**Whale Acoustics**

Practice Questions

1. Why do odontocetes make sounds?

2. Echolocation is particularly sophisticated – why put all the effort into evolving a new system?

3. How does sound travel to create echolocation? Put the following terms in order: “cochlea”, “prey item”, “Monkey lips”, “acoustic window in mandible”, “melon”.

4. The melon is thought to _______ sound which causes it to focus or concentrate into a beam

5. Air spaces and dense bone in the skull _______ sound.

6. How many pairs of “monkey lips” do odontocetes have? What might this enable?

7. What does the frequency of echolocation clicks tell you the range at which an organism can detect a target?

8. In what species do echolocation clicks travel from anterior to posterior before exiting the head?

9. What aspects of marine mammal science can acoustics provide important information?

10. At what angle is the beam of sound transmitted from a dolphin’s head? Is it a narrow focus or a wide beam? How do we know this?

11. Baleen whales are often use complex calls on _______ areas and simpler songs on _______ areas.

12. Humpback whale songs only change very slowly within a population. True/False?

13. How do we know the context of different call types in large whales?

**Anatomy**

Lecture Review:

**Skull Anatomy**

1. Form directly relates to function.
   
   a. Life history/amount of time in water are directly apparent in the anatomy of the skull.
   
   b. Skulls are just tools – tools to make a living – efficiently (everything is under selection).

   **NOTE: Some tools are specialized while some are general: think about pliers**
   
   i. Skulls are tools for what? What do they hold? What do they control?
   
   ii. Bones of the skull are tools for what? What do they hold? What do they do?
   
   iii. Jaws are tools for what? Some are long and some are short – why? And in who
iv. Teeth are tools for what? Homo/hetero---dont – what does this tell you about what the animal is doing with its teeth?

2. Skull Size varies widely across marine mammals as does the amount and placement of soft tissue around the skull. Think about sperm whales, right whales and sea otters. Why would the sizes vary?

3. Bones of the skull – all marine mammals have the same basic bones – although they vary in placement, size and function.

   A. Tooth---bearing bones:

      Function (s): food capture and mastication.


   B. Airway bones: Nasals

   C. Food---handling bones: Hyals

   D. Protection: Frontal, parietal, temporal, occipitals, Jugal/zygomatic arch

   E. Hearing: See last week's lectures.

   F. Attachment: Parietal, frontal, temporal, occipitals, jugal/Zygomatic arches: small and slim in cetaceans

4. Other features of the skull

   A. Teeth: otters: crushing; Shearing molars: seals/sea lions. Dolphins – grasping; Manatees: grinding; Baleen – filtering; Manatees just have cheek teeth – no incisors – continuously replaced throughout life.

   B. Foramina: ducts for nerves and blood vessels: Mental (on the mandibles).

   C. Fossa: Temporal fossa – massive area for muscle attachment of the jaw muscles

   D. Processes:

      i. Ramus (process where muscles attach) – bigger in pinnipeds, sirenians; smaller for dolphins

      ii. Condyls (hinges): Occipital condyles are the big one at the base of the skull. Point down in pinnipeds. Straight back in cetaceans. Mandibular condyle is

      iii. Mandibular symphysis (joining of bones) – fused early in manatee life, older in dolphins, never in mysticetes because need flexibility for lunge feeding

Soft Tissues:

   -- Nerves and blood vessels to follow the movement of bones and the pushing of airways.

   -- Reorganization of feeding and breathing structures. Airways cross with feeding tudes and are completely separate. Goosebeak structure. NO epiglottis.
--- Sperm whale is most extreme!

**Post---Cranium and Locomotion:**

Parts: Vertebral column and appendicular skeleton (limbs and girdles)

Function: Support and protect soft tissues – also gives animal overall form.

A. Vertebral Column:

   i. Individual Vertebrae – Centra, Neural Arch/Canal and Neural Spines and Transverse Processes
   
   ii. Intervertebral discs (just as they sound) and zygapophyses (areas of overlap between two vertebrae -- allow for movement (flexibility/rigidity of the column
   
   iii. Regions of column ---:

   1. Cervical – neck
   2. Thoracic – chest – Also in this region: vertebral ribs/Sternal ribs/Sternabrae – all odontocetes, most mysticetes and manatees
   3. Lumbar – lower back
   4. Sacral – attached to pelvis (gone in cetaceans and sirenians)
   5. Caudal – tail

**Internal Structures:**

--- The diaphragm divides the body cavity in two.

   a. Above (cranial to the diaphragm)

   -- Heart (Pericardium); Plural Cavities (lungs); Mediastinum (nerves and lymph nodes)

   b. Below – (Caudal to the diaphragm)

--- Liver/Gall bladder, Urogenital, Adrenal Glands

--- Digestive (a lot of variation – several stomachs in cetaceans), HUGE in manatees

--- Mammary glands:

   --- Caudal and ventral in cetaceans (slits) and pinnipeds

   --- Anterior and ventral (arm---pit area)
1. Forelimbs: No clavicle in cetaceans. Scapula is only attached to vertebrate by muscle. Olecranon (elbow) processes developed in sea lion and polar bear. Cetaceans arms are immobile elbow.

2. Pelvis/Hind limbs: Cetaceans/Sirenians have pelvic vestige (has a purpose – reproductive attachment). Seal lions have shortened tibia/fibula and big feet.

3. Flukes: Only vertebrae – no other bony support. Indicates swim speed. **Narwal Question in Class!!**


Locomotion in water: Fusiform shape. Evolution of cetaceans. Quadrupedal --- pelvis paddling ---> caudal undulation (think flexing of the spine – kinda like sea otters) ---> caudal oscillation (more efficient “thunniform” swimming restricted to caudal region.)
ANATOMY:

1. What are foramen and fossa? What are their functions? What can they tell you about the lifestyle of the animal?

2. Contrast the position of the nasal, maxilla, premaxilla and foramen magnum in pinnipeds vs. cetaceans.

3. Is the braincase large in mysticetes, relative to body size? Why?

4. What are the different soft tissues involved in sound production and reception?

5. What is the diaphragm and what does it do?


7. Why do beaked whales have dense head bones?

8. Are the arm bones in cetaceans longer or shorter relative to body size than ours? Why?

9. Large---wide pectoral flippers indicate _______ swim speed and _______ maneuverability.

LOCOMOTION
1) How does drag change as velocity increases?

2) What are some factors that can increase drag on a marine mammal?

3) What is metabolic energy used for?
   How is it lost?

4) Why might metabolic rate change in marine mammals depending on the season?

5) What are some adaptations to decrease locomotion costs?
   How do you measure these costs?

6) Place in order of locomotion efficiency in water:
   fully aquatic mammals, semi-aquatic mammals, humans, fish

DIVING PHYSIOLOGY
1. Why do marine mammals dive?

2. What are some of the challenges of deep diving

3. What are some adaptations for deep diving?
OSMOREGULATION – all about regulating salts and water

1. What is osmoregulation?

2. What are input and excretion routes for salts in the body?

3. How does prey choice influence osmoregulatory requirements of marine mammals? How does this relate to kidney size?

4. Describe the difference between preformed water and metabolic water.