Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

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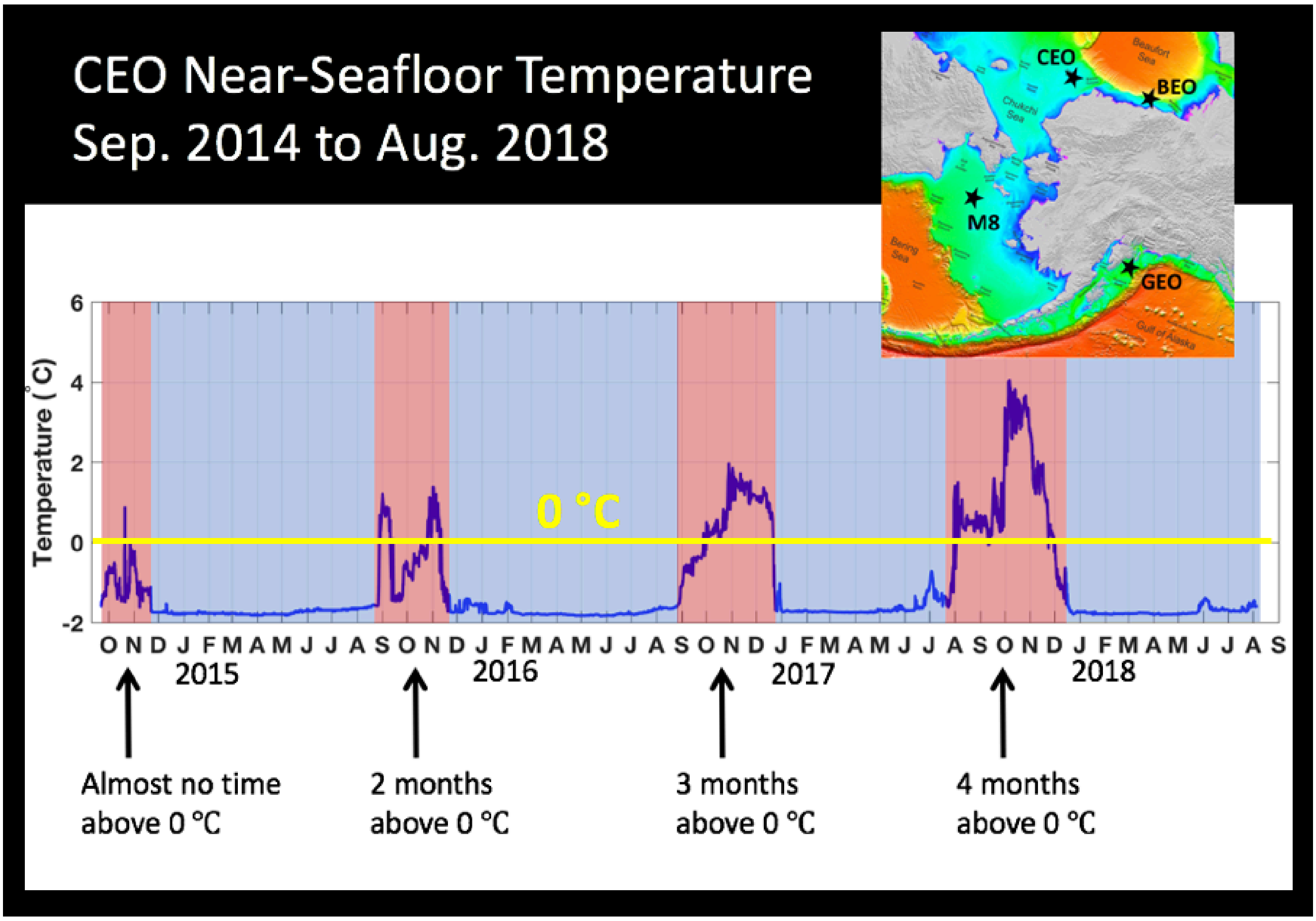
The recent century of increasing North Pacific marine temperatures culminated with a still ongoing multi-year marine heat wave over the Bering and Chukchi continental shelves. Relative to the modern observational record, 2014-2018 is characterized by anomalously elevated heat contents and temperatures, advanced spring sea ice retreat, delayed winter sea ice onset, and shifts in the timing and location of sea ice melt. To provide oceanic context to the satellite-derived sea ice concentration record, we construct a simple heat budget for the Chukchi shelf using atmospheric reanalysis model estimates of ocean-air heat fluxes (ECMWF ERA-Interim), lateral advection northward into the Arctic through Bering Strait, and in situ hydrographic profiles. We construct a new CTD climatology for the region, using a compilation of over 10^5 hydrographic profiles collected between 1950 and the present. Sea surface temperature analysis shows that 2014 was a transition year into a series of consecutive years for which the mean surface temperature exceeds 2 standard deviations from the longterm mean. Subsurface temperatures also exhibit steadily increasing temperatures over 2014 to 2018. Relative to 1979 to 2013, the most recent five years exhibits an acceleration of the Chukchi shelf heat engine: absorbing more incoming solar radiation in the spring and losing more latent and sensible heat to the atmosphere in the fall. On an annual basis the Chukchi shelf’ s rate of heat loss has modestly increased, but the Bering shelf is losing less heat to the atmosphere on an annual basis. However, the modeled heat flux changes are not temporally uniform over the course of the year and the anomalies exhibit spatial structure that is closely linked to the location of the sea ice cover. Our estimates suggest that the delivery of Pacific origin heat to the Arctic basin has appreciably increased in recent years. The analyses highlight the importance of the oceanic heat capacity, the heat loss rates of the cooling fall and winter, ice thickness, and tightly coupled positive feedbacks in heat exchanges between the ocean, ice and atmosphere. Understanding the new hydrograhic status quo is important for anticipating future physical and biological conditions on the Bering-Chukchi shelves. To the extent that ecosystem structure may be disrupted by altered seasonality, specie distributions, metabolic rates, and trophic exchange transfer efficiencies, we can use this work to better understand how the changing thermal environment may trigger a cascade of nonlinear reactions by the region’ s sympagic, pelagic and benthic communities.

Keywords: Ocean-atmosphere-ice heat fluxes, Bering-Chukchi shelf


CEO Near-Seafloor Temperature
Sep. 2014 to Aug. 2018
CEO
BEO
M8
GEO
Beaufort Sea
Chukchi Sea
Bering Sea
Gulf of Alaska
Temperature (°C)
6
4
2
0
-2
0 °C
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
2015
2016
2017
2018
Almost no time
above 0 °C
2 months
above 0 °C
3 months
above 0 °C
4 months
above 0 °C