Interannual Variability in Water Properties and Velocity in the U.S. Pacific Northwest Coastal Zone OS36D-23

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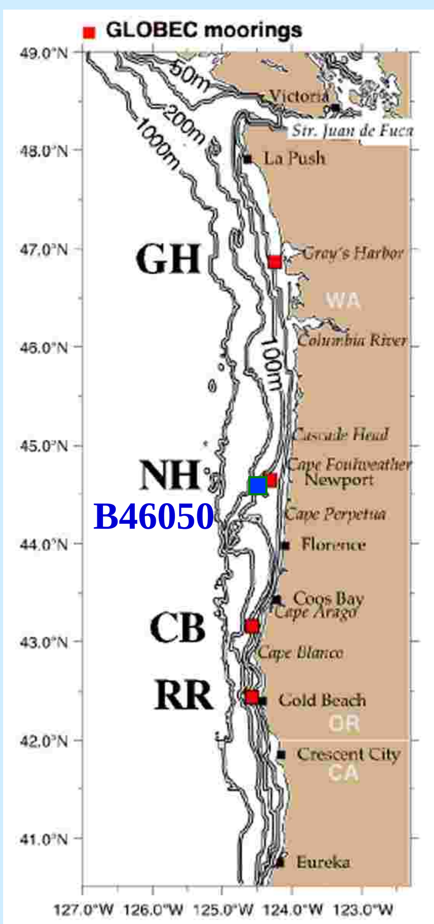
Overview

As a component of the GLOBEC Northeast Pacific program moored sensor arrays were maintained for up to 4 years on the continental shelves of the California Current System (CCS) over an alongshore distance of about 500 km. Moorings were equipped to sample water properties and velocities throughout most of the water column at each site. This is the first data set acquired in the CCS over such large distances for more than a year. Note that:

- The moorings spanned the area of influence of the plume from the Columbia River as well as Cape Blanco, a coastal promontory where the southward coastal jet frequently separates from the shelf.
- Moorings had different bottom depths, spanning the range from 40 m to 100 m.
- Upwelling-favorable wind stress varied by more than a factor of three over the latitudinal range, decreasing to the north.
- In spite of these latitudinal differences, seasonal cycles as well as year to year differences in water properties were remarkably similar at all sites, although south to north lags generally occur (see summary below).
- The overall conclusion is that large scale processes overwhelm local spatial scale differences on these time scales. The results reaffirm the importance of remote forcing in the CCS on seasonal to interannual scales.

Mooring Sites



NCEP winds are interpolated to mooring sites

Summary

- Year-to-year differences in seasonal water properties are very large scale (>500 km along the shelf) and affect the whole shelf water column; differences in the magnitude of the seasonal coastal jet have significantly shorter alongshelf structure.
- Water property differences from year to year are much more variable in winter (low S, high T) than in summer (high S, low T).
- A south to north lag of 1-3 months usually occurs in summer properties (T, S, V), with greater alongshelf lags in maximum coastal jet velocity.
- Maximum alongshelf velocity (V) precedes S, T and maximum local alongshelf wind stress at each location, with a greater lead in summer than in winter.
- Year-to-year differences in the speed of the summertime coastal jet are not related to the strength of the local upwelling-favorable wind stress.
- Year-to-year water property differences are not strongly related to alongshelf velocity at the same depth.
- Freshwater influences are apparent in near surface water properties at locations north and south of the Columbia River in both summer and winter.
- Year-to-year winter-time whole water column salinity differences are not related to regional freshwater input.
- Year-to-year water property differences are strongly related to alongshelf wind stress in winter but not in summer.
- Winter water properties may be related to the degree of onshore advection of warm, fresh, offshore water combined with downwelling of deeper isopycnals.

ALONGCOAST SEASONAL DIFFERENCES

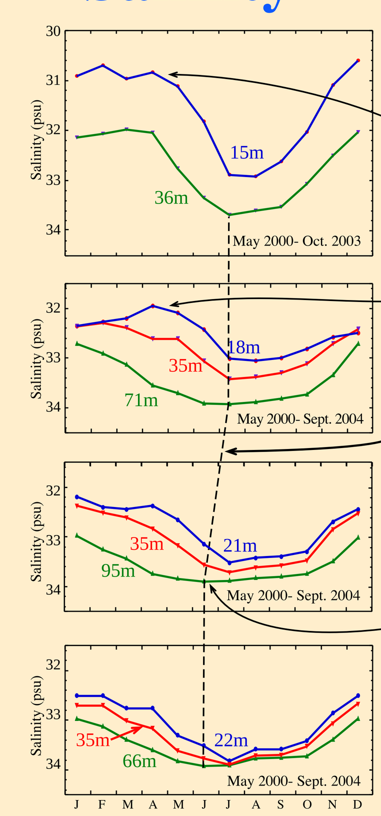
Salinity

46.9°N GH 41m

44.6°N NH 81m

43.2°N CB 100m

42.4°N RR 76m



Seasonal cycle is similar at all sites

Freshwater influence of Columbia River is seen to north

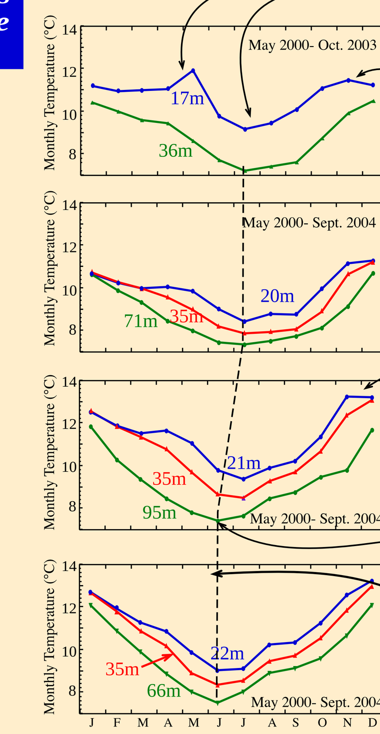
South to north lag in timing of maximum salinity

Maximum near-bottom salinity is similar at all sites

Seasonal cycle is the signature of the seasonal evolution of upwelling/downwelling in response to changes in the large-scale wind forcing.

Temperature

Seasonal cycle is similar at all sites below the surface layer



Columbia River warms surface layers to north in spring and summer

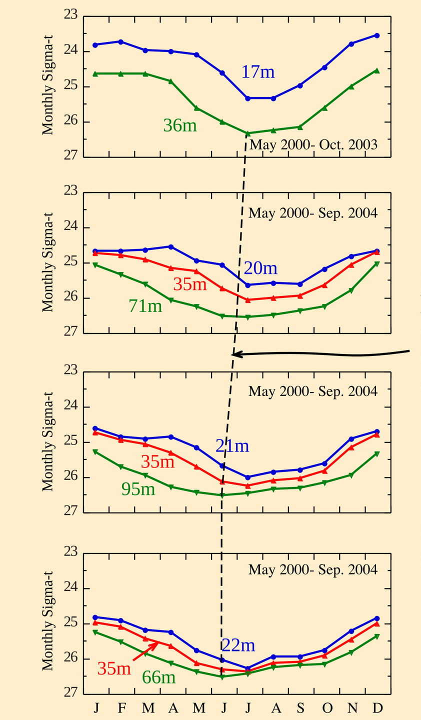
Temperature is colder toward north—the effect of the Columbia and other rivers. (Rivers are colder in winter than the ocean)

Minimum near-bottom temperature is similar at all sites

South to north lag in timing of minimum temperature in summer

Density

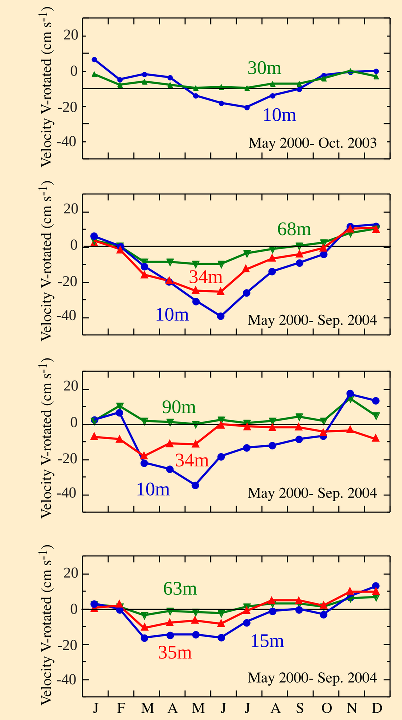
Seasonal cycle is similar at all sites



South to north lag in timing of maximum density in summer

Stratification increases south to north

Alongshore Velocity



GH weak (shoreward of coastal jet)

Maximum southward flow is lagged south to north

Lag in v is greater than lags in temperature and salinity

Most persistent shelf undercurrent at CB (deepest mooring and data depth)

Weaker southward flow at RR (south of coastal jet separation zone)

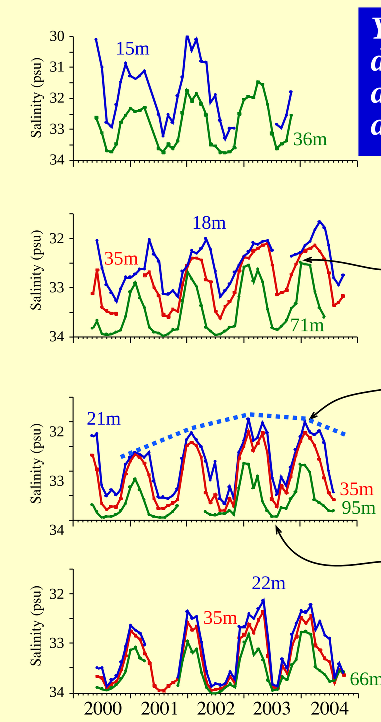
ALONGCOAST YEAR-TO-YEAR DIFFERENCES

46.9°N GH 41m

44.6°N NH 81m

43.2°N CB 100m

42.4°N RR 76m



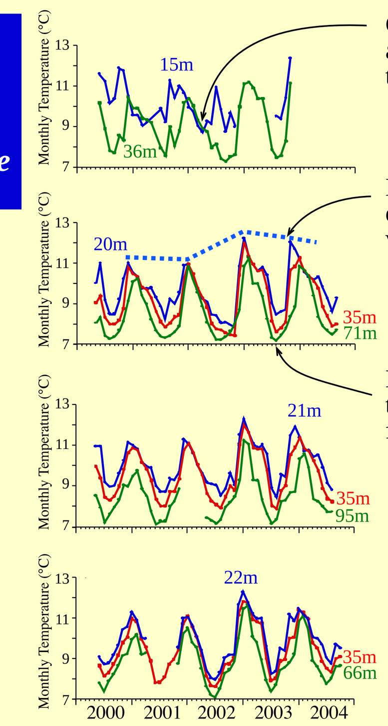
Year-to-year differences are similar at all sites

Winter freshening leads at depth

Year-to-year differences are largest in winter freshening

Maximum salinity in summer is similar from year to year

Year-to-year differences are similar at all sites below surface layer

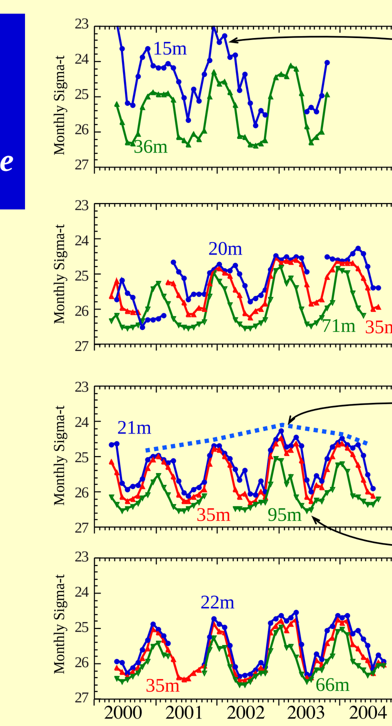


Columbia plume affects surface layer temperatures

Largest year-to-year differences are in winter warming

Minimum summer temperature is similar from year to year

Year-to-year differences are similar at all sites below surface layer

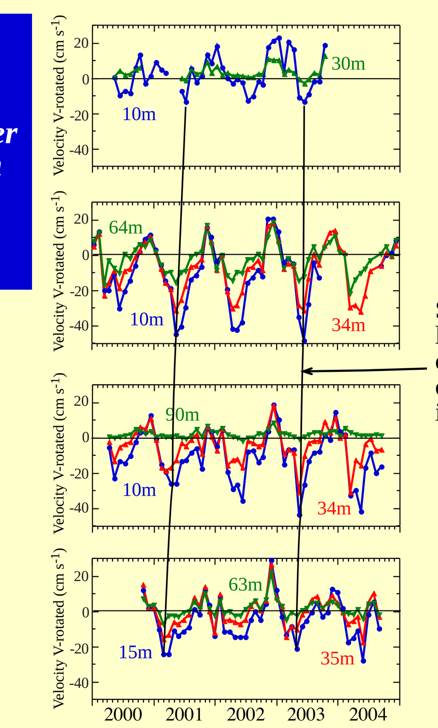


Columbia plume affects density especially in winter

Greatest changes in density occur in winter

Summer density is similar year-to-year

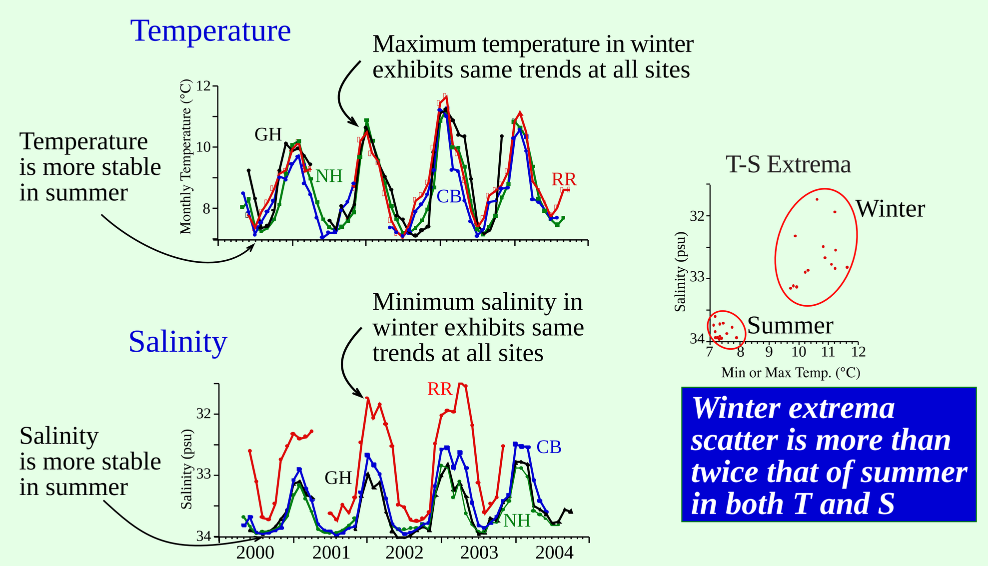
Year-to-year differences in the speed of the upwelling jet differ significantly from site to site (unlike summer water properties)



South to north lag in timing of maximum coastal jet in summer

WATER PROPERTY RELATIONSHIPS

All Sites Near-Bottom T and S



Temperature is more stable in summer

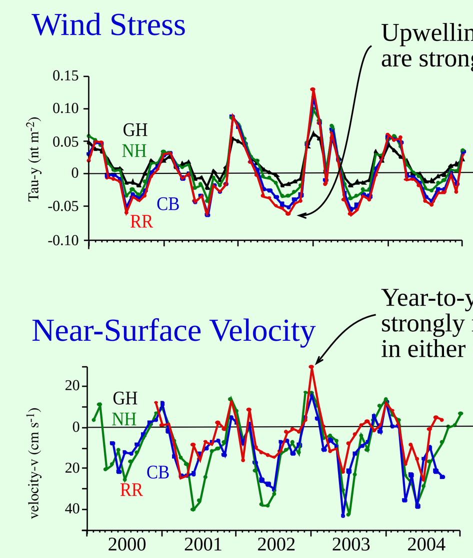
Maximum temperature in winter exhibits same trends at all sites

Salinity is more stable in summer

Minimum salinity in winter exhibits same trends at all sites

Winter extrema scatter is more than twice that of summer in both T and S

All Sites τ_y and v



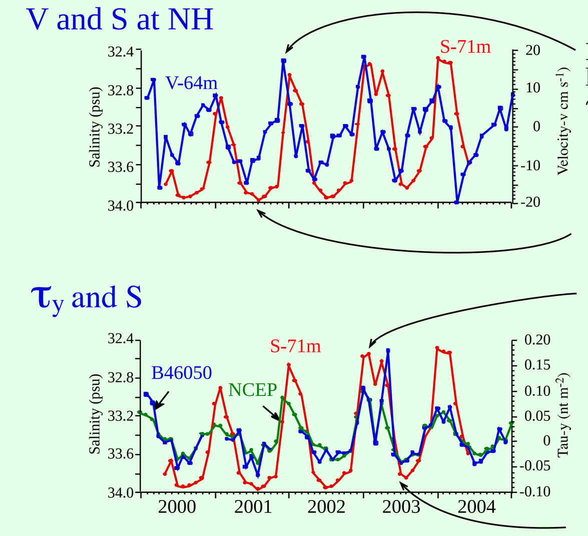
Upwelling-favorable winds are stronger to the south

Year-to-year differences are not strongly related to local wind stress in either summer or winter

Lags: τ_y, v and S

Lags similar at all sites;NH is shown

Winter: v(N), then τ_y (N) and S_{min}, T_{max}
Summer: v(S), then τ_y (S), then S_{max}, T_{min}



Maximum northward velocity leads minimum salinity by ~1 month for winter

Maximum southward velocity leads maximum salinity by ~2 months in summer

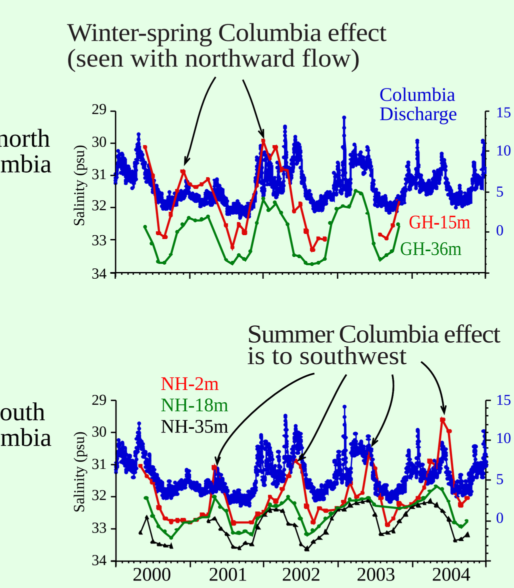
Maximum northward wind stress and minimum salinity are ~in phase

Maximum upwelling-favorable wind stress leads maximum salinity by ~ 1 month in summer

Columbia River Effects

GH is north of Columbia

NH is south of Columbia

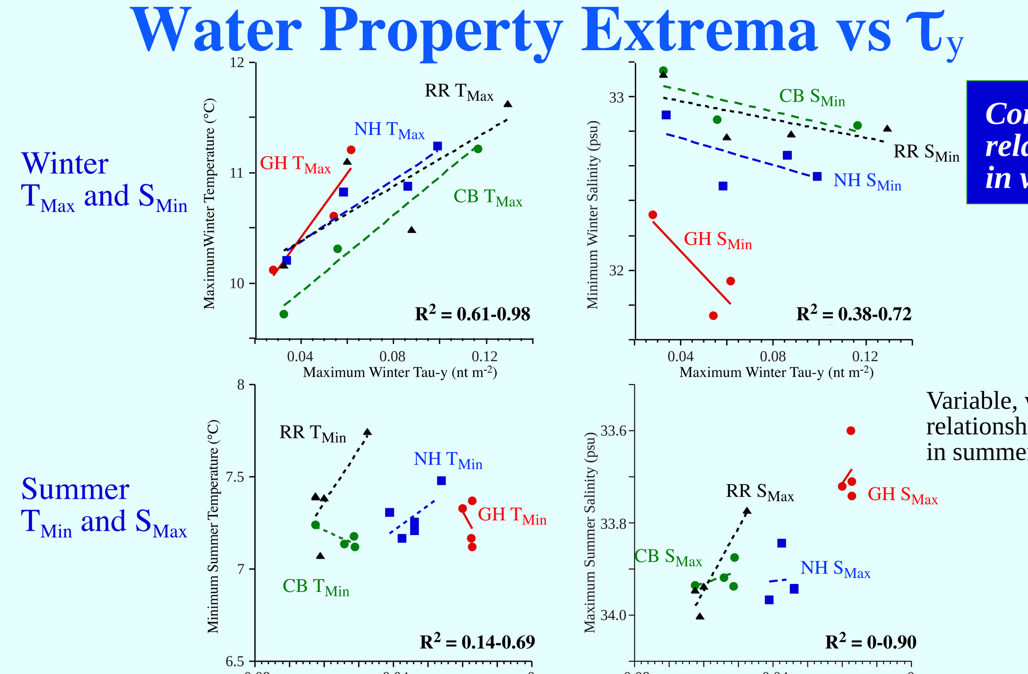


FORCING MECHANISMS

Water Property Extrema vs τ_y

Winter T_{Max} and S_{Min}

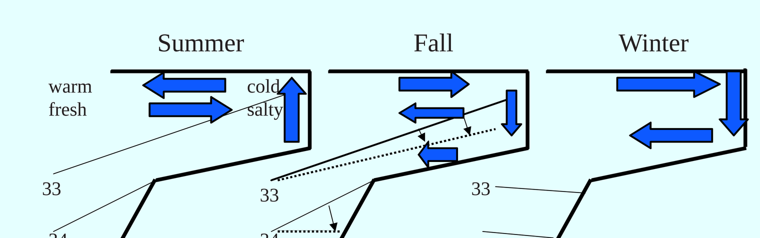
Summer T_{Min} and S_{Max}



Consistent relationships in winter

Variable, weak relationships in summer

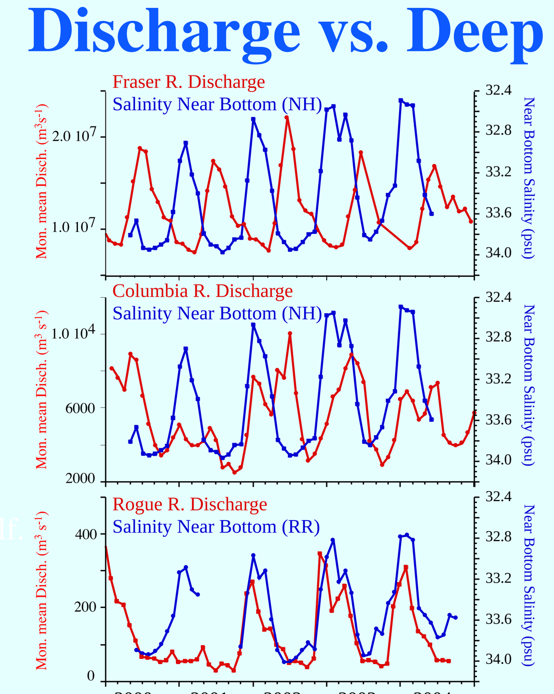
One Interpretation of Winter Freshening and Warming



In winters with greater τ_y, more off-shelf, fresher, warmer water moves onto shelf.

Note: Water from most rivers is colder in winter than ocean water (hence cannot account for warming that accompanies freshening)

Discharge vs. Deep S



Fraser River

Columbia River

Rogue River

No strong evidence for year-to-year connection betweeen winter or summer freshwater input and winter salinity freshening

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