Seasonal nutrient dynamics

in the western Bering Sea

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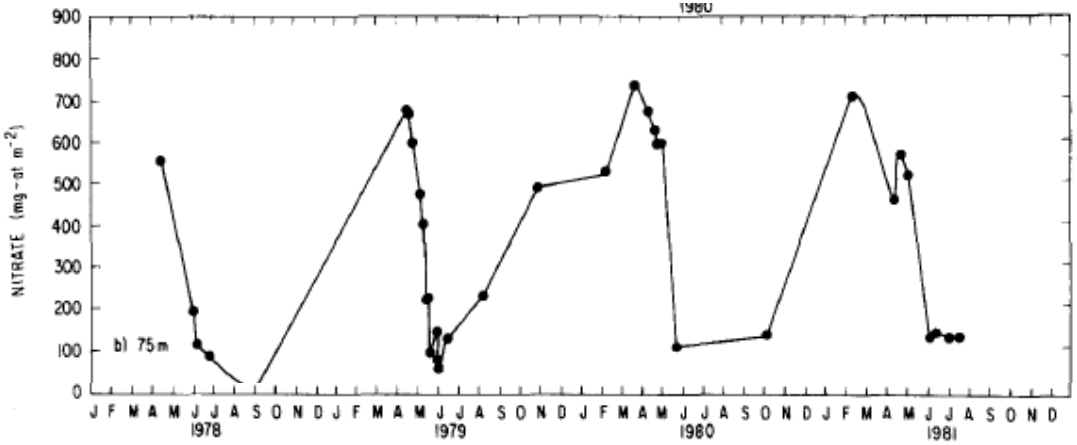
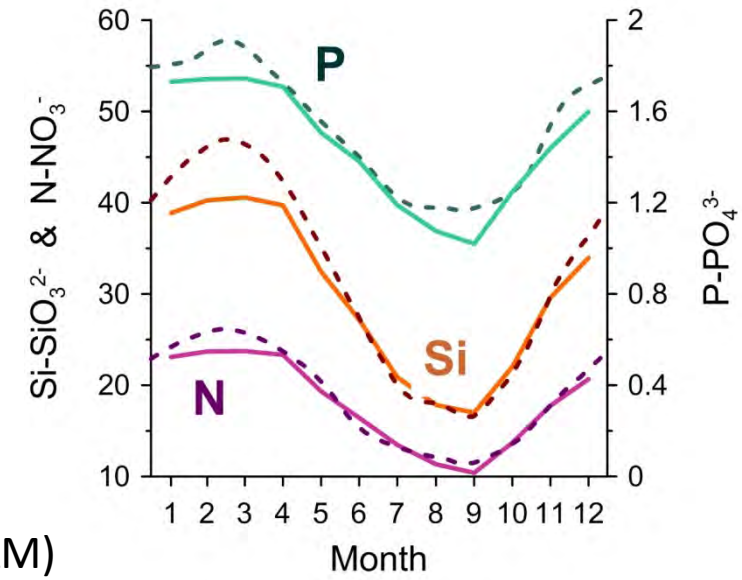
What is known?

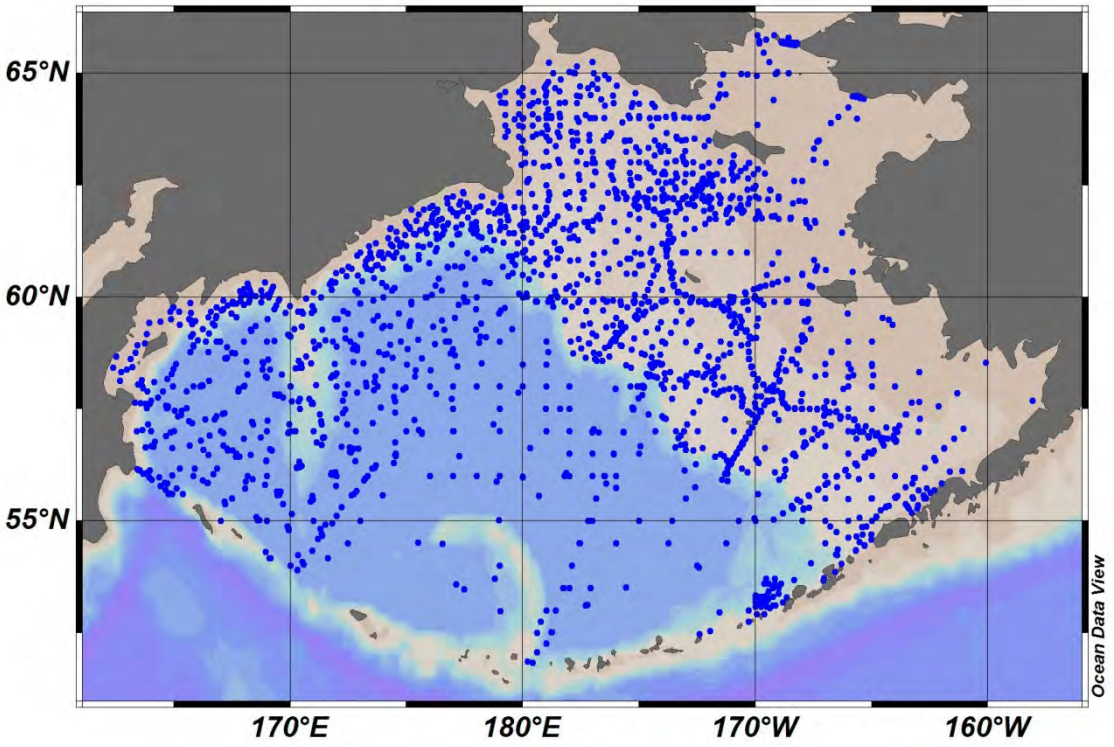


0-135 m integrated nitrate along main section of PROBES experiment (*Whitledge et al., 1986*)



Surface Si, N, and P concentrations (µM) from ships of opportunity for the southern Bering Sea

Data



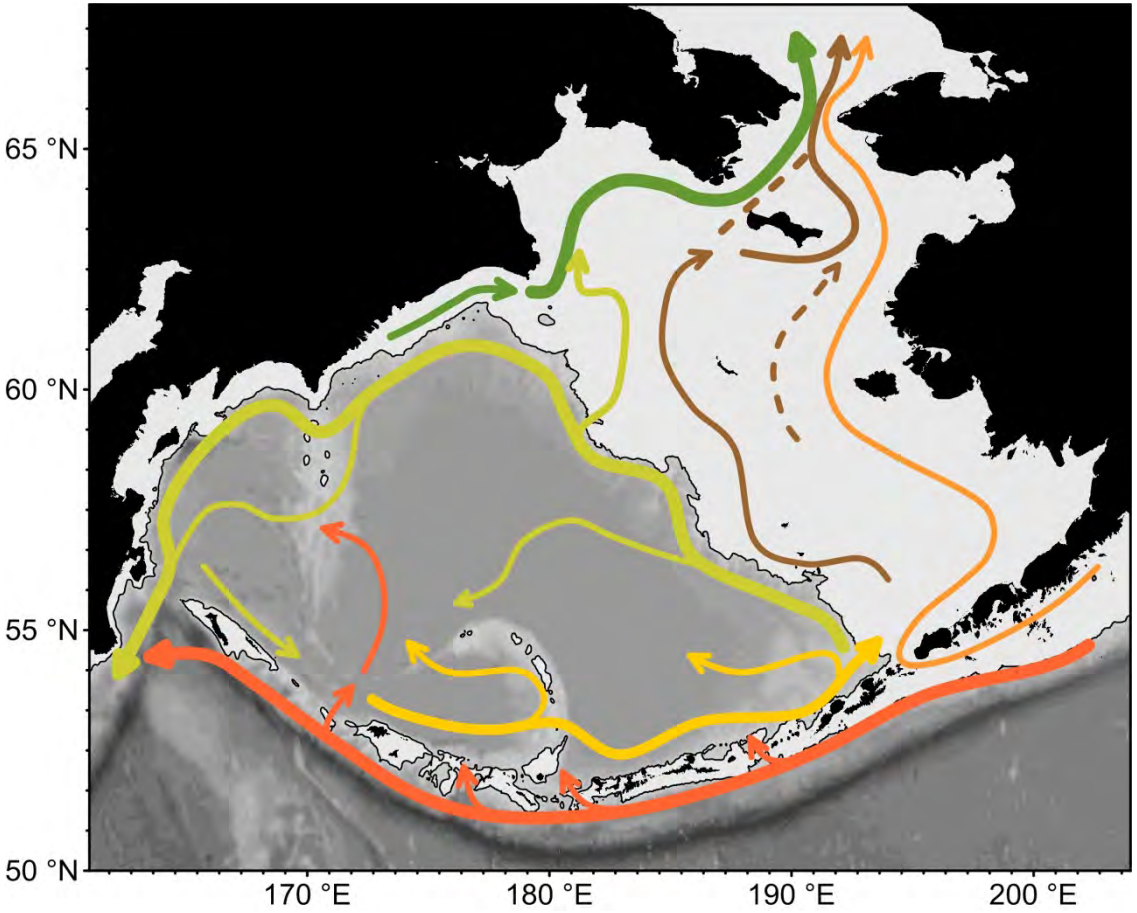
2700 stations including:

- TINRO-Center Surveys (Russia)
- World Ocean Dataset
- BEST-BSIERP (Bering Ecosystem Study-Bering Sea Integrated Ecosystem Research Project, USA)
- BERPAC (USSR-USA Project)
- R/V Mirai Surveys (Japan)

What is still missing:

- RUSALCA (RUSsian-American Longterm Census of the Arctic)
- BASIS (Bering-Aleutian Salmon International Survey, USA-Russia)
- T/V Oshoro-Maru & R/V Tahiro-Maru Surveys Data (Japan)

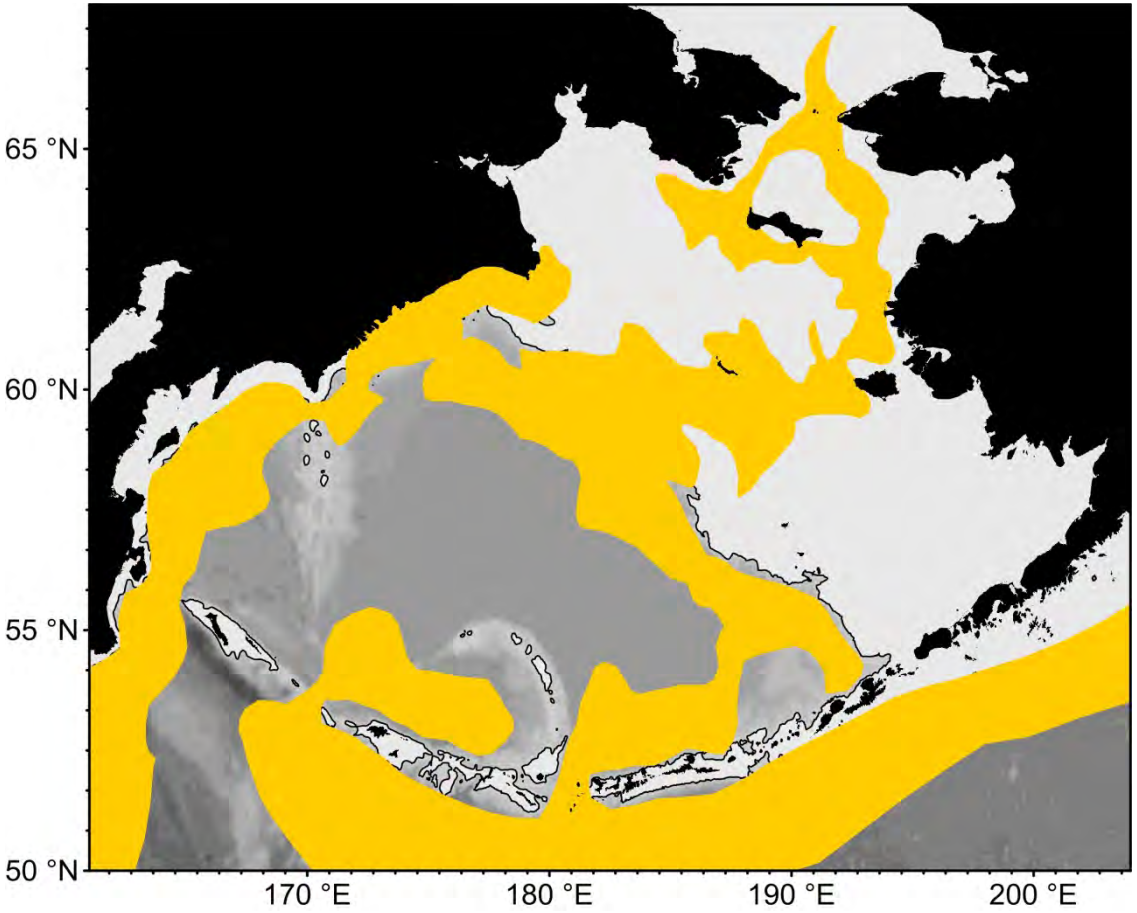
Introduction



Currents of the Bering Sea

Based on: *Verkhunov et al., 1995 (in Russian); Danielson et al., 2011; Kinney et al., 2009; Khen, 2001 (in Russian); Khen et al., 2013; Ladd, 2014; Panteleev et al., 2006, 2011*

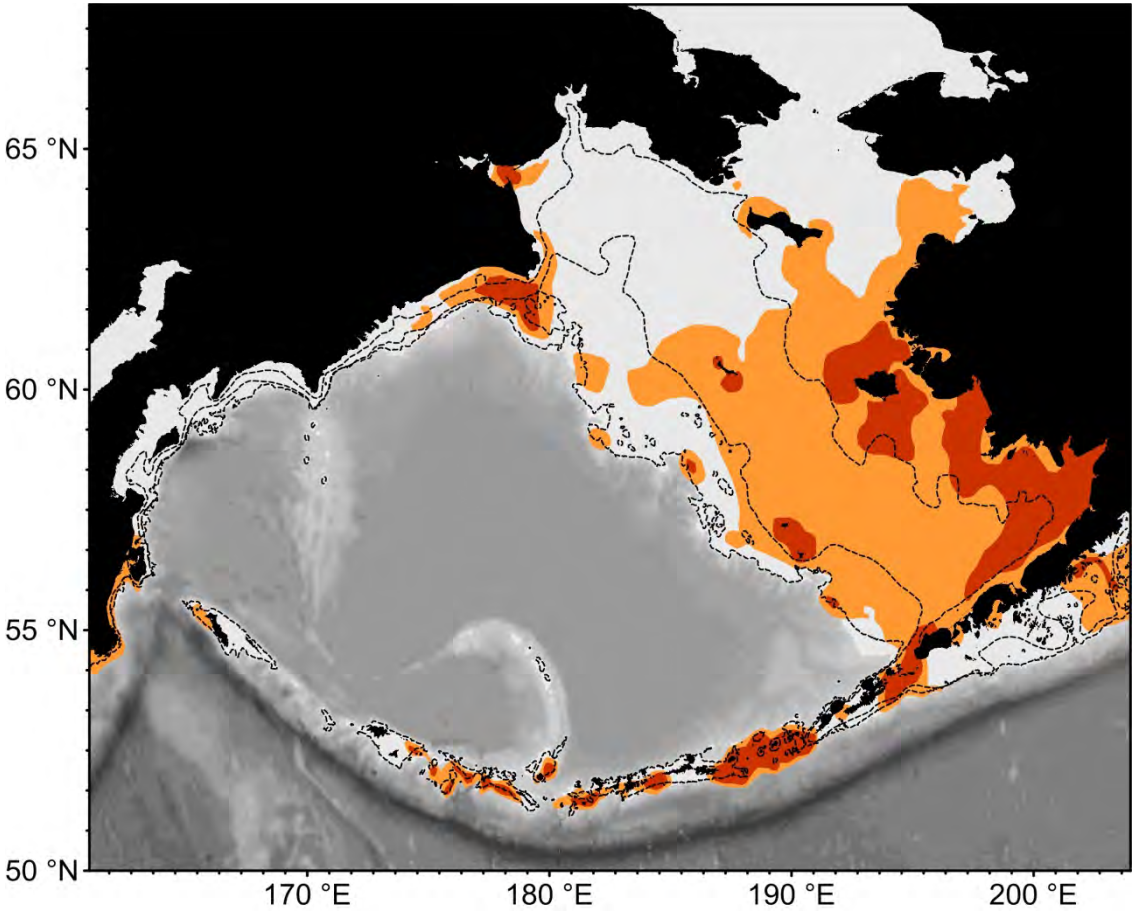
Introduction



Areas with eddy kinetic energy > 50 $cm^2\ s^{-2}$

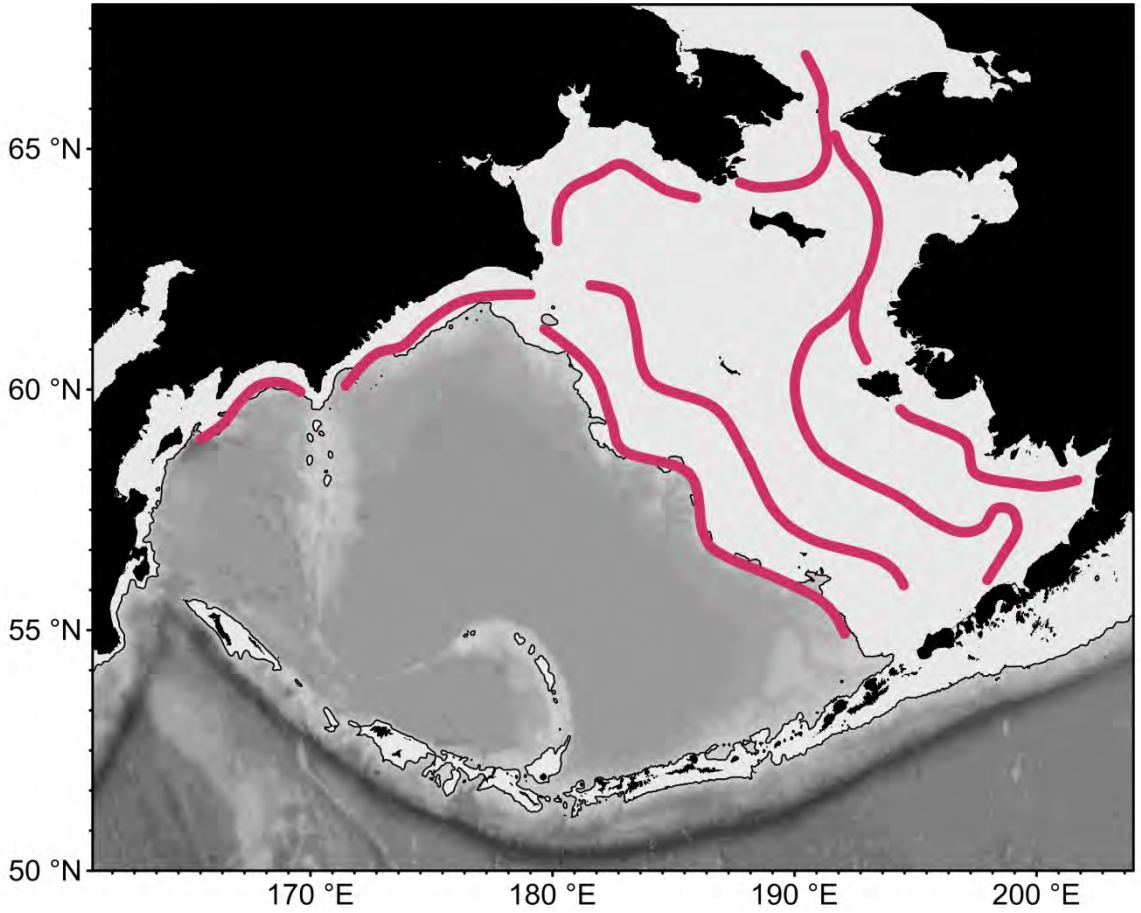
Based on satellite altimeter data averaged over 1993-2009 (*Ladd & Stabeno, 2012)* and numerical modeling where depth is < 200 m (*Clement et al., 2005*)

Introduction



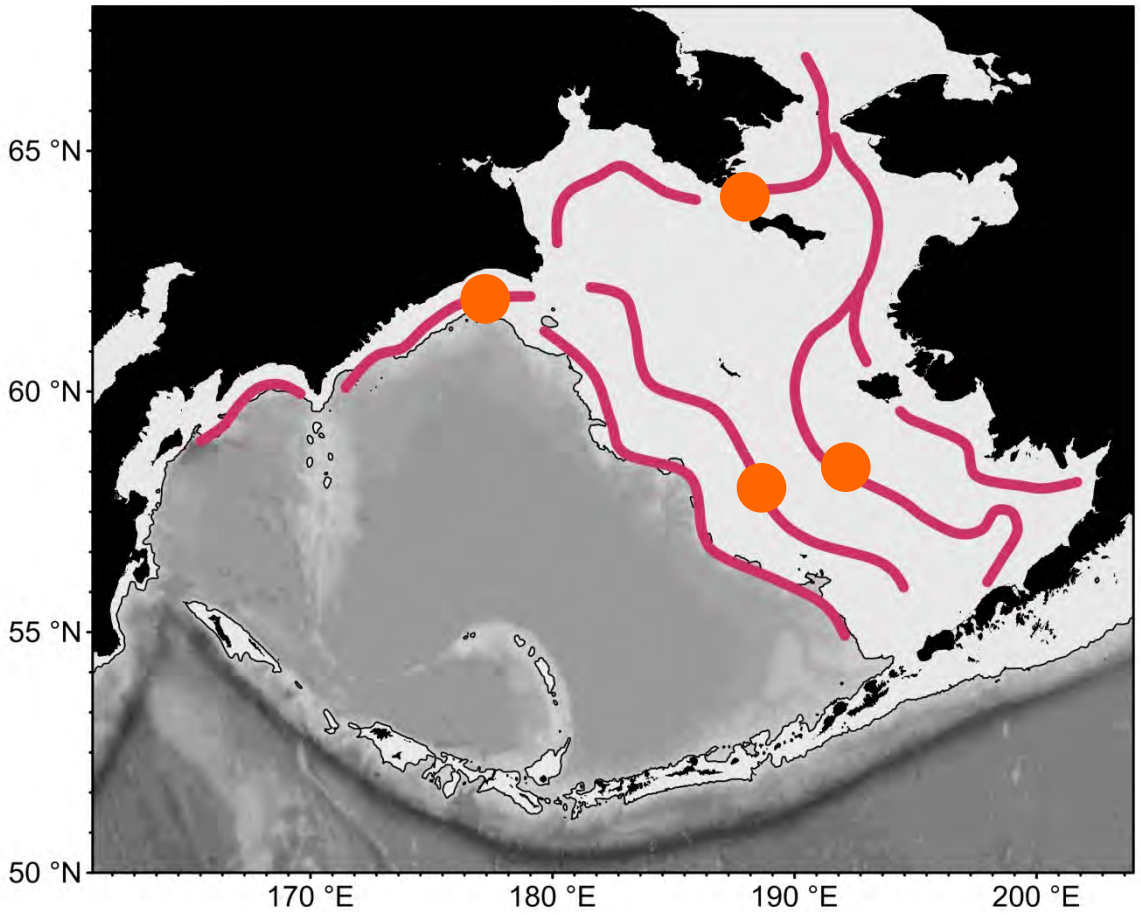
Coastal areas of tidal energy dissipation (M_2 or K_1) > 0.01 W m^{-2}
After *Foreman et al., 2006*

Introduction



Shelf frontal zones of the Bering Sea during May-September
Based on *Belkin and Cornillon, 2005* data compared with previously published data on frontal systems (*Verkhunov, 1995 (in Russian); Coachman and Charnell, 1979; Gawarkiewicz et al., 1994; Kinder and Coachman, 1978; Khen, 1999; Schumacher et al., 1979*) as well as VNIRO and TINRO data

Introduction

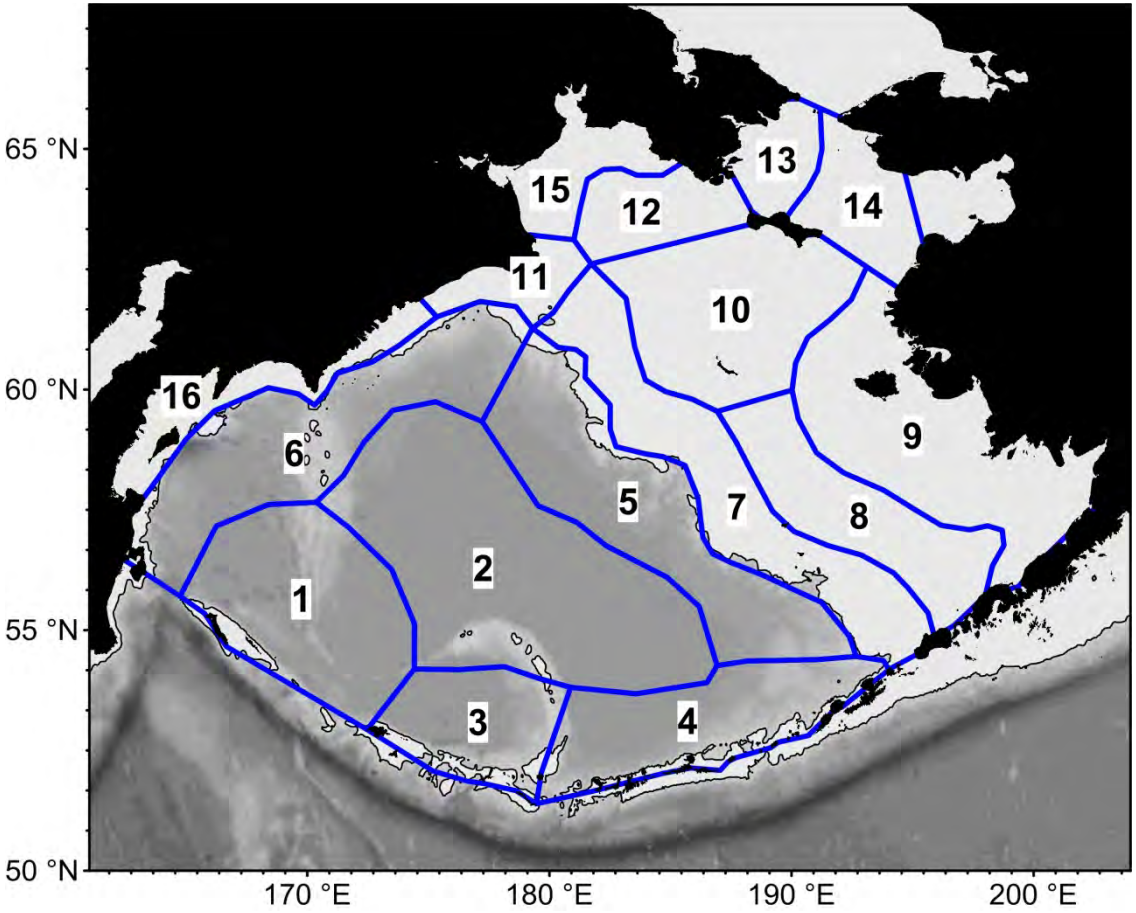


According to *Coachman, 1986*, there is upwelling of subsurface water within the frontal zones on the south-eastern Bering Sea shelf

Similar conditions are reported for the Koryak shelf region (*Verkhunov, 1995 – in Russian*)

Upwelling in the Anadyr Strait and Chirikov Basin is documented by several studies (i.e. *Nihoul et al., 1993; Ivanova, 2010*)

Regions delineation



Resulting qualitative regions delineation

For present study we focus on regions ## 1, 2, 6, 10

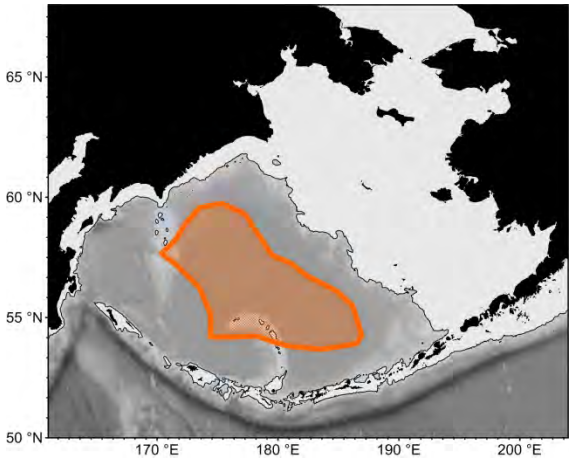
Methods

- Data collection in Ocean Data View (Shlitzer, 2011)
- Collection visual revision to skip questionable data
- Data were exported to ASCI-files for every region
- Exported data is processed in Fortran 90:

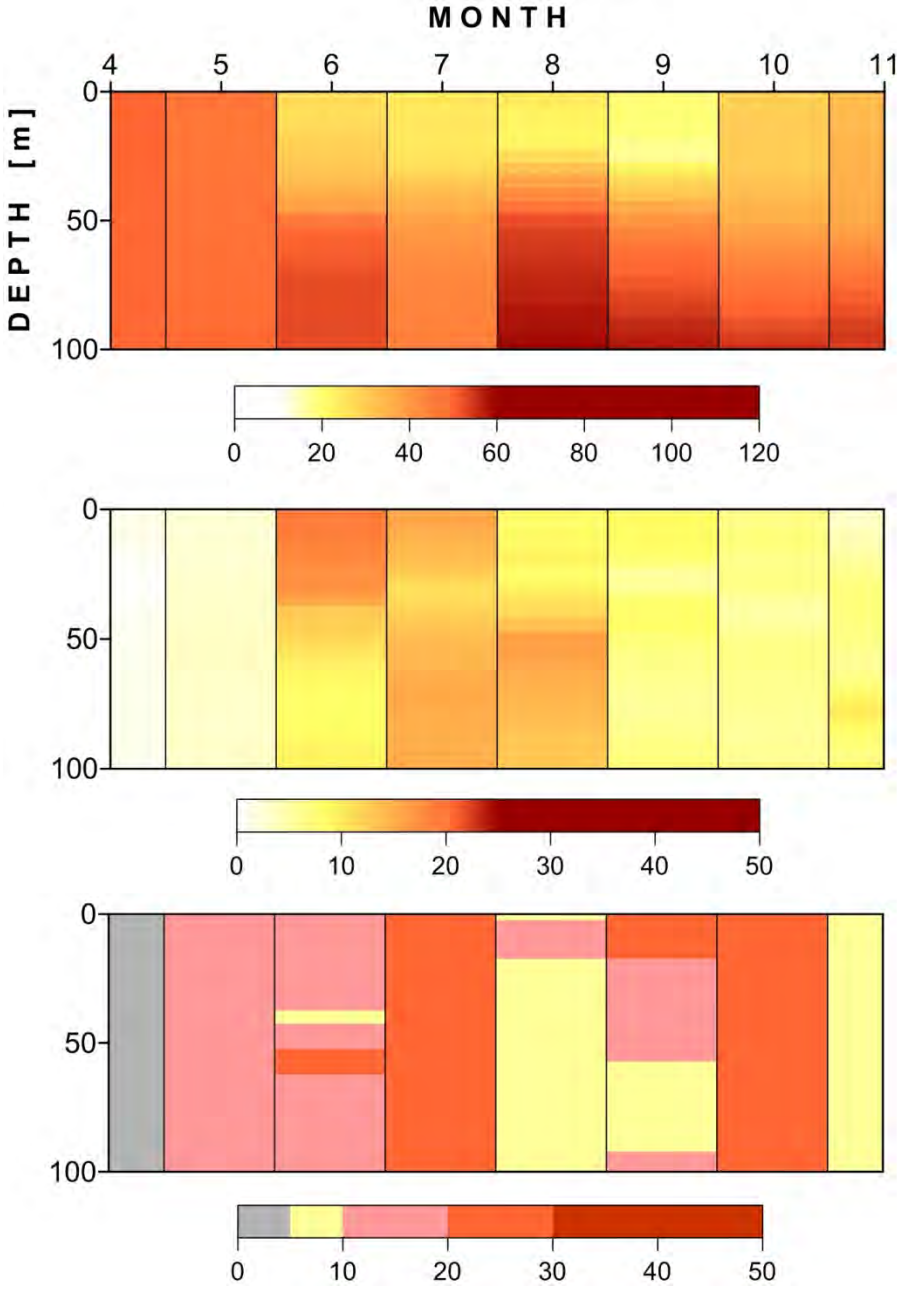
  1) linearly interpolated to 1 m bins if applicable

  2) mean regional monthly profiles and

  3) SD calculated
- Seasonal dynamics is visualized in Golden Software
- ΔSi / ΔN / ΔP values are assessed for selected time intervals



Example of mean seasonal silicate dynamic for region #2 (top panel), along with standard deviation (middle panel) and number of points per 5 m bin per month (lower panel)

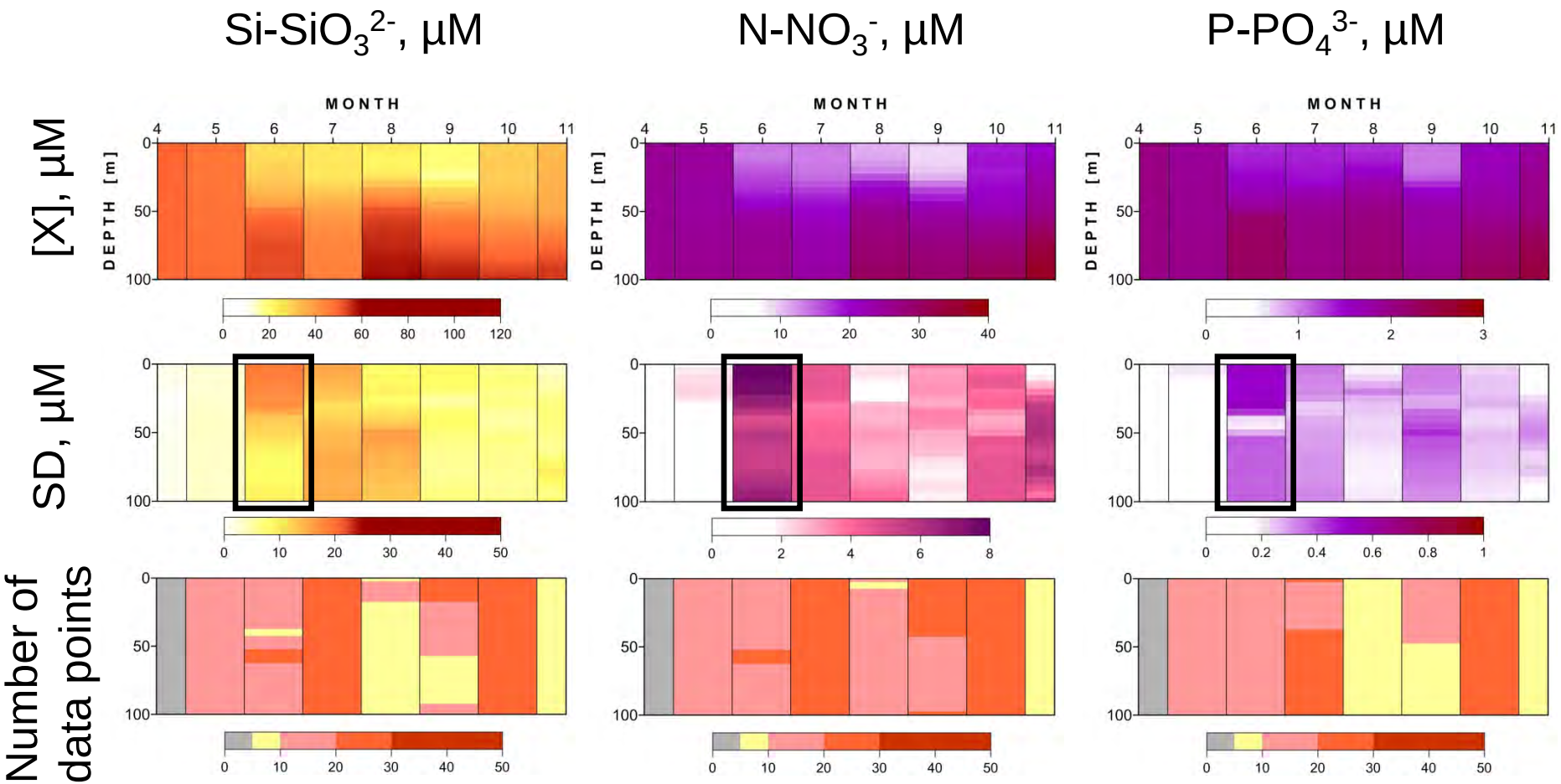


Si-SiO_3^{2-}, µM

SD, µM

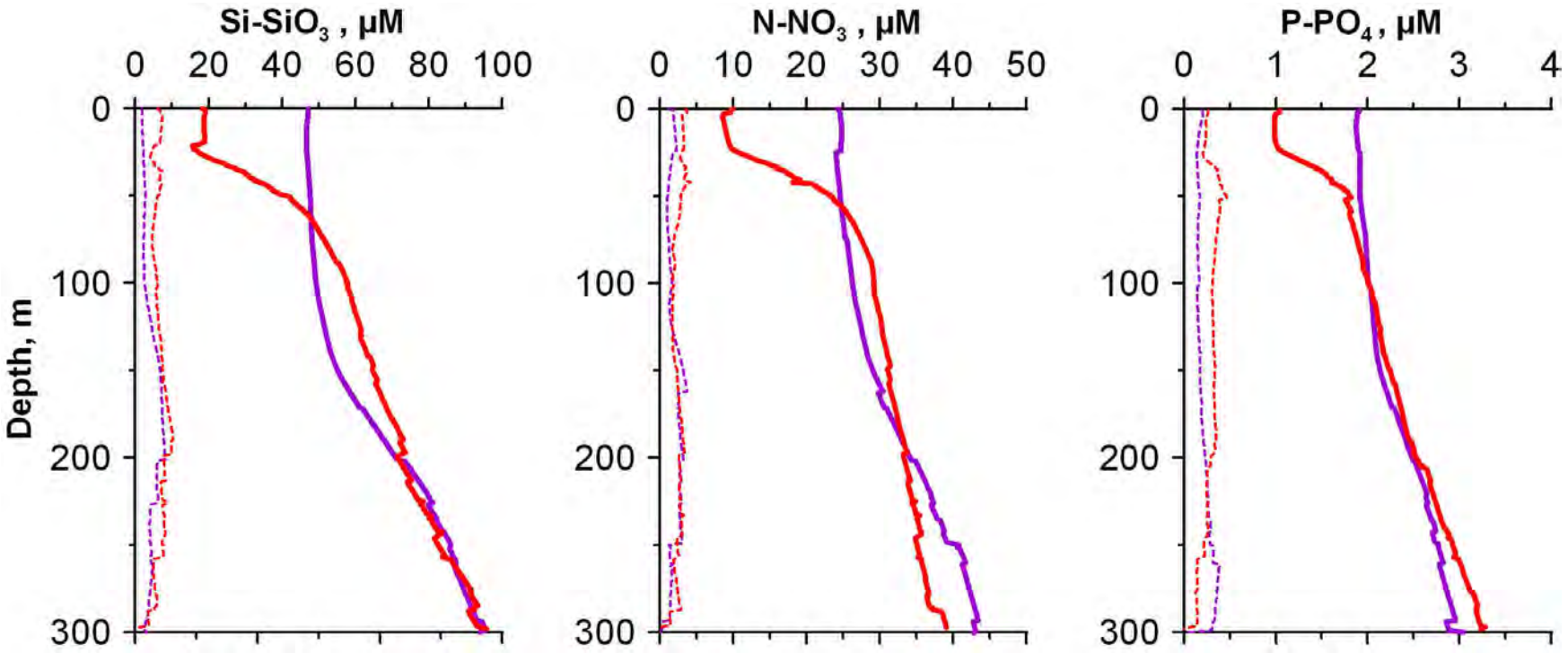
Number of data points

Results

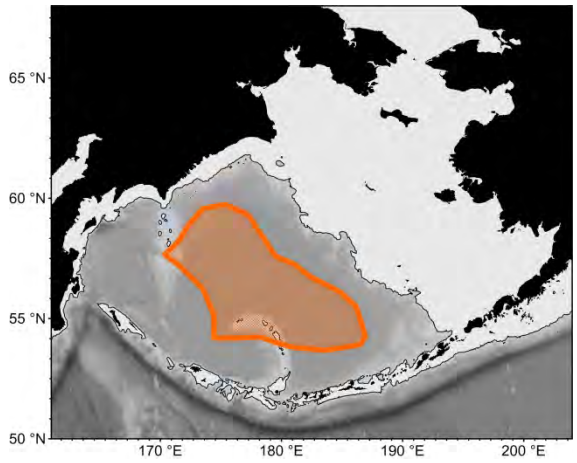


Examples of mean seasonal silicate, nitrate and phosphate dynamic for region #2 (top panels), along with standard deviation (middle panels) and number of points per 5 m bin per month (lower panels)

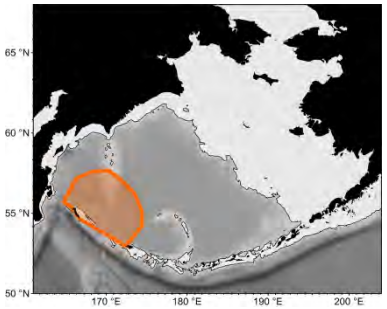
Results



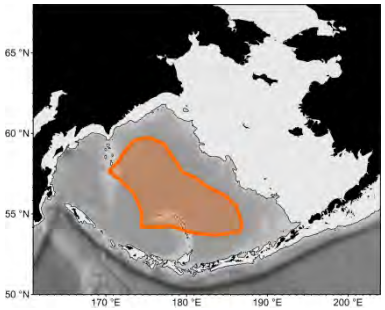
Example of monthly mean vertical profiles of nutrients for region #2 in May (blue) and August (red). Dashed lines represent standard deviation



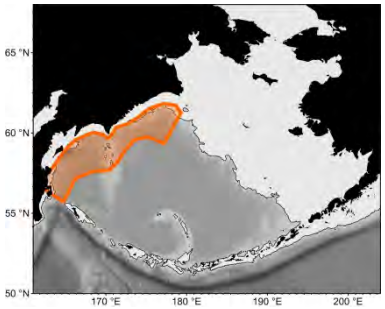
***Results:* net ΔSi / ΔN / ΔP ratios**



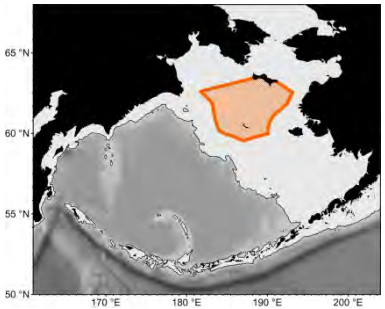
Apr-Aug ΔSi / ΔN / ΔP ≈ 45 / 19 / 1



May-Sep ΔSi / ΔN / ΔP ≈ 36 / 17 / 1



Apr-Sep ΔSi / ΔN / ΔP ≈ 45 / 18 / 1



Apr-Aug ΔSi / ΔN / ΔP ≈ 24 / 10 / 1

Conclusions

- Combination of available data for 1970-2013 allowed for reconstruction of seasonal nutrient dynamics in selected areas of the Bering Sea
- Despite wide temporal ranges of data collection and additional quality control procedures, data is not sufficient or too variable for some regions during several months
- Collected data revealed vide range of spatial variability in net seasonal ΔSi/ΔN/ΔP-ratios
- Net ΔSi/ΔP-ratios in basin areas may be as high as 36-45 in the western Bering Sea; net ΔSi/ΔP-ratios in the shelf areas is around 24, which is consistent with previous studies (i.e. *Arzhanova et al., 1995 – in Russian*)
- Net ΔN/ΔP-ratios ≈ 17-19 for the basin areas and ΔN/ΔP-ratios ≈ 10 for the shelf areas of the western Bering Sea

Thank you for attention!

非常感谢