



# Presentation prepared for:



## Policy on Sound and Marine Mammals: An International Workshop

**U.S. Marine Mammal Commission - Joint Nature Conservation Committee, U.K.**

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**A case study in NATO's  
response to a mass stranding:  
The establishment of a Marine Mammal  
Risk Mitigation Program**

**Sound Ocean and Living  
Marine Resources  
(SOLMAR)**



# Project History

**1998 NURC initiated research on the effects of anthropogenic noise on marine mammals after Bioacoustics Panel held with outside experts.**

- documented the facts related to the Greek stranding of 1996
- established a protocol for acoustic risk mitigation when using acoustic sources
- NURC project requested by the Italian Navy to develop Dual Use Technology applications for marine mammal risk mitigation.

**1999 Sound Ocean and Living Marine Resources (SOLMAR) project established as a multinational multidisciplinary joint research project**

- Sirena '99 in Ligurian Sea was first joint cruise

**1999 – Present 10 Research Cruises**



# NATO Research and Operations

- MMRM research at NURC is directed toward developing protocols and tools to protect marine mammals during active sonar tests.
- While the results of NURC research may be considered by NATO forces when developing protocols and rules for active sonar operations, the nature of research sonar trials and operational exercises require practical differences.



# SOLMAR

## Primary Objectives

- Develop marine mammal risk mitigation guidelines and protocols to prevent harm to marine mammals
- Develop tools to assist NATO researchers and operational forces assess risk factors prior to and during sonar tests and exercises



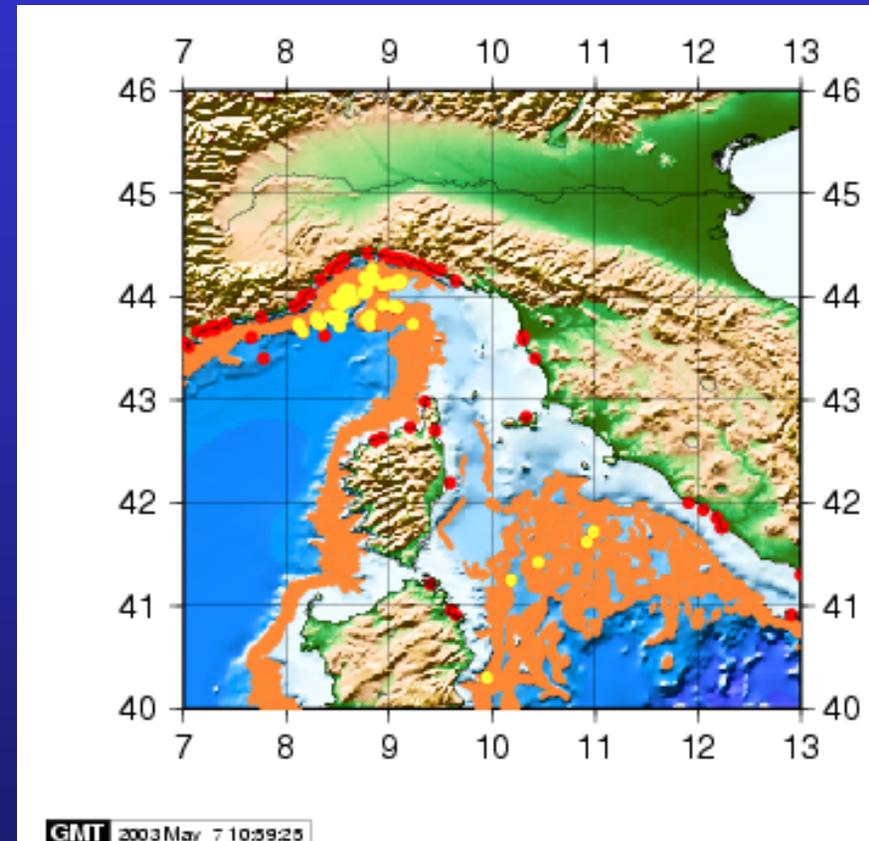
# SOLMAR

- Marine mammal and human diver risk mitigation rules
- Establishment of a marine mammal crisis action team to respond to mass strandings in the Mediterranean, especially those associated with NATO URC experiments or NATO exercises
- Expansion of JRP or SOLMAR partners to US, UK, Portugal, Italy, France, Spain, Holland, Belgium and Denmark



# SOLMAR

- Establish habitat models of “at risk” species
- Continue survey to test these models in new areas (Zifio 04 in Tyrrhenian sea)
- Participate in US Zc tagging and acoustic monitoring efforts (Sirena 03 Ligurian sea)
- Experiment with radar and IR detection of marine mammals





# MMRM Research at NURC

- Goals:
  - Refine and update NURC Marine Mammal Risk Mitigation Instruction (Policy)
  - Develop a cetacean species density prediction framework and acoustic-risk assessment and planning tool.
  - Develop on-site risk mitigation tools (such as transient detection devices, and possibly non-acoustics devices).



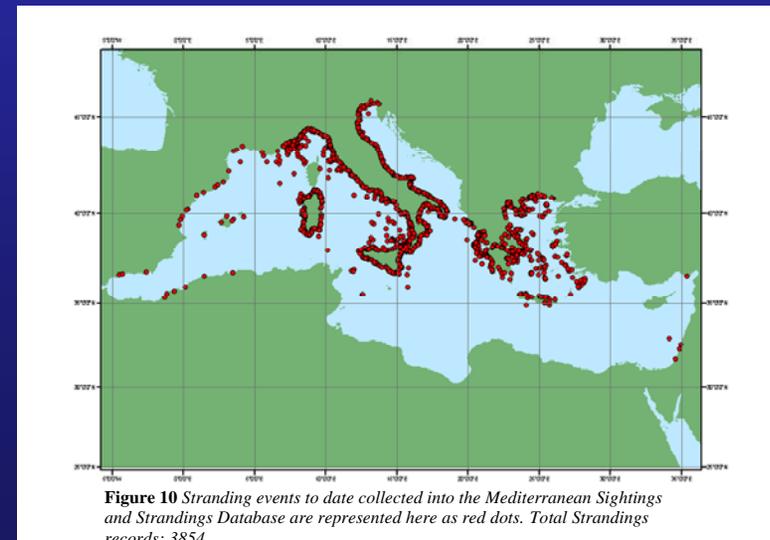
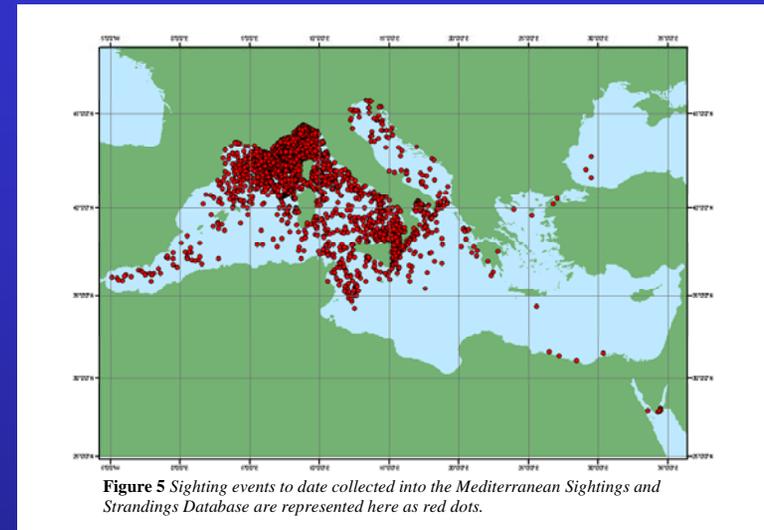
# MMRM Research at NURC

- MMRM research at NURC is being coordinated with similar research in the US, Italy, UK, and other NATO nations
- Research at NURC
  - Collection of information pertaining to cetacean density estimates
  - Visual focal follow and passive acoustic detection-classification-localization, tagging, behavioral analysis, and ultimately controlled exposure



# How Have We Done This?

- At sea surveys and controlled-exposure experiments
- Development and maintenance of marine mammal sightings and strandings data bases
- Development and testing of devices and techniques to detect, classify, and track targeted marine mammals
- Develop extensive network of joint research and SOLMAR partners

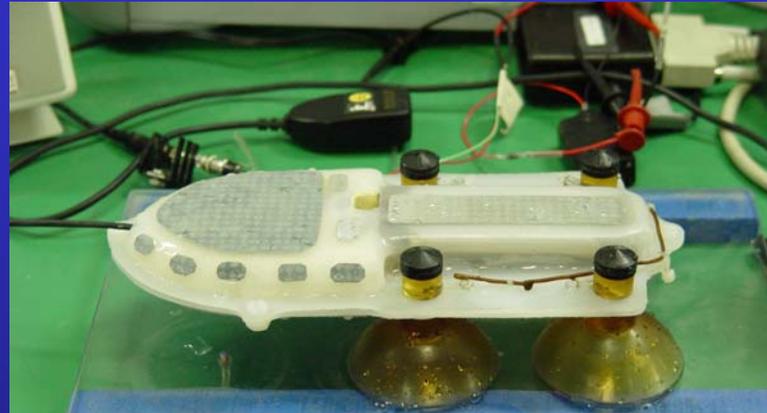




# Use of Tag to Record Responses to Sonar

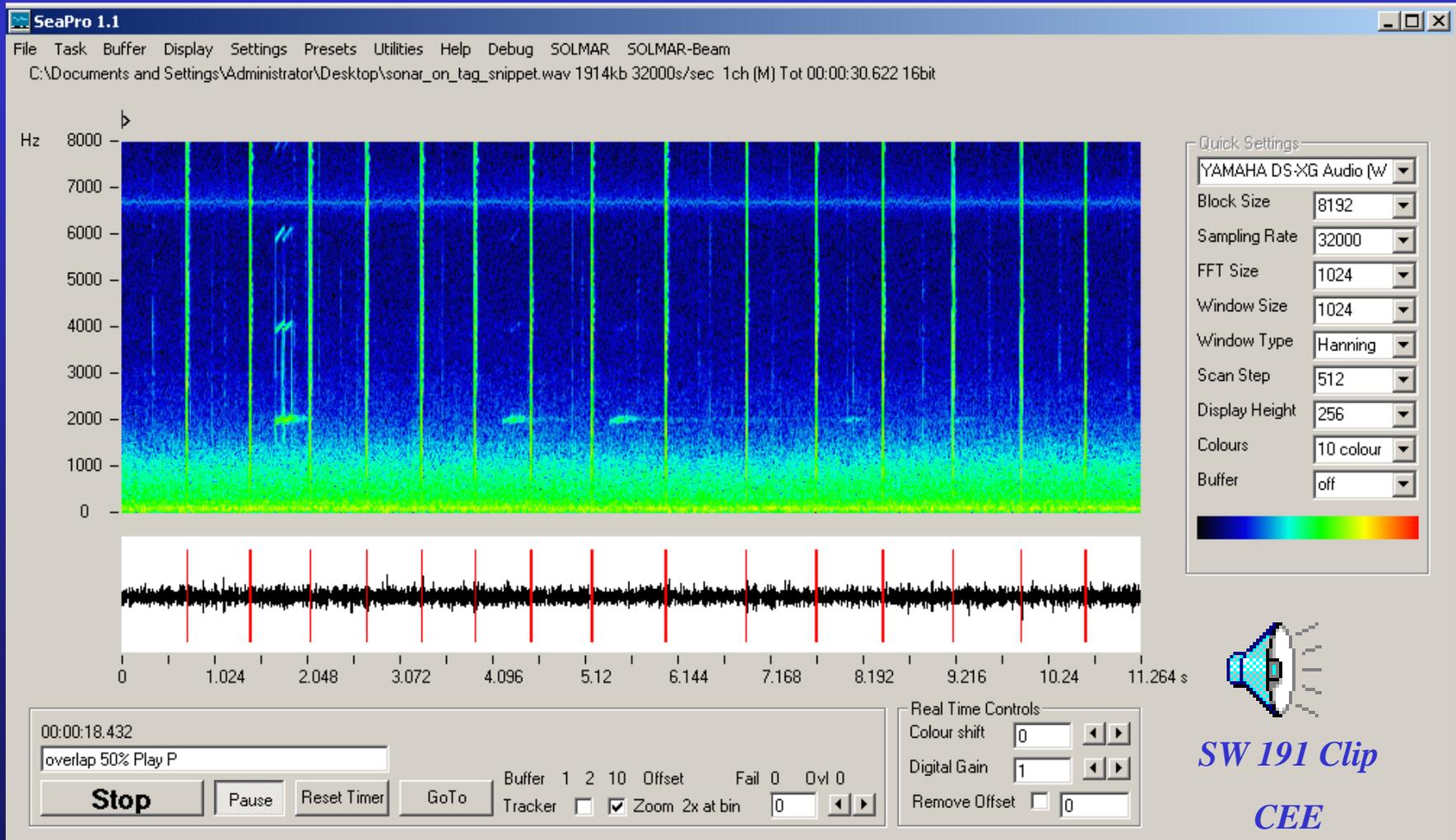


- Dive
- Pitch and roll
- Acceleration
- Signatures for Behavior
- Vocalizations
- Fluke beat





# Sperm Whale Passive Acoustic Tracking Controlled Exposure Experiment Frequency Shift (2kHz to 3 kHz)

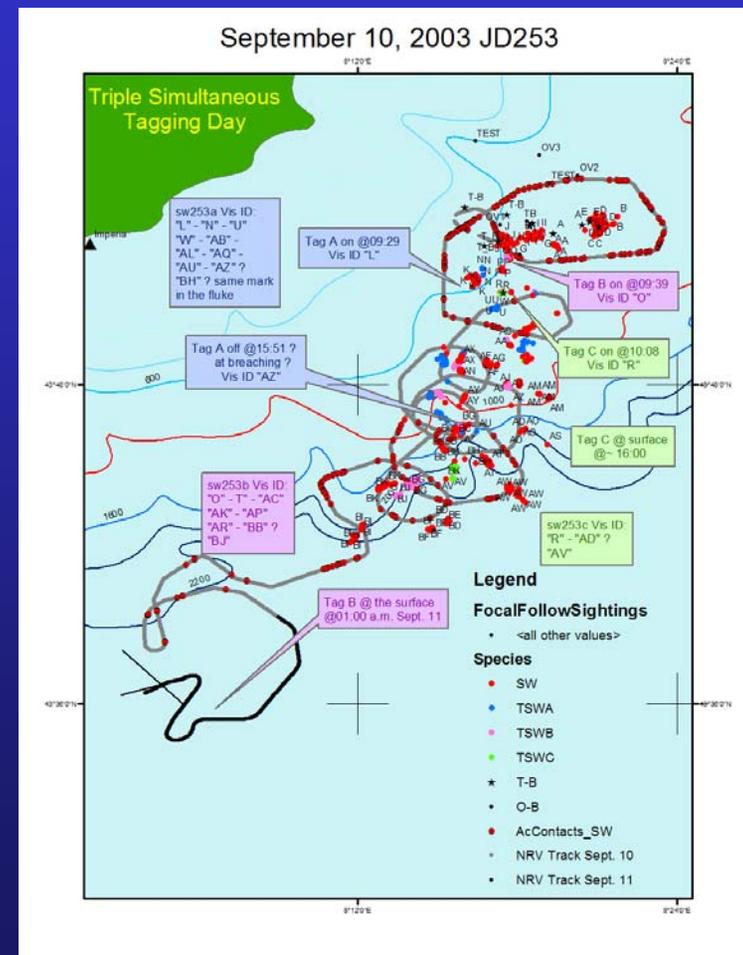


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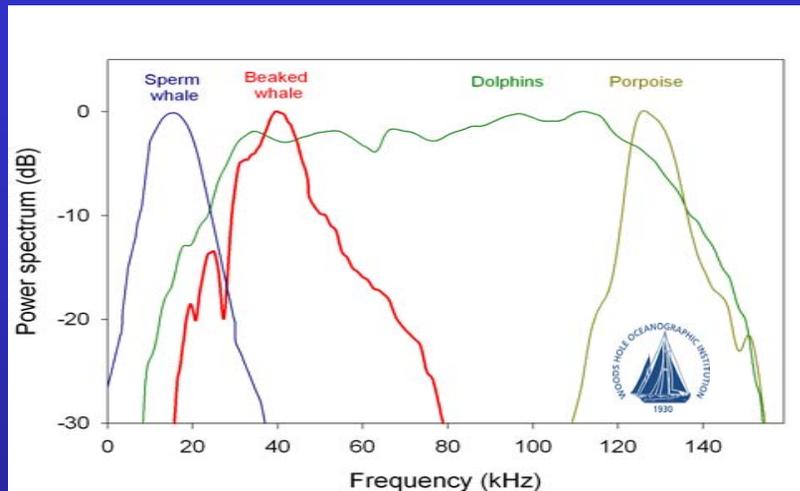
# Preliminary Analysis of Geometry of Triple Tag

- During Sirena 03 three sperm whales were tagged and tracked simultaneously



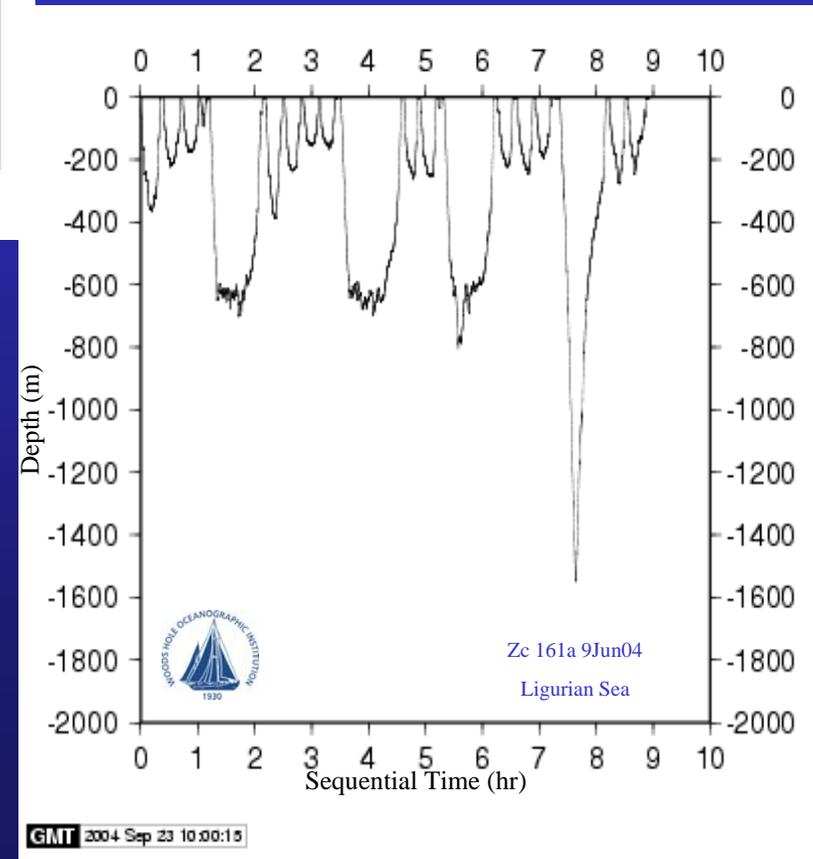


# Behavioral and Acoustic Analyses



- Primary Partner  
WHOI (US)

- Results of behavioral and acoustic analyses influence changes in MMRM protocol





# SOLMAR Marine Mammal Cruises

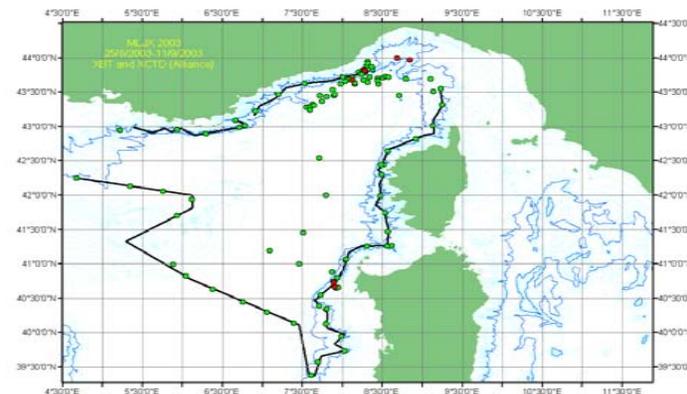
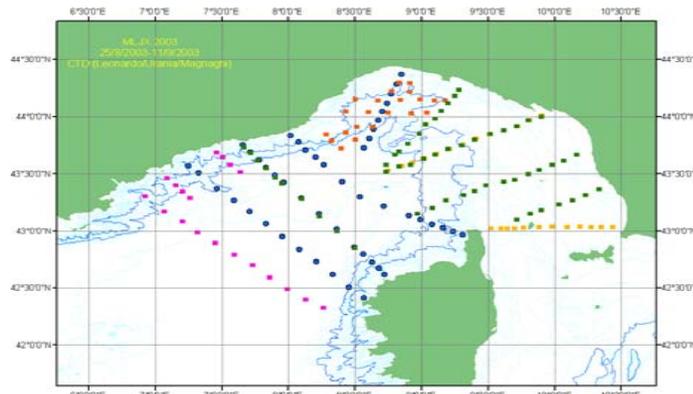
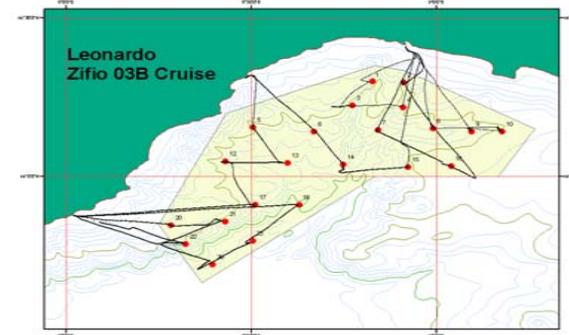
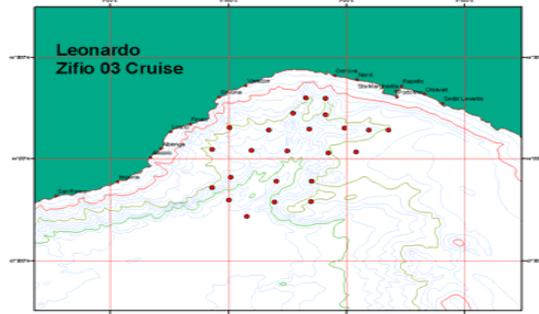
	<i>Alliance</i>	<i>Manning</i>	<i>Leonardo</i>	<i>Magnaghi</i>	<i>Bestiaccia</i>	<i>Urania</i>	<i>Elicottero</i>	<i>MPA/CG</i>	<i>ICRAM</i>
Sirena 99	X			X	X		X		X
Sirena 00	X			X	X			X	X
Zifio 01		X							X
Sirena 01	X	X		X					X
Sirena 02	X								X
Zifio 03A			X						
MLJX	X		X	X		X		X	X
Zifio 03B			X					X	
Sirena 03	X			X		X			X
Vulcano 04		X		X					CoNISMa



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# SOLMAR Marine Mammal Cruises 2003



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# Marine Mammal and Human Diver Risk Mitigation

## Instruction

- Establishes need for environmental scoping study be part of test plan
- Requires visual and acoustic watches
- Sets received level limitations
- Requires acoustic modeling
- Establishes incident action team



# What Are Sonar Trials and Exercises?

- A sonar trial is a tightly controlled experiment staffed (at sea) by experienced scientists (often with external MM observers).
- An exercise normally uses operational military units to simulate a combat situation.
  - Sept 2002 canary islands exercise was Spanish w/other nations (not NATO).
  - 1996 Greek strandings seem to be associated with a sonar test (NURC).



# NURC Active Sonar Protocol



- All active sonar experiments are governed by strict rules and protocols
- A series of steps must be followed prior to any active sonar experiment:
  - Environmental scoping study
    - Previous studies
    - Human swimming or diving
    - Marine mammal activity expected
      - Expected species
      - Breeding grounds
      - Seasonal variations

The screenshot shows a Microsoft Internet Explorer browser window displaying a PDF document. The address bar shows the URL: [http://zencle\\_web/mis/Staff\\_Instructions/77-04%20MARINE%20MAMMALS.pdf](http://zencle_web/mis/Staff_Instructions/77-04%20MARINE%20MAMMALS.pdf). The document content includes the NATO logo, the title 'STAFF INSTRUCTION', a table with metadata, and the main title 'STAFF INSTRUCTION 77' followed by 'NATO URC HUMAN DIVER AND MARINE MAMMAL RISK MITIGATION RULES'. The document is divided into sections, with '1 ANNEXES' containing a list of items (a) through (i).

	<b>STAFF INSTRUCTION</b>	Version	2.0
		Date	10 May 04
		Page	1 of 21

DOCUMENTS ON MIS ARE CONTROLLED - PRINTED COPIES ARE UNCONTROLLED

## STAFF INSTRUCTION 77

### NATO URC HUMAN DIVER AND MARINE MAMMAL RISK MITIGATION RULES

1 **ANNEXES**

- Background
- Procedures
- Assessment of Risk to Humans in the Marine Environment From High Level Sound
- Assessment of Risk to Marine Mammals in the Marine Environment From High Level Sound
- Environmental Scoping Study Matrix
- Visual Watch Recording Form
- Sighting Report Form
- Human Diver and Marine Mammal Incident Action Team Makeup and Responsibility
- Endangered Species List



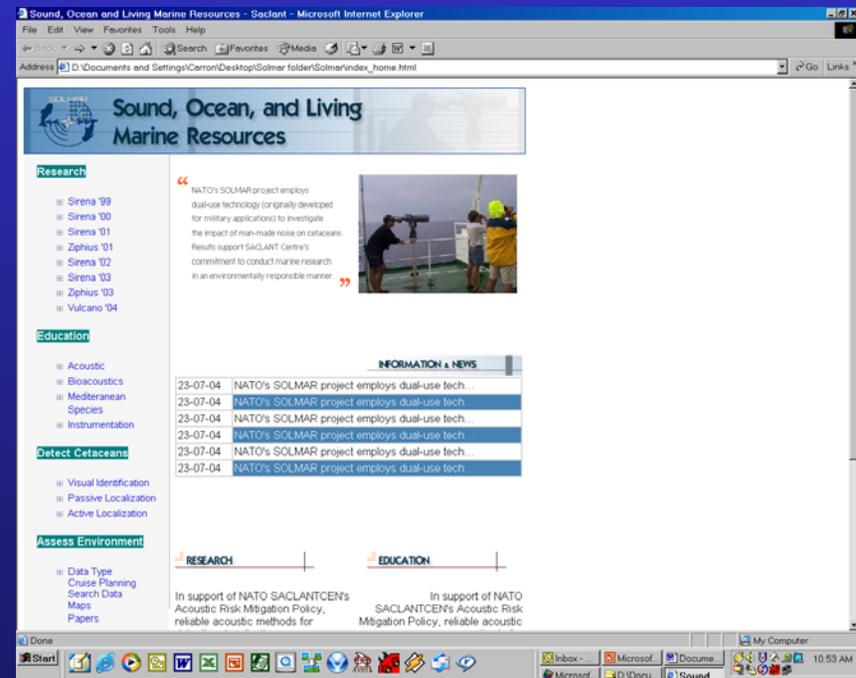
# NURC Active Sonar Protocol (cont.)

- In actuality, stricter rules are almost always imposed, especially if in a region known or suspected to be a habitat of Cuvier's beaked whales (*Ziphius cavirostris*).
- SOLMAR program advises all experiments as to best way to avoid insonifying with significant levels of sound  $Z_c$  or other marine mammals



# MMRM Program Web Page

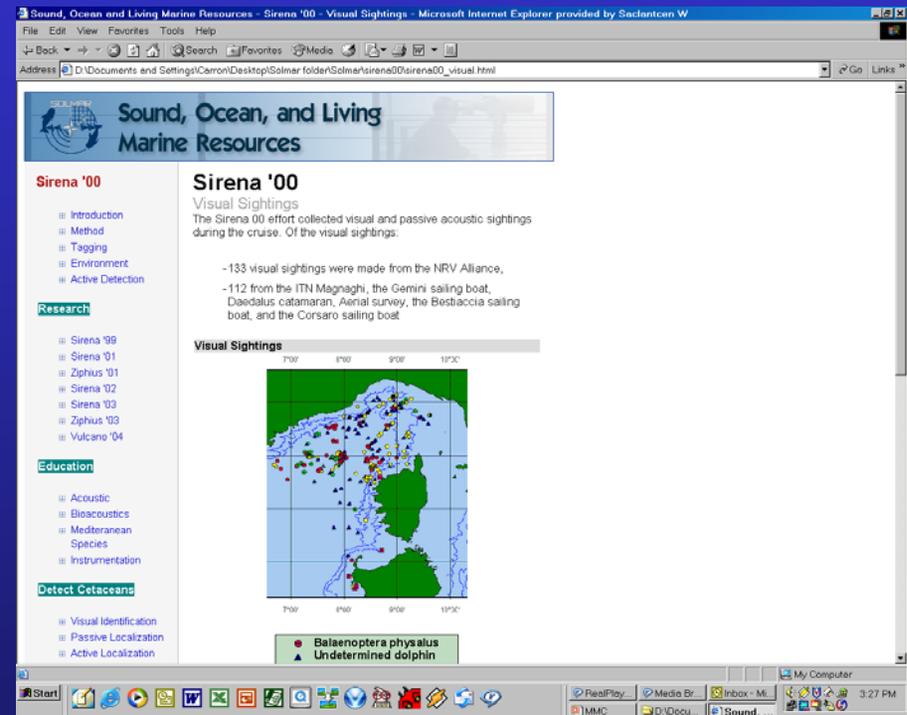
- Online by end of 2004
  - Cruise information and data
  - Marine mammal visual and acoustic identification information
  - Marine acoustics primer
  - Program publications





# Sea Trial Information and Data

- Direct link to descriptive information and data from MMRM program sea trials





# Marine Acoustics Overview

- Overview of basic marine acoustics, spectral analysis, beam-forming, etc.

**Sound, Ocean, and Living Marine Resources**

**RESEARCH**

- Sirena '99
- Sirena '00
- Sirena '01
- Zephus '01
- Sirena '02
- Sirena '03
- Zephus '03
- Vulcano '04

**EDUCATION**

- Acoustic
- Sound
- Propagation
- Noise
- Beamforming
- Spectrograms
- Bioacoustics
- Mediterranean Species
- Instrumentation

**DETECT CETACEANS**

- Visual Identification
- Passive Localization
- Active Localization

**ASSESS ENVIRONMENT**

**SPECTROGRAMS**

A pictorial representation of the frequency content of a sound over time is known as a spectrogram. This representation is useful for signals whose frequency characteristics change over time (non-stationary). Frequencies are plotted on the vertical axis, versus time on the horizontal axis. The intensity of each frequency is represented with a scale of grays or colours. For example, here is a 5 second dolphin vocalization, recorded during the Sirena '99 cruise, shown as a time series (top) and a spectrogram (bottom).

The dolphin whistles are clearly visible in the frequency vs. time

**Sound, Ocean, and Living Marine Resources**

**RESEARCH**

- Sirena '99
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- Sirena '01
- Zephus '01
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**EDUCATION**

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**ASSESS ENVIRONMENT**

**BEAMFORMING**

The mathematical process of combining signals from each hydrophone in an array is called beamforming. Beamforming enhances our ability to detect sound arriving from a particular direction, while reducing readings from other directions. In this way we can locate a target. In sonar terms, enhanced directional detections are called beams. For a line array, beams are conical. If the line array is horizontal, as when towed behind a ship, the horizontal component of the cone is the azimuth or bearing and is measured in degrees from the cone's axis.

**Beamforming Schematic**

**Constraints**

Aliasing  $d \leq \lambda/2$

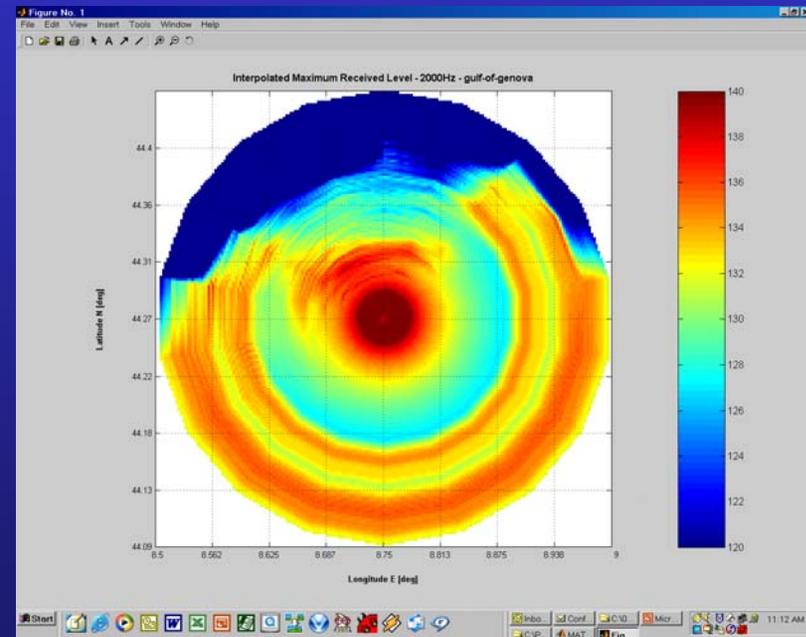
Near/Far Field  $R_2 \geq 2r_1 = 2L/2\theta$

Main Lobe width  $\theta_{3dB} = \lambda/L$



# Web Page 2005

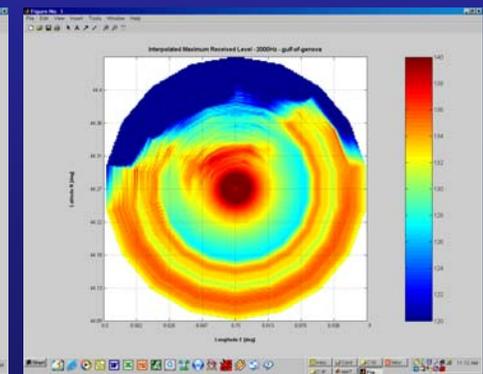
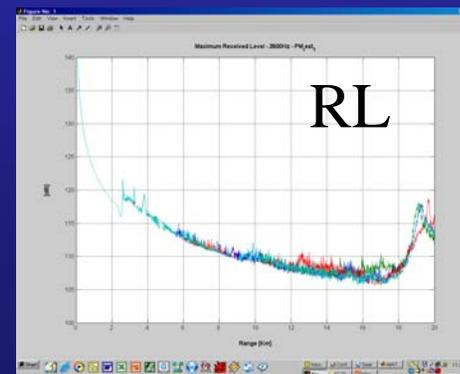
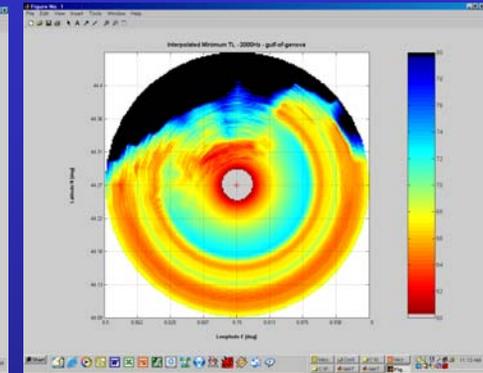
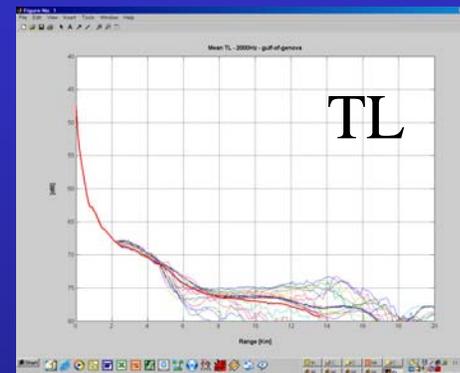
- Will contain links to:
  - Environmental scoping tool kit (GIS based)
    - Map server
    - Habitat models
    - Observational and stranding data
  - Educational DVD in English, Italian (developed in cooperation with the Italian navy), and Turkish





# Web-Based EST

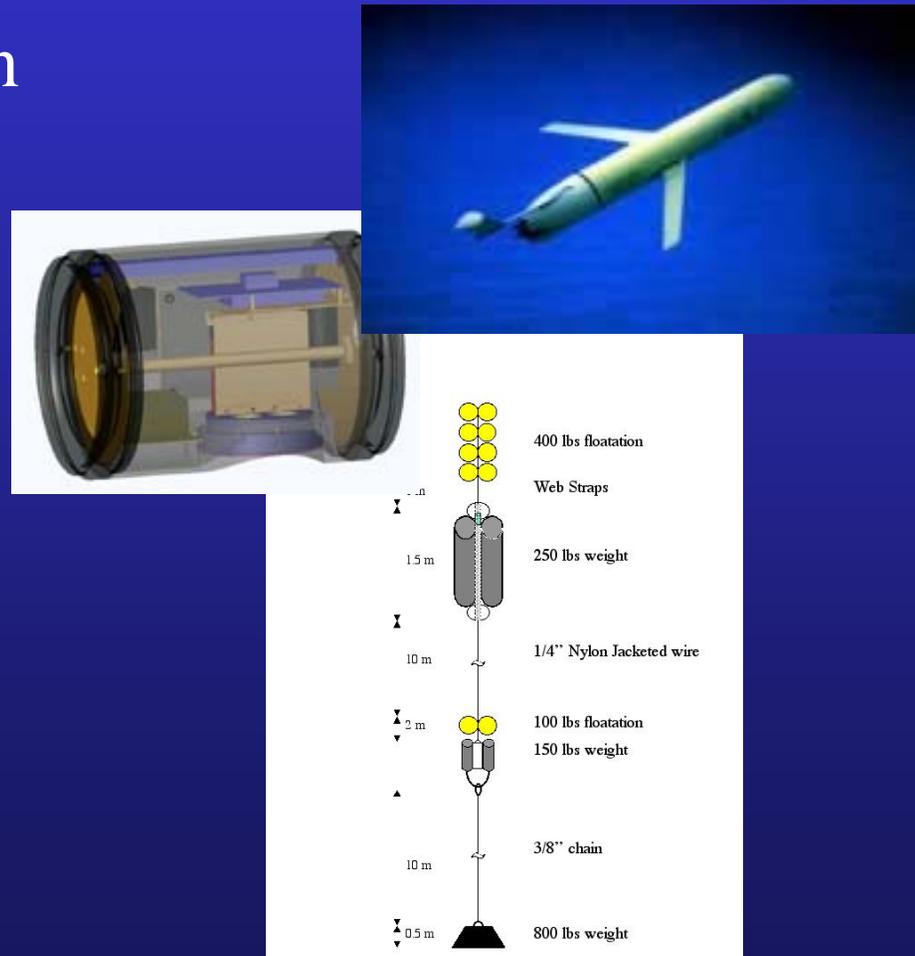
- Environmental scoping tool to determine acoustic danger zone around source
- Computes received level and transmission loss
- User defined inputs or climatologies available





# Risk Mitigation System

- 2005 NSIP submission
- Mixture of fixed and mobile assets to assist in clearing a “range” prior to a sonar experiment or naval exercise





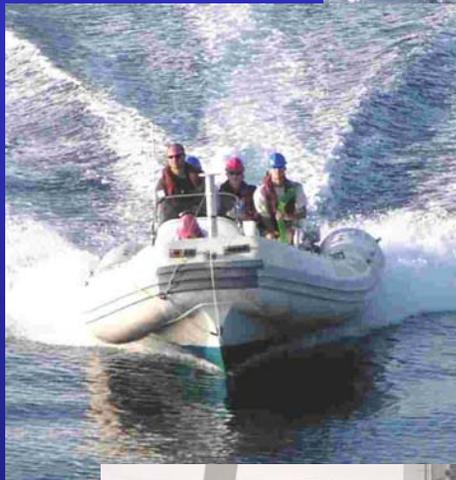
# Past - Future

- From 1999 – 2003 focus was on:
  - Exploratory research
  - Marine mammal risk mitigation guidelines
  - Technique development
- Present
  - Devices and tools
  - Operational models
  - Support to national research
  - Research and operational support
  - Expand partnerships (influence NATO navies)



# NURC Contact

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- Rene Laterveer [laterveer@saclantc.nato.int](mailto:laterveer@saclantc.nato.int)
- Odile Gerard [gerard@saclantc.nato.int](mailto:gerard@saclantc.nato.int)
- Nicola Portunato [portunato@saclantc.nato.int](mailto:portunato@saclantc.nato.int)



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# Example of Tagging





# Who's Rules?

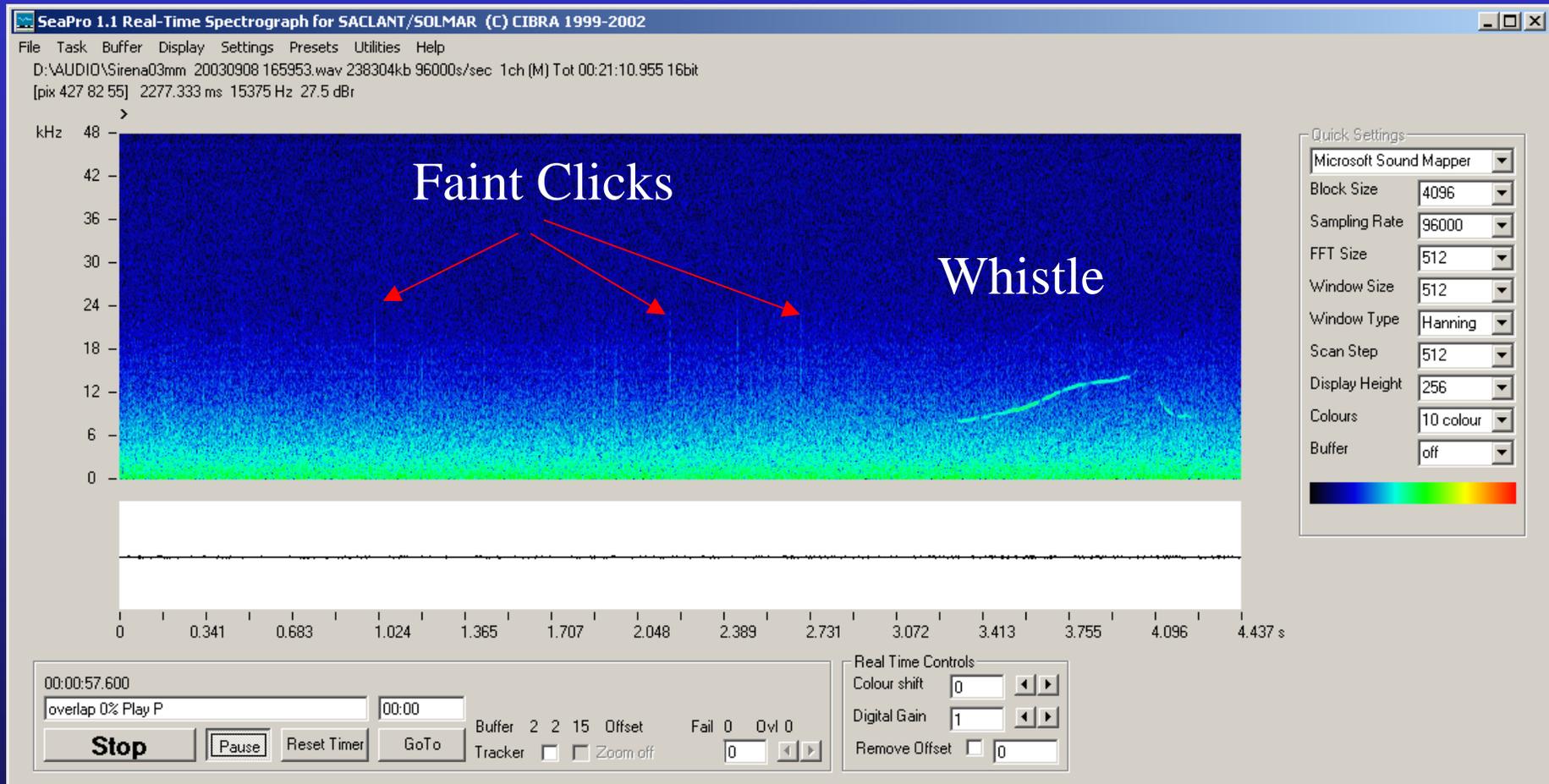
- During NURC sonar experiments, scientists must adhere strictly to NURC instruction and protocol for human and marine mammal risk mitigation
- When under NATO control military units must follow NATO protocols unless their own nation has stricter rules/protocols or host nation imposes stricter rules/protocols
- When not under NATO control military units must follow national or host nation rules and protocols



# MLJX



## Possible Zc Recordings on CRV Leonardo

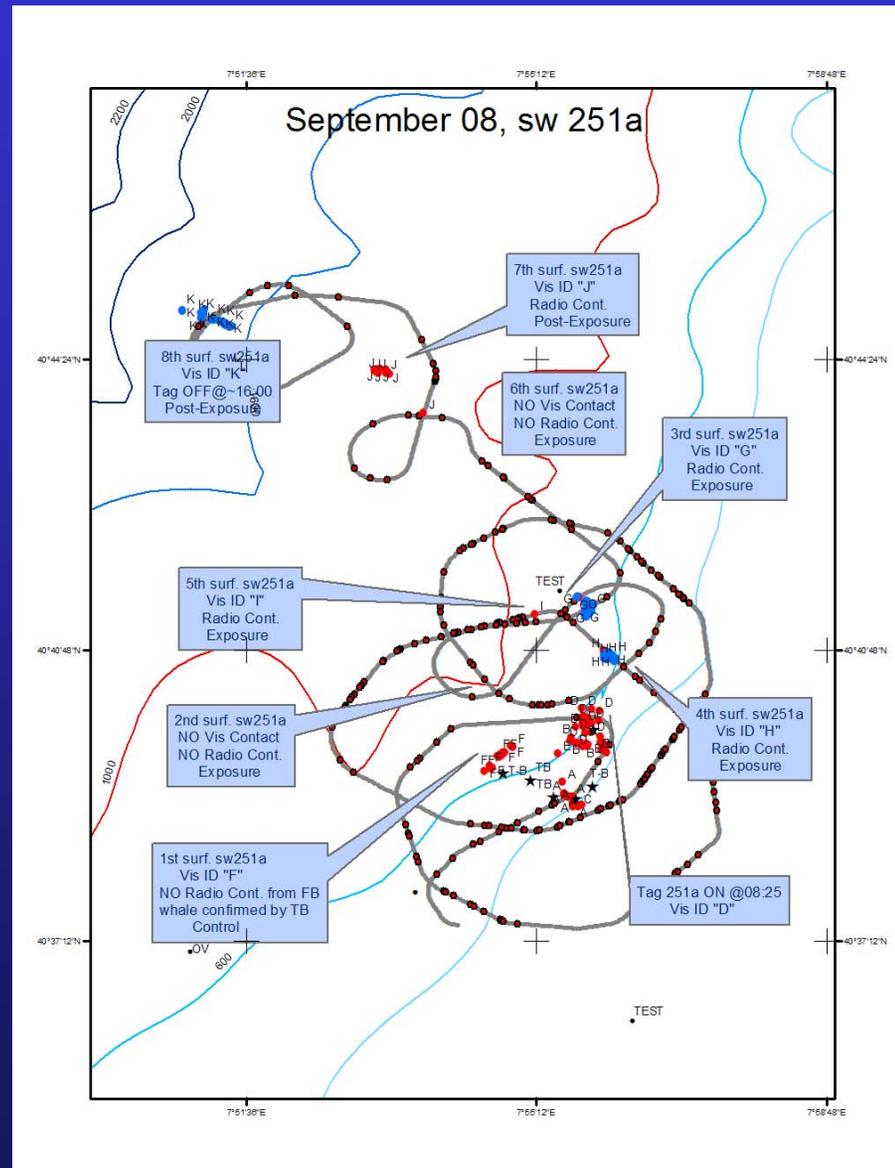


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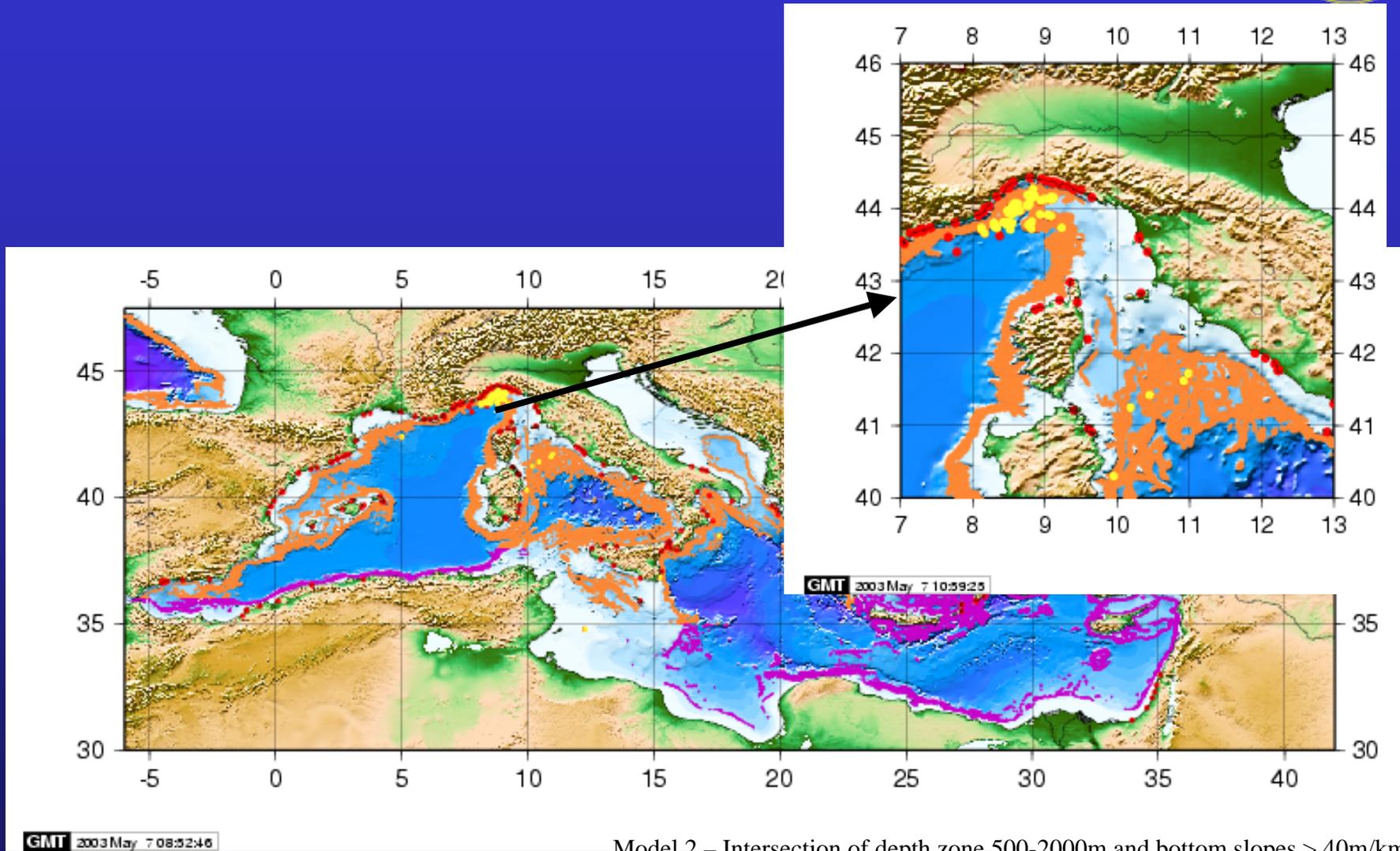


# Preliminary Analysis of Geometry of CEE



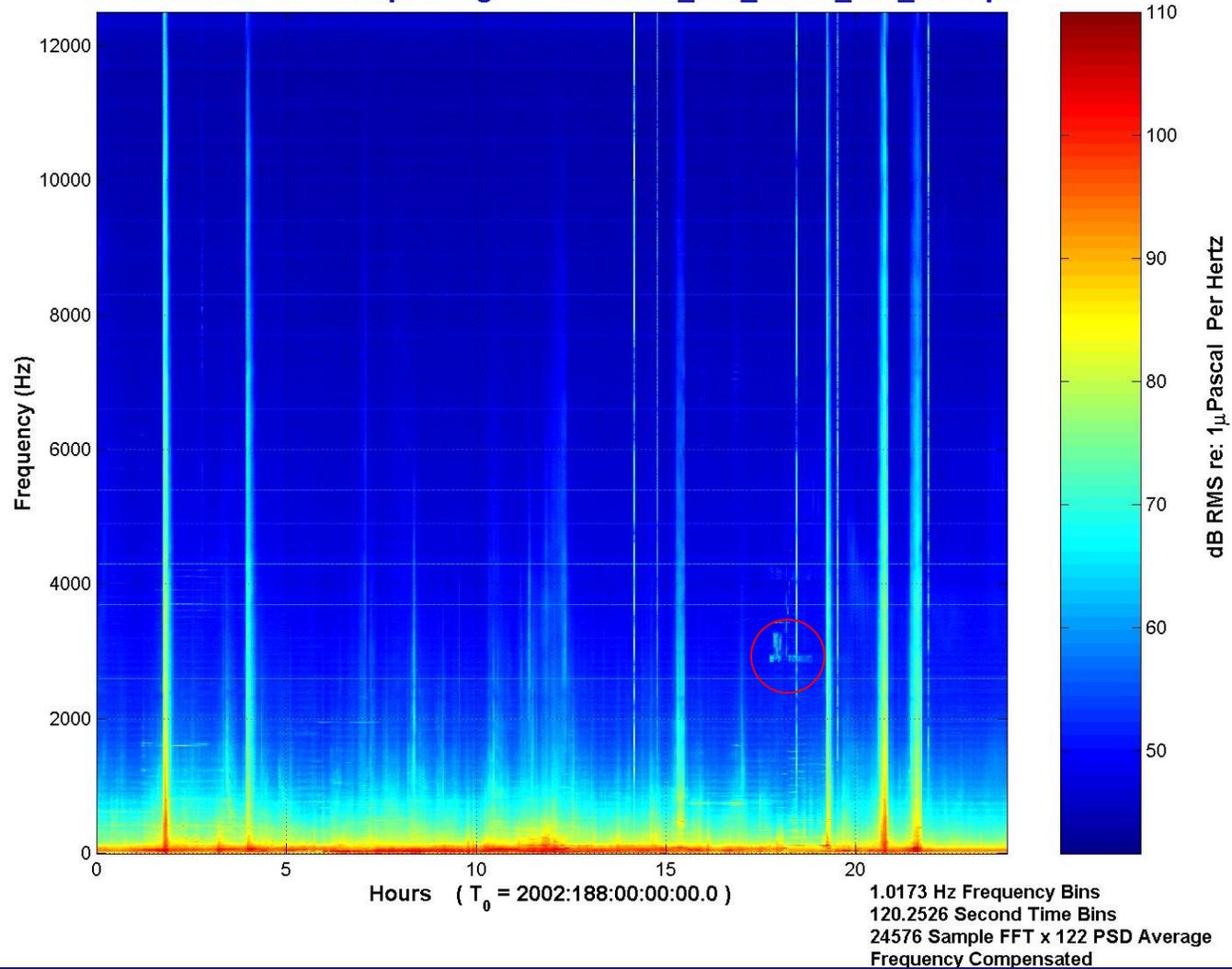


# Example of Ziphius Habitat Model





SIRENA 2002 JD 188 Spectrogram 19551872\_000\_24576\_122\_527.spx



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