

New satellite-linked depth-recording LIMPET tags permit monitoring for weeks to months and reveal consistent deep nighttime feeding behavior of short-finned pilot whales in Hawai'i

Russel D. Andrews¹, Greg S. Schorr², Robin W. Baird², Daniel L. Webster², Daniel J. McSweeney³, and M. Bradley Hanson⁴

1: School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and the Alaska SeaLife Center, Seward, AK
 2: Cascadia Research Collective, Olympia, WA
 3: Wild Whale Research Foundation, Holualoa, HI.
 4: NOAA, Northwest Fisheries Science Center, Seattle, WA



Attaching a LIMPET tag to a pilot whale

INTRODUCTION

- Short-finned pilot whales frequently mass strand - one recent mass stranding was temporally associated with naval sonar use
- High-speed deep diving behavior (1) may increase susceptibility to decompression sickness, but what little is known about their diving comes from short term (~ 1 day or less) recordings.

OBJECTIVES

- Develop method to monitor dive behavior of small - medium sized odontocetes for weeks to months without animal capture
- Obtain data on individual dive and surface events, and their temporal association, for pilot whales off Hawai'i

METHODS

- Mk10-A satellite-linked depth tag (Wildlife Computers) incorporated into the LIMPET (Low Impact Minimally Percutaneous External-electronics Transmitter) configuration (Fig. 1 & 2).



Fig. 1. Original location-only SPOT5 LIMPET tag (A [top] and B) and new Mk10-A depth-transmitting LIMPET tag (A [bottom] and C). Tags attach with 2 titanium barbed darts that penetrate 6.5 cm.

- Wildlife Computers' Behavior Log option used to send compressed data on individual dives via Argos satellite, including:
 - Max Depth (resolution varies, typically 1-2%, not > 3% for dives as deep as 2000m)
 - Dive duration (resolution 2% or less)
 - Dive shape (Square, U, V, & left & right skewed variants)
 - Duration of surface event (depth > qualifying dive threshold)
- Time Series: highly compressed depth values sampled at 2.5 min intervals - transmitted to validate Behavior Log data (Fig. 3).

- Prototype Mk10-A LIMPET tags were attached to 8 pilot whales off leeward coast of Hawai'i:
 - Tags attached remotely using modified air-rifle
 - Behavior Log "qualifying dives": > 20m and > 1 min
 - Argos-derived locations were evaluated for plausibility with the distance-angle-rate Douglas Filter

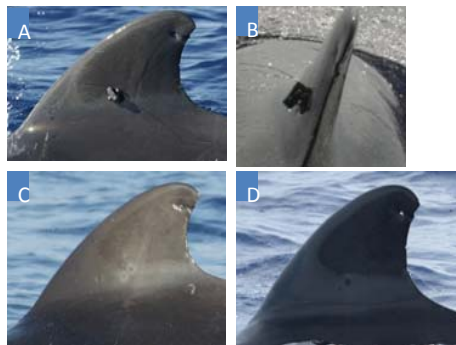


Fig. 2. Mk10-A LIMPET tag on pilot whale Gm38. A: day of tagging. B: 1 day after tagging. C and D: 110 and 213 days after tag stopped transmitting.

Table 1. Pilot whales satellite-tagged off Hawai'i. % Behavior Log coverage is percent of time over the initial period of continuous daily data collection and transmission for which Behavior Log dive data was received. ND = no data from Gm39, likely due to depth transducer failure.

Whale ID	Age & sex (years-at-birth, adult)	Date deployed	Transmit Duration (d)	Mean depth of deep (> 100m) dives	Mean duration of deep dives (min)	% Behavior Log coverage
Gm33	sa M	25-Oct-2009	42	388 ± 162	10.9 ± 2.7	89
Gm34	sa M	25-Oct-2009	30	318 ± 146	11.9 ± 2.6	96
Gm35	sa M	31-Oct-2009	40	502 ± 296	13.4 ± 3.6	83
Gm36	a F	15-Dec-2009	47	323 ± 151	10.2 ± 2.1	86
Gm37	a F	15-Dec-2009	20	293 ± 186	10.8 ± 2.5	64
Gm38	sa M	17-Dec-2009	5	404 ± 251	11.9 ± 3.8	58
Gm39	sa M	17-Dec-2009	42	ND	ND	ND
Gm40	sa M	18-Dec-2009	16	351 ± 159	11.8 ± 2.3	87

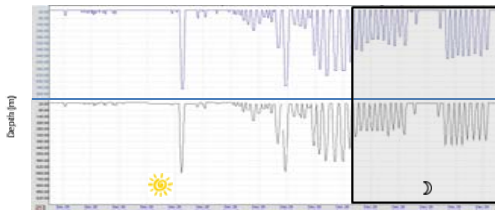


Fig. 3. Display of Wildlife Computers' Instrument Helper program, showing Behavior Log dive info (top panel) and Time Series depth data (bottom panel). 2.5 min sampling interval, both relayed via satellite from whale Gm36. Time is GMT, local Hawai'i = GMT - 10 h. There was overlapping Behavior Log and Time Series data for 2513 dives, and there was 100% correspondence within the resolution limits of Time Series data.

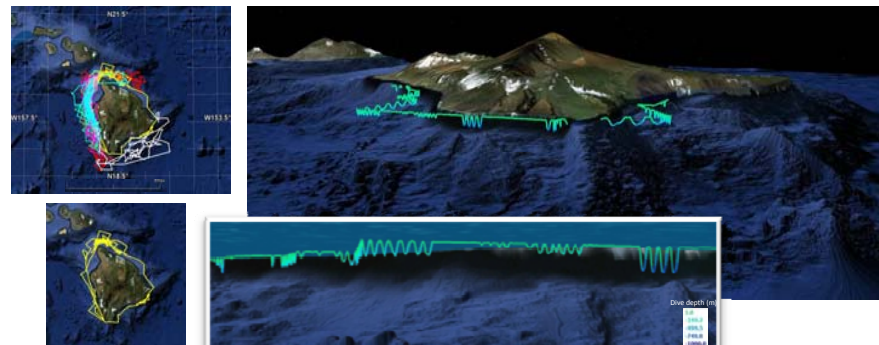


Fig. 4. Top left: Argos tracks of 8 pilot whales tagged with Mk10-A LIMPET tags. Bottom left: Track of Gm35. Right: 3D plot of a 3 day excerpt of interpolated Argos position estimates and time series dive data for Gm35 on Google Earth bathymetry (off SW coast of Hawai'i). Most deep dives are pelagic, and even deep dives close to shore are not benthic.

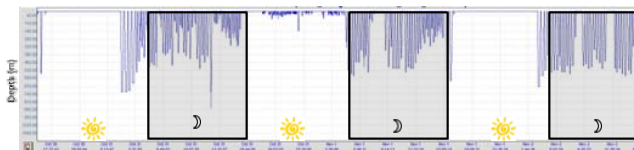


Fig. 5. Behavior Log dive data from whale Gm34. Pilot whales primarily feed on vertically migrating squid - so whales might dive more deeply during the day than at night. At night, whales regularly made long (mean: 11.5 min; maximum: 22.4 min) deep dives between 100 and 1296 meters (mean: 359 m). Daytime deep dives tended to be deeper, but difference was not significant.

CONCLUSIONS

- Whales spent most time on leeward side within 50 km of shore, (water depths 300 - 2500 m), but 4 whales spent some time in the Alenuihaha Channel, a site of frequent shipping traffic and Navy training exercises.
- Majority of deep dives (>100 m) were made during nighttime - but some whales did forage deeply during daytime while others presumably rested and socialized.
- With this successful development of a longer-term depth-recording tag, additional Mk10-A LIMPET deployments will help elucidate seasonal and habitat specific variation in dive behavior and exposure to risk from anthropogenic activities.
- Mk10-A LIMPET tags have also now been successfully applied to sperm whales, false killer whales, and Cuvier's beaked whales (see Schorr *et al.* poster)

References:
 1: Aguilar Soto, N. *et al.* (2008) Cheetahs of the deep sea: deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands). *J. Anim. Ecol.* 77:936-947.
Acknowledgments: Thanks to Shawn Wilton, Isaac Heizer, and Roger Hill of Wildlife Computers for incorporating the Mk10-A in the LIMPET configuration and for developing the Behavior Log data compression scheme. Thanks also to many volunteers for field assistance and to J. Waite for 'R' help. Funding provided by the Office of Naval Research (Program Manager Michael Weise) NOAA (PTFSC and SWFSC), and U.S. Navy N45. Authorized under NOAA MMPA scientific research permit 731-1774.
 Questions? e-mail: russ_andrews@alaskasealife.org and check Cascadia Research page: <http://www.cascadiaresearch.org/hawaii/shortfinnedpilotwhale.htm>