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Assessing reproduction and estimating survival of odontocetes tagged with LIMPET tags: case studies from Hawai‘i

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Presentation at the Cetacean Tag Attachment, Tag Follow-up, and Tagging Best Practices Guidelines Workshop, Silver Spring, MD, September 6, 2017

Using LIMPET tags to assess odontocete movements and behavior in Hawai'i

2006-2017

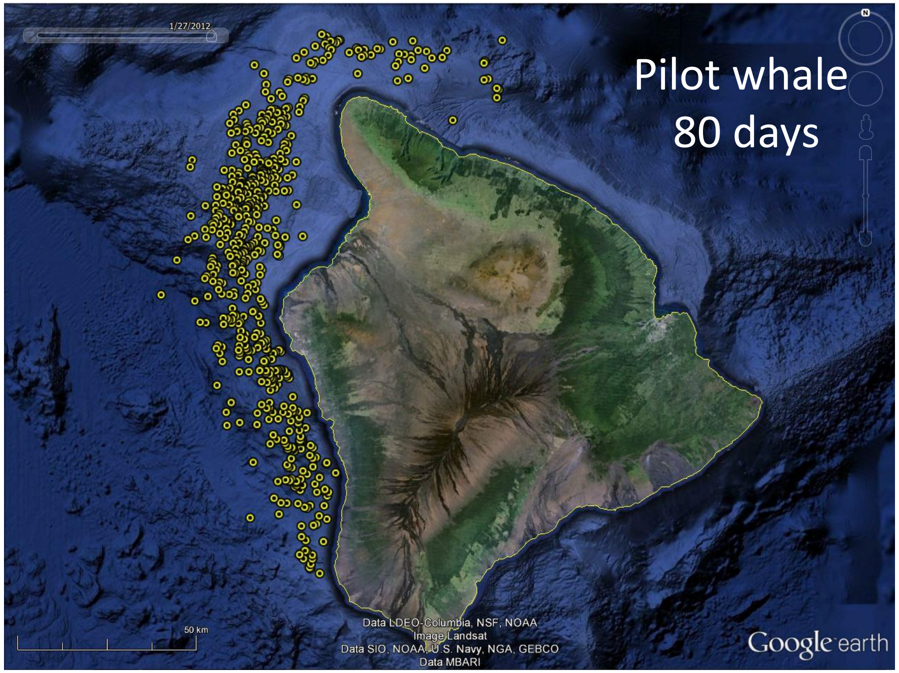
306 deployments (12 species)

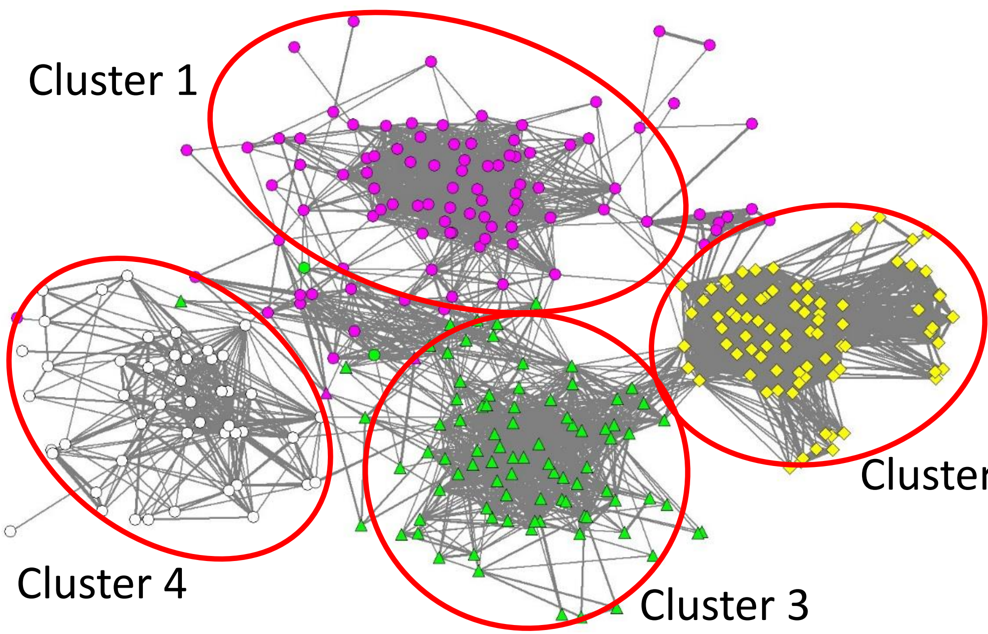
- **9 resident (8 with photo-ID catalogs)**

Do LIMPET tags influence odontocete reproduction and survival?

NOPP grant - Improving attachments of remotely-deployed dorsal fin-mounted tags: tissue structure, hydrodynamics, in situ performance, and tagged-animal follow-up 2009-2013
PI: Russ Andrews

- Resident populations
- Long-term photo-identification catalogs
- Social clusters identified





Comparison of rates of survival and reproduction of tagged versus non-tagged individuals

- For some species (i.e., pilot whales, false killer whales) must take social group into account, as re-sighting probability varies by group
- Quantitative comparison of reproductive rates problematic given sample size, long inter-birth intervals, and time frame of study, but can address reproduction on a coarser scale (i.e., are females reproducing post-tag loss)

Limitations to assessing reproduction post-tagging

- Bias towards tagging males (avoiding females with small calves), and for some species targeting larger individuals (i.e., pilot whales, false killers)
- Sex not known for all (females based on genetics, close association with small calf, or morphology, e.g., beaked whales)
- Long intervals between re-sightings
- Some species associate with calves for limited period (Blainville's beaked whales < 3 years)
- Long inter-birth interval (pilot = 5 years; false killer = 6-7 years)
- Post-reproductive phase for some (pilot/false killer)

Species	# females seen ≥1 year post-tagging	# with calves post-tag loss	Mean ($\bar{x}$) # years (y) seen post-tag loss (with or without calves)
Blainville's beaked	6	3	w/calves seen $\bar{x}$=5.3 y, without =1.3 y
Cuvier's beaked	5	3	w/calves seen $\bar{x}$=3 y, without =2 y
Bottlenose dolphin	1	1	seen 1 y
Pygmy killer whale	3	3	seen $\bar{x}$=5.3 y
False killer whale C1	10	3	w/calves seen $\bar{x}$=6.3 y, without =3.2 y
False killer whale C3	5	0*	seen $\bar{x}$=2.0 y
Short-finned pilot	16	3	w/calves seen $\bar{x}$=3.3 y, without =3.3 y

*One Cluster 3 individual appeared pregnant when last seen

Short-finned pilot whales

- 620 distinctive & very distinctive individuals photo-IDd between 2003 and 2013, with 6,094 records, in 34 social clusters
- Included capture histories of 46 individuals tagged between 2006-2012, in 15 social clusters
- Five tagged twice (51 deployments)
- Two analyses undertaken: 1) all individuals considered; 2) only social clusters (15) with tagged individuals considered*

*Cluster as a co-variate

Pilot whale results presented at the Workshop on Impacts of Cetacean Tagging: a review of follow up studies and approaches, Dunedin, New Zealand, December 8, 2013

False killer whales

- 267 distinctive & very distinctive individuals photo-IDd between 2007 and March 2017, in four different social clusters
- Included capture histories of 37 individuals tagged between 2007-2016 (total of 41 deployments, four whales tagged twice)
- Two analyses undertaken: 1) all four social clusters considered*; 2) cluster 1 only (~68% of records, 28 of 41 tag deployments)

*Cluster as a co-variate

Survival estimation

- Modeling in R-Mark 2.1.12
- Cormack-Jolly-Seber model to estimate apparent survival (Phi) and capture probability (p)
- Parameter estimation for tagged individuals only performed after they were tagged
- Number of models run including a time-varying tag effect as a covariate
- Overdispersion computed using TEST1 and TEST2 in program RELEASE
- Model selection with Akaike Information Criteria for small samples after accounting for overdispersion (QAICc) if necessary

Short-finned pilot whales

Approach 1 (all 34 clusters)
4 models run with a combination of effects

Phi (Apparent survival)	p (Capture probability)
null model	null model
Tag	Time

All models shown

Model	# par	QAICc	ΔQAICc	weight
Phi(.)p(~Time)	10	1309.570	0.000	0.652
Phi(~Tag)p(~Time)	11	1310.824	1.254	0.348
Phi(.)p(.)	2	1352.300	42.730	0.000
Phi(~Tag)p(.)	3	1353.628	44.058	0.000

Short-finned pilot whales

Approach 1 (all 34 clusters)
Model average estimates of apparent survival

Phi (apparent survival)	estimate	se	Lower CL	Upper CL
Tagged	0.901	0.060	0.709	0.972
Not tagged	0.869	0.015	0.836	0.896

But survival estimates low for a relatively long-lived species

Short-finned pilot whales

Approach 2 (15 clusters w/ tagged individuals)
16 models run with a combination of effects

Phi (Apparent survival)	p (Capture probability)
null model	null model
Cluster	Time
Tag	Cluster
Cluster + Tag	Tag

Top 3 models shown (100% of model weight)

Model	# par	QAICc	ΔQAICc	weight
Phi(.)p(~Cluster)	17	630.772	0.000	0.733
Phi(~Tag)p(~Cluster)	18	632.793	2.021	0.267
Phi(~Cluster)p(~Cluster)	32	645.077	14.305	0.001

Short-finned pilot whales

Approach 2 (15 clusters with tag deployments)
Model average estimates of apparent survival

Phi (apparent survival)	estimate	se	Lower CL	Upper CL
Tagged	0.966	0.033	0.795	0.995
Not tagged	0.961	0.012	0.930	0.979

False killer whales

Approach 1 (all four clusters)

30 models run with a combination of effects

Phi (Apparent survival)	p (Capture probability)
null model	null model
Cluster	Time
Tag	Cluster
Tag + Cluster	Tag
Acute Effect	Tag + Cluster
	Time + Cluster

Top 5 models shown (100% of model weight)

Model	# par	AICc	ΔAICc	weight
Phi(.)p(~Time + Cluster)	14	1726.82	0.00	0.49
Phi(~Tag)p(~Time + Cluster)	15	1728.41	1.59	0.22
Phi(~Acute Effect)p(~Time + Cluster)	15	1728.46	1.63	0.22
Phi(~Cluster)p(~Time + Cluster)	17	1731.87	5.05	0.04
Phi(~Tag + Cluster)p(~Time + Cluster)	18	1732.85	6.02	0.02

False killer whales

Approach 1 (all four clusters)
Model average estimates of apparent survival

Phi (apparent survival)	estimate	se	Lower CL	Upper CL
Cluster 1 tagged	0.962	0.026	0.857	0.990
Cluster 1 not tagged	0.960	0.015	0.919	0.980
Cluster 2 tagged	0.932	0.020	0.881	0.962
Cluster 2 not tagged	0.927	0.017	0.886	0.953
Cluster 3 tagged	0.933	0.018	0.888	0.962
Cluster 3 not tagged	0.928	0.014	0.895	0.951
Cluster 4 tagged	0.933	0.019	0.885	0.962
Cluster 4 not tagged	0.927	0.016	0.890	0.952

Capture probabilities by cluster

Cluster	Mean capture probability (p)
1	0.61
2	0.21
3	0.27
4	0.30

False killer whales

Approach 2 (cluster 1 only)
9 models run with a combination of effects

Phi (Apparent survival)	p (Capture probability)
null model	null model
Tag	Tag
Acute Effect	Time

Top 3 models shown (100% of model weight)

Model	# par	QAICc	ΔQAICc	weight
Phi(.)p(~Time)	11	608.96	0.00	0.52
Phi(~Tag)p(~Time)	12	610.52	1.55	0.24
Phi(~Acute Effect)p(~Time)	12	610.59	1.62	0.23

False killer whales

Approach 2 (cluster 1 only)
Model average estimates of apparent survival

Phi (apparent survival)	estimate	se	Lower CL	Upper CL
Tagged	0.938	0.018	0.892	0.965
Not tagged	0.933	0.015	0.894	0.957

Take home: survival of tagged and untagged false killer whales and short-finned pilot whales not significantly different*

*Power to detect an effect is very low, given average capture probability, proportion of population tagged