Impacts of Ex-Typhoon Merbok on the Bering Sea biophysical environment

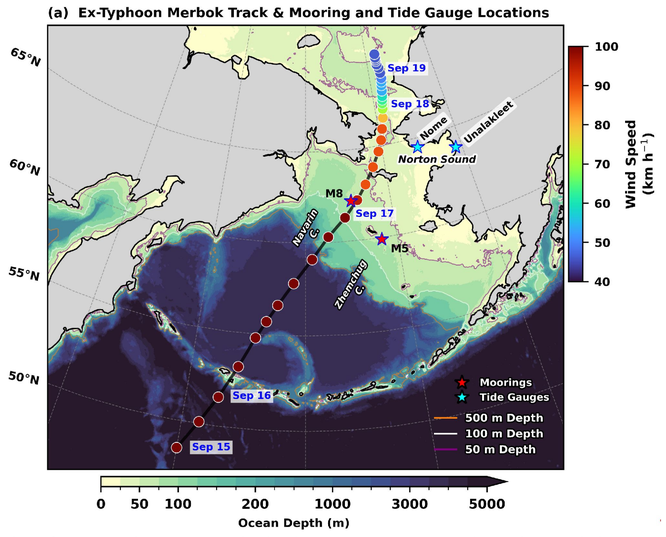


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Introduction

Typhoon Merbok formed on 10 September 2022 and strengthened into a typhoon three days later. It traveled northward becoming an extratropical cyclone on 15 September, entering the Bering Sea a day later as a powerful storm with winds exceeding 100 km/hr. Ex-typhoon Merbok (15–19 September 2022) tracked north across the Bering Sea causing major coastal flooding in western Alaska. Its passage over the stratified, ice-free eastern Bering Sea shelf offers a rare view of how an extreme storm reshapes upper-ocean physics, bottom-water properties and the shelf ecosystem. We explore the responding dynamics using a combination of observations and MOM6 regional numerical model.

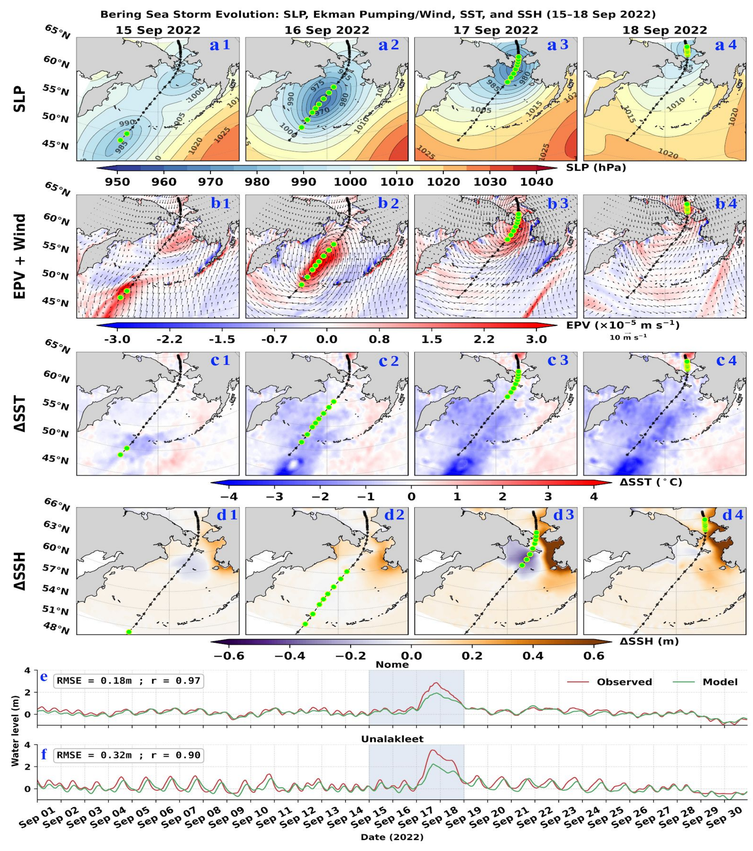


Track of Ex-typhoon Merbok (15–19 Sep 2022) coloured by wind speed (km/hr; dots at 3-hour intervals) over bathymetry (m).

Track of Ex-Typhoon Merbok

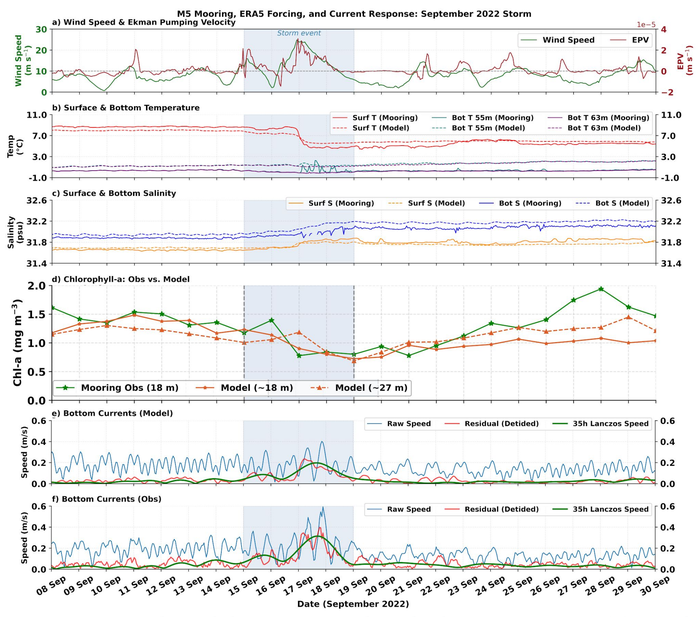
- Data: Moorings M5 and M8 are long-term (2005-present) biophysical moorings which measure temperature, salinity, currents, Chl-a fluorescence at multiple depths. Water level was obtained from tide gauges at Nome and Unalakleet, Ak. ERA5 provided sea-level pressure, winds and Ekman pumping velocity.
- Model: MOM6-COBALT-NEP10k, a ~10 km regional physical–biogeochemical model of the Northeast Pacific (Drenkard et al., 2025). It is forced by ERA5 at the sea surface and GLORYS at the lateral boundaries. We analyzed daily and hourly output of the model and compared it with observations.

Storm Evolution & Ocean Response



Daily SLP (a), Ekman pumping velocity with wind vectors (b), SST anomaly (c) and SSH anomaly (d) in 15–18 Sep 2022, and observed vs modelled hourly sea surface height at Nome (e) and Unalakleet (f).

Merbok intensified to a low sea level pressure center of ~970 hPa on 16 Sep, driving strong Ekman pumping and SST cooling of up to ~4 °C. Storm surge reached ~2.8 m at Nome and ~3.5 m at Unalakleet.



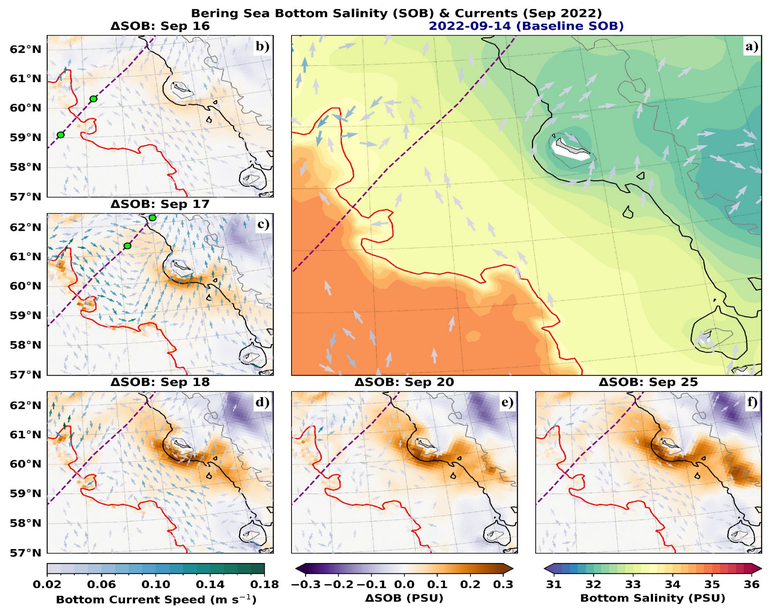
M5 mooring and model: ERA5 wind and Ekman pumping (a), surface and bottom temperature (b) and salinity (c), Chl-a at 18 m (d), and bottom currents from the model (e) and observations (f), Sep 2022.

Comparison between M5 and MOM6

- Winds peaked at ~25 m s^{-1} on 17 September, with strong positive Ekman pumping.
- In ~1 day, surface temperature dropped from ~9 to ~5 ° C, and surface salinity rose by ~0.2 psu.
- Chl-a fell from ~1.4 to ~0.8 mg m^{-3} during the storm and recovered after 23 September.
- Bottom currents reached ~0.6 m s^{-1} (hourly) and ~0.3 m s^{-1} (low-pass filtered).

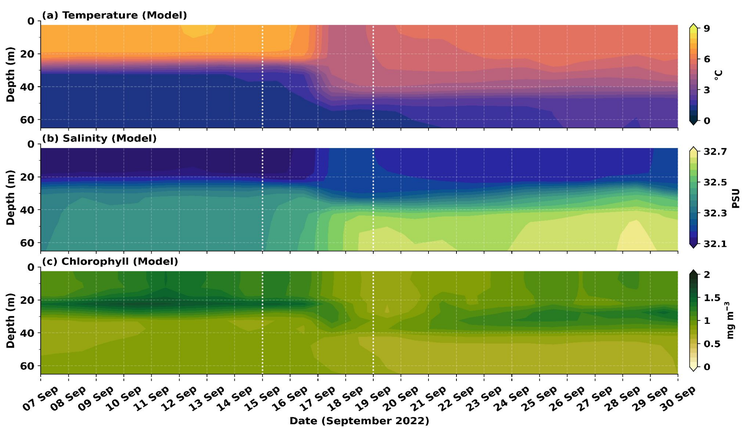
In general, MOM6-NEP10k simulations were in good agreement with the observed data from M5, although the model underestimates slightly the peak current speeds and the depth of vertical mixing.

Bottom Salinity & Currents



Modeled bottom salinity on 14 Sep (a) and bottom salinity anomaly (ΔSOB) with bottom currents on 16–25 Sep 2022 (b–f).

Observations showed an increase of bottom salinity at M5 with passage of Merbok. The model revealed it was a result of onshelf flow originating at Navarin Canyon. Bottom salinity increased by up to 0.3 psu on the middle shelf after 17 September, and the anomaly persisted well into October.



Modelled temperature (a), salinity (b) and chlorophyll (c) at M5, 7–30 Sep 2022; dotted lines mark storm period.

Upper-Ocean Vertical Structure

- Strong winds deepened surface layer from ~25–30 m to ~40–50 m
- The warm (~9°C) surface layer cooled as colder (~0 °C) water was mixed upward.
- The fresher (~32.3 psu) surface layer increased in salinity to 32.5 psu as saltier water was mixed upward.
- A subsurface chlorophyll maximum (~20–25 m) is typical at M5. The maximum was mixed away and re-formed near 30 m after passage of the storm.

Conclusions

- Merbok drove strong Ekman pumping and SST cooling of up to ~4 °C along its track.
- The model reproduced storm surge timing at Nome and Unalakleet, though peak surge heights were underestimated due to limitations in the coastal bathymetry in the model (10 km grid size).
- At M5, storm mixing deepened the warm surface layer to ~45m, raised surface salinity and lowered Chl-a.
- On shelf advection of slope water increased bottom salinity by ~0.3 psu at M5.
- MOM6-NEP10k captured the impact of Merbok on the eastern Bering Sea shelf. In particular it provided information on the intrusion of slope water onto the middle shelf.

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References

Drenkard, E., et al. (2025). A regional physical–biogeochemical ocean model for marine resource applications in the NE Pacific (MOM6-COBALT-NEP10k v1.0). Geosci. Model Dev., 18, 5245–5290.

Hersbach, H., et al. (2020). The ERA5 global reanalysis. Q. J. R. Meteorol. Soc., 146, 1999–2049.

Stabeno, P., et al. (2019). Distributed Biological Observatory Region 2: Rapid changing conditions in the southern Chukchi Sea and northern Bering Sea. Deep-Sea Res. Pt. II, 162, 83–97.