



DOLPHIN W
www.DolphinWo



Sotto le Onde, il Suono

Esplorare l'Oceano con Delfini Artificiali

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Massachusetts Institute of Technology

NATO Undersea Research Centre

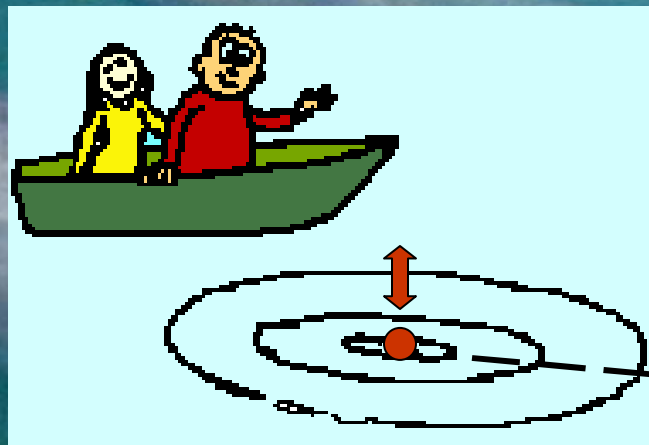
Festival della Scienza
La Spezia
Oct 25, 2007

October 2003						
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Le Onde Cosa sono?



Leonardo da Vinci ha notato che un oggetto gettato in mare oscilla su e giu', ma non si muove insieme alle onde che ha creato

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Le Onde Un Esempio

“La Onda Messicana”

1. Un disturbo che va in giro nello stadio, ma le persone stanno nello stesso posto
2. Il movimento di ogni persona e' molto meno del movimento della onda
3. Le onde sono periodiche nel senso che si ripetono con un certo periodo



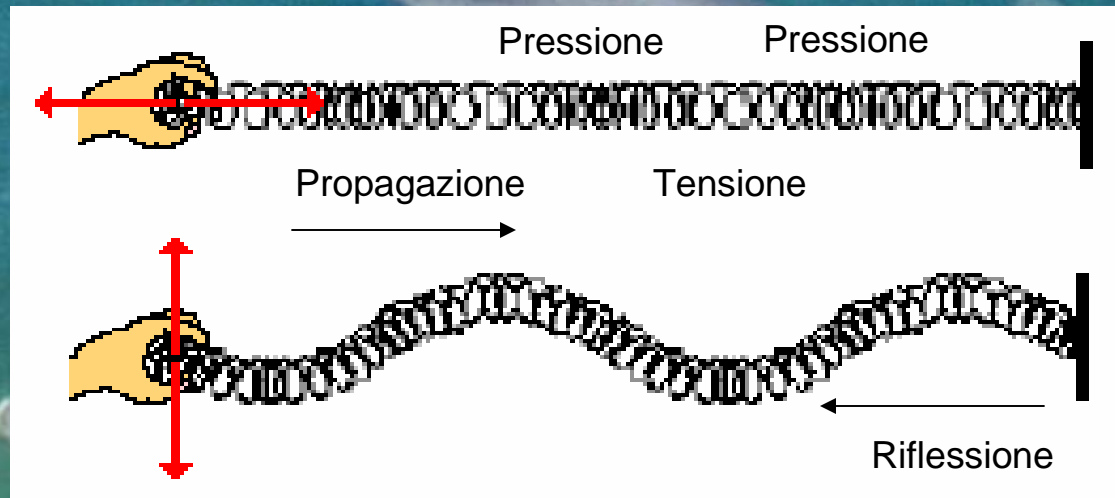
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26 27 28 29 30 31

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Onde Meccaniche

Esempio: una Molla



Onde Longitudinali
Acustiche, Sismiche

Onde Trasverse
Sismiche

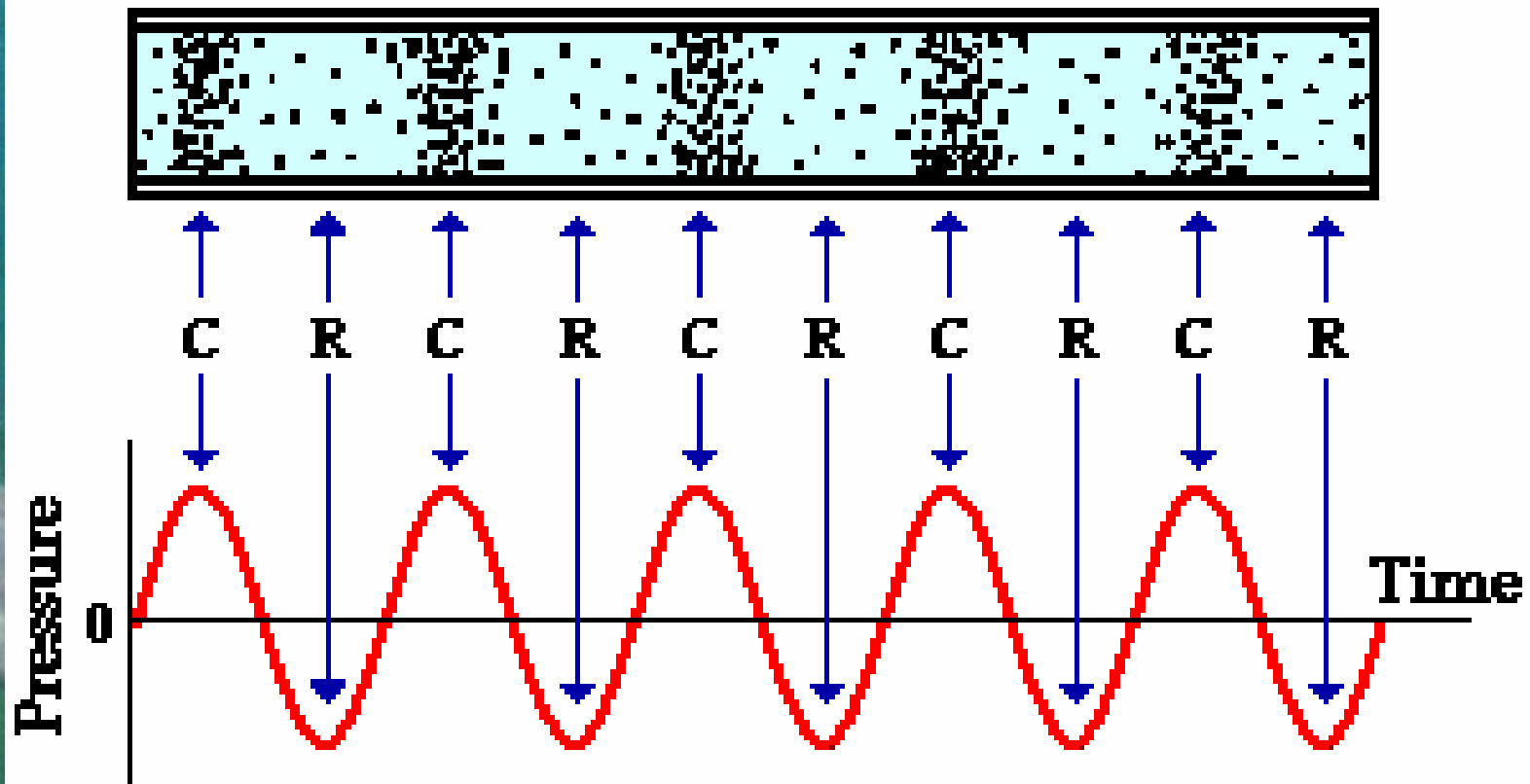
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Onde Acustiche

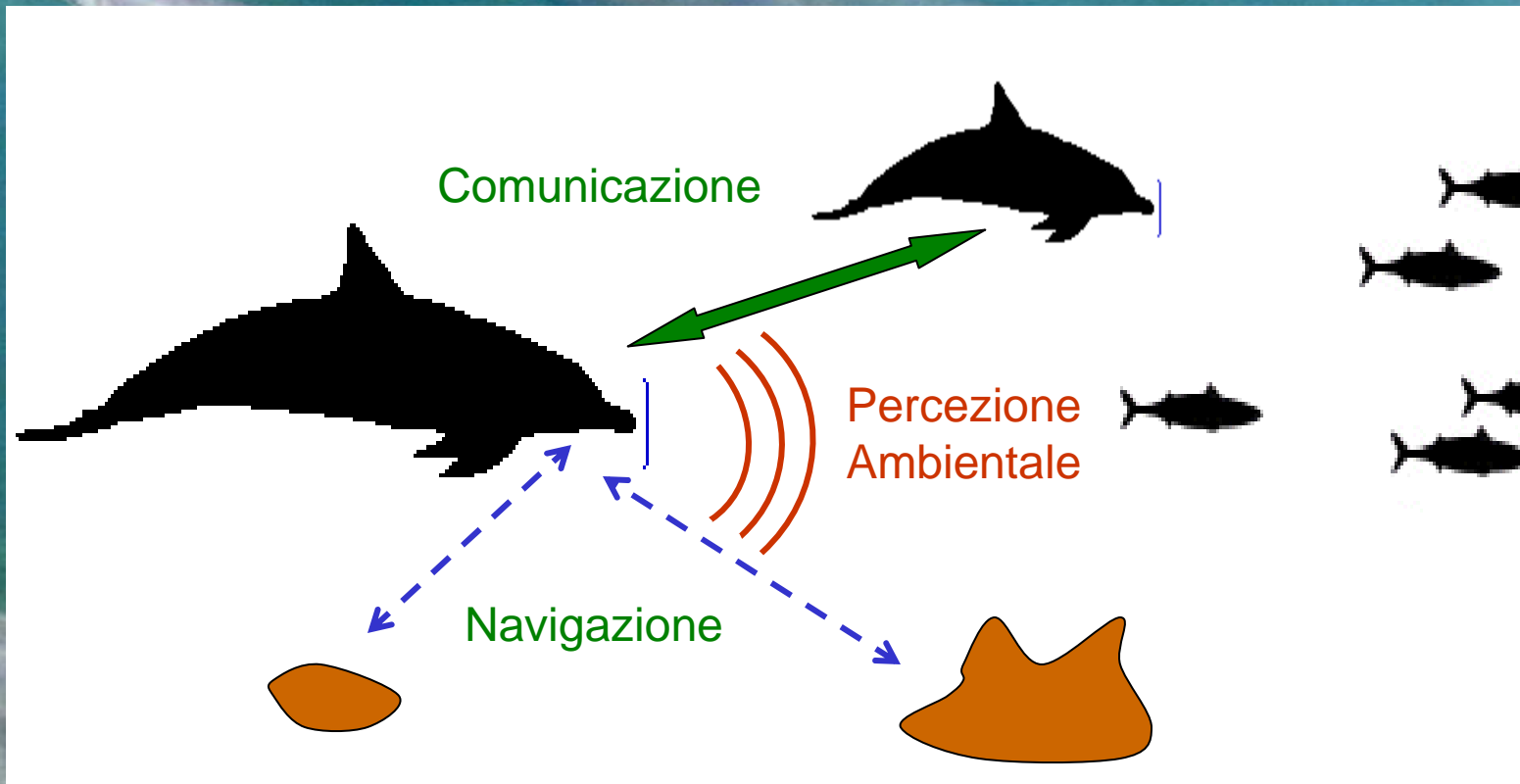
Il Suono

Sound is a Pressure Wave



NOTE: "C" stands for compression and "R" stands for rarefaction

Onde Acustiche Il Suono Sottomarino



Gli animali che vivono nella atmosfera e sono attivi durante il giorno (uomo) dipendono dalle onde elettromagnetiche (luce, radio)
Quelli notturni (pipistrelli) e gli animali sottomarini (balene) usano il suono

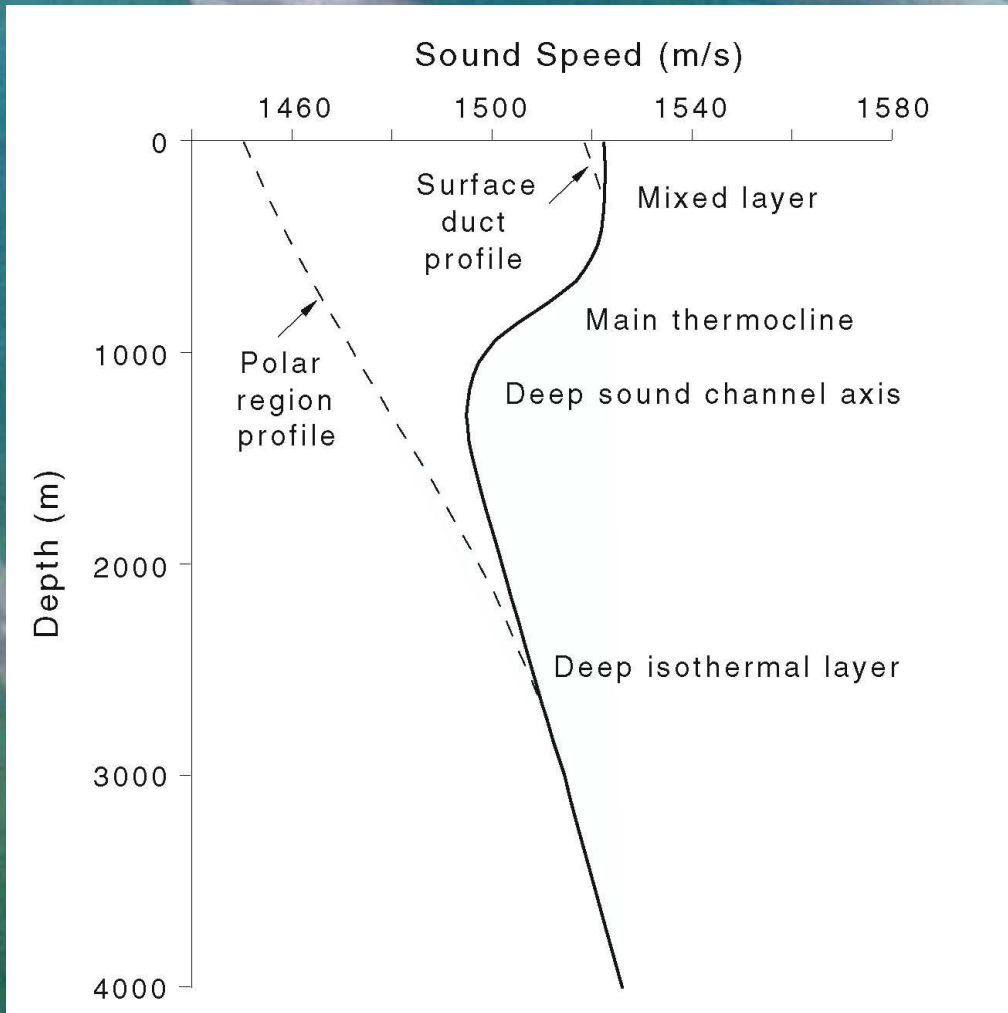
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La “Visione” nell’ Mare

- Onde Elettromagnetiche
 - Alta frequenza 3×10^{14} Hz
 - Alta velocita' 3×10^8 m/s
 - Alta risoluzione
 - Distanze molto corte ($< 10-20$ m)
- Suono
 - Bassa frequenza $< 10^5$ Hz
 - Bassa Velocita' 1500 m/s
 - Risoluzione bassa
 - Lunghe distanze (1 m – 5000 km)

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La velocità' del Suono



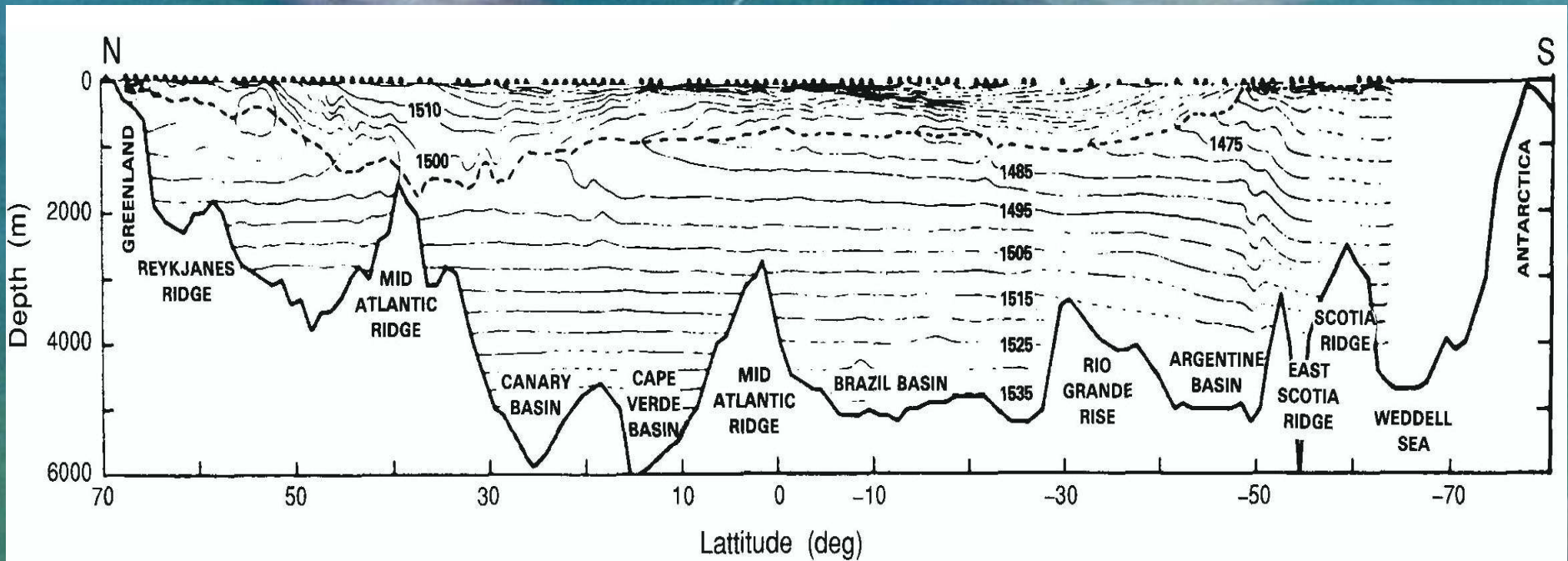
Onde Eletromagnetiche:

Quasi costante
300.000 km/s

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Velocita' del Suono Sottomarino Variabilita' Globale

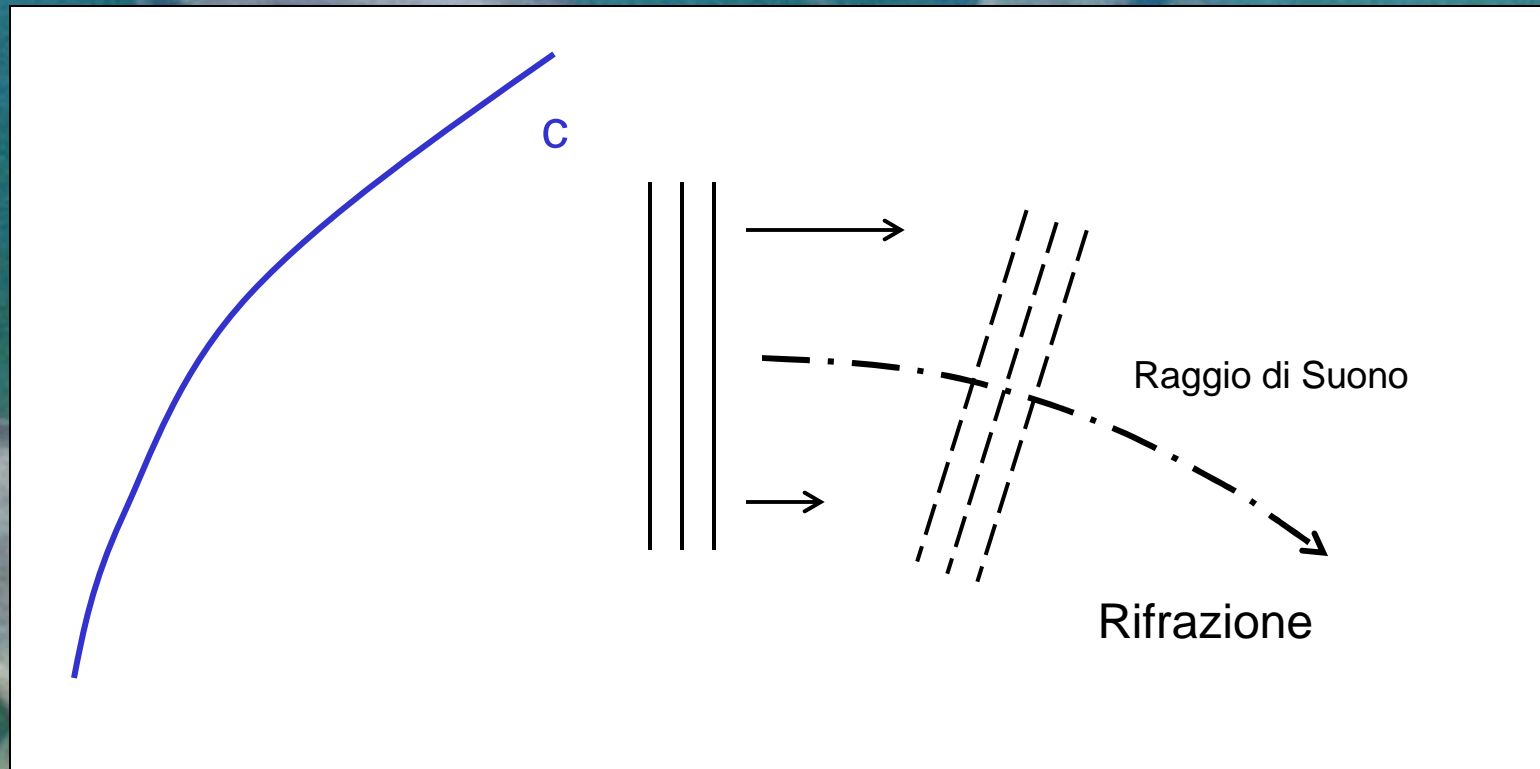


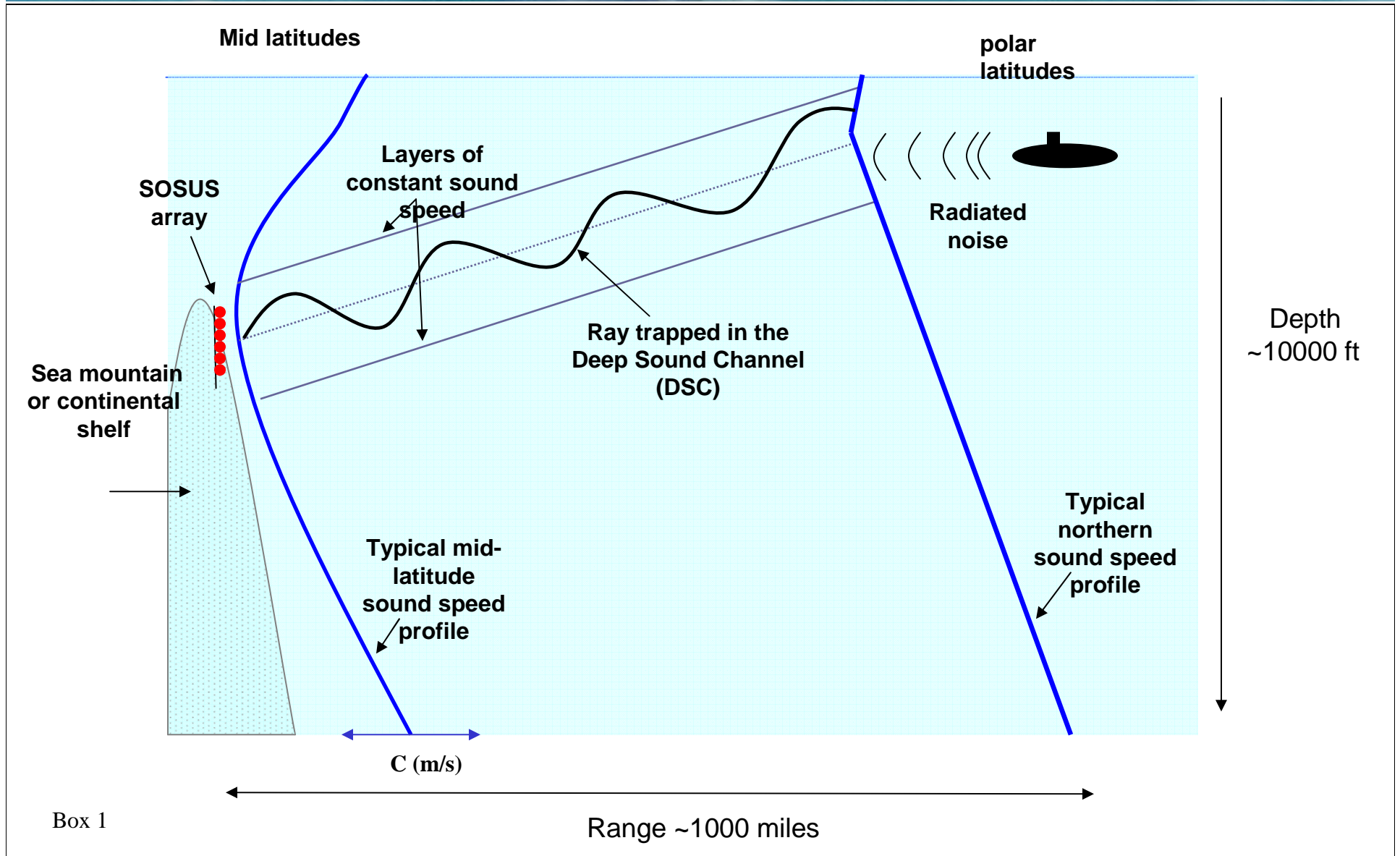
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Acustica Marina

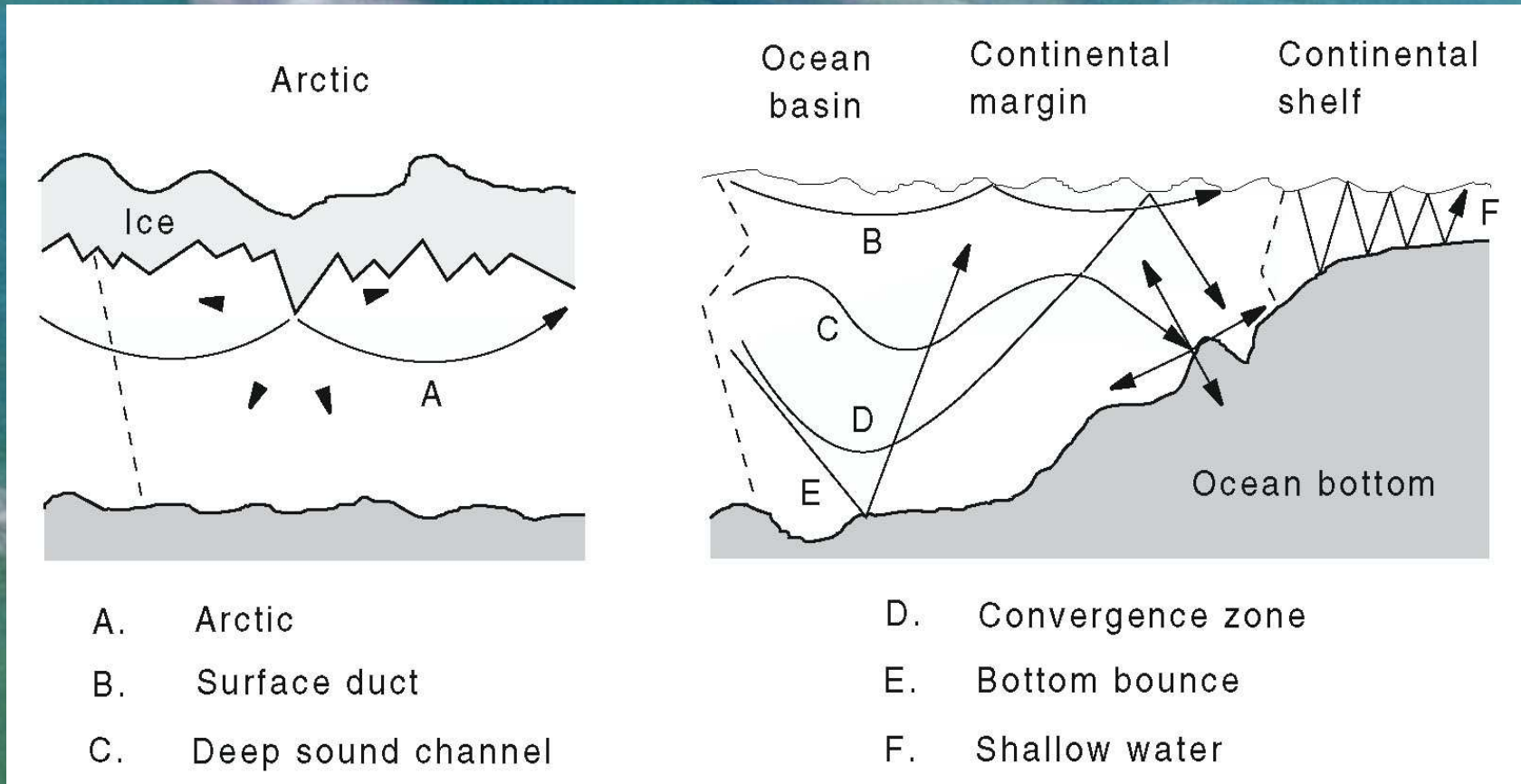
Il Principio Fondamentale

“Al suono piace la velocità minore”





Acustica Sottomarina Cammini di Propagazione



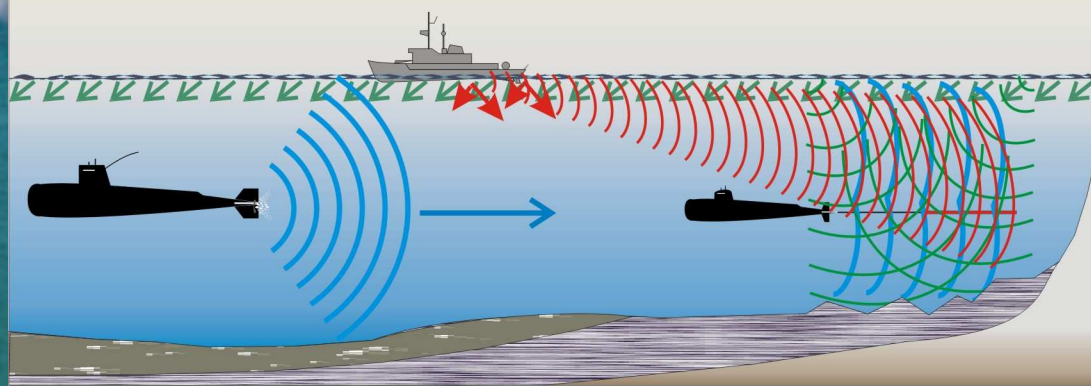
Applicazioni della Acustica Sottomarina

October 2003

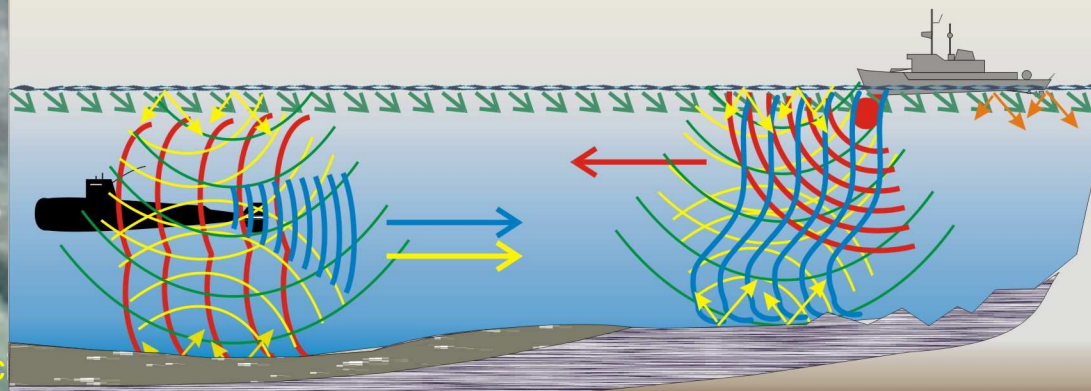
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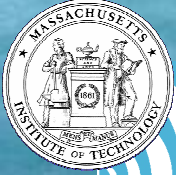
SONAR

PASSIVE



ACTIVE





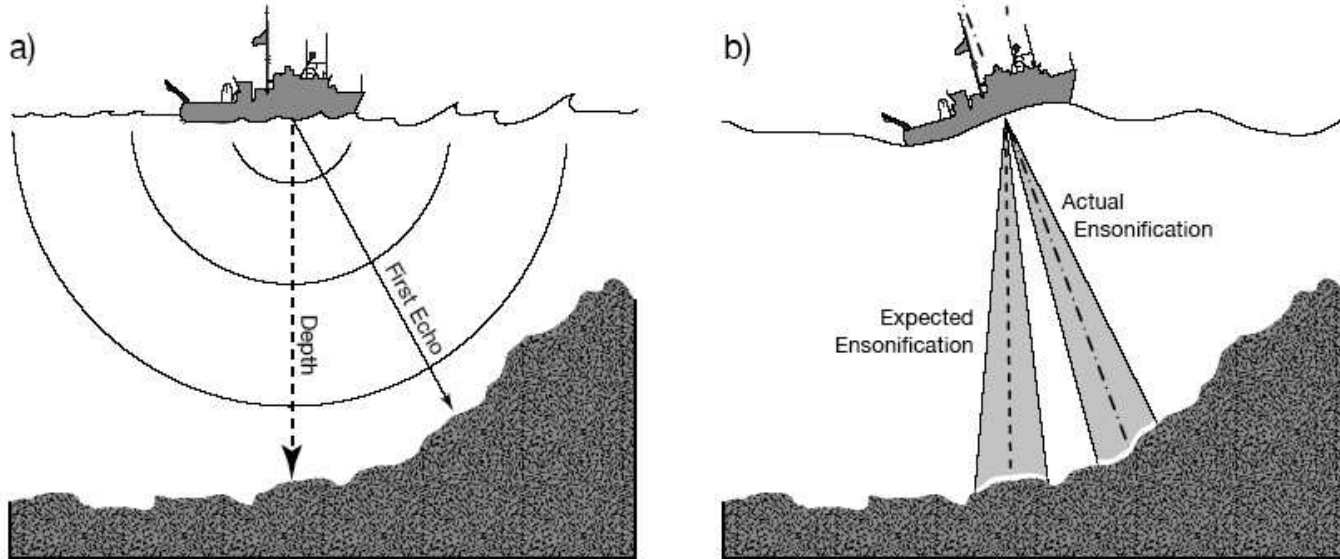
Ocean
ENGINEERING

Mappatura Acustica del Fondo

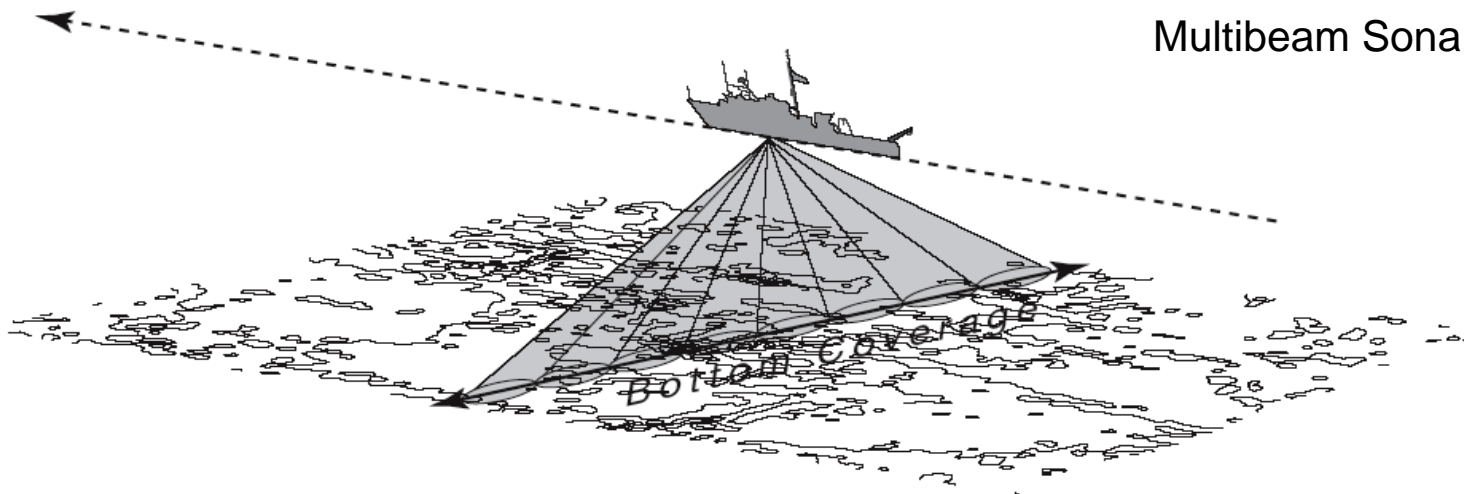
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Echosounder



Multibeam Sonar



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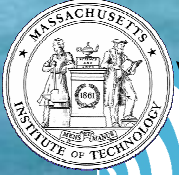
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IT/NURC

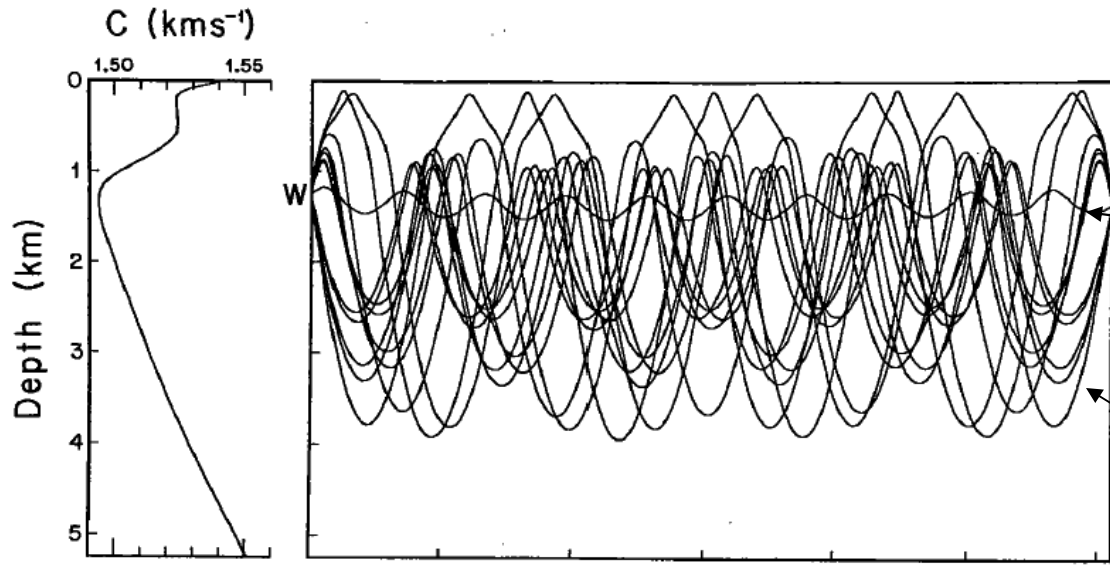
Festi



Ocean

Tomografia Acustica

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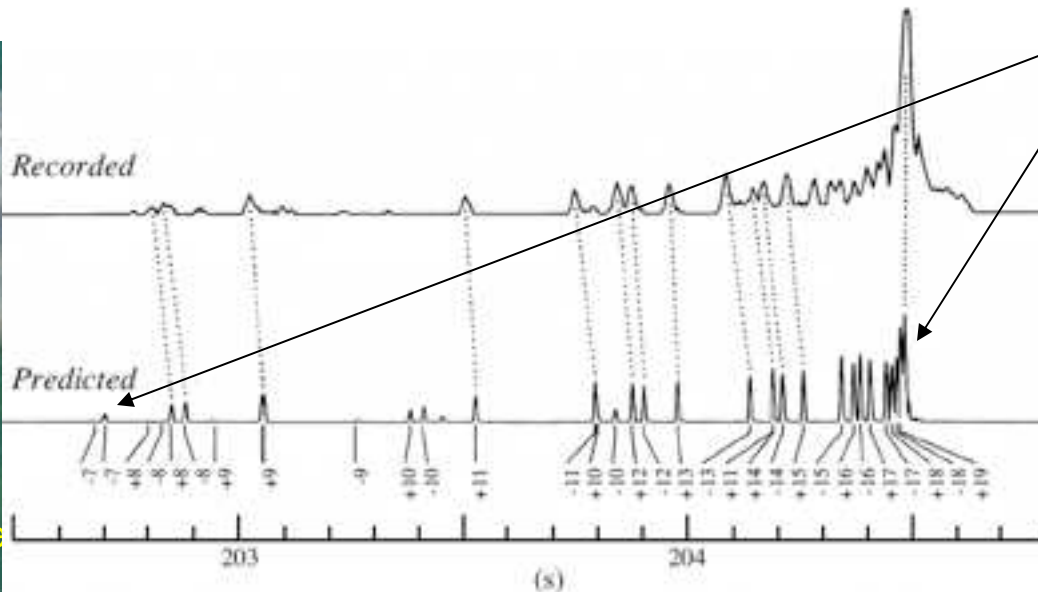
Piu' lento

Piu' veloce

Tomografia:

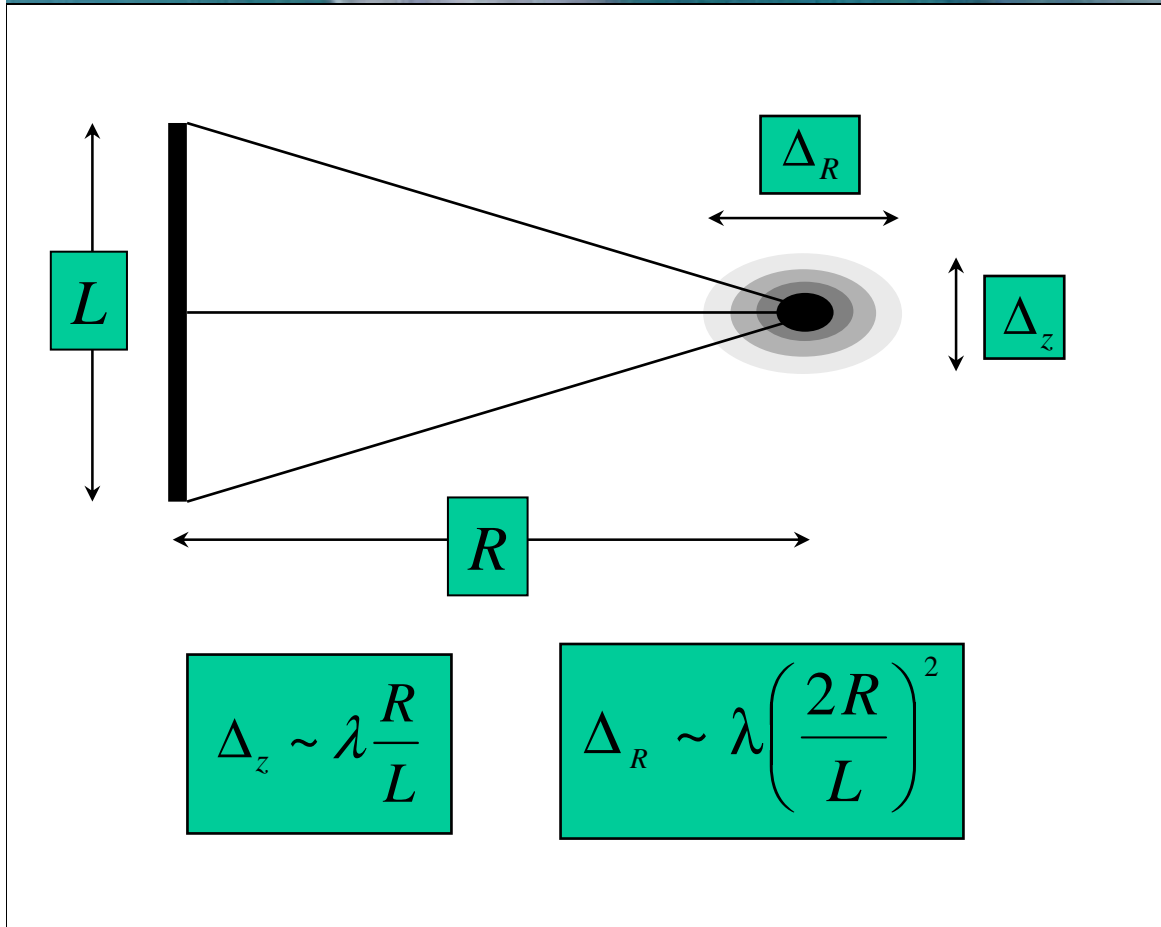
Determinazione della distribuzione della velocita' acustica dalla sequenza dei tempi di arrivo della energia acustica.

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Festival de

Mappatura Acustico Risoluzione



A 100 m distanza:

Occhio humano

$$\lambda = 1 \mu\text{m}$$

$$L = 3 \text{ mm}$$

$$\Delta_z = 3 \text{ cm}$$

Sonar 100 kHz

$$\lambda = 1.5 \text{ cm}$$

$$L = 1 \text{ m}$$

$$\Delta_z = 1.5 \text{ m}$$

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Robotica Sottomarina

Veicoli Sottomarini Autonomi

MIT Odyssey II (1995)



MIT/Bluefin Odyssey III (2002)



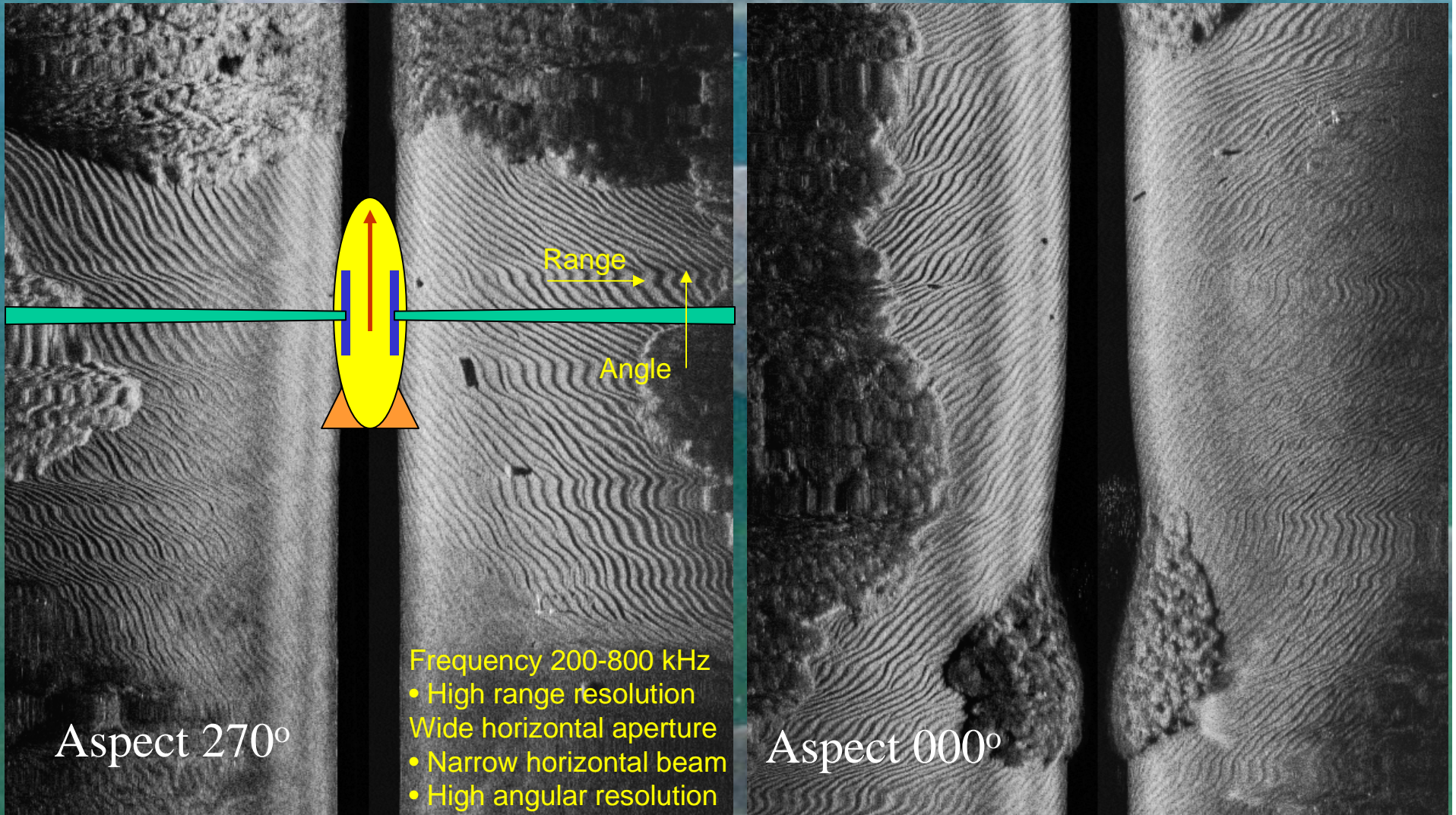
Applicazioni dei Robot Sottomarini:

- Mappatura del fondo.
- Ricerca delle mine e oggetti archeologici
- Ricerca di petrolio nel mare profondo
- Osservatori dell'oceano

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Side Scan Sonar





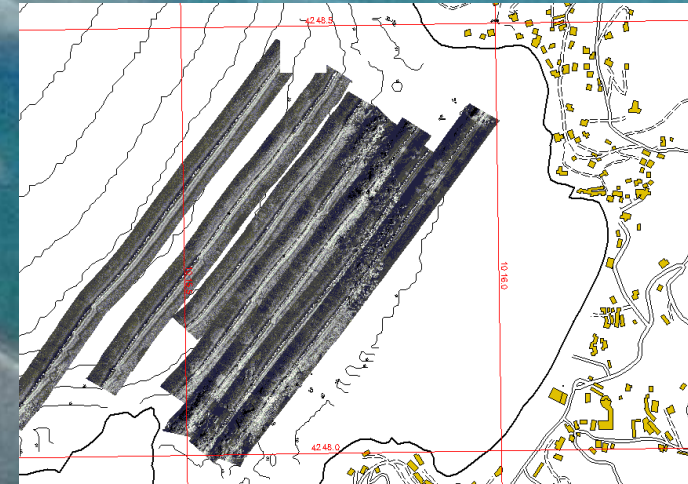
GOATS'2000

Side-scan Sonar Mappatura

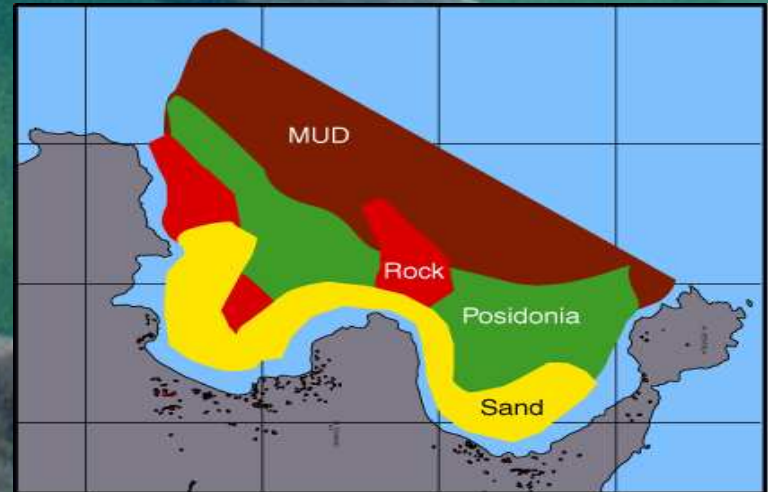
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Side Scan Tiled Images



Bottom classification



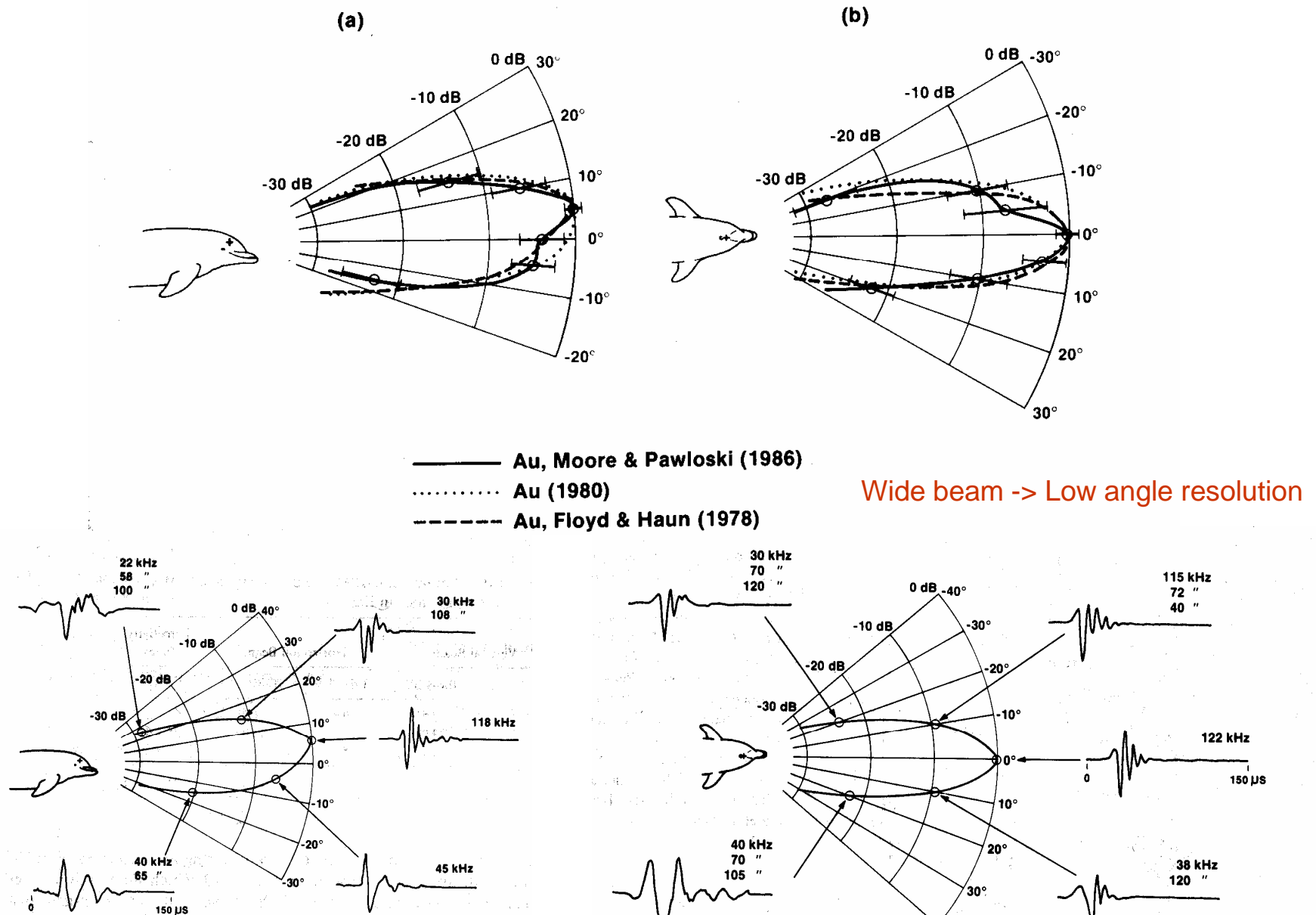
OEX



Festival

RC

Il Sonar dei Delfini - Risoluzione



Figures from "The Sonar of Dolphins" by W. Au (Springer Verlag, 1993)

Il Sonar dei Delfini - Frequenze

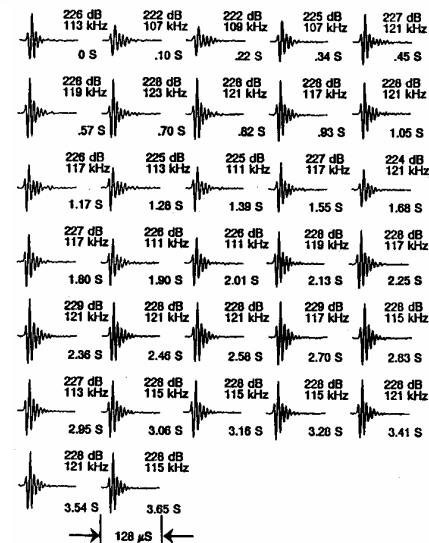
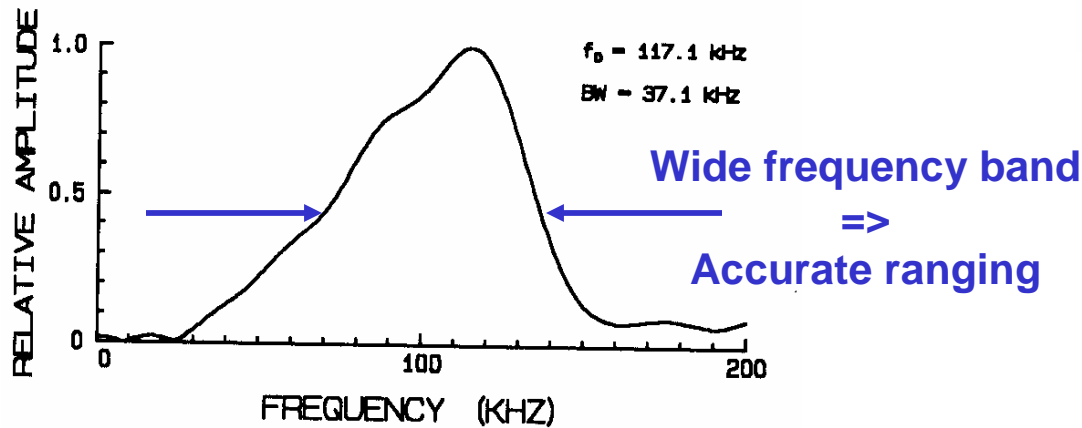
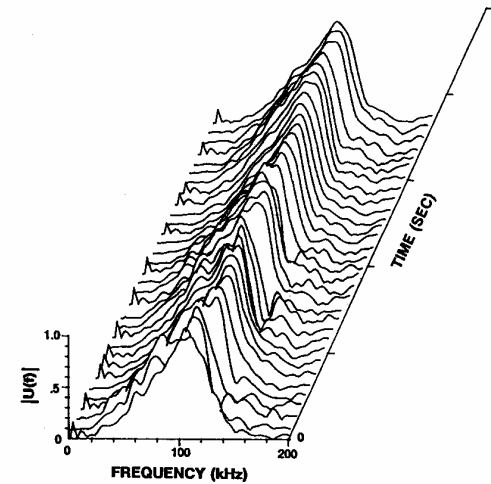
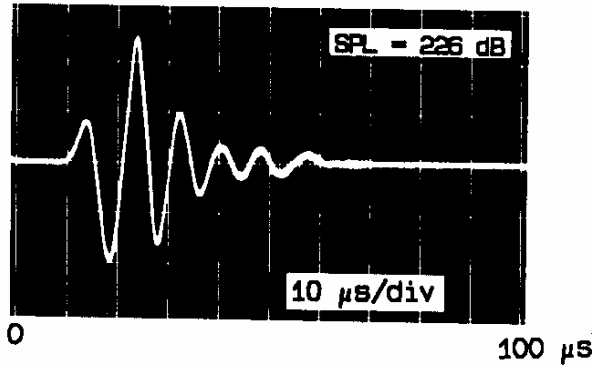
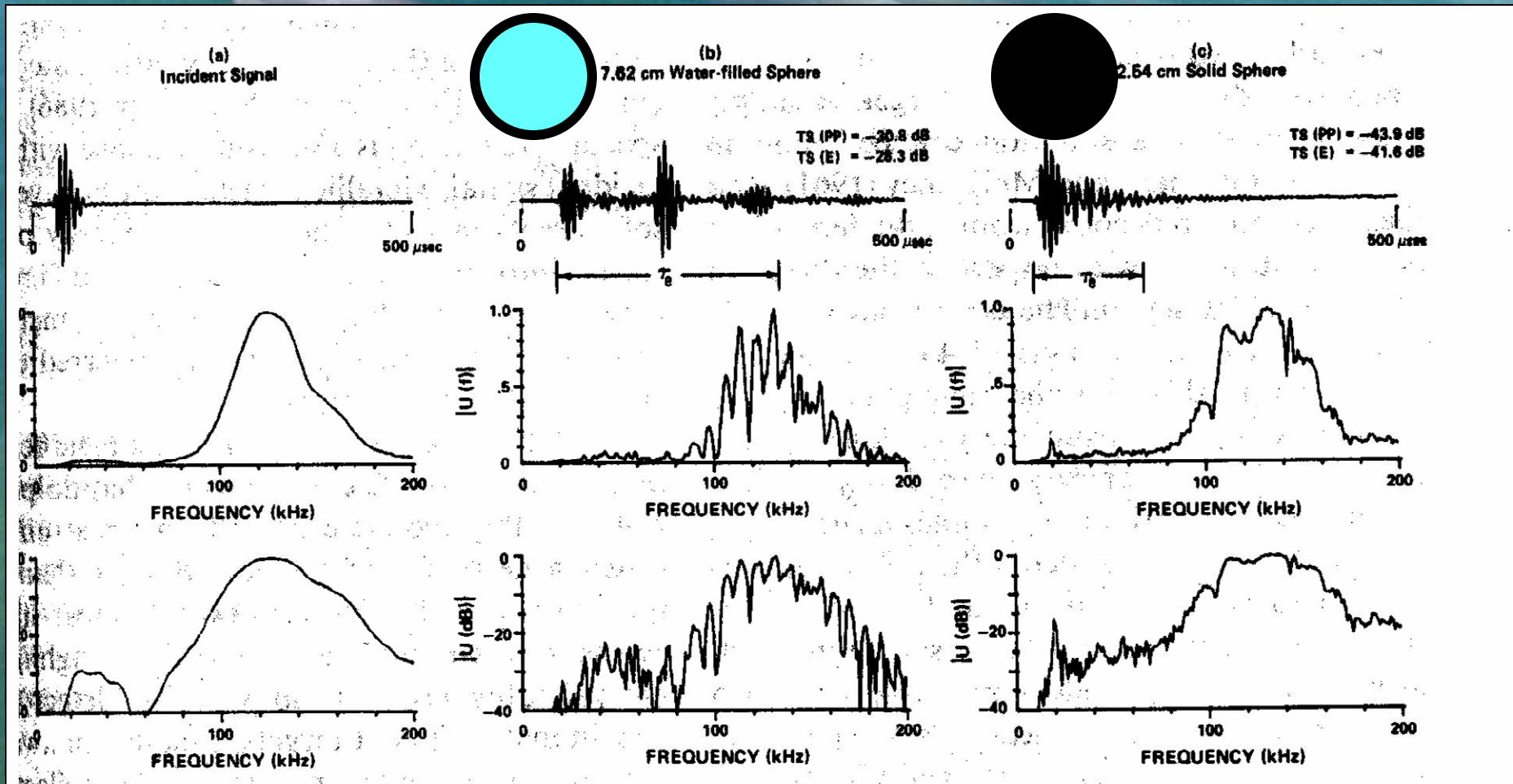


Figure 5.3. Averaged waveform and frequency spectrum for the click train of Fig. 5.2. (From Au 1980.)

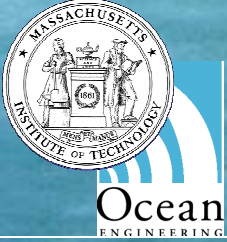
Figures from “The Sonar of Dolphins” by W. Au (Springer Verlag, 1993)

Il Sonar Delfino

Reflezioni dagli Oggetti

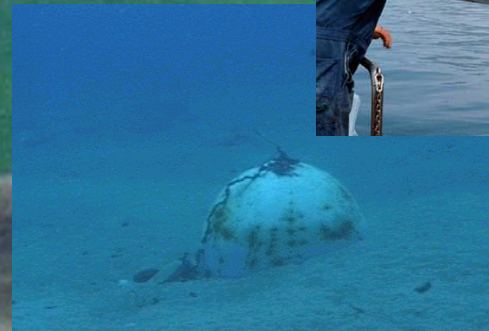


Figures from "The Sonar of Dolphins" by W. Au (Springer Verlag, 1993)



GOATS'98 Odyssey II Low-Frequency Sonar

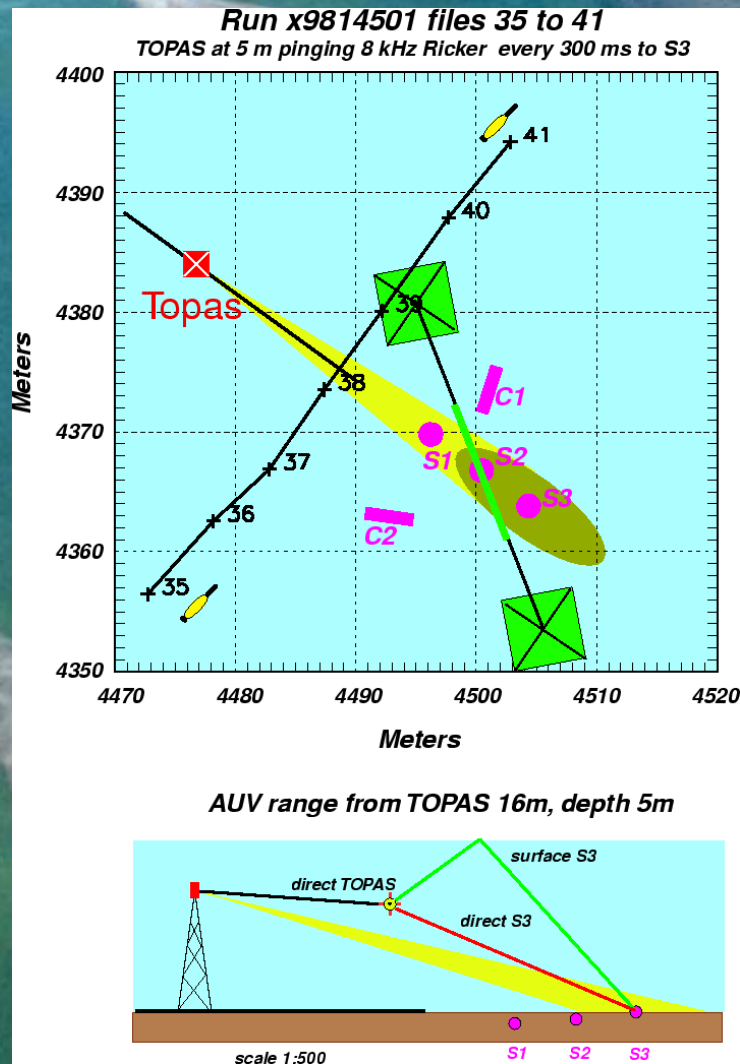
DOLPHIN WORKS
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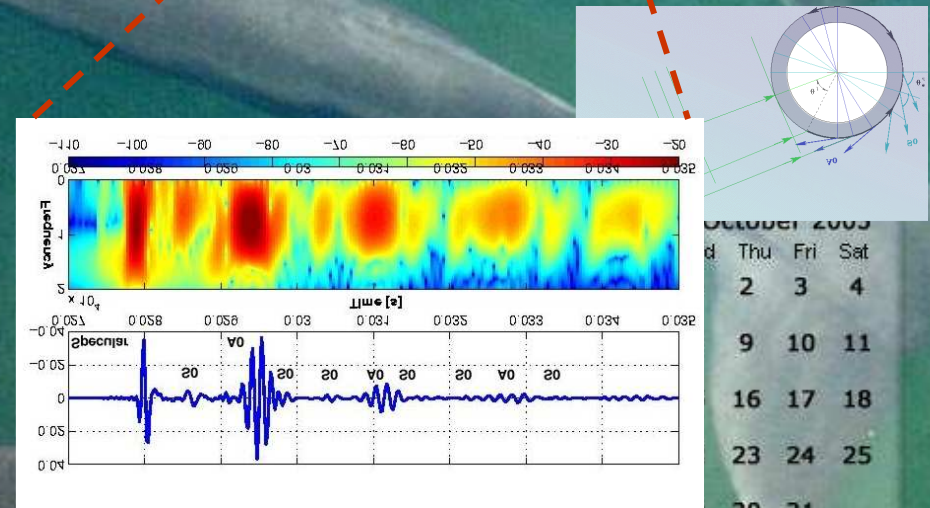
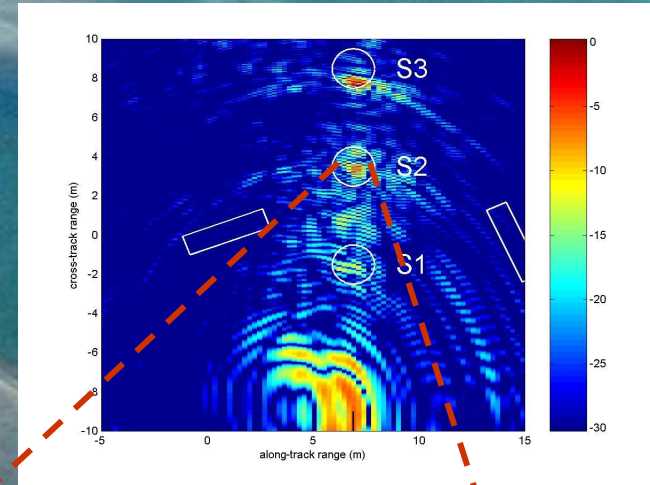
0 21 22 23 24 25
7 28 29 30 31
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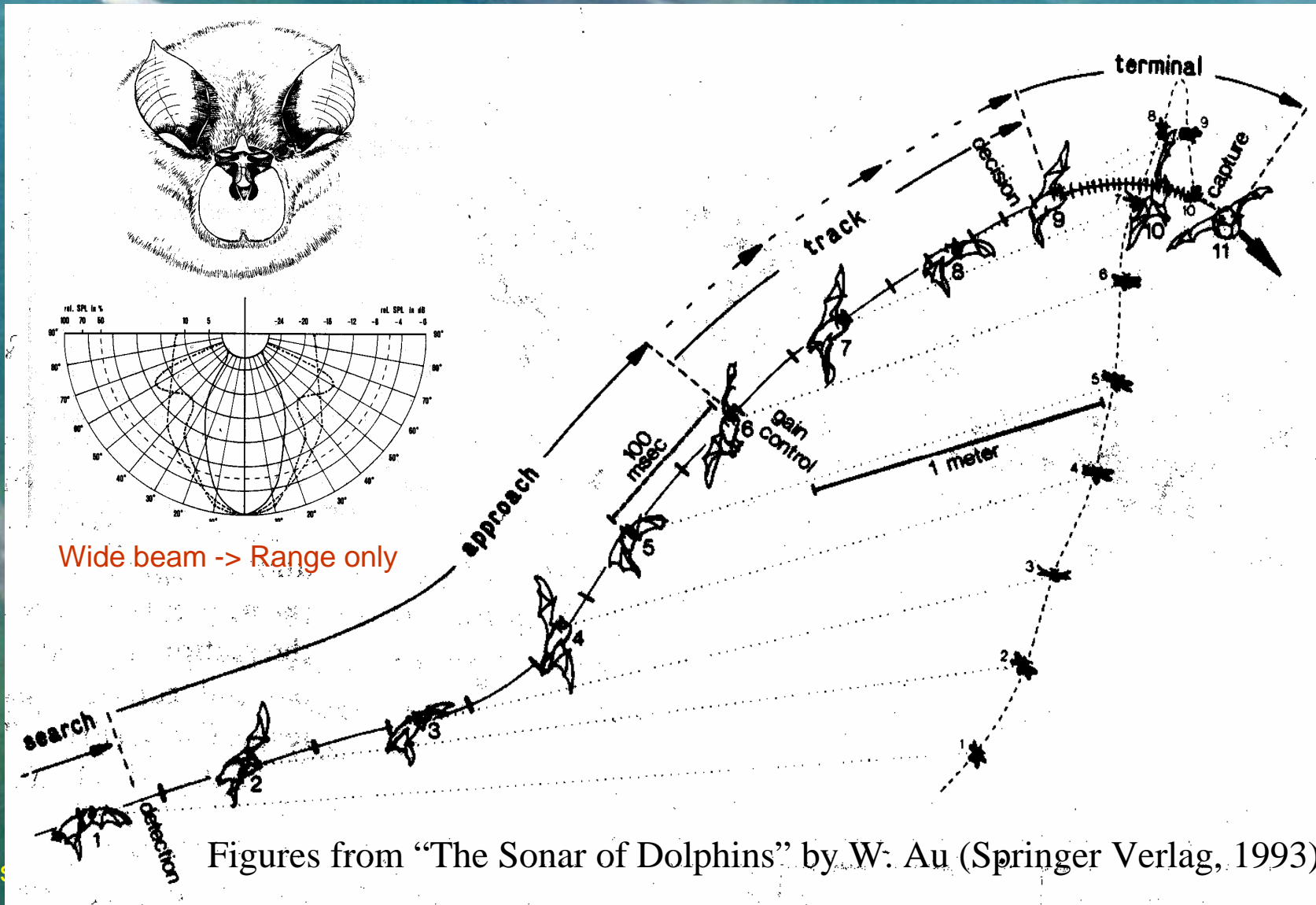
GOATS'98 Experiment Ricerca Oggetti Fondali



Super-critical Insonification

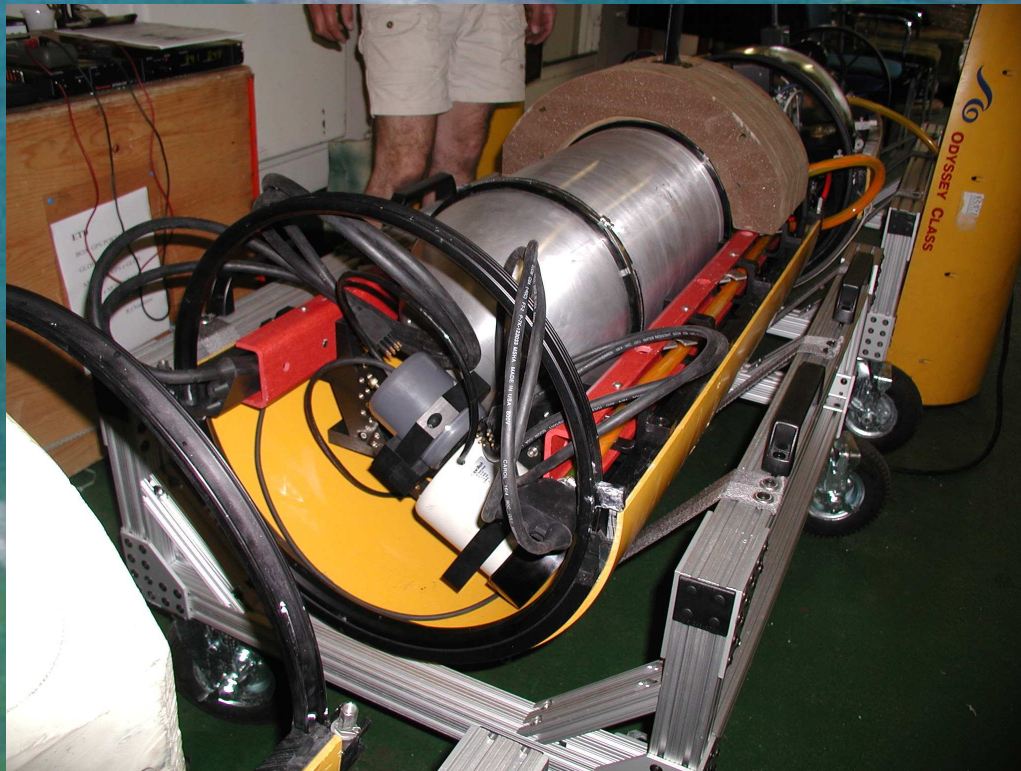


Navigazione Il Sonar del Pipistrello



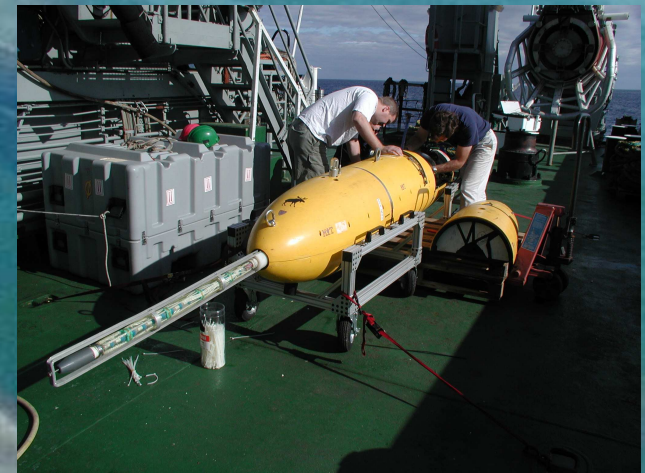
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Source and Acquisition Payload Section



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16-element Linear Array (15kHz)



2x8-element Linear Array (7.5kHz)



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GOATS'2002 BP'02 – MASAI'02

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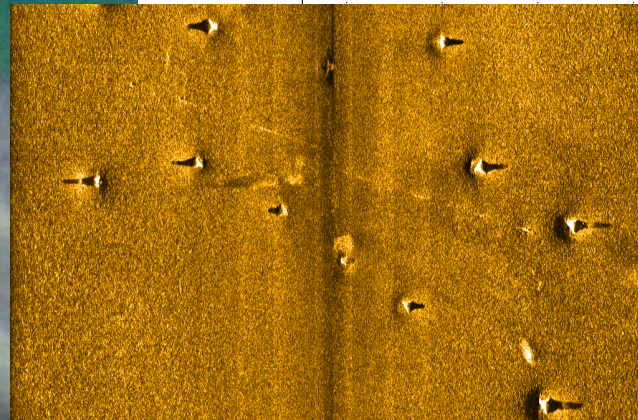
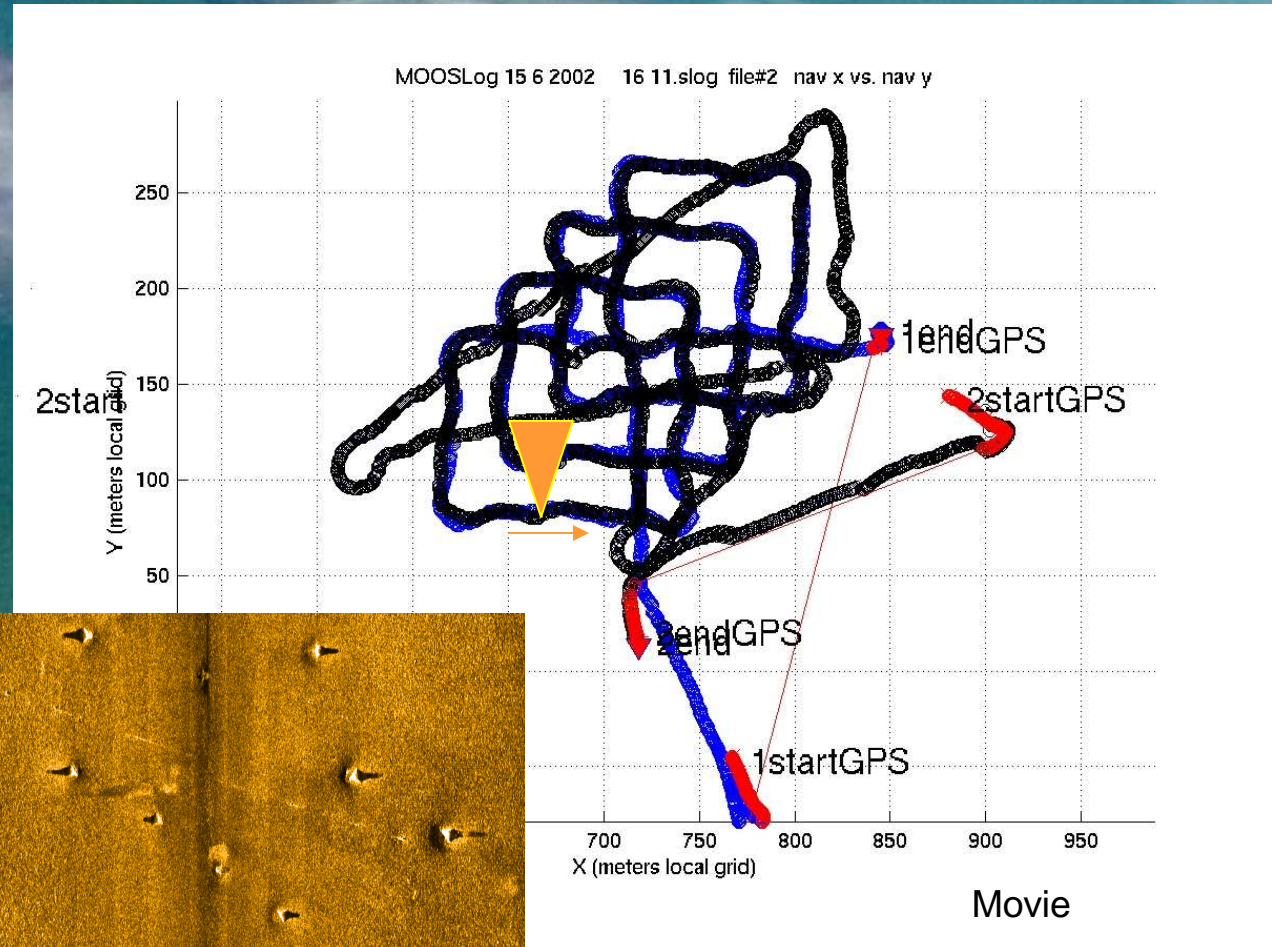
BP'02 - MASAI'02 SAS Zamboni Surveys

Navigation Sensors

- GPS (surface)
- Sonardyne LBL
- DVL
- Compass

SAS Sonar

- 4-16 kHz SBP Source
- 2x8 element nose array



Controllo Robotico Adattamento all'Ambiente

October 2003

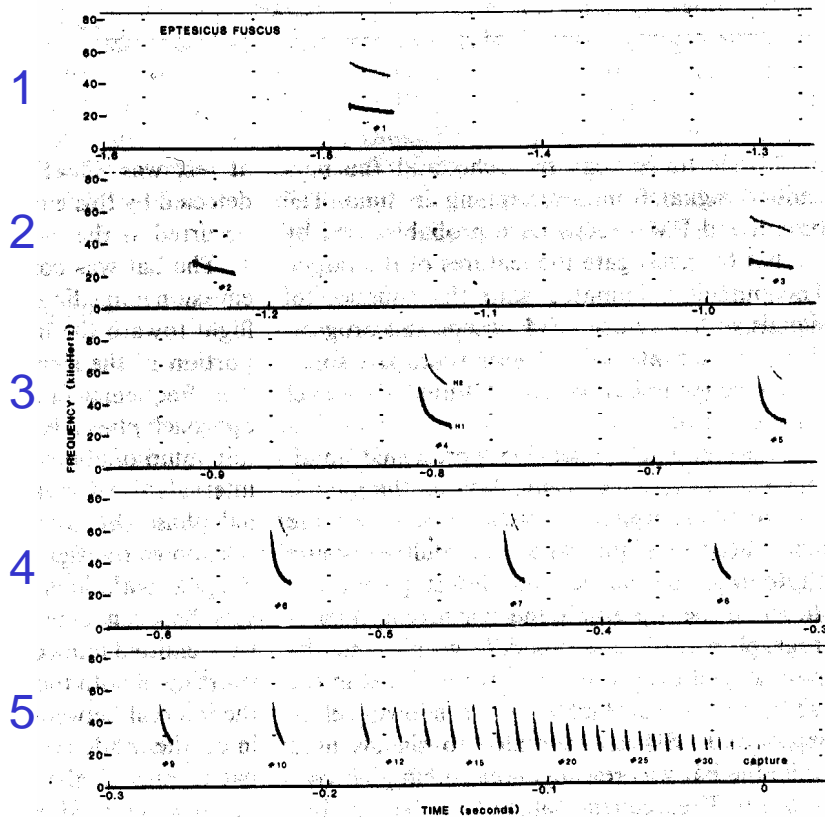
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Festival della Scienza, 2007

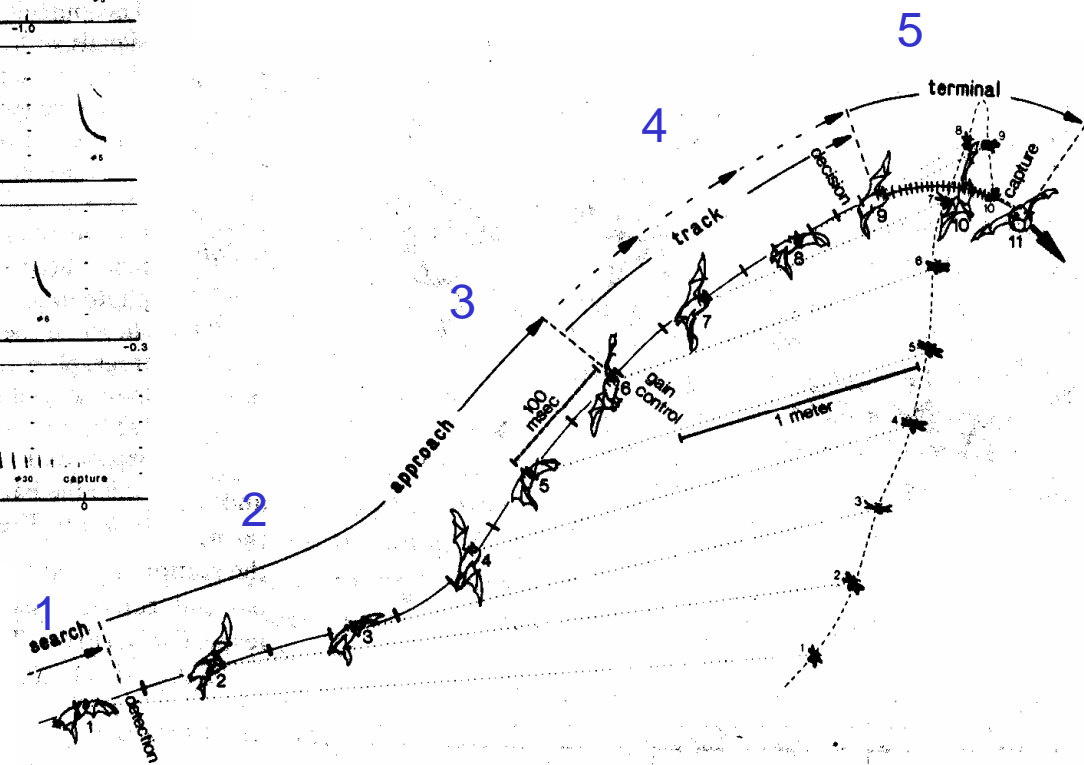
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Il Sonar dell' Pipistrello

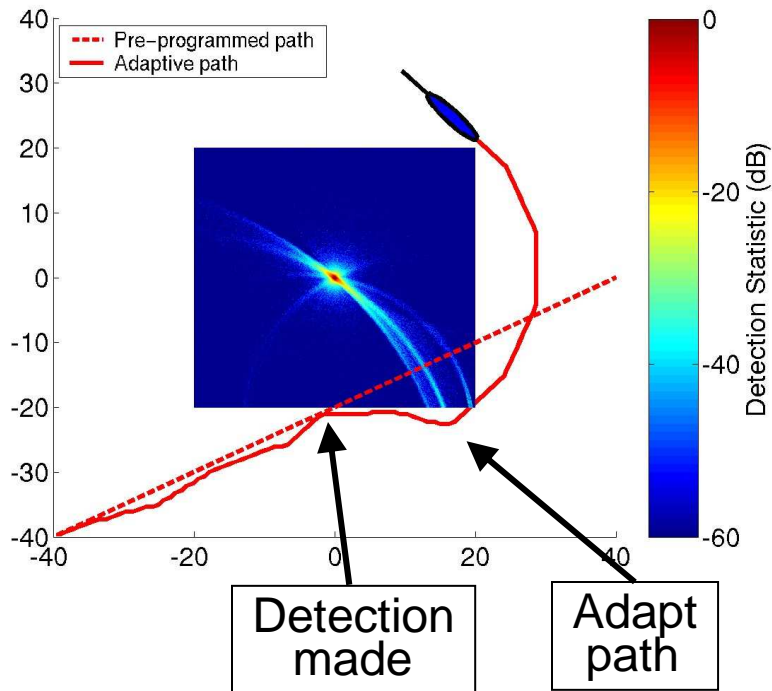
Controllo adattivo



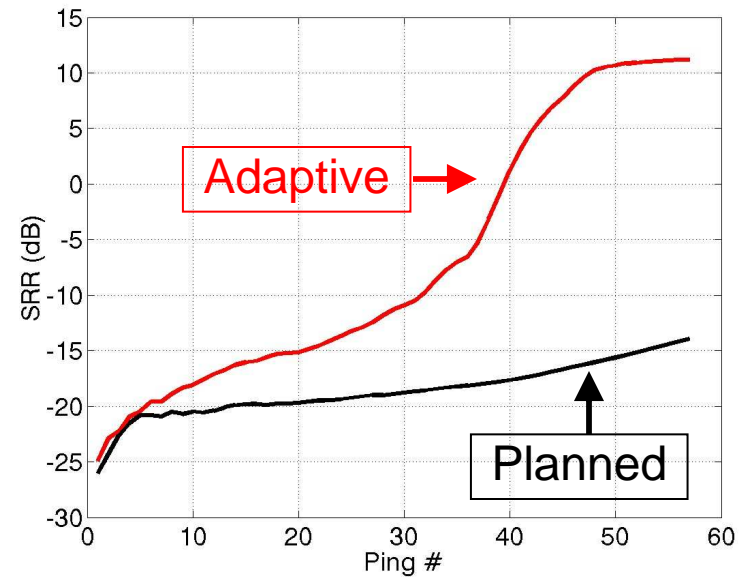
Figures from “The Sonar of Dolphins” by W. Au
(Springer Verlag, 1993)



Simulated Acoustic Data



Signal to Reverb (SRR)

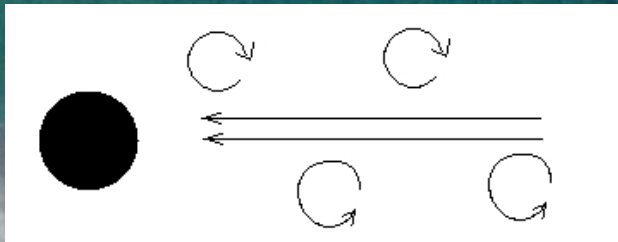
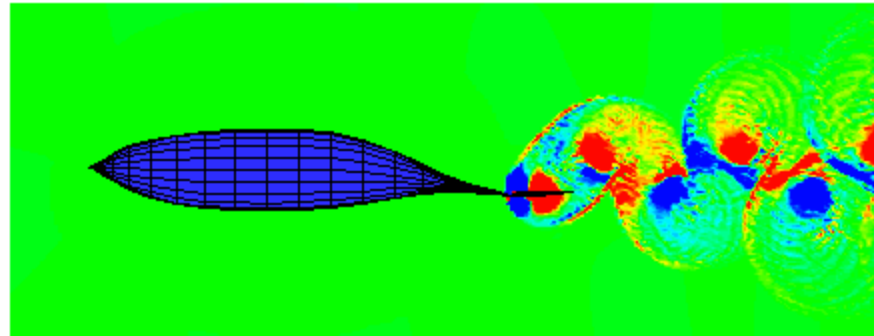


Mobilita', Propulsione and Manovrabilita'

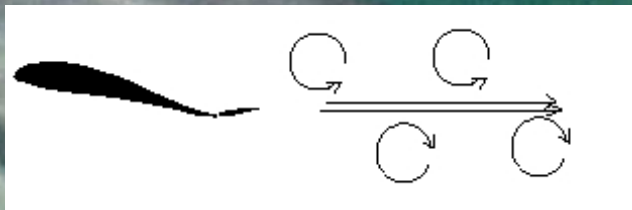
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Come nuotano i pesci



Cylinder wake: Karman vortex street, induced jet flow towards the body, causing drag force

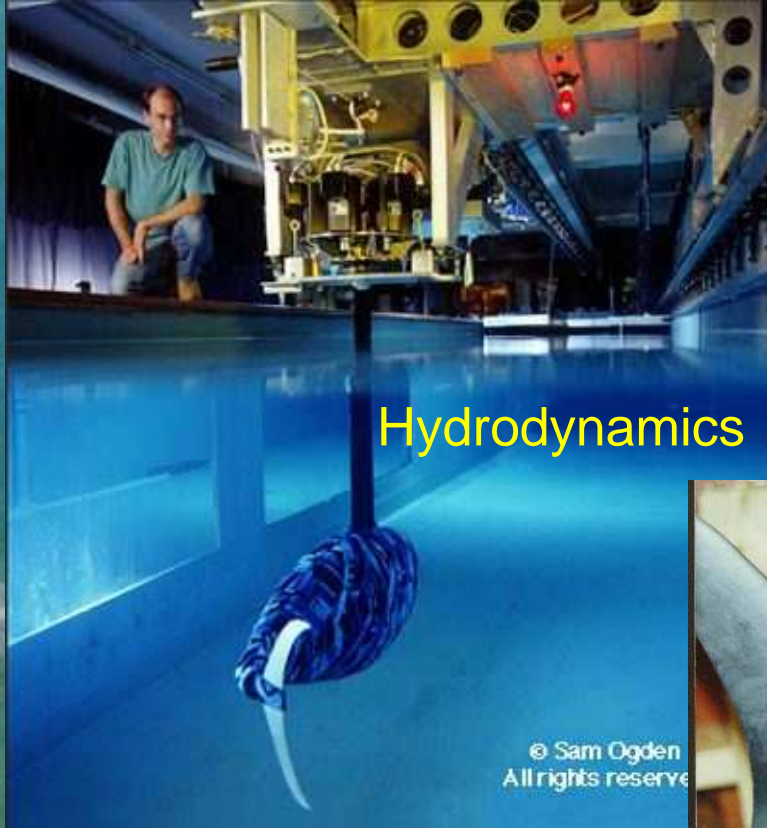


Fish wake: reverse Karman vortex street, induced jet flow away from the body, causing thrust force (Karman & Burges 1937)

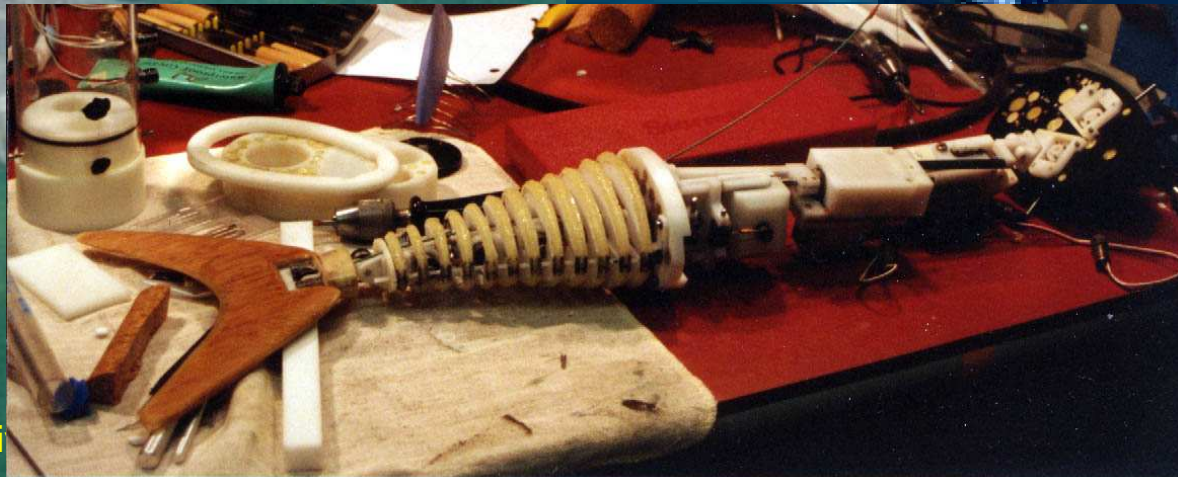
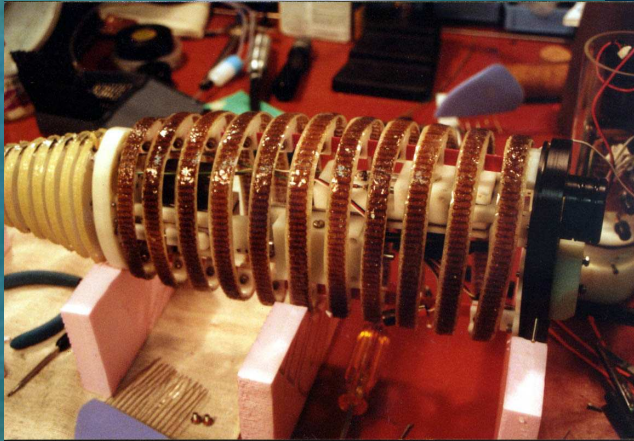
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Robo-Tuna Research



Robo-Pike



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Festi

Sistemi robotici per l'osservazione dell'ambiente

Conclusioni

I sistemi convenzionali non sono adeguati per esplorare il 95% del volume dell'oceano che rimane ignoto all'uomo, e per operare nell'ambiente costiero che e' pieno di insidie

Robot sottomarini che cooperano tra loro hanno un grande potenziale per esplorare l'oceano profondo e la costa. Serve pero' una nuova tecnologia che sfrutti meglio l'intelligenza a bordo dei veicoli. Questa e' la sfida per i ricercatori, le industrie e gli enti pubblici

I mammiferi marini e i pesci sono i padroni dell'ambiente marino e ci insegnano come percepire l'ambiente, come navigare, comunicare e cooperare sott'acqua

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