West Coast Salmon Climate Vulnerability Assessment

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Fish Stock Climate Vulnerability Assessments

Science

Management

Goal: Assess the vulnerability of all NMFS-managed fish and invertebrate species to changing climate/ocean conditions to help inform science and management actions.

Process

- Develop methodology
  - attributes, scoring bins, logic rules
- Literature review for each species : Species Profile
- Expert scoring
  - Preliminary scores online
  - Scoring workshop
- Analysis
- Species narratives
- Manuscripts
  - methodology, results CVA/Salmon

Fisheries Stock Climate Vulnerability Assessments

Sensitivity

- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

Exposure

- Sea surface temperature*
- Air temperature*
- Salinity*
- Ocean acidification (pH)*
- Precipitation*
- Currents**
- Sea level rise**

**modelled results (mean & variance)*
***written description only*

Salmon Vulnerability Assessment

1) Recovery domains and Distinct Population Segments (DPS)

2) New sensitivity and exposure attributes

3) Results – patterns in vulnerability

4) Conclusions and implications

Salmon Recovery Domains – 29 ESA-Listed DPS

Pink (1)

Chum (3)

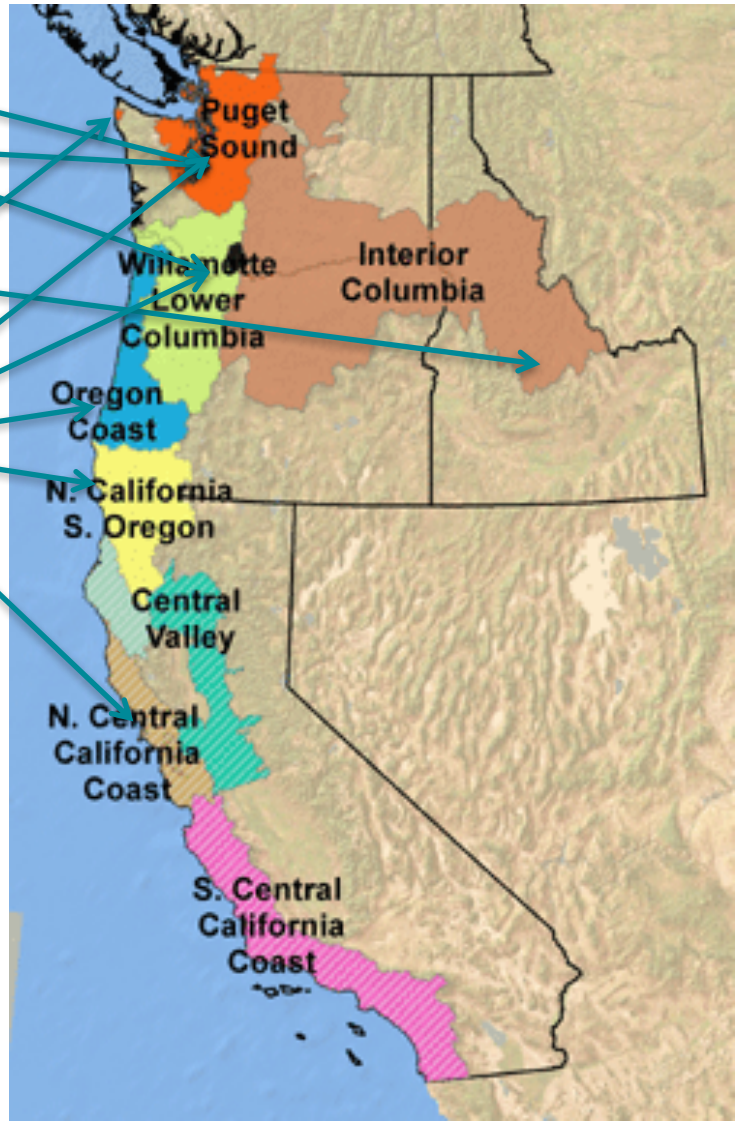
Added 4 unlisted DPS

Sockeye (2)

Coho (5)

Chinook (11, all domains)

Steelhead (11, all domains)



Salmon-specific Sensitivity Attributes

Life-stages – habitat specific

Population resiliency/Adaptive capacity

Specific Threats

Salmon-specific Sensitivity Attributes

Life-stages – habitat specific

- Egg
- Juvenile: freshwater, estuary, marine
- Adult

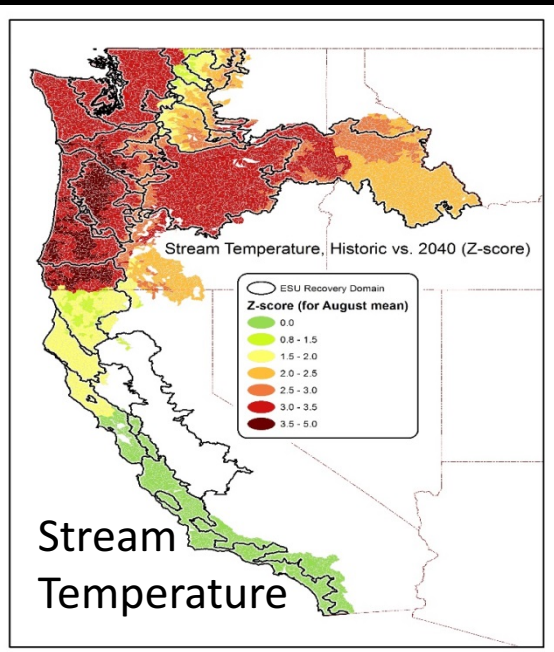
Population Population resiliency/Adaptive capacity

- Viable salmon population criteria

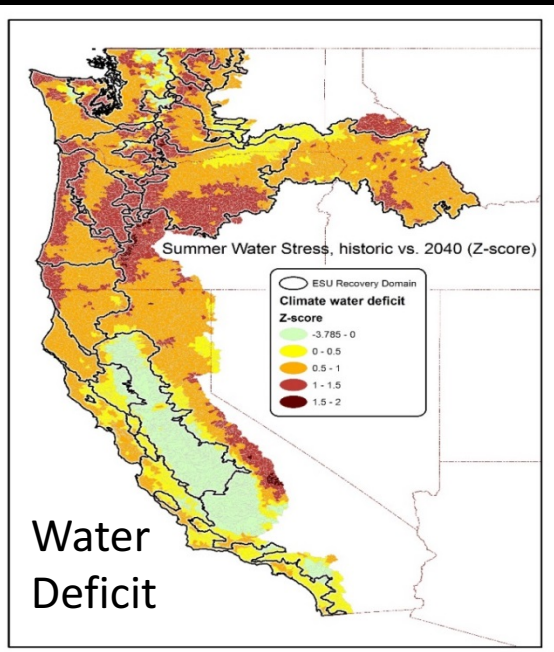
Threats

- Cumulative life cycle effects
- Hatchery impact
- Other Stressors
- Ocean acidification

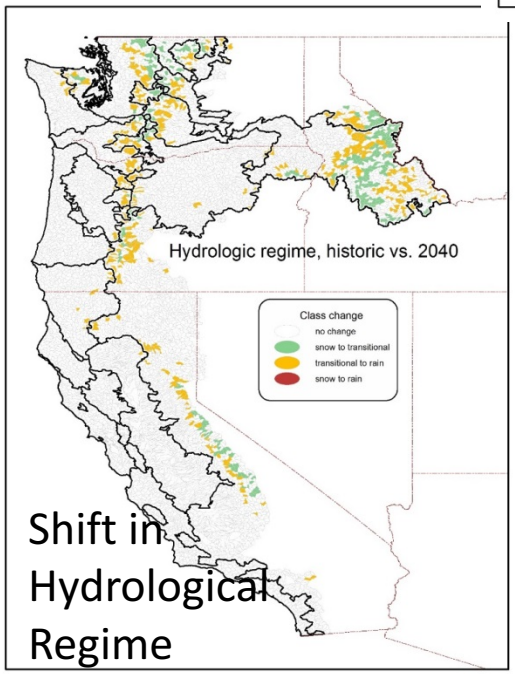
Freshwater exposure factors



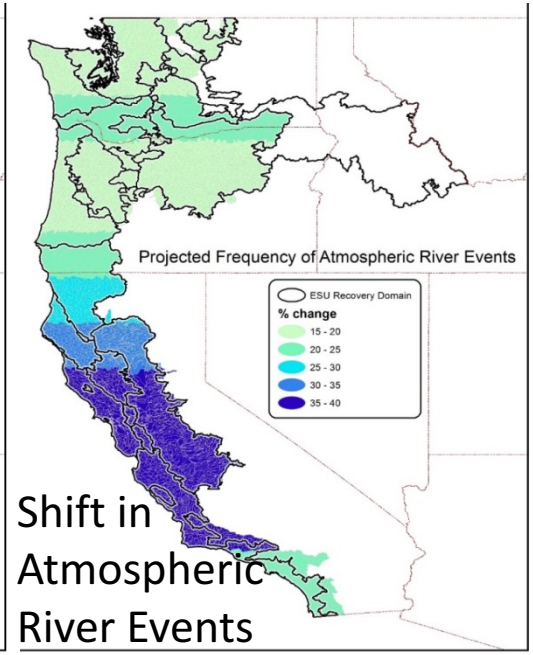
Stream Temperature



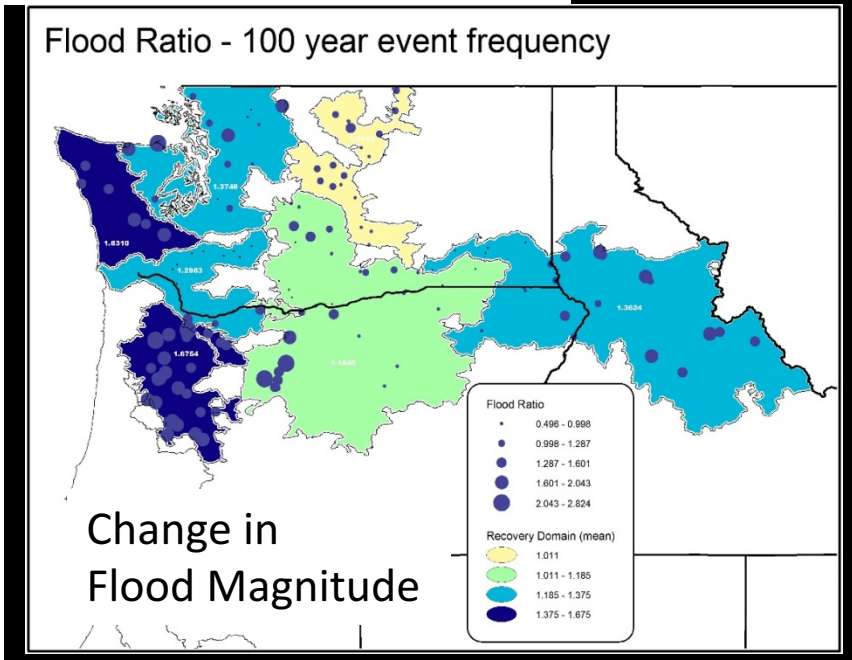
Water Deficit



Shift in Hydrological Regime



Shift in Atmospheric River Events



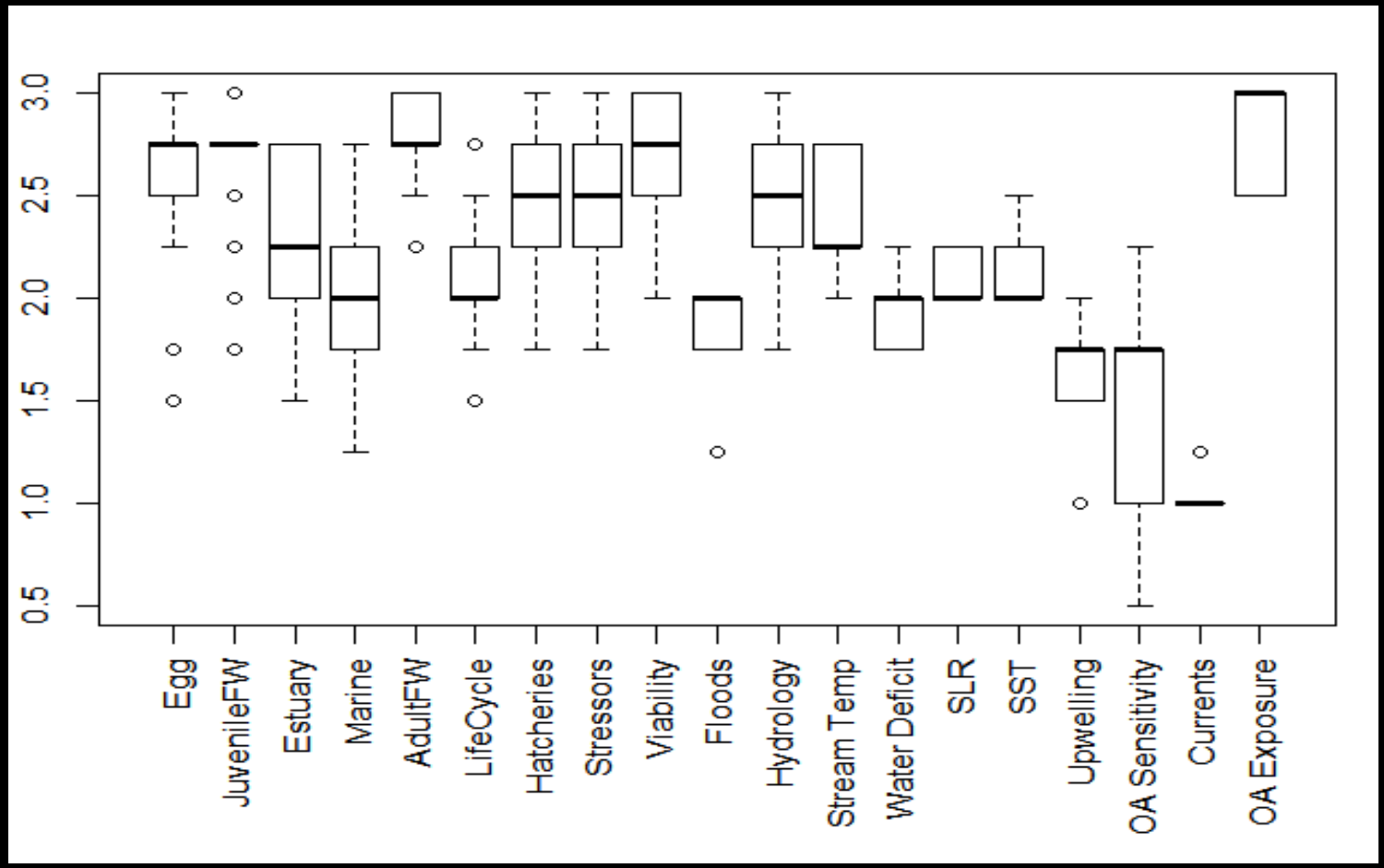
Change in Flood Magnitude

Data quality

Adequate data

Limited data

Expert judgment

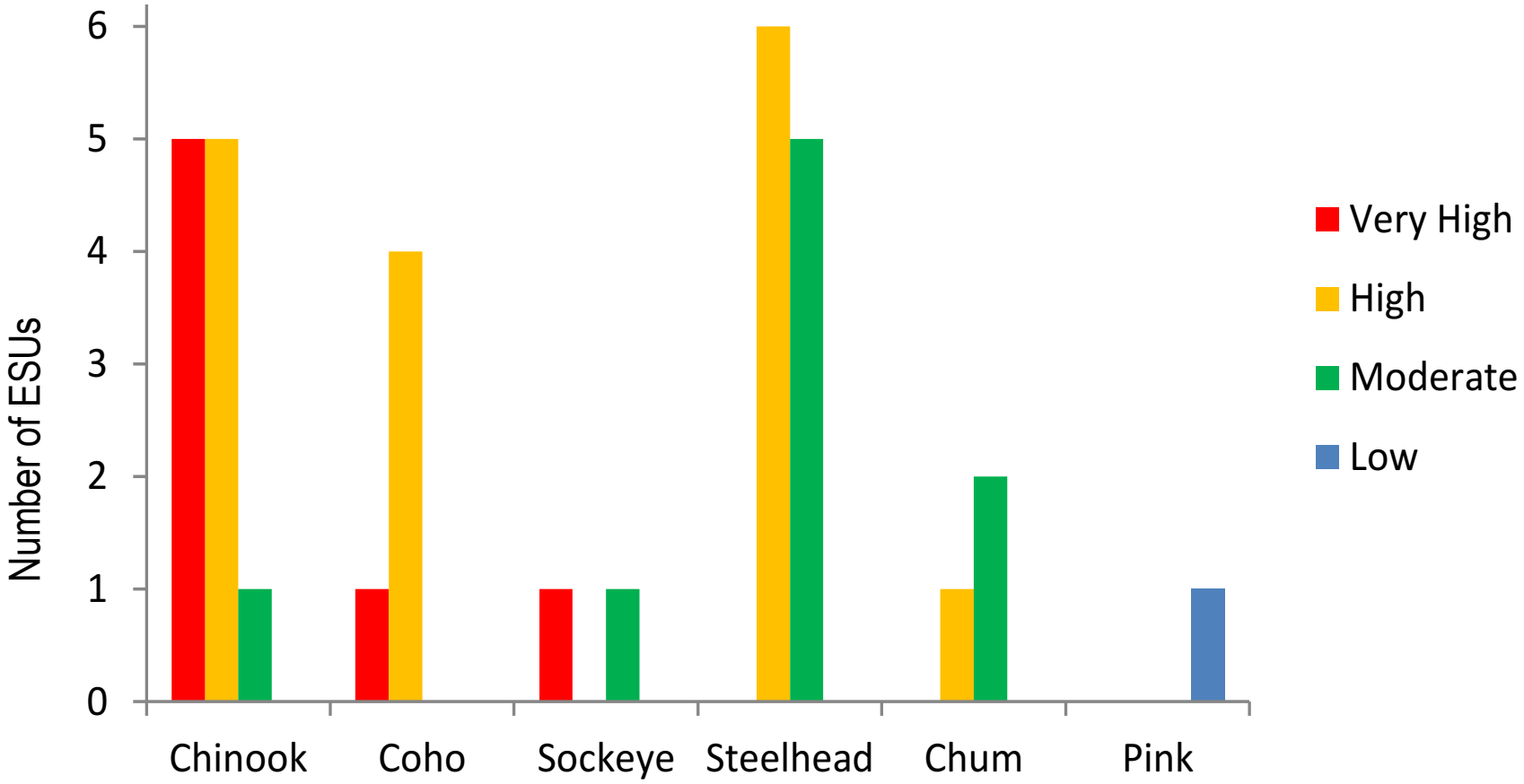


Results I: Final Vulnerability Ranking

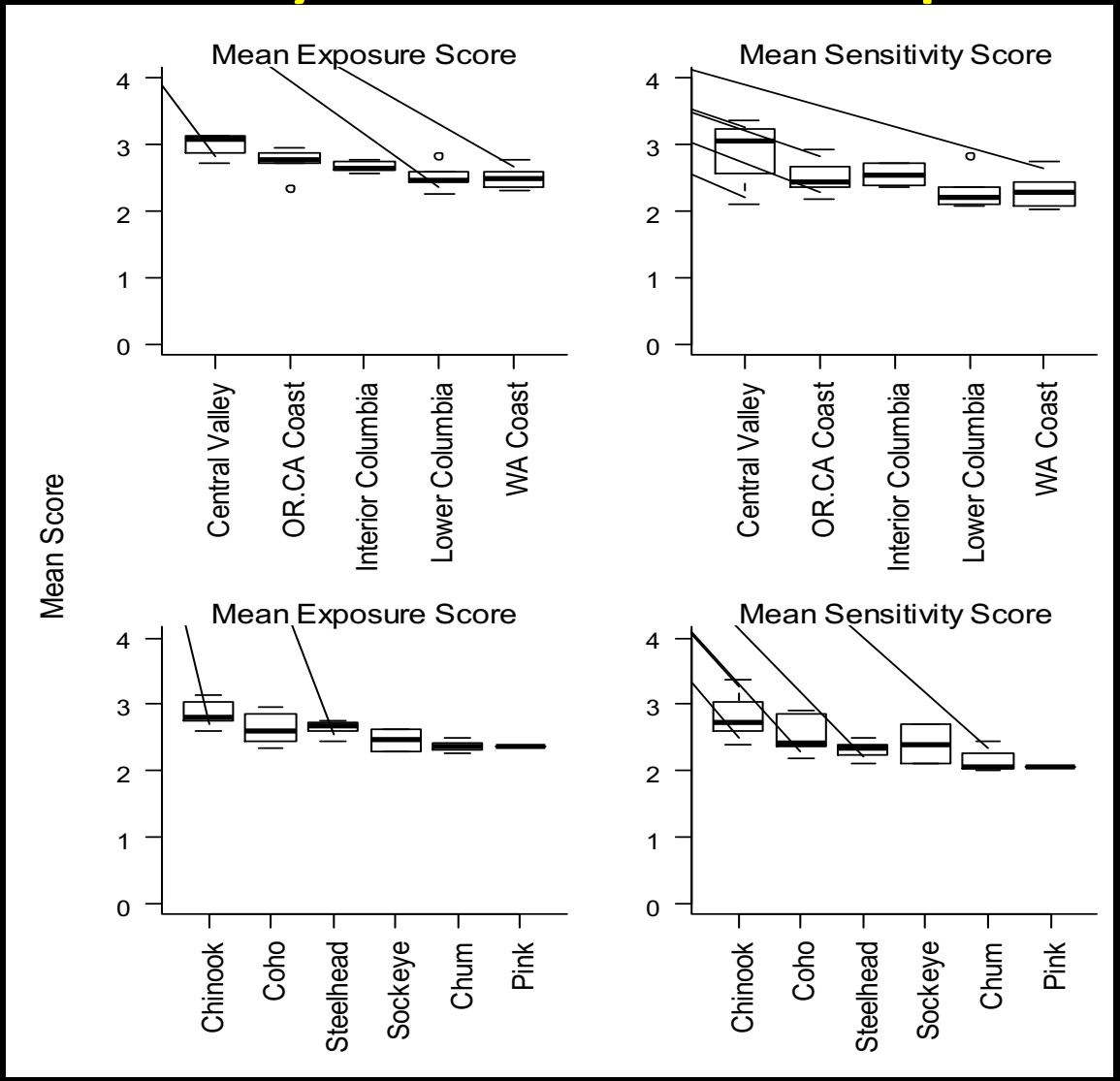
Sensitivity \ Exposure	Low	Moderate	High	Very High
Very High			Sacramento River winter-run Chinook Central Valley spring-run Chinook Central Valley fall-run/late fall-run Chinook Central California Coast Coho Upper Willamette River spring-run Chinook Snake River Sockeye	
High			*Southern Oregon/Northern California Coast Coho* *Mid Columbia Spring Chinook* *Upper Columbia River spring-run Chinook* California Coastal Chinook Puget Sound Chinook Snake River Basin Steelhead Southern California Coast Steelhead Middle Columbia River Steelhead Upper Columbia River Steelhead Puget Sound Coho Puget Sound Steelhead Snake River fall-run Chinook Hood Canal Summer-run Chum Upper Willamette River Steelhead Lower Columbia River Coho Oregon Coast Coho	Snake River spring/summer-run Chinook
Moderate		Puget Sound Chum Columbia River Chum	*Central California Coast Steelhead* *South Central California Coast Steelhead* Northern California Coast Steelhead California Central Valley Steelhead Lower Columbia River Steelhead Lower Columbia River Chinook Lake Ozette Sockeye	
Low		Puget Sound Pink		

Central Valley Chinook
Southern coho
Spring Chinook
Interior sockeye

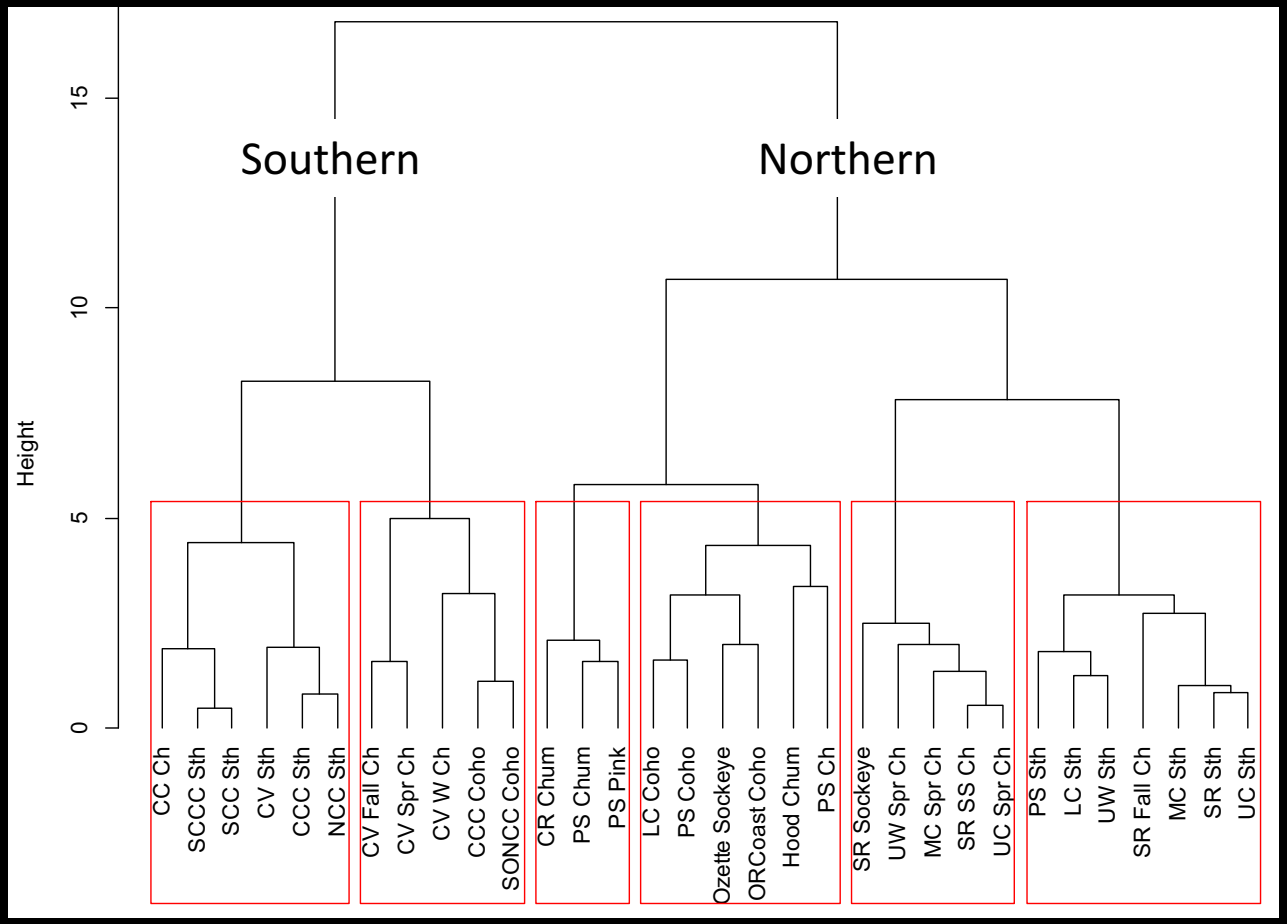
Spread of ESUs within each species



Mean component score by recovery domain and species



Cluster analysis of all attributes

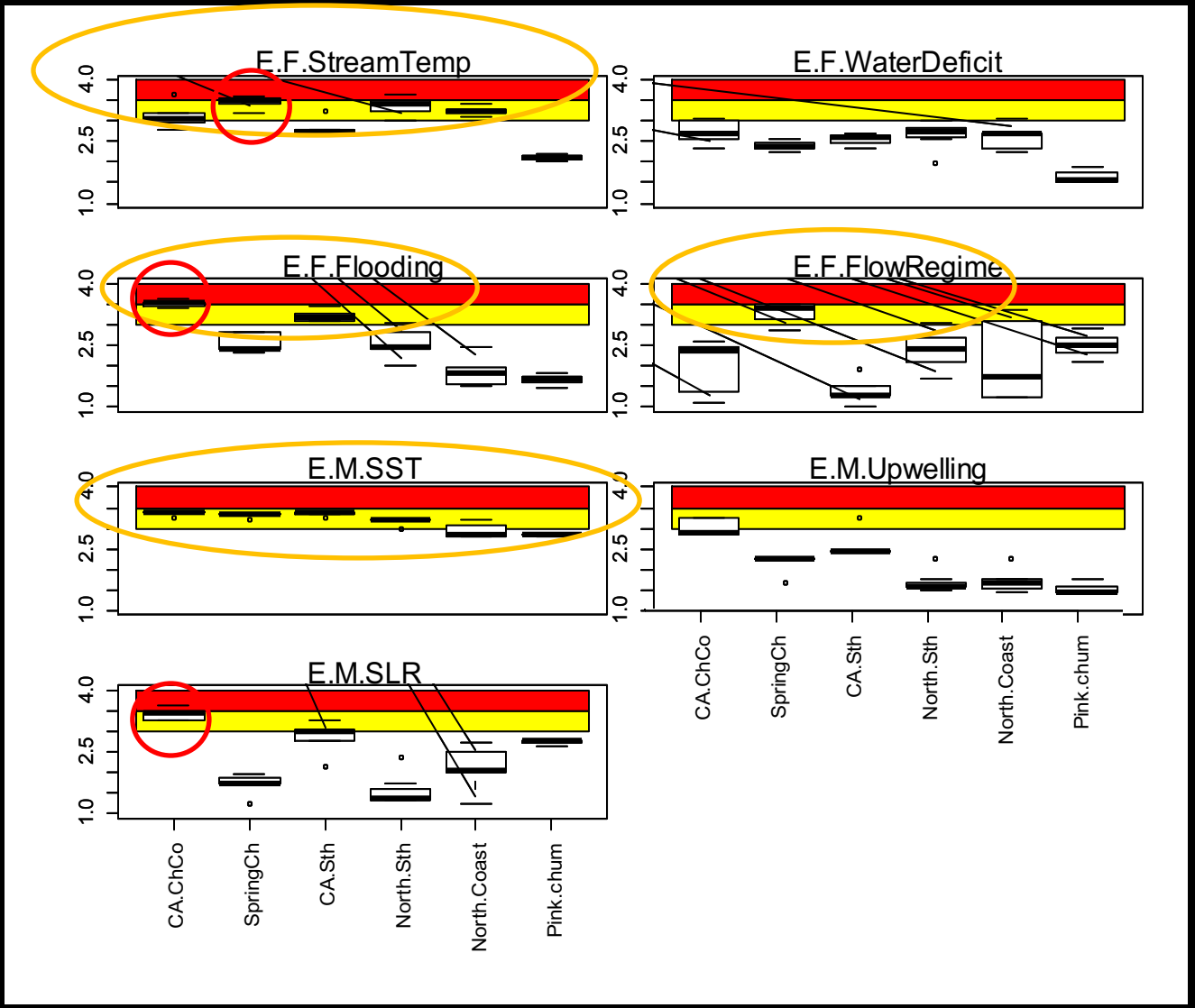


Exposure Scores

OA exposure very high for all ESUs
In addition:

Very High if
2 attributes ≥ 3.5
Snake River Spr/Su Ch
Stream Temp, Regime

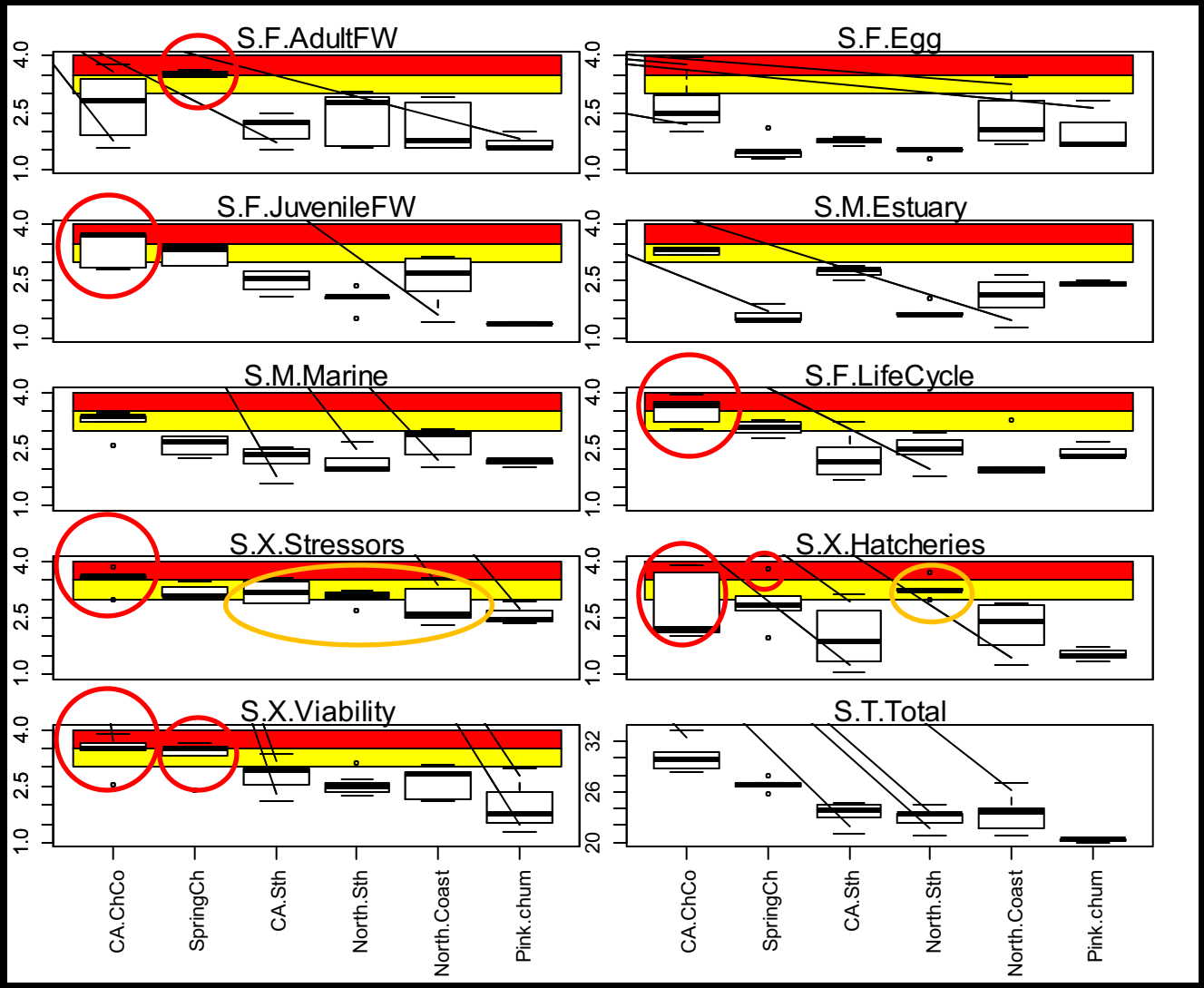
High if
1 attribute ≥ 3
Stream Temp, Flooding



Sensitivity scores

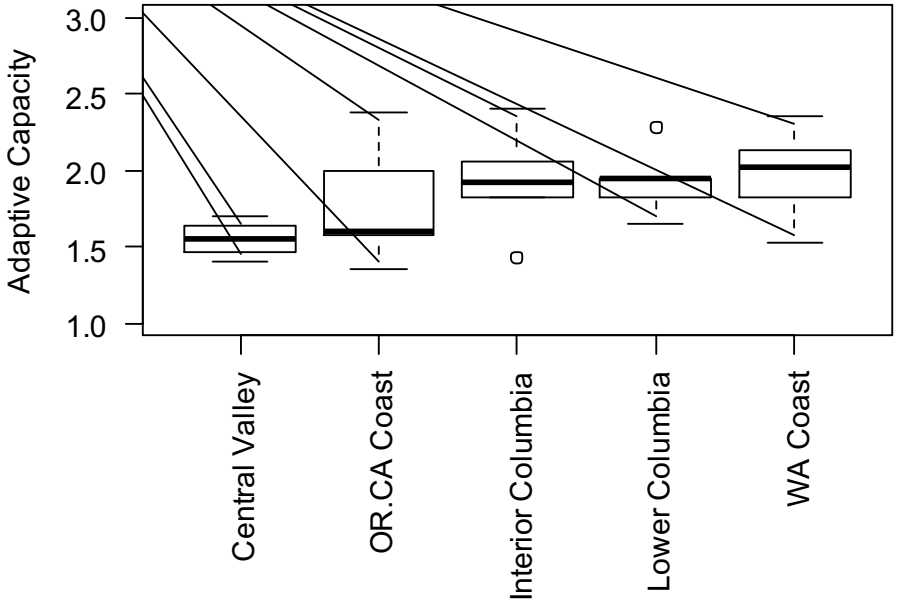
Very High if
3 attributes ≥ 3.5

High if
2 attributes ≥ 3

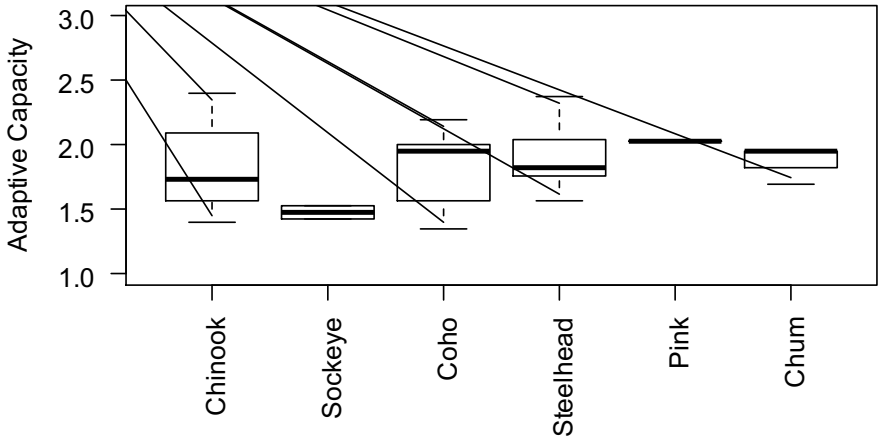


Likelihood of behavioral change

By recovery domain
North > South



By species



Hotspots:
High sensitivity and high exposure in the same life stage

	Adult	**Juvenile**	**Egg**	**Estuary**	**Marine**
Exposure:	*Stream Temperature*	*Regime Shift/Tstream (*both)*	*Flooding*	*Sea Level Rise*	*Upwelling*
	Snake River spring/summer-run Chinook	Snake River spring/summer-run Chinook*	Sacramento River winter-run Chinook	Central Valley fall-run/late fall-run Chinook	Central Valley fall-run/late fall-run Chinook
	Mid Columbia Spring Chinook	Mid Columbia Spring Chinook*		Central Valley spring-run Chinook	
	Snake River Sockeye	Upper Columbia River spring-run Chinook		Sacramento River winter-run Chinook	
	Upper Willamette River spring-run Chinook	Southern Oregon/Northern California Coast Coho			
Key:	Interior Columbia		Central Valley		

Other products: Species Score Sheet

California Central Valley Steelhead – *Oncorhynchus mykiss*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Moderate
Climate Exposure = High
Data Quality = 63% of scores ≥ 2

	Oncorhynchus mykiss	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Egg Incubation	1.6	2.8	
	Freshwater Juvenile Stage	2.1	2.8	
	Estuary Stage	2.5	1.8	
	Marine Stage	1.6	1.2	
	Sensitivity to Ocean Acidification	1.9	0.5	
	Adult Freshwater Stages	1.5	2.8	
	Life History Diversity and Cumulative Life Cycle Effects	1.7	2.2	
	Role of Hatcheries in Climate Resilience	3.1	2.0	
	Other Stressors	2.9	2.0	
	Current Population Viability	2.1	2.0	
	Sensitivity Score	Moderate		
Exposure variables	Mean Sea Surface Temperature	3.4	2.0	
	Ocean Acidification	4.0	3.0	
	Currents	1.8	1.0	
	Phenology of Upwelling	2.4	1.5	
	Sea Level Rise	2.1	2.0	
	Hydrological Regime	1.9	1.8	
	Flooding	3.2	1.8	
	Summer Stream Temperature	2.8	2.2	
	Summer Water Deficit	2.5	2.0	
	Exposure Score	High		
	Overall Vulnerability Rank	Moderate		

Sacramento River winter–run Chinook – *Oncorhynchus tshawytscha*

Overall Vulnerability Rank = Very High

Biological Sensitivity = Very High
Climate Exposure = High
Data Quality = 63% of scores ≥ 2

	Oncorhynchus tshawytscha	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Egg Incubation	4.0	2.8	
	Freshwater Juvenile Stage	3.7	2.8	
	Estuary Stage	3.5	2.0	
	Marine Stage	3.4	2.2	
	Sensitivity to Ocean Acidification	1.8	1.0	
	Adult Freshwater Stages	3.4	3.0	
	Life History Diversity and Cumulative Life Cycle Effects	4.0	2.5	
	Role of Hatcheries in Climate Resilience	2.0	3.0	
	Other Stressors	3.8	1.8	
	Current Population Viability	3.9	3.0	
	Sensitivity Score	Very High		
Exposure variables	Mean Sea Surface Temperature	3.4	2.0	
	Ocean Acidification	4.0	2.5	
	Currents	1.8	1.0	
	Phenology of Upwelling	2.9	1.0	
	Sea Level Rise	3.4	2.2	
	Hydrological Regime	2.4	1.8	
	Flooding	3.4	1.2	
	Summer Stream Temperature	3.0	2.0	
	Summer Water Deficit	2.5	1.8	
	Exposure Score	High		
	Overall Vulnerability Rank	Very High		

Low
Moderate
High
Very High

Other products: Species Narrative

- **Central California Coast Steelhead**, ***Oncorhynchus mykiss***

- Overall Climate Vulnerability Rank: **Moderate**(65% Mod, 35% High in bootstrap analysis)

- Climate Exposure: **Moderate**. Four exposure factors contributed to this score: Ocean Surface Temperature (3.4), Sea Level Rise (3.0), Flooding (3.1), and Ocean Acidification (4.0).

- Biological Sensitivity: **Low** . None of 10 sensitivity attributes scored above 3.0 but on the border were current population viability (2.9), Estuary stage (2.9), NS other stressors (3.0). CCC steelhead are listed as a threatened species and are extremely sensitive to degradation of and/or changes to streams and estuaries where they spend the 1-3 years of life but are probably less sensitive to long-term changes in ocean conditions. They presumably have some buffering from resident rainbow trout populations in headwaters, which can produce individuals that go out to sea.

- Climate Effects on Abundance and Distribution.
- …
- Life History Synopsis**:**
- …

- Literature Cited:

Conclusions

Rarest life histories at greatest risk

- Winter-run, late-fall run, spring-run

Southern range limits at high risk

- Climate-vulnerable life histories
- Less adaptive capacity
- Highest exposure

Anthropogenic impacts limit climate resilience

- Water quantity and quality

Management implications

- Recovery Plans and Biological Opinions
  - Prioritize actions by climate risk
  - Restoration decision tools (Beechie et al 2013)

- Fishery/Hydropower Management
  - Limit Columbia River and marine fisheries during climate stress
  - Hydropower planning for higher temperatures

- Research
  - Prioritize quantification of climate impacts
    - (e.g., life cycle models)
  - Targeted research on mechanistic links with marine survival and OA sensitivity
    - Ecosystem modeling with climate impacts

Many thanks!

- Profile and narrative writers, expert scorers
- Northeast Fisheries Science Center
- NOAA-Fisheries

Brian Spence
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David Boughton
David Boughton
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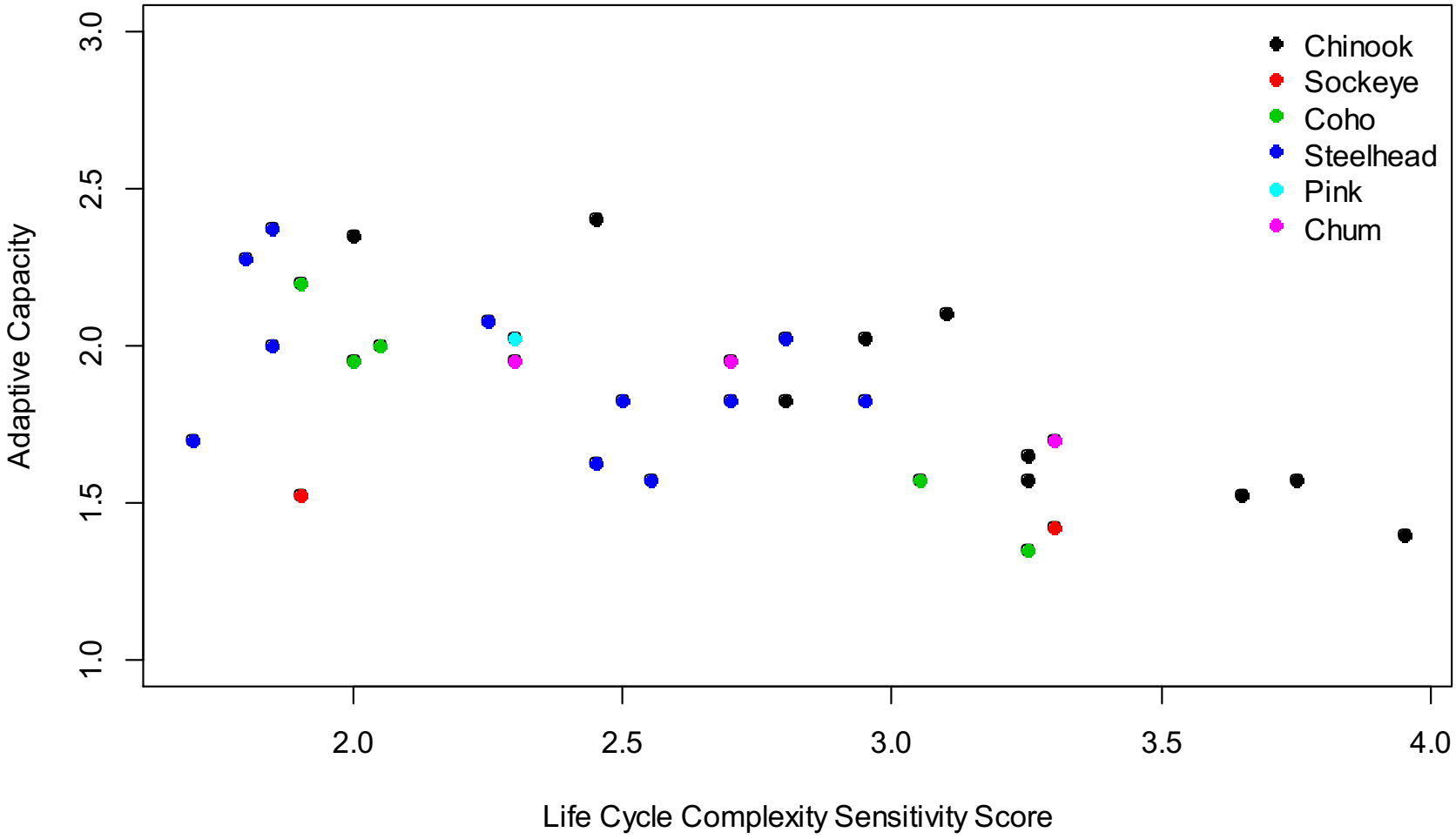
Jason Dunham
Jim Myers
Laurie Weitkamp
Lisa Crozier
Mark Carr
Melissa Haltuch
Michael Beakes
Michelle McClure
Nate Mantua
Peter Moyle
Ryan Ryckaczewski
Selina Heppell
Steven Bograd
Tim Beechie
Tom Cooney
Tom Wainwright
Tommy Williams

Extra slides

Adaptive Capacity

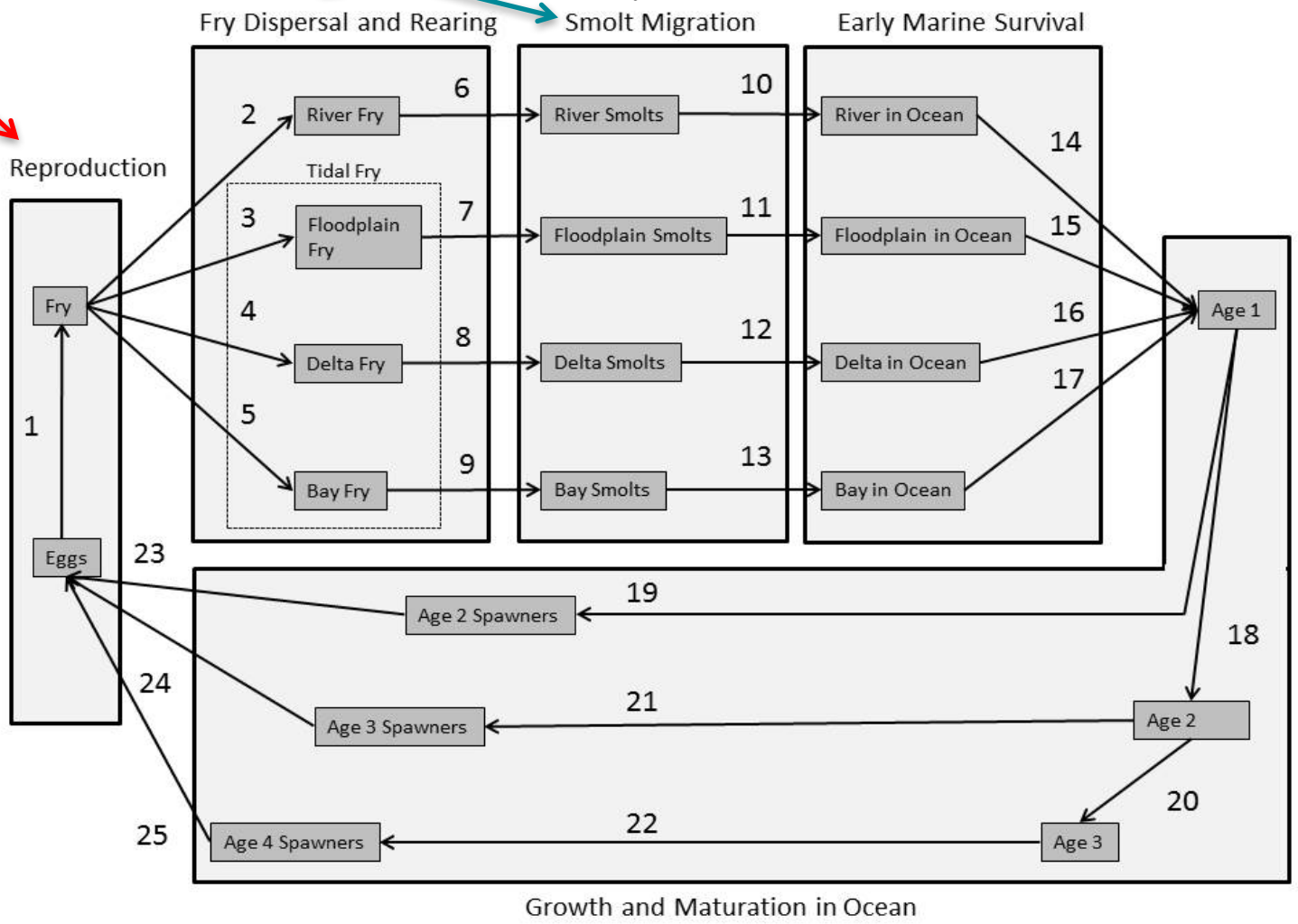
By life cycle complexity and species



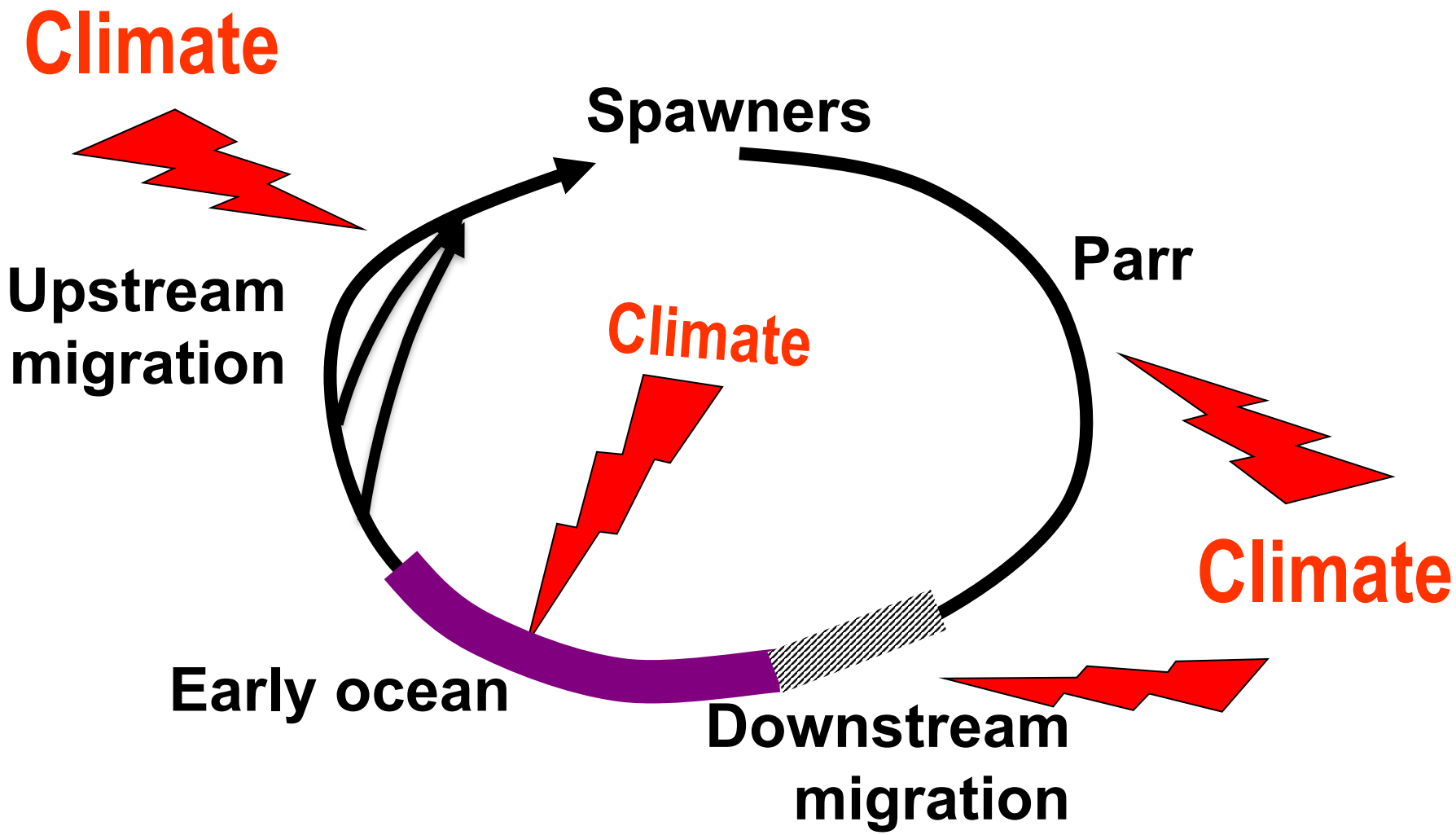
Integration of climate drivers into life cycle models

Central Valley Life Cycle Model Structure

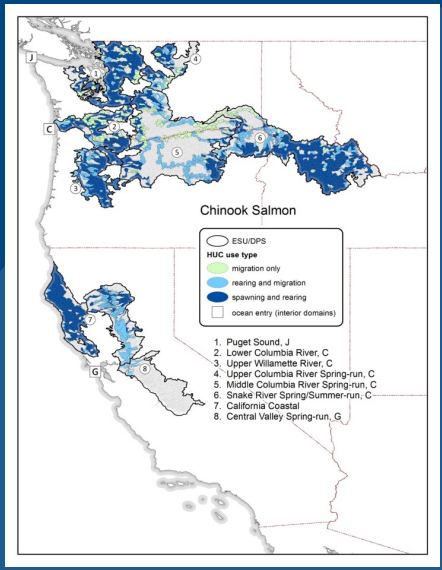
Temperature affects egg and fry survival
Flow affects timing behavior, habitat access, and survival
Empirically fit within full model

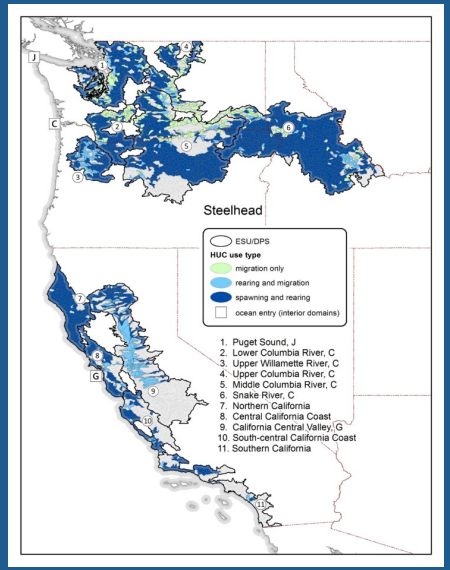


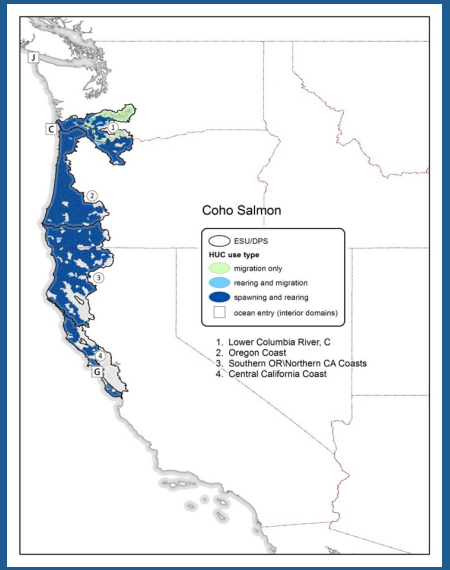
Interior Columbia River Life Cycle Models

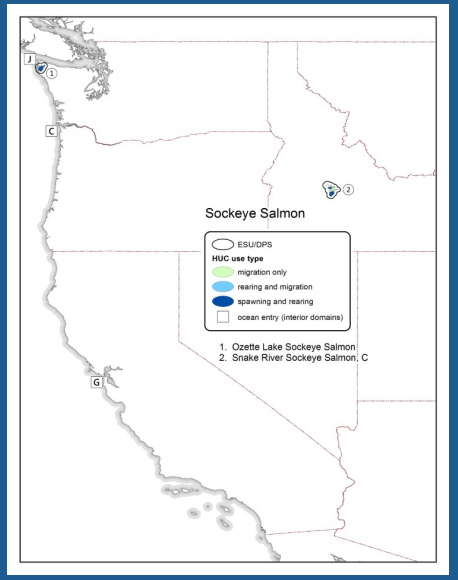


Distribution maps (4 spp)

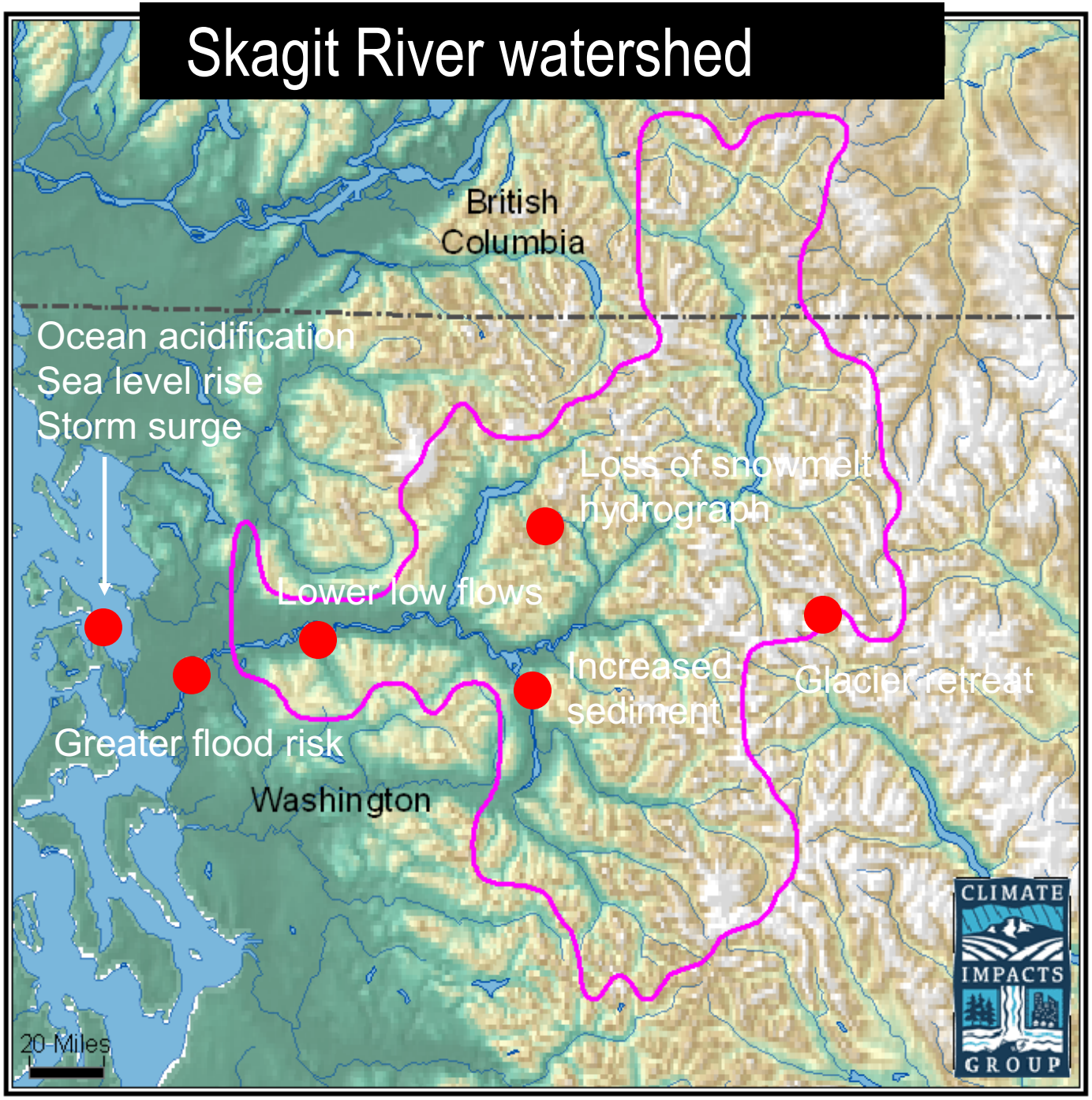




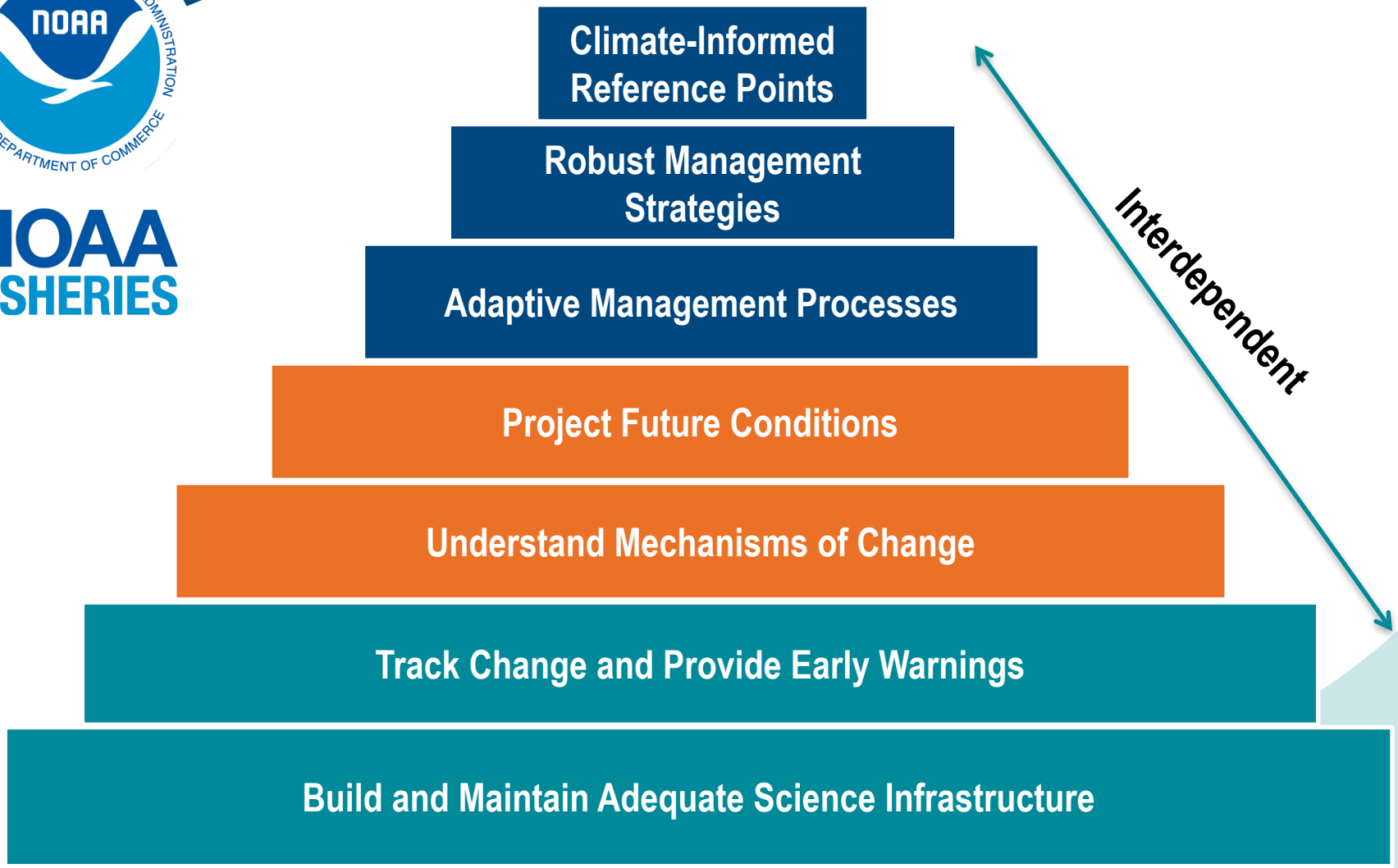




Skagit River watershed



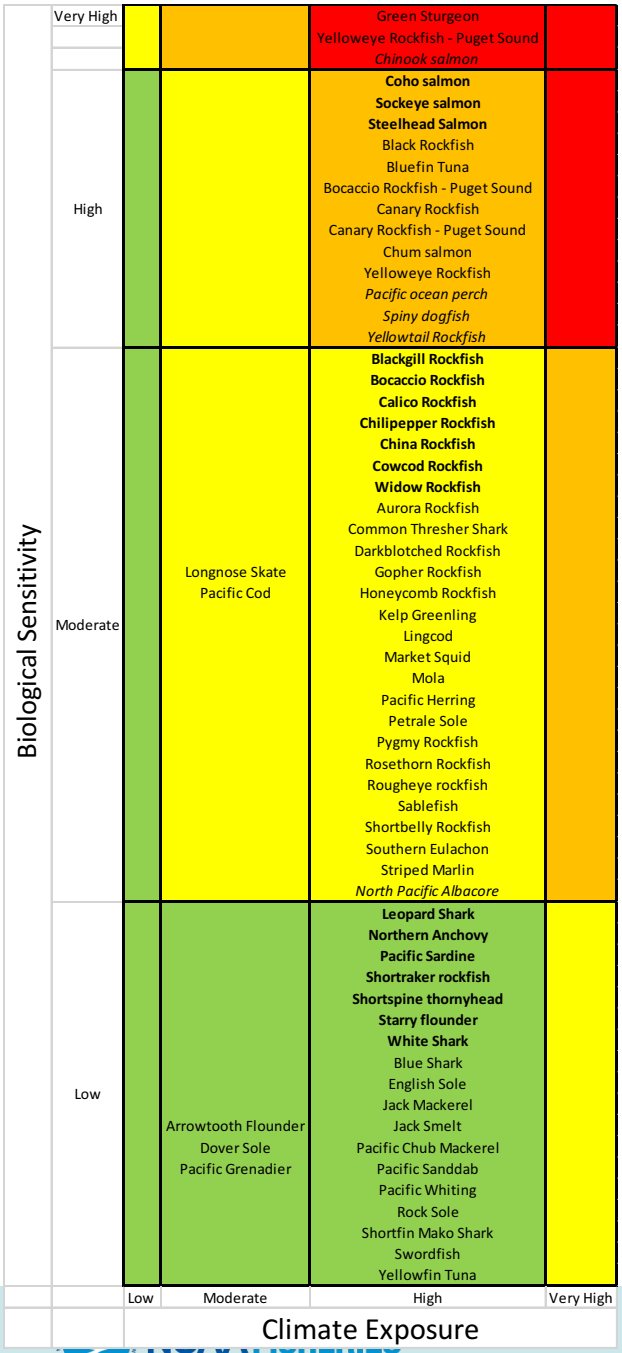
NMFS Climate Science Strategy



NMFS Climate Science Strategy (NCSS)

WHY	Growing demands and requirements for climate-related information.
GOAL	Increase the production, delivery, and use of climate-related information to support agency and stakeholder decisions.
Western Regional Action Plan	Conforms to the national framework, identifies strengths, weaknesses, priorities, and actions to implement the Strategy on the West Coast over the next 3-5 years

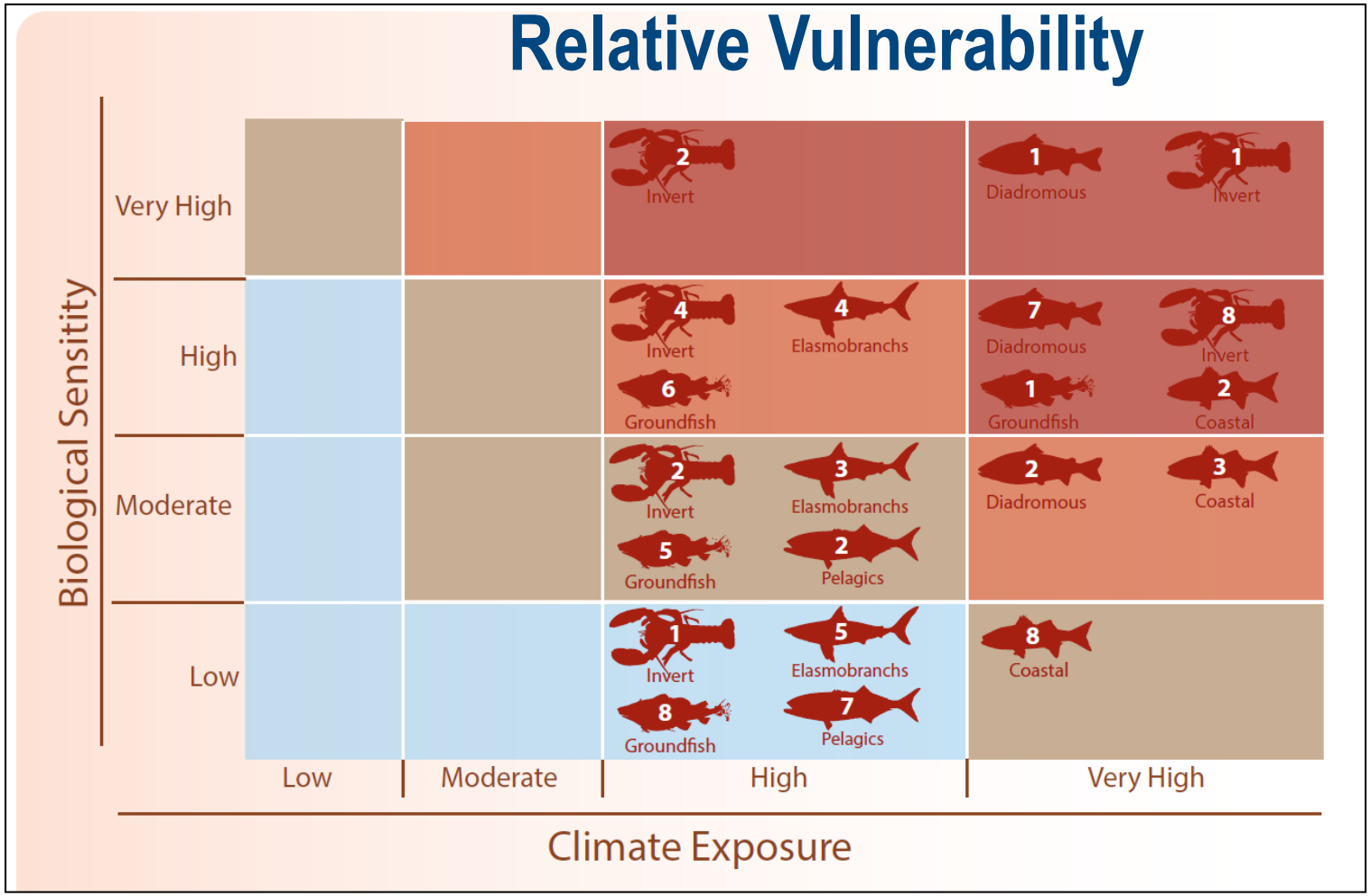
General CVA Results: Logic Rule Ranks



Green Sturgeon
Yelloweye Rockfish - Puget Sound
Chinook salmon

Coho salmon
Sockeye salmon
Steelhead Salmon
Black Rockfish
Bluefin Tuna
Bocaccio Rockfish - Puget Sound
Canary Rockfish
Canary Rockfish - Puget Sound
Chum salmon
Yelloweye Rockfish
Pacific ocean perch
Spiny dogfish
Yellowtail Rockfish

Results of Northeast Vulnerability Assessment



82 fish and invertebrate species from Northeast U.S. Shelf Ecosystem

Outline

- Salmon Vulnerability Assessment
  - Attributes
  - Final ranks
  - What attributes most affected final ranks?
  - Correlations
  - Knowledge gaps
- Conclusions

Salmon Vulnerability Assessment

Objectives:

1. Provide relative vulnerability rankings across species (**triage**)
2. Identify key attributes/factors driving vulnerability
3. Identify key data gaps or information needs