Diving and Foraging Behavior of Blue Whales Tracked With Intermediate-duration Advanced Dive Behavior Tags off Southern California

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Advanced Dive Behavior Tags

• Intermediate attachment duration (3 – 4 wks)
  • Modified version of Wildlife Computers Mk-10 TDR

Image source: Wildlife Computers
Advanced Dive Behavior Tags

- Intermediate attachment duration (3 – 4 wks)
  - Semi-Implantable tags
  - Attachments similar to Mate et al 2007

Image source: Wildlife Computers
Advanced Dive Behavior Tags

- Depth, 3-axis accelerometers and magnetometers at 1 Hz
- GPS quality locations (FastLoc; collected every 7 min)
- Release at scheduled time or if release criteria are met
Dive Summary Metrics

Isolated dives > 10 m depth and > 1 min duration
- Maximum dive depth (m)
- Dive duration (min)

GPS locations matched to each dive
- Location was estimated by linear interpolation between the two closest GPS locations if no location within 10 min of a dive.
Lunge Detection

Identified peaks in Minimum Specific Acceleration (MSA; Simone et al 2012)
  • Misses surface lunge feeding

Additional dive summary metrics
  • Number of lunges per dive
  • Average depth of lunges per dive
Baleen whale feeding lunge activities in:

2014 (N = 4)

2015 (N = 3)
## Deployment Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>PTT</th>
<th>Duration (d)</th>
<th># Dives</th>
<th># GPS locations</th>
<th>Dives/day</th>
<th>GPS Locs/day</th>
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Lunge Detection
Brief foraging bouts after leaving tagging area

- May indicate low prey density or very small scale prey abundance
Identification of Foraging Bouts

Foraging Bouts
Sequences of dives with < 3 consecutive non-foraging dives
  • Created a minimum convex polygon around each sequence (foraging bout)
Identification of Foraging Bouts

Foraging Bouts
Sequences of dives with < 3 consecutive non-foraging dives

- Created a minimum convex polygon around each sequence (foraging bout)
- Computed a range of summary statistics
  - Bout Duration
  - Average foraging depth
  - Average lunges/dive
Foraging Bouts: Area

Foraging Bouts were temporally distinct (median = 2.2 h apart) and generally small (median = 1.7 km$^2$)

- Sizes of Foraging Bout areas are likely an overestimate
- Many foraging segments were generally linear
Foraging Bouts

Median foraging bout across individuals contained 11 dives over 2.2 h (max = 77 dives over 14.4 h)
Foraging Bouts: Duration

Most foraging bout duration distributions were bimodal

Suggests they left low quality prey patches quickly
(Hazen et al 2015)
Foraging Bouts: Lunges per Dive

Lunges per dive in a foraging bout somewhat bimodal
Foraging Bouts: Lunges per Dive

Average lunges per dive was correlated to bout duration ($p < 0.001$, $R^2 = 0.37$)
## Foraging Bouts: Dive Depth

<table>
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<tr>
<th>PTT</th>
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<th>n Dives</th>
<th>Ave Max Dive Depth (m)</th>
<th>Ave Dive Duration (min)</th>
<th>Ave # Lunges</th>
<th>Area Of Bout (km²)</th>
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Foraging in Close Proximity (2014)

Tag #5650

Tag #5803
Foraging in Close Proximity (2014)

Tag #5650

Tag #5803
# Foraging Bouts

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Tag # 2015_840
Foraged throughout the area for days
• Foraged majority of daylight hours
Tag # 2015_4177
Appears to be searching the seamount
• No foraging behavior
• Passed through an area 1 d before 2015_840 foraged there
How can one whale forage constantly and another not?

- Unlikely prey increased abundance
- Unlikely 2015_4177 couldn’t find prey if available

- Suggests tag # 2015_840 can exploit prey that is not dense enough for other whales
- Tag 2015_4177 = better body condition?
Summary

• Tagged whales made many relatively short foraging bouts with less frequent long ones
  • Exception with tag #2015_840
• Duration of foraging bouts was related to the number of lunges
• Differences in dive depths between individuals
  • Evidence of two whales using different parts of the prey patch
• Possibility of different foraging strategies?
Acknowledgements

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• R/V Pacific Storm crew for field support
• Steve and Roxanne Parker for aerial surveys
• Kathy Minta and Minda Stiles for project and contract management
Results

Median Maximum Dive Depth per Hour for Dives Made by an ADE Tagged Blue Whale (H8820)

Outline Methods XXXXXX XXXXX Summary
Results: Diel and Temporal Variation

Outline Methods XXXXXX XXXXX Summary
Diel and Temporal Variation

Graph showing maximum dive depth over the course of a day.

Map indicating max dive depth ranges with symbols corresponding to depth categories.
Diel and Temporal Variation
Spatial Variation of Foraging Behavior
Tag # 2015_4177
Appears to be searching the seamount

- No foraging behavior
- Other examples of similar behavior in other tracks.
Foraging Bouts

Ave lunge depth of foraging bouts was unimodal but with a bit of a shoulder

• All but one tag had at least a small shoulder of deeper foraging
• Two tags had a distribution centered closer to 130 m depth
Foraging in Close Proximity

Summary of dive behavior when whales were within 1 km of each other.

<table>
<thead>
<tr>
<th>Tag #</th>
<th>Overlap Tag #</th>
<th>Bout #</th>
<th>Overlap Duration (h)</th>
<th>Number of Dives</th>
<th>Median Dive Duration (min)</th>
<th>Median Max Dive Depth</th>
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Turn into bullet points
Tag 5650 preferentially feeds at shallower depths?
Remote Tracking of Large Whales

Implantable location-only tags

- Long attachment duration
- Limited data throughput
Remote Tracking of Large Whales

Time Depth
Recorder/Data logger

- Many sensors
- Very high resolution data
- Short attachment duration (suction cup)

Simone et al. 2012
• Tags deployed using an air powered applicator (methods in Mate et al 2007)
• 2-4 m away to deploy a tag
• Biopsy samples collected simultaneous to tagging
Remote Tracking of Large Whales

What’s Missing?

High resolution behavior data over intermediate time periods
Group tracks (3 grps) by what they did: Offshore loop, coastal movements, moved to N. California