Distribution of risk to marine vegetation in Puget Sound

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PUGET SOUND INSTITUTE
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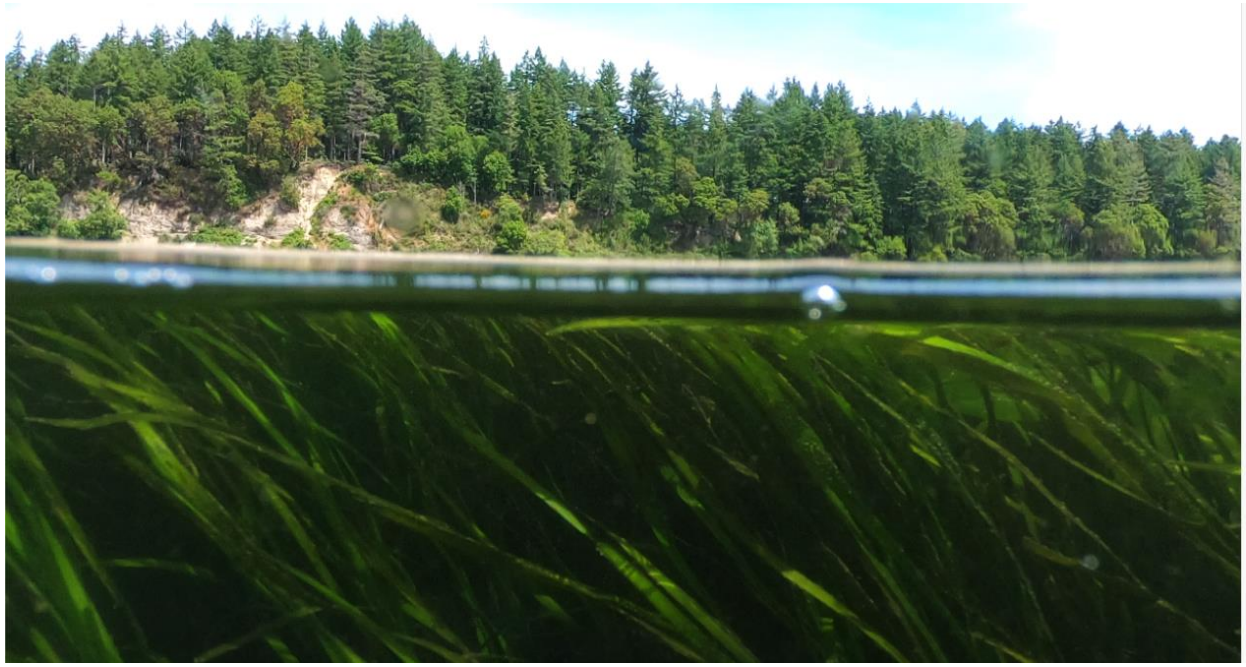
Washington Department of FISH & WILDLIFE

PUGETSOUND PARTNERSHIP

Goal: Perform a spatially explicit, cumulative risk assessment of current and future threats to **eelgrass** and **canopy kelp**

- Identify risk hotspots
- Evaluate the relative importance of individual threats
- Inform conservation, restoration, and monitoring




U.S. DEPARTMENT OF ENERGY
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Eelgrass (Zostera marina L.) Stressors in Puget Sound
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June 2011
Pacific Northwest NATIONAL LABORATORY
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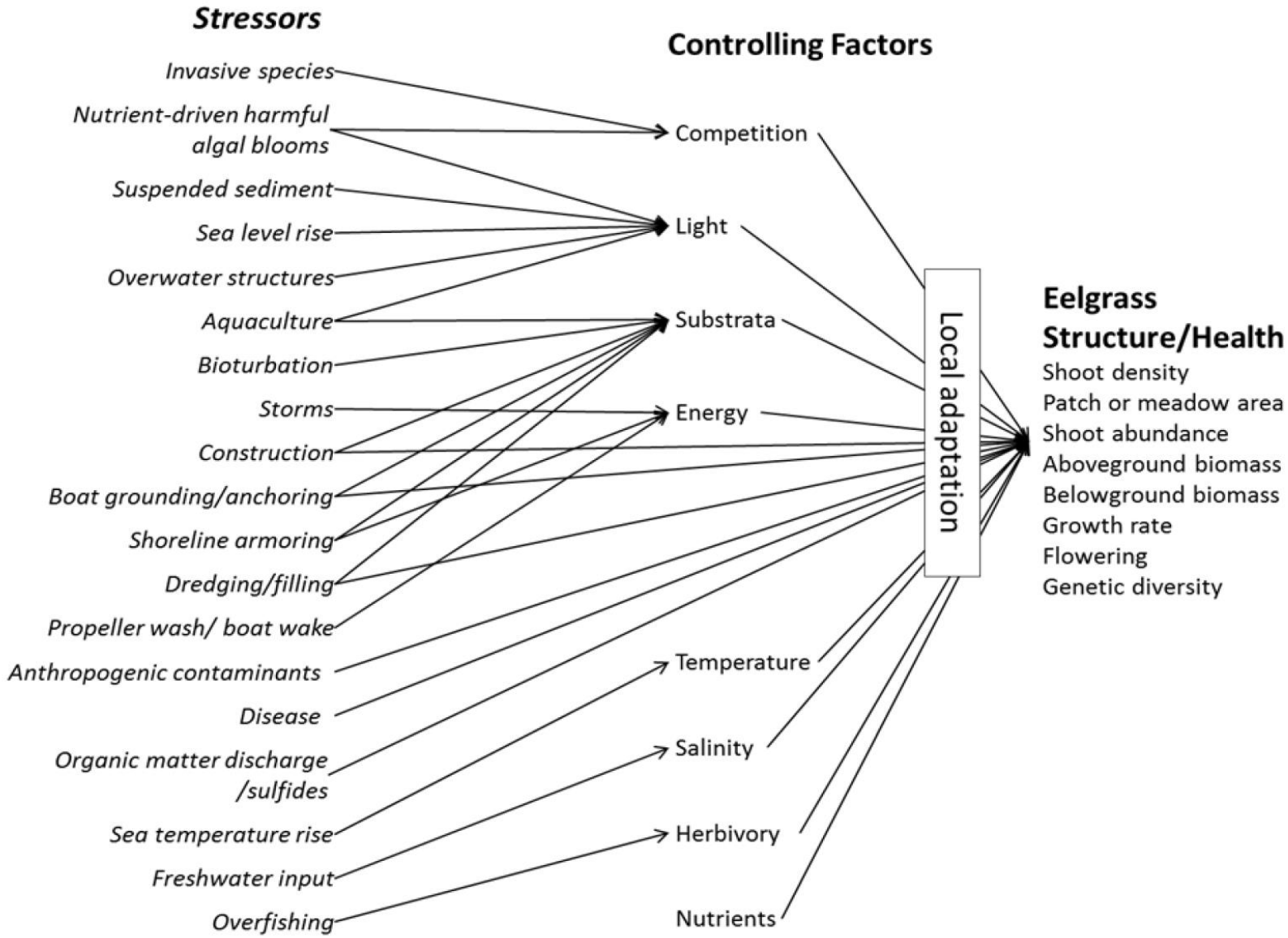
Stressors
Invasive species
Nutrient-driven harmful algal blooms
Suspended sediment
Sea level rise
Overwater structures
Aquaculture
Bioturbation
Storms
Construction
Boat grounding/anchoring
Shoreline armoring
Dredging/filling
Propeller wash/ boat wake
Anthropogenic contaminants
Disease
Organic matter discharge /sulfides
Sea temperature rise
Freshwater input
Overfishing
Controlling Factors
Competition
Light
Substrata
Energy
Temperature
Salinity
Herbivory
Nutrients
Local adaptation
Eelgrass Structure/Health
Shoot density
Patch or meadow area
Shoot abundance
Aboveground biomass
Belowground biomass
Growth rate
Flowering
Genetic diversity

Table 7.1. Stressor Ranking Table

		Characteristics of Stressor								
Stressor	**Controlling Factor**	**Magnitude**	**Spatial Extent**	**Temporal Extent**	**Reversibility**	**Trend**	**Case Study Evidence**	**Global Studies**	**Threat Score**	**Knowledge Score**
Invasive species	Competition	Low **	Med **	Med **	Med *	Increase **	Direct *	O	2.00	1.80
Nutrient-driven harmful algal blooms	Competition, light	Med **	Med *	Med *	Med **	Increase *	Direct *	SW, W, D, O	2.20	1.40
Suspended sediment	Light	Med ***	Med *	High *	Med **	Increase *	Direct *	SW, D, O	2.40	1.60
Sea level rise	Light	Med **	High *	High *	Low ***	Increase *	None	SN, D, O	2.80	1.60
Overwater structures	Light	High ***	Low ***	High ***	Low ***	Increase **	Direct ***		2.60	2.80
Aquaculture	Light, substrate	Med **	Low **	Med *	Med *	Increase **	Direct ***		2.00	1.60
Bioturbation	Substrate	Low *	Low *	Low *	Med *	Same *	Direct, spec. **		1.40	1.00
Storms	Energy	High *	Med *	Low *	High **	Increase *	None		2.00	1.20
Construction	Substrate, direct	High ***	Med ***	Med *	Med **	Increase *	Direct ***		2.40	2.00
Boat grounding /anchoring	Direct	High **	Low *	Low *	High *	Increase *	Direct *	W	1.80	1.20
Shoreline armoring	Substrate, energy	Low *	High ***	High *	Med *	Increase *	Ambiguous *		2.40	1.40
Dredging/ filling	Substrate, direct	High ***	Med **	High ***	Med **	Increase *	Direct **		2.60	2.20
Propeller wash/ boat wake	Energy	Med **	Low *	Med *	High *	Increase *	Direct/Ambiguous *		1.80	1.20
Anthropogenic contaminants	Direct	Low *	High **	Low *	Low *	Increase **	None	SW	2.20	1.40
Disease	Direct	Low *	High *	Med *	Med **	Increase *	None *		2.20	1.20
Organic matter discharge/sulfides	Direct	High **	Low *	Med *	Med *	Same *	Direct *		2.00	1.20
Sea temperature rise	Temperature	Med *	High *	Med *	Low **	Increase *	None	SN, O	2.60	1.20
Freshwater input	Salinity	Med **	High **	Med *	Med *	Same *	None *		2.20	1.40
Overfishing	Herbivory	Low *	Med *	Med *	Med *	Same *	None *		1.80	1.00

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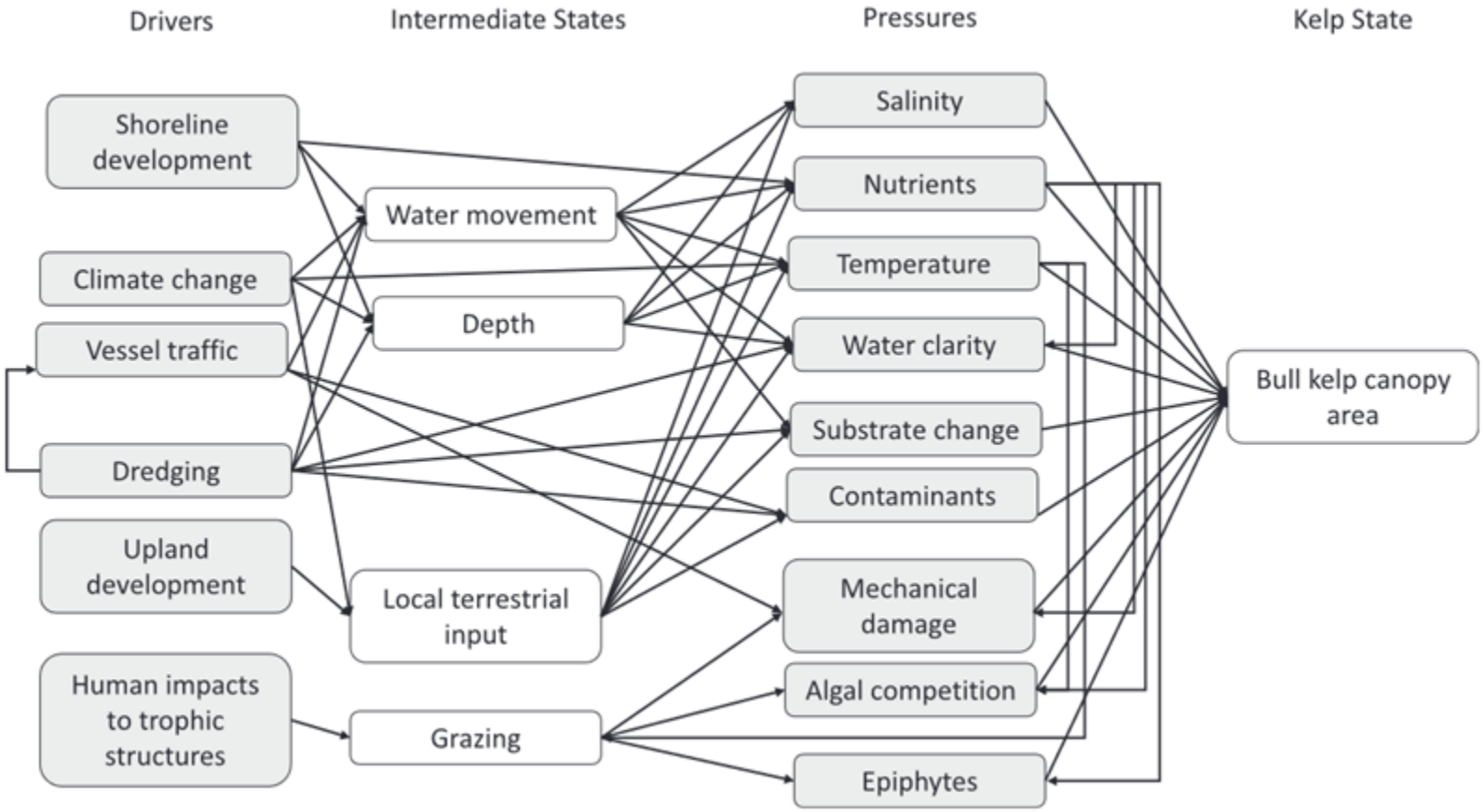
RESEARCH ARTICLE

Toward a conceptual framework for managing and conserving marine habitats: A case study of kelp forests in the Salish Sea

Jordan A. Hollarsmith[1,2,3] | Kelly Andrews[4] | Nicole Naar[5] | Samuel Starko[6] | Max Calloway[7] | Adam Obaza[8] | Emily Buckner[5,9] | Daniel Tonnes[10] | James Selleck[10] | Thomas W. Therriault[3]



Kelp stressor rating in Washington State

April 29th 2024

PREPARED BY:
Kelp stressor rating workgroup

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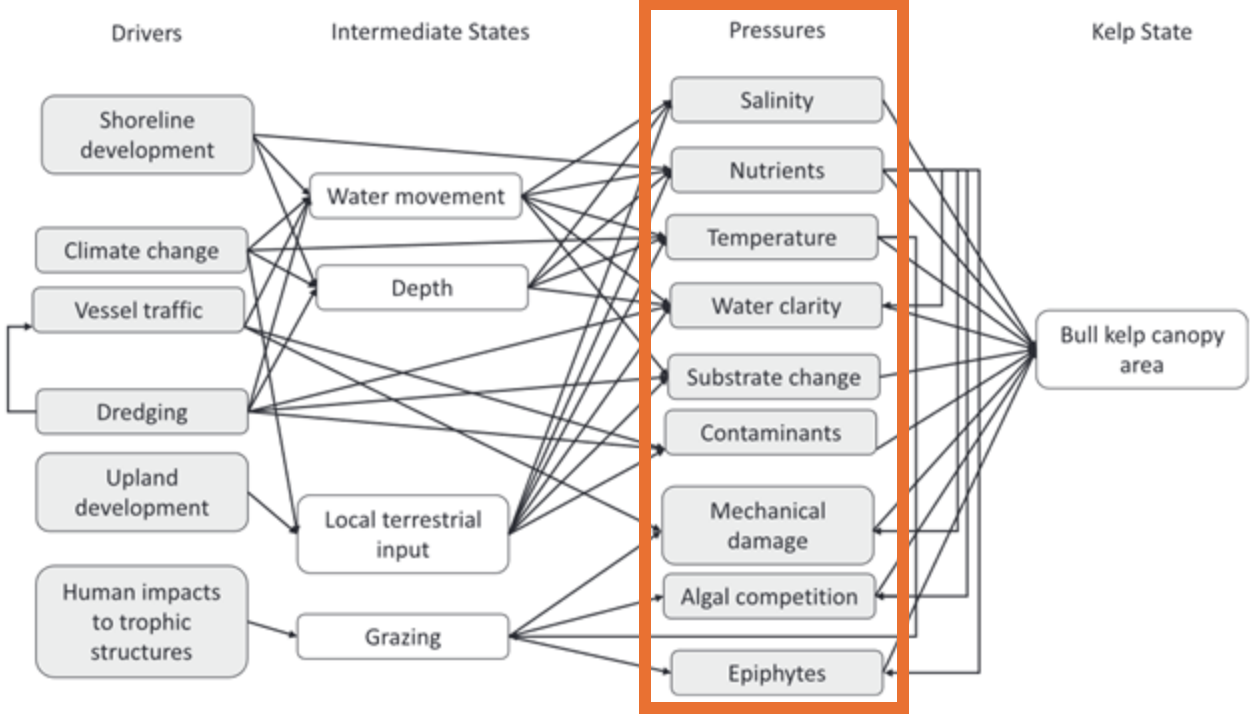
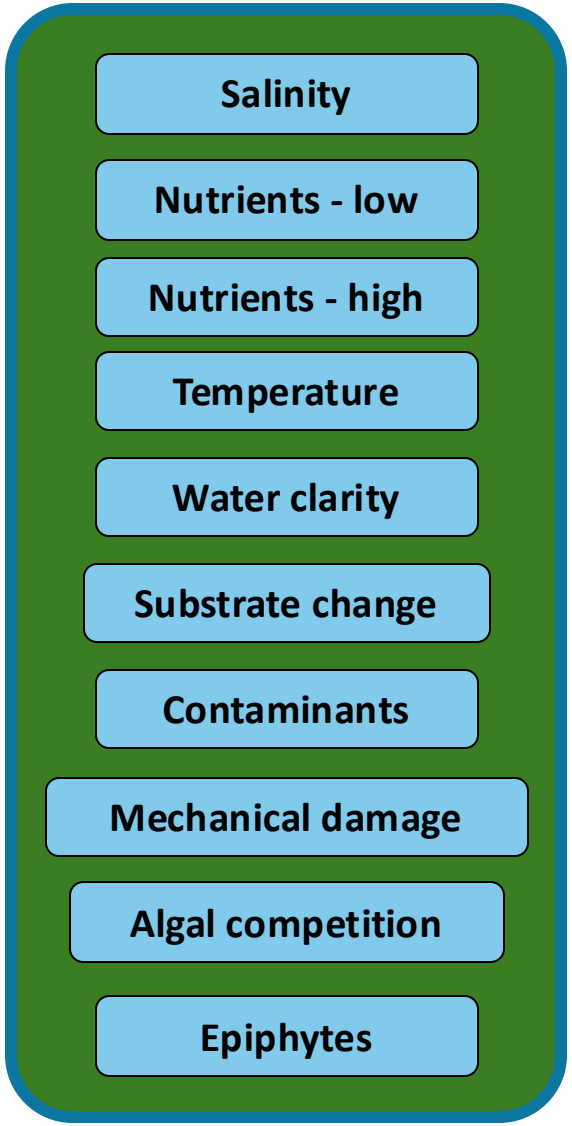


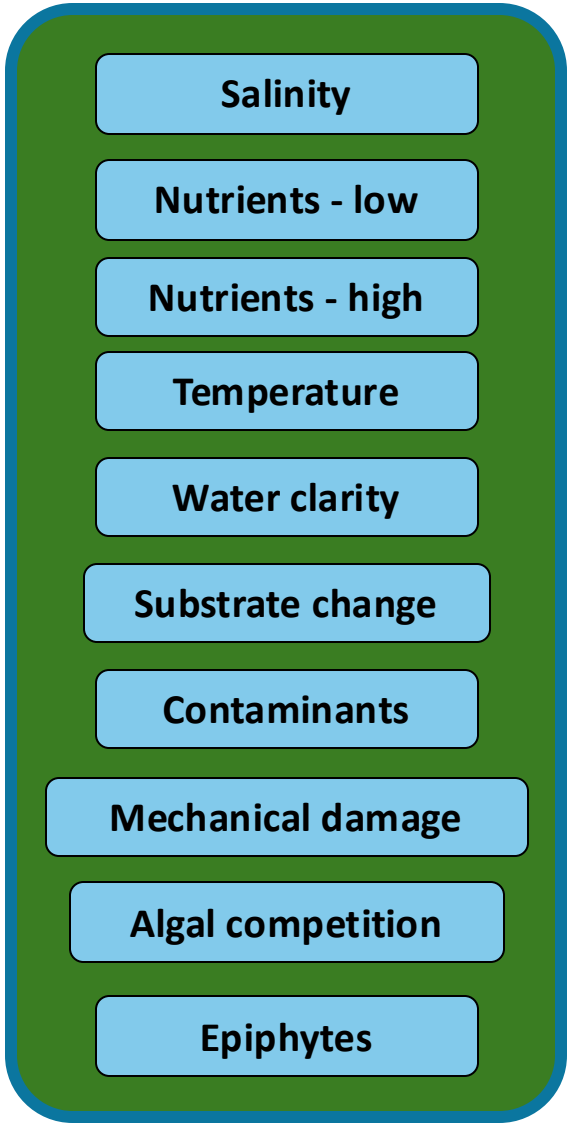
Approach



For each taxa × life stage

- Bull kelp
- Giant kelp
- Understory
- Sporophytes (adults)
- Gametophytes (juveniles)

Approach



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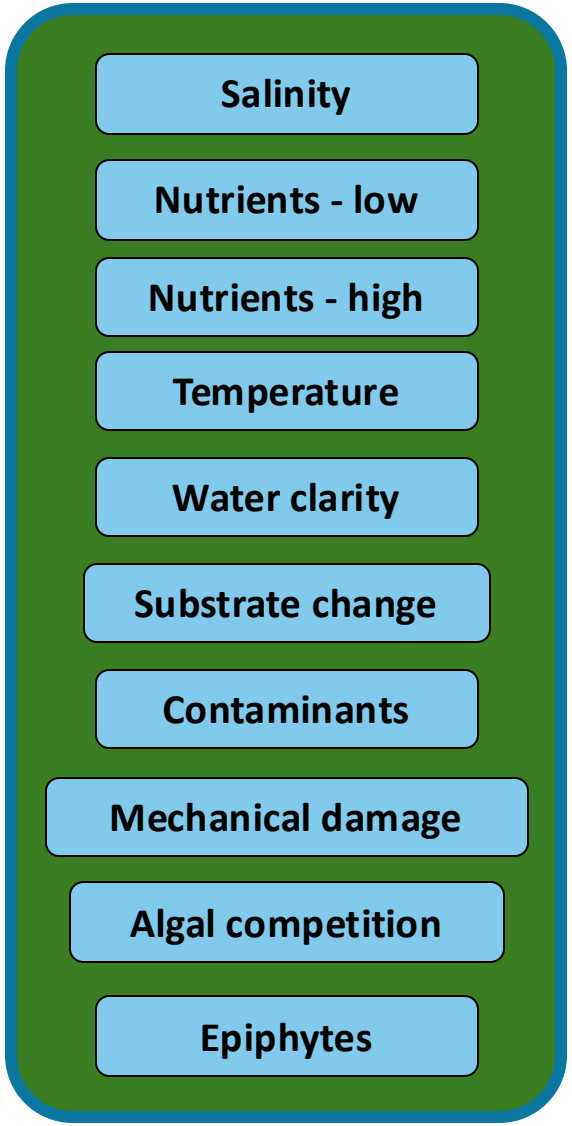
Rate stressor severity and certainty in 6 characteristics

- Magnitude
- Spatial extent
- Timing
- Reversibility
- Trend over time
- Depth extent

Approach



For each taxa × life stage

- Bull kelp
- Giant kelp
- Understory
- Sporophytes (adults)
- Gametophytes (juveniles)

Rating categorically

- High - 3
- Medium - 2
- Low - 1
- Very low (certainty only) – 0.5
- Unknown - 0

Rate stressor severity and certainty in 6 characteristics

- Magnitude
- Spatial extent
- Timing
- Reversibility
- Trend over time
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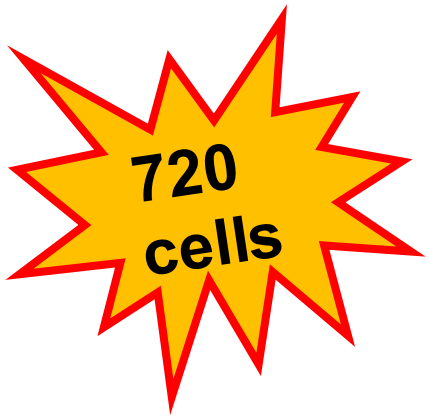
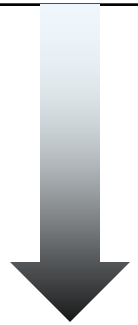
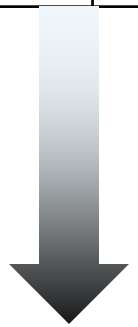
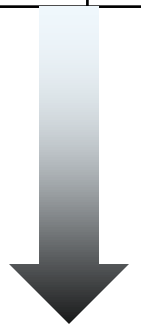


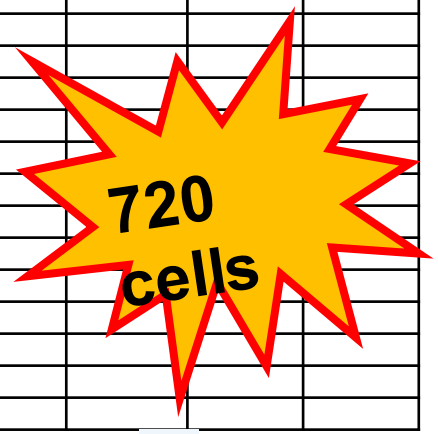
Workgroup rating

Stressor	Species	Life stage	Stressor characteristics											
			Magnitude		Reversability		Spatial Extent		Timing		Trend over time		Depth extent	
			Rating	Certainty	Rating	Certainty	Rating	Certainty	Rating	Certainty	Rating	Certainty	Level	Certainty
Algal competition	Macrocystis	Sporophyte												
Algal competition	Nereocystis	Sporophyte												
Contaminants	Macrocystis	Sporophyte												
Contaminants	Nereocystis	Sporophyte												
Epiphytes	Macrocystis	Sporophyte												
Epiphytes	Nereocystis	Sporophyte												
Mechanical damage	Macrocystis	Sporophyte												
Mechanical damage	Nereocystis	Sporophyte												
Nutrients - high	Macrocystis	Sporophyte												
Nutrients - high	Nereocystis	Sporophyte												
Nutrients - low	Macrocystis	Sporophyte												
Nutrients - low	Nereocystis	Sporophyte												
Salinity	Macrocystis	Sporophyte												
Salinity	Nereocystis	Sporophyte												
Substrate change / benthic sedimentation	Macrocystis	Sporophyte												
Substrate change / benthic sedimentation	Nereocystis	Sporophyte												
Temperature	Macrocystis	Sporophyte												
Temperature	Nereocystis	Sporophyte												



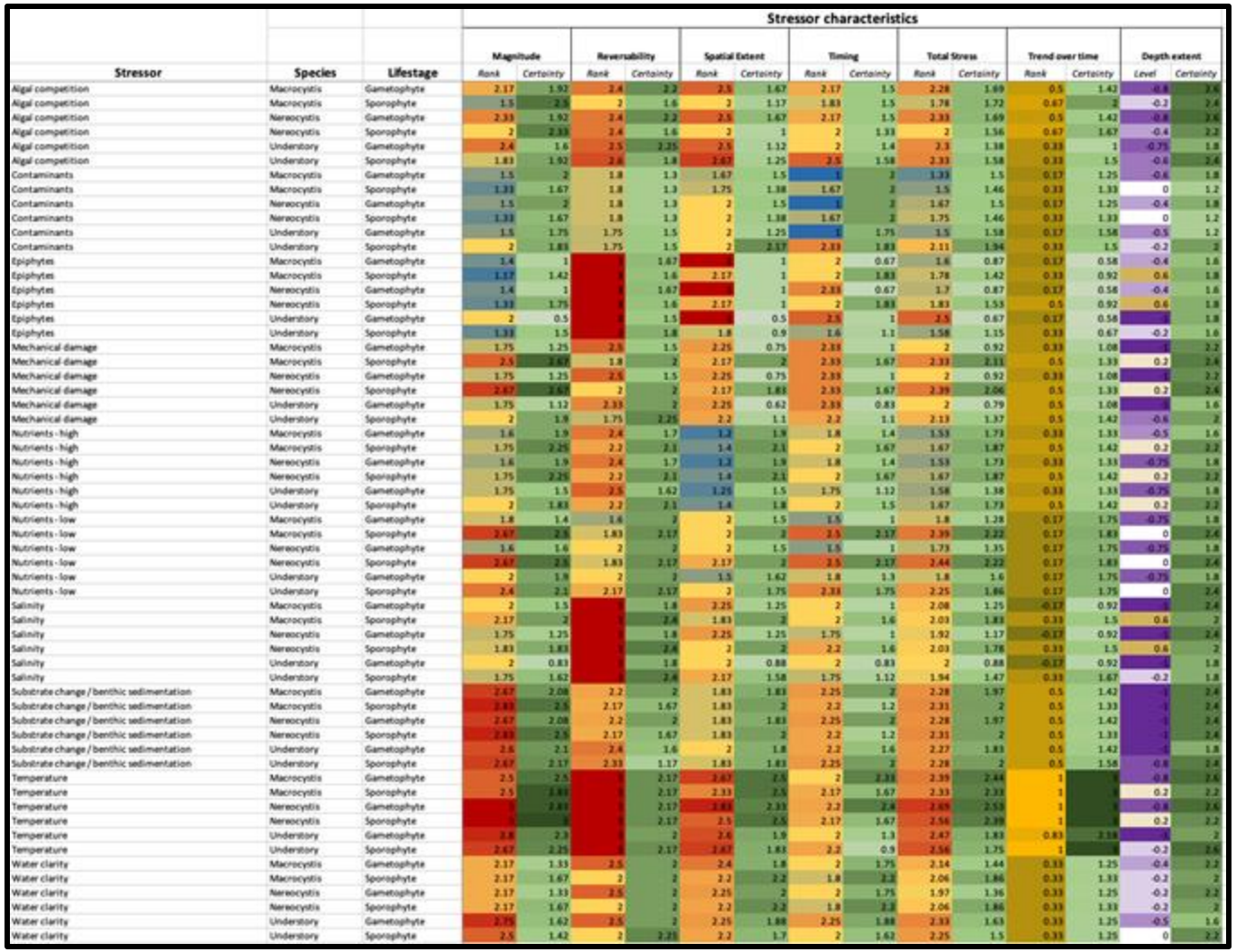






Compiling ratings

- Individual rating
- Compile and synthesize
  - Means and SD
  - Compute “Total Stress”
- In-person discussion
  - Review results
  - Build consensus
- Edit ratings
- Finalize ratings

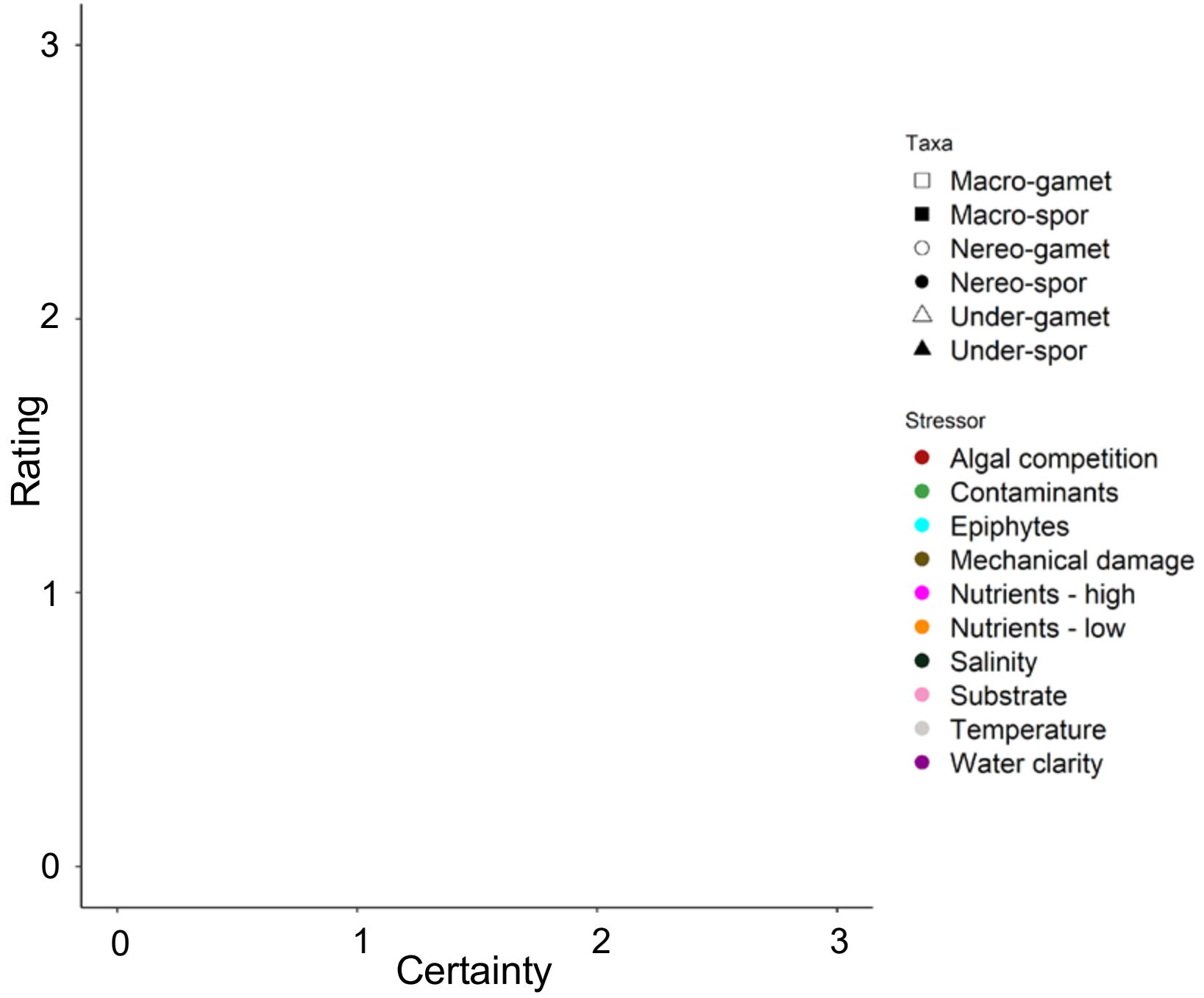


			Stressor characteristics													
			Magnitude		Reversability		Spatial Extent		Timing		Total Stress		Trend over time		Depth extent	
Stressor	Species	Lifestage	Rank	Certainty	Rank	Certainty	Rank	Certainty	Rank	Certainty	Rank	Certainty	Rank	Certainty	Level	Certainty
Algal competition	Macrocystis	Gametophyte	2.17	1.92	2.4	2.2	2.5	1.67	2.17	1.5	2.28	1.69	0.5	1.42	-0.8	1.6
Algal competition	Macrocystis	Sporophyte	1.5	2.5	2	1.6	2	1.17	1.83	1.5	1.78	1.72	0.67	2	-0.2	2.4
Algal competition	Nereocystis	Gametophyte	2.33	1.92	2.4	2.2	2.5	1.67	2.17	1.5	2.33	1.69	0.5	1.42	-0.8	1.6
Algal competition	Nereocystis	Sporophyte	2	2.33	2.4	1.6	2	1	2	1.33	2	1.56	0.67	1.67	-0.4	2.2
Algal competition	Understory	Gametophyte	2.4	1.6	2.5	2.25	2.5	1.12	2	1.4	2.3	1.38	0.33	1	-0.75	1.8
Algal competition	Understory	Sporophyte	1.83	1.92	2.4	1.8	1.67	1.25	2.5	1.58	2.33	1.58	0.33	1.5	-0.6	2.4
Contaminants	Macrocystis	Gametophyte	1.5	2	1.8	1.3	1.67	1.5	1	2	1.33	1.5	0.17	1.25	-0.6	1.8
Contaminants	Macrocystis	Sporophyte	1.33	1.67	1.8	1.3	1.75	1.38	1.67	2	1.5	1.46	0.33	1.33	0	1.2
Contaminants	Nereocystis	Gametophyte	1.5	2	1.8	1.3	2	1.5	1	2	1.67	1.5	0.17	1.25	-0.4	1.8
Contaminants	Nereocystis	Sporophyte	1.33	1.67	1.8	1.3	2	1.38	1.67	2	1.75	1.46	0.33	1.33	0	1.2
Contaminants	Understory	Gametophyte	1.5	1.75	1.75	1.5	2	1.25	1	1.75	1.5	1.58	0.17	1.58	-0.5	1.2
Contaminants	Understory	Sporophyte	2	1.83	1.75	1.5	2	2.17	2.33	1.83	2.11	1.94	0.33	1.5	-0.2	2
Epiphytes	Macrocystis	Gametophyte	1.4	1		1.67		1	2	0.67	1.6	0.87	0.17	0.58	-0.4	1.6
Epiphytes	Macrocystis	Sporophyte	1.17	1.42		1.6	2.17	1	2	1.83	1.78	1.42	0.33	0.92	-0.6	1.8
Epiphytes	Nereocystis	Gametophyte	1.4	1		1.67		1	2.33	0.67	1.7	0.87	0.17	0.58	-0.4	1.6
Epiphytes	Nereocystis	Sporophyte	1.33	1.75		1.6	2.17	1	2	1.83	1.83	1.53	0.5	0.92	-0.6	1.8
Epiphytes	Understory	Gametophyte	2	0.5		1.5		0.5	2.5	1	2.5	0.67	0.17	0.58		1.8
Epiphytes	Understory	Sporophyte	1.33	1.5		1.8	1.8	0.9	1.6	1.1	1.58	1.15	0.33	0.67	-0.2	1.6
Mechanical damage	Macrocystis	Gametophyte	1.75	1.25	2.5	1.5	2.25	0.75	2.33	1	2	0.92	0.33	1.08		2.2
Mechanical damage	Macrocystis	Sporophyte	2.5	1.67	1.8	2	2.17	2	2.33	1.67	2.33	2.11	0.5	1.33	0.2	2.4
Mechanical damage	Nereocystis	Gametophyte	1.75	1.25	2.5	1.5	2.25	0.75	2.33	1	2	0.92	0.33	1.08		2.2
Mechanical damage	Nereocystis	Sporophyte	2.67	2.67	2	2	2.17	1.83	2.33	1.67	2.39	2.06	0.5	1.33	0.2	2.4
Mechanical damage	Understory	Gametophyte	1.75	1.12	2.33	2	2.25	0.62	2.33	0.83	2	0.79	0.5	1.08		1.6
Mechanical damage	Understory	Sporophyte	2	1.9	1.75	2.25	2.2	1.1	2.2	1.1	2.13	1.37	0.5	1.42	-0.6	2
Nutrients - high	Macrocystis	Gametophyte	1.6	1.9	2.4	1.7	1.2	1.9	1.8	1.4	1.53	1.73	0.33	1.33	-0.5	1.6
Nutrients - high	Macrocystis	Sporophyte	1.75	2.25	2.2	2.1	1.4	2.1	2	1.67	1.67	1.87	0.5	1.42	0.2	2.2
Nutrients - high	Nereocystis	Gametophyte	1.6	1.9	2.4	1.7	1.2	1.9	1.8	1.4	1.53	1.73	0.33	1.33	-0.75	1.8
Nutrients - high	Nereocystis	Sporophyte	1.75	2.25	2.2	2.1	1.4	2.1	2	1.67	1.67	1.87	0.5	1.42	0.2	2.2
Nutrients - high	Understory	Gametophyte	1.75	1.5	2.5	1.62	1.25	1.5	1.75	1.12	1.58	1.38	0.33	1.33	-0.75	1.8
Nutrients - high	Understory	Sporophyte	2	1.83	2.2	2.1	1.4	1.8	2	1.5	1.67	1.73	0.5	1.42	0.2	2.2
Nutrients - low	Macrocystis	Gametophyte	1.8	1.4	1.6	2	2	1.5	1.5	1	1.8	1.28	0.17	1.75	-0.75	1.8
Nutrients - low	Macrocystis	Sporophyte	2.67	2.5	1.83	2.17	2	2	2.5	2.17	2.39	2.22	0.17	1.83	0	2.4
Nutrients - low	Nereocystis	Gametophyte	1.6	1.6	2	2	2	1.5	1.5	1	1.73	1.35	0.17	1.75	-0.75	1.8
Nutrients - low	Nereocystis	Sporophyte	2.67	2.5	1.83	2.17	2.17	2	2.5	2.17	2.44	2.22	0.17	1.83	0	2.4
Nutrients - low	Understory	Gametophyte	2	1.9	2	2	1.5	1.62	1.8	1.3	1.8	1.6	0.17	1.75	-0.75	1.8
Nutrients - low	Understory	Sporophyte	2.4	2.2	2.17	2.17	2	1.75	2.33	1.75	2.25	1.86	0.17	1.75	0	2.4
Salinity	Macrocystis	Gametophyte	2	1.5		1.8	2.25	1.25	2	1	2.08	1.25	-0.17	0.92		2.4
Salinity	Macrocystis	Sporophyte	2.17	2		2.4	1.83	2	2	1.6	2.03	1.83	0.33	1.5	0.6	2
Salinity	Nereocystis	Gametophyte	1.75	1.25		1.8	2.25	1.25	1.75	1	1.92	1.17	-0.17	0.92		2.4
Salinity	Nereocystis	Sporophyte	1.83	1.83		2.4	2	2	2.2	1.6	2.03	1.78	0.33	1.5	0.6	2
Salinity	Understory	Gametophyte	2	0.83		1.8	2	0.88	2	0.83	2	0.88	-0.17	0.92		1.8
Salinity	Understory	Sporophyte	1.75	1.62		2.4	2.17	1.58	1.75	1.12	1.94	1.47	0.33	1.67	-0.2	1.8
Substrate change / benthic sedimentation	Macrocystis	Gametophyte	2.67	2.08	2.2	2	1.83	1.83	2.25	2	2.28	1.97	0.5	1.42		2.4
Substrate change / benthic sedimentation	Macrocystis	Sporophyte	2.83	2.5	2.17	1.67	1.83	2	2.2	1.2	2.31	2	0.5	1.33		2.4
Substrate change / benthic sedimentation	Nereocystis	Gametophyte	2.67	2.08	2.2	2	1.83	1.83	2.25	2	2.28	1.97	0.5	1.42		2.4
Substrate change / benthic sedimentation	Nereocystis	Sporophyte	2.83	2.5	2.17	1.67	1.83	2	2.2	1.2	2.31	2	0.5	1.33		2.4
Substrate change / benthic sedimentation	Understory	Gametophyte	2.6	2.1	2.4	1.6	2	1.8	2.2	1.6	2.27	1.83	0.5	1.42		1.8
Substrate change / benthic sedimentation	Understory	Sporophyte	2.67	2.17	2.33	1.17	1.83	1.83	2.25	2	2.28	2	0.5	1.58	-0.8	2.4
Temperature	Macrocystis	Gametophyte	2.5	2.5		2.17	1.67	2.5	2	2.33	2.39	2.44	1	1	-0.8	2.6
Temperature	Macrocystis	Sporophyte	2.5	2.83		2.17	2.33	2.5	2.17	1.67	2.33	2.33	1	1	0.2	2.2
Temperature	Nereocystis	Gametophyte	3	2.83		2.17	1.83	2.33	2.2	2.4	2.69	2.53	1	1	-0.8	2.6
Temperature	Nereocystis	Sporophyte	3	3		2.17	2.5	2.5	2.17	1.67	2.56	2.39	1	1	0.2	2.2
Temperature	Understory	Gametophyte	2.8	2.3		2	2.6	1.9	2	1.3	2.47	1.83	0.83	2.18		2
Temperature	Understory	Sporophyte	2.67	2.25		2.17	2.67	1.83	2.2	0.9	2.56	1.75	1	1	-0.2	2.6
Water clarity	Macrocystis	Gametophyte	2.17	1.33	2.5	2	2.4	1.8	2	1.75	2.14	1.44	0.33	1.25	-0.4	2.2
Water clarity	Macrocystis	Sporophyte	2.17	1.67	2	2	2.2	2.2	1.8	2.2	2.06	1.86	0.33	1.33	-0.2	2
Water clarity	Nereocystis	Gametophyte	2.17	1.33	2.5	2	2.25	2	2	1.75	1.97	1.36	0.33	1.25	-0.2	2.2
Water clarity	Nereocystis	Sporophyte	2.17	1.67	2	2	2.2	2.2	1.8	2.2	2.06	1.86	0.33	1.33	-0.2	2
Water clarity	Understory	Gametophyte	2.75	1.62	2.5	2	2.25	1.88	2.25	1.88	2.33	1.63	0.33	1.25	-0.5	1.6
Water clarity	Understory	Sporophyte	2.5	1.42	2	2.25	2.2	1.7	2	1.62	2.25	1.5	0.33	1.25	0	2.2

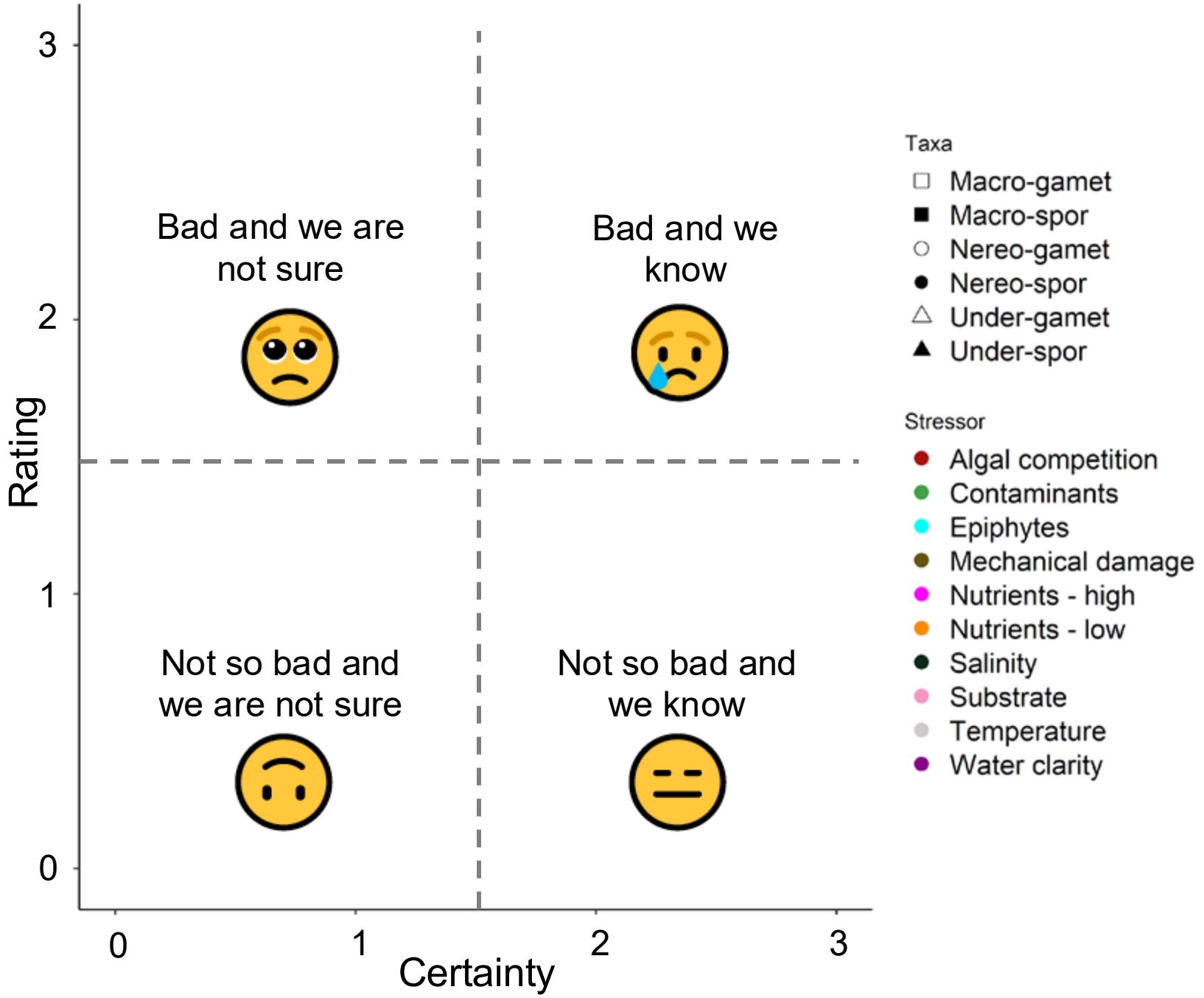
What does this all mean?

Total Stress =
Mean of

- Magnitude
- Reversibility
- Timing
- Spatial extent



What does this all mean?



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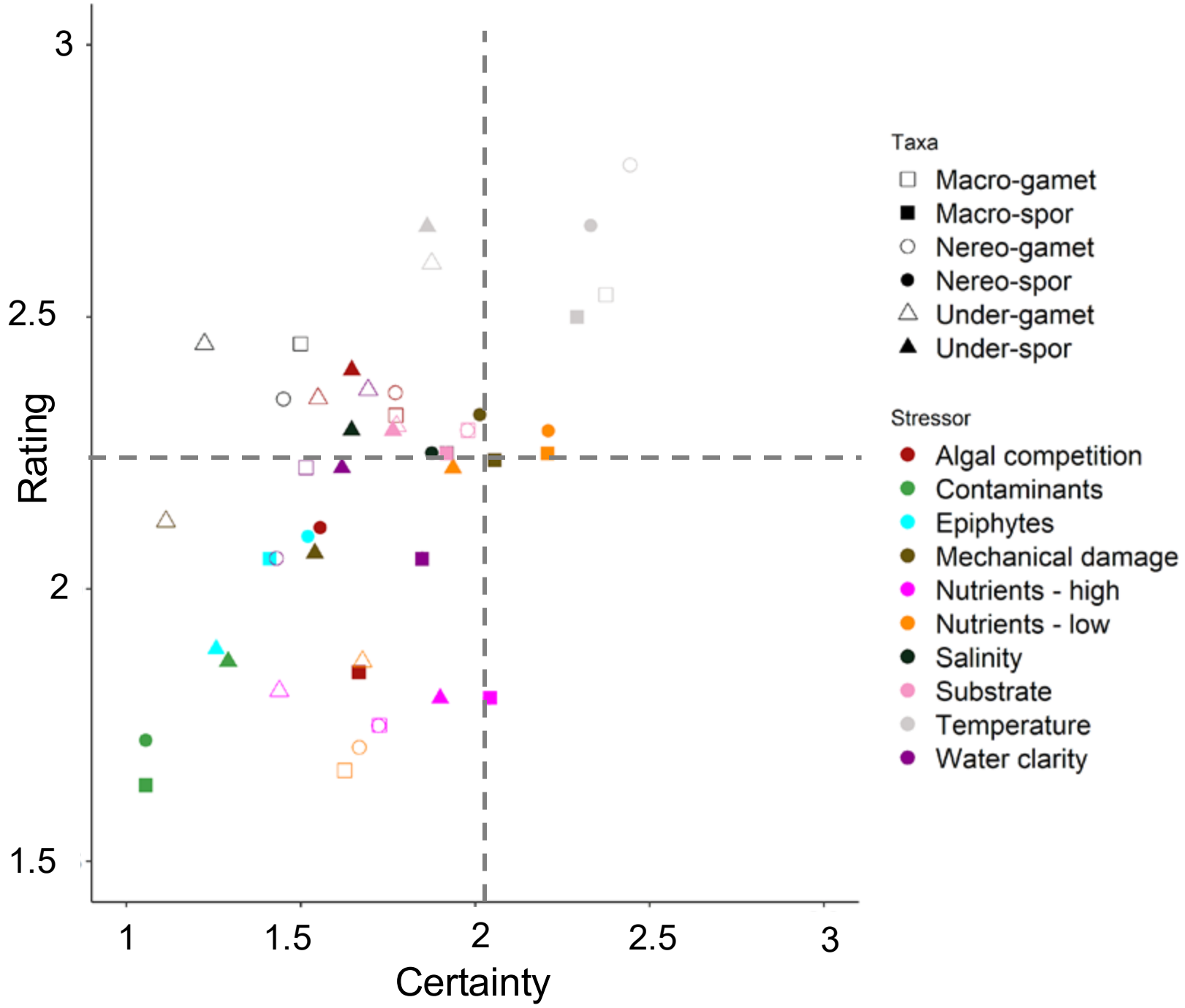


What does this all mean?

Bad and we know

- Temperature **for Macro and Nereo sporophytes**
- ~Low nutrients for Macro and Nereo sporophytes

Bad and we are not sure

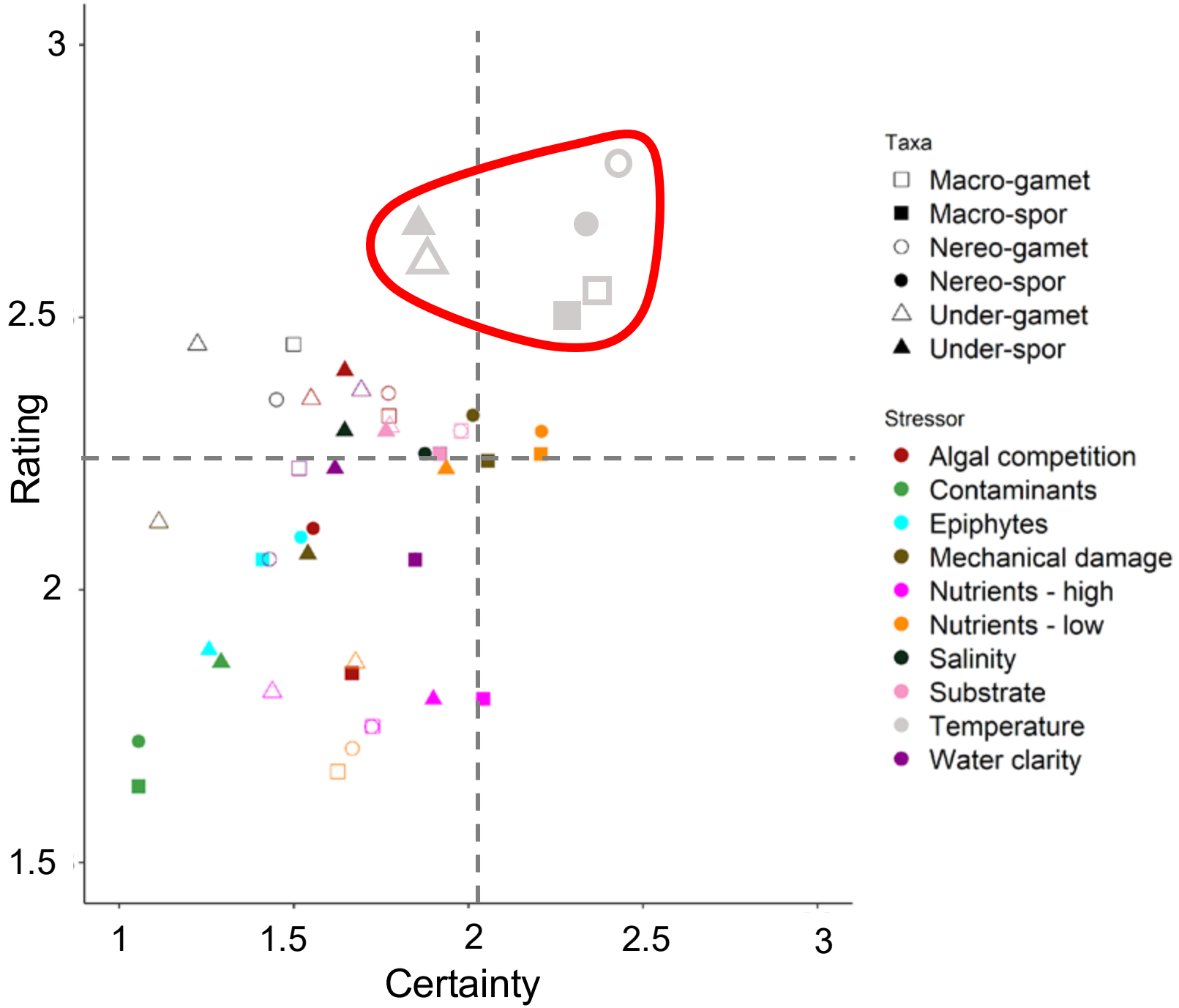
- Gametophytes for multiple stressors

Not so bad and we are not sure

- Contaminants, epiphytes, water clarity, high and low nutrients

No so bad and we know

- Nothing…?



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- **~Low nutrients for Macro and Nereo sporophytes**

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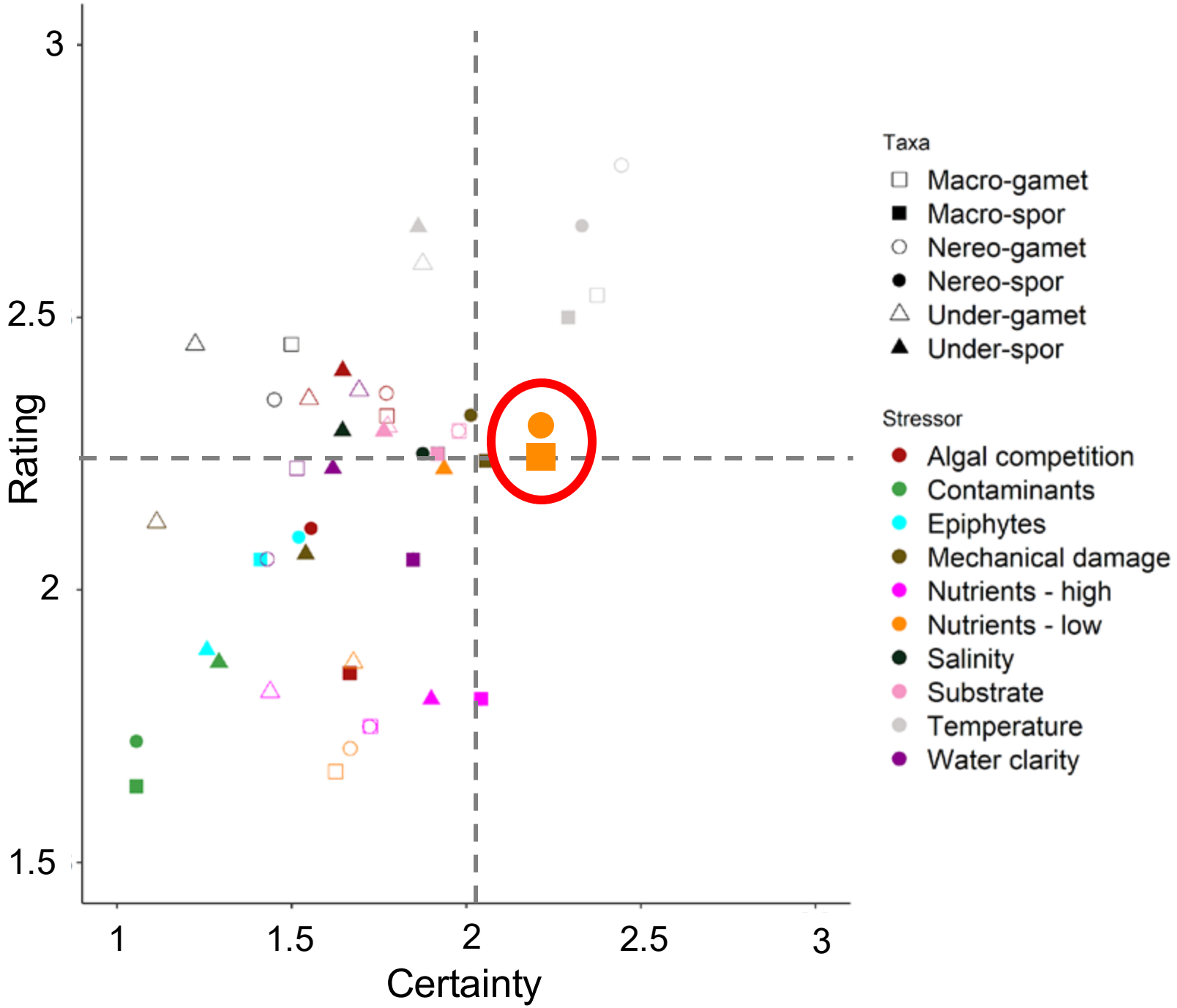
- Gametophytes for multiple stressors

Ok and we are not sure
- Contaminants, epiphytes, water clarity, high and low nutrients

Ok and we know
- Nothing…?



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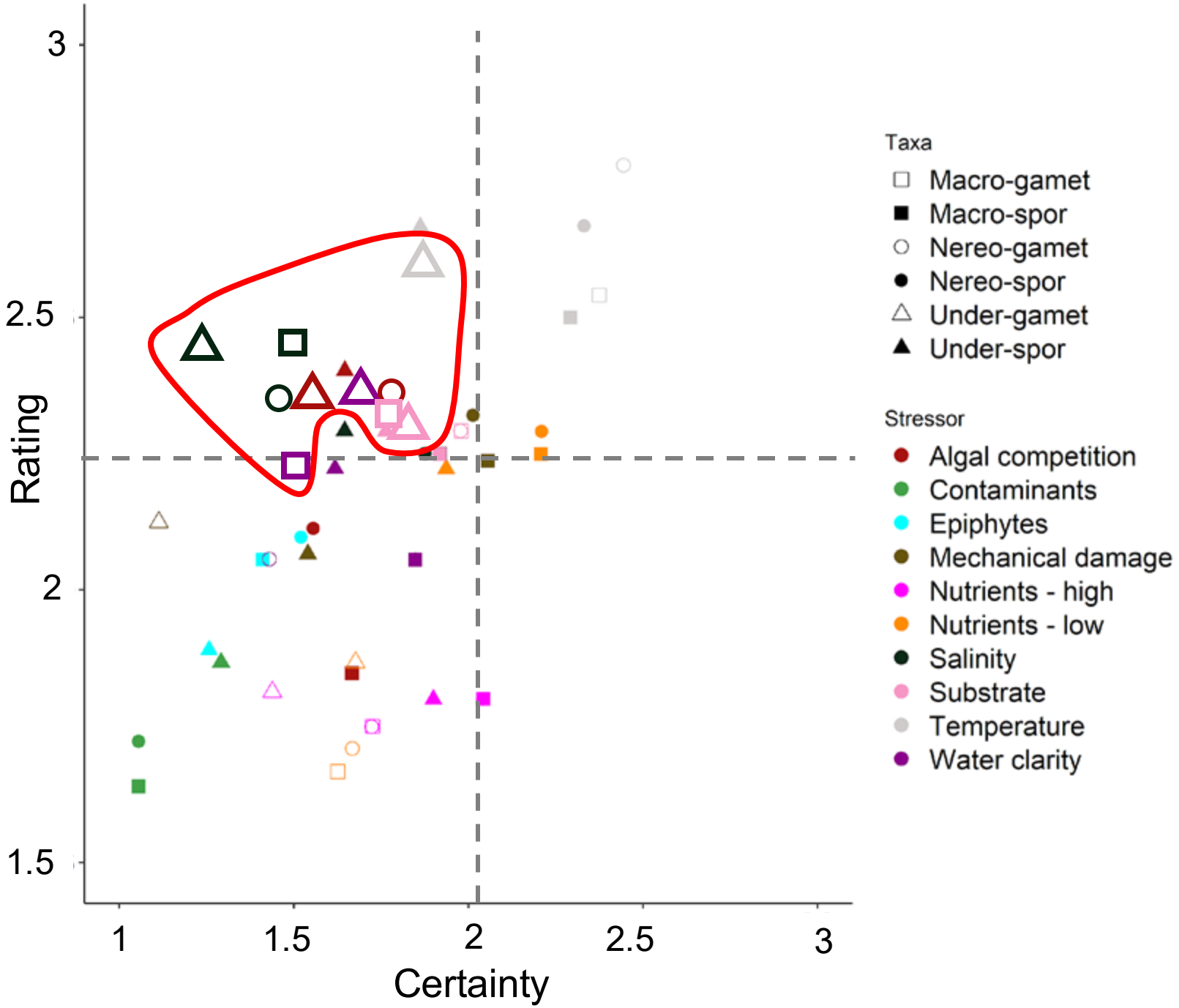

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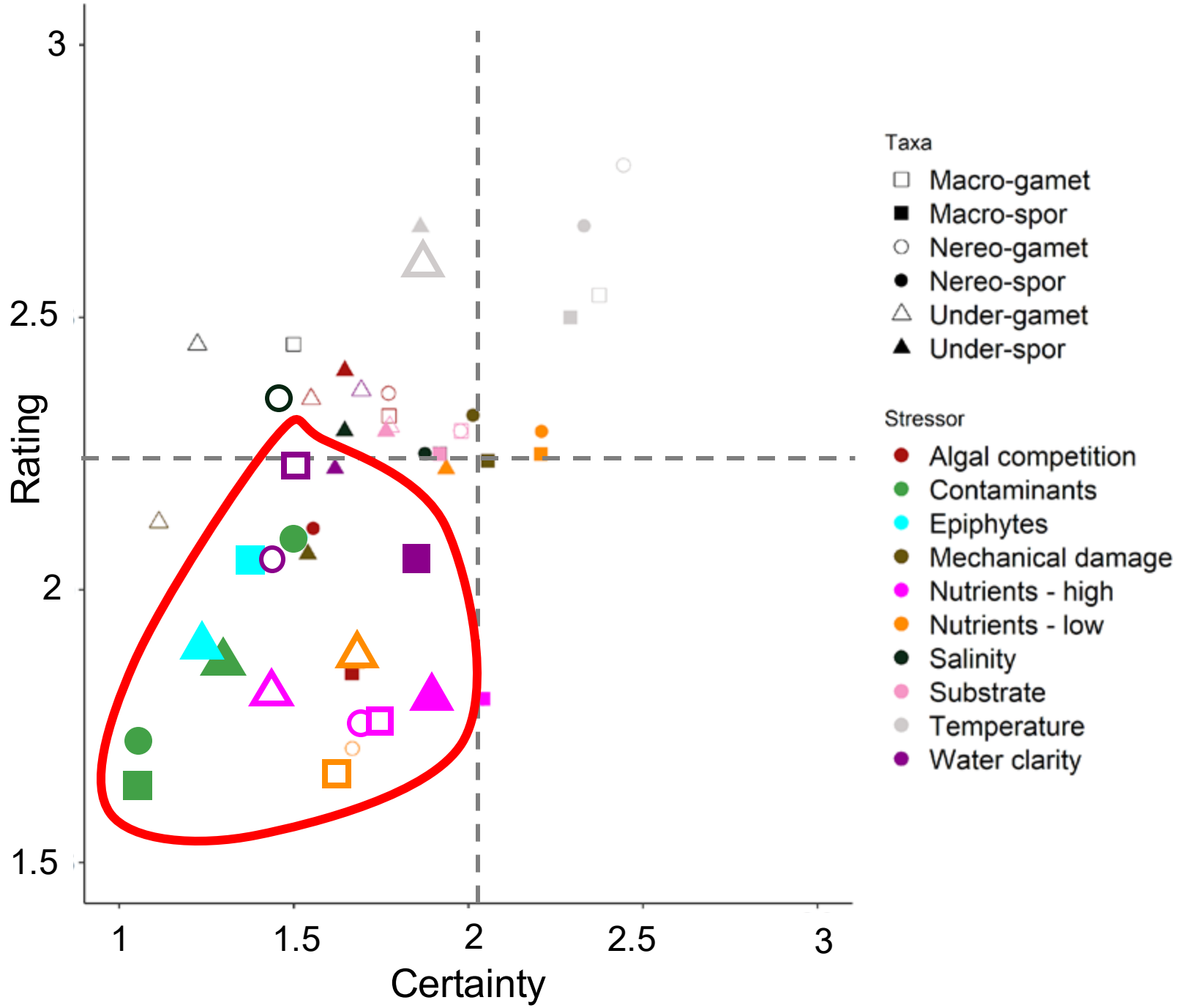
Not so bad and we know
- Nothing…?

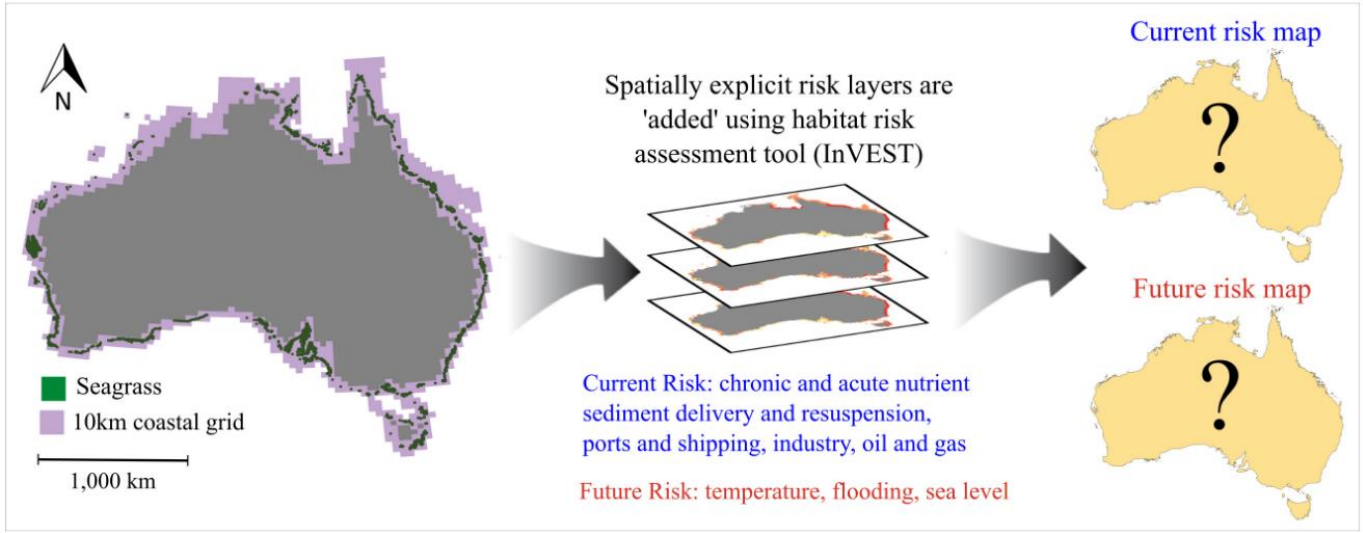


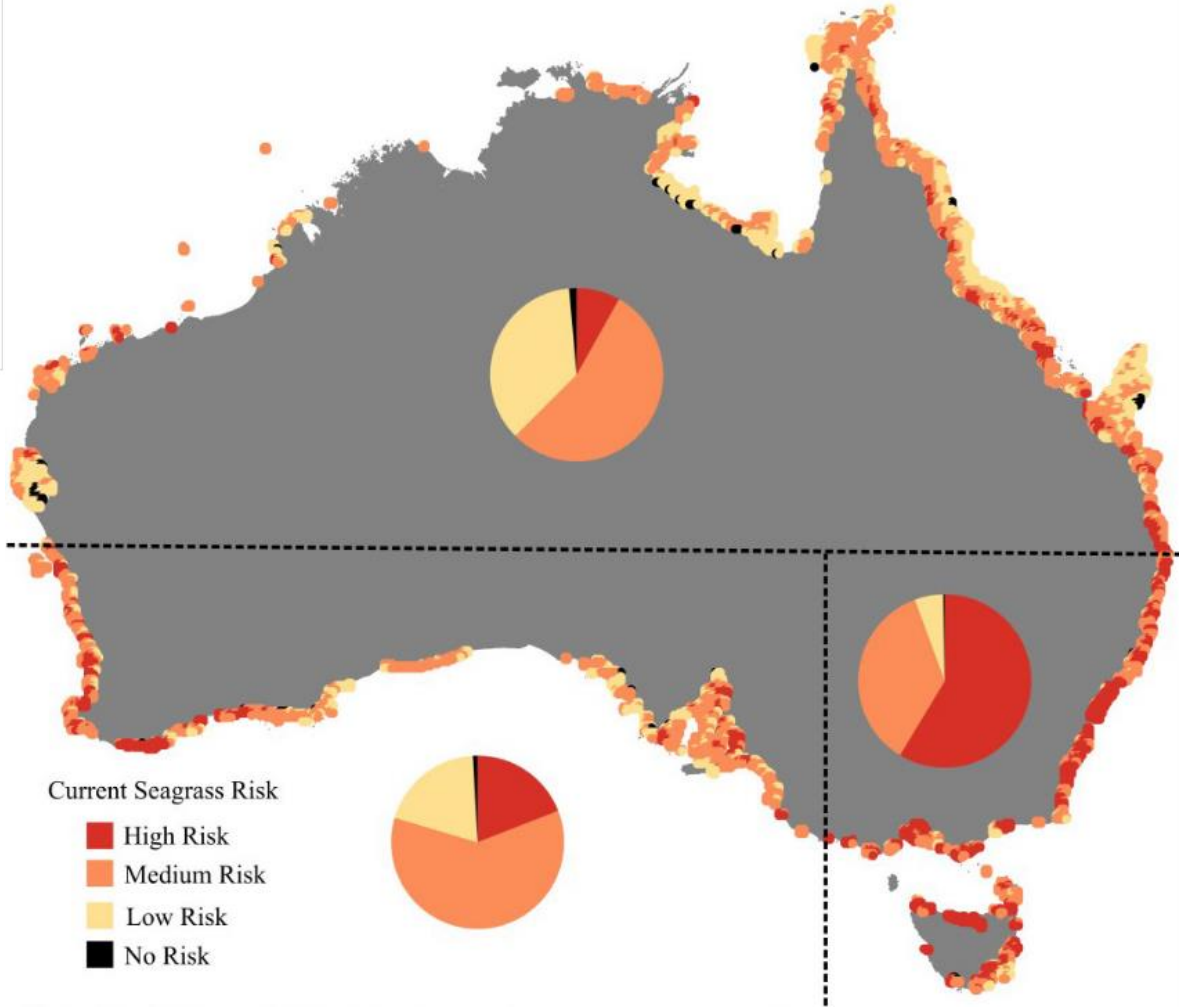
Kelp Threat Rating Conclusions

- Broad tool for research and management applications
- Rating and certainty were often positively correlated
- Interactive effects are difficult to quantify
- Reversibility scores may point to management/restoration priorities
- Certainty does not necessarily mean actionability
  - Temperature
- Research on gametophytes (juveniles) and understory species is needed
- Manuscript forthcoming


Questions?

Cumulative Risk Assessment





McMahon et al. (2022) *Frontiers in Marine Science*

Definition of Risk

Combination of:

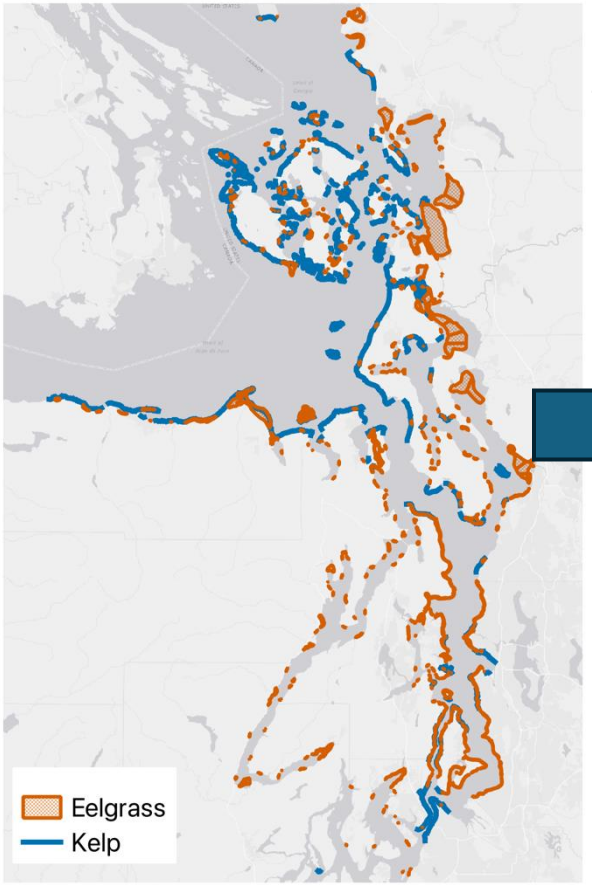
1. **Exposure** – degree to which the habitat experiences a threat
   - Geographic overlap
   - Intensity of the threat
   - Temporal extent
2. **Consequence** – sensitivity of the habitat to the effects of a threat
   - Magnitude
   - Reversibility
   - Trend

EXPERT SCORES

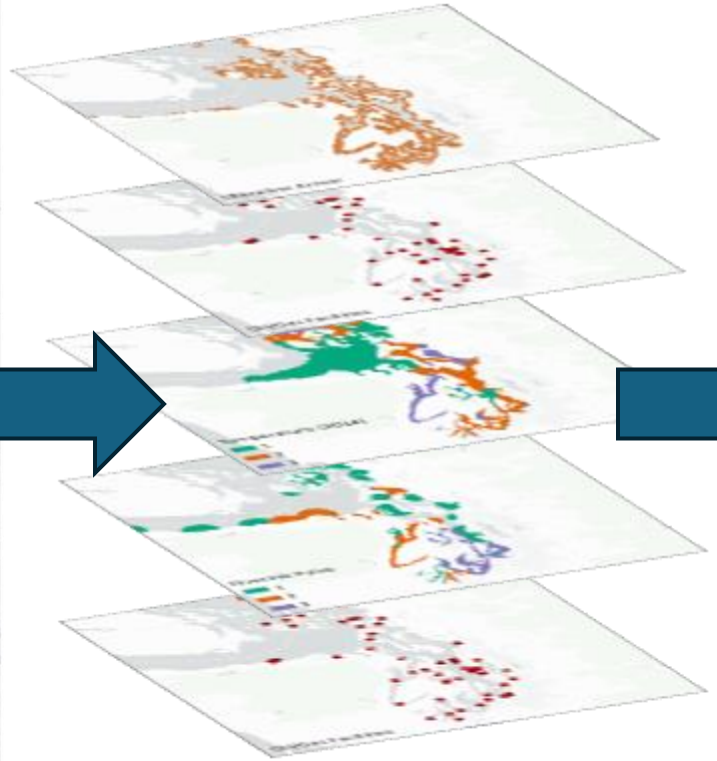
InVEST
Integrated Valuation of Ecosystem Services and Tradeoffs

Habitat Risk Assessment Model

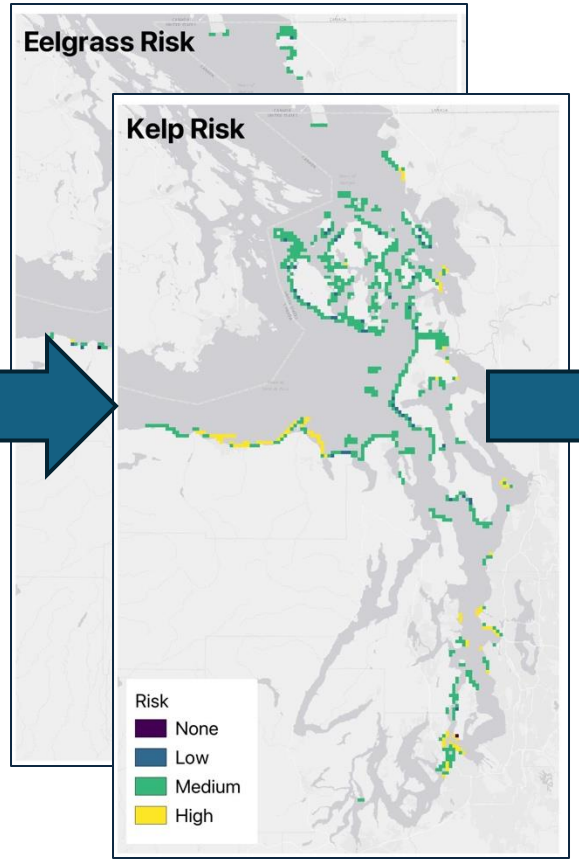
Habitats



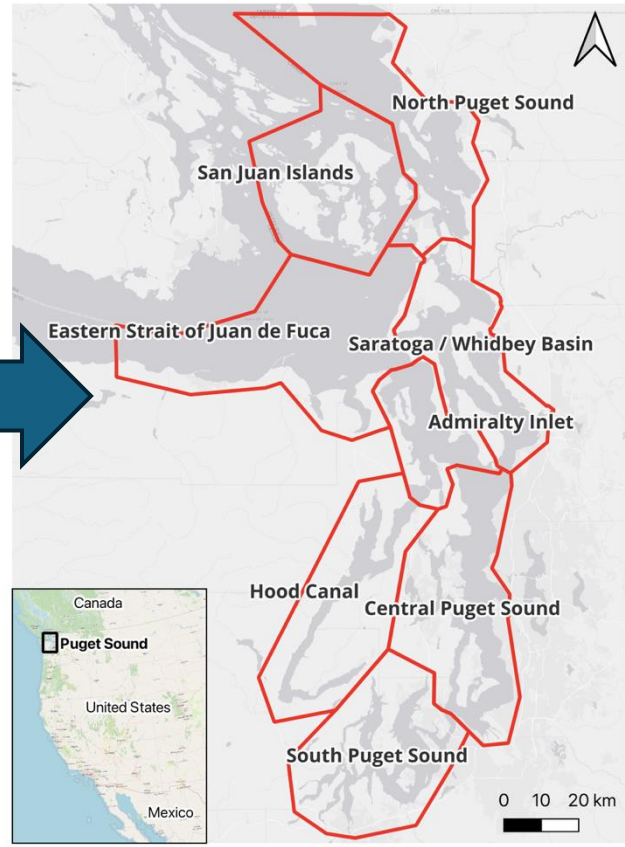
Threats: current & future



Total Risk



Risk by subregion



Threats – spatial data

Human activity (marine)

- Vessel traffic
- Shellfish harvest
- Dredge disposal
- Port facilities

Human activity (terrestrial)

- Shoreline armor
- Oil/gas facilities
- Impervious surface cover
- Industrial land use

Water quality (marine)

- Temperature
- Salinity
- Nutrients – low
- Nutrients – high

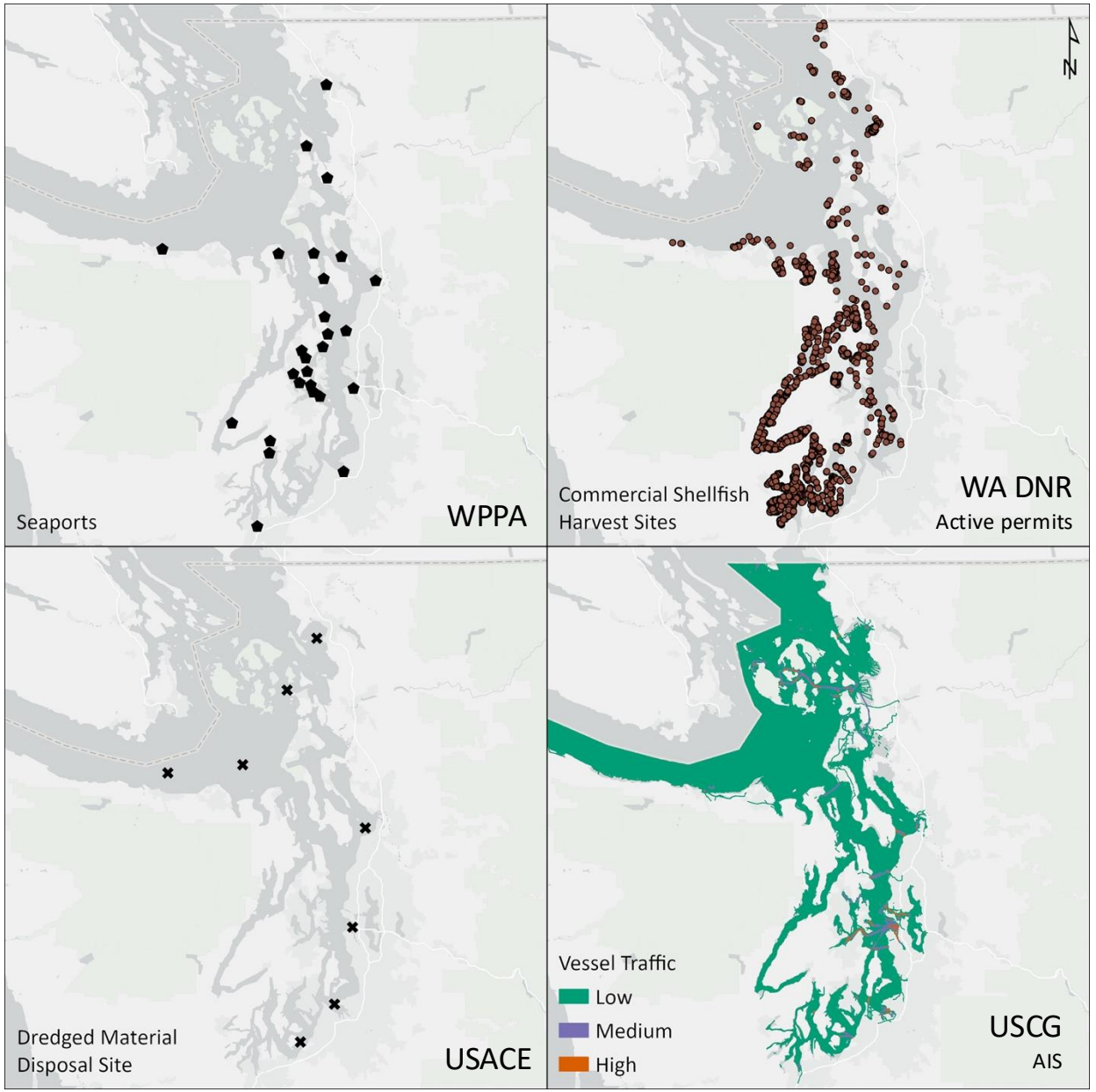
Water quality (terrestrial)

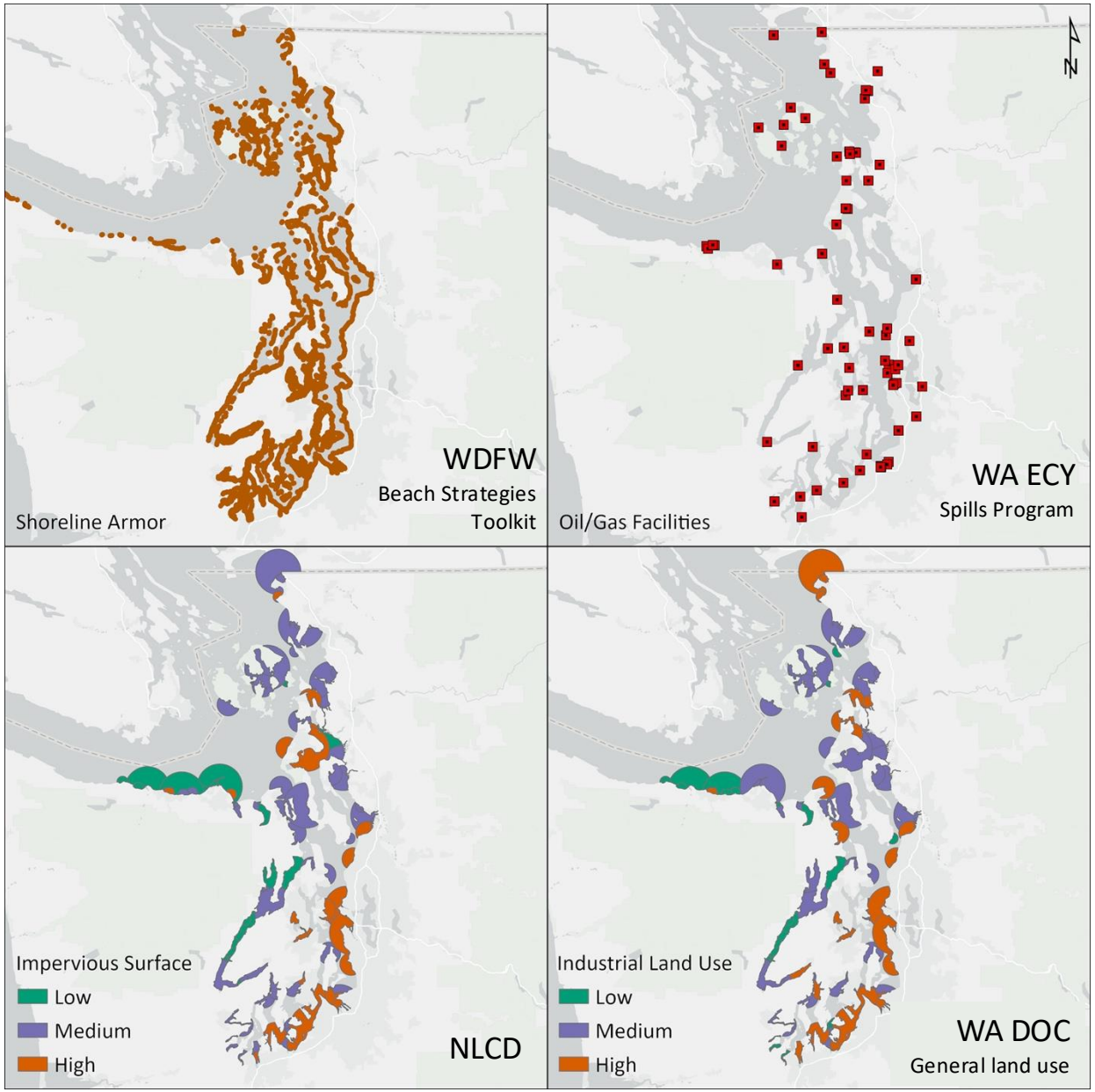
- River flow
- River pulse
- River nutrients
- WWTP nutrients

Future threats

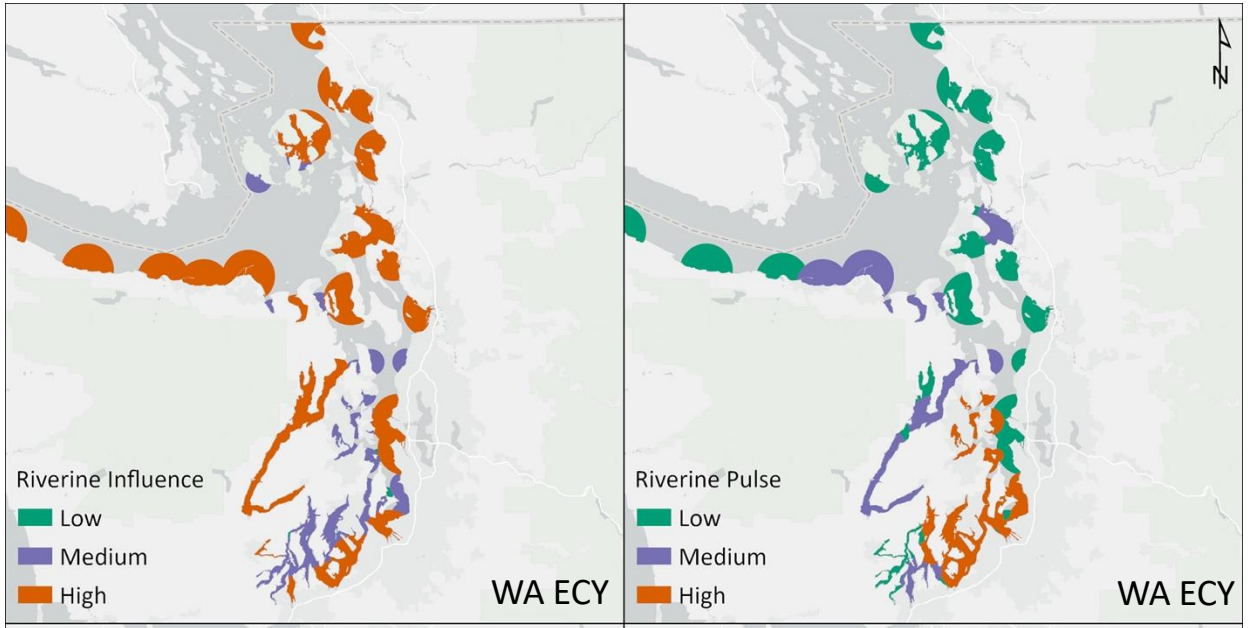
- Temperature
- Salinity
- Nutrients – low
- Nutrients – high
- Sea level rise

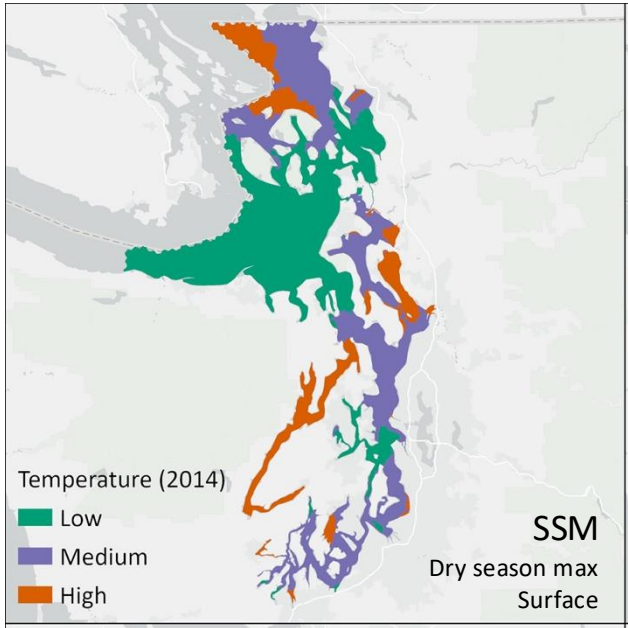
Current Threats – spatial data

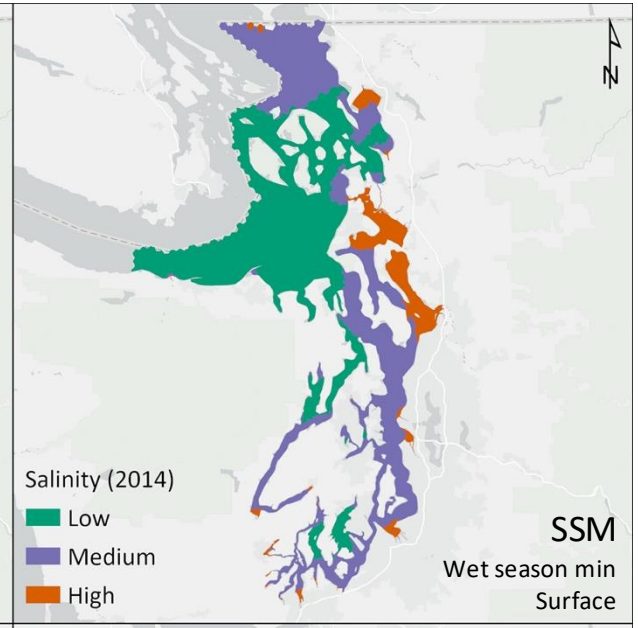


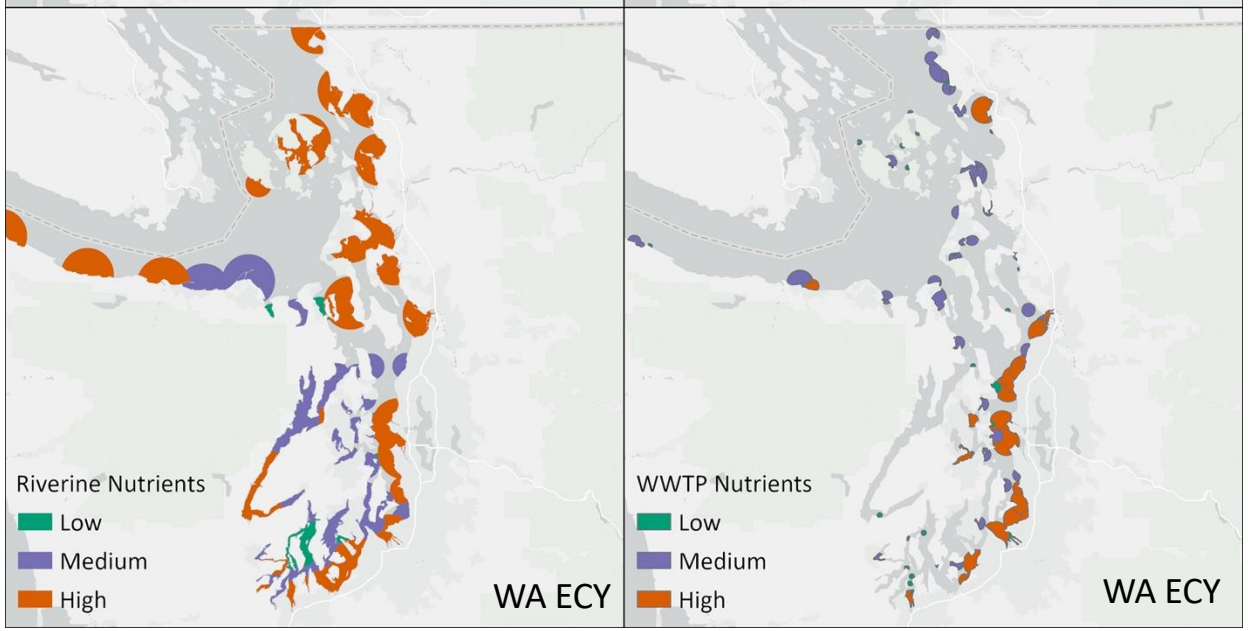


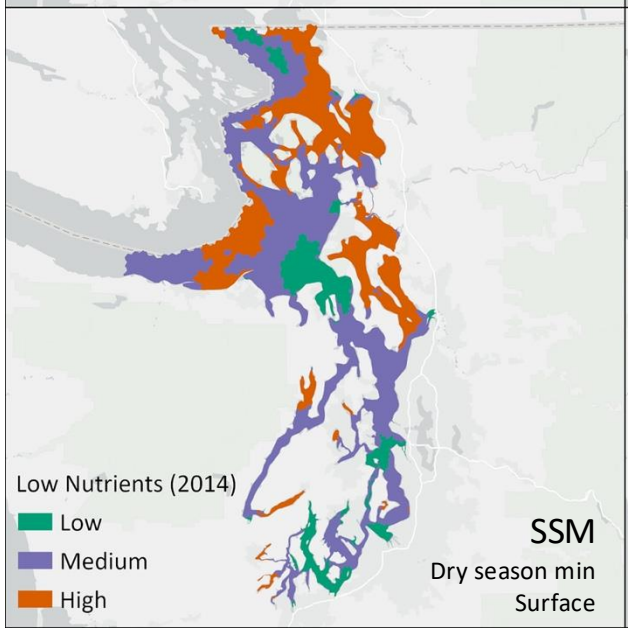
Current Threats – spatial data

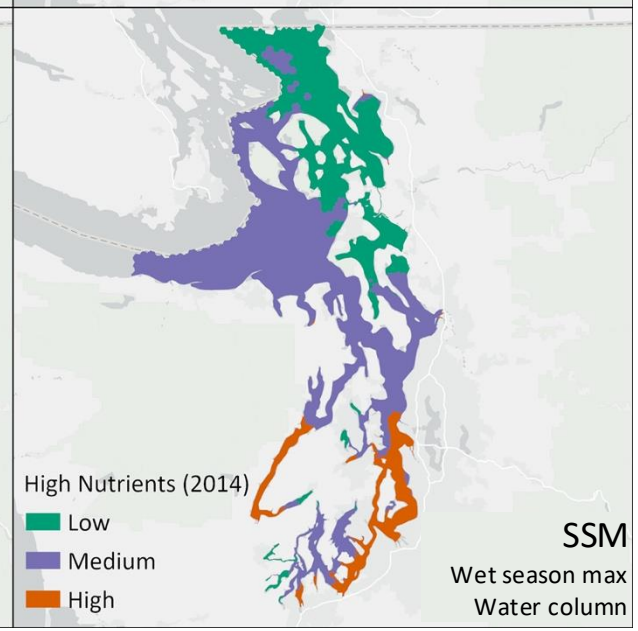




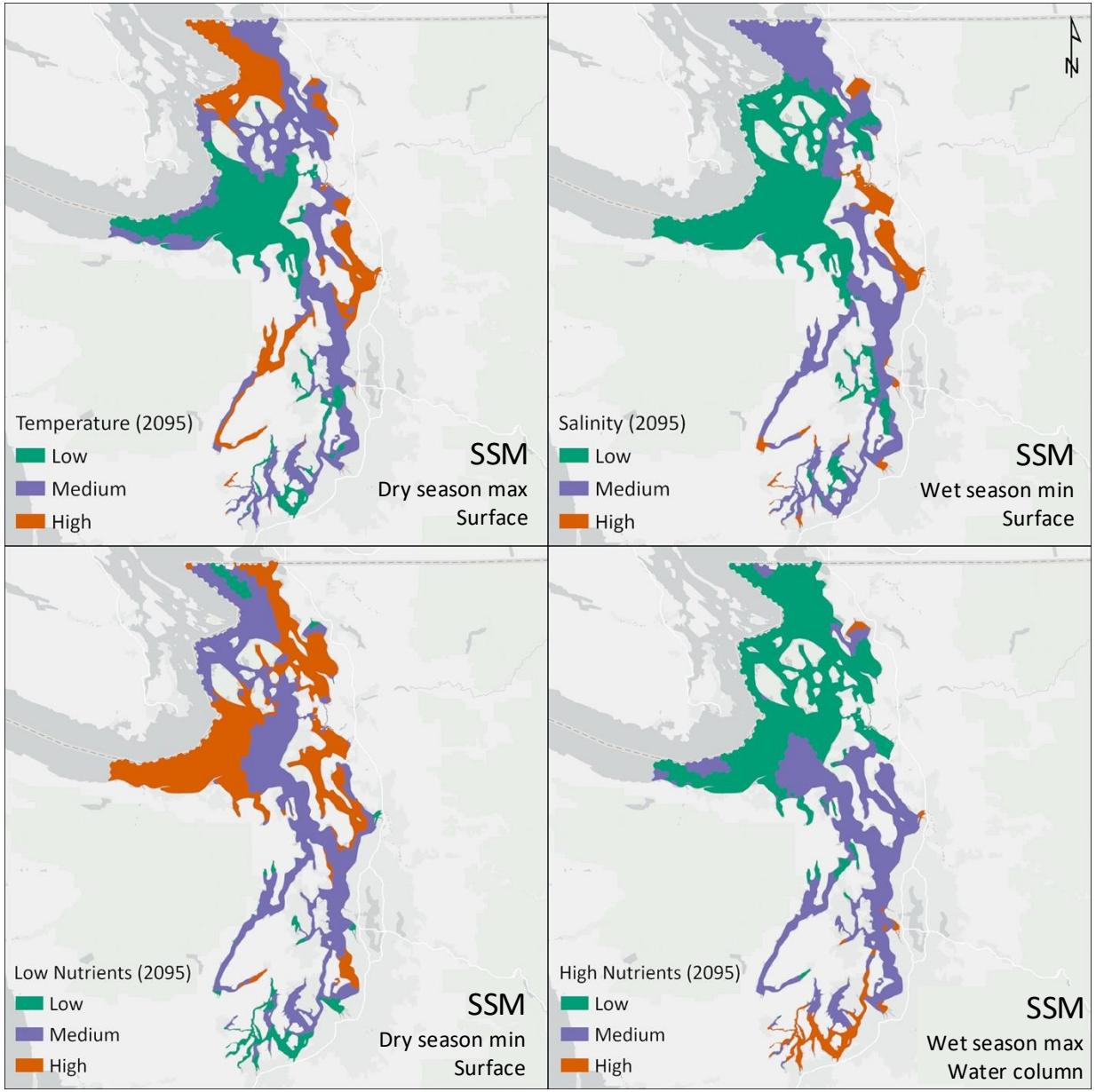


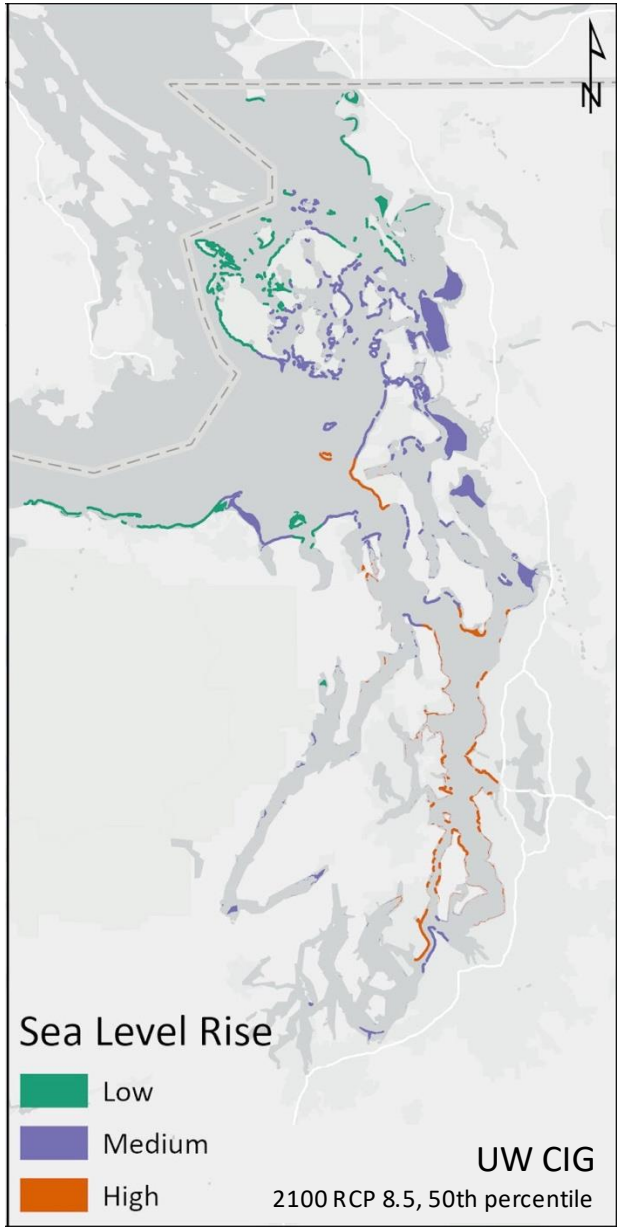






Future Threats – spatial data





Expert Ratings → InVEST Scores

Eelgrass
(Thom et al. 2011)

- *Nutrient-driven harmful algal blooms*
- *Suspended sediment*
- *Sea level rise*
- *Overwater structures*
- *Aquaculture*
- *Bioturbation*
- *Storms*
- *Construction*
- *Boat grounding/anchoring*
- *Shoreline armoring*
- *Dredging/filling*
- *Propeller wash/ boat wake*
- *Anthropogenic contaminants*
- *Disease*
- *Organic matter discharge /sulfides*
- *Sea temperature rise*
- *Freshwater input*
- *Overfishing*

Kelp
(Raymond et al. 2024)

- Salinity
- Nutrients - low
- Nutrients - high
- Temperature
- Water clarity
- Substrate change
- Contaminants
- Mechanical damage
- Algal competition
- Epiphytes

EXPERT SCORES

Percent of respondents indicating an association

	Hollarsmith et al. (2022) Kelp Pressure										
InVEST Threat layer	Algal competition	Contaminants	Epiphytes	Mechanical damage	Nutrients (high)	Nutrients (low)	Salinity	Substrate change/benthic sedimentation	Temperature	Water clarity	*Threat layer not applicable to kelp*
Vessel traffic intensity	0.00	85.00	0.00	95.00	0.00	0.00	0.00	80.00	0.00	40.00	0.00
Commercial shellfishing sites	5.00	5.00	7.69	10.00	5.00	0.00	0.00	15.00	0.00	5.00	75.00
Dredge disposal sites	0.00	65.00	0.00	45.00	0.00	0.00	0.00	60.00	0.00	60.00	30.00
Port facility locations	5.00	90.00	7.69	85.00	45.00	0.00	0.00	85.00	5.00	80.00	0.00
Shoreline armoring locations	0.00	0.00	0.00	45.00	0.00	0.00	0.00	90.00	5.00	5.00	0.00
Oil/gas facility locations	0.00	90.00	0.00	80.00	35.00	0.00	0.00	75.00	0.00	40.00	0.00
Impervious surface (watershed)	5.00	95.00	7.69	0.00	80.00	5.00	40.00	90.00	85.00	90.00	0.00
Industrial land use (watershed)	5.00	95.00	7.69	0.00	80.00	40.00	40.00	85.00	80.00	85.00	0.00
Riverine influence (flow magnitude)	5.00	80.00	7.69	0.00	70.00	35.00	90.00	90.00	85.00	90.00	0.00
Riverine flashiness (flow variability)	5.00	80.00	7.69	0.00	40.00	0.00	90.00	95.00	50.00	90.00	0.00
Riverine nutrients (load magnitude)	80.00	35.00	76.92	5.00	85.00	30.00	10.00	10.00	10.00	45.00	5.00
WWTP nutrients (load magnitude)	80.00	85.00	61.54	0.00	90.00	5.00	0.00	0.00	40.00	40.00	0.00
Temperature (from Salish Sea Model)	75.00	0.00	53.85	0.00	0.00	5.00	5.00	0.00	95.00	5.00	0.00
Salinity (from Salish Sea Model)	35.00	0.00	0.00	0.00	0.00	5.00	95.00	0.00	5.00	0.00	0.00
High nutrients (from Salish Sea Model)	85.00	5.00	61.54	0.00	95.00	35.00	0.00	0.00	0.00	80.00	0.00
Low nutrients (from Salish Sea Model)	70.00	0.00	46.15	0.00	35.00	95.00	0.00	0.00	0.00	65.00	0.00
Sea Level Rise (from UW CIG)	5.00	75.00	0.00	0.00	30.00	0.00	35.00	75.00	0.00	45.00	5.00

= expert rating included in additive threat score

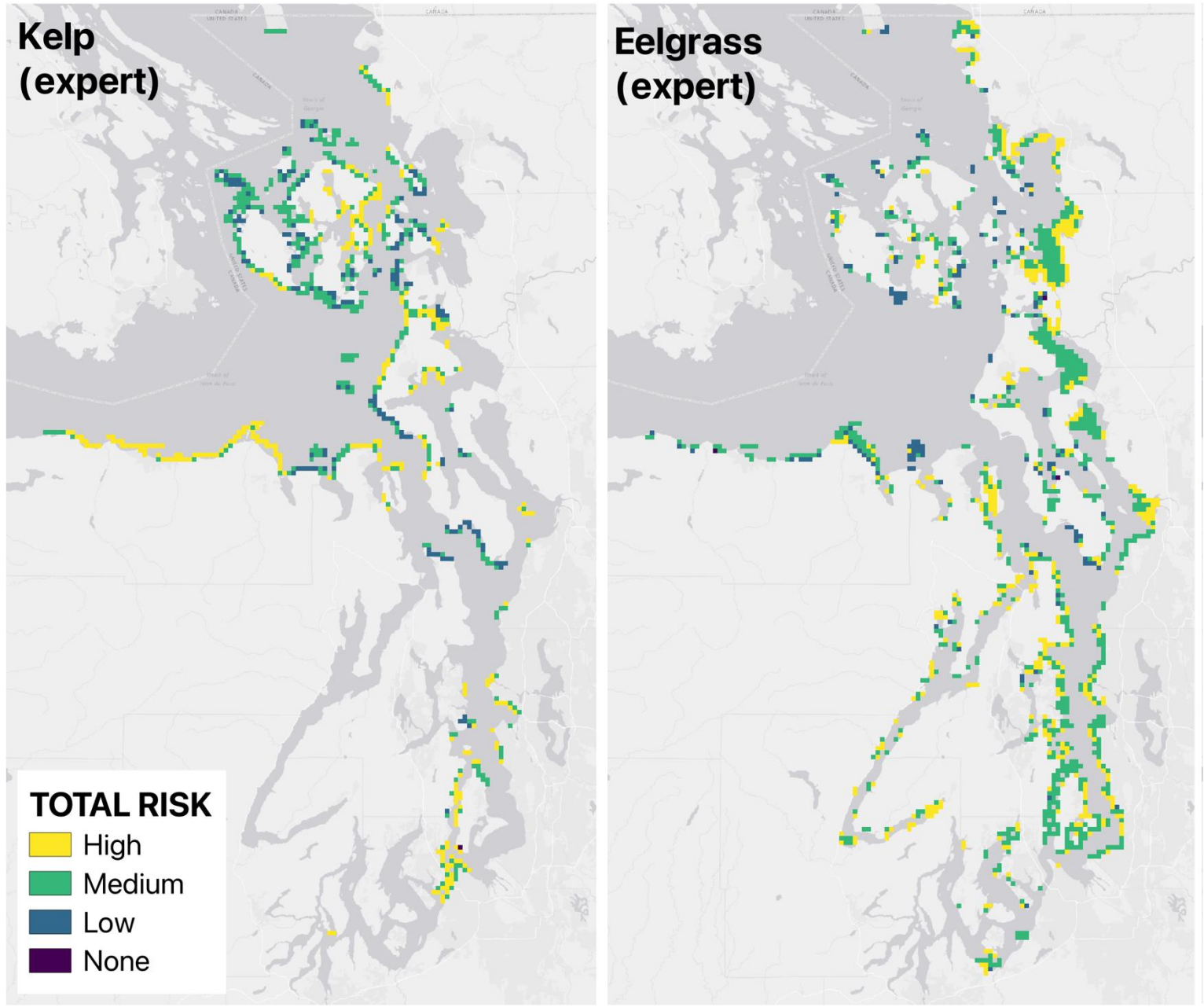
InVEST score for Timing, Magnitude, Reversibility, and Trend:

1 = lowest third of additive threat scores

2 = middle third

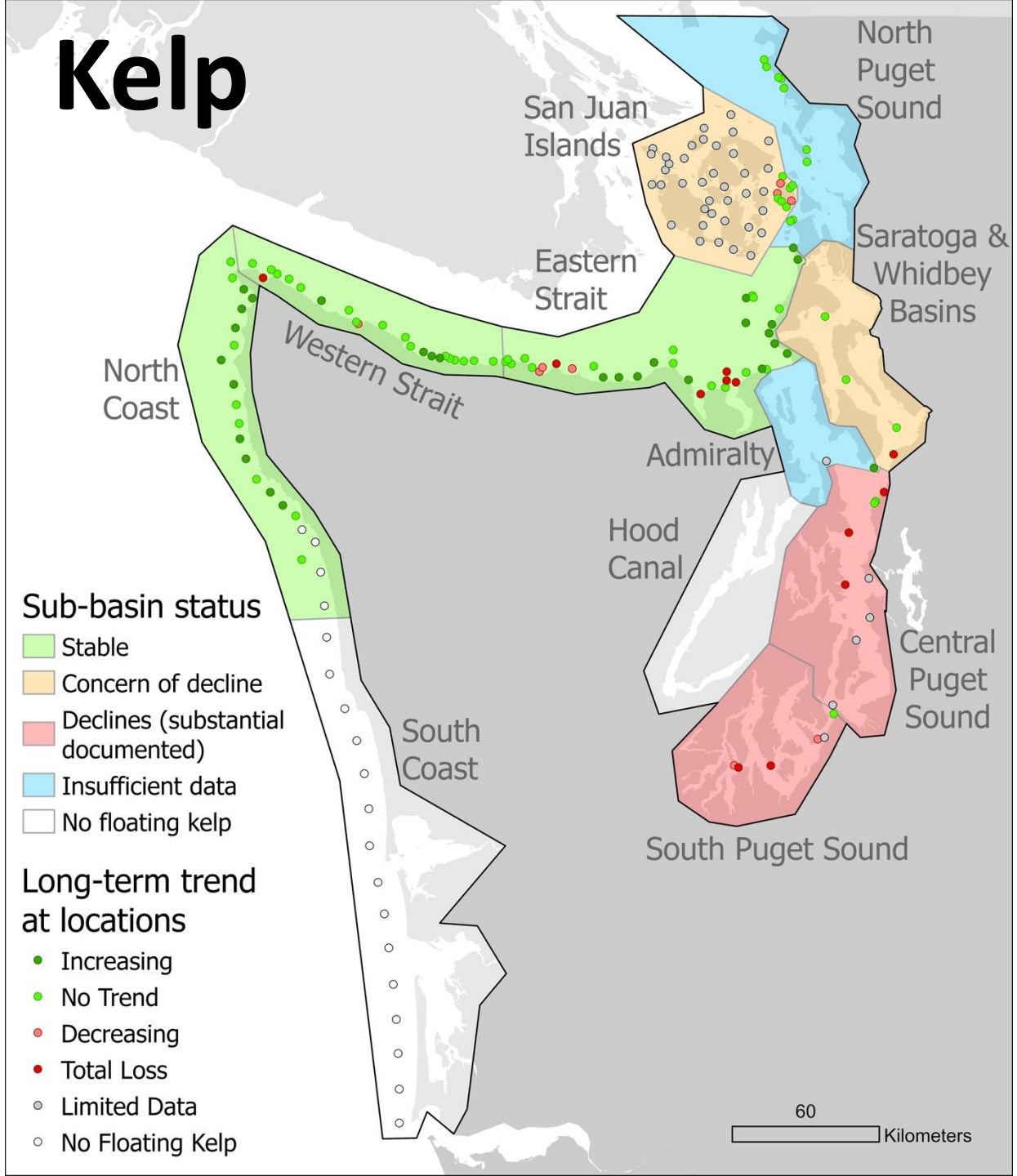
3 = upper third

Total Risk

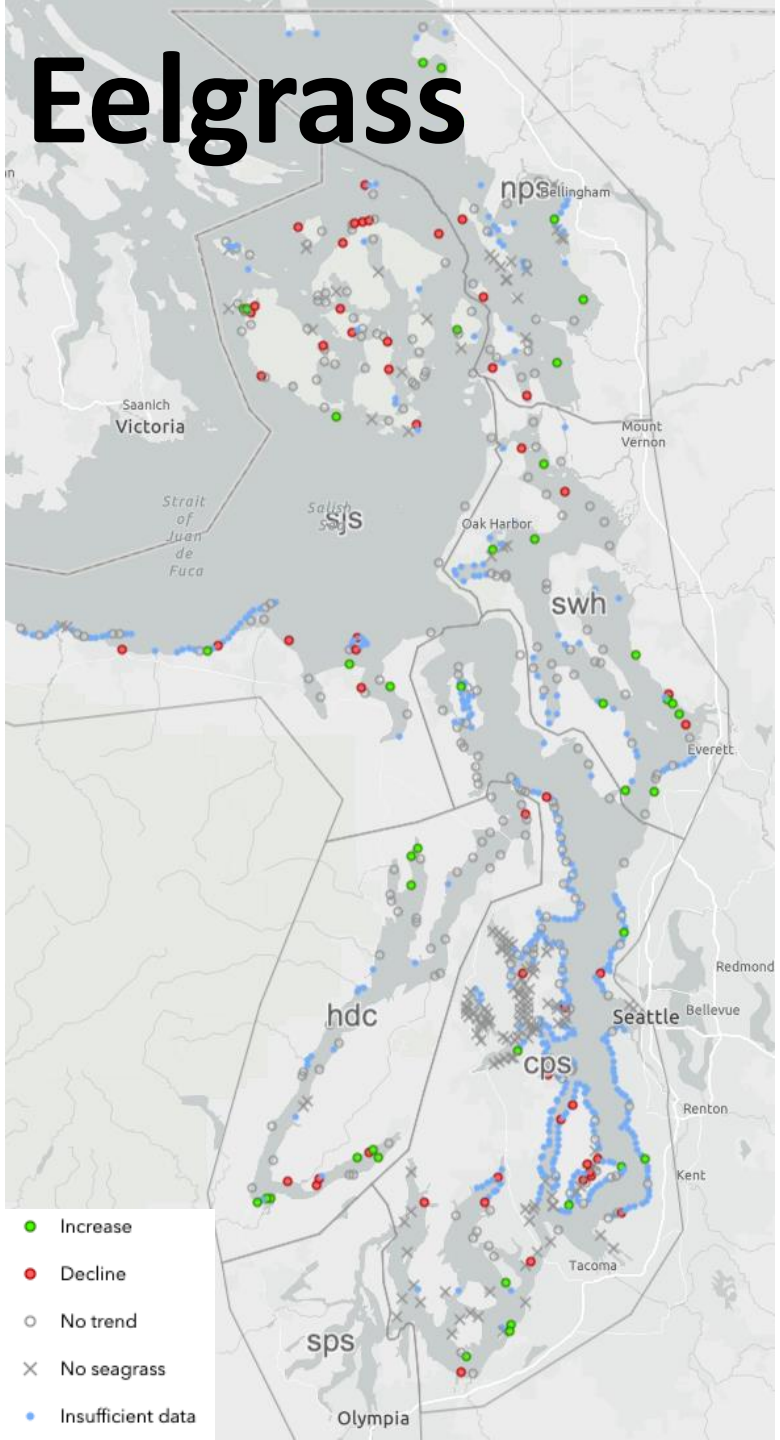


1 km resolution

Kelp



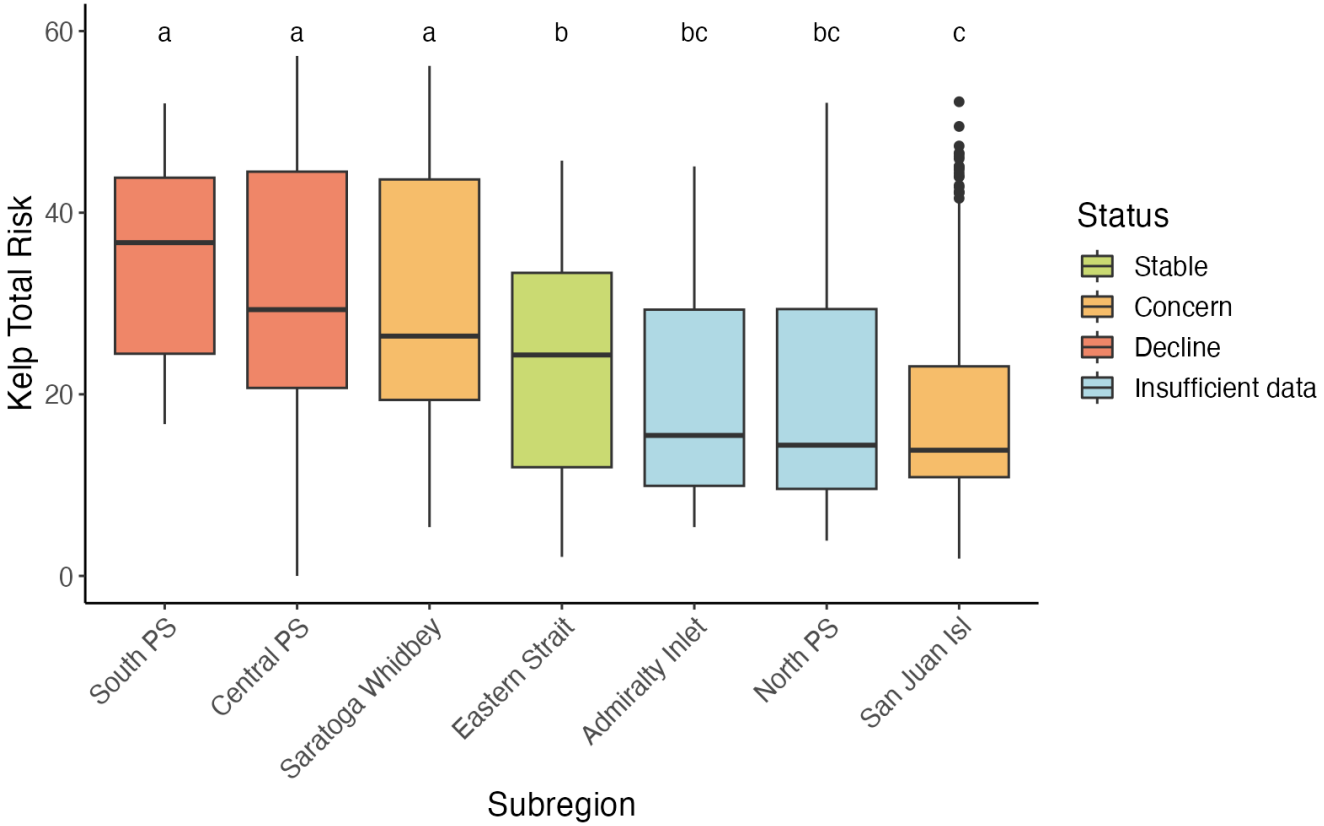
Eelgrass



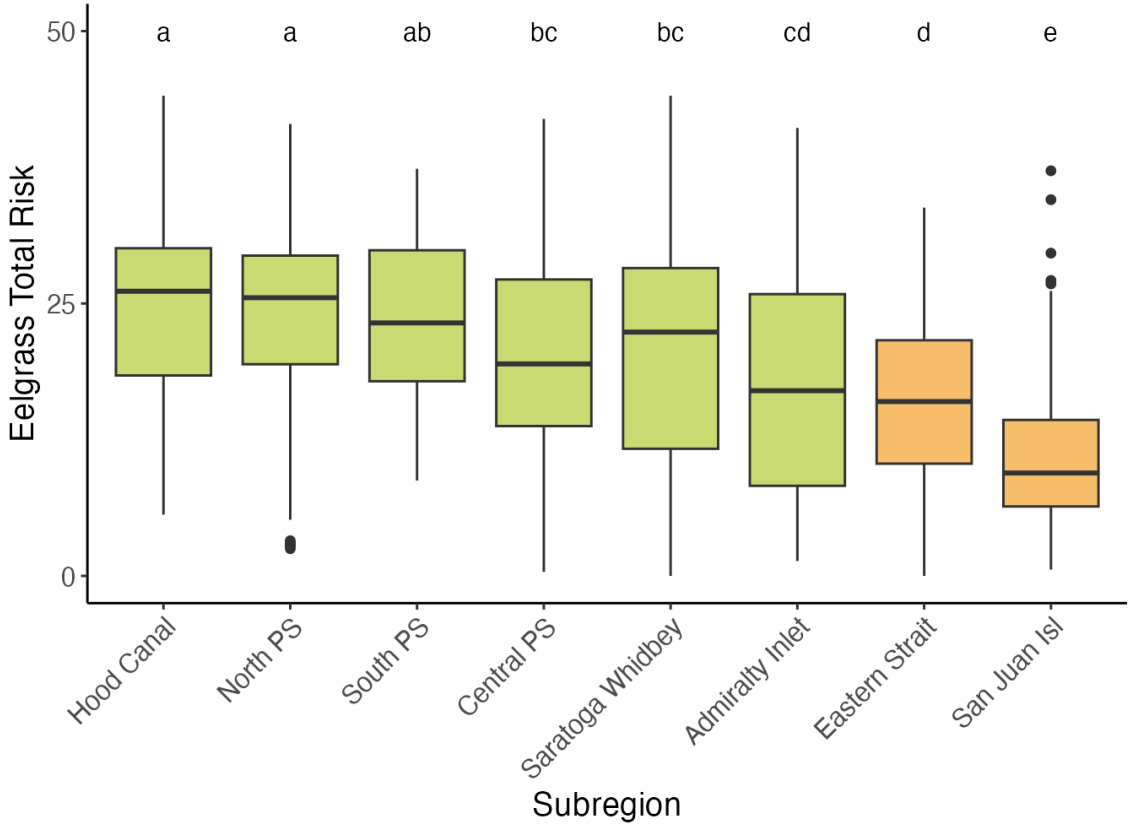
PUGET SOUND VITAL SIGNS
REPORTING ECOSYSTEM HEALTH

Risk by Subregion & Monitoring Status

Kelp

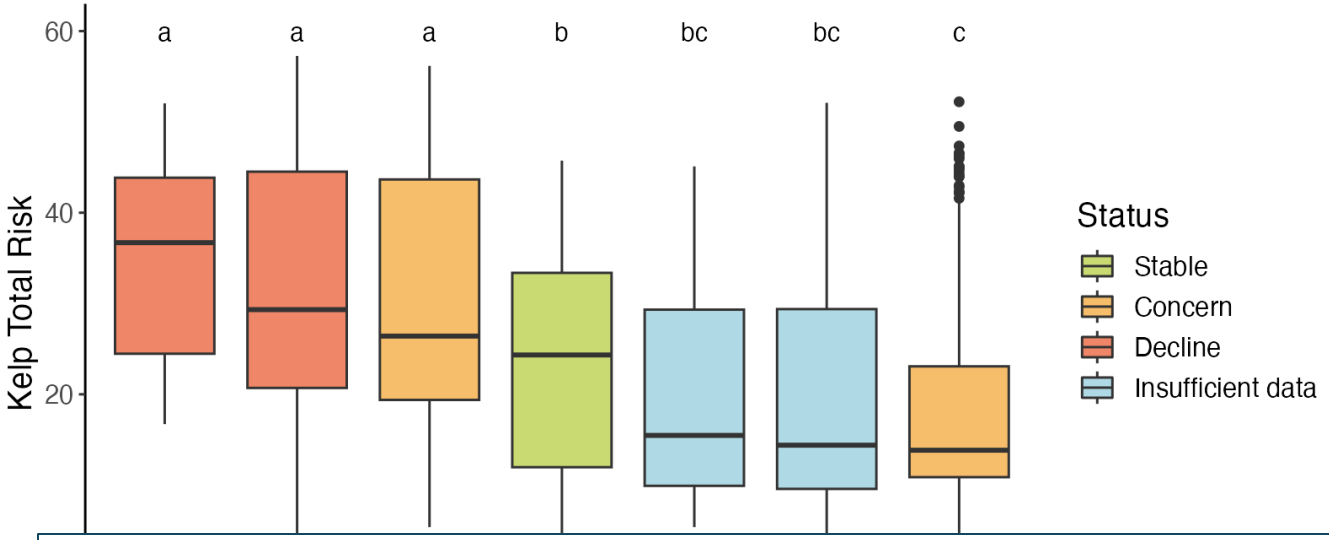


Eelgrass

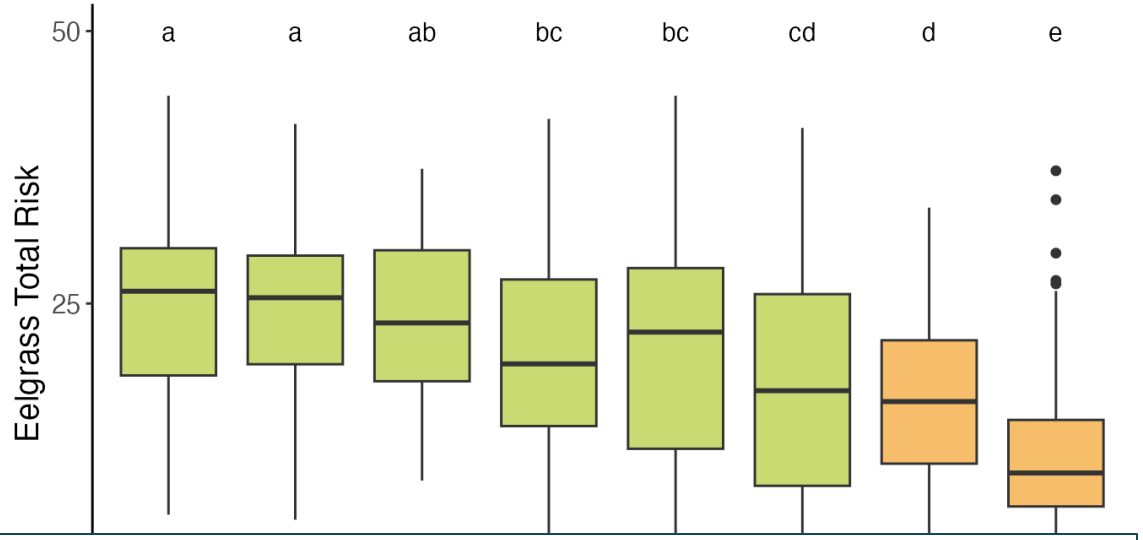


Risk by Subregion & Monitoring Status

Kelp



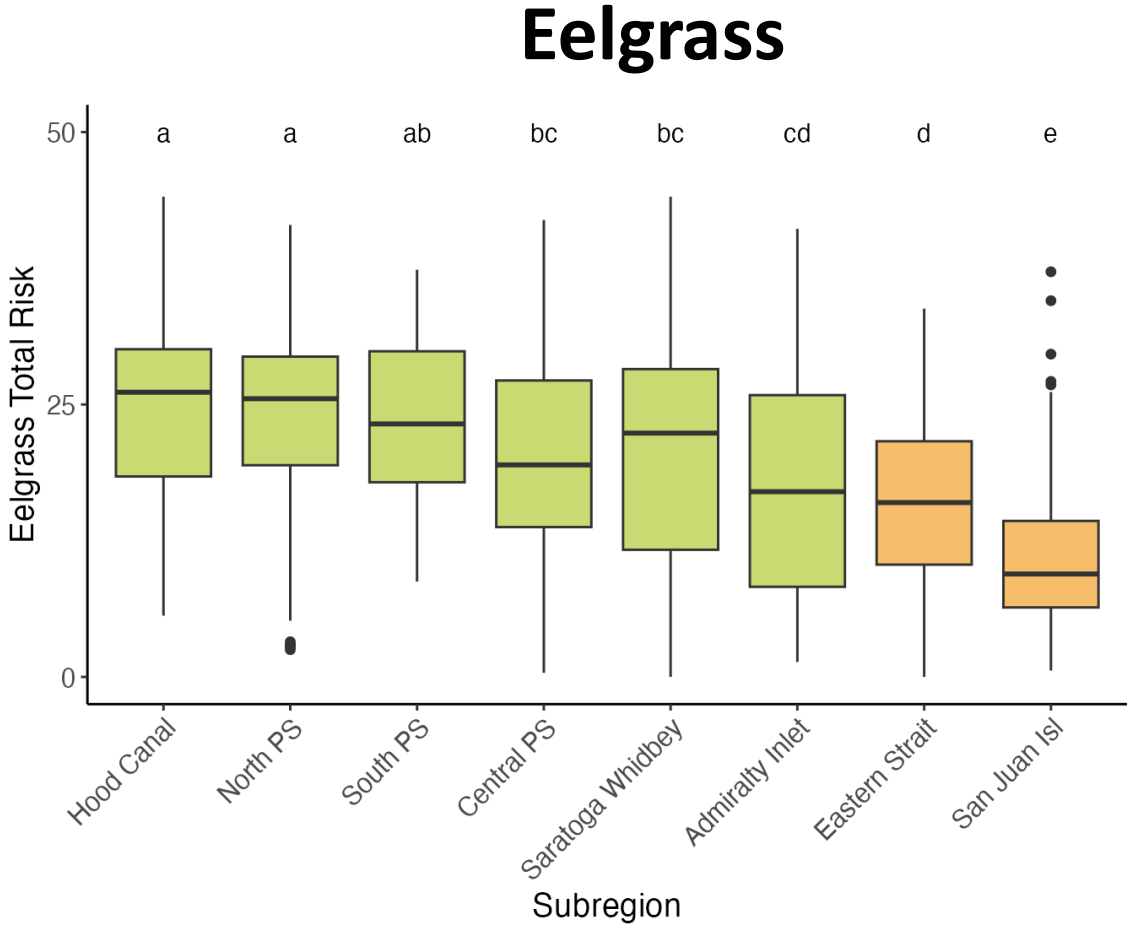
Eelgrass



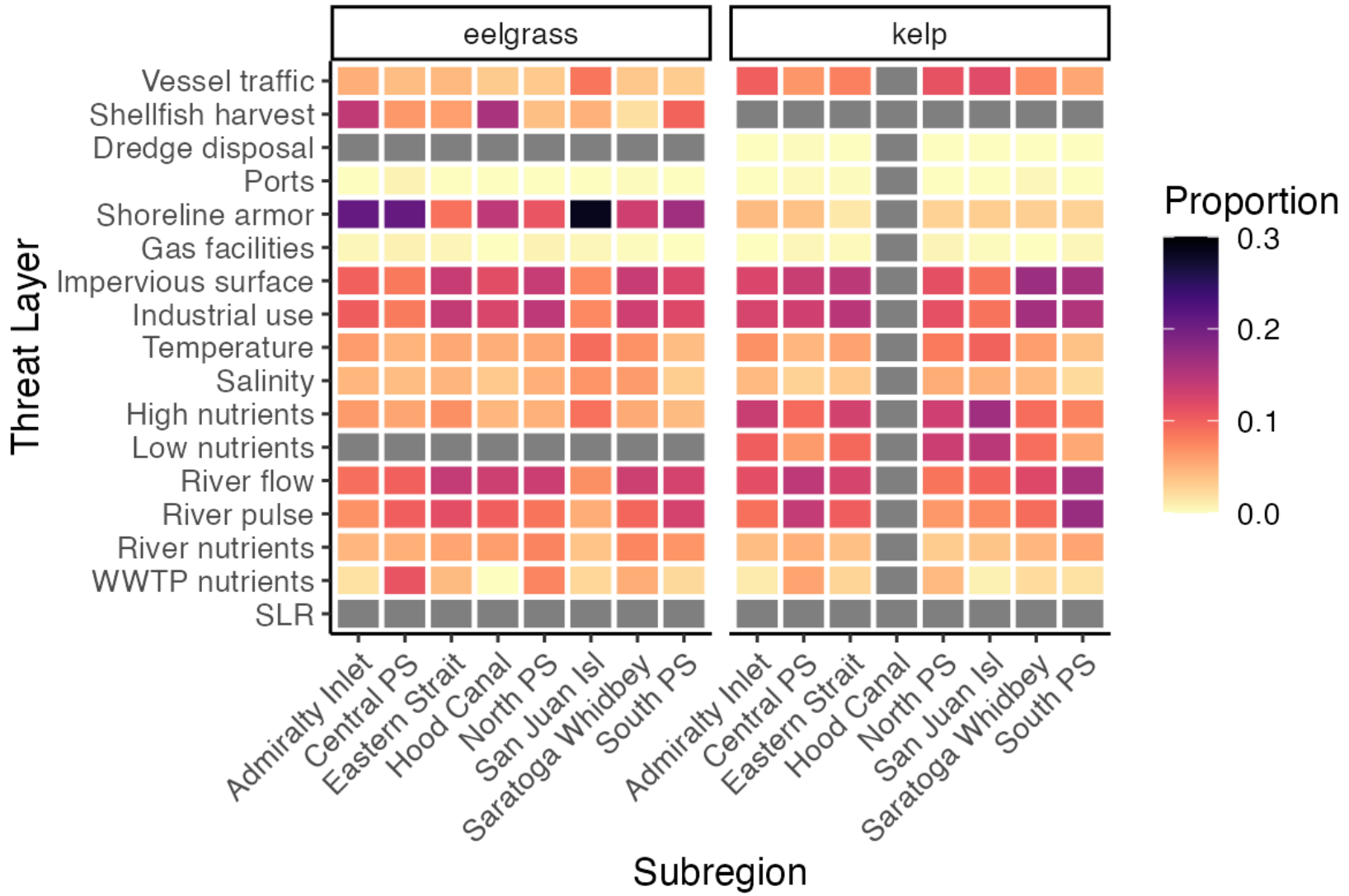
- **Risk differs by taxa and subregion**
  - Kelp: Highest – South and Central Puget Sound and Saratoga & Whidbey Basins
  - Eelgrass: Highest - Hood Canal and North PS
  - Both: Lowest - San Juan Islands (*but multiple high risk outliers!)*
- **Kelp Risk better aligned with status than Eelgrass**

Risk by Subregion & Monitoring Status

- **Possible explanations:**
  - Missing eelgrass threats
  - Threat datasets don't adequately capture conditions in eelgrass beds (shallower/more nearshore than kelp)
  - Eelgrass "status" is characterized differently from kelp



Relative Contribution of Threats



Relative Contribution of Threats

Common Top Threats – by proportional contribution

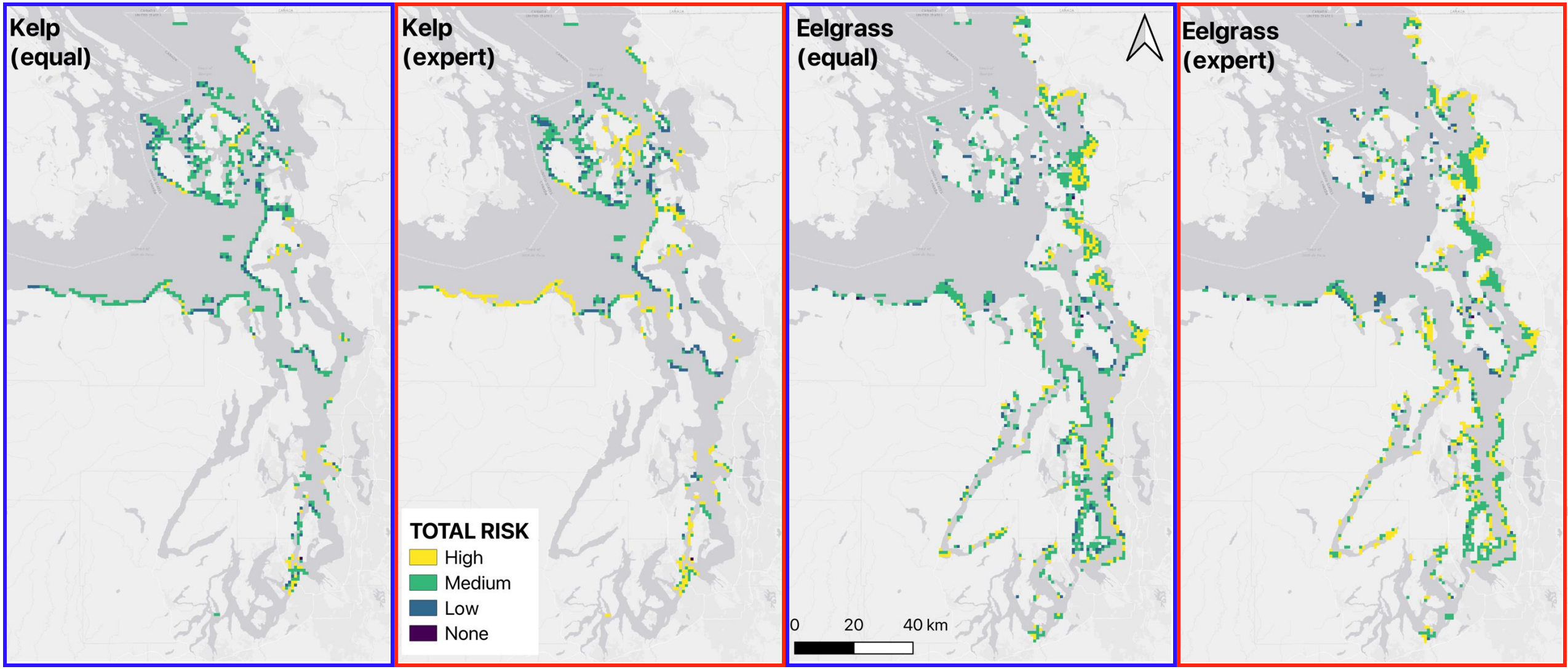
Eelgrass:

- Shoreline armor
- River flow
- Industrial land use
- Impervious surface

Kelp:

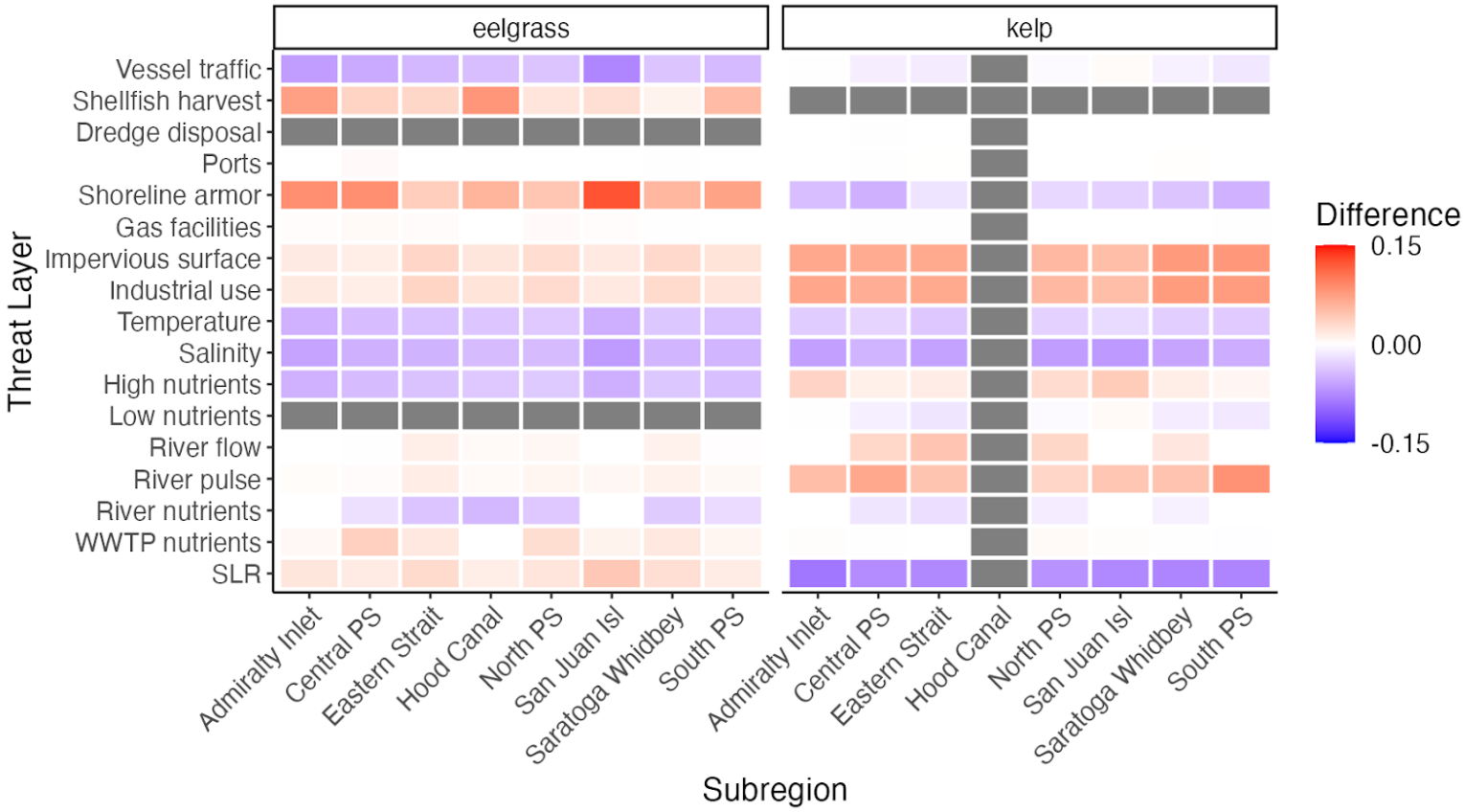
- Nutrients (low and high)
- Vessel traffic
- Industrial land use
- Impervious surface

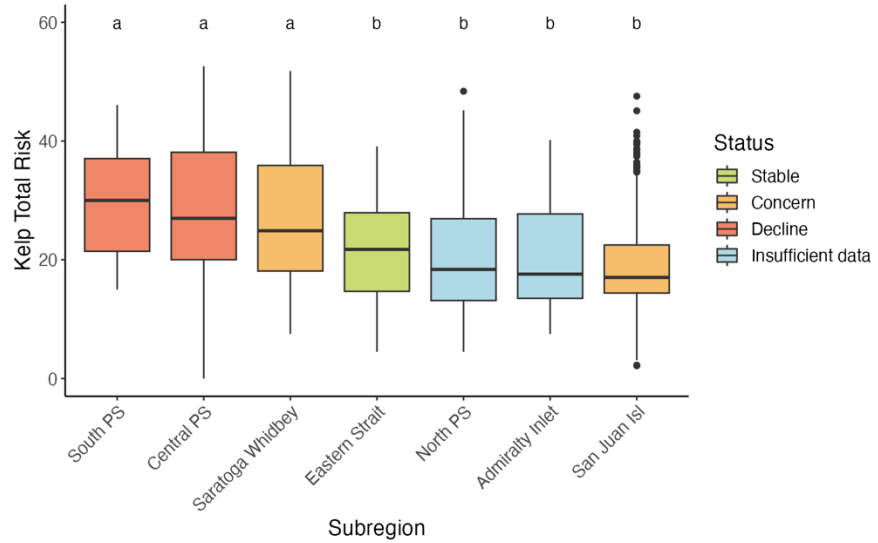
Total Risk: equal versus expert scores



1 km resolution

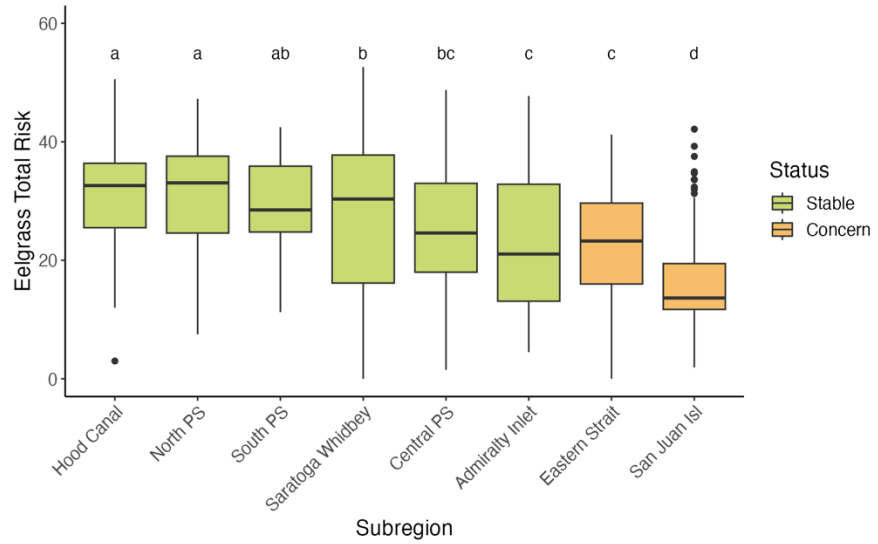
Influence of Expert Scores





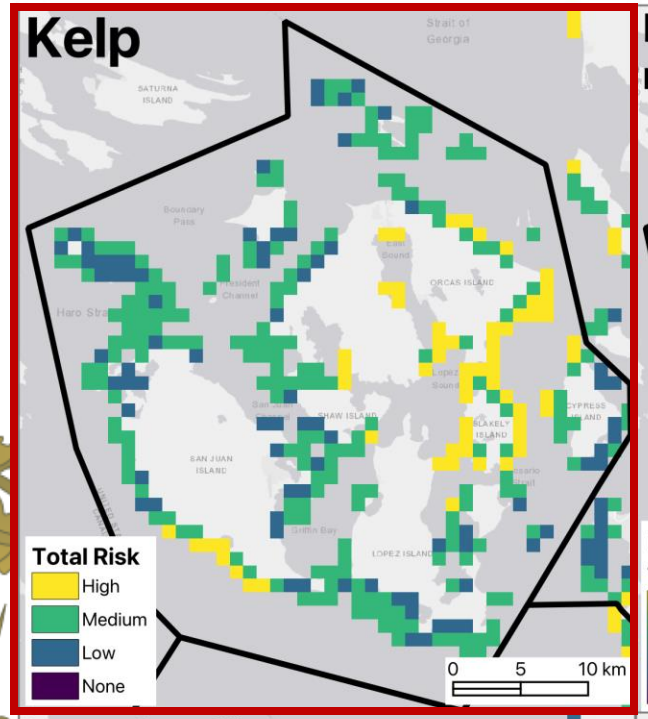
Expert score **increased** contribution of threat

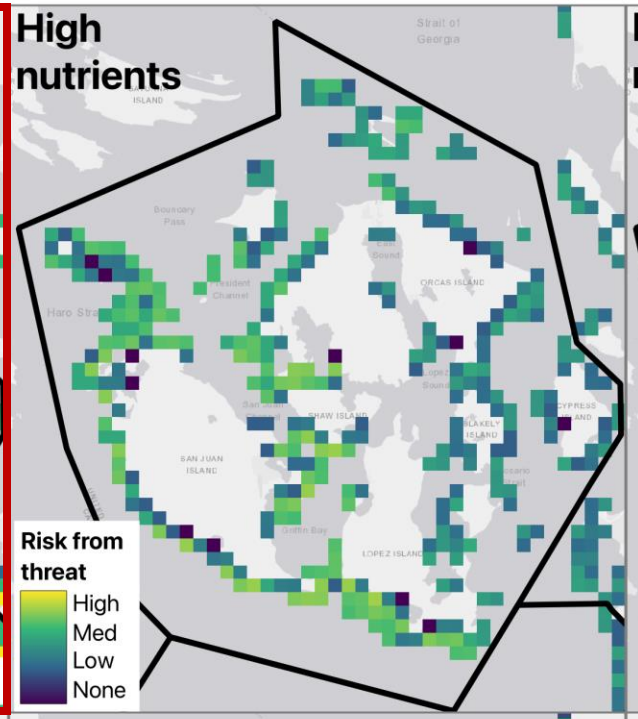
Expert score **decreased** contribution of threat

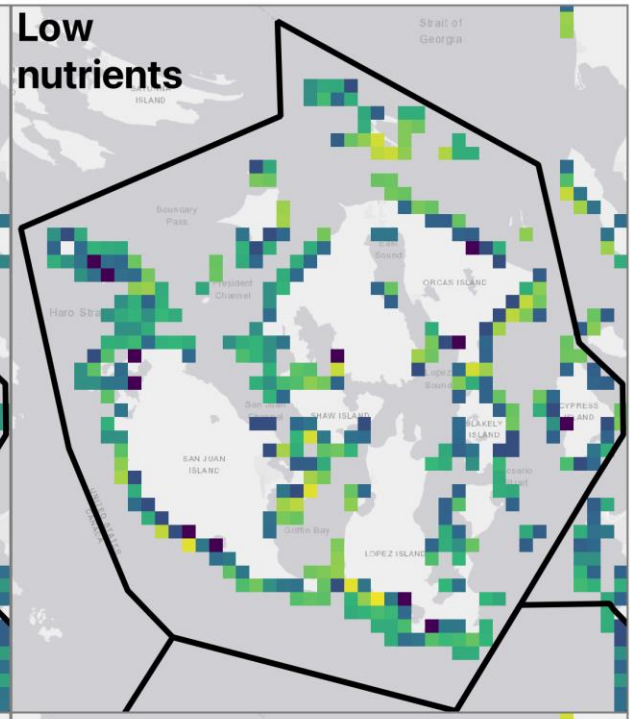


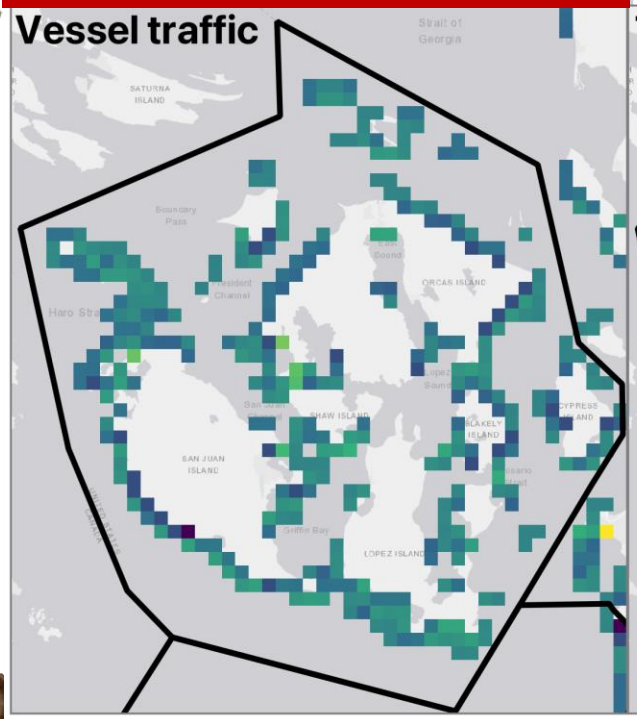
San Juan Isl. “Deep Dive”

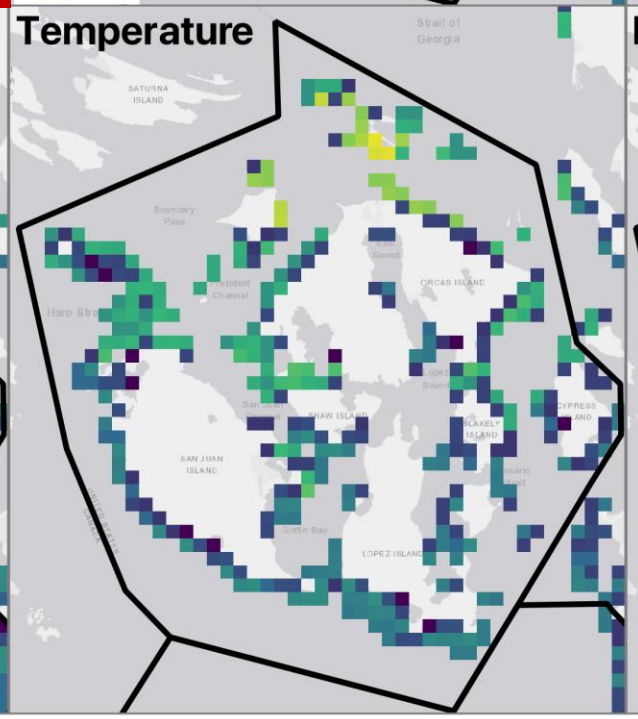
Symbols: UMCES IAN

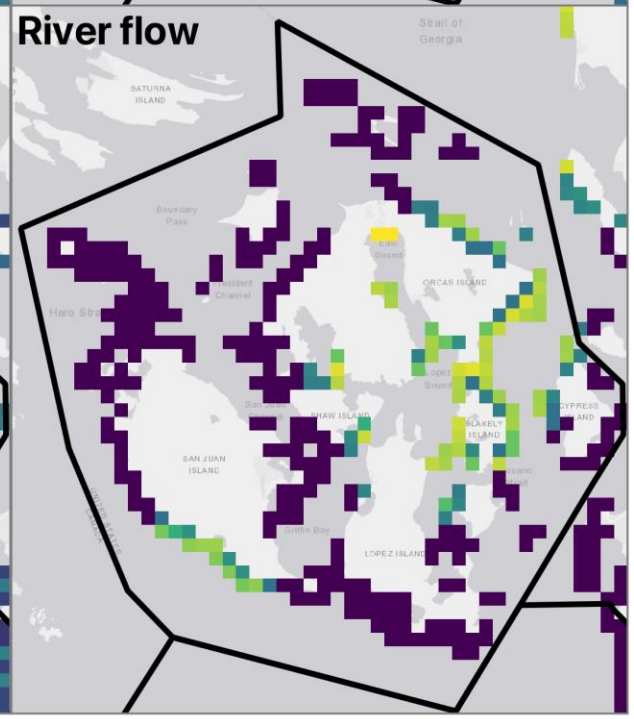




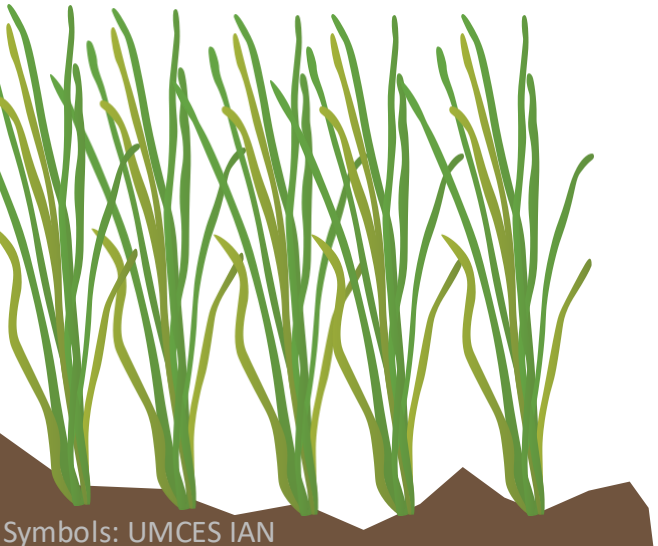








San Juan Isl. “Deep Dive”



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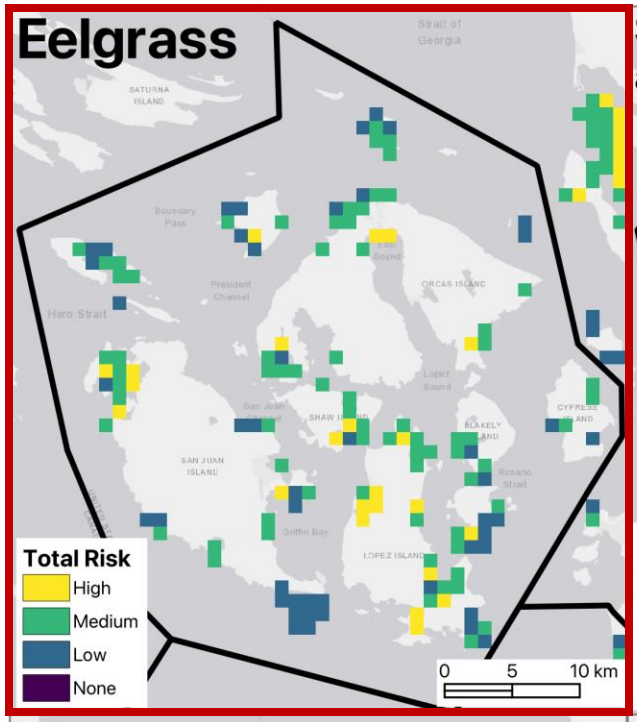
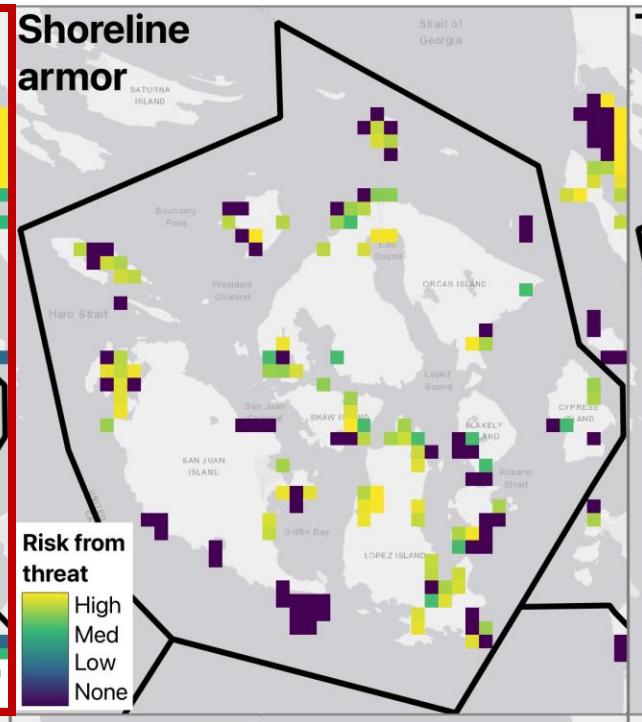
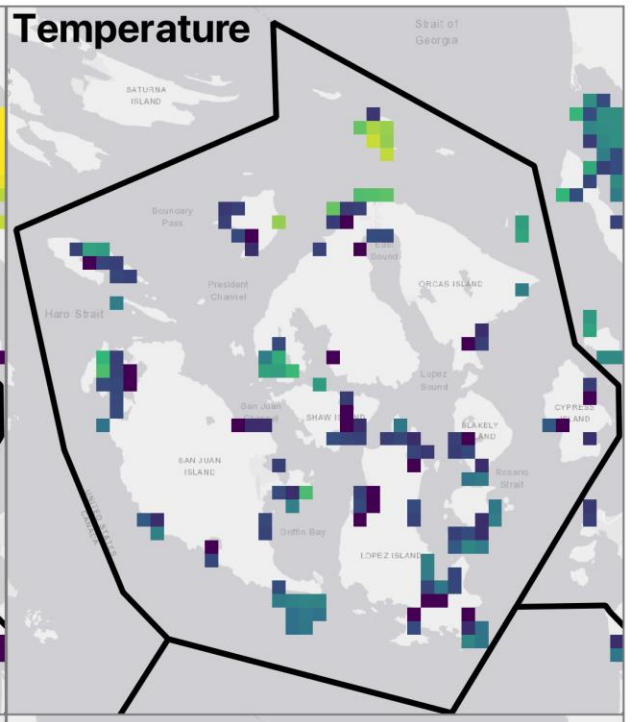
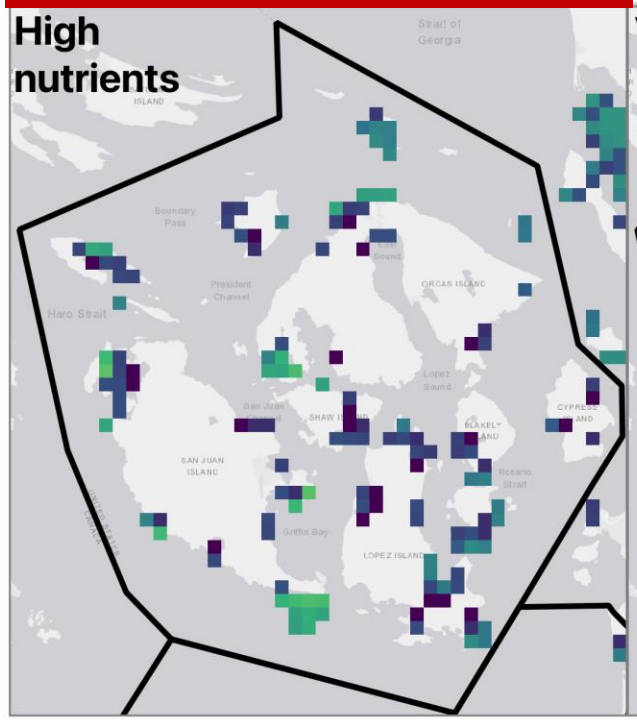
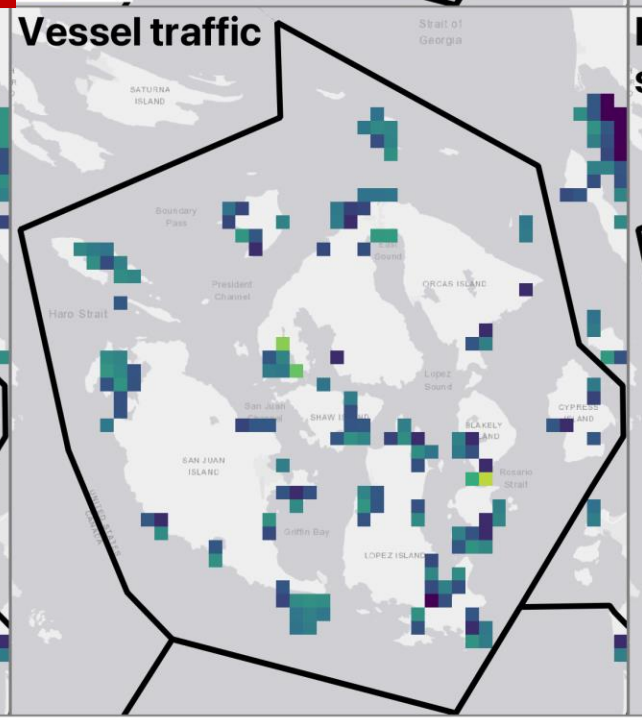
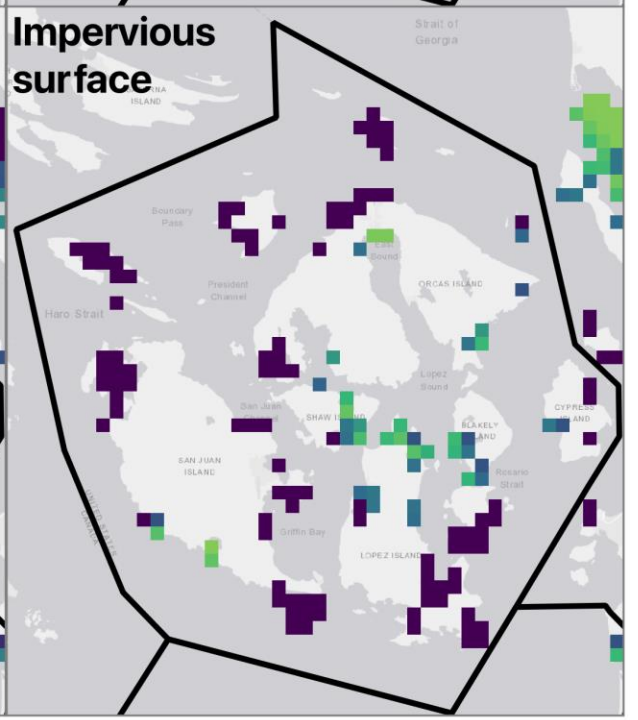












San Juan Islands “Deep Dive”

Kelp:

- Low nutrients a widespread risk across the subregion
- River flow risk highest in the center of the subregion (*No Canadian rivers*)
- Lower risk area – Stuart and Spieden Islands

Eelgrass:

- Shoreline armor risk distributed but with distinct hotspots
- Impervious surface coverage risk highest in center
- Lower risk area – southern end of SJI (Cattle Point)

Both:

- Temperature risk greater in the NE portion of the subregion
- High nutrients risk more prevalent in the SW

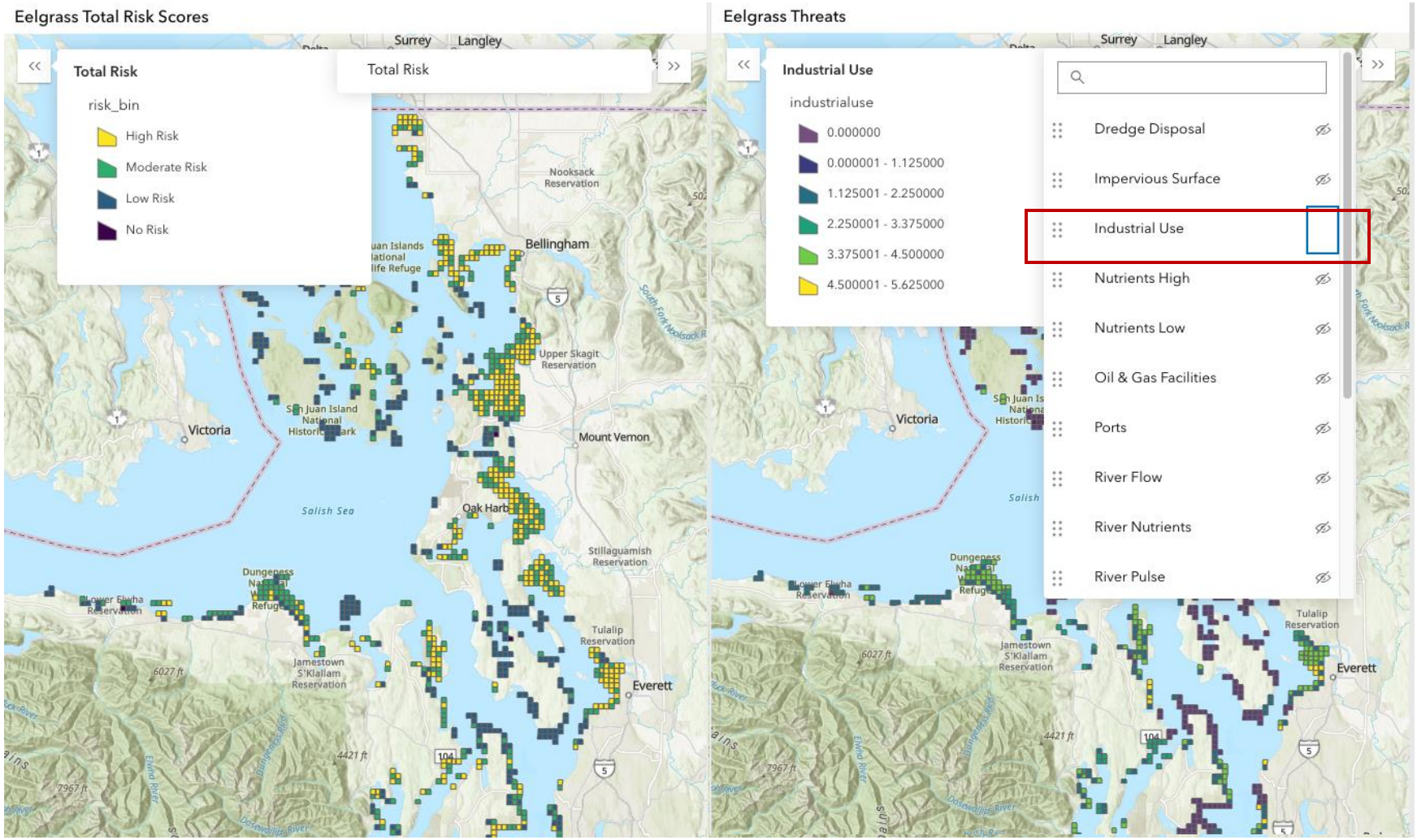
Conclusions

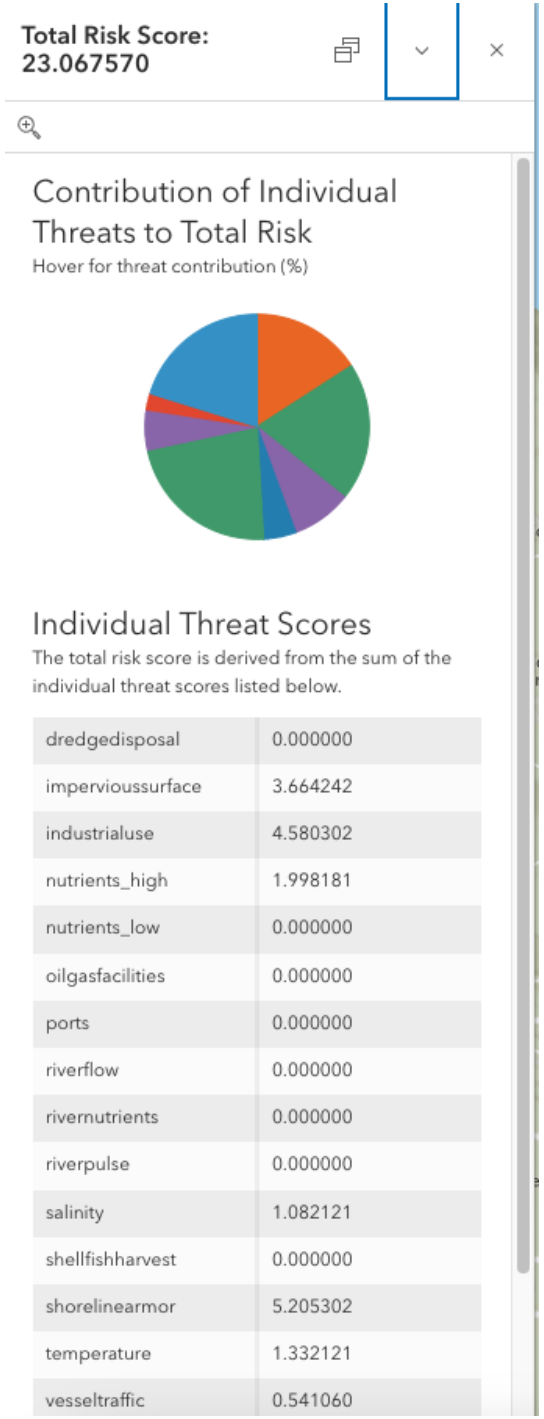
- Puget Sound's first attempts to:
  - rate threats to kelp
  - perform a habitat risk assessment
  - synthesize all available threat data for marine vegetation
- Risk to eelgrass and kelp in Puget Sound is spatially diverse
  - Low risk areas should not be considered "safe"
  - Regions with similar risk profiles but with different trends in marine vegetation can be compared to elucidate possible causes
- Complements ongoing work to identify drivers and management interventions at finer scales

Project Wrap-Up

- Manuscripts in preparation: kelp threat rating & risk assessment
- Finalize & launch **webtool** **Demonstration up next!**
- Archive files at UW Library
  - Habitat & Threat input layers
  - InVEST results files and layers
- Updates or refinements to risk assessment are possible but may require additional funding – reach out to Caitlin w/ ideas!

Intro to Webtool



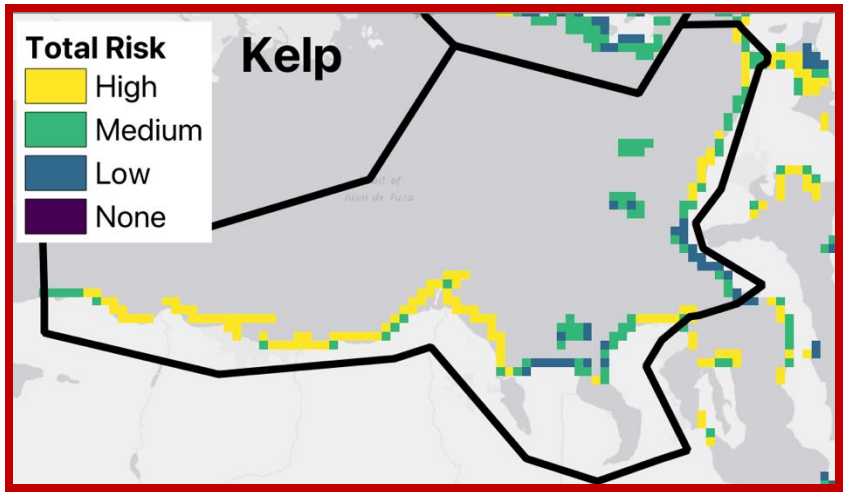


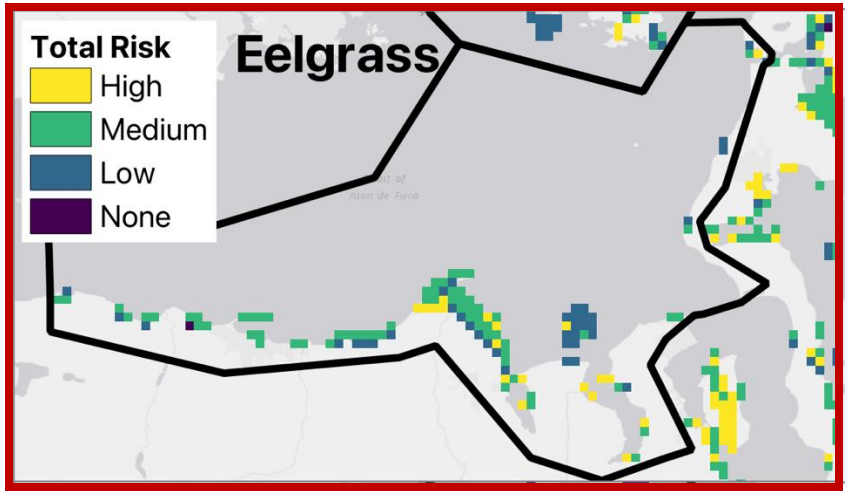
Notes: you may need to create a free account
these are not final – please do not use or distribute the webtools without permission

Your turn!

Take 8 minutes to:

1. Open the Kelp or Eelgrass webtool
2. Navigate to the Eastern Strait subregion
3. Look at these top threats:
   - Industrial use
   - Impervious surface
   - River flow
   - River pulse
   - High nutrients (kelp)
   - Shoreline armor (eelgrass)
4. If time, look at other threats





East. Strait
“Deep Dive”

Total Risk
High
Medium
Low
None

Kelp

Industrial use

Impervious surface

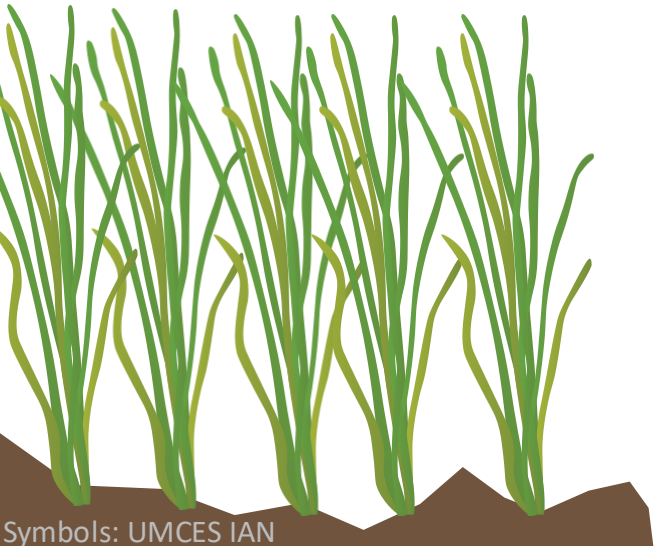
High nutrients

Risk from threat
High
Medium
Low
None

River flow

River pulse

East. Strait
“Deep Dive”



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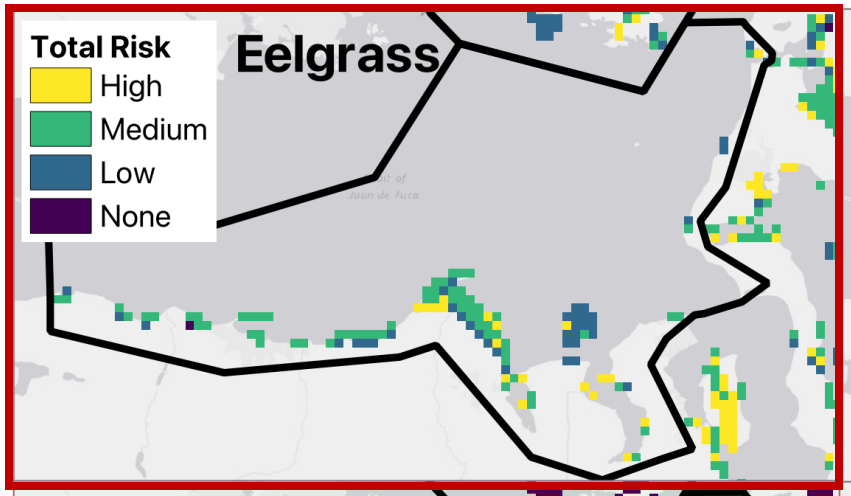
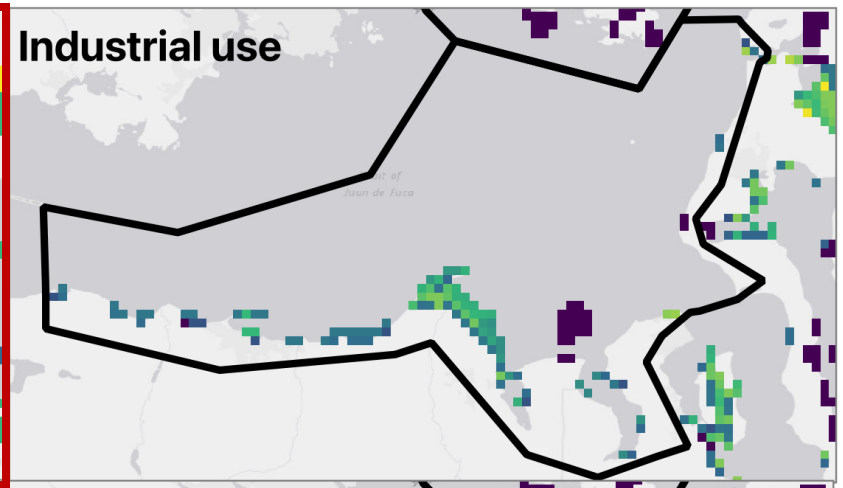
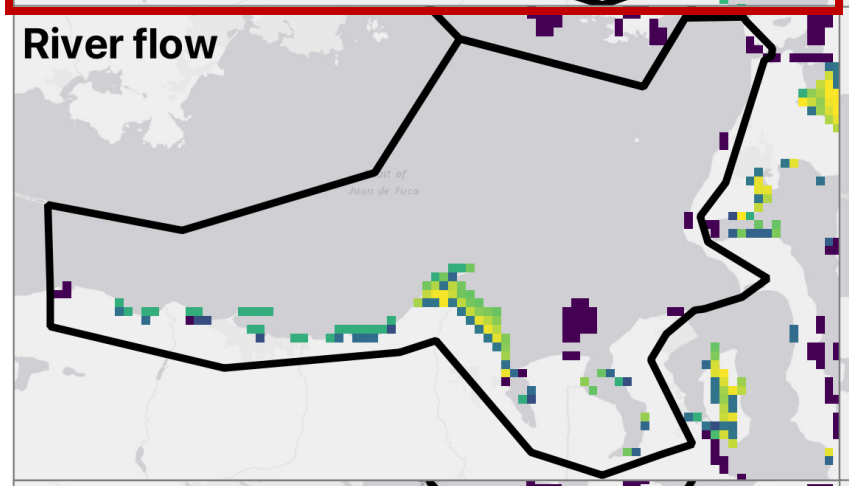
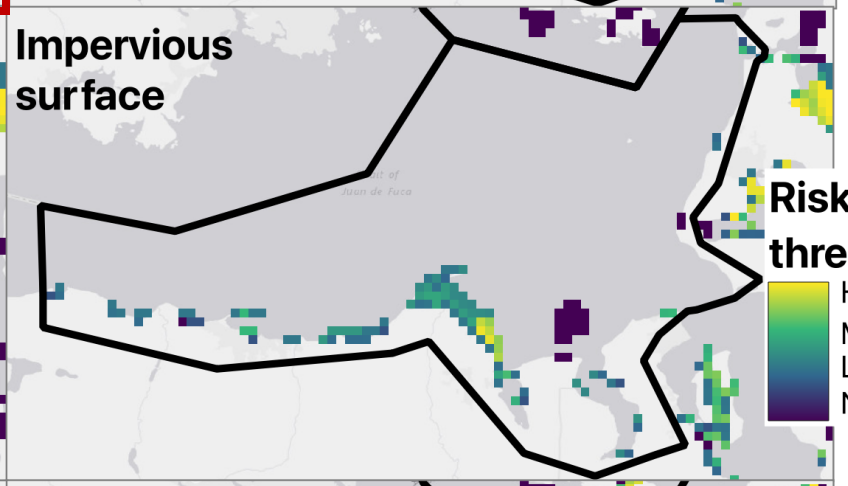
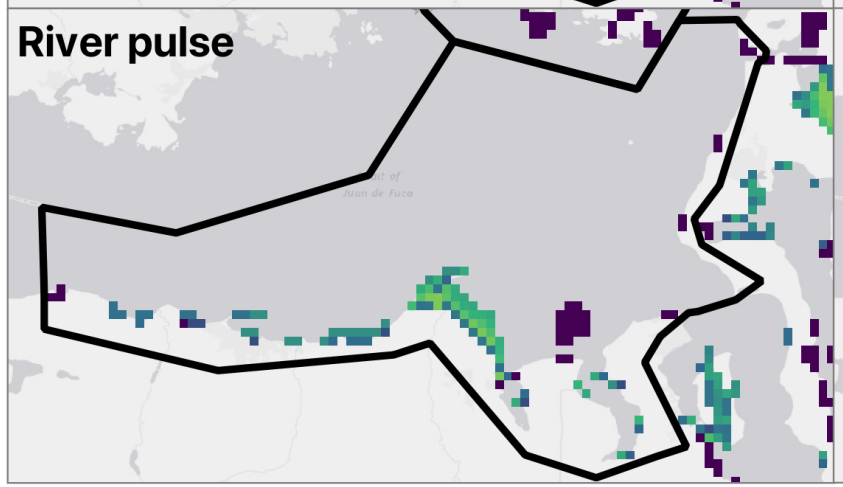
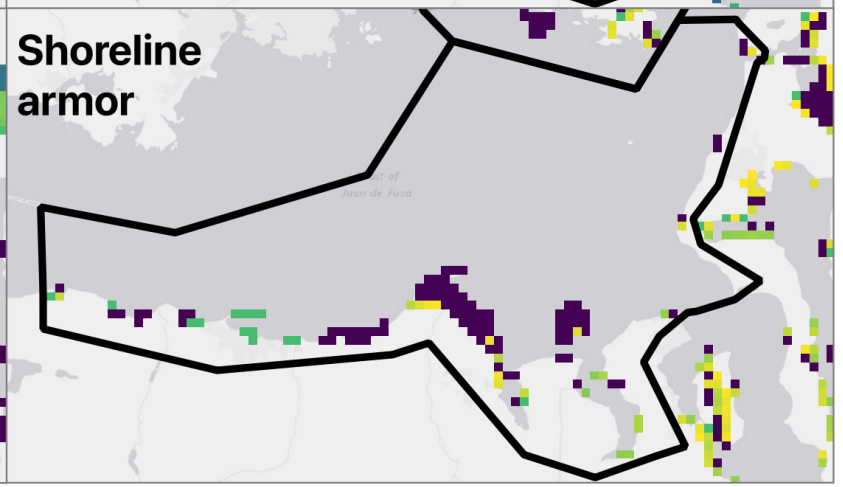












Risk from threat
High
Medium
Low
None

Eastern Strait “Deep Dive”

Kelp:

- Total risk is distributed broadly across the subregion from moderate levels of risk from most threats

Eelgrass:

- Total risk and risk from most threats is high in the center of the subregion
- Shoreline armor risk distributed but with distinct hotspots

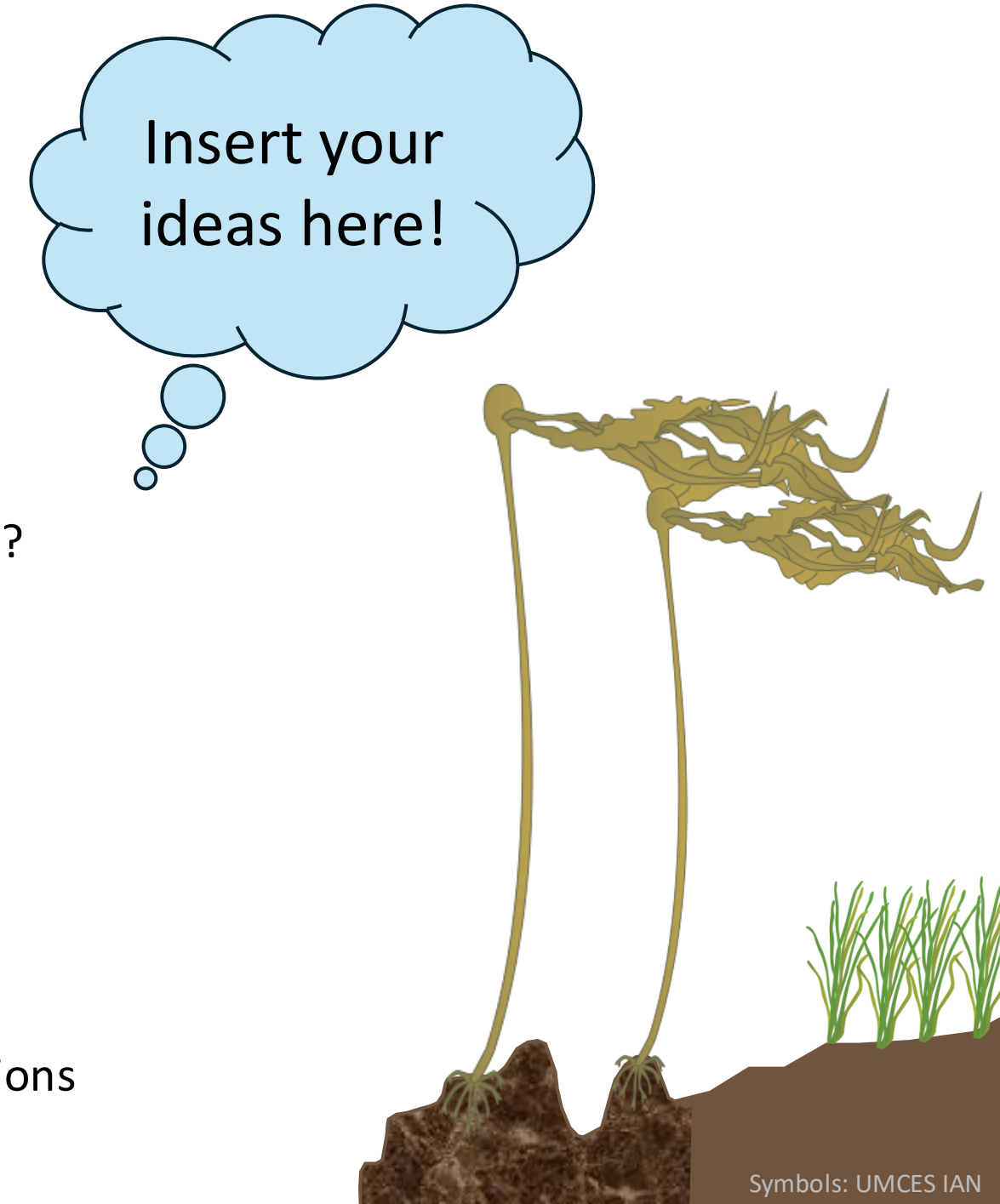
Both:

- River flow/pulse, impervious surface, and industrial use are shared threats
- High risk values from river flow and impervious surface
- Lower risk areas – Protection Island and tip of Miller Peninsula

Discussion

Possible topics:

- **Webtool Feedback**
  - Functionalities, overlays
  - What data do you want to be able to look at?
- **Analysis & Interpretation**
  - Resolution of output (currently 1 km)
  - Other ways to interrogate the risk results
- **Ideas for future application of this work**
  - Email Caitlin
- **Data**
  - Data gaps
  - Finer scale data available for specific subregions



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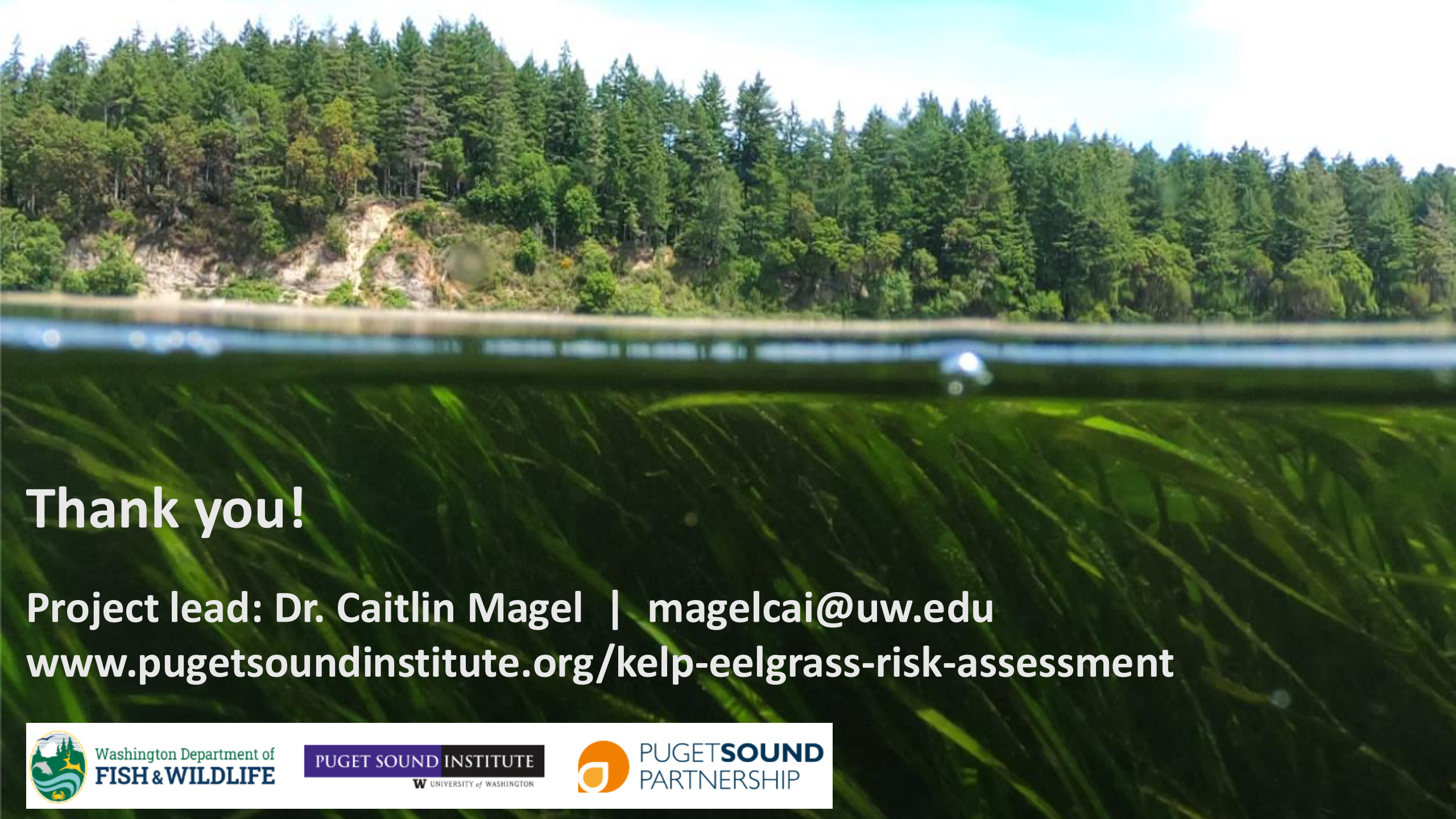

Thank you!

Project lead: Dr. Caitlin Magel | magelcai@uw.edu

www.pugetsoundinstitute.org/kelp-eelgrass-risk-assessment

Washington Department of FISH & WILDLIFE

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