The Role of Salinity and Temperature in Killer Whale's (*Orcinus Orca)* Ability to Effectively Locate Salmon in the Shalish Sea

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The Salish Sea, a large estuarine system located in northern Washington state and southern British Columbia, is the area in which the Southern Resident Killer Whales (SRKW) spend the majority of the year (NOAA recovery plan, Ford et al. 2000; Hauser 2006). There are two distinct ecotypes of Orca (*Orcinus Orca)* that can commonly be found in these coastal waters off Washington State and British Columbia: Transients and Residents (Ford and Ellis 2006).

Although physiologically these two ecotypes are virtually indistinguishable, they exhibit fundamental differences in diet, socialization, and behavior (Ford et al. 2000; Ford et al 1998). Transients travel in small pods, inhabit a large range, and eat—almost exclusively—marine mammals. Resident Killer Whales, on the other hand, travel in large pods made up of several matriarchal clans, inhabit a smaller range, and are fish eating (Ford et al. 2000). This central difference between these two ecotypes is attributed in part behavioral traditions that are passed down through generations (Ford and Ellis 2006).

The SRKW have been observed feeding on 22 different fish species in the Salish Sea, but observations of SRKW foraging, as well as collected poop samples, have led researches to believe that SRKW forage predominantly on Salmonid species, specifically Chinook (*Oncorhynchus Tshawytscha)* (Ford et al. 2000; Baird et al. 2003).

Usually, prey choice in predators is determined by a combination of prey availability and energetic profitability, but in the case of SRKW this doesn't seem to be true. Chinook Salmon are among the least abundant salmon species in the Salish Sea ecosystem. However, Chinook salmon are the largest of the salmonids and have an extremely high lipid content (Ford and Ellis 2006). It's evident from the SRKW selective dietary choice that the nutritional paybacks of Chinook salmon outweigh the energy expended to find and catch Chinook.

Very little is known about the diet of the SRKW during the winter months, but the SRKW requirement for Chinook during the spring, summer, and fall months can be seen through their movements into—and around—the Salish Sea. The SRKW travel somewhat predictably throughout the Salish Sea, foraging in core areas that presumably have an abundance of food (Ford et al. 2000; Samuel et al 1985). It has been observed that the SRKW movements through the Salish Sea follow the patterns of Chinook salmon migration (Ford et al. 2000).

Salmon migration is often studied, but relatively little is known about movements through the water column on their migration back to their natal streams (Candy and Quinn 1999). Adult salmon leave the open ocean where they feed to make a final journey back to their natal streams where they complete their life cycle with reproduction (Quinn et al. [No date]) Chinook and Coho Salmon make comparatively slower migrations than other salmon species, spending a longer amount of time in estuarine waters (Godfrey et al. 1975; Major et al. 1978; Fisher and Pearcy 1978). During their migration salmon undergo three major biological transformations in diet, osmotic processes, and hormone production.

These biological transformations occur as a direct result of environmental changes, such as salinity, temperature, and current (Truscott et al. 1986; Quinn 2005)

As a large estuary, the Salish Sea is an incredibly complex system. 19 large rivers feed into the Salish Sea creating a constant outflow of brackish water on the surface layer, whilst the lower layers contain water of lower-salinity coming in through the Strait of Juan de Fuca. The incredibly complex bathymetry carved out by glacial movement creates intense, somewhat unpredictable currents. (Khangaonkar et al. 2011; Pawlowicz et al. 2011; Banas et al. 2010).

Estuarine systems play a key role as transition zones, full of environmental extremes, that are potentially used for orientation by the organisms living, or passing through, the ecosystem (Quinn et al.) Studies suggest that salinity and temperature changes in coastal waters play a crucial role in orienting Chinook salmon back to their natal streams (Quinn 2005). This study aims to answer if SRKW sensitive enough to the annual changes in the Salish Sea environment to use them as orientation cues to find Chinook salmon. It is therefore hypothesized that SRKW are able to track salmon runs in part due to their sensitivities to salinity and temperature. This cannot be directly observed, but can be inferred through the transitive relation theory. This study will aim at establishing a connection between the seasonal fluctuation in salinity and temperature in the Salish Sea estuary due to Fraser River flow, and fluctuations in the number of SRKW sightings in the Salish Sea.

METHODS

Data Collection Sites

I am using a slightly varied version of a past Beam Reach student's methodology in order to create a comparable data set (Sharon 2011). The five primary sites, designated by GPS in the past study, are Salmon Bank, Eagle Point, Middle Bank, Pile Point And Lime Kiln (Figure 1). These five sites lay along the western edge of San Juan Island, an area where the SRKW are most often observed. CTD and YSI data will be taken from these sights on a regular basis. The previously mentioned study designated secondary sites around the Strait of Georgia, an area especially affected by the Fraser Flow. I will attempt to collect CTD and YSI data from these sites whenever possible. The straits in which the study sites are located in play a crucial role in the mixing of the Fraser River plume into the rest of the Salish Sea circulation.

Primary sites: A-E. Secondary sites: F-I

Fig. 1

Real Time Data

CTD and YSI data will be used to create a real time map of how the Fraser River Plume is circulating through the Salish Sea, and through the water column.

CTD and YSI data will be collected in the same location twice daily, when possible, during flooding and ebbing tides. CTD and YSI data will be compared to Fraser River flow, temperature, Chinook, and SRKW sightings. YSI, and GPS location data will be taken after, or during SRKW encounters. The tide and current will be taken into account during SRKW encounters.

ARCHIVED DATA

Real-time and historical data will also be obtained from Orcamaster, The Albion Test Fishery on the Fraser River, a fish passage center on the Columbia River, Nannos (Northwest Association of Networked Ocean Observing Systems), Fisheries and Oceans Canada, and a USGS station on the Columbia River.

Fraser and Columbia historical and real-time flow data will be compared to salinity and temperature data available on the Salish Sea, and the mouth of the Columbia river. Historical Columbia and Fraser River Chinook, temperature, and flow will be compared (Fig. 2). Orcamaster sightings will be compared against salinity, temperature, and Chinook caught at the Albion Test Fishery.

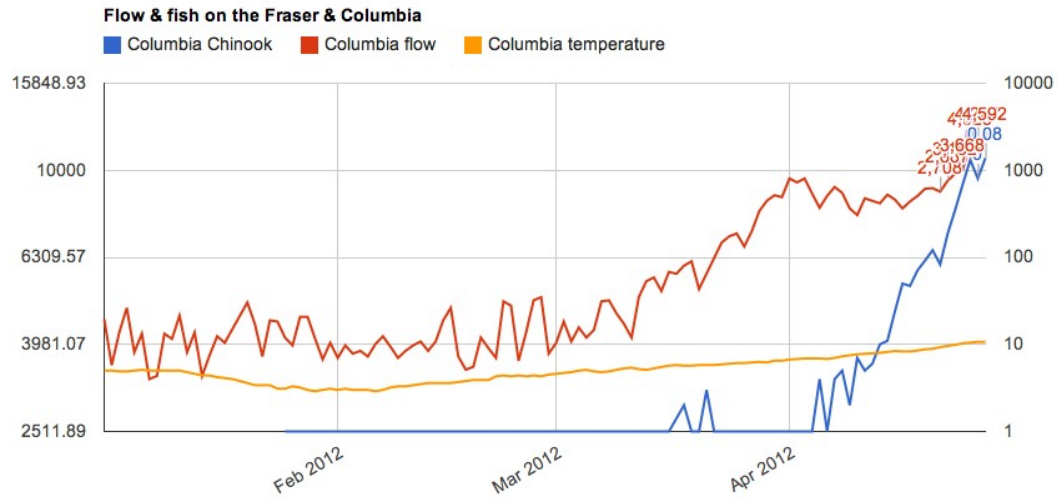

Fig. 2

CITATIONS:

Baird R.W., Hanson M.B., Ashe EE, Heithaus MR, Marshall GJ. 1993: "Studies of Foraging in "Southern Resident" Killer Whales During July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-surface Behavior." National Geographic.

Candy, J.R., Quinn, T.P. 1999: "Behaviour of adult Chinook salmon (Oncorhynchus tshawytscha) in British Columbis coastal waters determine from ultrasonic telemetry." Canadian Journal of Zoology. 77: 1161-1169

Fisher, J.P., and Pearcy,W.C. 1987: "Movements of coho, *Oncorhynchus kisutch*, and chinook, *O. tshawytscha,* salmon tagged at sea off Oregon, Washington, and Vancouver Island during the summers of 1982-85." Fish Bull, 85:819-826

Ford J, Ellis G. "Selective Foraging by Fish-eating Killer Whales Orcinus orca in British Columbia." Marine Ecology Progress Series. 316(2006): 185-199.

Ford JKB, Ellis GM, Balcomb, KC. 2000: "Killer whales: the natural history and genealogy of Orcinus orca in British Columbia and Washington State". UBC Press, Vancouver.

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

Godfrey, H.K, Henry, A., and Machidori, S. 1975. "Distribution and abundance of coho salmon in offshore waters of the North Pacific Ocean." Int. North Pac. Fish. Comm. Bull. No. 31

Hauser DDW, Longdon MG, Holmes EE, VanBlaricom GR, Osborne RW. "Summer Distribution Patterns of Southern Resident Killer Whales Orcinus orca: Core Areas and Spatial Segregation of Social Groups." Marine Ecology Progress Series. 351(2007): 301-310.

Major, R.L., Ito, J.,Ito, S., and Godfrey, H. 1978: "Distribution and origin of Chinook salmon (*Oncorhynchus tshawytscha*) in offshore waters of the North Pacific Ocean." Int. North Pac. Fish. Comm. Bull. No. 38

Khangaonkar T, Yang A, Kim T, and Roberts M. 2011: "Tidally Averaged

Circulation in Puget Sound Sub-basins: Comparison of Historical Data, Analytical Model, and Numerical Model." 93: 305-319.

NOAA's National Marine Fisheries Service (2011). http://www.nwr.noaa.gov

Quinn T.P., Olson A. "Vertical and horizontal movements of adult chinook salmon *Oncorhynchus tshawytscha* in the Columbia River estuary".

Quinn T.P., The Behavior and Ecology of Pacific Salmon and Trout. University of Washington; 2005. 53-61p.

Samuel MD, Pierce DJ, Garton EO (1985) "Identifying areas of concentrated use within the home range." J Anim Ecol 54: 711-719

Sharon B., "Movement and Surface Active Behavior of Killer Whale (*Orcinus orca)* in Response to Tidal Height, Current Velocity, and Salinity."2011

Truscott, B., Idler D.R., So Y.P, and Walsh J.M., 1986: Maturation steroids and gonadotropin in upstream migratory sockeye salmon." Gen. Comp. Endocrino. 62: 99-110