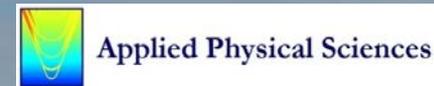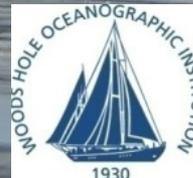# Measuring cetacean responses to military sonar: *Southern California Behavioral Response Study (SOCAL-BRS)*

Photo taken under U.S. NMFS permit # 14534

SOCAL-BRS Project Team

B. Southall (SEA, UCSC): co-PI: chief scientist
P. Tyack (WHOI/StA): co-PI: design, analysis
J. Barlow (NOAA): co-PI: Passive acoustics

S. DeRuiter (WHOI/StA): Tag data analysis
A. Stimpert (NPS): Field ops, data analysis
G. Schorr (Cascadia): Field ops, data analysis
E. Hazen (NOAA) : Prey mapping, stats

C. Spikes (MAI): Navy ship coordination
M. Wilson (MAI): Navy ship coordination
J. Hildebrand (Scripps); Sproul chief sci; PAM
R. Carlson (SPAWAR): Geospatial data (WILD)
A. Douglas (Cascadia): Visual observations
J. Foster (Cascadia): Field ops, logistics
K. Diehl (Cascadia): Field ops, visual obs
C. Casey (SEA): Data archive, visual obs
T. Yack (NOAA): PAM support, analysis

J. Calambokidis (Cascadia): co-PI: field ops lead
D. Moretti (NUWC): co-PI: sound source lead
C. Kyburg (SPAWAR): co-PI (ONR) geospatial data

A. Friedlaender (Duke/SEA): Field ops, tag analysis
J. Goldbogen (Cascadia): Tag data analysis
E. Falcone (Cascadia): Field ops, data analysis
P. Arranz (Univ. St. Andrews): Tag data analysis

J. Curtis (MAI): Navy ship coordination
F. Visser (3S team w/ONR): Vis obs data analysis
K. Southall (SEA): Permit, logistics, reports
T. Pusser (Independent): Visual observations
R. Morrissey (NUWC): Sound source team
S. Kennedy (NUWC): Sound source team
S. Guan (NOAA): PAM, source team
S. Fregosi (SEA): Data archive, visual obs
S. Rankin (NOAA): PAM support, analysis

Introduction

- **Drivers for Behavioral Response Studies for Military Active Sources**

  - Applied field research to determine sound exposure:response relationships using increasingly realistic operational scenarios to support of Navy environmental compliance requirements and to directly support improvements in regulatory assessments of potential effects

- **Prior and Related Projects and Collaborations**

  - AUTEC BRS (2007-08), MED-09 (and ongoing)

  - Norwegian/Dutch Navies: 3S project; SERDP project: Duke BRS

  - MOCHA statistical analysis, integration

- **Why SOCAL?**

  - Species density, diversity, and options

  - Area of high Navy activity

  - Leverage and collaborate with ongoing projects

OVERVIEW

- **SOCAL-BRS Sponsors, Stakeholders, and End Users**


- **Permits, Transparency, Socializing, Public Impact**
  - NMFS permit # 14534-2; CINMS #2010-003; CA Coastal Commission
  - Direct interaction and dialogue with eNGOs (e.g., NRDC, ACS)
  - **www.socal.brs.org**, from-the-field blog, webinars, significant press interactions

- **Overall SOCAL-BRS Status and Timeline**
  - **2010**: Adapt and apply BRS approach to SOCAL species
  - **2011-12**: Add to sample size with scaled source; refine/test methods
  - **2013**: Demonstrated success with 1st use of Navy ships in MFA CEEs!
  - **2014-15**: Focus is Navy sources realistic scenarios; scaled source option

SOCAL-BRS is an interdisciplinary, multi-team collaboration designed to *increase understanding* of marine mammal reactions to sound and provide a more robust *scientific basis for estimating impact* of Navy mid-frequency sonar
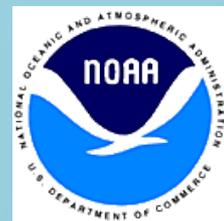
SOCAL-BRS focal species

Deep-divers (*Beaked whales, Sperm whales*)
- particular sensitivity: beaked whales
- endangered status: sperm whales

Mysticetes (*Blue, Fin, Humpback, Minke whales*)
- endangered status

Other Delphinids (*Rissos, Common, Bottlenose dolphin*)
- common occurrence, exposure
- large percentage of Navy "takes"

SOCAL-BRS: Overall Approach

- Acoustic tags and controlled exposures (A-B-A) to measure baseline behavior and changes

- Adapt multidisciplinary approach to new species (Southall *et al.*, 2012)

  ≥ PAPER
  Marine Mammal Behavioral Response Studies in Southern California: Advances in Technology and Experimental Methods

- Maximize flexibility re: weather and animals

Decentralized Vessel Strategy:

* Smaller, flexible central platform
* Fast, independent tag boats
* Towed PAM from sailboat
* Real Navy ships at real ranges

SOCAL-BRS Experimental Phases

Exposure
(*During* CEE)

- Explicit start-up, exposure, shutdown protocols
- Visual survey and focal follow maintained
- Scaled source (MFA/PRN)
- *Real Navy MFA* (53C)

Pre-exposure
(*Before* CEE)

- Animal(s) tagged
- Focal follow (RHIB)
- Scaled source ~ 1km
- Navy ship range modeled

Post-exposure
(*After* CEE)

- Visual survey, focal follow
- Source vessel ~1km
- Navy ship range modeled
- VHF tracking of tags

Photo taken under U.S. NMFS permit # 14534

SOCAL-BRS COORDINATION WITH NAVY TRAINING: *OVERALL OBJECTIVES*

- Evaluate the feasibility of conducting Behavioral Response Studies (BRS) in **coordination with ongoing unit-level Navy training ops**

- Obtain data on behavioral response of marine mammals to **actual mid-frequency 53C sonar**

- Evaluate how responses to small scaled [surrogate] source compare with those to actual 53C sonar
  - Better understand the interaction of sound Received Level (RL) and range to source as factors in animal response

BRS CEE PLANNING TOOL

PREDICTED SOUNDFIELD, REQUESTED SHIP TRACK AND PREDICTED RL
(CEE #2 - 10 JULY BLUE WHALE)

END SHIP-WHALE RANGE: 7.7 nm
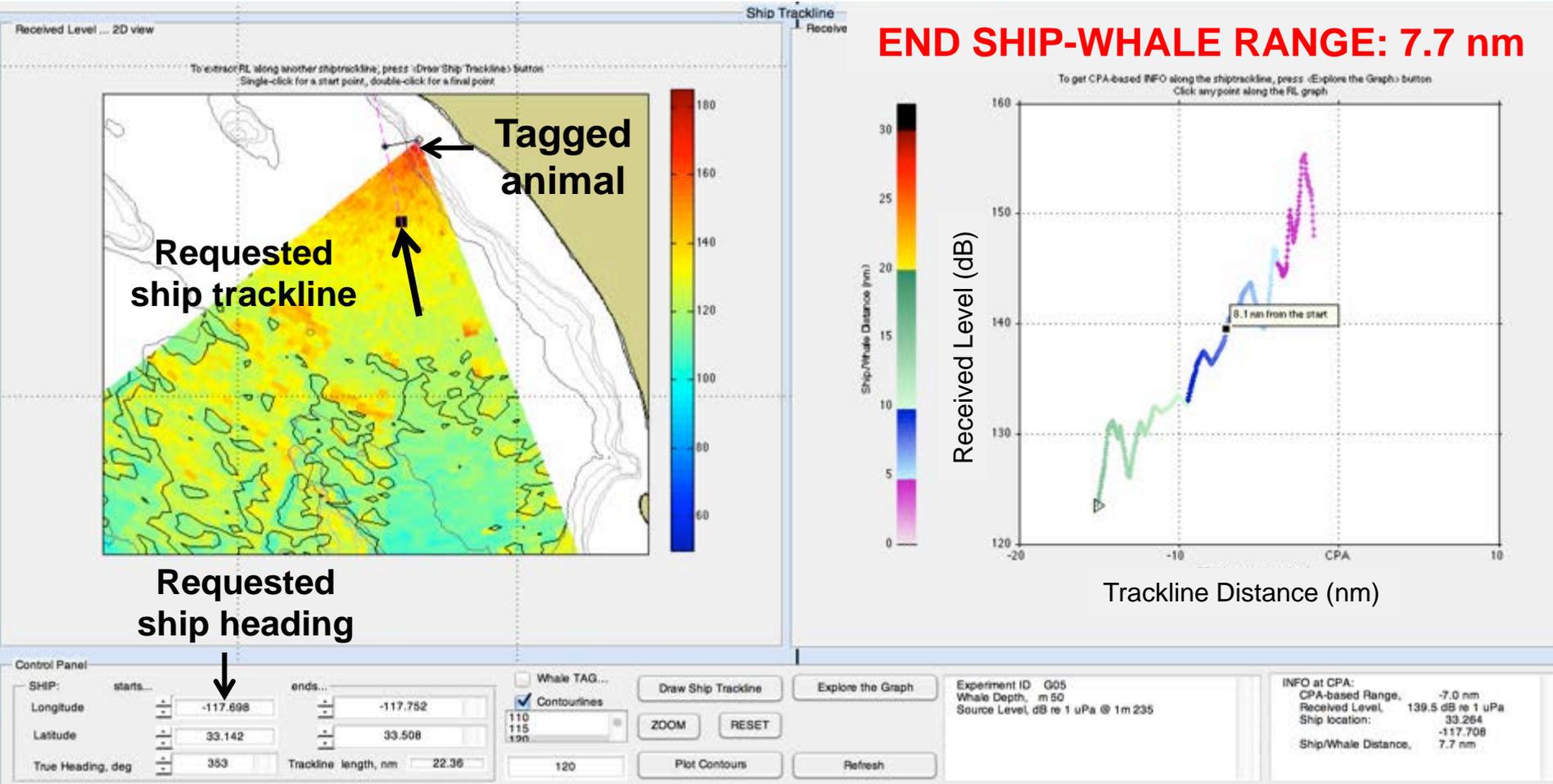
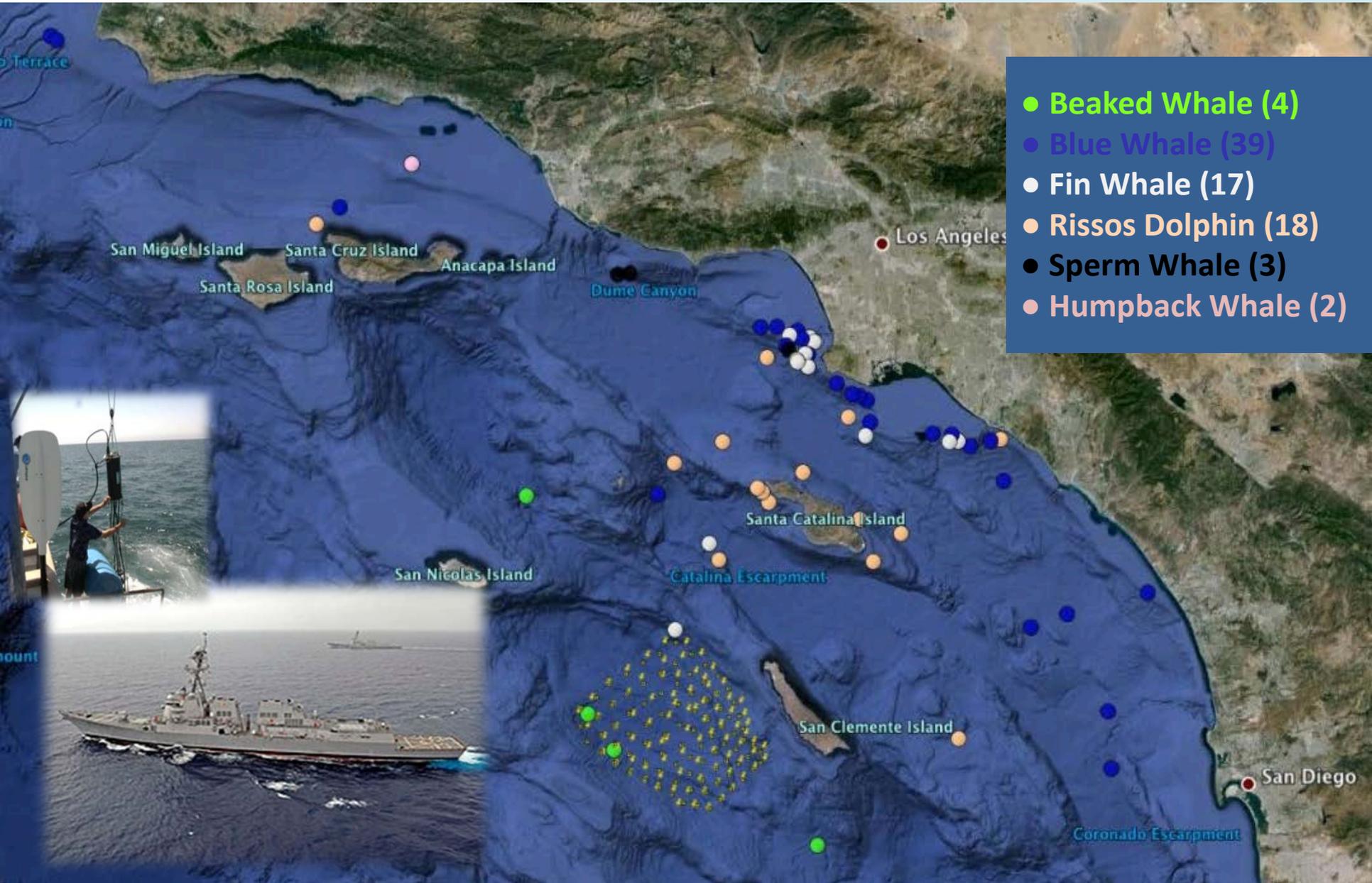# ACCOMPLISHMENTS JULY TO AUGUST 2013 FIELD OPERATIONS

- **Successful, close field coordination** between SOCAL-BRS team and two Navy vessels conducting regular MFA sonar and other training operations. Both the U.S. DDG and U.S. CG were extremely accommodating

- **SOCAL-BRS Team tagged nine animals** from the 4 focal species (Cuvier's beaked whale, Risso's dolphin, fin whale, and blue whale)

- **Five full CEE sequences** using full-scale 53C MFA sonar (**first ever conducted, including first-ever with Cuvier's beaked whale**).

  - All were conducted IAW specified protocols (most at or near full duration) and with no required shut-downs for nearby animals.

- **Demonstrated that CEE with actual Navy MFA sonar can be done safely.**

SOCAL-BRS Animals Tagged (2010-2013)

- Beaked Whale (6)
- Blue Whale (67)
- Fin Whale (19)
- Rissos Dolphin (28)
- Sperm Whale (3)
- Humpback Whale (2)
- Minke Whale (1)
- Bottlenose Dolphin (8)
- Common Dolphin (2)

Photo taken under U.S. NMFS permit # 14534

SOCAL-BRS CEEs (2010-2013)

- **Beaked Whale (4)**
- **Blue Whale (39)**
- **Fin Whale (17)**
- **Rissos Dolphin (18)**
- **Sperm Whale (3)**
- **Humpback Whale (2)**

SOCAL-BRS Accomplishments (2010-13)

Species	Animals Tagged	Total CEEs	Real Navy MFA	Scaled Source MFA	Scaled Source PRN	Silent Control
Cuvier's Beaked Whale *	6	3	1	2		
Baird's Beaked Whale *	1	1		1		
Sperm Whale	1	3		1	1	1
Blue Whale *	67	39	2	20	15	2
Fin Whale *	19	17	1	8	4	4
Humpback Whale	2	2		2		
Minke Whale	1	0				
Risso's Dolphin *	28	18	2	8	2	6
Bottlenose Dolphin	8	0				
Common Dolphin	2	0				

* Focal Species

SOCAL-BRS DATA AND ANALYSIS TYPES

Diving, Kinematics

(Tag Sensors)
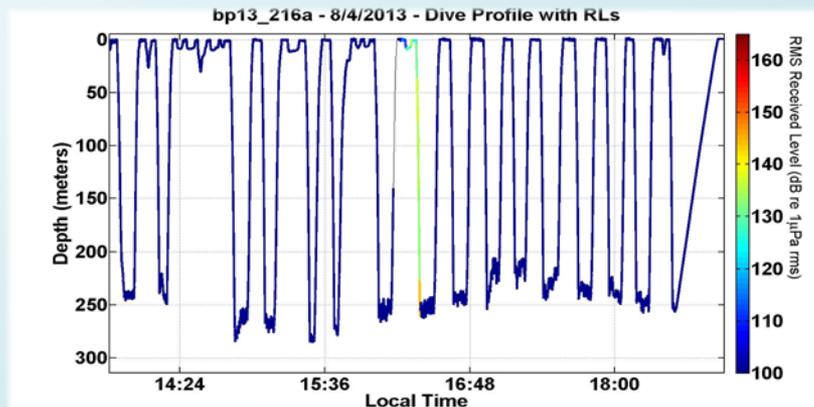
Acoustics: vocals, noise exposure (Tag Sensors)

(Arranz et al. – poster 49 Tues)
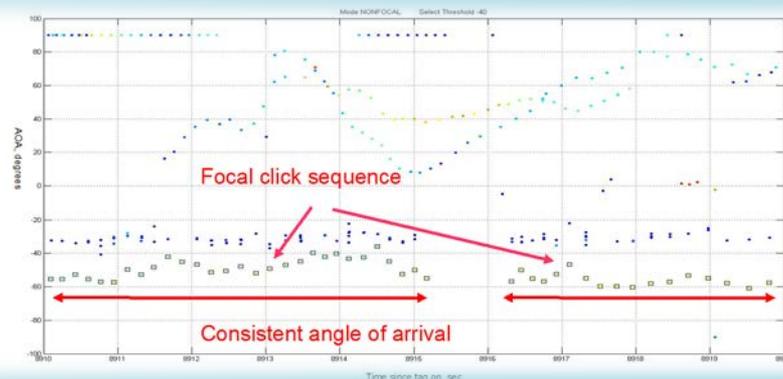
Position, Social Behavior

(Visual Focal Follow)
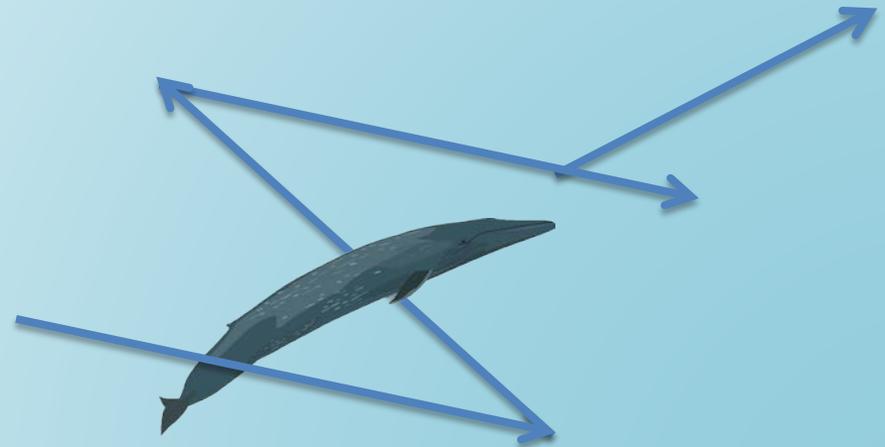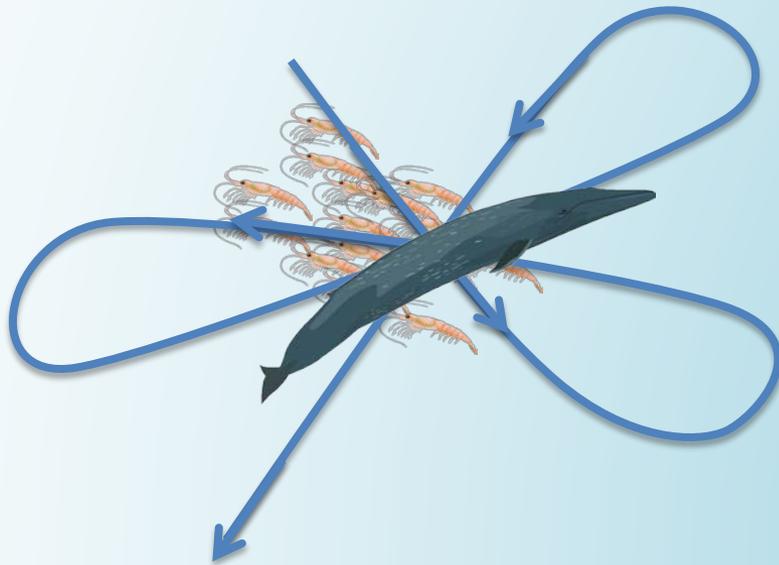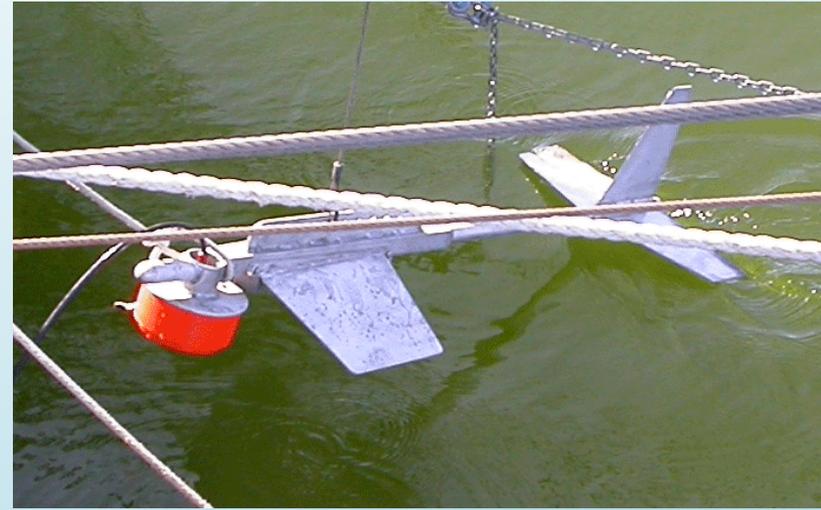
Baleen Whale Tags & Prey Data
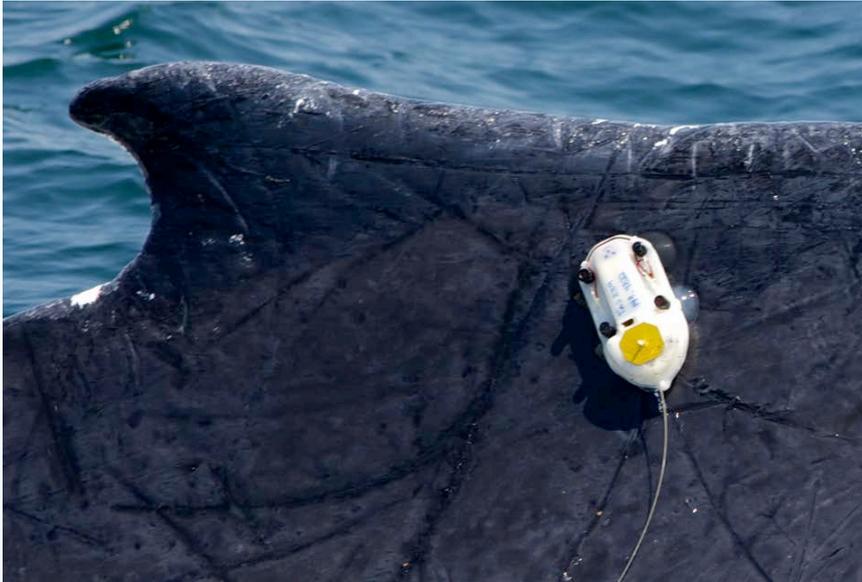
D-tag to measure fine-scale kinematics below the water (Johnson and Tyack 2003)

Fisheries acoustics (38 kHz and 120 kHz) to measure prey patch metrics (e.g. size, depth, density)

Prey Mapping Protocol (Baleen whales)

- Calibrated echosounders
- One hour of prey data collected before and after BRS playback (~2-3 hours apart)
- Adaptive sampling:

Fine scale kinematics

- Foraging strategies change with prey
  - Whales are more "acrobatic" with shallower and less dense prey patches.

- Implies **more energy** expended on **lower quality** prey.

- Effects of playbacks on foraging whales?
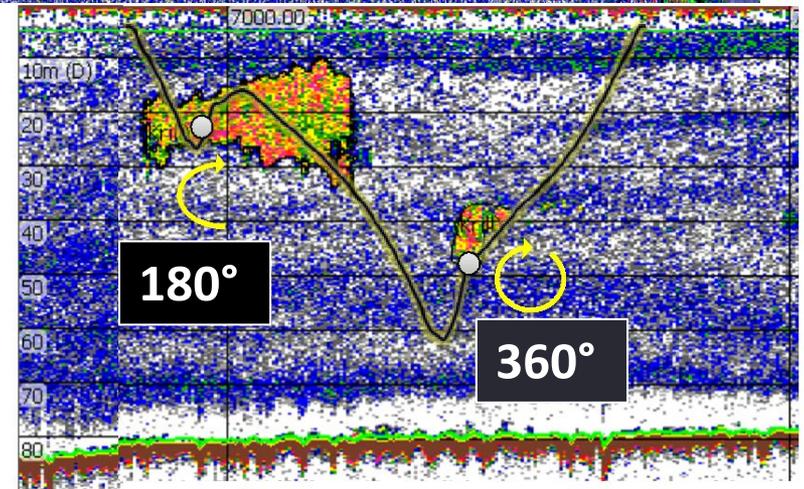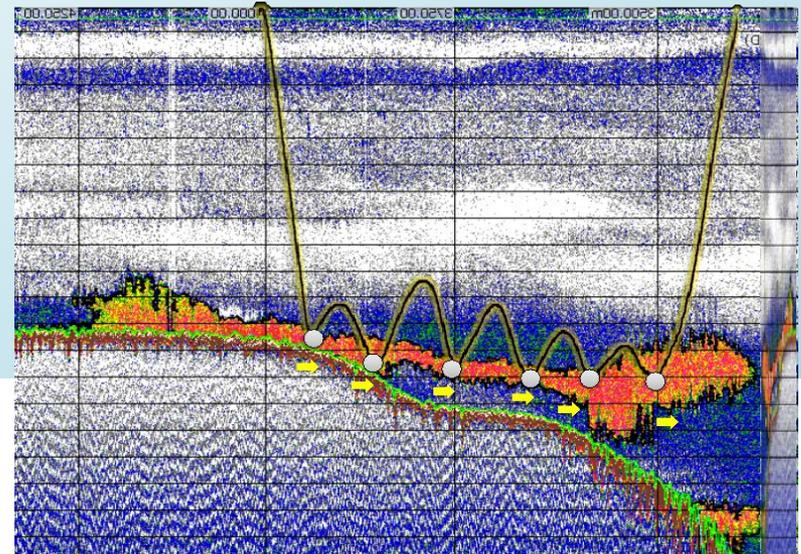
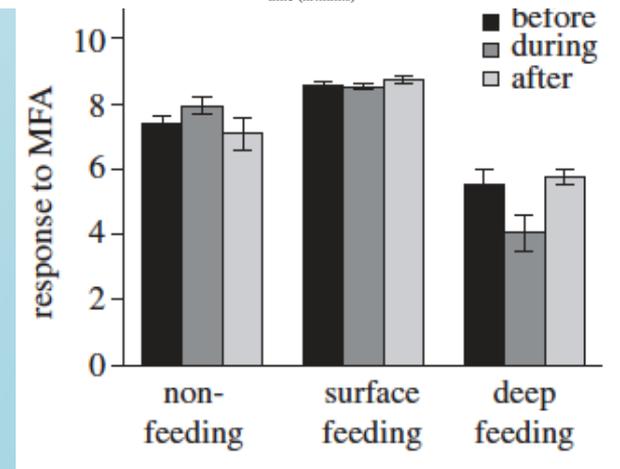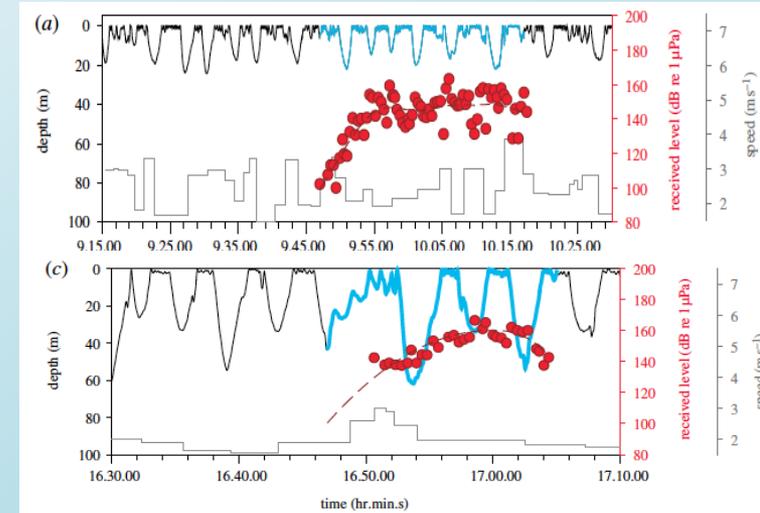# SOCAL BRS RESULTS SUMMARY: *BLUE WHALES*

Scaled source MFA CEEs

- Prey influences feeding behavior
- No clear responses in many whales
- Clear responses at low RLs in some whales (rapid recovery)
- Responses context-dependent

Real Navy MFA CEEs

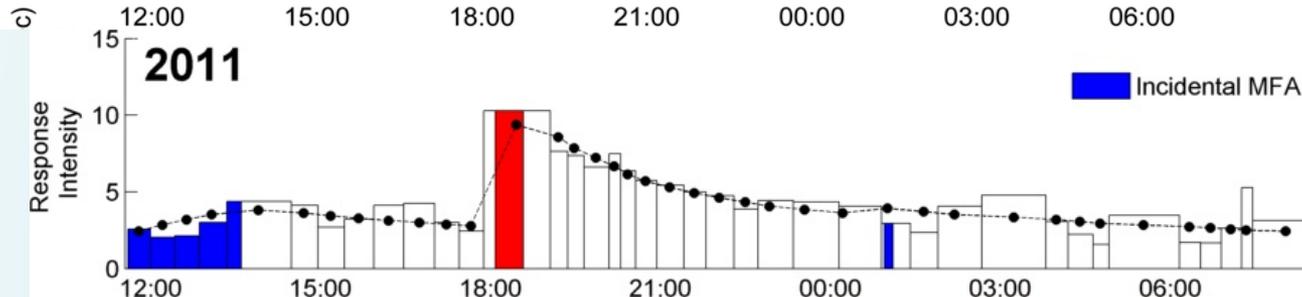- Analysis ongoing (+ fin, Rissos)
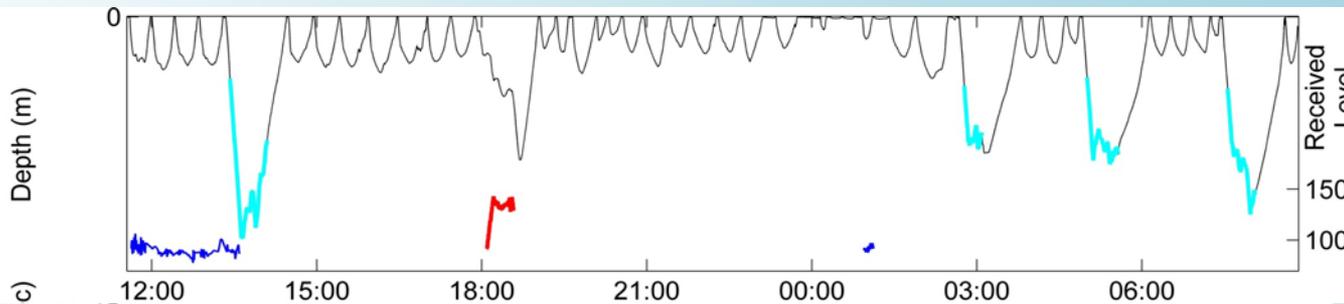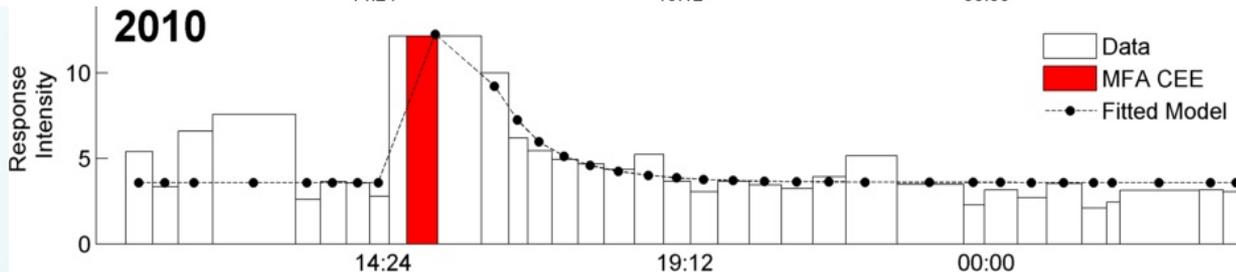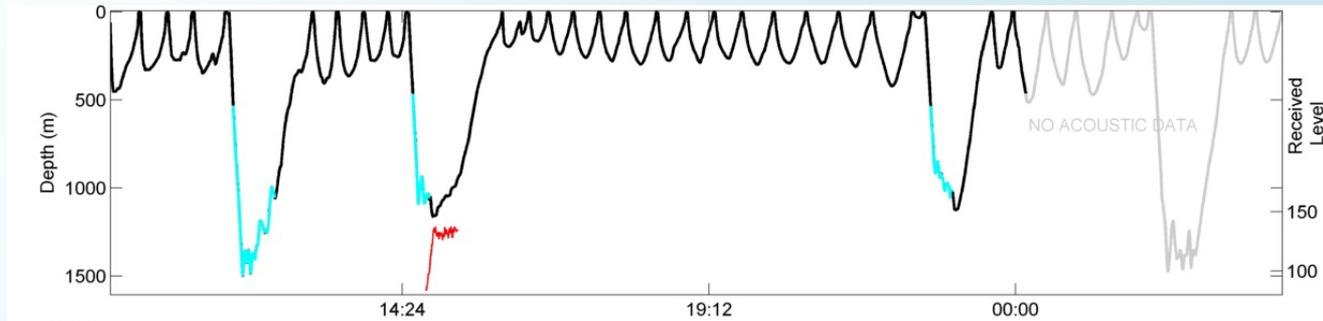- Top priority in 2014-15

(Goldbogen *et al.*, 2012)

SOCAL-BRS RESULTS:
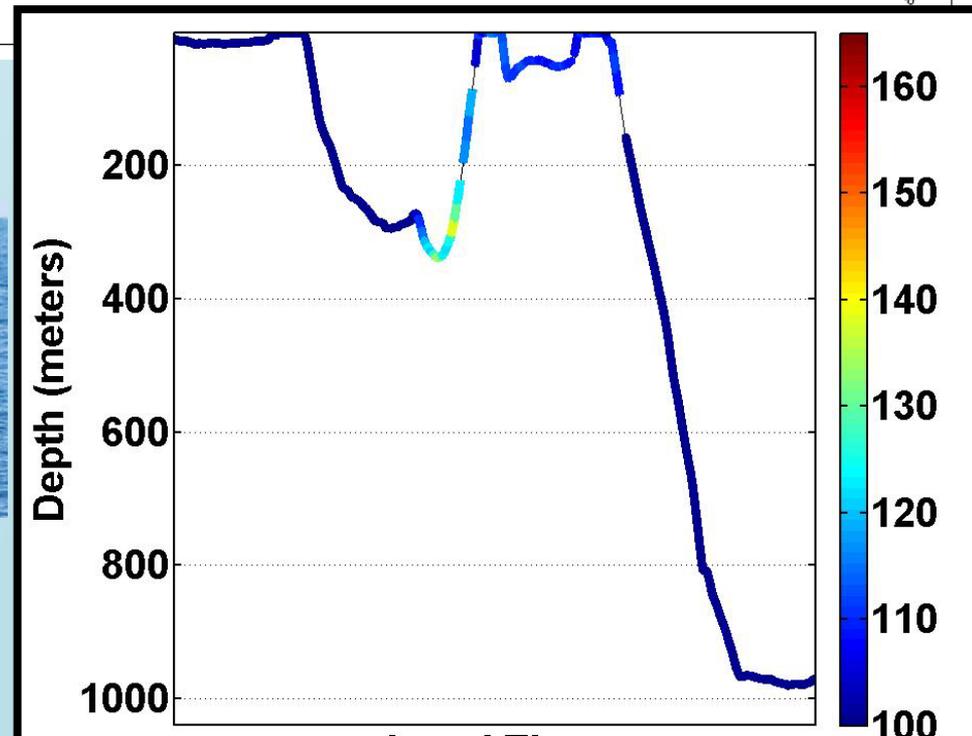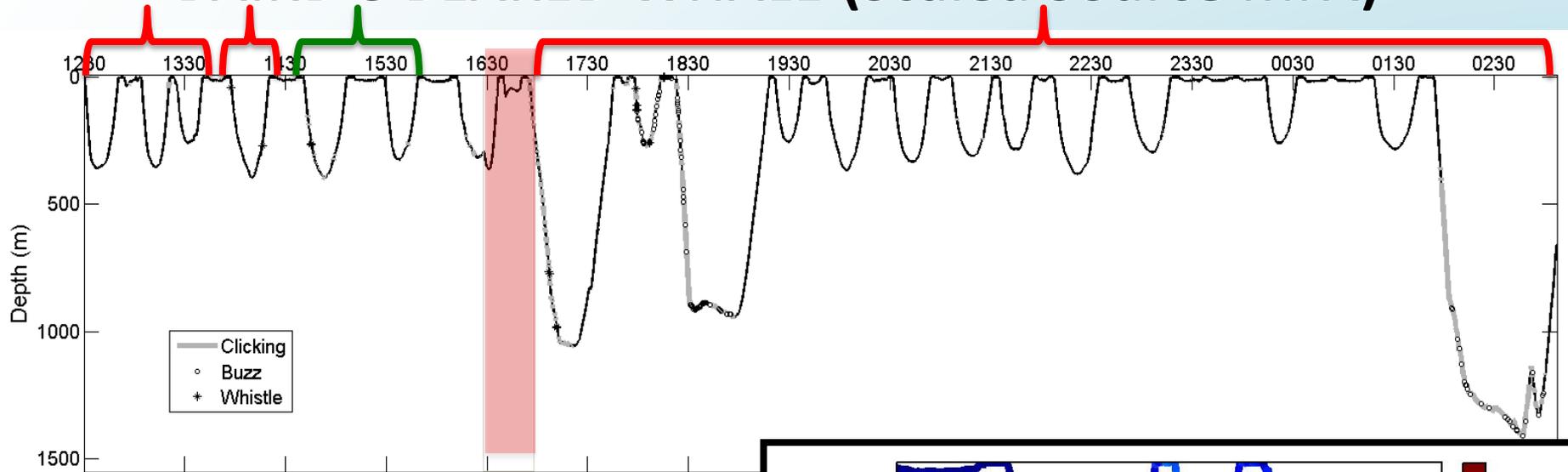## *CUVIER'S BEAKED WHALES* (Scaled Source MFA)

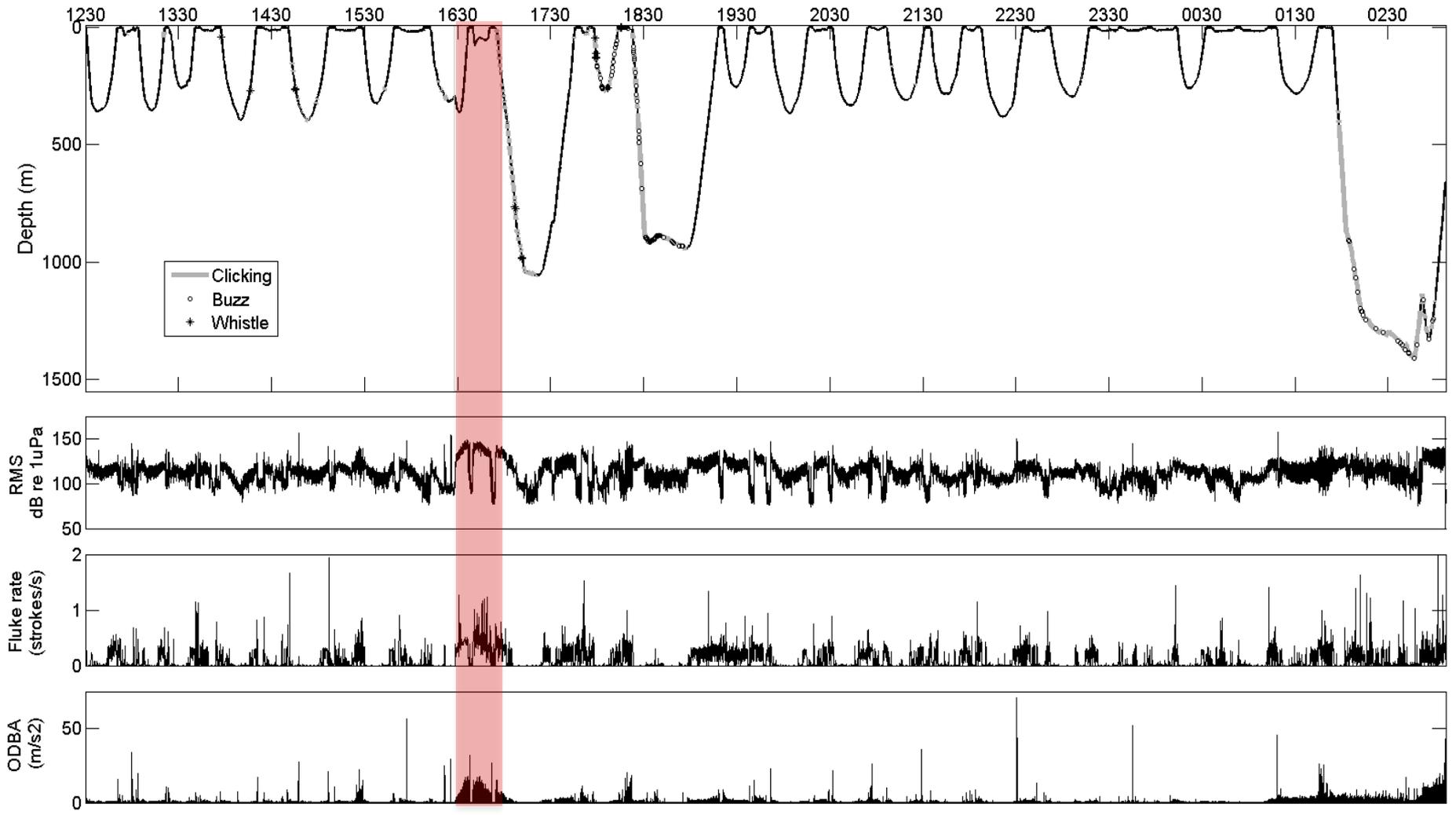De Ruiter *et al.*, 2012)

SOCAL-BRS RESULTS:
BAIRD'S BEAKED WHALE (Scaled Source MFA)

SOCAL-BRS RESULTS:
BAIRD'S BEAKED WHALE (Scaled Source MFA)

SOCAL BRS RESULTS:
BEAKED WHALES (Real Navy MFA CEE)

SOCAL-BRS Collaboration with *USS Dewey* (DDG 105) 29 July 2013

END SHIP-WHALE RANGE: 37.9 nm

Photo taken under U.S. NMFS permit # 14534
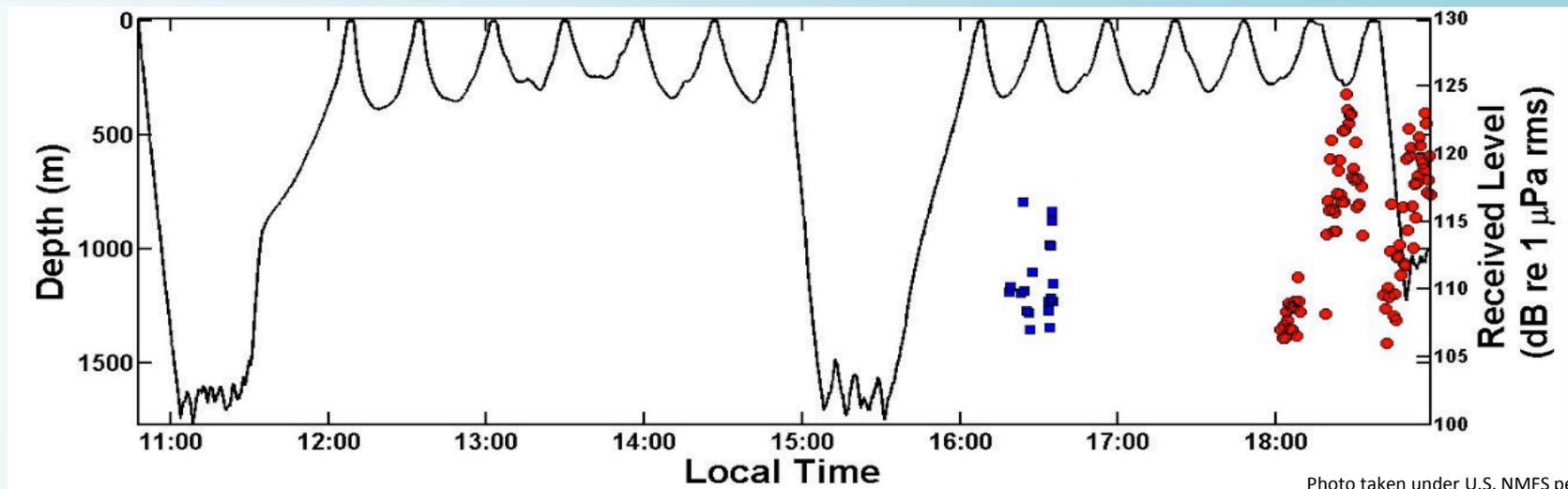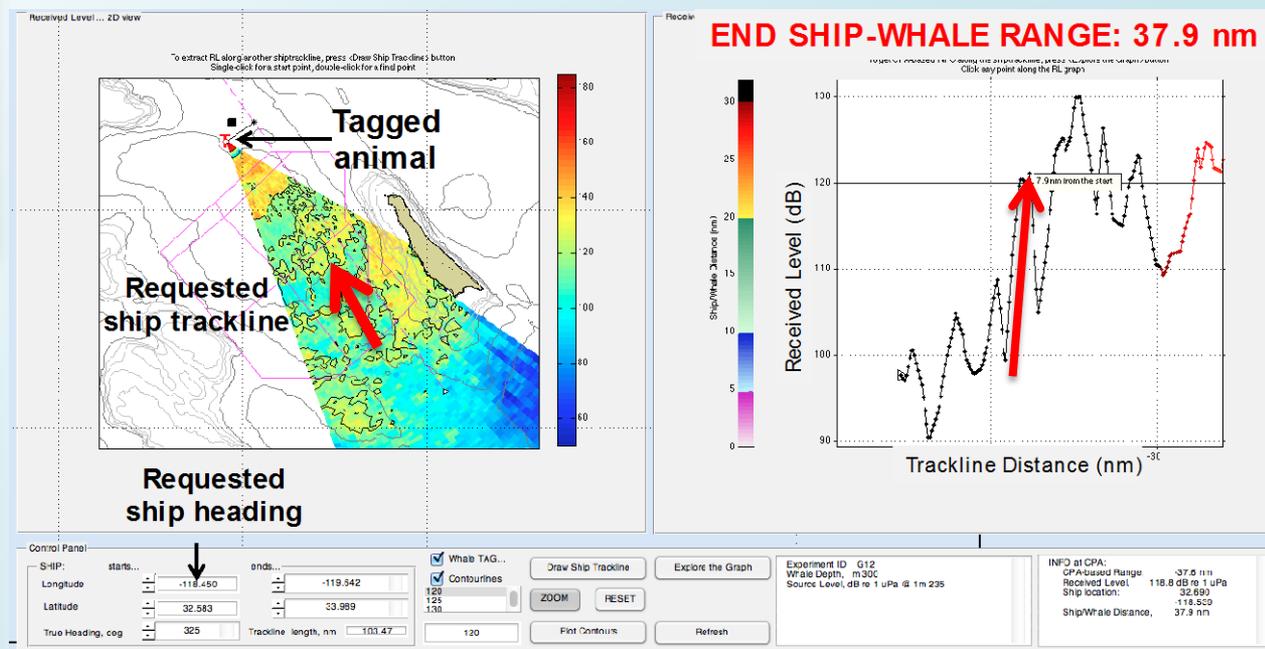
SOCAL-BRS RESULTS: *BEAKED WHALES*

2 Cuvier's beaked whales (nearby scaled source MFA)

(De Ruiter *et al.*, 2012)

- Strong, sustained responses - very low RLs
- No clear response to distant, incidental real sonar

1 Baird's beaked whale (nearby scaled source MFA)

- Similarities to Cuvier's (and Blainville's – Tyack *et al.*, 2011) scaled source responses, but rapid recovery

(Stimpert *et al.*, in review)

1 Cuvier's beaked whale (distant real Navy MFA)

- Analysis ongoing but similar to 2011 distant incidental - lack of clear response to real sonar CEE but some caveats

SOCAL-BRS Conclusions and Next Steps

Novel findings using simulated sonar CEEs

- Species differences (beaked whales most sensitive)

- Strong context dependence in response type, probability

- Relevant and useful starting point

Going to realistic scales and scenarios

- Major step forward using real Navy ships in CEEs

- Top priority for 2014-15 (adaptive approach)

- Monitor large areas, multiple tags, PAM; extend duration

New approaches for smaller delphinids

SOCAL-BRS Acknowledgements

Sponsors: **US Navy Living Marine Resources Program, OPNAV N45 & ONR Marine Mammal Program**

NOAA: NMFS Offices of Science & Technology, Protected Resources, and SWFSC; Channel Islands National Marine Sanctuary; SW Stranding Network

Crews of the *R/V Truth* (Truth Aquatics) and *R/V Sproul* (SIO)

CA Coastal Commission, Mark Delaplaine, Michael Jasny, Sarah Wan, Tammy Adams, Sarah Wilkin, Ned Cyr, Jason Gedamke, Teri Rowles, Walter Zimmer, Fleur Visser, Doug Nowacek, Dave Johnston, Ian Boyd, Chris Clark

RESERVE SLIDES

SOCAL-BRS Publications

- Southall, B. L., D. Moretti, B. Abraham, J. Calambokidis, P.L. Tyack. (2012). Marine Mammal Behavioral Response Studies in Southern California: Advances in Technology and Experimental Methods. Marine Technology Society Journal 46, 46-59.

- Goldbogen J.A., Calambokidis J., Friedlaender A.S., Francis J., DeRuiter S.L., Stimpert A.K., Falcone E., Southall B.L. (2012). Underwater acrobatics by the world's largest predator: 360° rolling manoeuvres by lunge-feeding blue whales. Biology Letters 9:20120986. http://dx.doi.org/10.1098/rsbl.2012.0986

- DeRuiter S.L., Southall B.L., Calambokidis J., Zimmer W.M.X., Sadykova D., Falcone E.A., Friedlaender A.S., Joseph J.E., Moretti, D., Schorr G.S., Thomas L., Tyack P.L. (2013). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. Biology Letters 9: 20130223. http://dx.doi.org/10.1098/rsbl.2013.0223.

- Goldbogen J.A., Southall B.L., DeRuiter S.L., Calambokidis J., Friedlaender A.S., Hazen E.L., Falcone E.A., Schorr G.S., Douglass A., Moretti D.J., Kyburg C., McKenna M.F., Tyack P.L. (2013). Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society B: 20130657. http://dx.doi.org/10.1098/rspb.2013.0657

SOCAL-BRS Publications

- Yack, T.M., J. Barlow, J. Calambokidis, B. Southall, S. Coates. (2013). Identification of previously unknown beaked whale habitat in the Southern California Bight using a towed hydrophone array. J. Acoust. Soc. Amer. 134, 2589-2597.

- Friedlaender A.S., Goldbogen, J..A. Hazen E.L., Calambokidis, J.A., Southall, B.L. (2014). Feeding performance of sympatric blue and fin whales exploiting a common prey resource. Marine Mammal Science (online)

- Goldbogen, J. A., A. K. Stimpert, S. L. DeRuiter, J. Calambokdis, A. S. Friedlaender, G. S. Schorr, D. J. Moretti, P. L. Tyack, B. L. Southall. (in press). Using accelerometers to determine the calling behavior of tagged baleen whales. Journal of Experimental Biology xx: xx-xxx.

Various Tags Used and Deployment Strategies

Tag type (manufacturer)	Application	Acoustic, Movement Sampling Specs	Deployment Strategy
DTAG v2 (WHOI)	Acoustic 3D movement	196 kHz acoustic 50 Hz non-acoustic	- Primary initial tag proven on many species (best baleen) - Geo-referencing or 2nd sensor required for GPS position
DTAG v3 (WHOI)	Acoustic 3D movement	500 kHz acoustic 500 Hz non-acoustic	- Higher acoustic, sensor sampling ideal for odontocetes - Geo-referencing or 2nd sensor required for GPS position
Bprobe (Greeneridge)	Acoustic 2D movement	7.4 kHz acoustic Tilt/roll @ 1Hz	- Used in early deployments; link to related studies off California - Limited acoustic and movement sensor capabilities
ACOUSONDE (Greeneridge)	Acoustic 3D movement	464 kHz acoustic 800 Hz non-acoustic	- Acoustic and sensor capabilities increased; similar to DTAG v3 - Lack GPS and timed release mechanism
Mk-10F (Wildlife Computers)	Time-depth (2D) Fast Lock GPS	No acoustic 1 Hz depth	- Used primarily as 2nd/dual tag for GPS position (baleen whales)
Sirtrack F2G	Fast Lock GPS	–	- Used as piggyback tag (on DTAG v2 or ACOUSONDE) for GPS
Spot5 and MK-10A (Wildlife Computers)	Location, simple dive stats	–	- Companion project for longer-term satellite tagging and tracking but also in re-locating tagged animals for short-term tags