Oceanography of the Gulf of Alaska and Bering Sea

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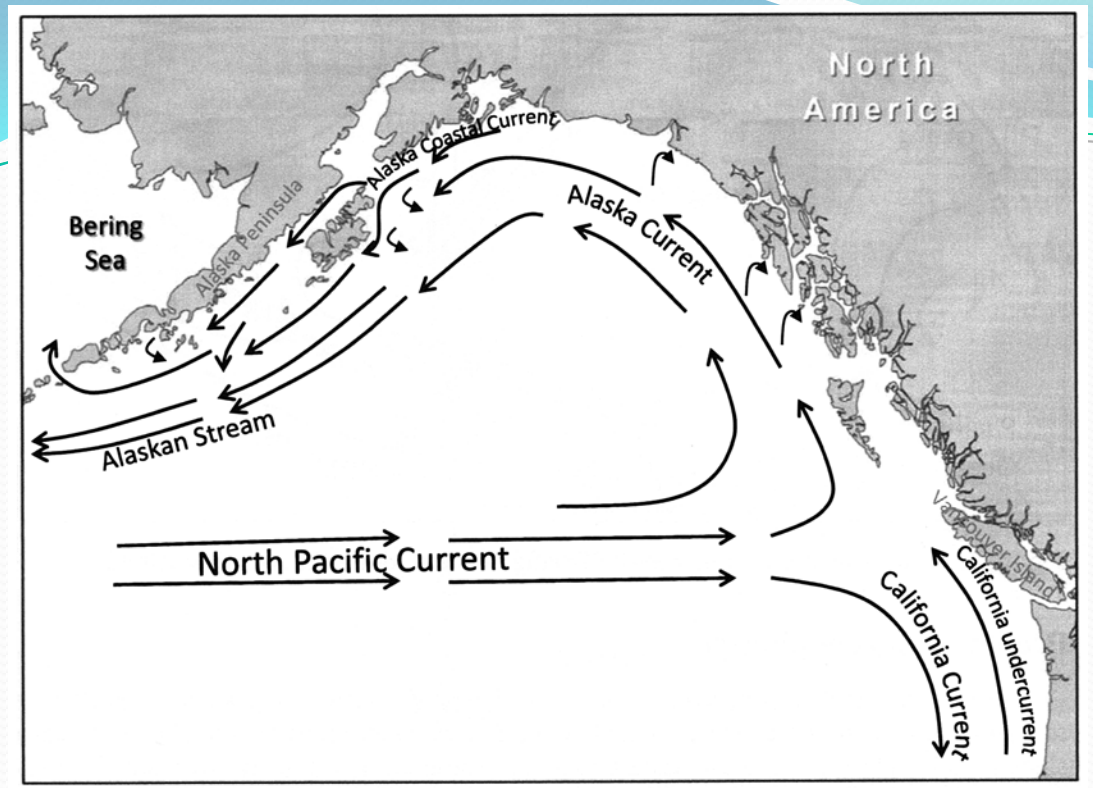
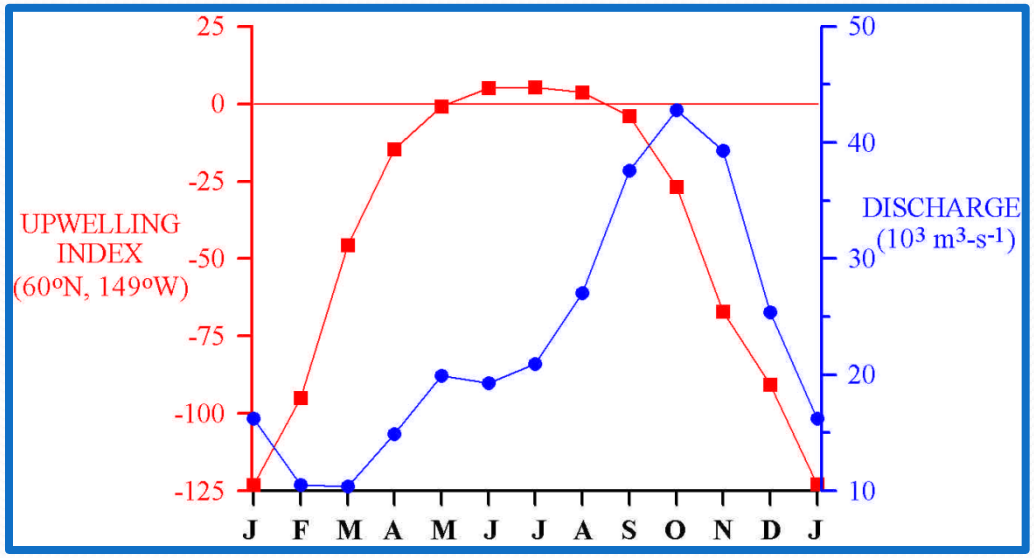
NOAA


Russia
Alaska
ring
a
Bering Slope Current
Aleutian North
Slope Current
Alaska Coastal
Current
Alaskan Stream
Gulf of
Alaska
Alaska Current



Alaska Coastal Current (ACC) driven by winds & freshwater discharge:

ACC transport is maximum in fall



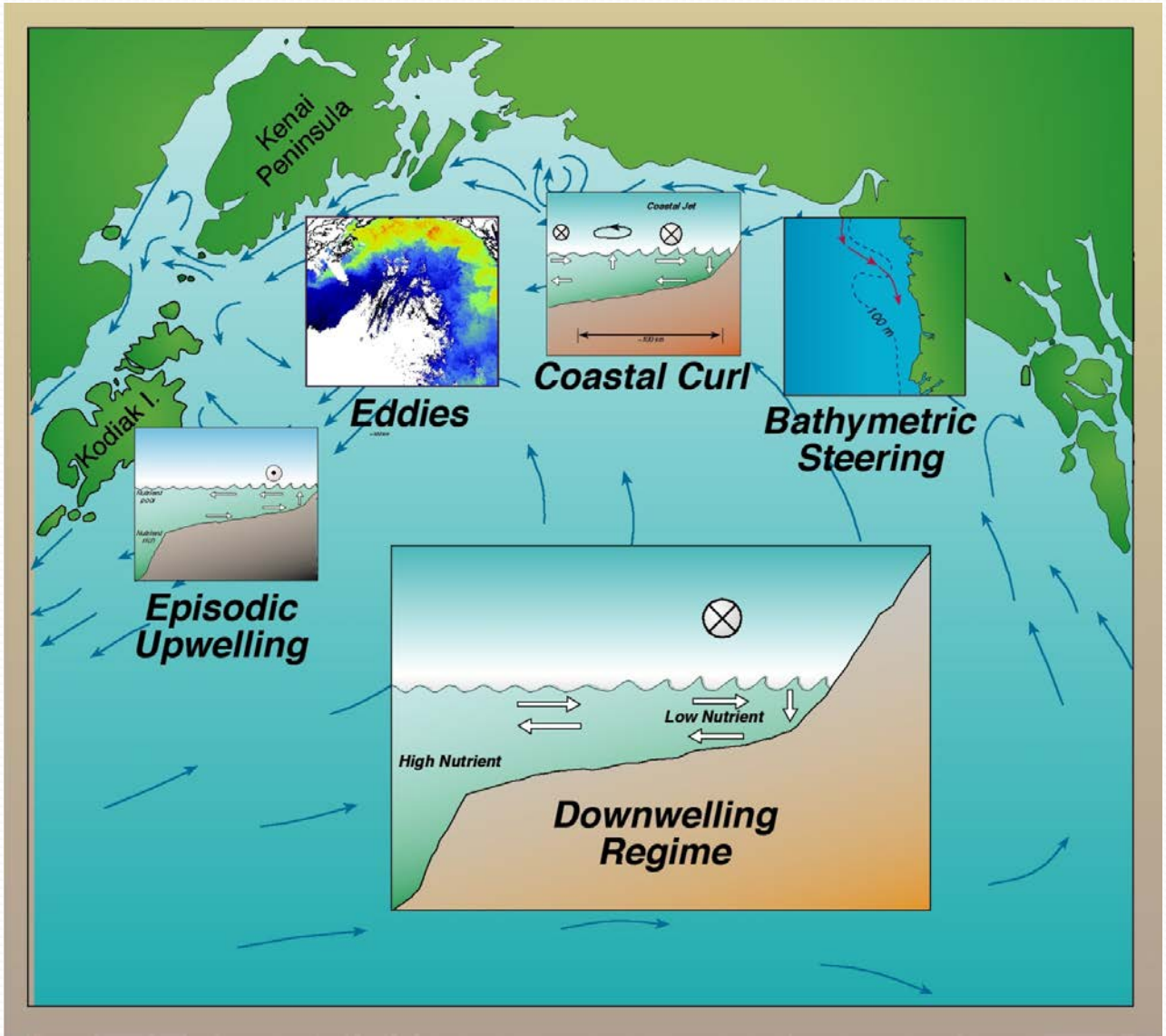
Weingartner et al

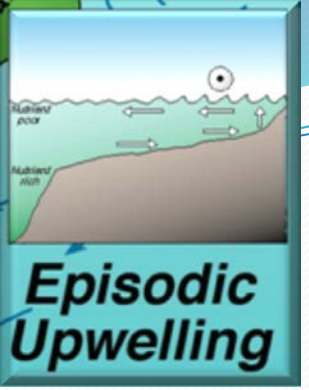

Tourism
Recreation
Commercial Fishing
Sport Fishing
Subsistence
Airborne contamination
Precipitation
Alaska Current
Eddy
Aleutian Low Pressure
WIND
Continental Shelf Break
Mid-shelf Front
Alaska Coastal Current
Coastal Communities
Freshwater runoff
Ekman Transport
Fry
Salmon Migration
Adults
Sea Birds
W
N
Plankton
Phytoplankton
Zooplankton
Forage Fish
Marine mammals
Turbulence
Photic boundary
Downwelling
Shelf-break Front
Carbon pump
DETRITUS
NUTRIENTS
Large Fish
Lunar forcing
GULF OF ALASKA
Sill
Tidal mixing
Overwintering copepods
Benthic Communities
Continental shelf
"Old carbon" + Nutrients
Upwelling
Deep hole
Alaska Digital Graphics

GOA Summary

- Shelf
  - Coastal Current
  - Highly productive Macronutrient limited (after spring bloom)
- Basin
  - Winter mixing replenishes macronutrients to surface
  - Iron limited (HNLC)
- Shelf-break
  - Alaska Current / Alaskan Stream
  - Cross-shelf exchange provides nitrate to shelf and iron to basin

Cross-shelf Exchange Mechanisms





Episodic Upwelling

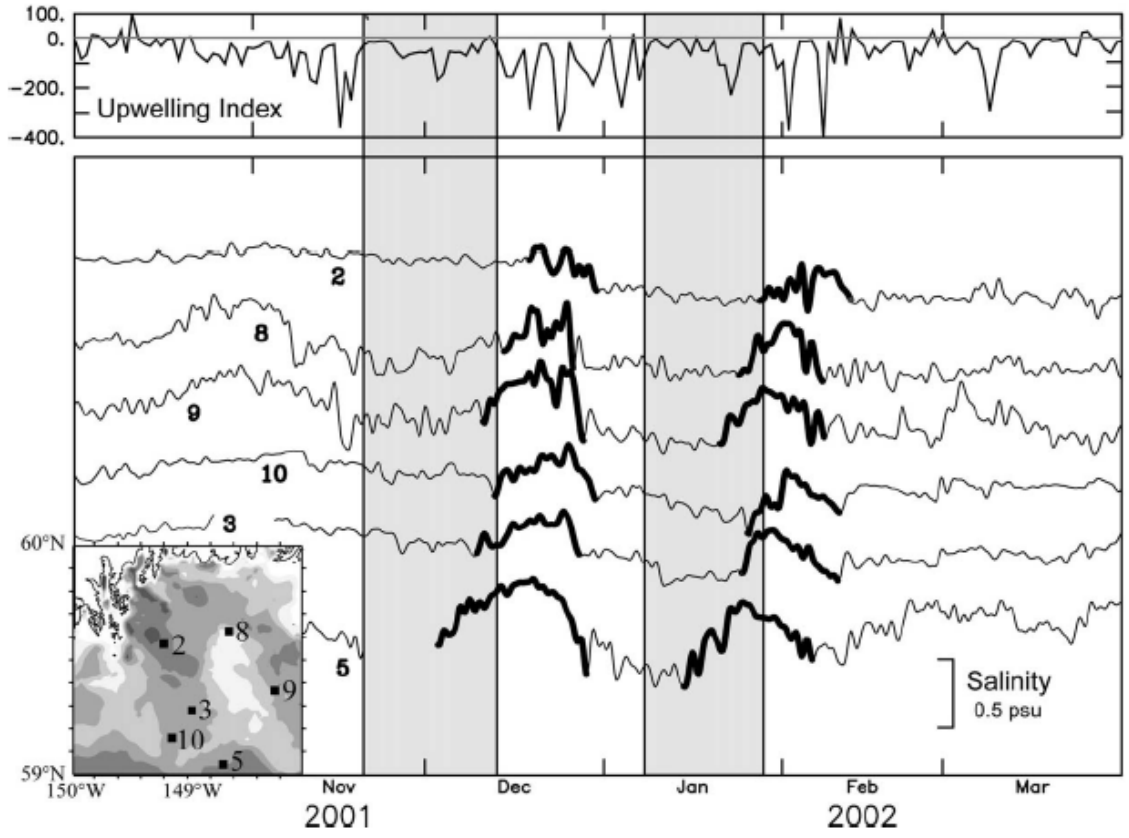
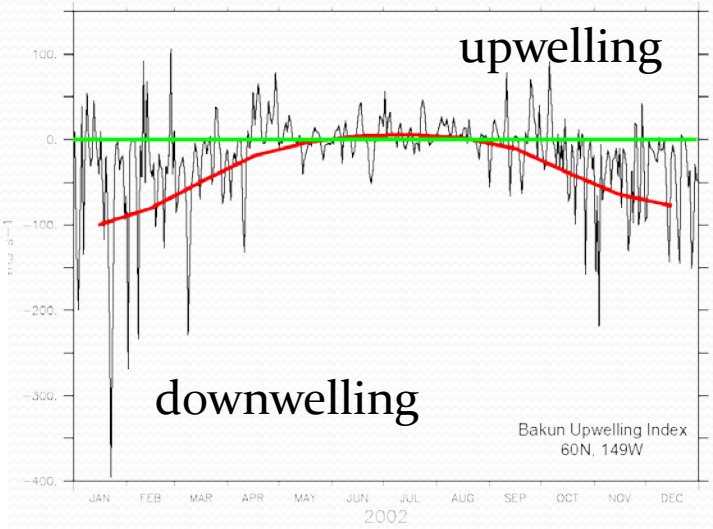
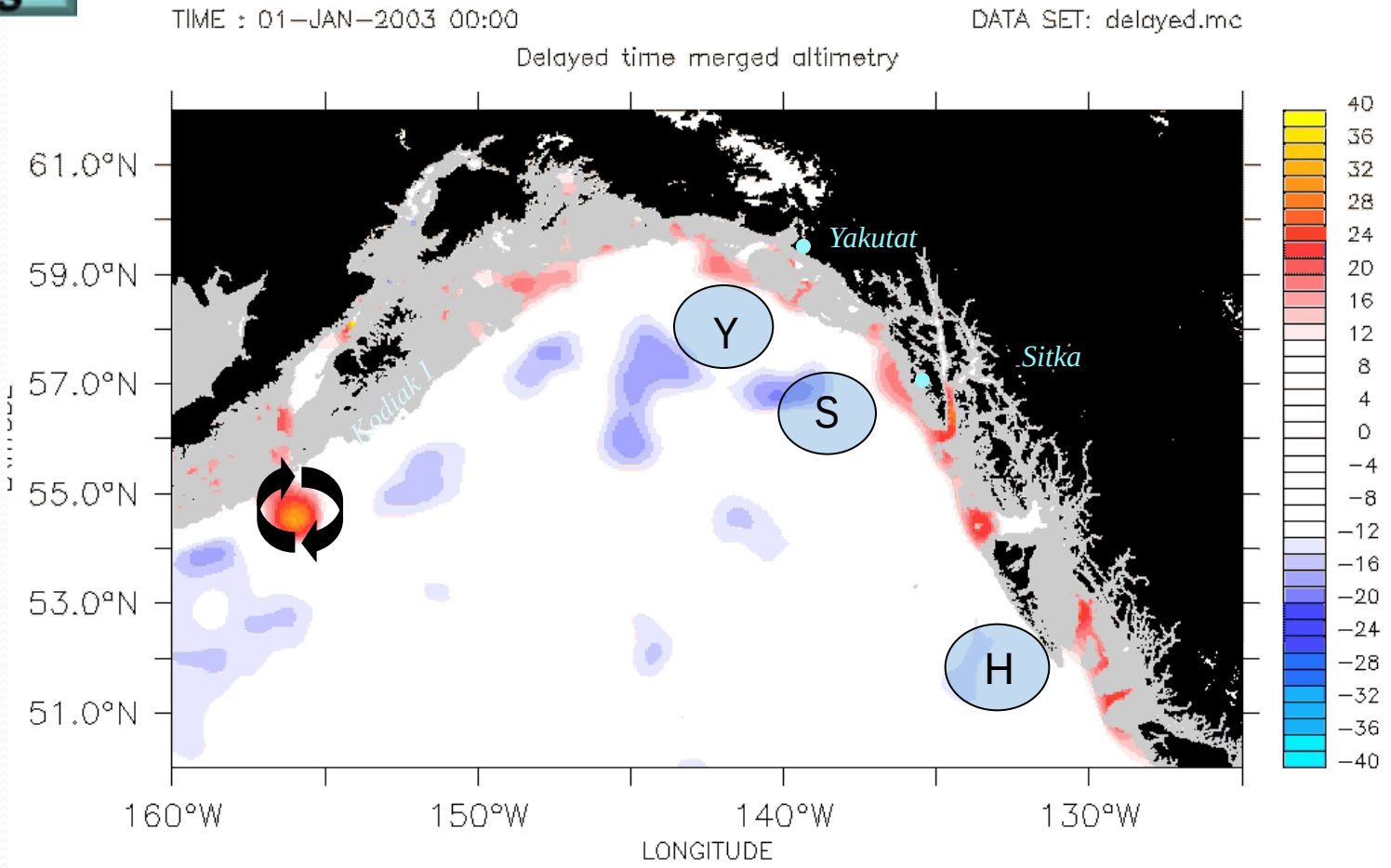


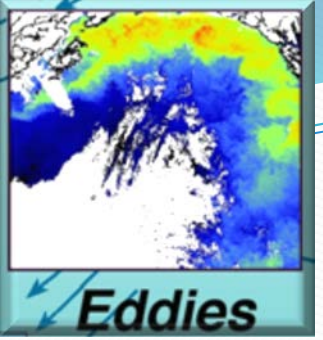
Fig. 3. PFEL Upwelling index ($m^3 s^{-1}$ per 100 m of coastline) at 60°N, 146°W (top), and salinity (psu) from six moorings during October 2001–March 2002. Gray shading denotes periods of weak downwelling winds. Map showing mooring locations is inset. Gray shading on inset denotes bathymetry in 50-m increments from light gray (shallowest) to dark gray (deepest).



Movie – sea surface height

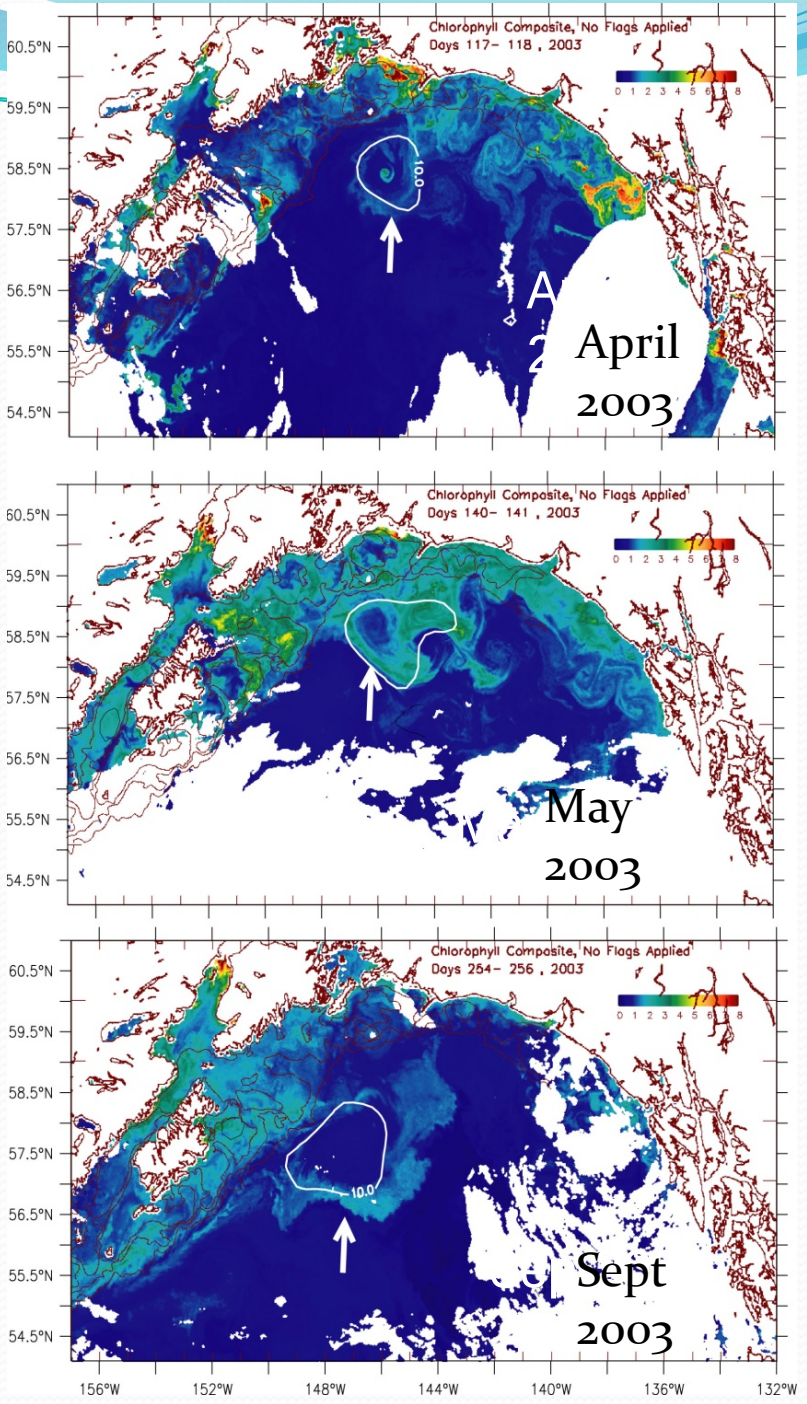


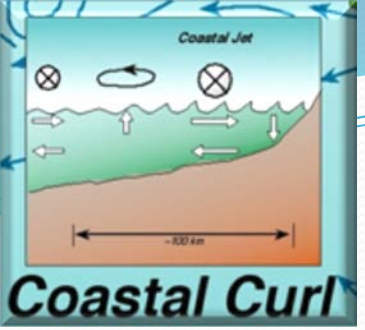
= Formation regions (Yakutat, Sitka, Haida)



Eddies and Chlorophyll

- Advection of coastal chlorophyll into basin
- Vertical processes within the eddy supplying macronutrients and/or iron to euphotic zone.



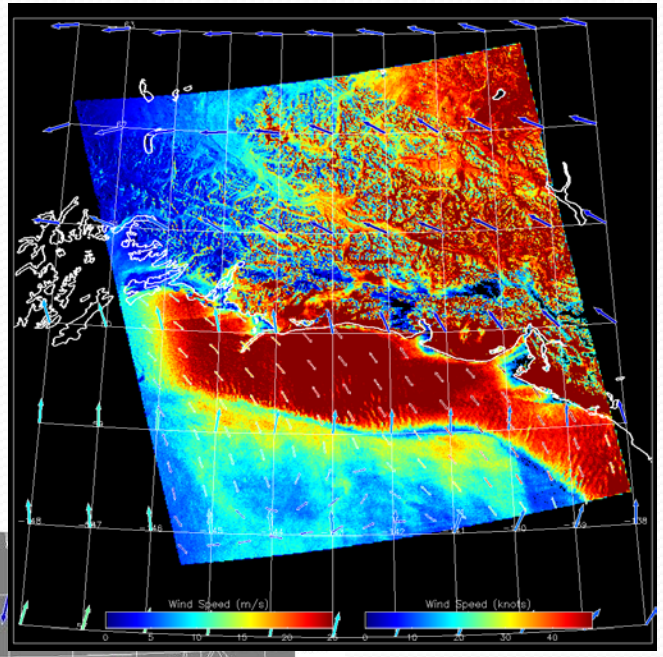


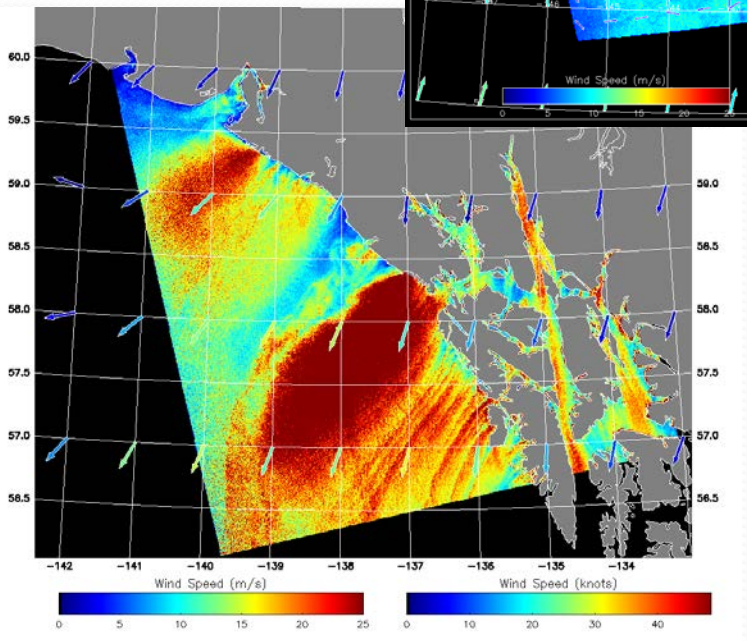
Coastal Winds

Barrier Jets

- Conditions favorable to barrier jets occur 1/3 of time during cool season
- avg Ekman pumping velocity of 10 m/day over cool season

SAR satellite wind data (warm colors are high wind speeds)



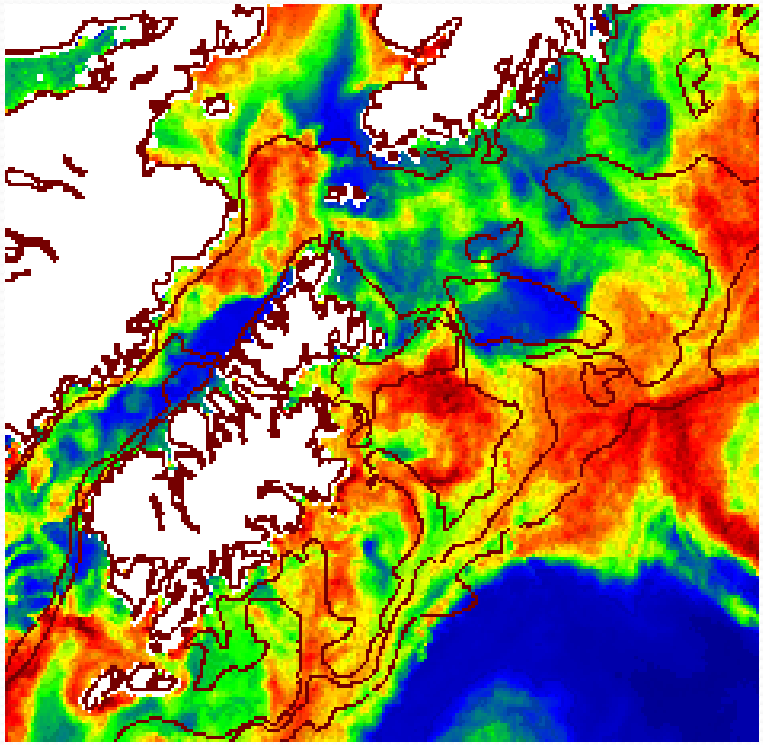


Gap Winds

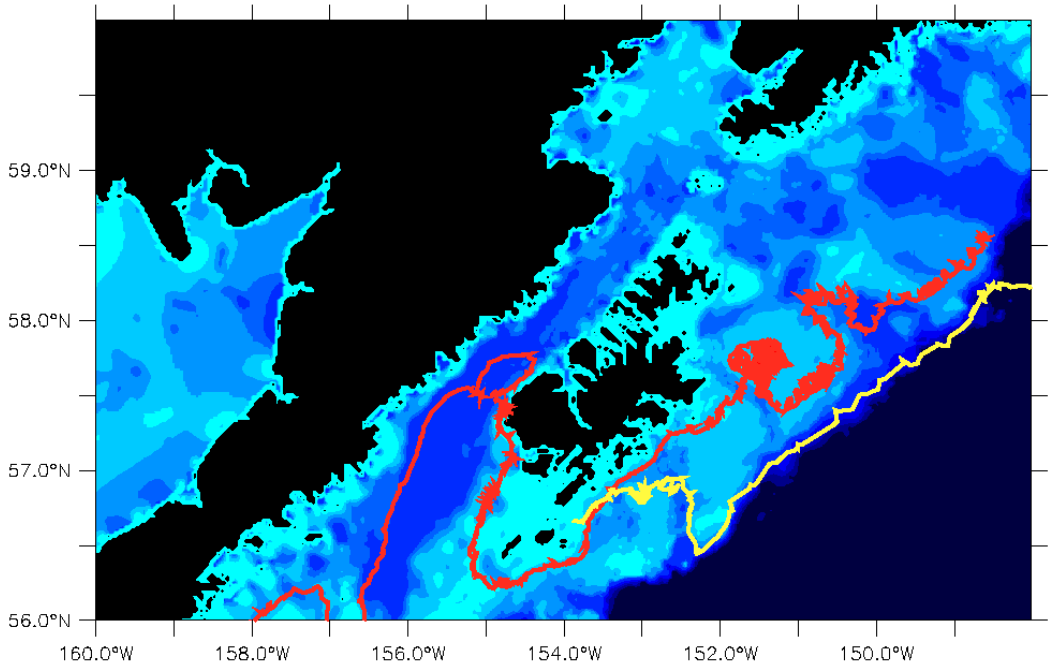
- Influence eddy formation
- Extend region of coastal influence off-shelf

Bathymetric Steering

SeaWiFS chlorophyll data



15 May – 29 May 2002



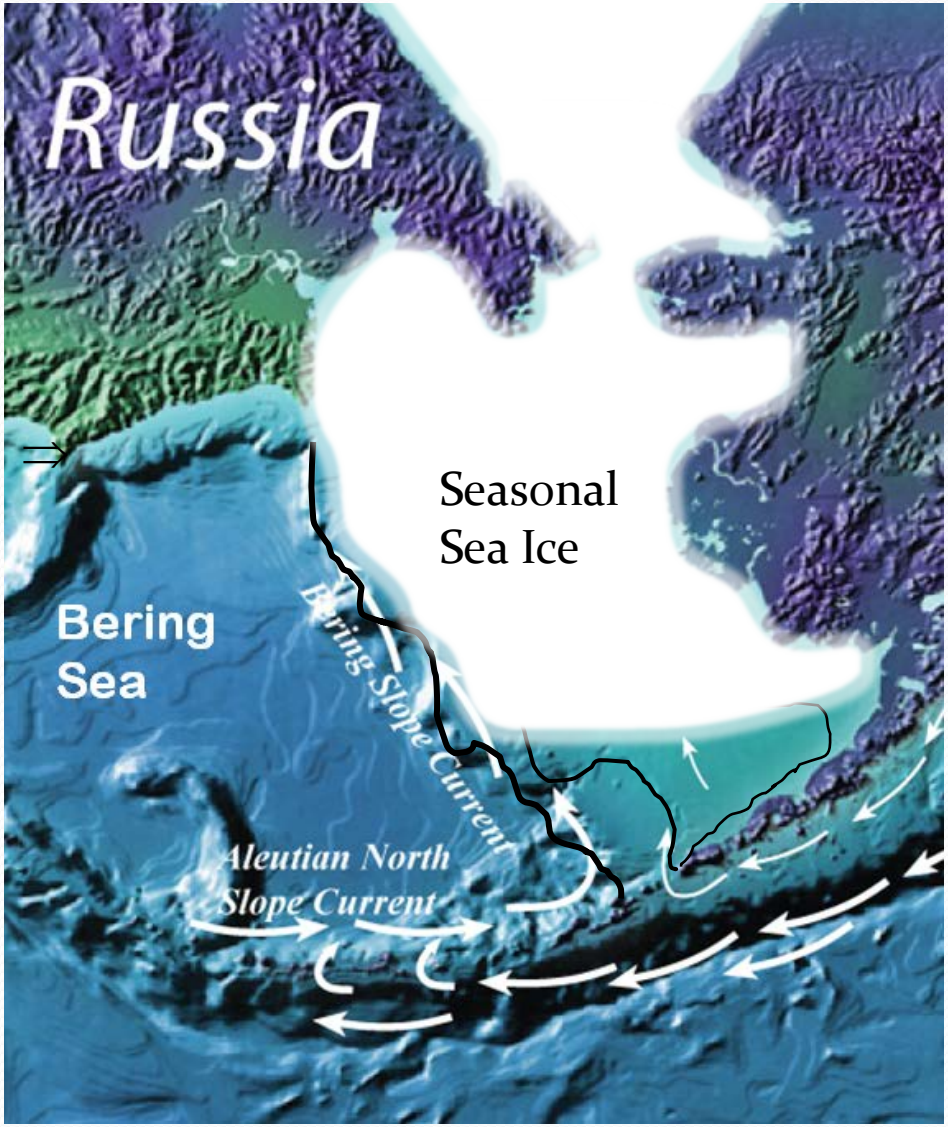
Drifter Data

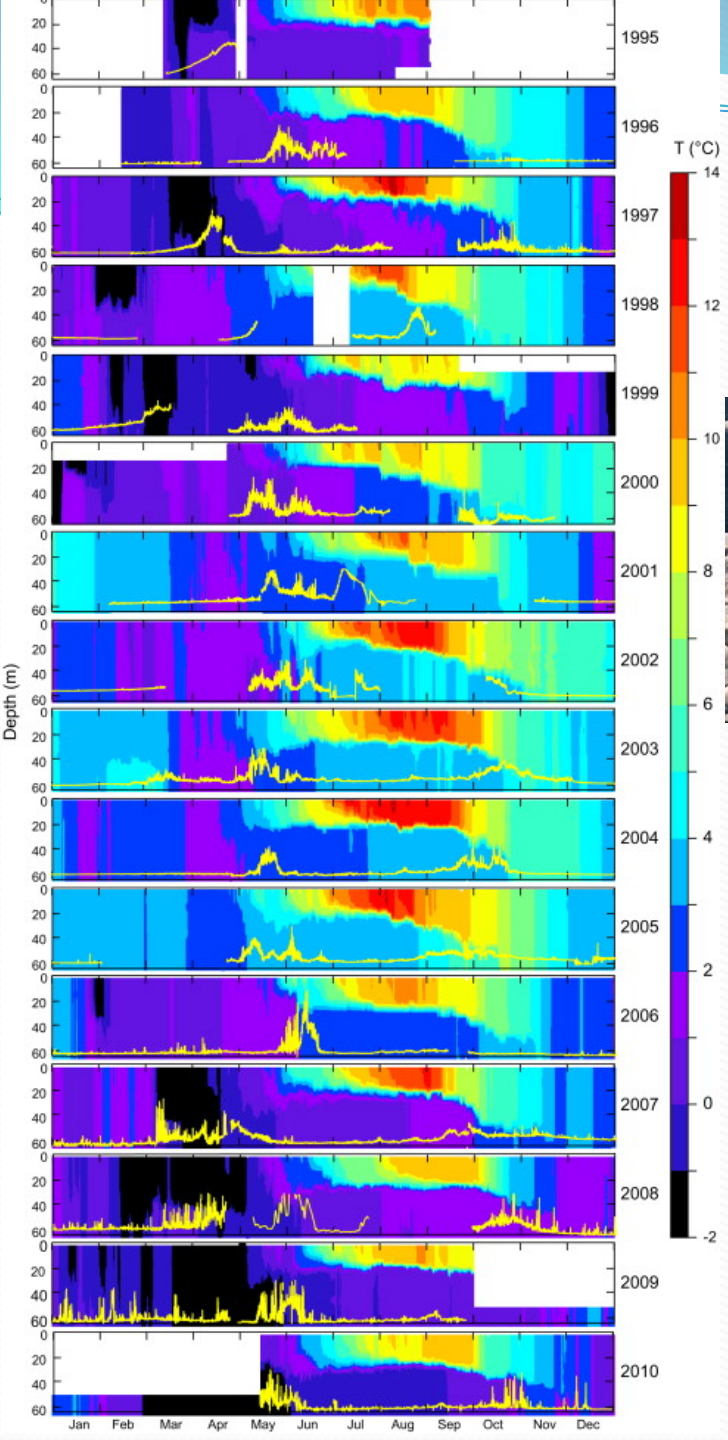
Cross-shelf Exchange Mechanisms in the GOA

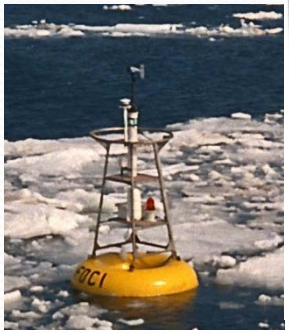
- Downwelling winds ⇒ onshore flow at surface (inhibited by boundary currents)
- Episodic upwelling winds ⇒ onshore flow at depth
- Eddies carry coastal water off-shelf both in core of eddy and advected around edges; may also result in on-shelf flow by reducing the strength of shelf-break front
- Coastal wind jets ⇒ variations in upwelling strength
- Bathymetric steering ⇒ on/off-shelf flow and mixing in canyons

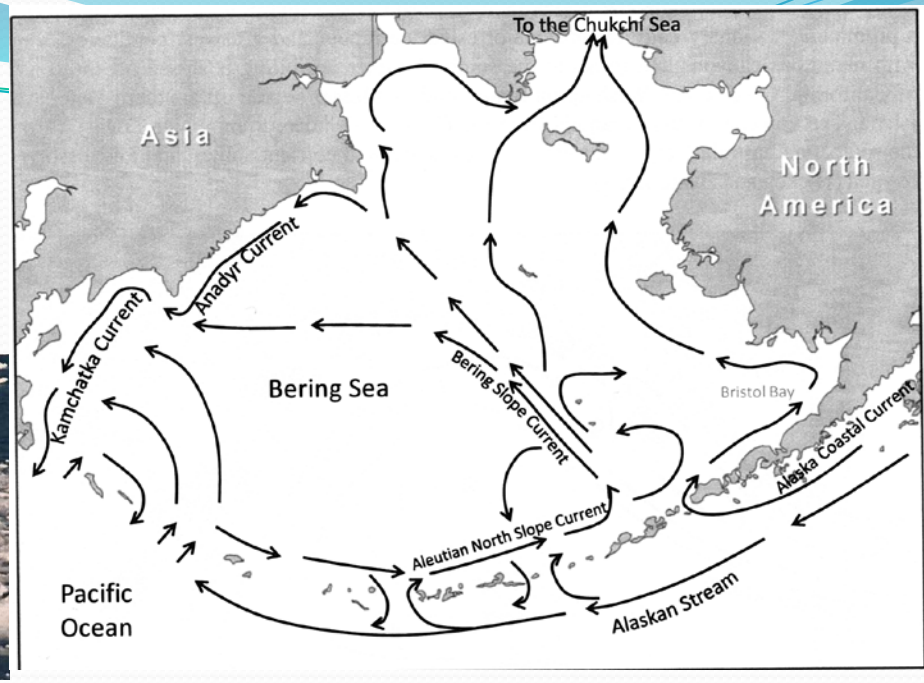
Bering Sea

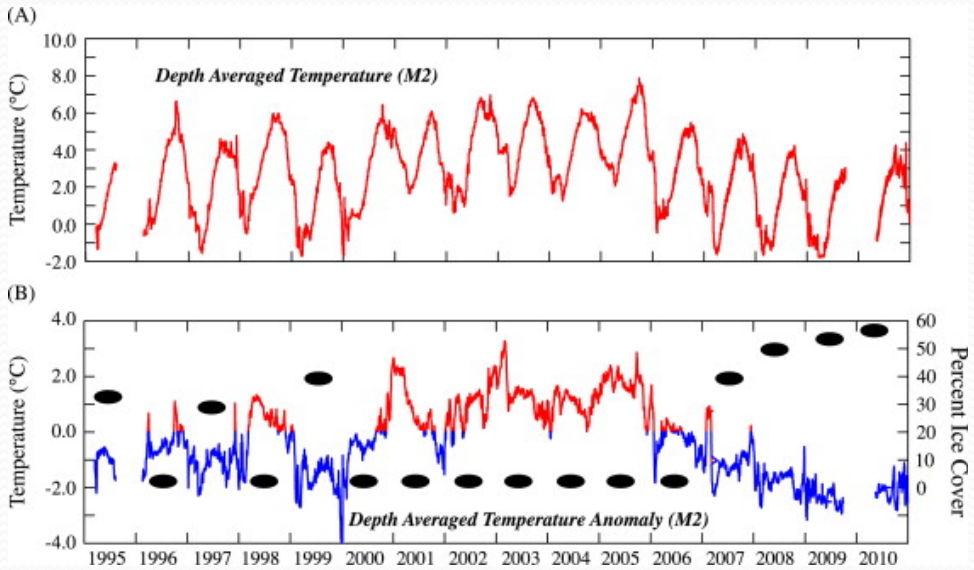
- Wide shelf (>500 km)
- 3 shelf domains (coastal, middle shelf, and outer shelf)
- Marginal Ice zone
- Sea ice, temperature, stratification important to ecosystem



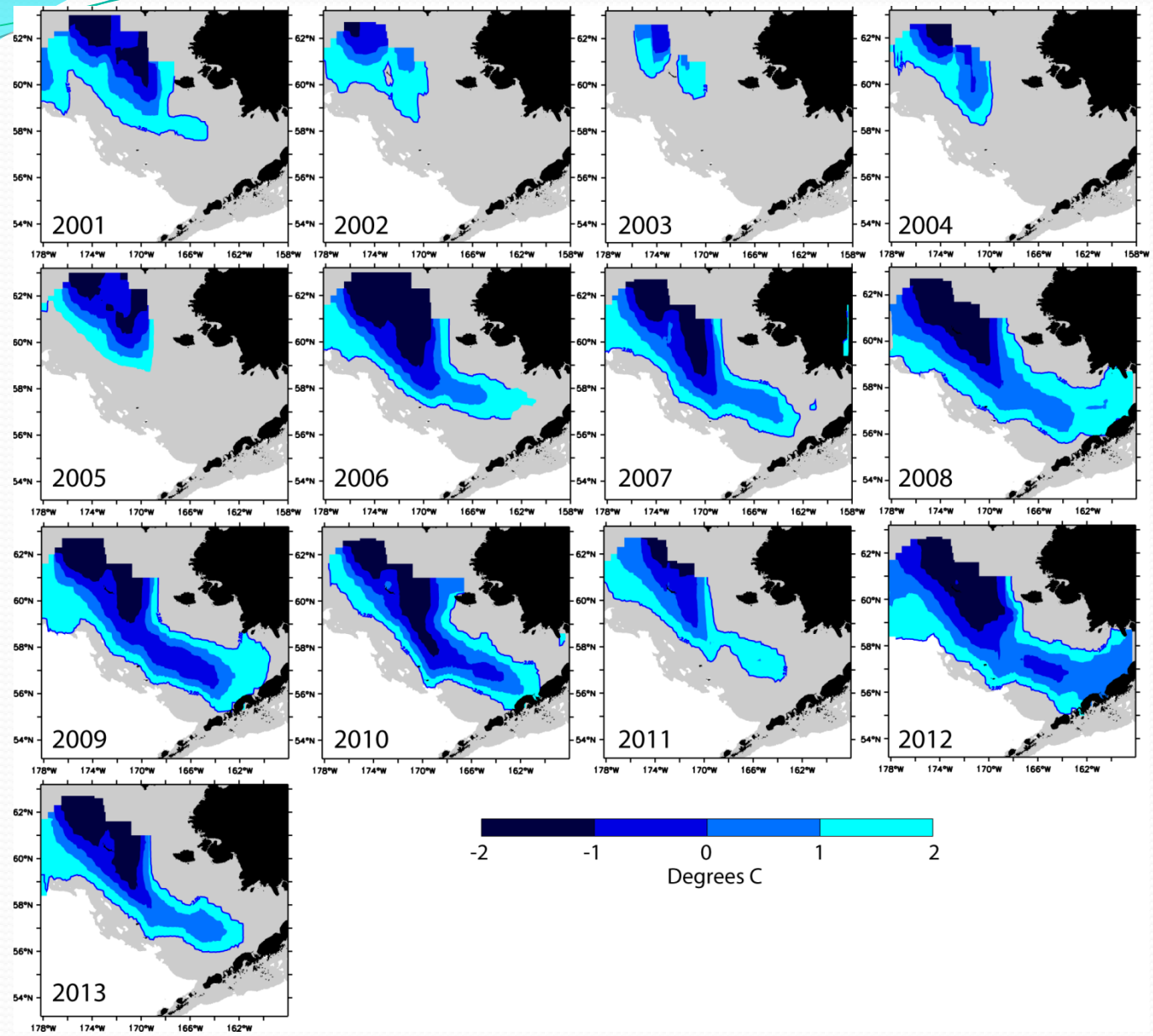








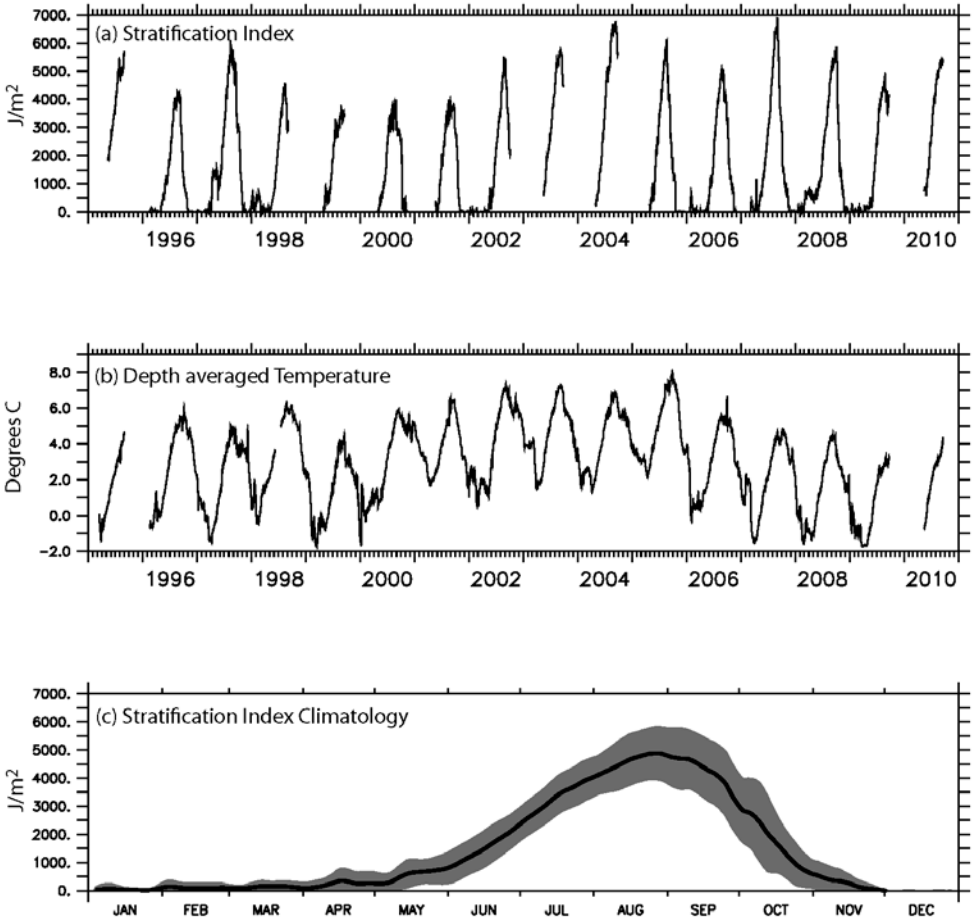
Stabeno, et al. 2012



Bottom Temperatures (Cold Pool)

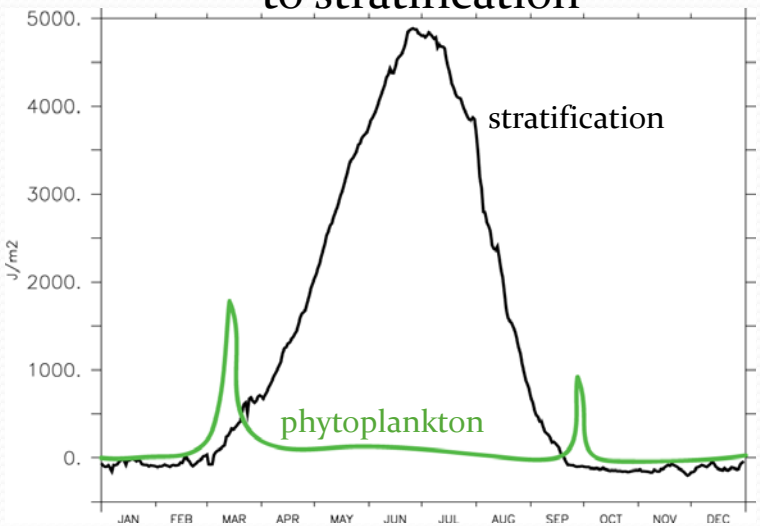
Stratification

Interannual variability of stratification



Ladd & Stabeno, 2012

Phytoplankton response to stratification



- Strength of maximum annual (summer) stratification (influences phytoplankton species composition & size)
- Timing of initiation and break-down of stratification (influences timing of blooms)

Bering Sea variability

Sea Ice:

- Very extensive in early 1970s; very little ice in early 2000s; more ice since 2006
- Timescale of variability has changed: interannual prior to 2000; ~5 yr cycles after
- Timescale of variability is important! (interannual variability has less influence than ~5 yr strings of warm/cold conditions)
- Influences ice associated marine mammals and birds, timing of spring bloom, zooplankton species composition, water column vs benthic dominated ecosystem

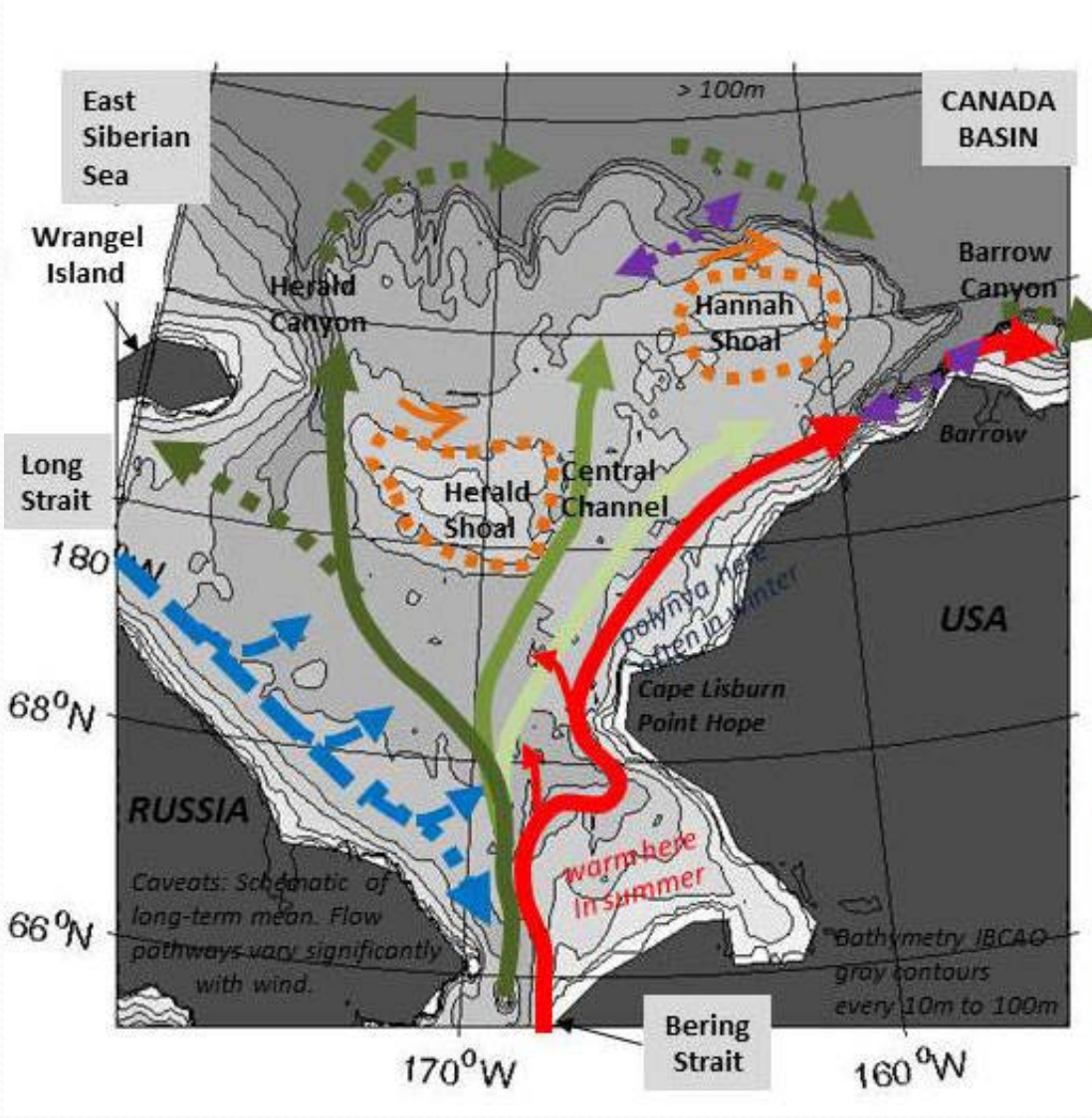
Temperature:

- Variability is associated with sea ice distributions
- Influences habitat available to some species (northward shift in distribution of some species has been observed with warming)
- Cold pool avoidance reduces habitat availability during heavy ice years

Stratification:

- Weak stratification in late 1990s, early 2000s
- Stronger stratification since 2002
- Trend toward later stratification break-down in fall may result in reduction or absence of fall bloom

Chukchi Sea Circulation



Bering Sea Water, made up of nutrient–rich Anadyr Water (in west, dark green) and lower nutrient Bering Shelf water (lighter greens)
- Exits Arctic via Barrow Canyon, Central Chann Herald Canyon, and maybe Long Strait.
- Some follows shelf break to east, some moves into Canada Basin

Alaskan Coastal Current
- fresh, warm
- present summer to late fall
- loses water to central Chukchi

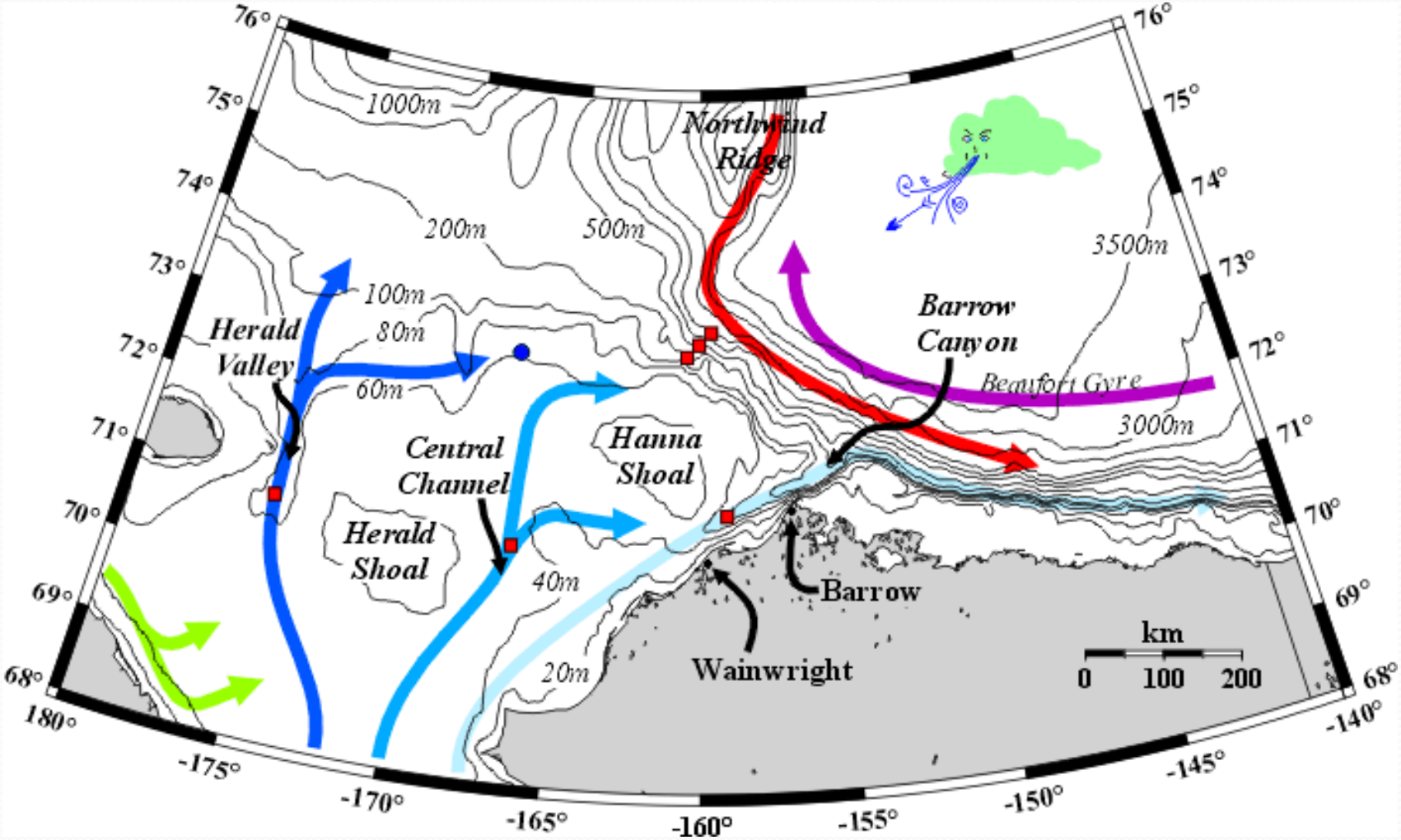
Siberian Coastal Current
- fresh, cold
- present some summers
- may reach Bering Strait, or may exit into central Chukchi

Likely **topographically trapped anticyclonic (clockwise) circulations** over Herald and Hannah Shoal, (Topography may be inaccurate here.)

Upwelling up shelf break canyons brings Arctic waters up onto Chukchi Sea. E.g.,

Woodgate, Aagaard, Weingartner

Beaufort Sea Circulation



Weingartner et al. 2016