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Abstract: Marine spatial planning is the process of acquiring and applying scientific data to better understand and minimize the environmental impact of anthropogenic activities. Conventional and alternative energy companies have turned their attention to new and varied marine environments, resulting in unique data needs and requiring innovative impact assessment modeling techniques. In order to implement effective marine spatial planning, activities within an individual's life history must be enumerated, simulated, and synthesized. This requires a comprehensive understanding of the species' behavior, habitats, and sensitivities at multiple spatial and temporal scales. The Marine Assessment, Decision, and Planning Tool (MADPT) is a one-stop-shopping data portal that integrates multiple databases into a single centralized tool to

support marine spatial planning and environmental risk assessments to protected marine species. Users query the data portal in a web-based geographic framework to view or acquire data. Information is presented in a consistent format across nine data categories in order to efficiently complete consistent, accurate, up-to-date environmental studies. MADPT has been put into practice with the Acoustic Integration Model (AIM) that can simulate multiple anthropogenic activities and marine species in an interactive framework (Frankel et al. 2002 IEEE Oceans). As a four-dimensional (3D space plus time), individual-based model, spatial and temporal interactions among species and activities are elucidated and potential effects of individual and multiple activities can be integrated and estimated. Only through such a comprehensive, science-based, ecosystem approach can marine spatial planning be effectively implemented.

Step 1: Gather data in the field

The level of exposure of individual animals and how they react to individual stressors remains poorly known. Several research projects are being undertaken by MAI and SEA to directly record the acoustic exposures that animals experience at various spatial and temporal scales:

- monitored and modeled the acoustic space within Stellwagen Bank NMS at ecosystem scales
- measured source levels of bottlenose and spotted dolphins and their available acoustic space off Florida
- led behavioral response studies in the Bahamas, Mediterranean Sea, and off the U.S. west coast (<http://sea-inc.net/social-brs/>).

Integrating acoustic exposure with ongoing studies of diving, foraging, social behavior, and sound production extends previous studies of whether and how animals change their behavior when they hear different sounds.



Cuvier's beaked whale with acoustic monitoring tag.

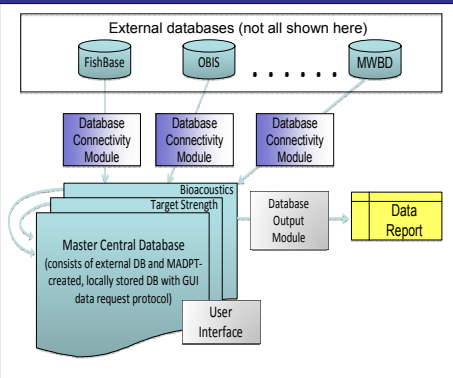


Risso's dolphin with acoustic tag.



Bottlenose dolphin and passive acoustic array.

Step 2: Archive data in the Marine Assessment, Decision, and Planning Tool (MADPT)



Ready, consistent access to pertinent information is vital for making informed science-based decisions and simulating the biological component of the marine environment. MADPT is a software-based tool that provides scientific data and information on marine species, such as:

- **Taxonomy:** classification information (genus, species, common names)
- **Management/Legal Status:** ESA, MMPA, MSFCA, IUCN protection levels
- **Basic biology:** morphometrics, inter-individual distances, life history stages
- **Habitat:** temperature, substrate, bathymetry, oceanographic features
- **Abundance:** stock, worldwide abundance and density estimates; presence/absence
- **Behavior:** dive depth, time, speed, angle, activity budget; aversions/attractions
- **Bioacoustic Production:** signal types, frequencies, source level, duty cycle
- **Hearing:** audiogram method, frequency of best hearing, threshold type
- **Target strength:** aspect, declination, group size, frequency, target strength

MADPT is under development, with a planned launch in July 2012 with one geographic area and several environmentally-sensitive species. Full functional capability will require investment in populating data portal/database for specific uses, species, seasons, or areas.

Step 3: Simulate exposure of individual animals to multiple activities in the Acoustic Integration Model (AIM)

AIM is a state-of-the-art, quasi real-time virtual model for assessing the net impact of sound from a variety of sources (moving or stationary) on a dynamic population of marine wildlife. Individual animals are simulated with rule-based behaviors based on data obtained in the field and archived in MADPT. AIM has become the standard for the analyses of acoustic impacts on marine animals for a series of environmental planning and compliance documents, including environmental assessments and environmental impact statements approved by the U.S. and the European Union. AIM is currently being used to

- assess vessel management strategies in Glacier Bay National Park
- monitor the acoustic scene of Stellwagen Bank NMS
- investigate the exposure of migrating bowhead whales to multiple oil and gas activities

Without basic information obtained in the field and archived by MADPT, these modeling and simulation efforts would not be possible.

