Bioacoustic techniques & technology to study cetaceans

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Photo by D. Nowacheck

Photo by F. Gohier

Bioacoustics is a very strong research tool because sound is

a *key sensory modality* for many aquatic animals

the *most reliable* long range signal channel under water

the only existing method for *large scale monitoring* of marine life

is having negative effects on animals through human-induced *noise pollution*

Vision

Mechanoreception

Hearing

Echolocation

Sensory modalities for cetaceans

Echolocation

Prey finding

Prey discrimination

Predator-prey interactions

Photo by F. Gohier

Bioacoustics is not an easy disciplin because sound recordings and analyses are

technically challenging

not necessarily intuitively appealing

not *cheap* at all

not always rendering easily interpretable *results*

Acoustic communication

Properties of vocalizations

Information transfer

Habitat degredation

Active space

Signature encoding

Predator avoidance

Impacts of anthropogenic noise

and so…

Photo by Herzing

Photo by N. Tregenza

Program

What is sound?

Introduction to hydrophones and sound recording

Applications
- Passive acoustic monitoring
- Hydrophone arrays and acoustic localization
- Acoustic tags
  Controlled exposure experiments (CEE)

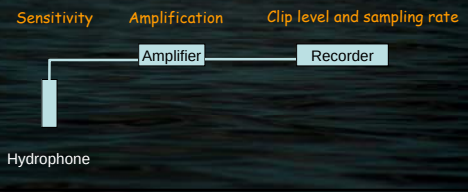
  Biosonar-based foraging in free-ranging toothed whales

Basic requirements for sound recordings:

Consider the species in question in terms of expected vocalizations:

A) Frequency range, B) Received levels, C) Recording time

Know your recording gear:



What is sound?

Pressure =

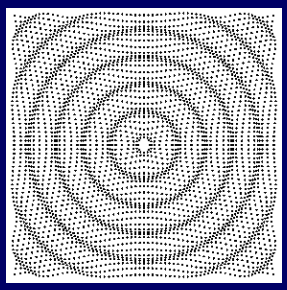
Force / Area

1 Pa = 1 N / m²

Sound pressure is given on a log scale using 1uPa as a reference:

dB re 1uPa = 20log(x uPa / 1 uPa)

e.g. 1Pa = 120 dB re 1uPa



Sound is pressure oscillations *and* particle vibrations

Photo by N. Tregenza

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Hydrophones

Underwater microphone:

Pressure to voltage tranducer

-180 dB re 1V / 1uPa
=
10^{-9} V / uPa
=
1V / 180 dB re 1uPa

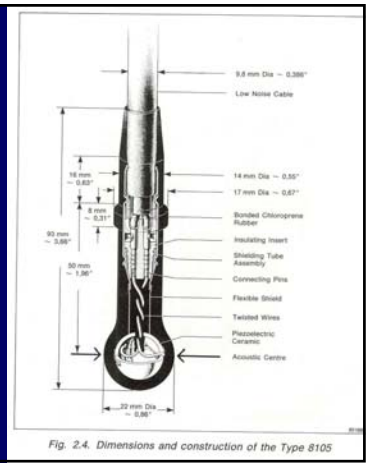

Fig. 2.4. Dimensions and construction of the Type 8105

E.g. TPODs (N. Tregenza)

Can record for months and log porpoise clicks "exclusively"

Photo by N. Tregenza

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Tracking blue whales

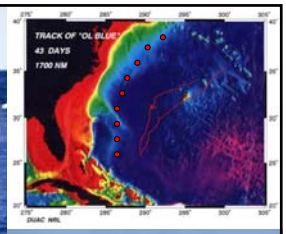
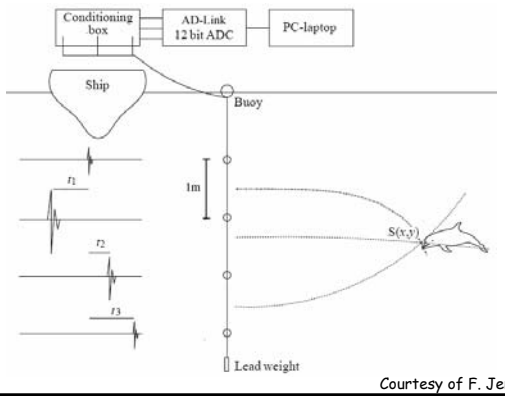


Photo by C. Johnson

Photo by C. Johnson

Acoustic source localization



Courtesy of F. Jensen

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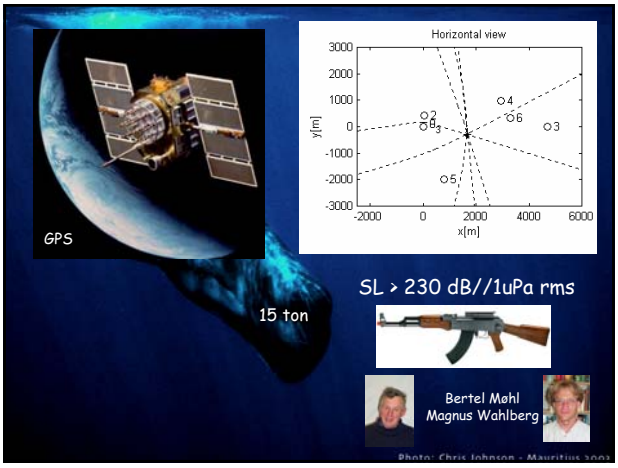
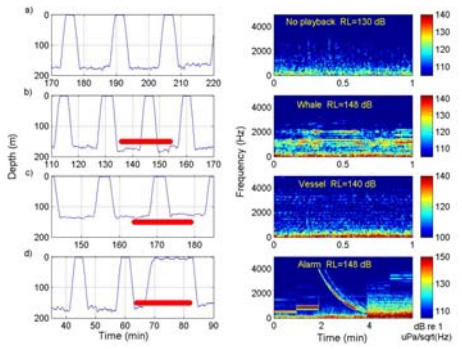


Dive Responses of Tagged Whales

Data from Nowachek et al, 2001, 2003

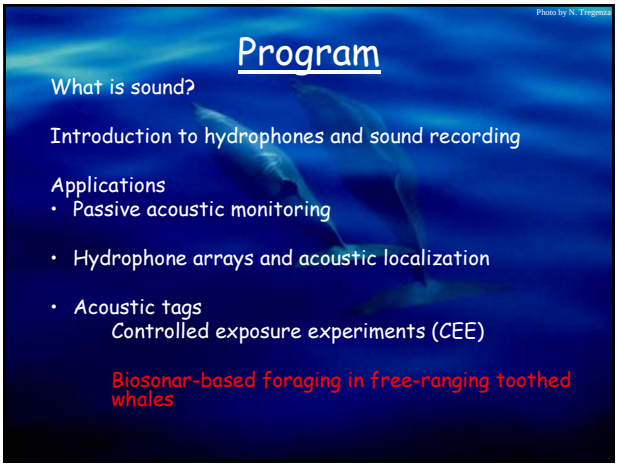


Silent Control

Whale Calls

Vessel Noise

Alerting Control



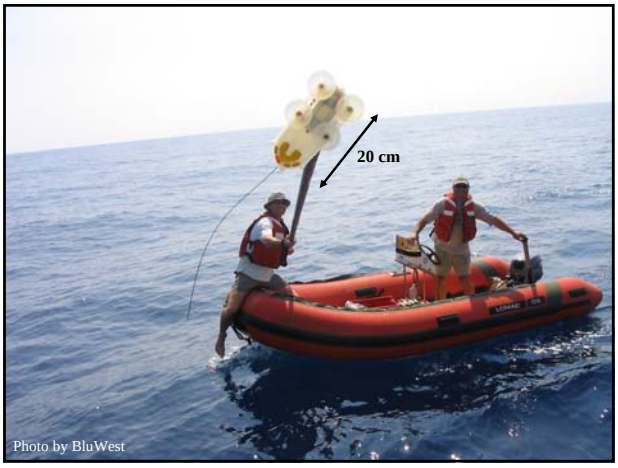



Photo by T. Pusser


Natacha Aguilar Soto, El Hierro


Photo by T. Pusser

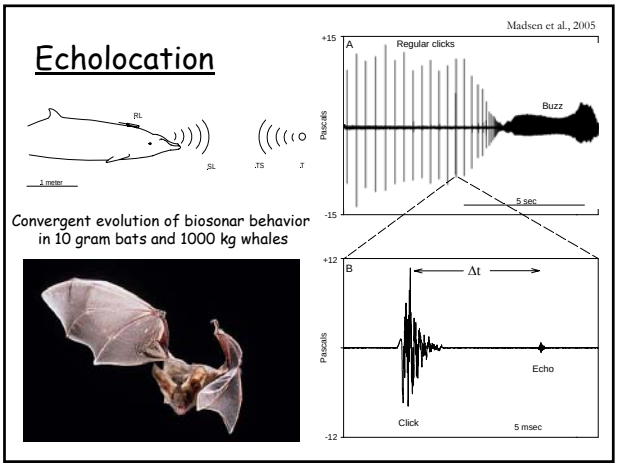
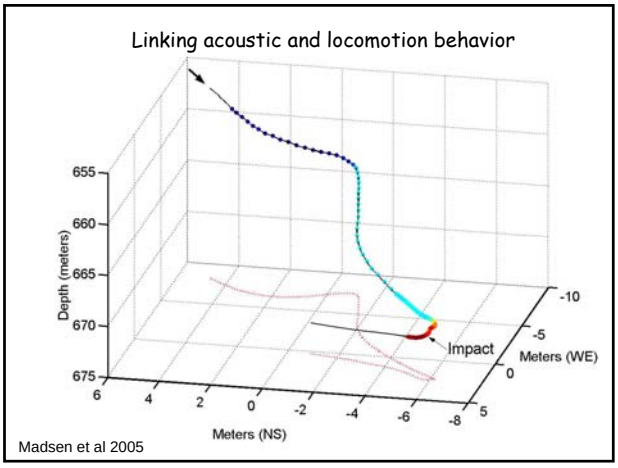
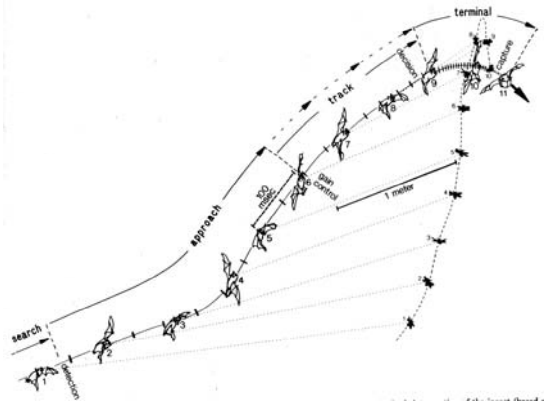

Echolocation
Madsen et al., 2005
Regular clicks
Buzz
Pascals
+15
-15
5 sec
Convergent evolution of biosonar behavior
in 10 gram bats and 1000 kg whales
+12
-12
Δt
Echo
Click
5 msec


Photo by F. Poglione

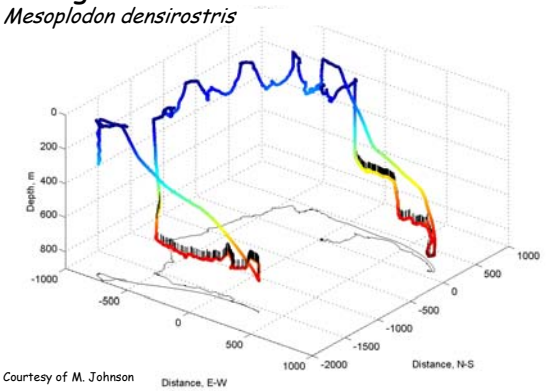

Linking acoustic and locomotion behavior
Depth (meters)
655
660
665
670
675
Impact
Meters (WE)
-10
-5
0
5
Meters (NS)
6
4
2
0
-2
-4
-6
-8
Madsen et al 2005

Beaked whales catch prey like bats



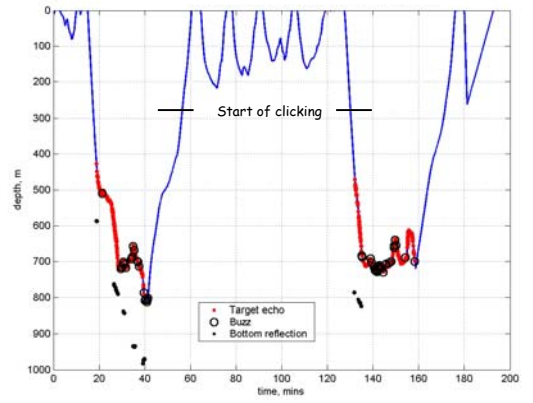
Diving behavior

Mesoplodon densirostris



Courtesy of M. Johnson

Photo N. Aguilar Soto, ULL



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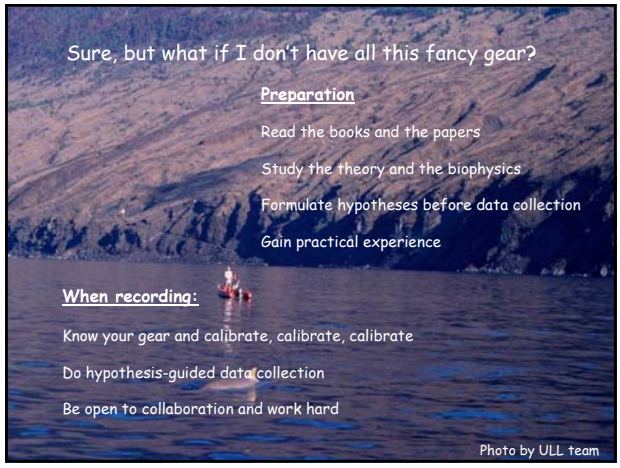

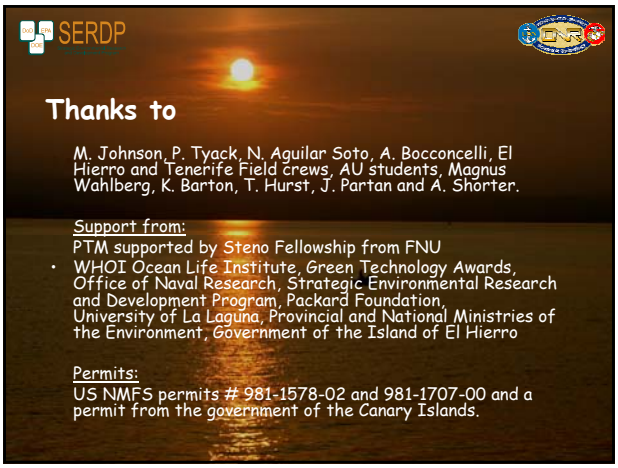
SERDP
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