Climate change threatens Chinook salmon throughout their life cycle

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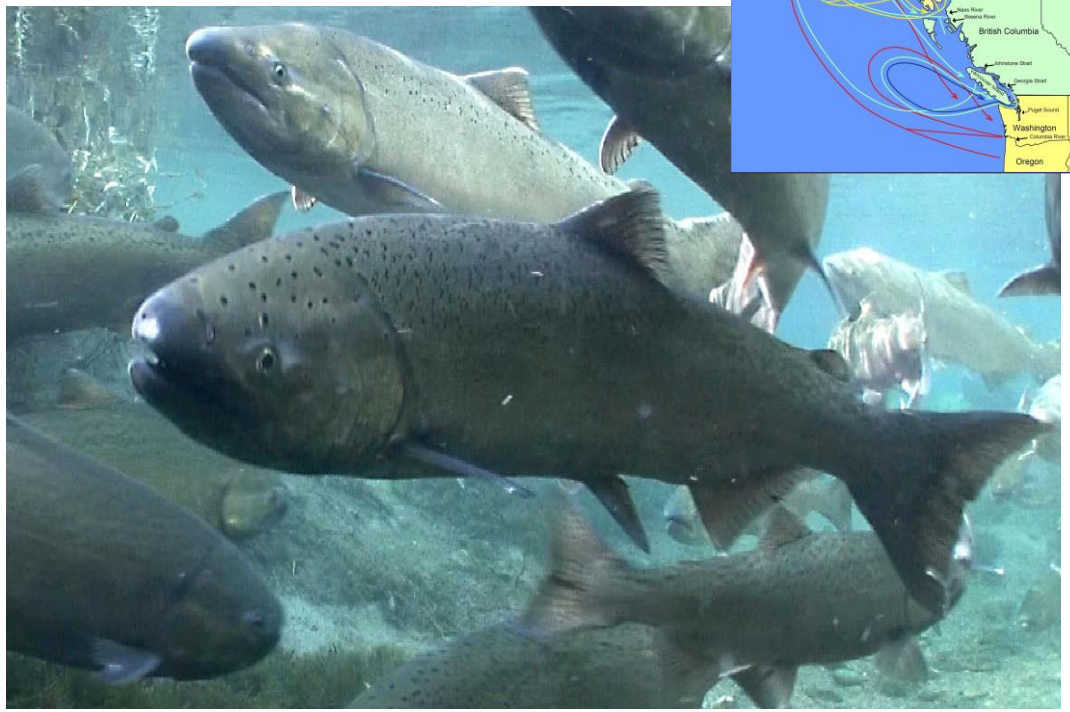
Northwest Fisheries Science Center
Seattle, WA

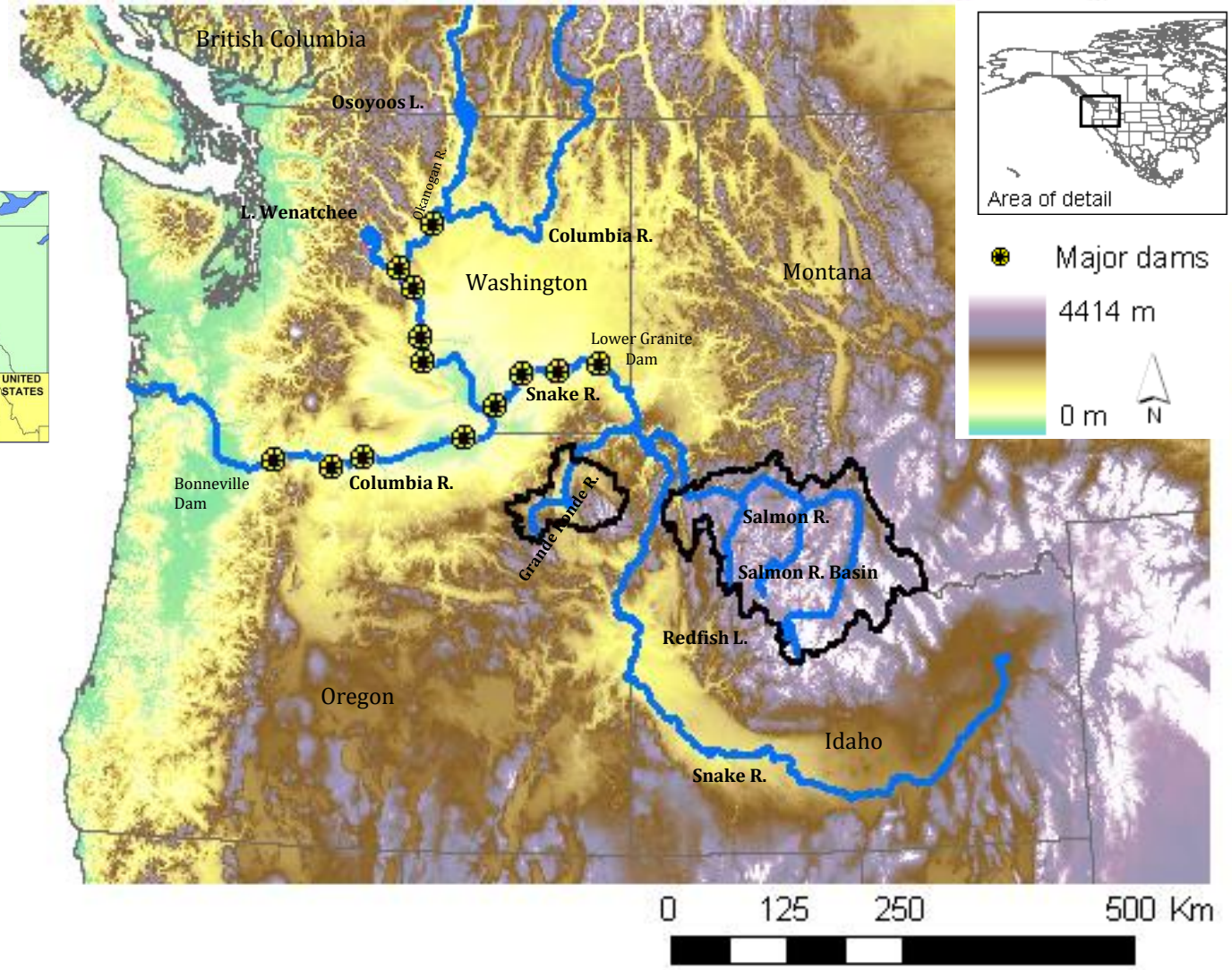
AFS Idaho Chapter Annual Meeting 2021
Fishes Without Borders Workshop
Monday, March 1st, 2021
Virtual Event

Spring Chinook once thrived in PNW

- 1100-1400 km freshwater migration,
- vast marine migration,
- 6 year old spawners,
- ~1 million fish



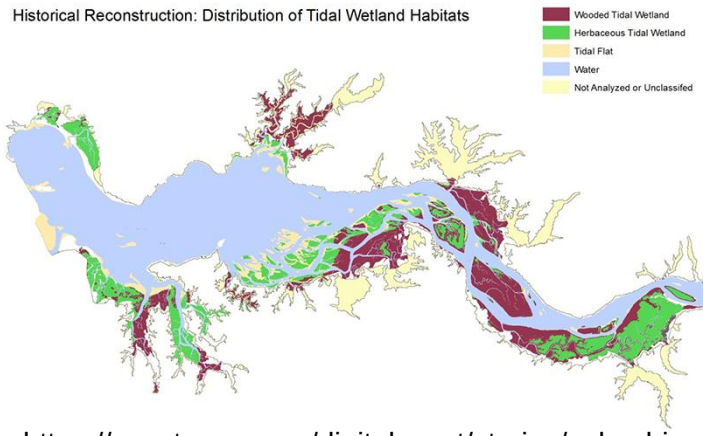
Snake River spring/summer Chinook salmon ESU



But human impacts grew

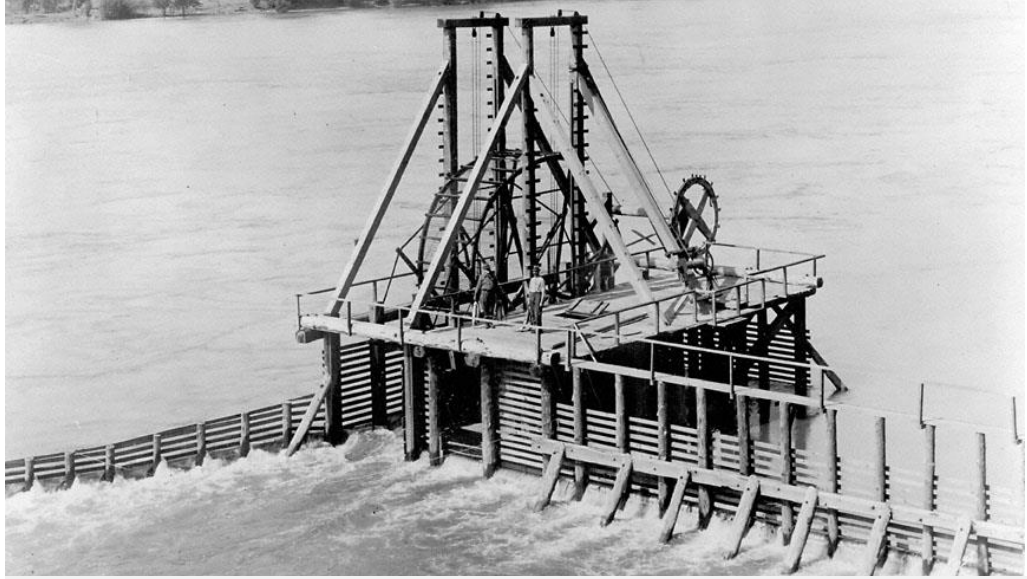
https://www.livescience.com

https://www.oregonmetro.gov/



https://coast.noaa.gov/digitalcoast/stories/columbia-river.html

Fishwheels devastated runs on the Columbia River
Oregon History Project, Oregon Historical Society
https://www.oregonhistoryproject.org/



Impassable dams, e.g., Hells Canyon Project.
Hells Canyon National Recreation Area
Photo: https://www.terragalleria.com/

Splash dams, mining, ag, grazing, development,…
degraded habitat and migratory corridors

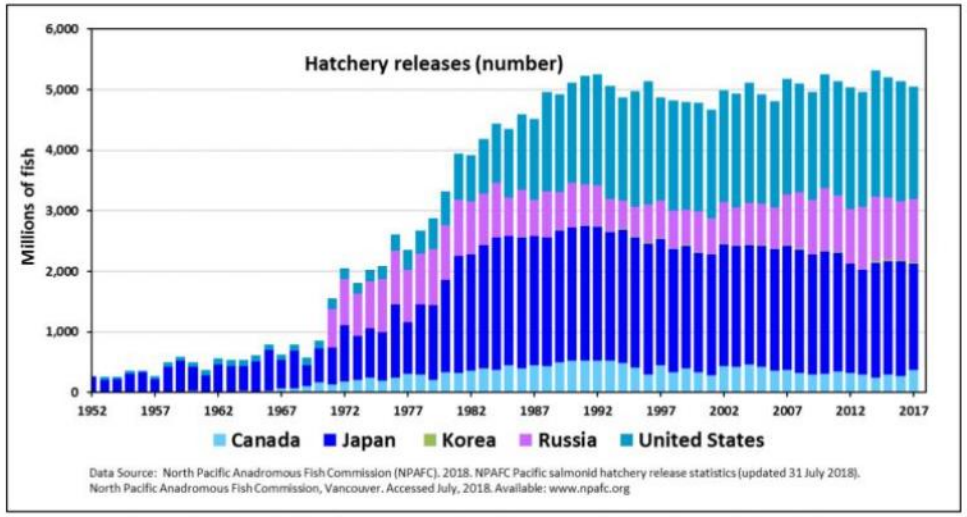
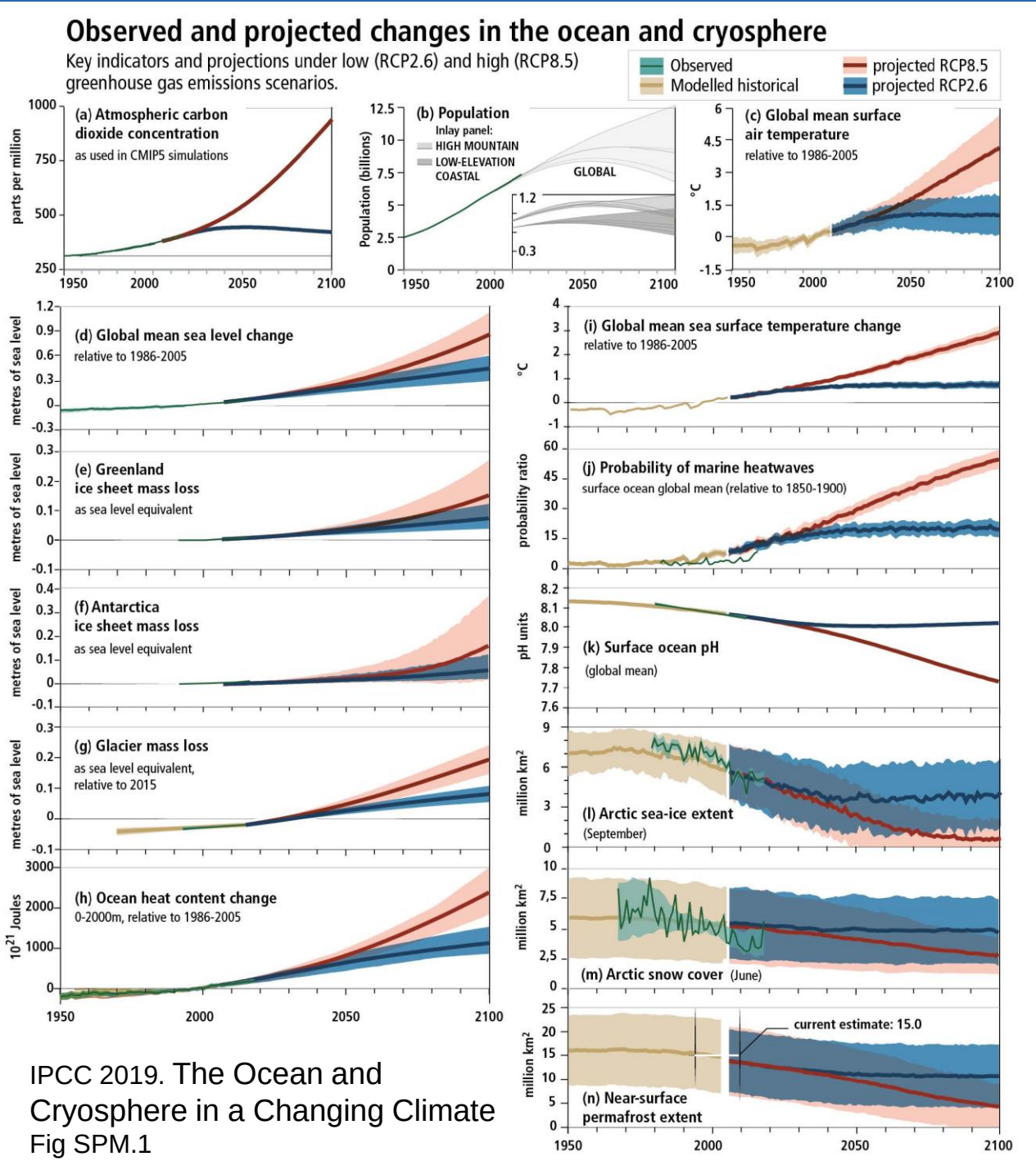


Figure 5. Annual hatchery release of salmon and steelhead trout by country in millions of fish.

North Pacific Anadromous Fish Commission graphic



IPCC 2019. The Ocean and Cryosphere in a Changing Climate
Fig SPM.1

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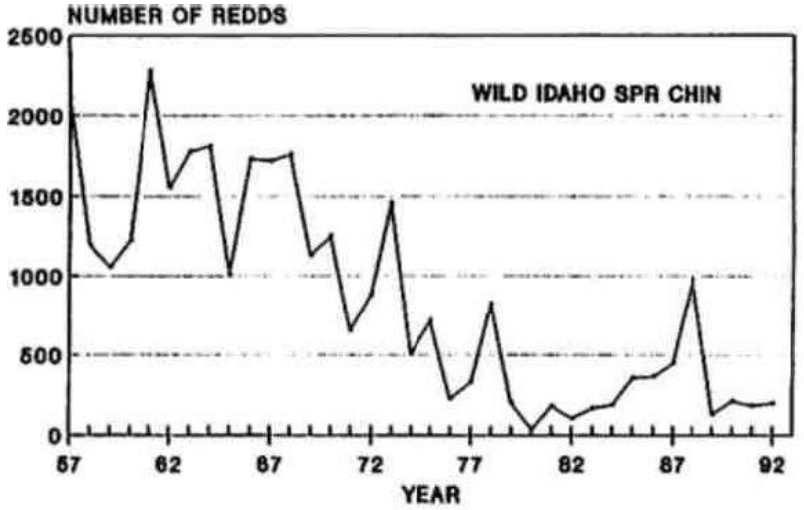
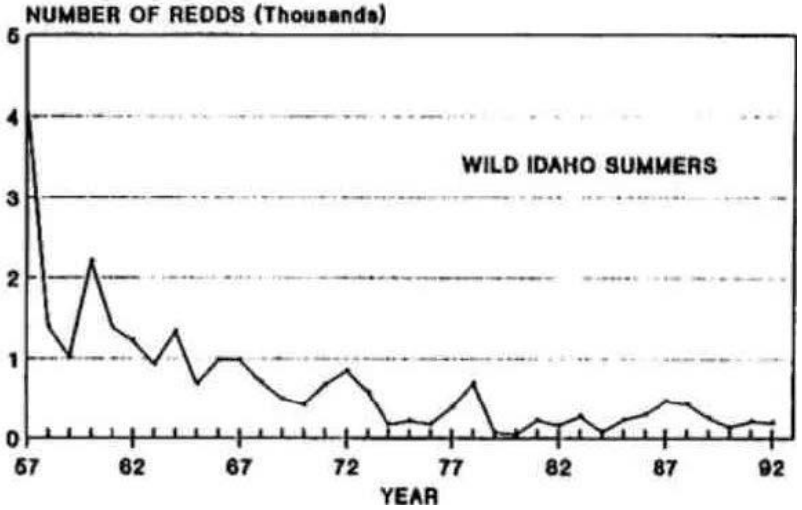
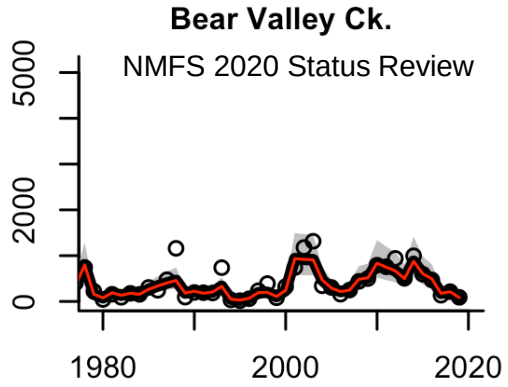
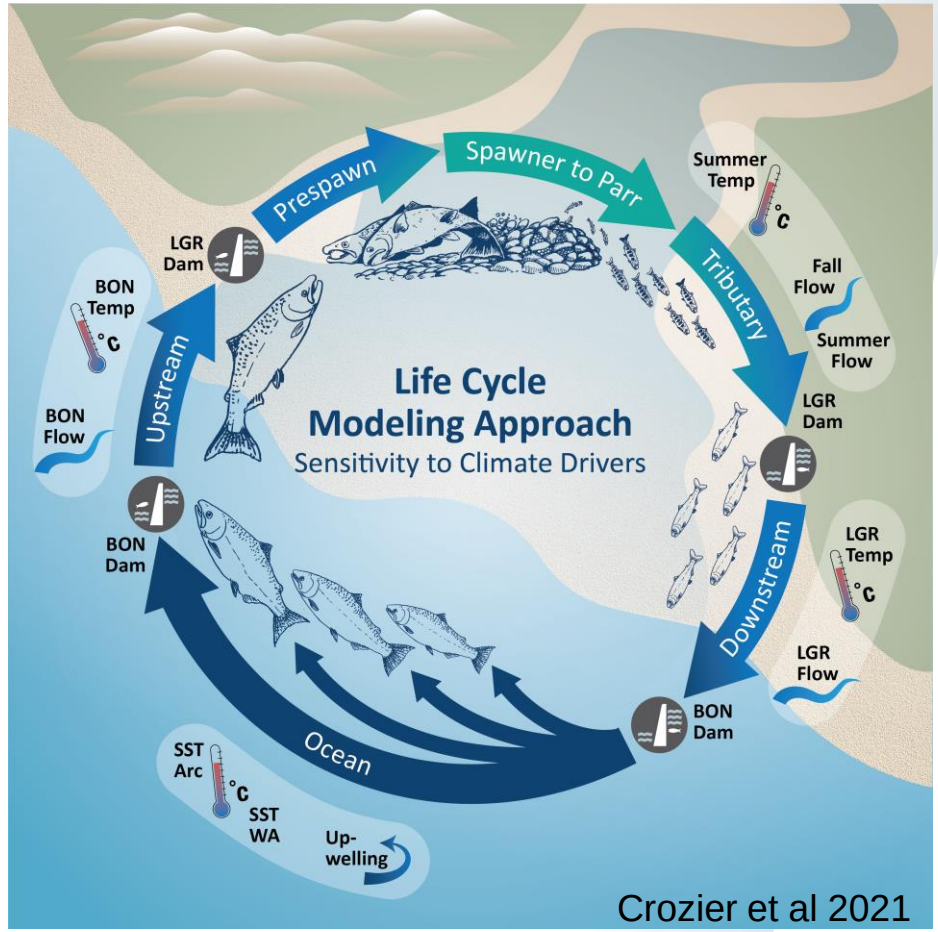
These human impacts caused population declines









NRC 1996. Upstream: Salmon and society in the PNW
FIGURE 4-5 (a) Index area redd counts for wild spring chinook in Idaho.
(b) Index area redd counts for wild summer chinook salmon in Idaho.

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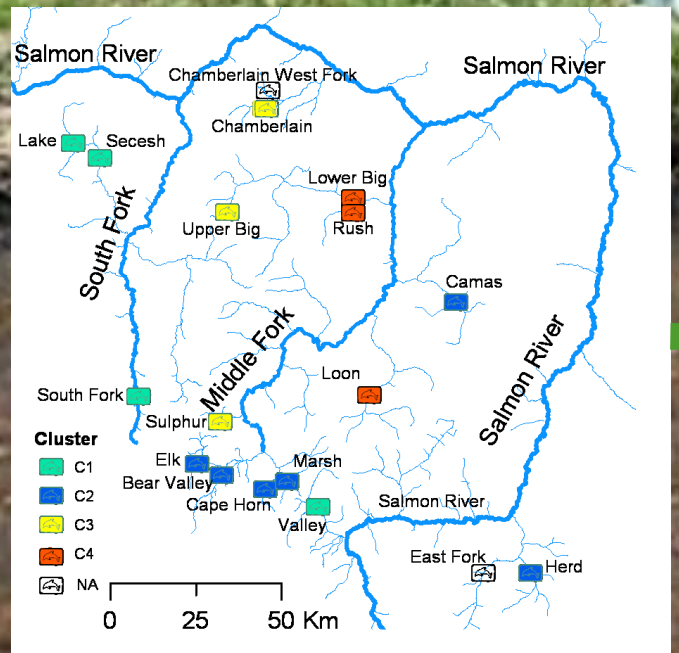
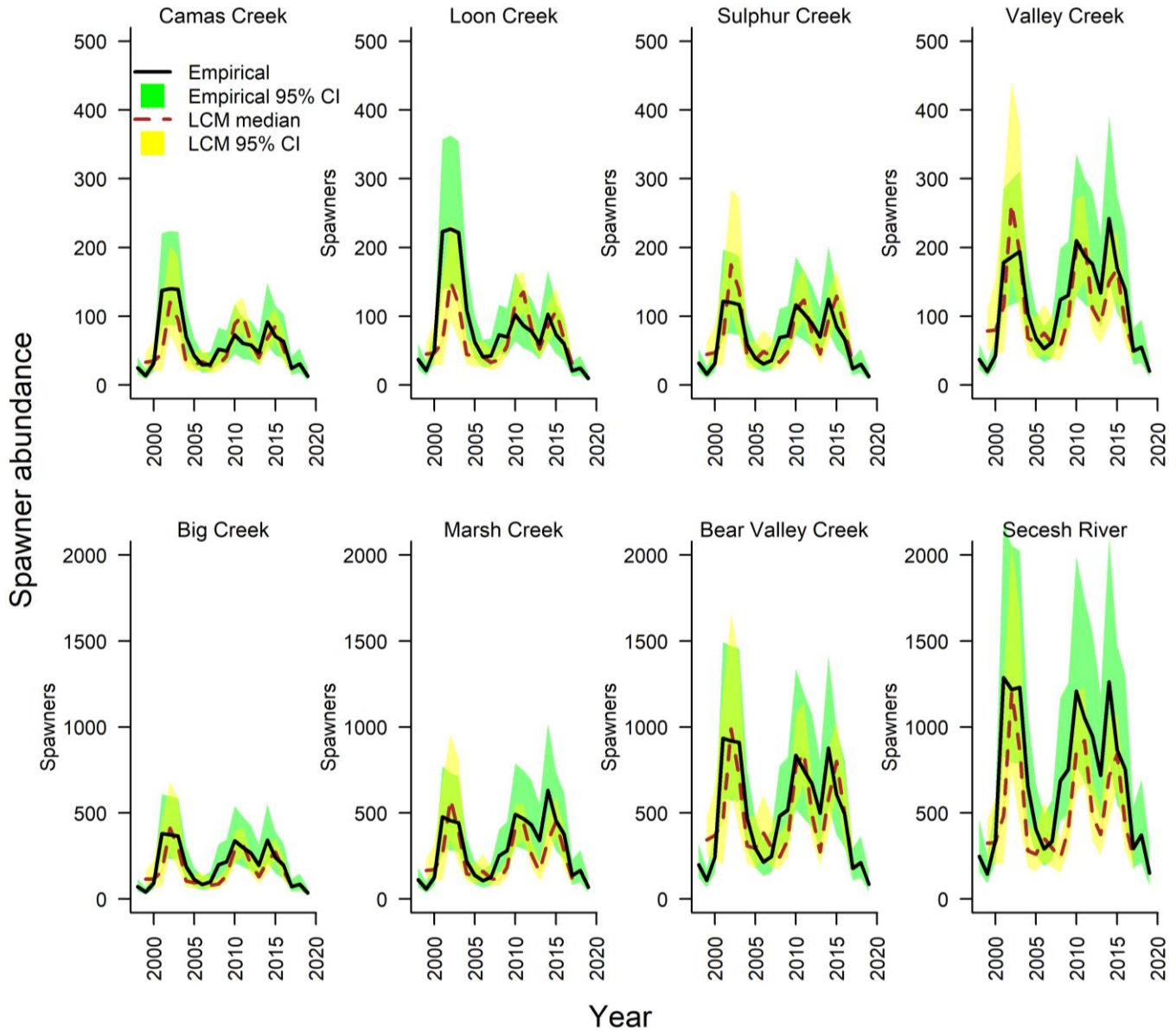
Life stage	Years	N	Reference
Spawner abundance	1998-2016	33542	IDFG et al. 2018; Nez Perce Tribe 2019
Stributary (s_2)	2000-2014	171004	Lamb et al. 2018
Smainstem (s_2)	2000-2014	~1,600,000	Faulkner et al. 2019
SAR (s_3, s_0)	2000-2017	33795	Chasco et al. 2021
Supstream	2004-2017	7553	Crozier et al. 2016, Crozier et al. 2018



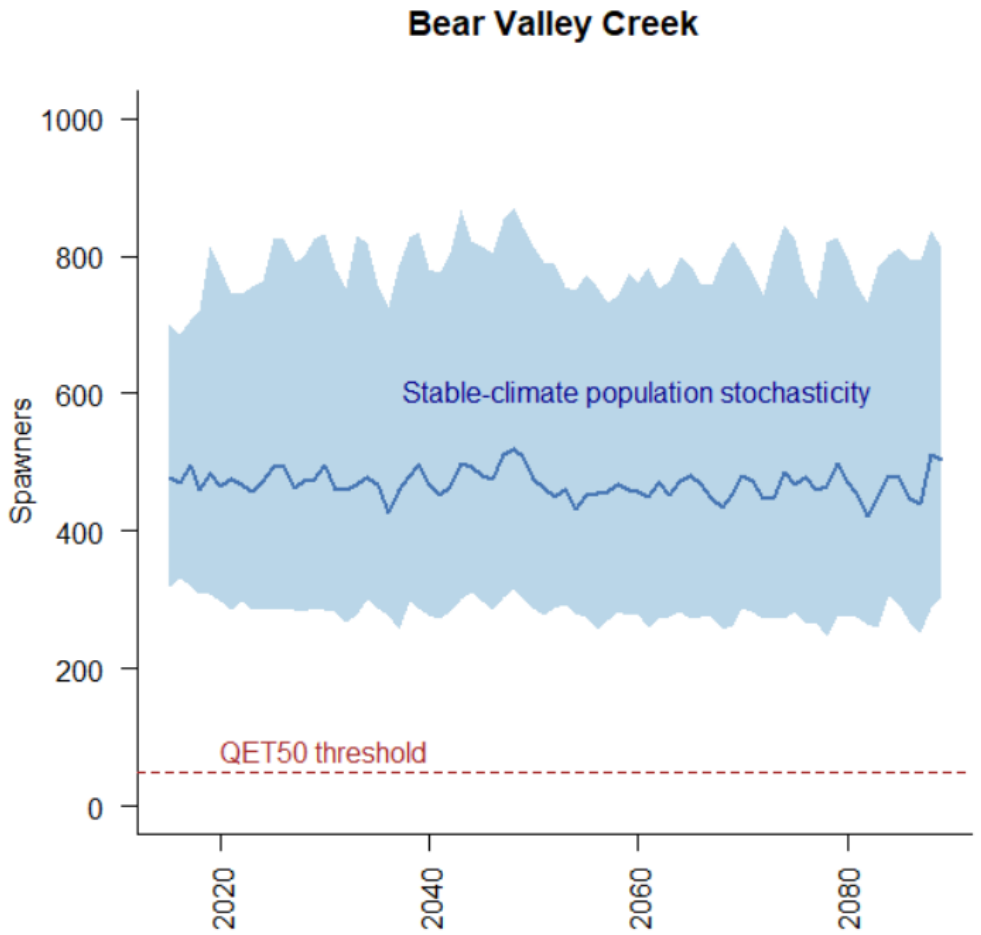
LOTS of Pit-tag and redd data

Strong model performance looking back



Crozier *et al.* 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications Biology 4:222.

Looking toward the future:



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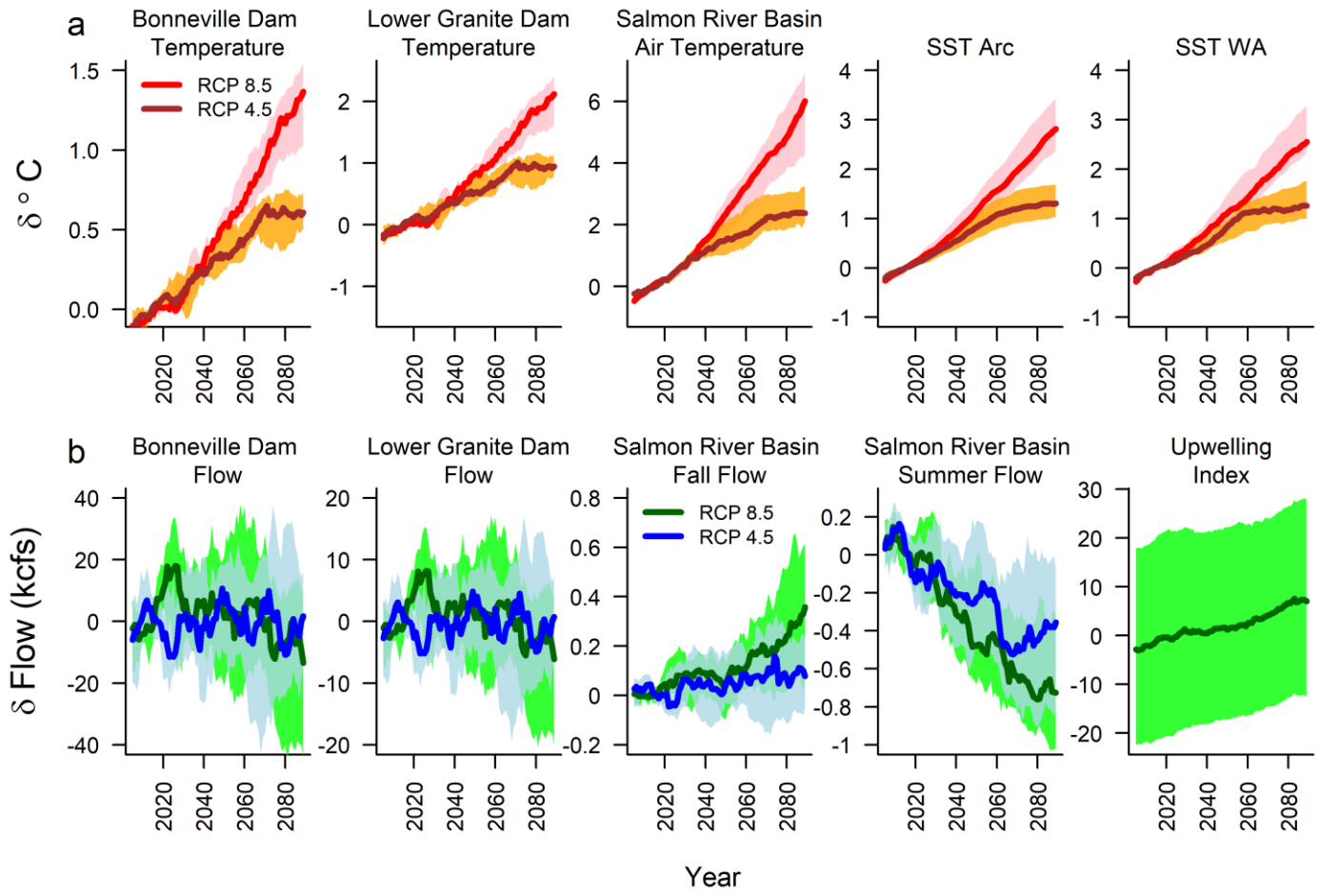
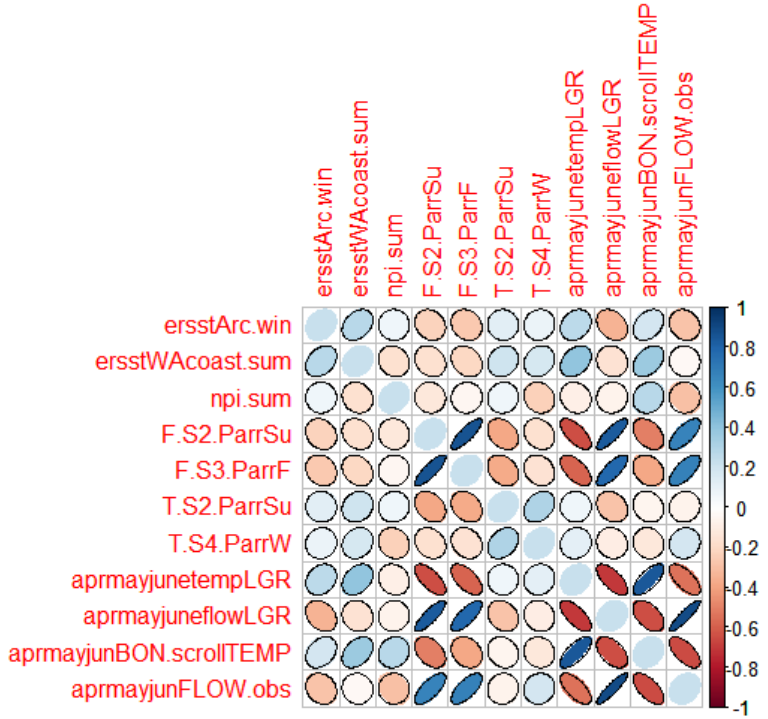
Future trends from GCMs:

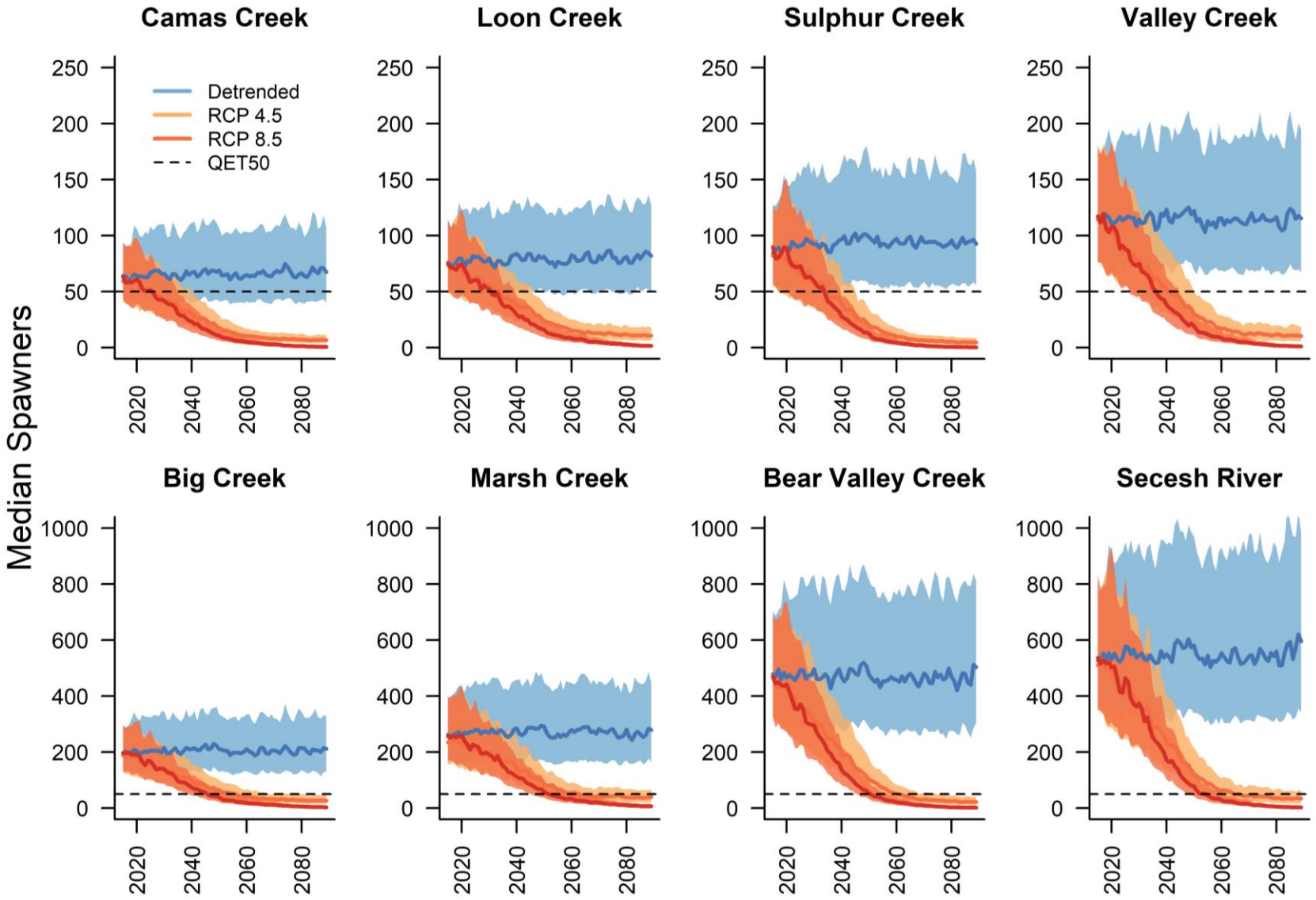


Correlation structure between freshwater and marine environments maintained



Crozier *et al.* 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications Biology 4:222.

RESULTS: Populations quickly declined in climate change scenarios



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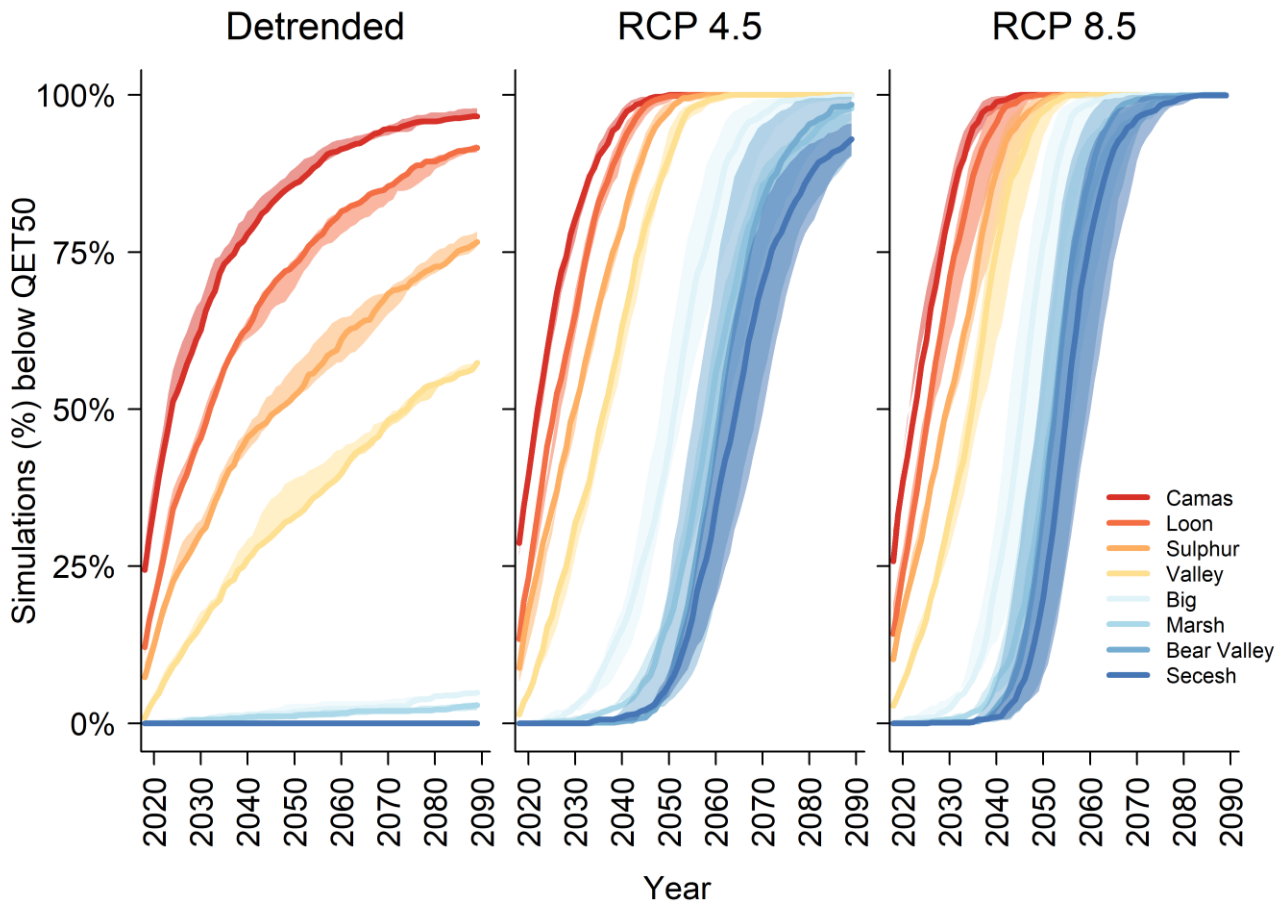
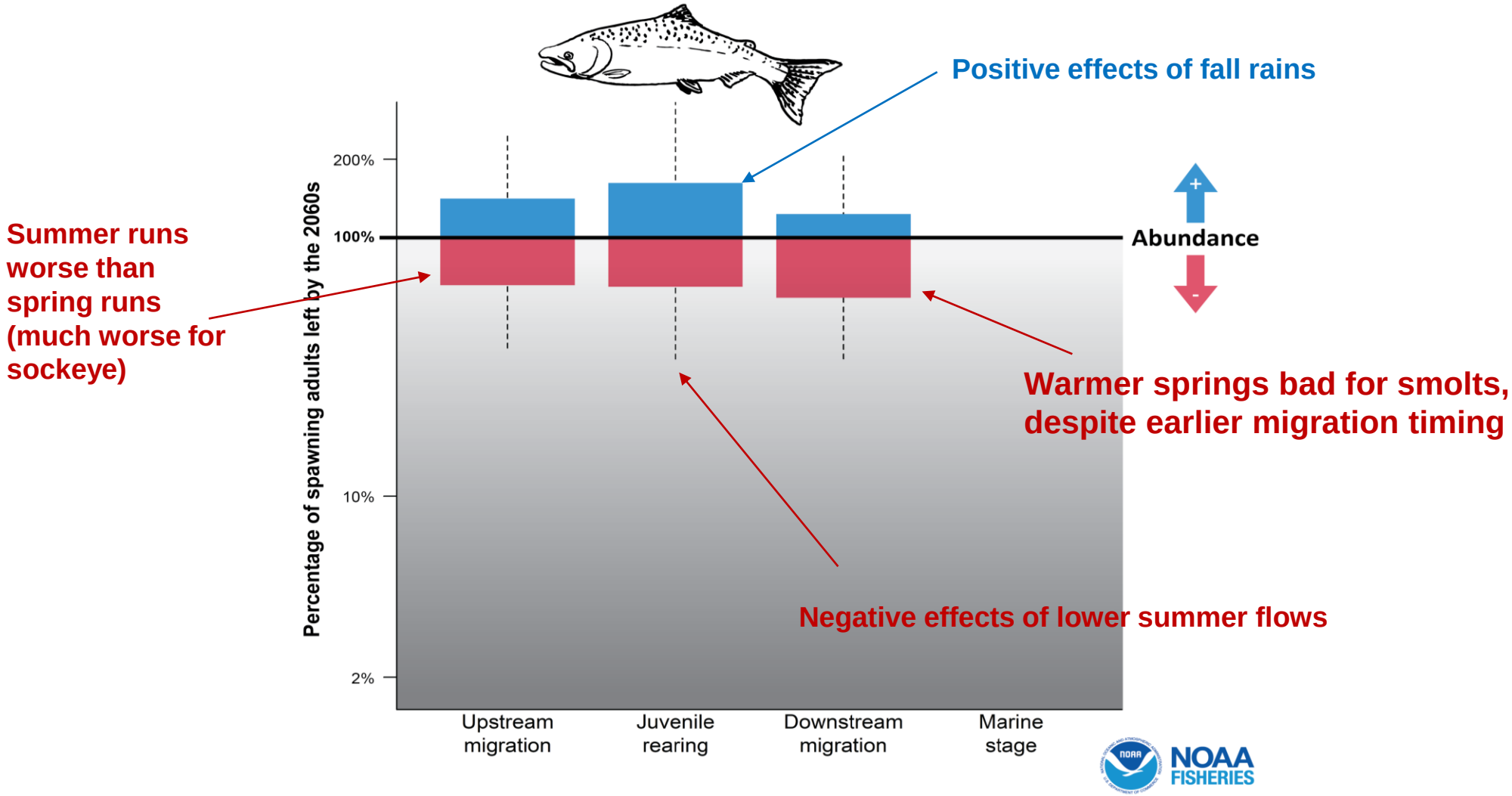
RESULTS: Extinction risk increased dramatically in all populations



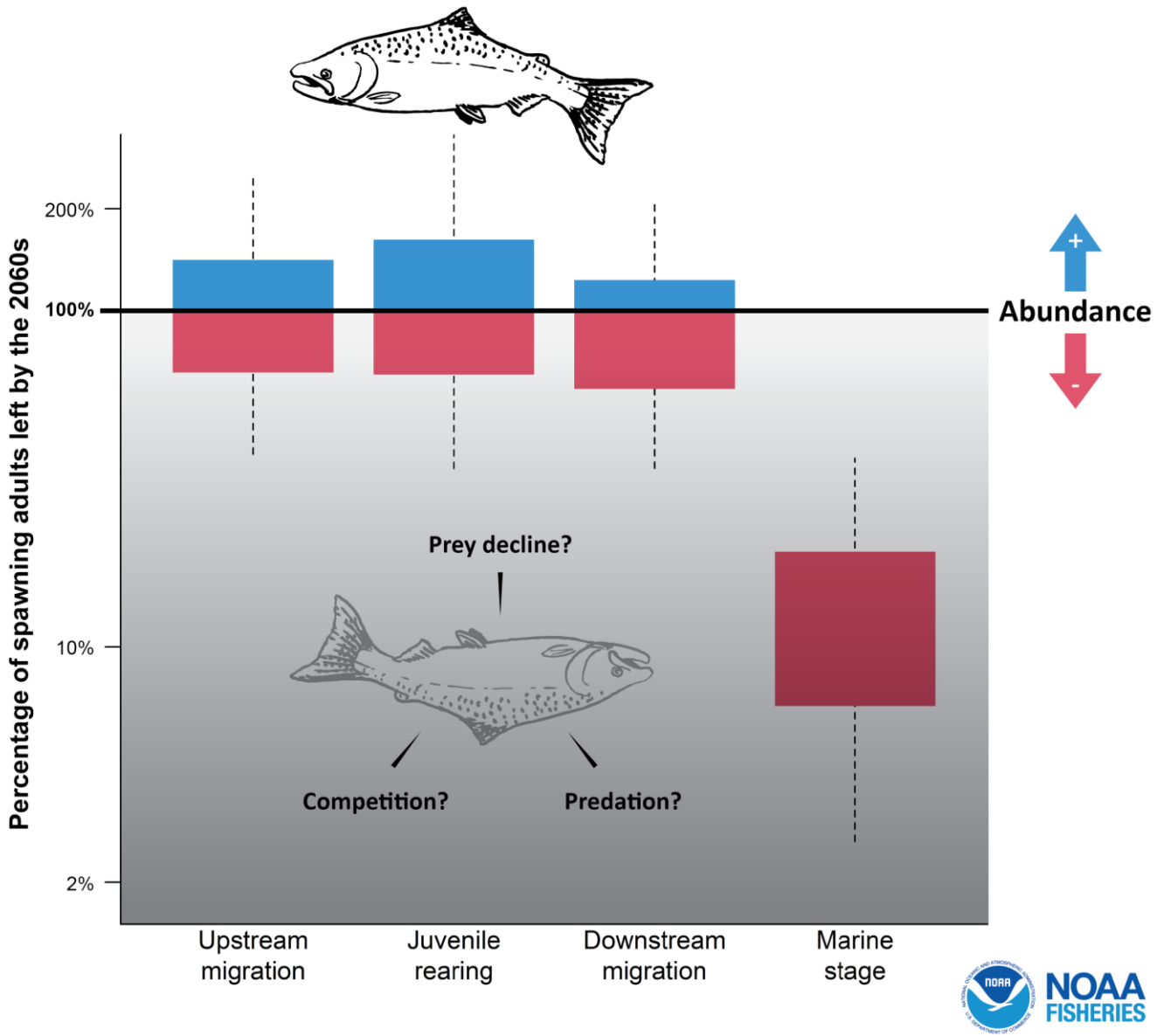
Crozier *et al.* 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications Biology 4:222.

Sensitivity in different life stages:

PROJECTED CHANGE IN CHINOOK SALMON SURVIVAL AS FRESHWATER WARMS



Sensitivity in different life stages:



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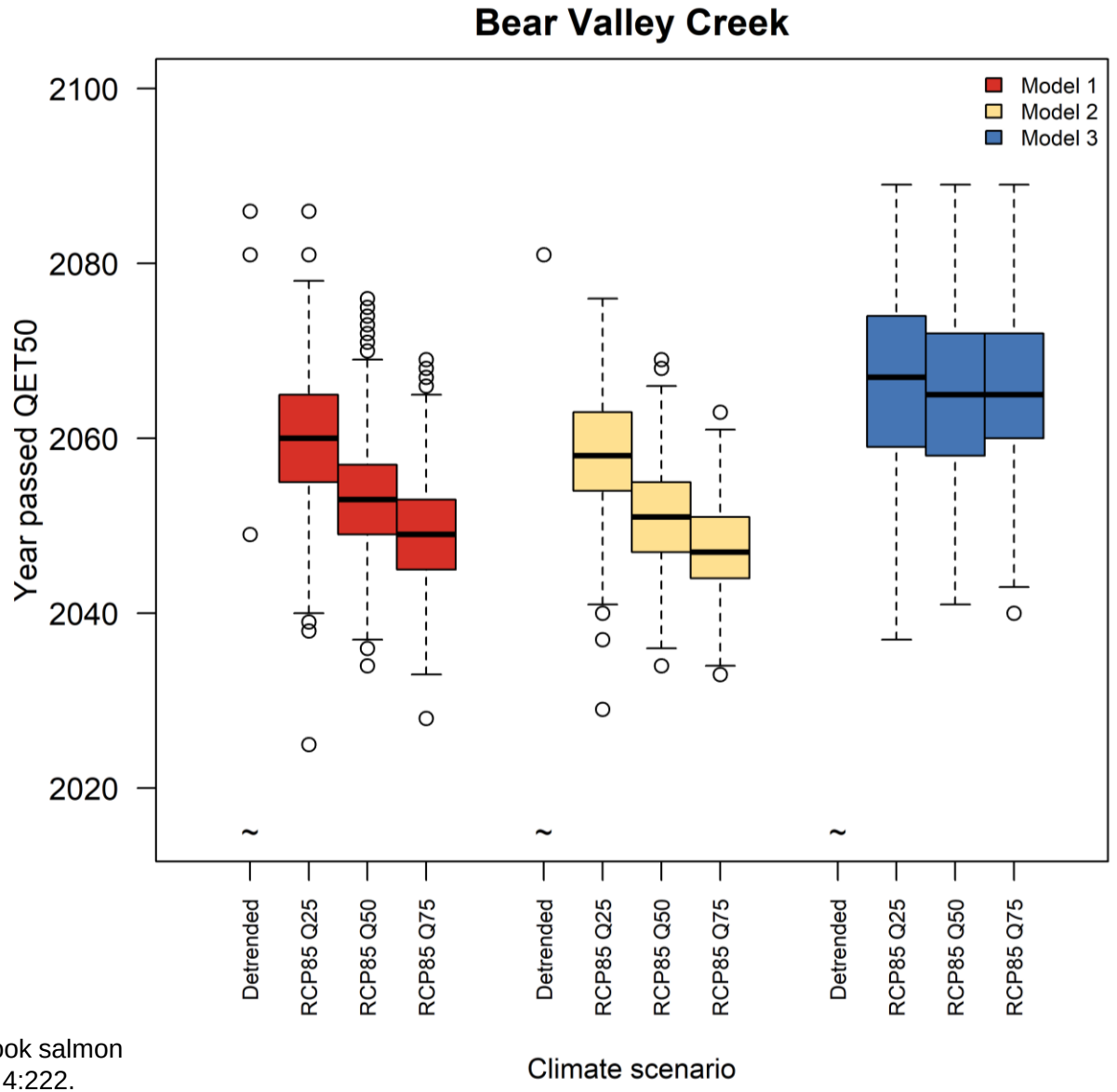
RESULTS: If upwelling or productivity from another source increases, it improves prospects



Model 1:
FW: Fall flow+Tsummer
M: SSTarc + SSTwa

Model 2:
FW: Summer flow
M: SSTarc + SSTwa

Model 3:
FW: Fall flow+Tsummer
M: SSTarc + upwelling

Crozier *et al.* 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications Biology 4:222.

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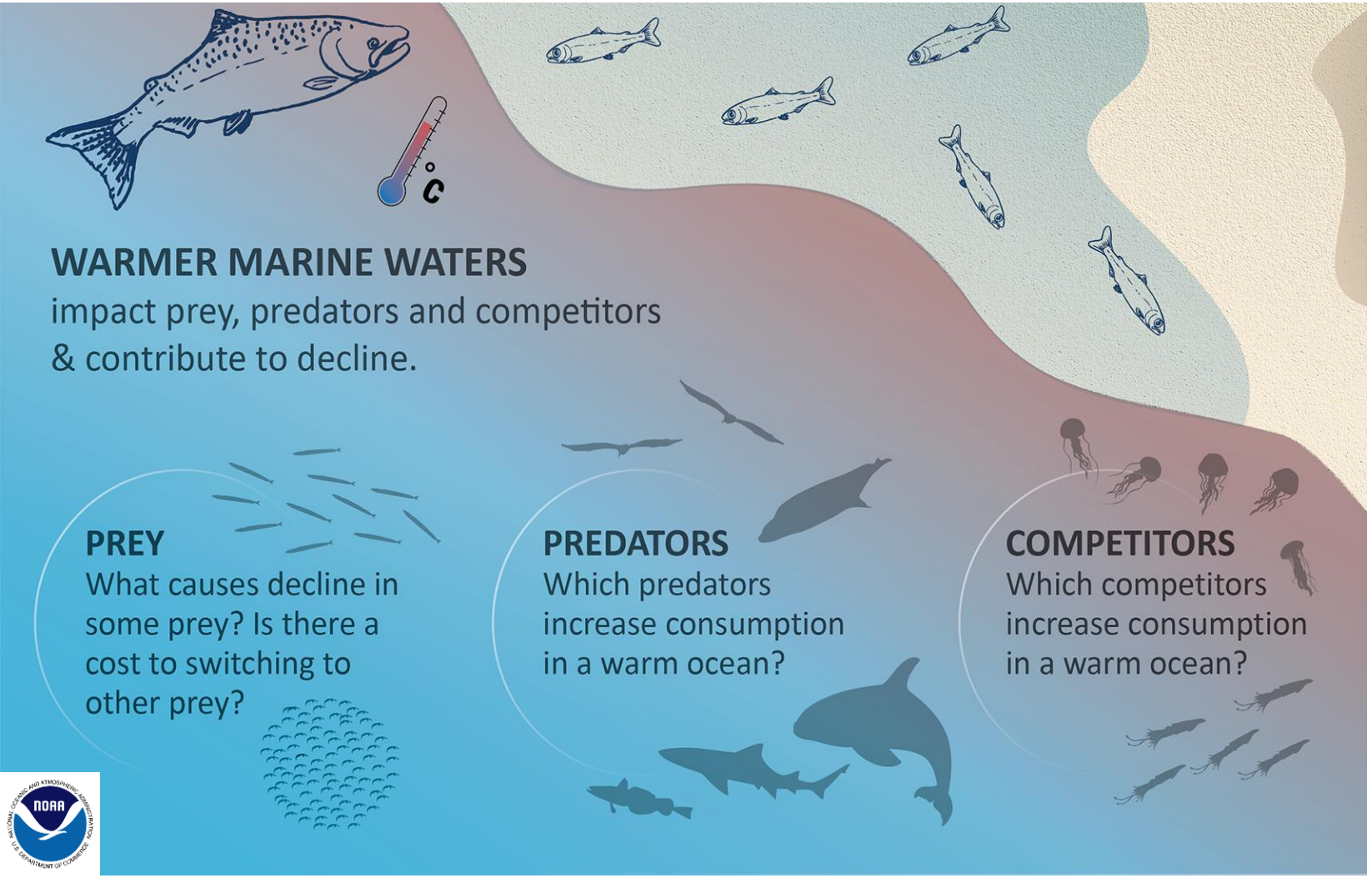
RESPONSE:



Action Items

1. Monitoring and Modeling of marine stage
   - Fill critical ocean ecology data gaps on predators, competitors and prey
   - Test hypothesized trophic interactions through modeling

2. Experimental Studies
   - Acoustic tag study to estimate spatio-temporal predation and unaccounted-for mortality
   - Test effectiveness of freshwater actions

3. Estuary habitat improvements
   - Replace losses to diet from terrestrial sources
   - Restore nursery habitat for prey species
   - Plan for sea level rise, storm surge, extreme events, and human population growth

4. Actively manage other marine species
   - Prey (forage fish, squid, rockfish)
   - Predators (marine mammals, birds)
   - Plan for increase in warm-water species

RESPONSE: marine research on management levers

MANAGEMENT ACTIONS

Estuary Restoration Act

Wetlands provide key habitat and nursery grounds for valuable wildlife like shrimp, salmon, and crabs.

Harvest plans:
Coastal Pelagic Species
Hake
Salmon

Colony management

Marine Mammal Protection Act Section 120 Pinniped Removal Program

https://www.fisheries.noaa.gov/west-coast/marine-mammal-protection/marine-mammal-protection-act-section-120-pinniped-removal

Smolt body size and timing

Zooplankton, invertebrates, fish larvae — Prey

Anchovy — Competitor, Prey

Hake — Predator, Competitor

Seabirds — Predator

Marine mammals

Fisheries

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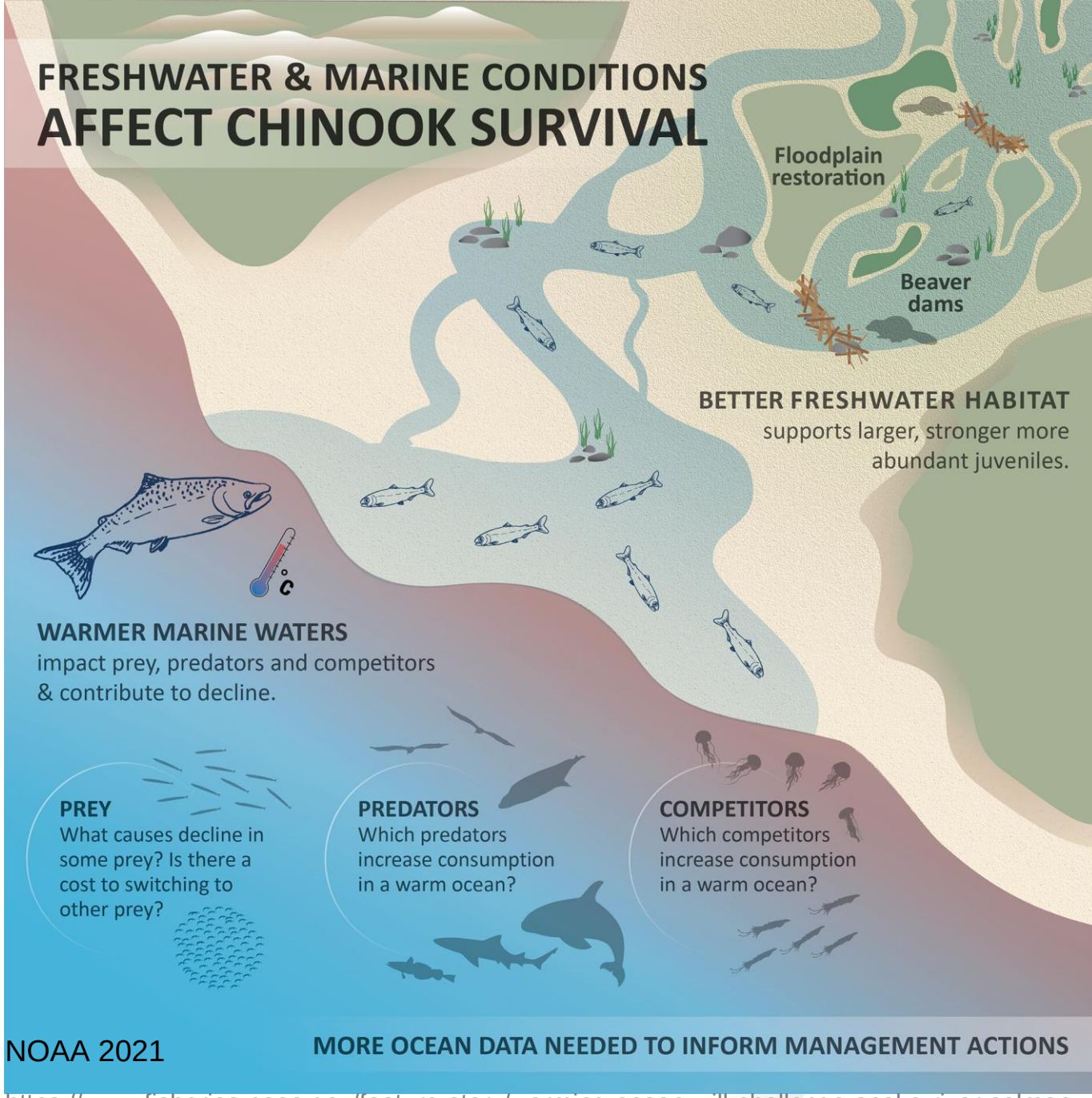
Conclusions

- Improved modeling approach
- Dire consequences for spring Chinook salmon
- **Called to action:**
  - **Invest in marine research to understand how management actions can reduce these impacts**
  - **Reduce density-dependence in freshwater**



https://www.fisheries.noaa.gov/feature-story/warming-ocean-will-challenge-snake-river-salmon-survival-coming-decades-new-research

Many thanks to:

State Fish and Wildlife Agencies:

Washington Dept. of Fish and Wildlife

Oregon Dept. of Fish and Wildlife

Idaho Dept. of Fish and Game

Tribes and Tribal Consortia:

Colville Confederated Tribes

Shoshone-Bannock Tribe

Umatilla Tribe

Warm Springs Tribe

Yakama Nation

Columbia River Inter-Tribal Fish Commission

Northwest Indian Fisheries Commission

Federal Fish and Wildlife Agencies:

U.S. Fish and Wildlife Service

NOAA Fisheries/National Marine Fisheries Service

Other Involved Entities:

Pacific States Marine Fisheries Commission, StreamNet Project

U.S. Fish and Wildlife Service, Fish Inventory System (FINS)

WA Governors Salmon Recovery Office

WA Recreation and Conservation Office

Northwest Power and Conservation Council

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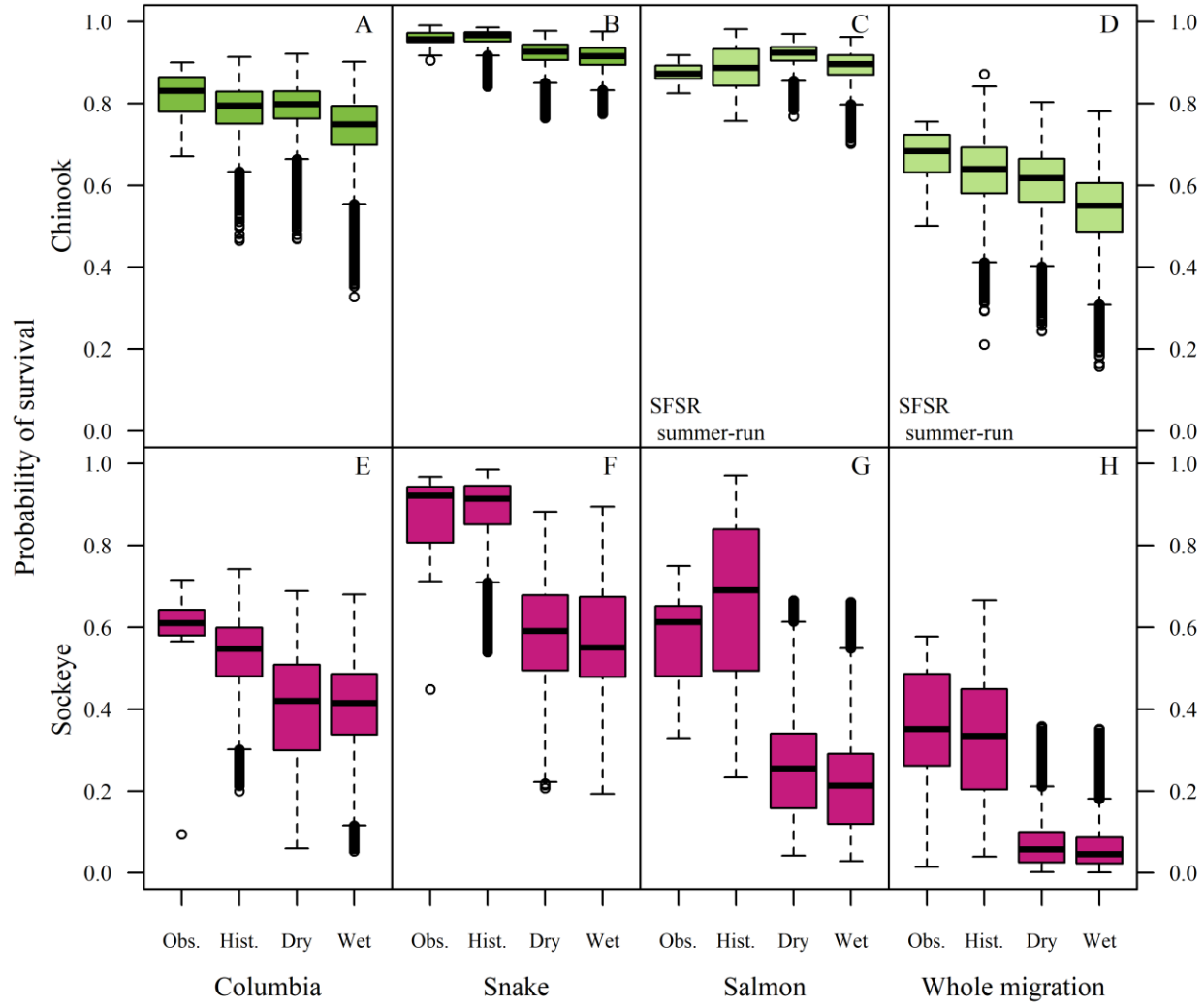
RESULTS: Upstream migration survival



Crozier, et al. 2020. Snake River sockeye and Chinook salmon in a changing climate: implications for upstream migration survival during recent extreme and future climates. Plos One 15(9):e0238886.

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