Ecosystem Structure and Function on the Gulf of Alaska Shelf*

(an evolving story)

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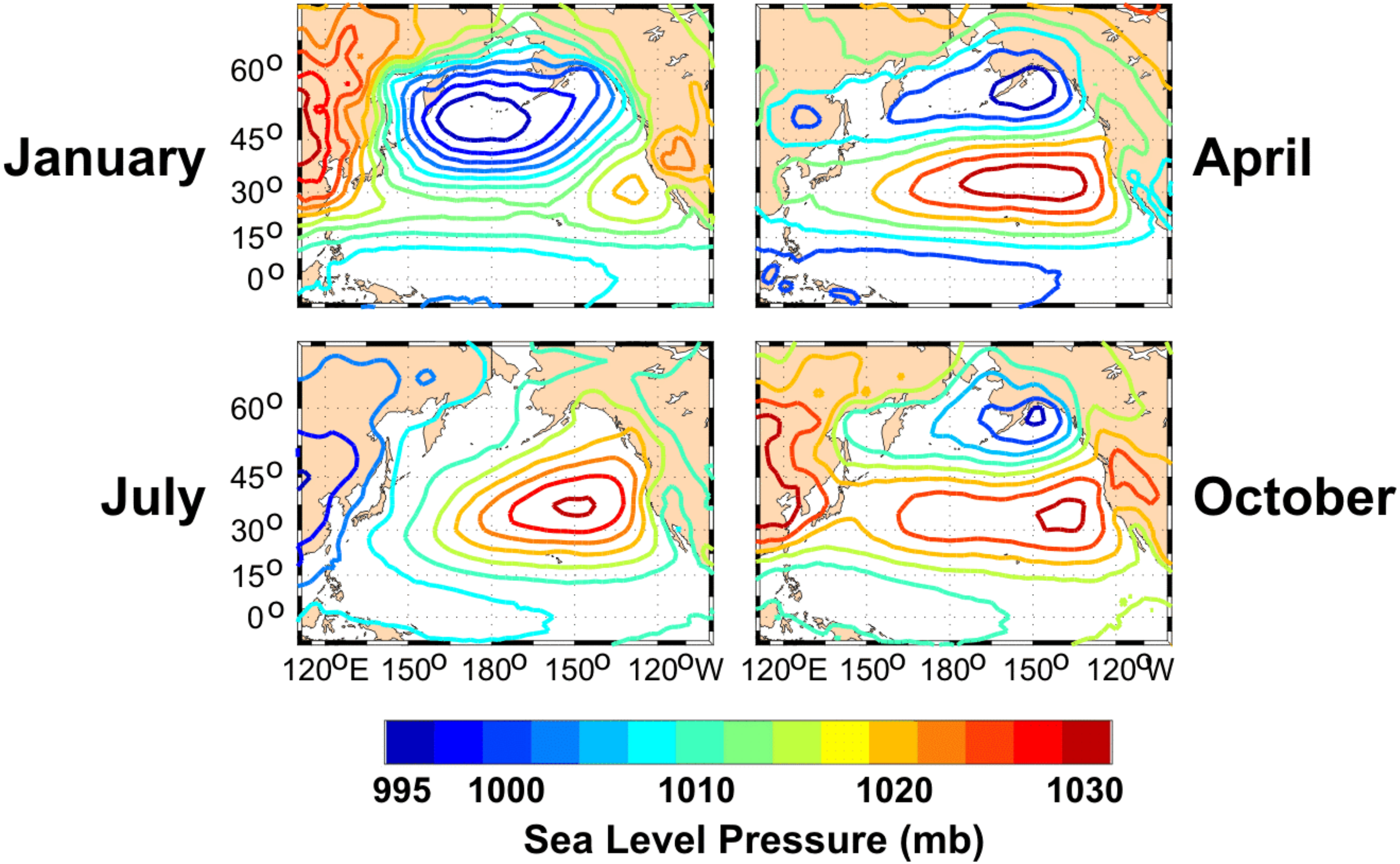
OUTLINE

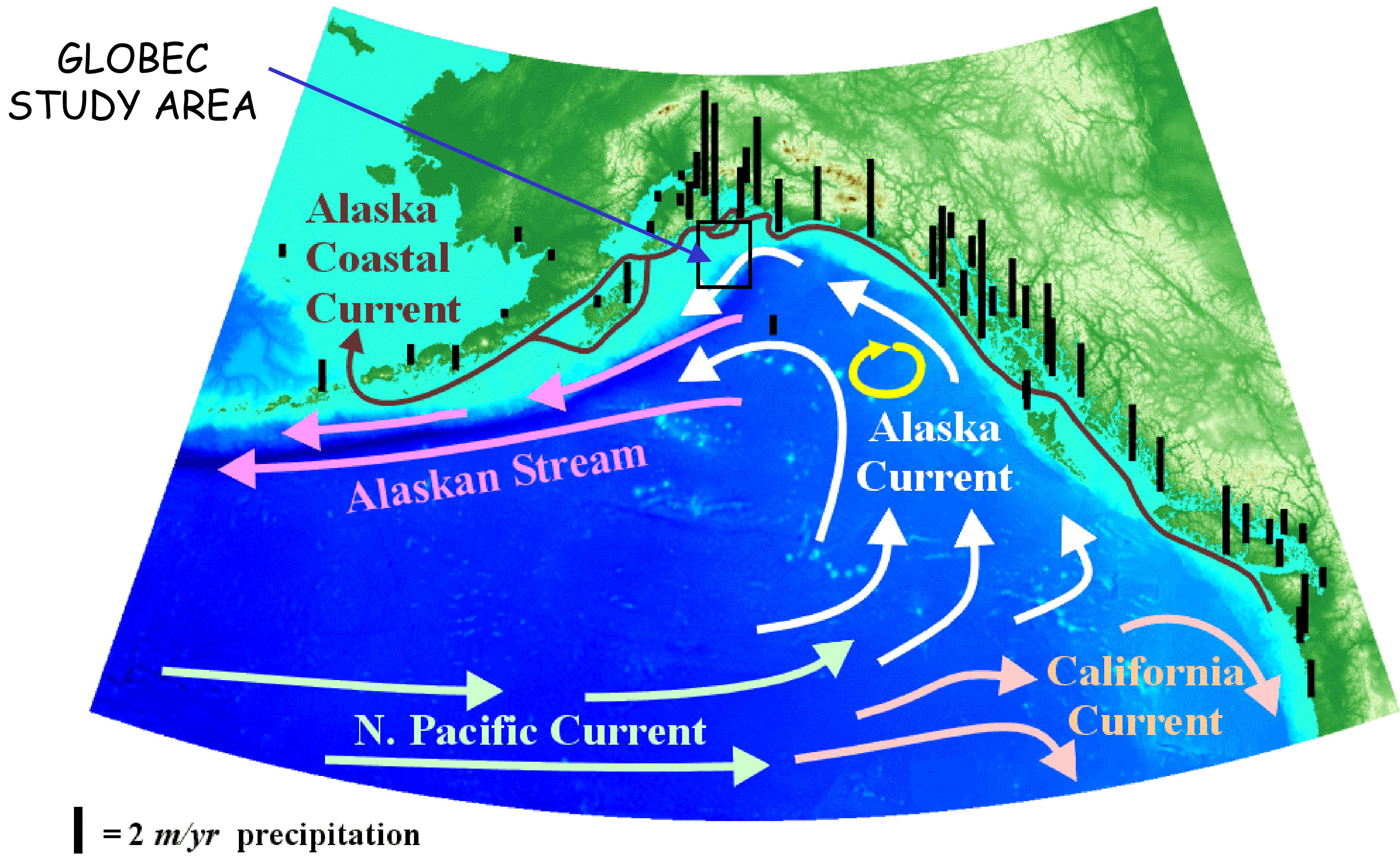
1. The physical setting

2. Factors controlling production (emphasis on cross-shelf)
    - Temporal/spatial Stratification patterns
    - Macro- & Micronutrient Limitation
    - Light Limitation
    - Microzooplankton Grazing
    - Copepod Distributions
    - Juvenile Salmon

3. Things to think about

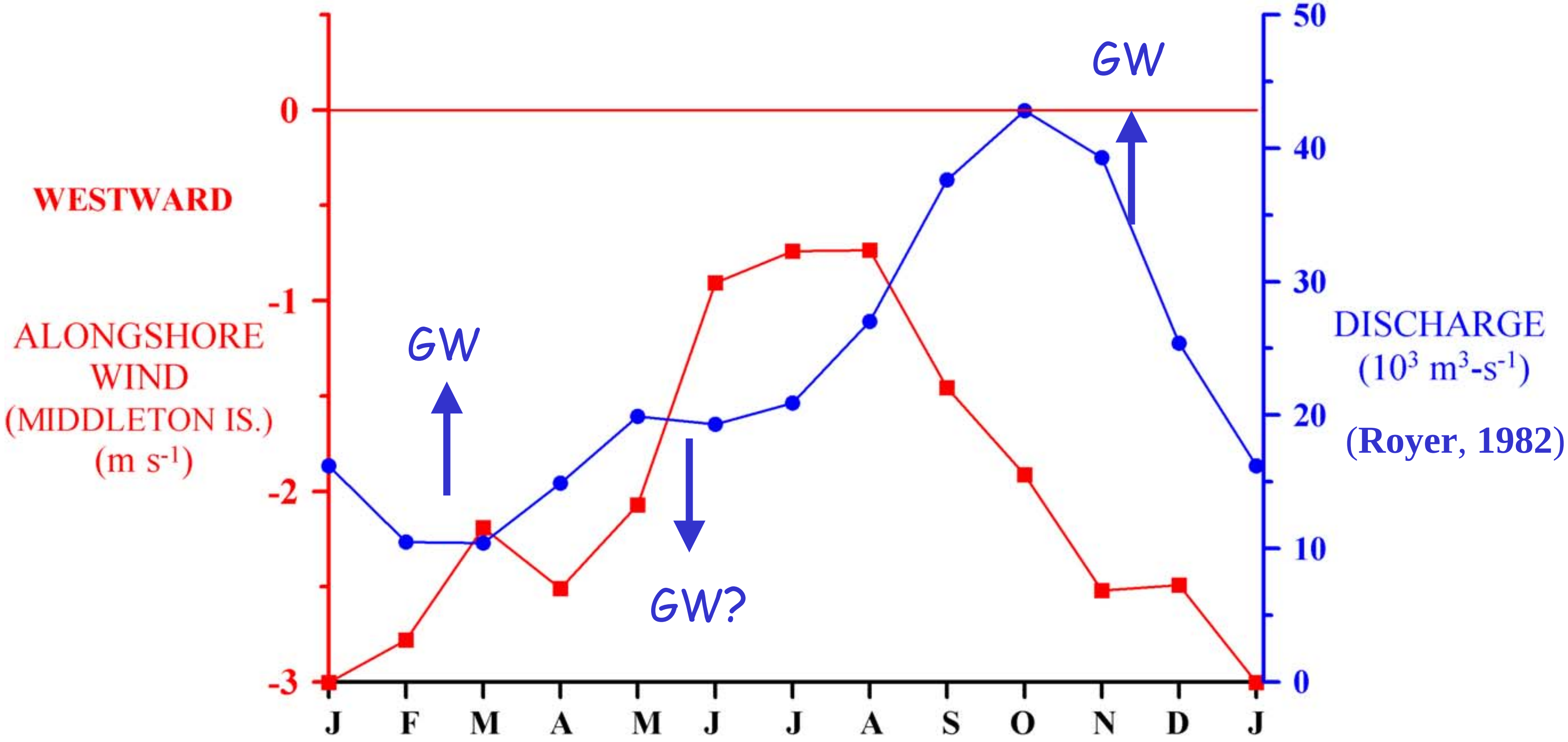


Storms enter the Gulf year-round: frequency and intensity varies seasonally. How does the large-scale variability affect production at regional and smaller scales?



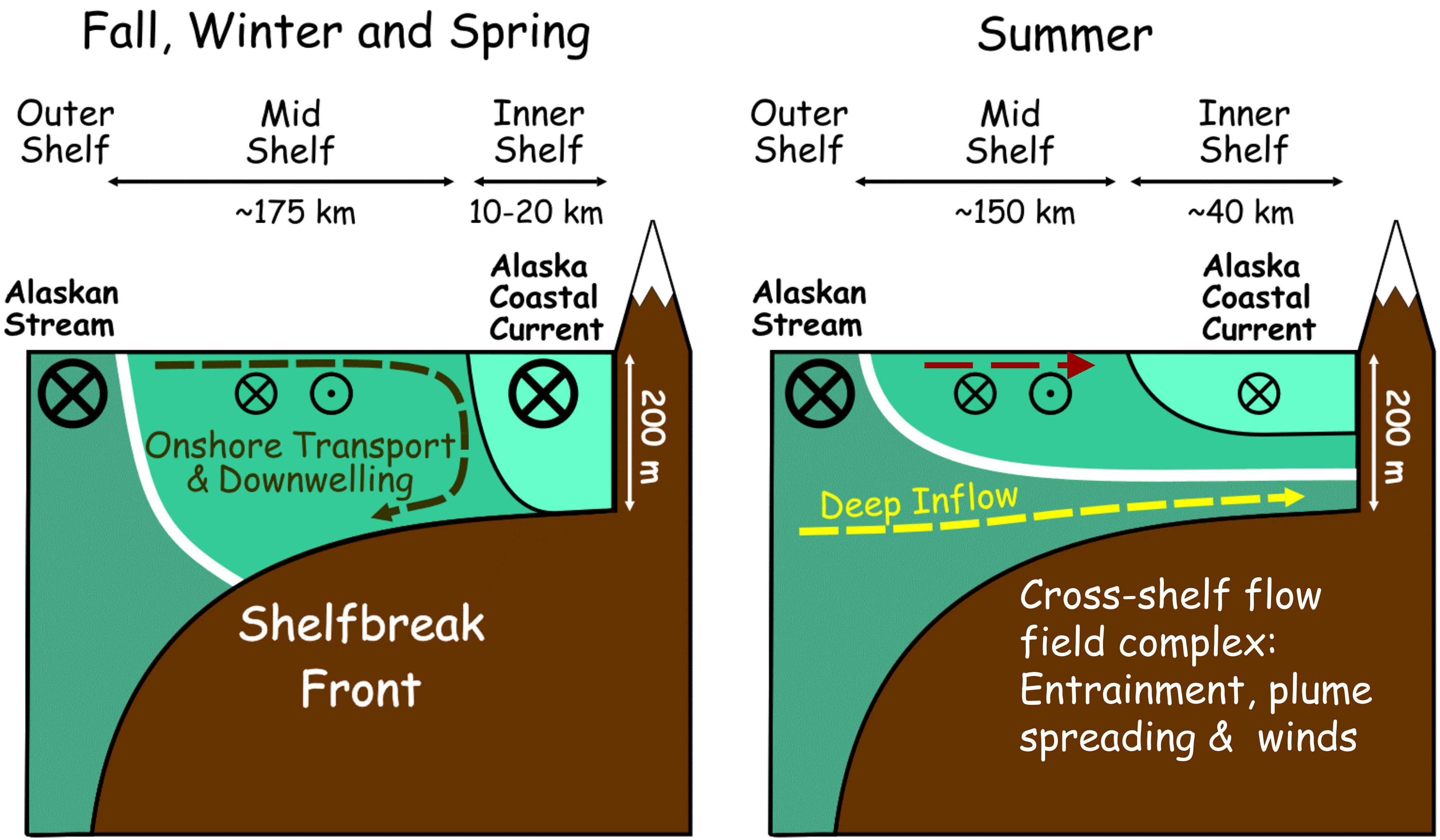
Wind stress curl: Slope Flows (Alaska Current and Alaskan Stream). Coastal Runoff and Alongshore Wind Stress: Alaska Coastal Current and shelf.

Annual Cycle of Alongshore Winds and Freshwater Runoff



- year-round downwelling and
- a large coastal freshwater discharge with low NO_3, high Fe
    - ~24,000 m^3-s^{-1} (annual average),
    - Salinity gradients control shelf dynamics.

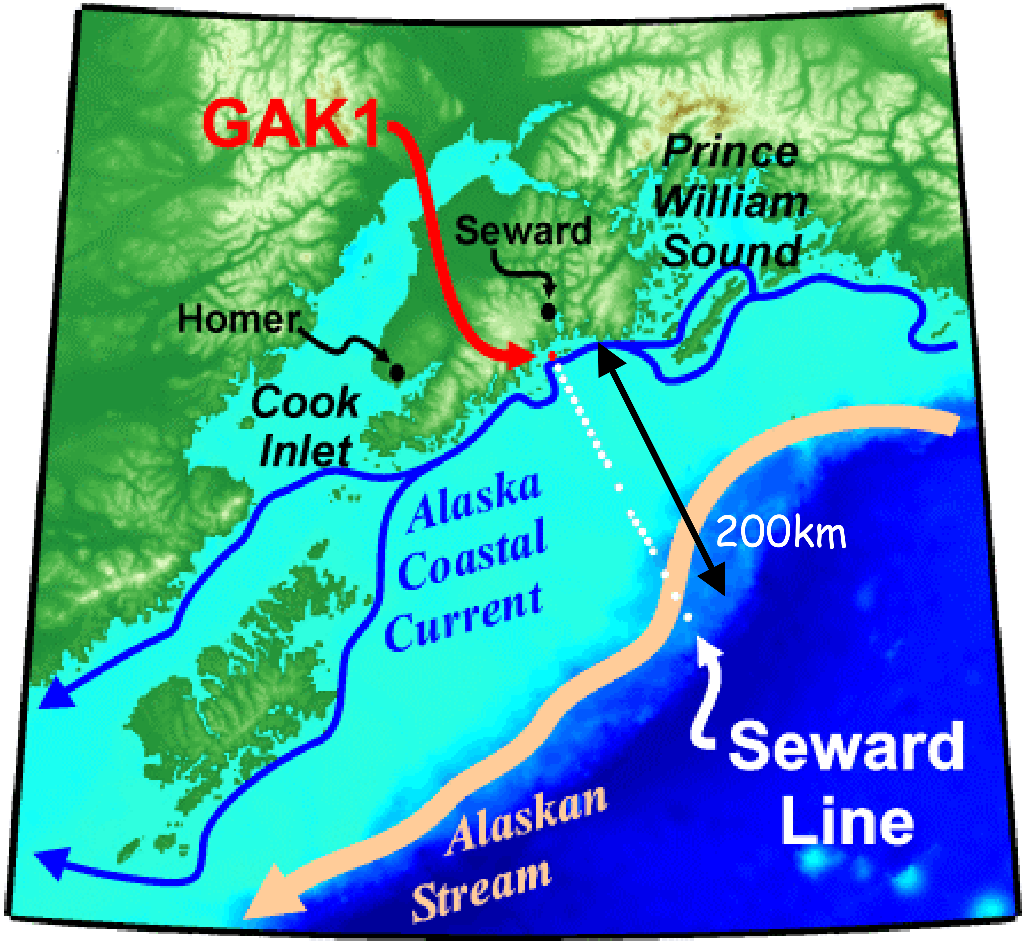
Seasonality of GOA Continental Shelf Flow Fields



Strong alongshore winds & transport

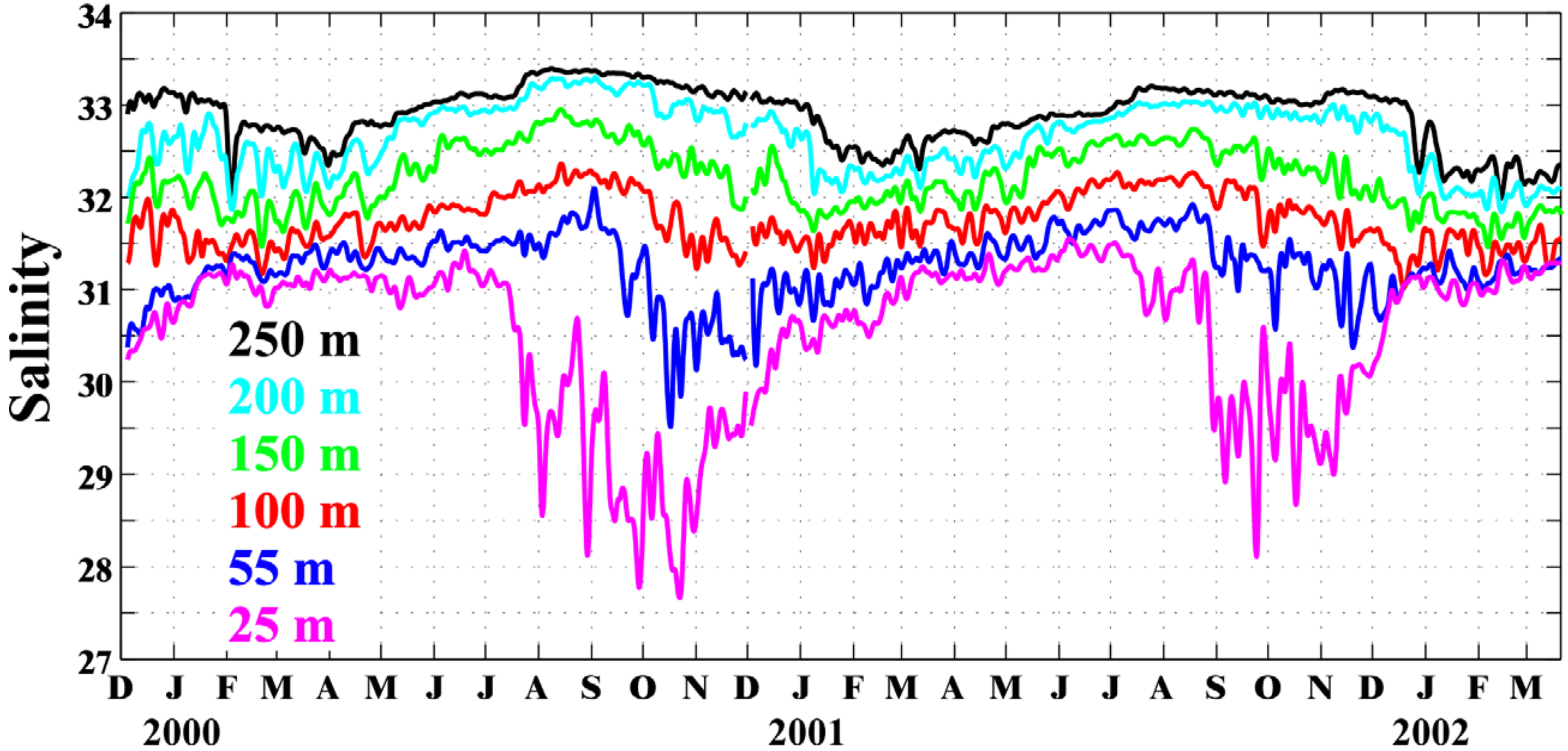
Weak alongshore winds & transport

GLOBEC COASTAL GULF OF ALASKA STUDY AREA



Inner shelf includes Prince William Sound (PWS) and the Alaska Coastal Current (ACC)

Annual Salinity Cycle Reflects Wind and Runoff Forcing



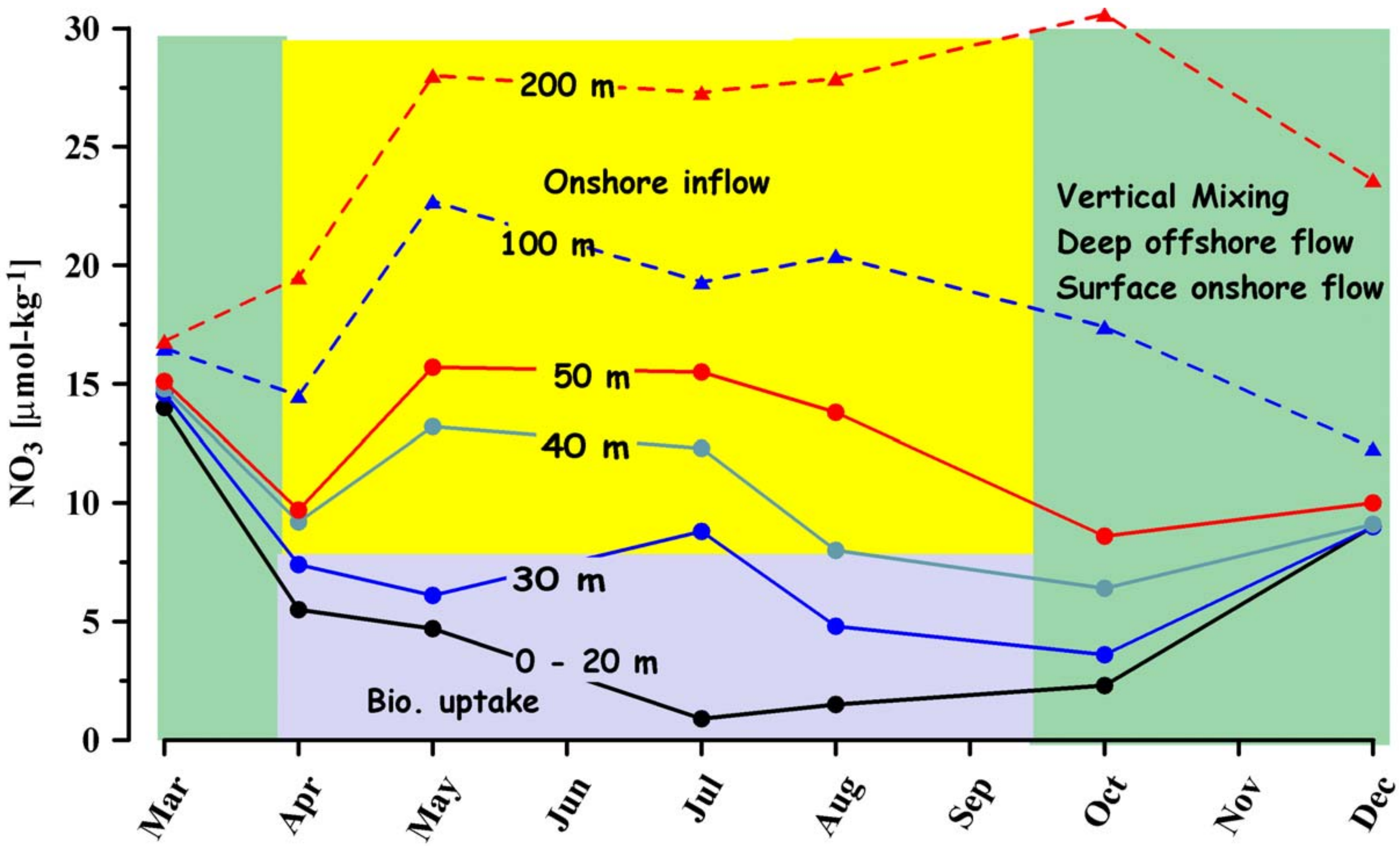
Near-surface salinities in-phase with freshwater discharge

Bottom & Mid-depth salinities out-of-phase with winds/outer shelf transport.

Bottom and surface salinities: out-of phase

Annual surface salinity amplitude on outer shelf ~ 1 (psu)

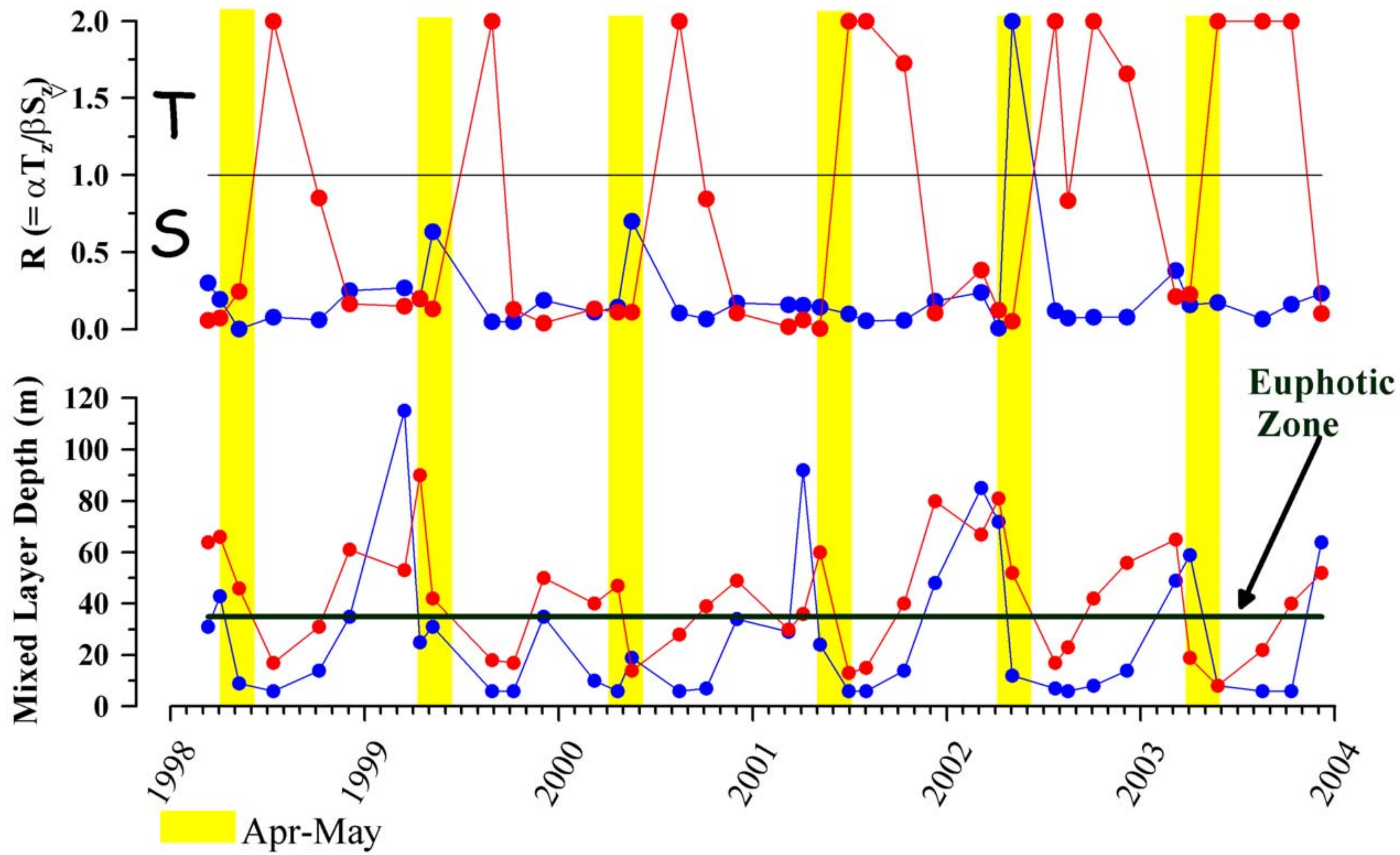
Annual nutrient cycle mimics salinity cycle



A NUTRIENT RESERVOIR AT DEPTH IN SUMMER

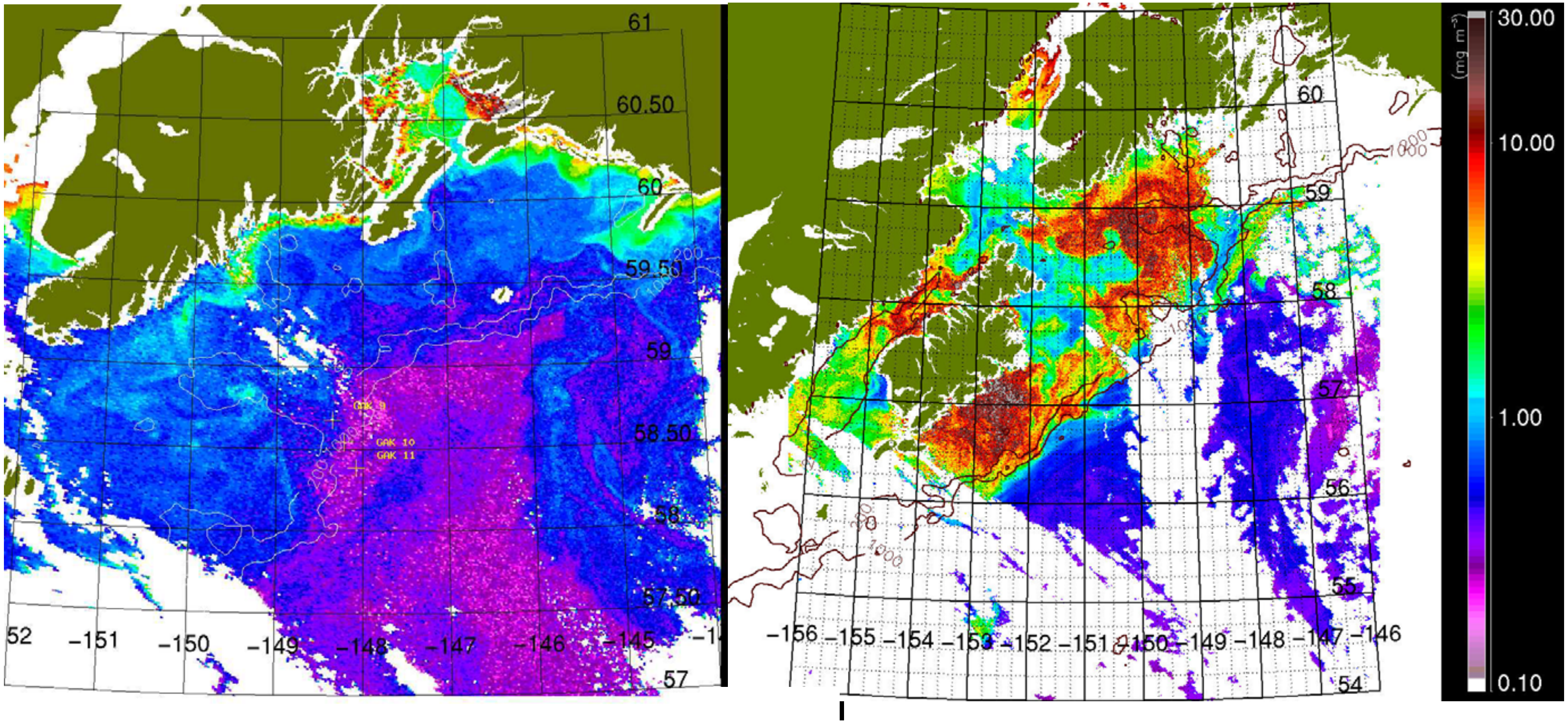
(Silicate and phosphate are similar)

(Childers & Whitledge)



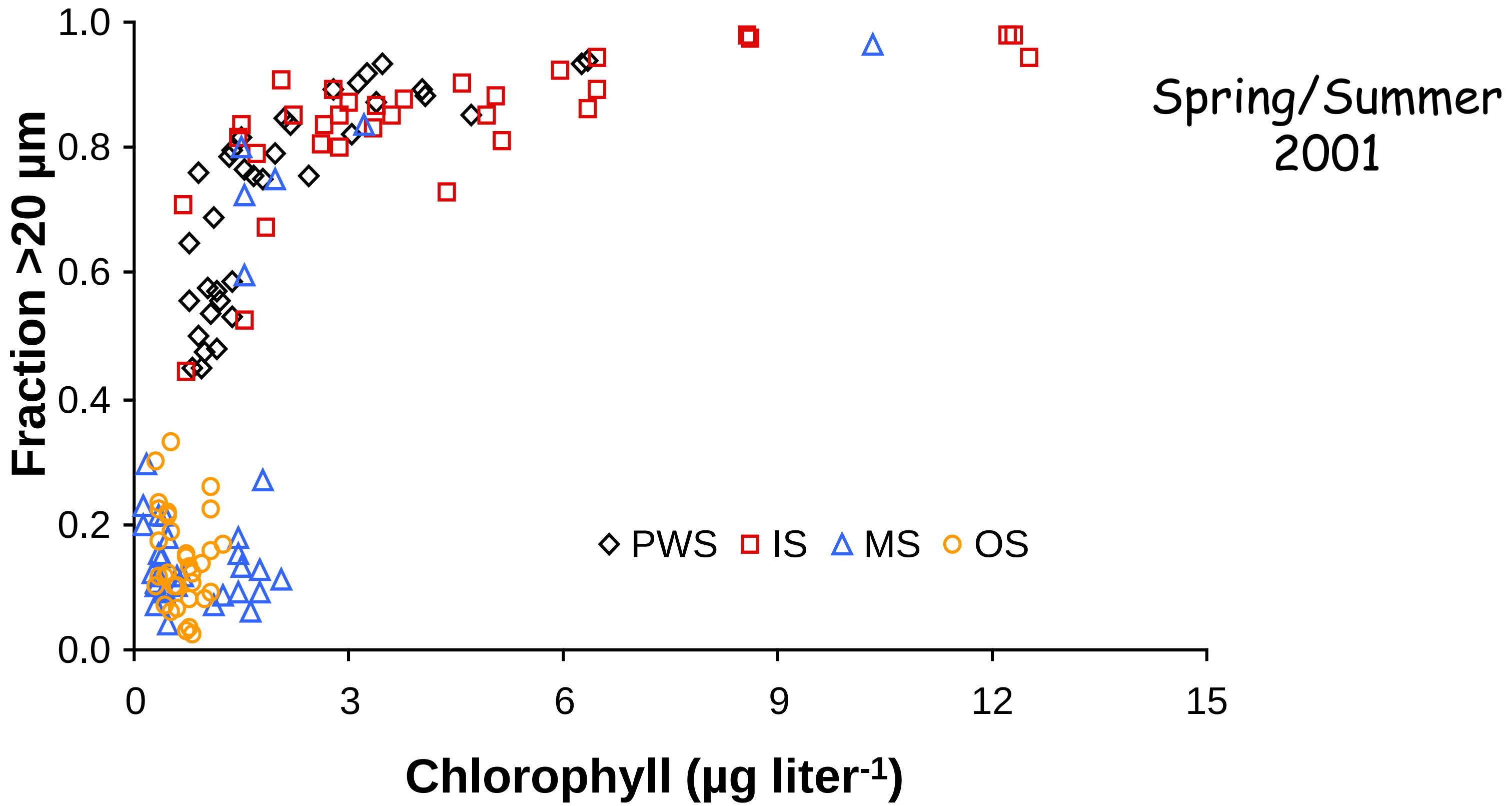
Spring & Summer Stratification Controlled by:	Inner Shelf ●	Outer shelf ●
	Salinity	Temperature
	Winter Precipitation Freeze/Melt	Solar heating/ Wind-mixing
Processes:	3-D	1-D

April 1, 2003 May 16, 2003



Different stratifying mechanisms lead to differences in the spring onset of primary production. Production begins on the inner shelf earlier (0.5 – 1.5 month) than on the mid- and outer shelf.

Cross-shelf differences in phytoplankton communities



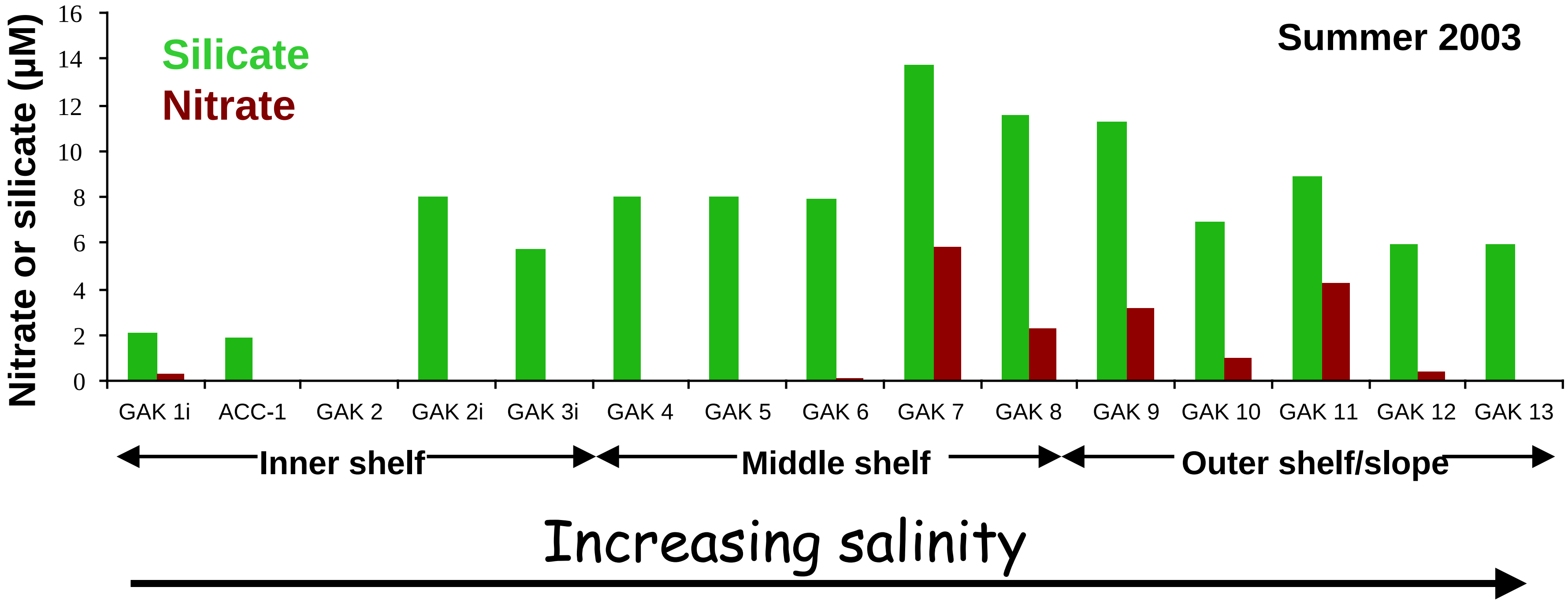
Large phytoplankton cells dominate <u>inner shelf</u>

Small phytoplankton cells dominate <u>outer shelf</u>

Mid-shelf is a transition zone

(S. Strom)

Cross-shelf gradients in nutrient utilization reflect differences in phytoplankton communities



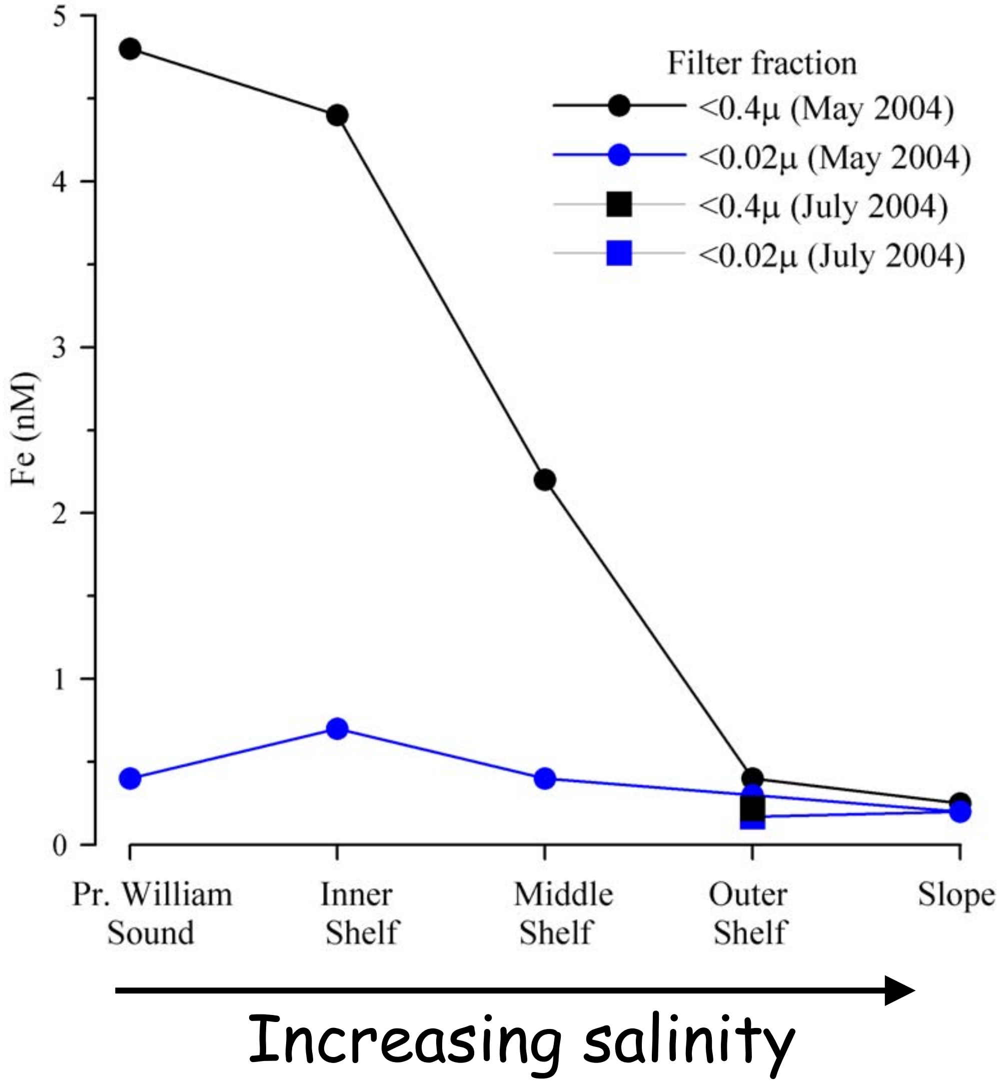
Inner shelf: Spring/Summer Production limited by NO_3

Outer shelf: Iron limitation might inhibit diatom growth and hence silicate utilization

Middle shelf: A transition zone

(S. Strom)

Surface bio-available iron concentrations decrease offshore

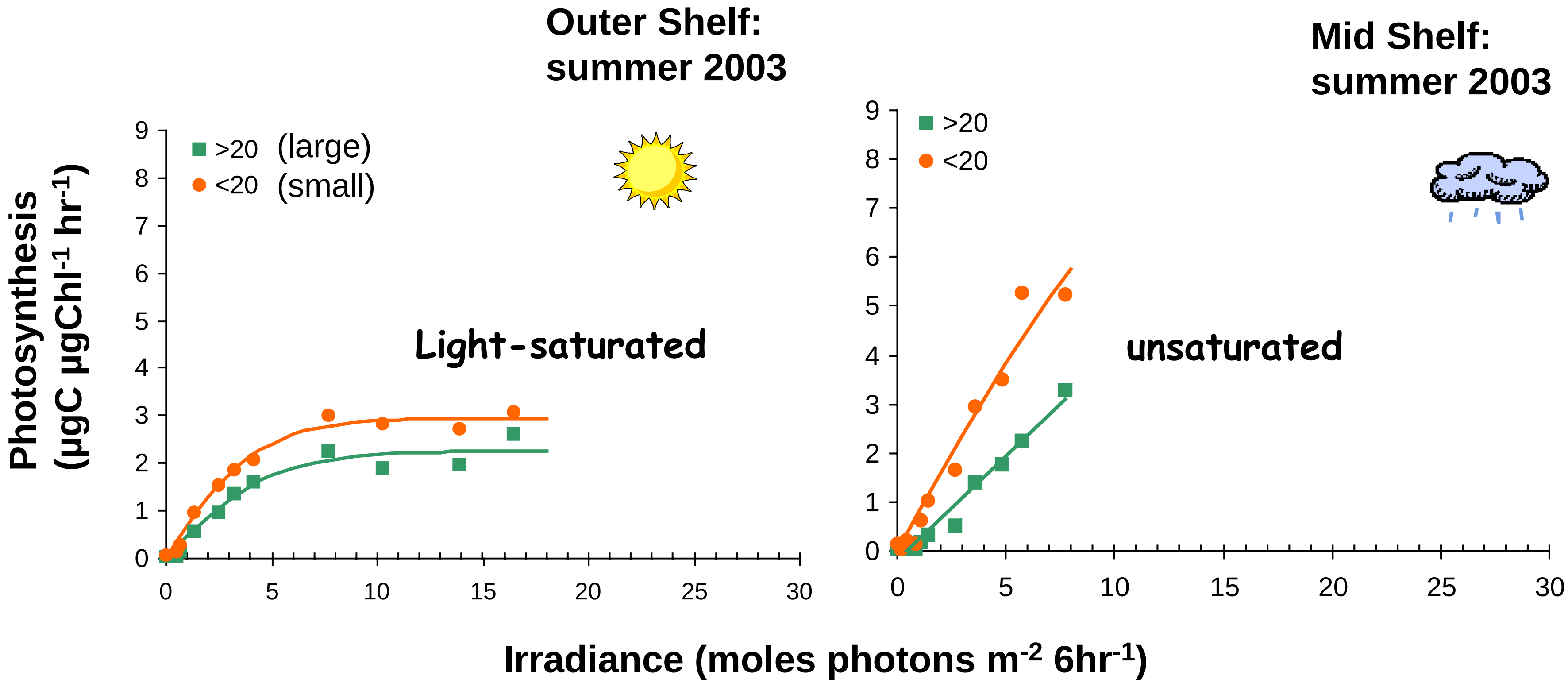


Deep (≥50m) iron concentrations > 1 nM

Is outer shelf production controlled by mixing and/or the offshore spread of low-salinity, high Fe waters?

J. Wu (preliminary data)

Production might not be only nutrient-limited

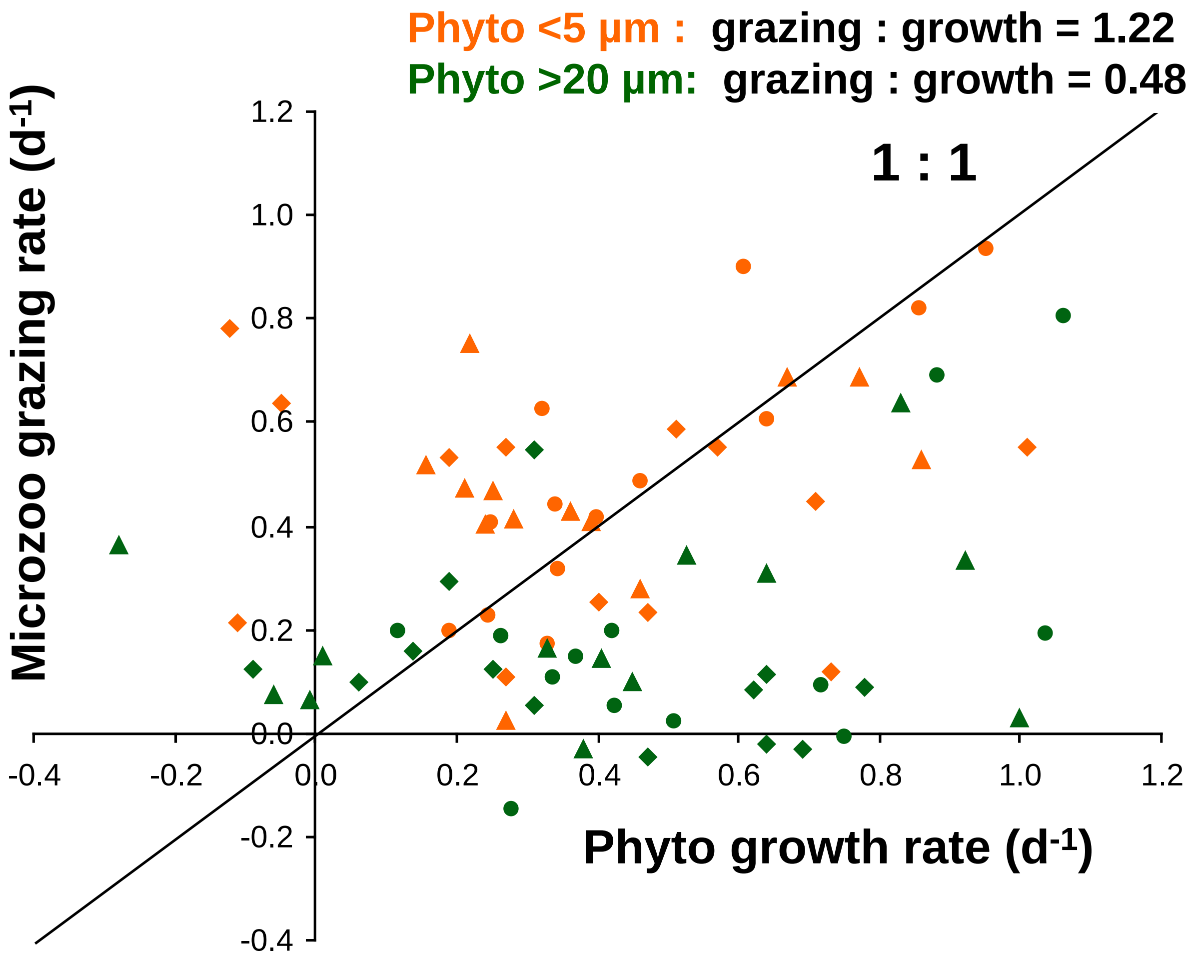


Photosynthesis is saturated on sunny days but light-limited on cloudy days: Cloud cover results in light limitation ~50% of the time.

Runoff carries a huge sediment load that might affect light levels

Warmer, wetter winters imply earlier inshore stratification than at present. Will spring blooms occur earlier and be dominated by low-light adapted phytoplankton communities?

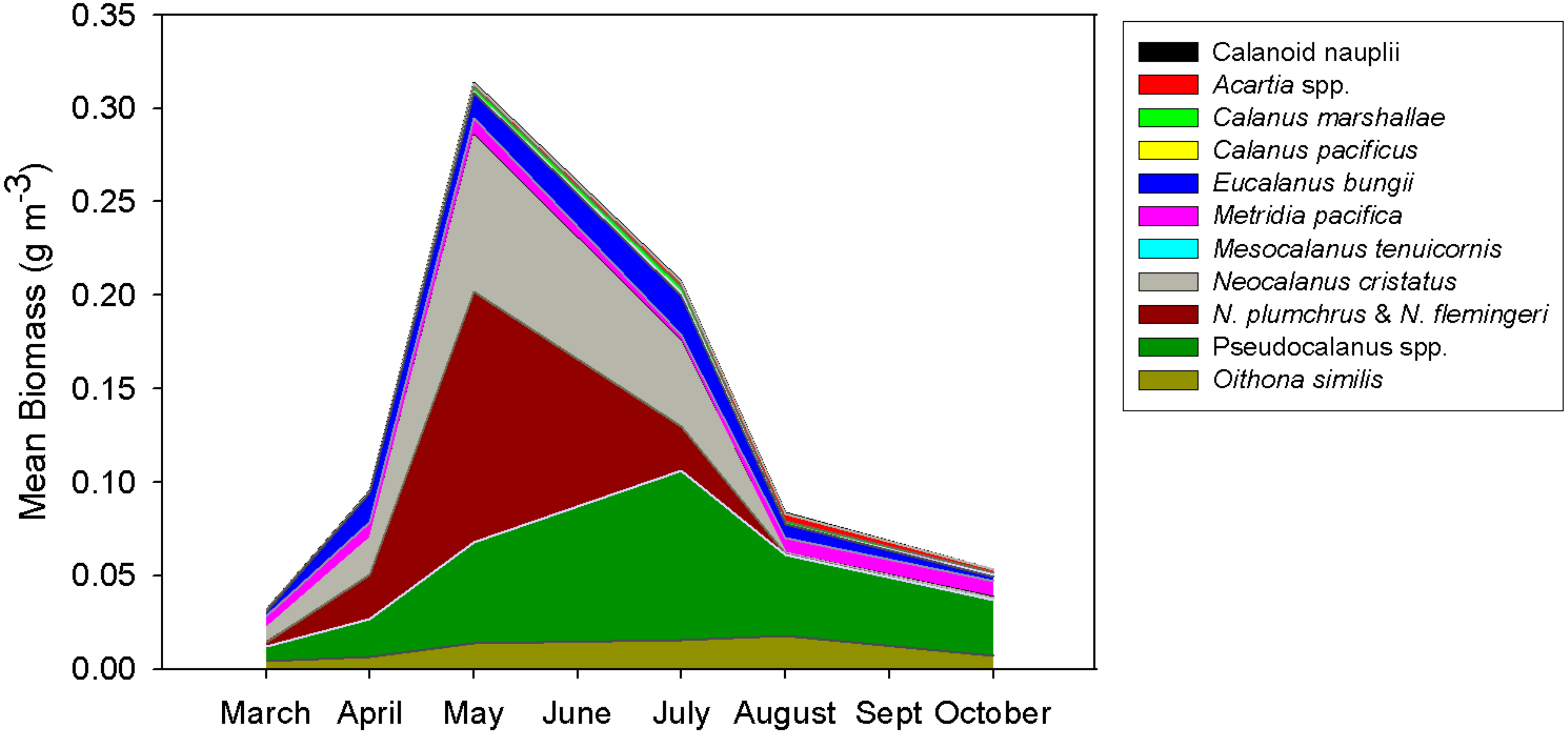
(S. Strom)



Microzooplankton consume ~50% of large phytoplankton production – the shelf supports a complex food web suggesting biological controls on energy transfer to higher trophic levels.

(S. Strom)

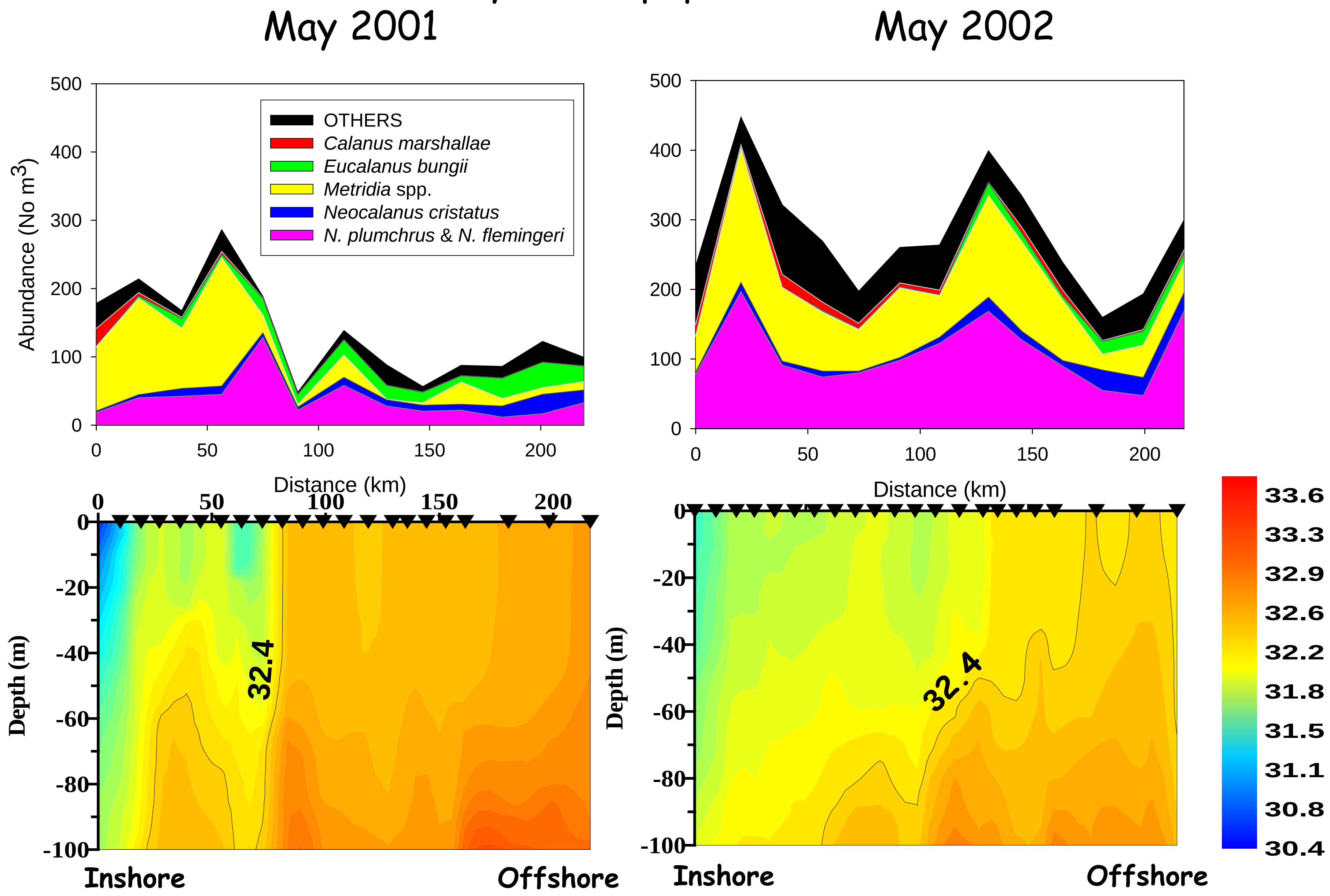
Annual Cycle in Biomass of Major Calanoids (Spring/early summer juvenile salmon food)



Emerging Diapause	Feeding & Growth	Entering Diapause

(K. Coyle)

Salinity and Copepod abundance



(K. Coyle)

May abundances (and biomass) of *Neocalanus* and *Pseudocalanus* are:

1.) Strongly anti-correlated with salinity

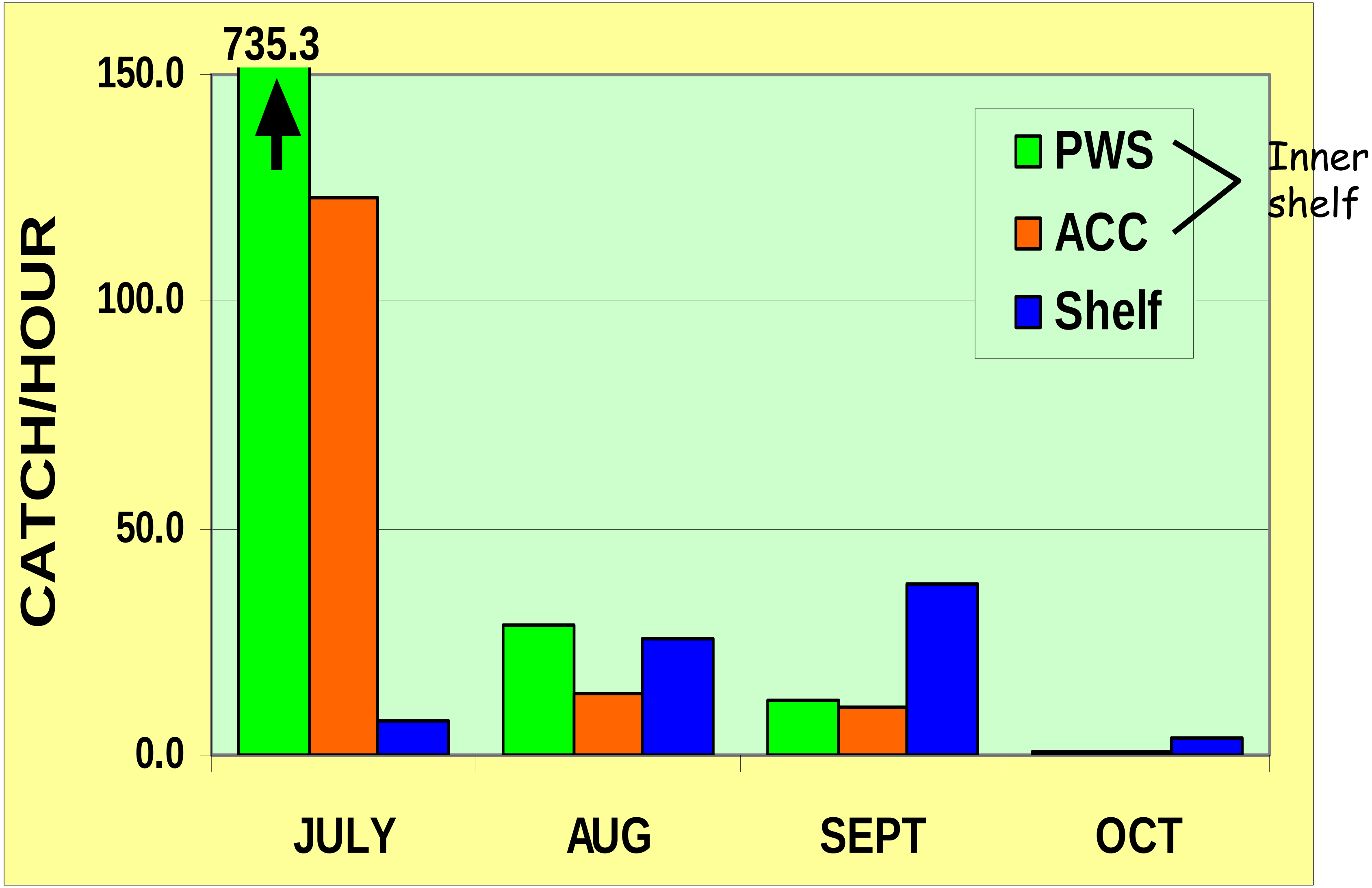
2.) Weakly anti-correlated with stratification

3.) Weakly correlated with temperature

A freshwater-iron-diatom-copepod link?

(K. Coyle)

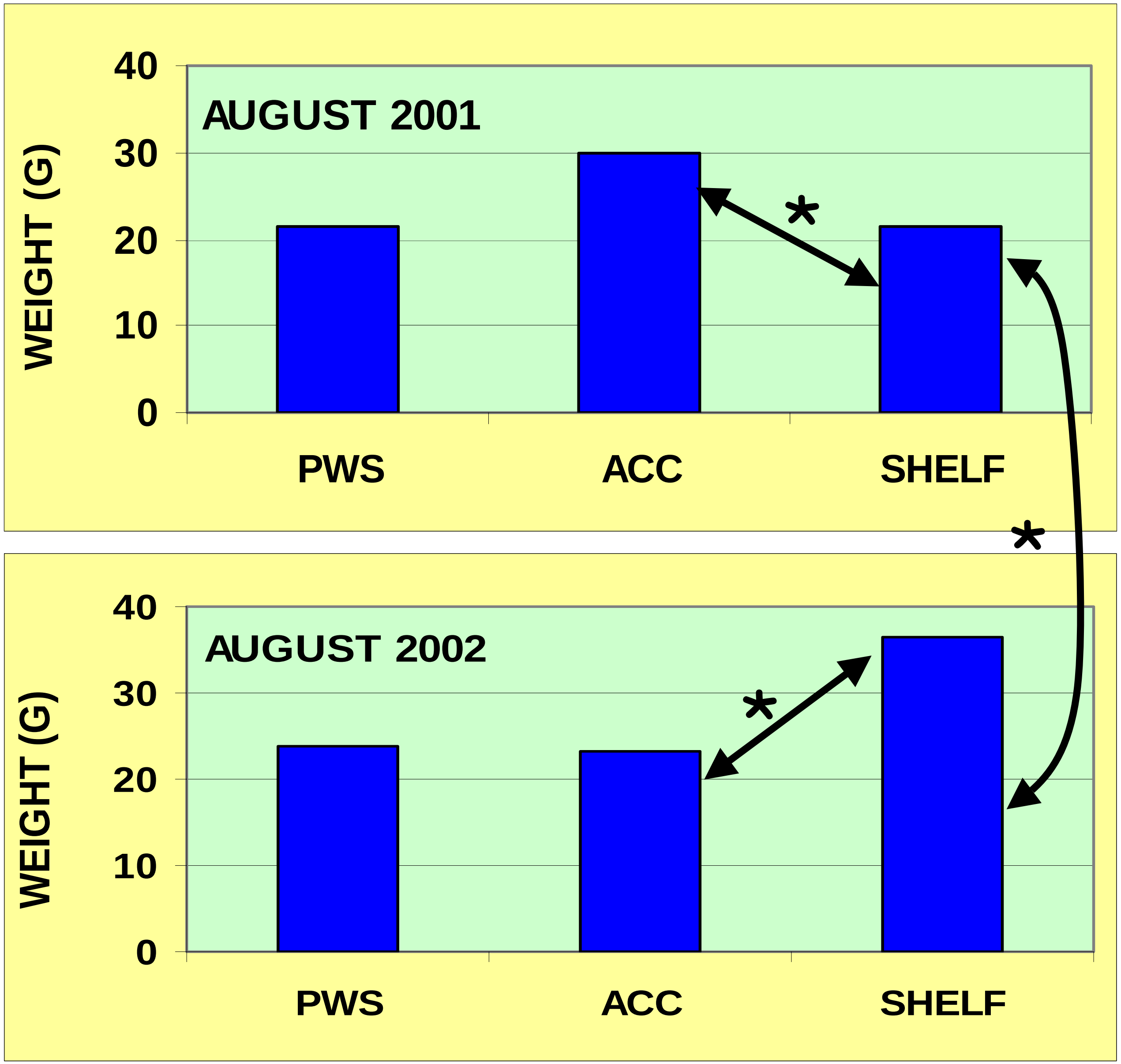
2001 Catch Rates (CPUE) of Juvenile Pink Salmon in Surface Trawl



Juveniles inhabit different portions of the shelf seasonally

(L. Haldorson)

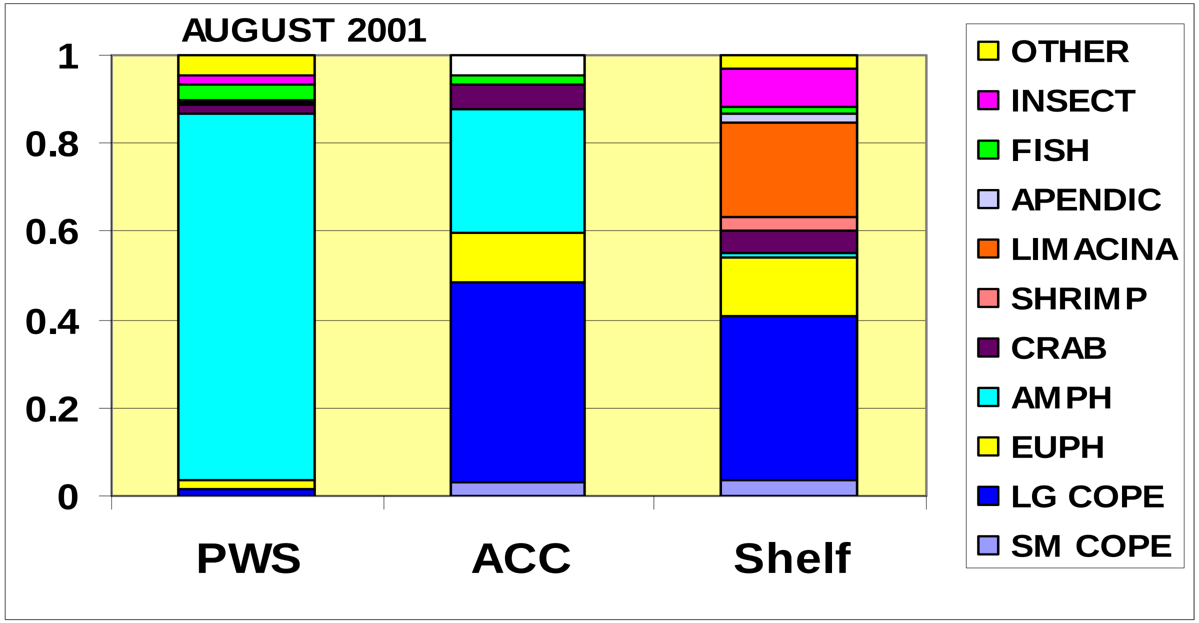
Mean Weights of Juvenile Pinks: August 2001 and 2002



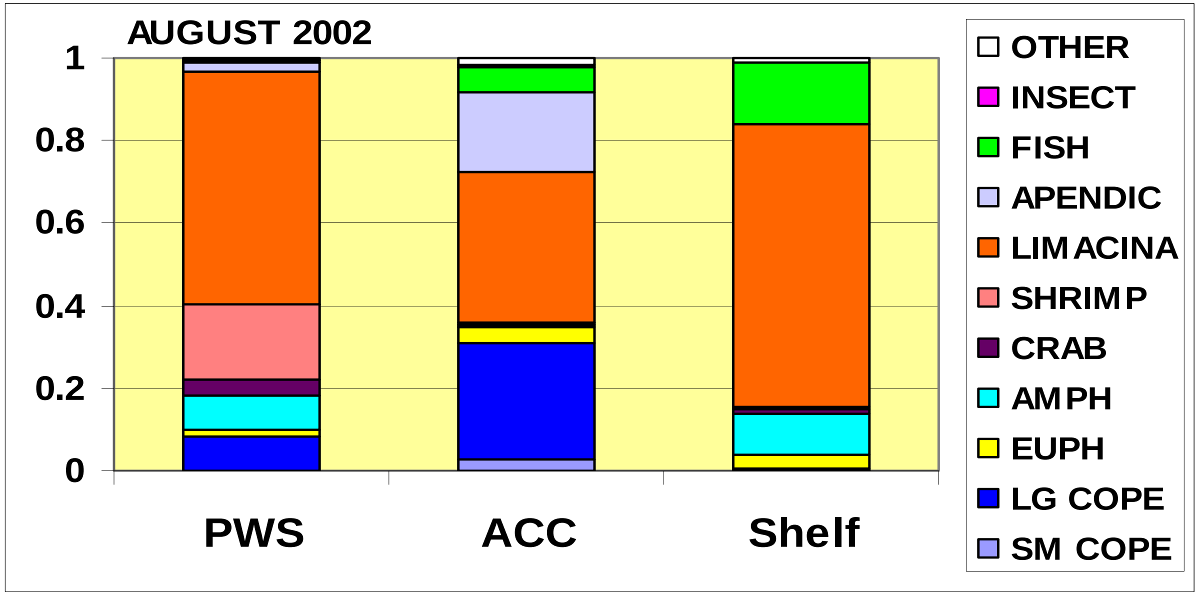
Significant (*) size differences suggest differences in food quality or quantity on mid- and outer shelf between these years.

(L. Haldorson)

Juvenile Pink Salmon Diets - August 2001, 2002



August 2001:
Shelf diet: Diverse
(low availability of
preferred foods);
2002 Adult return:
2.5% - LOW



August 2002
Diets: *Limacina*
2003 Adult return:
8.5% - HIGH

Shelf Salinities:
$S_{2002} < S_{2001}$

(L. Haldorson)

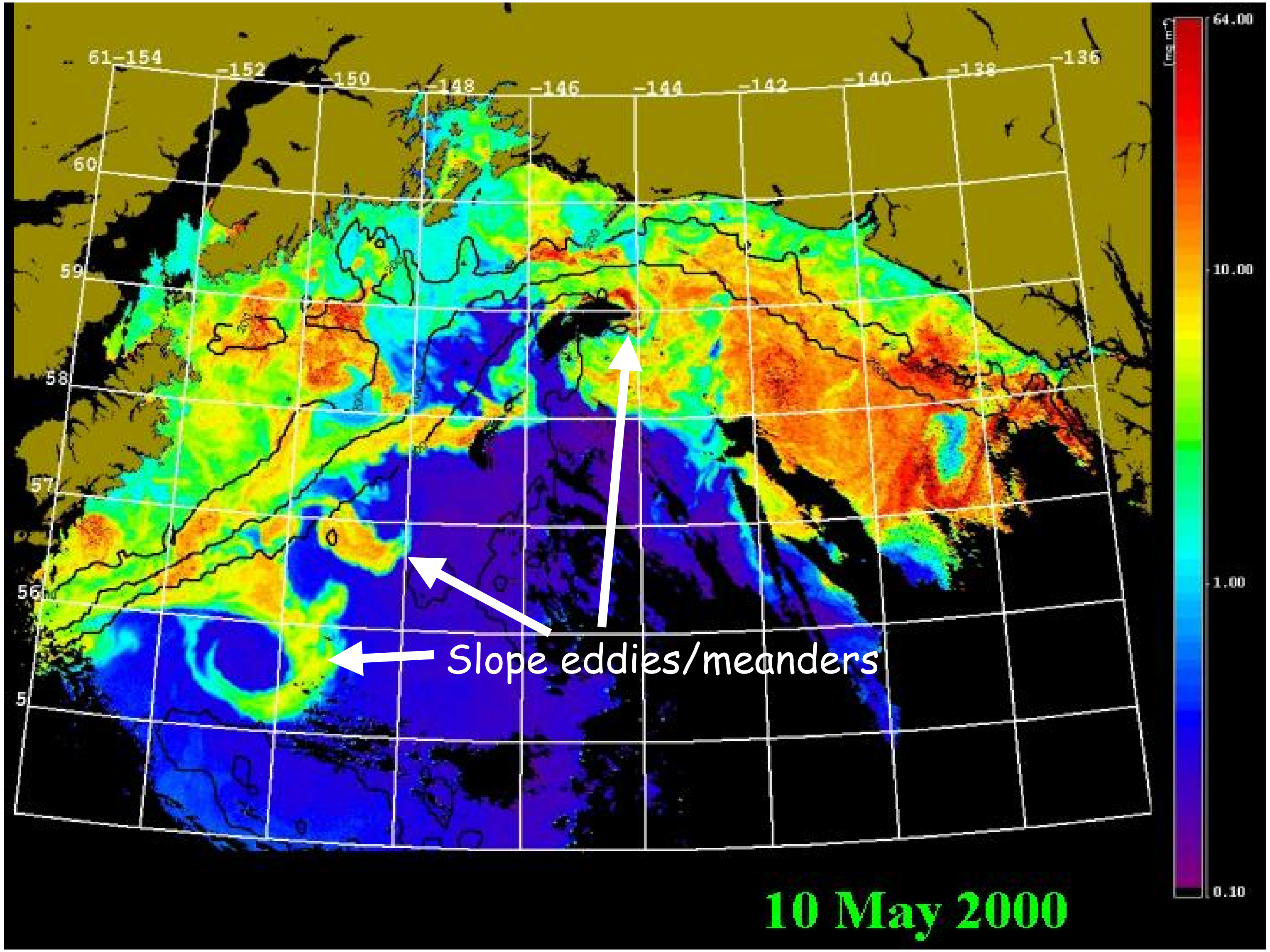
Things to think about

1. Cross-shelf gradients in phytoplankton and zooplankton community structure and production appear related to the cross-shelf salinity structure (perhaps through stratification and/or Fe availability).

   If so, then what controls the cross-shelf spread of freshwater in summer?

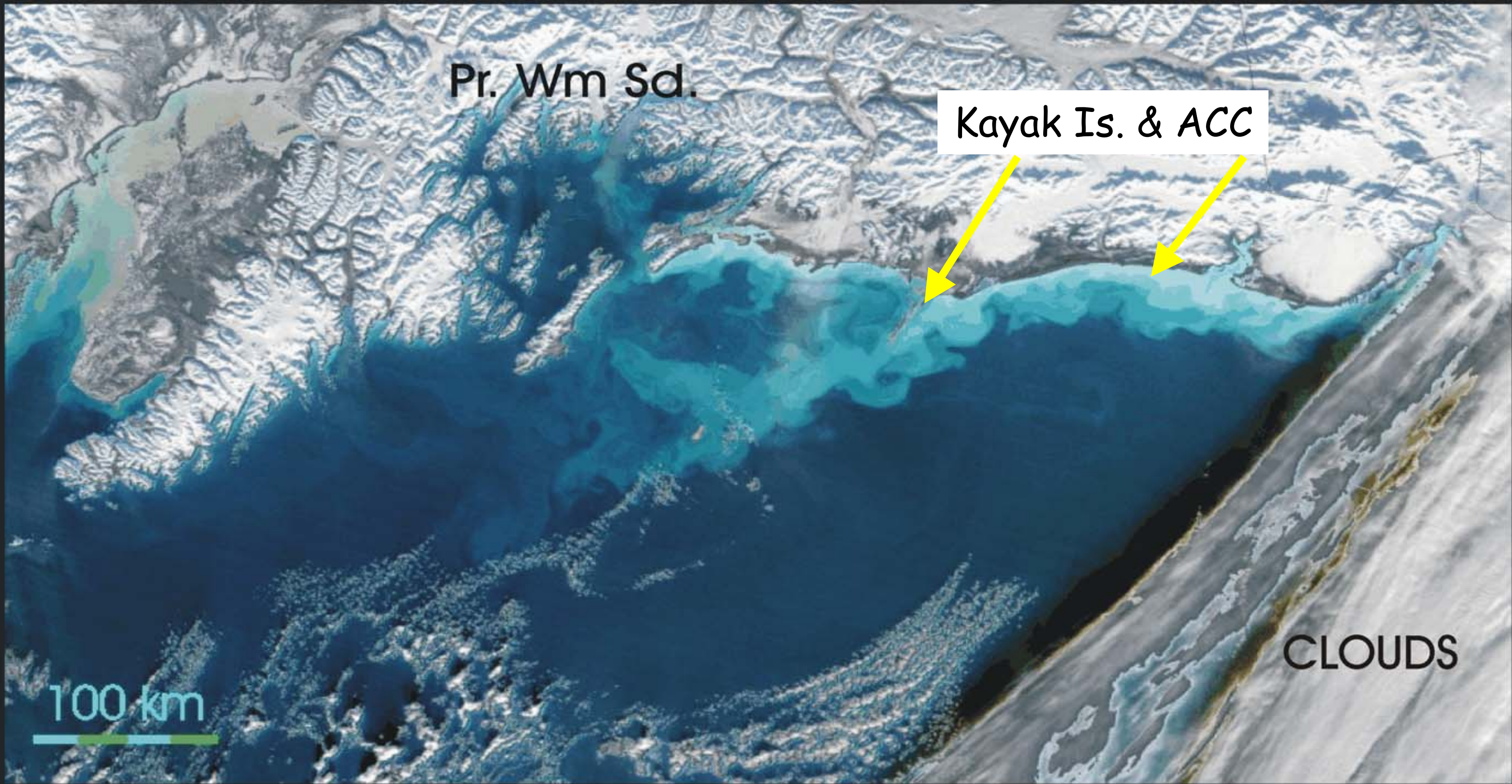
   Wind stress not obvious in data

   Alongshore/Upstream Episodic events?



Potential cross-shore exchange mechanisms and vertical motions.

Alaska Coastal Current-coastline interaction: wind and runoff control potential vorticity structure of inner and outer shelf.



MODIS, Nov. 7, 2001

2. Warmer, wetter winters (see Royer) will alter the hydrologic cycle affecting timing/patterns of inshore stratification and freshwater dispersal. This might have consequences (via light and/or nutrients) on ecosystem structure.

3. The GOA shelf contains distinct functional phytoplankton and zooplankton groups that operate on different space and time scales. Multiple, and possibly interacting, limitations (biotic and abiotic) control biological production (and possibly salmon recruitment).

   Models that examine ecosystem response to climate change must be configured accordingly.

4. Climate change involves alterations in:

   a) the seasonal mean state AND/OR

   b) intra-seasonal physical variability that affects mixing and freshwater dispersal.

   (a) has received most attention, but (b) could be as important.

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