Status of humpback, blue, and gray whales along the US West Coast and relevance to entanglements

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Goals of talk

- Updated status of humpback, blue and gray whales as it relates to entanglement threat
  - Relevant aspects of population structure
  - Current trends and how that relates to risk
  - Focus on humpback whales but also relevant issues for blue and gray whales
  - Some of the new tools available to examine whale behavior and interaction with human activities.
- Research and results from some specific research efforts on entanglements

Activities related to entanglements

- Long term photo-ID of humpback, blue and PCFG gray whales
  - Abundance and trends
  - Dedicated surveys, other research and collaboration with whale watch industry
  - Matching identification photographs of entangled whales
- NOAA Scientific Review group, Pacific Offshore Take Reduction Team
- Disentanglement Level 4 responder
- Sect 6 grant from NOAA to WDFW, ODFW, CDFW
- Study on entanglement scaring rates in humpback whales along the US West Coast
- Working groups on impact/mitigation of ship strike and ship noise off N and S California

Long-term studies by Cascadia Research

Humpback whale

- Abundance
- Long-term trends
- Movements & migrations
- N Pacific wide studies (SPLASH)

Blue whale

- Abundance
- Movements
- Tagging work
- Feeding behavior
- Vocal behavior

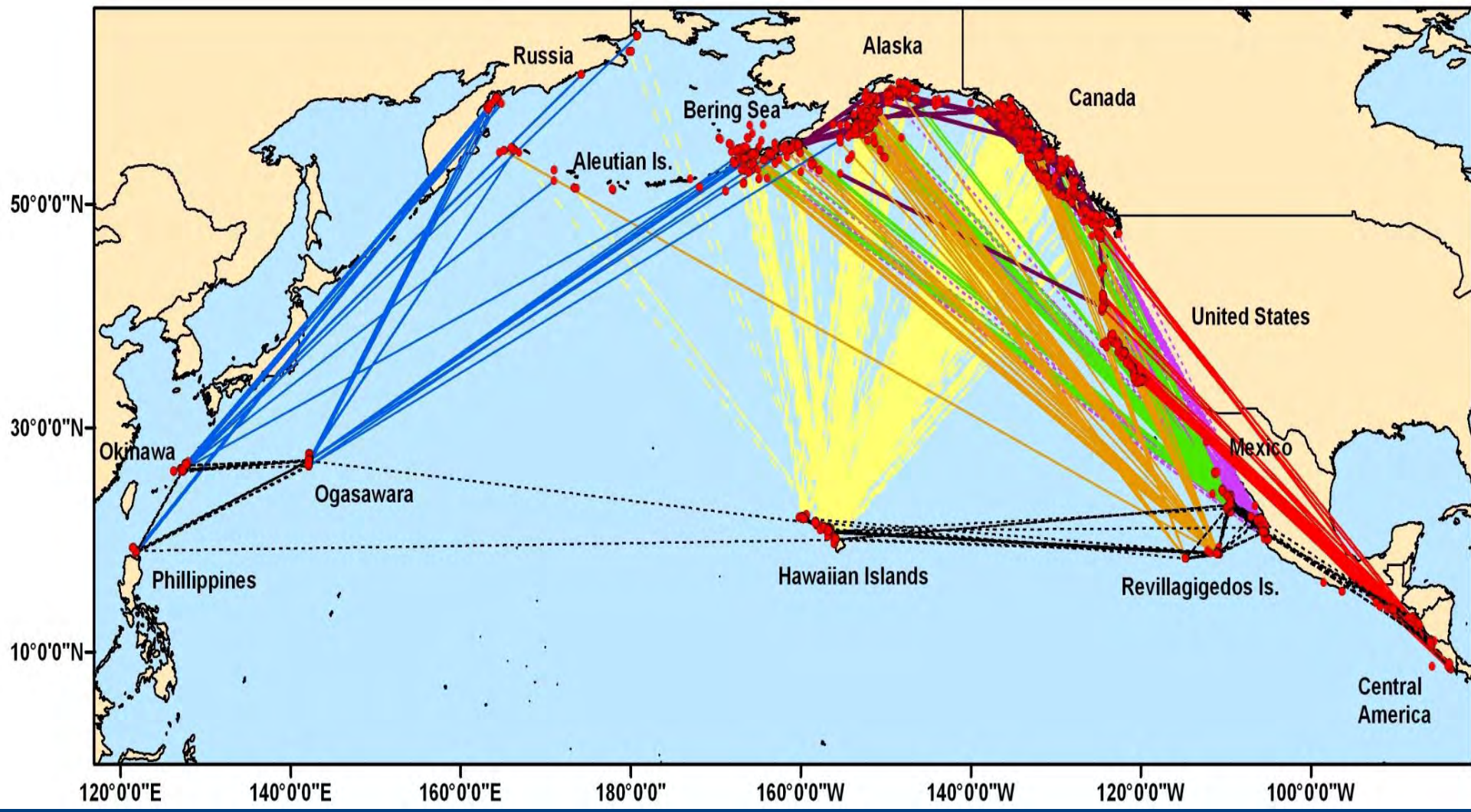
Gray whale

- Existence of seasonal residents
- Movements
- Abundance
- Site fidelity
- Strandings

Cascadia Photo-ID catalogs and encounters for E N Pacific

Species	Start of primary effort	Photo-ID catalog (unique IDs)	Sightings/ IDs
Humpback whales	1986	3,564	25,715
Gray whales	1998	1,732	26,265
Blue whales	1986	2,257	14,043

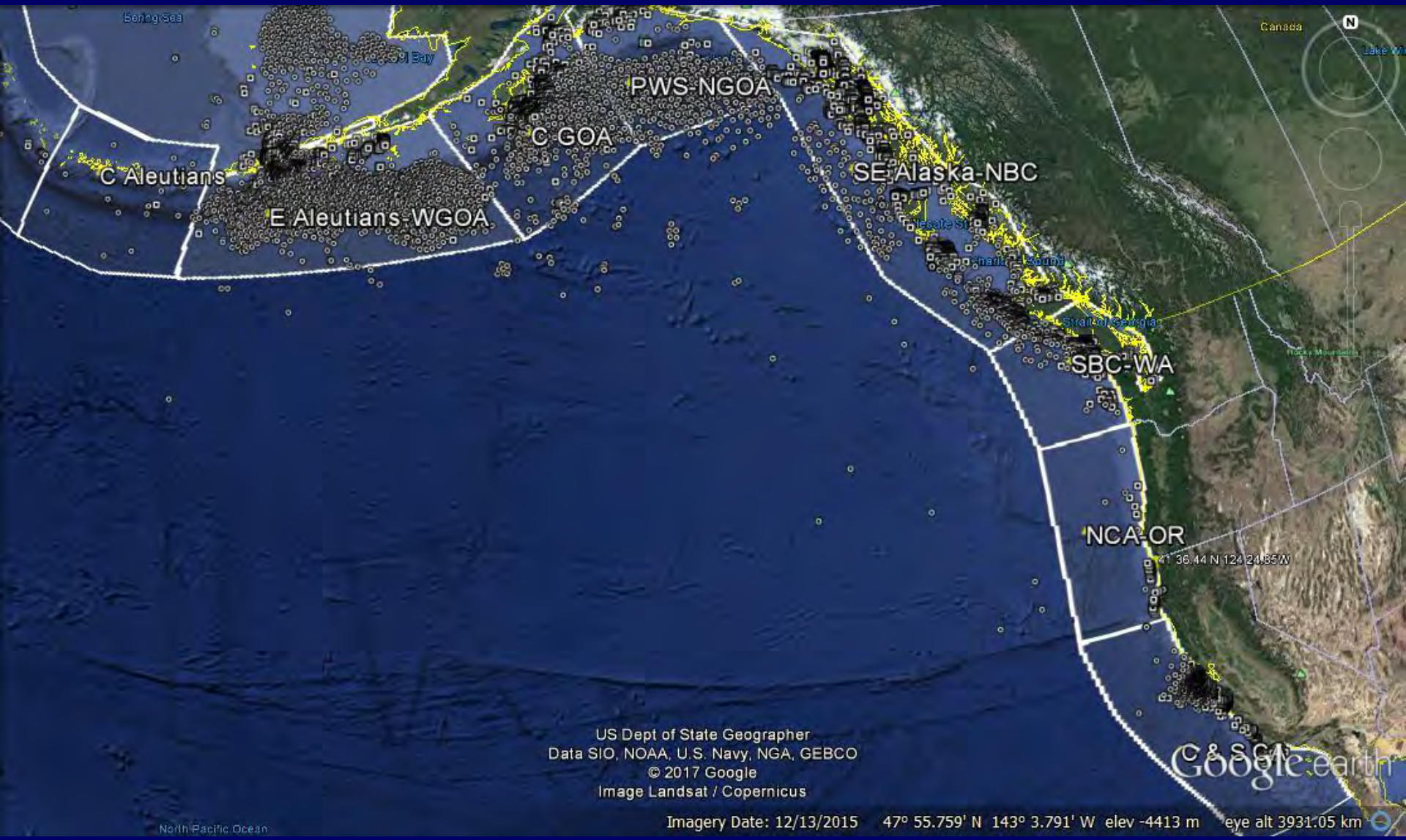
Resightings of identified whales



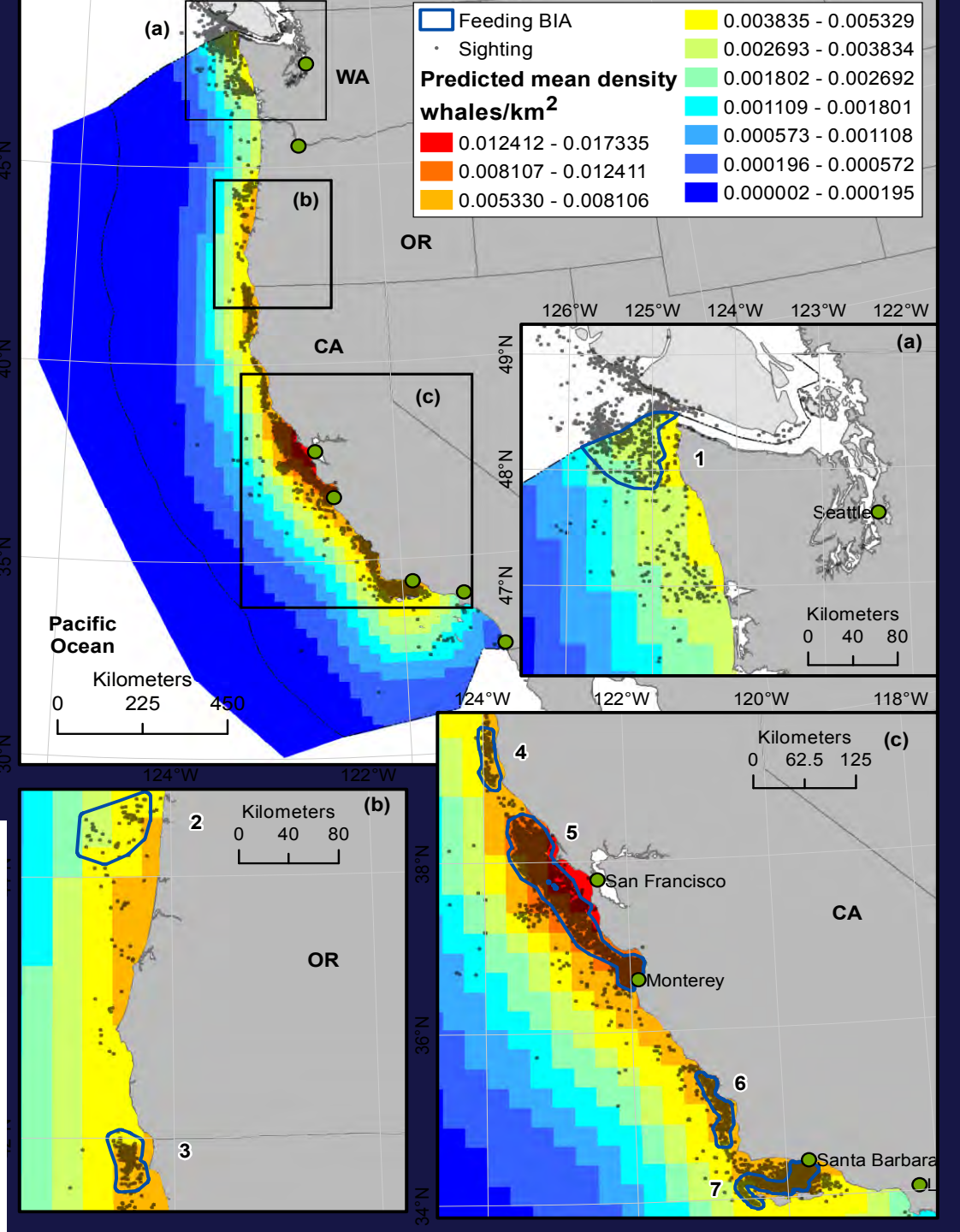
Based on results from SPLASH

SPLASH multi-strata estimates (Wade et al.)

E N Pacific humpback whaling and SPLASH ID locations with regions



Humpback whale Biologically Important Feeding Areas



Aquatic Mammals 2015, 41(1), 39-53, DOI 10.1578/AM.41.1.2015.39

4. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region

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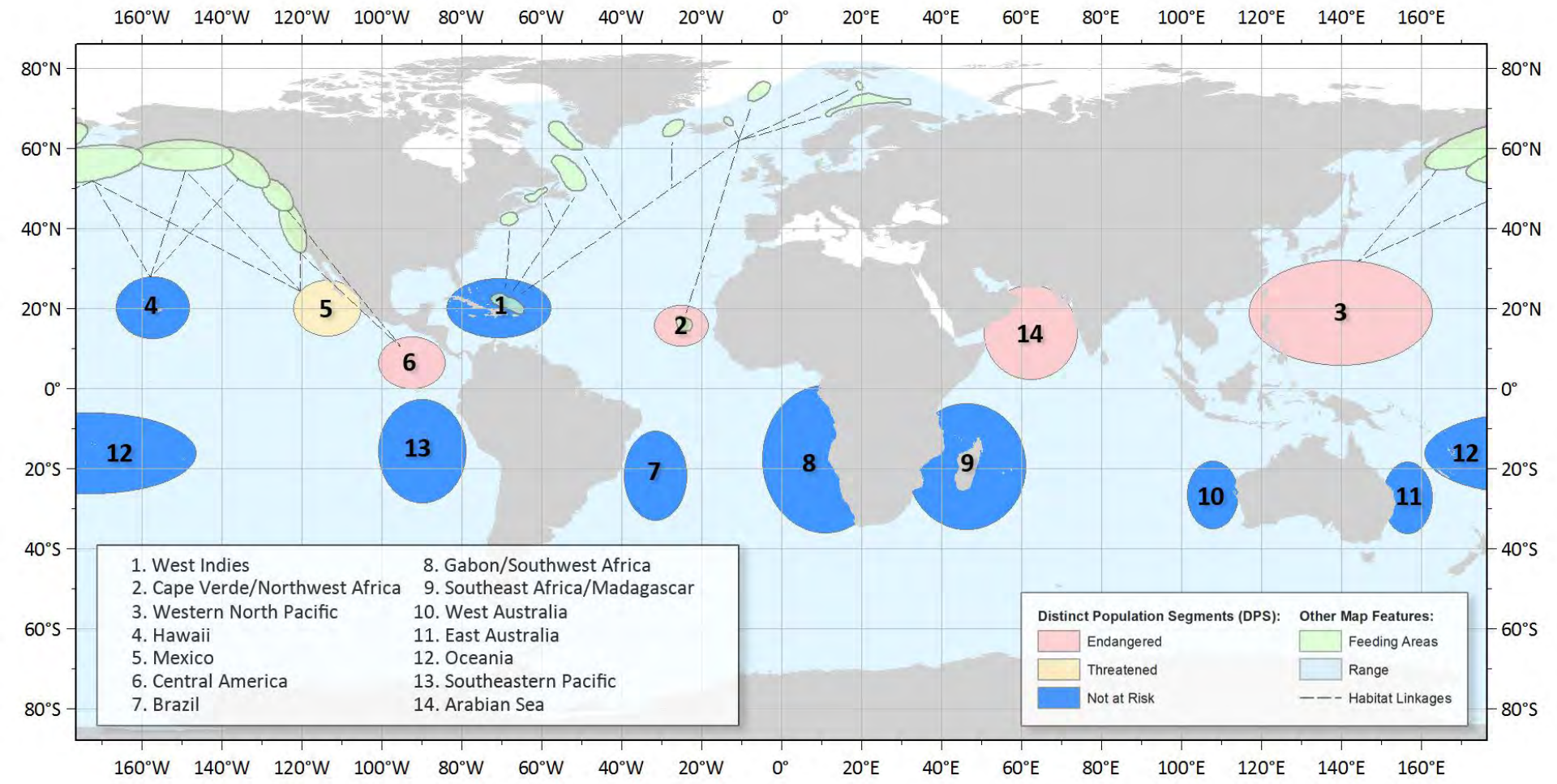
New ESA status of humpback whales

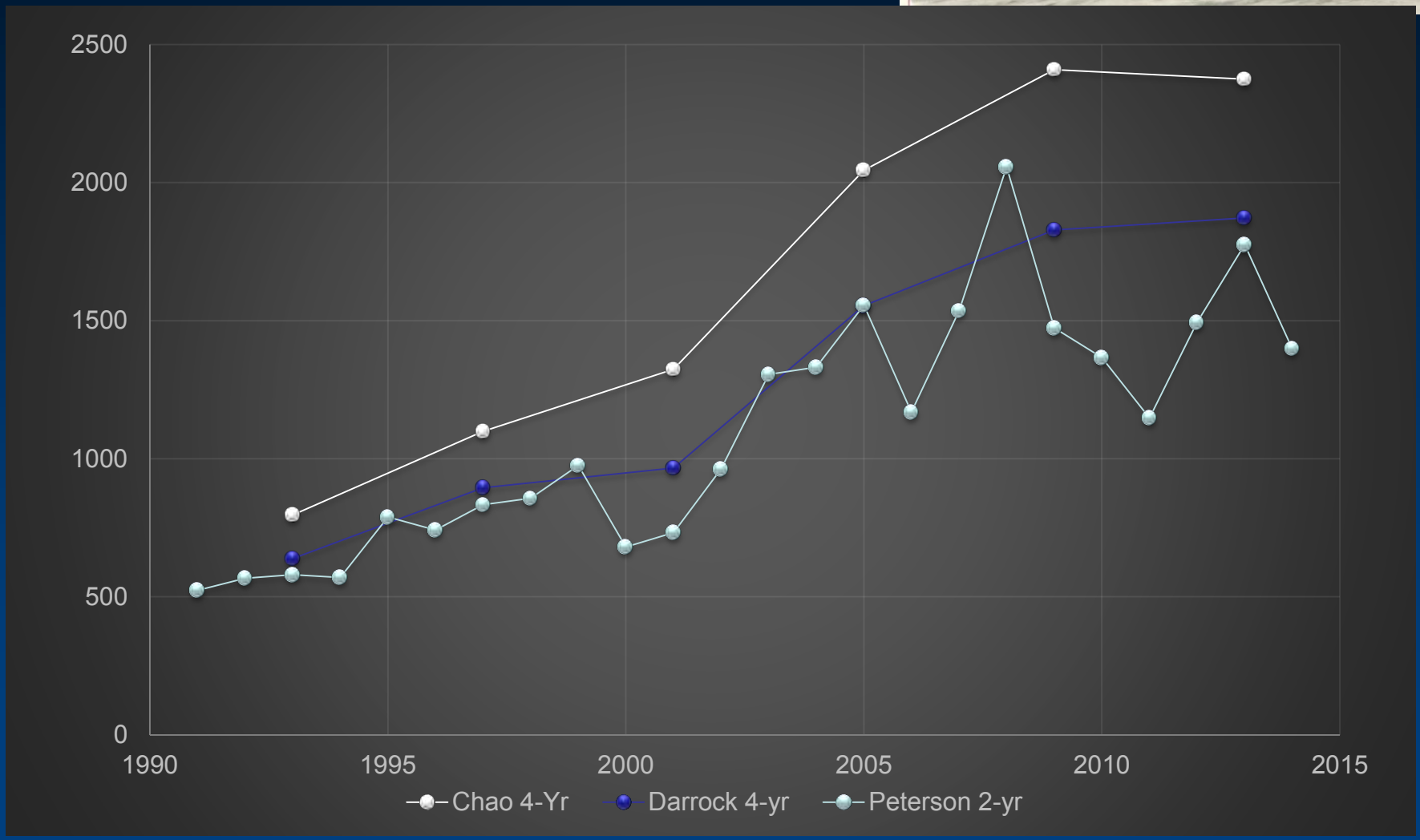


Match rate to US West Coast

Region, Sub-area	Matches	% Breeding Collection
Mexico, Mainland	254	30%
Mexico, Baja California	84	12%
Mexico, Revillagigedo	18	1.7%
S Mexico	42	60%
Central America	69	90%

Proportion of humpback whales matching breeding areas

Humpback whale trends – California and Oregon

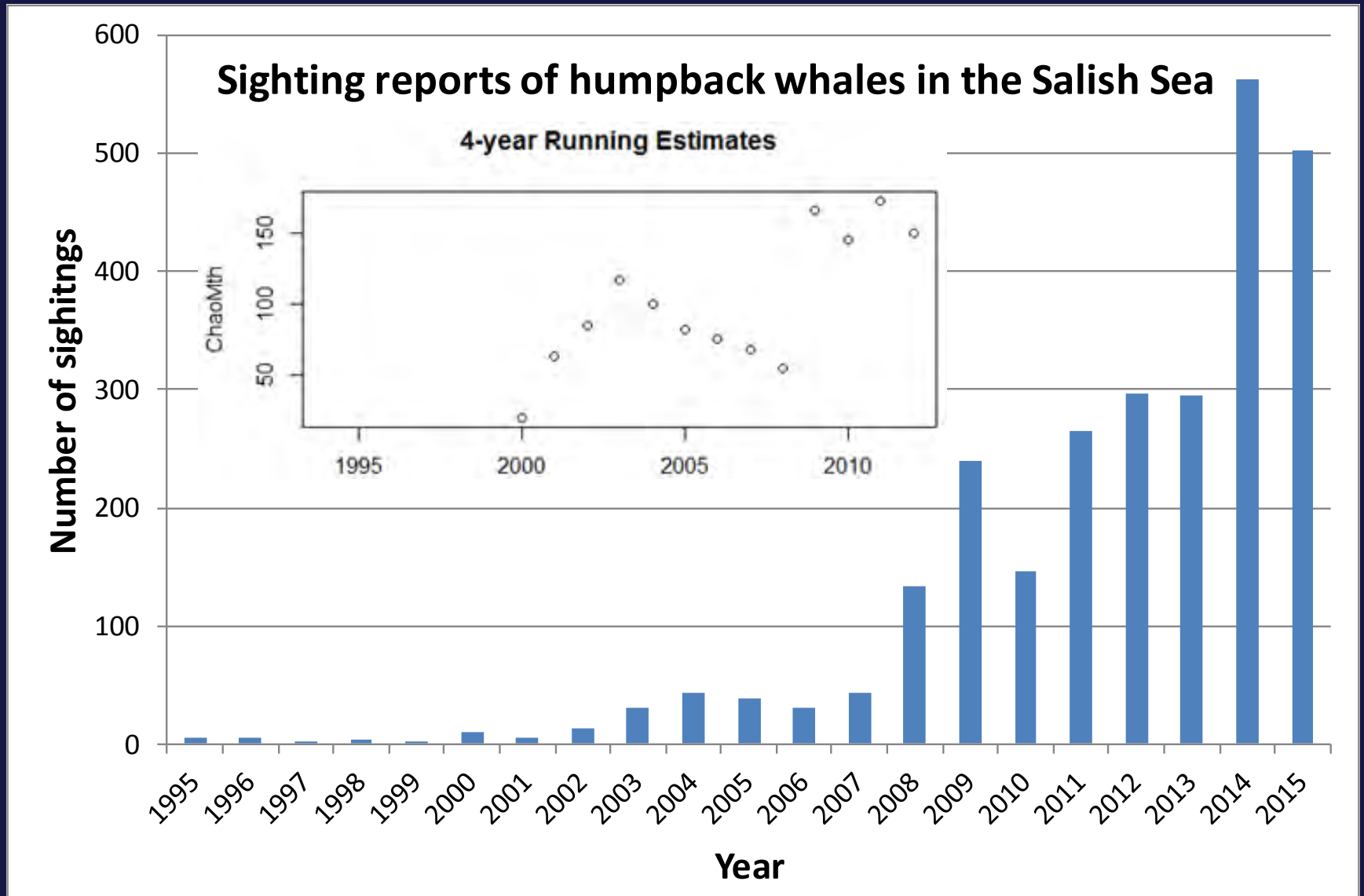


Likely implications of increased whale abundance reaching carrying capacity

- Increased number of whales
- Expansion into peripheral habitats and fully utilizing habitat / prey
- Increased time on feeding grounds including more animals over-wintering on feeding grounds and arriving earlier on feeding grounds

Areas of recent expansion of humpback whale occurrence

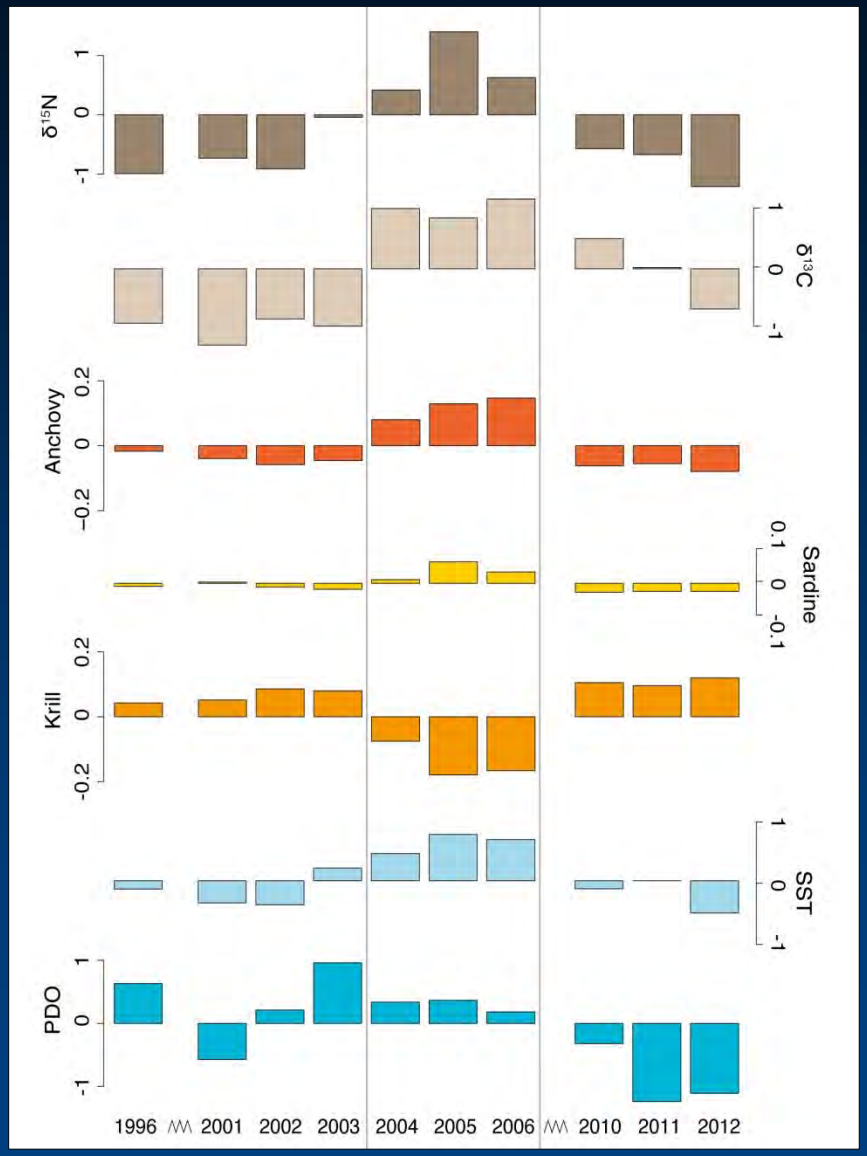
Increased sighting reports of humpback whales in Salish Sea

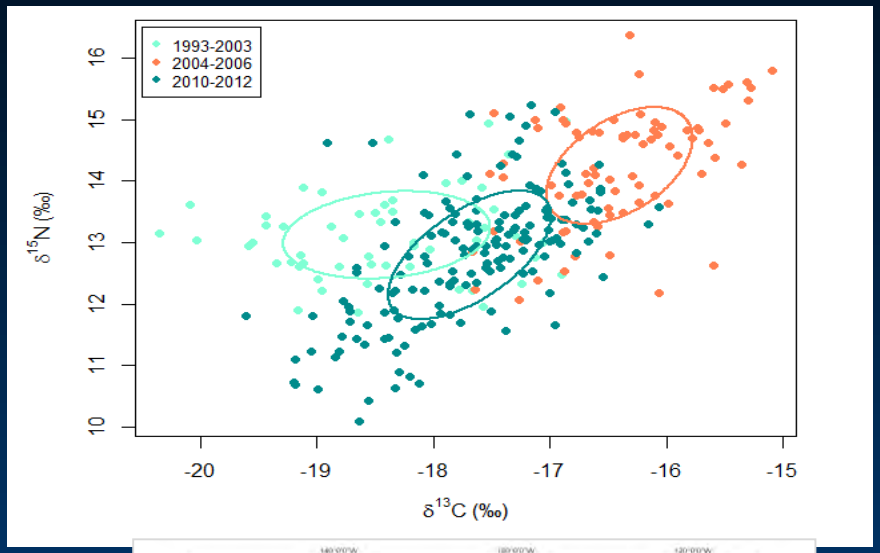


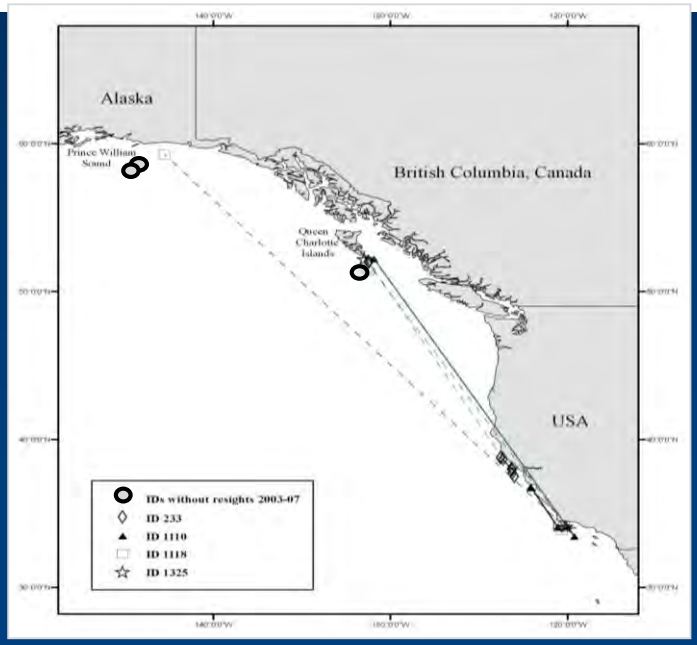
Sighting reports of humpback whales to Cascadia and Orca Network through 2015


WHALING STATION
GRAYS HARBOR, WASH.

Humpback switch prey but blue whales switch locations







Flemming et al. 2015

Use of scarring in live animals to examine trends in entanglements

- Has incidence of entanglement scarring increased in last 10-15 years?
- Is higher incidence of entanglement reports in Monterey Bay reflective of the higher effort there or is incidence also high in other areas?

Photo-identifications of entangled whales along US West Coast 2006-16

Species	Records	IDs
Humpback whale	77	15
Gray whale	23	4
Blue whale	3	1

Entangled humpback whales with known sighting histories

CRC ID	CaseID	Observat Date	Year	County	# Resight	Central America	Mexico	US West Coast	US West Coast	Min Loc Code	Max Loc Code	Min Dec Lat	Max Dec Lat
12315	20071016Mn	2007/10/16	2007	San Mateo	9			2007	2014	52	63	37.4846	41.9374
12056	20071029Mn	2007/10/29	2007	San Francisco	3			2005	2007	33	53	34.209	37.8041
12415	20080510Mn	2008/05/10	2008	Monterey	3			2008	2009	51	51	36.6648	36.812
15401	20110510Mn	2011/05/10	2011	Monterey	26			2011	2014	39	51	32.7376	36.849
10720	20140828Mn	2014/08/28	2014	Monterey	18	2001	2004	1993	2014	33	53	34.17167	37.85
15695	20150217Mn	2015/02/17	2015	Monterey	3			2012	2013	33	51	34.1188	36.78
12093	20150625Mn	2015/06/25	2015	Monterey	23			2005	2014	33	51	34.0773	36.819
11502	20150719Mn	2015/07/19	2015	Monterey	5			2001	2013	51	53	36.6833	37.66617
16082	20150810Mn	2015/08/10	2015	Monterey	1			2013	2013	51	51	36.75	36.75
15769	20150925Mn	2015/09/25	2015	Los Angeles	4			2013	2014	53	53	38.1165	38.3445
15769	20151028Mn	2015/10/28	2015	Santa Barbara									
12428	20151108Mn	2015/11/08	2015	Monterey	4			2008	2014	51	53	36.79	37.9846
12094	20160824Mn_1	8/24/2016	2016	San Luis Obispo	5		2005	2005	2009	33	51	34.0773	36.746
11809	20161009Mn	10/9/2016	2016	San Francisco	3		2003-06	2004	2009	52	53	37.4366	38.1528
15617	20161026Mn	10/26/2016	2016	Monterey	5			2012	2013	51	53	36.7639	38.1686

Interaction with gear: why do whales get entangled

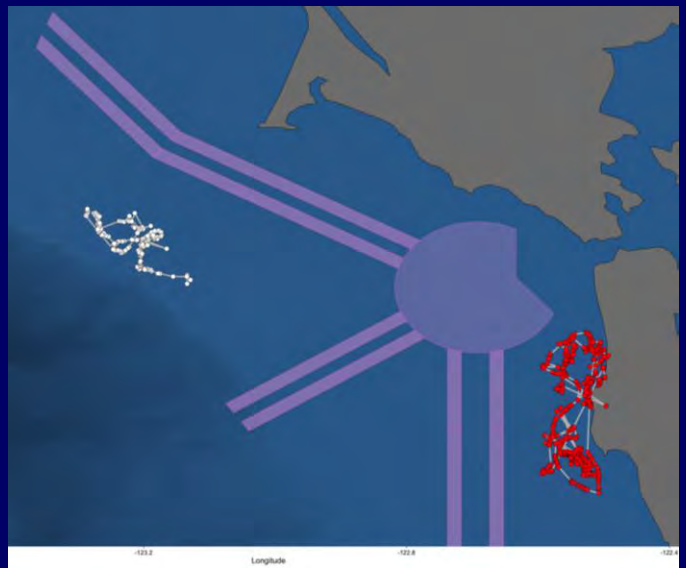
Track of two humpback whales off the Bay area in 2016 from dart-attached TDR-10 tags

Recent research on whales around crab gear in 2016 and 2017

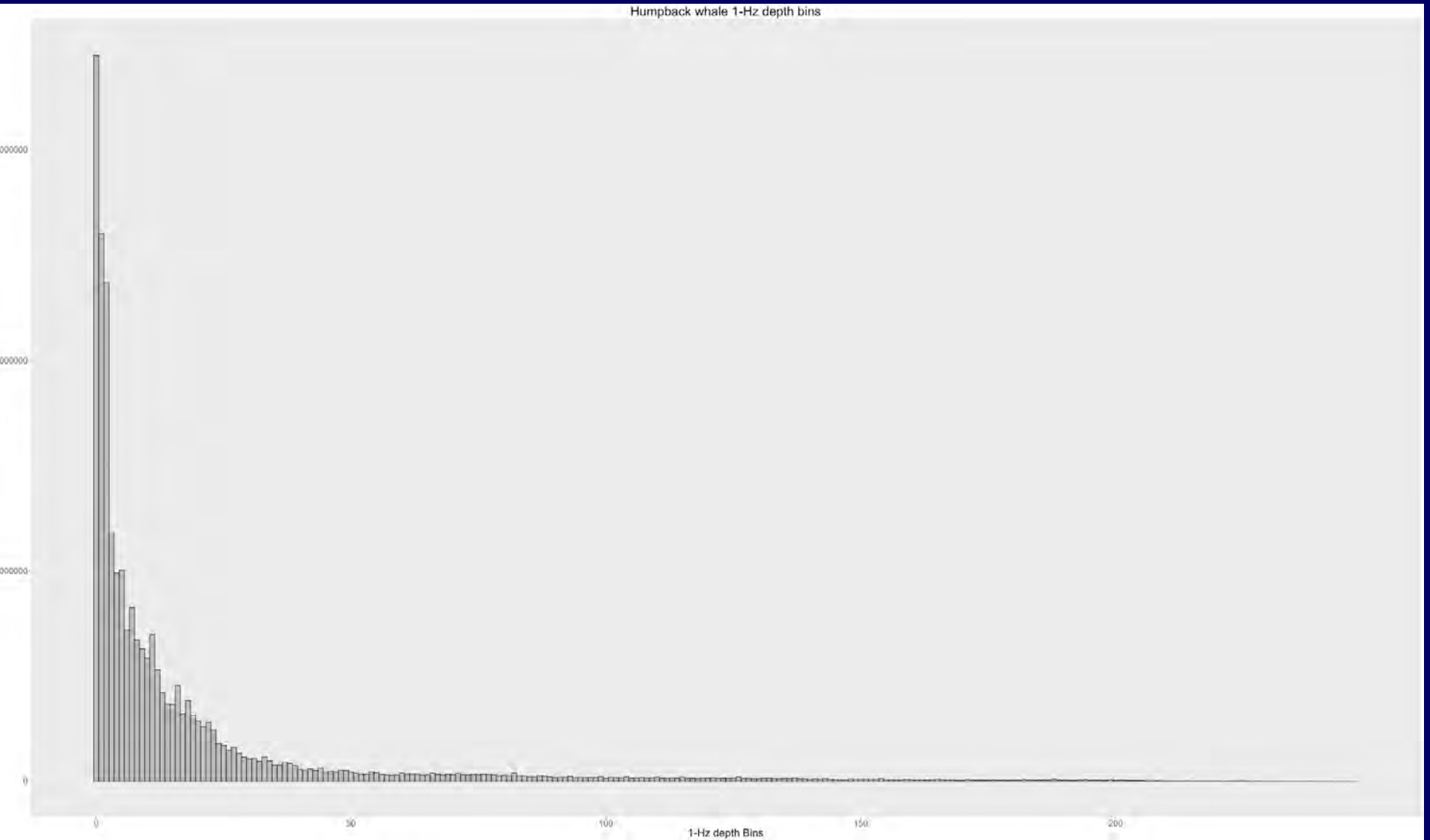
Research in Monterey Bay in collaboration with Stanford Univ.
9-11 April 2017

1. Fewer whales nearshore'
2. More whales offshore
3. Lower density of crab gear
4. Two multi-sensor video tags deployed

Tags deployed in Monterey Bay and off HMB in May 2016



Depth distribution of humpback whales from longer term tag data



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Santa Barbara Channel is a key Biologically Important Area for blue whales

4. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region

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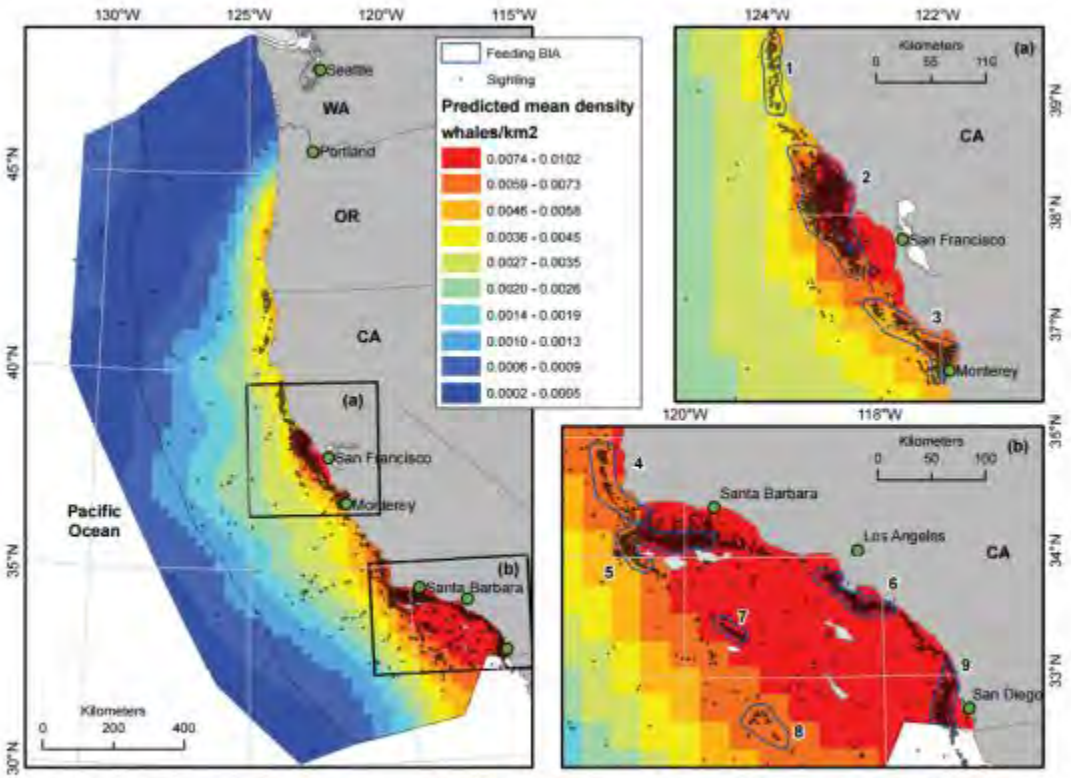
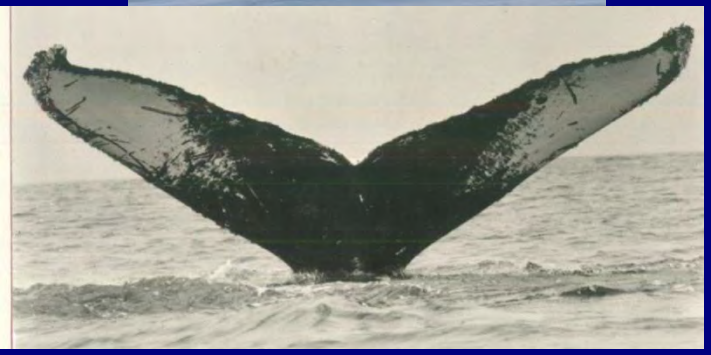
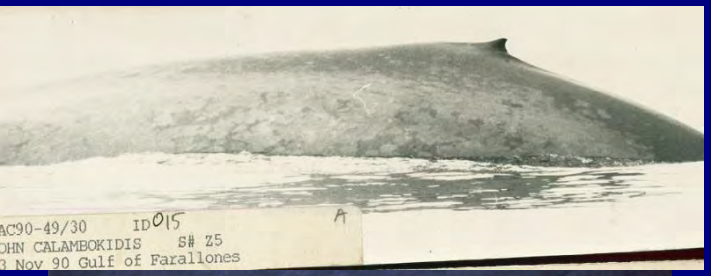
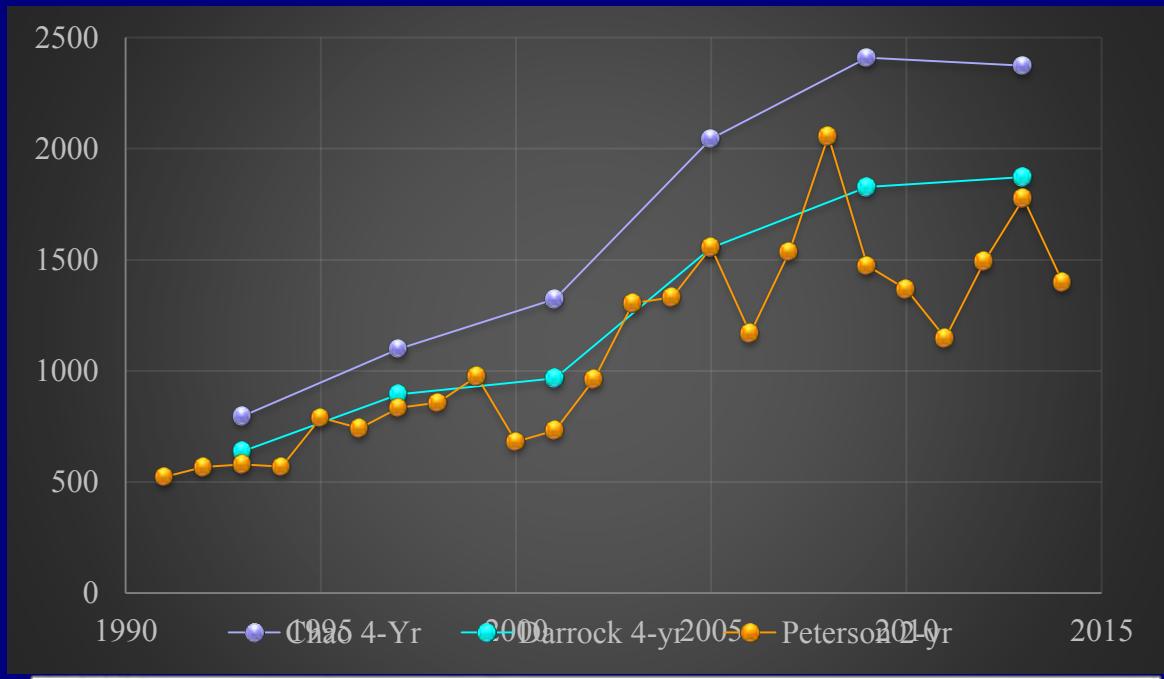


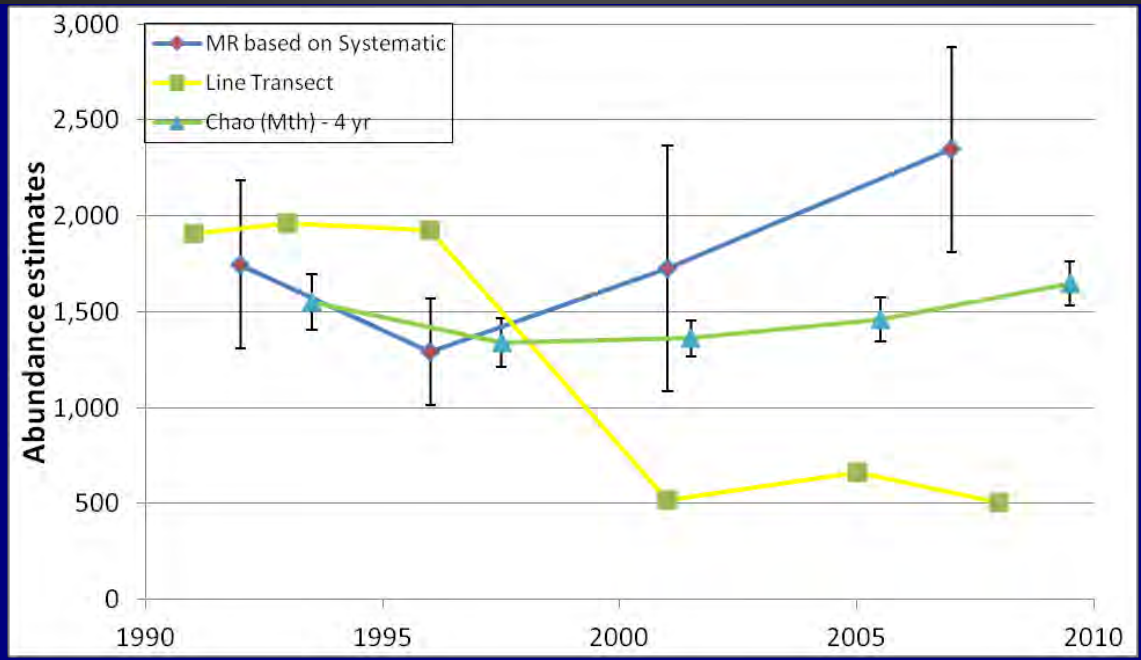
Figure 4.1. Nine blue whale (*Balaenoptera musculus*) Biologically Important Areas (BIAs), overlaid with all sightings and predicted mean densities of blue whales from habitat-based density (HD) models generated from Southwest Fisheries Science Center ship surveys (see Becker et al., 2012a). Panels a and b show more detail for the areas where the BIAs are located. The BIAs are (from north to south) (1) Point Arena to Fort Bragg, August-November; (2) Gulf of the Farallones, July-November; (3) Monterey Bay to Pescadero, July-October; (4) Point Conception/Arguello, June-October; (5) Santa Barbara Channel and San Miguel, June-October; (6) Santa Monica Bay to Long Beach, June-October; (7) San Nicholas Island, June-October; (8) Tanner-Cortez Bank, June-October; and (9) San Diego, June-October (see Table 4.1 for details).

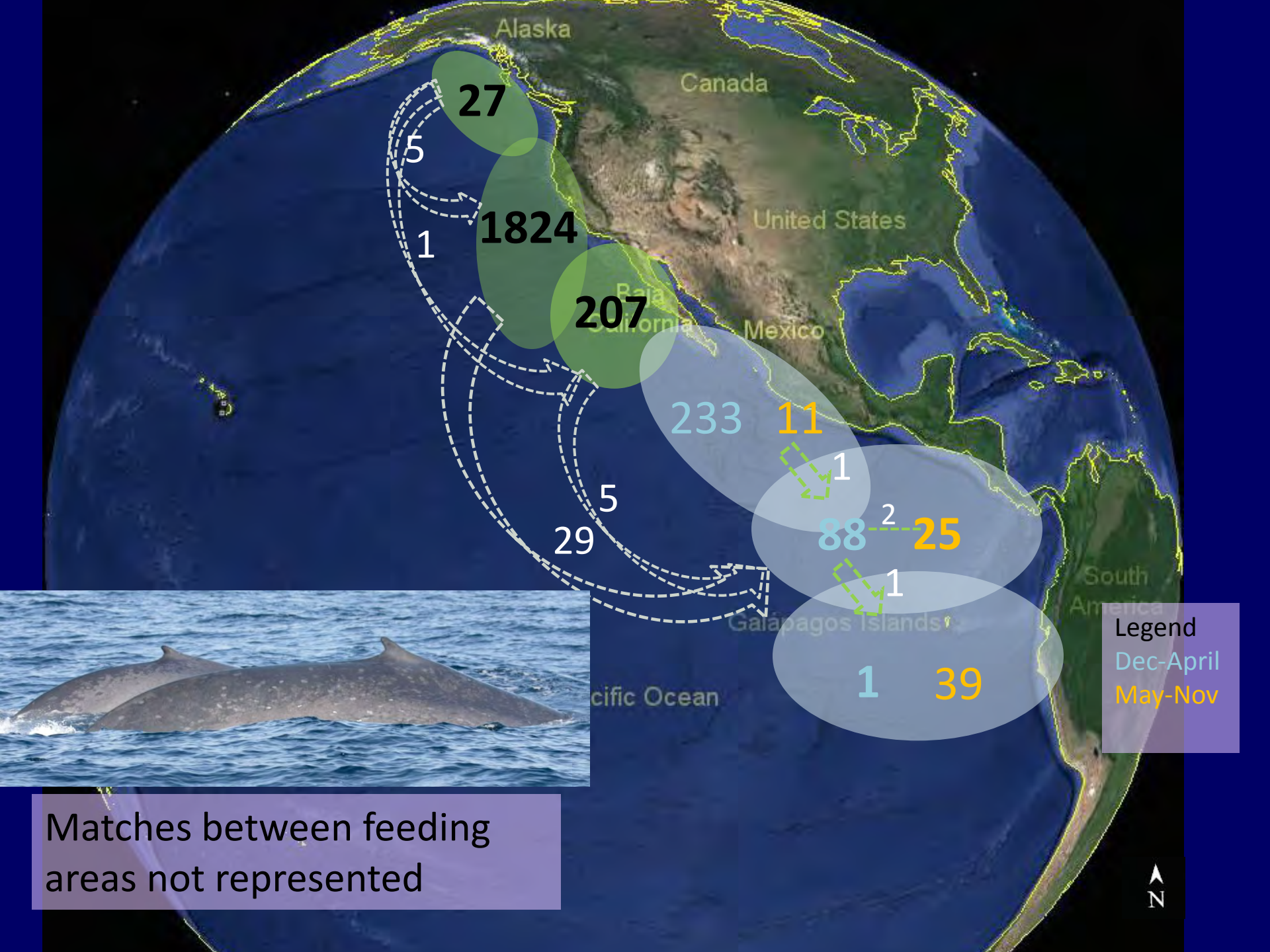
Humpback and blue whale trends - US West Coast





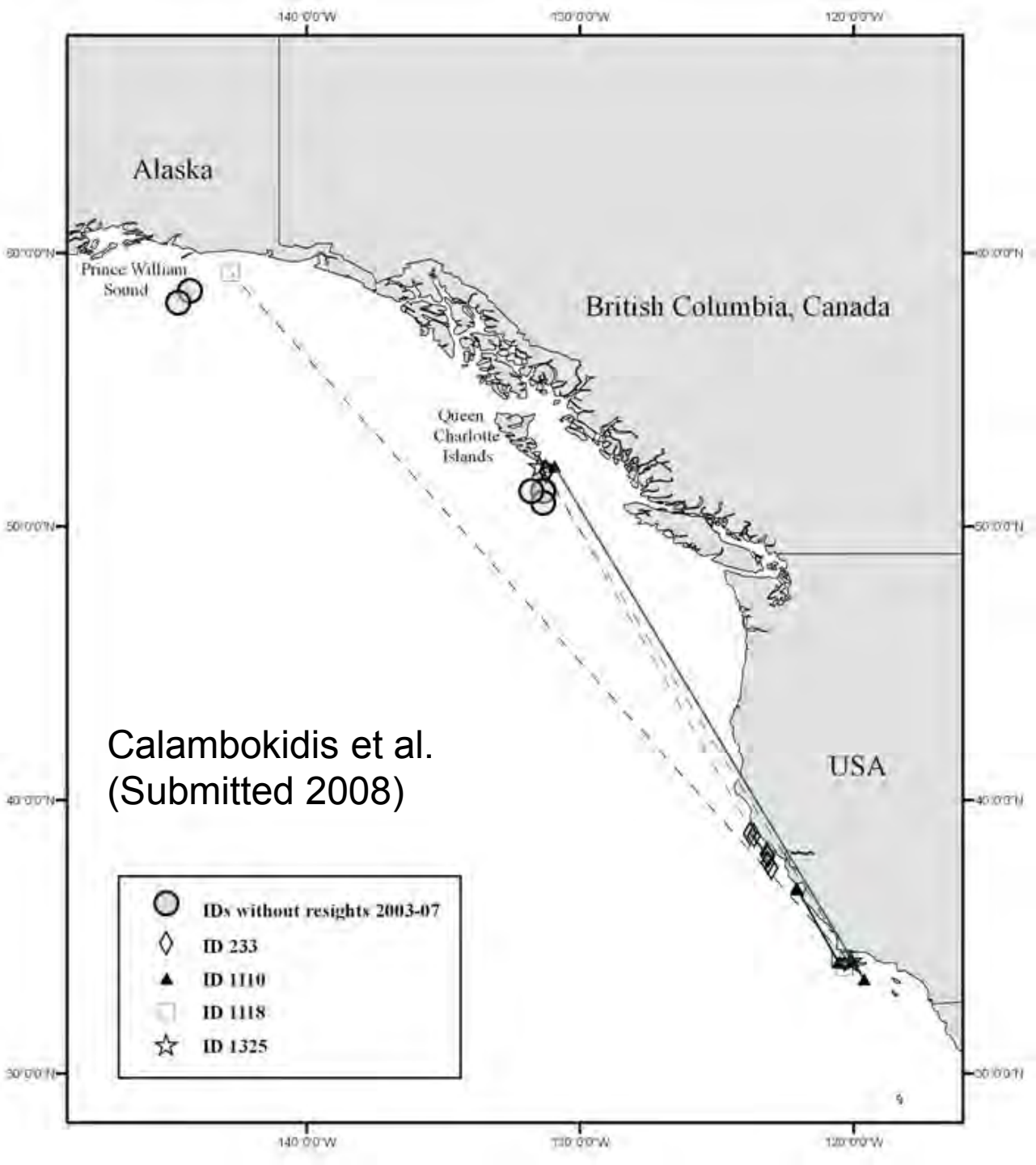






Matches between feeding areas not represented

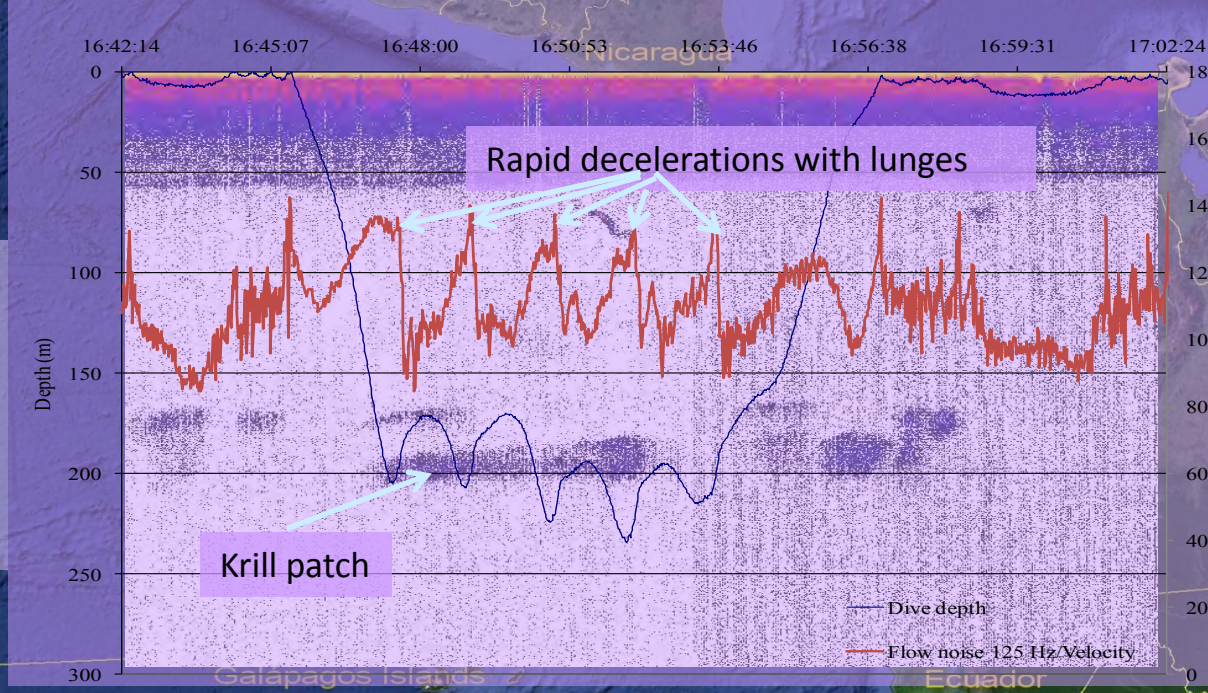
Return of blue whales to the B.C. coast and Gulf of Alaska included whales from California and likely related to the PDO shift to cold regime.



Blue whale behavior and Group types

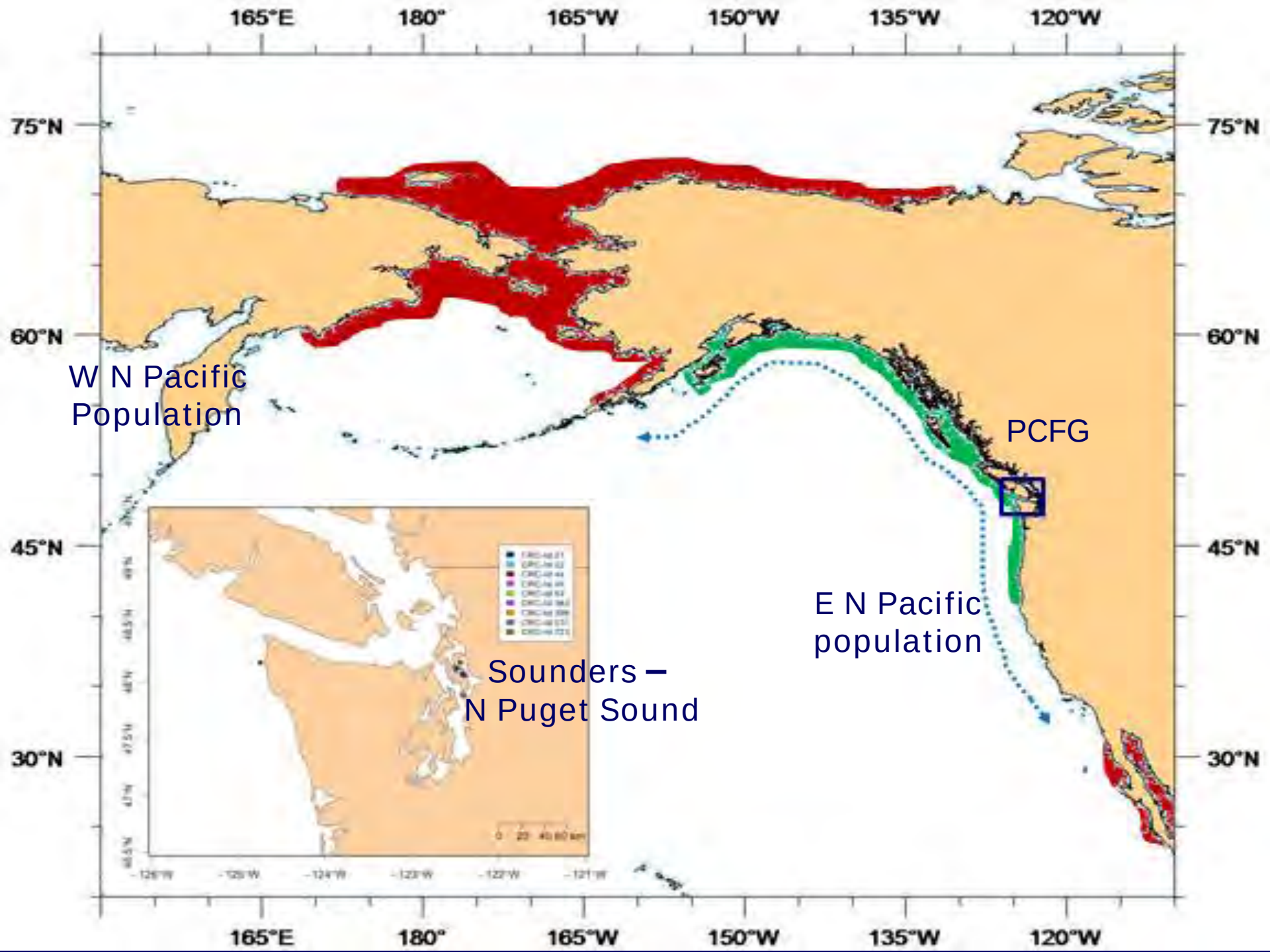
Prey patches found at depth

Active lunge feeding from tag



Mother with young calf on Costa Rica Dome in 2008.

Mother first identified as a calf off California in 1986.


165°E
180°
165°W
150°W
135°W
120°W
75°N
60°N
45°N
30°N
W N Pacific Population
PCFG
E N Pacific population
Sounders – N Puget Sound

Biologically Important Areas

Aquatic Mammals 2015, 41(1), 39-53, DOI 10.1578/AM.41.1.2015.39

4. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region

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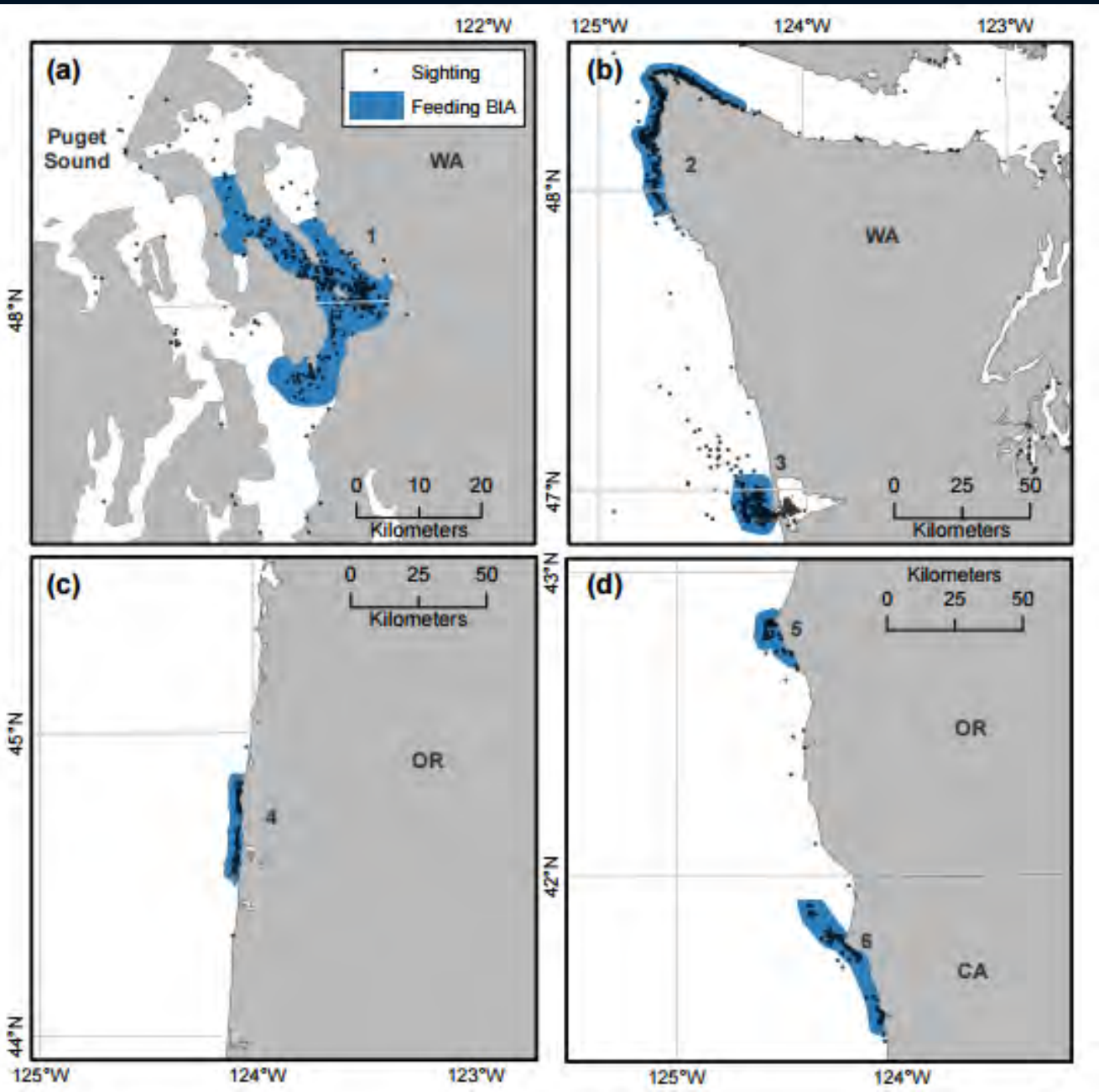
Abstract

In this review, we combine existing published and unpublished information along with expert judgment to identify and support the delineation of 28 Biologically Important Areas (BIAs) in U.S. waters along the West Coast for blue whales, gray whales, humpback whales, and harbor porpoises. BIAs for blue whales and humpback whales are based on high concentration areas of feeding animals observed from small boat surveys, ship surveys, and opportunistic sources. These BIAs compare favorably to broader habitat-based density models. BIAs for gray whales are based on their migratory corridor as they transit between primary feeding areas located in northern latitudes and breeding areas off Mexico. Additional gray whale BIAs are defined for the primary feeding areas of a smaller resident population. Two small and resident population BIAs defined for harbor porpoises located off California encompass the populations' primary areas of use. The size of the individual BIAs ranged from approximately 171 to 138,000 km². The BIAs for feeding blue, gray, and humpback whales represent relatively small portions of the overall West Coast area (< 5%) but encompass a large majority (77 to 89%) of the thousands of sightings documented and evaluated for each species. We also evaluate and discuss potential feeding BIAs for fin whales, but none are delineated due to limited or conflicting information. The intent of identifying BIAs is to synthesize existing biological information in a transparent format that is easily accessible to scientists, managers, policymakers, and the public for use during the planning and design phase of anthropogenic activities for which U.S. statutes require the characterization and minimization of impacts on marine mammals. To maintain their utility, West Coast region BIAs should be re-evaluated and revised, if necessary, as new information becomes available.

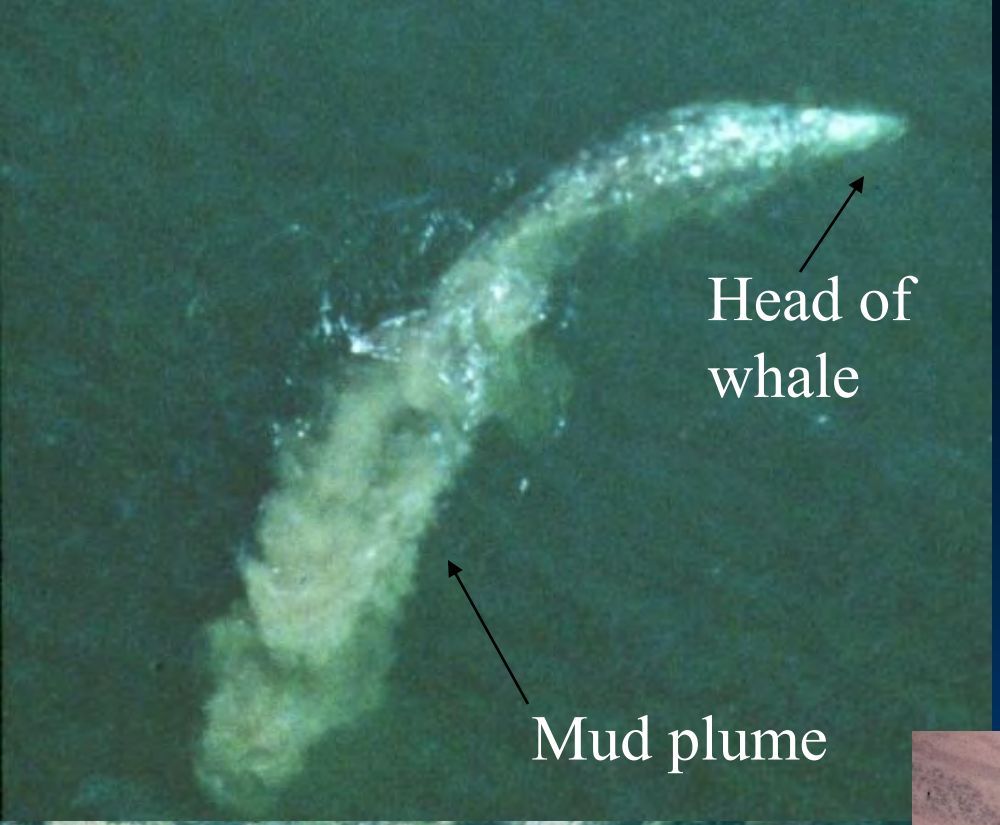
Key Words: feeding area, migratory corridor, resident population, anthropogenic sound, species distribution, U.S. West Coast, North Pacific Ocean

Introduction

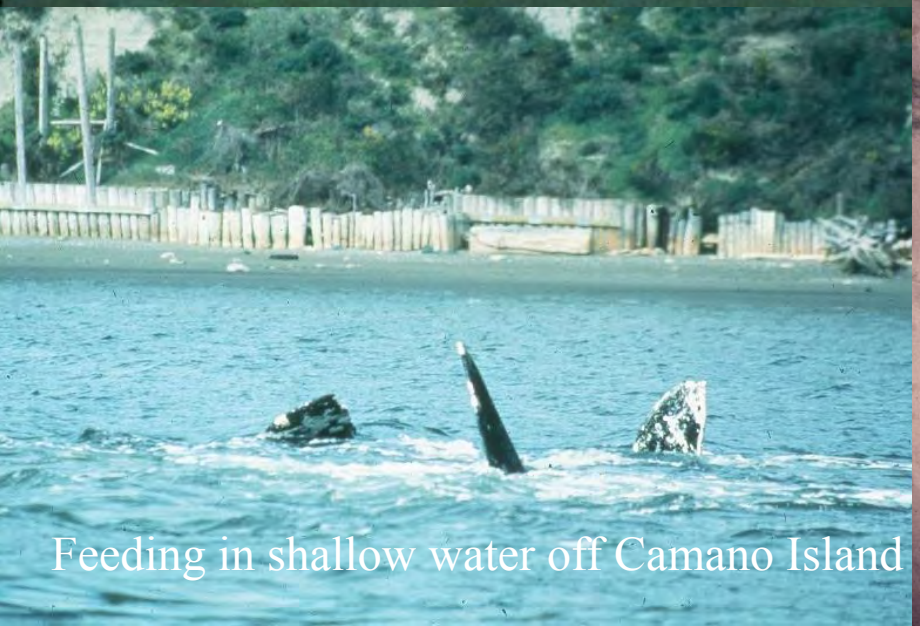
This review document coalesces existing published and unpublished information to define Biologically Important Areas (BIAs) in U.S. waters of the West Coast region (shoreward of the offshore boundary of the U.S. Exclusive Economic Zone [EEZ]) for cetacean species that meet the criteria for feeding areas, migratory corridors, and small and resident populations defined in Table 1.2 of Ferguson et al. (2015b) within this issue. A comprehensive overview of the BIA delineation process; its caveats (Table 1.4), strengths, and limitations; and its relationship to international assessments also can be found in Ferguson et al. Table 1.3 provides a summary of all BIAs identified, including region, species, BIA type, and total area (in km²). A summary also can be found at http://cetsound.noaa.gov/important. Table 1.1 defines all abbreviations used in this special issue. Metadata tables that concisely detail the type and quantity of information used to define many of these BIAs are available as an online supplement. Our intent is to delineate BIAs by synthesizing information that is not publicly available from existing sources, is only partially represented through peer-reviewed publications,



Variety of prey and habitats



Aerial photograph of feeding whale in Strait of Juan de Fuca

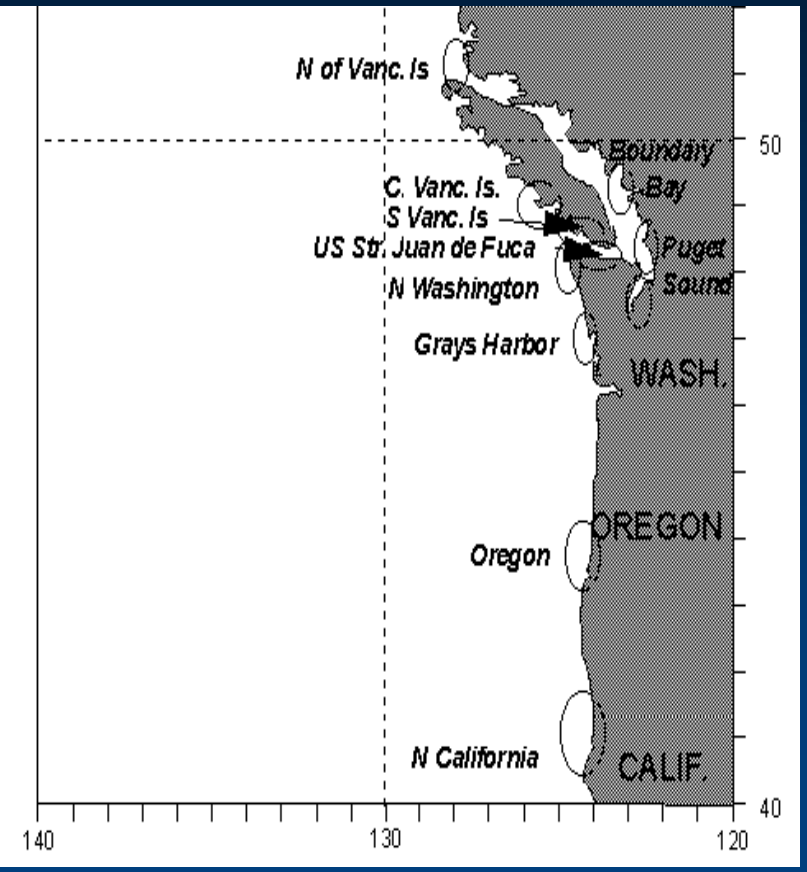


Feeding in shallow water off Camano Island

Feeding pits made by gray whales off Whidbey Island, Puget Sound

Movement of gray whales

Frequent interchange within and between years among coastal sites



N of Vancouver Island, BC

Central Vancouver Island

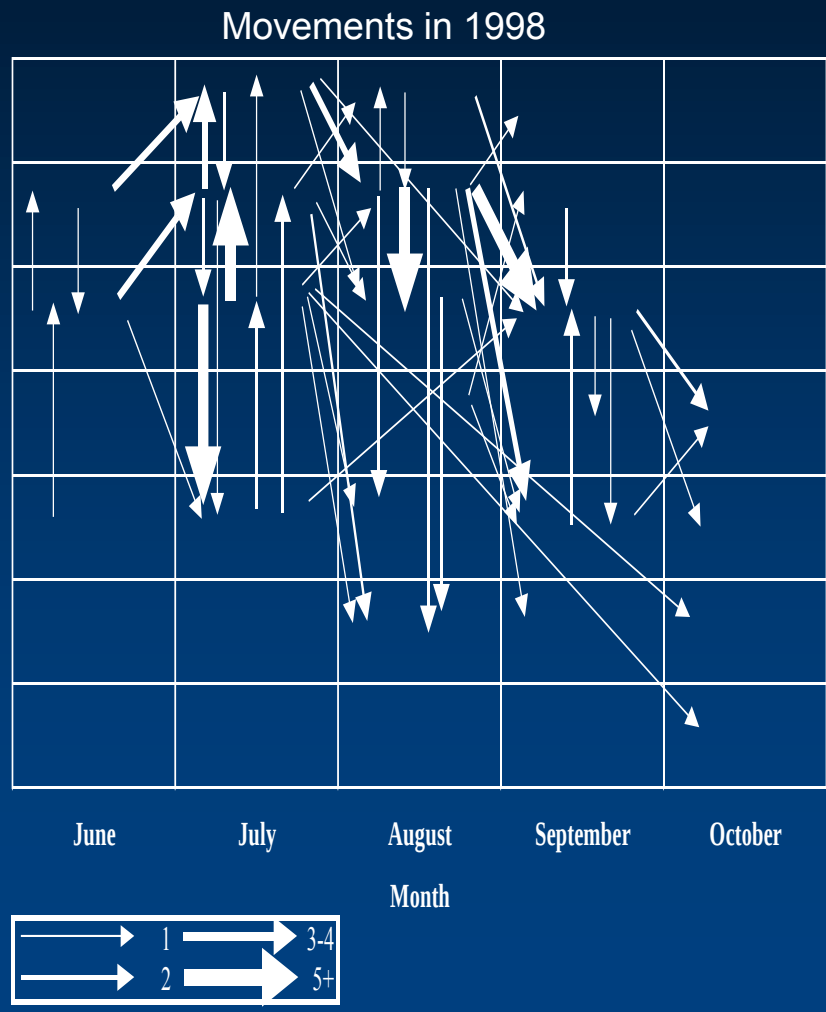
S. Vancouver Island

U.S. Strait of Juan de Fuca

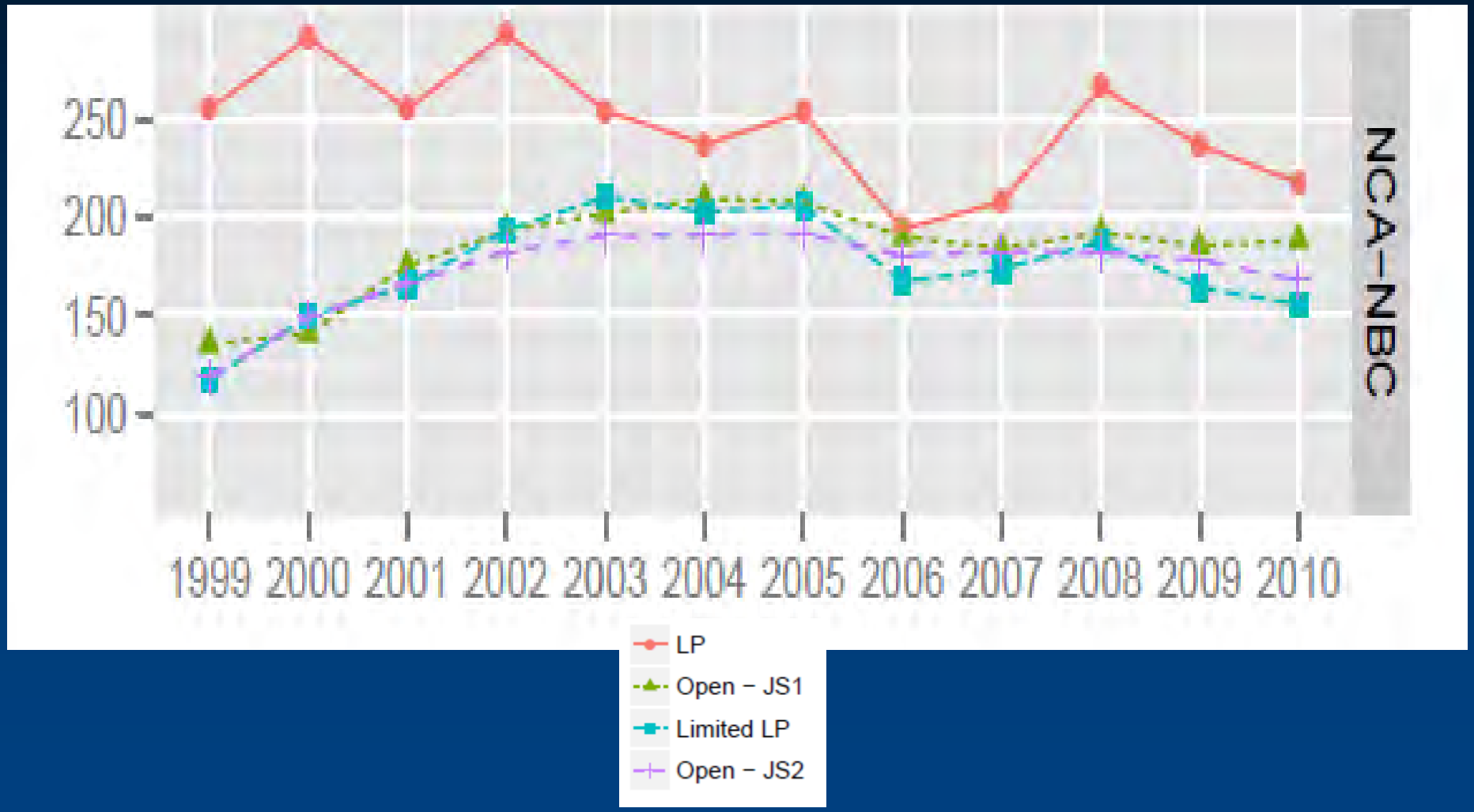
N. Washington coast

Oregon coast

Northern California



PCFG Gray Whale Abundance



Significant differences in mtDNA between feeding areas

Marine Mammal Science

MARINE MAMMAL SCIENCE, **(*): ***–*** (*** 2014)

DOI: 10.1111/mms.12129

Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds

Table 4. Results of pairwise comparisons across strata using (a) mtDNA and (b) 12 microsatellites. Comparisons that are statistically significant are shown in bold.

Pairwise comparison	Φ_{ST}	*P*-value	F_{ST}	*P*-value	Fisher exact test *P*-value
(a)					
North[a] (103) *vs.* PCFG (71)	0.012	0.0740	0.012	**0.0045**	**0.0067**
Chukotka (69) *vs.* PCFG (71)	0.020	**0.0386**	0.010	**0.0349**	**0.0254**

Pairwise comparison	F_{ST}	*P*-value	F_{ST}'	*P*-value	χ^2 *P*-value
(b)					
North[a] (105) *vs.* PCFG (70)	0.000	0.5269	0.000	0.5271	0.3491
Chukotka (70) *vs.* PCFG (70)	0.001	0.2539	0.003	0.2539	0.3503

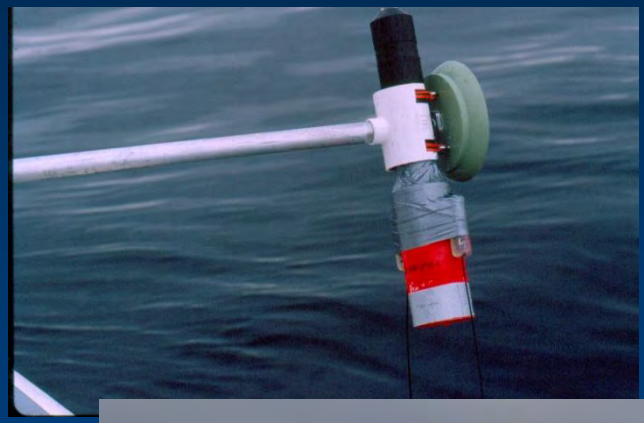
[a]Samples from Chukotka are included as part of the North stratum.

Variety of tag types

- Short term suction-cup archival
- Medium duration dart-attached archival
- Medium duration LIMPET satellite tags
- Deep implant position-only implant tags

Initial tag types deployed

- National Geographic Crittercam
  - video, sound, depth, temperature
- Acoustic tags
  - digital sound, temperature, pitch and roll angle, VHF, & satellite
- WHOI dTag
  - digital sound, temperature, accelerometers and magnetometers
- Multi-sensor video tags



Deploying tags on whales

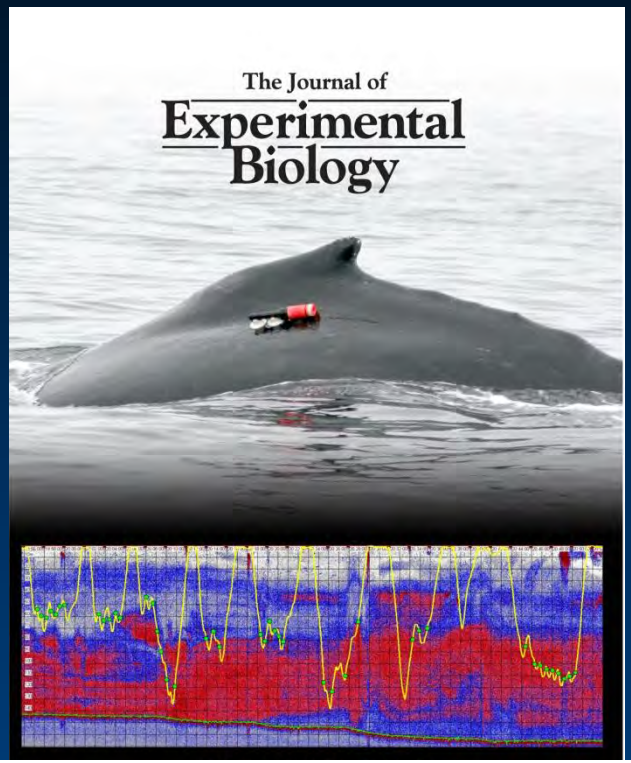
Publications on underwater behavior of blue, fin, and humpback whales

Vol. 330: 269–284, 2007 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published January 25

OPEN ACCESS

Behavioral context of call production by eastern North Pacific blue whales

Erin M. Oleson[1,*], John Calambokidis[2], William C. Burgess[3], Mark A. McDonald[4], Carrie A. LeDuc[5], John A. Hildebrand[1]



PAPER

Insights into the Underwater Diving, Feeding, and Calling Behavior of Blue Whales from a Suction-Cup-Attached Video-Imaging Tag (CRITTERCAM)

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ABSTRACT

We examined the underwater behavior of blue whales using a suction-cup-attached video-imaging instrument (Crittercam). We made 13 successful deployments (defined as tag duration of >15 min and successful recovery of the tag and data) totaling 19 hours of Crittercam on blue whales off California and in the Sea of Cortez from spring through fall (26 February to 30 September) between 1996 and 2005. Whale diving depth and behavior varied widely by region and period, although deployments on different individuals in the same area and period often showed very similar feeding behavior. One deployment extending into night showed a diurnal shift in diving behavior with progressively shallower feeding dives as it became dark, with shift to shallow, apparently non-feeding dives during the night. Data and video from tags demonstrated that the characteristic series of vertical movements blue whales make at depth are lunges into dense aggregations of krill. These krill were visible streaming by the camera immediately before the whale lunged and more clearly when the whales' forward motion stopped as a result of the lunge. The progression of events leading up to and during the lunge could be documented from the head movement of whales and occasional views of the expanding throat pleats or lower jaw, and by changes in flow noise about the tag, indicating a rapid deceleration. One set of deployments in the Southern California Bight revealed consistent feeding at depths of 250–300 m, deeper than has been previously reported for blue whales. A loud blue whale vocalization was heard on only one deployment on a male blue whale in an interacting trio of animals.

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Kinematics of foraging dives and lunge-feeding in fin whales

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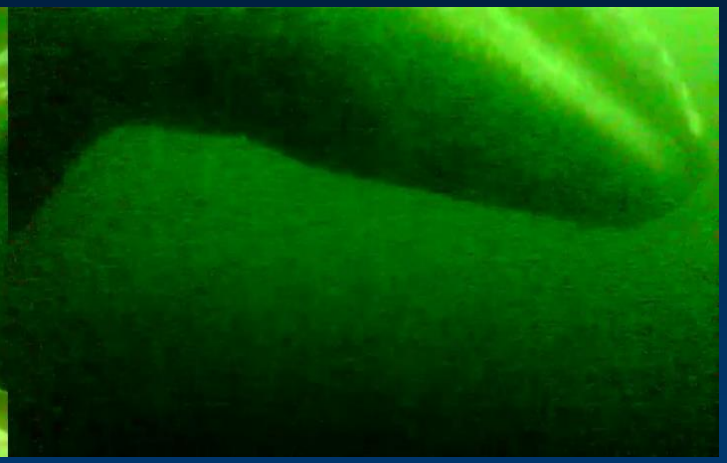
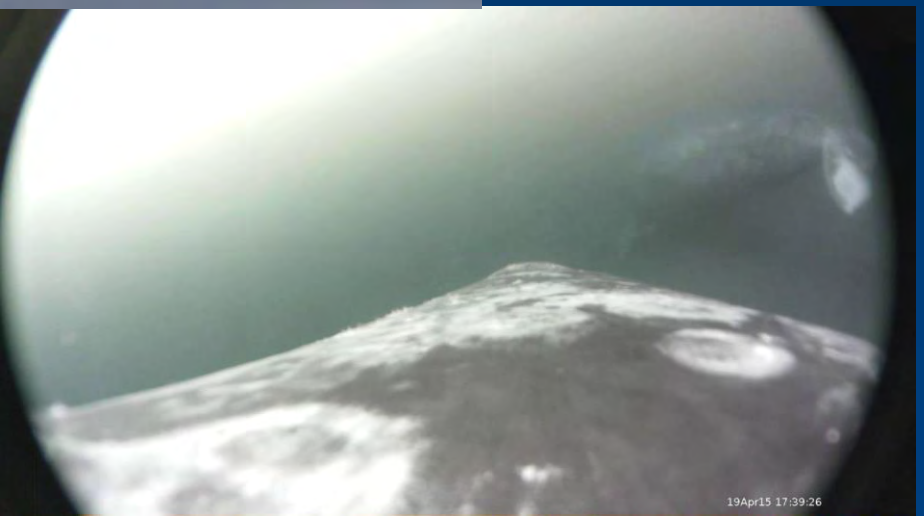
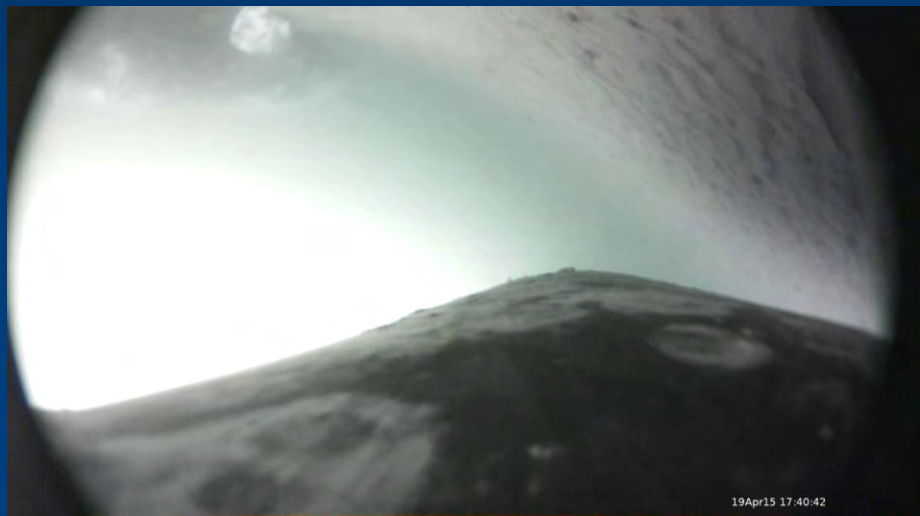
2015-16 whale tag deployments

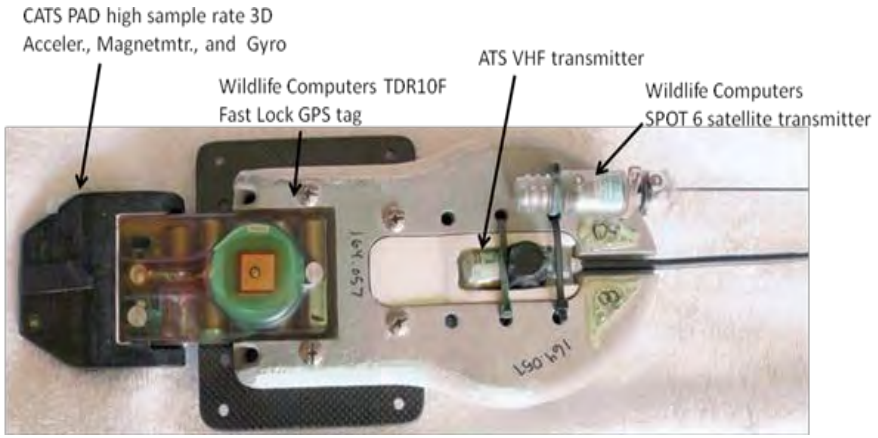






Medium duration dart-attached tags & new acoustic tag

Surgical stainless darts designed after LIMPET titanium darts



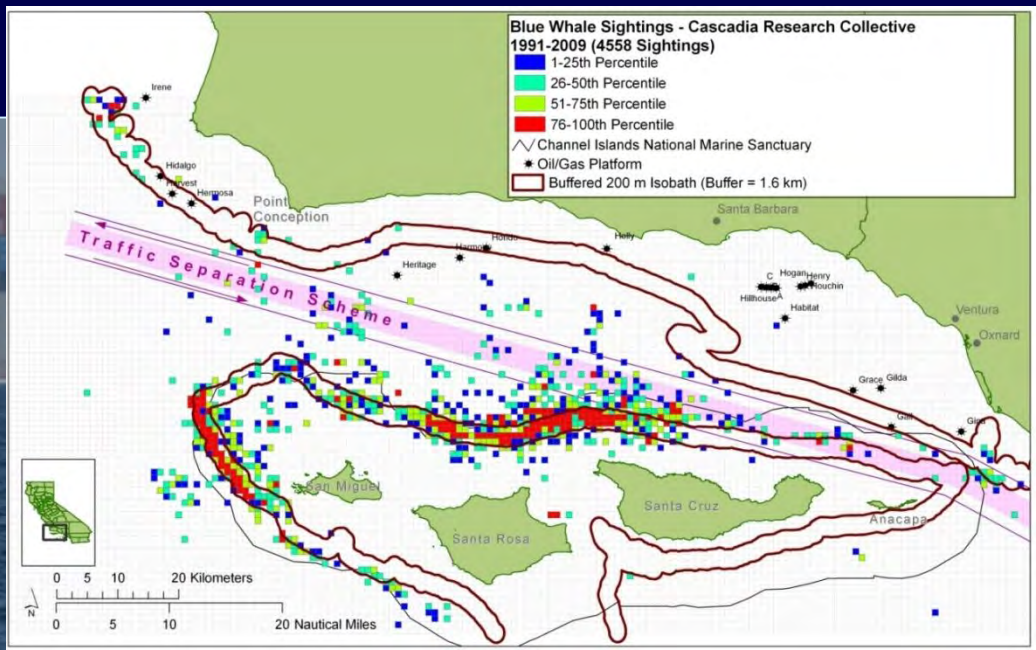
Dart attached Acousonde with GPS and satellite SPOT6. Acoustic and GPS data for up to 3 weeks. With high resolution accelerometry up to 4 days of multi-sensor data in current configuration.

Szesciorka AR, Calambokidis J, Harvey JT. 2016. Testing tag attachments to increase the attachment duration of archival tags on baleen whales. Animal Biotelemetry 4(1):1-12. doi: 10.1186/s40317-016-0110-y.

Blue whale ship strikes Sept-Oct 2007

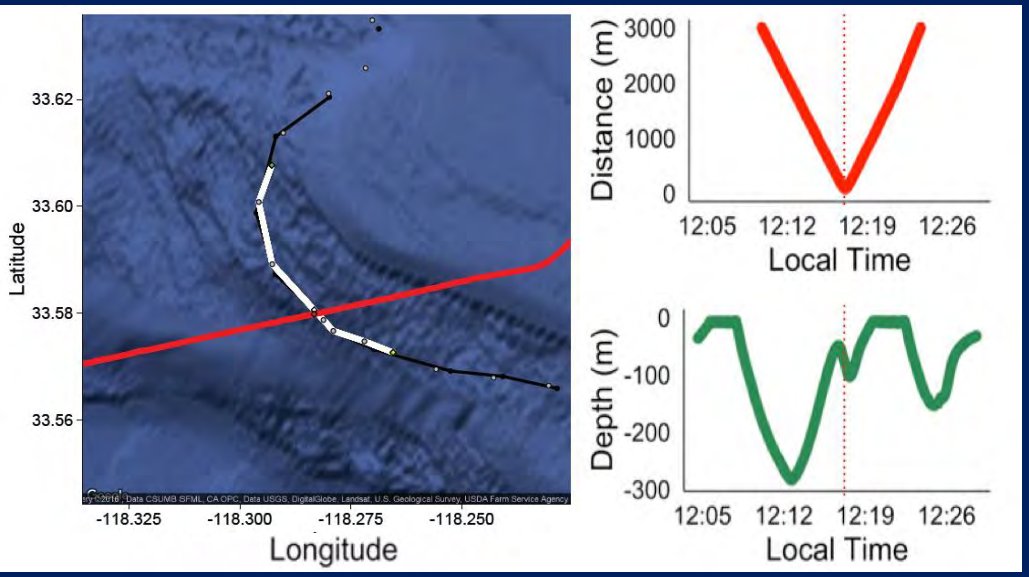
Min. 5 blue whales off S Calif. and Baja found dead

Heaviest ship traffic in and out of Los Angeles and Long Beach goes through Santa Barbara Channel



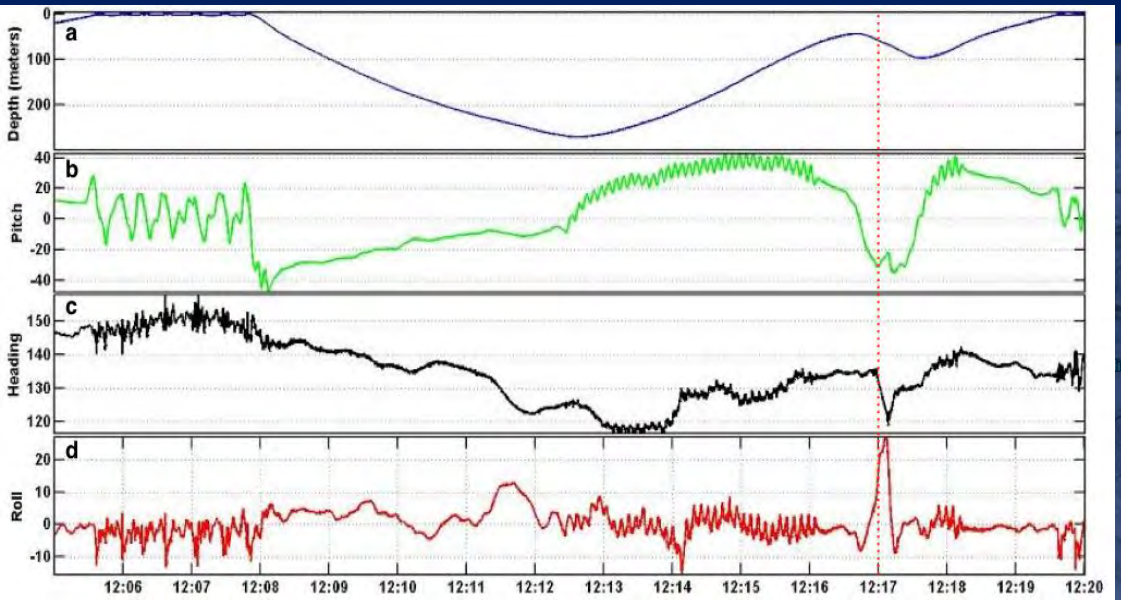
Interactions between ships and whales off California

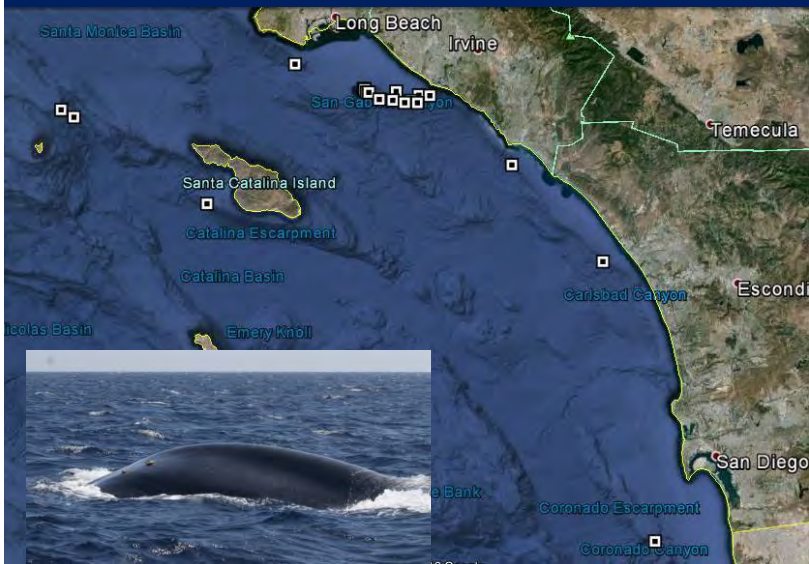
Near miss of ship to a blue tagged blue whale 13 Sept 2014



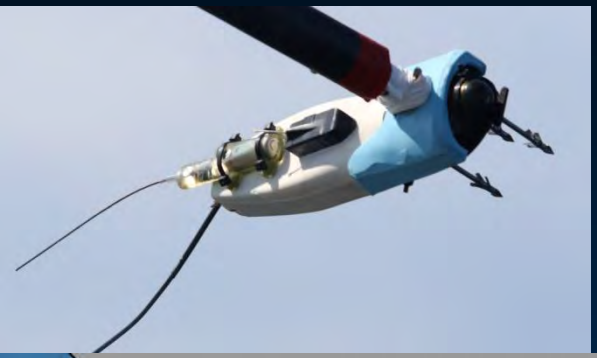
History of whale

- First identified in 1987 in Gulf of Farallones
- 25 sighting, 1987-90 off central CA, 1998-2014 off San Diego-LA, extended stays off LA-Long Beach
- 1 of 2 whales involved in overturning boat off San Diego on 2 July 2014

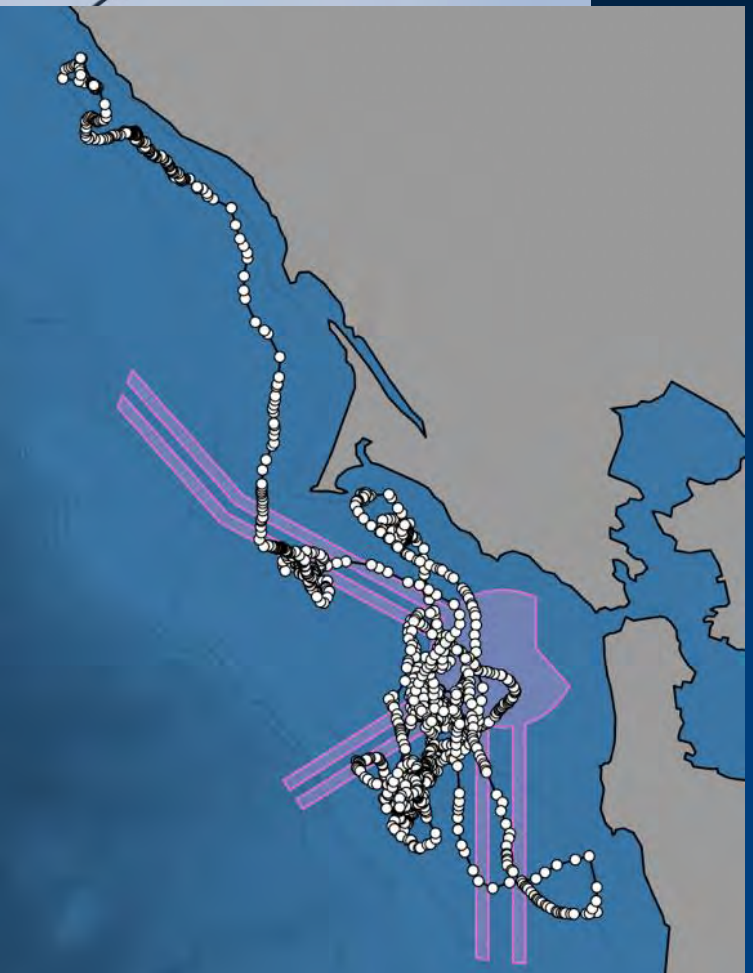


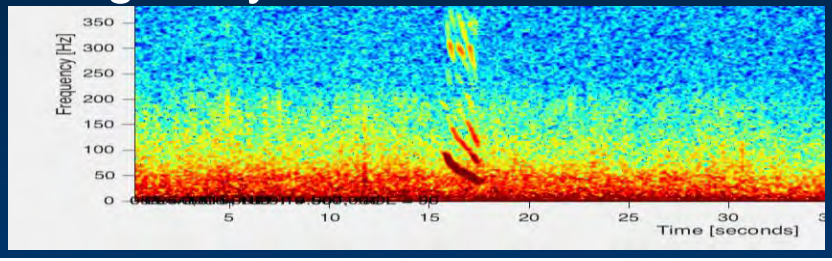


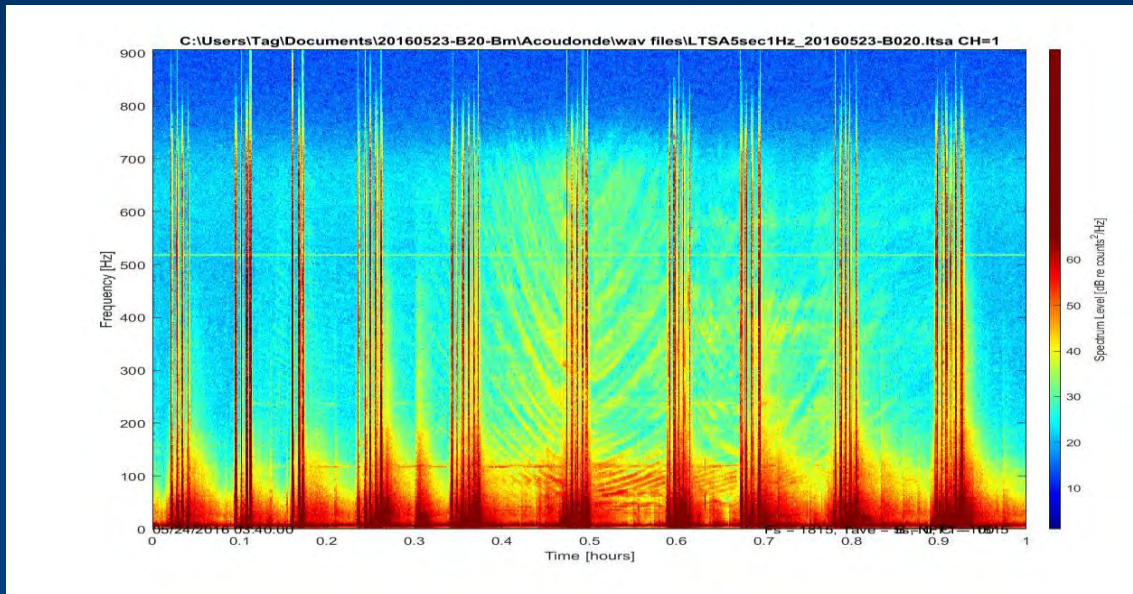
Acousonde deployment – B020



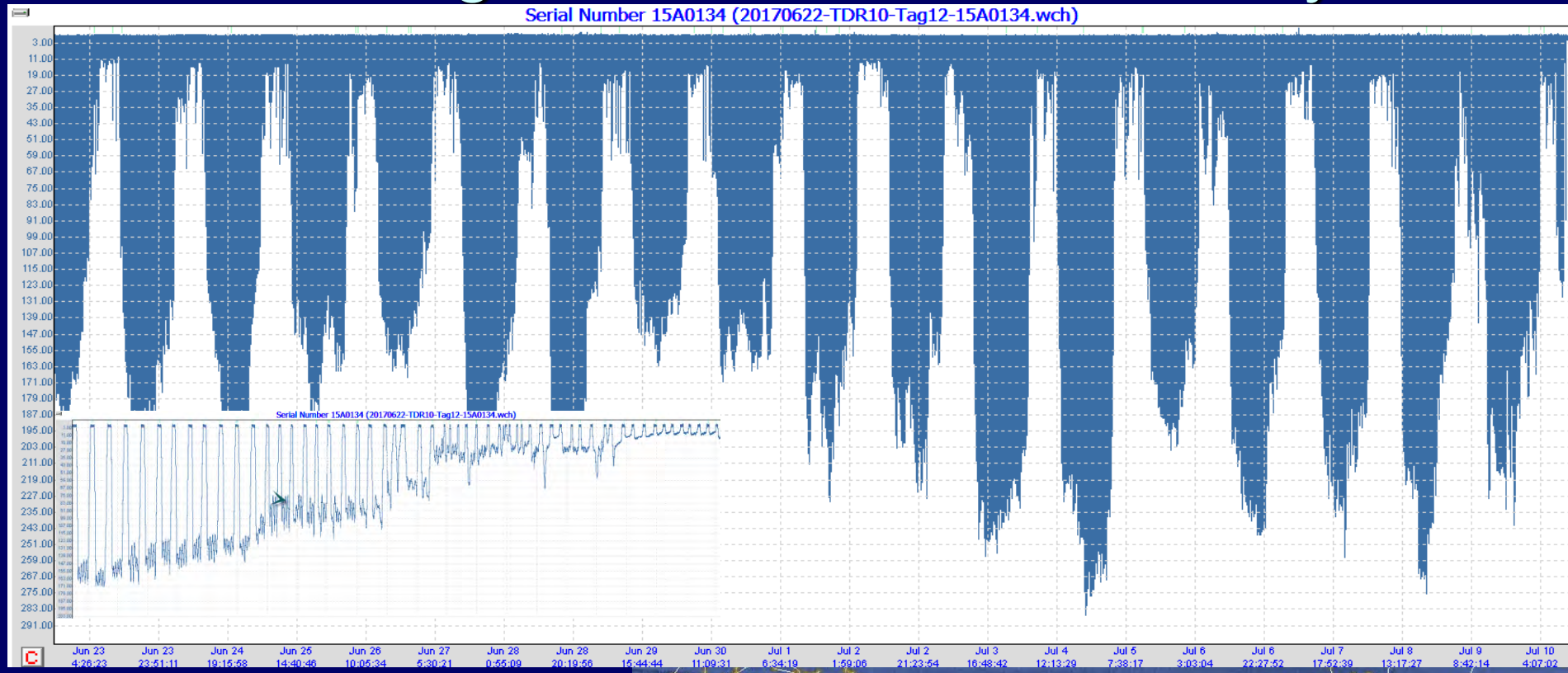
- Deployed 23 May 2016 in near W shipping lane off SF Bay
- >10 close ship approaches documented acoustically
- 2 June tag detaches from whale N of Bodega Bay and recovered same day

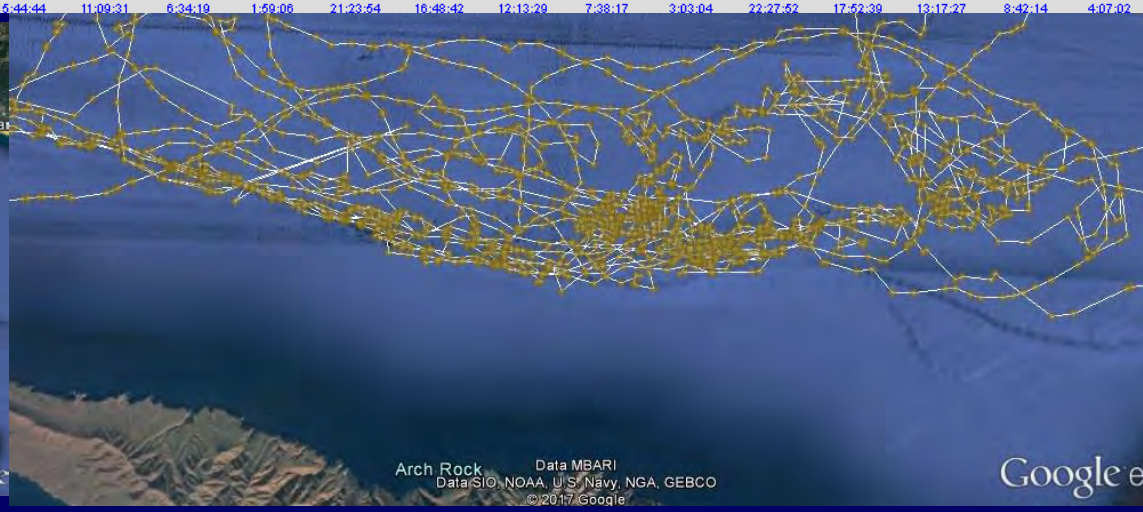






Two TDR10 tags on blue whales June-July 2017





Planned and continuing work with humpback whales

- Continued stock structure and abundance data from photo-ID and genetics under Sect 6 grant
- Deployments of suction cup tags on humpback and other species in collaboration with Stanford and OSU
- Pending proposal to use entanglement scaring to look at temporal and spatial trends in entanglements
- Pending proposal for continued development of medium duration archival tags and deployments
- Expanded work on overall N Pacific humpback whale status (IWC and post-listing monitoring)

Conclusions

- Changes in humpback whale status and management more accurately represent true status but present major challenges. Importance of management that emphasizes the feeding areas because:
  - Most time spent there
  - Most impacts occur on feeding grounds
  - Humpback whales most loyal to feeding areas
- Humpback whale distribution influenced by
  - Wider distribution and longer periods on feeding areas as population hits carrying capacity
  - Prey choice with krill near shelf edge and fish closer to shore
- Whale interaction with gear likely partly a result of their tendency to interact with kelp and other objects