Seasonal cycle of nutrients, phytoplankton and zooplankton in the coastal upwelling zone off Oregon, U.S.A.

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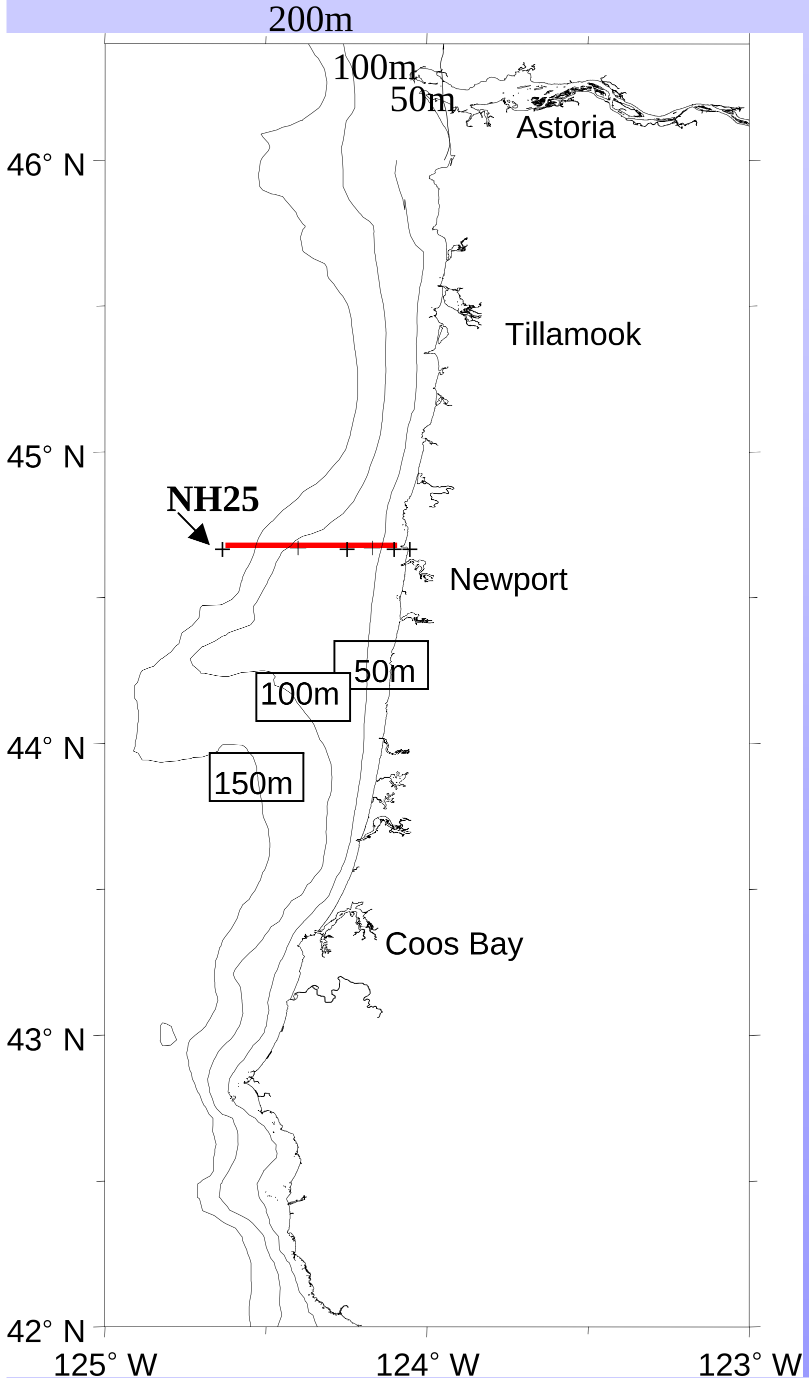
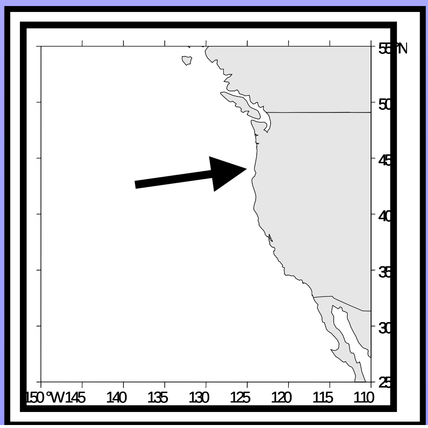


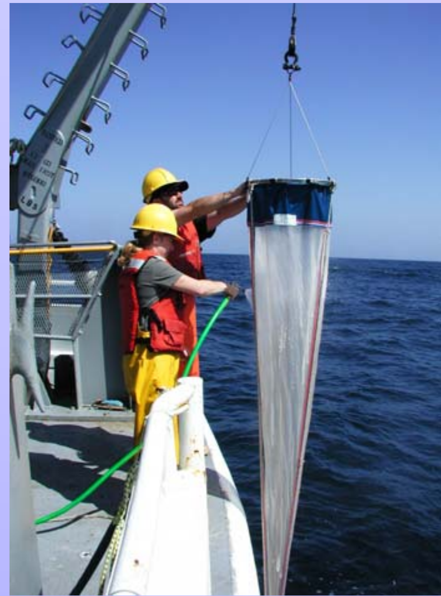
NH-Line Zooplankton Time Series

Bi-weekly Sampling:

- **1969 – 1973** (Miller, Pearcy, Peterson
- **1983** (Miller)
- **1996 – present** (Peterson et al.)



Sampling methods



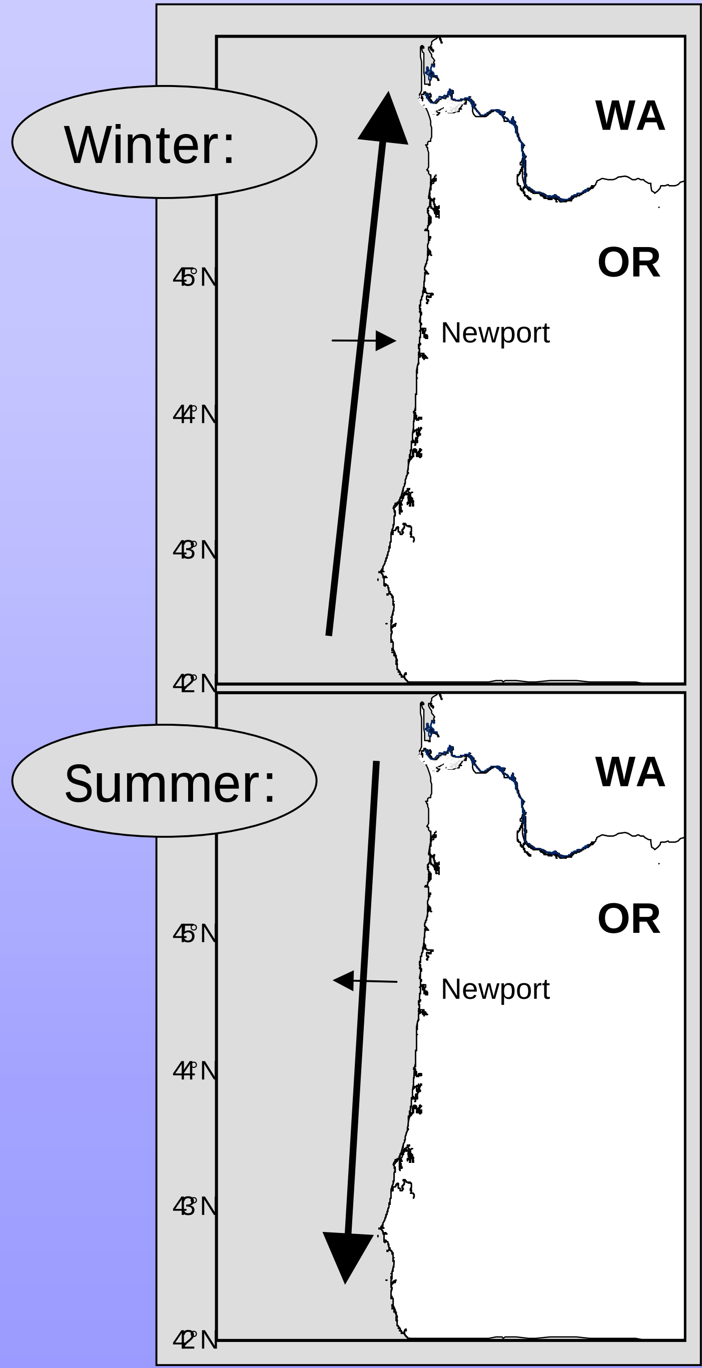
- Water sampling with CTD, Niskin Bottles, and buckets for hydrography, chl-a and nutrients
- Mesozooplankton with ½ m 200 um net towed vertically
- Euphausiids with 70 cm 505 um net towed obliquely

Tutorial: *On Upwelling*

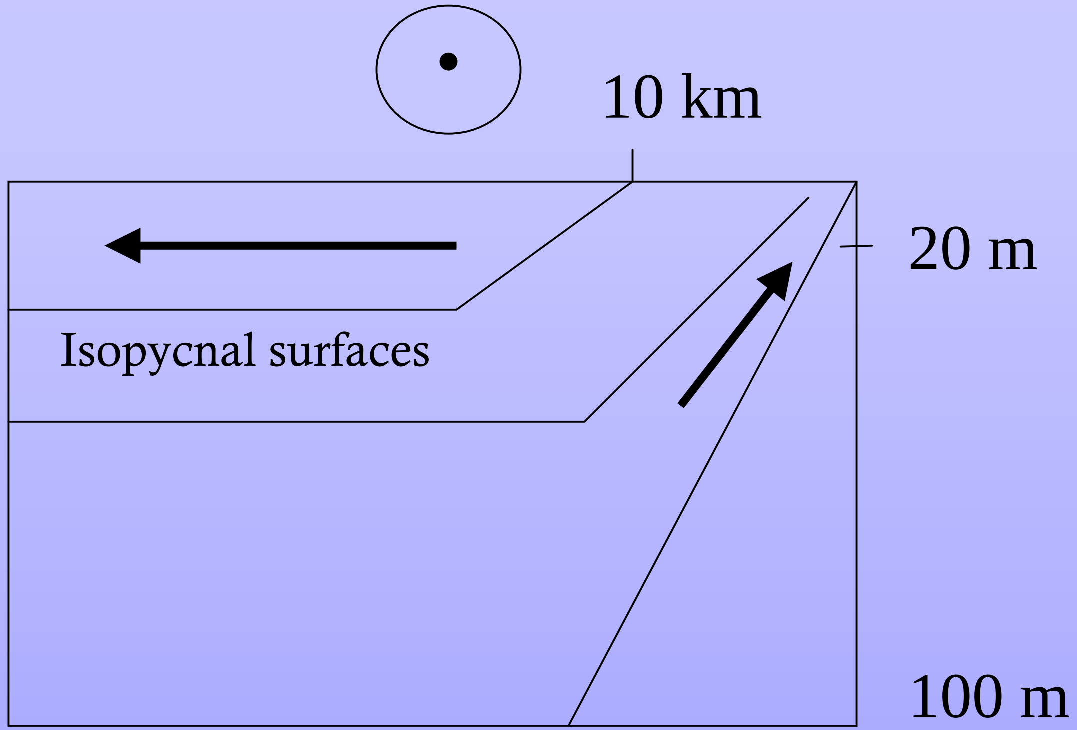
- Seasonal variations in circulation patterns
- Seasonal variations in winds
- Weekly variations in coastal upwelling
- Some examples

Winds and current structure off coastal Oregon:

- Winter:
  - Winds from the South
  - Downwelling
  - Poleward-flowing Davidson Current
  - Uniform cross-shelf hydrography
- Spring Transition in April/May
- Summer:
  - Strong winds from the North
  - Coastal upwelling
  - Equatorward alongshore transport
  - Strong cross-shelf physical gradients
- Upwelling-favorable winds cease in September/October

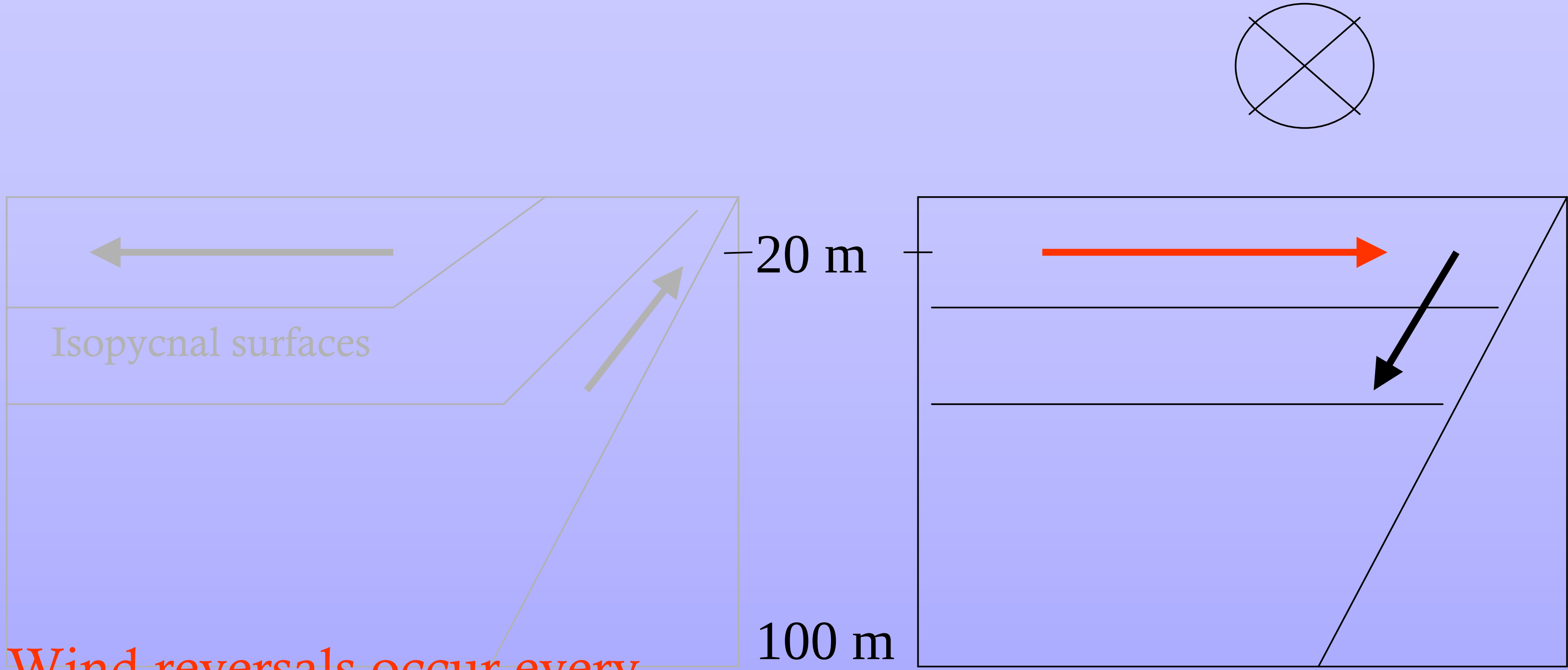


Coastal Upwelling is a nearshore phenomenon

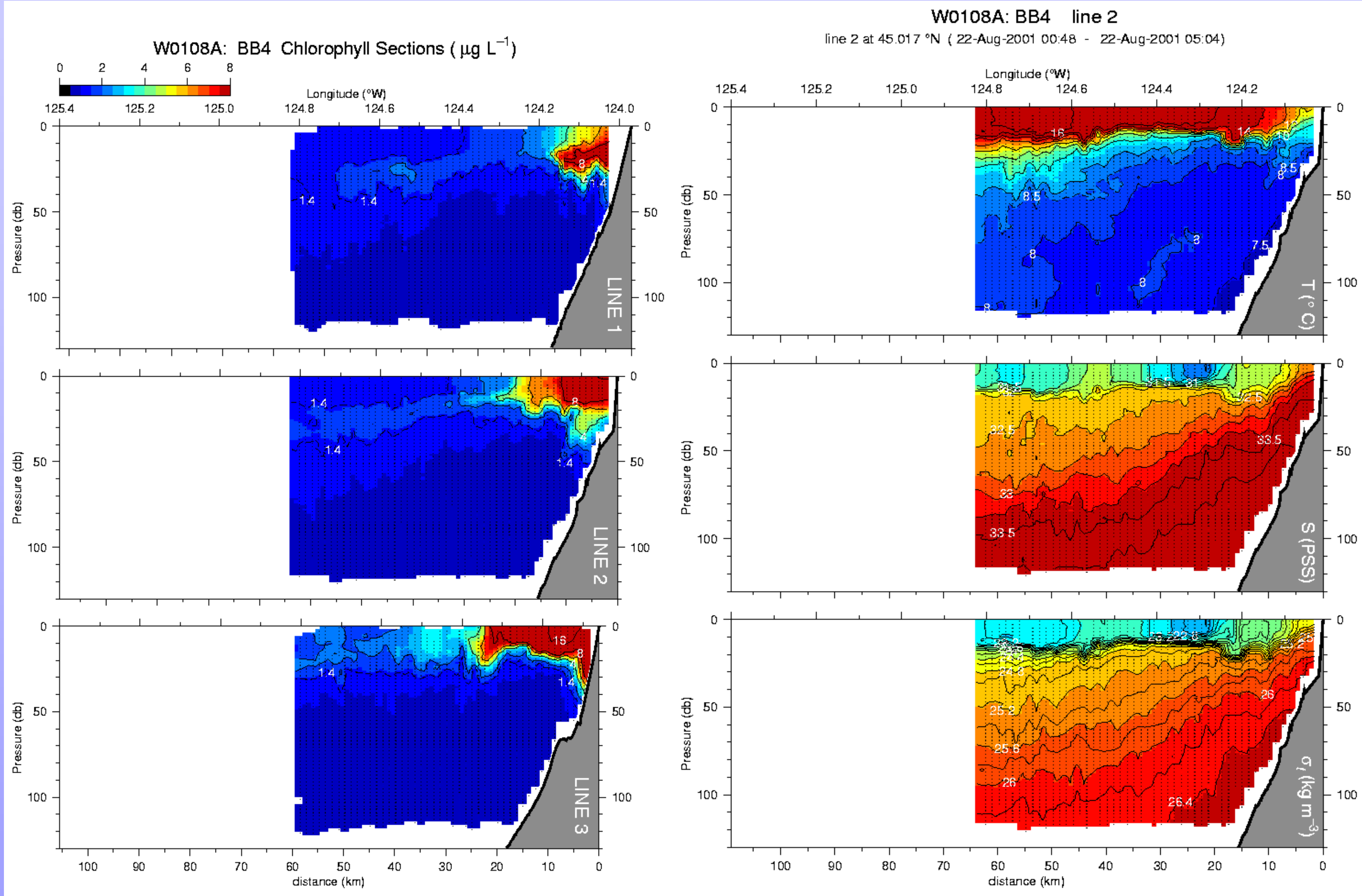


Equatorward winds create active upwelling at the coast, driving the upper 20 m of the water column offshore. Most active upwelling is within 10 km of the shoreline.

Coastal Upwelling is a nearshore phenomenon

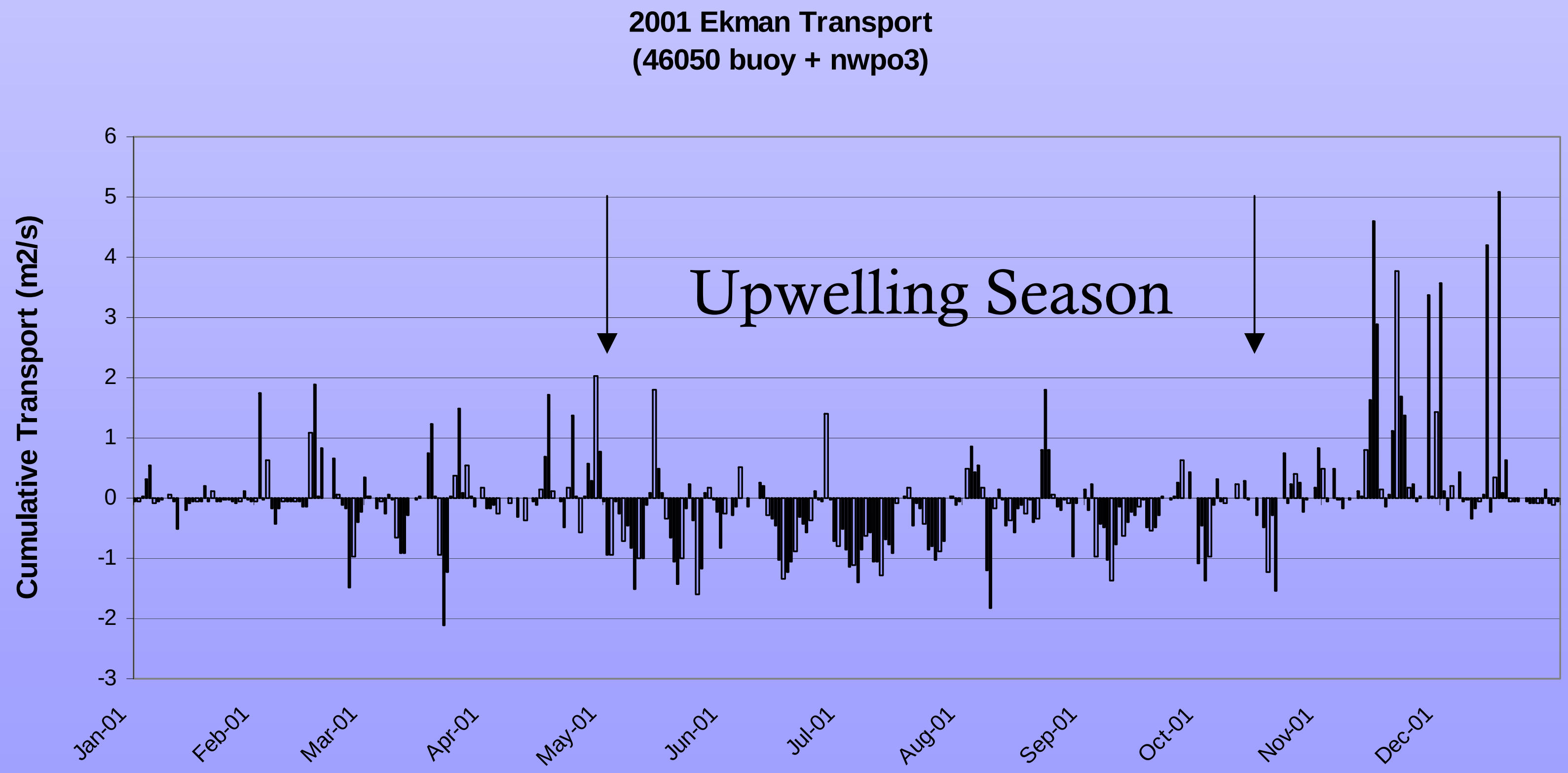


Wind reversals occur every 5-10 days; poleward winds result in “relaxation” of the upwelling and surface waters flow landward.

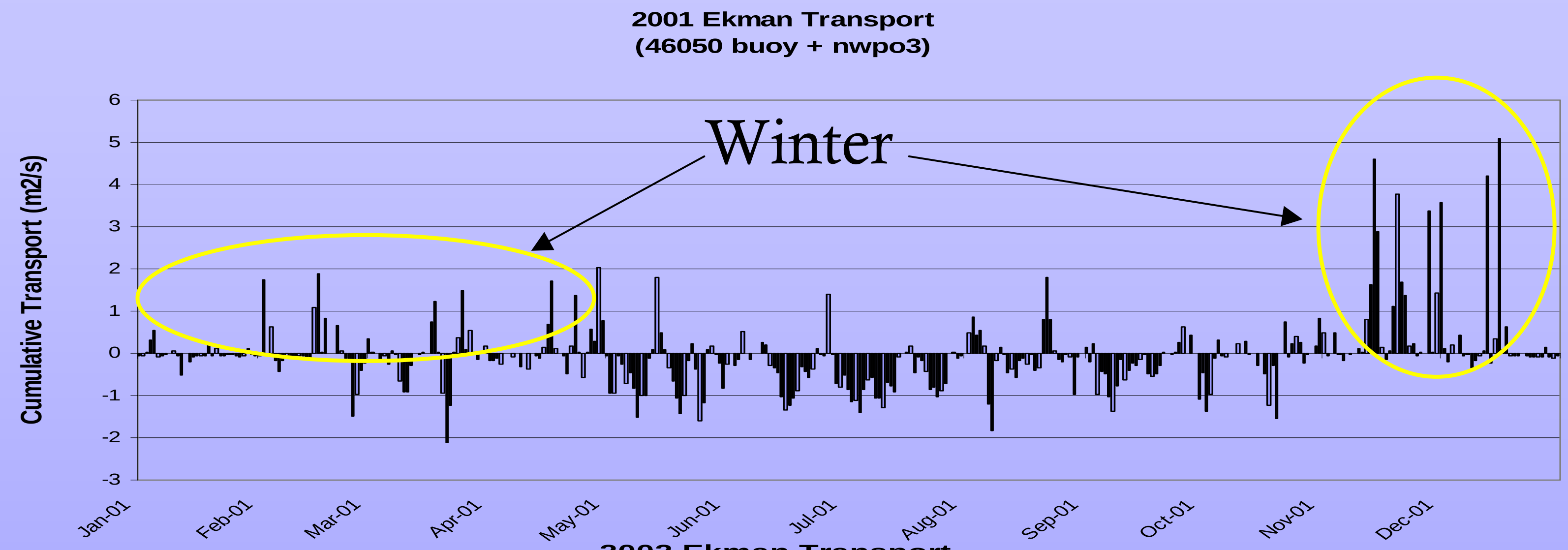


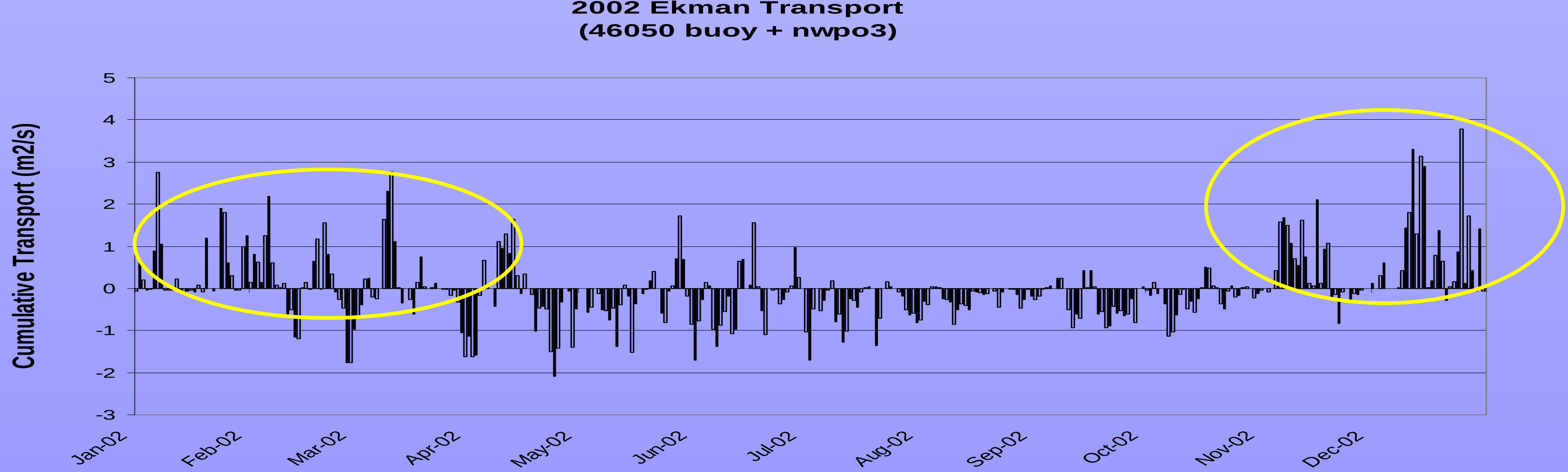
Data from NSF/CoOP/COAST program; courtesy of Jack Barth

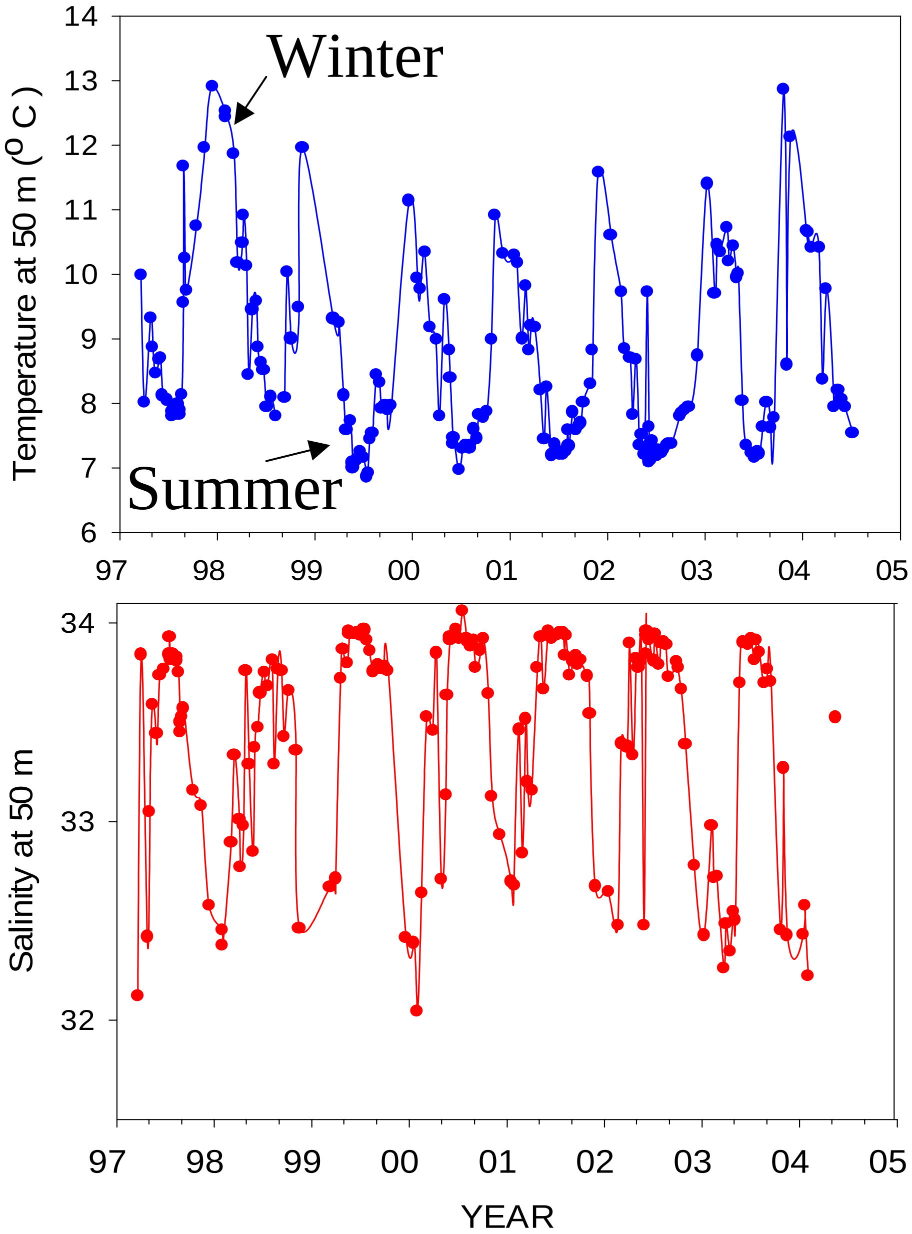
Winds measured at an offshore buoy (22 miles offshore) and at a shore station in 2001. Upwelling season May-September (periods of *negative transport*) although events occur in March-April and October and Novermber



Winds measured in 2001 and 2002 (for example) show strong contrasts: (1) moderate winter in 2001; (2) storms most intense in November-December



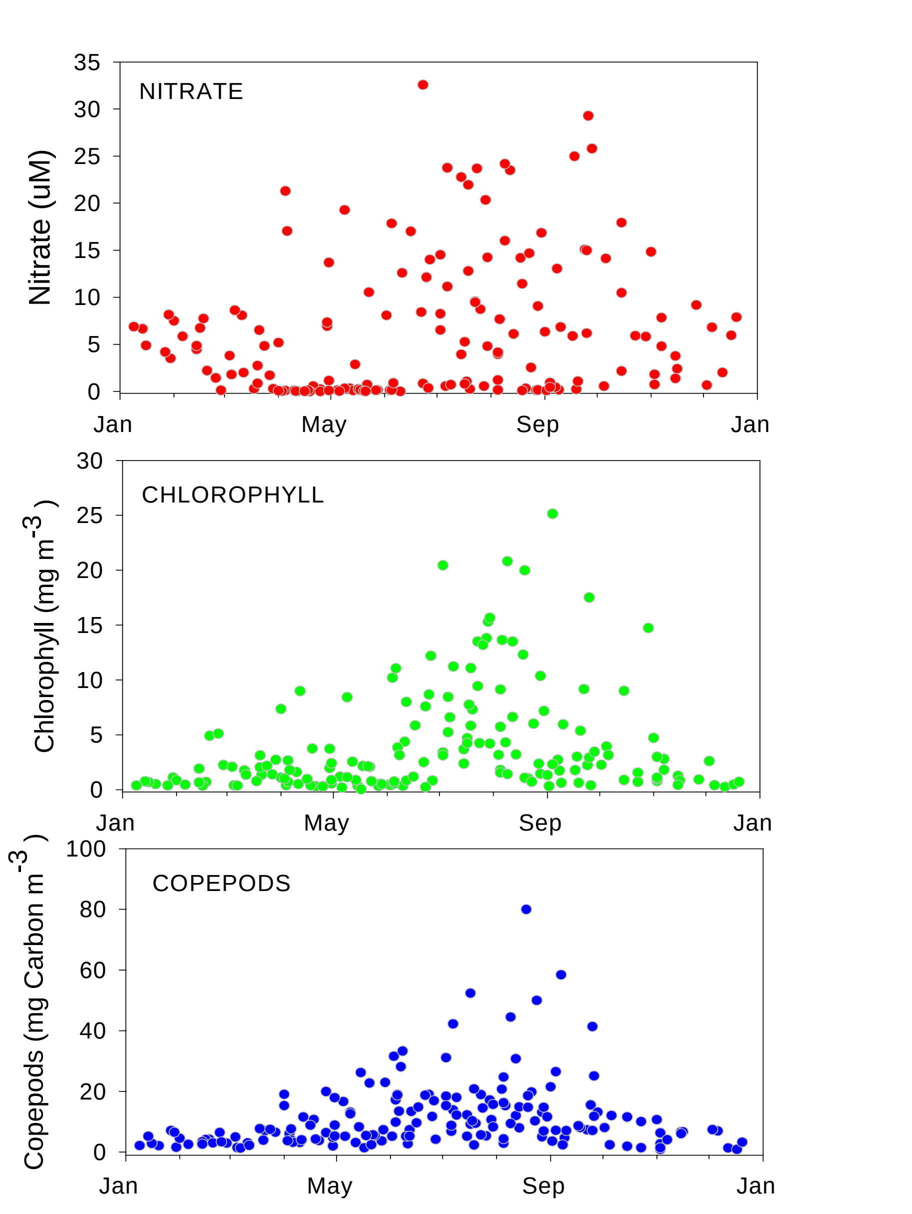




Bottom water hydrography NH 05 at 50 m

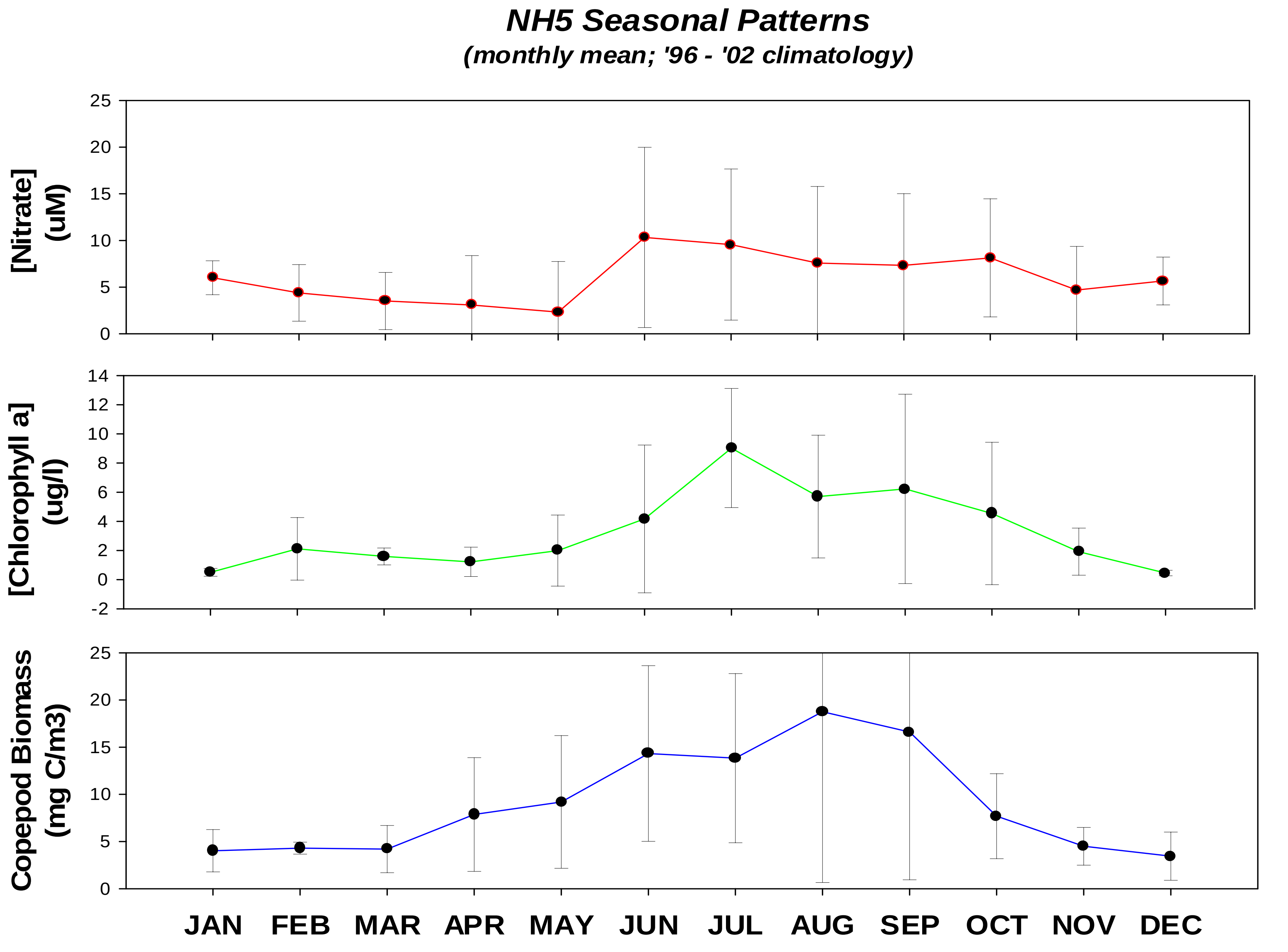
Note: Seasonal cycle of temperature and salinity

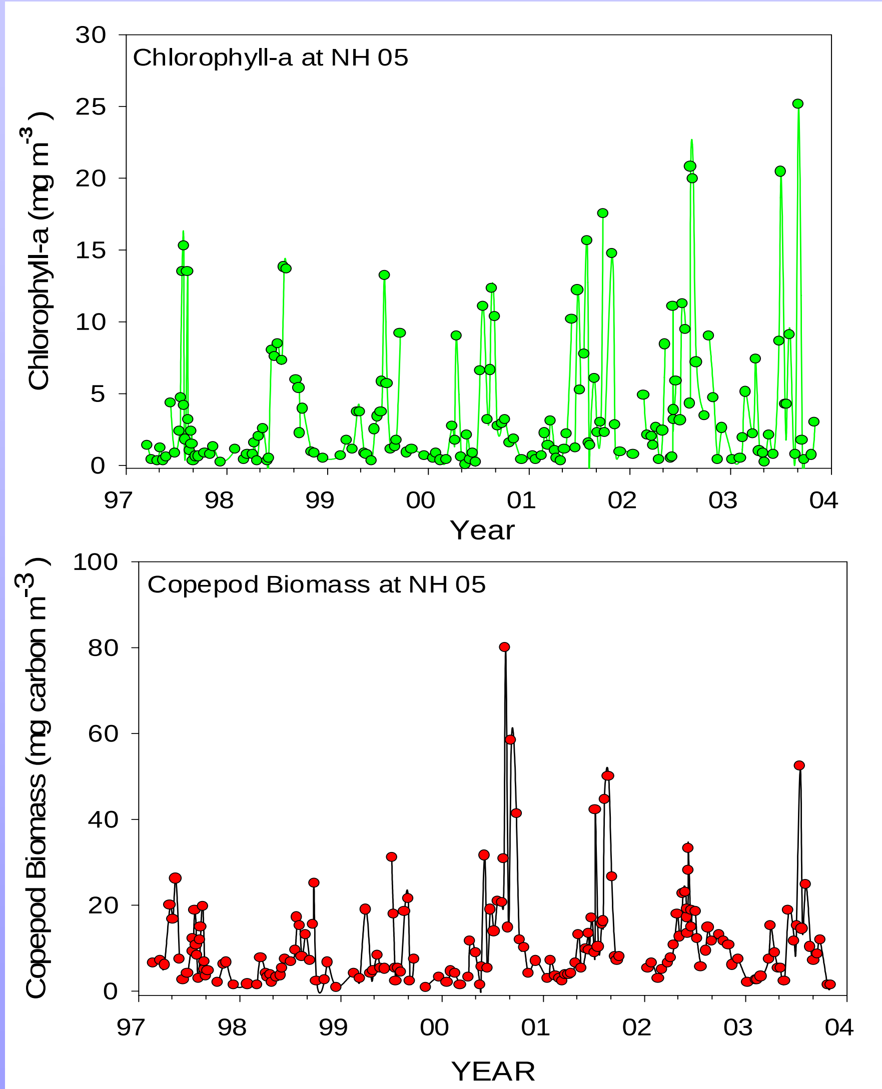
Note:
1998 = warm winter; 2000-2003 = cool winter; 2004 = warm winter



Climatology: 1997-2004 NH 05

- ***Nitrate*** to 30 micromolar during summer but is often zero;
- ***Chlorophyll*** to 25 micrograms per liter; typically 5-10 ug L^{-1};
- ***Copepods*** to 80 micrograms carbon per Liter but typically 10-20 ug L^{-1} ;
- ***Peaks*** seen during upwelling season (May-September);
- ***Lags*** between peaks in nitrate, chl-a and copepods.

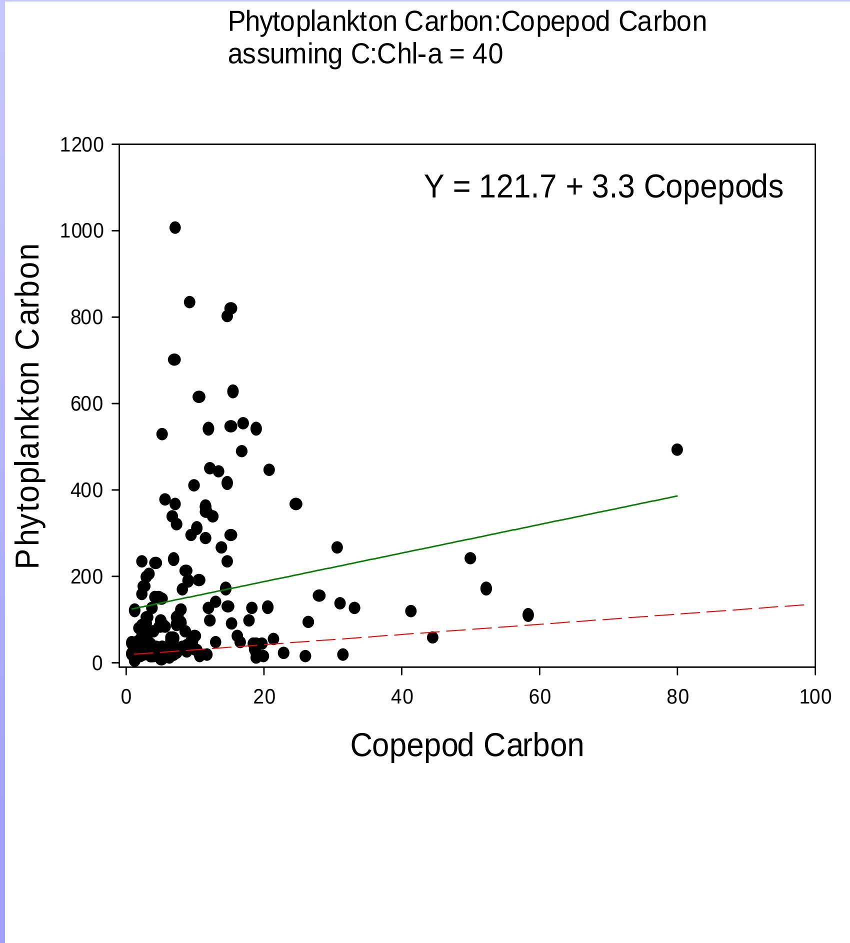

NH5 Seasonal Patterns
(monthly mean; '96 - '02 climatology)
[Nitrate] (uM)
[Chlorophyll a] (ug/l)
Copepod Biomass (mg C/m3)
25
20
15
10
5
0
14
12
10
8
6
4
2
0
-2
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC



Interannual variations not large

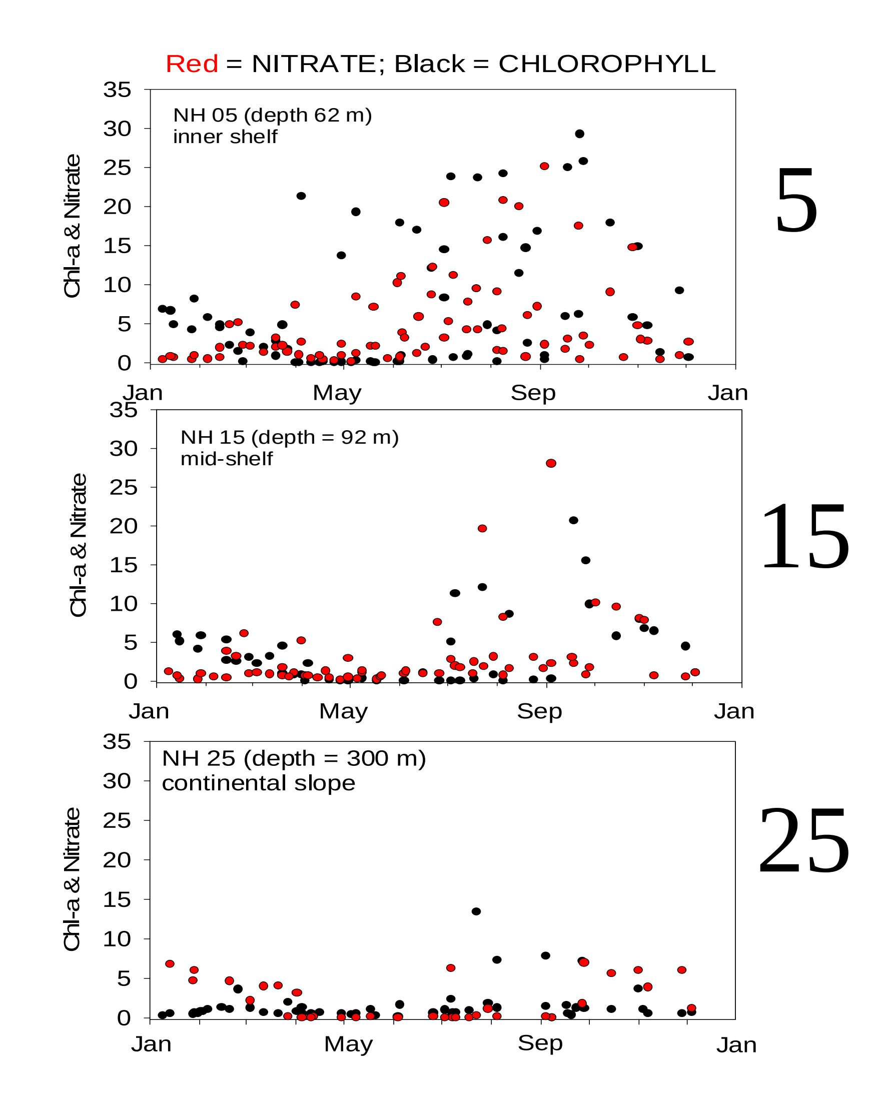
	Annual Average	
	Chl-a	Copepods
• 1997	3.0	9.2
• 1998	3.9	7.2
• 1999	3.0	8.7
• 2000	3.3	17.2
• 2001	4.4	13.2
• 2002	5.4	13.3
• 2003	4.6	10.6
• 2004		

In carbon units, phytoplankton usually has a far higher biomass than copepods, at NH 05

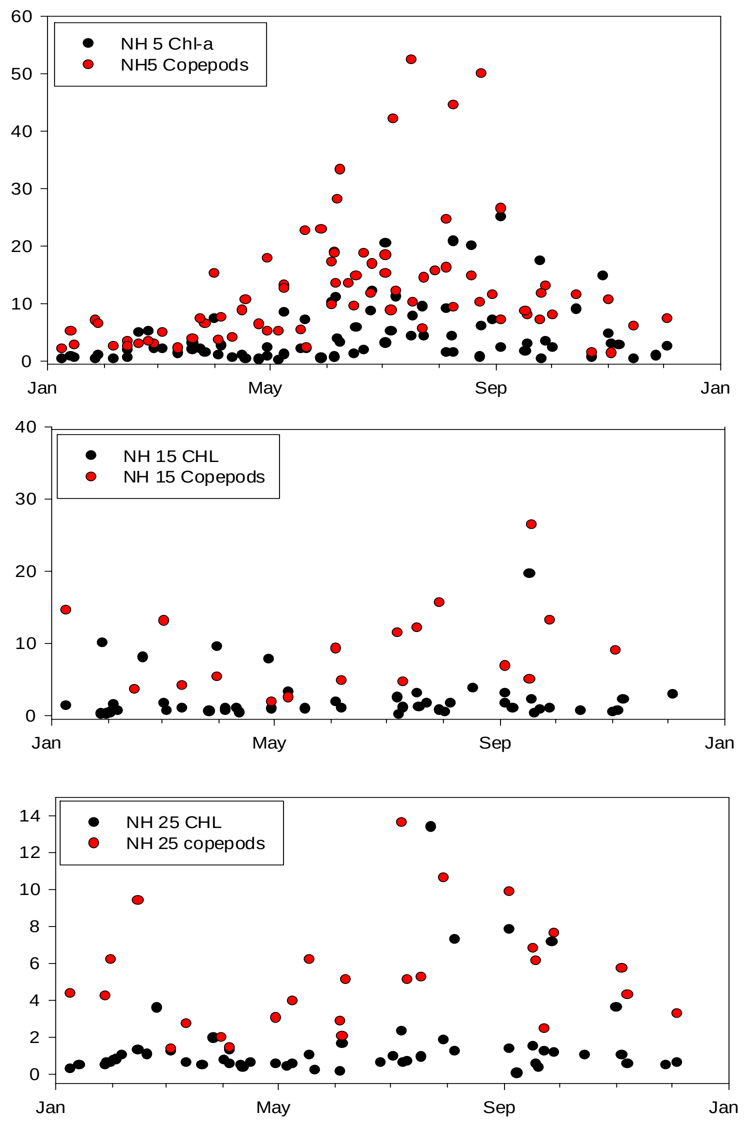


- Red Line is a slope = 1
- Green Line is fitted regression line = 3.3
- Fitted line explains very little variance (3.8% !!)
- Standing stock of Chl-a carbon often 10 times greater than copepod carbon

Strong cross-shelf variations in N & P



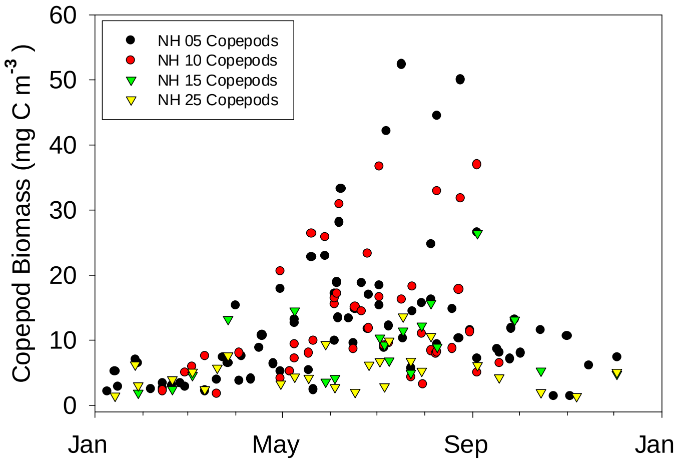
- Nitrate highest nearshore; lowest ofshore;
- Chl-a appears to track changes in nitrate concentration;
- Cross-shelf gradient in growing season: longest at NH 5and shortest at NH 25;
- Nitrate zero offshore during upwelling season but 5 micromolar during winter months;
- The occasional high values of chl-a seen at NH 25 in summer may be due to advection rather than in situ growth.



Strong cross-shelf variations in P & Z

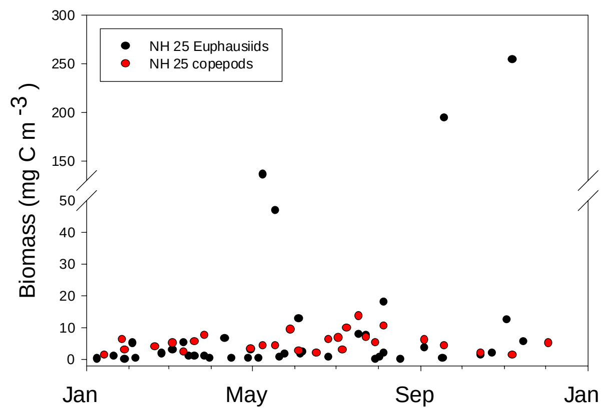
- Pronounced seasonal cycle at NH 5; less so at NH 15 and NH 25;
- High copepod biomass in winter due to *Neocalanus*
- Hint of spring bloom offshore Jan-Feb

Cross-shelf gradients in copepod biomass



- Highest at NH 5; lowest at NH 25
- NH 05 and NH 10 similar; NH 15 and NH 25 similar.
- Maximum biomass in July-August

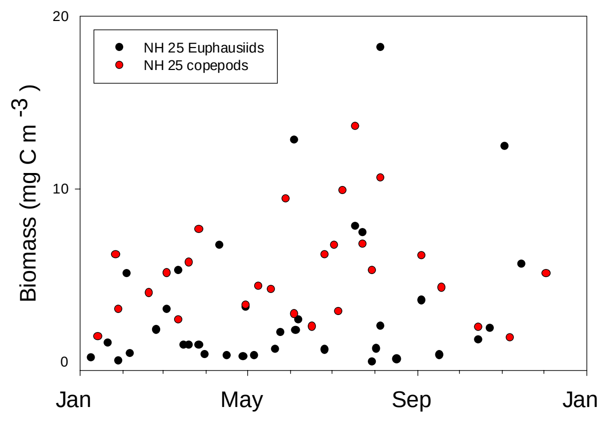
Euphausiids can dominate at NH 25, the shelf break



YEARS 2001-2004

	average copepod biomass	average euphausiid biomass
NH 25	5.3 mg C m^{-3}	17.8 mg C m^{-3}
NH 15	10.9	0.6
NH 10	13.7	1.7
NH 05	12.5	0.1

- Difficult problem because euphausiids are extremely patchy: 4 of 41 samples had extraordinary abundance (Ressler et al. Deep-Sea Res. In press;
- On average euphausiids have 3X more biomass than copepods;
- NEMURO able to include euphausiids as producers and consumers.



- If we delete the four euphausiid “outliers”, result is that on average euphausiid biomass is equal to copepods (~ 3.0 mg carbon m^{-3}

Conclusions

- Strong cross-shelf variations in N, P and Z due to strong gradients in coastal upwelling. Upwelling is expressed primarily in the nearshore zone, within 10 km of shore.
- Year to year variations not great but are significant (discussed in next week's talk).
- Euphausiids important only at the shelf-break but do equal or exceed copepod biomass.

Acknowledgements

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