Oceanographic and ecosystem response to the 2013-2015 Pacific Warm Anomaly in Kachemak Bay Alaska

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Overview

Subarctic estuarine waters in Kachemak Bay Alaska responded to the 2013-2015 Pacific Warm Anomaly starting in late 2013, with a transition from an eight year period of below average or near-average conditions to persistently warmer than average temperatures throughout 2014 and 2015. The cooler period from 2005-2013 was interrupted briefly by warmer conditions in the winter of 2010. Relative to 2004-2015 mean monthly conditions, the largest warm anomalies, at greater than 2.5 degrees Celsius, were recorded in Kachemak Bay during the winter of 2014-2015. Kachemak Bay is a subarctic fjord estuary in the northern Gulf of Alaska, located within and near the southeast entrance of Cook Inlet. Marine conditions in the bay are affected by atmospheric temperature and wind forcing, large tides with 8.7 meter maximum range, and freshwater input from precipitation and snowpack and glacier meltwaters. Kachemak Bay is also influenced by exchange with waters from the inlet and by exchange with and upwelling of waters from the adjacent shelf, including from the Alaska Coastal Current which flows westward along the Gulf of Alaska coast in this region. In addition to the direct temperature effects examined here, shifts in large-scale weather patterns associated with the Pacific Warm Anomaly can change the amount and timing of freshwater input, as well as wind-driven exchange and upwelling from the adjacent Gulf of Alaska shelf. In contrast to limited biological responses in 2014, dramatic changes were observed in 2015 across the food web, affecting plankton, fish, whales, sea birds and sea otters. The oceanographic monitoring data summarized here will be used to assess potential mechanisms for the observed 2014-2015 changes in coastal Alaska species, including how persistently warm conditions in estuarine and shelf waters, as well as changes in ocean transport and freshwater input may be driving bottom-up food web shifts.

Study Area

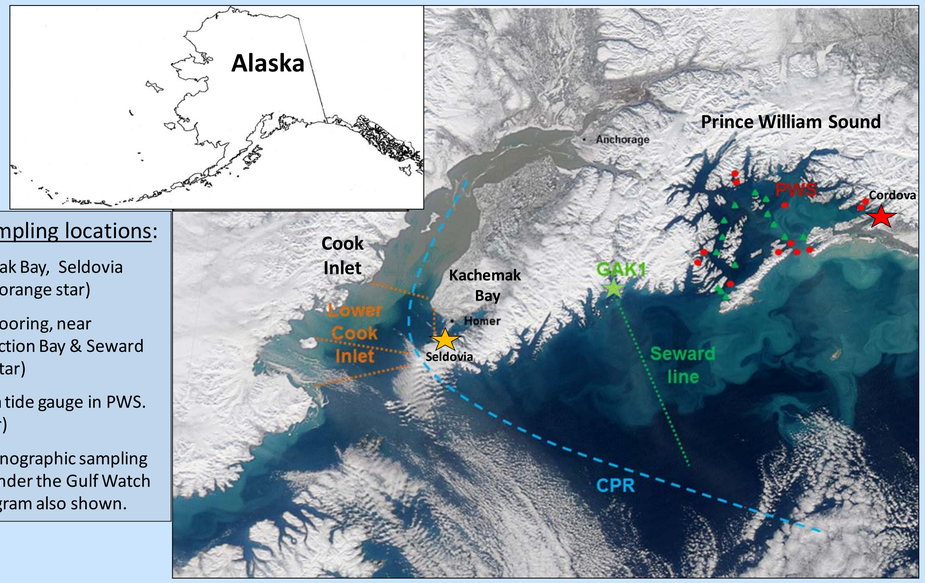

Fig 1. Sampling locations:

- Kachemak Bay, Seldovia harbor (orange star)
- GAK1 mooring, near Resurrection Bay & Seward (green star)
- Cordova tide gauge in PWS. (red star)

Other oceanographic sampling locations under the Gulf Watch Alaska program also shown.

Data Sources

- **Seldovia harbor:** Kachemak Bay National Estuarine Research Reserve (KBNERR) water quality monitoring station, part of the national System-wide Monitoring Program (SWMP). YSI 6600 sonde at ~ 8 m depth.
- **GAK 1 mooring.** Temperature and salinity sensors at ~30m depth (depth varies with deployments).
- **Cordova harbor.** Temperature sensors on NOAA National Water Level Observation Network (NWLON) tide gauge station.

See www.gulfwatchalaska.org for additional information and data

Acknowledgements

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Oceanographic Monitoring Data

Fig. 2

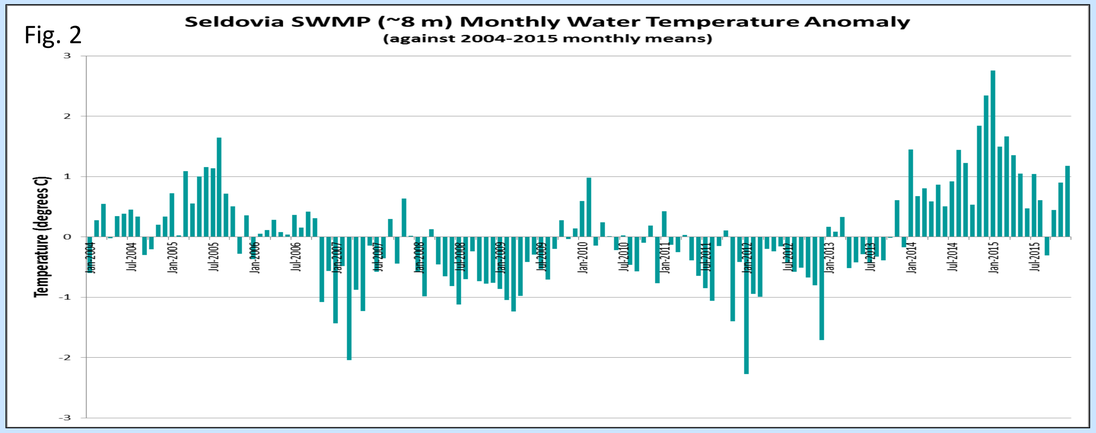


Fig. 3

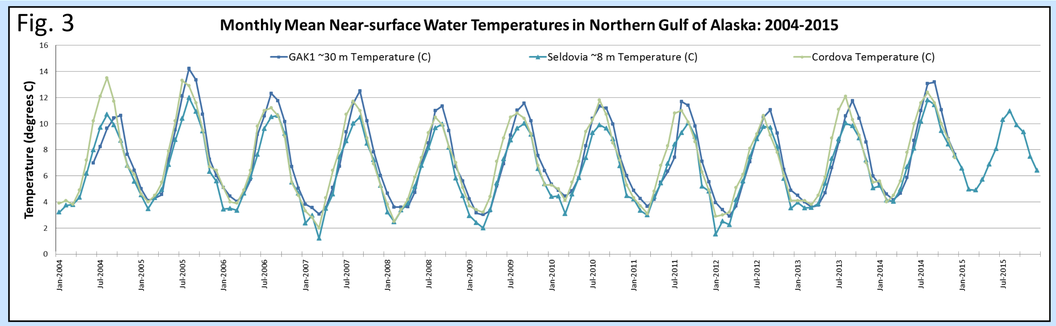
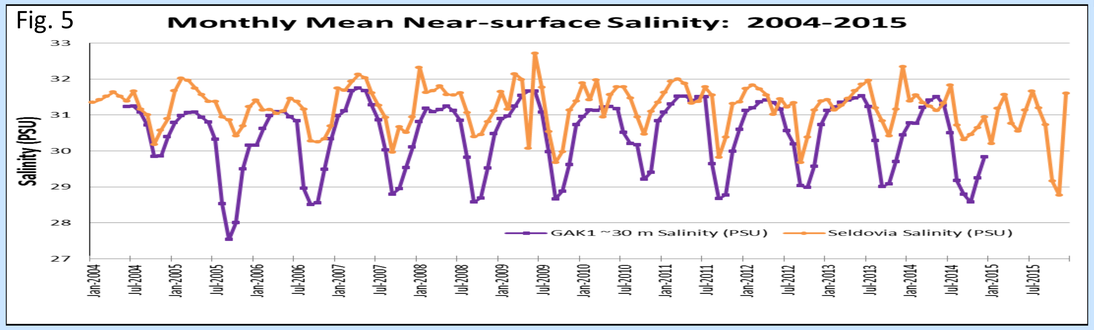


Fig. 5



Average monthly water temperatures at Seldovia were above the 2004-2015 means for most of 2014 and 2015 and were warmer than at any time since 2005 (Fig 2), with summer temperatures near 12 C (Fig 3) and the highest warm anomaly observed in January 2015. Winter temperatures in February/March 2015 were near 5 C, compared to the March mean of 3 C and 2012 winter temperatures of 2 C. Oceanographic changes are very similar across the region at time scales greater than 3 months, as shown by comparing estuary (Seldovia, Cordova) and shelf (GAK1) time series data (Figs 3, 5). Conditions at GAK1 are also generally warmer and fresher than at Seldovia (Figs 4, 6). During 2013-2015, the summer differences persisted between Seldovia and GAK1, but winter warming was stronger at Seldovia, which resulted in smaller winter temperature differences between the estuary and shelf waters.

Fig. 4.

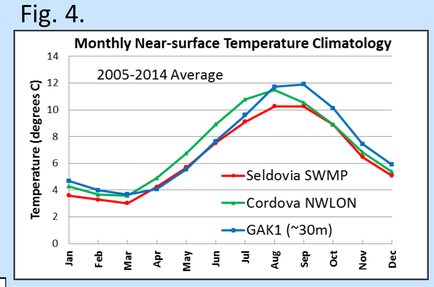
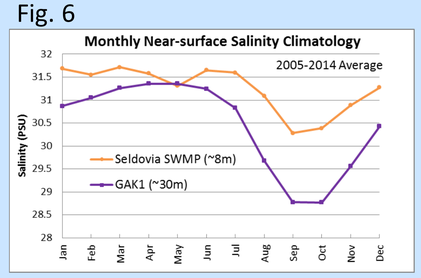


Fig. 6



Kachemak Bay Biological Responses to the Warm Anomaly .... limited in 2014, dramatic in 2015

Potential Mechanisms: Bottom-up food web changes; Direct/indirect effects from harmful algal species; Warmer 2014-2015 winter; Transport of herring to bay from Prince William Sound and coastal spawning locations; Bay/shelf water temperature differences

- ↑ **Herring**. Large schools of young (age 0, age 1?) herring observed in Kachemak Bay for first time in decades (summer and fall 2015).
- ↑ **Whales**. Unusual numbers of humpback whales (> 50) were persistently present and feeding in the bay (Jun-Nov 2015)
- ↑ **King salmon**. Improved sport fishing within bay for feeder (not spawning) king salmon (most of 2014 and 2015).
- ↓ First **paralytic shellfish poisoning** event due to *Alexandrium* phytoplankton blooms in over a decade in the bay, with oyster farm closures (Sep 2015).
- ↓ Significant **seabird and sea otter mortalities**, including large numbers of emaciated common murres (summer to winter 2015).
- ? *Pseudo-nitzschia* phytoplankton blooms. Low domoic acid toxins in plankton/shellfish, but DA found in seabirds/marine mammals (Jun, Aug 2015).
- ? Changing timing of phytoplankton blooms – Chaetoceros increased early in 2015 (February vs normal start in April).

Chaetoceros

Potential climate change connection in earlier events? Declines occurred in 2011-2015 in Kachemak Bay little neck and butter clams (>90% in some areas) and eastern Cook Inlet razor clam populations, with 2015 closure of the recreational razor clam fishery by Alaska Department of Fish and Game.