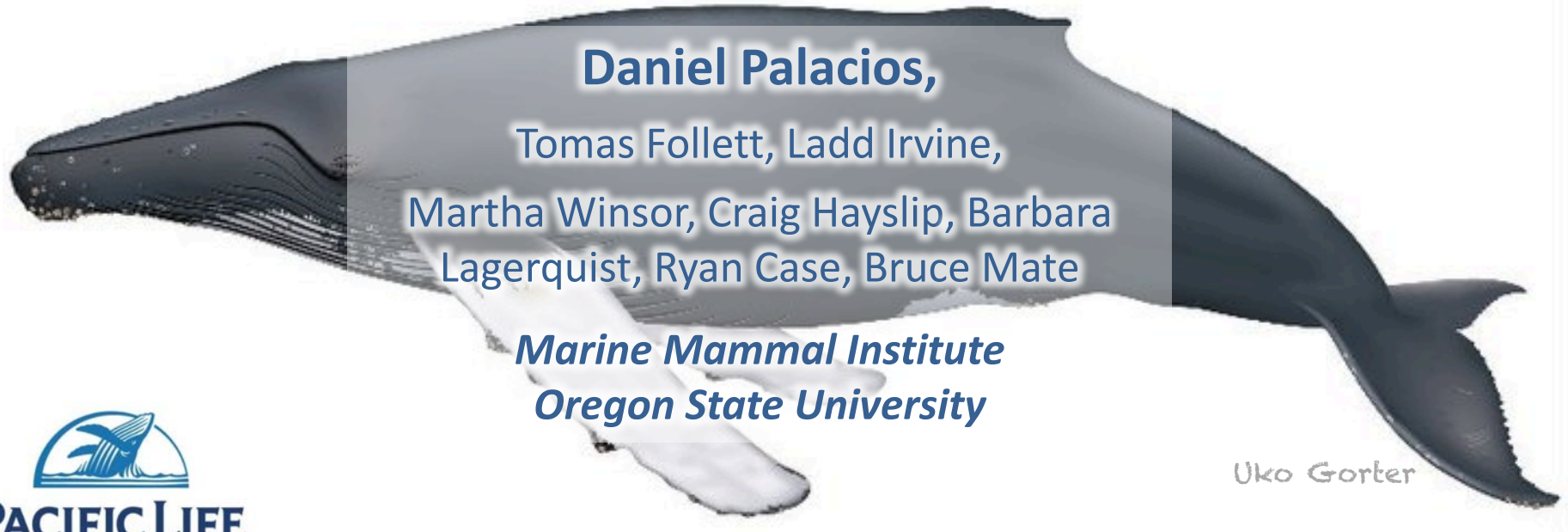
Insights Into The Migration Of Humpback Whales In The North Pacific Ocean From Satellite Telemetry



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Tomas Follett, Ladd Irvine,

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Marine Mammal Institute
Oregon State University

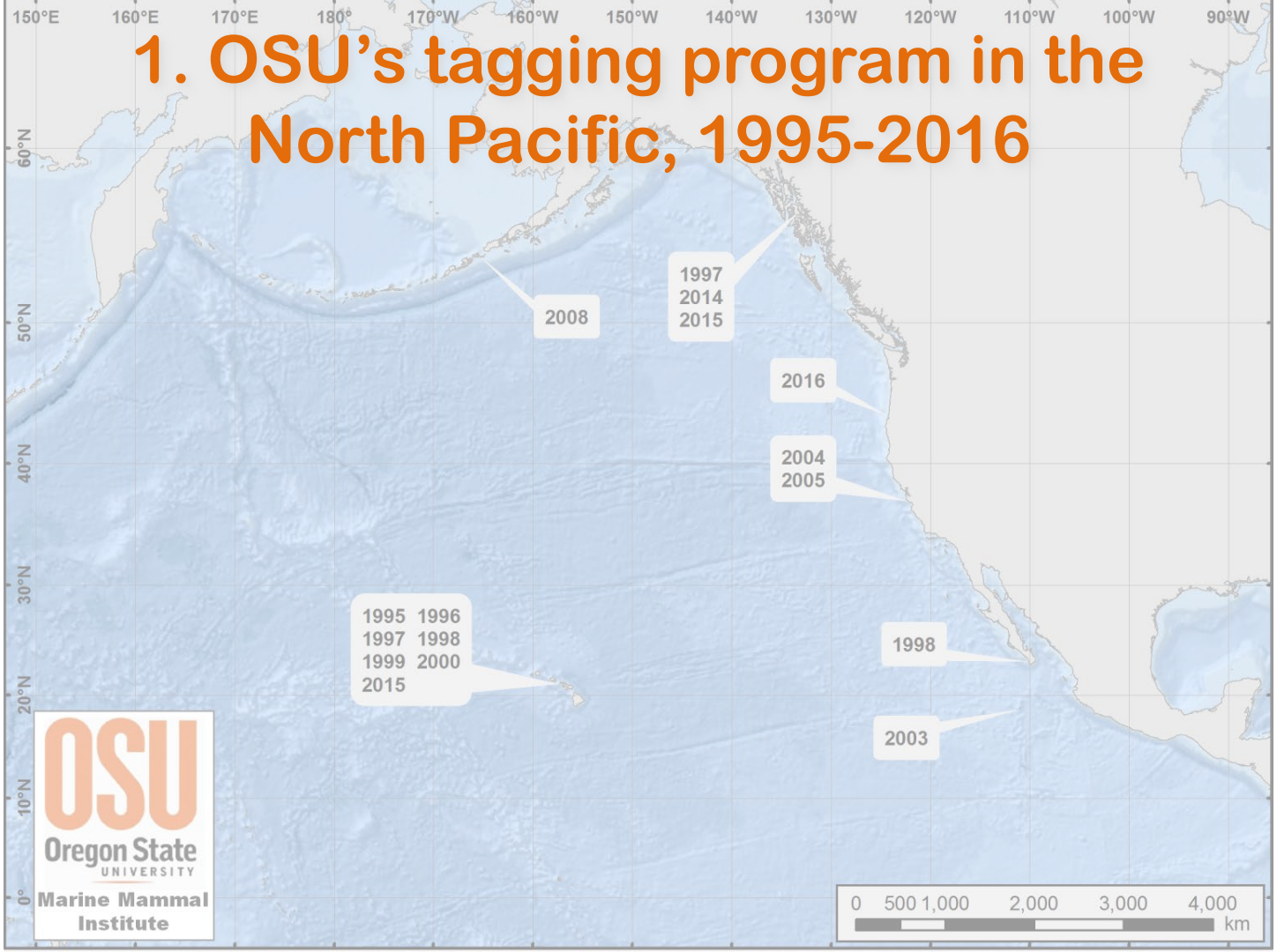
PACIFIC LIFE FOUNDATION

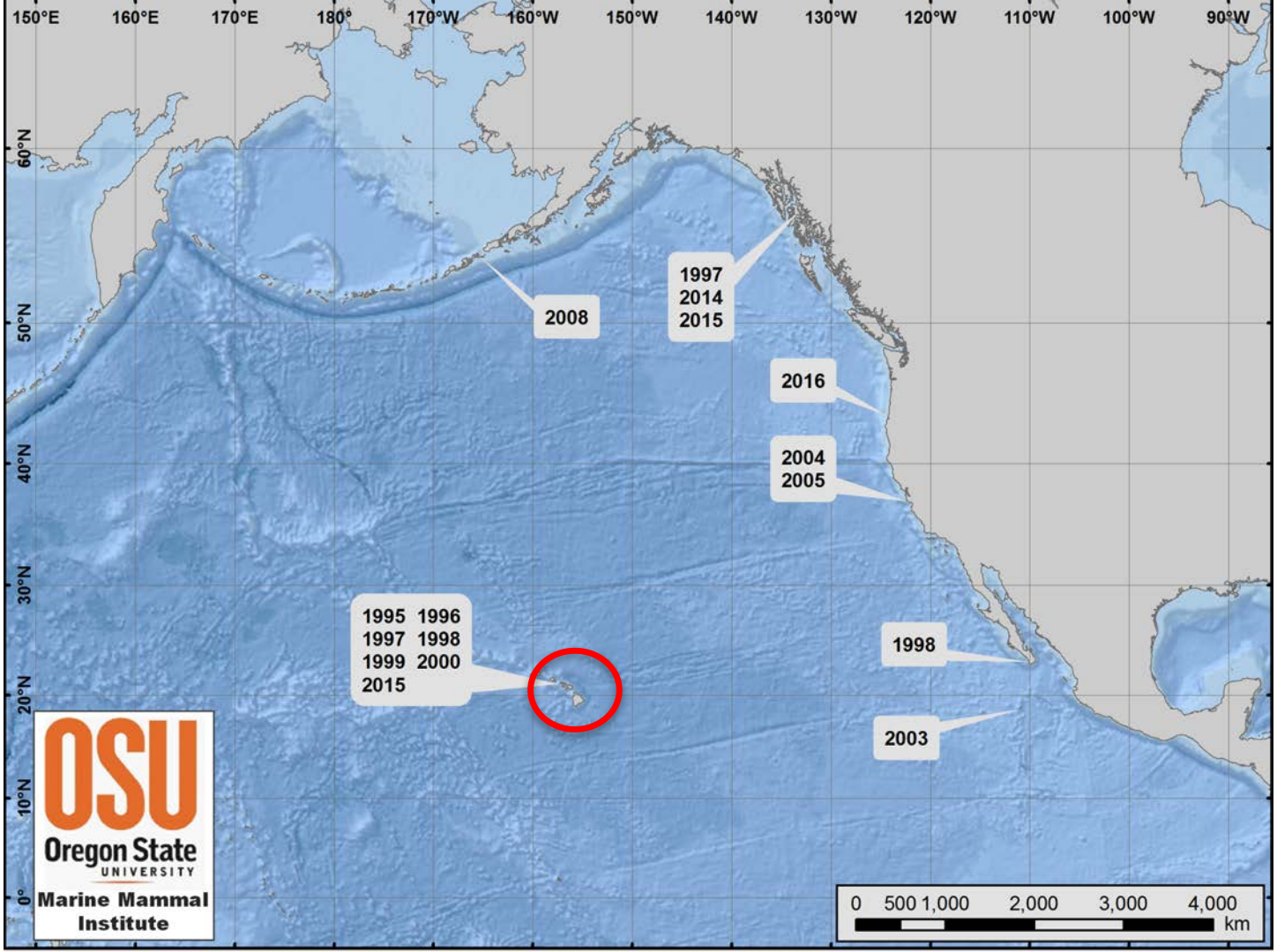
#SMM2017 @danielequs of @OregonState

OUTLINE

1. Overview of OSU's tagging program in the North Pacific
2. Phases of migration
3. Residency in breeding & feeding areas
4. Connectivity (ESA, IWC, MiCO)
5. Future: behavior monitoring tags, orientation in flows, …

1. OSU's tagging program in the North Pacific, 1995-2016

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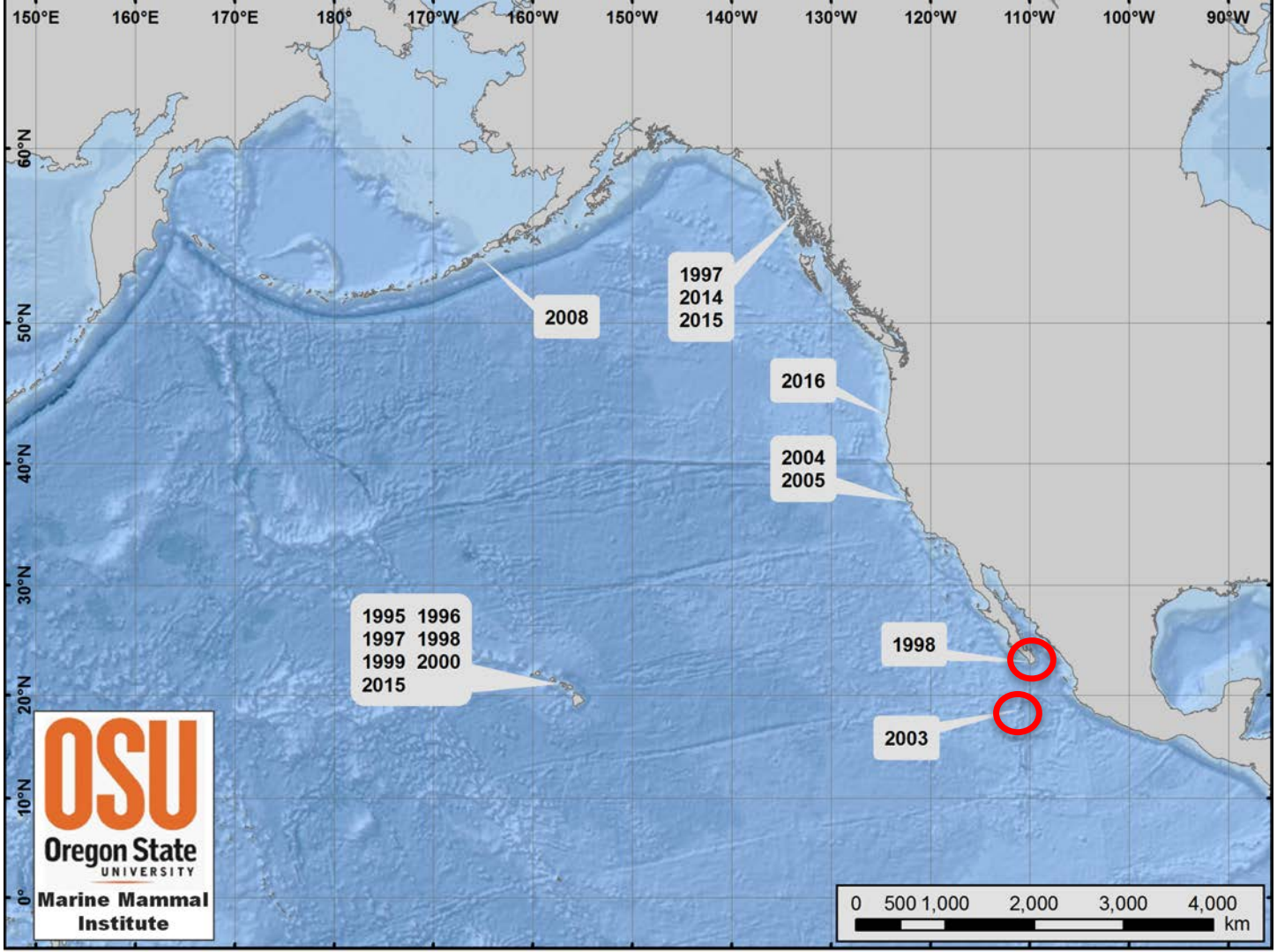
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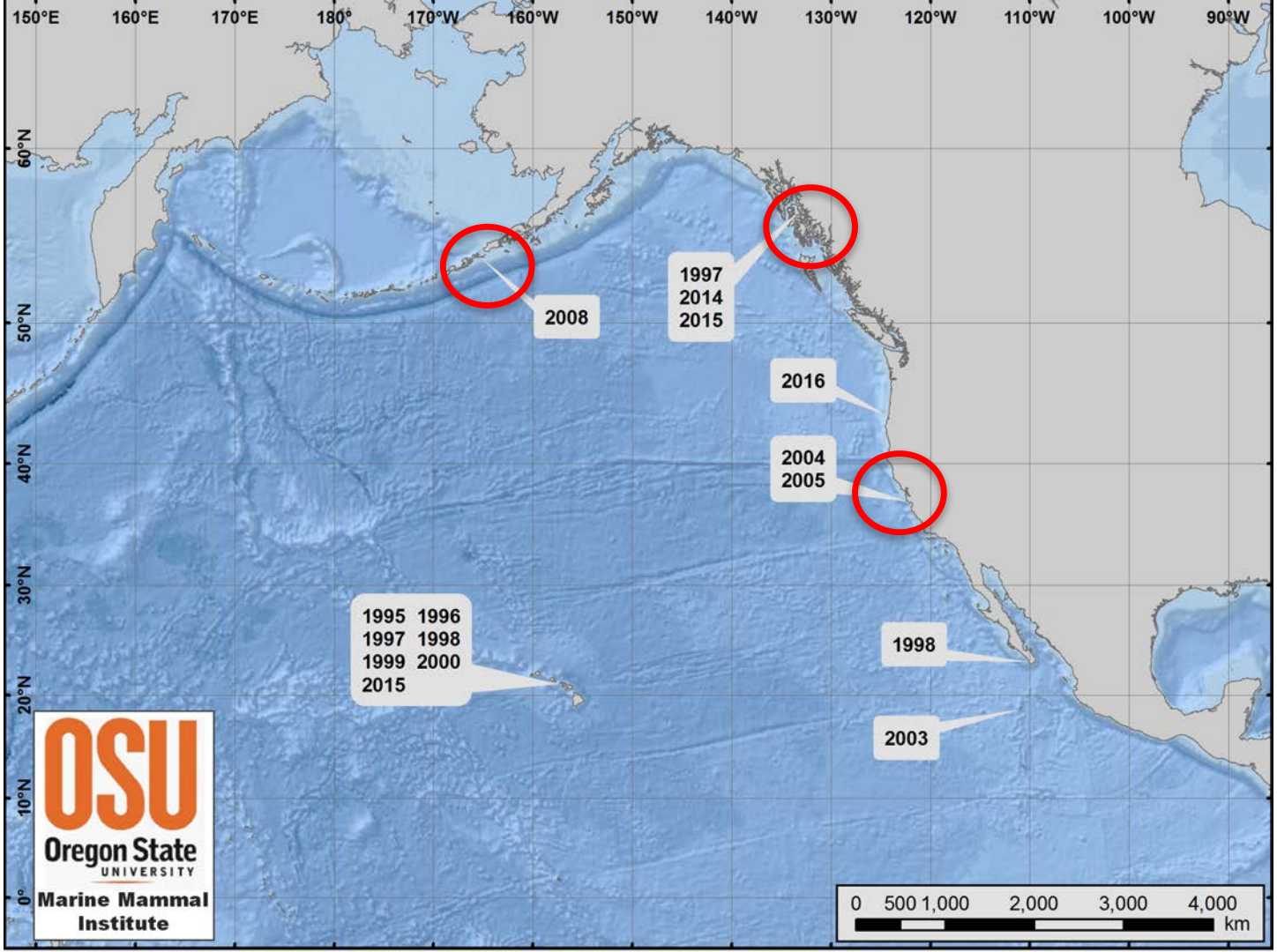
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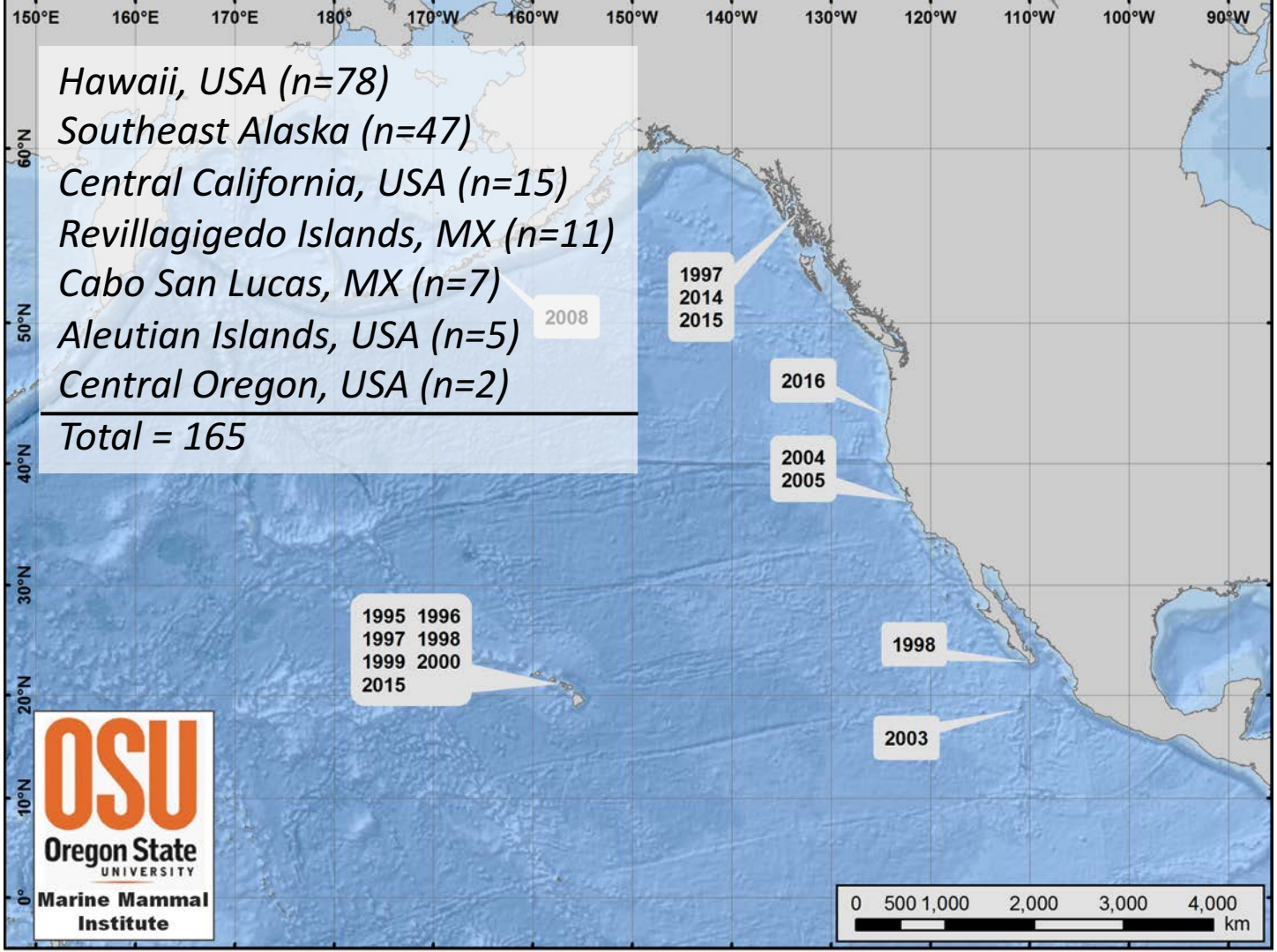
km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60°N
50°N
40°N
30°N
20°N
10°N
0°
Hawaii, USA (n=78)
Southeast Alaska (n=47)
Central California, USA (n=15)
Revillagigedo Islands, MX (n=11)
Cabo San Lucas, MX (n=7)
Aleutian Islands, USA (n=5)
Central Oregon, USA (n=2)
Total = 165
2008
1997
2014
2015
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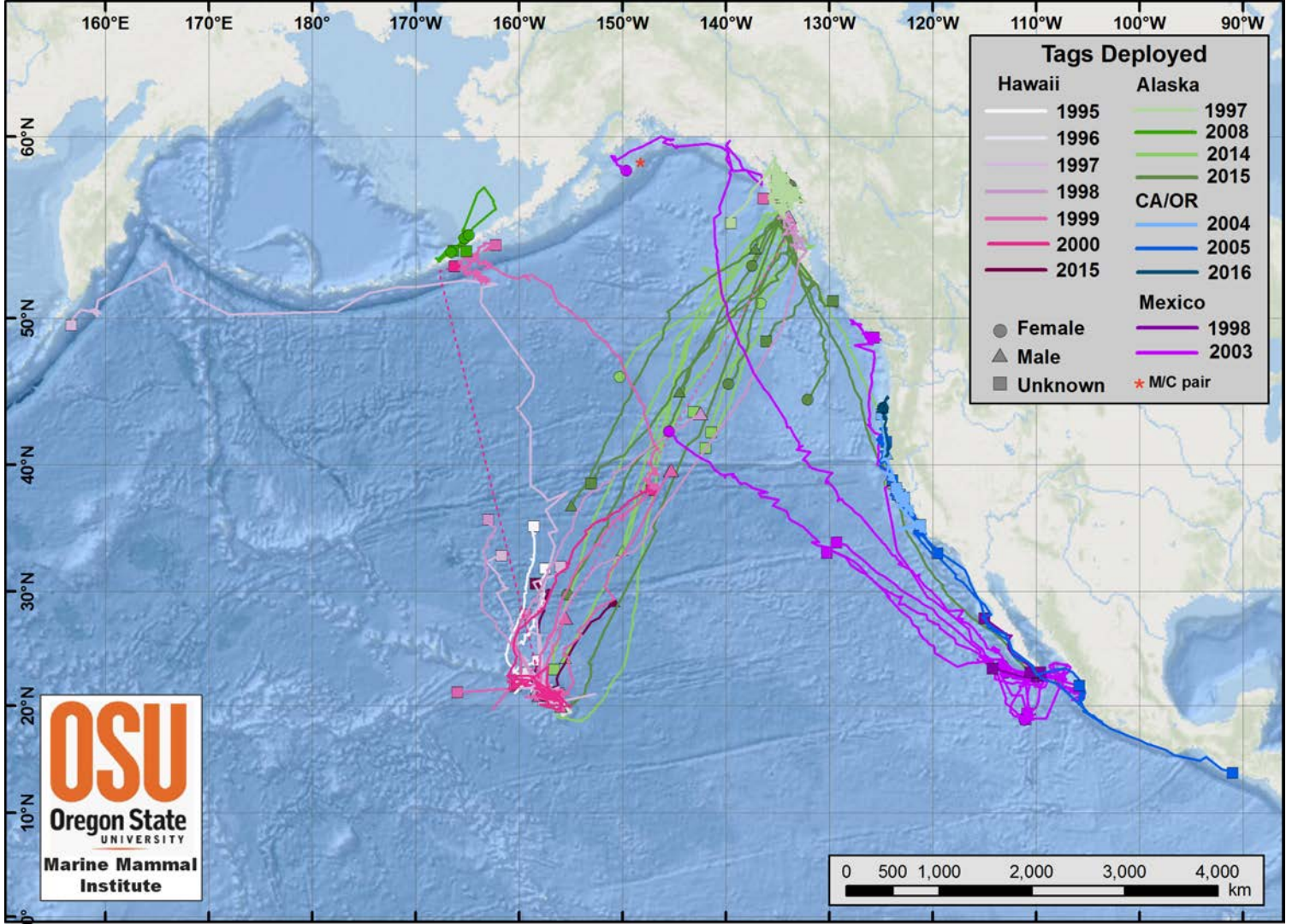
km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Tags Deployed
Hawaii
1995
1996
1997
1998
1999
2000
2015
Alaska
1997
2008
2014
2015
CA/OR
2004
2005
2016
Mexico
1998
2003
Female
Male
Unknown
M/C pair
OSU
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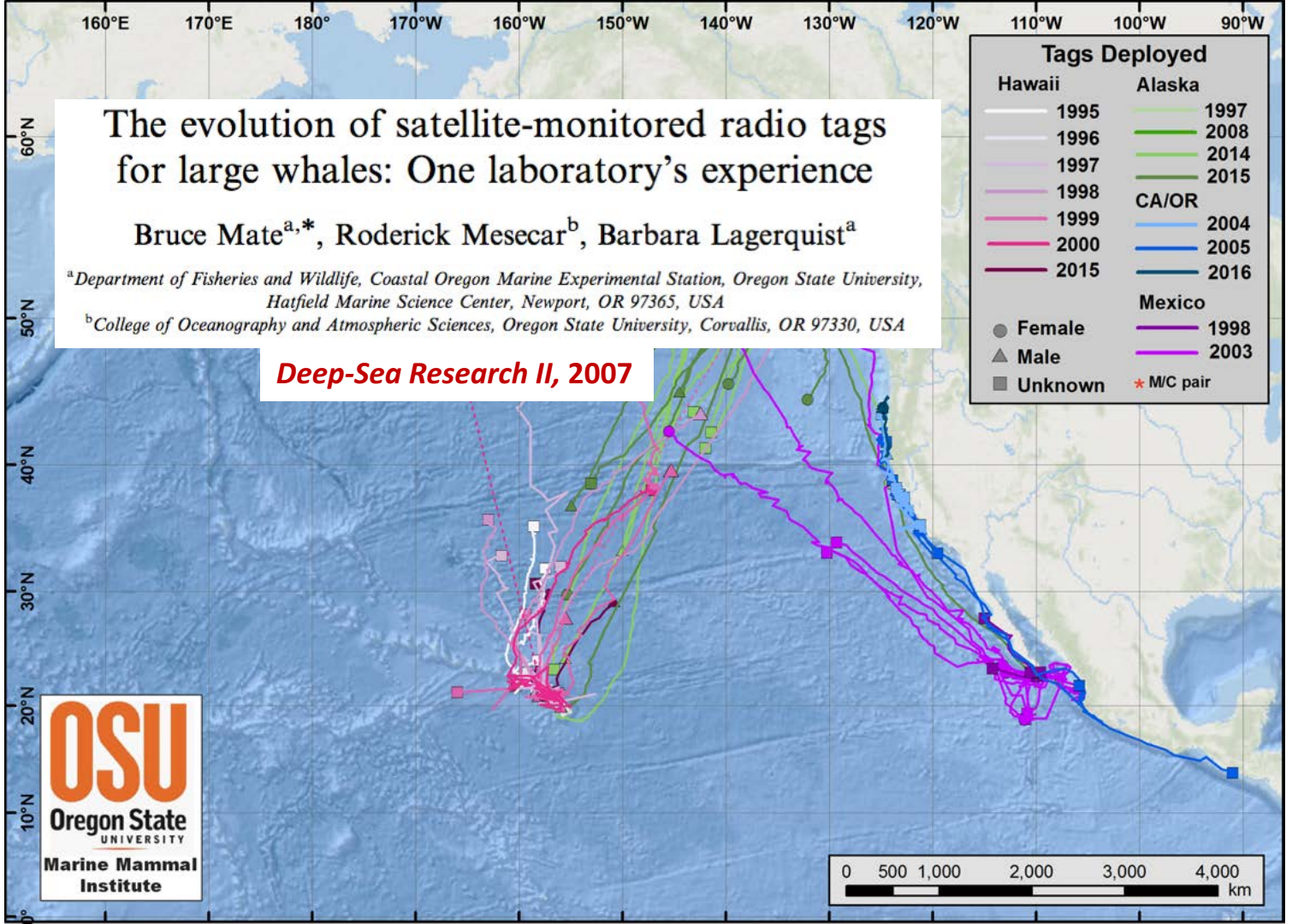
0 500 1,000 2,000 3,000 4,000
km



The evolution of satellite-monitored radio tags for large whales: One laboratory's experience

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[b]*College of Oceanography and Atmospheric Sciences, Oregon State University, Corvallis, OR 97330, USA*

***Deep-Sea Research II*, 2007**

OSU Oregon State University Marine Mammal Institute

Tracking summary

- All tracks (1995-2016): n = 165
- Deployed in both breeding and feeding areas

>1 locs:	147	tags	89%
>7d:	110.0	tags	66%
>30d:	43.0	tags	26%
Complete migrations:	12		7%
Almost migrations:	2		
Incomplete tracks:	152		
Longest:	178.1	d	
Females:	33		
Males:	41		
Unknowns:	92		
Total days:	4,575.5	d	
Total distance	263,619.0	km	

[Earth–Moon distance: 385,000 km]

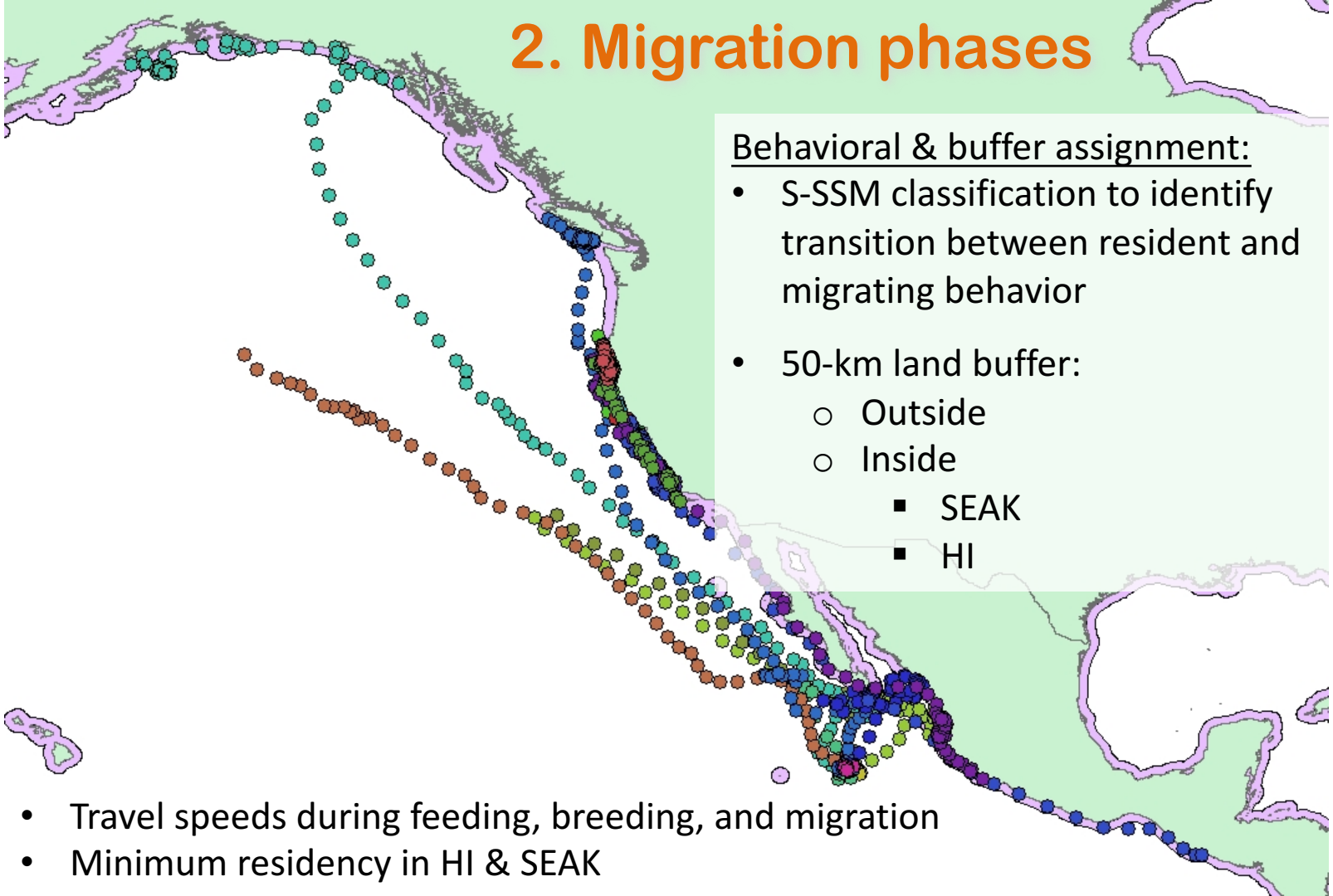
2. Migration phases

Argos location pre-processing:

- Remove duplicates
- Remove points on land: GSHHS
- Orbit redundancy: 20 min
- Tracks with > 1 loc
- Speed filter: 14 km/hr
- Interval bet. locs: < 1 d
- Distance bet. locs. < 120 km

Tags: 130
Total: 8535 locs
4 tagging areas: AK, CA/OR, HI, MX

2. Migration phases

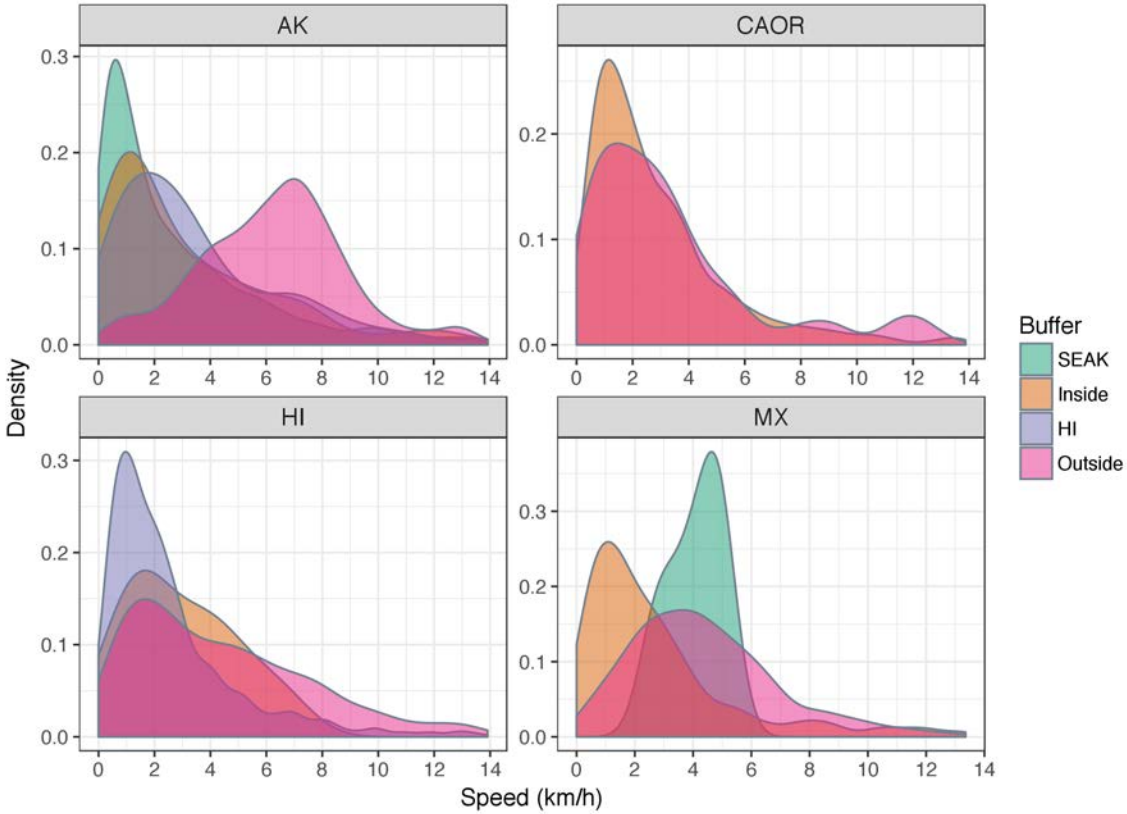


Behavioral & buffer assignment:

- S-SSM classification to identify transition between resident and migrating behavior
- 50-km land buffer:
  - Outside
  - Inside
    - SEAK
    - HI

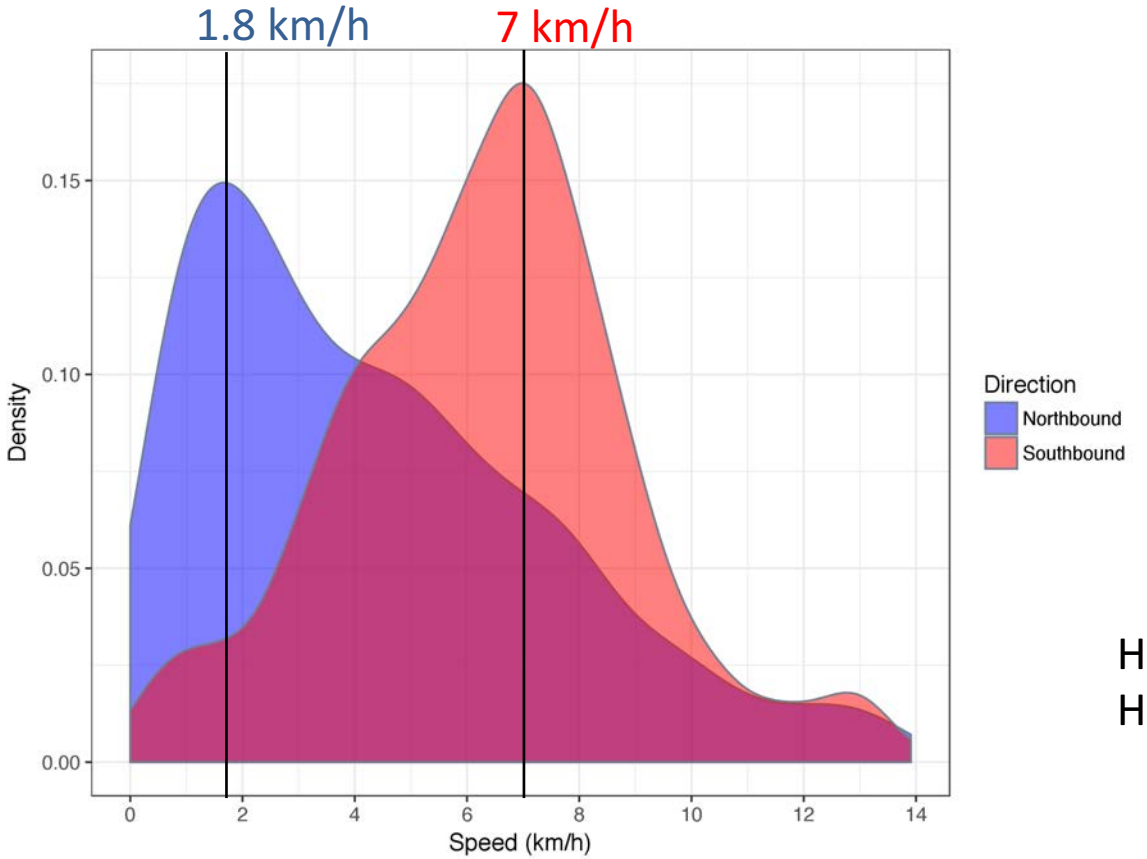
- Travel speeds during feeding, breeding, and migration
- Minimum residency in HI & SEAK

2. Migration phases



Phase	Out	In	SEAK	HI
N	3627	3765	2983	1352
Avg. speed (km/h)	5.18	2.91	2.80	2.69
Med. speed (km/h)	5.02	2.05	1.69	1.96

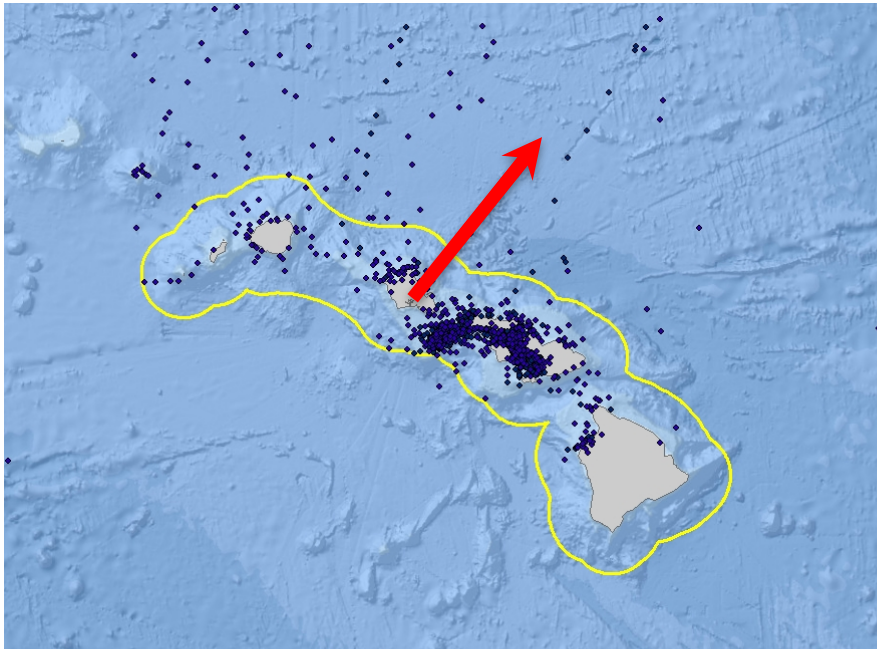
2. Migration phases

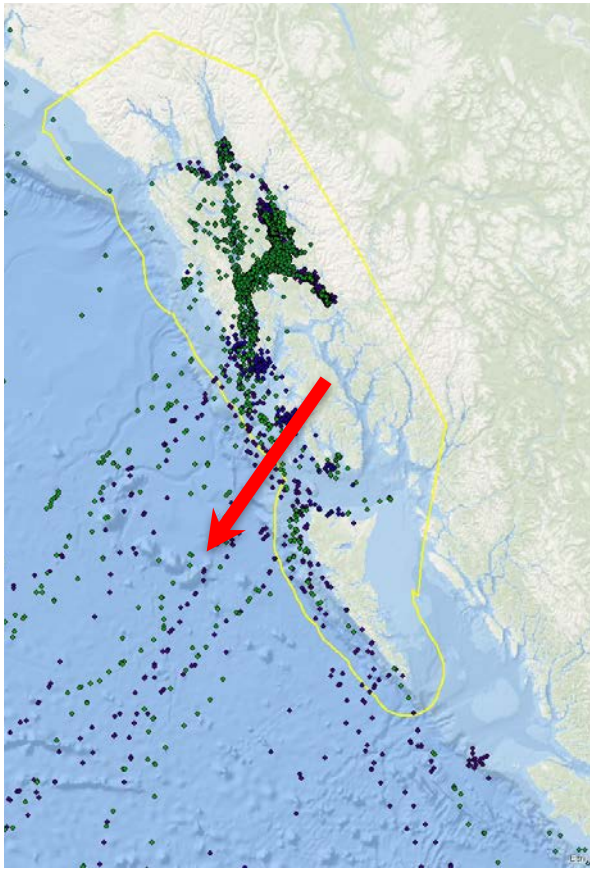


Phase	Sbound	Nbound
N	1483	685
Avg. speed (km/h)	6.28	4.38
Med. speed (km/h)	6.41	3.70

HI-SEAK migration: 27-50 d (35 d)
HI-Aleutians-Kamckatka: 70-81 d

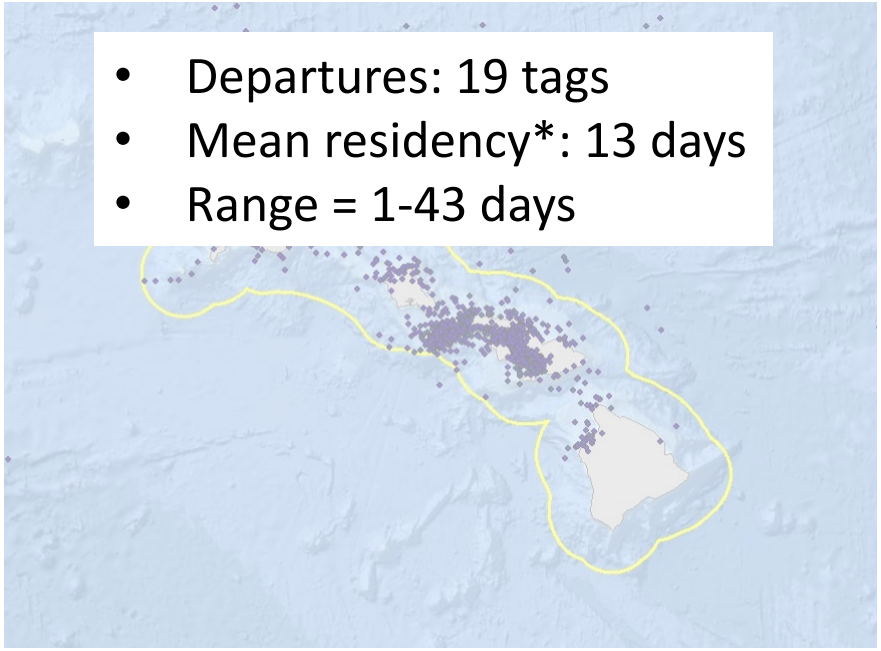
3. Residency in HI & SEAK



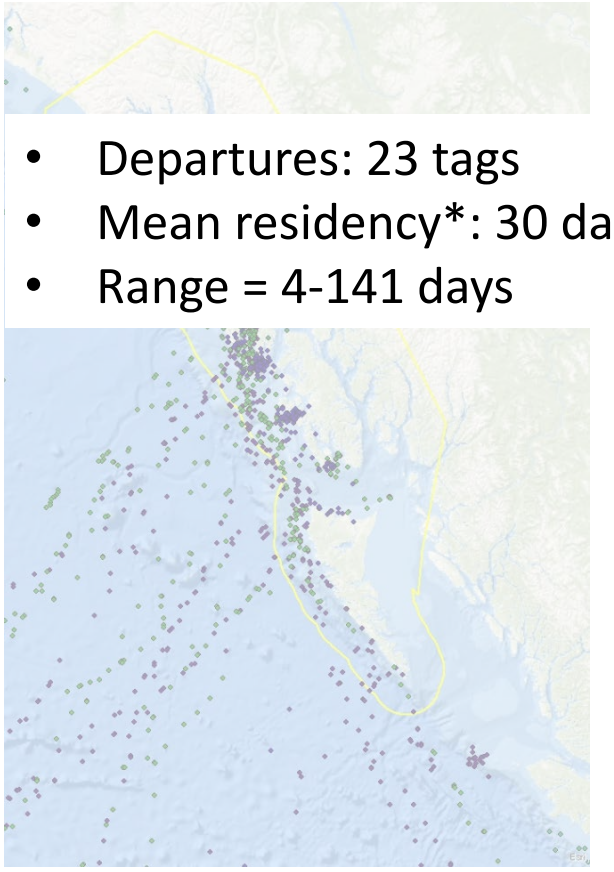


50-km buffer

3. Residency in HI & SEAK

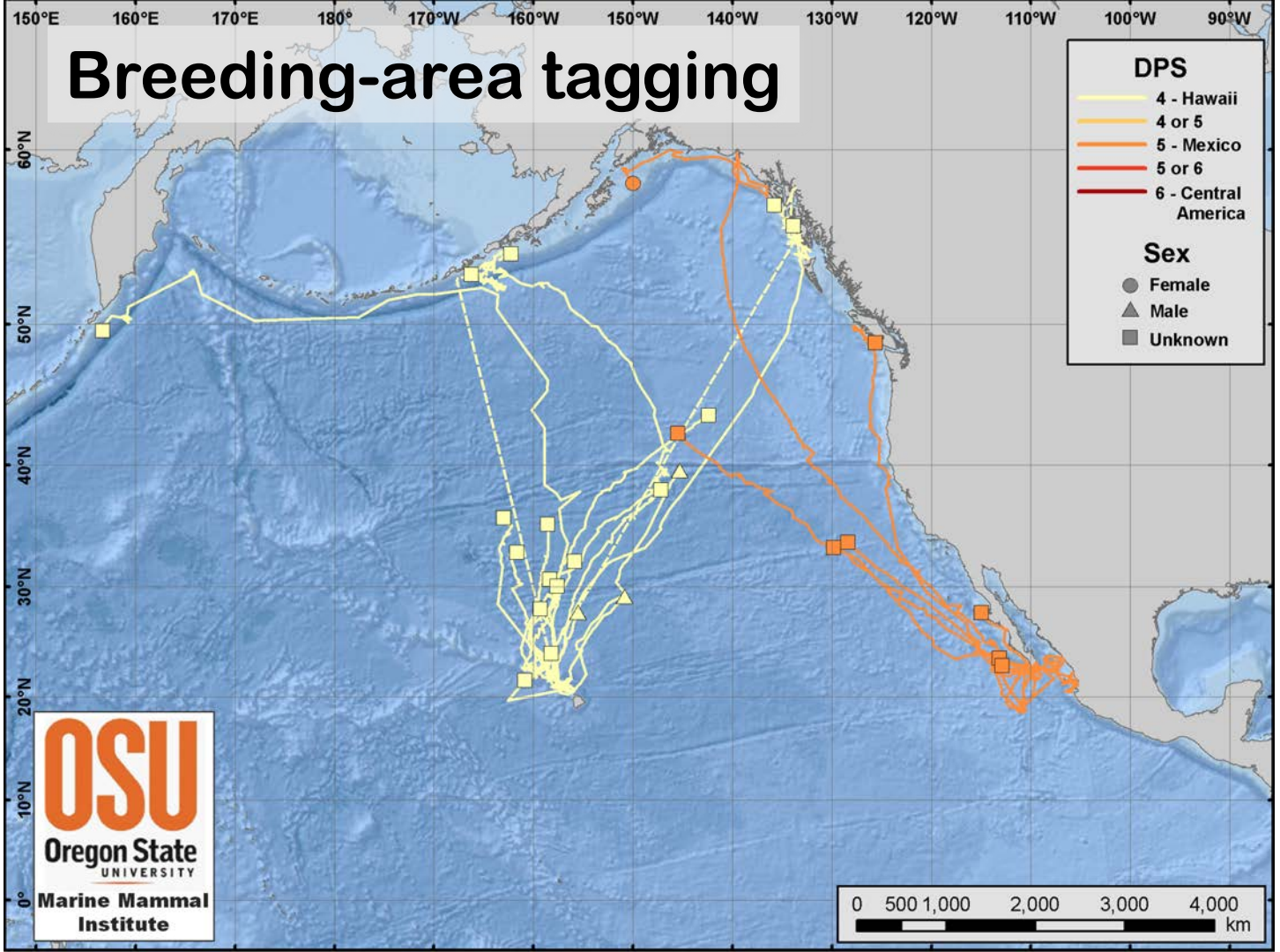


- Departures: 19 tags
- Mean residency*: 13 days
- Range = 1-43 days



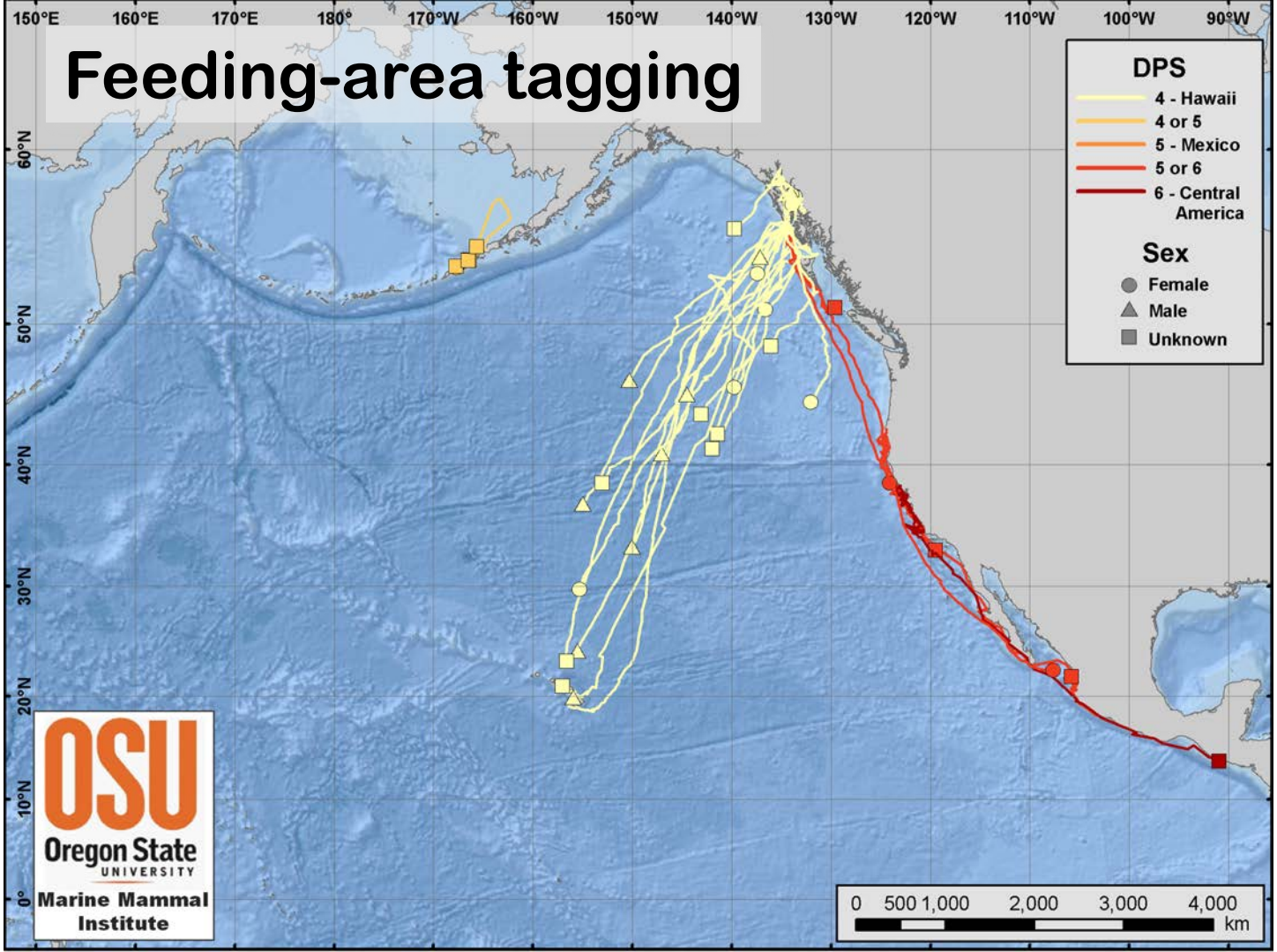
- Departures: 23 tags
- Mean residency*: 30 days
- Range = 4-141 days

4. Connectivity (ESA)



4. Connectivity (ESA)

Feeding-area tagging



4. Connectivity (IWC)

IWC's *First Workshop on the Comprehensive Assessment of North Pacific Humpback Whales*, Seattle, USA, 19-21 April 2017 (IWC, 2017)

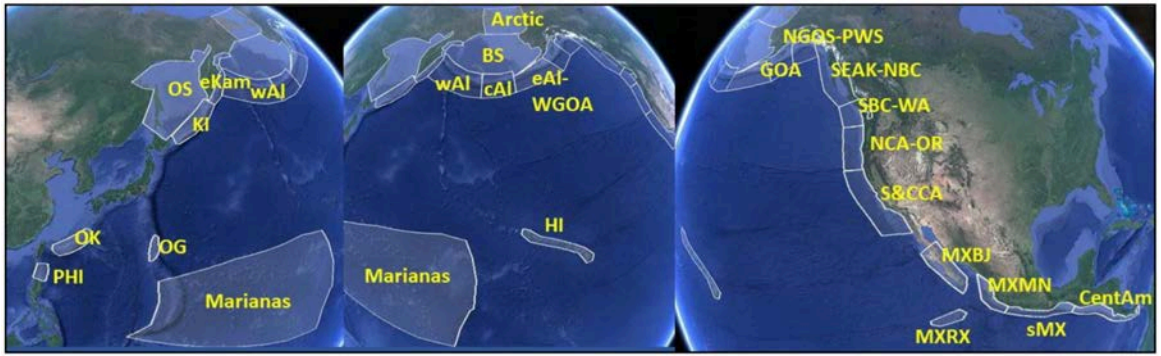


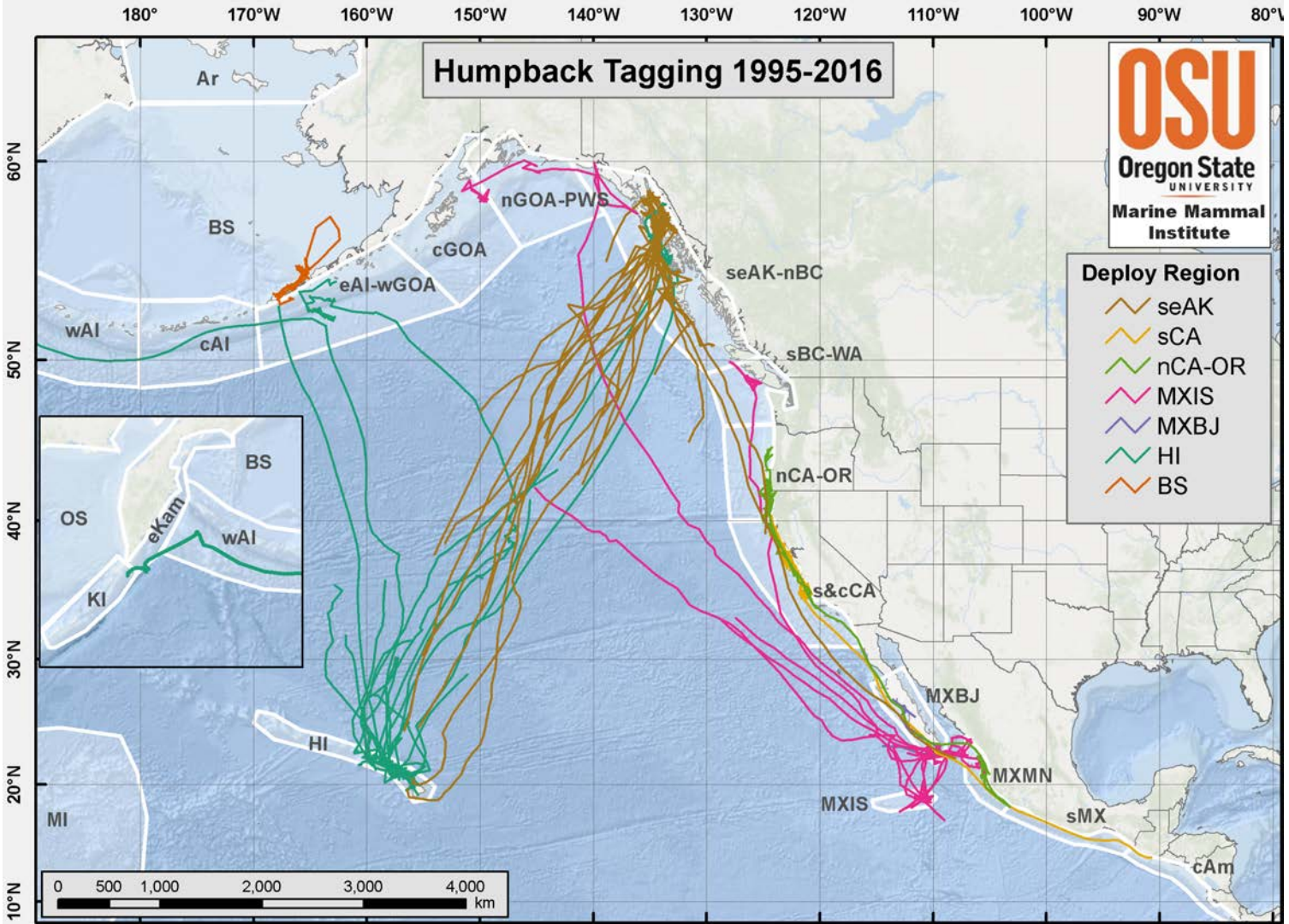
Fig. 1. Geographic areas used to describe stock structure hypotheses (see Table 1)

Table 3

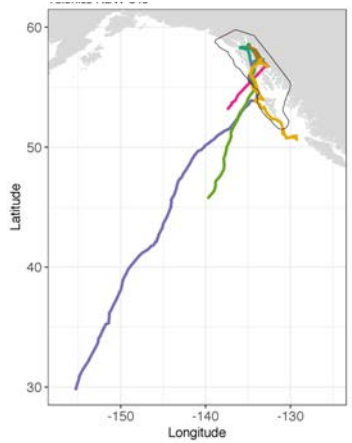
Summary of consideration of links between areas used to describe feeding grounds (Y=separate feeding ground on its own). For areas see Table 1 and Fig.1

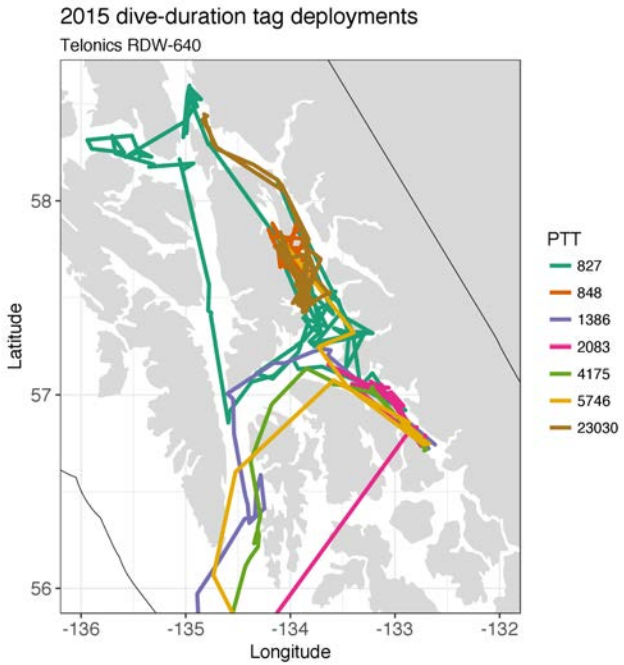
Area	Links with			
KI	Y	With eKam	With wAI	
OS	With KI			
eKam	With KI			
wAI	With BS, cAI and eAI	With BS and cAI		
cAI	With BS, wAI and eAI	With BS and wAI	With BS and eAI	
eAI	With BS, cAI and eAI	With BS and eAI		
Ar	With BS			
BS	With A	With wAI, cAI and eAI	With wAI and cAI	With cAI and eAI
wGOA	With aAI and cGOA	With nGOA, eAI, cGOA		
cGOA	With aAI and wGOA	With nGOA, eAI, wGOA		
nGOA-PWS	With nGOA-PWS			
seAK-nBC	T			
sBC-WA	With nCA-OR			
nCA-OR	With s&cCA	With sBC-WA		
c&cCA	Y	T		

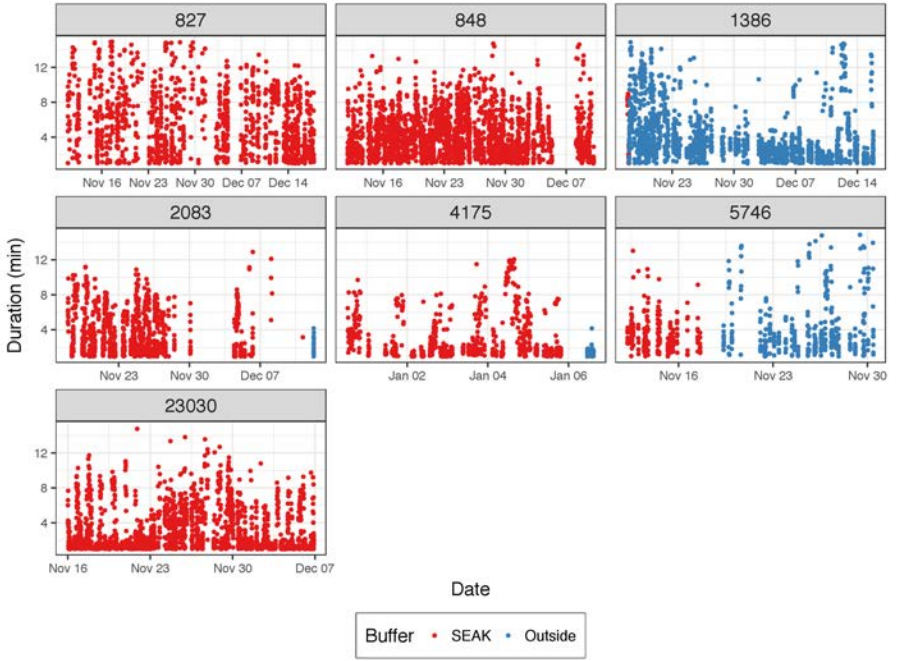
4. Connectivity (IWC)



5. Future Work: Behavior Monitoring Tags

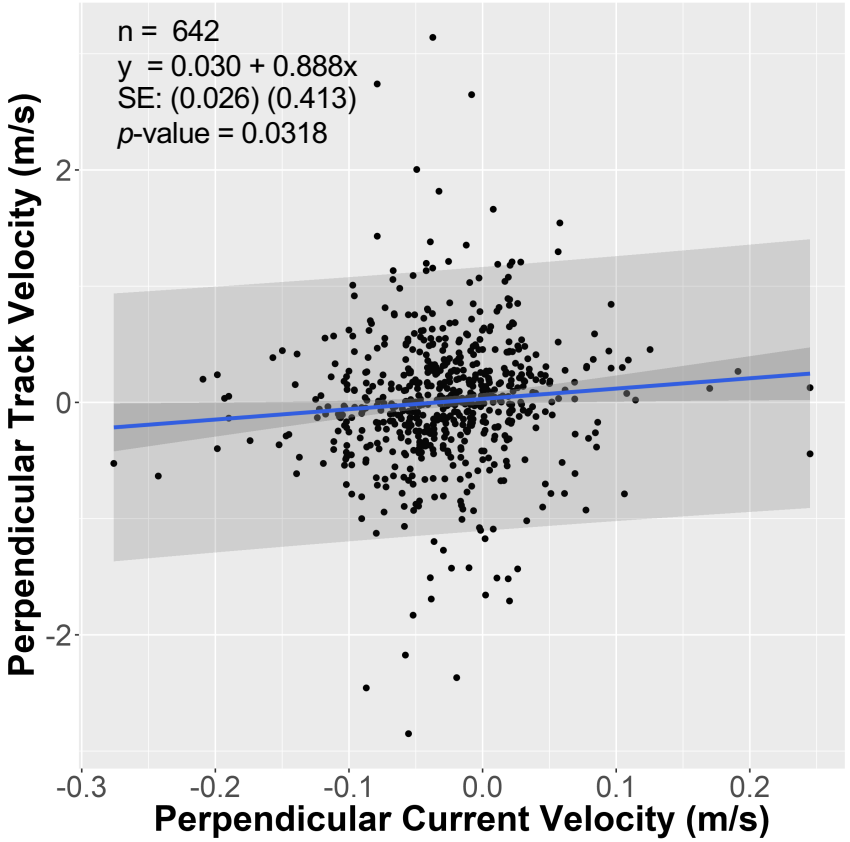




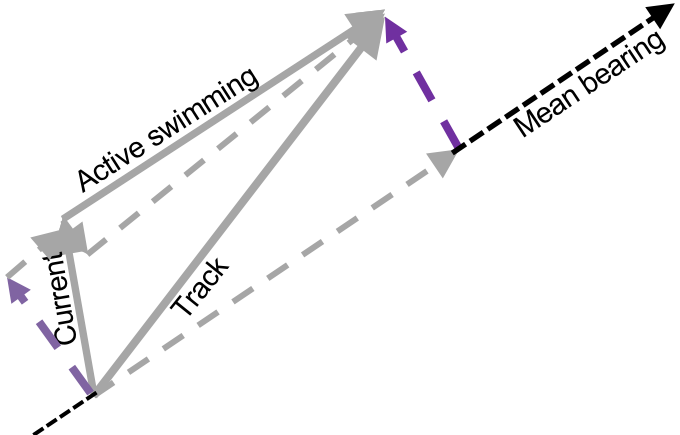


5. Future Work: Orientation in Flows

Is there evidence of ocean current drift?



- Fit a linear model using generalized least squares for perpendicular track velocity as a function of perpendicular current velocity
- Found a statistically significant correlation between perpendicular current velocity and perpendicular track velocity
- This is evidence that humpbacks are drifting due to the ocean's currents



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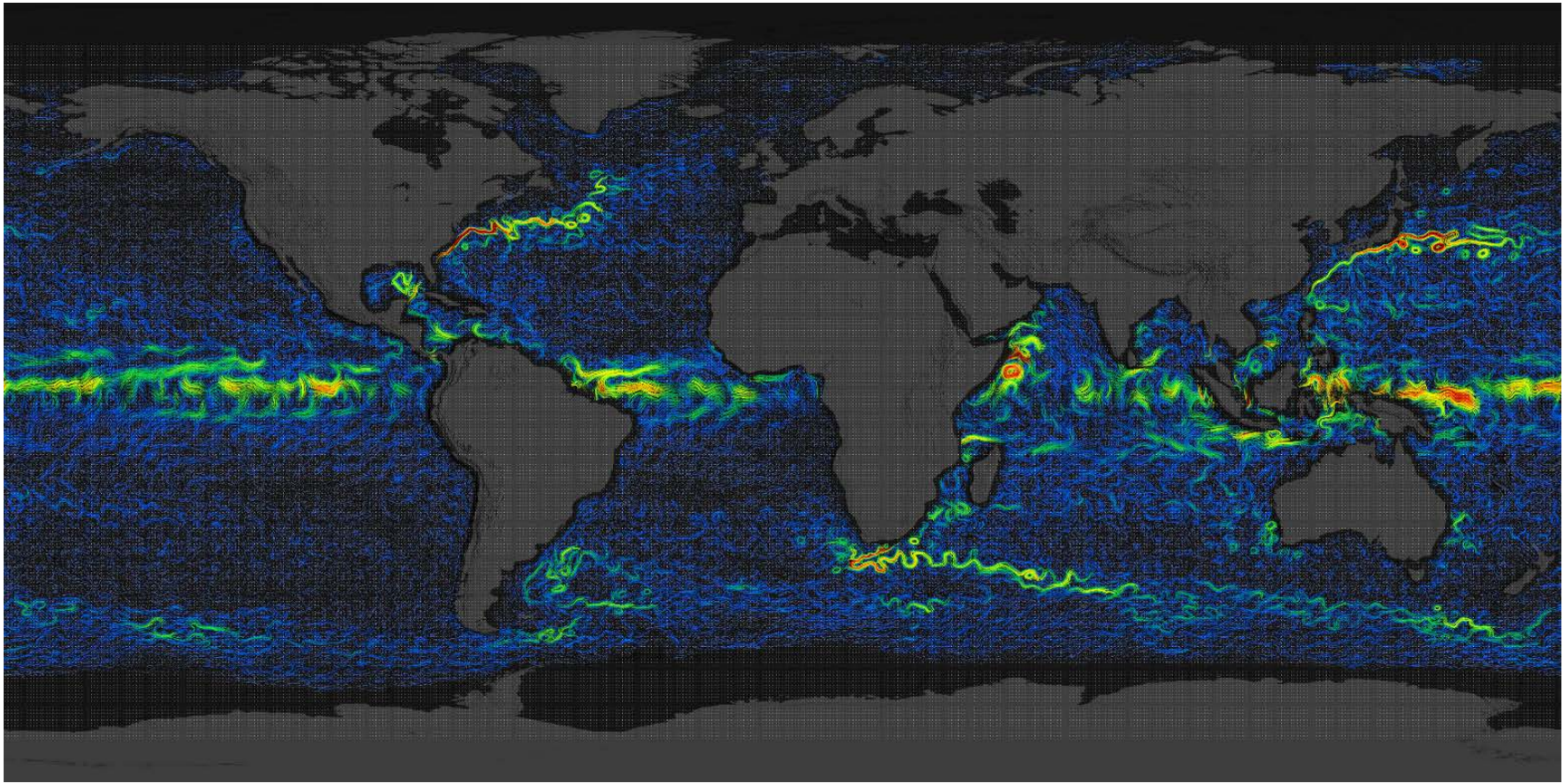

Acknowledgments

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- SEAK: Cpt. Dennis Rogers and the crew of the M/V *Northern Song*
- HI: Flip Nicklin, Ed Lyman and operators of Sanctuary boat *Koholā* (Carmen De Fazio, Casey Cohan, Lee James, Grant Thompson)
- Volunteers: Dave Gosselin, Brian Thorsness, and Ken Sexton
- NMFS Permit No. 14856 and OSU IACUC Permit No. 4495
- Dr. Scott Baker and Debbie Steel of the OSU/MMI Cetacean Conservation and Genomics Lab for sex determination
- Kathy Minta and Minda Stiles at the MMI for logistical and administrative support

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