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Google Earth satellite images provide novel method for examining feeding areas of gray whales in Puget Sound, Washington

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GRAY WHALE FEEDING ON THE SNOHOMISH DELTA



GRAY WHALE FEEDING CAPTURED FROM SUCTION CUP MOUNTED VIDEO CAMERA



FEEDING PITS FROM GOOGLE EARTH



Investigating freely available satellite images of the North Puget Sound for gray whale feeding pits

Satellite images provide a valuable research tool though their use in whale research has been more limited due to challenges in resolution and catching whales at the surface. We explore a novel use of Google Earth to identify gray whale feeding pits exposed at low tide. We searched all images available on Google Earth as of March 2017, for northern Puget Sound spanning from 47.8 N to 48.4 N and 122.2 W and 122.7 W and found 10 different dates with suitable low tide images from 23 May 2005 to 17 July 2015. For Images where pits were visible each pit was individually marked in Google Earth with a placemark. Pit counts were done utilizing the Google Earth table function.

FEEDING PIT STUDY AREA

Above we have a still image taken from a multi-sensor tag with dual video cameras. On the left you can see the body of the whale in a muddy cloud, and on the right is the substrate that this animal is feeding in. See "A high risk intertidal feeding strategy for gray whales examined with new suction-cup attached multi-sensor video tags." in Foraging Ecology by John Calambokidis Tuesday morning.

Four main Sub-Regions of the North Puget Sound contained images of feeding pits with the majority located on the Snohomish delta

Feeding pits were seen in images from 10 unique dates in 5 different years from 2005 to 2015. From these images we documented 19,447 identifiable feeding pits of gray whales. Pits were only visible in images where the intertidal zone was exposed with the maximum visible at low tide and none visible during high tide. The highest number were seen on the Snohomish River Delta which accounted for 14,289 (73%) . The locations identified were consistent with observed locations gray whales were seen feeding at high tide and higher resolution images obtained from aerial flights



The North Puget Sound Resident gray whales and their unique feeding habits

The North Puget Sound Resident Population is a subgroup of the Eastern North Pacific Population. Current population estimate is 14 individuals. During their northern migration from Baja California Sur, the North Puget Sound Residents forage on ghost shrimp in the Puget Sound for 2-3 months in the spring (March-May) before continuing north to the Bering and Chukchi Seas for summer feeding. Some of these resident whales have been spotted since 1991.

Key Findings



GOOGLE EARTH IMAGE SHOWING DOTS FOR OVER 10,000 FEEDING PITS IDENTIFIED FROM MULTIPLE IMAGE DATES



FEEDING PITS WERE ONLY VISIBLE FROM APRIL TO JULY WITH THE MOST PITS LOCATED ON THE SNOHOMISH DELTA

	Apr	May	Jun	Jul	Total	Percent
E Port Susan	Х	542	957	995	2,494	13%
Snohomish Delta	651	10,395	446	2,797	14,289	73%
SE Whidbey Island	371	1,630	Х	16	2,017	10%
W Camano Island	30	525	Х	92	647	3%
Total	1,052	13,092	1,403	3,900	19,447	
Percent	5%	67%	7%	20%		

MAXIMUM NUMBER OF FEEDING PITS WERE VISIBLE IN A FEW IMAGES DURING LOW TIDES WHEN THE INTERTIDAL ZONE WAS EXPOSED

	Low Tide	Medium Tide	Total	Percent
E Port Susan	1,952	542	2,494	13%
Snohomish Delta	12,132	2,157	14,289	73%
SE Whidbey Island	1,124	893	2,017	10%
W Camano Island	92	555	647	3%
Total	15,300	4,147	19,447	
Percent	79%	21%		

- Studying freely available satellite images can be used as a non-invasive method to investigate the spatial and temporal feeding behaviors of benthic feeding gray whales
- Feeding pits located in satellite imagery were located in areas that have been documented in previous surveys.
- Low tide images containing pits were only found during the months of April through July
- The majority of feeding pits (73%) were located on the Snohomish delta which also had the longest span of years and the most image dates available.
- Higher resolution and more precise temporal information would improve this approach and potentially expand the ability to detect either whales or the signs of their activities.
- While it was more challenging to locate whales at the surface in the images, in three images at high tide, whales were identified in these same areas.

IMAGES WHERE WHALES WERE IDENTIFIED WITHIN THE STUDY AREA



LOW TIDE IMAGES WERE AVAILIBLE BETWEEN 2005 AND 2015 WITH THE MOST COVERAGE OVER THE SNOHOMISH DELTA

	Span of years	Number of Years	Number of Different Image Days
E Port Susan	2014-2015	2	4
Snohomish Delta	2005-2015	5	9
SE Whidbey Island	2005-2015	4	5
W Camano Island	2009-2015	3	3

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