Pinniped Evolution

• The Debate
  o Through most of the last hundred years, there has been a debate over whether the pinnipeds (seals, sea lions and walruses) are monophyletic or paraphyletic (specifically diphyletic)
    ▪ Monophyletic- all members of a taxon evolved from a common ancestor
    ▪ Paraphyletic- not all members of a taxon evolved from a common ancestor
      ▪ Diphyletic means that there are two points of origin for the taxon.
  ▪ Monophyletic Argument
    • All pinnipeds evolved from an ursid (bear-like) ancestor
    • In particular, the phocids (true seals) evolved from the otariids (sea lions)
  ▪ Diphyletic Argument
    • The otariids evolved from an ursid ancestor
    • The phocids evolved from a mustelid (weasel-like) ancestor.

o How to resolve the issue?
  ▪ Zoogeography
    • Otariids are found mostly in the Pacific
    • Phocids are found mostly in the Atlantic
    • Odobenids (walruses) are found exclusively in the Arctic
  ▪ Fossil Record
    ▪ Otariid fossils are found strictly in the Pacific, while Phocid fossils are found only in the Atlantic
  ▪ Diphyletic Argument
    ▪ Suggests two separate origins of evolution
      ▪ Otariids evolved in the Pacific
      ▪ Phocids evolved in the Atlantic
  ▪ Monophyletic Argument
    ▪ Otariids, which evolved first, moved easily from the Pacific to the Atlantic, through the Arctic because of the geography during the Pliocene.
    o This lead to speciation of different groups

▪ Morphology
  ▪ Otariids and Phocids have similar flippers
  ▪ However, Phocids use their hind flippers for propulsion and cannot rotate them forward.
  ▪ Otariids use their front flippers from propulsion and can rotate their hind flippers forward
  ▪ Diphyletic Argument
    ▪ Otariids and Phocids have similar flippers because of convergent evolution (
- **Convergent Evolution**: when the same trait appears in two different lineages as an adaptation to the same environment.
  - Ex: Bird wings and Bat wings
    - The differences between the flippers indicates different origins

- **Monophyletic Argument**
  - Convergence is overrated
  - The flippers of **phocids**, **otariids** and **odobenids** are more alike than they are like the flippers of any other group of marine mammals.
  - Assuming **parsimony** the development of structures so anatomically identical, yet functionally completely dissimilar, could only be explained by descent from a common ancestor
    - **Parsimony**: the simplest of two or more competing theories is preferable.

- **DNA**
  - With the advent of molecular techniques it has been possible to see how genetically similar the different pinnipeds are and thus construct a cladogram
  - Definitively show that **phocids** are more closely related to **otariids** than they are to weasels and otters
  - This gives strong evidence in support of the monophyletic argument

- **How did phocids evolve from Otariids?**
  - **Let’s look at maternal feeding strategies**
    - While nursing their young, all mammals face the tradeoff of feeding their offspring and feed themselves.
    - Because all pinnipeds must return to a solid substrate in order to give birth, yet feed in the ocean, this tradeoff can be particularly problematic.
    - How do they manage this?
      - **Otariids** feed while nursing
        - Being smaller, the otariids must forage while nursing
        - This leads to longer lactation periods
      - Almost all **phocids** fast while nursing
        - **Phocids** tend to be large animals with large fat reserves and can therefore withstand not eating for a few weeks while their offspring mature
        - The lactation period is also shortened
        - The harbor seal, however, is a small **phocid** and thus forages during lactation
Size, not phylogeny, seems to play an important role in determining maternal feeding strategy.

Dan Costa at UCSC suggested a scheme in which life history trait and feedback looks may be important in the evolution of phocid and otariid breeding patterns and therefore their overall evolution

- Phocids
  - Being bigger has some benefits
    - The larger you are, the longer you can go without eating, making it possible for you to use more disparate food sources
      - Remember the Albatross?
    - Larger body mass also leads to a low, at-sea metabolic rate
    - Low metabolic rate, makes for better diving abilities
    - Better diving means better utilization of patchy resources

- Otariids
  - Being smaller limits you
    - Tend to live near areas of abundant resource, such as upwelling zones
    - Reduced transit time while feeding leads to rapid surface swimming.
    - Rapid swimming leads to elevated metabolic rate, which reduces absolute food requirements and allows to maintain smaller body size

Field study to support this

- During the 1983 El Nino, California Sea Lions living in Baja California were found to spend longer during their feeding trips because nearshore resources were scarce.
- Demonstrates selective pressure on an otariid for larger body size in order to utilize patchy resources.