

## Introduction to Oceanography Lecture 24: Nekton

**True's Beaked Whale** *Mesoplodon mirus*

Video by R. Edler, from de Soto et al., 2017, <https://peerj.com/articles/3059/> Creative Commons License

### Announcements:

Review Session: Thursday, Dec. 7, 3:00-3:50pm, Young CS24

Video Screening: Wednesday, Dec. 6, 3:00-3:50pm, Young CS76



Mako Shark, *Isurus oxyrinchus*, photo by Mark Conlin, SWFSC Large Pelagics Program, Public Domain, <http://swfsc.noaa.gov/ImageGallery/Default.aspx?moid=532>

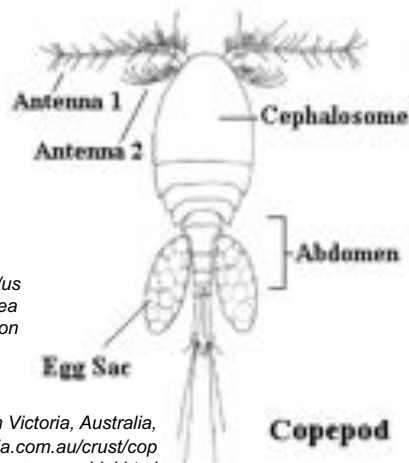
# Copepod

- Crustacean: average sizes 0.5 - 15 mm
  - Max size ~ 25 mm
  - ~ 9000 known species
- Voracious feeder/filterer
- Forms key food for many other larger plankton and nekton



Photo Alfred Wegener Institute,  
[http://www.awi.de/fileadmin/user\\_upload/News/Press\\_Releases/2006/3\\_Quarter/Plankton\\_3\\_p.jpg](http://www.awi.de/fileadmin/user_upload/News/Press_Releases/2006/3_Quarter/Plankton_3_p.jpg)

Image from Museum Victoria, Australia,  
<http://museumvictoria.com.au/crust/cop/biol.html>



**Zooplankton**

**COPEPOD FEEDING STRATEGY**

**Calanoid Copepod**

antennule  
antenna  
setae

PARTICLES ARE CAPTURED IN THE FINE SETAE HERE

VORTICIES SET UP BY THE FILTER FEEDING MECHANISM

DORSAL VIEW

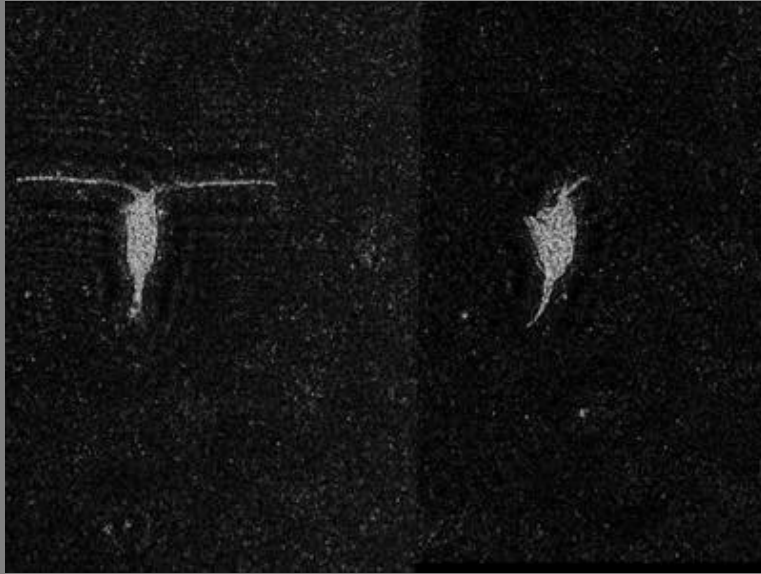
MAIN SCREEN

The feeding mechanism of the copepod is extremely efficient. The vortices formed around the body by the feeding appendages direct particles into the fine setae which are then directed to the mouth. The feeding motion also propels the copepod through the water.

Although they prefer large phytoplankton, such as diatoms, they are capable of consuming small particles when necessary.

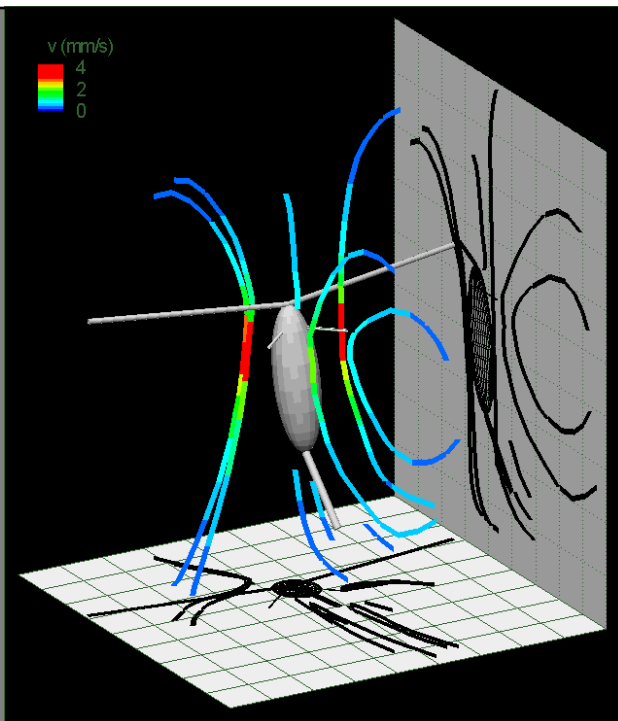
<http://www.seaprofiles.com/copepod.html>

## Copepod motion



<http://jeb.biologists.org/cgi/content/full/206/20/3657/DC1>

## Reconstructed feeding currents



## Copepod motion

Feeling, following, feeding, fleeing:  
a copepod's life at low Reynolds number

David Murphy, Rachel Lasley,  
Donald Webster, Jeannette Yen  
Georgia Institute of Technology

Entry #V048

Video by Murphy et al., Georgia Tech (2011) <https://arxiv.org/abs/1110.2975>



## Diurnal Migrating Plankton

- Upwards vertical migration by night
- Downward vertical migration by day
  
- Occurs in some species of every major group of zooplankton
  - Some nekton & possibly phytoplankton as well

## Polar Seasonal Vertical Migration

- North Atlantic copepods & Antarctic krill undergo seasonal vertical migrations
  - Feed during spring/summer
  - Dive to ~ 500-2000 m during winter
    - **Diapause**: slow metabolism, no feeding
    - Lay eggs at depth that slowly float upwards
  - Return to surface in spring

## Planktonic Patchiness

- Plankton are often found in patches
- Physically due to:
  - Gyre circulations, water mass boundaries, turbulence & mixing, wind-induced mixing, wave action
- Biologically due to:
  - Ecosystem scale (water masses), spring blooms, different growth rates of different species, reproductive cycles, grazing/predation, diurnal migration



NASA/MODIS, Public Domain,  
<http://veimages.gsfc.nasa.gov/5608/NovaScotia.A2003183.1720.500m.jpg>

## Questions

Anchovies, NOAA image, Public Domain,  
<http://www.photolib.noaa.gov/htmls/nur00009.htm>



# Multicellular life



## Origin of Animals

Rise of oxygen: ~2,500 million - 400 million years ago

- Photosynthetic autotrophs pump out  $O_2$
- Atmosphere goes from  $\ll 1\%$  to  $20\% O_2$

Allows respiration to occur

Evolution of multicellular

heterotrophic animals.

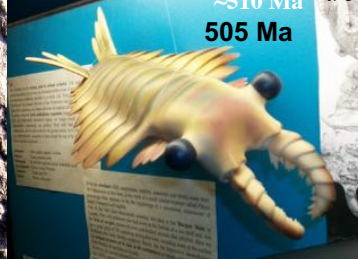
*Dickinsonia*, Verisimilus, Creative Commons A S-A 2.5,  
<http://en.wikipedia.org/wiki/File:DickinsoniaCostata.jpg>



*Cyclomedusa*, Verisimilus, Creative Commons A S-A 2.5,  
[http://en.wikipedia.org/wiki/File:Cyclomedusa\\_cropped.jpg](http://en.wikipedia.org/wiki/File:Cyclomedusa_cropped.jpg)




*Anomalocaris*, Photnart, Public Domain,  
<http://commons.wikimedia.org/wiki/File:AnomalocarisDinoMcanb.jpg>



# What kinds of Animals exist?

- Invertebrates
  - No internal skeletons
  - Includes simplest animals, evolved first
- Vertebrates
  - Internal backbone
  - Evolved from invertebrates



The diagram illustrates a vertical cross-section of the ocean with various organisms. At the top, a green oval highlights 'Phytoplankton' and 'Zooplankton'. Below this, a red oval highlights 'Migrating Midwater Fishes' and 'Migrating Predators'. At the bottom, 'Wreckfish' are shown near the seabed. A scale bar indicates '450 meters'.

**Plankton**

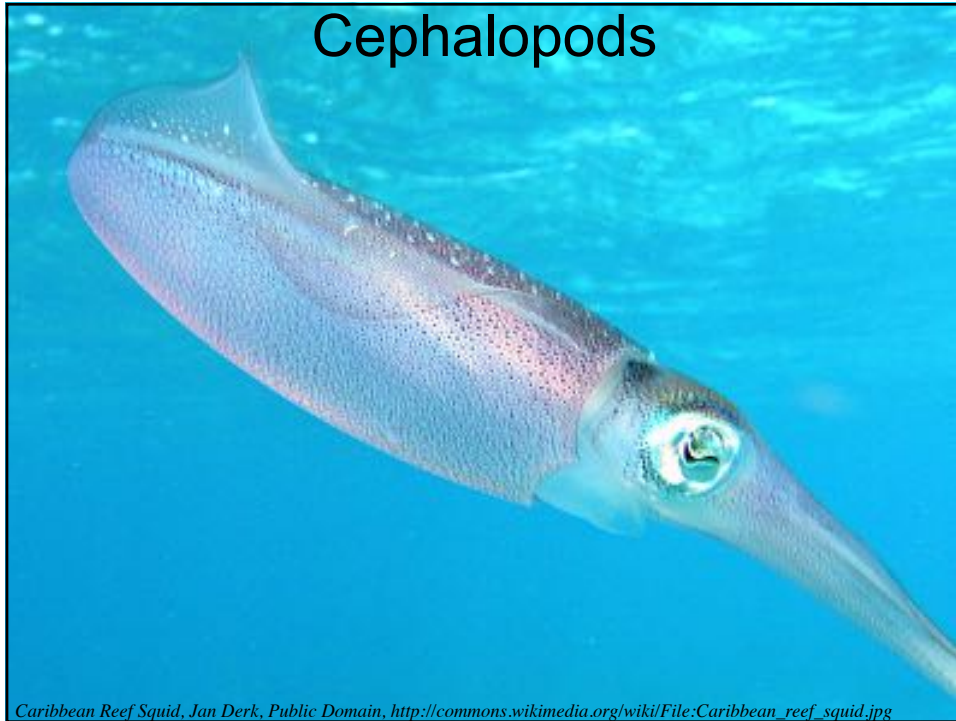
**NEKTON**

Lifestyle classification: organisms that swim strongly in the water column (able to overcome currents). Must be big enough to swim “fast” & far.

*Food web of Charleston Bump, NOAA/Weaver and Sedberry, 2001, Public Domain, <http://oceanexplorer.noaa.gov/explorations/03bump/background/lifeonbump/media/foodweb.html>*



# Cephalopods



*Caribbean Reef Squid, Jan Derk, Public Domain, [http://commons.wikimedia.org/wiki/File:Caribbean\\_reef\\_squid.jpg](http://commons.wikimedia.org/wiki/File:Caribbean_reef_squid.jpg)*

# Cephalopods

Invertebrates - no internal skeleton

- some species have firm “cuttlebone” support structures

Subdivision of Molluscs

- Cephalopods (“head-foot”)

- Most complex and intelligent molluscs
- Mostly nektonic or nekto-benthic lifestyle
- Swim along the bottom



*Nautilus, video by Shizhao, Creative Commons C A S-A 3.0, <http://commons.wikimedia.org/wiki/File:Nautilus.ogg>*



*Mastigoteuthis flammea, Carl Chun, Public Domain, [http://commons.wikimedia.org/wiki/File:Mastigoteuthis\\_flammea.jpg](http://commons.wikimedia.org/wiki/File:Mastigoteuthis_flammea.jpg)*

# Cephalopods

Include squid, octopus, cuttlefish, nautilus

Have three hearts, blue blood  
copper based; blue when its oxygenated  
ours is iron based; red when oxygenated

650 living species, around at least  
~ 500 Mya

Many change color rapidly

Reef octopus, Okinawa, video by goebelle,,  
<http://www.youtube.com/watch?v=TcGwtExuenY>



Ordovician nautiloid (490-440 Ma), China



Photo Dloyd,, Creative Commons A S-A 3.0,  
[http://en.wikipedia.org/wiki/File:Nautiloid\\_trilacinoceeras.jpg](http://en.wikipedia.org/wiki/File:Nautiloid_trilacinoceeras.jpg)

Video by Joel Ang,  
<http://www.tonmo.com/images/vids/CFvsFish.MPG>



# Cephalopods

- Motion
  - Some swim by moving tentacles/fins



Video by Vecchione and Young, Smithsonian Museum of Natural History (1997) *Vie et Milieu*, 47:101-110.  
<http://www.mnh.si.edu/cephs/vy97/grimp01.mpg>

Jet propulsion by forcing water through siphon

Video by Vecchione and Roper, Smithsonian Museum of Natural History (1991) *Bulletin of Marine Science*, 49(1-2):433-445.  
<http://www.mnh.si.edu/cephs/vr91/tpavo1.mpg>



# Cephalopods

Giant squid

up to 18 m long

Deep Water

~ 2000 m

Feed on what?

Hunted by sperm whales



National Institute of Water and Atmospheric  
Research - NIWA  
Greta Point, Wellington, New Zealand, Public  
Domain(?),  
[http://seawifs.gsfc.nasa.gov/OCEAN\\_PLANET/](http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/)

# Cephalopods

## • *Cuttlefish, squid, & octopi:*

Color change ability

Intelligence

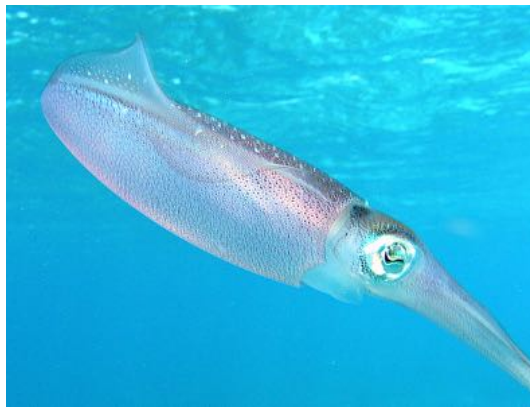
Short-range jet propulsion

Advanced nervous systems

Acute eyesight

Other special adaptations?

***Why such unique  
adaptations?***



Caribbean Reef Squid, Jan Derk, Public Domain,  
[http://commons.wikimedia.org/wiki/File:Caribbean\\_reef\\_squid.jpg](http://commons.wikimedia.org/wiki/File:Caribbean_reef_squid.jpg)

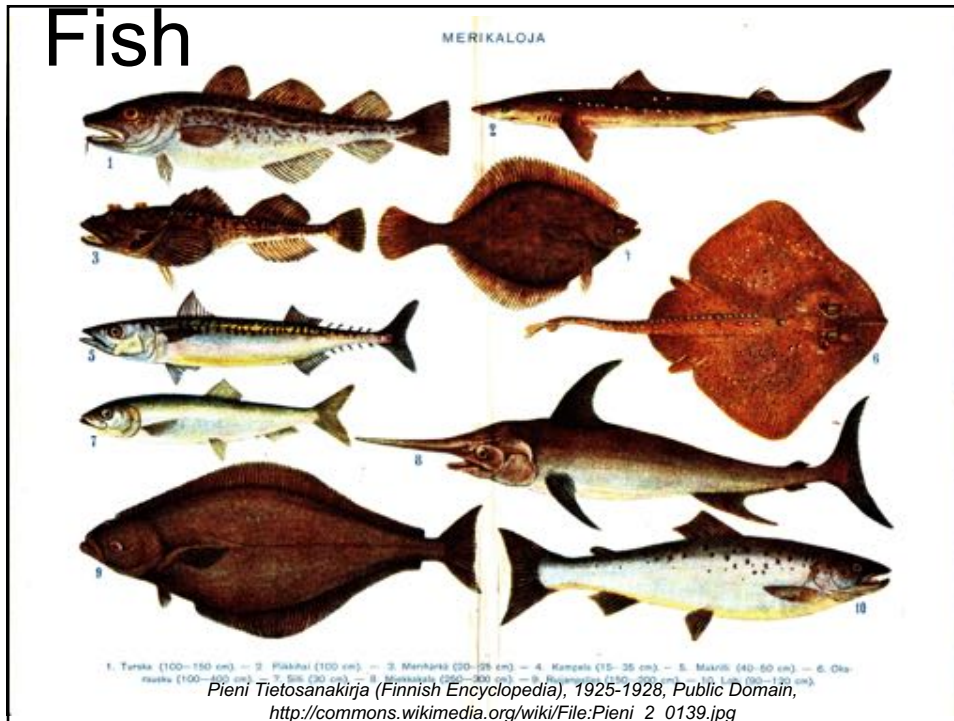
# Questions



## Fish



# Fish



## Jawless Fish (Class Agnatha)

- Jawless fish, flexible snake-like bodies, no paired appendages for movement
- Earliest related fossils ~ 500 Mya
- Survive by sucking on wounds of other fish, eating out interiors
- Include hagfish (right) and lampreys (below)

Self-camming flesh pullers



*Image Patricia J. Wynne, 2004, Natural History Magazine/American Museum of Natural History, [http://biomechanics.bio.uci.edu/\\_html/nh\\_biomech/slime/slime.htm](http://biomechanics.bio.uci.edu/_html/nh_biomech/slime/slime.htm)*



**Becomes slimy when provoked!**

*Photo by Drow male, Wikimedia Commons, Creative Commons A S-A 3.0, [http://upload.wikimedia.org/wikipedia/commons/6/6f/Diversas\\_lampreas.1\\_-\\_Aquarium\\_Finisterrae.JPG](http://upload.wikimedia.org/wikipedia/commons/6/6f/Diversas_lampreas.1_-_Aquarium_Finisterrae.JPG)*

Hagfish face a similar problem to cephalopods – they're soft!  
Their defense? Slime predators when provoked!



Video by Nimrod Levy (U. British Columbia), YouTube, <http://www.youtube.com/watch?v=Bb2EOP3ohnE>

July 13, 2017



**Oregon State Police**  
@ORStatePolice

Follow

OSP @OregonDOT & @LincolnCountySO on scene overturned #Slime #Eel truck Hwy101 MP131 closed. #Cleanup on Aisle 101



Photo by Oregon State Police

# Questions



## Bony Fish

30,000 living species: Most diverse of all vertebrate groups

90 million tons removed by humans each year

Equivalent to ~15 kg per person per year

US residents ate about 7 kg/person per year in 2003, more goes to fertilizer and animal feed products.

- Buoyancy
  - Many have swim bladders (gas filled sac)
    - Allows fish to maintain position in water column
    - Some swallow air at surface, release at depth
    - Some have gas gland that transfers gas from blood
    - Swim bladders are a hindrance to bottom dwellers and fast swimmers (tuna)

# Shape of Fast-swimming Fish

Fineness = diameter/length  $\approx 0.25$  in tuna  
 Minimal drag at high speed  
 (large Reynolds number)

Aspect ratio of tail = span/chord  
 most efficient for generating lift

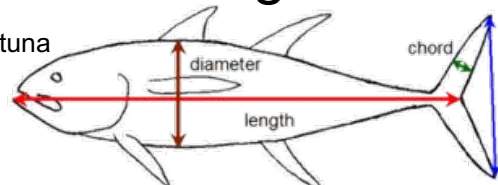


Figure John Merck, U. Maryland,  
<http://www.geol.umd.edu/~jmerck/bsci392/lecture10/fineness.gif>



Teardrop shape minimizes frictional drag  
 Thrust by waves of body motion and fins

Fins  
 Pelvic and pectoral: turning, braking, balance, little thrust  
 Dorsal & anal: stability and steering  
**Caudal (tail):** Most thrust

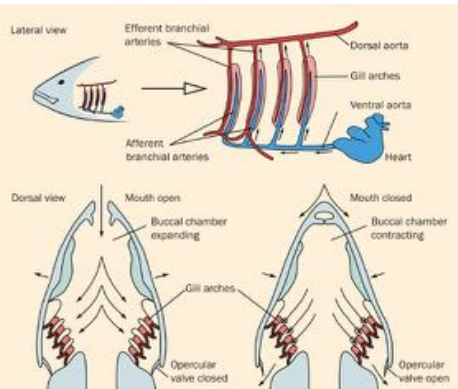
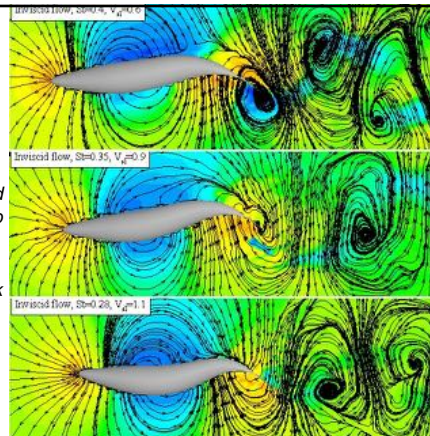
Video by onitube, YouTube,  
<http://www.youtube.com/watch?v=6lv51E->

## Bony Fish

• A fish's hinged tail generates efficient forward motion

U. Minnesota Computational hydrodynamics and biofluids laboratory, <http://cfdlab.saf1.umn.edu/fmlao.php>

U. Michigan Museum of Zoology,  
[http://animaldiversity.ummz.umich.edu/site/resources/Grzimek\\_fish/structure\\_function/v04\\_id131\\_con\\_gillfun.jpg](http://animaldiversity.ummz.umich.edu/site/resources/Grzimek_fish/structure_function/v04_id131_con_gillfun.jpg)

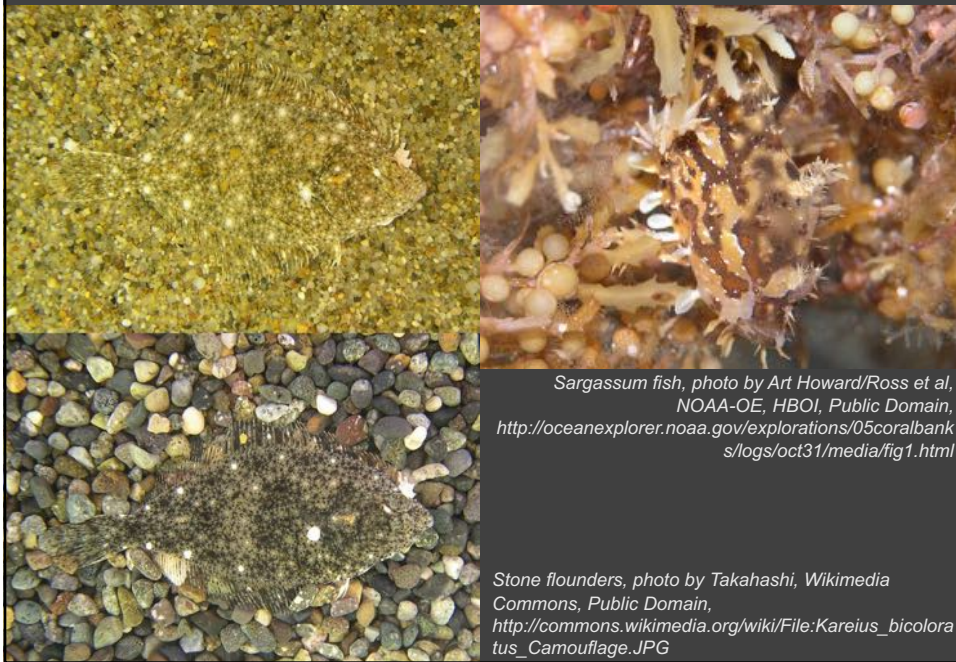


• **GILLS:** extract dissolved oxygen from sea water. Oxygen-rich sea water **diffusively** exchanges with oxygen-poor blood in gills

• Faster swimming fish have bigger gills (and higher body temperatures)



## Coloration

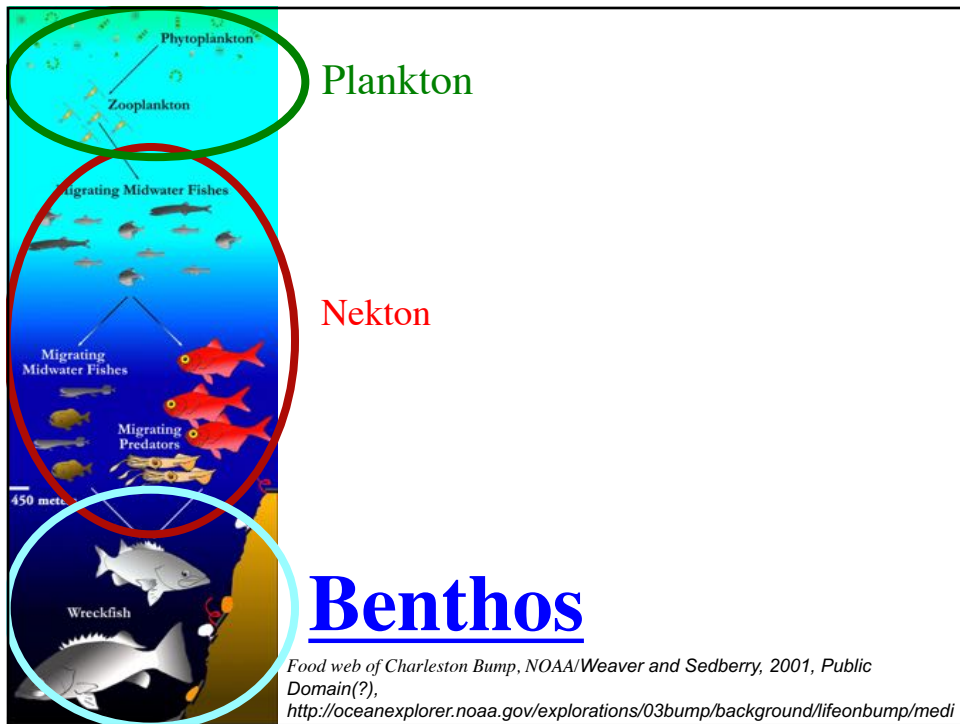
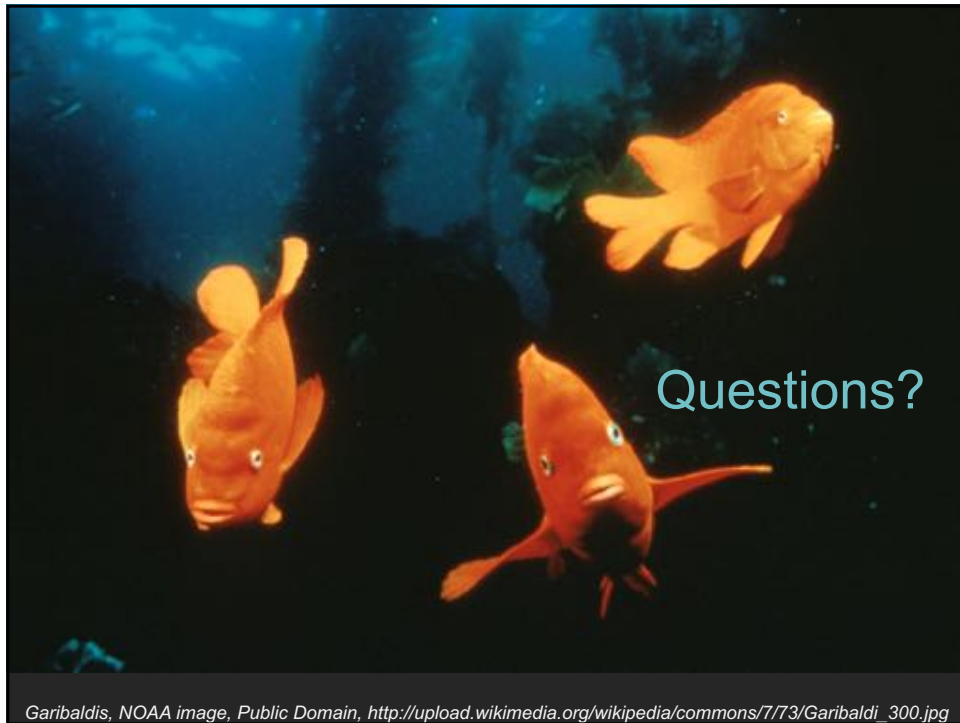


## Counter-Shading: a type of crypsis

Dark above -- blends with deep water

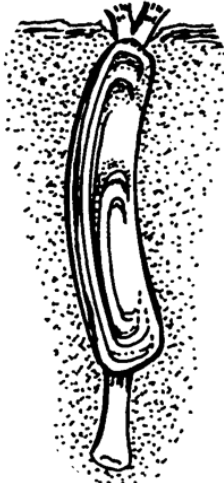


*Great white shark, photo by Sharkdiver68, Wikimedia Commons, Public Domain, [http://commons.wikimedia.org/wiki/File:Carcharodon\\_carcharias.jpg](http://commons.wikimedia.org/wiki/File:Carcharodon_carcharias.jpg)*



## Habitats

Infauna: Live in sediment and rocks



Drawing from City of Barnstable, Mass.  
<http://www.town.barnstable.ma.us/Images/ShellfishPics/razrclam.gif>

Razor clams burrow into the sand or mud



Photo by David Ansley, Wikimedia Commons,  
Creative Commons A 2.5,  
[http://en.wikipedia.org/wiki/File:Jackknife\\_clam.JPG](http://en.wikipedia.org/wiki/File:Jackknife_clam.JPG)

## Habitats

Epifauna: Live on the surface

Sea anemone



Photo by Esculapio, Wikimedia Commons, Creative Commons A S-A 3.0,  
[http://en.wikipedia.org/wiki/File:Actinia\\_equina\\_0009.J](http://en.wikipedia.org/wiki/File:Actinia_equina_0009.J)

Purple Sea Urchin



Photo by Tomasz Sienicki, Wikimedia Commons,  
Creative Commons A S-A 3.0,  
<http://commons.wikimedia.org/wiki/File:Woda->

## Habitats

**Nektobenthos:** Swimmers living on the bottom

Examples: Octopus, shrimp, halibut



*Horn shark, La Jolla, CA, photo by Magnus Kjaergaard, Wikimedia Commons, Creative Commons A S-A 3.0, [http://en.wikipedia.org/wiki/File:Horn\\_shark.JPG](http://en.wikipedia.org/wiki/File:Horn_shark.JPG)*



## Nutrition

Autotrophs are the base of the food web:

Photosynthesizers  
(usually)

Algae live in the photic zone (not found below the photic zone)

– Kelp beds: autotrophic benthic algae

*High productivity or low productivity?  
Neritic or Oceanic?*

*Photo by Stef Maruch, Flickr,  
Creative Commons A S-A 2.0,  
<http://www.flickr.com/photos/79257269@N00/1228333269/>*

## Nutrition

**Heterotrophs:** Eat others to live

### Eating Styles of Benthic Heterotrophs

- Suspension Feeders
- Filter Feeders
- Deposit Feeders
- Active Herbivores
- Active Carnivores

*Crinoid, a suspension feeder, photo by Richard Ling,  
Wikimedia Commons, Creative Commons A S-A 3.0,  
[http://upload.wikimedia.org/wikipedia/commons/f/f6/Ptilometra\\_a\\_australis\\_Passion\\_Flower\\_feather\\_star.jpg](http://upload.wikimedia.org/wikipedia/commons/f/f6/Ptilometra_a_australis_Passion_Flower_feather_star.jpg)*

