Ichthyology

ECOL 482/582

Fish Envy - Is It Wrong?

Ichthyology - ECOL 482/582

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- Teaching Assistant: Mary Jane Epps, mycota@gmail.com Office: W-F 3:00-4:00
- Lectures and Labs: Lecture 11:00 – 11:50 Wednesday and Friday (CBS 411); Lab - 12:00 – 2:50 Wednesday and Friday (CBS 411)
- Web-site address: http://eebweb.arizona.edu - go to Courses, EEB course websites, Ecol482/582 or the URL is http://eebweb.arizona.edu/courses/ecol482_582/index.htm
- Books: Helfman, G., Collette, B., Facey, D. 1997. The Diversity of Fishes. Blackwell Science, Inc. – Or another Ichthyology Text – Bond 2nd ed. Or Moyle et al. can be used
- Suggested – This is a great book for fish aficionados - Paxton, J.R. and W.N. Eschmeyer (eds.) 1995. Encyclopedia of Fishes. Academic Press, N.Y.
- Lecture notes will be available as PDF files and there will be a series of handouts available as pdf files.

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- The purpose of this course is to expose the participants to various topics in ichthyology. This includes laboratory, field and lecture work. The goals of the course are as follows:
- 1) To give the student a background and conceptual framework in phylogenetic systematics. Given that an entire course (or lifetime) can be devoted to such intellectual pursuits, the professor strongly advocates that a phylogenetic framework is necessary to fully comprehend the other goals of the class.
- 2) To expose the student to the diversity of fishes (BOTH living and fossil). A phylogenetic approach will be used to survey the diversity of fishes – starting with presumed primitive lineages and fossil ancestors and working through the more advanced fishes. We will also look at major types of fishes found in Arizona and the Gulf of California.
- 3) To familiarize the student with the structure and function of fishes. This is important for three reasons: 1) you should be familiar with the basic structure of fishes, 2) many structures are important for identification purposes and 3) we will discuss the functional morphology of many of these systems and how function/structure is used to in determining phylogenetic relationships.
- 4) To understand how fishes interact with their environments both ecologically and physiologically.
- 5) To understand the challenges and tools available for the conservation and management of fishes both in Arizona and throughout the word.

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- Great expectations:
- Exams (60%) - You can take three exams and I will drop the lowest score of the three exams. If you miss an exam for any reason, you are required to take other two and there will be no make up exams. All exams include lecture (20%) and laboratory material (10%) and both the lecture and lab periods are scheduled for exams.

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- Great expectations:
- Paper or Project with Presentation (15%) - You are also requested to do either a paper or laboratory project that is to be written up (10 page write up max - 10%) and present this to the class for 10 minutes (5%). Projects will address the systematics, morphology, evolution and/or ecology of fishes. You are permitted to work in teams and projects must be approved by Dr. Reinthal. No duplicate projects are permitted and projects are approved on a first come first served basis.

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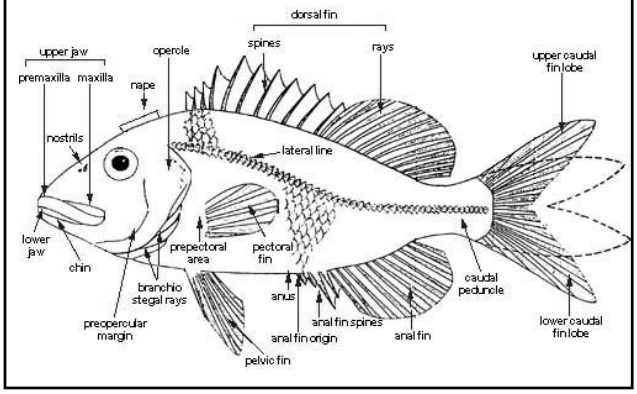
- Great expectations:
- Lab (25%) - You must turn in a laboratory notebook with all your lab work, identifications, field trips, dissections, notes, drawings, etc. You are not permitted to copy other student's laboratory notebooks. If you miss a lab, see the TA or the Professor about getting access to the lab to make up the missed work.
- Field Trips: Aravaipa and Mexico

Introduction

- What is a fish?
- Distribution of water and fishes.
- What about water?
- Early fishes – overall context

What is a fish?



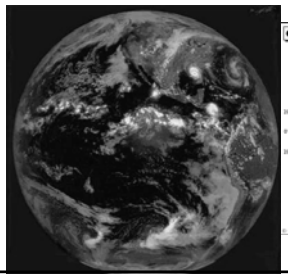
What is a fish?

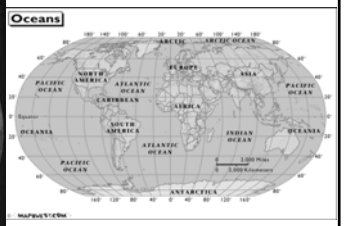
Of all vertebrate groups - fishes most plesiomorphic – Primitive phylogenetic position not equal unsuccessful - radiation of fish is unparalleled among vertebrates.

- Approximately 50,000 species of vertebrates, approximately 25,988 species of fish in 483 families and 57 orders.
- 4500 mammals, 9100 birds, 7082 reptiles, 4880 amphibians
- ~85 jawless; ~850 cartilaginous and ~24,000 bony fish.
- Why and how successful?

Distribution - Where are the fish?

Marine - Approximately 58% (about 13,630) of all species of bony fishes live in marine environments.



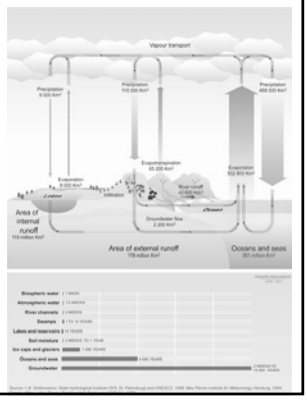


Distribution - Where are the fish?

Freshwater - approximately 42% (about 9,870) of fish species (Wootton, 1990)

BUT - Only about 0.01% of earth's water is fresh.

Why? – So many species? In so little water?



Where are the fish?

If potential aquatic way of life open to vertebrate, highly probable some fish has tried it somewhere at some time.

- Found all over the globe:
- Vertical distribution - ocean abyss to high altitude mountain streams (5200 m in hot springs in Tibet; 3812 m Lake Titicaca to 8000 meter deep – (cusk eels) - spans almost 13 km.

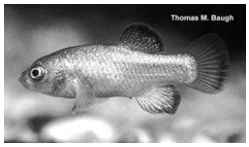
Where are the fish?

If potential aquatic ways of life open to a vertebrate, highly probable some group of fish has tried it somewhere at some time.

- Temperature - Physiologically cope with hot soda lakes (43c) to sub-freezing waters of Antarctica (-2 c). How do they survive?? Anti-freeze in blood.
- Stunning range of morphologies and adaptations: adaptation vs. phylogenetic constraint.

How many fish?

- Vast and diverse assemblage of organisms - consider variation in life history traits;
- 1. Fish populations vary in size from 400 - 1000 individuals (*Cyprinodon diabolis* - the devil's hole pupfish – actually 125), to 10 to the 15 (for some mesopelagic stomiatids - *Cyclothone* spp. - no other vertebrate populations approach this number).



How big are fish?

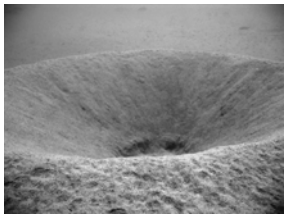
- Consider variation in life history traits;
- 2. Adult body size:
- Small as 7.5 mm (tropical gobies, cyprinodonts, and cyprinids vie for title of smallest living vertebrate).
- Largest fish is Whale shark (Rhincodon) - reaches lengths of up to 12m+, Ocean sunfish (Mola mola) = weight of two tons, etc. tunas, swordfish, giant seabasses and catfish reach lengths of 10-12 feet and weigh half a ton.

How long do fish live?

- Consider variation in life history traits;
- 3. Life span ranges from less than one year (annual fishes) to 150 years (halibut, carp).

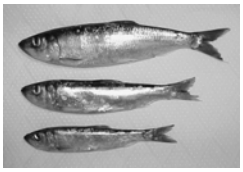
How do fish breed?

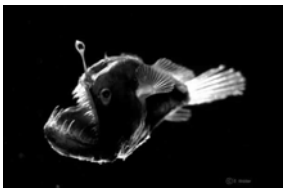
- Consider variation in life history traits;
- 4. Reproduction = open water spawning; spawning in nests, true viviparity, ovoviviparity, or internal fertilization followed by egg deposition.
- Sex changes, parental care etc.



Are fish dimorphic?

- Consider variation in life history traits;
- 5. Secondary sexual dimorphism
- absent in herrings and anchovies;
- highly developed in ceratioid Anglerfish
- Parental care ranges from non-existent to highly developed.



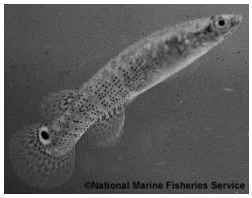


How many fish in broods?

- Consider following variation in life history traits;
- 6. Fecundity = # of eggs shed in a single spawning varies
- From one (Tomeurus sp.)
- Hundreds of thousands in fish like cod (many eggs fail to be fertilized).

Kinky sex in fish?

- Consider variation in life history traits;
- 7. Individuals may have gonads of one sex only or of both sexes. Hermaphroditism may be protandrous, protogynous or simultaneous. At least one species (*Rivulus marmoratus*) capable of fertilizing own eggs.



Asexual fish?

- Consider variation in life history traits;
- 8. Asexual reproduction occurs in *Mollienesia formosa*, a hybrid species consisting solely of females, which mate with males of either *M. sphenops* or *M. latipinna*. Offspring = all female *M. formosa*.

Metamorphosis in fishes?

- Consider variation in life history traits;
- 9. Some young miniature replicas of adults (e.g. viviparous surfperches),
- Others - young very different existence and are completely different in appearance (e.g. some pelagic larvae of flatfishes).

Get the point yet?

- List could go on - but point is made (I think).
- Fish do it all
- Diversity in and of itself interesting, yet somehow we need to make sense of it. We need a context.
- Theme of course will be understanding and exploring fish diversity within framework provided by phylogenetic history.

All sorts of way to look at diversity

- Use of the term "fish".
- Fish vs. Fishes - clearly fish (in the taxonomic sense of Pisces) is not a real entity - because although it would include hypothetical ancestor of fish (i.e. the first fish) and many of its descendents (some entirely fossil e.g. placoderms - acanthodians), it does not include tetrapods - which are descendents of fish.
- If early tetrapods did evolve from particular group of "fish" (evidently they did - either from rhipidistians or lungfish) - then tetrapods are, in fact, specialized fish.....concept of monophyly;
- "Fish" as I have been using term NOT any monophyletic group - it does not include ancestral fish and all descendents.
- Members certainly cannot be characterized by any unique feature(s) that don't also apply to vertebrates as a whole.

What is monophyly?

- Monophyletic Groups
- Paraphyletic Groups

What to do?

- So let's accept "Fish" as a group

This course is going to concentrate on.

- 1) Morphology and physiology
- 2) Diversity of fish
  - Overall - phylogenetic context
  - Arizona and Gulf of California - identifications
- 3) Ecology, behavior and conservation

What about the water?

- High density, more viscous
- Low compressibility
- Effective solvency – Universal solvent
- Low transparency

Structural Patterns and Trends in Diversification

- Fish subsume (since Cope (1889) proposed) - **Agnatha** - jawless fishes and **Gnathostome** lines - hasn't really stood the test of time (explain later).
- Consider Agnathan briefly.
- Earliest fish-like vertebrates with reasonable fossil record - middle Ordovician (440-510 mya) of North America, Europe and Australia.
- Many early vertebrate groups tried hard external armor (dermal bone) – this is preserved. ~ 500 mya dermal bone with structural complexity evolved.
- Evolution of calcified tissues has had profound effect on vertebrate evolution - and the origin of vertebrate skeletal structure - considerable interest
- All oldest fish-like vertebrates sometimes called **ostracoderms** (shell-like skin).
- All (at least partly) encased in some bony armor, lacked jaws, paired lateral fins.
- Mouth was slit or oval opening towards front of animal.
- From tail structure - adapted to bottom dwelling existence, feeding probably by suction?? using flexible floor of oralobranchial chamber and associated ventral branchial muscles as a pump.

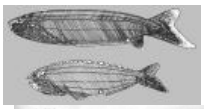
Major Groups of Agnathans

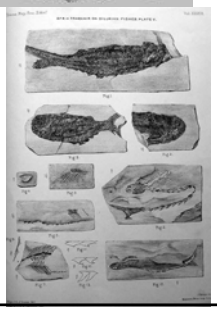
- 1. Osteostracida 2. Anaspida 3. Pteraspidomorphida
- 1) Osteostracidan agnathans - include thumb sized cephalaspids (see Swedish ichthyologist Stensio) - characteristic anatomy = head shield, pair of openings (presumably for the eyes) and single aperture for naso-hypohyseal canal.
- Stensios - external surface of brain = lampreys - suggested related. Are Lampreys living osteostracidan that lost head shield - little support now

Major Groups of Agnathans

1. Osteostracida 2. Anaspida 3. Pteraspidomorphida

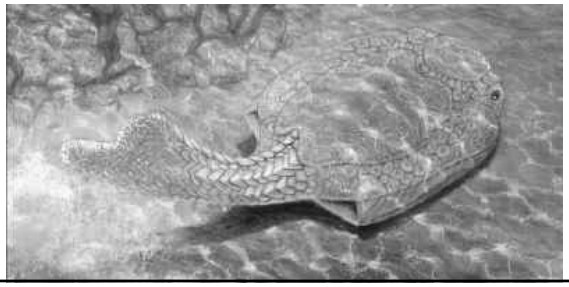
2) Anaspidan agnathans - streamlined bodies and small scales suggest strong swimmers. Strange hypocercal tail probably raised anterior end of body in swimming. Immediately behind head is row of pores - thought to be gill openings.





Major Groups of Agnathans

- 1. Osteostracida, 2. Anaspida, 3. Pteraspidomorphida
- 3) Pteraspidomorphidan agnathans - Most successful in abundance, taxonomic diversity and duration in fossil record – head, trunk enclosed in bony plates



2 living groups of agnathan fishes

- Hagfish and Lamprey = Traditionally together in cyclostomata
- Not a good group BUT many uncertainties surrounding evolutionary interrelationships of various agnathan groups (both fossil and living)
- Will go over in LIVE FISH SECTION

Jaws = GNATHOSTOMES

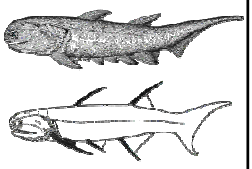
- Gnathostomes: the jawed fishes
- While agnatha cannot be called good (monophyletic) group - there is very good evidence for gnathostome monophyly.
- 4 major groups of jawed vertebrates:
- Living Chondrichthyes and Osteichthyes
- Extinct Acanthodii and Placodermi.

GNATHOSTOMES

- Living Chondrichthyans - usually divided into Selachii or Elasmobranchi (sharks and rays) and Holocephali (chimeroids).
- Living Osteichthyans commonly regarded as forming two major groups -
  - Actinopterygii
  - Sarcopterygii (coelacanths, lungfish, Tetrapods).

FOSSIL GNATHOSTOMES

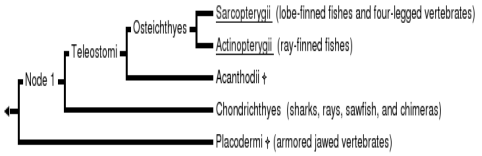
- Briefly - two fossil gnathostome radiations:
- 1) Acanthodians, or spiny-sharks = relatively conservative "fish-like" body form. Middle Silurian (440-408 mya) - disappear by middle Permian (290-245 mya).
- Acanthodians are teleostomes with small square crowned scales, stout spines before dorsal, anal and paired fins. Most acanthodians small fish, rarely exceeding 20 cm - some reached over two meters.
- Large eyes, appear to be active mid-water swimmers. Show array of feeding specialisations, some developing stout teeth, others were edentate with modifications for filter feeding.



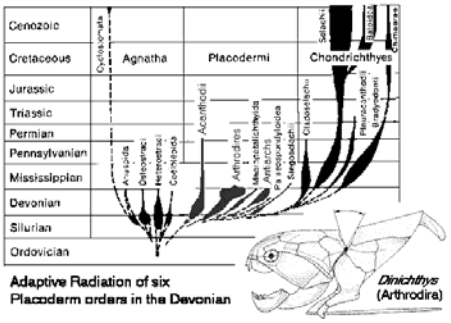
FOSSIL GNATHOSTOMES

- Briefly - two fossil gnathostome radiations:
- 2) Placodermi - diversified and somewhat bizarre group of heavily armored gnathostomes - flourished in Devonian (408-360 mya) - almost restricted to this period.
- Typically Placoderms are dorsoventrally compressed. All have head shield movably articulated with a trunk shield covering the anterior parts of body.

Gnathastome Summary



SUMMARY



Adaptive Radiation of six Placoderm orders in the Devonian