Identifying multiple stressors and potential habitat responses in marine ecosystems of Pacific Canada

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Study objectives

Develop a structured process to identifying multiple stressors in the Strait of Georgia, and the responses of selected (key) habitats to these stressors

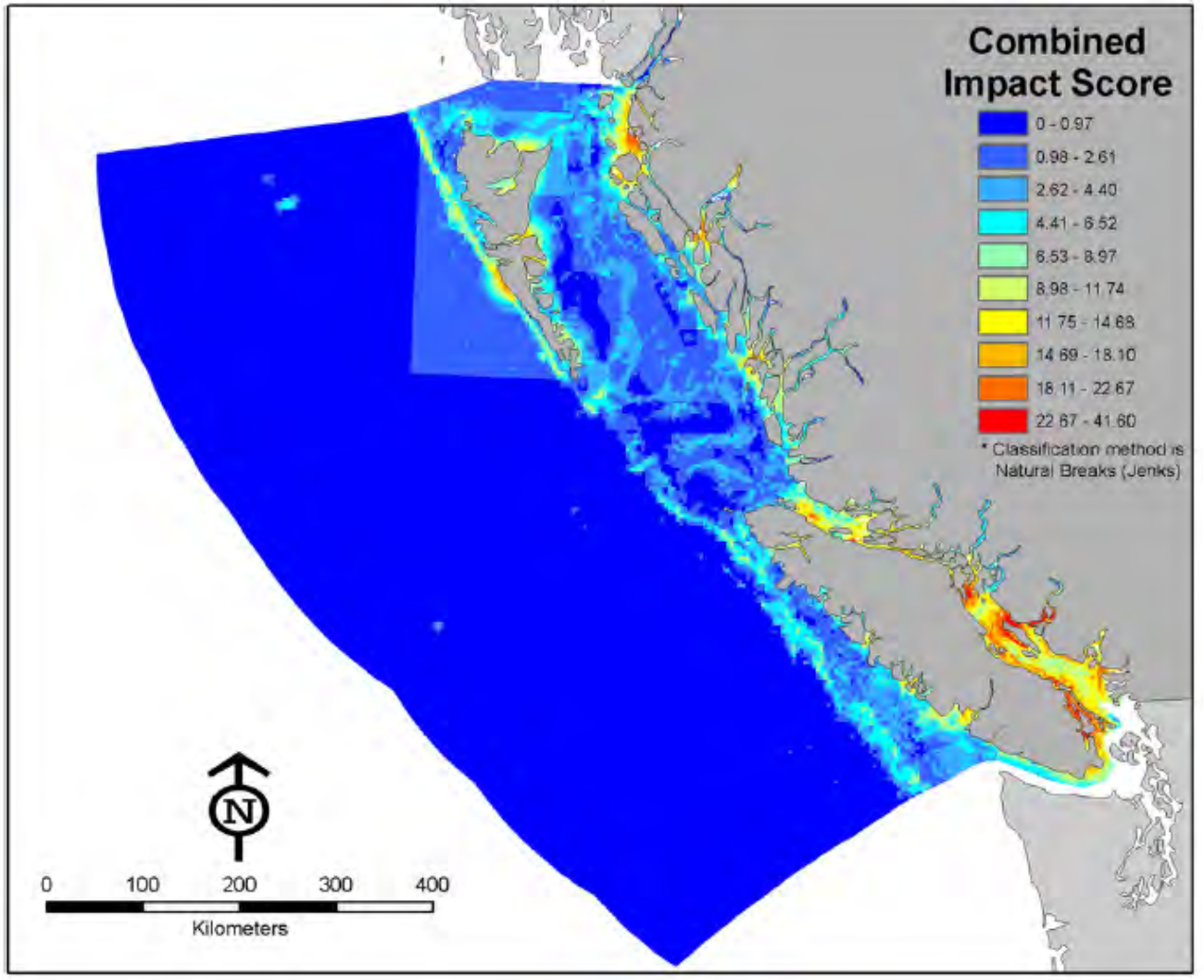
Which habitats are more vulnerable to which stressors?

Base information needed to develop indicators of ecosystem responses to multiple stressors in this area

A contribution to PICES Working Group 28

(still a “Work-in-Progress”)

Cumulative impact mapping of the B.C. coast



Ban et al. 2010. Marine Policy

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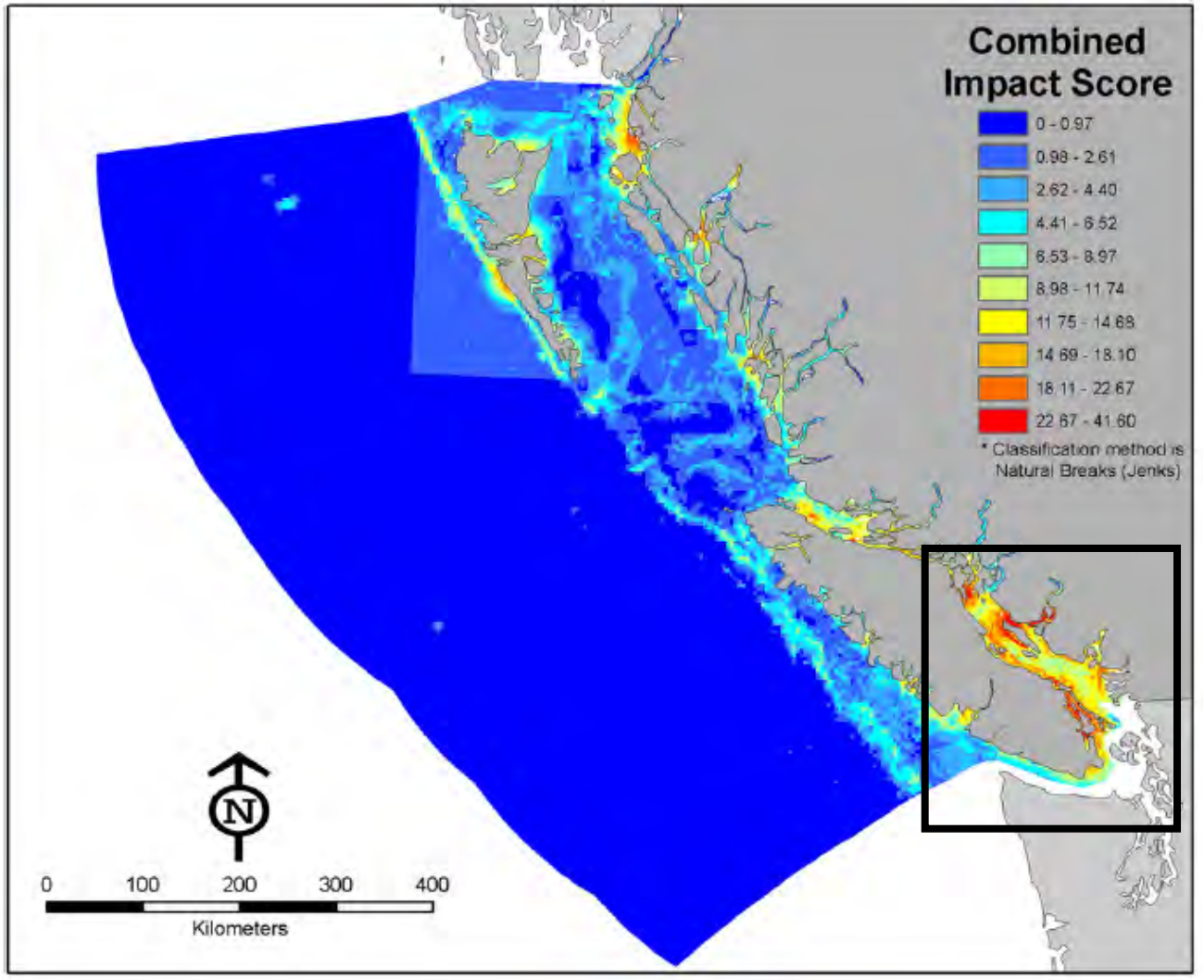
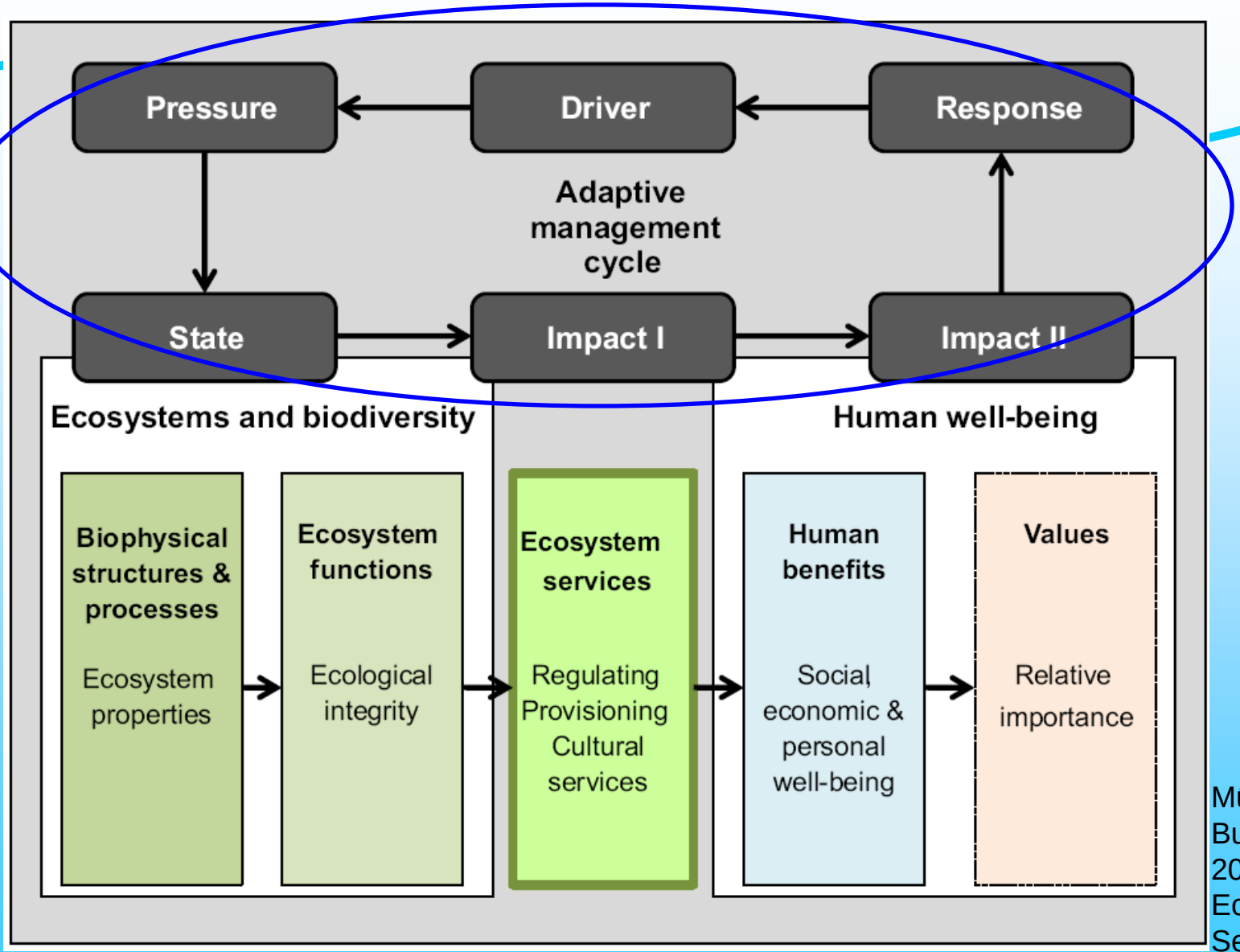


Ban et al. 2010. Marine Policy

Conceptual (DPSIR) model for Drivers of Change



Műller & Burkhard. 2012. Ecosystem Services

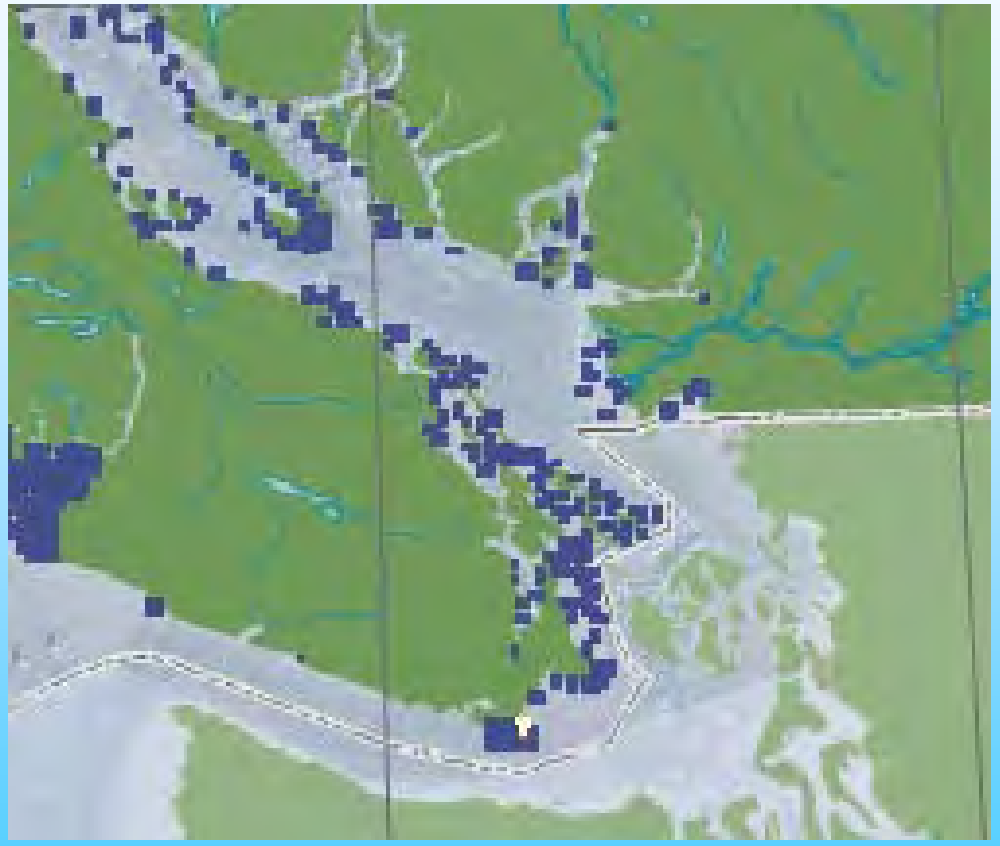
B.C. Marine Conservation Analysis for the Strait of Georgia

Class	Feature type	Number of features	% of total SofG area with 1 or more feature	Examples of features
Ecological	Birds	72	62	bird colonies, staging areas, at-sea surveys, etc.
Ecological	Plants	40	57	algae, etc.
Ecological	Mammals	5	12	CA sea lion haulouts, harbour seal haulouts, Steller sea lion haulouts and rookeries
Ecological	Herring spawning	1	12	
Human	Commercial fishing	35	96	salmon, groundfish, invertebrate fishing locations
Human	Recreational fishing	4	72	salmon, groundfish, crab, shrimp
Human	Shipping	17	76	Ferry routes, terminals, fishing vessels, bulk carriers, cruise ship routes, etc.
Human	Tenures	17	42	Aquaculture, powerlines, industrial uses, etc.
Human	Tourism	45	63	Anchorages, marinas, boating routes, etc.
Human	No human stressors	0	1.3	

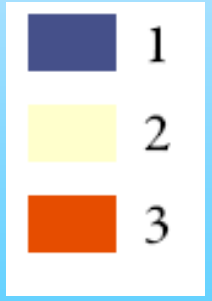
www.bcmca.org

B.C. Marine Conservation Analysis for the Strait of Georgia

Marine mammals



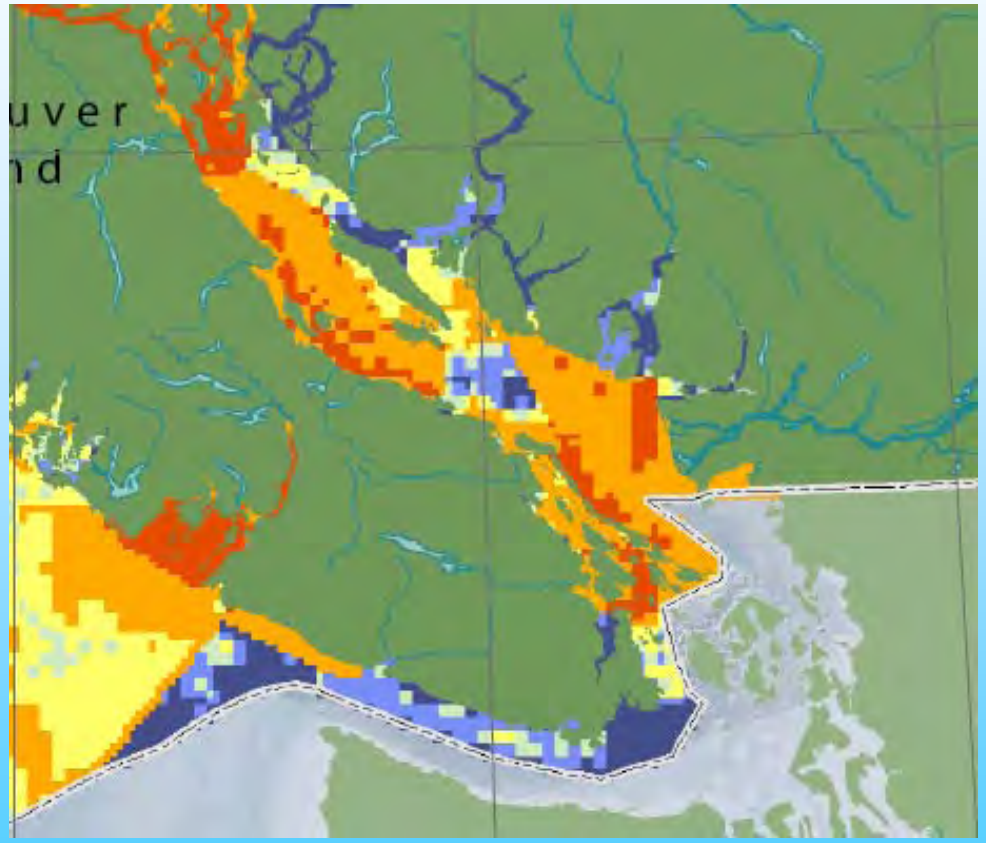
Feature count – i.e. number of planning units with 1 or more marine mammals features



Planning units ('pixels') are 2x2 km^2

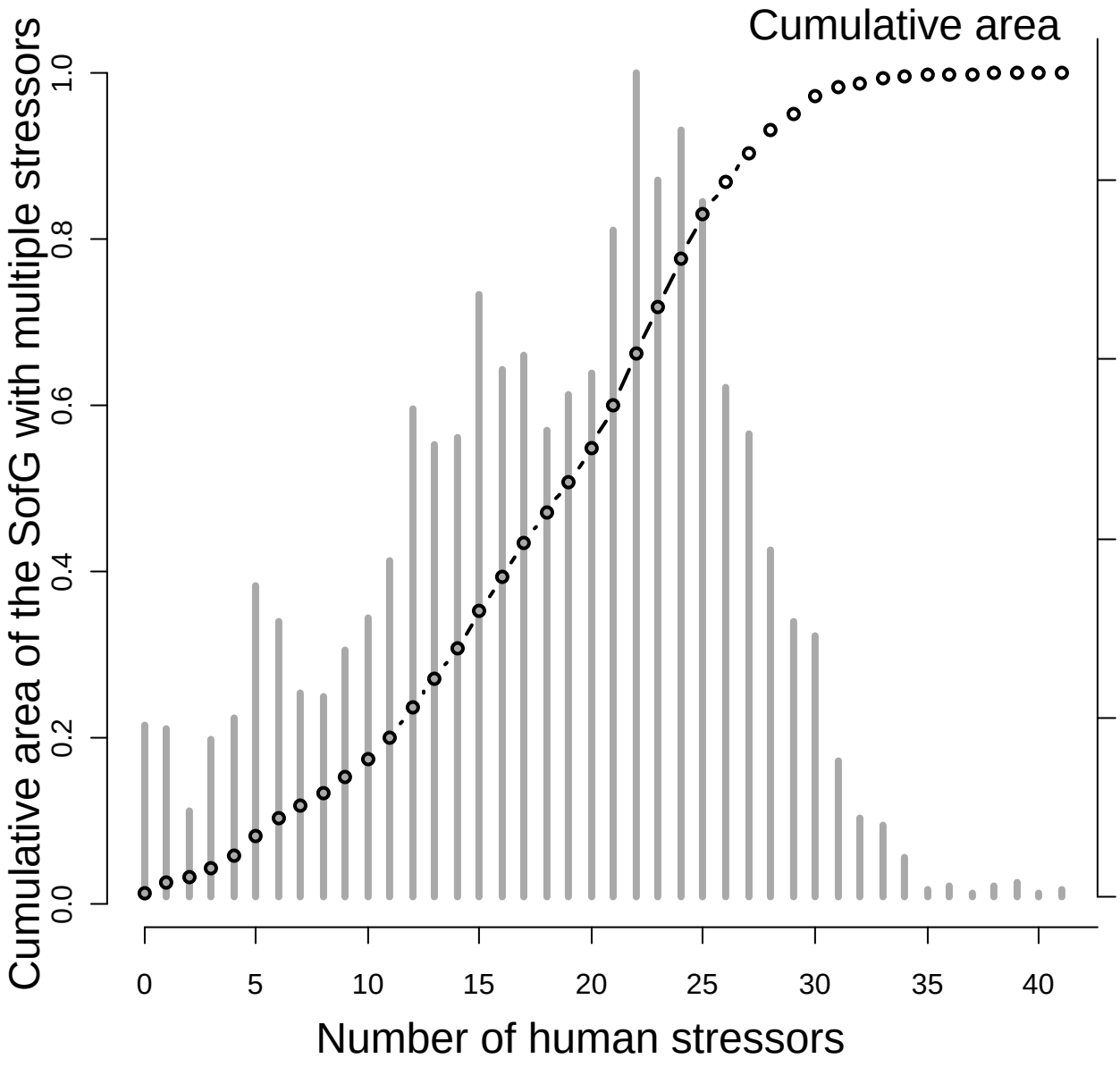
B.C. Marine Conservation Analysis for the Strait of Georgia

Commercial fishing



Feature count – i.e. number of planning units with 1 or more commercial fishing features

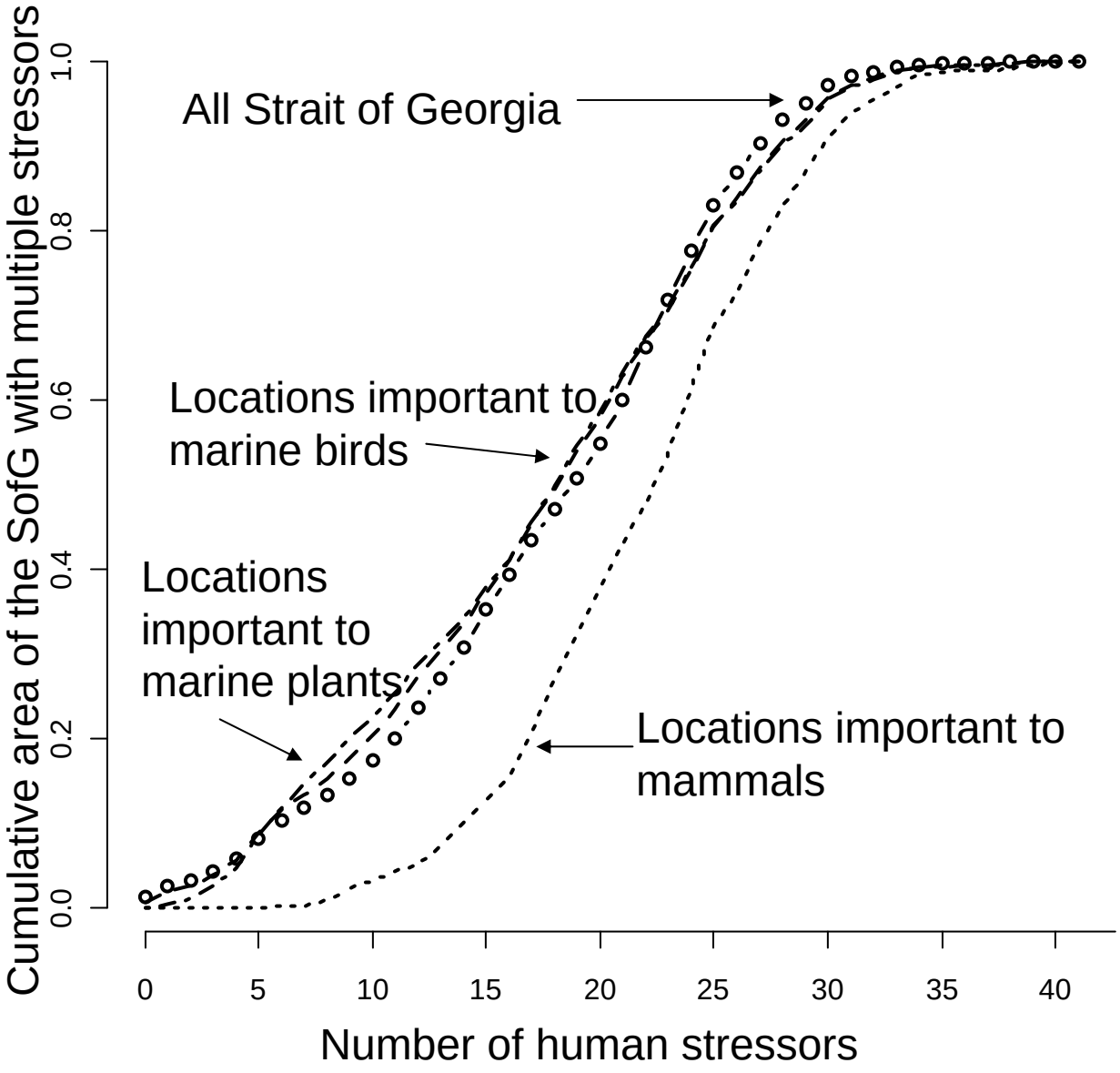
Planning units (‘pixels’) are 2x2 km^2



"Most common" number of stressors in any 2x2 km^2 planning unit is 20-25;

relatively few planning units have >30 stressors

Number of stressors on selected ecological areas of importance



Taxa-specific cumulative curves are significantly different from total (KS test, $P<0.05$), likely because of high number of pixels (3652)

Indicates that numbers of stressors differ among locations important to marine birds, plants, and mammals

What are the potential impacts of these stressors to the habitats in the Strait of Georgia?

Vulnerability = f { Exposure, Sensitivity, Adaptive Capacity }

Exposure = spatial scale and temporal frequency of stressors

Sensitivity = community level and resistance to change of the habitat

Adaptive capacity = recovery time of the habitat

What are the potential impacts of these stressors to the habitats in the Strait of Georgia?

Conducted a web-based survey of experts on the Strait of Georgia

Spatial Extent: spatial scale of a single event of the activity/stressor

Scoring: 1: <10 km^2; 2: 10-100 km^2; 3: 100-1000 km^2; 4: >1000 km^2

Frequency: average annual frequency at which activity/stressor occurs

Scoring: 1 = rare (>5 yrs); 2 = occasional (1-5 yrs); 3 = seasonal; 4 = persistent

Trophic impact: primary level affected by the activity/stressor

Scoring: 1 = species; 2 = single trophic level; 3 = >1 trophic level; 4 = community

Resistance to change: degree to which habitat's "natural" state is impacted

Scoring: 1 = positive impact; 2 = high resistance; 3 = moderate; 4 = low

Recovery time: time required to return to 'natural' state

Scoring: 1 = <1 year; 2 = 1-10 years; 3 = 10-100 years; 4 = >100 years.

What are the potential impacts of these stressors to the habitats in the Strait of Georgia?

Web-based survey of experts on the Strait of Georgia

For each vulnerability element, respondents were asked to indicate their 'certainty' to their selected score:

1: very low (<15%); 2: low (15-50%); 3: high (50-85%); 4: very high (>85%)

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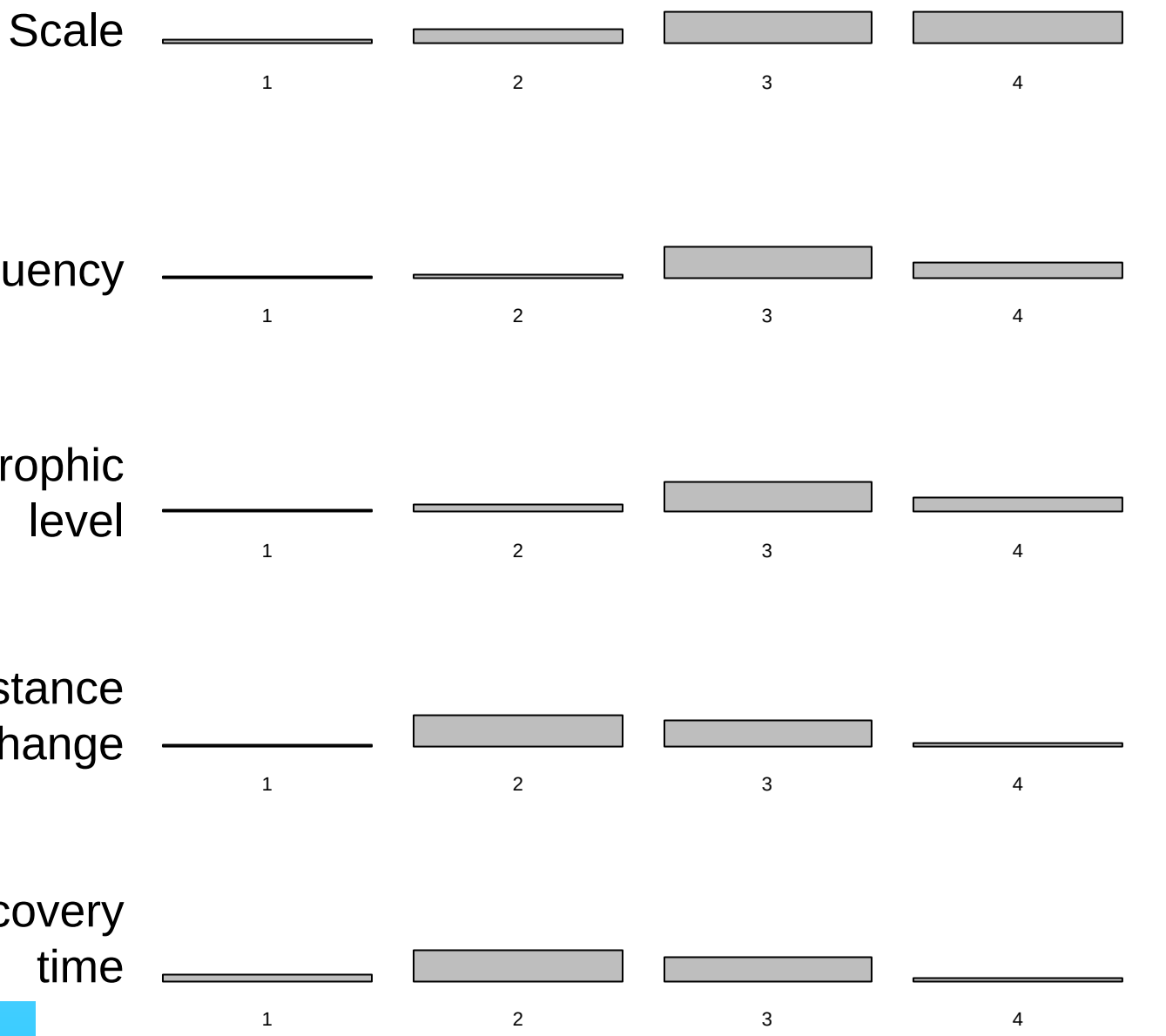
Strait of Georgia survey was sent to 56 people:

	Sent:	Returned to date:
Government:	34	12
University:	14	6
NGO:	8	0

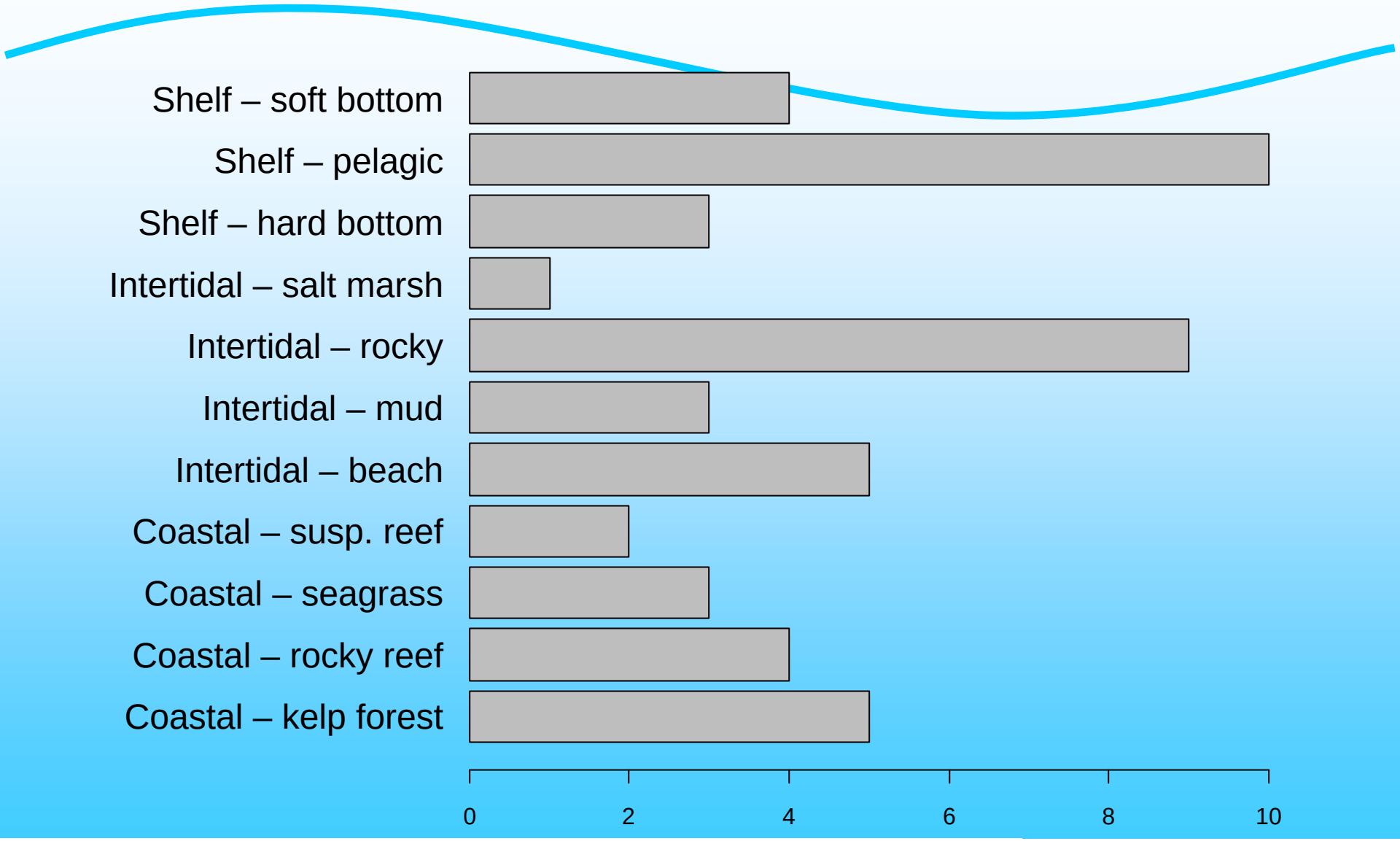
Plot of ‘certainty’ values for each of the vulnerability elements



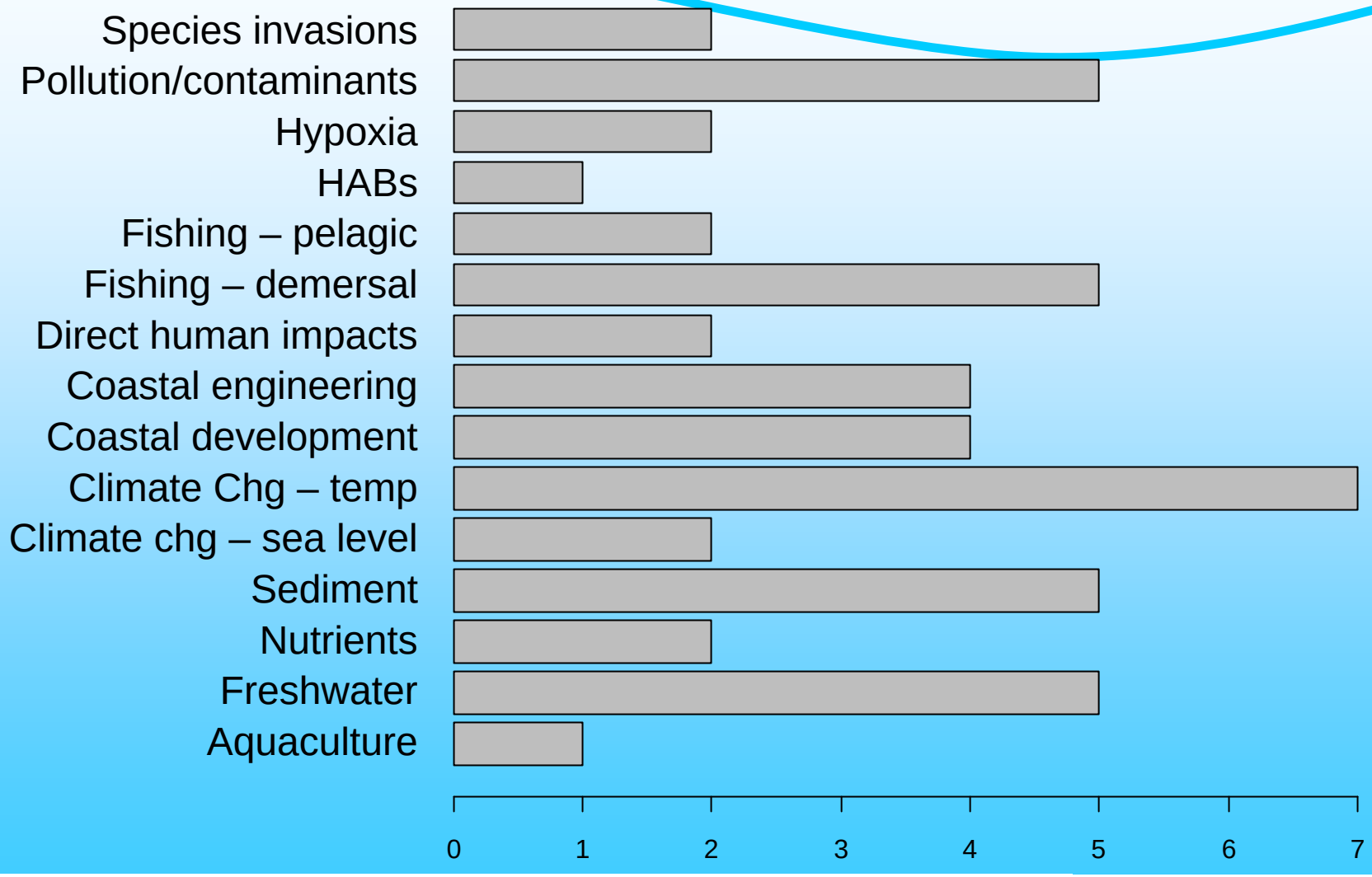
Most respondents appear comfortable with Scale, Frequency, Trophic level;

less so for Resistance to change and Recovery time

Number of stressors identified per habitat type



Number of habitats per stressor



Calculation of Vulnerability scores

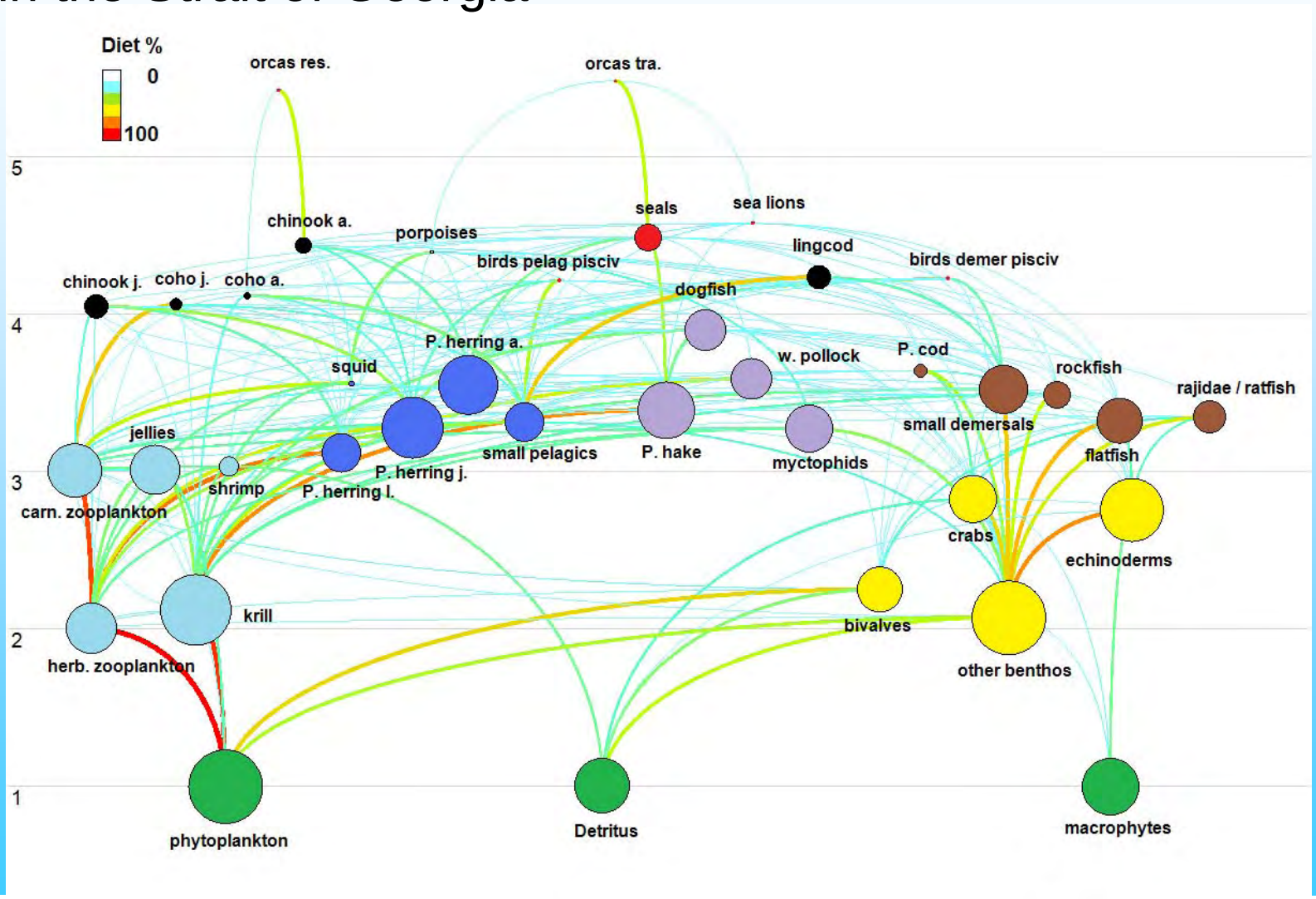
Recode certainty scores:

			Certainty	
			Low 1 or 2	High 3 or 4
Impact score	Low	1 or 2	2	1
	High	3 or 4	1	2

Vulnerability scores for selected Habitat x Stressors (range: 1-8)

		Fresh-water	Sedi-ment	Coast develop-ment	Coast engin-eering	Fishing - demersal	Fishing - pelagic	Climate chg - temp
Intertidal	beach		5.0		4.0			
Intertidal	mud		4.4		5.8			
Intertidal	rocky	5.2		5.6	4.8			6.0
Intertidal	salt marsh							5.8
Coastal	kelp forest	5.2		5.4		3.8	3.6	5.6
Coastal	rocky reef	4.2	3.4			3.4		5.0
Coastal	seagrass		4.6	5.6				
Coastal	susp-feeder reef		5.2					5.0
Shelf	hard bottom					3.8		5.2
Shelf	soft bottom	3.6				4.9		
Shelf	pelagic	4.4		3.4	4.6	6.0	4.1	5.2

Exploring the use of ecosystem models to understand impacts of multiple stressors and vulnerabilities of habitats in the Strait of Georgia



Conclusions

- Considerable (but not complete) information is available for the Strait of Georgia on:
  - spatial patterns of important marine habitat features,
  - human stressors
- Beginning to understand knowledge gaps on measures of habitat vulnerability and resilience
  - expert surveys are one method to obtain information, but needs to be cross-linked with empirical data
- Ecosystem models may provide useful ‘platforms’ to understand ecosystem responses to multiple stressors
  - but need to be supported and cross-checked with empirical data and expert surveys