Examination of Health Effects and Long-Term Impacts of Deployments of Multiple Tag Types on Blue, Humpback, and Gray Whales in the Eastern North Pacific

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LONG-TERM GOALS

The goal of this project is to provide new insights into the long term consequences of different types of tags on several additional species of large whales including blue, humpback, and gray whales by conducting long term follow up of previously tagged individuals in the eastern North Pacific. We examine the long term impacts on health, reproduction, and mortality unitizing the past deployments of implant and suction cup tags on blue, humpback, and gray whales in the eastern North Pacific and our extensive monitoring of these populations. Despite extensive use of implant tags for more than 30 years (Mate et al. 2007), only limited studies have been conducted of the health effects and long-term consequences of tag deployments on whales. This field is rapidly expanding including increased use of deep penetration tags on many populations including critically endangered populations such as the North Pacific right whale and the western gray whale. Studies of North Atlantic rights whales revealed a wide variety of conditions of the tag site after deployments of penetration tags varying from very minor divots to more extensive swellings.

OBJECTIVES

The overall objectives for this multi-year project are as follows:

1. Examine the long-term survival of tagged animals in relation to animals that were not tagged.
2. Test for differences in the visual health status of tagged versus untagged animals.
3. Examine the condition of the tag site and evaluate healing in tagged animals.

APPROACH

Long term impacts of tagging are being examined by conducting detailed follow-up of blue, humpback, and gray whales that have had tags deployed on them to examine site healing, health, and any long-term consequences of tag deployment on reproduction, health, or survival. Our focus on three

species of baleen whales in the Eastern North Pacific represents an ideal test case to study this for two primary reasons:

1. Some of the longest histories of tag deployments have been conducted in this area on these species. This includes over 400 deployments of a wide variety of tags ranging from suction-cup, external tags anchored into blubber, and full implant tags on blue whales (Mate et al. 2007, Calambokidis et al. 2008). This sample includes the largest number of implant tag deployments of any whale population (OSU implant tag deployments on approximately 183 eastern North Pacific blue whales, for example).

2. Extensive sighting histories of blue, humpback, and seasonal-resident gray whales are available off the US West Coast from photo-identification studies; these studies have been virtually uninterrupted since 1986 with continued monitoring planned (Calambokidis et al 2002, 2010, Calambokidis and Barlow 2004). In all three species, the majority of the population has been photo-identified and resighting rates are very high. Seasonal resident gray whales in this region have annual resighting rates of 70% or more and catalogs of identified blue and humpback number over 2,000 individuals each.

We used both photographs and genetics to conduct the first systematic reconciliation of the animals tagged with the long-term photo-ID datasets. Photographs and video taken from deployments were used to catalog both the photo-ID identities and the markings immediately around the tag site of whales to add to those where a match between tagged animal and photo-ID has already been made and those gathered of during the study. Additional determinations of identity is being made based on genetic matches between samples taken from about 100 implant-tagged whales and those collected from animals in these populations.

WORK COMPLETED

The following major areas of work were conducted in 2014:

- Conducted additional field work in 2014 to continue to obtain follow up photographs and sightings of previously tagged individuals. This has included paying closer attention to getting both photographs suitable for tag site evaluation, health assessment scoring, and collecting biopsies where appropriate.
- Processed and matched identification photographs of blue and gray whales taken in 2013 to evaluate where previously tagged animals (or those selected as controls for tagged animals) had been resighted.
- Worked with collaborators in Mexico to and other areas to complete a comparison of photo-identifications to add to our available resighting data and follow up on tagged animals.
- Where new encounters with previously tagged animals were determined by photo-identification, we selected the best tag site photographs and added these to our tag site healing chronology.
- Scored the updated tag site condition photographs for 2013 and submitted these to our veterinary evaluation team for updated scoring of condition.

- Worked with OSU genetics lab and Dr. Scott Baker to conduct additional genetic identification comparison of samples of our control animals to help verify they are not any of the tagged animals for which adequate photo-identifications were not available.
- Continued our collaboration with OSU tagging team (Dr. Bruce Mate) to verify we have as complete and accurate records on their tag deployments and follow up photographs.
- The above additional efforts have increased the number of OSU implant tagged whales that now have a clear photo-identification suitable for tracking to 82 blue whales and 36 gray whales.
- Organized a workshop for 8 December 2013 in Dunedin ahead of the Biennial Conference on the Biology of Marine Mammals specifically on follow up studies on the impacts of tagging. Workshop quickly filled to capacity.

RESULTS

Summarized below are the results of different components of the research completed to date. These reflect updated results obtained during 2014 including the identification of additional animals from more detailed examination of photos taken during tagging as well as using more photos obtained through the 2013 field season which helped identify animals. We have also increased the years of resighting data available to include 2013 field effort and also to further score follow up wound healing. Results of genetic analyses conducted of whales satellite tagged by OSU have been completed and were summarized in the previous annual report. The updated summary of the whales that have been tagged that this study has sought to determine photo identifications of blue, humpback, and gray whales to allow follow up tracking of survival, tag site condition, and health effects are summarized below (Table 1).

Table 1. Summary of photo-ID of different species of whales tagged with suction cup or implant tags through 2013.

Species	*Attach Type*	*Total Tags Deployed*	*Deployments whale photo-IDed*	*Unique identified whales Tagged*
Blue whale	Cup	270	201	120
Blue whale	Satellite tag total	185	82	79
	External	56	19	19
	Internal	129	63	63
Gray whale PCFG -2009	Implant	18	18	18
Gray Whale PCFG-2012-13	Implant	17	17	17
Gray whale MX	Implant	17	6	6
Humpback	Cup	20	12	10
Humpback	Implant	33	4	4

Our best sample for examining follow up comes from 18 PCFG gray whales OSU satellite tagged in the Pacific Northwest in fall 2009, all 18 were photo-identified either with photographs taken at the time or later and all were known animals present in Cascadia's catalog of eastern North Pacific gray whales. (Table 2). Cascadia maintains a catalog of eastern North Pacific gray whales that consists of about 1,000 individuals identified off California, Oregon, Washington, and British Columbia by Cascadia and other collaborators under a project primarily sponsored by the National Marine Mammal Laboratory (Calambokidis et al. 2002, 2010). The core of this catalog is the estimated 200-250 gray whales that regularly use the Pacific Northwest for feeding each spring, summer, and fall termed the Pacific Coast Feeding Group (PCFG). In addition to photo-ID, recent genetics studies have revealed significant differences in mtDNA between these animals and other eastern North Pacific gray whales suggesting these should be treated as an independent demographic unit (Frasier et al. 2011, Lang et al. 2014).

Resightings of the 2009 tagged PCFG whales through 2013 (Table 2) appears to be different compared to a control group of individuals (identified in the same area and time in 2009 but not tagged, Table 3, Figure 1). Overall, 16 of the 18 PCFG gray whales tagged in 2009 have been resighted in a subsequent year (2010-13). Highlighted in the table are four whales potentially reflecting a problem, three that have not been seen Jan 2010 at the latest and one known to have died at the end of 2011 (CRC 411, a tagged whale known to have died in late 2011, though cause of death was not known and no examination conducted). While 4 of the 18 tagged whales had not been resighted or were known to have died, the same was only true for 1 of 30 animals identified as controls (Table 3) which were selected due to their having been identified in the same region and time period as the tagged animals (but not tagged) and like the tagged animals were known individuals from the PCFG. A comparison of the rate of sightings of these controls showed they were similar to the tagged whales prior to the tagging year but diverge after tagging (Figure 1).

While they do not have as frequent a resighting history, we have the largest number of identification for tagged blue whales (Table 1). We have been able to improve the number of implant tagged blue whales with known identifications to 82 of the 185 tag deployments (representing 79 individuals). Resightings of these individuals has been more sparse than for the PCFG gray whales and this is being compared to a control group of blue whales that were not tagged but this will not have the power to detect a difference as was the case with the PCFG gray whales because resighting rates of blue whales overall is much lower with only about 10-20% of identified blue whales seen annually. We have participated in a publication In Press in Endangered Species Research focusing on the resighting history of one of these blue whales that developed a large swelling apparently after one of the prongs broke off from an early generation OSU external satellite tags and was retained by the whale for a number of years. This swelling as a result of tagging appeared to impeded the health and reproduction of this whale which was regularly resighted in the Gulf of California; 2 of 3 years it had a calf prior to the swelling developing but had no calves in any of the 8 years during the swelling (Gendron et al. 2014).

Table 2. Identification histories of PCFG gray whales that were tagged by OSU in fall 2009 through 2013. Numbers underneath years indicate the number of times the whale was sighted that year. Highlighted area indicates period whales not sighted in three or more consecutive years subsequent to tagging and in one case whale known to have died in 2011.

ID	TAG Number	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
32	PTT 5205938	2	16			18	3	6			2		**4**				
89	PTT 5223029	20	21	30	13	4	23	10	19	16	8	16	**19**	20	24	32	11
164	PTT 5210836			3	1	1			1	1		1	**9**	14	9	4	3
196	PTT 5210838			2		1	9		6	14	6	8	**21**	24	14	**31**	9
205	PTT 5210842		6	1	3	3	5					7	**19**	5	6		
206	PTT 5205923	3	2	1	3	4	3				2		**10**	1	3	16	3
215	PTT 5205670	1				5	4	1			3		**15**	2			
291	PTT 5223032	2	2	1	3	6	10	4	1	5		1	**10**	3	16	18	2
302	PTT 5205801	4	8	1		4	14	10	1	15	6	15	**8**	16	14	14	12
411	PTT 5223038		1	4	8	4					2	3	**12**	7	11*		
525	PTT 5200847			1	2	1		1	2	1	4	23	**16**	4		1	7
537	PTT 5200831			2			1				1	1	**14**	12	5	7	5
615	PTT 5223033				1	1						2	**3**	5	4	4	1
643	PTT 5204174				1	2	1		2			3	**13**	1	9	6	9
659	PTT 5200827					2		5		1		1	**19**	7	5	9	
797	PTT 5223035						1	2	7	18	12	13	**7**				
854	PTT 5201385								1			3	**11**	8	9	5	16
981	PTT 5223041					1	2				1		**11**	7	8	22	11

Table 3. Sighting histories of whales selected as controls for the 2009 tagged whales (identified in the same region and time period as the tagged whales and previously identified). Similar to Table 2, highlighted record is for a whale not seen in 3 or more consecutive years post 2009.

ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
42	24	26	9	13	24	7	5	2	15	2	19	**10**				
87	24	12	36	18	10	8	5	3	10	1	13	**7**	7	18	17	2
107	7	1	34	10	1	15	11	9	10	3	13	**8**	25	29	24	15
123	8	6	9	8	22	10	8	7	21	1	2	**17**	7	30	26	24
127	1	3	26	19	1	14		9		4		**1**	20	13	4	5
166	9	9	22	22	9	15	13	6	11		6	**9**	2	1		
204	1	2	45	3	5	14		10	3	4	3	**8**	11	16	14	7
277	4		1									**5**		9	10	9
278	1			2	2	2		1				**2**	6	9	11	3
280	3				3	1			3	2		**10**	1	19	2	3
289	1		1	4	1					1		**6**	4	13		
297	2	2		4	1	1		1	2		1	**4**	1	1	7	
364		1	2		3			1		6		**8**	11	11	14	4
365		1	1	3	4	3					1	**2**	5	17	12	6
464		1	2		6						1	**1**	3	7	7	7
510			2	1	11	6	1		2	1	7	**3**	22	14	15	11
551			1		2							**3**	5	4	2	59
554			3	2	2	2	6		1	1	10	**11**	15	22		1
555			6		4	3			1		1	**9**	15	28	4	4
565			1		2					8		**9**	7	12	17	12
583				5	1	6		6	2	12	13	**27**	4	18	3	3
657					2	1		1	1	3	2	**7**	4	3	14	6
669					3	2	1			1	1	**4**	9	3	2	1
696					3	16	11	14	15		21	**19**	24	41	28	19
698					4	8	1	12	9	1	11	**3**	2	65	14	31
703					2		1			1		**5**		6		1
759	3				16	9	17		2	2	26	**3**	1		1	7
780											4	**11**	11	23	7	16
791						7	3	3				**2**	4	20	18	
840								3			1	**10**	1	11	8	11
Total	13	11	17	14	26	21	13	16	16	18	20	30	27	28	25	25

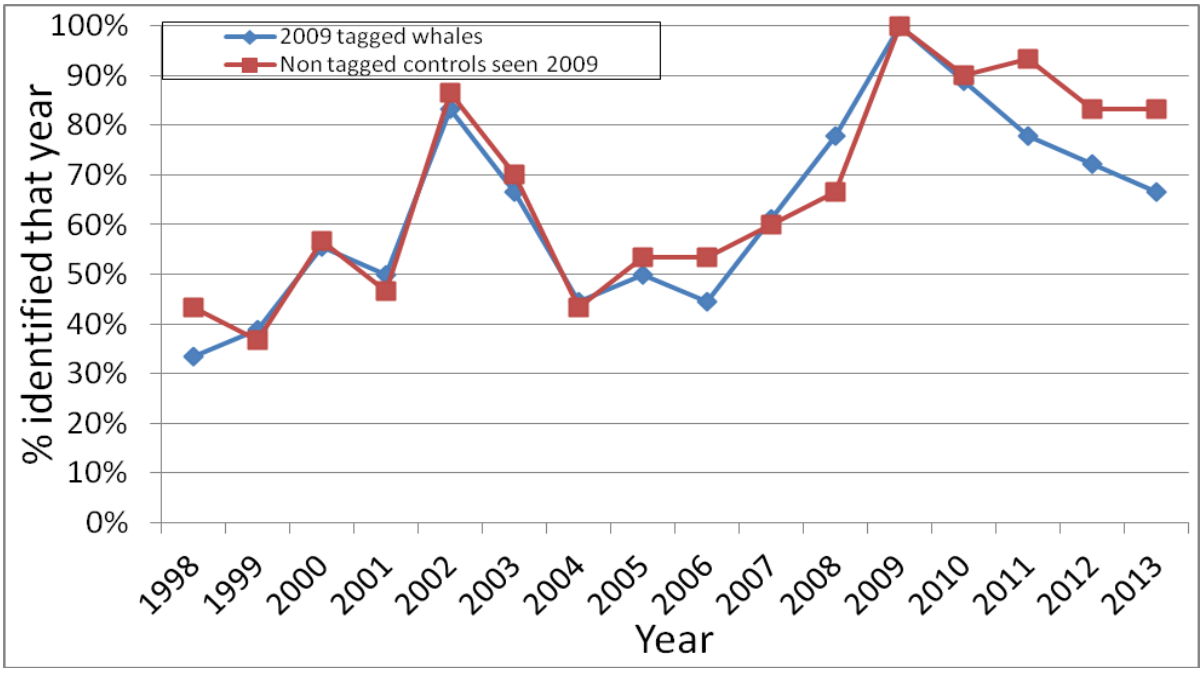

Figure 1. Proportion of tagged and control whales for 2009 tagging resighted for all years from 1998 to 2013 (see text).

Additionally, due to deployments in recent year an even larger sample of blue whales were individually identified that had been tagged with suction cup archival tags (Table 1). Good identification photographs have been verified for over 200 cases and these represented over 120 different individuals (some whales were tagged more than once). Our resighting rates for tagged blue whales is currently slightly higher for implant tagged blue whales than suction cup tagged whales due to most of the suction cup tagging having occurred in recent years from work on ship strike and the SOCAL BRS (Southall et al. 2012, Goldbogen et al. 2013, Calambokidis et al. 2013) so there have not been many opportunities to resight these animals since they were tagged. This large sample now available of blue whales that had suction-cup tags applied will be useful both as a comparison to implant tags but also to assess impacts of these tags as well. While suction-cup tags have been considered lower impact than implant tags, some preliminary results indicate that in some cases these types of tags can cause injuries that penetrate the skin.

Results of evaluation of the condition of the tag site has been conducted for satellite tagged blue and gray whales using two approaches: 1) objective scoring conducted independently by two researchers (Stephanie Norman and Kiirsten Flynn) of individual photographs, and 2) an expert evaluation of the overall time series for each tagged whales individually by a team of five veterinary/pathologists familiar with large whales (Drs. Gulland, Moore, Norman, Raverty, and Rotstein). These show that the most common tag site conditions are swelling and depression. While most of the swellings were small, two blue whales (CRC ID 1573 and 2208) showed dramatically larger areas of swelling and were confirmed this year to both be the result of deployment of early satellite tags. Both had been tagged in 1995 by OSU with early versions of their tag which was external but was anchored with two long barbs (Mate et al. 2007). We suspect that these more extreme prolonged swellings were the result of one of these barbs breaking off and staying in the animal for an extended period. One of these two whales was extensively encountered by CICIMAR in the Gulf of California, Mexico and serves as a

case study describing the long term sighting history of this individual described above (Gendron et al. 2014).

RELATED PROJECTS

None of the animals tagged and the subject of this study were actually tagged as part of this research project and are from previous or current project funded separately, many of them with support from ONR. Analysis of the follow up satellite tagged PCFG gray whales conducted under this project has also been undertaken by OSU more focused on some of the more short term portions of the follow up and Cascadia more focused on longer term follow up.

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