# Ichthyology

BIOL 530, 530L, 529J

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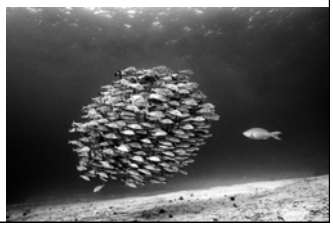
## Course Objectives

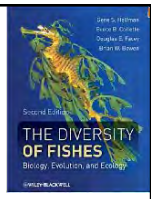
1. gain a broad understanding of the biology of fishes
2. be able to identify major taxonomic groups of fishes
3. be able to identify most local fishes
4. understand how to apply a broad array of field and laboratory techniques to the study of fishes



## Format of Course

1. **Lecture**
   - key concepts and theories
   - start with kinds of fishes, then to how they work, then to their behavior & ecology
2. **Lab & Field (participation mandatory)**
   - hands on experience with fishes in lab & field
   - elaborate on concepts from lecture
   - learn common methods for studying fishes

## Text and other Reading




Textbook:
- *The Diversity of Fishes* (Helfman, Collette, Facey, & Bowen)

Lab/Field:
- *Guide to the Coastal Marine Fishes of California (California Fish. Bull. 157)* (Miller and Lea)

**or**

- *A Field Guide to the Pacific Coast Fishes* (Eschmeyer, Herald, and Hamman)

Research Papers:
Downloadable from the class website

Recommended Books:
Several -- see syllabus

Please read all assigned reading before lecture
*(See online schedule)*

## Grading

| | |
|---|---|
| Midterm Exam | 15% |
| Final Exam | 20% |
| Lecture Quizzes | 5% |
| Lab Practical 1 | 15% |
| Lab Practical 2 | 15% |
| Lab Report | 8% |
| Research Paper | 10% |
| Skull & Skeleton Prep | 2% |
| Field/Lab Study Q sets | 10% |
| Total | 100% |

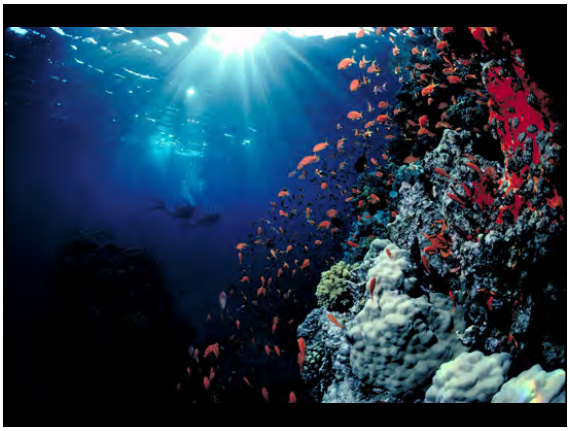
- Exams will be short answer
- Final will be cumulative

**Field Study & Lab: (530L & 592J)**

***20% of your grade will be based on participation***

## Attendance & General Information

1. This class will be demanding, but fun
2. Field activities will usually extend beyond hours listed in the catalog
3. Attendance at all field & lab studies is mandatory
4. There will be no make-ups for exams or other work
5. Late work is graded down 10% per day late
6. If you're not up to the demands, you should carefully consider whether you want to take this class



I. What is a fish?
II. Diversity
III. Taxonomy
IV. Introduction to major groups of fishes

What's the difference between "fish" and "fishes"?


I. What is a fish?

A stupid question?

What is a fish?

Typical, but not diagnostic features of fish:

| Feature | Exceptions |
|---|---|
| 1. aquatic | walking catfish, mudskippers, lungfish |
| 2. scales | eels, gobies, etc. (& reptiles have scales, too) |
| 3. fins | eels and some others |
| 4. gills | amphibians have gills early in development |
| 5. ectothermic | some tunas, billfish, & sharks (amphibians & reptiles are ectotherms, too) |
| 6. simple heart | African lungfish |
| 7. neuromast cells | some salamanders and ascidians also have them |

not always aquatic

warm blooded


So what is a fish?

Generally:

- aquatic
- cold blooded (poikilothermic)
- vertebrate
- with scales
- with fins
- with lateral line
- with gills & 2-chamber heart

*But lots of exceptions...*

Why so many exceptions?

Because "fish" is used to describe members of many separate evolutionary lines:

- remnants of ancient groups (e.g., hagfishes)
- old, but still successful lines (e.g., sharks and rays)
- new successful lines (e.g., bony fishes)

## II. Diversity:

- ≈ **30,000** species
- ≈ **250** new species described /year
- ≈ **50%** of all vertebrates are fishes

*Vanderhorstia steelei*

The "average" fish is a bony fish

Total species: **27,977** (32,500 expected)

Breakdown:

| | |
|---|---|
| Jawless Fishes: | 85 species |
| Sharks, Skates, Rays: | 970 species |
| **Bony Fishes**: | **26,891** species |

based on Nelson 2006

## Fish Diversity

- ≈ 1/2 of all vertebrate species
  28,000 Fishes vs.
  - 6,300 Amphibians *(3 orders)*
  - 8,200 Reptiles *(4 orders)*
  - 10,000 Birds *(29 orders)*
  - 5,400 Mammals *(29 orders)*
- 515 different families of fishes (extant)
- 62 extant orders!

Fish live almost any place there is water:

- **hot springs** (40˚ C) — **subzero** (-2˚ C)
- **hypersaline** water (3x seawater) — **mineral-free** water
- **high $O_2$** — almost **no $O_2$**
- **low pH** (4) — **high pH** (>10)
- **turbid** waters (0 vis.) — **crystal-clear** waters
- **high light** (e.g., shallow coral reefs) — **no light** (e.g., caves)
- **deep ocean** (-7,000 m) — **high altitude** lakes (+4,000 m)
- **temporary** (pools and streams) — **stable** (deep open oceans)

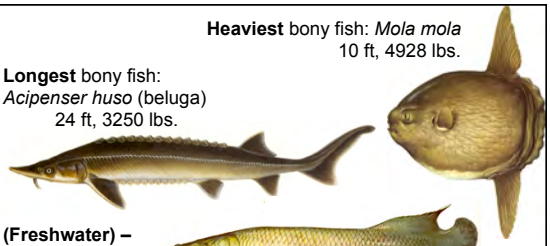
**Diversity in size:**

*Schindleria* matures around 8 mm

Whale shark (*Rhincodon typus*) reaches 59 ft. est. 90,000 lbs

**Heaviest** bony fish: *Mola mola*
10 ft, 4928 lbs.

**Longest** bony fish:
*Acipenser huso* (beluga)
24 ft, 3250 lbs.



**(Freshwater) –**
*Arapaima gigas*,
arapaima - 8 ft, 325 lbs.

*Lepisosteus spatula*, alligator gar - 10 ft, 300 lbs.

Higher diversity & density in freshwater habitats:

| Habitat | % of total species | # individuals/species | % of water volume |
|---|---|---|---|
| Marine | 58 | $10^{10}$ | 97 |
| Freshwater | 41 | $10^{8}$ | 0.01 |
| Diadromous | 1 | ? | |

4 orders of magnitude more marine water than freshwater:

- but nearly same number of species ⇒ so, much higher density of spp. (≈ **7,500x**)
- but only 2 orders of magnitude more individuals ⇒ so, much higher density of individuals (≈ **75x**) in freshwater

Why?

Most marine fishes are found in the coastal zone

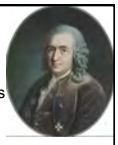
**Distribution of Marine Fishes** (58% of all fishes)

- **coastal zone** (<200 m): **78%** (44% of all fishes)
- **open ocean**: **13%**
  - **surface layer** (epipelagic): **1%**
  - **deepwater** (deepwater pelagic): **5%**
  - **bottom** (deepwater benthic): **7%**

## III. Taxonomy uses nomenclature

- International Code of Zoological Nomenclature
- Binomial, (or trinomial if a subspecies)
  - based on genus and species
  - e.g., *Thunnus thynnus*, or *Thunnus thynnus thynnus*
- Type specimens and type localities
  - single specimen upon which description of species is based: the **holotype**
- **Authority** of the species:
  - author of first description follows species name

**Taxonomy** = science of describing and classifying organisms



Carl Linnaeus

| Units of class: | Mnemonic: | e.g. bluefin |
|---|---|---|
| Kingdom | Kings | Animalia |
| Phylum | Play | Chordata |
| Class | Chess | Actinopterygii |
| Order | On | Perciformes |
| Family | Fine | Scombridae |
| Genus | Grained | *Thunnus* |
| Species | Sand | *thynnus* |

Categories are like directories and subdirectories

There are many sub- and super- directories

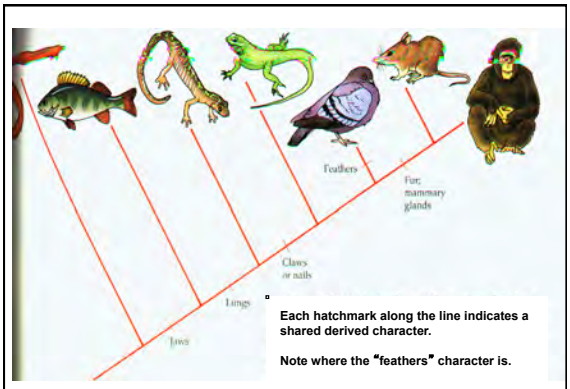
| Taxonomic Unit | Herring | Perch | Mackerel |
|---|---|---|---|
| Division | Teleostei | ⇒ | ⇒ |
| Subdivision | Clupeomorpha | Euteleostei | ⇒ |
| Order | Clupeiformes | Perciformes | ⇒ |
| Suborder | Clupeoidei | Percoidei | Scombroidei |
| Family | Clupeidae | Percidae | Scombridae |
| Subfamily | Clupeinae | Percinae | Scombrinae |
| Tribe | Clupeini | Percini | Scombrini |
| Genus | *Clupea* | *Perca* | *Scomber* |
| Species | *harengus* | *flavescens* | *scombrus* |
| subspecies | *harengus* | | |
| Author | Linnaeus | Mitchell | Linnaeus |

## Systematics

- Study of evolutionary relationships among organisms
  - reconstruction of evolutionary relationships
  - based on characters shared by a group
    - Morphological characters
    - DNA sequences
- Cladistics
  - a defined method for systematics
  - also known as Phylogenetic Systematics

## Cladistics

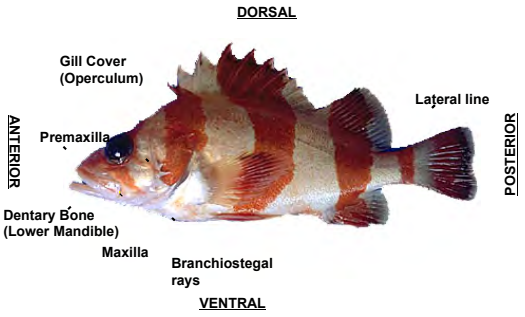
- Goal of cladistics is to find shared derived characters
  - groups with shared derived characters form monophyletic groups or clades
- **Monophyletic groups**
  - groups containing an ancestor and all its descendants
- **Polyphyletic groups**
  - multiple origins of a group, not having a recent common ancestor
- **Parsimony**
  - selection of hypothesis that explains the data in the simplest or most economical manner




Each hatchmark along the line indicates a shared derived character.

Note where the "feathers" character is.

## Some of the characters used in constructing cladograms for "fish"

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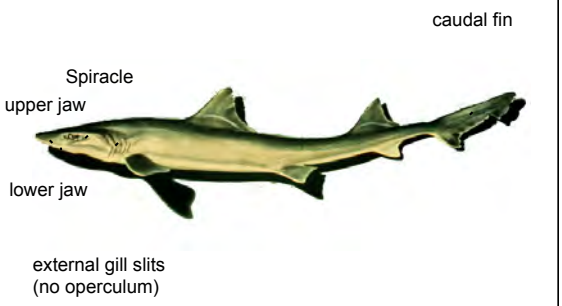



## IV. Introduction to major groups of fishes

(In Phylogenetic Order)

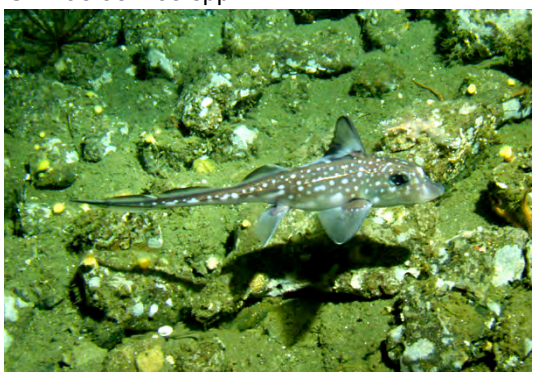
**Agnathans, ≈ 110 sp.**

Class Chondrichthyes
Cartilaginous Fishes

Sharks ≈ 400 spp.

Skates and Rays ≈ 530 spp.

Chimaeras ≈ 33 spp.



Class Sarcopterygii
(Lobe-Finned Fishes)

Coelacanths, 2 spp

Lungfishes, 6 species

Class Actinopterygii
Ray-finned Fishes

**Sturgeons and Paddlefishes, 27 spp.**

**Gars, 7 spp.**

**The bowfin, 1 species**

## Teleosts

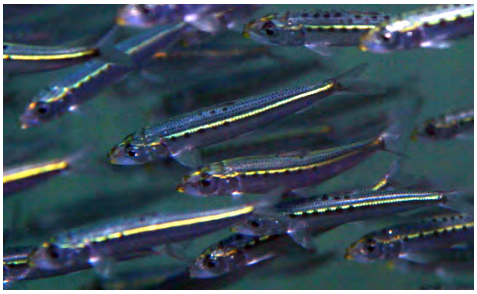
- "Perfect bone"
- rest of fishes after this slide

**Bonytongues ~ 220 spp.**

Subdivision **Osteoglossomorpha**

Eels, Tarpons, Bonefishes, etc. ~ 900 spp
Subdivision (**Elopomorpha**).

Herrings ~ 360 spp.
(Subdivision **Clupeomorpha**)



## Subdivision Euteleostei

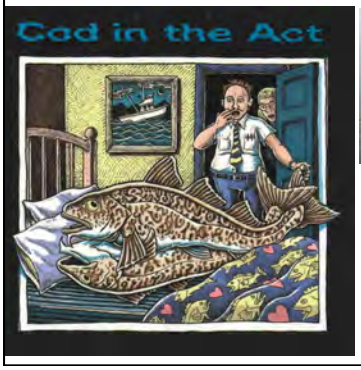
- 9 Superorders
- everything after this slide

Minnows, Suckers, Characins, Catfishes, and Knifefishes
~8,000 spp.
(Superorder:**Ostariophysi**)

Smelts, Salmons, and Pikes ~370 spp.
Superorder: **Protacanthopterygii**

Weird deepsea fishes ~ 1300 spp.
Five Superorders:
Stenopterygii
Cyclosquamata
Scopelomorpha
Lampridiomorpha
Polymixiomorpha

Cods, Anglerfishes, Cavefishes, Cusk Eels, Etc., ~ 1,300 spp.
Superorder: **Paracanthopterygii**




## "SPINY RAYED FISHES" (Superorder: Acanthopterygii)

- ADVANCED TELEOSTS
- 14,797 species (the rest)
- 3 Series
  - Mugilomorpha
  - Atherinomorpha
  - Percomorpha

Mullets ~ 70 species

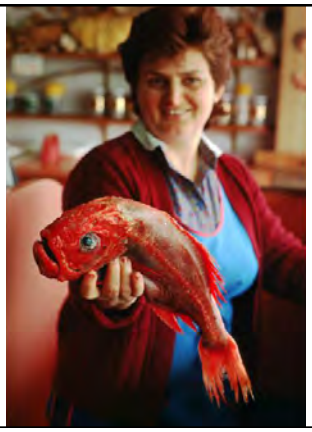
(Series: **Mugilomorpha**)

Silversides, needlefishes, flyingfishes, killifishes, livebearers, etc.
~ 1,500 spp. Series: **Atherinomorpha**


## SERIES PERCOMORPHA

- 9 Orders
- 245 Families
- 13,173 Species

Squirrelfishes, ~ 140 spp. (Order: **Beryciformes**)



Sticklebacks, Seahorses, etc., ~ 275 spp.
Order: **Gasterosteiformes**

Mail-Cheeked Fishes ~ 1,500 species
Order: **Scorpaeniformes**

## Order Perciformes

- largest order of vertebrates!
- 20 suborders
- 160 families
- 10,033 species

Suborder **Percoidei ~ 3,200 spp.**

Croakers ~ 270 spp.

Darters ~ 200 spp.

Sunfishes ~ 31 spp.

Seabasses ~ 475 spp.

Suborder **Labroidei ~ 2,200 spp.**

Cichlids ~ 1350 spp.

Wrasses ~453 spp.

Suborder **Gobioidei ~ 2,200 spp.**

Gobies ~1950 spp.

Sleepers ~ 155 spp.

Suborder **Blennioidei ~ 800 spp**

Suborder **Scombroidei ~ 150 spp.**

Barracudas ~ 21 spp.

Tunas and Mackerels ~ 51 spp.

Billfishes ~ 11 species

**Flatfishes, 700 spp.**
**Order Pleuronectiformes**

**Puffers, Triggerfishes, Ocean Sunfishes ~ 360 spp.**
**Order Tetraodontiformes**