



Basic Biological and Behavioral Response Studies of Marine Mammals to Human Sound [Southern California, 2010 (SOCAL-10)]

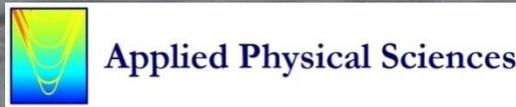
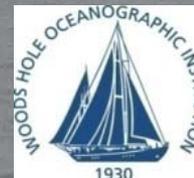
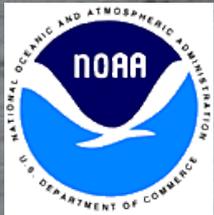
NOAA Library, Silver Spring, MD

5 January 2011

Brandon Southall (SEA, Inc, UCSC)



Photo taken under U.S. NMFS permit # 14534



Institute of Marine Sciences
an Organized Research Unit
at UC Santa Cruz

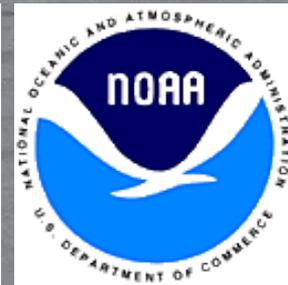
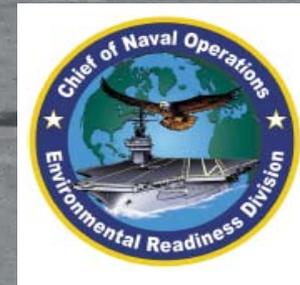




SOCAL-10: Overall Description and Objective

SOCAL-10 is an *interdisciplinary research collaboration* designed to *increase understanding of marine mammal behavior and reactions of sound.*

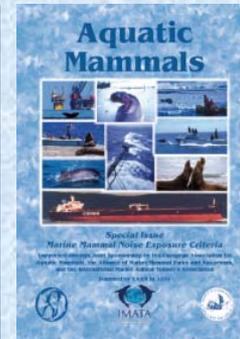
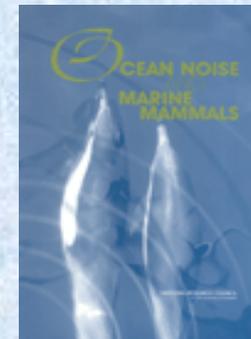
Objective is to provide a *scientific basis for estimating risk and minimizing impacts for U.S. Navy and regulatory agencies*



Overview - Marine Mammals and Sonar: *Need for Directed Behavioral Response Studies*



- Strandings coincident with some sonar training exercises in certain circumstances
- Vast scientific uncertainty = divergent speculation on possible adverse impacts (litigation, media, delays)
- Numerous scientific and government panels/task forces have called for *behavioral response studies (BRS)*



Marine Mammal Behavioral Responses to Sound: *Experimental Field Studies*



Behavioral Response Study 2007-2008 (AUTEC, Bahamas)



MED-09: Behavioral and Biological Studies in the Mediterranean Sea



Cetacean responses to military sonar (Norway)

Humpback Whale Responses to Seismic Airguns (Australia)

SOCAL-10: Biological and Behavioral Studies of Marine Mammals in Southern California





SOCAL-10: Objectives

- 1) Tag a variety of species and obtain baseline behavioral data***
- 2) Conduct controlled exposure experiments (CEEs) using similar methods to pioneering studies (before, during, after)***
- 3) Test optimal configuration for subsequent studies, which may include realistic/actual military sources.***
- 4) Obtain data to support range monitoring/habitat models***

Provide a scientific basis for estimating risk and minimizing impact of sound to navies and regulators





SOCAL-10: Overall Approach and Focal Species

Approach: *Extend* previous BRS methods to and *integrate* with ongoing range monitoring and mammal studies in southern CA



Focal Species: Blue, Fin, Beaked, Sperm whales; Various dolphins (Risso's, Common, Bottlenose, White-sided, northern right whale)



SOCAL-10: Timing, Vessels, & Operational Area

TIMING and VESSELS

Scouting Leg: 6 to 18 Aug (*R/V Truth*)

Leg I : 22 Aug to 10 Sept (*R/V Truth*)

Leg II: 21 Sept to 1 Oct (*R/V Sproul*)



Operational Area: Inshore and Offshore waters from Morro Bay to San Diego



SOCAL-10: Multidisciplinary Approach



Visual observers, experienced in sighting animals miles away with powerful binoculars, search for subjects and monitor during tagging, CEEs.

Photo identification to catalog and track of individuals (incl. long-term) and groups sighted and involved in CEEs





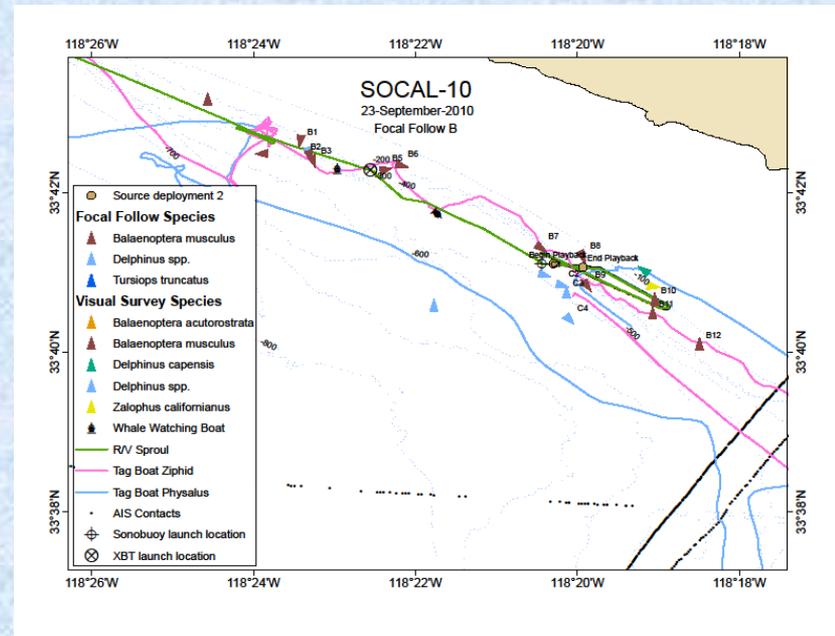
SOCAL-10: Multidisciplinary Approach



Photo taken under U.S. NMFS permit # 14534

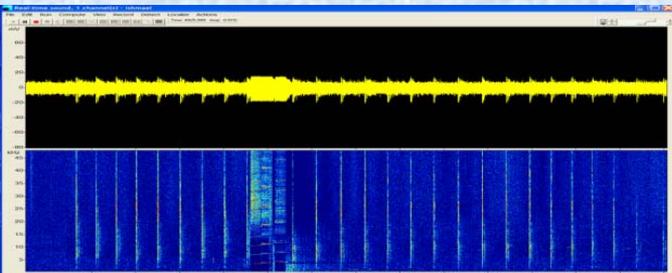
Tagging teams carefully approached animals and deployed acoustic monitoring tags (Dtag, Bprobe, AcouSonde) with suction cups; provided visual monitoring during CEEs

Whale Identification Logging and Display (WILD) engineers integrated vessel position, visual sightings, and environmental data, for operational awareness and data archive





SOCAL-10: Multidisciplinary Approach



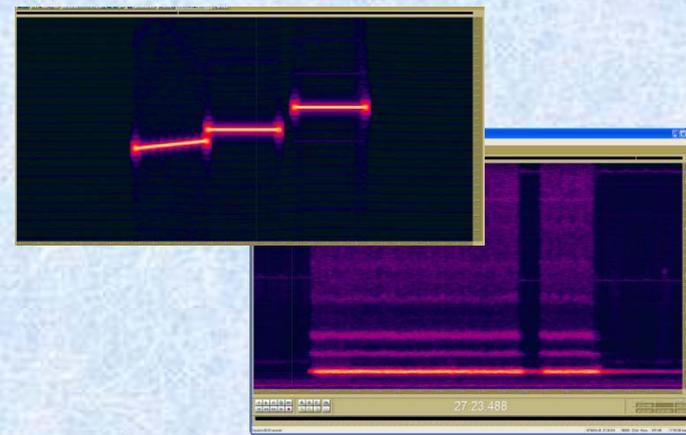
Passive acoustic observers used listening sensors to detect animals and monitor exposures and responses

SOCAL-10 sound source was custom-built, relatively light, vertical array (up to 210 dB)



CEE signal types:

- Simulated mid-freq (MFA) sonar
- Pseudo-random noise (PRN)



BRS scouting effort - 2010



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Data SIO, NOAA, U.S. Navy, NGA, GEBCO

33°31'05.76" N 118°49'34.90" W elev -3855 ft

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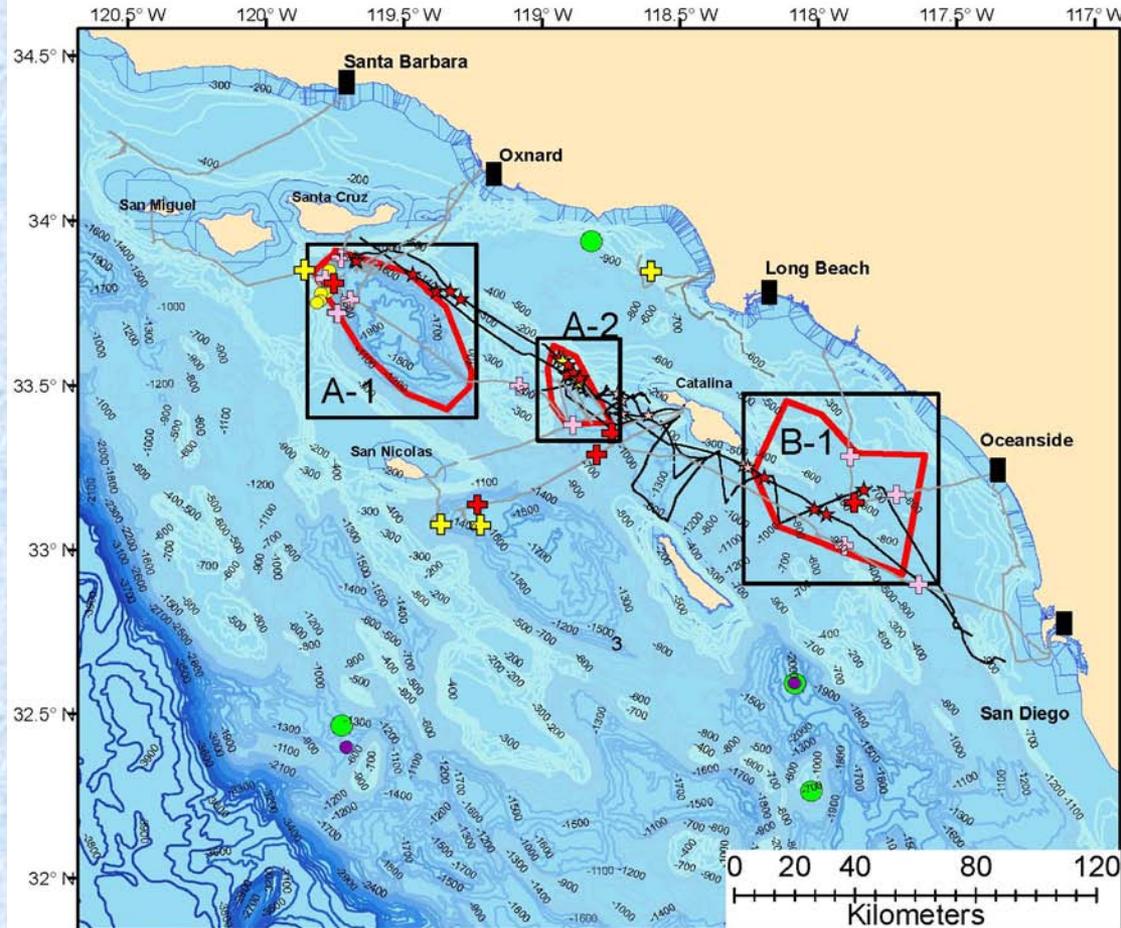
Eye alt 19

Scouting sightings, IDs, and samples

Species	Truth		RHIBs					LIMPET
	Sghtings	# Ind	Sightings	# Ind	Est IDs	# Samples	SC Depl.	Depl.
Blue whale	73	121	130	178	161	18	4	0
Fin whale	11	19	30	44	35	4	0	0
Humpback whale	33	83	20	59	45	3	0	0
Minke whale	5	5	5	5	3	0	0	0
Sperm whale	2	2	3	1	1	2	0	1
Baird's beaked whales	2	11	2	11	6	0	0	1
Cuvier's beaked whale	2	2	1	1	1	1	0	0
Killer whale								
Risso's dolphin	10	64	6	72	42	0	0	0
Bottlenose dolphin	9	114	2	17	17	0	0	0
Long-beaked common dolphin	23	1,721	3	90		0	0	0
Short-beaked common dolphin	11	1,431	2	56		0	0	0
Common dolphin	85	2,283	45	2792	801	0	0	0
Pacific white-sided dolphin	2	8	2	11		0	0	0
Dall's porpoise	1	6						
Total	269	5,870	251	3,337	1,112	28	4	2

SOCAL-10 Scouting Leg: PAM Detection of Beaked Whales

SWFSC/Cascadia Acoustic Beaked Whale Detections 2009-2010



Legend

- 2010 Beaked Whale Survey Area
- OW08 Squid Jigging Station Start
- 2009 Ship Track
- OW08 Squid Catch
- 2010 Ship Track

Acoustic BW Detections Detection Quality

- | 2009 | 2010 |
|--|--|
| ★ Possible | ✚ Possible |
| ★ Probable | ✚ Probable |
| ★ Definite | ✚ Definite |
| | ● Re-Sight |

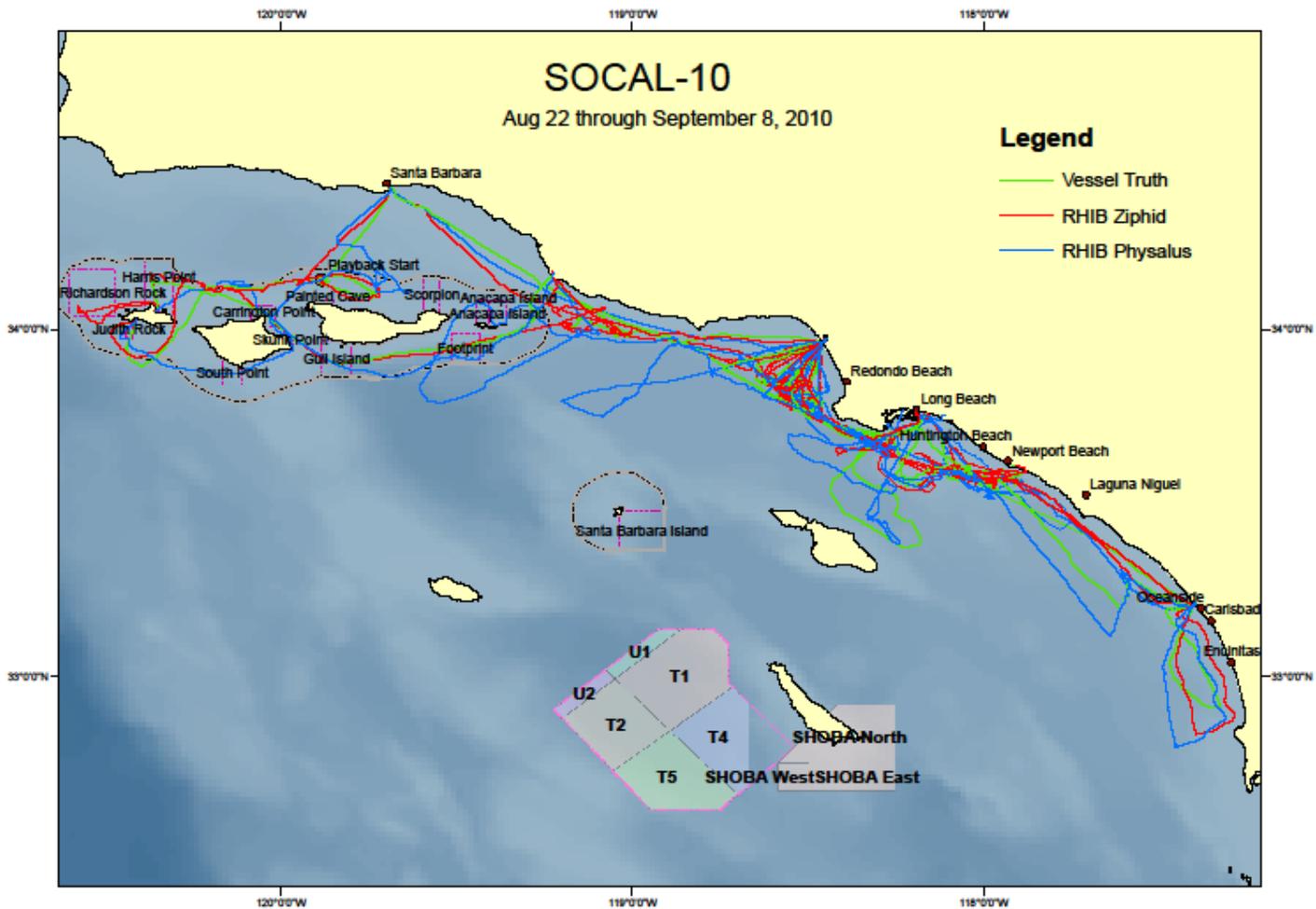
DEPTH

- | | |
|---|--|
| — -5300 - -4500 | — -2799 - -2300 |
| — -4499 - -4100 | — -2299 - -1800 |
| — -4099 - -3700 | — -1799 - -1300 |
| — -3699 - -3200 | — -1299 - -800 |
| — -3199 - -2800 | — -799 - -200 |





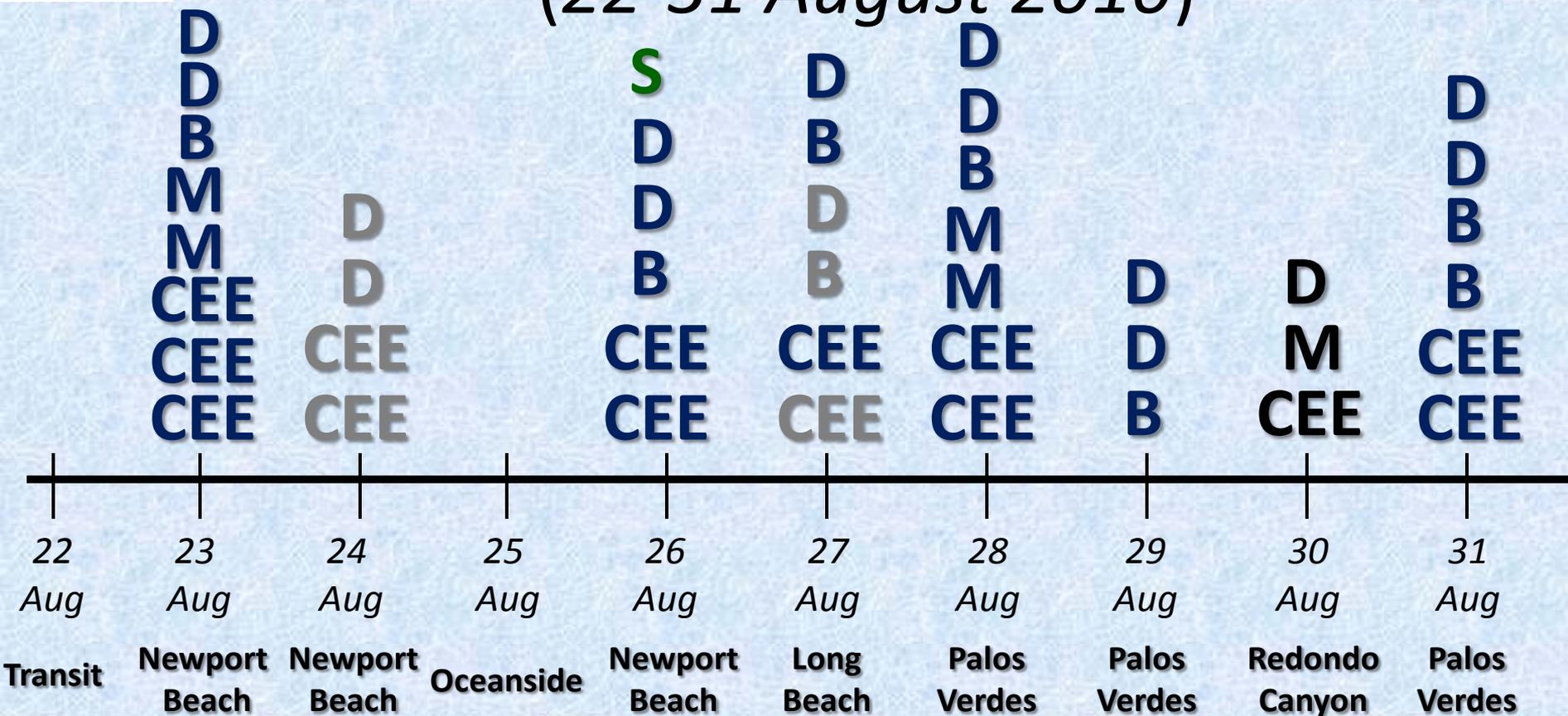
LEG I – R/V Truth GIS Track (22 Aug – 10 Sept 2010)





LEG I Operations Summary (1)

(22-31 August 2010)



D = Dtag (blue, fin, sperm)

B = Bprobe (blue, fin, sperm)

M = MK-10 (blue, fin, sperm)

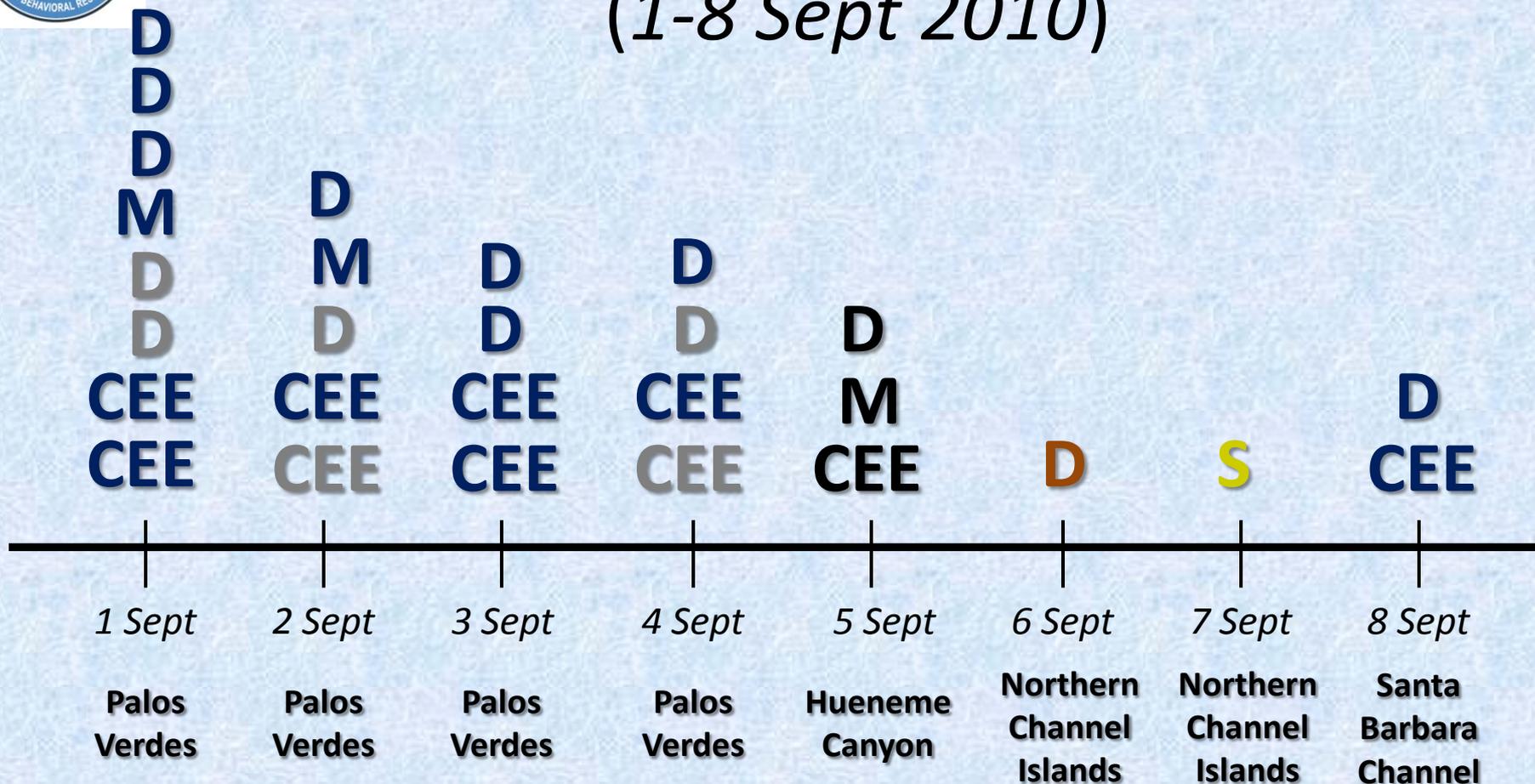
CEE (blue, fin, sperm)

S = Sat tag (sei)



LEG I Operations Summary (2)

(1-8 Sept 2010)



D = Dtag (blue, fin, sperm, bottlenose dolphin)

B = Bprobe (blue, fin, sperm)

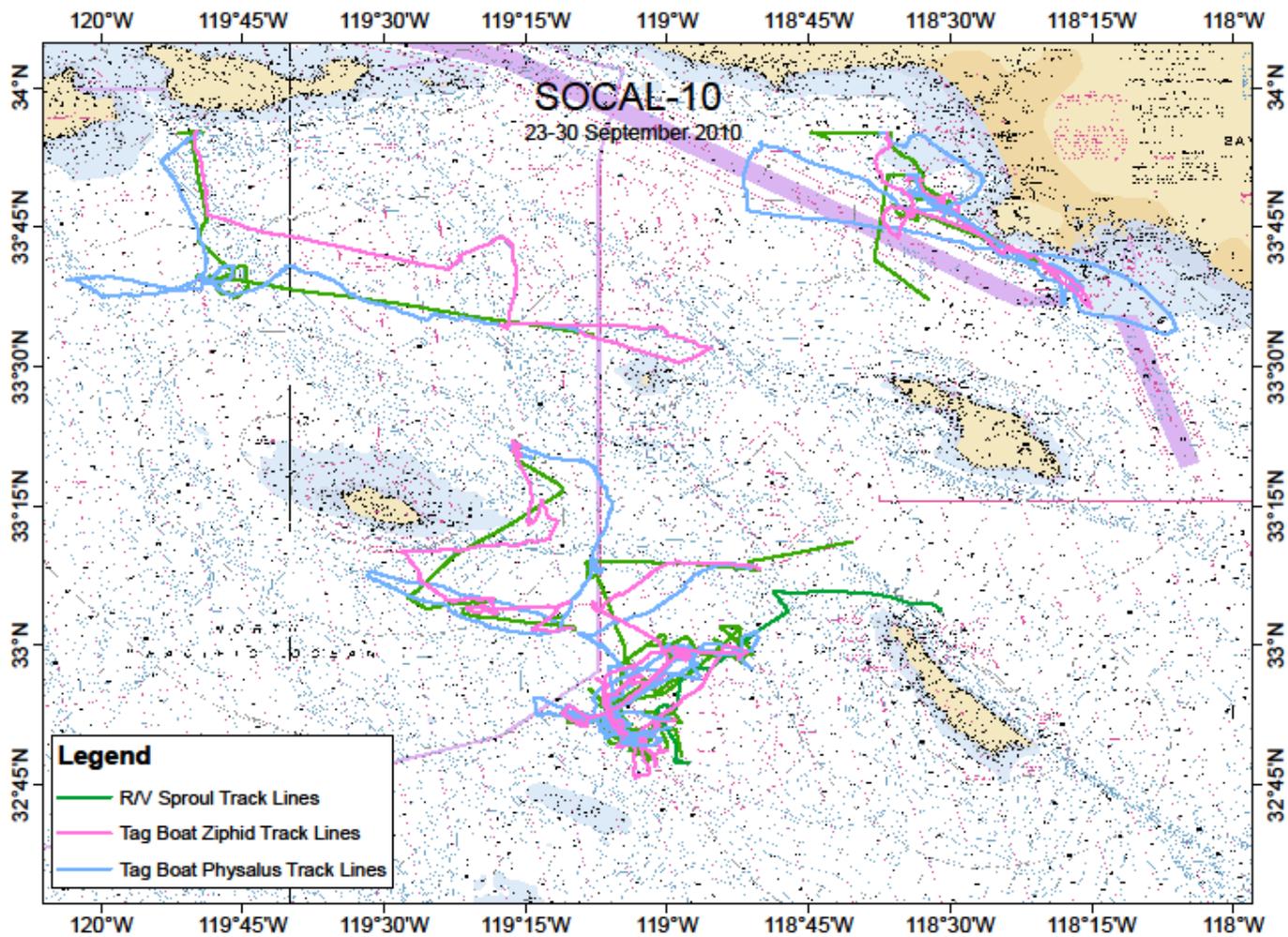
M = MK-10 (blue, fin, sperm)

CEE (blue, fin, sperm)

S = Sat tag (Orca)



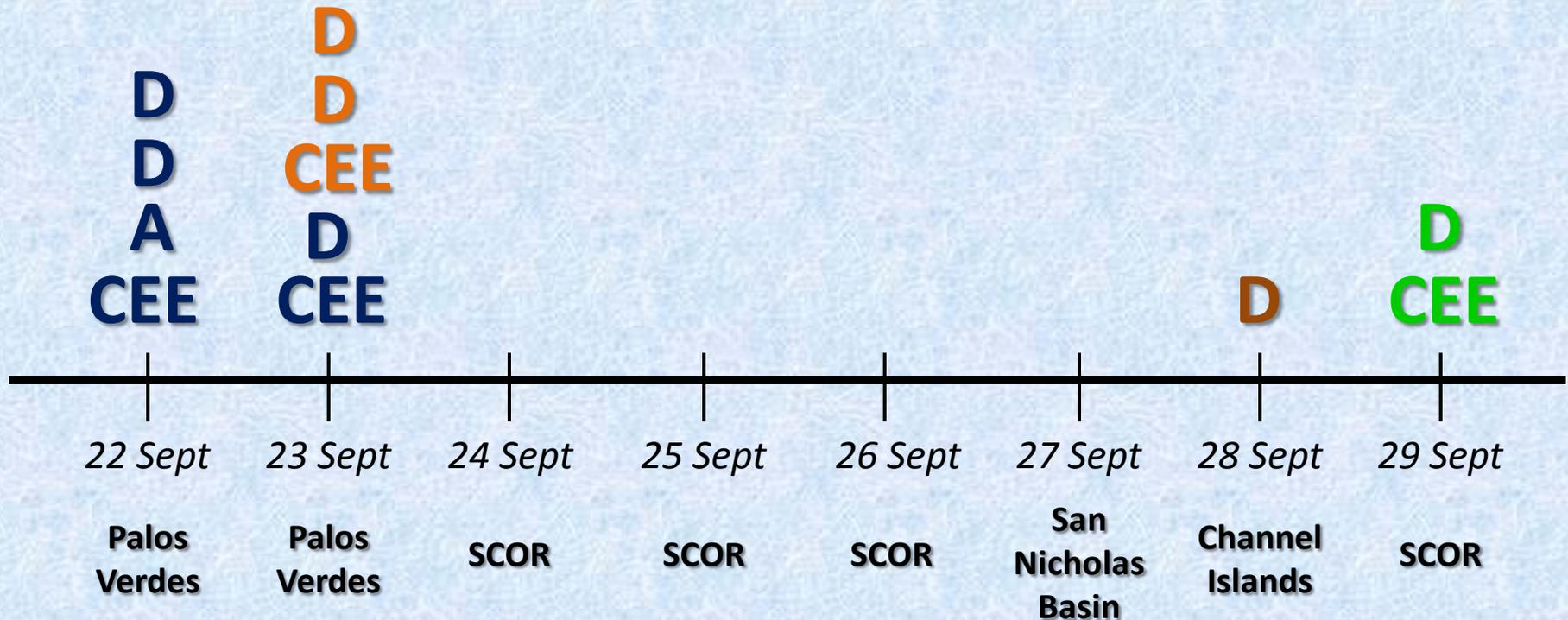
LEG II All vessels GIS Tracks (22-30 September 2010)





LEG II Operations Summary

(22-30 September 2010)



D = Dtag (blue, bottlenose, Risso's, Cuviers)

A = ACOUSONDE (blue)

CEE (blue, Risso's, Cuviers)



Preliminary Results from Visual Observations from Source Vessel

	Scouting <i>Truth</i>	Leg I <i>Truth</i>	Leg II <i>Sproul</i>
Number Survey Days	14	18	9
Survey Sightings	342	382	97
Focal Follows (tag & tagless)	3	38	9
Mitigation Sightings (post playback)	NA	64	6
Ave. Dist. of initial sight (km)	*	1.2	1.5
Number of mar.mam. Species	16	20	13
Number of groups photographed	69	51*	9*

*Data pending

RHIB sightings, photo-IDs, samples, and deployments – All BRS legs

Species	Sightings	Individuals	Est IDs	Samples	SC Depl.	LIMPET	Comments
					events	Depl.	
Blue whale	275	466	358	46	40	-	
Fin whale	81	135	104	19	7	-	
Sei whale	1	1	1	1	-	1	
Brydes/sei whale	1	1		-	-	-	
Brydes whale	3	3	3	1	-	-	
Minke whale	20	21	9	2	-	-	
Humpback whale	31	75	49	4	-	-	
Sperm whale	5	5	5	2	4	1	All same individual
Baird's beaked whale	4	62	10	-	-	1	
Cuvier's beaked whale	8	19	16	2	1	-	
Long beaked common dolphin	13	1,286	166	-	-	-	
Short Beaked common dolphin	10	842	-	-	-	-	
Delphinus species	87	5,820	813	-	-	-	
Grampus	25	522	203	5	2	-	
N right-whale dolphin	1	60	60	-	-	-	
Bottlenose dolphins	17	238	62	2	2	-	
Pacific white sided dophin	5	54		2	-	-	
Killer whale	1	7	7	2	-	1	
Dall's popproise	1	2	2	-	-	-	
Unident. Lg Cetacean	3	4		-	-	-	
Unident. Mar. Mamm.	2	2		-	-	-	
Unident. Sm Cetacean	1	4		-	-	-	
Total	595	9,629	1,868	88	56	4	

SOCAL-10 Observations of Human/Vessel Interactions





SOCAL-10 ACCOMPLISHMENTS: TAG DEPLOYMENTS

Scouting/LEG I Summary: 55 tags of five different types on 37 individuals of seven marine mammal species

30 Days	Blue Whales:	25 total individuals (21 Dtags; 9 Bprobes; 7 MK-10s)
	Fin whales:	7 total individuals (7 Dtags; 1 Bprobes)
	Sperm whale:	One individual (2 Dtags; 2 MK-10)
	Baird's Beaked whale:	One individual (satellite tag)
	Sei whale:	One individual (satellite tag)
	Bottlenose dolphin:	One individual (Dummy Dtag with TDR - 3 minutes)
	Killer whale:	One individual (satellite tag)

LEG II Tag Summary: 7 tags of two different types on 7 individuals of four marine mammal species

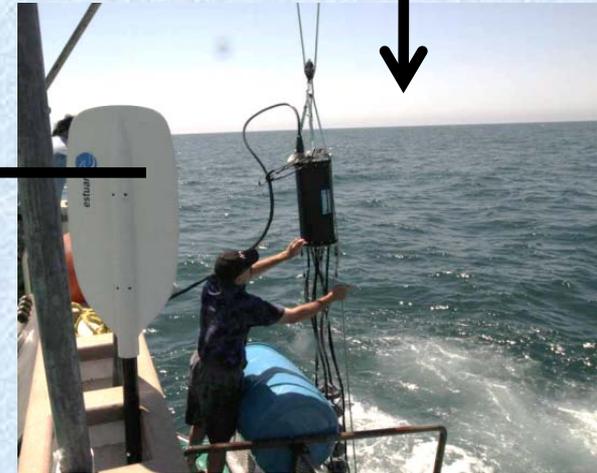
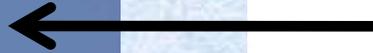
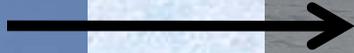
10 Days	Blue Whales:	3 total individuals (2 Dtags; 1 ACOUSONDE)
	Rissos dolphins:	2 total individuals (2 Dtags)
	Bottlenose dolphin:	One individual (Dtag - 0.5 min)
	Cuvier's Beaked Whale	One individual (Dtag)

SOCAL-10 TOTAL Tag Summary:

63 tags (6 types) on 44 individuals of 9 marine mammal species



SOCAL-10: CEE Procedure





SOCAL-10 ACCOMPLISHMENTS: Controlled Exposure Experiments

**Blue
Whales:
19**

**Fin
Whales:
5**

**Sperm
Whale:
2**

**Risso's
Dolphin:
1**

**Cuvier's
beaked
whale:
1**

28 Complete CEEs (18 Transmissions – 10 with 2 animals)

3 Mock Exposure (Control)

31 TOTAL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS:

BLUE WHALE - CEE Summary

Species	Exposure Type	N	Behavioral State Breakdown
BLUE WHALE	MFA-1	11	Surface/shallow feeding: n = 7 Deep feeding/travel: n = 4
BLUE WHALE	PRN-1	7	Surface/shallow feeding: n = 2 Deep feeding/travel: n = 5
BLUE WHALE	CONTROL	2	Surface/shallow feeding: n = 2 Deep feeding/travel: n = 0
BLUE WHALE	TOTAL	21	TOTAL - ALL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS:

FIN WHALE - CEE Summary

Species	Exposure Type	N	Behavioral State Breakdown
FIN WHALE	MFA-1	3	Surface/shallow feeding: n = 3 Deep feeding/travel: n = 0
FIN WHALE	PRN-1	2	Surface/shallow feeding: n = 2 Deep feeding/travel: n = 0
FIN WHALE	CONTROL	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
FIN WHALE	TOTAL	5	TOTAL - ALL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS:

SPERM WHALE - CEE Summary

Species	Exposure Type	N	Behavioral State Breakdown
SPERM WHALE	MFA-1	1	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 1
SPERM WHALE	PRN-1	1	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 1
SPERM WHALE	CONTROL	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
SPERM WHALE	TOTAL	2	TOTAL - ALL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS:

RISSOS DOLPHIN - CEE Summary

Species	Exposure Type	N	Behavioral State Breakdown
RISSOS DOLPHIN	MFA-1	1	Surface/shallow feeding: n = 1 Deep feeding/travel: n = 0
RISSOS DOLPHIN	PRN-1	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
RISSOS DOLPHIN	CONTROL	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
RISSOS DOLPHIN	TOTAL	1	TOTAL - ALL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS:

CUVIER'S BEAKED WHALE CEE Summary

Species	Exposure Type	N	Behavioral State Breakdown
CUVIER'S BEAKED WHALE	MFA-1	1	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 1
CUVIER'S BEAKED WHALE	PRN-1	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
CUVIER'S BEAKED WHALE	CONTROL	0	Surface/shallow feeding: n = 0 Deep feeding/travel: n = 0
CUVIER'S BEAKED WHALE	TOTAL	1	TOTAL - ALL SEQUENCES



SOCAL-10 ACCOMPLISHMENTS: *CEE sequence #2010_01 - SUMMARY*

When: **1147-1217 on 23 August 2010 (Julian Day 235)**

Where: Near Newport Beach Harbor (33° 34' N; 117° 56' W)

Species and # Individuals Involved: **Blue whales (n= 2)** together in surface feeding mode

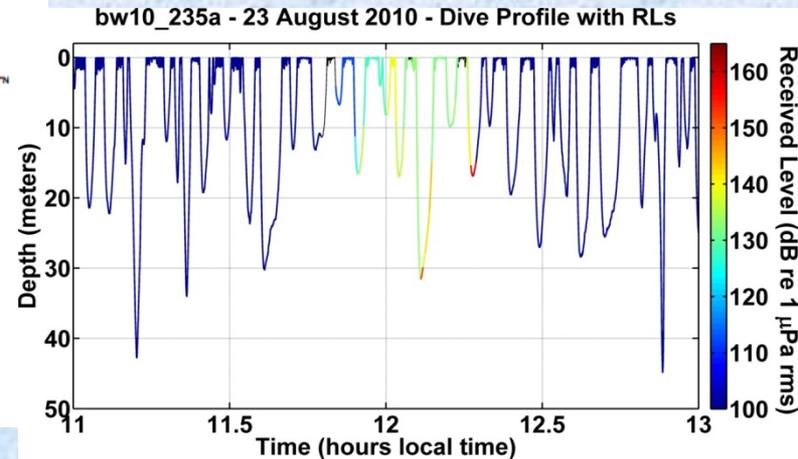
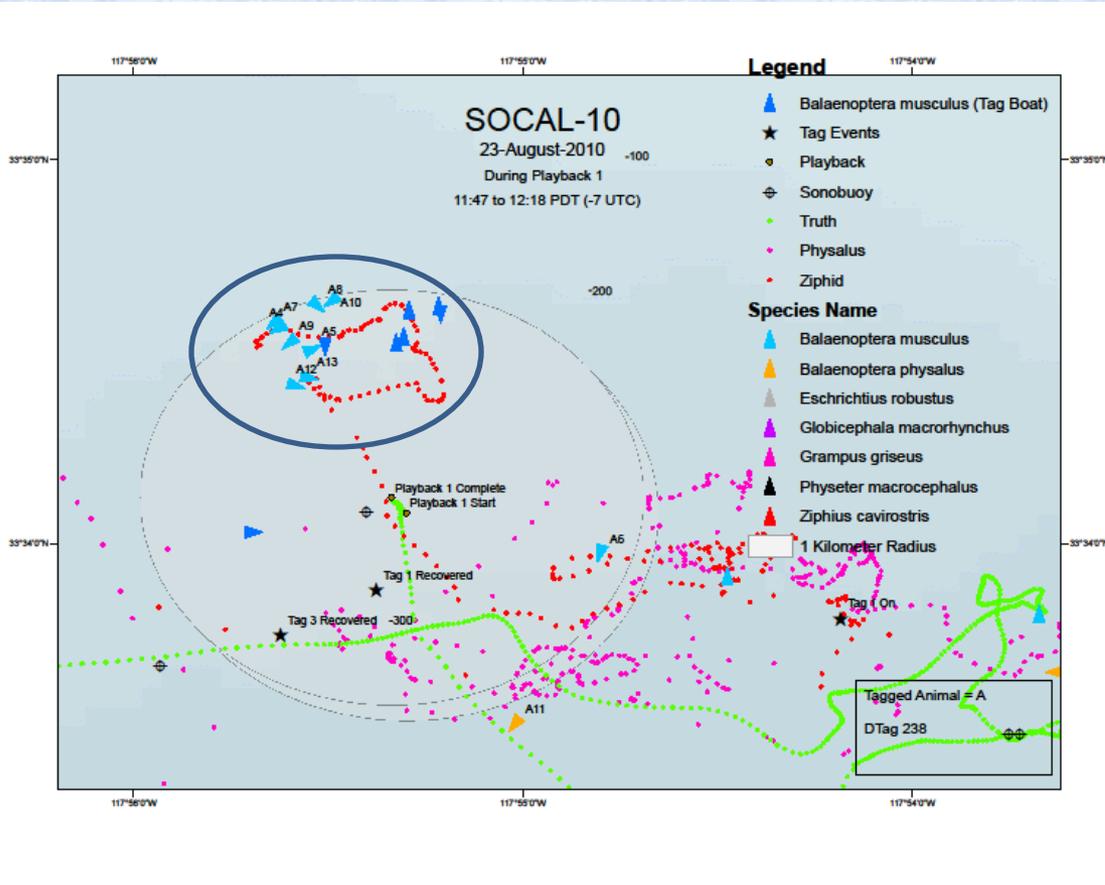
Tags deployed: Dtag 238 (bw_235a) & Dtag 224 (bw_235b)

Signal Type/Duration: **MFA-1** for complete **30:00** sequence

Short Narrative Description: First CEE of SOCAL-10 on two blues engaged in surface feeding behavior. Many other vessels around the whales, including during CEE. Repositioned initially b/c two fins w/in 200m; moved 1 km and completed sequence. No obvious reactions during CEE from visuals and tag record.

Permit Implications: 2 tag + PB blue whale takes; 1 no tag + PB on blue whale

Blue whale CEE (MFA) – Surface Feeding





SOCAL-10 ACCOMPLISHMENTS:

CEE sequence #2010_02 - SUMMARY

When: **1647-1705 on 23 August 2010 (Julian Day 235)**

Where: ~10 miles west of Newport (33° 35' N; 118° 06' W)

Species and # Individuals Involved: **Blue whales (n=1)** in deep feeding/diving mode

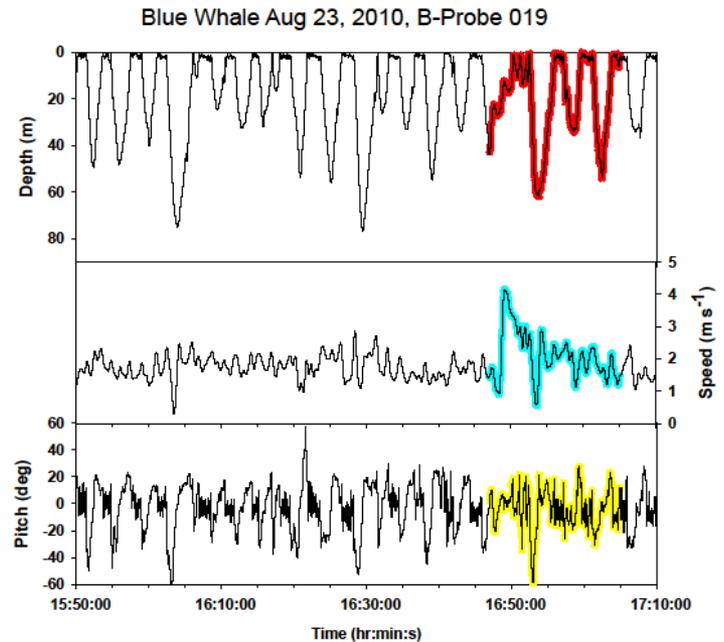
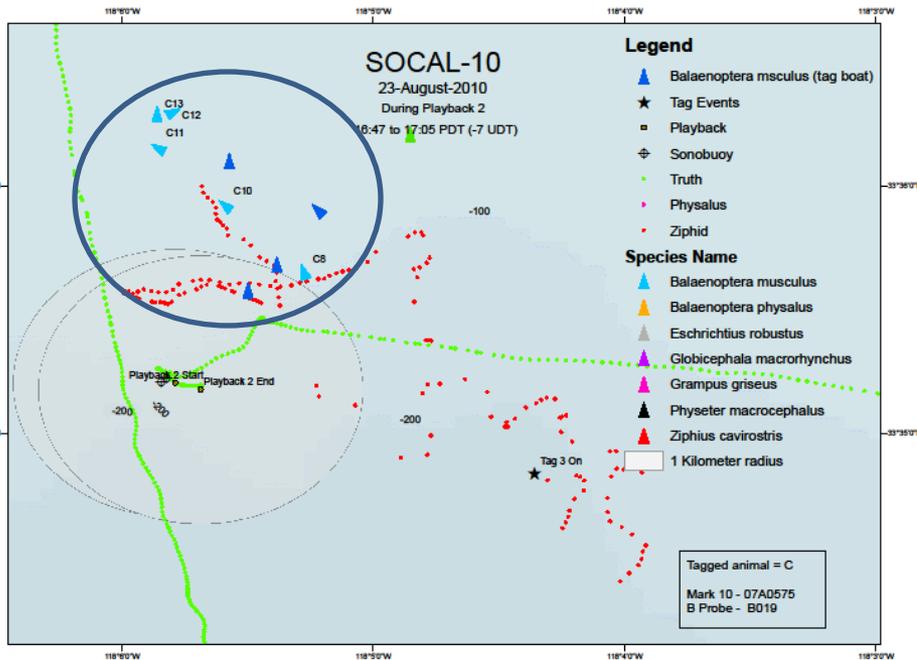
Tags deployed: Bprobe 019 (twice; fell off then re-attached) & MK-10 07A0575

Signal Type/Duration: **MFA-1** for **18:00** total – Exposure shut-down by California sea lion w/in 200m

Short Narrative Description: Following earlier CEE on two blue whales off Newport, single blue whale tagged with Bprobe then MK-10 (then Bprobe re-attached). One other whale in the area and ultimately the Zc that lead to shut-down. Animal seemed to avoid source and show changes in diving behavior

Permit Implications: 1 tag + playback blue whale take; 1 no tag PB on blue whale

Blue whale CEE (PRN) – Deep Feeding





SOCAL-10

Sperm Whale:

***Novel integration
of tracking
technologies***





SOCAL-10 ACCOMPLISHMENTS:

CEE sequence #2010_08 - SUMMARY

When: **1314-1344 on 30 August 2010 (Julian Day 242)**

Where: Redondo Canyon (33 48' N; 118 32' W)

Species and # Individuals Involved: **Sperm whale (n=1)** CEE during a deep foraging dive

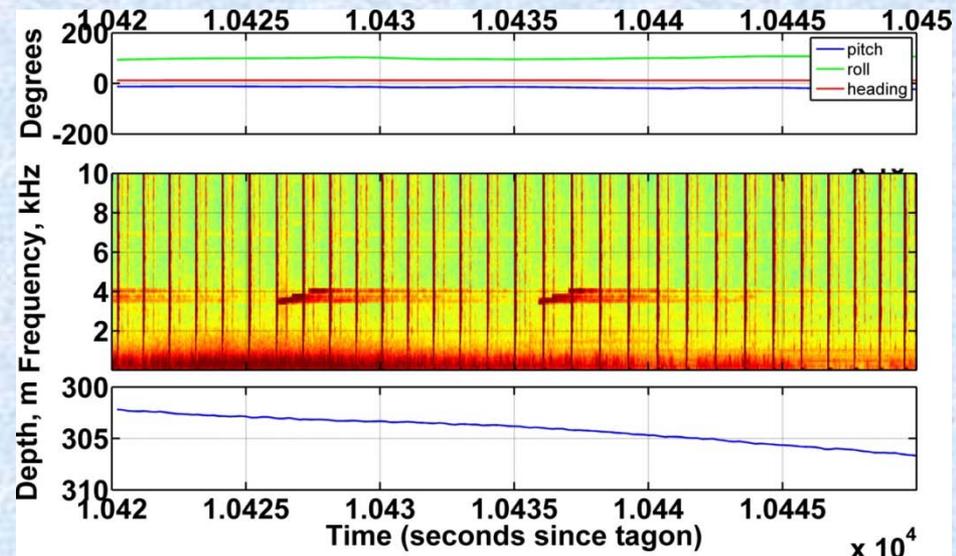
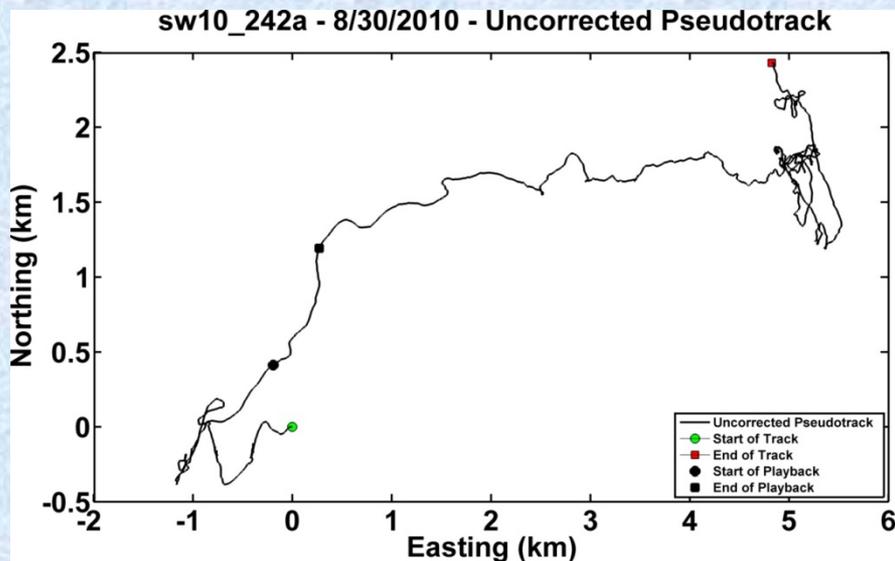
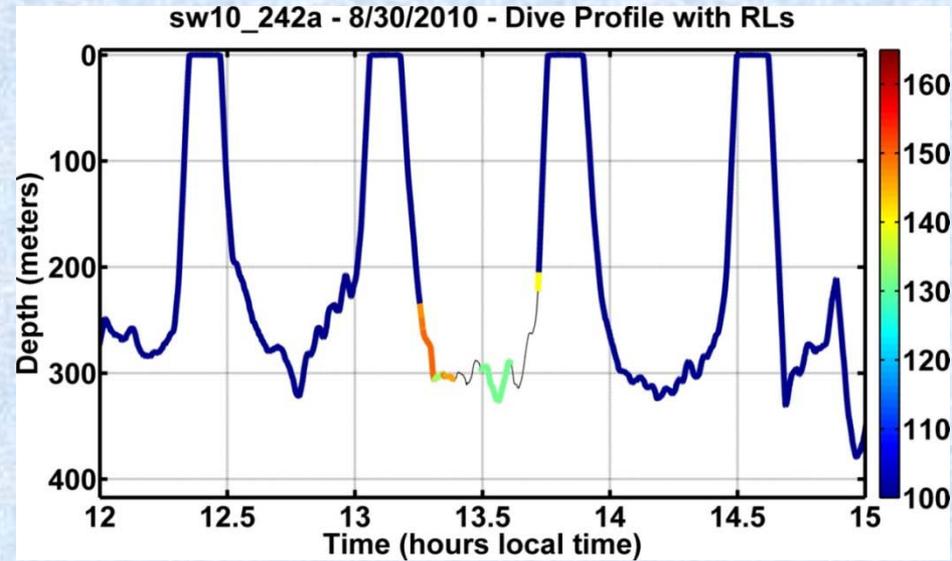
Tags deployed: Dtag 245 and MK-10 07A0592

Signal Type/Duration: **MFA-1** for complete **30:00** sequence

Short Narrative Description: After tracking Mango the sperm whale since scouting leg we were close enough and re-located using ARGOS position and directional hydrophone. Good baseline sequence, complete 30 min on deep dive, and post monitoring. No obvious responses from visuals and in tag record

Permit Implications: 1 sperm whale tag + PB (no incidentals)

Sperm whale CEE (MFA)





SOCAL-10 ACCOMPLISHMENTS: *CEE sequence #2010_20 - SUMMARY*

When: **1446-1516 on 29 September 2010 (Julian day 272)**

Where: SCOR range (32 49' N; 119 3' W)

Species and # Individuals Involved: **Cuvier's beaked whale (n=1)** in a group of 5 in a larger group of ~20 in sight in deep feeding/travel mode during CEE

Tags deployed: Dtag 232 on a Cuviers beaked whale (*zc10_272a*)

Signal Type/Duration: **MFA-1** for complete **30:00** sequence

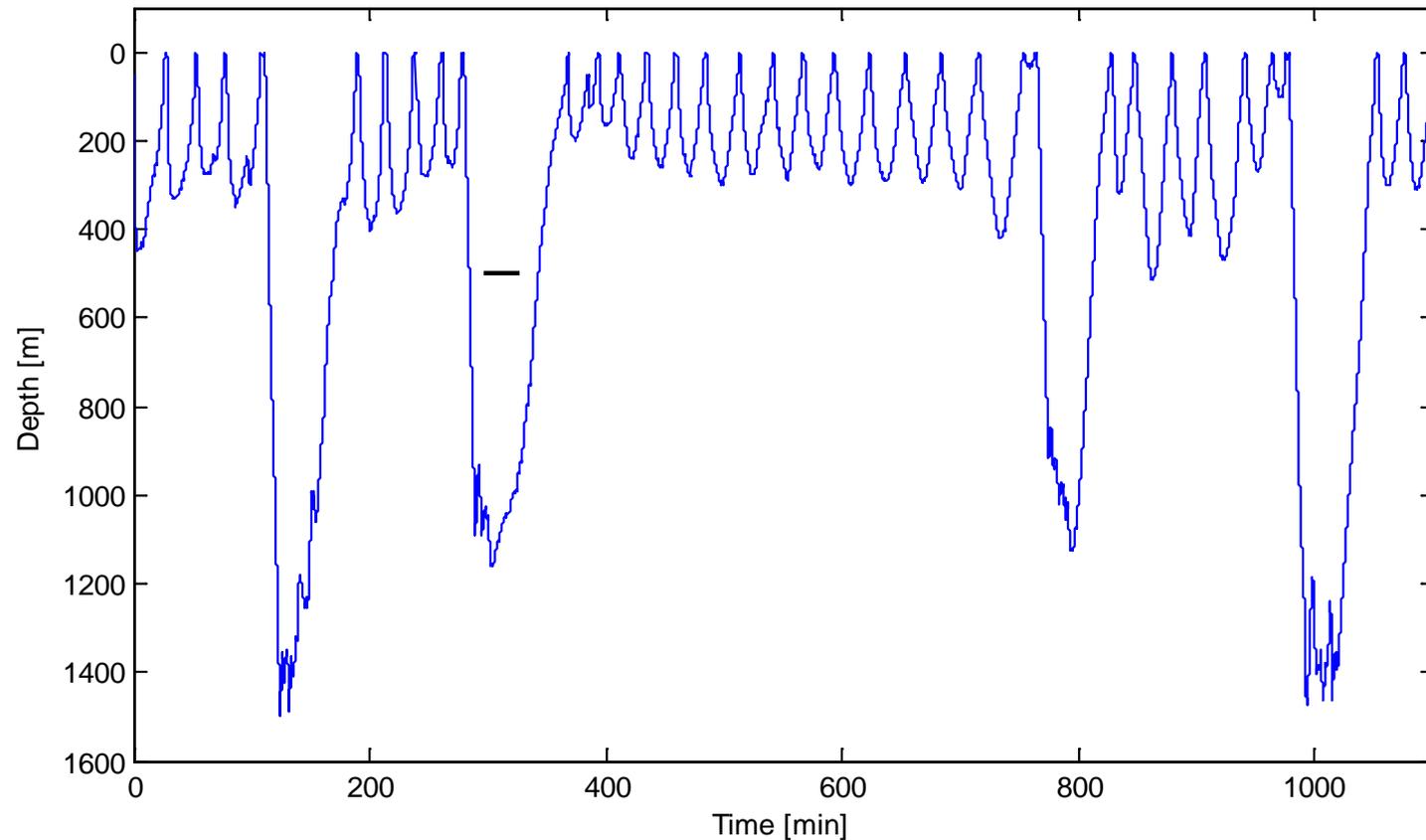
Short Narrative Description: First ever CEE with simulated military sonar on a Cuvier's beaked whale. Tag on earlier but fog delayed CEE, then cleared and enough belief in location of whales (not directly sighted on last SI) to proceed. Monitored with both SCOR and sonobuoy phones and ran full 30 mon

Permit Implications: 1 Cuviers tag + PB; 4 Cuviers tag + no PB

Cuvier's beaked whale CEE (MFA): Full Dive Record



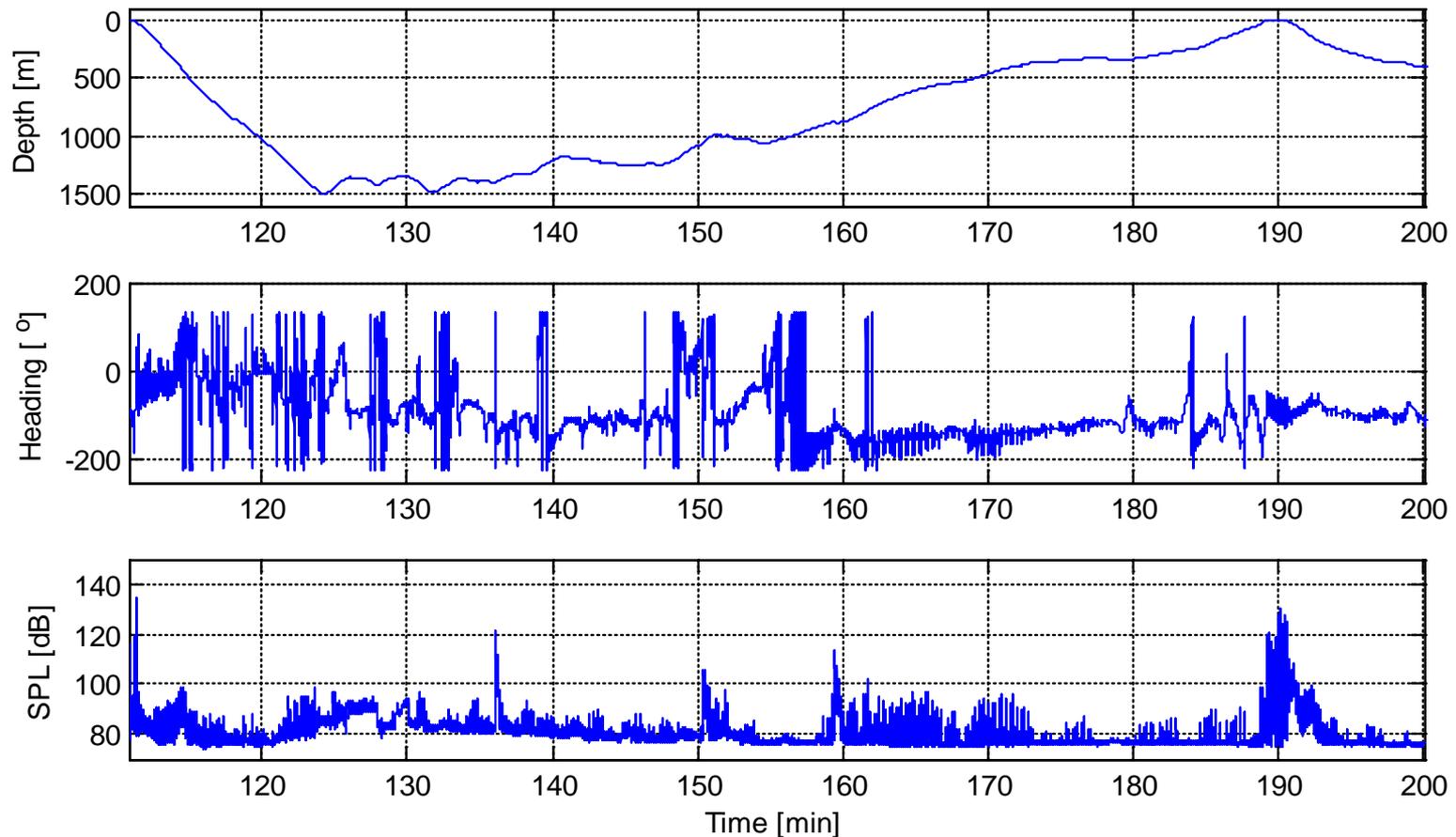
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Cuvier's beaked whale CEE (MFA): Pre-exposure dive



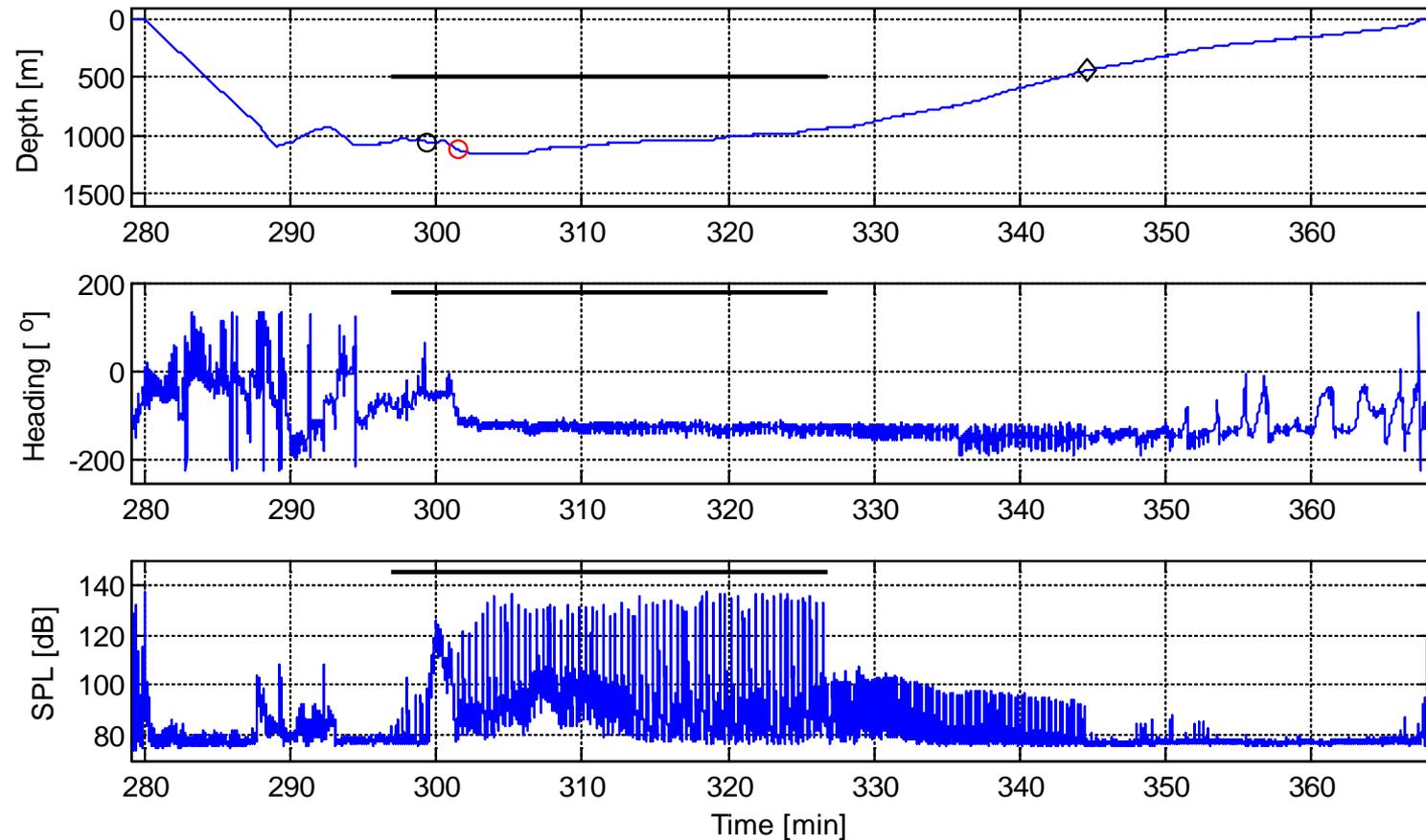
Photo taken under U.S. NMFS permit # 14534



Cuvier's beaked whale CEE (MFA): Exposure dive



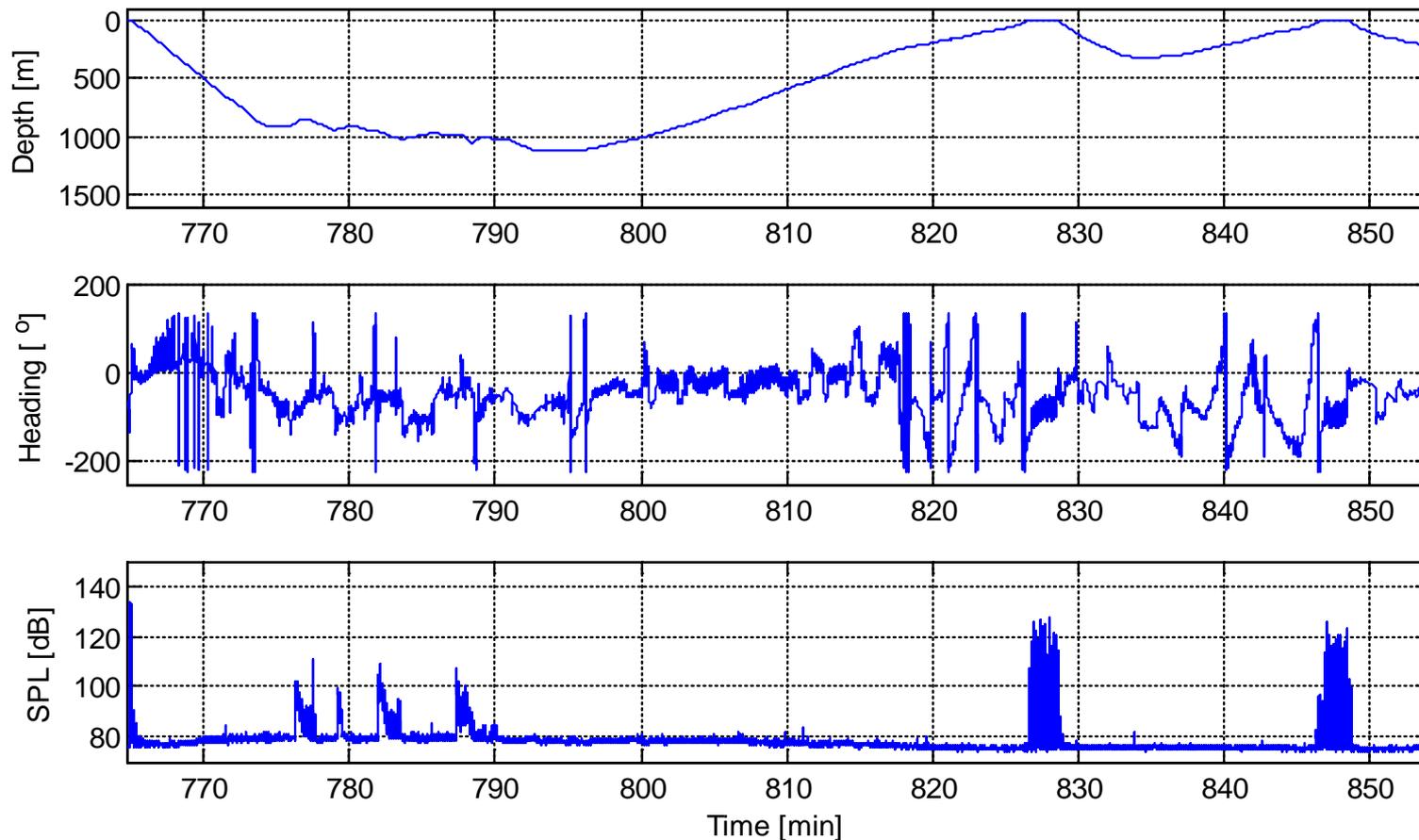
Photo taken under U.S. NMFS permit # 14534



Cuvier's beaked whale CEE (MFA): Post-exposure dive



Photo taken under U.S. NMFS permit # 14534





SOCAL-10: Objectives vs. Accomplishments

- 1) Tag a variety of species and obtain baseline behavioral data***
62 tags of 6 types on 44 individuals of 9 species (~400h)
- 2) Conduct controlled exposure experiments (CEEs) using similar methods to previous pioneering studies***
28 CEEs on individuals of four species (MFA and PRN)
- 3) Test optimal configuration for subsequent studies, which may include realistic/actual military sources.***
Successful aspects of both configurations (2nd on SOAR range)
- 4) Obtain data to support range monitoring efforts***
Thousands of sightings of 21 marine mammal species, hundreds of photo IDs, biopsy/skin samples

SOCAL-10: Transparency and Public Impact

~ SOCAL-10 is committed to openness and transparency of the project and to the timely and effective transmission of results ~

- **5 November 2009:** *Naval Postgraduate School, Monterey, CA*
- **2 December 2009:** *NMFS, Southwest Fisheries Science Center, Pacific Grove Laboratory*
- **7 January 2010:** *NMFS Headquarters, Silver Spring, MD*
- **9-10 January 2010:** *Southern California Marine Mammal Workshop, Newport, CA*
- **25 February 2010:** *Moss Landing Marine Laboratory, Moss Landing, CA*
- **7 April 2010:** *Teleconference and Q&A with NRDC and CA Coastal Commission*
- **29 April 2010:** *Sponsors brief House Natural Resources Committee*
- **13 May 2010:** *California Coastal Commission meeting, Santa Cruz, CA*
- **18 May 2010:** *Channel Islands National Park & Marine Sanctuary, Ventura, CA*
- **19 May 2010:** *Scripps Institute of Oceanography, San Diego, CA*
- **24 June 2010:** *Hopkins Marine Station, Monterey, CA (American Cetacean Society)*
- **7 July 2010:** *California Coastal Commission meeting, Santa Rosa, CA*
- **18 July 2010:** *Seymour Marine Discovery Center, Long Marine Laboratory, Santa Cruz, CA*
- **16 August 2010:** *2nd International Conf. on Effects of Sound on Marine Life, Cork, Ireland*

SOCAL-10 website <<http://www.sea-inc.net/SOCAL10/>>;

SOCAL-10 blog <<http://sea.typepad.com/sea-blog/>>; and

SOCAL-10 Facebook page: <<http://www.facebook.com/pages/Behavioral-Response-Studies-of-Marine-Mammals/153316228012219>>



Overall Conclusions

- 1. Modification of previous BRS approaches and application in southern California on new species was successful**
- 2. First ever CEE on Cuvier's beaked whale supports conclusions from other data sets of particular sensitivity to sound**
- 3. Preliminary results in other species indicate observable responses to sonar/noise sounds in some (not all) conditions**
- 4. Data will enable Navy & NOAA to better fulfill requirements to understand and assess impacts on marine mammals – year 1 of 5**

SOCAL BRS Next Steps:

Overall configuration for SOCAL-11 and beyond...

SOCAL-11: Similar configuration & objectives as -10

- R/V *Truth* as operational platform (both legs)
- Pilot testing of smaller source on RHIB

Subject to change based on -11:

SOCAL-12: Transition to smaller vessel but also preparation for operational/real sources in CEEs

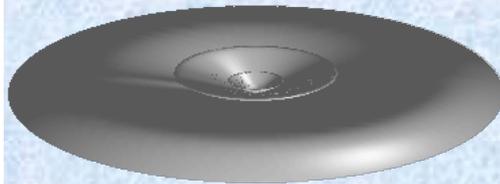
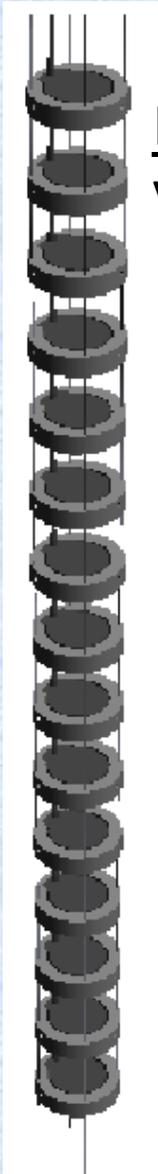
SOCAL-13/14: Combination approach with small vessels for scaled sources and operational CEE sources

SOCAL-11 Next Steps:

Transducer Configurations to be Analyzed

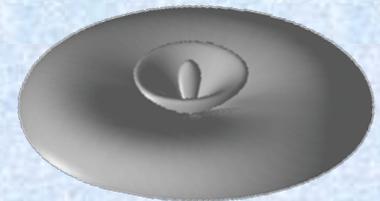
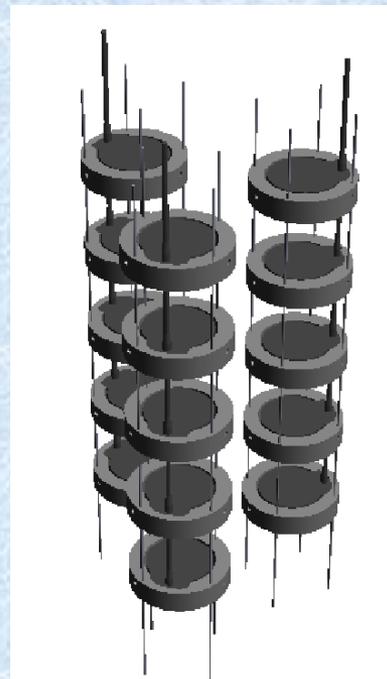
Baseline Vertical Line Array

Vertical Beamwidth $\sim 9^\circ$ at 3.6 kHz

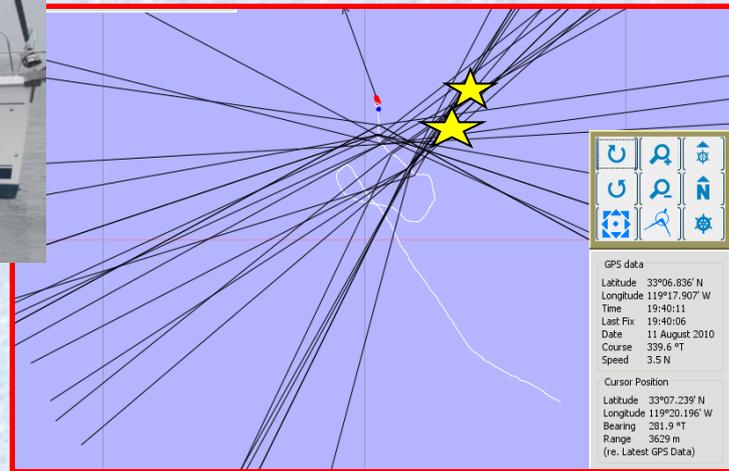


Compact Volumetric Array

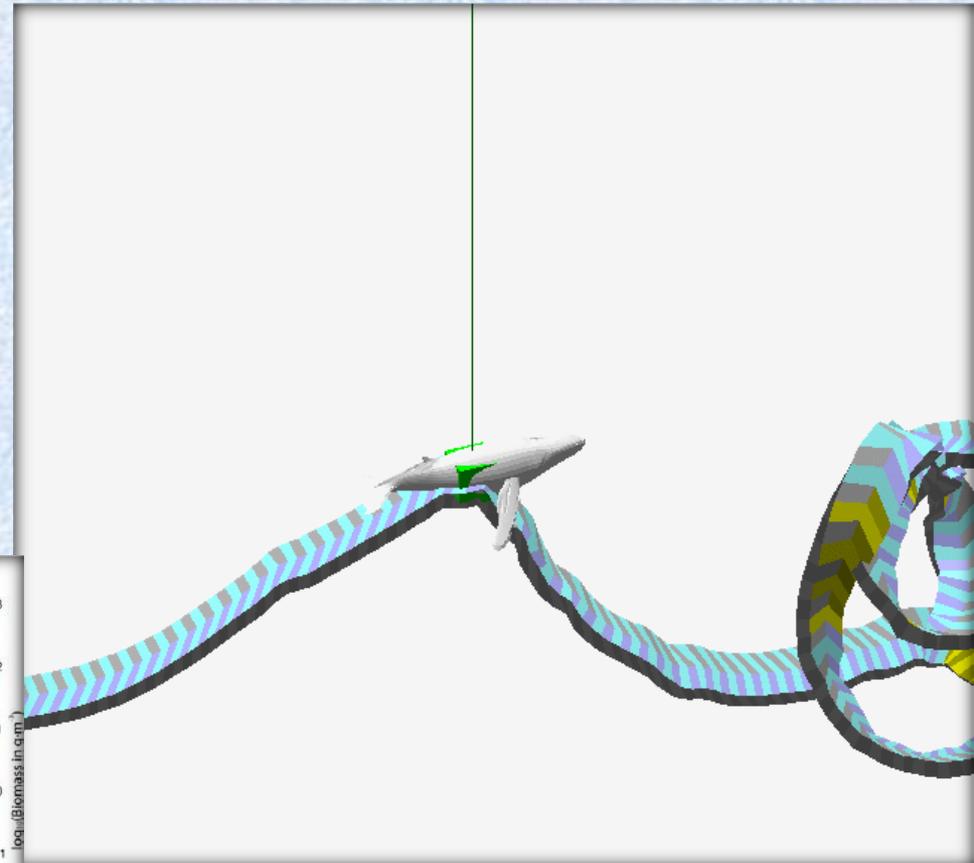
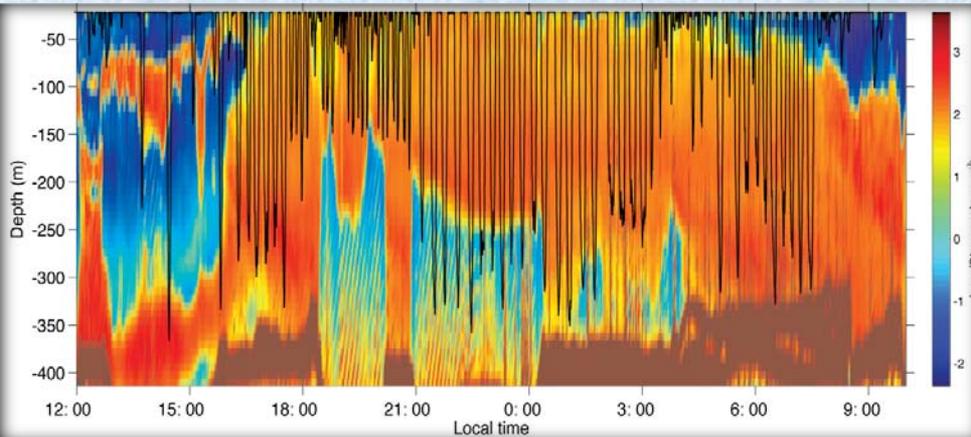
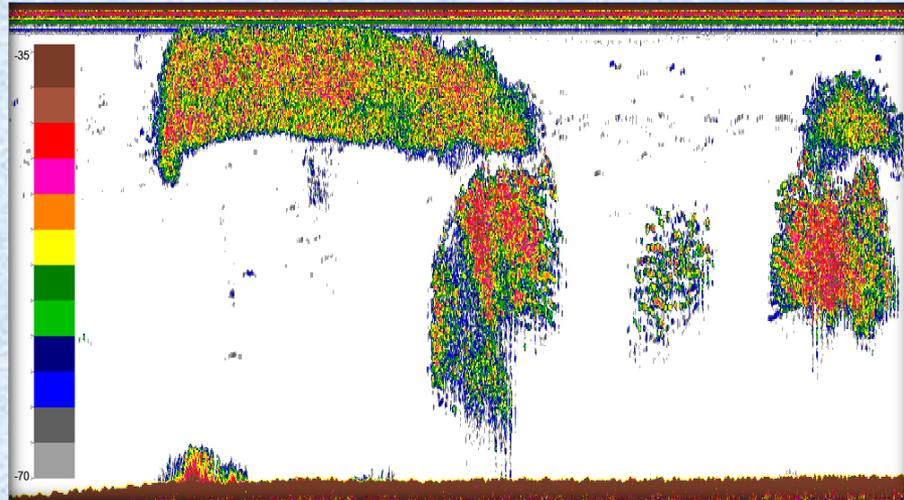
Vertical Beamwidth $\sim 23^\circ$ at 3.4 kHz



SOCAL-11 Next Steps: Passive Acoustic Monitoring (PAM) for off-range detection of odontocete cetaceans



SOCAL-11 Next Steps: Integrating prey measurements with tagged whale foraging behavior at fine scales



(Courtesy A. Friedlaender)