

Correlating Southern Resident Orca Sightings with Pacific Salmon Densities: A Three Scale Analysis

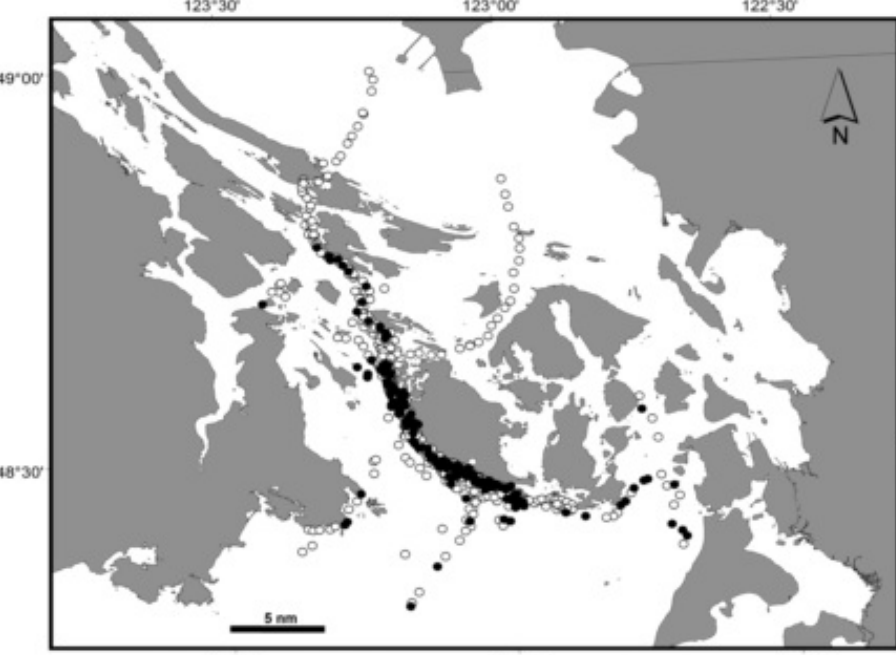
Charla Basran

Beam Reach Marine Science and Sustainability School

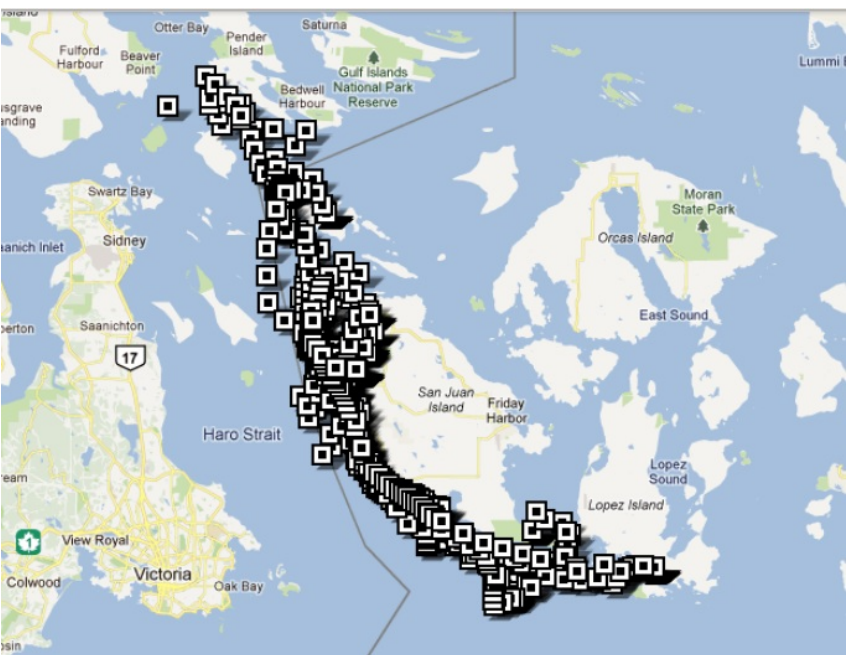
University of Washington Friday Harbor Marine Labs

Background

The Southern Resident Killer Whales (SRKWs) inhabit the Salish seas of Northern Washington, USA and Southern British Columbia, Canada, during the late spring to early fall months. These whales were listed as endangered in 2009, and feed very selectively on threatened and endangered Chinook salmon which migrate through the area on their way to and from their native streams. Chinook abundance has been found to directly relate to killer whale mortality (Ford et al. 2009) and PCB toxin load in the killer whales is also linked to their Chinook prey (Cullon et al. 2009). The most notable Chinook runs occur from late spring to fall for the Columbia and Fraser rivers, and appear to correspond with the movement of the SRKWs to and from, and within the Salish Seas (specifically on the west side of San Juan Island).



Foraging behaviour sites around San Juan Island (Ashe et al. 2009)



Tracks of field observation locations from this study.

Methods

Broad-Scale Analysis of Archive Orca Sightings and CPUE of Salmon

❖ Obtained archive catch per unit effort (CPUE) of Chinook and Chum salmon at the Albion test fishery on the lower Fraser River from April to October, 2006-2010 from Department of Fisheries and Oceans, and archive orca sightings from the Whale Museum's Orcasmaster database for the same time period (queried in SQLShare)

❖ Averaged CPUE and orca sighting per week, for a total of 29 weeks

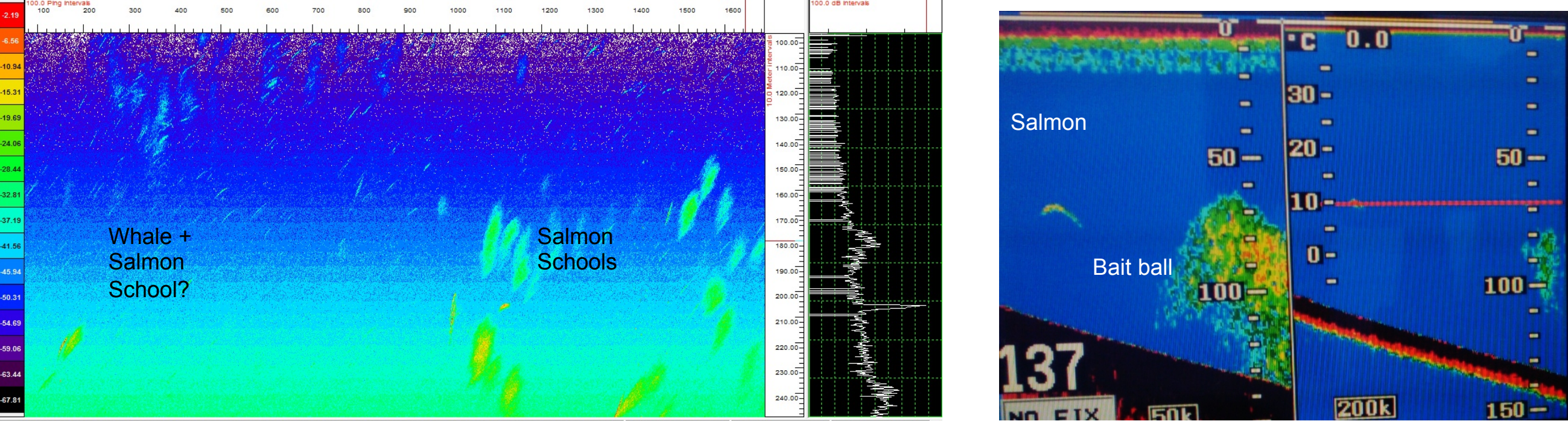
❖ Ran a Pearson correlation test using Systat statistical software (Systat version 13 © Systat inc. 2008) to test for a significant correlation between the two factors ($\alpha = 0.05$)

Localized-Scale Analysis of Archive Echosounder Images and Orca Sightings

❖ Obtained archive Biosonics echosounder images for August 8th, 10th, and 14th, 2008 at Lime Kiln State Park, WA, and orca sightings data from Dr. Bob Otis' database for the same dates

❖ Counted salmon targets (with a backscatter frequency of -25 to -15 dB) for pre-, during, and post-whale sighting times and averaged. Schools of salmon were denoted a minimum number of 5 fish.

❖ Compared the three time categories using a Wilcox test in R statistical software (R development core team. 2010)



Echosounder image (left) and fish finder image (right) containing salmon targets.

Fine-scale Analysis of Field Observations and Fish Finder Images

❖ Recorded percent time orcas spent foraging and collected fish finder images every 30-45 seconds during whale encounters while aboard a sailing catamaran for 20 days from late September and early October, 2011

❖ Trolled for salmon at study sites to confirm presence of salmon species

❖ Used a Pearson correlation test to test for a significant correlation between percent time spent foraging and percent of fish finder images containing large target fish for eight separate days

❖ Also compared average percent of large target images with average click rate (data obtained from Hayley Dorrance) for foraging events on four separate days



SRKW foraging.



Juvenile Chinook caught by trolling.

Abstract

This study investigates the correlation between orca sightings and Chinook salmon abundance in the Salish Sea region on three different scales. For a broad scale analysis, a sightings database was used to obtain orca sightings in the San Juan Islands, WA, and Chinook catch data was obtained for the Fraser River from the Department of Fisheries and Oceans. Data was used from April to October of 2006 to 2010, and average number of "whale days" per week was correlated with average catch per unit effort (CPUE) of Chinook. For seasonal scale analysis, echosounder data from August 2008 was analyzed, using depth and backscatter frequency, to determine salmon counts at Lime Kiln State Park, San Juan Island, WA. These salmon counts were conducted for three days when there were multiple whale sightings recorded specifically at Lime Kiln State Park, and before, during, and after whale sighting counts were compared. For a fine scale analysis, field data was collected over a twenty day period through the end of September and beginning of October, 2011. On each "whale day", percent of time spent foraging was calculated. Fish finder images were collected each day and analyzed for presence and absence of large targets considered to be salmon. Trolling at depths where large targets were seen was performed in order to confirm the presence of salmon species. The percent time the orcas were observed foraging was correlated with the percent of images with salmon present. Results show that whale days per week positively correlates with CPUE of Chinook salmon in the Fraser River. Over the three days at Lime Kiln State Park, there was a trend showing higher salmon counts when the whales were present. The time spent foraging also positively correlated with the percent of images containing salmon. This reinforces the idea that SRKWs are highly dependent on their salmon prey, and this dependence is reflected in the time spent, and movements within, the Salish Seas region.

Results

Broad-Scale Analysis of Archive Orca Sightings and CPUE of Salmon

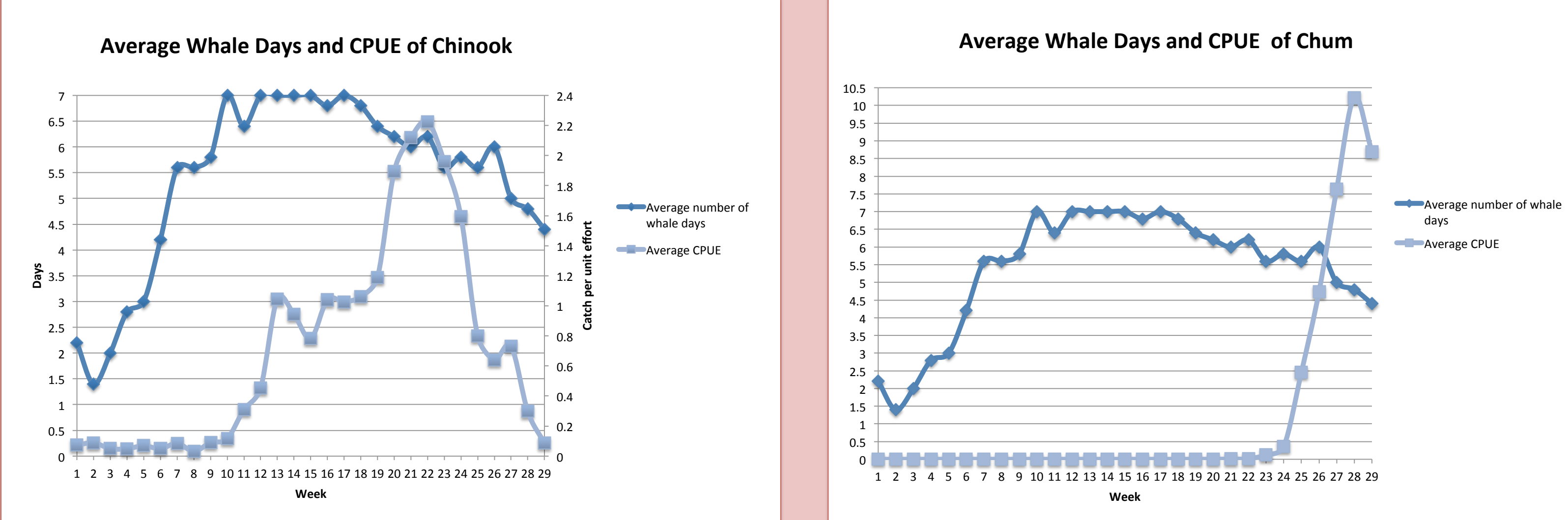


Figure 1. There is a significant positive correlation between the average number of whale days per week from April to October of 2006-2010 and the average CPUE of Chinook Salmon at the Albion test fishery on the lower Fraser River ($r=.492$, $p<0.05$). For comparison, the average whale days were plotted with Chum salmon CPUE and there is no significant correlation ($r=-0.109$).

Localized-Scale Analysis of Archive Echosounder Images and Orca Sightings

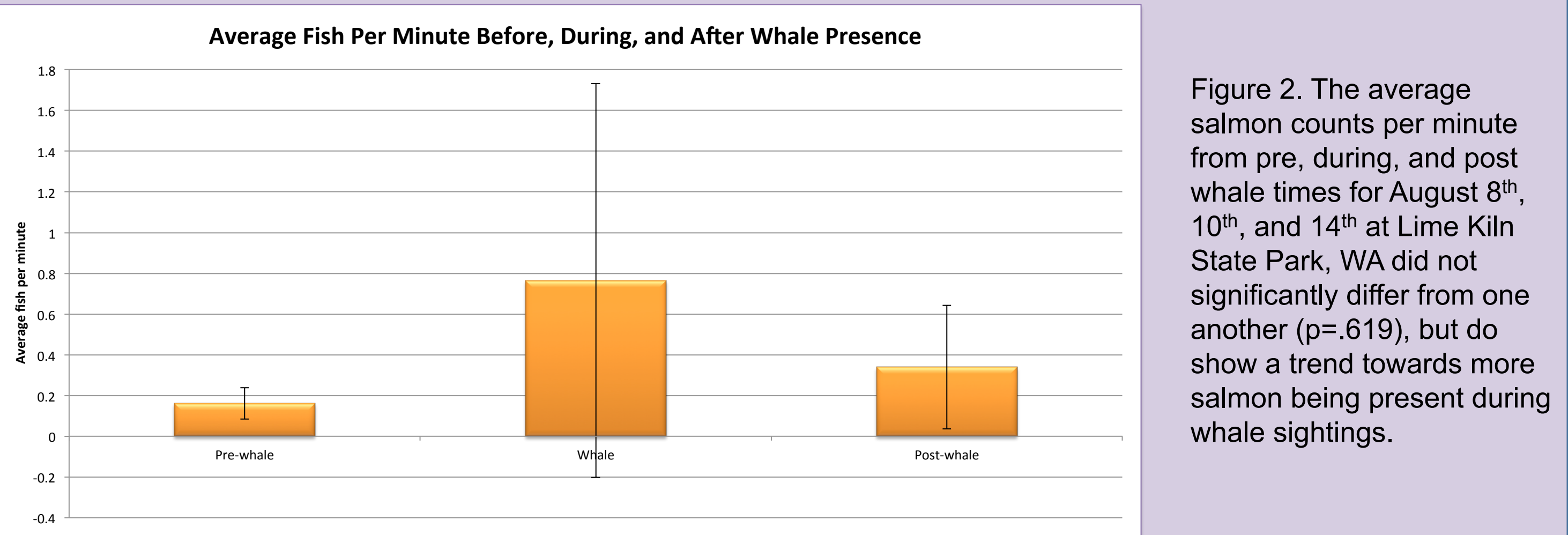


Figure 2. The average salmon counts per minute from pre, during, and post whale times for August 8th, 10th, and 14th at Lime Kiln State Park, WA did not significantly differ from one another ($p=.619$), but do show a trend towards more salmon being present during whale sightings.

Fine-scale Analysis of Field Observations and Fish Finder Images

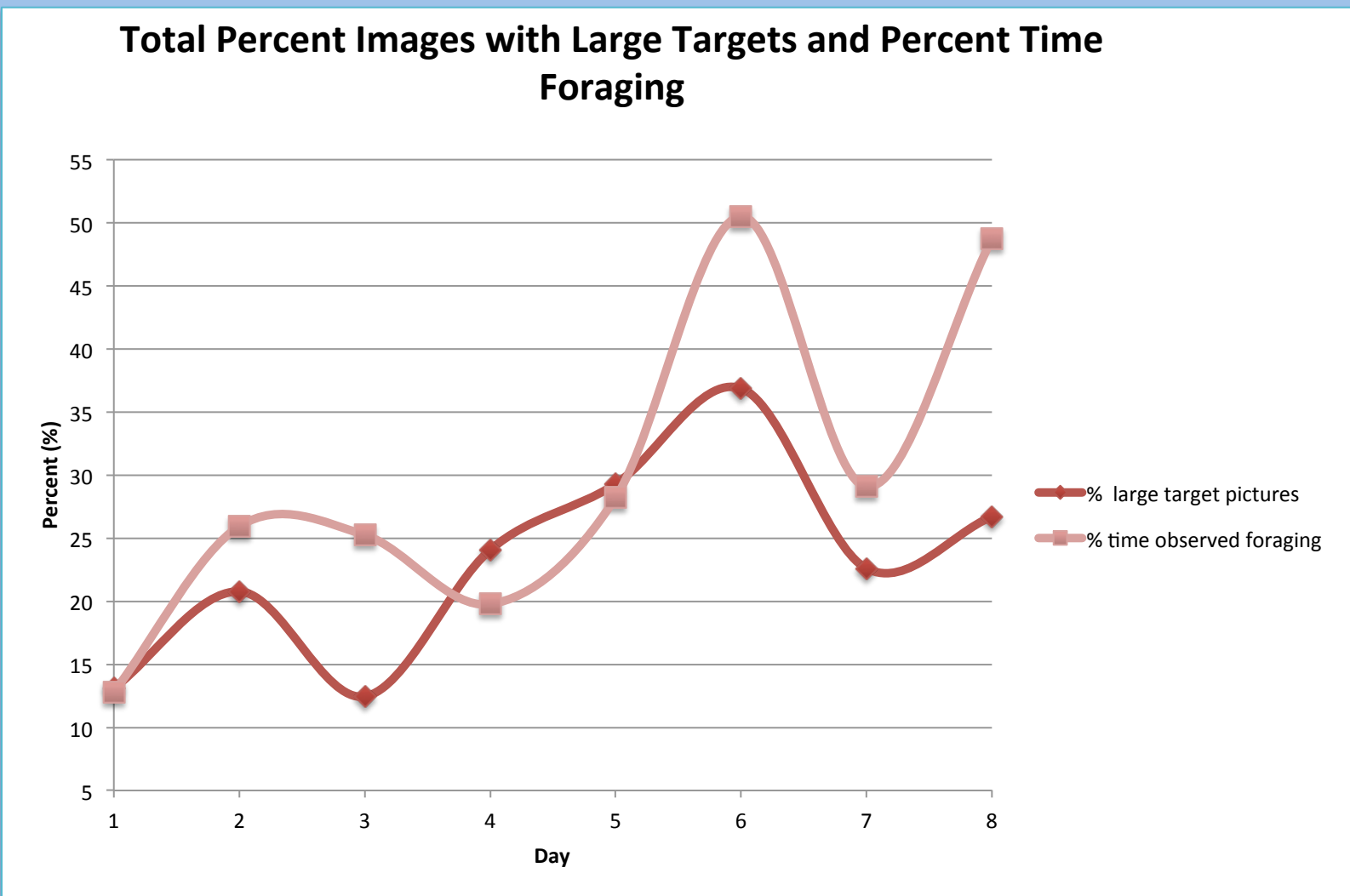


Figure 3. There is a significant positive correlation between the percent of fish finder images containing large targets and the percent of time the orcas were observed foraging ($r=.751$, $p<0.05$).

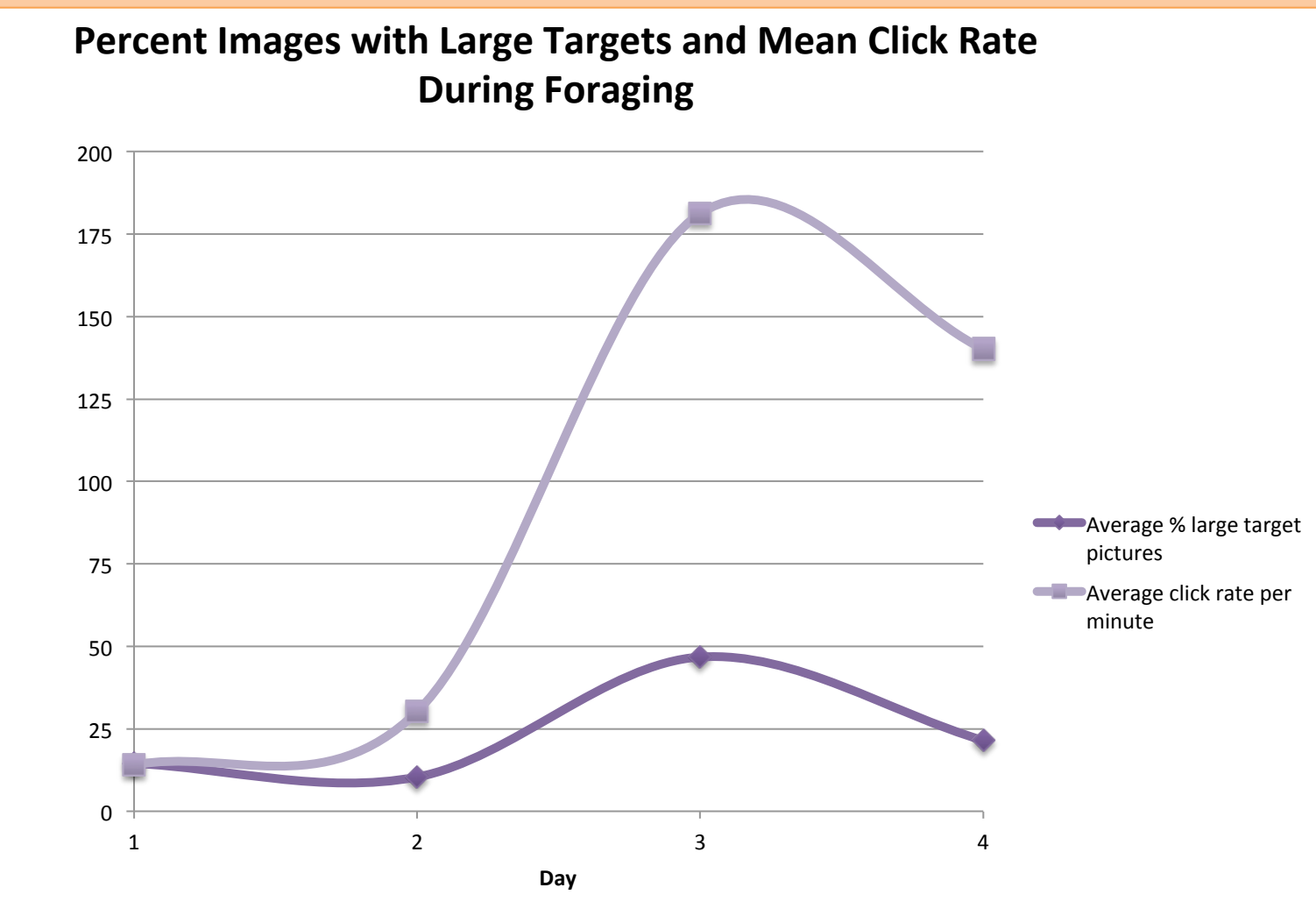


Figure 4. The average percent images with large targets and the average click rate during foraging on four whale days were not significantly correlated ($r=.869$), but did show a strong trend towards percent images and mean click rates increasing together.

Discussion

Broad-Scale Analysis of Archive Orca Sightings and CPUE of Salmon

- ❖ Average whale days per week and average CPUE of Chinook in the Fraser River had a significant positive correlation as hypothesized
- ❖ Orcas eat an estimated 50kg of fish a day (Cullon et al. 2009) with an estimate of over 65% of their diet being Chinook (Ford et al. 1998), explaining this correlation
- ❖ Orcas are known to eat Chum when Chinook are scarce, but there was no significant correlation between whale days and CPUE of Chum (Ford and Ellis. 2006), supporting that SRKWs' dependence on the Chinook

Localized-Scale Analysis of Archive Echosounder Images and Orca Sightings

- ❖ Average number of salmon targets pre-, during, and post-whale sightings at Lime Kiln State Park did not differ significantly
- ❖ Have small sample sizes with large standard deviations, but there is a trend towards more salmon targets during whale sighting than pre or post suggesting the SRKWs are following their prey at a local scale



SRKWs in front of Lime Kiln State Park lighthouse, WA.



Salmon captured on the underwater camera at Lime Kiln State Park lighthouse, WA.

Fine-scale Analysis of Field Observations and Fish Finder Images

- ❖ Percent of fish finder images with large target fish and percent time the orcas were observed foraging had a significant positive correlation as hypothesized
- ❖ 4/5 of fish caught while trolling were juvenile Chinook supporting the images on the fish finder can be counted as orca prey, and supporting that the behaviour observed is in fact foraging
- ❖ Average percent of fish finder images with large targets during foraging and average click rate during foraging were not significantly correlated, but showed a strong trend
- ❖ This trend showed average foraging click rate increased as average number of large target images increased, which makes sense since orcas use echolocation clicks to hunt



Birds circling (left) and lunging (right) are used as indicators of foraging events.

Conclusions

- ❖ Results support the dependence SRKWs have on Chinook Salmon
- ❖ Suggest migratory patterns of Chinook play an important role in the movements of the orcas to and from, and within the Salish Seas
- ❖ Both species are endangered in this region, therefore it is critical to monitor and protect them, especially given their unique, dependent relationship

References

*Cullon, D.L., Yunker, M.B., Alleyne, C., Dangerfield, N.J., O'Neill, S., Whitcar, M.J., Ross, P.S. (2009): Persistent organic pollutants in Chinook salmon (*Oncorhynchus tshawytscha*): implications for resident killer whales of British Columbia and adjacent waters. *Environmental Toxicology and Chemistry*, 28: 148-161
*Ford, J., Ellis, G. (2009): Selective foraging by fish-eating killer whales. *Marine Ecology Progress Series*. 316: 185-199
*Ford, J.K.B., Ellis, G.M., Barrett-Lennard, L.G., Morton, A.B., Palm, R.S., Balcomb III, K.C. (1998): Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. *Can. J. Zool.* 76: 1456-1471

Acknowledgements

Special thanks to: Robin Kodner, Scott Veirs, Val Veirs, and Todd Shuster for all their help with this project, Biosonics for their data analysis software, and Hayley Dorrance for the click rate data.