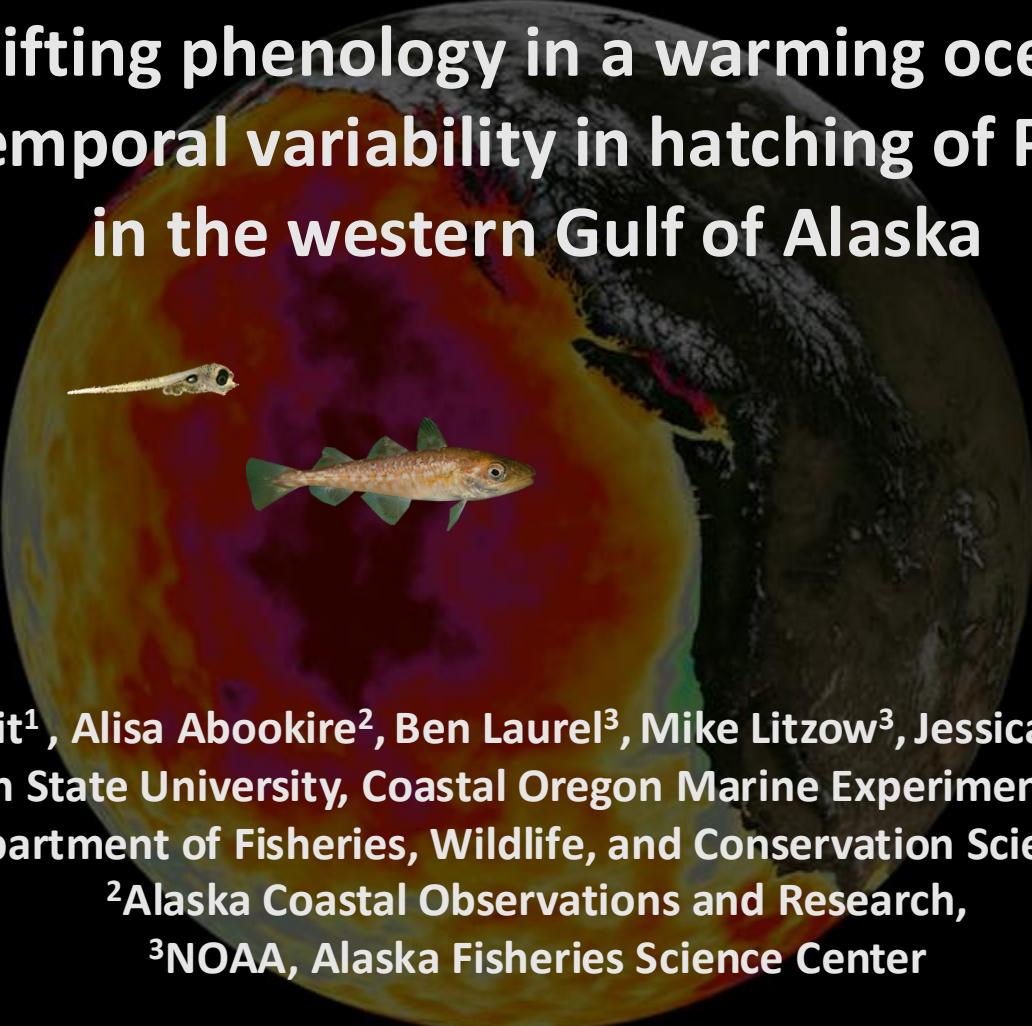


Shifting phenology in a warming ocean: Spatio-temporal variability in hatching of Pacific Cod in the western Gulf of Alaska



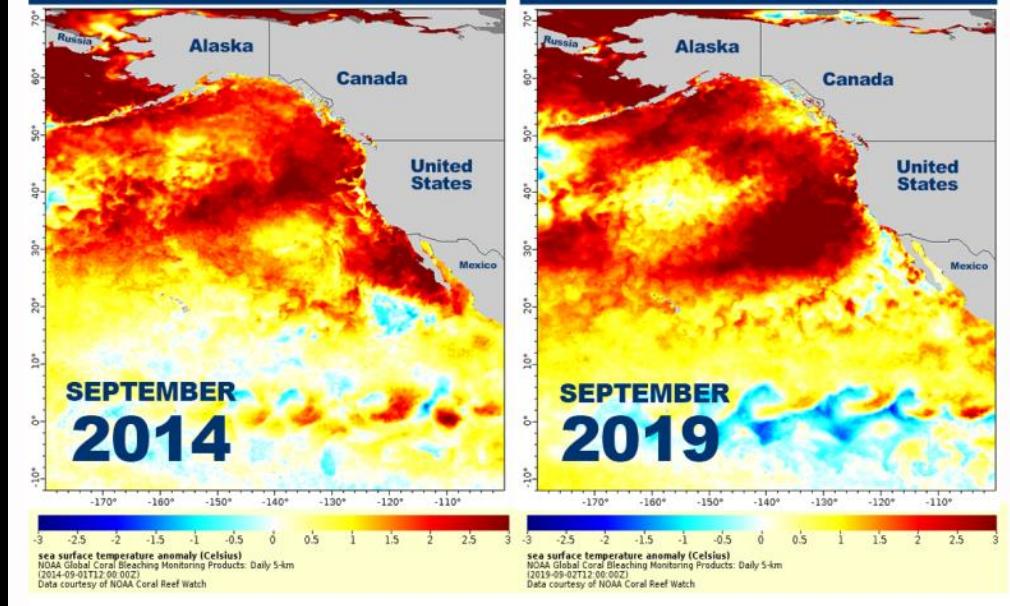
Nick Strait¹, Alisa Abookire², Ben Laurel³, Mike Litzow³, Jessica A. Miller¹

¹Oregon State University, Coastal Oregon Marine Experiment Station,
Department of Fisheries, Wildlife, and Conservation Sciences,

²Alaska Coastal Observations and Research,

³NOAA, Alaska Fisheries Science Center

Marine Heatwaves in the Gulf of Alaska



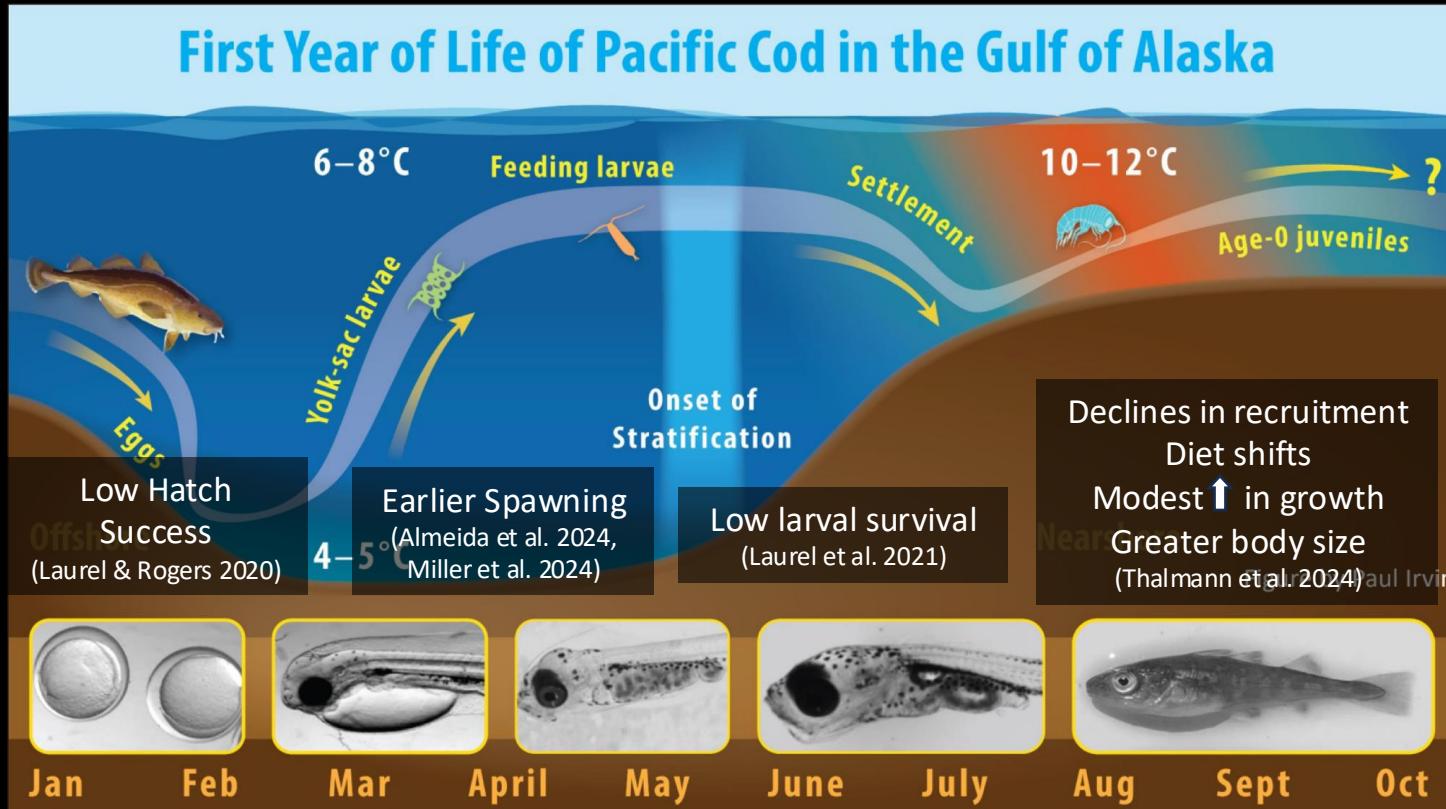
Pacific Cod (*Gadus macrocephalus*)

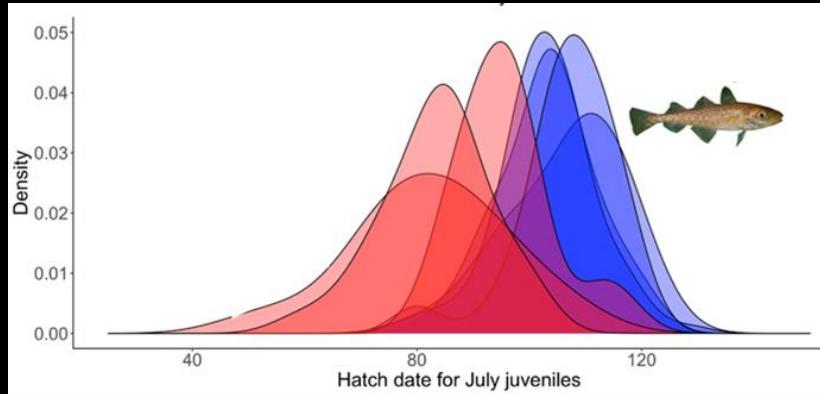
\$103 million fishery

>70% decline in population biomass

2020
Alaska Cod Fishery Closes

Impacts of marine heatwaves on early life





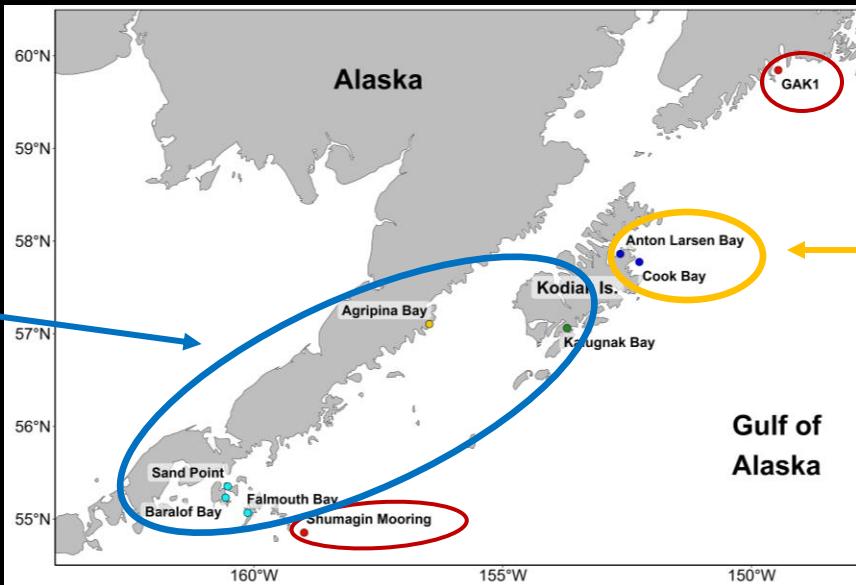
- (1) Has hatch phenology returned to pre-MHW values during recent, cooler years?
- (2) Does hatch phenology vary along the Alaskan Peninsula?

Juvenile Collections



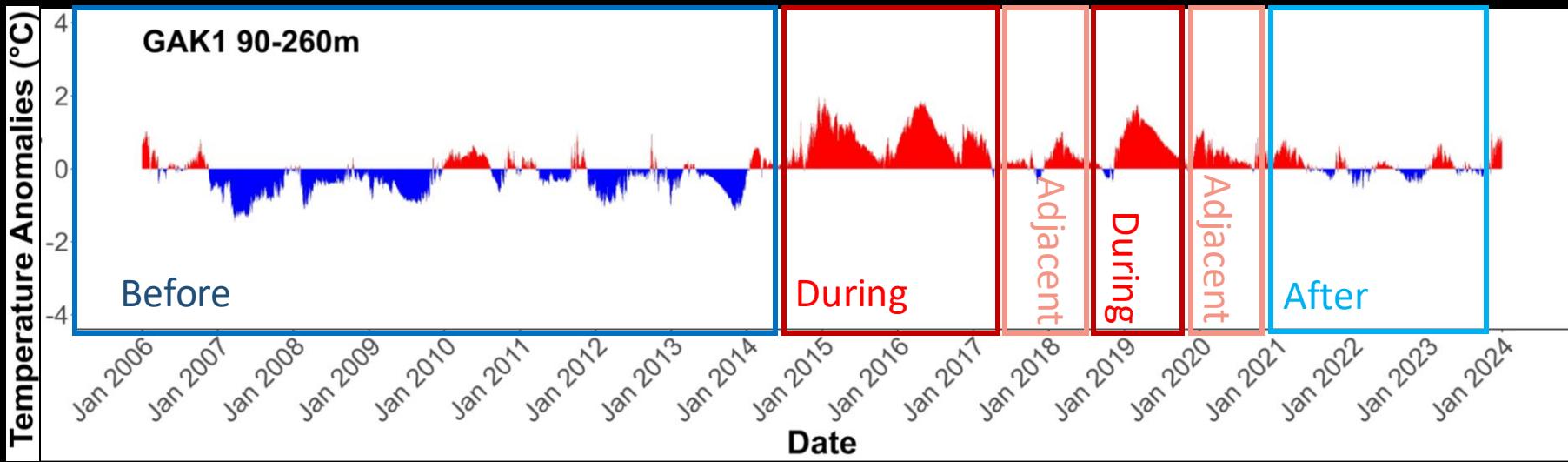
Juveniles
July & early August
2018-2023

Alaska
Coastal Observations
and Research



Juveniles
July
2007, 2009, 2010, 2012-2023

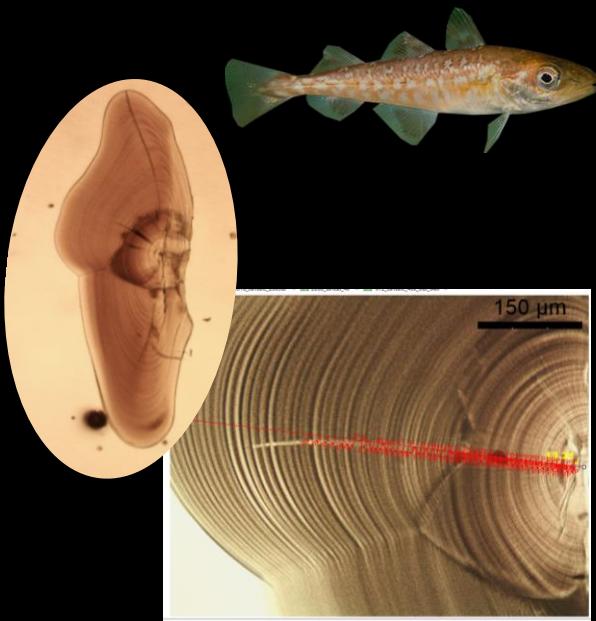
NOAA AFSC
Eastern Kodiak Island
Beach Seine Survey



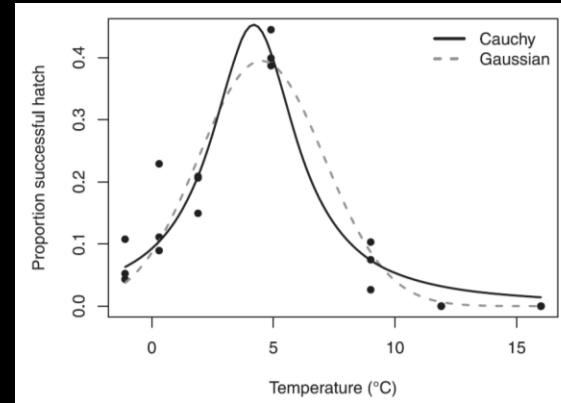
Before MHWs -- 2007, 2009, 2010, 2012-2014
During -- 2015-2017, 2019
Adjacent -- 2018, 2020
After -- 2021-2023

Methods

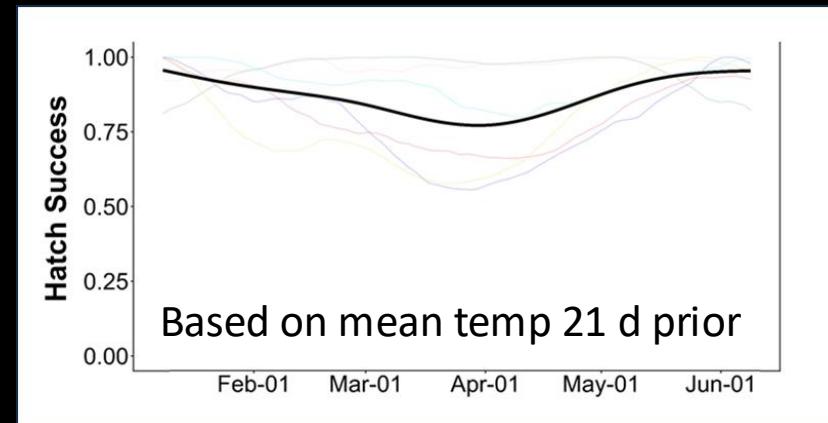
Hatch Date Daily otolith interpretation



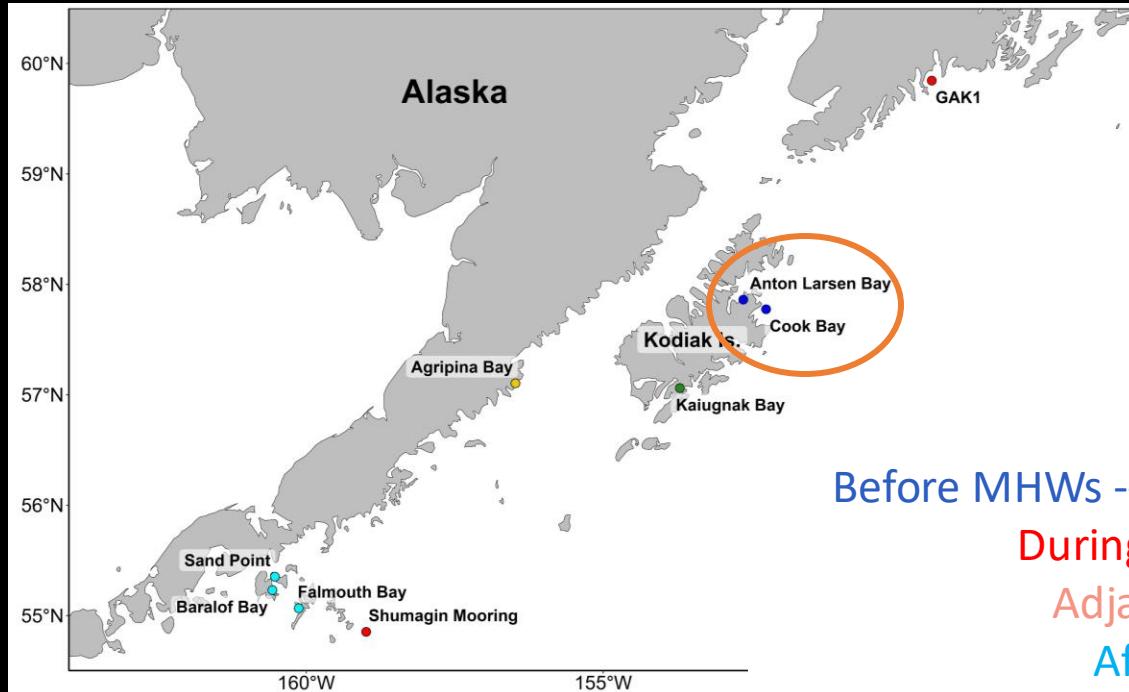
Temperature-based probabilities of hatch success



Laurel & Rogers 2020



Temporal Comparison



Eastern Kodiak Island:
Anton Larsen Bay
Cook Bay

Before MHWs -- 2007, 2009, 2010, 2012-2014

During -- 2015-2017, 2019

Adjacent -- 2018, 2020

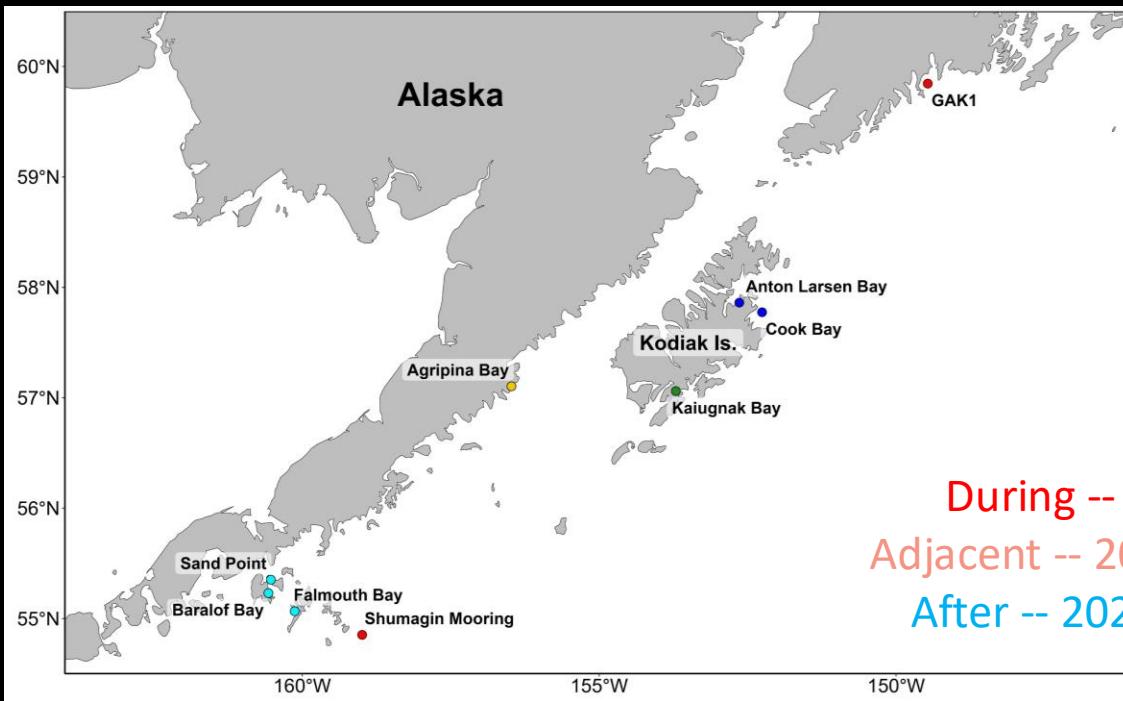
After -- 2021-2023

**Partial return to pre-MHW phenology:
Hatch dates 1 to 2 weeks earlier during recent cooler years**

&

**Emergence of winter spawning cohort
(Laurel et al., accepted, CJFAS)**

Spatial Comparison



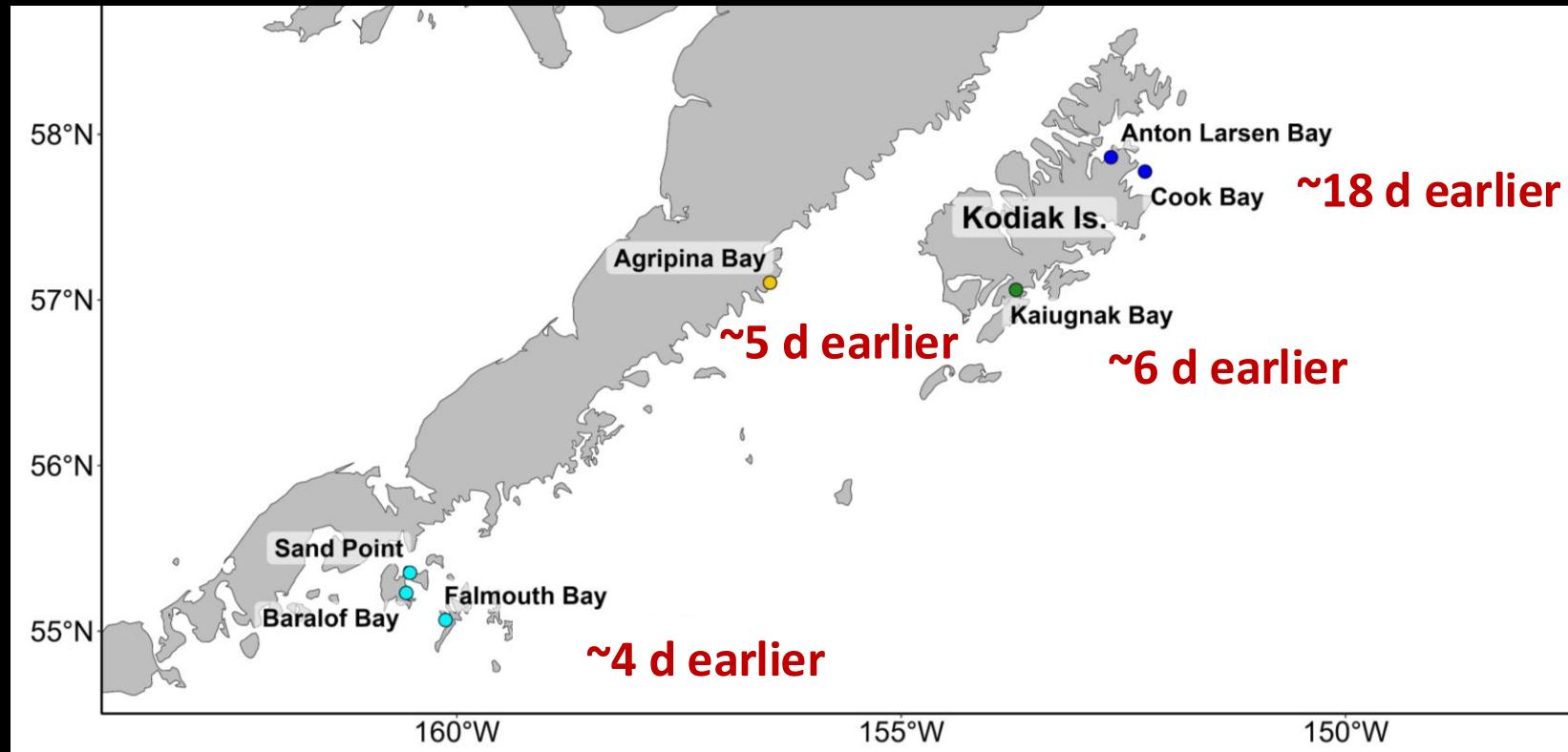
Overall mean hatch date = 9 April

[same as long-term mean before MHWs along Eastern Kodiak Island]

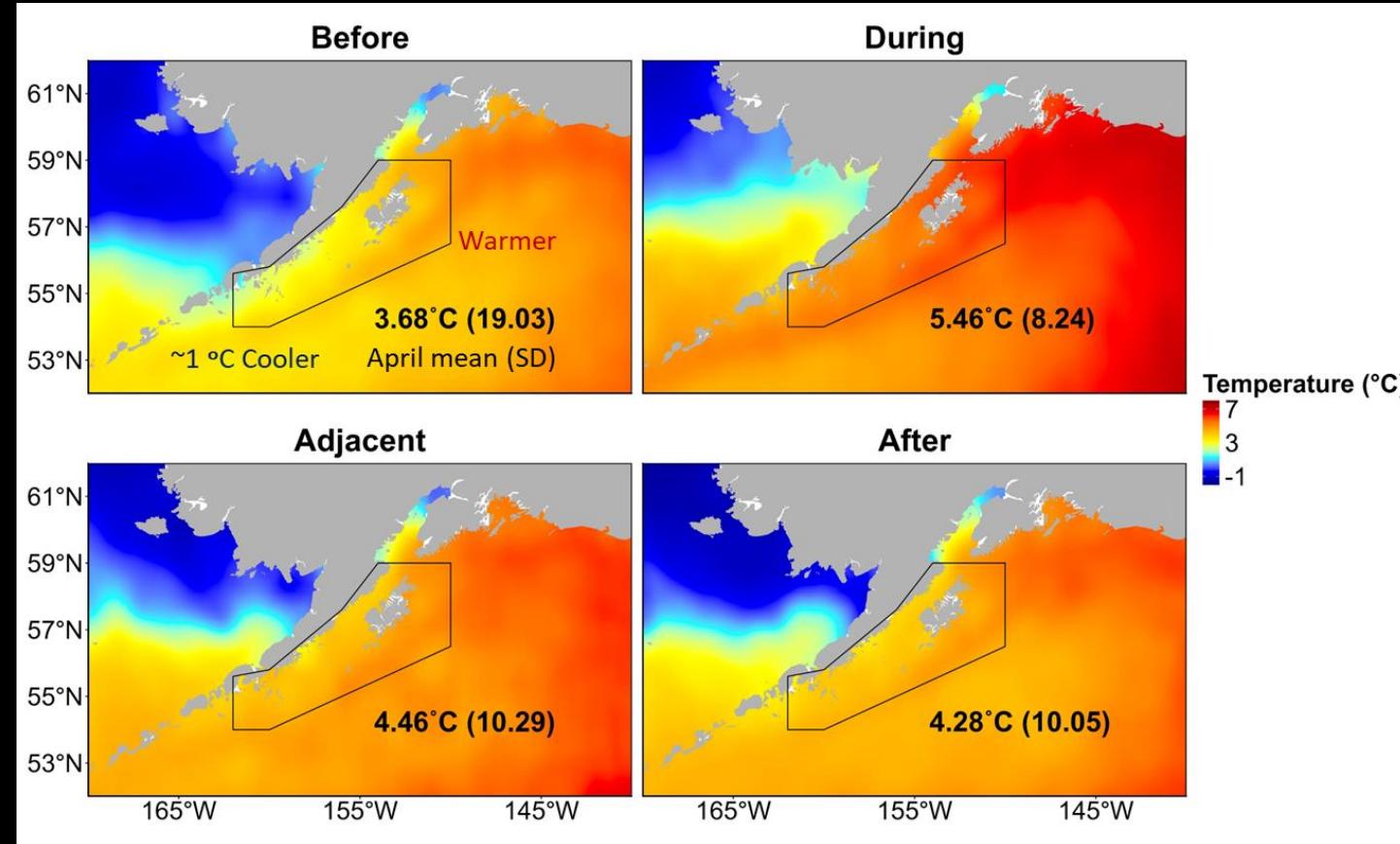
Progressively later hatching moving south-westward



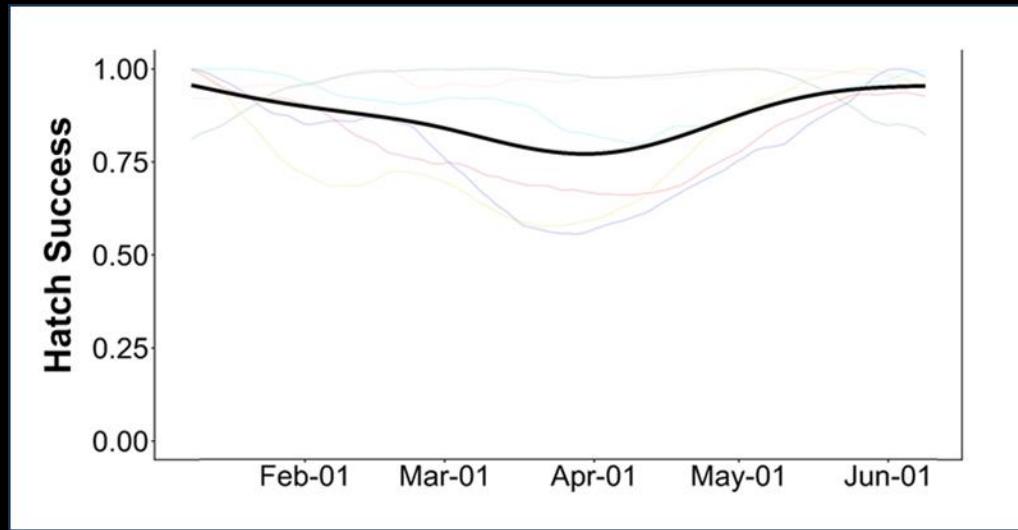
Spatial gradient in the effect of MHW on hatch phenology: Muted response in the southwest



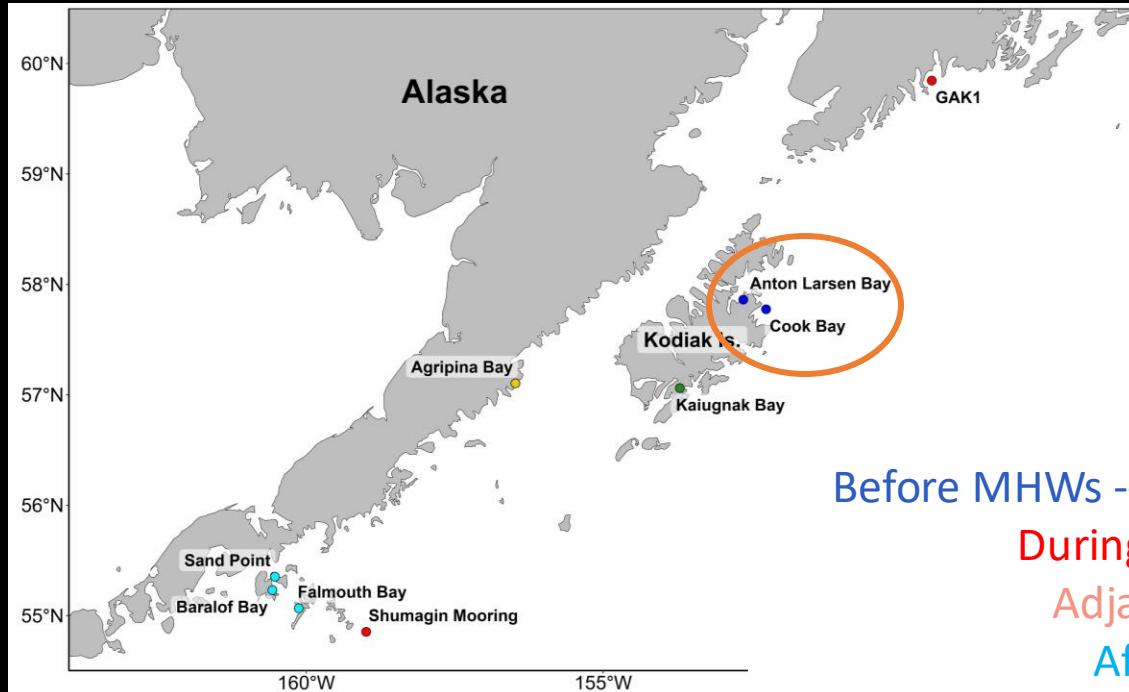
Spatial gradient in temperature: Cooler in the southwest



Probability of successful hatching



Temporal Comparison



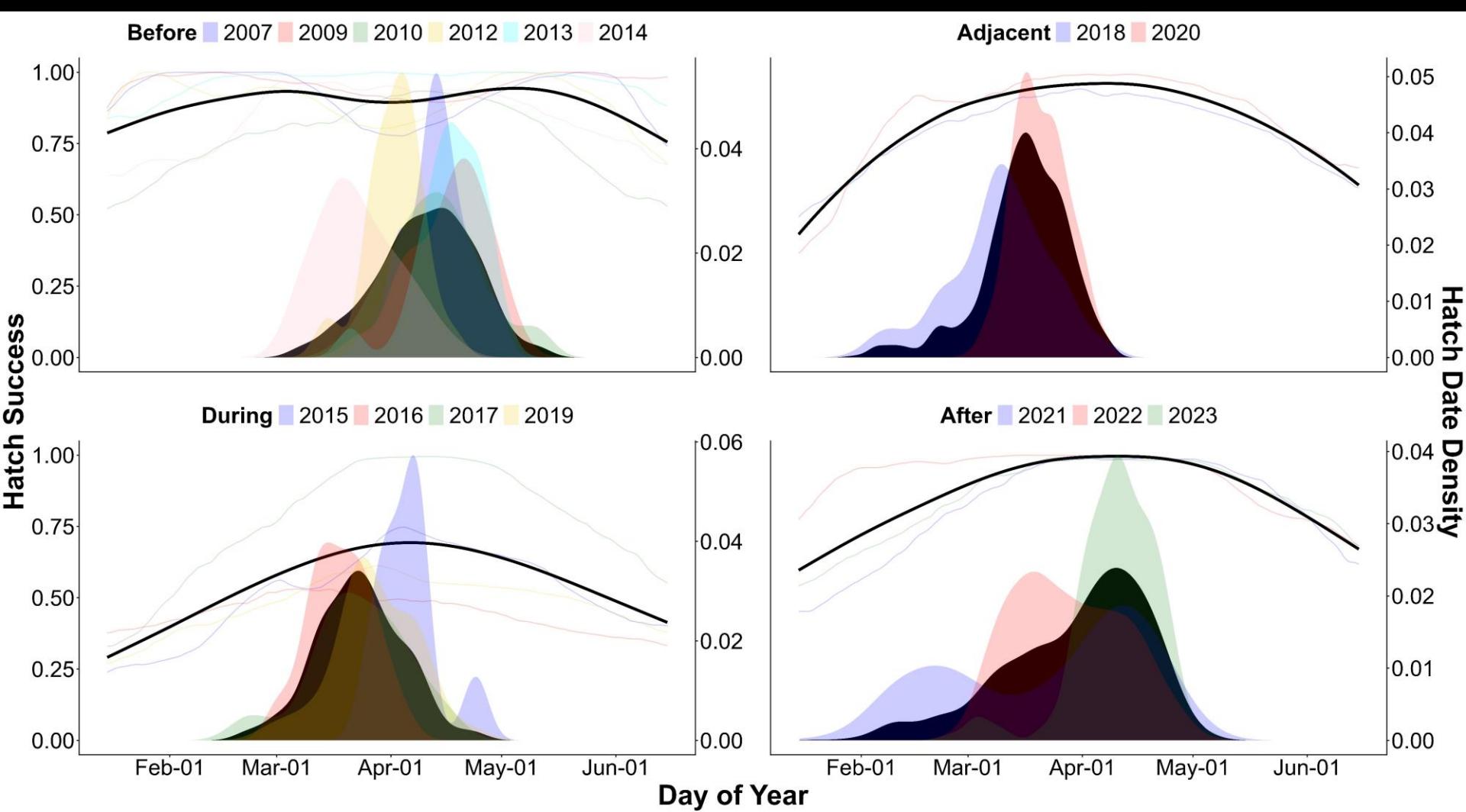
Eastern Kodiak Island:
Anton Larsen Bay
Cook Bay

Before MHWs -- 2007, 2009, 2010, 2012-2014

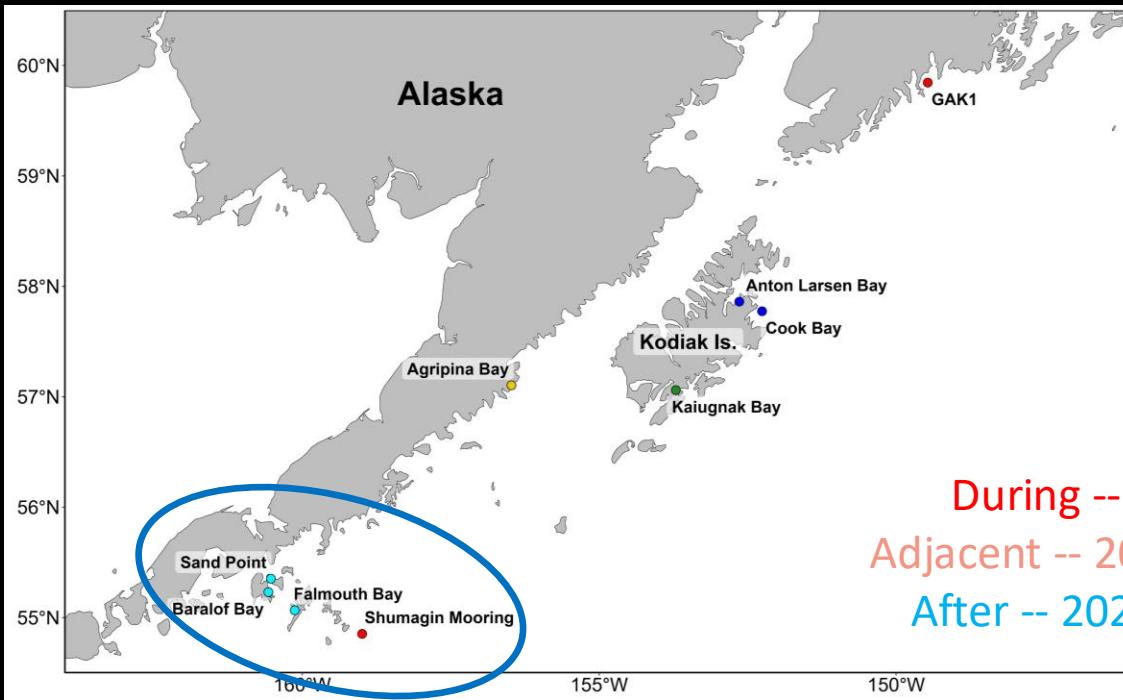
During -- 2015-2017, 2019

Adjacent -- 2018, 2020

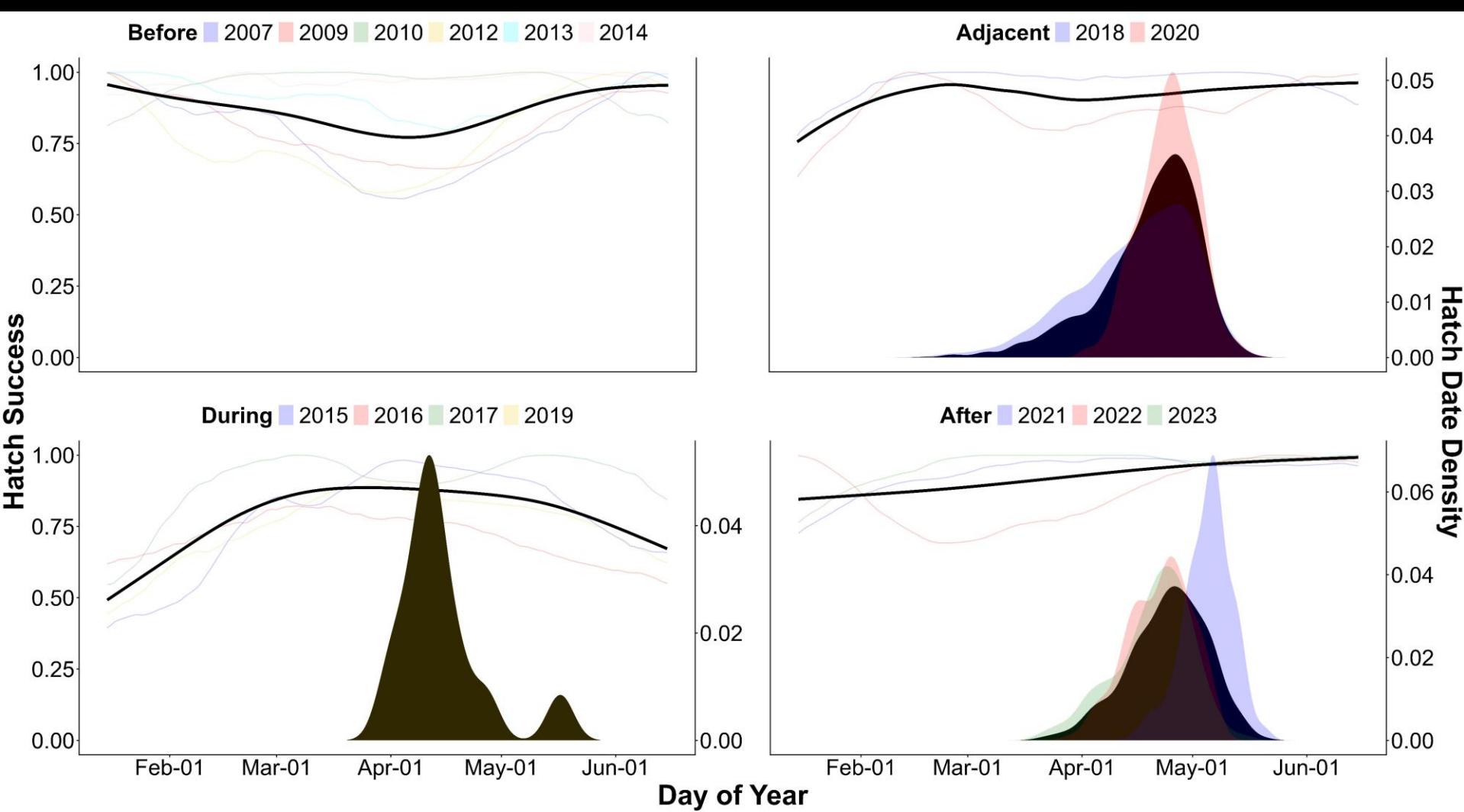
After -- 2021-2023



Shumagin Islands



During -- 2019
Adjacent -- 2018, 2020
After -- 2021-2023

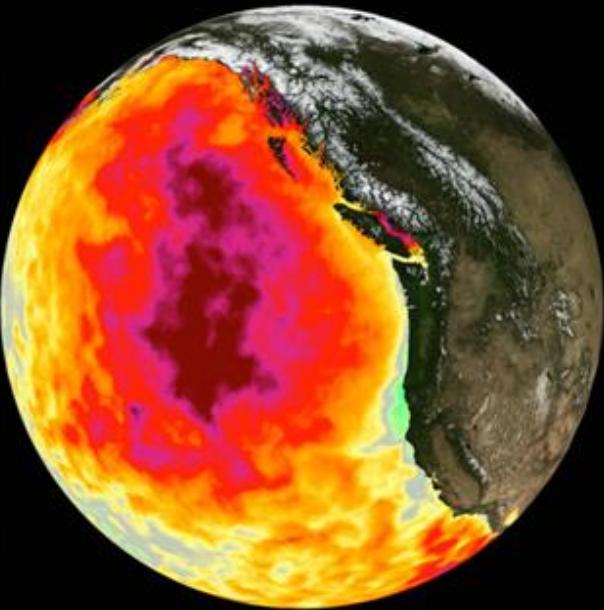


Summary

- ✓ Partial return to pre-MHW hatch phenology in Eastern Kodiak:
remains 1-2 weeks earlier & emergence of winter spawning cohort
- ✓ Notable spatial gradient in hatch phenology:
~1 month later in the Shumagin Islands (to the southwest)
compared with Eastern Kodiak (to the northeast)
- ✓ Hatch phenology aligns with predicted probability of hatch success based
on available temperature data
- ✓ Thermal variation along Alaska Peninsula could provide some level of
climate resilience (but recruitment uniformly low)

Acknowledgements

Tom Hurst and many others at
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NOAA
FISHERIES



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Coastal Oregon Marine
Experiment Station