



Biology 465: *Diversity and Evolution of Fishes*

“Whether we live by the seaside, or by the lakes and rivers, or by the prairie, it concerns us to attend to the nature of fishes, since they are not phenomena confined to certain localities, but forms and phases of the life in nature universally dispersed.”

H.D. Thoreau, *A Week on the Concord and Merrimack Rivers*, 1849



1.1 Basic Info

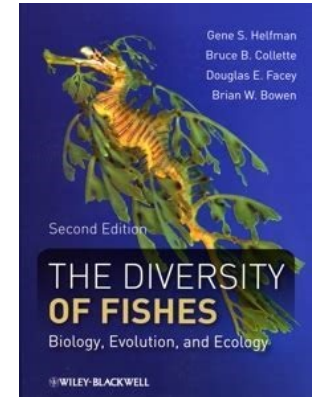
- Eric B. (Rick) Taylor, Professor, etaylor@zoology.ubc.ca, Biodiversity 310
- TBA

- Website:
<http://www.zoology.ubc.ca/~etaylor/426www/bio465home.html>

- Upload assignments/video lectures – see CANVAS

1.1 Basic Info

- First Lab is NEXT week, Biodiversity 060
- No textbook, but this is a great book and can be downloaded from Academia



[https://www.academia.edu/25477389/The Diversity of Fishes Biology Evolution and Ecology Helfman Collette Fracey and amp Bowen](https://www.academia.edu/25477389/The_Diversity_of_Fishes_Biology_Evolution_and_Ecology_Helfman_Collette_Fracey_and_amp_Bowen)

Primary literature will be key source of info

1.1 Basic Info

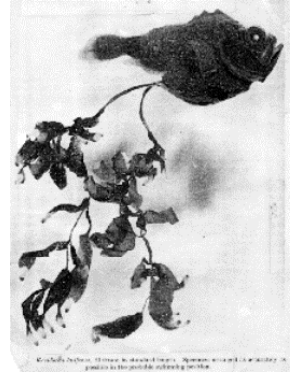
- Grading: Lab/assigned readings (15%); term paper (30%); lab exam (20%); final exam (35%)
- Take home practice “mid-term”: Oct 10th
- Expectations: also on website

1.1 Basic Info

Biol 465: Goals, objectives, expected outcomes

1. To gain a basic understanding of the diversity of fishes, their place in the tree of life, and how they illustrate basic concepts in biodiversity and evolution (especially form and function, adaptation)
2. To gain a basic understanding of fishes as a model system for asking and answering fundamental questions in evolution and ecology, often with relevance to conservation, i.e., fishes as a portal to “a way of knowing”
3. You will be able to access, synthesize, and evaluate primary literature in fishes-related science
4. You will be able to articulate your ideas succinctly orally (during tutorials) and, most importantly, in written fashion through short essays and a term paper.
5. If you don't already, you will learn to love fish and NEVER (NEVER) call them “ugly”!!

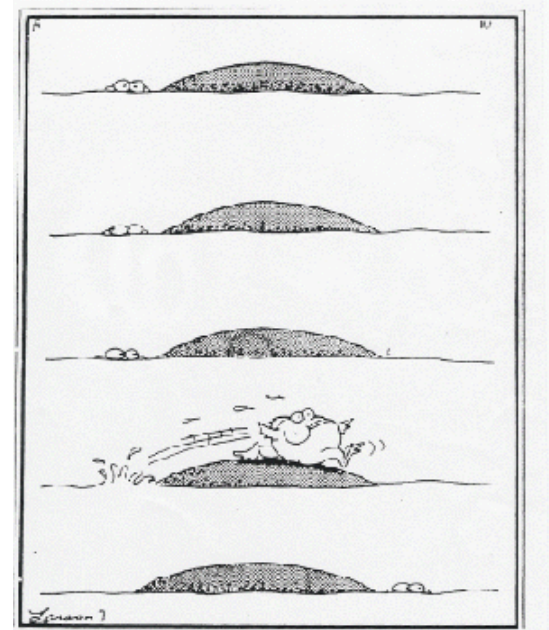
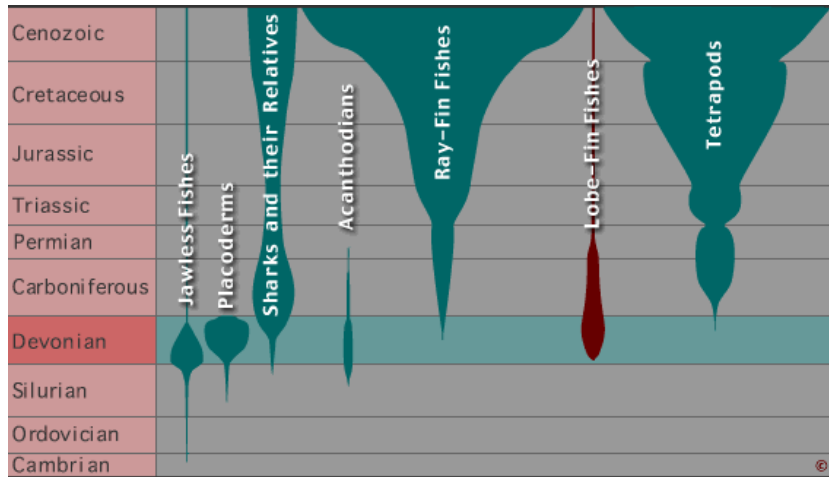
1.2 Why Study Fishes??



- **1.2.1 Vertebrata?? Fishes Rule!!**
- ~ 35,000 species (in 568 families), more described every year, fishes constitute the largest group of vertebrates
- Birds, with about ~9,500 species are a distant second. If we are to know anything about vertebrate evolution, we have to know something about fishes
- Major evolutionary transition in vertebrates was the transition from an aquatic to terrestrial life >> knowledge of the adaptations that facilitated such a transition

1.2 Why study fishes?

Fishes are the oldest vertebrates (~0.5 billion years old) – to understand *human* (vertebrates) evolution we need to understand *fishes*



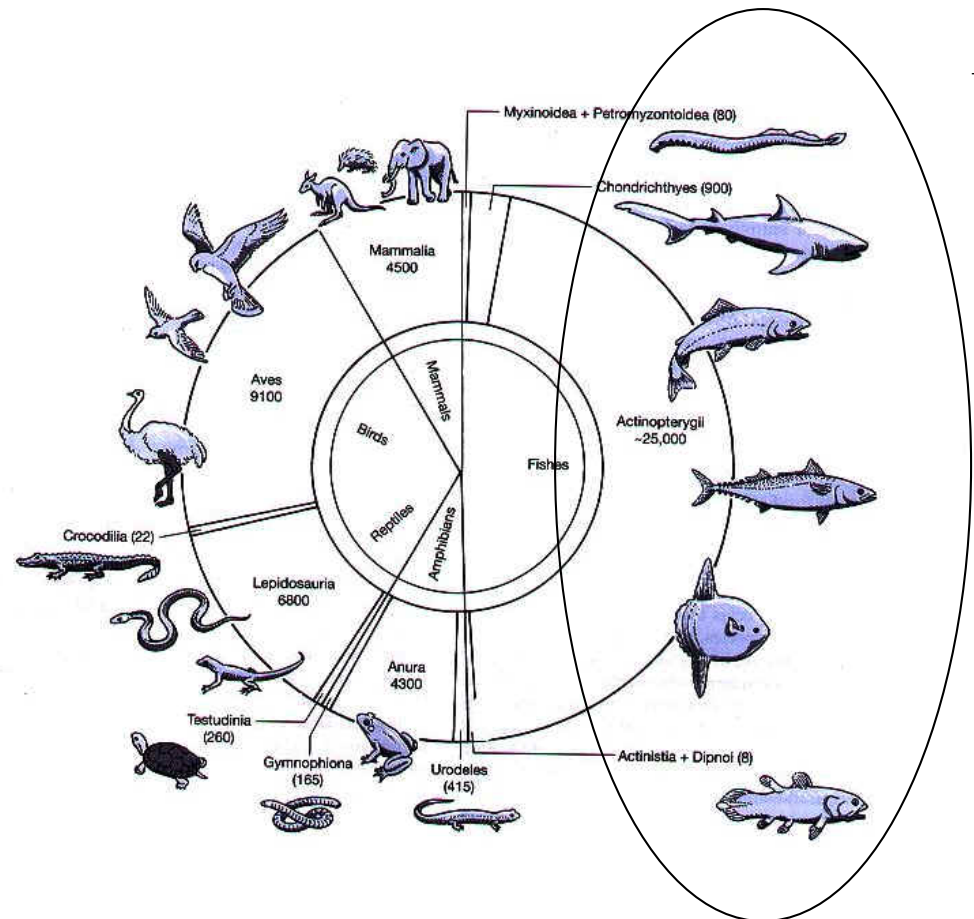
“Another great moment in evolution” - Larsen

1.2 Why study fishes: Biodiverse!



WHY?? What generates such diversity?

“Homage to Santa Rosalia or why are there so many kinds of animals” G.E. Hutchinson (1959)



1.2 Why study fishes?

1.2.2 Humans and fishes: a close knit

- Single largest source of animal protein (2013: aquaculture now trumps animal agriculture)
- Cave paintings, 1000s of years old, art and culture, industry, recreational, religion, literature

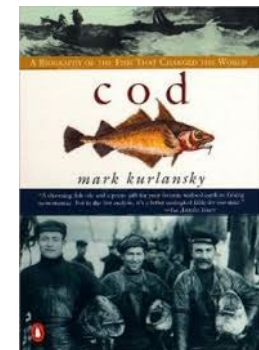
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Evidence for the cooking of fish 780,000 years ago at Gesher Benot Ya'aqov, Israel



1.2 Why study fishes?

Fishes are intimately linked with human civilization [Largest source of animal protein, ecosystem services, and direct \$\$ - more than cruise ships and Whistler combined in BC]

Ex-465 student!



*In Jan. 2013, one bluefin tuna (489 lbs) sold for \$1.8 MILLION at a Tsukiji market in Tokyo!

Pro sports – *meh?*

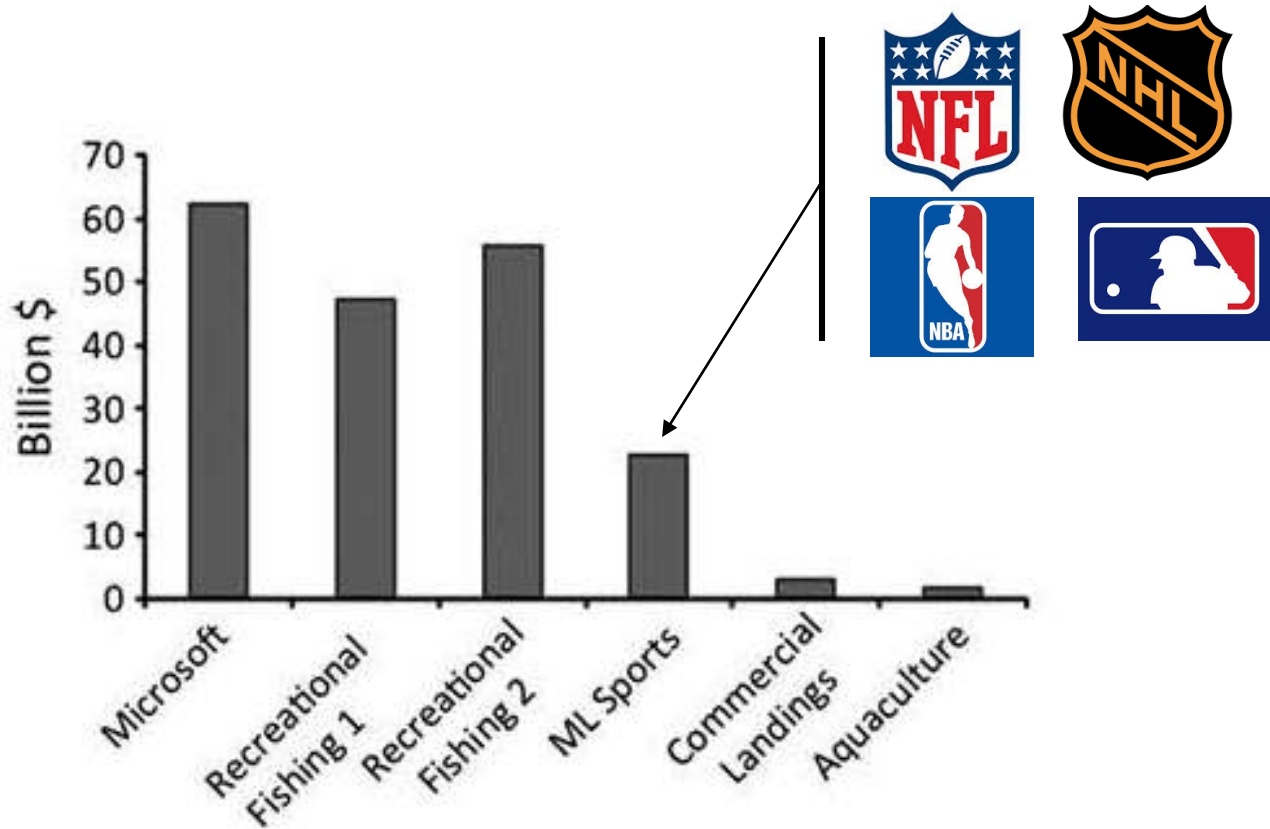


Figure 3. Comparison of the economic impact of recreational fishing (1 = DFO & USFWS; 2 = DFO & ASA doc), revenues for Microsoft in 2011, ML Sports (combined NFL [8.8 billion], NBA [3.7 billion], NHL [3.4 billion] and MLB [6.8 billion]) for 2011/2012 [34], commercial landings for finfish in North America and North American aquaculture landings for finfish [35-37].

1.2 Why study fishes?

1.2.3 Because they are so darned interesting!



Giant ocean sunfish, Mola mola



Megalodon jaws (25 – 2.5 mya)

Water constitutes > 70% of the Earth's surface area (should it not be called planet "Water"?) and fishes inhabit every bit of it from ~ 8,336 m deep ocean trenches, to Arctic waters to high elevation "soda" lakes, and some fishes spend most of their time on land!



Hadal depth snailfishes

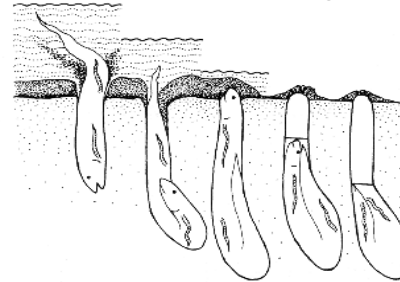


Antarctic fishes



Pyramid Lake, NV, cutthroat trout

Japanese mudskipper



Aestivating African lungfish

As the water level falls lungfish burrow into the bottom mud to form a cocoon and aestivate through the dry season.

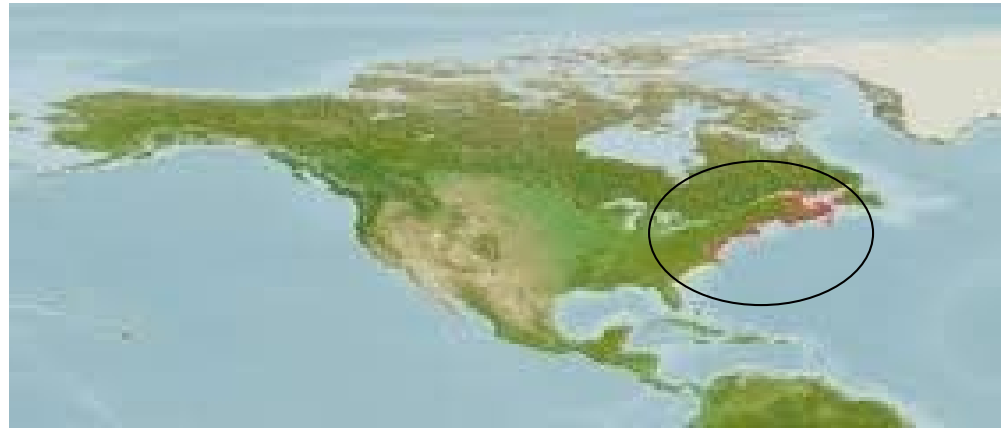
1.2 Why study fishes?

1.2.4 Evolutionary physiology and adaptation

- The mummichog, *Fundulus heteroclitus*

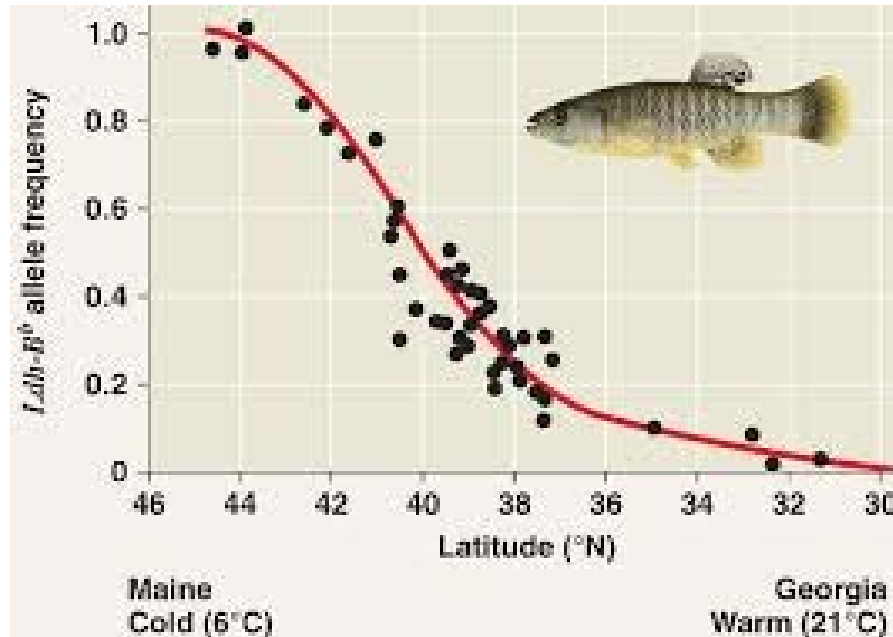


10 mm



1.2 Why study fishes?

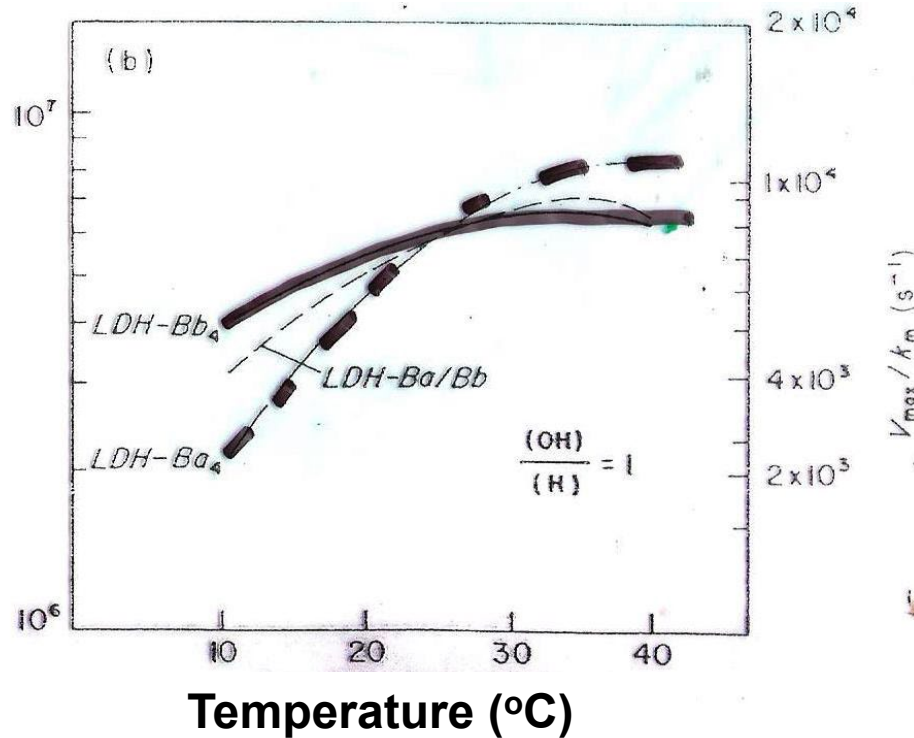
- A “cline” in Ldh-B: enzyme important in anaerobic metabolism: Powers, Schulte (UBC)



What causes this non-random distribution of alleles??? – selection, secondary contact, drift?

1.2 Why study fishes?

Catalytic efficiency



LdhB-b better at **cold WT**, LdhB-a better at **warm WT**
(pyruvate → lactate)

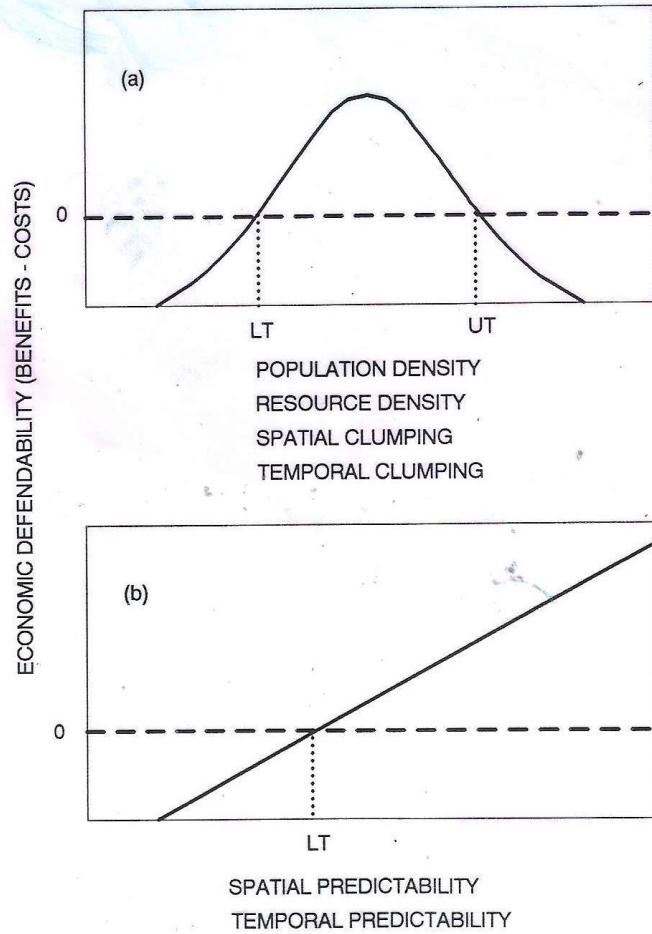
1.2 Why study fishes?

1.2.5 Behavioural ecology (with input from economic theory!)

- Evolution of territoriality. Why are some species territorial, others not? Individual to individual variation, variation within individuals with time – why?
- “Economic defendability”: only defend a territory when it is profitable to do so (currency = energy!)

1.2 Why study fishes?

WHETHER OR NOT TO DEFEND? THE INFLUENCE OF RESOURCE DISTRIBUTION 135



**“Economic”
defendability**

**Used to make
predictions about
when fish should
be territorial**

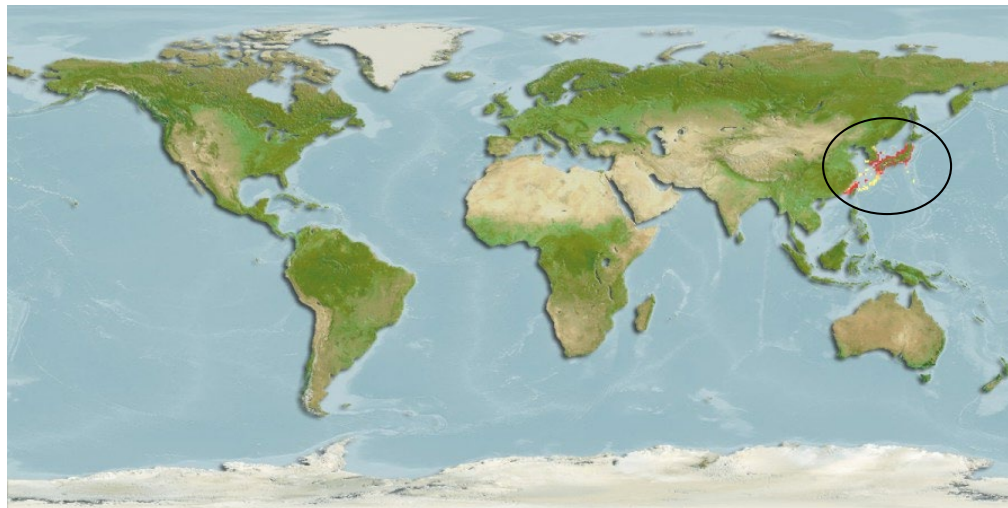


Coho salmon (*Oncorhynchus kisutch*)

Figure 1 Economic defendability and hence the aggressiveness of animals are predicted to (a) peak at intermediate levels of population density, resource density and spatial or temporal clumping of resources or (b) increase as the spatial or temporal predictability of resources increase (LT=low threshold for defence; UT=upper threshold for defence).

1.2 Why study fishes?

- Ideas tested in Japanese ayu, *Plecoglossus altivelis*



1.2 Why study fishes?

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J. W. A. GRANT

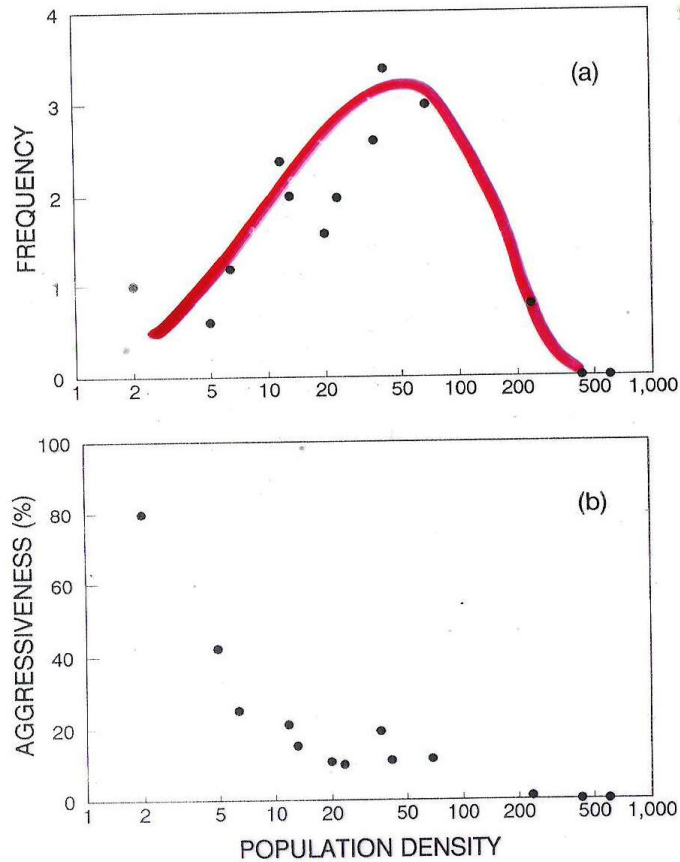


Figure 2 (a) Frequency of aggression (no./15 min) and (b) aggressiveness (% of encounters resulting in aggression) of juvenile *Pseudolabrus celiodotus* in relation to population density. Modified from Jones (1983).

WHETHER OR NOT TO DEFEND? THE INFLUENCE OF RESOURCE DISTRIBUTION 143

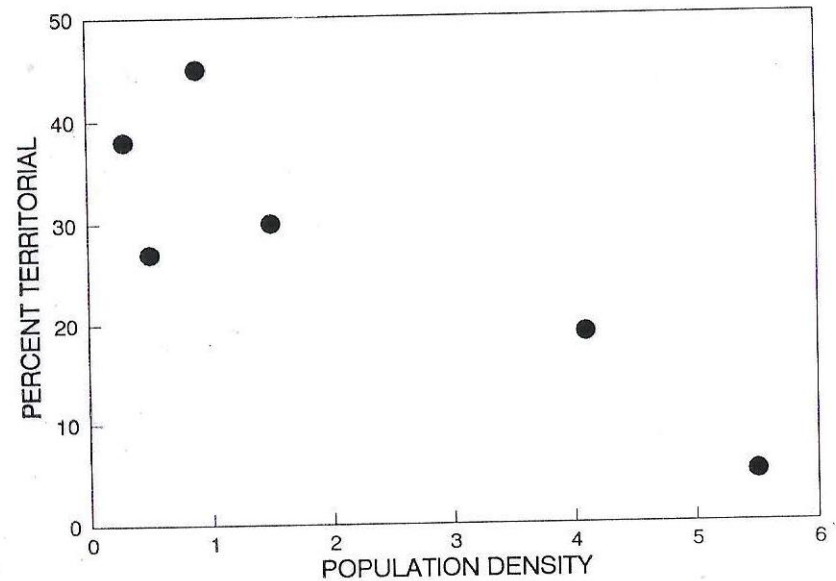
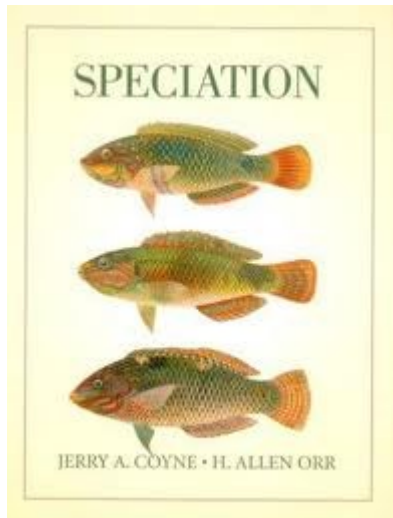


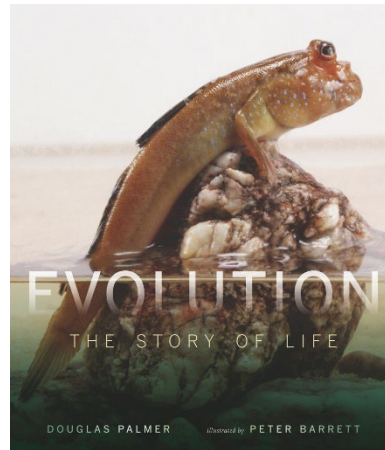
Figure 3 Percentage of ayu that defend feeding territories decreases with increasing population density ($r=-0.88$, $P=0.021$). Data are from Kawanabe (1969).

1.2 Why study fishes?

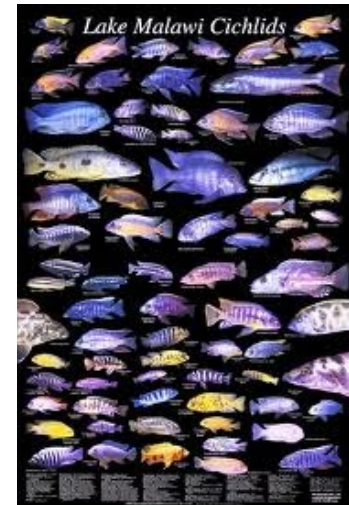
1.2.6 Model systems in Darwin's "mystery of mysteries" – what are "species" and how do they originate??



On the cover of
Coyne and Orr's
Speciation



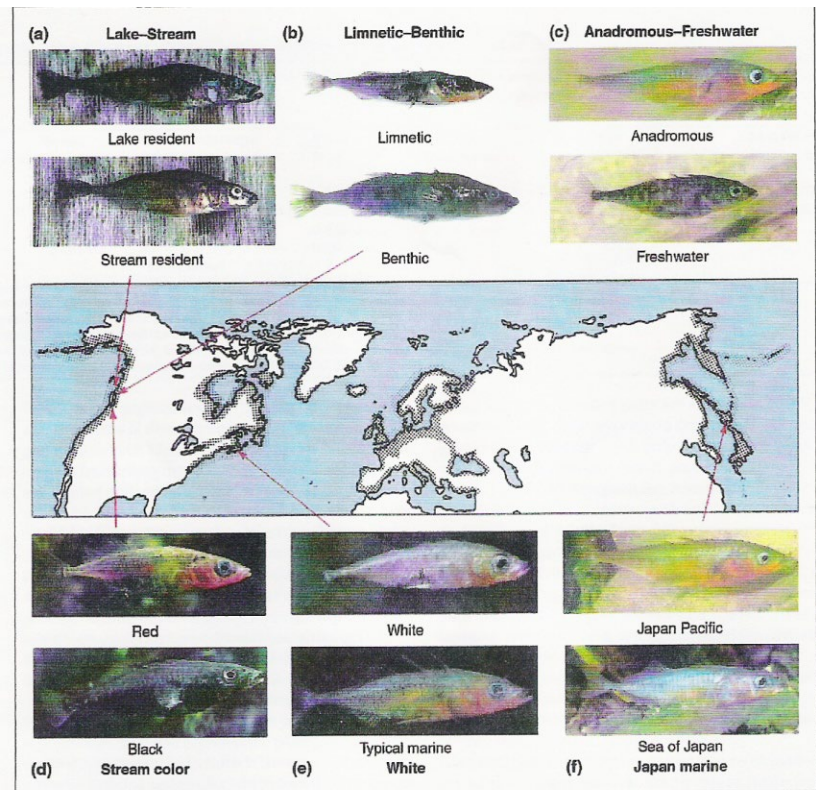
On the cover of
Palmer's
Evolution



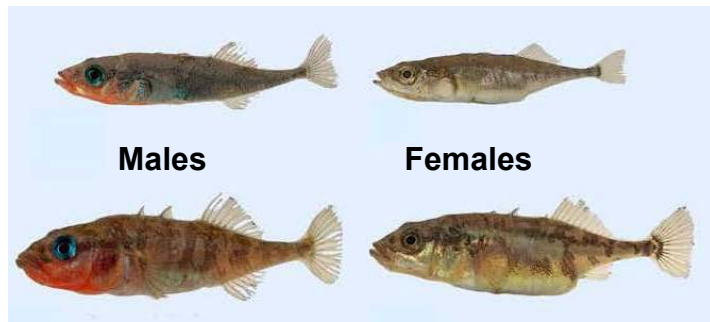
African cichlids –
poster children for
speciation research

1.2 Why study fishes?

- Local hero in speciation research – the threespine stickleback (*Gasterosteus aculeatus*)



Some BC fishes are among the youngest vertebrate species on Earth: BC's “species pairs” of threespine stickleback

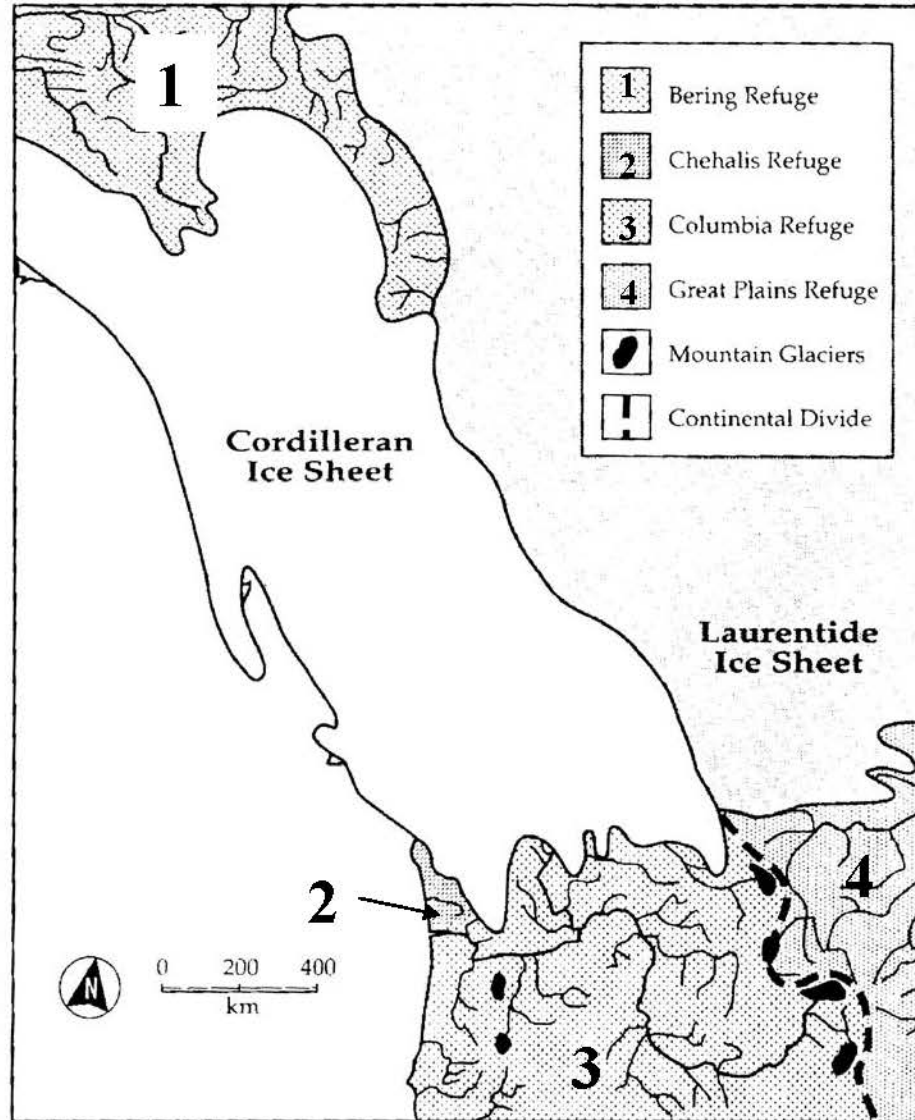


Limnetics (top) and benthics (bottom)

Less than 10,000 years old!



Postglacial Origin



DISTRIBUTION

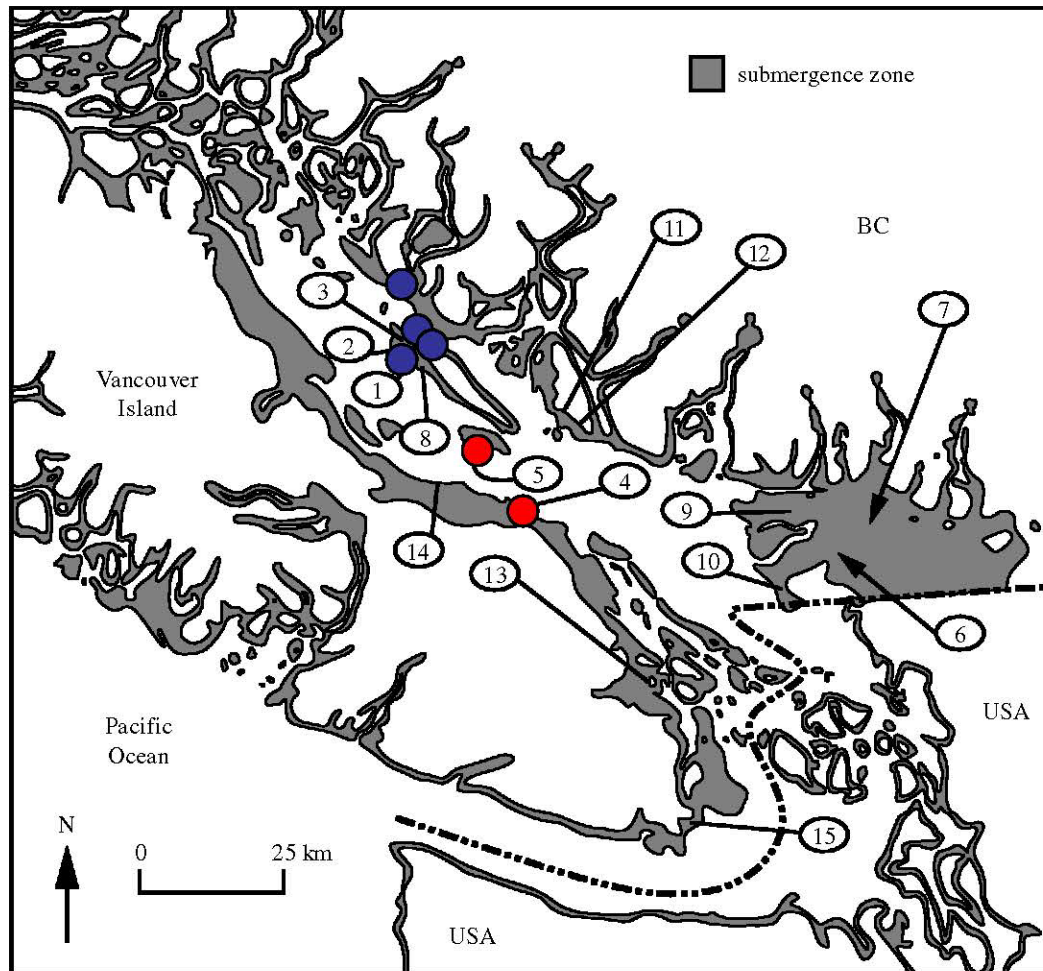
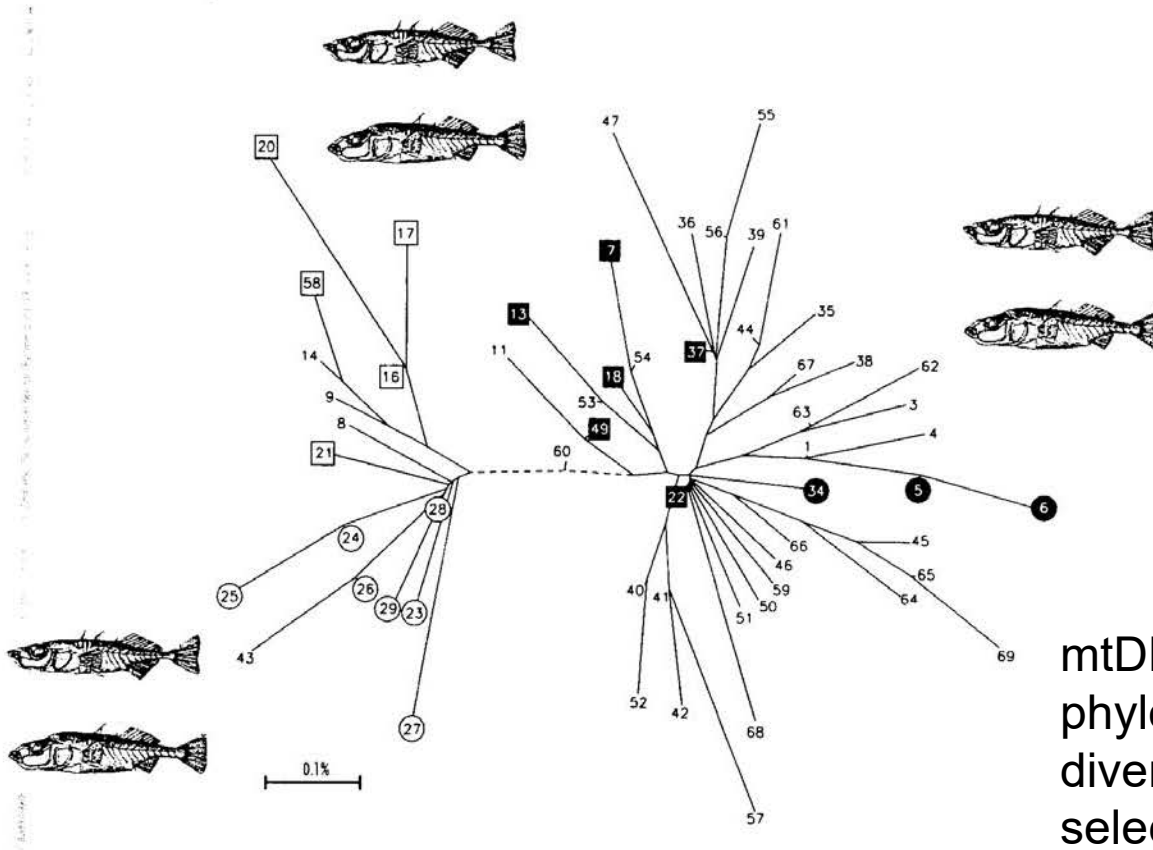


Figure 1. Locations of sticklebacks collected for microsatellite DNA analyses. Dark shading indicates maximum extent of marine submergence zone (after Mathews *et al.* 1970). 1, Paxton Lake; 2, Priest Lake; 3, Emily Lake; 4, Enos Lake; 5, Tremerton Lake; 6, Little Campbell River (freshwater); 7, Salmon River (freshwater); 8, Cranby Lake; 9, Salmon River (marine); 10, Little Campbell River (marine); 11, Salt Lagoon; 12, Oyster Lagoon; 13, Nanaimo River; 14, French Creek; 15, Witty's Lagoon.

Species Pairs Evolved Independently



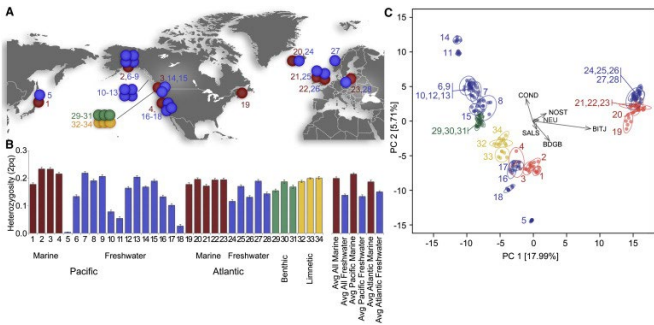
mtDNA-based phylogeny - Parallel divergence, role of selection, divergence with gene flow

1.2 Why study fishes?

- Sticklebacks: BC-based research (McPhail, Schluter, Taylor) has spurred a global industry looking at genomic basis to adaptation and speciation



Postdoc & PhD Positions Available
Contact: fcjones@tuebingen.mpg.de



PEICHEL LAB



1.2 Why study fishes?

- Hope the question has been answered – something for everyone!
- Fish = singular or plural when referring to the same species: “Look at all the sockeye salmon, I have never seen so many fish.”
- “Look at all the sockeye and pink salmon, I have never seen so many fishes.”