that attempt to fill data gaps. Specifically, we will focus on environmental impacts on growth and survival towards ultimately understanding productivity and informing stock assessments in the region. River herring are an interesting species because spawning locations in lakes are isolated across the landscape, providing for replication not typical of larval studies. This replication has provided an ability to test different conditions within years and understand the role of year-year variability.
Relationship between larval growth and survival of Atlantic mackerel (*Scomber scombrus*) derived from juveniles ingested by the Northern gannet

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Atlantic mackerel (*Scomber scombrus*) is a migratory pelagic fish that supports an important fishery in the Gulf of St. Lawrence. However, this stock has experienced a continuous decline in biomass over the past 15 years and is now considered collapsed. The lack of high recruitment events following the last strong year class in 1999 is a key factor that has limited the recovery potential of this stock. Strong recruitment events have been linked to the combination of optimal conditions for fast growth and low selective mortality (i.e., predation) during the larval stage. Currently, a strong year class can only be detected when fish are recruited to the commercial fishery (Age 2). The early juvenile stage currently represents a black box and the effect of mortality beyond the larval stage in setting recruitment strength remains unknown. In this study, we used the northern gannet (*Morus bassanus*), an important mackerel predator, to sample young-of-the-year (YOY) juveniles from the 2015 and 2017 cohorts. Larval growth trajectories were reconstructed using otolith microstructure analysis. To detect potential growth-dependent mortality beyond the larval stage, growth trajectories of YOY juveniles will be compared to that of 1-year-old juveniles from the same cohorts captured the following summer by commercial fishing. Preliminary results suggest that the northern gannet is an efficient "sampling platform" for YOY mackerel. We sampled 94 YOY mackerel in 2015 and 265 in 2017, potentially aged from 1 to 3 months. These collections spanning two annual cohorts will allow the comparison of early growth trajectories between metamorphosis and the pre-winter period, and thus improve our understanding of the contribution of the juvenile stage in shaping year-class strength in Atlantic mackerel. Shedding light into the juvenile-stage "black box" may facilitate the early detection of strong year classes and benefit to the assessment and management of marine fish stocks.

On larval aggregation and Chinese restaurants

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Dispersal by the larval phase of coral-reef fishes is of paramount importance for their demography and ecology. Despite recent advances, some aspects of larval biology remain inaccessible; especially when species-level resolution is required. One such aspect is larval aggregation - a necessary correlate of collective dispersal and a putative driver of chaotic genetic patchiness. To date, empirical evidence for collective dispersal is restricted to a very small number of species, providing little information of the overall pattern in the larval pool. Here we report on the first attempt at a species-level analysis of the extent of aggregation in a regional pool of coral-reef fish larvae. Our analysis is based on 158 ichthyoplankton samples, with a median of 17 larvae and 8 species per sample and total of 220 species. Larval aggregation across species, per sample, was quantified by the 'concentration' parameter ($\phi$) of the "Chinese Restaurant Process" - an analogy to the accumulation of larvae and species during net-tows. We used a Bayesian framework to test two models of the dependence of sample species-richness on sample total-abundance; one with a constant $\phi$ and the second with $\phi$ as an asymptotically-increasing function of abundance. Leave-one-out cross-validation indicated higher support in favor of the second model, which accounted for 73% of the sum-of-squares of sample richness. The positive dependence of $\phi$ on abundance implies that larvae in samples of total abundance tend to be more evenly distributed across species. For comparison, MacArthur's broken stick distribution has $\phi = 1$ whereas our sample-specific estimates of $\phi$ had a median of 5.9. Hence, we conclude that, overall, larvae tend to be found in small same-species aggregates that, when overlapped in space, contribute to larger aggregates of higher richness and evenness. We suggest that these findings provide the first synoptic snapshot of the underlying processes implied by collective dispersal.
Temporal patterns in fish communities, their coherence and response to ocean forcing along the west coast of North America based on analysis of ichthyoplankton time series

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Ichthyoplankton time series from the Gulf of Alaska (GoA) and along the California Current (CC) (Vancouver Island, Oregon, central, southern, and Baja California) were analyzed for patterns of coherence and fish community responses to local and large-scale ocean forcing. Previous studies have reported significant decadal-scale declines in suites of mesopelagic taxa, highly correlated with declining midwater oxygen concentrations, and also the decline of several dominant CC endemics, such as northern anchovy, Pacific hake, and rockfishes, associated with changes in temperature, upwelling, and transport of the CC. Off Baja California, a similar assemblage of mesopelagic fishes was similarly correlated with midwater oxygen conditions from 1951 to 1978, when sampling was interrupted. When sampling resumed in 1998, tropical-subtropical mesopelagic taxa adapted to low-oxygen conditions became increasingly abundant despite declining oxygen concentrations. Examining coherence between the waters off California, Oregon, Vancouver Is., and Alaska, the dominant taxa within the CC generally exhibit coherent responses, although there is also a tendency for taxa to show opposite trends at the extremes of their range. However, the trend for the dominant fishes in the GoA generally appears to be out of phase with that in the CC. Temperature was the variable most consistently correlated with these patterns, consistent with the expectation that taxa are affected oppositely at the northern and southern extremes of their ranges.

Spawning behavior of Atlantic herring (Clupea harengus) and its dependence on littoral macrophytes

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In contrast to the majority of small pelagic fish species often spawning pelagic eggs in the open ocean, Pacific and also numerous Atlantic herring populations rely on littoral spawning grounds in sheltered coastal and transitional waters. Both species produce extremely adherent eggs which are usually attached to benthic structures on the spawning beds. Atlantic herring in the Baltic Sea spawns annually during spring time and major spawning beds are mostly situated in mesohaline waters of river estuaries, lagoons and bays. We investigated the role of the corresponding resident macrophytes as spawning substrate by combining field investigations with experiments in an important herring spawning area in the Southern Baltic Sea. An intensive semi-quantitative grid sampling on a known spawning bed showed a clear relation between the macrophyte coverage and the amount of spawn found per area, indicating that the spawning intensity of herring strongly depends on the general availability of macrophytes. In an experimental approach, where different macrophyte types were offered as potential spawning substrate in parallel, the spawners showed a clear preference for specific plant species. Considering these specific responses to the availability of particular macrophytes for spawning, we conclude that ongoing changes of coastal ecosystems, including habitat fragmentation and losses of macrophyte meadows, have a high potential to negatively affect the successful reproduction of important ecosystem components, including economically relevant species such as herring.
Use of algae and clay in rearing larval sablefish (*Anoplopoma fimbria*)

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In marine aquaculture, turbid water is required to successfully rear larvae of many marine species. Turbidity is commonly achieved by adding algal paste to seawater, but algae is expensive and can decay in rearing tanks. We tested whether inexpensive, inorganic clay could substitute for algae in the rearing of larval sablefish (*Anoplopoma fimbria*), as has been demonstrated for some other species. We found that while algae led to superior survival in the first week after first feeding, switching from algae to clay at the start of the second week led to improved growth and survival compared to rearing larvae in algae for the entire larval period. To explore why algae might be superior to clay in the first week after first feeding, we conducted experiments to test possible mechanisms through which algae may be beneficial to larvae. In the ocean, dimethylsulfoniopropionate (DMSP) is released by phytoplankton upon grazing by zooplankton and has been shown to stimulate feeding behaviors in some planktivorous fishes and birds. Some species of algae used in aquaculture might also contain DMSP and stimulate feeding in larvae. To test the hypothesis that DMSP might increase survival around the first feeding stage, we reared larval sablefish for one week in varying concentrations of DMSP. DMSP at 10⁻⁷ M increased larval survival by 70% compared to the treatment with no DMSP. Follow-up studies on DMSP effects on feeding were inconsistent and suggested that DMSP effects on feeding may vary depending on larval age or other factors. Larvae also might derive nutrition from consuming algae directly, as has been shown in other species. To explore this hypothesis for larval sablefish, we withheld live feed (rotifers) from larvae either in the presence of algae and clay, or in the presence of clay alone. Larvae showed higher survival rates in the former treatment, but only when the experiment began with young larvae.

Variation in behavior of larval fishes as bet hedging

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Since the late 1990s, laboratory and in situ we have learned that swimming, orientation, and behavioral and sensory capabilities of larval marine perciform fishes are remarkably strong for much of their pelagic larval duration. This changed the way we view larval dispersal in these fishes, and it is increasingly recognized that behavior of larvae plays an important role in dispersal outcomes. Studies on fish-larvae behavior, particularly in situ, routinely find significant relationships between swim speed or depth and size of larvae but there is always high variability associated with the relationships. Some larvae have a more meandering swimming path through the ocean than others and therefore pass over different demersal habitat, and have a slower net swim speed than more directional swimmers. Also, fish larvae often have significant among-individual swimming directionality, but invariably many individuals swim in directions other than the overall mean. These variations mean that a proportion of larvae will have different dispersal outcomes than the majority. The minority with different dispersal outcomes due to variation in behavior can be regarded as contributing to bet-hedging and to colonizing new localities as they will be at different locations than the majority, either in direction or distance from their origin, at settlement. Theoretical considerations commonly cite bet hedging and colonization of new localities as reasons for the evolution of a pelagic larval dispersal stage in demersal species. I will present examples of behavioral variation in marine perciform larvae, and discuss the implications of it for bet-hedging. Such behavior - particularly orientation - depends on good sensory abilities. But, ocean acidification due to anthropogenic input of pCO₂ causes sensory dysfunction, and is predicted to strongly degrade sensory abilities of larval fishes by the middle to end of the century, with serious implications.
Understanding and predicting climate change impacts on yellow perch recruitment in Lake Erie

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Climate change has been altering physicochemical conditions throughout the North American Great Lakes basin. These changes are expected to alter the capacity of these ecosystems to support existing fish communities and the cultural and economic services that they provide. At present, however, our understanding of how climate change has been affecting most Great Lakes fish populations remains limited. Herein, we discuss our ongoing efforts to identify the impact of climate warming on Lake Erie yellow perch (YP; Perca flavescens) survival to the age-0 juvenile stage, which is a strong predictor of recruitment to this system’s recreational and commercial fisheries at age-2. First, we summarize results from analyses of historical recruitment datasets (1969-2016), contemporary spawning data, and laboratory experiments, which (1) show that climate warming can negatively affect YP recruitment and reproduction, and (2) led us to hypothesize that failed recruitment is also caused by a temperature-driven phenological mismatch between the production of larval YP and their zooplankton prey. Second, we test this latter hypothesis using historical zooplankton and ichthyoplankton time-series data from multiple Lake Erie local larval YP production areas. Finally, we combine the knowledge gained from this suite of investigations with modeling projections of YP recruitment under climate scenarios (through 2065) to show why we expect the frequency of strong YP recruitment events in Lake Erie to continue to decline into the 21st century.

Spatial risk: Influence of piscivorous fish on selection of nursery habitat by Age-0 juvenile cod

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Fish experience elevated levels of predation during their early life history stages. Upon reaching the juvenile stage, Atlantic (Gadus morhua) and Greenland (G. ogac) cod reduce their predation risk by settling into coastal eelgrass nursery beds. Although these nursery habitats restrict predator movements, predation mortality nevertheless remains high. This pattern suggests that habitat adjacent to eelgrass beds may hold a greater predation risk than eelgrass beds. Juveniles must balance their need for food with predation avoidance, and movement of predators may therefore influence the distribution of juveniles. We characterized habitat and the distribution of Age-0 cod among habitat types through video transects. To determine how predators shaped habitat use by Age-0 juvenile cod we tagged a total of 37 predators (Age-1+ G. morhua, G. ogac, cunner Tautogolabrus adspersus and shorthorn sculpin Myoxocephalus scorpius), and used acoustic telemetry to determine their habitat use. Age-0 juvenile cod utilized shallow-water eelgrass beds less than 7-m deep, whereas predators predominantly occupied the habitat surrounding eelgrass. From these results we infer that eelgrass habitat indeed provides protective habitat for Age-0 cod, but predators may nevertheless exert a reduced predation effect by focusing on the periphery of protective habitat.
Differential persistence favors habitat preferences at settlement that determine the distribution of a coral reef fish

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A central focus of population ecology is understanding what factors explain the distribution and abundance of organisms within their range. This is a key issue in marine systems, where many organisms produce dispersive larvae that develop offshore before returning to settle on benthic habitat. We investigated the distribution of the neon goby, *Elacatinus lori*, on sponge habitat and evaluated whether variation in the persistence of recently settled individuals (i.e., settlers) among different sponge types can result in habitat preferences and establish their observed distribution. We found that *E. lori* settlers were more likely to occur on large yellow tube sponges (*Aplysina fistularis*) than on small yellow sponges or brown tube sponges (*Agelas conifera*). An experiment seeding settlers onto multiple species and sizes of sponge habitat revealed that settlers persist longer on large yellow sponges than on small yellow sponges or brown sponges. Habitat preference experiments also indicated that settlers prefer large yellow sponges over small yellow sponges or brown sponges. Settlers achieved these preference behaviors using visual, but not chemical, cues. Finally, new settlers arriving from the water column were more likely to occur on large yellow sponges than on small yellow sponges or brown sponges. Habitat preference experiments also indicated that the observed habitat preferences existed independent of prior experience. These results support the hypothesis that *E. lori* have evolved behavioral preferences for sponge habitats that will maximize their post-settlement persistence, and that decisions at settlement will shape the population level pattern of settler distribution on coral reefs.

Comparing adult and larval red hake distribution patterns to determine stock structure in the Northeast US Atlantic Shelf Ecosystem

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Red Hake, *Urophycis chuss*, is managed as two stocks: a northern stock in the Gulf of Maine and a southern stock in Georges Bank and area south. Historically, the distribution of spawning did not factor in to the establishment of management stocks because adult sampling only occurs during a portion of the spawning season, and the larvae of three *Urophycis* species, Red Hake, White Hake, and Spotted Hake, could not be separated. After identifying morphological traits to separate the three species, we analyzed species-level data from the Northeast Fisheries Science Center’s shelf-wide Ecosystem Monitoring survey from the peak spawning season, July-September, during six years spanning three decades. The areas of high larval abundance were identified using hot spot analysis (Getis Ord Gi* statistic). We will present analyses examining larval and adult fish distributions with age-structure and growth of adults and relate the patterns to the two-stock hypothesis used in management versus a single stock hypothesis with seasonal or age-based migrations. By examining data from both the larval and adult-stages, we are able to understand the life history and migratory patterns of the species with available monitoring data, overcoming the limitations of the narrow seasonal sampling of the adult population.
Trophic niche overlap in native and alien clupeiform larvae in the eastern Mediterranean

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Larval clupeiforms have similar eco-morphological characteristics, and they have adapted to different spawning times and areas in the Mediterranean Sea in order to avoid inter-specific competition during early life stages. *Etrumeus golanii*, which is a well-established non-native clupeiform in the eastern Mediterranean, has broken this segregation and coexists with *Sardina pilchardus* in the coastal ichthyoplankton assemblages in winter period. In this study, stomach contents of 104 *E. golanii* and 90 *S. pilchardus* larvae were examined to investigate comparative feeding ecology and trophic niche overlap of two species. The rate of full stomachs and median number of food items per larva were significantly higher (p<0.001) in *E. golanii* (85%; 3 item/larvae) than *S. pilchardus* (61%; 1 item/larvae). Whereas mean of log₁₀-transformed prey width was significantly higher in *E. golanii* (p<0.001), its standard deviation, trophic niche breadth was higher in *S. pilchardus* (p<0.001) due to the ingestion of phytoplankton. Regarding to diet composition, the diversity of food items was higher in *E. golanii*. The most important prey item was nauplius stage of copepods for the both species. Following important items were phytoplankton in *S. pilchardus*, adult and copepodite stages of calanoids in *E. golanii*. Horn's index was 0.67 that revealed a strong overlap between the trophic niches of two species. These findings indicate that feeding habits of investigated species could lead to competition for the similar resources.

Fishery threats the spawning aggregations of mottled groupers (*Mycteroperca rubra*) in northeastern Mediterranean

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Groupers are one of the most important fish species of the coastal ecosystems. Their populations are decreasing all over the world mainly due to overfishing. Fishery pressure on spawning aggregations constitutes an important threat on their sustainability. In this study, we combined the data from ichthyoplankton surveys with local fishermen’s knowledge in order to investigate (1) the overlap between fishery and spawning of mottled groupers (*Mycteroperca rubra*, MG), and (2) to detect the important periods and areas which can be proposed for fishery restrictions in Iskenderun Bay, the northeastern Mediterranean. Larval MG were detected in April (30.75±27.26 (±sd) larvae/m²), May (12.64±4.00 (±sd) larvae/m²) and June (17.57±10.21 (±sd) larvae/m²). Local fishermen reported that this period was also the peak season for grouper fishery in the area. In addition, we detected a spatial overlap between spawning aggregations of MG and grouper fishery around the northwestern coasts of Iskenderun Bay. In conclusion, fishery pressure on spawning aggregations seemed to be an important threat, and mentioned area could be proposed for a temporal fishery restriction as a management strategy plan for mottled groupers.
Plasticity in animal migration is a key attribute that allows for flexible responses to unstable environments and climate change. Salmonids are classic examples of migratory organisms that exhibit a variety of life histories, enabling them to exploit a wide variety of environments across mid- to high-latitude environments, and contributes to their success as invasive species. One of the most variable and invasive salmonid species is brown trout (*Salmo trutta*). Brown trout exhibit a variety of life strategies, migratory tactics and may occupy lentic, lotic, estuarine and sea environments as adults. However, a common feature of all brown trout life histories is that spawning and early juvenile stages always occur in cold, well-oxygenated streams. If downstream juvenile migration occurs, then upstream migration back to spawning streams is required to complete the brown trout life cycle. Our study focused on the factors initiating juvenile downstream migration, specifically testing the hypothesis that juvenile competition for resources initiates migration. Juvenile trout density, growth, migration intensity and food supply were measured *in situ* in streams in which migratory or resident trout population were present. Preliminary assessments suggest that as juvenile brown trout grow, population densities will become unsustainable in streams that support migratory populations, whereas juvenile trout densities are significantly lower in streams supporting resident populations. The results of bioenergetic modeling predicting carrying capacity in relation to habitat complexity, temperature, and food supply will be presented and compared to actual juvenile brown trout densities present in migratory and non-migratory streams over summer and into autumn.

Spatial and temporal variation in recruitment of amphidromous gobies on the island of Hawaii

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Amphidromous native fishes play an important role in Hawaiian stream ecosystems and were an important cultural resource. There are five endemic species, four in the family Gobiidae, *Awaous stamineus*, *Lentipes concolor*, *Sicyopterus stimpsoni*, *Stenogobius hawaiiensis*, and one Eleotridae, *Eleotris sandwicensis*. There is minimal monitoring of recruitment or adult populations, and the last known study of larval ingress was completed in 1995. Observational data indicate that recruitment levels may be declining, potentially due to changes in land use, climate, and water diversion. Therefore, we examined spatial and temporal variation in recruitment along the Hamakua Coast on the Big Island. In 2015 and 2016, recruiting larvae were sampled hourly for 24 hr at 3 estuaries for 5 to 7 months. One location, Hakalau Estuary, was sampled extensively in 1994-1995, which provided a comparison with contemporary recruitment. We also sampled recently recruited *L. concolor* (*O'opu alamo'o*) at one location, Ka'awa'li'i Stream, monthly for 10 months to examine temporal variation in recruitment. We observed very low levels of recruitment (<1 fish/hr) at all 3 estuaries. In the Hakalau Estuary, the current catch (mean fish/hr = 0.96 (0.92 SD) was nearly 10x lower than in 1994-95 (mean = 8.94 (11.86 SD). The species composition also differed with much lower representation of *L. concolor* in recent collections (mean percent contribution = 42% (28.7% SD) in 1994-95 versus 7.3% (8.4% SD) in 2015-16). At Ka'awa'li'i Stream, *L. concolor* recruits were present every month sampled. Otolith analysis of those recruits indicated that size at metamorphosis and pelagic larval duration were negatively correlated (*r* > 0.60) with ocean temperature during the larval phase. These findings underscore the conservation challenges associated with endemic island fish fauna and have implications for dispersal and connectivity as the ocean continues to warm.
Assessment of the larval fish community in the Solitary Islands Canyon off south-eastern Australia and its potential role in cross shelf movement of larvae

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As part of a preliminary assessment of the biota of the Solitary Islands Canyon off south-eastern Australia in June 2015, the larval fish communities were sampled twice at three locations (outer, middle and inner sections) in a transect along the canyon. At each location, replicate depth stratified samples at the surface, 0-50 m and 50-100m water depth were collected. The larval fish community in the canyon was diverse with a total of 72 taxa caught, with 42 taxa in neuston samples and 65 taxa in oblique samples. Approximately 5,000 larvae were caught in the canyon with slightly higher numbers in oblique compared with neuston samples. The neuston samples were dominated by eel leptocephali, followed by myctopids, notosudids, Gonorrhynchus greyi, Scombersox saurus and Engraulis australis. Obliques samples were dominated myctopids followed by notosudids, gonostomatids, phosichthyids and labrids. Individual taxa showed variable patterns of abundance across locations within the canyon and water depths. Patterns of distribution of different taxa along the canyon will be described and the potential role of the canyon in facilitating movement of larvae across the continental shelf will be assessed.

Contribution of an inshore nursery area to the Atlantic herring (Clupea harengus) population in the Western Baltic Sea

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Although the understanding of fish migration patterns and population structure is crucial for a successful fishery management, there is still a lack of knowledge on spatial habitat connectivity of economically important clupeid fish species, such as herring. Atlantic herring (Clupea harengus) in the Western Baltic Sea rely on inshore coastal spawning grounds, attaching their benthic eggs predominately to submerged aquatic vegetation. Hence, herring early life stages are vulnerable to multiple stressors, acting on a local scale of important spawning grounds. Since recruitment of Western Baltic herring population decreased during the last two decades, estimations on the contribution of single herring spawning areas to the overall Western Baltic herring population are vital to evaluate their potential function as nurseries. We used elemental fingerprinting in 0-group herring otoliths from four different spawning areas along the Western Baltic coastline to identify habitat-specific chemical signatures and combined these natal fingerprints with otolith core signatures from adult herring to investigate the contribution of single spawning habitats to the overall population. Analysis revealed that the contribution of one main spawning area to the adult population was high but varied between the years. Moreover, analysis on herring homing behavior showed that Atlantic herring in the Western Baltic Sea return to their natal spawning areas with some straying individuals from other areas. With respect to the high anthropogenic impact on coastal inshore waters, these findings highlight the essential function of local spawning habitats for the persistence of herring populations and support the need for sustainable coastal zone management strategies.
Exploring the link between metabolism and growth in marine fish larvae

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Certain physiological traits may confer fish an advantage to cope with environmental stressors. Metabolic flexibility has been suggested to be one of these key traits, but its role in early life stages has never been investigated. In this study, we first measured changes in standard metabolic rate (SMR) in Atlantic herring (Clupea harengus) larvae under different levels of feeding (ad libitum vs no prey added) and temperature (5, 7, 10°C). Larval SMR decreased up to 37% after larvae experienced three days of sub-optimal feeding conditions. Inter-individual differences in SMR and nutritional condition (RNA–DNA ratio) were unrelated. In a second experiment, inter-individual differences in SMR were not explained by short-term (otolith marginal increment width) or long-term (size-at-age, otolith diameter-at-age) indicators of growth rate in well (ad libitum) fed larvae. In those larvae, however, a significant, negative relationship existed between SMR and otolith core diameter (formed between hatching and first feeding). The present results suggest that metabolic flexibility can exist, particularly when larvae experience contrasting feeding environments, which needs to be taken into account when evaluating factors affecting larval growth and survival in future ocean environments. Also, this research highlights the potential benefits of combining the various "loggers" of individual growth (RNA-DNA ratio and otolith microstructure) to explore links between growth and metabolism.

Left high and dry: the importance of getting off the beach for capelin survival

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Capelin (Mallotus villosus) is a small forage fish that plays a key role in the transfer of energy from secondary producers to vertebrate predators in Arcto-boreal food webs. Profound changes in abundance and distribution of capelin occurred in 1991 in Newfoundland, which corresponded with the collapse of the groundfish stocks. Capelin biomass has yet to return to pre-1991 levels. Capelin spawn on beaches as well as in nearshore demersal areas (<40 m water depth). Previous research found that capelin larval survival and year-class strength was related to onshore winds, which act as a mechanism to release larval capelin in pulses from the beach sediments. However, post-1991, which has been characterized by small adult size and late spawning, there is now a mismatch between capelin spawning and onshore wind events. Capelin larvae are now stuck for longer periods on the beach. I characterized the magnitude and duration of larval pulses from the beach into the nearshore area post-1991 and related to age-2 recruitment. For the years 2001-2016, three variables explained 91% variation of age-2 recruitment: spawning times, duration of the larval pulses from the beach, and larval prey availability (Pseudocalanus spp.). This suggests that earlier spawning times, longer duration of larval pulses over the emergence period, and increased prey availability for larvae in the nearshore area are all important for increased survival of capelin post-1991. Unfortunately, most years are characterized by late spawning, which is likely inhibiting the recovery of this important forage fish species.
Early life stages of the northern sand lance *Ammodytes dubius* show high sensitivity to acidification and warming in a CO₂ × temperature factorial experiment

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Fish early life stages are potentially vulnerable to ocean acidification, yet divergent responses are well documented across similar species and even populations. This variation may reflect local adaptation to existing CO₂ variability prevalent in many coastal systems. For example, populations that spawn in shallow and highly productive systems like saltmarshes likely produce offspring capable of tolerating large, biologically driven CO₂ fluctuations typical during spring and summer. Conversely, fish that spawn in the open-ocean or during winter generally experience more stable CO₂ conditions during early life and may lack adaptations necessary for high CO₂ tolerance. We conducted a factorial CO₂ × temperature exposure experiment on offspring of the northern sand lance *Ammodytes dubius*, an ecologically important forage fish that spawns on the northwest Atlantic shelf in early winter. Spawning-ripe adults were collected from Stellwagen Bank National Marine Sanctuary. Fertilized embryos were reared at two temperatures (5° and 10°C) crossed with three CO₂ levels (~400, 900, and 2,000 µatm). At both temperatures, embryo survival at 400 µatm CO₂ was high (80% at 5° and 75% at 10°C), but we observed a significant survival reduction in elevated CO₂ treatments. At 5°C, embryo survival was 19% and 36% at 900 and 2,000 µatm, respectively. At 10°C, a larger reduction was found, with embryo survival near 0% at both elevated CO₂ levels. These results closely match findings from a preliminary experiment conducted in 2016. Together, these studies indicate embryos of *A. dubius* may be highly sensitive to the combined stressors of acidification and warming. Furthermore, the contrasting CO₂ sensitivity of *A. dubius* to other temperate forage fish (i.e. *Menidia menidia*) suggests life history characteristics, like spawning habitat and phenology, might influence early life CO₂ tolerance.

Interannual variation of mesopelagic larval fish assemblage in the Southeast Brazilian Bight

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Mesopelagic fish larvae were collected in the Southeast Brazilian Bight (SBB) (23°S-25°S) during nine oceanographic summer cruises, performed between 1974 and 2002. A total of 6603 mesopelagic larvae were sorted from 117 samples, representing 13 families, 33 species or types, belonging to 26 genera. *Maurolicus stehmanni* was the most abundant species, and accounted for 33% of mesopelagic fish larvae, followed by *Diaphus* spp. (17%), *Myctophum affine* (12%), *Polichthys mauli* (5%), *Cyclothone* spp. (5%), *Lepidophanes guentheri* (2%), *Vicinguerria nimbaria* (2%) and *Lestidium atlanticum* (2%). The El Niño Southern Oscillation (ENSO) influence was most evident during the shift from La Niña (1974-1975) to El Niño (1976-1978) because the mean diversity, richness and abundance greatly increased from one period to another. Moreover, during El Niño events, offshore taxa (e.g. *Cyclothone* spp., *H. reinhardtii*) were more widespread toward shallower areas than during La Niña. Cross-shelf and interannual differences in the composition of mesopelagic fish were related to the Brazil Current and the distribution of Tropical Water and South Atlantic Central Water in the SBB. Although the ENSO influence on variation of mesoscale mechanisms in the Brazil Current is not clear, it is possible that during El Niño years more larvae of offshore species are transported to the shelf of the study area. Further studies on interannual variability of mesoscale activities comparing ENSO events would bring valuable information that may confirm or dismiss this hypothesis.
Advances in our understanding of juvenile fish ecology: A challenging area for field sampling and experimentation

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Our current understanding of juvenile fish ecology is generally much less than for the adjacent life stages i.e. pre-metamorphosis and post-maturation (adult). With the exception of a few species this is partially brought about by our inability to effectively and efficient sample this life stage in the field. The causes are many fold, ranging from inappropriate equipment e.g. gear designed for sampling either larvae or adults rather than life stage specifically designed equipment to juveniles occurring in areas which are very difficult to sample e.g. mixed in with a very wide range in size of other organisms, in deep water, over very rough or hard topography, or in surf zones. A further sampling challenge in regard to understanding juvenile ecology is associated with the logistics of sampling both juvenile predators and prey and undertaking this in a quantitative and unbiased manner. Here we will explore the advances made in flatfish ecology, mainly in relatively shallow water and highlight some of the challenges with investigating offshore nursery areas. Where appropriate we will also examine some of the challenges with respect to other fish species and their different life styles.

Analyses of multispecies ichthyoplankton data along the US west coast as indicators of ecosystem changes

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Ecological indicators can be used to track ecosystem change and assess impacts from natural and human mediated pressures. Ichthyoplankton data are particularly useful for assessing temporal ecosystem changes as they respond quickly to environmental variability and furthermore may provide a link to fish recruitment dynamics. However, what has so far only been tentatively explored is the use of multispecies larval indices as ecological indicators. Here, we combine ichthyoplankton time-series from long-term monitoring programs ranging from California to Alaska, to identify if ichthyoplankton data can be used as indicators for tracking and predicting marine ecosystem dynamics. Specifically, we analyzed ichthyoplankton time series data from the Gulf of Alaska (33 years) and the Northern and Southern California Current (Oregon 20 years, California 63 years). Dynamic factor analysis and chronological clustering analysis was used to assess common trends in the ichthyoplankton time series data. First, we assessed if there are shared or divergent responses to environmental changes among ichthyoplankton assemblages from different regions. Second, we explored the relationship between fish larvae dynamics and recruitment. Because early life stages of a single species often exhibit high variability, we used analysis of multiple species to assess how data of fish larvae can be used as a leading indicator of future recruitment dynamics of adult fishes of economic importance. By combining extensive time-series data from multiple regions the complementary multispecies approaches can help categorize species synchronies within sub-regions and between Large Marine Ecosystems along the US west coast.
Foraging of juvenile northern anchovy under light backgrounds of different polarization characteristics

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In addition to colour and intensity, light has another physical attribute termed its polarization. The polarization of light refers to the predominant orientation of electric field vibrations of the photons that comprise it. If all the photons have electric fields that vibrate in the same plane, light is termed 100% linearly polarized in that plane (the E-vector plane). Many invertebrates can detect the polarization of light and use it for a variety of purposes including orientation and contrast enhancement of visual targets. The northern anchovy is the only vertebrate with a proven retinal polarization detection mechanism supporting its polarization sensitivity. But the ecological use of polarization vision in the northern anchovy was, until this work, unknown. Here, I filmed young of the year anchovies free foraging on saltwater tolerant Daphnia magna under light backgrounds that differed in electric field (E-vector) orientation and percent polarization (from 0% to 100%). I then analyzed the location distance (LD) and horizontal (LAh) as well as vertical (LAv) angles associated with attacks on Daphnia as measures of anchovy foraging performance. Under light backgrounds with percent polarization as low as 20%, anchovies showed greater LD, LAh and LAv compared with similar measures under 0% polarization. In addition, anchovy attacks under such polarization backgrounds aligned the lamellae of the long cone photoreceptors in the ventral retina with the predominant electric field direction, demonstrating dynamic polarization vision for contrast enhancement of the prey. These results are the first to show dynamic polarization contrast vision in a vertebrate for enhanced foraging performance.

Environmental effects on larval fish ontogenetic vertical migration

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Ontogenetic Vertical Migration (OVM) is described by the changes in the depth of center of mass between early pre-flexion and more developed post-flexion larval stages. This behavior is mainly driven by taxa and ontogeny and is one of the prominent trait retaining larvae near their birth place. When incorporated into biophysical models of larval transport, this particular behavior contributes to change the outcome of the dispersal within sheered flows, decreasing dispersal kernels and changing connectivity patterns. Yet, only a few studies have reported the OVM of fishes and none has so far focused on investigating environmental forcing mechanisms. Here we test the hypothesis that fish larvae are responding to changes in environmental conditions by modifying the center of mass and range of their vertical distribution in the water column. We use an extensive ichthyoplankton survey around the island of Barbados to demonstrate that OVM changes not only between day and night times, but also with water chemistry. This study provides a basis for evaluating expected OVM and dispersal changes in a changing ocean.
Quantifying condition in young-of-year Pacific herring using six metrics

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Quantifying the condition of fish can help researchers understand how fish have responded to changes in their environment, and to estimate the quality of prey that the fish represent to their predators. Although various condition metrics can be used to address these questions, typically no more than one or two are applied on an individual fish in any given study. This study aimed to quantify condition in juvenile Pacific herring (Clupea pallasii) from the Strait of Georgia using six metrics measured on each individual: (i) Fulton’s K, (ii) the residuals from a length:weight regression, (iii) the RNA:DNA ratio, (iv) recent growth via otolith microstructure analysis, (v) lipid content, and (vi) the ratio of DHA:EPA. Metrics were then compared via pairwise linear models to test for correlation. Proxies for morphometry of fish were not correlated with growth indices and were only related to total lipids in fish where lipid content was high. Growth indices were also only conditionally related to total lipids.

This study provides evidence of the different results from condition metrics that test processes occurring at different physiological and temporal scales within a fish. Care should be taken to select the appropriate condition metric for a study, as a fish ranking at the top of the group with respect to one metric will not necessarily rank at the top for all.

Potential effects of phenology shifts on herring (Clupea harengus) recruitment in the Western Baltic Sea

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The past decade included a period of reduced production of larval herring (Clupea harengus) in a nursery area in the Western Baltic Sea, which is considered a major contributor to overall population dynamics. Record low years of recruitment of the spring-spawning herring population went together with exceptionally mild winter conditions. However, water temperatures during the main spawning and larval development phase generally remained below critical values for physiological temperature stress reported in the literature, and direct effects of warming on survival of eggs and larvae are not yet observed. Besides immediate effects on early life stage physiology and metabolism, climate driven shifts of the seasonal timing of reproduction processes (i.e. spawning-hatching-feeding) might significantly affect the year class strength of recruits. We analyzed a multi-decadal time series on larval herring abundance, hypothesizing that according to changes in the climate regime, the seasonal timing of spawning has shifted over time and that the timing of larval hatching is related to annual recruitment success. Results indicate a trend of earlier seasonal occurrence of maximum yolk-sac larvae abundance. Early hatching explained much of the variability of the year class strength expressed as an annual index (N20), which is an established proxy in stock assessment. Along the entire reproduction period, phenology shifts might have affected initial cohorts of hatching larvae. They potentially encountered lower densities of plankton prey since the critical period now occurs prior to the spring plankton blooms. Together with severe eutrophication effects on larval cohorts later in the season, climate change induced phenology shifts might presently structure herring populations in the Baltic Sea.
Drifting and swimming response of Asian carp eggs and larvae to different flow conditions in a laboratory flume experiment

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A series of laboratory experiments was conducted to better understand the drifting and swimming behavior of Asian carp eggs and larvae in both stagnant and moving water. Three rounds of laboratory experiments were conducted using a settling column and a Race-Track Flume (RTF). The settling column was used to estimate ranges of diameters, densities, and settling velocities of eggs, while the RTF was used to determine vertical distributions and traveling and swimming speeds of eggs and larvae, with continuous analysis over a period of ~80 hours. Three different mean flow velocities were applied to the flume, where an initially flat sediment bed was placed in a straight test section. Detailed flow analysis provided evidence of the influence of mean and turbulent flow in the suspension of eggs and swimming patterns of larvae. Findings support the development of strategies for monitoring the spread of eggs and larvae in rivers and provide new inputs to predict conditions favorable for spawning and hatching, allowing for mitigation measures to prevent recruitment in a specific water body.

Sex-specific growth and mortality patterns in juvenile Atlantic silversides (Menidia menidia) from Connecticut waters

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The Atlantic silverside is an important forage fish along the North American Atlantic coast and a well-known model for studies addressing ecological and evolutionary questions. How growth and mortality shape the characteristics of survivors at the end of their growing season, however, is still insufficiently understood. We used otolith microstructure analysis to determine sex-specific size-at-age, growth, and hatch date distributions in young-of-the-year juveniles sampled monthly between October-December 2015 in Mumford Cove in northeastern Long Island Sound. Sex-specific hatch date distributions were examined to test the prediction that temperature-dependent sex determination in this species results in females hatching earlier in the spawning season than males and should therefore be older at the end of the growing season. However, we found no significant differences in back-calculated hatch dates between sexes. Yet, growth back-calculations indicated that female silversides grew significantly faster than males, thereby attaining >2cm larger body sizes than males at the end of the growing season. Furthermore, back-calculated growth trajectories were correlated with temperature, pH, and dissolved oxygen records from Mumford Cove and used to characterize growth patterns of early vs. later born individuals. Repeated collections were used to test the hypothesis that juvenile mortality in fall is biased against smaller, slower growing individuals; hence size-selective mortality significantly alters the characteristics and sex ratios of the populations prior to their overwintering phase in deeper, potentially offshore waters.
Ocean acidification may lead to smaller otoliths in newly-settled winter flounder (*Pseudopleuronectes americanus*)

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Winter flounder (*Pseudopleuronectes americanus*), an economically important flatfish in the northwest Atlantic, inhabits variable carbon dioxide (CO₂) environments during spawning and early life stages. Winter flounder in the Gulf of Maine (GOM) may be especially susceptible to ocean acidification (OA); as a cold water body with freshwater and nutrient loading inputs, the GOM may have less capacity to buffer against acidification. We examined if different OA scenarios would alter otolith morphology of winter flounder during the early life history period. Adult winter flounder were collected from southern GOM, spawned, and larvae reared under different combinations of pCO₂ treatments (482, 860, and 1320 μatm), and temperature (~7, 10, and 13°C). Upon metamorphosis, classified by left eye migration, fish were preserved for otolith analysis. Sagittal otoliths from offspring of one parental lineage (n=68) were extracted, imaged using scanning electron microscopy, and analyzed using ImageJ to measure morphological metrics. Otolith dimensions were analyzed at the three different larval temperature levels for deviations driven by CO₂ from ambient conditions. Under elevated CO₂ levels (1320 μatm) at 13°C, newly-settled winter flounder otoliths were smaller in diameter (X²=7.04, p<0.03), area (X²=6.60, p<0.04), perimeter (X²=6.44, p<0.04), and width (X²=6.06, p<0.05) than those from the other CO₂-temperature treatments. Additionally, no shape changes (circularity, ellipticity, aspect ratio) were observed between any treatments. Although our results indicate that early life stage winter flounder from offshore spawning populations in the GOM are fairly resilient to OA scenarios, these fish may be susceptible to acidified conditions if coupled with increased temperatures. The implications of smaller otoliths in winter flounder are unknown as well as if these morphometric patterns hold true for inshore and estuarine spawners and southern winter flounder populations.
Life in the fast lane: revisiting the fast growth - high survival paradigm during early life of fishes

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The "Growth-Survival" paradigm aims to predict recruitment strength from early life dynamics. A central assumption of the paradigm is that larval growth and survival are positively correlated. The primary methodological approach that has been used for detecting and assessing the effect of growth-selective mortality during the larval stage consists in the comparison of the growth-rate frequency distribution of a given larval population to that back-calculated from the otoliths of juvenile survivors originating from the same cohort. Over the years, this approach provided evidence that fast growth is not always linked to higher survival, suggesting that the current paradigm does not fully capture the complexity of the links between early life growth and survival. We propose a new conceptual framework reconciling these apparently contradictory results. Similar to the traditional approach, changes in the mean and variance of growth-rate frequency distributions are considered as analytical tools to quantify growth-selective losses in a given cohort. Under a random mortality scenario, moderate selection for fast growers is expected to occur based on the stage-duration mechanism. Simple stochastic simulations showed that differences in characteristic of survivors were driven by average and variability in growth rates, mortality rates, and the timing in the establishment of serial correlation in individual growth rates. Year-class strength is increasingly poor as the shift of the growth-rate frequency distribution towards slower or faster growth rates increases. A shift of the distribution towards slower growth rates indicates particularly high larval mortality. The strength of our approach is that it provides a basis for recruitment forecast even in the context of data poor situations. However, the development of further predictive capacity will only be achieved if greater effort is directed toward identifying and quantifying the sources of loss in a given system.
Predation strategies of larval fish capturing evasive copepod prey

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Fish larvae depend on finding and capturing prey for rapid growth during the larval phase. Based on gut contents, the diet of many larvae is dominated by copepods, small crustaceans that are highly sensitive to hydrodynamic disturbances and respond with rapid escape swims. We examined how larvae with immature feeding apparatus, musculature, and fins successfully capture such evasive prey. Using high-speed videography, we recorded predator-prey interactions between larval clownfish (Amphiprion ocellaris) and three developmental stages of the copepod Bestiolina similis (nauplii, copepodites and adults). We analyzed kinematics of strikes that resulted in capture and those in which copepods escaped, using logistic regression and model selection to identify measures most associated with probability of capture success. Escape performance of copepods improved with developmental stage; adults were more likely to initiate an escape response and avoid capture than either copepodites or nauplii. At 1 day post-hatch (dph), A. ocellaris captured nauplii by maneuvering close to the immature copepods, but were unable to capture adults. During the mid-larval phase (6-9 dph), clownfish captured adult B. similis with limited success, as copepod escapes decreased capture success. Through the larval phase (1-14 dph), fish transitioned to capturing larger and more evasive copepods. The developmental stage of prey and interaction between strike distance and peak strike speed were the strongest predictors of capture success. At the closest strike distances, the probability of successful capture was nearly 100% for nauplii and copepodites, regardless of strike speed. At the largest strike distances, fish did not capture adults until reaching the fastest strike speeds. By including kinematics of failed strikes and a range of evasive prey, we are elucidating how specific characteristics of both fish and copepods affect predation strategies and capture success.

Spatial and temporal variability of ichthyoplankton in the St. Clair-Detroit River System: Community changes between the 1970s and 2000s

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Larval fishes are sensitive to abiotic conditions and provide a direct measure of spawning success. We assessed the spatial and temporal variability in the ichthyoplankton community of the St. Clair-Detroit River System (SCDRS), a Laurentian Great Lakes connecting channel with a history of environmental degradation, and compared the modern larval fish community (2006-2015) to that of the 1970s (1977-1978). The larval fish community of the SCDRS was highly structured in time and space. During both time periods we observed a predictable phenology, with taxa from the sub-family Coregoninae dominant in early spring, followed by the families Osmeridae, Percidae, and Moronidae from May to June, and Cyprinidae and Clupeidae from June to August. Many taxa appeared in the Detroit River before the St. Clair River. While higher densities of larval fish and most density "hot spots" were found in the Detroit River, greater taxa richness and Shannon diversity were observed in the St. Clair River. System-wide, fourteen new taxa were observed in the current study period. In addition, relative densities of two non-native species, alewife Alosa pseudoharengus and rainbow smelt Osmerus mordax, declined since the 1970s. The increased larval fish richness and decreased densities of non-native taxa in the 2000s are consistent with improved water quality and habitat conditions.
Larval fish habitats and deoxygenation in the Pacific off Mexico

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The study aim is to determine the actual stage of deoxygenation in the Pacific off Mexico and to detect its effects on larval fish habitats, considering the fish larvae sensitive to dissolved oxygen. From a series of cruises, including a warm event (2003 to 2016), a vertical expansion of suboxic water was detected. The 4.4 µmol/kg oxyleth has risen ~ 100 m off Cabo Corrientes and ~ 50 m near the Gulf of California. Its geographical variability was related with the larval habitat distribution detected from five cruises made from Cabo Corrientes to Gulf mentioned. Two recurrent larval habitats were defined although with variations in extension. One, located off Cabo Corrientes throughout the water column between ~ 4.4 and 220 µmol/kg with Bregmaceros bahthysmater larvae like indicator species. The second recurrent habitat was located between the oxycline (> 44 µmol/kg) and the surface near the Gulf, with Benthosema panamense like indicator species. During a warm event, a tropical larval fish habitat (Auxis spp.) was detected, which modified the larval habitat distributions. These results indicate a differential response of the fish larvae to the dissolved oxygen concentrations and the interannual events, showing some species characterized by a high resilience to environmental changes.

Possible contribution of submarine groundwater on coastal fisheries production: increase in feeding and growth of juvenile marbled flounder Pseudopleuronectes yokohamae in a cage experiment

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In order to detect possible effects of submarine groundwater discharge (SGD) on fish feeding and growth, a cage experiment was conducted in Seto Inland Sea, Japan. Juvenile marbled flounder Pseudopleuronectes yokohamae dominate fish community on tidal mudflat of the coastal waters of central Seto Inland Sea from February to May. Sixteen cultured juveniles (49.7 mm in total length) were kept in a cage (0.45 x 0.45 x 0.3 m, 10 mm mesh) for each. Juvenile growth rates for two weeks were compared between two sites with high and low SGDs which were evaluated by the use of radon (222Rn) concentrations in the water. Water temperature was monitored with a data logger at each site. Carbon-based primary production of benthic microalgae was compared between the two sites. Abundance of major prey for the juveniles were examined by towing a sledge-net (0.4 x 0.3 m, 0.3 mm mesh) for 20 m at each site (four replicates). Stomach contents of the juveniles were analyzed at the end of the experiment. Water temperature ranged between 16 and 19°C during the experiment and was slightly lower at the site with high SGD. Carbon-based production of benthic microalgae was significantly higher at the site with high SGD. Stomach contents of the juveniles were dominated by gammarids at the site with high SGD and molluscs at the site with low SGD. Dry weight of stomach contents of the juveniles was significantly higher at the site with high SGD. Juvenile growth rate was higher at the site with high SGD. We concluded that the SGD had positive effects on feeding and growth of the juvenile marbled flounder.
Preliminary insights on the knock-on effects of harmful algal blooms on dominant larval fish and zooplankton species in a warm temperate estuary, South Africa

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Eutrophication is a global threat to aquatic ecosystems. While phytoplankton blooms have been the focus of many studies in estuaries, far less have been assessed regarding the effects on higher trophic levels. This study assessed the responses of the larval stages of a common clupeid (Gilchristella aestuaria), its main zooplanktonic prey (Pseudodiaptomus hessei and Paracartia longipatella) and the main zooplanktonic predators (Mesopodopsis wooldridgei and Rhopalophthalmus terranatalis) during the development and decay phases of harmful algal blooms in a warm temperate estuary in South Africa. Physico-chemical data, larval fish, zooplankton and phytoplankton samples were collected for one month under peak bloom conditions in summer. Three distinct phases of the harmful algal bloom, namely "bloom", "decay" and "intermediate", were identified associated with Heterosigma akashiwo. Zooplankton density declined during the decay of the bloom when biologically stressful oxygen concentrations (>2 but ≤5 mg·l⁻¹) predominated. Peak densities of larval G. aestuaria and their copepod prey became mismatched. There was a near absence of larval grow-out beyond late postflexion. Analyses showed that during the decay of the bloom, rank abundance shifted and was significantly different to the bloom. Findings are preliminary and serve as an impetus for further research on the knock-on effects of harmful algal blooms in estuaries and the implications for food webs.

Temporal and spatial patterns in occurrence, feeding, growth and survival of early individual of mandarin fish Siniperca chuatsi: the impacts of Three Gorge Dam and recovery processes

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The operation of Three Gorges Dam (TGD) modified the river flow regime, and hypolimnetic discharge from the reservoir lower the water temperatures in downstream. Retention of sediments in the reservoir can induce a lowered nutrient state, and consequently lower primary productivity of downstream waters. The impacts of river regulation on downstream river environments can be buffered with increased distance from the dam and the joining of tributaries, thus forming environmental gradients downstream. We hypothesized that temporal and spatial patterns of larvae in the middle reach of the Yangtze River downstream the TGD display patterns corresponding to these environmental gradients. In the present study, we test the above hypotheses by comparing the occurrence, feeding, growth, and survival of Siniperca chuatsi, an anti-potadromous species, among different sections downstream the dam. Larvae in the section near to the dam tended to had the lowest abundance, latest occurrence, highest percentage of empty guts, slowest growth rate, and highest mortality rate; in contrast, larvae farther from the dam had highest abundance, earliest occurrence, and lowest percentage of empty guts, fastest growth rate, and lowest mortality rate. Our results demonstrated that the correspondence of occurrence, feeding, growth and survival of larval S. chuatsi to environmental gradients according to the distance from the dam, inducing that the TGD significant influence the early recruitment process. We recommend that the river section around the mouth of Poyang Lake, should be set as a priority for conservation of fish resources. Population dynamics, Siniperca chuatsi, Three Gorges Dam, early life history, recovery process.
Performance of herring larvae under ocean acidification in an ecosystem approach

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In a future ocean, fish larvae will face changes in multiple abiotic variables; one of which is ocean acidification, the decrease in seawater pH by increasing CO₂ concentrations. Fish larvae will not only be directly challenged by OA, but also indirectly via OA-induced changes on the different trophic levels of the food web. This combined direct and indirect effect of OA was assessed in a pelagic mesocosm study, where fully functional communities up to fish larvae were enclosed for several weeks and manipulated with CO₂ concentrations projected for the end of the century. The experiment was performed in the Gullmarsfjord, Sweden, and lasted for 113 days. Five of ten mesocosms were set to CO₂ levels of ~760 μatm pCO₂, while the other five served as untreated controls. An enhancement of primary production under elevated CO₂ was followed by an increase in zooplankton abundance, which served as prey organisms for larval herring, Clupea harengus. After six weeks, herring larvae survival was significantly higher in the elevated CO₂ mesocosms. A significant effect on larval growth of the surviving herring larvae was not detected. One explanation may be drawn from otolith growth analyses, which suggest an effect of intraspecific competition between the larvae. The results of herring larval performance from this study will be discussed in the context of food web effects of ocean acidification and will be used as "food for thought" to highlight knowledge gaps regarding species interactions in ocean acidification research.

Counting the costs of bias in fish ecology? Lessons learned from studying larvae and juveniles in temperate South African estuaries

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Fish ecology is by nature compartmentalized within schools of thoughts and existing focus areas, often driven by habitat, researchers, time limits for degrees and grants. Using examples from South Africa that have focused on the early stages of fishes from larvae to juveniles in estuaries and neighboring waters, I provide evidence for tunnel vision creep and make a case for breaking down silos of thinking. Schools of thought have resulted in overemphasis of value of certain types of habitats while ignoring others. Tagging of older juveniles is showing species to be less dependent on estuaries than previously thought, spending as little as 30% of their time in estuaries. Diel and gear sampling bias has rendered some species absent when actually present. Habitat use studies show conflicting results for juvenile fishes but most were based on too few comparisons to fully elucidate patterns. Research has often tried to attach value to certain habitat types, an essential action for conservation planning. However our belief in winners and losers precludes understanding plasticity in habitat use during and after metamorphosis. Recent work showing plasticity in microhabitat use and residency in small areas in mangrove estuaries shows that typical winner habitat is not selected equally by individuals of the same species. First prize and second prize habitat choices contribute to species success in nursery areas. Some species undergo ontogenetic habitat shifts forming a nursery continuum and this contributes to early life history strategies that are often missed in a compartmentalized research approach that will focus on either marine, estuarine or riverine habitats. Habitat continua must be included in seascape conservation and protected area planning worldwide. Anthropogenic alterations to nurseries are taking place faster than our abilities to change our thinking in aid of holistic fish conservation efforts.
Fine-scale horizontal and vertical distribution of larval fishes, their prey, and their predators in the tidally modulated Columbia River Plume

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Tidally-controlled river plumes form distinct frontal boundaries that can change the spatial distributions of zooplankton. By altering spatial overlap between zooplankton taxa, these frontal boundaries have the potential to influence trophic interactions at the base of marine food-webs. Because many traditional sampling techniques cannot resolve fine-scale zooplankton distributions and spatial overlap, the physical effects of tidally-controlled river plumes, such as the Columbia River Plume (CRP), on larval fish trophic interactions remain poorly understood. Here, we use the in situ ichthyoplankton Imaging System (ISIIS), to examine changes in the fine-scale horizontal and vertical distribution of larval fishes and their zooplankton prey and predators over a CRP ebb and flood tide series. Two ~26-km cross-plume transects were sampled in June 2016, each capturing plume, frontal, and oceanic water masses from the surface to ~50m depth. Temperature, salinity, fluorescence, and oxygen values varied greatly ranging from 7.57 to 16.44 °C, 16.2 to 35.61, 0.03 to 0.8 volts, and 1.67 to 7.83 mL/L, respectively. In total, 161 plankton groups were identified including multiple larval fish taxa and prominent prey (e.g., copepods) and potential predators (e.g., gelatinous zooplankton and chaetognaths). We observed distinct spatial distributions of zooplankton taxa in the flood and ebb tides. Notably, larval fish tended to be found in the upper water column, while gelatinous zooplankton were observed in low oxygen waters below the 15m deep halocline. To further elucidate the influence of the CRP on larval fish predator-prey interactions, we quantify spatial overlap using distance to next encounter and refined nearest-neighbor analysis.

Assessment of the knowledge acquired on the early life stages of temperate freshwater fish species: comparisons between European and North American fauna.

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Teleost fish represent more than half of living vertebrates, with more than 30,000 species described today. Besides being the largest and most diverse vertebrate group, teleosts also display the greatest reproductive diversity. Yet, to date, no one has ever persuasively explained this outstanding diversity. In addition, this plethora of reproductive strategies has slowed the application of quantitative methods to studies on reproduction. This is the reason why in 2005 a research program entitled STOREFISH was launched to study the reproductive strategies of European freshwater fish species. Thirty years later, a new database has been created (more than 2000 references analyzed so far) that contains information about 80 species and 50 traits. Based on this new database, three studies were published aiming at (i) establishing a new typology of reproductive strategies of European freshwater fish, (ii) studying the relationship of oocyte diameter and incubation temperature to incubation time for temperate freshwater versus marine fish, (iii) analyzing how the different trade-offs at the early life stages ensured that the first feeding of larvae of temperate freshwater fish occur in spring and early summer. To our best knowledge, neither equivalent database exists for the North American fauna, nor have similar comparative analyses been performed. Therefore the main objective of the present project is to reassess the knowledge acquired on the North American freshwater fish building on the experience acquired during STOREFISH. After a brief presentation of the European and North American fauna, we will present preliminary results focusing on the early life stages, because they are the most stenothermal (narrowest thermal tolerance) during the fish life cycle, and our main goal is to evaluate how such comparative work could help to better understand how fish populations in temperate regions could be impacted with a change of few degrees in the coming decades.
Survival of larval fish is dependent upon their ability to find and capture food, and grow quickly. To do so, many larvae target abundant yet evasive copepods. Thus, the larvae must avoid detection by the prey prior to launching a predatory strike. We quantified these early predator-prey interactions using a clownfish-calanoid copepod system to (1) assess the hydrodynamic properties ahead of an approaching predator (*Amphiprion ocellaris*) that might cue a copepod (*Bestiolina similis*) to escape prior to an attack; and (2) analyze the kinematics and directionality of subsequent escapes. During their first 14 days post-hatch (dph), fish increased in size (radius of head 5% per day) and approach speed (11% per day). These measurements, along with distance to the copepod, informed a hydrodynamic model that estimated the rate of water deformation around the copepod just prior to escape. Fish produced low deformation rates that were similar across their first 14 dph. However, the range of deformation rates needed to trigger escapes was larger for early copepodites (CII-CIII stages; 0.03-1.53 s\(^{-1}\)) than for late copepodites (CV; 0.05-0.32 s\(^{-1}\)) or adult copepods (CVI; 0.06-0.91 s\(^{-1}\)), indicating that early copepodites were less likely to detect the approaching fish larva. These deformation thresholds were lower than predicted from experiments that used artificial stimuli to induce copepod escape behavior. Copepods of all stages escaped away (30°-180°) from the fish larva (0° approach). Adult copepods escaped faster (≤374 mm/s) and further (≤14 mm) from larval fish than did copepodites. Low to intermediate Reynolds numbers (0.2-16.3) characterized the hydrodynamic environment of the fish-copepod interactions, suggesting that both viscous and inertial forces are important. Our experimental results are consistent with the observation from gut-content analyses that many young fish larvae preferentially prey on immature copepods.

**Enhanced North Sea herring management through improved larval surveys**

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Recruitment is one of the major drivers of fish stock dynamics. Getting a correct perception of recruitment is therefore essential for successful fisheries management. Predicting the level of recruitment is still one of the most difficult aspects in fish stock dynamics, even if dedicated surveys are in place to sample larvae or juveniles. In the case of North Sea herring (*Clupea harengus*) there is a larvae survey (IBTS-MIK) for estimating recruitment. Once considered as a very good predictor of herring recruitment, in recent years the MIK index has become a poorer forecaster because the samples collected do not cover the increasing spawning component in the English Channel. A new larvae survey has been setup and carried out in April 2018, to collect information on the recruitment of this winter spawning component. The temporal and spatial coverage of this new survey was based on larval drift modelling. This survey is being implemented without increasing the survey budget available for the herring larvae surveys. Results of the new survey will be presented as well as a more realistic North Sea herring recruitment index.
Feeding, growth and mortality of young-of-the-year striped bass: a comparison among habitats in the St. Lawrence Estuary

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In the St. Lawrence Estuary, the striped bass population was extirpated by the mid-1960, due to cumulative effects of habitat destruction and overfishing. A reintroduction program started in 2002 and it is now recognized that the population self-reproduced during the last decade. However, very little is known about the ecology of this newly reintroduced fish population, especially about habitat utilization of early life stages, which might be essential for successful recruitment. In this study, we compared feeding success, growth and mortality of young-of-the-year Striped Bass among four distinct habitats located at the interface between fresh and brackish waters of the St. Lawrence estuary. Habitats were characterized by turbidity and salinity: an upstream freshwater section (UFS), oligohaline and mesohaline Estuarine Turbidity Maximum habitats (O-ETM and M-ETM) and a downstream mesohaline section (DMS). Between June and September 2014, 602 Striped Bass larvae and juveniles were sampled with a bongo net and a beach seine. We analyzed gut contents and otolith microstructure. In June, the O-ETM habitat provided the best suitable conditions for feeding, growth and survival of pelagic larvae. In July, feeding and growth were better in the UFS compared to downstream habitats. In August and September, feeding success and growth were improved in the downstream habitats. In summary, our results highlighted the importance of upstream habitats (UFS and O-ETM) as a nursery area to sustain the new Striped Bass population in the St. Lawrence Estuary.

The best approach for predicting egg development time from temperature is both context- and species-dependent

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We used published egg development and temperature data from 64 freshwater and anadromous fishes to compare six regression models in terms of their ability to i) describe relationships between days to hatch and incubation temperature (i.e., predict hatch date when incubation temperature is constant), and ii) predict hatch date when incubation is temperature is variable. Although the exponential model was "best" at describing development-temperature relationships for 45% of species (ΔAIC=0), 72% of species showed strong support (ΔAIC<2) for at least two models. This pattern was largely independent of family and sample sizes >30 observations. We then evaluated model performance using published data describing egg development and hatch under variable incubation temperature regimes (126 data sets across 17 of our 64 species). The degree-day model was "best" at predicting hatch date when temperature was variable, but we again found strong support for at least one other model in 71% of species. Overall, these results show that the "best" model for predicting egg development time from temperature depends on the species of interest and the nature of the temperature regime (e.g., constant vs. variable).
Survival of Atlantic herring eggs on Baltic Sea spawning beds

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Western Baltic herring (Clupea harengus) migrate annually into shallow coastal areas for spawning. They attach their eggs to submerged aquatic vegetation. Due to continuous eutrophication over the last decades, the community structure of aquatic plants changed and the vertical distribution severely declined, resulting in a depth limit of about four meters. Nevertheless, herring regularly return to the same spawning areas. It is assumed that herring spawning behavior is non-selective in respect of spawning substrates. However, little information is available on the effects of different spawning substrates on egg development. Hypothesizing that the substrate affects the survival of herring eggs, we artificially spawned eggs on different plant species that are frequently used by herring in this region. Those were incubated in field experiments and the egg survival was monitored. The results indicate that all tested plant species with a relatively solid structure resulted in egg survival well over 50 %, showing conspicuous but not significant differences between the species, including macroalgae (Fucus vesiculosus, Furcellaria lumbricalis) and angiosperms (Stuckenia pectinata, Zostera marina). Further tank and field experiments revealed a significantly negative influence of filamentous brown algae (such as Pyllaella littoralis) on herring egg vitality. Regarding herring reproduction success, this finding is especially alarming since increasing early spring water temperatures and nutrient loads during the last decades triggered mass occurrences of those algae on the spawning beds. Increasing our knowledge on substrate requirements and the role of particular plant communities for herring reproduction is essential to evaluate consequences of environmental changes and anthropogenic alteration on coastal spawning grounds and their effects on population dynamics. This is a basis for effective management of coastal habitats and thus a foundation for resilient herring stocks.

The spatial-temporal patterns of ichthyoplankton in the upper mainstem of the Yangtze River: influences of upstream dam cascade discharge and downstream impoundment of the Three Gorges Reservoir

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Construction of dam cascade has been a major threat on fish biodiversity in the Upper reach of the Yangtze River. The river segment between the Xiangjiaba Dam (XD) and tail of the Three Gorges Reservoir (TGR) provides critical refuge for riverine endemic fishes. However, this river segment has been impacted by upstream hypolimnetic discharge from dam cascade and impoundment of the TGR downstream. Knowledge about temporal-spatial patterns of ichthyoplankton in this river segment will provide critical information understanding influences of the dam cascade, and will contribute to efficient conservation for fish biodiversity. In this research, we investigated distribution of eggs and larvae of fish at three sections in this river segment, i.e. Yibin (distance to XD: 30 km), Zhuyang (290 km), and Mudong (500 km, and locating in the tail of TGR). A total of 92 species were identified in 2015. Numbers of species at Yibin, Zhuyang and Mudong were 46, 85, and 55, respectively; and average densities were 3.3, 6.2, and 23.0 ind/1000m³, respectively. We observed clear environmental gradients: during spawning season, water temperature tended increasing, water transparency decreasing, and water runoff increasing with the distance to the upstream dam cascade increased. Compared to the situations pre-impoundment of the upstream dam cascade, relative abundance of stenotopic riverine species has declined, and that of eurytopic species increased. Our results demonstrated that discharge of the upstream dam cascade and impoundment of the downstream reservoir dramatically impacted ichthyoplankton assemblages in the mainstem of the upper Yangtze River. Highest diversity of ichthyoplankton observed at Zhuyang suggested that the river section up and down there should be set as conservation priority for endemic riverine fish species. Key words: ichthyoplankton, the upper mainstem of the Yangtze River, hypolimnetic discharge, dam cascade, impoundment, Three Gorges Reservoir.
How do coral reef fish larvae find a home? Insights from sensory organ ontogeny

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The ability of pelagic fish larvae to navigate the open ocean and orient towards suitable settlement sites is a feature of the life history of most marine fishes with important implications for their ecology and evolution. The sensory basis for orientation behavior in coral reef fishes has been explored through experimental field or lab studies using late stage larvae from several families. They suggest that vision, olfaction and/or hearing play roles in orientation behavior. However, parallel analyses of sensory organ anatomy and interpretations of sensory capabilities in the species studied behaviorally are still needed. As part of an integrative field and laboratory study of orientation behavior in the larvae of the line snout goby, Elacatinus lori, we carried out a detailed study of the developmental anatomy of the sensory organs (olfactory, gustatory, auditory, lateral line) in lab-reared ontogenetic series of E. lori and in a congener, E. colini. In addition, analysis of the ontogeny of the olfactory, gustatory, and auditory systems of two pomacentrids and an apogonid provide a larger comparative context. Results have revealed the absence of an obvious mechanism for olfactory ventilation and suggest a potential role for gustation in the detection of chemosensory cues. The conserved features of the percomorph ear were revealed, with inter-familial variation in the ontogeny and morphology of the sensory maculae and otoliths, but functional insights are elusive. The analysis of lateral line ontogeny in E. lori is revealing the developmental basis for the complex patterns of superficial neuromasts in gobies. The behavioral implications of the pattern and timing of development and variation in sensory organ morphology in larval coral reef fishes are discussed.

The impact of ocean acidification on larval yellowfin tuna (Thunnus albacares) development

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Increasing ocean acidification is a concern for its potential effects on the growth, development, and survival of early life stages of tunas in oceanic habitats and on the spatial extent of suitable spawning and nursery habitat for tunas. To investigate the potential effects of ocean acidification on yellowfin early life stages, an experiment was conducted with multiple collaborating scientists at the Inter-American Tropical Tuna Commission’s Achotines Laboratory in Panama during 2011. The study was conducted to test the impact of increased pCO₂ on eggs, yolk-sac larvae, and first-feeding larvae. Acidification levels tested ranged from present day to levels predicted to occur in some areas of the Pacific in the near future (50-100 years) to 300 years in the long term. The study results indicated the potential for significantly reduced survival, condition, and size of larvae at acidification levels that are similar to near future predicted levels. Abnormal otolith growth and significant organ damage (from histological analysis) in larvae were detected at pH levels higher than those at which significant impacts were detected on survival and growth of first-feeding larvae. The study results can be used to parameterise models to predict acidification effects on pre-recruit survival and the spatial extent of spawning and nursery habitat of yellowfin.
Bring the noise: the influence of larval recruitment variability on the adaptive management of marine protected areas

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Marine protected areas (MPAs) are an increasingly common conservation and management tool worldwide. Typically, managers expect that after fishing ceases inside an MPA, previously fished populations will steadily increase in abundance as they return to unfished levels. Hence adaptive management typically involves examining the ratio of fish density after:before MPA implementation or inside:outside MPAs (the latter is often more common because 'before' data are lacking). However, the expectation of a steady, positive increase in these response ratios is complicated by high variability in larval recruitment to populations in MPAs, both over time (pulses and droughts) and over space (hotspots and coldspots). We use a combination of theoretical models and data on kelp bass, *Paralabrax clathratus*, from southern California MPAs to show that a) realistic levels of recruitment variability produce huge uncertainty in response ratio calculations; b) including information on larval recruitment improves detection of population increases; and c) the time scale of recruitment variability should influence the time scale over which MPA effects are expected to be measured. In general we show that variability introduced at the larval stage has a strong influence on the successful management of coastal populations.

Environmental biology of Kootenai River burbot, *Lota lota*, early life stages

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Following the completion of Libby Dam in 1974, the native Kootenai River Burbot population in Idaho and British Columbia experienced severe declines in abundance. By 2000, the population below Libby Dam was classified as functionally extirpated. More recent, 2011-2018, a conservation aquaculture program has produced Burbot for general population restoration; for laboratory studies of early life environmental requirements/tolerances; and for experimental releases of early life stages to investigate the environmental biology in the altered river habitat. The laboratory studies and experimental releases have targeted pre-feeding pelagic larvae to fully transitioned benthic juvenile stages. A summary of basic results from these early life stage studies will be presented. Further, the application of these results exhibits the importance of understanding the environmental biology of early life stages of fish to restore habitat and to rebuild populations in altered ecosystems.
Morphospace and niche partitioning in larvae of two sympatric *Diogenichthys* species

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Myctophids are the most abundant and diverse group among mesopelagic fishes. They play an important role in pelagic ecosystems by linking primary and tertiary consumers. Larvae are distributed in the upper 200 m and feed on zooplankton, shifting their diets according to food availability. *Diogenichthys atlanticus* (DA) and *D. laternatus* (DL) are widely distributed in the Pacific Ocean, associated to the Humboldt Current. The aim of this study is to assess the relationship between diet and skull shape in two sympatric *Diogenichthys* species and to compare these variables among species to identify niche partitioning. Four oceanic surveys perpendicular to Chilean coasts were carried out during spring of 2015, 2016 and 2017. Only postflexion larvae were used to avoid the effect of ontogeny on geometric morphometry (GM) analyses. After gut extraction, larvae were cleared and stained to photograph skull structures. An 8 landmark configuration was digitalized. Until now, the gut content of 107 individuals was analyzed. Feeding incidence was low for both species (DA: 34.33%; DL: 20%). Although the diet of DA differs from DL in terms of prey composition (DA: 14 prey items; DL: 7) and in volumetric, numeric and frequency indexes, there were no significant differences in number of prey per gut (Mann-Whitney U-test, P= 0.336), total prey volume per gut (P= 0.087) or maximum prey width (t-test, P> 0.05) among species. Principal Component Analysis performed on skull GM data showed that, along with the 3 first PCs (68.64% of the total variability), DL’s morphospace is more restricted than DA’s, described by a larger mouth gape in the latter. A Discriminant Function Analysis classified both species separately (Mahalanobis distance: 3.45, P <0.0001). It’s been reported that larger mouth gaps correlate positively with the variability of prey sizes and that variations in this trait might result from divergent natural selection by resource competition.

POSTER PRESENTATIONS

**Migratory movements of juvenile Greenland halibut between the estuary and the Gulf of St. Lawrence**

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Greenland Halibut (*Reinhardtius hippoglossoides*) is a deep-water flatfish species with a circumpolar distribution and support significantly the Canadian fisheries industries. In 2016, landings of Greenland halibut accounted for over 50% of total value landings in the Estuary and Gulf of St. Lawrence (EGSL). It has been documented that the EGSL populations are sustained by two nurseries separated by several hundreds of kilometres. The objective of our study is to examine migratory movements of juveniles and the potential exchange between the two nurseries to ultimately characterise the contribution of each nursery to different stocks and/or populations in the EGSL. In 2016 and 2017, we sampled one hundred juveniles in each nursery. Migratory movements of each juvenile was established by measuring chemical elements concentrations along a transect on the sagittal otolith with a LA-ICP-MS. The elemental fingerprint is recorded, by accretion, in its otoliths throughout the life of the individual and varies according to the chemical nature of different water mass in which the fish evolves. Preliminary results will be presented and further investigations on otolith chemistry on Greenland Halibut collected at a larger spatial scale in the Northwest Atlantic will improve our understanding on population structure and connectivity of this important fisheries resource.
Interactions between neonicotinoids and ultraviolet radiation on yellow perch (*Perca flavescens*) larvae: A biomarker approach

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Neonicotinoids (NEOCs) are insecticides widely used in the culture of maize and soya in the southern portion of Lake St-Pierre (LSP) (St. Lawrence River System, Quebec, Canada). Their leaching in the aquatic ecosystems has become of major concern since high concentrations of these contaminants have been found in surface waters in the agricultural watershed of this region (> 8.33 ng/L). Unfortunately, we have poor knowledge of their effects on the aquatic life and their potential interactions with other environmental factors such as UV radiation. This is potentially important for the yellow perch (*Perca flavescens*) population in LSP since their larvae are found in shallow waters (<120cm) nearby the agricultural lands, and are thus potentially exposed to both threats. The objective of this study is to test the potential synergistic effects of two commonly used NEOCs (imidacloprid and thiametoxam) with UV radiation on yellow perch larvae. Larvae were exposed to both NEOCs and natural UV radiation in common garden factorial experiments in semi-natural conditions. Our results showed an interaction between UV radiation and both NEOCs in terms of mortality of larvae. Biomarkers helped to explain partly these results, by showing that at least imidacloprid was associated to both increased acetylcholinesterase activity and reduced lipid peroxidation. These results should contribute to understanding the potential factors hindering the recover of the yellow perch population in LSP, which experienced a collapse in the mid-1990’s.

Understanding factors driving juvenile growth of fish species in the Upper Mississippi River

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Within-species, larger age-0 fishes are more likely to survive into the next year as compared to smaller age-0 fishes. For some species, there is a critical size at which individuals are less vulnerable to predation while for others increased size reduces the likelihood of starvation during winter conditions. With the presumption that larger age-0 fishes are more likely to recruit, we have sought to improve our understanding of factors hypothesized to influence age-0 growth within the Upper Mississippi River. Relying upon the Upper Mississippi River Restoration Program’s Long Term Resource Monitoring (LTRM) element of the Upper Mississippi River System (1993-2017), we used linear regression to quantify mean length of age 0 fishes in early fall on an annual basis. The LTRM occurs within six distinct reaches across a 1200 kilometer gradient of hydrogeomorphic conditions. Therefore, we used a linear mixed model approach to evaluate the role of hydrology, temperature, and habitat conditions on juvenile growth of a diversity of fish species across the six study reaches. Evaluation of the factors associated with increased young-of-year growth across a range of species will provide insight into how hydrology, temperature, and the habitat template interact to support early life history requirements of the native fish community of the Upper Mississippi River.
Trophodynamics and growth of *Sebastes mentella* larvae to determine environmental drivers of recruitment in the Gulf of St. Lawrence

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Adult populations of deep-water redfish, *Sebastes mentella*, have been depleted due to overfishing and adverse environmental conditions since the early 1990s in the Gulf of St. Lawrence. A series of strong-year classes beginning in 2011 has led to a massive increase in *S. mentella* numbers in the region, but the environmental drivers responsible for generating these strong cohorts are unknown. Little is known about the larval ecology of larval *S. mentella* within the Gulf. In particular, knowledge is lacking on larval feeding preferences and behavior, limiting our ability in linking recruitment to plankton abundance indices. The objective of this project is to determine environmental drivers that affect the trophodynamics, growth, and ultimately recruitment, of larval *S. mentella* in the Gulf of St. Lawrence. Preserved specimens of larval *S. mentella* collected between 1997-2000 will be measured for length and dissected for stomach content analysis. Consumed prey items will be quantified and categorized by prey species and stages. Larval growth will be compared among individuals between collection stations and years based on otolith analyses and stomach content data. Environmental data collected by Fisheries and Oceans Canada through its Atlantic Zone Monitoring Program will be used to determine links between biophysical oceanographic parameters in the Gulf of St. Lawrence, larval feeding dynamics and recruitment of larval *S. mentella*. Results from this work will be used by fisheries management to better predict annual population dynamics of *S. mentella* in the region.

Stable isotopes δ¹³C y δ¹⁵N variability in anchoveta (*Engraulis ringens*) eggs and larvae and in response to oceanographic condition variation in north and Central Chile

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Because enrichment of stable isotopes occurs along trophic webs, δ¹⁵N is utilized as indicator of trophic position of organisms along the web, and δ¹³C to trace whether the sources of organic carbon in coastal areas is from allochthonous sources (terrestrial) or autochthonous (marine phytoplankton). We compared the isotopic (δ¹³C and δ¹⁵N) signals in particulate organic matter (POM), eggs, yolk sac and exogenous feeding anchoveta larvae during the reproductive season (late winter – spring, 2016) in two spawning zones along the Humboldt Current: northern Chile (Iquique, 20°S) and central Chile (Talcahuano, 36°S). Both zones are subject to seasonal variations due to coastal upwelling (spring and summer) but differ in wind intensity (stronger in central Chile) and hydrographic conditions (colder and influenced by freshwater river input in central Chile in winter). We utilized δ¹³C to determine if the carbon in anchoveta eggs included carbon from terrestrial and/or marine sources, and δ¹⁵N in exogenous feeding larva to infer whether their nitrogen was mainly from their preys (microplankton, POM) or from the eggs from where they hatched. Our results show that strong variations in δ¹³C in eggs occurred between seasons, particularly in central Chile where organic carbon from terrestrial origin (δ¹³C >23‰) due to higher freshwater input to the coastal zone is higher in winter. In spring, instead, δ¹³C in eggs were mostly from marine origin (δ¹³C <20‰). δ¹⁵N in eggs varied scarcely along the spawning season in both zones (14-16‰) suggesting the trophic levels of prey for adult female did not vary over the seasons. In central Chile, monthly δ¹⁵N in exogenous feeding larvae was within the same range (14-16‰) as eggs (higher than POM, range 7-11‰) also with scarce changes during the season. Our result, therefore, suggest that changes in rain and river flows affect the load of terrestrial organic carbon in coastal waters and reach adult fish females and their offspring.
Projected effects of climate change on life history and population processes in an estuarine-oriented codfish, Atlantic tomcod (*Microgadus tomcod*), at the southern limit of its geographic range

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The rising and more variable global temperatures associated with a changing climate are likely to have effects in a range of fish life history and population processes. Some regions of ocean and coastal waters, such as the NW Atlantic along the US and Canadian coasts, are expected to be warmer and more variable than average global projections, and fishes that live in this region are likely to be especially at risk to changing thermal habitats. We have been studying an estuarine codfish, the Atlantic tomcod (*Microgadus tomcod*), which spawns in upstream fetches of estuaries of the NE USA and Canadian Maritime Provinces. Spawning occurs in early winter in low salinity (< 5 PSU) waters. Eggs are demersal and hatch into relatively advanced larvae in about 3 weeks and maturation occurs by the first autumn. Larvae, juveniles, and adults reside within estuaries for their entire lives with little gene flow among populations from different estuaries along the coast. Tomcod is at the southern extreme of its geographic range in New York / New Jersey waters, likely making fish from this region especially susceptible to changes in climate. We have conducted a series of experimental and retrospective studies on Atlantic tomcod from the Hudson River (HR), the southernmost spawning locale of this species. This poster summarizes our experimental findings on thermal effects on critical life-history rates (growth, survival, developmental rates) of HR tomcod, and the thermal tolerances of fish from this population. With increasing water temperatures we can expect more rapid developmental rates with earlier hatching at smaller sizes, advection of larvae downriver at smaller sizes, and higher risk of juveniles to summer thermal maxima. Collectively, these outcomes place the population at risk to climate change with its vulnerability magnified by co-occurring environmental stressors of low dissolved oxygen and higher toxicant loads in this urbanize waterway.

Depth-stratified larval drift of lake sturgeon (*Acipenser fulvescens*) in a Laurentian Great Lakes connecting channel

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In most riverine systems throughout their range, larval lake sturgeon (*Acipenser fulvescens*) drift along the bottom, thus bottom set nets are used to measure dispersal of this life stage. Given the deep, fast flowing habitat of the St. Clair-Detroit River System, we investigated whether larval lake sturgeon were limiting their drift solely to the bottom, or if they were distributed vertically in the water column. We used benthic D-frame nets to sample drifting larvae during nocturnal drift and depth-stratified conical nets to sample larvae throughout the water column (up to 15 m deep) day and night, above and below known spawning locations. Larvae were detected upstream and downstream of spawning locations at the bottom, and throughout the water column; however the vertical distribution was not consistent among sites. Larvae were captured in middle and bottom depths during the day and throughout the water column at night. While the majority of larvae were collected near the bottom, our results demonstrate the importance of sampling throughout the water column to obtain a more complete perspective of larval drift. Quantification of larval lake sturgeon production will be improved using drift data from throughout the water column in deep water habitats.
How do anchovy and sardine eggs and larvae abundance and distribution vary within the same spawning period?

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Fluctuations in the size of small pelagic fish populations are studied in different species worldwide, but the reasons why sardine stocks flourish while anchovy stocks collapse and vice-versa remain uncertain. Some authors have invoked climate-induced environmental variations (e.g. El Niño/La Niña), upwelling effects, trophodynamics, and optimal temperatures for growth rates during the early life stages, and variations in the spawning habitat. The two dominant pelagic fish species in Southeastern Brazil Bight (SBB) are *Sardinella brasiliensis* and *Engraulis anchoita*. The former spawns only during late-spring and summer, while *E. anchoita* spawns year-round with a peak, in the SBB, during late austral spring and early summer. Preliminary results showed interannual anchovy-sardine egg abundance alternations, but intraseasonal variability is unknown. We selected three oceanographic cruises (Sep/Oct 1976, Dec 1976 and Jan/Feb 1977) from a single spawning season, to describe the intraseasonal fluctuations of egg and larval abundances and distributions of *E. anchoita* and *S. brasiliensis* in the SBB. During Sep/Oct 1976 only *E. anchoita* eggs and larvae were found; they also presented highest abundance and frequency of occurrence values when compared with the rest of the studied period. *Sardinella brasiliensis* eggs and larvae were more abundant in Dec 1976. During Jan/Feb 1977 the abundance of eggs sampled decreased for both species; but the larval abundance remained similar to the previous period for *S. brasiliensis* and increased for *E. anchoita*. In general, anchovy and sardine eggs were concentrated in certain oceanographic stations, but they do not co-occurred. The opposite was noticed for larvae: they were sampled all over the SBB and they were sampled at the same oceanographic station. Our results showed that despite the co-occurrence of both species in the same spawning season, eggs and larvae distribution and abundance are spatially and temporally segregated.

Serranidae larvae from the Southeastern Brazilian Bight

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Serranidae (e.g. groupers) are economically and ecologically important, however some species are listed by the International Union for Conservation of Nature (IUCN) as critically endangered and in danger. It is always the concern of the species preservation that leads researchers to deepen their knowledge in the biological and ecological aspects, including the early stages of their development. Thus, we described the taxonomic composition and horizontal distribution of Serranidae larvae along the Southeastern Brazilian Bight (SBB, roughly 22°S and 28°S), investigating how environmental factors influence their distribution. Ten oceanographic cruises were conducted from 1975 to 1981, totaling 1,114 oceanographic stations. Zooplankton was collected using a bongo fitted with 0.333 and 0.505 mm mesh nets. The ichthyoplankton of 0.505 mm mesh net was analysed. The serranids larvae accounted for 0.35% of a total of 266,975 larvae. Fifteen taxa included in nine genera from three subfamilies were identified: Serraninae, Epinephelinae (two tribes - Epinephelini and Grammistini) and Anthiinae. Local depth, latitude and distance from the closest island were significant factors on the abundance variation of the most abundant taxa: *Diplectrum formosum*, *Diplectrum spp.*, *Serranus* spp., *Epinephelus* type1, *Mycteroperca* spp. and *Dules auriga*. Most species were distributed mainly in the north portion of the SBB, not exceeding the 200 m isobath. *Diplectrum formosum* was widely distributed throughout the SBB, and *Epinephelus* type1 and *Hemanthias vivanus* were distributed only in the south portion of the SBB. A significant progress was done in the identification and description of grouper larvae (*Epinephelus morio*, *E. itajara* and *E. nigritus*).
Reproductive tactics of southern hake *Merluccius australis* in the Chilean Patagonia

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*Merluccius australis*, known as southern hake, is a demersal fish that inhabit the southern tip of South America. The main spawning area is located in the outer sea of the Chilean Patagonia, where they aggregate to reproduce during the austral winter. An alternative spawning ground has been suggested within the inner sea where eggs of a few days old have been found. The relative importance of this spawning zone as well as the main environmental features that makes this inner zone suitable for spawning has not been assessed. We analyzed ichthyoplankton samples along with hydrographic data from oceanographic cruises (2003-2015) carried out in winter and spring to characterize both spawning zones. The observations were combined with a biophysical model that couples a hydrodynamic model (Regional Ocean Model System, ROMS) with an individual-based model (IBM, Ichthyop) to assess the connectivity of early life stages in the Chilean Patagonia. Field data show that the mean abundance of southern hake eggs in the outer sea exceeds 30 times the inner sea in winter, and four times the mean abundance during spring in the inner sea. Accordingly, the main spawning of the species occurs in winter in the outer sea and in spring in the inner sea. Preliminary results from biophysical model simulations show transport from the inner to the outer sea in winter but an increased retention in spring. At the outer sea occurred a significant retention in winter which decreased in spring. The seasons at which spawning occurs at both areas is associated with local oceanographic processes that enhance retention at the nursery areas. The development of different spatial spawning seasons at different zones is apparently linked to the inter-annual variability in environmental conditions at the main spawning zone offshore, by which the secondary spawning in the inner sea could be part of a reproductive strategy to ensure offspring survival when conditions in the outer sea are not favorable.

Association between zooplankton and invertebrate assemblages and young-of-the-year striped bass in the St. Lawrence River

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Extirpated by the mid-1960, the striped bass (*Morone saxatilis*) population of the St. Lawrence River has been re-introduced gradually since 2002. The population self-reproduced during the last decade. Nevertheless, little is known about it’s the ecology, especially the associations between early life stages and their prey. We aim to determine if young-of-the-year Striped Bass are associated to particular zooplankton and invertebrate assemblages in 4 distinct habitats of the St. Lawrence Estuary. We sampled once per month between June and September 2014 along a 200 km section of the St. Lawrence Estuary. In June, we used a Bongo net (mesh 333 µm) to collect pelagic larvae as well as zooplankton (mesh 158 µm). In July, August and September, we used a beach seine to capture juvenile Striped Bass and a seine-type net (mesh 500 µm) for invertebrates. Zooplankton and invertebrates were identified to the lowest taxonomic level. Assemblages were discriminated by multivariate analyses and corresponded to 1) the upstream freshwater group (UFG), 2) the oligohaline ETM group (O-ETMG), 3) the mesohaline ETM group (M-ETMG) and 4) the downstream mesohaline group (DMG). This study provides insights for a better understanding of interactions within ichthyoplankton communities based on a detailed prey species description.
Determination of interannual larval feeding in sandlance (Ammodytes sp.) in the St. Lawrence Estuary

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Sandlance (Ammodytes sp.) is a key forage fish species in the ecosystem of the St. Lawrence Estuary, where it transfers a large proportion of the energy from secondary producers to large vertebrate predators, including the endangered Saguenay beluga whale population. The population is currently not monitored and factors regulating its dynamics remain unknown. As a first step in identifying drivers of recruitment and abundance for this population, the general objective of this study is to reveal key aspects of the trophodynamics during the larval stage. In particular, we will describe diet composition at a high taxonomical resolution to identify main prey through early ontogeny to the species level. We will also estimate prey selectivity by comparing the relative frequency of prey taxa in the diet to that in the plankton, and assess whether prey selectivity varies with larval size and in time. Knowledge on larval sandlance preferred prey will allow assessing long-term variation in larval prey field using the zooplankton abundance time series available from Fisheries and Oceans Canada's Atlantic Zone Monitoring Program.

Characterizing the response of the winter-spring ichthyoplankton community to environmental change

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Estuaries provide essential nursery habitats for many marine fish. Narragansett Bay, the largest estuary in New England, has long been a significant habitat for resident and transient fish species, and contributes to the productivity of regional fisheries. While the ichthyoplankton community of this system has been sampled in previous decades, the spatio-temporal dynamics and drivers of the ichthyoplankton community through time have yet been fully described. This work focuses on fish larvae spawned during the winter-spring period, a season most severely impacted by climate change in Narragansett Bay. Larval fish were collected, identified, and counted in monthly plankton tows conducted by the RI Department of Environmental Management (DEM) between February and April across 14 stations throughout the Bay from 2001 - 2008. These data were then supplemented with an identical survey performed by the URI Graduate School of Oceanography and DEM during the same portion of the year in 2016 and 2017. Using this time series, the abundance, diversity, and spatial distribution of the ichthyoplankton were evaluated. Further, analyses testing differences in larval fish community between the original (2001-2008) and update (2016-2017) surveys sought to identify any environmentally-driven ecological shifts that occurred over the intervening decade. With an improved understanding of the nursery dynamics of Narragansett Bay, the results from this project will aid in creating better assessments of the role of this estuary in fisheries production and anticipating future trends in community composition with continued climate change.
Effect of temperature on the growth of blackthroat seaperch juveniles (*Doederleinia berycoides*) under laboratory conditions

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Blackthroat seaperch (*Doederleinia berycoides*) is a commercially important species in Japanese coastal waters. Due to its high value and market demand, they are expected to potentially be a new target species for the stock enhancement program. In previous seedling rearing trials, slow growth of juveniles was observed during winter (ambient water temperature: about 10-13°C), which leads to a longer rearing period prior to release. Therefore, we conducted rearing experiments to examine the effects of temperature on the growth of blackthroat seaperch juveniles. Twenty fish (113DAH, initial TL: 40.3±3.3mm, initial BW: 0.96±0.22g) were stocked in 100L duplicate tanks maintained at 10, 13, 16, 19°C. Fish were reared for 21 days, and their total length and body weight were measured at the end of experiments. Total length and body weight of juveniles in 16°C (47.0±2.6mm, 1.5±0.2g) and 19°C (51.6±2.9mm, 2.1±0.4g) treatments, were significantly higher compared to their initial values (Dunnett’s test, P<0.05). On the contrary, no significant difference was observed in 10°C (43.0±3.3mm, 1.1±0.3g), 13°C (43.5±3.3mm, 1.2±0.3g) treatments (Dunnett’s test, P>0.05). We conclude that warming rearing temperature to 19°C during winter is effective to hasten the growth of blackthroat seaperch juveniles, shortening the period required to attain the release size of ca. 50mm.

Effect of hydrodynamic and substrate on White Sturgeon larval recruitment in the Columbia River (Washington, USA)

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In the Northwest USA, White Sturgeon populations have drastically declined. The main cause of this decline is attributed to river regulations impacting early life stages habitat. To identify the possible causes of White Sturgeon low recruitment in the Columbia river (WA) and particularly the recruitment failure observed in 2004 and 2005, we developed an individual-based model coupled to a hydrodynamic model called the Fish Individual Numerical Simulator (FINS-STURGEON). The individual-based model allows the representation of each early life stage (i.e. spawning, incubation, free embryo, early larvae) and includes biological processes such as movement, growth, and survival. Predicted mortality of embryo was higher in 2004 due to high water temperatures which could explain the recruitment failure observed. Moreover, mean larval drift distances differed depending on the spawning location and suitable habitat. To further compare our results with empirical data, future research will include collecting in situ larval drift data using the Automatic Holographic imagery system (AUTOHOLO).
Larval connectivity of endemic Sciaenidae species in the Upper Gulf of California

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Because of the fishery and ecology importance of endemic Sciaenidae species in the Upper Gulf of California, a Biosphere Reserve since 1993, it was analyzed the distribution and potential retention of their larval phases in relation to hydrographic conditions from a March, June and September. Larvae of Totoaba macdonaldi, Micropogonias megalops, Menticirrhus nasus and Cynoscion othonopterus were identified based on morphological and meristic characteristics. However, due to that some DNA sequences of C. othonopterus were assigned with Isopisthus remifer (a species not morphologically identified), it was defined C. othonopterus-I. remifer complex. The most relevant hydrographic structure in the Upper Gulf was the permanent stratification front ($\Phi=10$ $J/m^3$) that result of the convergence of mixed water with high salinity (37.4 g/kg) with less salty water (35.4 g/kg) and stratified coming from the adjacent oceanic water. This front showed strong influence in the larval distribution. Totoaba macdonaldi larvae were only collected to northwest area in March, but the M. megalops, M. nasus and C. othonopterus- I. remifer complex larvae were found along of the frontal zone in June and September. The connectivity matrixes showed high particles retention in the along of the frontal zone, with the highest retention (>80%) in the eastern side. Results indicate that the stratification front could retain to the planktonic phases of these fish species avoiding their advection outside the UGC. It can be a factor that contributes to endemism, not only of these species, but also of others coastal demersal species inhabit this region.

Saithe (Pollachius virens): Egg development and characteristics as an important part of understanding spawning ground to nursery ground connectivity

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Saithe (Pollachius virens) are abundant along the Norwegian coast at all life history stages, but there is some debate about the connectivity between inshore and offshore spawning and the inshore nursery areas for juveniles. There is the suggestion that cod and saithe spawning in almost the same area yet the juvenile nursery areas are in very different locations, suggesting very different drift trajectories for the early life history stages. Basic data on temperature-dependent development rates and egg buoyancy was measured for eggs produced by a captive spawning group from the North Sea population. Eggs were collected within 12 hours of fertilization and incubated at 4°C, 6°C, 8°C, and 10°C. Development was monitored daily through hatching. Egg buoyancy, measured as the salinity of neutral buoyancy, was measured at different development stages, including newly hatched larvae. Hatching began approximately 6 days after fertilization at 10°C and 14 days after fertilization at 4°C. Saithe eggs were neutrally buoyant at a salinity of 31 - 32 during early development, increasing slightly to 33 during embryo formation, before rising to 31 close to hatching. The buoyancy of newly hatched larvae ranged from 30 - 32. This basic information is key to developing biophysical models of egg and larval drift, making use of a robust time series of ichthyoplankton survey data. The combination of laboratory experiments, field data, and high resolution oceanographic models will help to resolve the question of spawning locations along with the links between spawning areas and nursery grounds which can be spatially disparate.
Hydrodynamic transport of Asian carp eggs and larvae in a flume: implications for sampling

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Asian carp (grass carp, silver carp, black carp, and bighead carp) are invasive species in the waterways of the central United States. Because they have rapidly spread and are reproducing in new areas, ichthyoplankton sampling has become an important tool for early detection and monitoring in areas of new invasion. Using a race-track flume, we tracked vertical distributions, swimming speed, and orientation for grass carp eggs and larvae at three different flow velocities. Vertical distribution and swimming speeds were dependent on developmental stage and flow velocity, while orientation into the current was consistent at all flows and developmental stages. Vertical distributions at higher velocities show the largest proportion of grass carp eggs and larvae at all developmental stages near the bottom. Most ichthyoplankton sampling in North America for Asian carp is done as surface tows. Depending on water velocity, these surface tows may not be adequate for detection and accurate determination of density for Asian carp larvae. Using the Sandusky River as a model, we suggest changes in sampling methods including sampling at multiple depths (notably near surface and near bottom), site selection based on river characteristics (such as depth and flow velocity), and lateral coverage including the thalweg and near shore environments.

Influence of hydrographic characteristics on assemblage structure of small pelagic fish larvae in the Gaoping coastal waters off southwestern Taiwan

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Small pelagic fish (such as anchovy and herring) are widespread in all oceans and represent about 20-25% of the total annual world fisheries catch. They are highly mobile with short, plankton-based food chains and have short life, strong fecundity, and some can spawn year-round. These biological characteristics make them highly sensitive to environmental forcing and are ideal targets for testing the impact of climate variability on fish populations, assemblages, and whole ecosystems. The hydrographic and fish larvae samples were collected in the Gaoping coastal waters using the cruises of RV Ocean Research III from 2014 to 2017. Four species of Engraulidae (Engraulis japonicus, Engraulis heteroloba, Engraulis punctifer, and Thryssa chefuensis) and five species of Clupeidae (Sardinella jussieui, Sardinella lemuru, Sardinella melanura, Sardinella fimbriata, and Amblygaster sirm) were identified in the present study. The larvae of anchovy and herring occurred mostly in the inshore stations of the transect Gaoping River estuary and the adjacent waters. The abundance of larvae of anchovy and herring was higher during the warm period (spring and summer) than during the cold period (autumn and winter). Among the nine fish species, E. heteroloba and S. melanura were most dominant two species and occurred year-round; E. punctifer and S. jussieui occurred seasonally; and E. japonicus only was found at station 9 of transect Fangshan township in December 2014 and stations 4 and 18 of transect Gaoping River estuary in October 2015. The distribution of larvae of anchovy and herring was closely linked to the hydrographic characteristics, influenced by the terrestrial runoff in this study area, with chlorophyll a being the most important factor.
Fish larvae connectivity in a tropical river plume fronts zone

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The lifecycle of most teleost fishes includes a planktonic phase, when larvae vulnerability is highest. Physical dynamic of the coastal zone could enhance connectivity for several planktonic organisms, while river plume fronts could act as barriers for them. Interaction and coupling between spawns, currents and river plume fronts is crucial for larval fish development. In this study we aim to describe fish larvae community in a highly important fishing coastal region of the Mexican Intertropical Eastern Pacific, composed by several mangrove estuaries mouths, river mouths and plume fronts, three rocky reef insular areas, and a close deep-sea area. Sampling were conducted in the late spring of 2017, in addition, a larval fish sampling all along the shelf was analyzed to compare species. CTD cast and surface zooplankton tows were conducted in the islands vicinity small fronts, inside the river plume, and on the river plume front. Larval fish composition showed three different groups associated with three different zones, one in the river plume, one for the rocky reef islands, and one for the river plume front. However, the front assemblage grouped species from all different habitats, while the plume assemblage mainly grouped coastal and estuarine species, the islands assemblage was mainly composed by reef species, and the blue water assemblage by oceanic species. New regional and local ocean dynamics should be done in order to understand larval fish connectivity in this highly seasonal and multiannual transition zone, and its importance for fisheries species.

Fish larvae associations off the west coast of the Baja California Peninsula during climate anomalies of 2014 and 2015

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During 2013 to 2016, a series of climatic events developed in the northern hemisphere of the Pacific Ocean that affected the dynamics of the California Current System (SCC). The oceanic region off the western coast of the Baja California Peninsula (WCBCP) was affected in 2015-2016 by one of the most intense El Niño events recorded (comparable with those of 1982-1983 and 1997-1998), which was preceded by the warm water mass that originated in the Gulf of Alaska in 2013, and by a short-lived El Niño event in 2014. Although the effect of those processes on different faunal groups from the north and center of the SCC has been studied, there is still discussion about the effect they had on the southern portion. This work provides evidence of the influence of environmental variables on the distribution of fish larvae associations of the WCBCP during the summers of 2014 and 2015. Based on techniques of classification and ordination using environmental and ichthyoplanktonic data, four associations related to values of high larval abundance of mesopelagic species were found during 2014, where the species richness was contributed by demersal populations in a community dominated by tropical-subtropical species. In 2015 there were five associations related to low values of abundance and species richness in a community that registered an increase of coastal species with a wide faunal affinity.
Molecular markers: an auxiliary tool to morphological Identification of fish larvae from the Gulf of Mexico

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The Gulf of Mexico ecosystem has been targeted by several industries for its valuable resources of biological and mineral nature. Due this, several environmental quality problems have been outlined, originated either from natural processes, from anthropogenic pollution, or their combination. So, how do we achieve the goal of protect the Gulf of Mexico ecosystem and yet use, in a sustainable way, its resources? The first challenge is to understand what is out there. The present work shows the first results of project "Ichthyoplankton and Zooplankton diversity in the Gulf of México: a Metagenetic and Taxonomic approach" (CIGoM; www.cigom.info). The goal is to combine morphological taxonomic tools with molecular taxonomic techniques in order to facilitate and/or corroborate the knowledge of the biodiversity in the Gulf of Mexico. Morphological identification was possible to the species level for most of the fish larvae, 34 of these were selected to molecular corroboration. COI sequences were analyzed in BOLD Identification System by comparison to BOLD Species database. Species level assignations were used only if a solid match was found, otherwise genus level top hit taxon name was assigned. Conversion to WoRMS nomenclature through taxize R package was used to compare morphology to molecular assignations. BEAST Software was used to construct a Bayesian consensus tree. Conflict exists in larval types identified at least to genus by both methods. Mayor factors limiting morphological identification are the lack of descriptions of the early life stages and mistakes in the specific assignation due to too subtitle characters between morphotypes. Factors limiting molecular assignation are the lack of accurate reference databases, and the need of high quality sequences for accurate molecular assignation. Next step is to conciliate the results of both identifications techniques in order to obtain the most accurate recount of fish species inhabiting the Gulf of México.

Bahía Vizcaíno as a transitional area for fish larvae communities in the Southern California Current

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In 20 years of continuous sampling by the IMECOCAL Program, fish larvae communities in the Southern California Current have been widely studied regarding to species composition and community structure on seasonal and inter-annual scales. According to this, the region can be divided in three mayor zones: Ensenada, Bahía Vizcaíno, and South Punta Eugenia. Larvae of coastal pelagics Engraulis mordax, Sardinops sagax and Scomber japonicus rank among the seven most abundant. Variability in their trends of abundance in the last 20 years, seem to be related wit long term periods of both, rise and decay of the average sea surface temperature. Along with coastal pelagic larvae, those of mesopelagic are dominant year round in Bahía Vizcaíno and three species rank in the first four by their abundance: Vinciguerria lucetia, Triphoturus mexicanus and Diogenichthus laternatus. These larvae maintain their dominance despite the seasonality and the high variability observed in the Southern California System. Although, the response to this environmental forcing is different among species and zones. Synodus lucioceps is the only demersal species which larval abundances rank between the first seven. High abundances of these larvae have been associated to El Niño Events in the transitional zones of the California Current. Data series of fish larvae abundances, as well as registers of environmental variables such as temperature, Chl-a concentration and zooplankton abundance, have highlighted the importance of Bahía Vizcaíno as a center of high diversity and as a transitional zone between the northern and southern fauna.
Larval orientation behavior begins shortly after hatching in a coral reef fish

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Most marine fishes disperse as tiny larvae that develop for several days to months in the upper water column before returning to settle in benthic habitats. Though once considered passive particles, it is now widely recognized that late-stage larvae can detect and orient their movements in relation to olfactory, visual, and auditory cues. The onset of orientation behaviors early in development is expected to enhance the probability of survival to settlement and could help to retain larvae closer to their natal origin. Yet, little is known about when larvae develop the ability to orient. In this study, we deployed lab-reared larvae of the neon goby Elacatinus lori offshore from their natal reef in a Drifting In Situ Chamber (DISC) designed to monitor and quantify larval orientation behavior in the marine environment. Larvae were deployed every two days throughout development from shortly after hatching through settlement (2 to 30 days post hatch). We found that individual larvae oriented directionally at all ages. The proportion of directional larvae did not increase with age; but instead, was consistently high across all ages. Finally, the precision of orientation also did not improve with age. These results contradict the assumption that, as larval sensory systems develop, a greater proportion of individuals will be capable of orienting, and the precision of their orientation will improve. Instead, neon goby larvae were able to orient along a constant bearing beginning shortly after hatching. Together, swimming abilities and orientation behaviors could allow larvae to influence their displacement by ocean currents.

Paralarval cephalopods of the Northeast US: the larval fish of the invertebrate world

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Paralarva is the term used for pelagic early stages of cephalopods, which differ morphologically and ecologically from juveniles and adults. Cephalopod paralarvae were identified from year-round continental shelf surveys from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia, from 2010 to 2012 and from summertime surveys from 2009 to 2013 in the Slope Sea region between the northeast U.S. continental shelf and Gulf Stream. Twenty-four unique taxa of cephalopod paralarvae from 14 families: including butterfly squids (Sepioidea), squids (Teuthoidea), and octopus (Octopoda) were identified. The commercially and ecologically important benthic spawning, neritic species, longfin inshore squid (Doryteuthis pealeii), was the most abundant and comprised over 75% of the total abundance of paralarvae collected on the shelf. Longfin inshore squid were collected primarily on the inner-shelf (<60 m) with surface water temperatures from 16 - 25° C and salinities less than 33. The other paralarvae collected on the shelf were dominated by oceanic taxa that were most abundant on the outer-shelf (>80 m) with surface water temperatures >22 o C and salinities >34. Preliminary analyses of the summer Slope Sea paralarvae indicate that the dominant taxa were from pelagic spawning, oceanic families Enoploteuthidae and Pyroteuthidae. Future work will focus on completing the identification of the Slope Sea samples and comparing and contrasting the cephalopod communities among the adjacent regions.
Horizontal and vertical distribution of ichthyoplankton post Hurricane Harvey flood plume

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Hurricane Harvey was a major ecological disaster that hit the coast of Texas in the late summer of 2017. The storm sent thousands of gallons of eutrophic freshwater into the Gulf of Mexico (GoM). Already vulnerable, early life stages of fish can be greatly affected by changes in environmental parameters. The purpose of this study is to assess how the Hurricane Harvey floodwaters affected the ichthyoplankton community off of Galveston, Texas. This is part of a larger research project which also assesses the response of phytoplankton and zooplankton community composition and trophic interaction as a result of the flood plume. We are interested in answering the three following questions: (1) Did coastal fish larvae undergo geographic displacement, being flushed out farther onto the GoM shelf than normal? (2) Did the increased primary production stimulated by floodwaters and resultant possible higher food availability lead to elevated larval fish densities? (3) Did fish larvae avoid or aggregate in the fresher surface water layer, and if so which taxa? Here we present preliminary data collected in September and October 2017, approximately three and eight weeks after the storm occurred. We show data on horizontal and vertical community distribution, species richness, diversity, and abundance. Ichthyoplankton samples were collected along two transects, perpendicular to the Galveston Bay shoreline using a 61 cm Bongo net (335 μm mesh) and a1m² frame MOCNESS (335 μm mesh). The Bongo net sampled the entire water column up to 200 m depths, and the MOCNESS targeted three depth strata: surface, chlorophyll max, and below the chlorophyll max. In the future, we plan to expand our analysis for samples collected in January, March, and September 2018 as well as analyze the stomach content and growth rate of select species.

Growing up in a plastic ocean - the impact of microplastic uptake in juvenile seabream

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Coastal ecosystems are known to face severe exposure to MP particles as a result of riverine input in combination with the continuously increasing urbanization of on- and offshore regions. Conflicting with their acknowledged ecological, economic and social importance, these ecosystems nowadays represent the gateway of MP pollution to the global oceans. Accounting for the high spatial diversity of coastal habitats, it is hypothesized that early life stages (ELS) of fish, using near shore habitats as nursery grounds and showing a high site fidelity, encounter a gradient of habitat quality and pollution within the coastal environment. In relation to the ingestion and bioaccumulation of marine pollution, MP has recently become the focus of scientific and public attention: on the one hand, due to their size ranges allowing the interaction with plankton at the base of the food web and on the other hand, due to their cumulative application resulting in increasing quantities in marine habitats. Although the impacts of ingestion likely differ depending on the size relation between the organism and the MP particles, the exposure of ELS to MP has not been analyzed in-situ to a sufficient extent. Direct ingestion as targeted or mistaken prey items is reportedly the major pathway of MP in fish, however studies on the effects of ingestion seldom cover ELS. Therefore the aim of this research project is to assess the spatial and temporal variability of MP pollution along with different habitat quality parameters in coastal ecosystems, to compare this with the uptake of MP by ELS and to evaluate the physiological effects on survival and growth of ELS seabream in the East Atlantic. The in-situ approaches are complemented by feeding experiments, biochemical and microbiological analyses. Initial results indicate a high exposure of ELS to MP particles in vital recruitment areas; stomach content analyses will provide information on the potential uptake in relation to natural prey items.
Seasonal variability of ichthyoneuston assemblage in the continental shelf and slope of the Southwest Atlantic Ocean, Brazil (20°-23°S)

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Neuston samples were collected in the daylight between 20°S-23°S from February to April 2009 (final summer/early autumn; rainy season) and from August to September 2009 (final winter/early spring; dry season). Tropical Water (TW) was dominant in the study area, mainly in the oceanic region. On the continental shelf a Mixture Water that is colder and less saline than TW was detected. The ichthyoneuston abundance and composition did not differ significantly between the upper and lower nets and seasonality seemed to be important to larval fish occurrence in both nets. Eggs of six taxa were identified: Anguilliformes, Engraulidae, Clupeidae, Synodontidae, Trichiuridae and Maurolicus stehmanni (Sternoptychidae). The neustonic fish larval assemblage was composed by 40 families and 63 species. Mullidae and Myctophidae larvae were the most abundant in the rainy period while Mullidae and Mugilidae dominated in the dry season. Members of the euneuston and pseudoneuston mainly occurred in the continental shelf, while facultative neuston was represented in the continental shelf and slope. Data obtained in our study stressed the importance of the neustonic layer to evaluate some ecological aspects of many fish species that spend part of their lives in neuston. Further studies would investigate the influence of daily migration, and the effects of eddies and upwelling in the neustonic layer of the southeast Brazilian waters.

Thermal influence on the potential spawning habitat and juvenile growth of Coryphaena hippurus (dolphinfish) in the Mediterranean Sea

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Dolphin fish (Coryphaena hippurus) inhabit the tropical and subtropical waters of the world and supports commercial, artisanal and recreational fisheries. Dolphin fish are known to exhibit strong responses to thermal changes through shifts in spawning areas, growth and behavior, among others. Here, a statistical potential spawning habitat envelope has been created for the species in its traditional spawning ground in the Mediterranean Sea by combining i) spatially-explicit environmental variables and occurrence data of adults and sizes from longline discards, ii) preferred dates and temperatures for spawning, inferred from aged juvenile otoliths from a wide array of Mediterranean locations, and iii) size-based reproductive rules. Further, a hierarchical Bayesian temperature-dependent growth model was built to best predict juvenile growth as a function of i) temperature at birth and ii) photoperiod. Both the spawning and the growth model showed good performance when confronted with new data. We aim at using the present models to extract useful information for both short-term predictions, and for the analysis of potential effects of extreme thermal events.
Evidence of immediate and continued use of artificially constructed reefs by spawning lake sturgeon

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The St. Clair-Detroit River System (SCDRS) is a 115 km waterway connecting Lake Huron to Lake Erie. Beginning in the early 1900's large scale modifications removed lithophilic spawning habitat through the construction of shipping channels and disposal of dredge spoils. In 1987, the St. Clair and Detroit rivers were designated as Areas of Concern do to habitat loss and other anthropogenic disturbances. Additionally, lake sturgeon (Acipenser fulvescens), a culturally and economically important lithophilic spawner endemic to the Laurentian Great Lakes, have been listed as a species of concern in the SCDRS. In order to increase the availability of spawning habitat for lake sturgeon, eight artificial spawning reefs were constructed throughout the SCDRS between 2004 and 2017. Egg mats, benthic D-frame nets, and stratified conical nets have been used to assess the response of fish to the reefs. Assessment data provide evidence of immediate and continued use of the reefs by spawning lake sturgeon and survival of eggs to the larval stage. Assessment of physical characteristic of reefs showed that two reefs suffered from infilling with sediments, while others remain in good condition. Remediation efforts aimed at addressing factors limiting reproductive success of threatened and endangered species, such as lake sturgeon, are critical to recovery, and lessons learned in the SCDRS provide a framework for future remediation efforts throughout the Laurentian Great Lakes.

Illustrations depicting larval and juvenile development of flathead chub

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The flathead chub Platygobio gracilis (Cyprinidae) has an extensive native range in central North America from the Mackenzie and Saskatchewan drainages of Canada to the Missouri, western Mississippi (mostly below Missouri R. confluence), and upper and middle Rio Grande drainages of the United States. Populations in much of its southern and eastern range have been declining and accorded state endangered, threatened, or special concern status. Adults, which seldom exceed 19 cm TL, are typically found in turbid, moderate to fast-flowing, main-channel habitats of rivers and tributaries. As either a nonguarding, open-substrate, lithopelagophil or pelagophil, they broadcast spawn non-adhesive, semibouyant, 1.8-2.9 mm diameter eggs in relatively shallow flowing waters usually in late May to August at 17-25 °C. Laboratory reared fish hatch in 4-7 days at 20-22 °C; in the wild, recent hatchlings drift with the current. The larvae and early juveniles have not been previously illustrated or described. Here, based on specimens reared or collected from the upper Rio Grande (NM, CO) and tributaries of the Arkansas River (CO), we illustrate Flathead Chub development from a recently hatched, 6.1-mm-TL, protolarva to a 40.1-mm juvenile. Larvae typically hatch with undeveloped mouths, oval, moderately pigmented eyes with a darker band across their greater diameter, and no or very little body pigment except above the yolk and ventrally near the vent and thereafter under the base of the finfold. The eyes rapidly darken and a large subterminal mouth soon develops. The eyes remain oval until late in the postflexion mesolarval phase. The larvae have 39-43 total myomeres, 26-29 preanal (to the posterior margin of the vent including those transected by a vertical therefrom), and 11-14 postanal (entire myomeres posterior to the vent). Larvae from more northern populations will likely have more myomeres corresponding to their greater number of vertebrae.
Larval bully respiration in different salinity and temperature conditions

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The common bully (Gobiomorphus cotidianus) is a small freshwater fish found throughout New Zealand, it occupies a range of latitudes (35 to 46°S), meaning that must have a wide ranging thermal tolerance. It is facultatively diadromous, with both coastal and landlocked populations. Therefore, spawning and larval rearing can occur in a wide range of salinities. This study focusses on common bully larvae and investigates how respiration rate varies in different salinity and temperature conditions, with the aim of understanding how this impacts the energy requirements and osmotic stress experienced by the larvae. Larvae were acclimatized in one of nine temperature and salinity combinations (8, 14 or 21°C, and fresh, brackish or salt water), individually their respiration rate was measured using a microrespirometry system. Respiration rate of fish can then be converted into energy used for respiration, allowing an understanding of food requirements for larval survival. This can in turn provide evidence on why certain populations are more prolific than others, as larval survival and distribution is a key factor in population success.