

**Study of seasonal resident gray whales feeding strategy in N Puget Sound, Wa. in 2016**  
**Contract Report for Cooperative Agreement CA-16-320**

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This report summarizes research conducted in 2016 examining gray whale occurrence and feeding in northern Puget Sound by Cascadia Research under a cooperative agreement from the Washington Department of Natural Resources (DNR). This is the 2<sup>nd</sup> year of expanded research conducted on this topic. The DNR Aquatics Lands Program is implementing an adaptive management research approach to understand impacts from human activities that influence habitat and species on state owned aquatic lands (SOAL). Ghost shrimp have been harvested historically from areas around Saratoga Passage to be used as live fishing bait. According to Washington Department of Fish and Wildlife estimates, the commercial harvest of ghost shrimp totals more than 50 tons annually. DNR suspended harvesting on DNR lands in April 2014 over concern about impact of the harvest on gray whales and concerns raised by local residents. Estimates of biomass of ghost shrimp on DNR lands were just over 9,000 Metric Tons in 2015 with the harvest representing about 20 Metric Tons (Pruitt and Donoghue 2015). These findings prompted DNR to lift the moratorium on harvesting.

Around northern Puget Sound (NPS) a small but stable group of gray whales return seasonally primarily from March to May to feed prior to continuing their northern migrations (Calambokidis et al. 2002, 2010, Weitkamp et al. 1993). These whales have been individually identified and cataloged by Cascadia Research and a core group of just under a dozen of these individuals are documented returning each year including some of the individuals in the first years of directed research (1990 and 1991). One of their primary prey has been documented to be ghost shrimp in intertidal areas and they can be observed feeding at high tide in intertidal areas where there are dense aggregations of prey. While their feeding on ghost shrimp has been documented there is little quantitative data on which to calculate their consumption of ghost shrimp or the relative importance of this prey items.

Dedicated work to examine the feeding of gray whales on ghost shrimp to assist DNR began in 2015 (Pruitt and Donoghue 2016, Calambokidis 2016). The project would address a number of objectives related to key elements required to address gray whale consumption and reliance on ghost shrimp in the northern Puget Sound region. The following activities were conducted in 2016:

1. Continue sighting surveys and individual identification of gray whales to identify the number and timing of individuals present to evaluate changes in use of this region over time. Conduct surveys during at least three different periods during the spring to document feeding locations as well as put trained observers on whale watch boats to get supplemental sighting and photo-ID data.
2. Deploy and recover video tags in association with the above effort to document detailed feeding behavior and locations to allow better assess proportion of feeding on intertidal ghost shrimp versus other prey and number feeding events on ghost shrimp. Deployments

would target three time periods during the spring to better sample the entire period and region.

3. Collect feces of gray whales during above activities to identify prey items and proportion of diet attributable to ghost shrimp.
4. Compare occurrence in 2016 with past years to examine changes in number of animals, duration, and locations of feeding.

Some of the key preliminary results from some of this research are summarized below with figures or tables highlighting some of the findings. While analysis of this data is still underway, we summarize key results below.

## Methods

Surveys were completed aboard both whale watch boats as well as from dedicated small boat surveys (Table 1, Figure 1) which covered large areas of the habitat used by gray whales for feeding around Whidbey Island. Dedicated small boat surveys were conducted starting on 16 March and extending through 11 May 2016. Additionally, Cascadia personnel and interns went out on Whale Watch boats going out of Everett extending from 27 February through 8 May 2016 to obtain identification photographs. We also received identification photographs and sighting reports from other whale watch boats, though we only treated an identification as confirmed if it was an experienced observer or was backed up with photographs we could use to confirm the identification. Whale watch boats generally covered a more limited area than our surveys where we tried to cover major portions of the area used by whales.

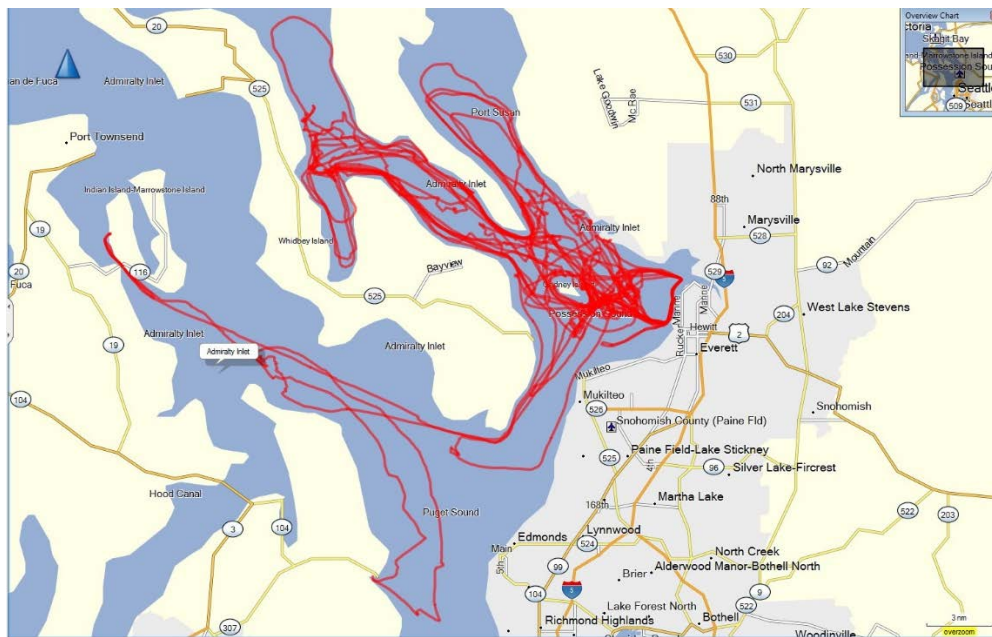


Figure 1. Tracks of dedicated small boat surveys conducted in Northern Puget Sound by Cascadia Research in 2016, see Table 1 for details.

*Table 1. Days of survey effort including dedicated surveys and those aboard whale watch boats.*

<b>Date</b>	<b>Ves- sel</b>	<b>Survey Type</b>	<b>Launch</b>	<b>Return</b>	<b>Start Time</b>	<b>End Time</b>	<b>Total Survey</b>
27-Feb-16	IE4	Whale Watch	Everett	Everett	9:53	13:31	3:37
05-Mar-16	IE4	Whale Watch	Everett	Everett	9:51	13:00	3:09
12-Mar-16	IE4	Whale Watch	Everett	Everett	9:55	13:22	3:27
16-Mar-16	ZIP	RHIB	Everett	Everett	7:35	19:25	11:50
17-Mar-16	IE4	Whale Watch	Everett	Everett	9:55	13:12	3:17
23-Mar-16	IE4	Whale Watch	Everett	Everett	14:03	16:54	2:51
25-Mar-16	ZIP	RHIB	Everett	Everett	7:00	19:19	12:19
26-Mar-16	ZIP	RHIB	Everett	Everett	8:00	18:30	10:30
31-Mar-16	IE4	Whale Watch	Everett	Everett	9:43	12:57	3:14
05-Apr-16	IE4	Whale Watch	Everett	Everett	9:50	12:35	2:45
06-Apr-16	ZIP	RHIB	Everett	Everett	7:14	17:23	10:09
07-Apr-16	ZIP	RHIB	Everett	Everett	7:45	17:35	9:50
08-Apr-16	ZIP	RHIB	Everett	Everett	7:23	19:04	6:17
09-Apr-16	ZIP	RHIB	Everett	Everett	7:42	16:02	8:19
09-Apr-16	IE4	Whale Watch	Everett	Everett	10:00	13:00	3:00
13-Apr-16	IE4	Whale Watch	Everett	Everett	13:30	17:00	3:30
16-Apr-16	ZIP	RHIB	Everett	Everett	6:59	19:10	12:10
17-Apr-16	IE4	Whale Watch	Everett	Everett	10:00	12:53	2:53
21-Apr-16	IE4	Whale Watch	Everett	Everett	9:55	12:53	2:58
25-Apr-16	IE4	Whale Watch	Everett	Everett	10:00	13:00	3:00
28-Apr-16	IE4	Whale Watch	Everett	Everett	10:00	13:00	3:00
03-May-16	IE4	Whale Watch	Everett	Everett	9:51	12:58	3:07
05-May-16	ZIP	RHIB	Everett	Everett	10:58	22:31	8:47
08-May-16	IE4	Whale Watch	Everett	Everett	9:45	13:16	3:31
10-May-16	ZIP	RHIB	Kingston	Kingston	17:30	20:30	3:00
11-May-16	ZIP	RHIB	Everett	Everett	7:31	16:20	8:48

Suction cup attached video tags were deployed on gray whales using a long pole after approach with our 5.9 m RHIBs (Figure 2). Tags contained dual side by side video cameras and recorded depth (pressure), temperature and three-dimensional magnetometer, acceleration, and gyroscope. They also had a regular GPS that depending on initialization and position on the body could sometimes record good positions. The tags were constructed by Customized Animal Tracking Solutions in collaboration with Cascadia, Stanford, and OSU. Details on the deployments are included in the Results.

During boat operations we also conducted focal follows to track the precise positions and movements of individual whales, especially when tagged. Positions were recorded either by noting the footprint where the whale dove after it had submerged or with range and bearing from the boat. The positions of feeding events were also precisely recorded.

During encounters and operations around whales we searched for feces from whales and collected these with a dip net when encountered. Skin and blubber samples were collected with small dart fired from a cross-bow. These were primarily collected when either the sex of a whale was not known or in one case to test whether a known female was pregnant.

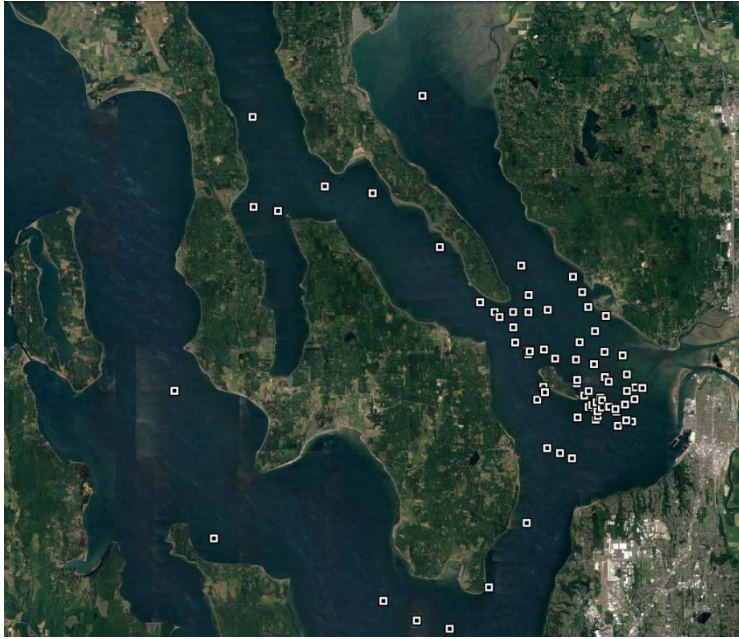


*Figure 2. Tag and deployment on 25 March 2016 (top) and photograph of two whales (bottom), both with suction-cup attached tags with the Snohomish Delta in the background.*

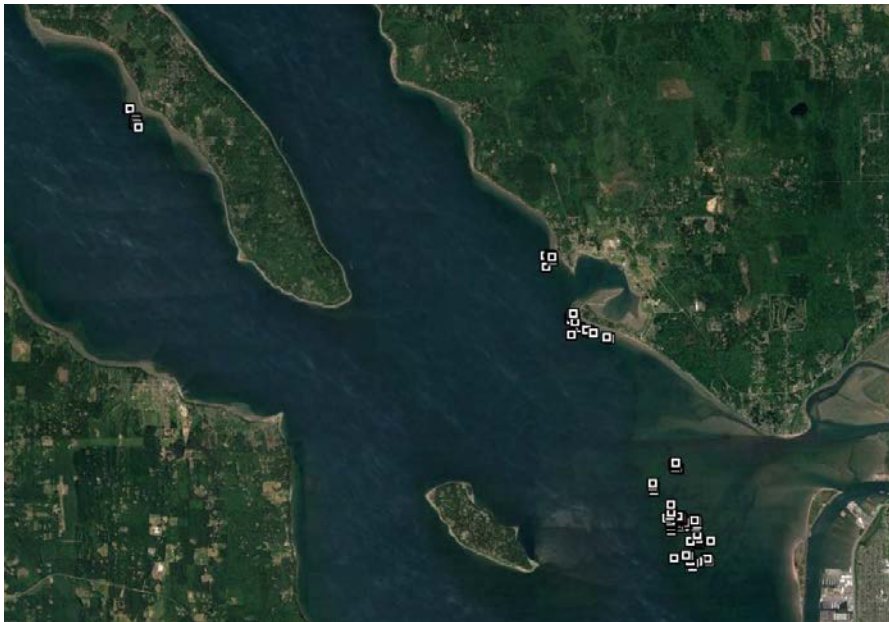
## **Results**

A total of 79 sightings of gray whales in N Puget Sound were documented during the Cascadia RHIB surveys and our effort aboard whale watch boats (Figure 3). Most included sightings in Port Gardner, Port Susan, Saratoga Passage, Possession Sound and Admiralty Inlet. The greatest concentration of sightings was on the Snohomish Delta and around Hat Island, especially off the SE side of the island (Figure 3). Locations where feeding was directly observed (n=140) during boat surveys were in three primary areas (Figure 4); Snohomish River Delta, around the entrance to Tulalip Bay in off the W side of Camano Island in Saratoga Passage.





*Figure 3. Locations of initial gray whale sightings from dedicated and opportunistic platforms in 2016.*



*Figure 4. Locations where intertidal feeding was documented with precise positions during focal follows from dedicated small boat surveys in 2016.*

Identifications of individuals confirmed seven different individuals using the N Puget Sound waters during our surveys (Table 2). Up to six of these whales were present at any one time since one whale left before the final whale arrived. The largest number of whales (6) were present from 25 March to 14 April. One whale (ID 723) stayed the longest and appeared to stay

throughout the spring and summer into fall, a highly unusual occurrence for one of these whales and not see previously.

*Table 2. Dates of identifications by individuals (confirmed) during 2016.*

Date	CRC ID #						Min in area	Comments:	
	21	44	49	56	383	531			723
17-Feb							X	1	
18-Feb							X	1	
27-Feb						X	X	2	CRC WW trip
5-Mar				X				3	CRC WW trip
9-Mar				X				3	
11-Mar							X	3	
12-Mar						X	X	3	CRC WW trip
13-Mar						X	X	3	
15-Mar				X	X			4	
16-Mar				X		X	X	4	CRC RHIB survey
17-Mar			X			X	X	5	CRC WW trip
18-Mar				X		X	X	5	
19-Mar			X			X	X	5	
20-Mar			X	X	X	X	X	5	
21-Mar			X	X		X	X	5	
23-Mar						X	X	5	CRC WW trip
25-Mar	X		X	X	X	X	X	6	CRC RHIB survey
26-Mar	X		X	X	X	X	X	6	CRC RHIB survey
27-Mar	X		X		X	X	X	6	
28-Mar	X		X	X	X	X	X	6	Oo altercation
30-Mar			X		X	X	X	6	
31-Mar				X	X		X	6	CRC WW trip
1-Apr	X				X		X	6	
2-Apr	X		X	X	X	X		6	
3-Apr	X		X	X	X		X	6	
4-Apr						X	X	6	
5-Apr					X	X	X	6	CRC WW trip
6-Apr	X		X	X	X	X	X	6	44 off Victoria, CRC RHIB survey
7-Apr	X		X	X	X	X	X	6	CRC RHIB survey
8-Apr			X		X	X	X	5	CRC RHIB survey
9-Apr		X	X		X	X	X	6	CRC RHIB survey & WW trip
11-Apr						X	X	6	
12-Apr		X	X		X		X	6	
13-Apr						X	X	6	CRC WW trip
14-Apr						X		6	
15-Apr			X		X		X	5	
16-Apr	X				X			5	CRC RHIB survey
17-Apr	X	X	X		X		X	5	CRC WW trip
18-Apr		X	X		X		X	5	
19-Apr	X						X	5	
20-Apr		X			X		X	5	
21-Apr		X						5	CRC WW trip
22-Apr	X	X	X		X		X	5	
23-Apr		X	X		X		X	5	
24-Apr	X	X	X		X		X	5	
25-Apr							X	5	CRC WW trip
27-Apr		X	X				X	5	
28-Apr							X	5	CRC WW trip
29-Apr		X					X	5	
30-Apr			X		X			5	
1-May		X	X				X	4	
3-May	X		X				X	3	CRC WW trip
4-May							X	3	
5-May			X				X	3	CRC RHIB survey
6-May			X					3	
7-May	X		X				X	3	
8-May								2	CRC WW trip
11-May							X	2	CRC RHIB survey
13-May							X	2	
15-May	X						X	2	
17-May							X	1	

The seven individuals identified in 2016 is one less than the eight identified in 2015 (Table 3). All seven whales identified in 2016 were known individuals identified from multiple past years first identified from 1990 to 2000. Sex was known on all seven whales seen in 2016 including ID 383 whose sex was just determined from a biopsy collected in 2016) and six were known males and only one was a known female (531). Three individuals seen in 2015 were not seen in 2016 and this included ID 22, a known female that does not show up every 2-5 years likely when she has a calf as well as ID 356, whose sex is not known but is suspected to be a female from her regular absences every 2-4 years as well. More puzzling was not seeing ID 53, a known male seen the last 7 years in a row but not in 2016. The one known female seen in 2016, ID 531, was not seen in 2015 but returned in 2016.

*Table 3. Overall annual sighting histories of whales seen in N Puget Sound more than 2 years. Rows are individuals by ID number, and shaded areas show either number of days encountered (1990-2013) or first date confirmed present in N Puget Sound (2014-2016).*

ID	Sex	1990	1991	1992	1993	1994	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Yrs	
21	M	1	16	5	2		7	6	4	5			1	13	1	9	3	12	10	1	2	2	3	12-Mar	2-Apr	25-Mar	22	
22	F	1	1	2	1		5	7	4	3			4		2	14		9	7	13		4	11		15-Mar		17	
44	M		14	9	3		3		1	1	1		1	15	2		5	1	4	2	2	1	2	7-Apr	4-Apr	9-Apr	20	
49	M		6	4	2	2	2	5	1	1	5	2	2	11	2	5	5	15	14	12	18	5	8	7-Apr	14-Mar	17-Mar	24	
53	M		12		2	2	2		1	2		2	5	9	2	9			10	6	22	10	12	18-Mar	8-Mar		18	
56	M		2					1		5	2		1	6	2	7	2	9	1	1	4	5	12	10-Apr	14-Mar	5-Mar	18	
356									1		1		1	1		1		2	2	2				7-Apr	20-Mar		10	
383	M								2		1		1	7	1	7	6	4	9	4	1	3	9	7-Apr	21-Mar	15-Mar	16	
396	F								4	1									2								3	
531	F									2					2	3	8	10		4	12	11		1	9-Mar		27-Feb	11
723	M									1				19	3	5				4	2	11	5		9-Mar	7-Mar	17-Feb	11

The timing that new individual whales discovered this feeding area matches with periods of high strandings (Figure ). Six gray whales appear to have discovered this feeding area in 1990-1991. This was when we first became aware of regular sightings of gray whales in the spring in this area and when we first obtained identification photographs of these initial animals. While it is possible some whales used this area prior to this, most local residents who spend time on or overlooking the water do not recall seeing whales on a regular basis prior to this. During a second period in 1999-2000, six additional whales (five who have returned for more than 2 years) joined the original group. These two periods, 1990-91 and 1999-2000 were the two periods of highest strandings of gray whales in Washington State with most of these animals dying very emaciated. The 1999-2000 period was declared an Unusual Mortality Event for gray whales and was when thousands of gray whales died along their entire range as an apparent result of the population recovering from whaling and reaching carrying capacity (Moore et al. 2001).

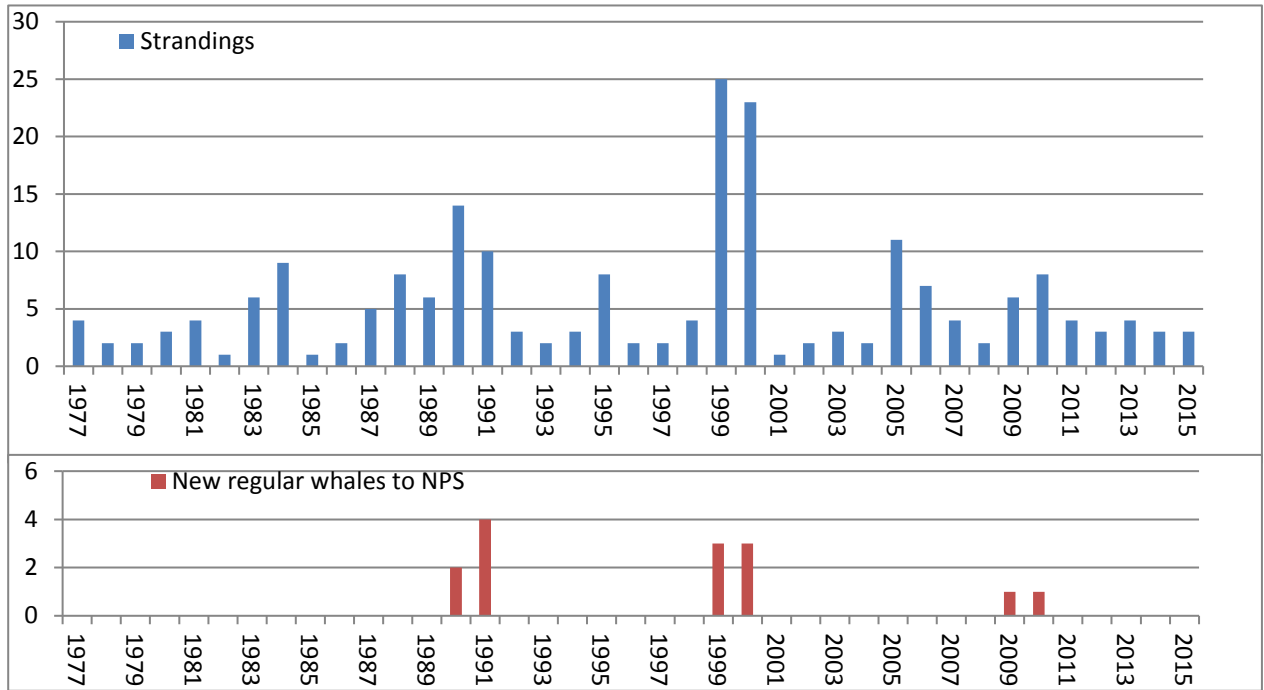


Figure 5. Relationship between number of strandings of gray whales in Washington State and the initial appearance of new individuals feeding in N Puget Sound.

We collected three skin and blubber biopsies from gray whales (including the first from ID 383 showing it was a male) as well as one from a humpback whale feeding in the same area (Table ). We were not as successful seeing or collecting fecal samples in 2016 but did get one additional samples to add to the four fecal samples we collected in 2015. All of these had visible carapices of ghost shrimp in them. Samples have been frozen for more detailed identificasiton of prey by visual and possible genetic means in future months.

Table 4. Samples collected in 2016. First four are from gray whales and last is from a humpback whales that was feeding in the same area.

Date	Vessel	Sighting	Field ID	Time	Sample #	Sample Type
25-Mar-16	ZIP	2	383	11:05	CRC-20160325-ZIP-01	Skin and Blubber
25-Mar-16	ZIP	9	531	14:52	CRC-20160325-ZIP-02	Skin and Blubber
26-Mar-16	ZIP	3	56	10:48	CRC-20160326-ZIP-01	Skin and Blubber
26-Mar-16	ZIP	5	49	14:10	CRC-20160326-ZIP-02	Fecal
26-Mar-16	ZIP	8	MN	15:53	CRC-20160326-ZIP-03	Skin Only Biopsy

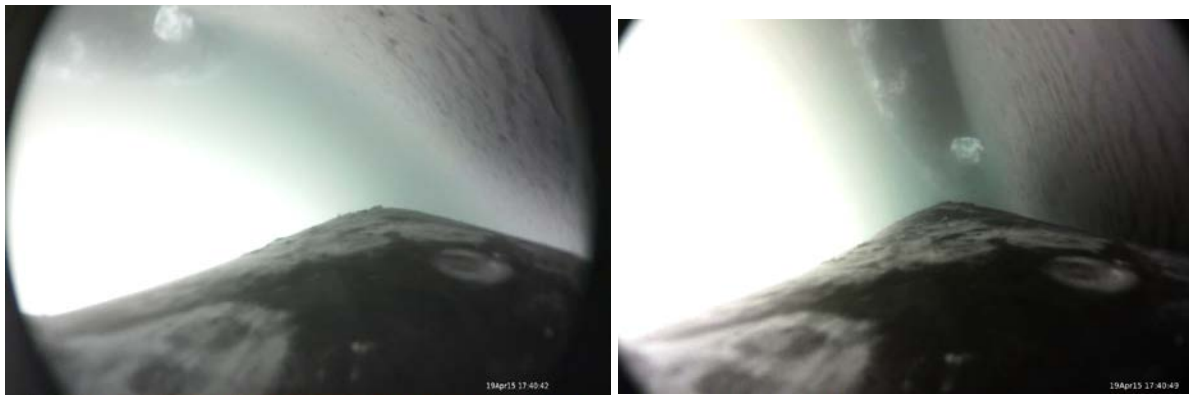
Deployments of suction-cup attached video tags were conducted on eight occassions in 2016 spread among three time periods representing early (25 March) , middle (6-7 April), and late (5 May) portions of the spring feeding season (Table 3). These complimented the three deployments conduced in 2015 primarily in one time period (17-19 April 2015). Figure 4 shows the four longer 2016 deployments and our longer deployment from 2015 (of whale 22, one of our



few females known since 1991 that does not show up in all years, including 2016, which we suspect are years she has a calf).

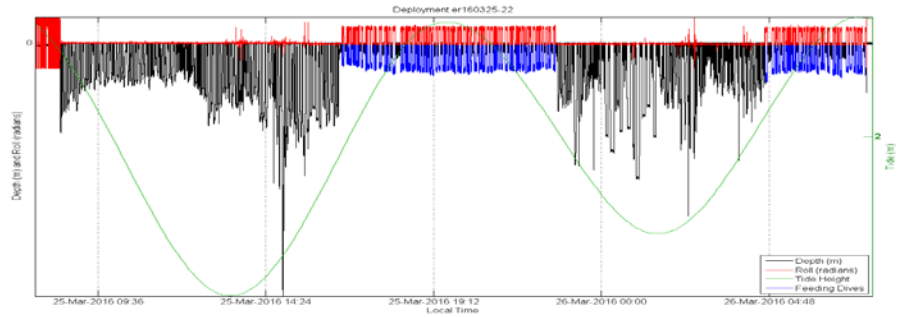
*Table 5. Tag deployments conducted in 2016.*

DateTimeOn	Tag #	Depl. Lat	Depl. Long	OffTime	H-on	H-data	RecTime	Recov. Lat	Recov. Long	Vessel	SN#	CRC ID	Sex
03/25/2016 08:31:31	22	47.999	-122.297	03/26/2016 07:34:37	23.1	23.1	03/26/2016 11:25:16	47.9863	-122.3165	ZIP	1	723	M
03/25/2016 14:39:07	25	48.001	-122.286	03/25/2016 15:38:19	1.0	1.0	03/25/2016 16:19:21	48.0007	-122.2855	ZIP	9	49	M
03/25/2016 18:01:55	25	47.991	-122.284	03/26/2016 07:02:30	13.0	13.0	03/26/2016 11:34:43	47.9765	-122.3160	ZIP	11	383	Biopsy
04/06/2016 14:29:00	22	48.065	-122.3	04/07/2016 08:39:17	18.2	18.2	04/07/2016 12:12:48	48.1133	-122.3607	ZIP	5	21	M
04/06/2016 15:52:00	21	48.004	-122.259	04/09/2016 11:24:00	67.5	37.6	04/09/2016 11:24:25	48.0040	-122.2958	ZIP	6	723	M
04/07/2016 13:56:20	25	47.985	-122.309	04/07/2016 18:21:52	4.4	4.4	04/07/2016 20:15:30	47.9960	-122.2588	ZIP	7	383	Biopsy
05/05/2016 13:17:26	22	48.022	-122.316	05/05/2016 17:42:00	4.4	4.4	05/05/2016 18:16:58	48.0140	-122.2623	ZIP	2	723	M
05/05/2016 13:52:40	25	48.012	-122.306	05/05/2016 20:22:00	6.5	6.5	05/05/2016 22:31:08	47.9702	-122.2802	ZIP	2	49	M

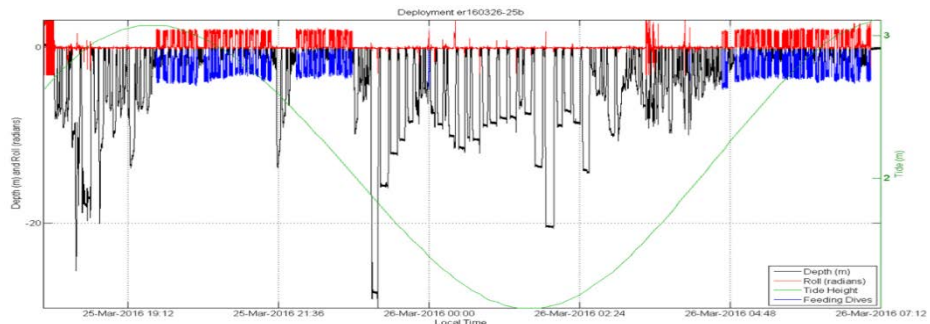


*Figure 6. Images captured on video on video tag deployments on gray whales in May 2015. Photographs are two frame grabs from forward facing video from deployment in 2015 showing a 2<sup>nd</sup> whale lying on the bottom in subtidal area off Hat Island. This was an area where whales spent time resting and socializing on the bottom but did not appear to feed though they would sometimes roll on their sides briefly.*

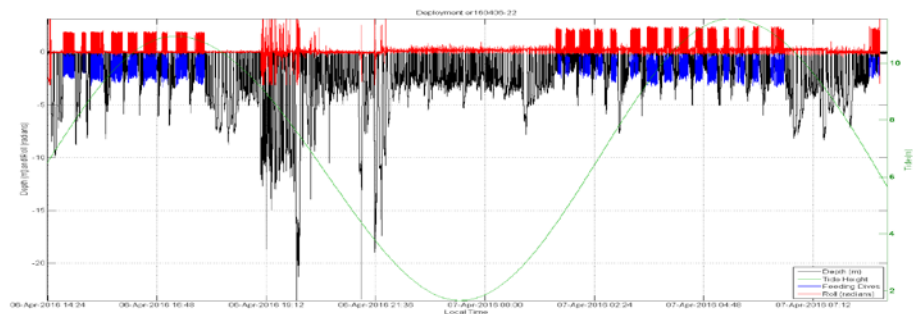
Deployment on ID 723 (male) on 25 March 2016 at 0831 which recorded 23 h of data



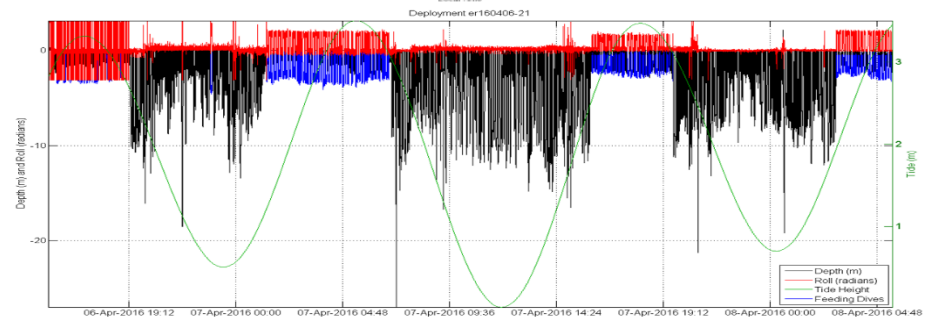
Deployment on 383 on 25 March 2016 at 1801 and recorded 13 hours of data



Deployment on ID 21 at 1429 on 6 April 2016 which recorded 18.2 h of data.



Deployment on ID 723 at 1552 on 6 April 2016 that recorded 37.6 h of data during a record deployment of 67.5 h.



Deployment on ID 22 at 1015 of 17 April 2015 that recorded 18 h of data.

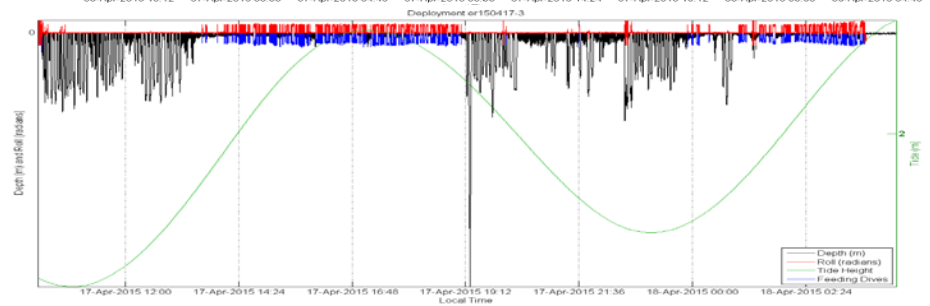


Figure 7. Detailed tag and tide records for five longer deployments showing dive depth both for non-feeding (black) and feeding (blue) dives as well as roll angle (red) and tide height (orange).

Table 6. Summary of feeding events observed on tag records in 2015 and 2016. Each feeding event represents a near continuous period with frequent feeding dives and roles.

File Name	Feeding event	Feeding event start time	Feeding event end time	Number of rolls	Duration of event	CRC- ID	Animal sex	Comments
er20150417-3-ID22	1	4/17/2015 13:37	4/17/2015 19:06	182	5:29	22	Female	
er20150417-3-ID22	2	4/17/2015 23:52	4/18/2015 3:39	89	3:31	22	Female	
er20160325-22	1	3/25/2016 16:33	3/25/2016 22:42	117	6:09	723	Male	
er20160325-22	2	3/26/2016 4:40	3/26/2016 7:34	47	2:54	723	Male	Data ends mid feeding event
er20160325-25b	1	3/25/2016 19:38	3/25/2016 21:29	76	3:08	383	Male	
er20160325-25b	2	3/25/2016 21:52	3/25/2016 22:46	47	0:54	383	Male	
er20160325-25b	3	3/26/2016 4:40	3/26/2016 7:02	100	2:22	383	Male	Data ends mid feeding event
er20160406-22	1	4/6/2016 14:45	4/6/2016 17:50	170	3:05	21	Male	
er20160406-22	2	4/7/2016 1:32	4/7/2016 6:33	249	5:01	21	Male	
er20160406-22	3	4/7/2016 8:26	4/7/2016 8:39	11	0:13	21	Male	Data ends mid feeding event
er20160406-21	1	4/7/2016 1:21	4/7/2016 6:54	95	5:33	723	Male	
er20160406-21	2	4/7/2016 15:59	4/7/2016 19:38	57	3:39	723	Male	
er20160406-21	3	4/8/2016 2:57	4/8/2016 5:30	37	2:33	723	Male	Data ends mid feeding event

## Conclusions and Recommendations

This long term photo-ID dataset combined with the recent use of new tags and tools have provided new insights into this stable group of whales that have discovered a somewhat unique off-migration feeding area. Major insights from the recent research includes:

- The N Puget Sound whales (Sounders) appear to have discovered this highly productive but risky off-migration feeding area during two periods of high food stress in 1990-91 and 1999-2000.
- These whales feed almost exclusively on ghost shrimp in the intertidal zone only accessible to them at high tide. Feeding in other areas appears limited at best.
- Snohomish Delta the most important of the feeding areas in recent years though their use appears to change over time.

While the Department of Natural Resources has lifted the moratorium on the ghost shrimp harvest based almost solely on the estimates of biomass of ghost shrimp in relation to the estimated amount of harvest and whale predation, to better understand the potential competition between the fishery and whales we recommend:

1. Evaluate whether there is a tidal height difference between primary area harvest could be conducted and whale feeding and whether this could be used to further separate the overlap and potential competition between the whale feeding and harvest.
2. Snohomish Delta was the most important feeding area for whales in 2015-16 and since

this is not currently a target of harvest, protecting this area from future harvest would be an easy way to reduce the potential for future conflict.

3. A robust inexpensive experiment would be to split sites that have had historical harvest and whale feeding into two groups allowing harvest on one and not on another and test for future changes in whale use.
4. It is important to integrate harvest information and management with tribes since tribal harvest is a significant part of the harvest and is currently not coordinated with the DNR managed harvest.

## **Acknowledgments**

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