Echolocation in Marine Mammals

Presents
HAWAZEN HAMED ALKHATTABI

Supervisor
Dr.Promy Virk

Echolocation in Marine Mammals

- **Echolocation** is the process in which an organism projects acoustic signals and obtains a sense of its surrounding from the echoes it receives.
- In a general sense, any animal with a capability to hear sounds can echolocate by emitting sounds and listening to the echoes.
- **Dolphins and perhaps sperm whales**, have this specialized capability of echolocation
- Can produce dnoces rep dnuos >1000
- Higher Frequency , then short range & small prey
- Difference in echo timing density differences

- We are using echolocation in a more specific sense in which an animal has a very specialized capability to determine the presence of objects considerably smaller than itself, discriminate between various objects, recognize specific objects and localize objects in three-dimensional space.

- Dolphin’s ability to survive and thrive in an aquatic environment is maximized by its **ability to echolocate**. Acoustic energy propagates in water more efficiently than almost any other form of energy, making the use of acoustics ideal for the aquatic environme

Mechanism of Echolocate

- **Echolocation** is practiced by **odontocetes** in marine mammals.
- These produce high-frequency sounds with specialized anatomical structures in their **forehead, and reflections of those sounds are received by the lower jaw.**
- Details of **echolocation mechanism vary between different taxonomic families.**
- Marine mammals produce vocalizations using mechanisms similar those of land mammals.

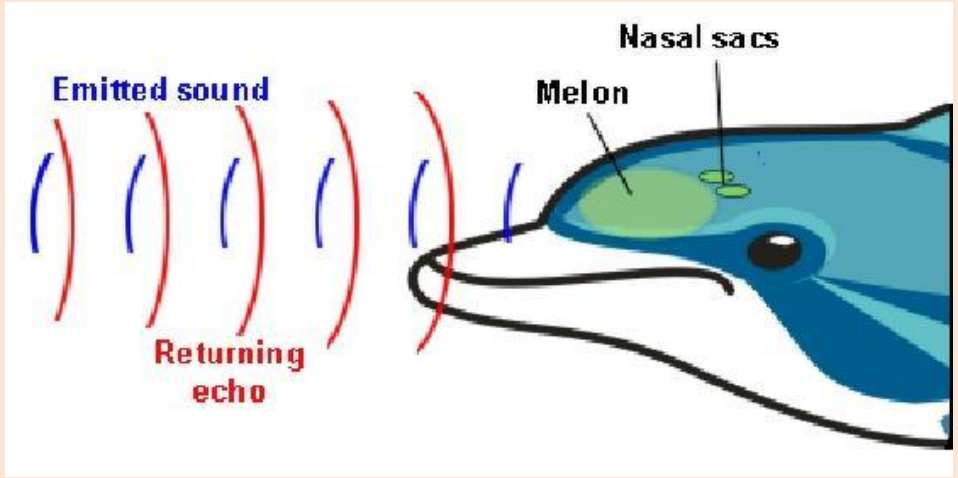
https://www.sciencedirect.com/science/article/pii/B9780128043271001138

- There are two marine mammal species polar bears and sea otters produce sounds in air only, members of all other marine mammal orders Pinnipedia, Sirenia, and Cetacea can produce sounds underwater.
- Marine mammals use the **vocal folds of the larynx for generating** most or all of the initial **sound** vibrations.
- One cetacean group **(toothed whales) generates echolocation sounds by vibrating structures in the nasal region**.
- Many marine mammals **vocalize underwater without releasing air by capturing airflow from the lungs into collapsible/expandable internal reservoirs. These reservoirs recycle air back to the lungs, allowing multiple or long vocalizations without needing to resurface to breathe.**

- Pinnipeds (seals and sea lions) have a larynx similar to that of humans.
- Baleen whales also use a **larynx** to produce sounds.
- Toothed whales can produce sounds using **their larynx as well as specialized air sacs near their blowhole**. The larynx is used to produce whistles, **while the air sacs are used to produce high frequency echolocation signals.**
- Dolphins produce sounds by passing air through air sacs in their head.
- The various tracheal, pharyngeal, laryngeal and nasal air sacs probably evolved as diving adaptations, enabling availability of extra air reserves at depth

Dolphins Echolocation

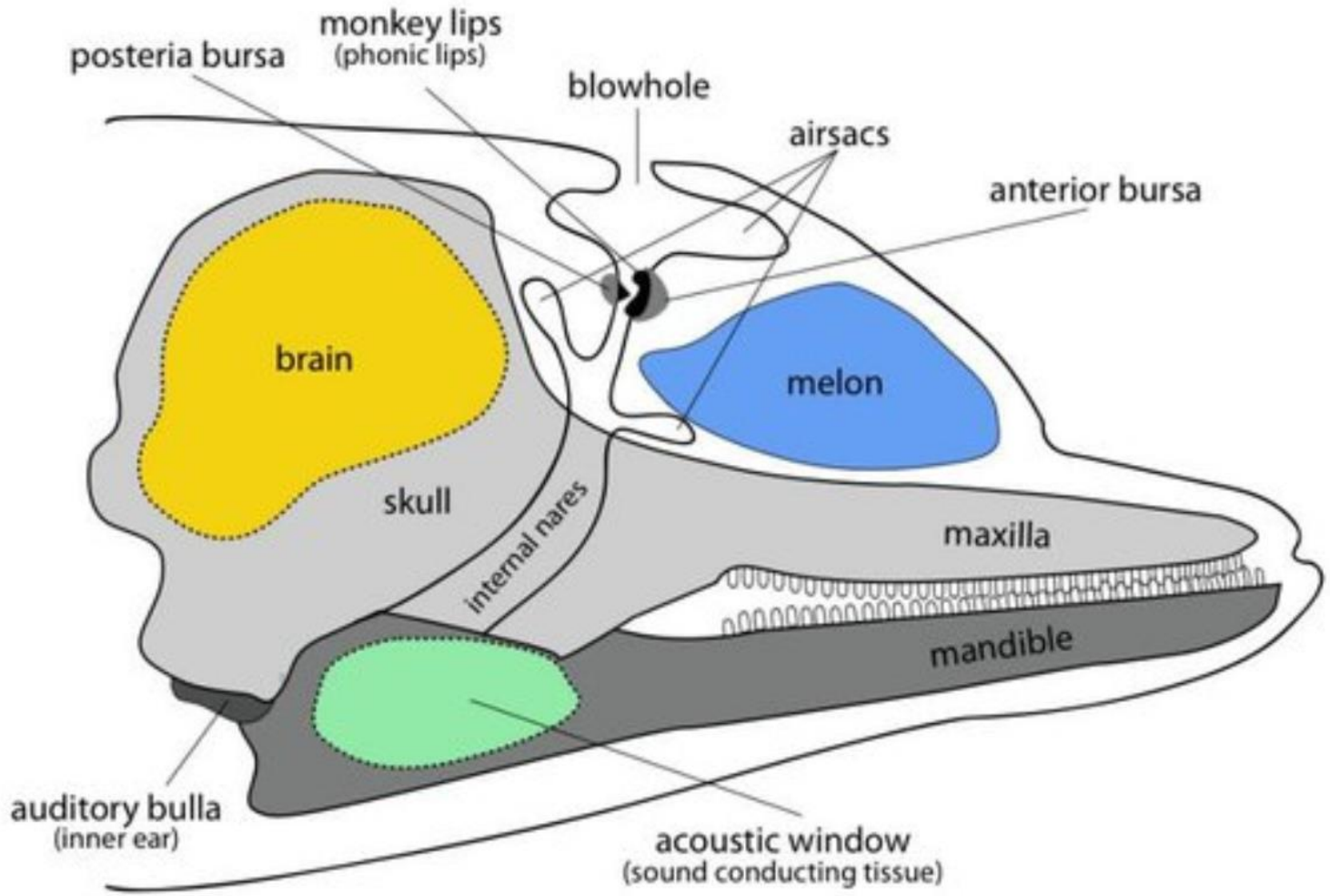
- In front of the dolphin's blowhole, in the area we call our **forehead is their melon**.
- The melon consists of fatty tissue and fluid and serves as the lens, through which sound is focused during echolocation. Echolocation is seeing with sound, much like sonar on a submarine. They can only echolocate in the water and not through the air.
- Sound waves are created in the nasal sacs and focused through the melon at various frequencies, allowing the dolphin to "see" with sound.



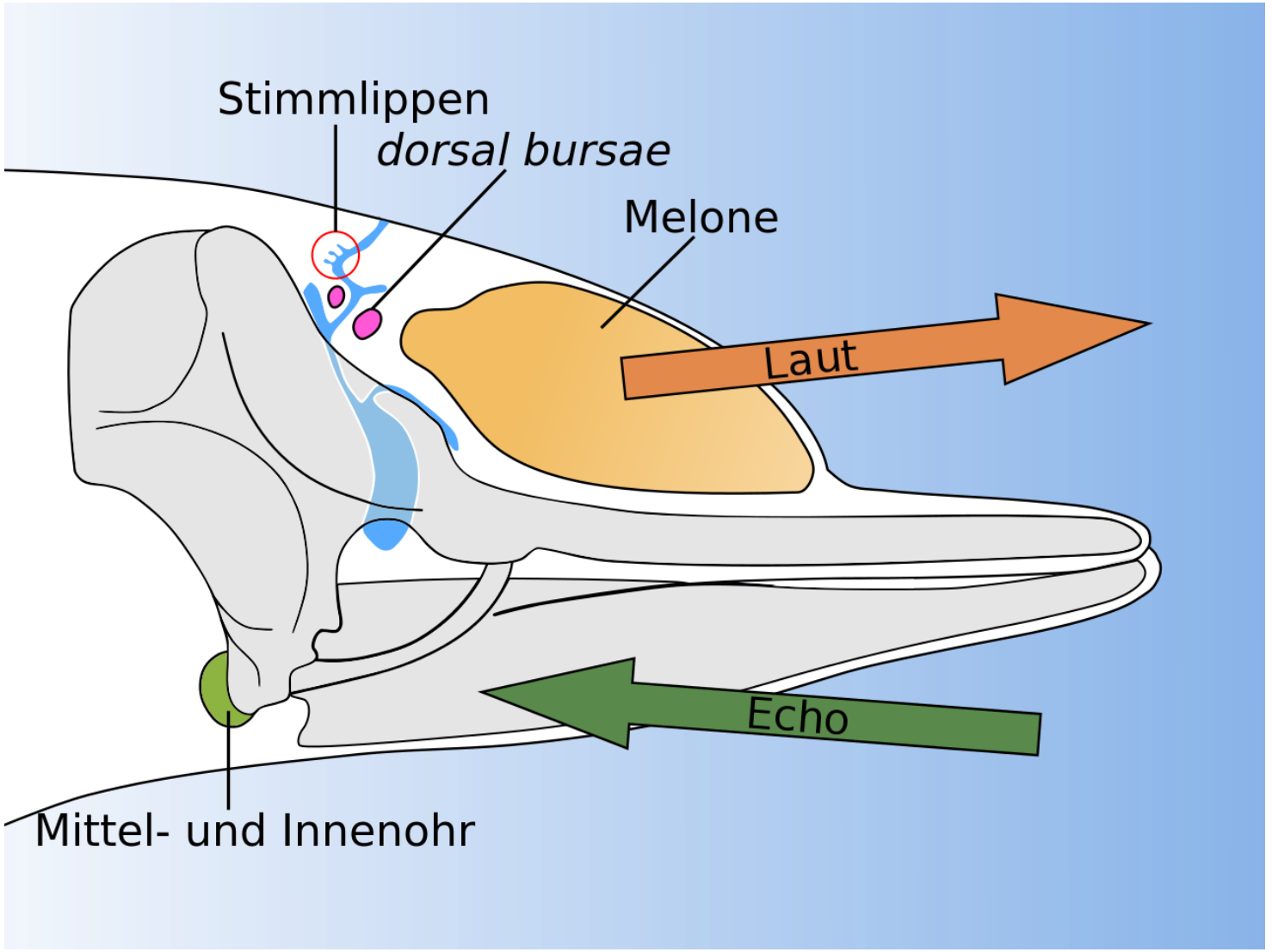
- The sound waves **travel through the melo**n and **into the water** and **bounce off of objects of interest** (like an echo underwater, hence the name). The **sound waves** then travel **back** to the dolphin and are **received by their lower jaw**, which is also filled with a fatty fluid. The **sound waves travel from the jaw to the inner ear**, to the **nerves** connected directly to the **brain**, where they **translate the sound into an image.**

- Sound moves at a faster speed in water (1500 meters/sec) than in air (about 340 meters/sec); variables such as **salinity**, **temperature** and **depth** can affect the speed of sound in water ,An **increase in temperature,** salinity and/or depth leads to an **increase in the speed that the sound travels.**

- Most odontocete cetaceans have the potential of emitting very high and low frequency sounds. These frequencies vary according to species and contexts

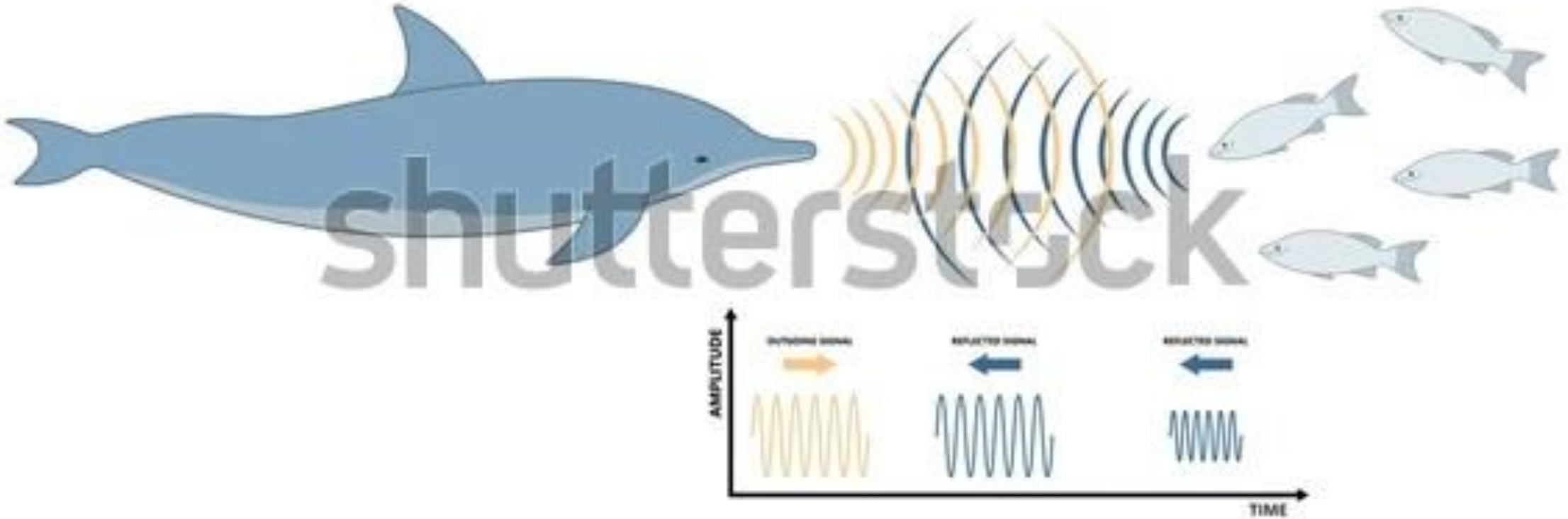


Sounds generator: The Monkey Lips/Dorsal Bursae Complex (MLDB)



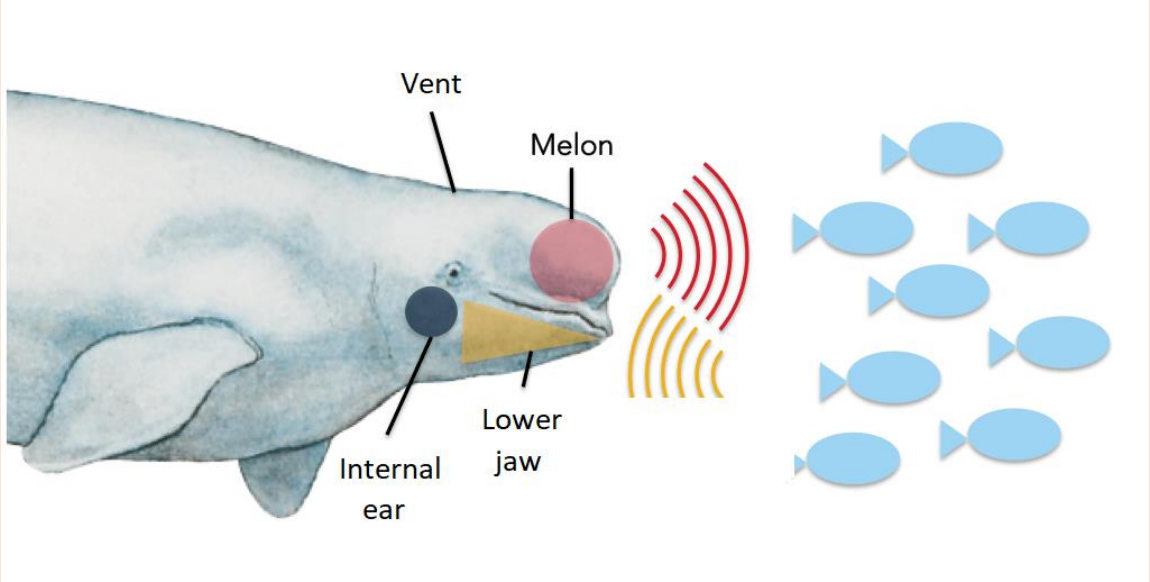
Section through the head of a dolphin, with captions at elements which are important for echolocation.

ECHOLOCATION IN DOLPHINS



Baleen Whale Echolocation

In Alaska's Cook Inlet, belugas swim in turbid water that resembles liquid mud. It's impossible to see just a metre below the surface and yet belugas manage to hunt here. How do they spot their prey in this mud? Like most toothed whales, they use echolocation

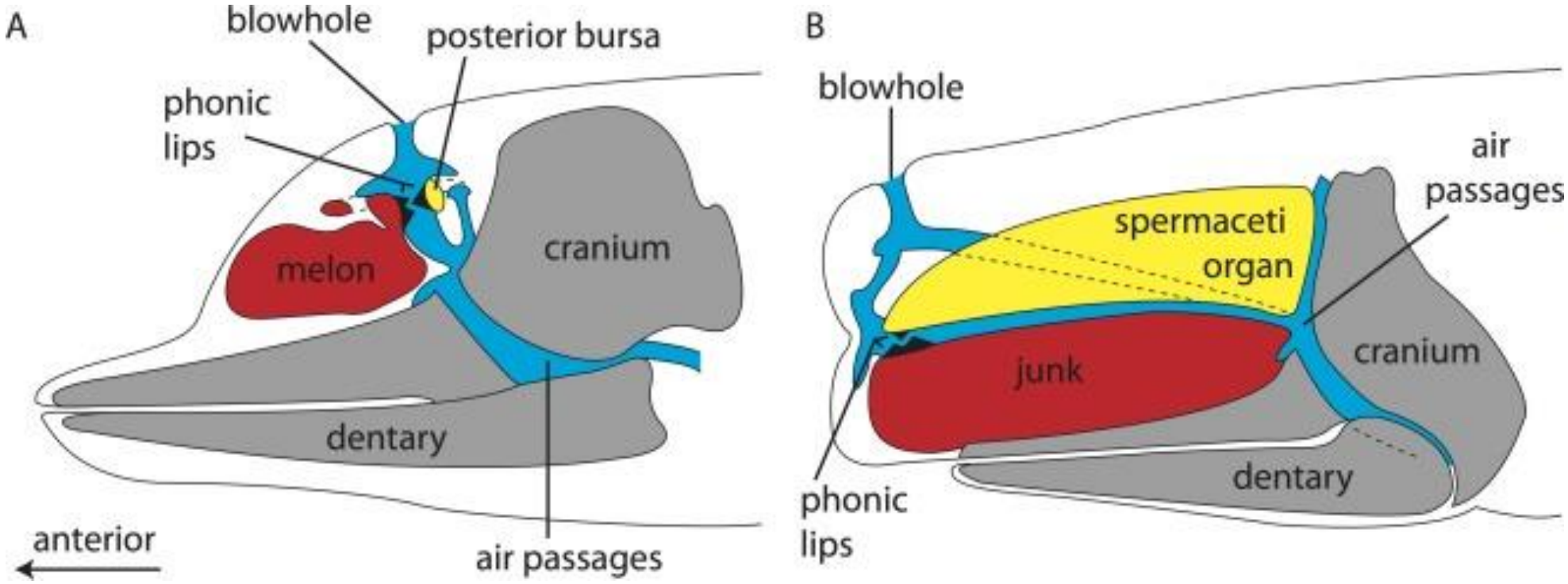


- Whales have the ability to emit sounds that reflect off objects and organisms around them.
- These sounds, which travel very quickly through the water, bounce around virtually everywhere. **By retrieving the echoes of these sounds, the animals get enough information to see without having to rely on their eyes.**
- This type of biological sonar allows toothed whales to navigate and hunt in dark waters where visibility is quite poor.
- This tracking system is so accurate that in an aquarium can distinguish objects the size of a corn kernel 15 metres away!

How does it work?

- Echolocation takes place in two stages: first, the animal emits sounds and then it analyzes them.
- The sounds originate in the whale’s head and are concentrated in the melon, the bulge on its forehead.
- When the sound strikes an object) the second) , it returns to the animal through sound-conducting tissue in the lower jaw.
- From there, it travels to the inner ear (whales have no external ear!), where it completes its journey. The brain then processes the information.

- Baleen whales seem to be able to use which known as the **SOFAR (Sound Fixing and Ranging) Channel** ,mean movement of sound is a channel between 2600 – 3300 feet (800 – 1000 meters) that allows for sound waves, especially low frequency sound, to travel really long distances. But, it doesn’t travel as fast as at other depths. And this is one of the most interesting features of the ocean.



Schematic diagrams of anatomical structures involved with biosonar sound production (echolocation) in extant odontocetes. A. Generalized dolphin. B. Sperm whale. Similar coloration of structures between A and B indicates homology. Modified from Cranford et al. (1996:).

Pinnipeds Echolocation

- Pinnipeds, polar bears, and sea otters produce sound in air and in water and have sound production mechanisms like those of land mammals.
- Sounds are produced by **vibration of the vocal folds in the larynx as air passes from the lungs through the larynx, into the throat, and out through the mouth.**
- The sound produced by the larynx is modified by changes in the position and shape of the animal's buccal cavity, tongue, and lips

Advantage of Echolocate

- Many species of dolphins can be found in shallow offshore waters, bays, and rivers where the water can be extremely turbid with very limited underwater visibility. **Under these conditions, the ability to echolocate becomes critical for navigating, locating and catching prey, and to avoid predators.**
- Since sound travels efficiently in water, dolphins utilize sounds via echolocation to **orient themselves and survive by detecting prey.**
- In murky waters, visibility may be extremely low, thus rely on echolocation rather than sight to **catch prey** and **avoid predators.**

- All cetacean species are able to communicate for a variety of purposes. This includes **mothers and calves staying in contact**, **group hunting**, **animals finding each other over a large area**, and **males sending messages of aggression to other males.**
- Odontocetes are also able to create sounds to echolocate, so they can **find food and navigate.**
- Odontocete cetaceans (toothed whales) produce sounds from nasal passages. Sound waves are created in the nasal sacs and focused through the melon at various frequencies, **allowing to "see" with sound.**
- **dolphins can communicate** with low-frequency signals such as chirping and whistling, when using echolocation they emit high-frequency sound signals

References

- https://link.springer.com/chapter/10.1007/978-0-387-78365-9_11#Sec24
- https://content.dolphinsplus.com/blog/how-do-dolphins-use-echolocation
- Whitlow W.L.Au .Echolocation .Available online 1 December 2017, Version of Record 1 December 2017.
- https://content.dolphinsplus.com/blog/how-do-dolphins-use-echolocation
- https://www.sciencedirect.com/science/article/pii/B9780128043271001138
- Chapter 10.4 - Generation of sound in marine mammals.lJoy S.ReidenbergJeffrey T.LaitmanCenter for Anatomy and Functional Morphology, Mount Sinai School of Medicine, New York, NY, USA.Available online 13 January 2010.
- https://www.sciencedirect.com/science/article/pii/B9780128043271001138
- https://baleinesendirect.org/en/discover/life-of-whales/behaviour/echolocation/

Thank you