



# THE MESOPELAGIC BOUNDARY COMMUNITY AND ITS ROLE IN HAWAII FISHERIES

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## The Issue/Research Rationale

During daylight hours, a community of marine organisms—including lantern fish, mid-water shrimp and small squid—creates a layer off the steep bottom slope of the Hawaiian islands, where ocean depths are greater than 500 feet. At dusk these organisms, known as the mesopelagic boundary community (MBC), begin an upward and shoreward migration from several miles offshore. This mobile MBC layer is often referred to as a sound scattering layer because fish finder sonar will detect its upward migration.

## 2002 - 2003 Sea Grant Funding

\$45,631 SG; \$87,560 match

## Hawaii Discoveries/Contributions to Science

Acoustics were used to study the properties of the MBC layer and led to the discovery of the horizontal component of the layer's nightly migration, including its speed, and the caloric content of the layer along the shoreline. Inward movement peaks slightly after midnight when the MBC is about 20 feet below the surface and one-half of a mile from shore. The MBC then begins its outward migration, reaching deep waters just before dawn. The study found that the layer moves slightly faster outward than shoreward and that its horizontal velocity is much greater than vertical velocity. This study also provided a synoptic view of predator-prey interaction in a pelagic system, i.e. spinner dolphins intercept the inward migrating MBC, pursue it inward, and then outward until the layer migrates into waters too deep for effective feeding.

Equipment included: echosounders operating at 200 kHz, modified to be controlled remotely with a small computer; a remote controlled digital camera for still

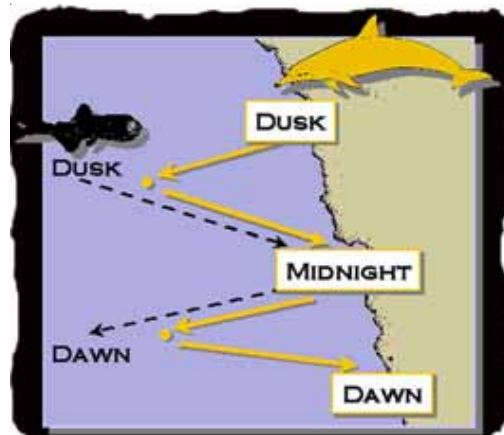


Bottom-mounted sonar was used to profile mesopelagic animals down to 500 feet. Graphic courtesy Benoit-Bird

pictures; and a conductivity, temperature, depth (CTD) profiler. The sonar system and camera were mounted to the frame of the CTD profiler, and sonar moorings mounted on the ocean bottom directed the echosounder beam toward the surface. The echosounder transmitted 10 signals every 15 minutes between 6:00 p.m. and

7:00 a.m. The digitized envelope of the echoes showing density, spatial and temporal distribution of MBC animals was stored into the computer.

Digital photographs were taken at 1 m depth intervals, for a total of 70 images per transect. A high resolution, dolphin-sonar system was used to collect backscatter data at 0.3 m intervals. Twelve 70 m vertical transects assessing the MBC's fine scale distribution were conducted within



Spinner dolphins follow the horizontal migration of small mesopelagic prey. Graphic courtesy Benoit-Bird

patches to measure size spacing between patches and overall variation of density within patches. This data enabled investigators to see small-scale heterogeneity within patches of MBC animals, e.g. sub-patches with complex geometric shapes and high animal densities. These areas are correlated with areas of high primary productivity (as indicated by chlorophyll 'a' measures), demonstrating coherence between mesopelagic animals and the trophic level that serves as prey.

On the Wai'anae coast, moorings were deployed in 0.5 km increments perpendicular to shore; with depth

increased in increments of 100-125 feet, 1 km from shore. The deepest mooring was deployed at approximately 500 feet. Four days of nighttime soundings provided a unique data set that clearly shows the migrational pattern of the mesopelagic boundary animals on a temporal scale of 15 minutes. The horizontal velocity averaged 1.7 km/hr, with a maximum vertical velocity of 1.7 m/min concentrated at certain periods.

## Research Impacts/Benefits

The MBC's nightly migrations link nearshore and distant pelagic oceanic systems by rapidly moving energy and nutrients between the two. This link significantly impacts Hawaii's coastal ecosystem and suggests that the extensive MBC may play an important role in these waters.

The foraging characteristics of pelagic predators change as they follow the MBC's migration. As a result, its importance to the pelagic system's predators, including tunas, billfish and spinner dolphins, as well as those in deep-water benthic systems, has been established. This biomass-rich MBC also serves an important role in nearshore systems, potentially impacting reef systems as the kilometers-wide layer moves into nearshore, shallow water.

## Publications and Presentations

Benoit-Bird, K.J. and W.W.L. Au. Submitted for review (SFR). Fine-scale diel migration dynamics of an island-associated sound-scattering layer. *Deep-Sea Research Part 1*.

Benoit-Bird, K.J. SFR. Prey value and energy needs: Foraging predictions for wild spinner dolphins. *Marine Biology*

Benoit-Bird, K.J. and W.W.L. Au. Accepted for proposal. Echo strength and density structure of Hawaiian mesopelagic boundary community patches. *Journal of the Acoustical Society of America*.

Benoit-Bird, K.J. and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales. *Behavioral Ecology and Sociobiology*.

Benoit-Bird, K.J. and W.W.L. Au. 2003. Spatial dynamics of a nearshore, micronekton sound-scattering layer. *ICES Journal of Marine Science*, 60:899-913

Benoit-Bird, K. J., and W. W. L. Au. 2002. Energy: Converting from acoustic to biological resource units. *J. Acoust. Soc. Am.* 111: 2070-2075.

Benoit-Bird, K.J. and W.W.L. Au. 2002. Fine-scale diel migration dynamics of an island-associated sound-scattering layer. *First Pan-American/Iberian Meeting on Acoustics*, Cancun, México, December 2-6, 2002.

Benoit-Bird, K.J. and W.W.L. Au. 2002. Dynamics of the Hawaiian mesopelagic boundary community studied with active acoustic moorings. *ICES Symposium on Acoustics in Fisheries and Aquatic Ecology*. Montpellier, France, June 10-14, 2002.

Benoit-Bird, K.J. 2002. Dynamics of the mesopelagic boundary layer and their effects on predator foraging. *80th Meeting of the SSC, WPRFMC*, Kaua'i, HI, May 16, 2002.

Benoit-Bird, K.J. and W. W. L. Au. 2001. Target strength measurements of animals from the Hawaiian mesopelagic boundary community. *J. Acoust. Soc. Am.* 110: 812-819.

Benoit-Bird, K.J., W.W.L. Au, R.E. Brainard, and M.O. Lammers. 2001. Diel

horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically. *Mar. Ecol. Prog. Ser.* 217: 1-14.

## Outreach Highlights

Interactions with the fishing community are a regular part of our research activities. Our goal is to be approachable and openly discuss our research in a way that is accessible to others in the community.

## Students Educated

Kelly J. Benoit-Bird, Ph.D. 2003

## Significant Partnerships

Kaho'olawe Island Reserve Commission

Medical Association for the Study of the Environment and the Human Body

National Marine Fisheries Service, Honolulu Laboratory

National Science Foundation and Office of Naval Research

Oceanwide Science Institute

## Biography

In recent years Dr. Au's research has expanded to the study of the acoustics of dolphins and humpback whales in the field, the mesopelagic boundary community around the Hawaiian Islands, and the acoustics of bottomfish. Dr. Au is a fellow of the Acoustical Society of America, a recipient of the society's silver medal in Animal Bioacoustics, and a member of the society's Executive Committee. He wrote, *The Sonar of Dolphins*, a Springer-Verlag published book, and has edited two other books, the latest being *The Hearing of Whales and Dolphins*, Springer-Verlag.

During Benoit-Bird's doctoral studies, she was awarded three Best Student Paper awards in Acoustical Oceanography and one in Animal Bioacoustics for presenting her University of Hawai'i Sea Grant funded research at the Acoustical Society of America meetings. She also received a National Science Foundation Doctoral Dissertation Improvement Grant and an Excellence in Research award from the University of Hawai'i Regents.



Whitlow Au received a B.S. degree from the University of Hawai'i, and an M.S. and Ph.D. from Washington State University, all in electrical engineering. He is a senior scientist at the Hawai'i Institute of Biology. His career has been in marine bioacoustics with an emphasis on the sonar systems of dolphins.

Kelly Benoit-Bird received her B.S. with honors in Aquatic Biology from Brown University in 1998. She recently completed her Ph.D. in Zoology at the University of Hawai'i working with Whitlow Au studying the dynamics of the mesopelagic boundary layer around Hawai'i. She began a post-doctoral fellowship at the Hawai'i Institute of Marine Biology in May, and will continue to study foraging on the boundary layer.

For further information:

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