



Acoustics



Sound

- “Waves of energy travelling through air and water as vibrations”
- The vibration rate (frequency) is measured in cycles per second or hertz
 - Sound in water travels at 5 times that as in air



Hearing ranges

Mysticetes:

10 Hz ----- 1000 Hz

Humans:

20 Hz ----- 20 kHz

(infras.) (ultras.)

Odontocetes:

100 Hz ----- 200 kHz

Bottlenose dolphin:

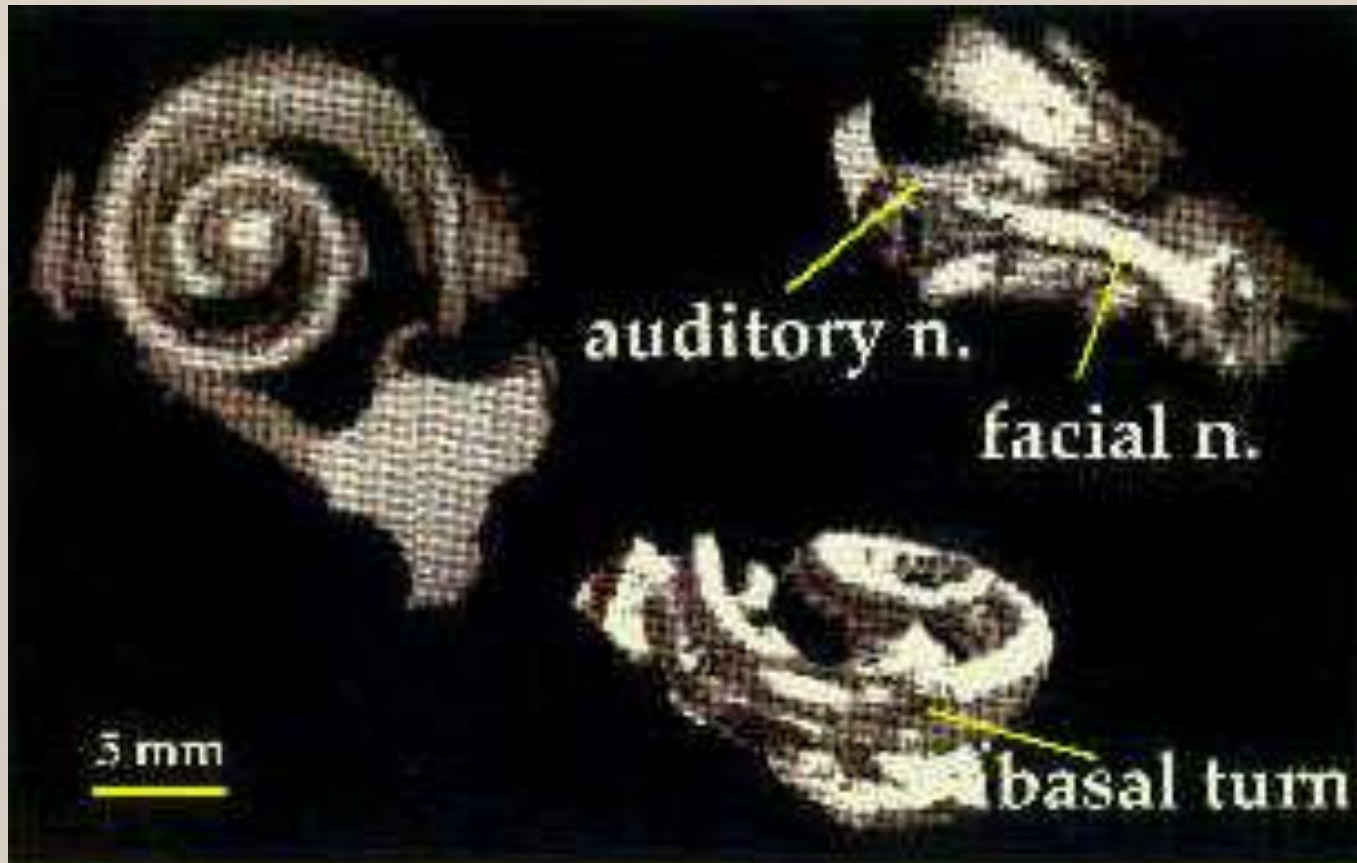
1 kHz ----- 150 kHz

(peak of sensitivity)

40 kHz ----- 100kHz

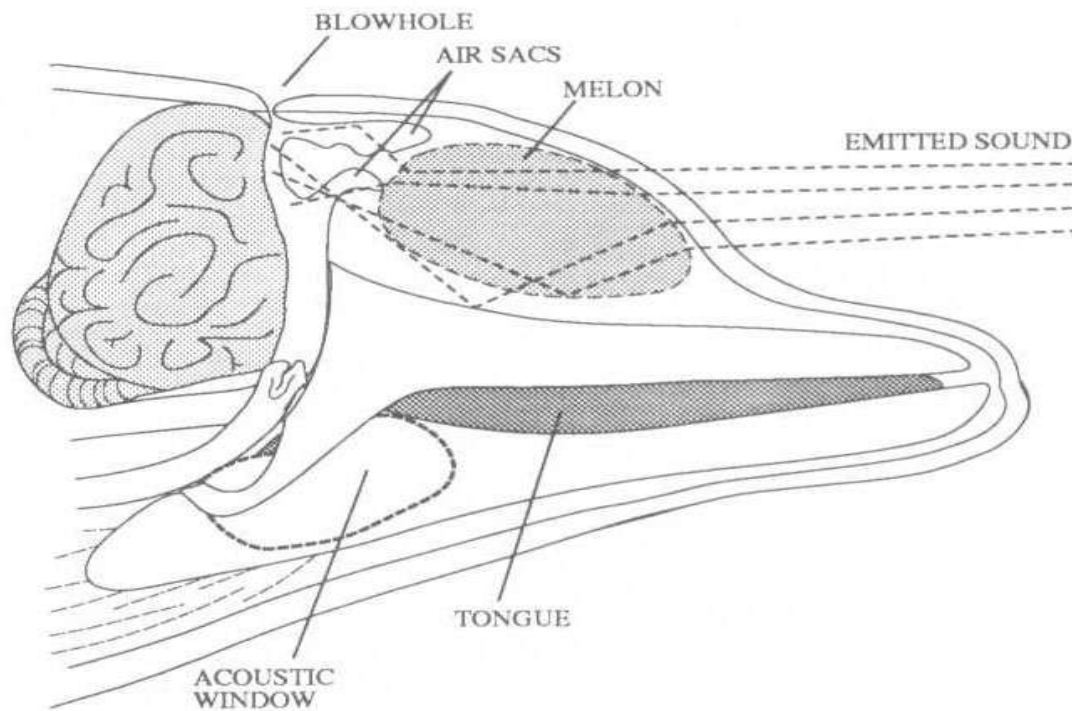


Cetacean Ear Structure



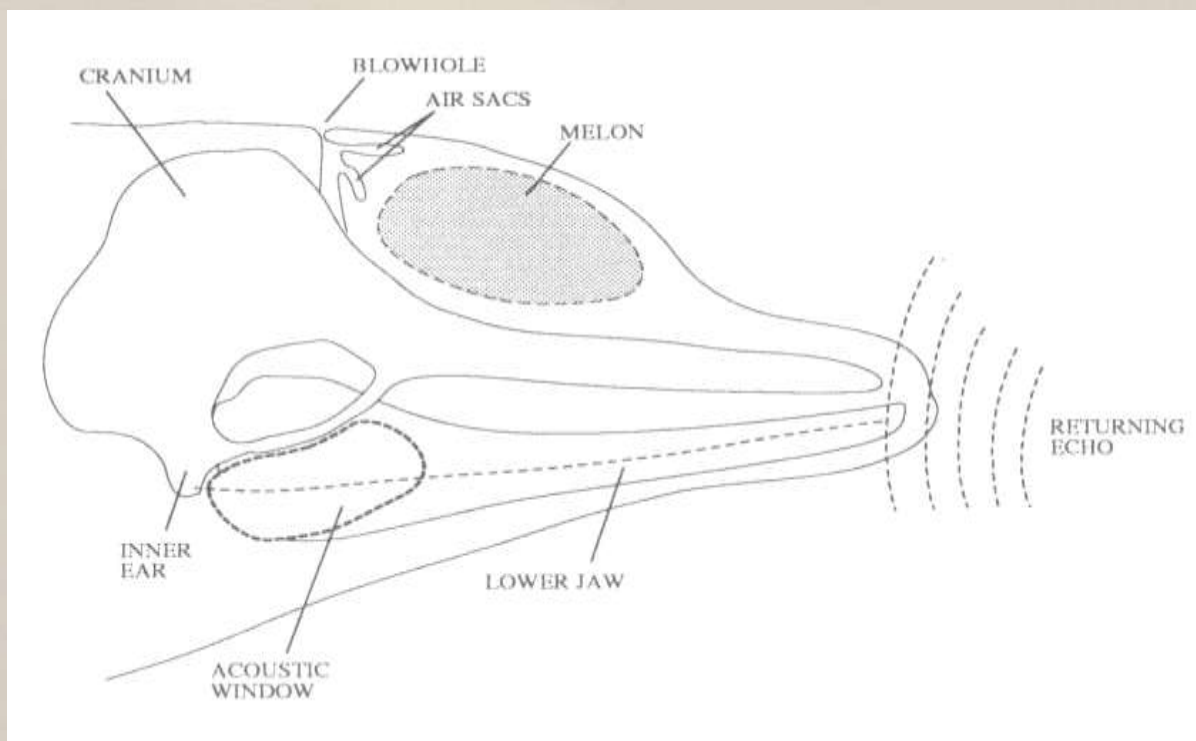


Sound Production





Sound Reception





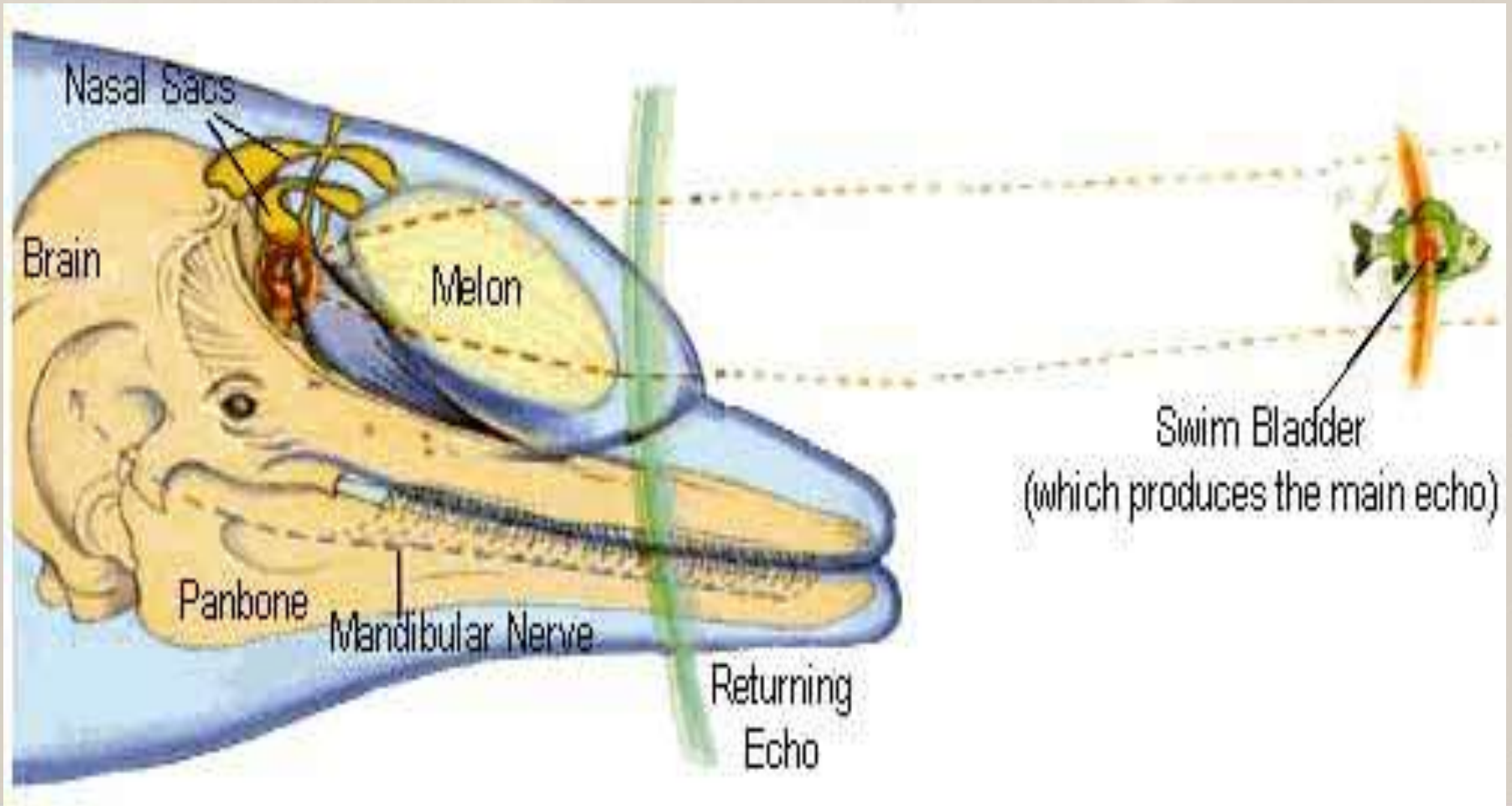
Vocalization

Pulsed sounds: Clicks
Click trains
Bursts

Non pulsed sounds: Whistles
Squeaks



Echolocation





Whistles

MODELS :

Repertoire - wide variety of different whistles

Signature - every dolphin has a personal "signature" whistle (V. Janik)



Sounds & Communication

Production learning

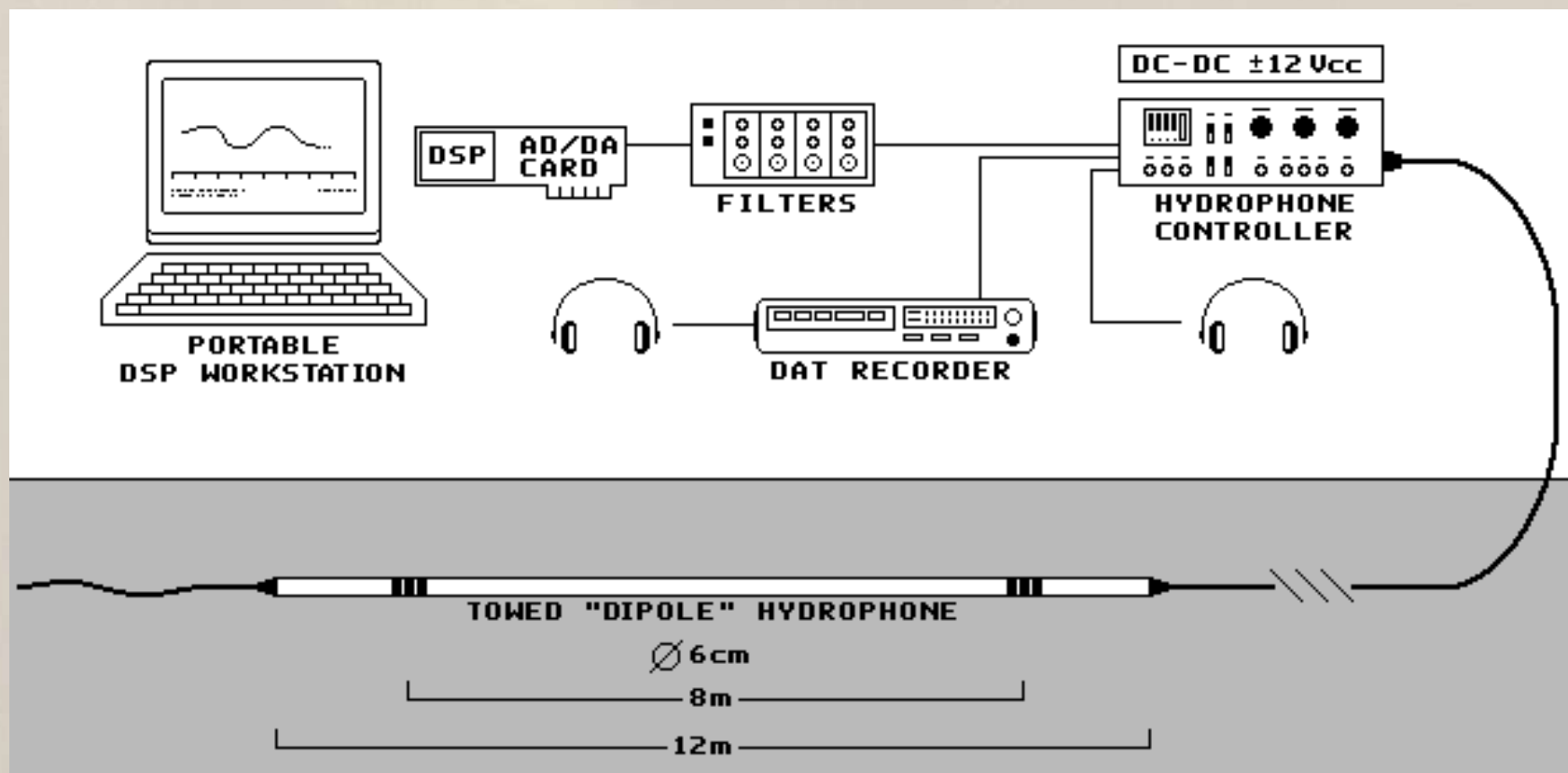
- The "song" of Humpback whales
- Horseshoe bats

Contextual learning

- Dolphins?



Measurement of Sound





The Losinj Dolphins

- Sylvan 1996
- Recognised 10 categories of vocalisations



Pulsed sounds

Single clicks	-	10.94 %
Creaks	-	21.03 %
Click Trains	-	13.05 %
Moans	-	6.22 %
Brays	-	3.80 %



Non pulsed sounds

Whistles	-	5.42 %
Buzzes	-	0.85 %



Others

Percussive Sounds	-	0.51 %
Bangs	-	0.26 %
Not defined	-	0.79 %



Clicks

- 1 - Click intervals > 30ms = a slow search or orientation phase

- 2 - Click intervals 7-30ms = a faster hunting phase

- Click intervals < 7ms = a tonal sounding phase of fast click repetitions in order to lock on the target or to debilitate the prey. This phase occurs just before attempting to snap the jaw closed on the prey.



Feeding behaviour – 62,27%

Pulsed sounds – 55%





Socializing 7%

Non pulsed sounds 5,42%





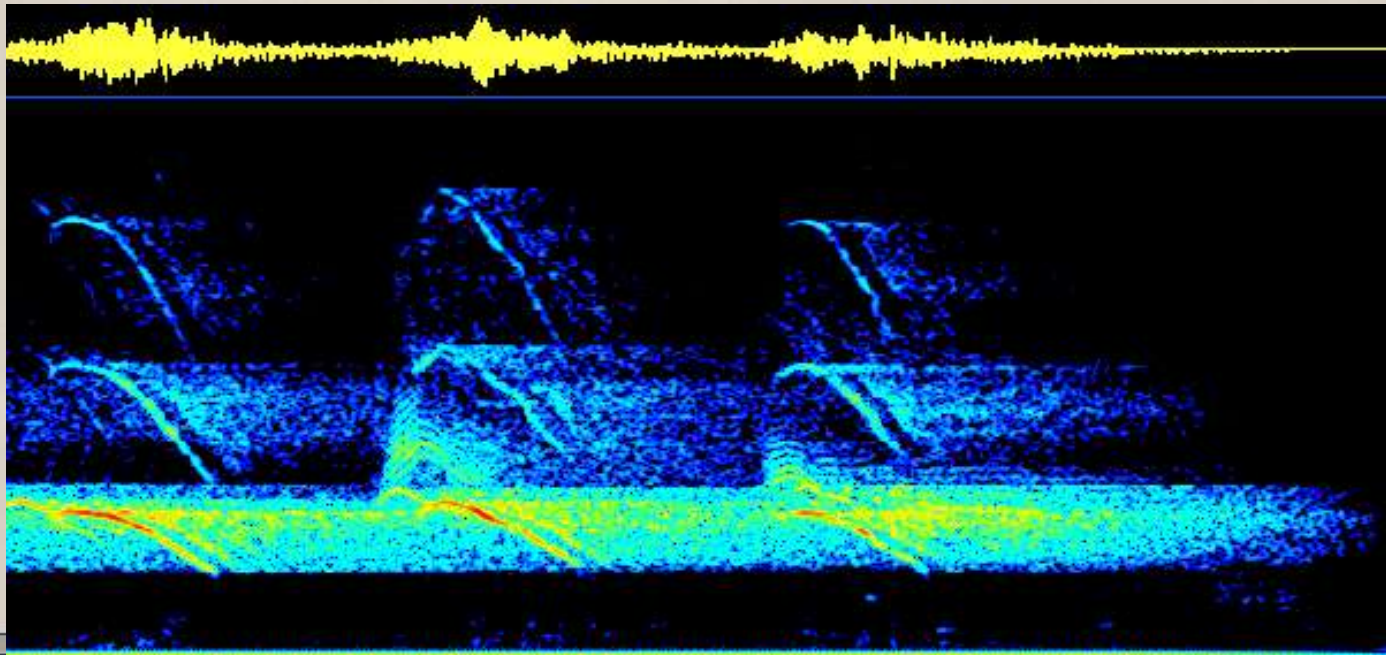
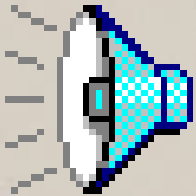
Why?

- 1- Limited food resources
- 2- Unpredictable seasonal food availability
- 3- Widely dispersed prey
- 4- Small prey size



Bottlenose Dolphin

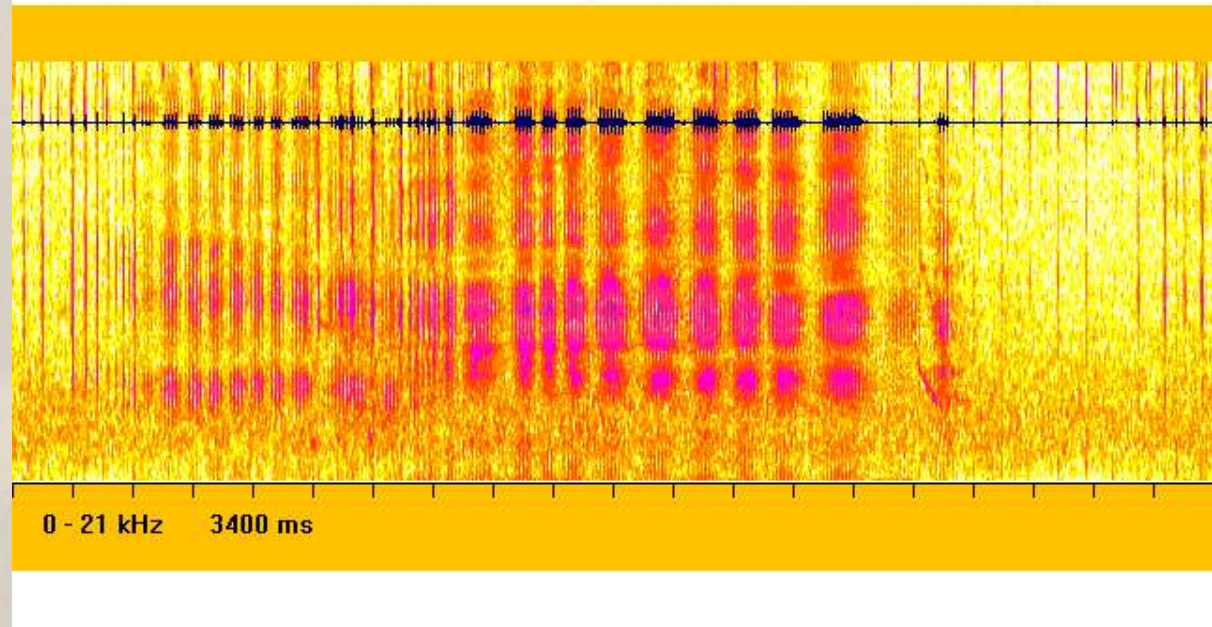
- Ecolocation clicks
- Communication whistles
- Signature whistle



Risso's Dolphin

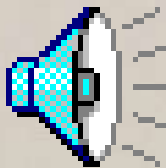


Risso's dolphin
Grampus griseus



0 - 21 kHz 3400 ms

- Isolated clicks
- Composed clicks
- Whistles (8-16 kHz)



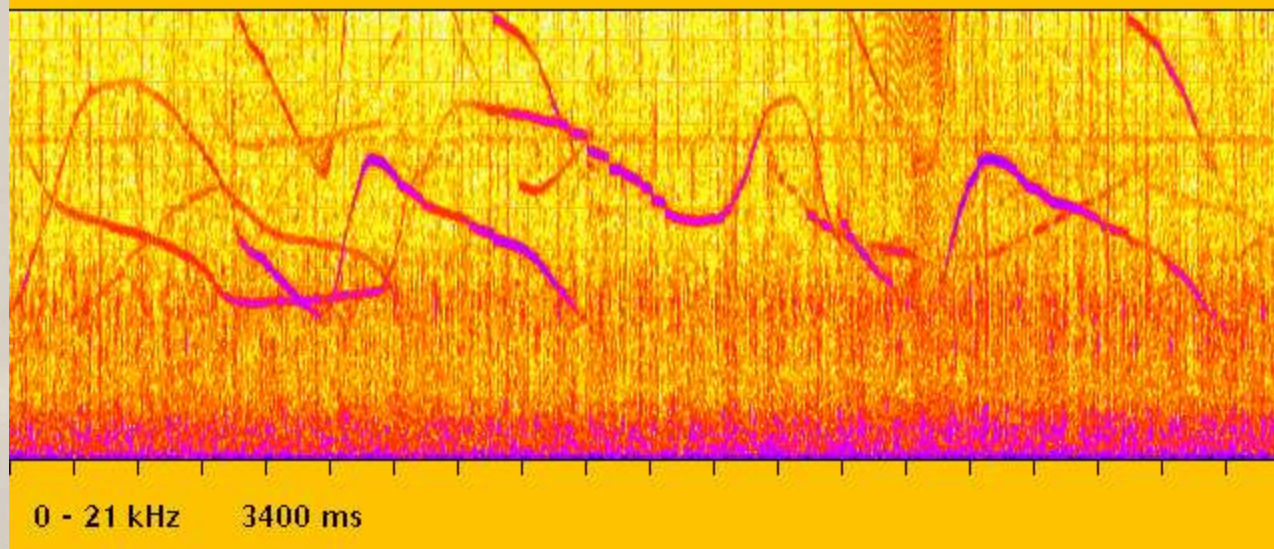


Striped Dolphin

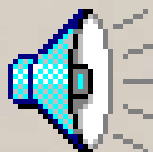
Striped dolphin
Stenella coeruleoalba



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- Clicks
- Modulated whistles up to 24 kHz



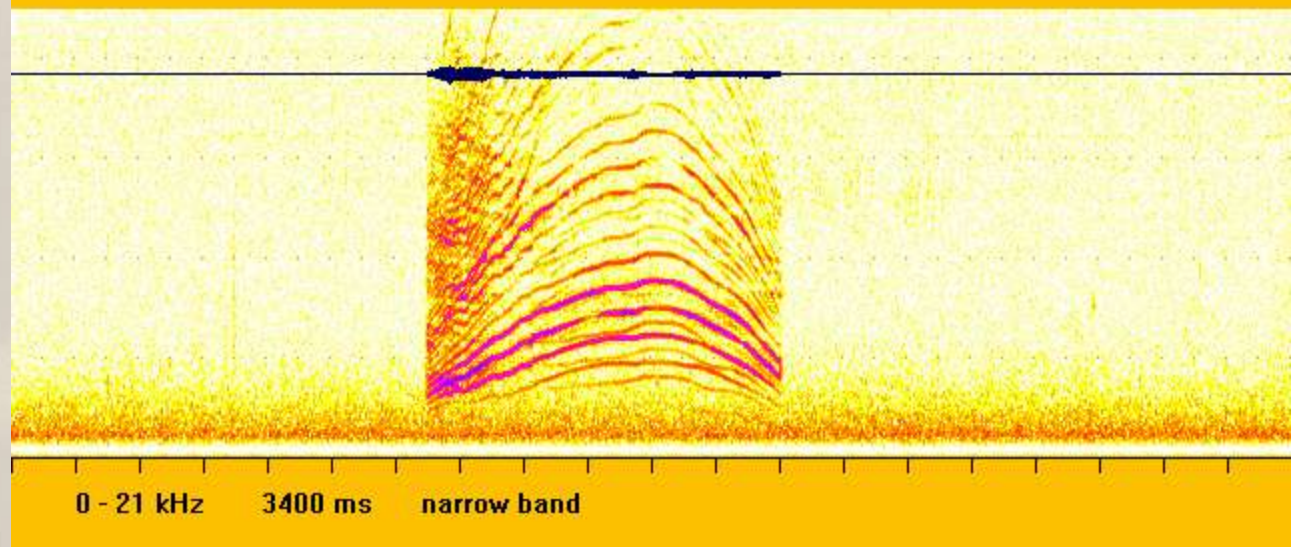


Pilot Whale

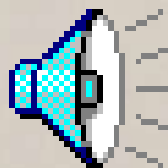
Pilot whale
Globicephala melas



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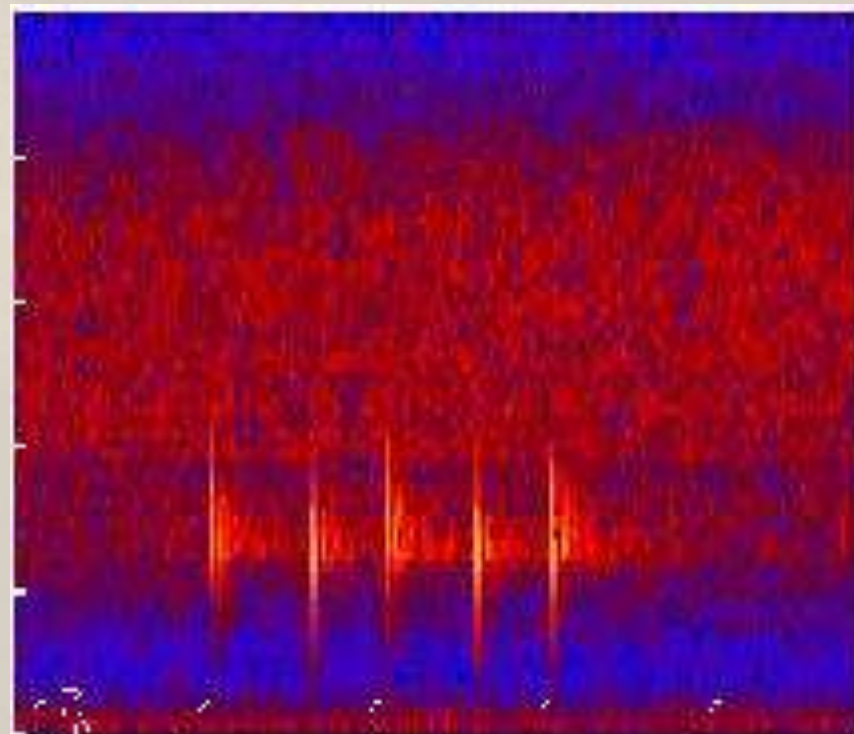
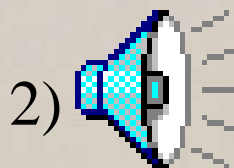
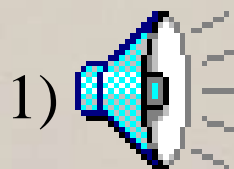
- Whistles < 5 kHz (simples or composed)
- Ecolocation clicks
- Signature whistles





Humpback Whale

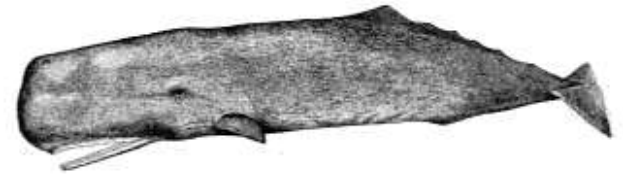
- 1) High-frequency vocalisations (40-75 Hz)
- 2) Isolated low-frequency vocalisations (20 Hz)
- 3) Sequencies of low-frequency vocalisations
- 4) Irregular grumblings of alarm (<30Hz)
- 5) Hydrodynamics sounds



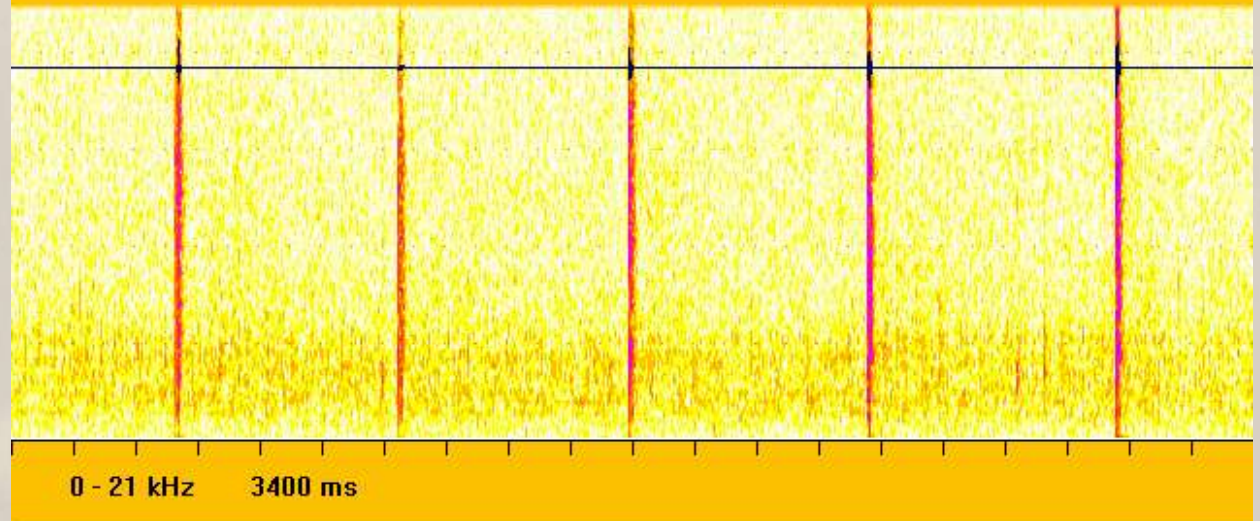


Sperm Whale

Sperm whale
Physeter macrocephalus



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- High-frequency clicks
- Irregular frequency codas

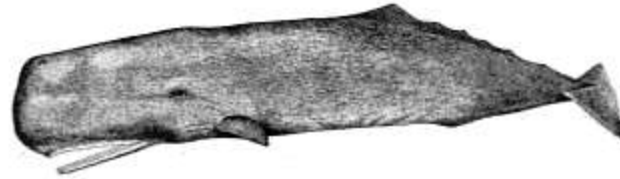
Click



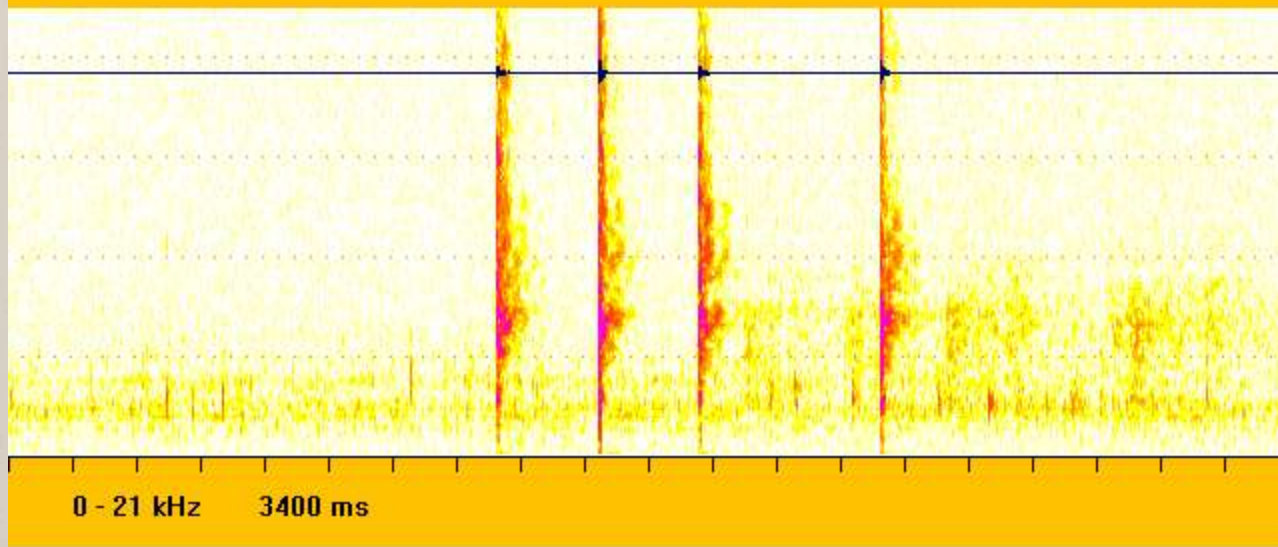
Sperm Whale



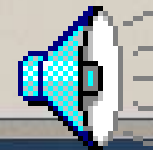
Sperm whale
Physeter macrocephalus



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Coda





Killer Whale

- Dialects of pods
- Examples of playing killer whale sounds in other areas.

