Plume soup: How a dash of river water affects Washington’s coastal ecosystem

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Paradox: Along the WA-OR coast, where biological productivity has long been associated with upwelling strength, the productivity is highest to the north, where upwelling is weaker.
Juvenile salmonid study off WA and OR

Cape Flattery to Newport; June and September 98-present (n = 6 yr).
8 transects sampled in June & September

2 transects sampled every 10 days April-July

CTD, nutrients, chl, zooplankton, and juv. fishes with pelagic trawl.
Plume soup

Average discharge = 7000 m³/s

Approximate volume of shelf waters = 4 x 10^{12} m³

Daily contribution from river = 0.02% = a dash
Density of river water is less than that of ocean water due to salt.
Earth's rotation causes flow in the northern hemisphere to be deflected to the right.
Laboratory modeling of river plumes
Laboratory plume

Velocity profile shows re-circulation
Depth
Approximately 50% of river discharge accumulates in an eddy near the mouth, referred to as “the bulge”
River Influences on Shelf Ecosystems

Two vessels: R/V Pt. Sur (physical), R/V Wecoma (biological, geochemical)
**Sampling configuration**

**Triaxus tow-fish:**
- CTD sampling between -60m and -1m depth
- ~1 minute repeat time
- 7 knots boat speed
- an uneasy relationship with crab pots

**1200 kHz ADCP**
- Vessel mounted
NS transect

Salinity

East Velocity
25cm plume predicts 35km plume!

Laboratory plume  Columbia River plume
NS transect

SAR Image
Thanks to Jiayi Pan (PSU)

MODIS Image
Thanks to Raphael Kudela (UCSC)
Volume of freshwater

\[
V_{fw} = \int_0^\pi \int_0^H \int_0^R \frac{\Delta S}{S_o} dr dz d\theta.
\]

Bulge volume = 4-8 days worth of discharge
**Consequences**

Timescale for plankton growth ~ 4-5 days
Bulge retention time ~ 4-8 days

Draw-down of nitrate, silicate and iron
Plume productivity

CoOP RISE, June 2005

Primary Production (mg C/m^3/d)
Chlorophyll (mg/m^3)

Non-Bulge PP  Bulge PP  Non-Bulge CHL  Bulge CHL
The average abundance of zooplankton-sized particles in the vicinity of the bulge was higher than other regions of similar surface salinity.
The Columbia Plume

• mixes upwelling-derived nutrients with nutrients from the river

• provides long residence times (under certain conditions) in near-surface waters, which make for optimal growth conditions

• has significantly enhanced rates of primary productivity compared with local waters

• supports enhanced productivity up the food chain
Thanks