Nutrients in the Elwha River Estuary

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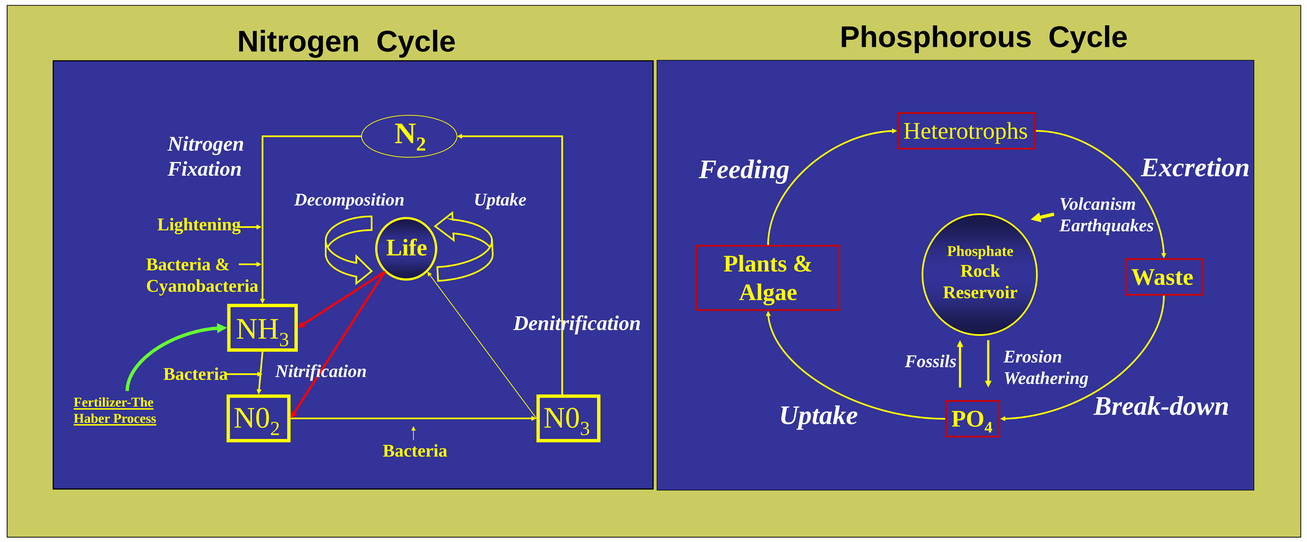
Goal: *Describe spatial patterns of water chemistry and nutrient dynamics in the Elwha River Estuary*

- Previous work in the Elwha River watershed classified the system as oligotrophic
- We see similar nutrient levels in the estuary, but samples from the inter-tidal showed that the Strait of Juan de Fuca has higher nutrient levels than the estuary and river, likely due to upwelling in the Strait
- The spring fed Boscoe Creek, which flows through mature forest, had higher nutrient levels than the river and estuary complex
- Nutrient diffusing substrates were deployed to determine the patterns of biological productivity along the nutrient gradient in the estuary

Water Chemistry Sampling Location (Monthly)

Nutrient Diffusing Substrate Deployment (Sep. 10th – Oct 9th)



I. Water Nutrients

Sampling

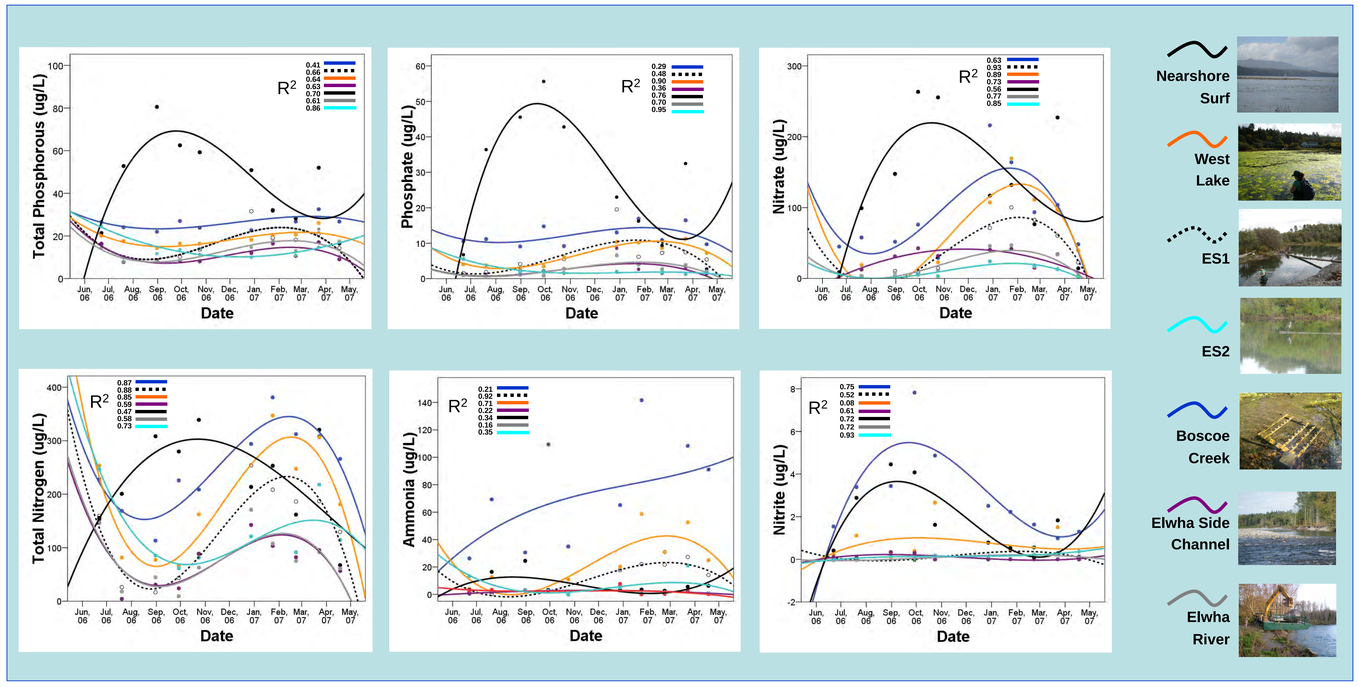
- Collected filtered (dissolved nutrients) and unfiltered (total nutrients) water samples on a (roughly) monthly basis from 7 locations (see green symbols in map, above).
- Samples from Nov. 06 not taken due to storms.
- Samples frozen until analysis at UW Marine Chemistry Laboratory.
- Samples from Jun – Sep being process in lab and will offer a more complete picture of seasonal dynamics.

Analysis

- Curves fit using a least squares cubic regression model
- 10 time periods analyzed (4 more yet to come)

Results

- Consistent seasonal fluctuations in nutrients - nearshore and estuary out of phase.
- The comparatively nutrient rich Boscoe Creek could be an important contributor to the nutrient status of the estaury.
- Despite large green algae blooms, west lake not Eutrophic.



II. Nutrient Diffusing Substrates

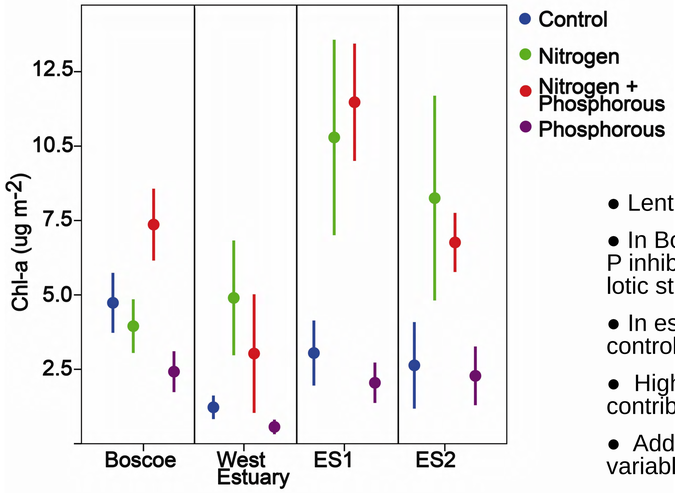
Method

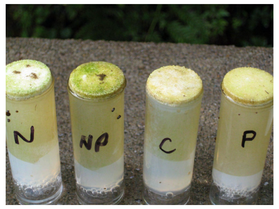
- Plastic vial filled with agar, poured into plastic vial, and sealed with heated, porous silica disk (27 mm dia.). Agar diffuses through disk and cools.
- Agar spiked with known amount of nitrogen (0.5 mol/L NH_4NO_3), phosphorous (0.2 mol/L KH_2PO_4), nitrogen + phosphorous, or control (no nutrients).
- Deploy *in vivo* for 4 weeks. Vials randomly placed in racks, with depth of rack held constant (but different between lotic (1) and lentic (3) environments).
- Store & process in dark. Chl-a extracted with 90% HPLC-grade acetone (for 22 hrs). Chl-a concentration measured using a TD-700 laboratory fluorometer.

Deployment

- 4 weeks in late summer

Results





- Lentic (estuary) vs. lotic (creek) patterns apparent.
- In Boscoe Creek, clear N/P co-limitation and possible P inhibition. This pattern similar to results from similar lotic study upriver.
- In estuary, both N and N+P have higher growth than control, indicative of nitrogen limitation.
- Higher levels of ammonia in Boscoe Creek may contribute to patterns seen in algal growth response
- Additional analyses, incorporating environmental variables and nutrient levels, are forthcoming

Habitat Utilization and Dispersal Patterns of Juvenile Chinook Salmon Inferred from Otolith Analysis

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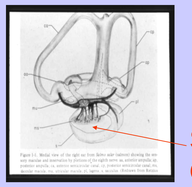
What are otoliths?

Small calcium carbonate structures found beneath the brain of fishes and used to orient or maintain balance.

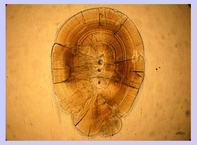


Sagittal Otolith

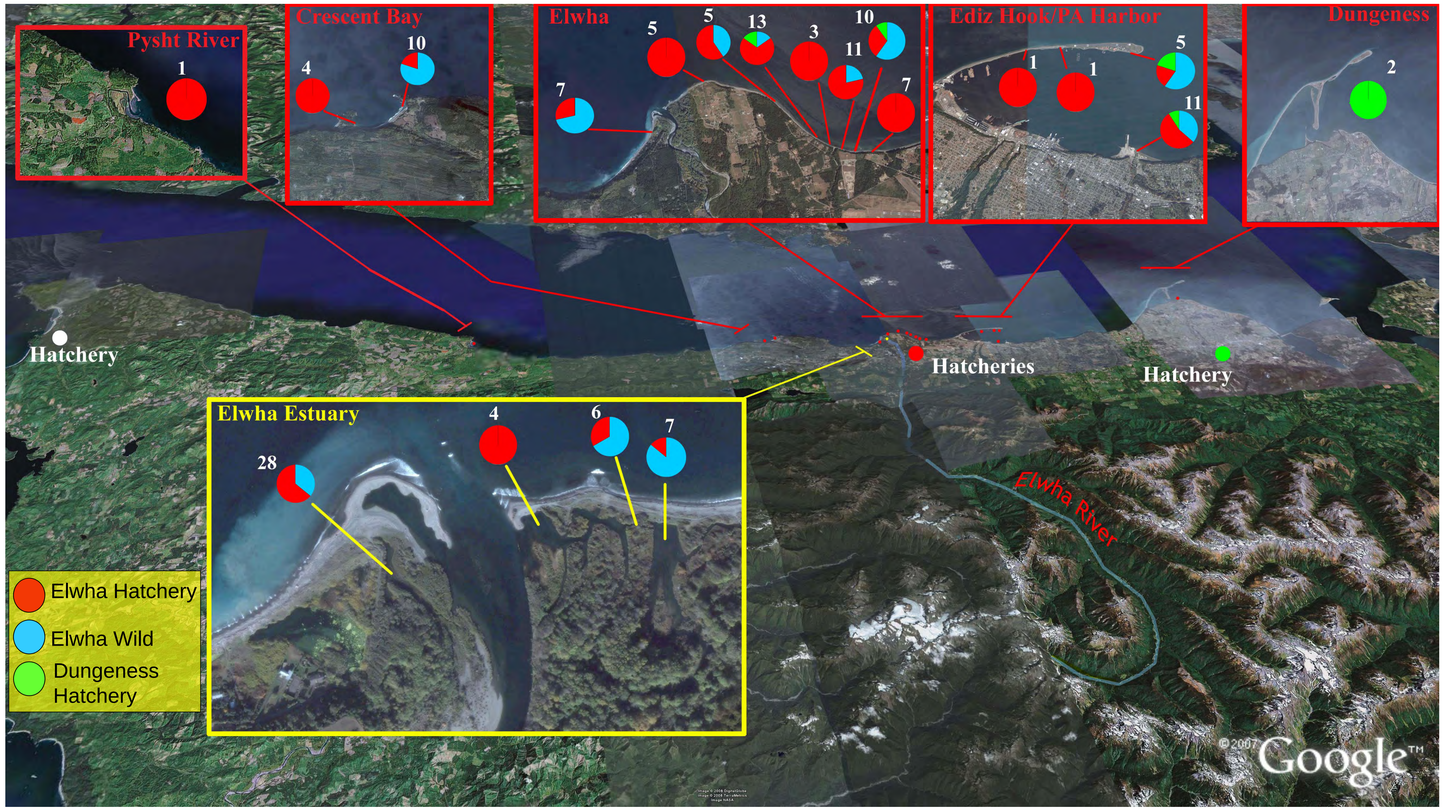
Because otoliths grow as a fish grows daily "growth increments" provide evidence of growth rate and residence time.

How are they analyzed?

Sagittal otoliths are extracted, embedded in resin, and ground to expose a cross-section.

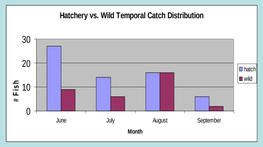


Magnified images are processed with image analysis software to mark, count, and measure daily growth increments.



I. Dispersal patterns into the Strait of Juan de Fuca†

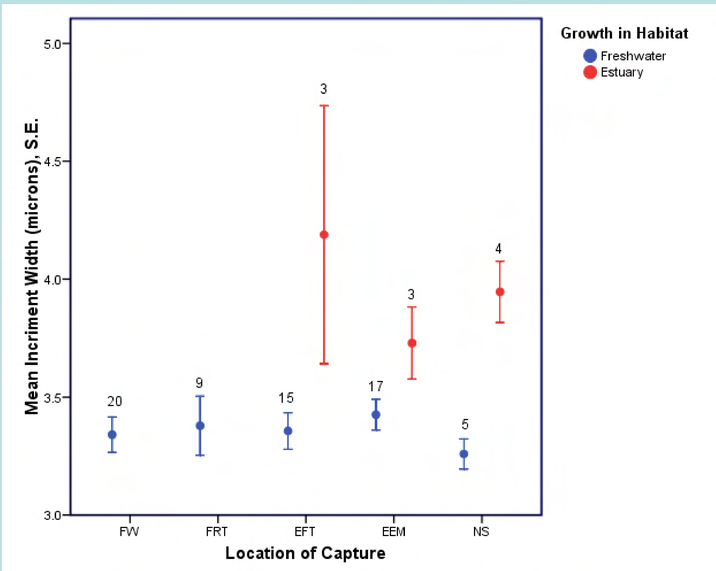
- In 2007, we obtained samples of **juvenile Chinook** salmon collected throughout the Strait of Juan de Fuca and the Elwha River estuary.
- We used otoliths to discriminate between Elwha and Dungeness origin.
- Most fish through all sampling months were hatchery origin.
- Once in the Strait, Elwha wild juveniles migrated **east** and **west**.
- Dungeness hatchery juveniles migrated **west** and were caught near the Elwha mixed with Elwha wild and hatchery fish, but we had limited samples from east of the Dungeness.
- Growth increments from wild fish (BY06) have yet to be analyzed for habitat use.
- We will be obtaining CWT information, when available, as a validation



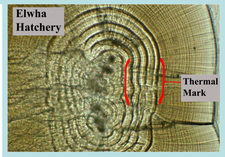
Location	# Hatchery	# Wild
Pysht	1	0
Crescent Bay	6	10
Elwha	40	15
Ediz Hook/PA Harb.	12	6
Dungeness	2	0
Elwha Estuary	25	20

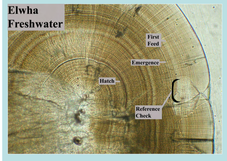
†Preliminary analysis subject to revision

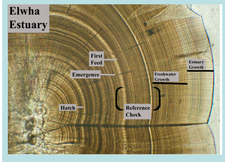
II. Juvenile growth differences among habitat types

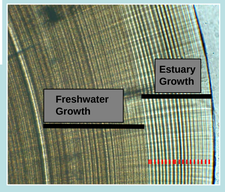


Average daily growth estimates, based upon mean increment width measured from otolith microstructure of wild juvenile Chinook salmon captured from March-October, 2006 in the Elwha River. We captured 20 fish in FW, 9 in FRT, 15 in EFT, 17 in EEM, and 5 in the NS.

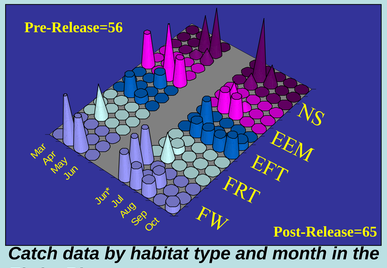








- We studied the otolith microstructure of juvenile Chinook salmon to better understand the relative importance, for fish growth, of the lower Elwha River, the estuary complex at the mouth of the river, and the sub-tidal and near tidal areas (i.e., nearshore).
- We obtained samples of juvenile Chinook salmon throughout the migration period in 2006 (BY05). About half of the samples were collected prior to the date when the hatchery, operated by the Washington Department of Fish and Wildlife (WDFW), released 3.1 million yearling and sub-yearling Chinook salmon that were thermally marked.
- We identified 3 early life history checks (hatch, emergence, first feed), 2 habitat patterns (freshwater and estuary), and hatchery patterns from otolith microstructure.
- The mean increment width (a proxy of fish growth) was 3.35 microns in freshwater and 3.96 (↑18%), a difference much smaller than other systems like the Skagit River.
- BY05 sample size in the estuary was small. Additional processing of BY06 samples is underway



Catch data by habitat type and month in the Elwha River estuary

III. Age of Returning Adults

Collections of spawned-out adult Chinook from the Elwha River during fall of 2006

Fish #	Location	Date	Sex	F.L. (cm)	Age
Elwha06-1	Index-Zoey's	9/27/06	M	78	4
Elwha06-2	Index-T.O.J	9/27/06	M	86	4
Elwha06-3	Index-Mid	9/28/06	F	75	4
Elwha06-4	Zoey's P.	10/5/06	M	65	4
Elwha06-5	Top of Big Jam	10/5/06	F	85	4
Elwha06-6	Big Riffle-T.O.I.	10/5/06	M	77	4
Elwha06-7	Morril Springs	10/9/06	F	76	4
Elwha06-8	T.O.J	10/9/06	M	59	3
Elwha06-9	L. Spruce	10/10/06	F	75	4
Elwha06-10	L. Sissons	10/10/06	M	89	4
Elwha06-11	State Outfall	10/10/06	M	83	4
Elwha06-12	1 Way	10/11/06	F	76	4
Elwha06-13	State Outfall	10/11/06	M	89	4
Elwha06-14	Canyon	10/11/06	F	82	4

- 92% of the spawned out adults sampled were 4 years old.
- All fish were wild origin.
- Samples have not been processed yet for microstructure patterns, but superficial analysis suggest that growth differences were apparent between freshwater and estuary growth .
- Lack of clear otolith "checks" makes determination of habitat transition in adults difficult.
- Larger sample sizes are needed.