Assessing impacts of climate stressors on near-coastal species at a regional scale (Gulf of California through Beaufort Sea)

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Project objective

- Identify species most vulnerable to climate change
- Predict how vulnerability changes geographically
- Identify major climate stressors for vulnerable species

Insufficient information to develop statistical, physiological, or mechanistic models for 98% to 99% of coastal species.

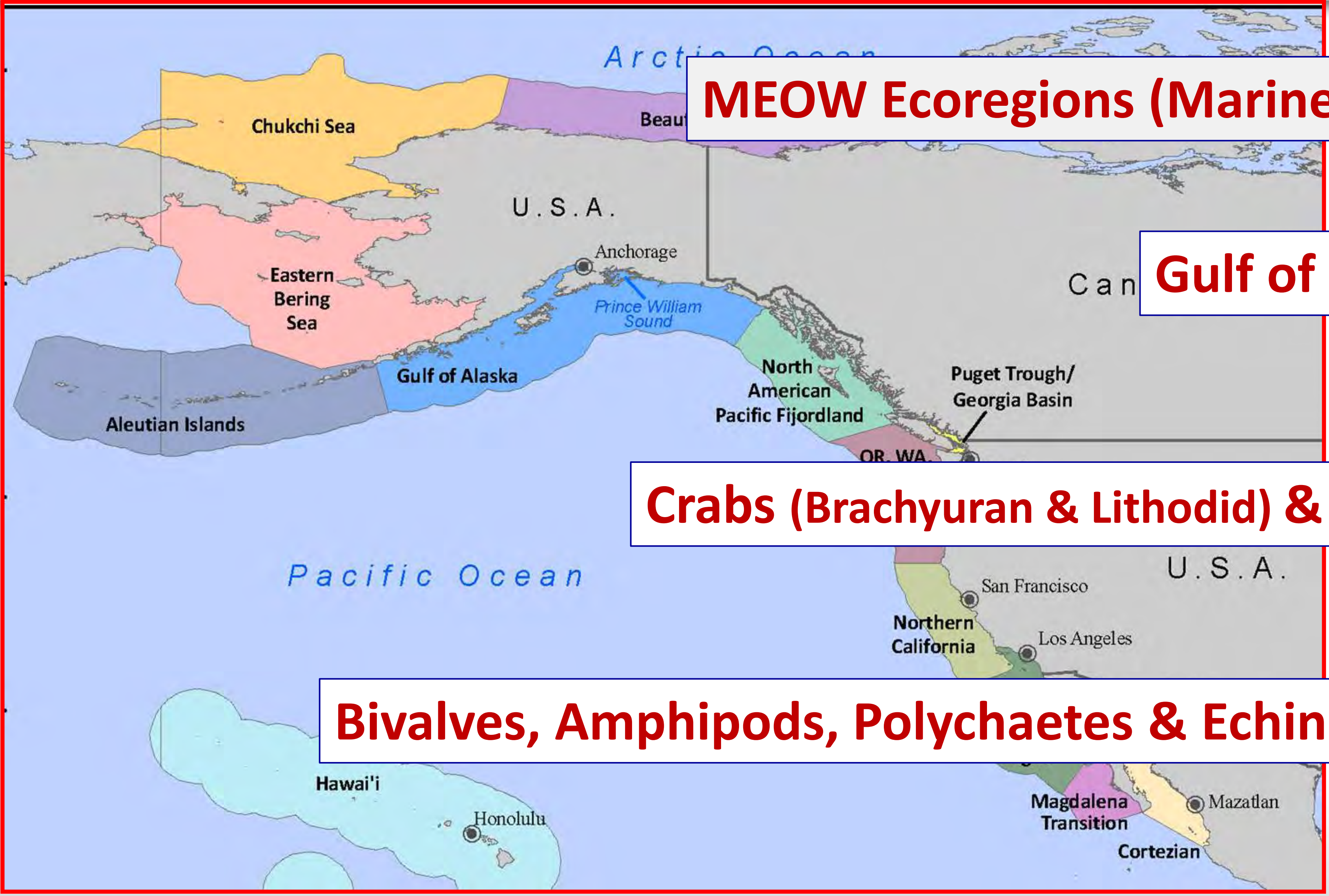
APPROACH – Risk assessment, cuts through the complexity of many species & many locations

Risk assessments based on environmental thresholds and biotic traits as a practical solution to assess vulnerability in hundreds to thousands of species over large regional scales.

Comparable to health questionnaires in resolution:

- Use existing data about the species
- Relatively inexpensive to conduct
- Generate relative risks for multiple species
- Generate risk patterns across geographic regions

METHODS - Scale, Scope & Taxa



MEOW Ecoregions (Marine Ecoregions of the World)

Gulf of California to Beaufort Sea

Crabs (Brachyuran & Lithodid) & Rockfish (ca. 450 Species)

Bivalves, Amphipods, Polychaetes & Echinoderms (ca. 2500 Species)

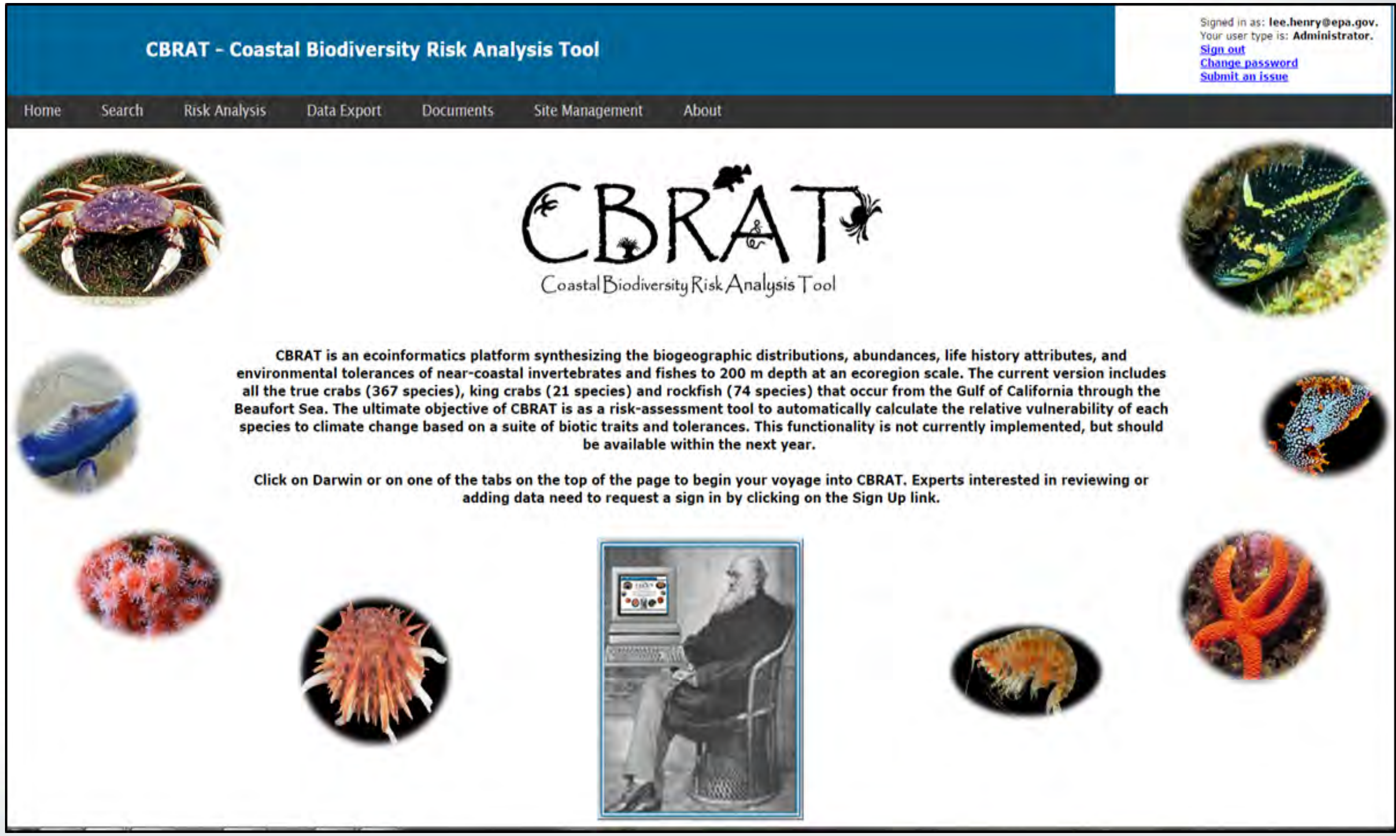
Implementation - CBRAT

Climate Risk Assessments Implemented as a Web-Based Tool 'Coastal Biodiversity Risk Analysis Tool'- (www.cbrat.org)

≤ 2016: CBRAT functions as a powerful ecoinformatics platform synthesizing biotic & environmental information on Pacific crabs & rockfish

2017: **Risk assessments implemented** for crabs & rockfish and updated analysis of regional climate risks, including bivalves

Preliminary Results



METHODS - Phases of Implementation

Phase I: Synthesize biotic and environmental data at a species level

Phase II: Generate rules and climate thresholds based on literature & workshops

Phase III: Implement an algorithm-based risk assessment - uses biotic & environmental data-based rules instead of expert opinion

Versus

Expert Opinion Based

Algorithm Based

Advantages of Algorithm-Based Risk Assessments:

- Reduce biases
- Increase transparency
- Reproducible
- Model different climate scenarios

METHODS – Algorithm Considers 2 Types of Risk

Baseline Risks: Species traits related to population viability but not readily linked to specific climate drivers (e.g., endemic, habitat specialists).

Climate-Related Risks: Ecoregion-specific projections, thresholds compared directly to climate driver.

- Sea Level Rise
- Ocean Acidification
- Temperature

Baseline climate rules derived from biogeographic and life history traits.

Rules are classified as a Risk or a Resilient depending upon whether the trait results in increased or reduced risk to climate change. Risk is scored from -3 (high risk) to 3 (high resiliency).

Trait	Risk / Resilient	Type	Global or Ecoregion Specific	Baseline Rule	Risk	Comments & Exceptions
Endemic	Risk	Distribution	Ecoregion	If species present in only one ecoregion AND not Abundant	-3	
				If species present in only one ecoregion AND Abundant	-2	
				If species present in more than one ecoregion	0	
Restricted Distribution	Risk	Distribution	Ecoregion	If species present in only two ecoregions AND Hyper-rare in one or both	-3	Do not include ecoregions where the species is Transient or Hyper-rare.
				If species present in only two ecoregions AND Rare in both	-2	
				If species present in only two ecoregions AND Present or Moderate or Abundant in one or both	-1	
				If species present in more than two ecoregions	0	
Wide Distribution	Resilient	Distribution	Global	If species occurs in Arctic & Cold Temperate & Warm Temperate Provinces	2	Do not include ecoregions where the species is Transient or Hyper-rare.
				If species occurs in Cold Temperate & Warm Temperate & Tropical Provinces	2	
				If species does not occur in three Provinces with different temperature regimes	0	
Nonindigenous Species (NIS)	Resilient	Distribution	Global	If species is classified with a Master NIS anywhere globally WITH a Master Established value	2	
				If species has a Master NIS classification but Establishment is Not Established or Unknown OR only Stocked	0	
Habitat Specialization	Risk	Life History	Global	If no Specialized Habitats -> 0	0	If multiple specialized habitats, take the greatest risk
				Obligate & Preferred Habitat -> -3	-3	
				Facultative & Preferred Habitat -> -2	-2	
				Facultative & Observed Habitat -> -1	-1	
				Incidental & Observed Habitat -> 0	0	
				Obligate & Preferred Habitat -> -2	-2	
				Facultative & Preferred Habitat -> -1	-1	
				Facultative & Observed Habitat -> -1	-1	
Trophic Specialization	Risk	Life History	Global	If Moderate Trophic Specialization -> -1	-1	
				If Specialist Trophic Specialization -> -3	-3	
				If Generalist Trophic Specialization -> 0	0	

METHODS - Overview

Historical Enviro. Conditions

- pH or Ω
- Temperature
- What habitats
- Depth within those habitats

Projected Enviro. Conditions

- pH or Ω
- Temperatures
- SLR rates

Habitat Thresholds

Establish taxa or habitat specific tolerances to stressors.

Biotic Modifiers

Natural history traits, distributions, etc. modify climate risk

Relative Risk at ecoregion scale

SLR METHODS – Developing Habitat Thresholds

Net SLR (mm) by 2110 associated with different % habitat loss at a regional scale

Habitat / Threshold Class	Increase/Minor (Increase to -10% loss)		Low (-11 to -29% loss)		Moderate (-30 to -49% loss)		High (≥50% loss)	
	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained
Rocky Intertidal	–	400	–	800	–	1400	–	>1400
Low Marsh	**360**	**270**	**630**	**450**	**1440**	**1890**	**>1440**	**>1890**
Mangroves	750	–	1150	–	1600	–	>1600	–
Submerged Aquatic Vegetation	540	1080	720	1440	900	1800	>900	>1800
Tide Flats	180	360	630	990	1260	1440	>1260	>1440
Coastal Beaches	550	650	600	800	800	1000	>800	>1000

Unconstrained=Inland migration of habitat not artificially limited Constrained=Inland migration of habitat limited by structures; coastal squeeze

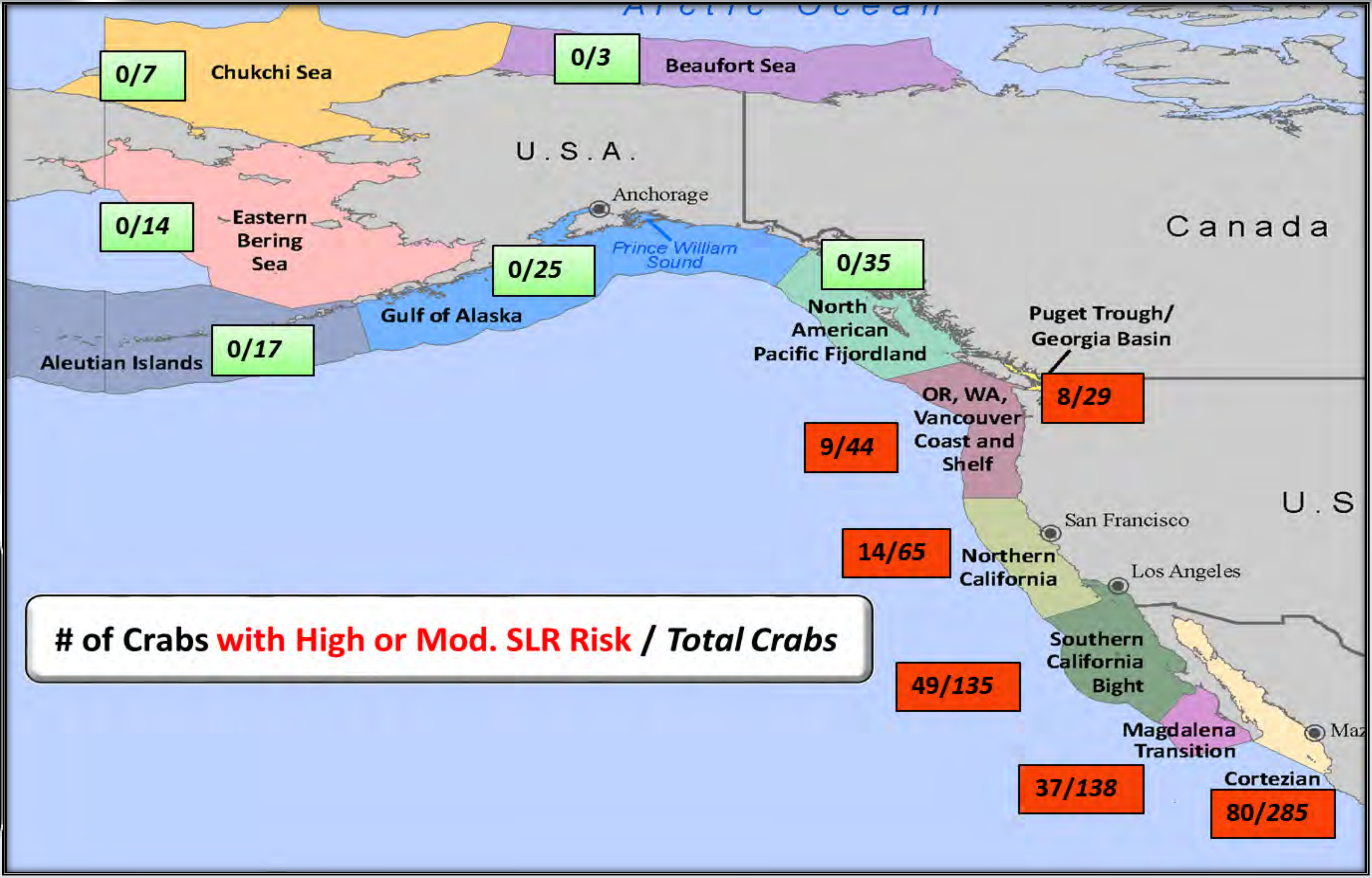
SLR - RESULTS

Geographical Pattern of Sea Level Rise Risk

Across Ecoregions – using 8 mm/yr eustatic SLR

Alaskan & Arctic Ecoregions:

- Few or no crabs are ‘primarily’ intertidal in Arctic ecoregions
- High potential for habitats to migrate inland
- Isostatic uplift high in several ecoregions



OA METHODS – Developing Taxa Thresholds

34 Studies
25 Species
177 Sig. Tests

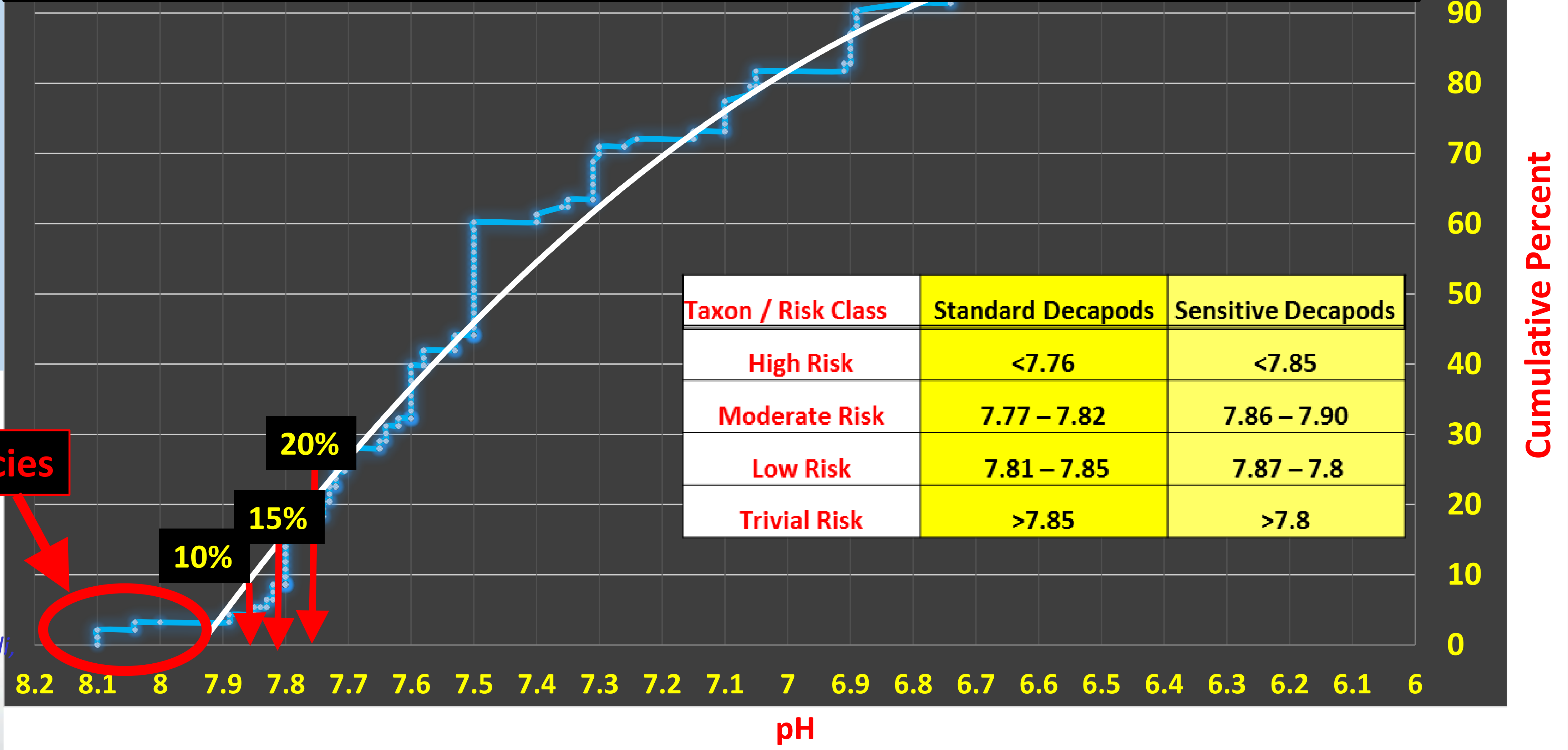
Response variables:

- Behavior
- Calcification
- Development
- Genetics
- Mortality
- Physiological

Sensitive Species

- *Paralithodes camtschaticus,* Alaska King crab
- *Chionoecetes bairdi,* Tanner crab

Cumulative Percent effects experimental results - Decapods

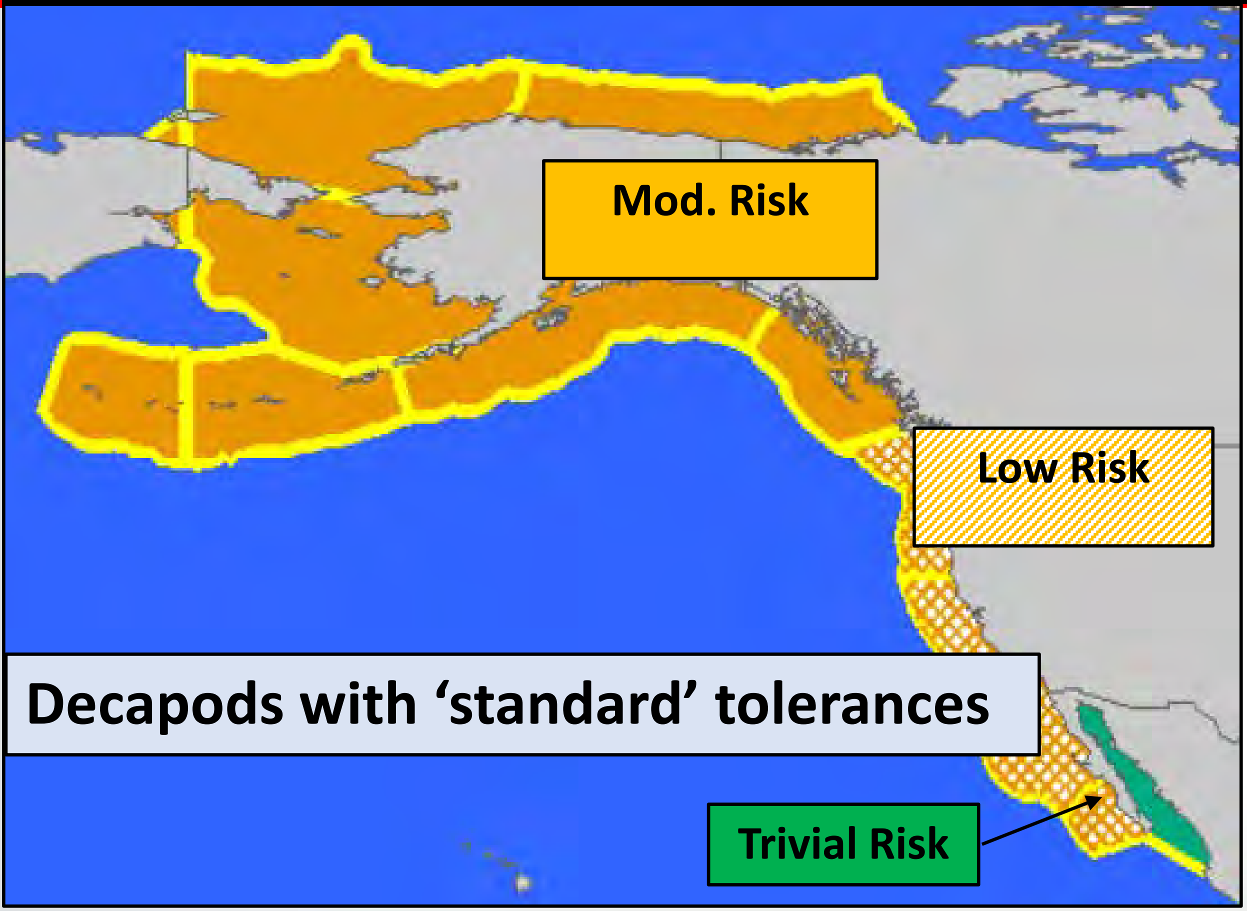


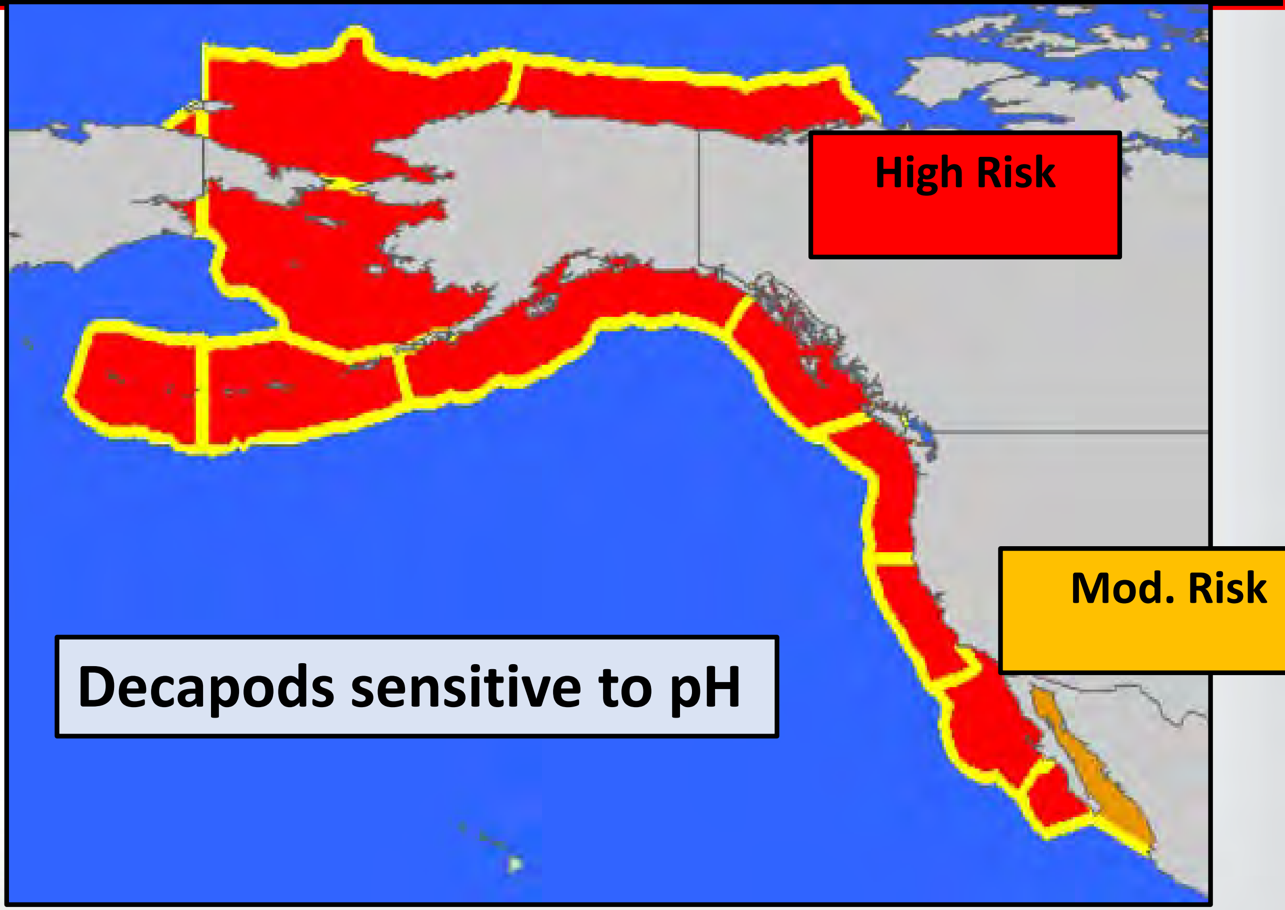
Taxon / Risk Class	Standard Decapods	Sensitive Decapods
High Risk	<7.76	<7.85
Moderate Risk	7.77 – 7.82	7.86 – 7.90
Low Risk	7.81 – 7.85	7.87 – 7.8
Trivial Risk	>7.85	>7.8

Ocean Acidification - RESULTS

Regional Patterns of Risk to pH

Decapods – RCP 8.5



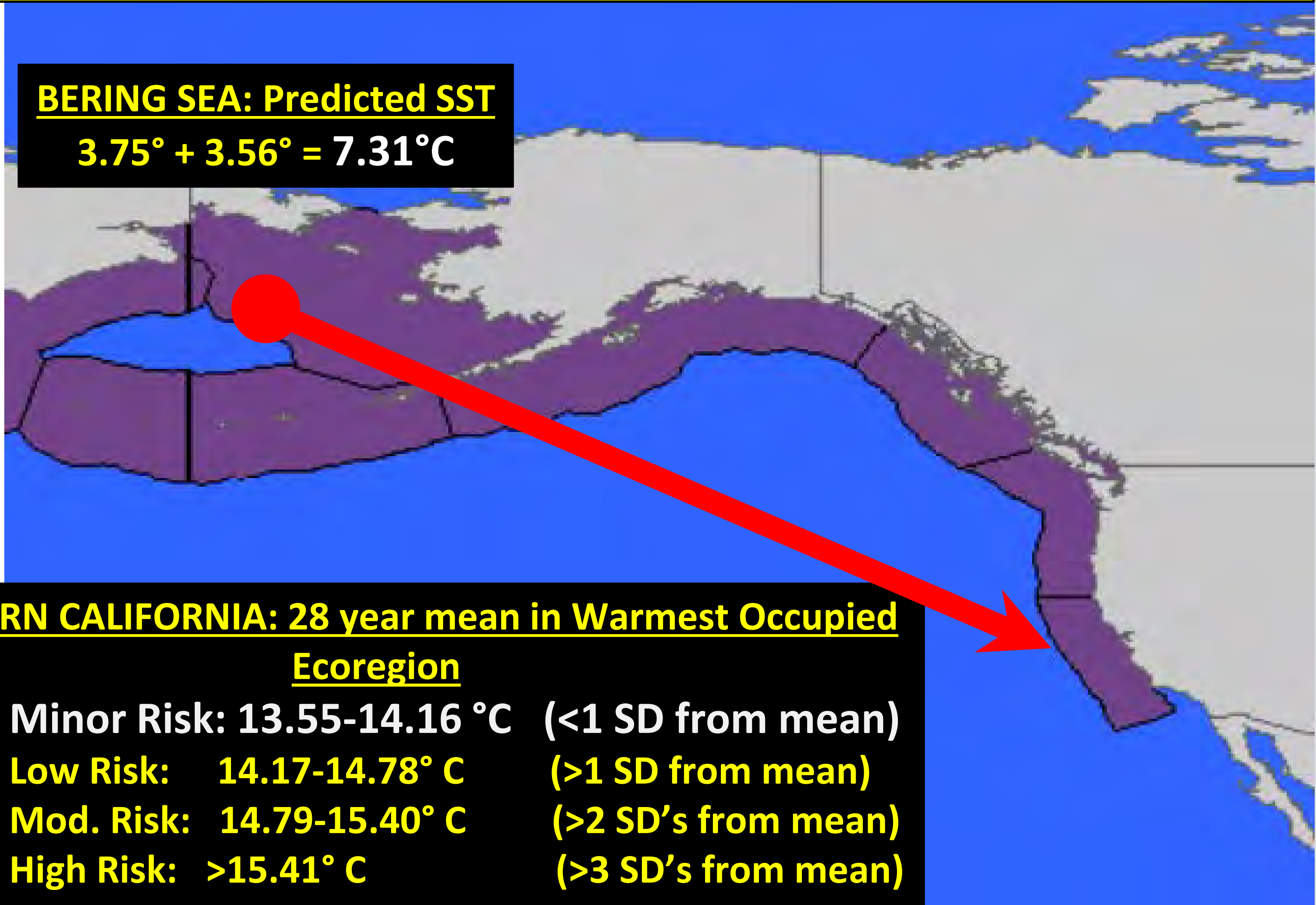


pH data CMIP5 downloaded from NOAA's Climate Web Portal

Ecoregional Thermal Window Approach

Tanner Crab, Yearly SST, IPCC RCP 8.5, 2099

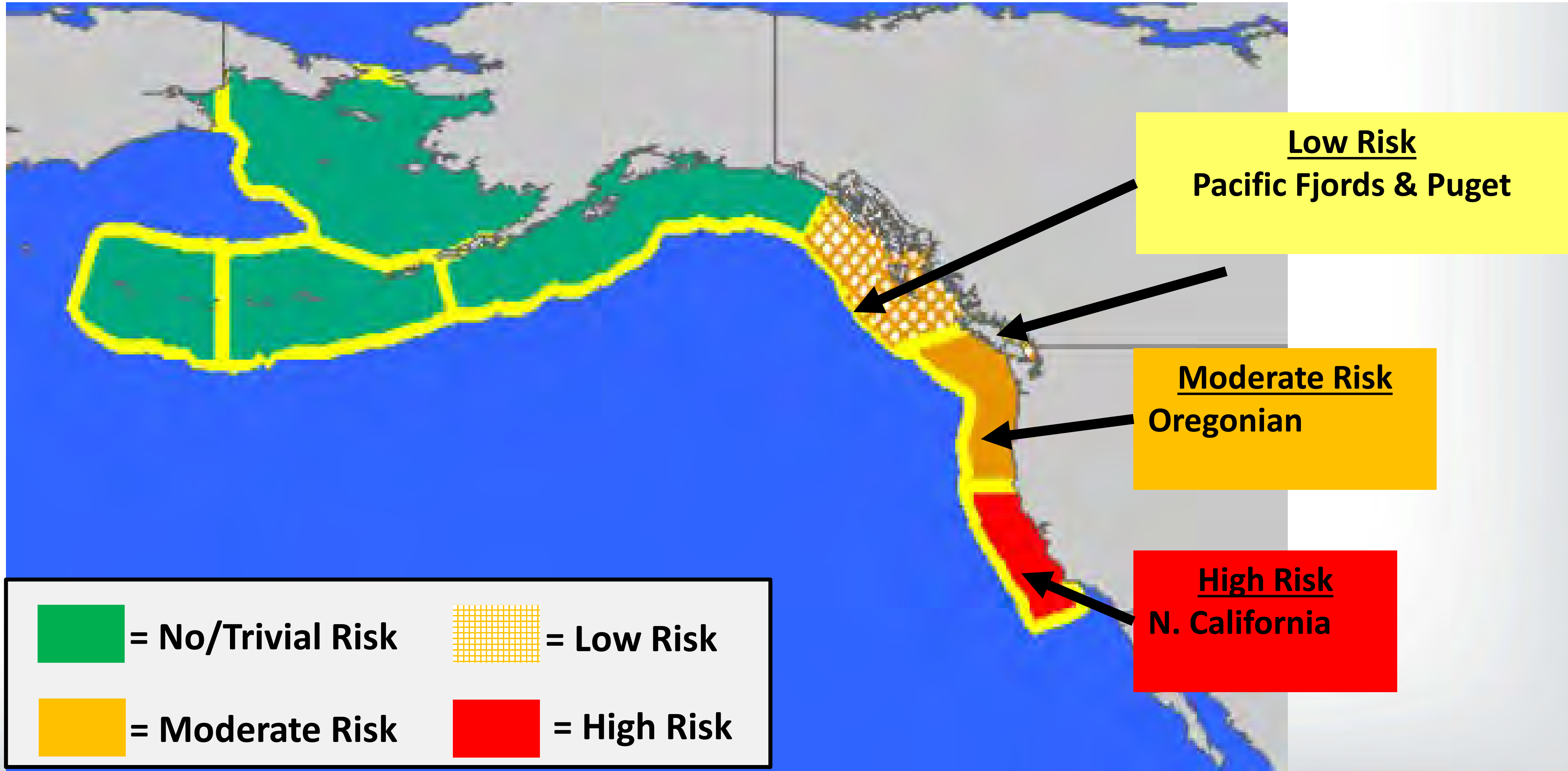
- Compare Predicted SST to Ranges in Warmest Occupied Ecoregion
- Assessment can be run for yearly, just summer, or just winter temperature increases – user defined



Temperature RESULTS

Chionoecetes bairdi (Tanner Crab)

Summer SST,
RCP 8.5
Risk in 2099

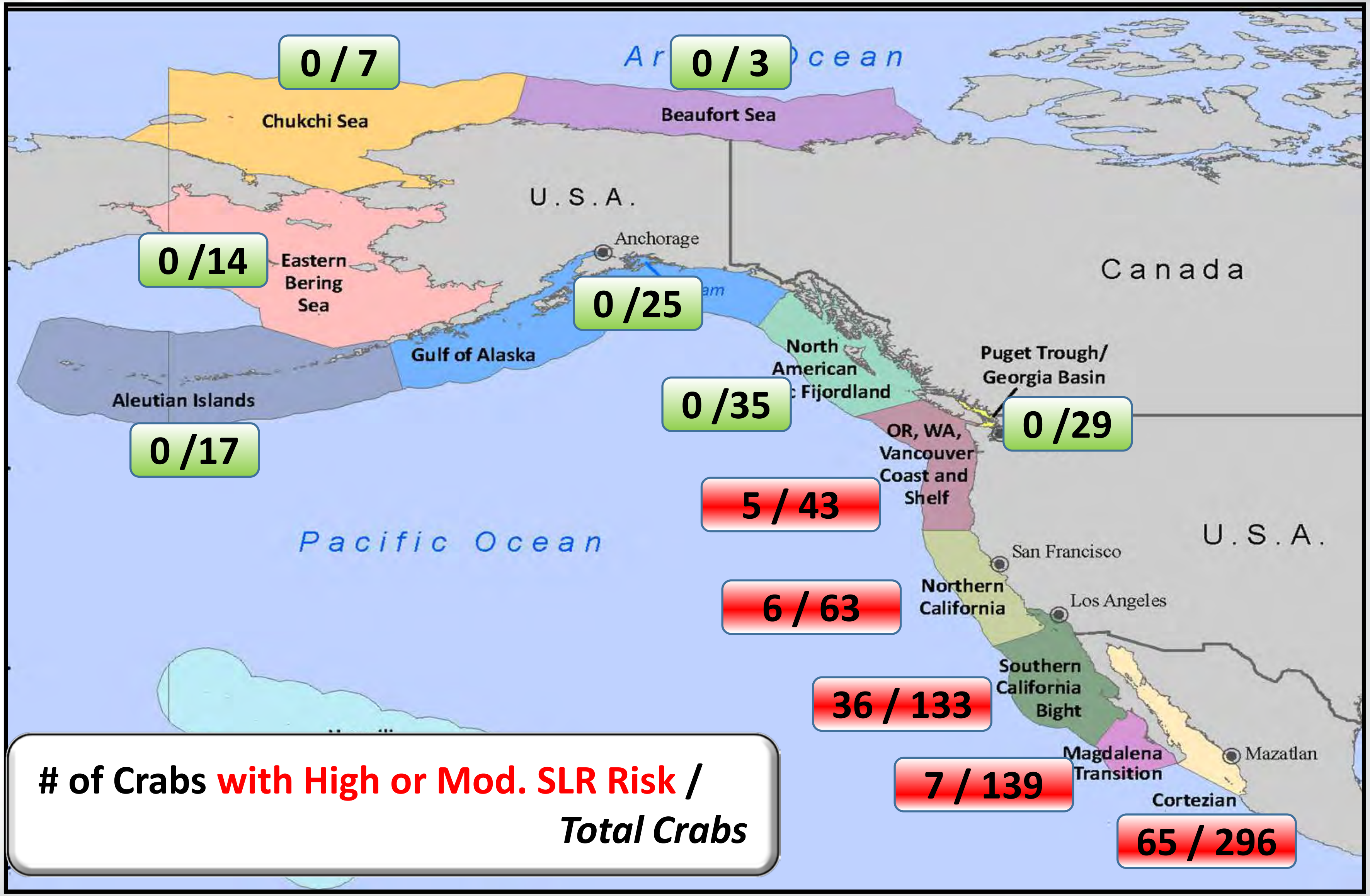


Temperature - RESULTS

Temperature Risk Analysis Yearly

SST - RCP 8.5

- Risk largely limited to southern most occupied ecoregions
- Best case scenario for northern ecoregions
- In U.S., 47 of 152 crabs (31%) are classified at risk in at least one ecoregion.



Overarching Conclusions:

- Climate change associated with an RCP 8.5 emission scenario will result in moderate to high risk in over half the crabs in U.S. Pacific waters in at least one ecoregion.
- Algorithm risk assessments are a practical and rigorous approach to assessing relative risk for large number of species at a regional scale.
- Strong geographical and taxonomic patterns to risk evident.
- Distribution and migration rates of warm genotypes may be key for the potential of species to adapt to increased temperatures in the northern limit of their range.

Climate Change is Likely to Have Multiple Impacts on Near-Coastal Species & Ecosystem Services…..

Thank You