Discovery of Sound in the Sea (DOSITS)
Marine Mammal Hearing, Video Summary

Marine animals use sound to communicate, locate food, attract mates, navigate underwater, and otherwise sense their surroundings.

For more information on the DOSITS website:
www.dosits.org/animals/importanceofsound/whyissoundimportant/

Marine mammal hearing

- Hearing is the detection of sound. Both modern terrestrial mammals, including humans, and marine mammals evolved from ancestors that had air-adapted ears. Thus, many of the structures of the ear in both terrestrial and marine mammals are similar.
- Some marine mammals that live exclusively in water hear very well in water but hear poorly, if at all, in air. Marine mammals that live on land at least part of the time, such as seals, sea lions and walruses, have ears that are **amphibious** and can hear in both air and water.
- Hearing is the result of the combined activity of the ear's three basic divisions:
    - The **outer ear**, which collects and directs sound;
    - The **middle ear**, which ear filters and transfers the acoustic energy to the inner ear; and
    - The **inner ear**, which transforms the acoustic energy to electrical signals to be processed by the brain.
- There are many similarities in the basic hearing processes in marine mammals and terrestrial mammals. We will use the human ear as a model for terrestrial ears.
    - The outer ear includes the ear flap (or **pinna**), which funnels sound to the outer ear canal. The outer ear canal ends in the eardrum, or **tympanic membrane**, which separates the outer and middle ear.
    - The middle ear in terrestrial mammals is an air-filled space that contains a series of three small bones (or **ossicles**) called the incus (anvil), malleus (hammer), and stapes (stirrup). These bones are connected to the tympanic membrane and the **oval window**, which is the opening to the inner ear.
    - Sound energy from the outer ear causes the tympanic membrane to vibrate. The ossicles transform and amplify this energy at the tympanic membrane into vibrations to the fluid-filled **cochlea** via the oval window.
    - The cochlea, a spiral-shaped organ within the inner ear, transforms sound waves into nerve impulses. Membranes in the cochlea determine an animals' **hearing range** and **sensitivity**.
    - As sound waves moves through the inner ear, the **basilar** and **tectorial membranes** vibrate. As the membranes move, fine **stereocilia** on the hair cells are bent, triggering a nerve impulse that conveys sound information to the brain.

For more information on the DOSITS website:
www.dosits.org/animals/soundreception/mammalshear/
www.dosits.org/animals/soundreception/mammalshear/landmammals/

Marine mammal adaptations for hearing underwater

- Scientists know that some amphibious marine mammals have mechanisms to close the outer ear canal.
    - When the animal is underwater, a valve clamps down on the outer ear canal, preventing water from entering.
    - Specialized middle ear tissues may also assist with pressure equalization during diving.
- Adaptations for hearing underwater are really extreme in whales and dolphins. Instead of a normal outer ear canal, they have developed specialized fats that channel sound to the middle ear.
    - The jaw fats have different shapes and dimensions in each species, which are related to the frequencies of best hearing sensitivity.

For more information on the DOSITS website:
www.dosits.org/animals/soundreception/mammalshear/hearinginpinnipeds/
www.dosits.org/animals/soundreception/mammalshear/hearingincetaceans/

Hearing sensitivities of marine mammals

- Like land mammals, each species of marine mammal has inner ears with membranes that respond, or resonate, according to differences in stiffness along the length of the ear canal. These differences determine their hearing ranges and sensitivities.
    - The largest marine mammals ears (e.g. gray whale) can hear infrasonics, that is, frequencies below 20 Hz. These large ears in baleen whales are specialized to hear well at very low frequencies.
    - Most marine mammals, however, have ears like the harbor porpoise that are able to hear best at ultrasonic frequencies, well above 20 kHz.
    - Typically, species that hear well at very high frequencies do not hear well at lower frequencies, below 500 Hz, which is where many human-generated sounds in the ocean occur.

For more information on the DOSITS website:
www.dosits.org/science/soundmeasurement/soundsanimalshear/
www.dosits.org/science/soundmeasurement/hearingmeasured/

Discovery of Sound in the Sea (DOSITS; www.dosits.org) is a comprehensive, educational website on underwater sound, designed to provide accurate scientific information at levels appropriate for all audiences, including decision-makers. This video series is being sponsored by the Exploration and Production, Sound and Marine Life Joint Industry Programme (www.soundandmarinelife.org).