Animals of the Pelagic

I. Making a Living
To make a living organisms must meet the following challenges:
1) where to live
2) what food to eat and how to obtain it
3) how to avoid predators
4) where, how, when to reproduce

- They are strongly influenced by the usual factors which we have been discussing throughout this class:
  - temperature
  - density
  - salinity (vertebrates…less so for invertebrates)
  - light
  - food availability

II. Zooplankton
A. Zooplankton classification
- We can classify pelagic organisms based on size and locomotion:
  - planktonic forms cannot control their horizontal distribution
  - This group (zooplankton) includes representatives from every phylum of the animal kingdom
  - size can range from microns (the protists) up to several meters for colonial organisms (the jellies and related groups)

- Zooplankton abundance is primarily controlled by food—both what they eat, and what eats them
  - zooplankton distributions are often patchy, and related to physical properties:
    - concentrations on fronts, pycnoclines, thermoclines
    - formation of the deep scattering layer
    - availability of phytoplankton (prey)
- zooplankton abundance is less limited by growth…they are capable of explosive growth, and can often keep up with their prey (phytoplankton, other zooplankton) given the right conditions

- Common Zooplankton:
  - copepods, euphasids, other crustacean-like organisms
  - Foraminifera and radiolarians
  - jellies and comb jellies
  - tunicates, appendicularians, etc.

B. Zooplankton and Foodwebs

- **Microzooplankton** (the smallest, microscopic forms)
  - This group has been “discovered” in the last 20 years or so.
  - Includes nanoflagellates, ciliates, some dinoflagellates, choanoflagellates
  - They provide an important intermediate step between bacteria and larger organisms
  - They are an important link between particulate and dissolved material

- **Macrozooplankton** (what we normally think of)
  - primary food chain to larger organisms (e.g. fish)
  - Important for controlling phytoplankton blooms, such as the North Atlantic Bloom
  - Major source of export production, through the packaging of fecal material (fecal pellets, marine snow)

- **Gelatinous zooplankton**
  - Includes both indiscriminate filter feeders and predators
  - many can feed across a wide size range, from bacteria to small fish, etc.
  - capable of explosive growth through asexual reproduction

III. True Nekton

- This group are capable of regulating both vertical and horizontal position
- includes fish, birds, marine mammals, reptiles, molluscs

A. Buoyancy

- For all but the smallest organisms (microzooplankton, some macrozooplankton), it is necessary to stay above the bottom.
- Strategies Include:
  1) Size independent (small things that don’t sink)
  2) Gas Containers
  3) Floaters
  4) Swimmers
Gas Container
- This group use gases extracted from seawater to fill some sort of buoyancy chamber in their body cavity
- An example is the Nautilus…it is limited to about 500m depth because below that depth, the shell would be crushed
- Fish bladders are a special subset of this class
  - Fish bladders are either connected to the throat, so that fish can rapidly change the volume, or completely isolated, so that volume changes must utilize diffusion (slow) across the membrane
  - As with the nautilus, below 500m the external pressure makes it harder to maintain a swim bladder
  - below 7000 m, the air in the bladder is completely replaced by fat, which is not compressible

Floaters
- These organisms contain very little hard tissue, which helps them to maintain neutral buoyancy
- Includes:
  - Coelenterates (bodies are more than 95% water!)
    1) Siphonophores
      - use a pneumatophore (float bag) for buoyancy…float at the surface of the water
      - colonial organism, as are scyphozoans (see below)
      - Examples include the Portugese Man o’ War
    2) Scyphozoans
      - True jellyfish
      - don’t contain a float bag
      - use muscular contraction of the bell for movement
      - colonial, with specialized cells designed for eating (guts), motion (the bell), and prey capture (nematocysts)
      - capable of explosive growth by asexual budding
  - Tunicates
    - also called sea squirts, salps
    - this group are chordates, but the adults don’t have spinal cords
    - use jet propulsion for movement…the body is essentially a hollow, muscular tube
    - capable of 40% growth per day!
    - extremely important as voracious scavengers, with subsequent export to depth of organic material
- Will eat anything they can catch
- Ctenophores
  - Also called comb jellies, sea gooseberries
  - Always pelagic, marine, carnivorous
  - size can range from a few millimeters to several centimeters
- Chaetognaths
  - could be placed with the zooplankton
  - voracious, vicious predators
  - also called arrow-worms
  - several centimeters in length, nearly transparent
  - important in certain commercially important food chains (pollock, for example)

Nekton (true swimmers)
- Includes everyone else…fishes, squid, marine mammals, reptiles (turtles, for example)
- All of these groups expend a great deal of energy to maintain buoyancy
- Fish adaptations to buoyancy and also feeding include Caudal Fin morphology:
  Aspect Ratio = (fin height)^2/fin area
  - 5 types of caudal fin:
    1) Rounded (Aspect Ratio = 1)
    2) Truncate (AR = 3)
    3) Forked (AR = 5)
    4) Lunate (AR = 7-10)
    5) Heterocercal (Assymmetric--sharks)

IV. Nekton Adaptations
- Besides buoyancy, most nekton are also adapted for how they feed
  - mobility and speed are largely dependent on 3 factors:
    - body length to width ratios
    - caudal fin morphology
    - how much red vs. white muscle mass the fish has
- Temperature is also important. Most pelagic organisms don’t experience wide ranges in temperature…exceptions are deep diving or migrating species
  - Tuna, marine mammals, birds (anything that wants to keep a fairly constant body temperature) have adapted to fluctuations in temperature by developing counter-current circulation of their blood
- Some fishes and invertebrates in extremely cold waters have also developed antifreeze proteins, to allow them to survive in extremely cold waters.

V. Marine Mammals
- All marine mammals have adapted to regulate their temperature (see above). Deep diving mammals must also adapt for pressure, oxygen consumption.
- Some examples of diving adaptations include:
  - Increasing blood volume, capacity
  - "Gliding" as they dive
  - Shutting off unnecessary organs during dives
  - Developing flexible ribs
  - No nitrogen narcosis
- Polar Bears are also considered marine mammals. Their adaptations are mostly to temperature, and include:
  - Extremely well insulated, through a combination of their hair (hollow) and a thick layer of fat
  - Webbed rear feet
  - Water resistant coats

VI. Behavioral Adaptations
- There are many examples of behavioral, rather than physiological, adaptations to the marine environment...some examples include:
  - **Schooling**
    - This has evolved in over 2000 species of fish
    - Possible roles include:
      - Reduce the predator-prey encounter rate
      - Less likely to eat any given individual
      - May appear as a "single" organism
      - Confuse predators
  - **Migration**
    - Very common in nektonic organisms
    - Many organisms migrate across entire basins (e.g. the Pacific) annually, such as tuna, sea turtles
    - *Catadromous* organisms reproduce in salt water, spend most of their adult life in the fresh water (eels)
    - *Anadromous* organisms reproduce in fresh water, spend most of their adult life in saltwater (salmon)