A preliminary Climate Change vulnerability assessment of Canada's Pacific Marine Ecosystems

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BRITISH COLUMBIA CHAPTER

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IN MARINE CONSERVATION

University of Victoria

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   - Model projections
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   - Habitat & Ecosection summaries

THIS PRESENTATION

Chapter 5
Toward vulnerability assessment

Outline

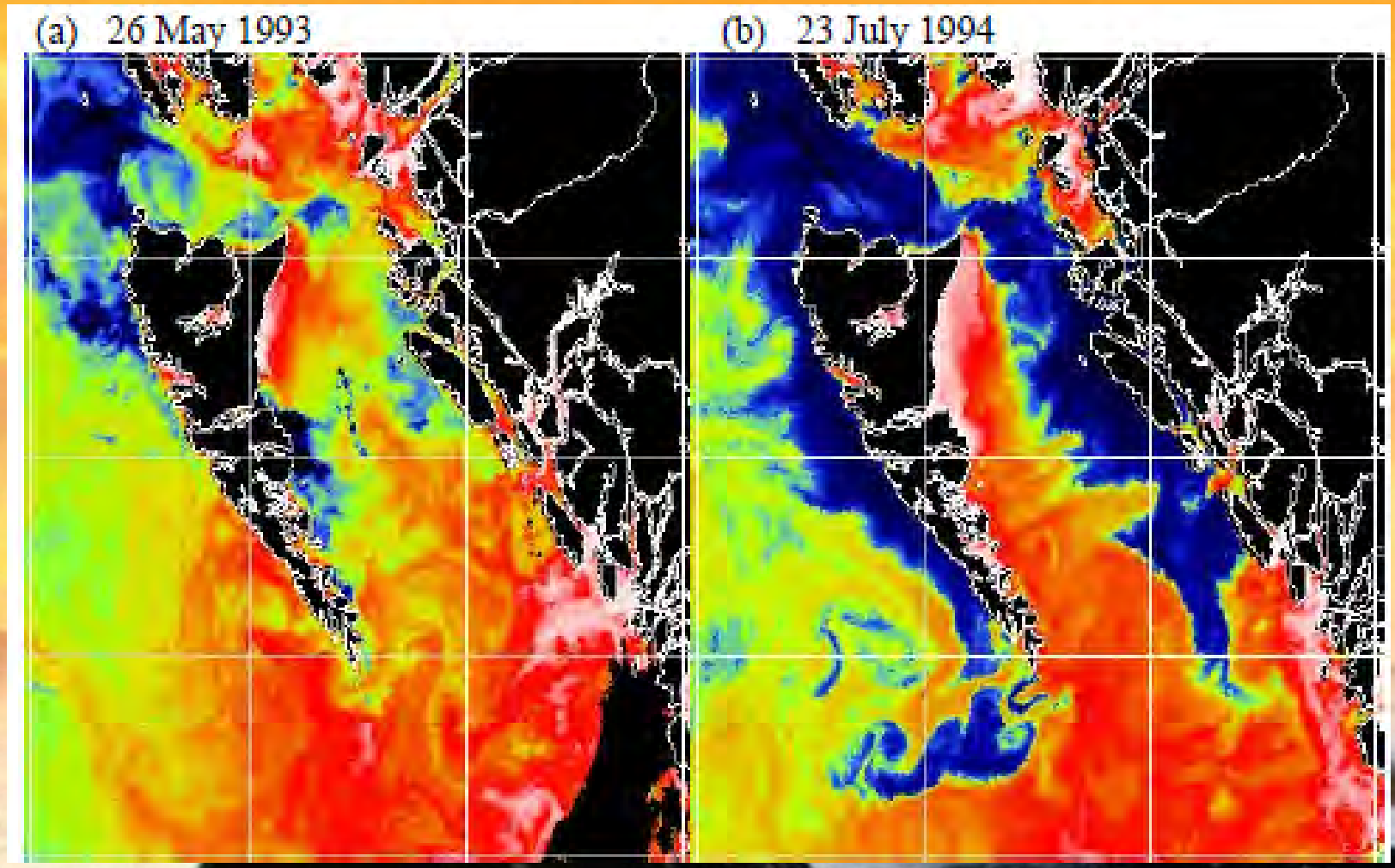
- Regional context
- Vulnerability approach/methods
- Some outputs
- Moving on


Canada's Pacific Ecosystems
Canada
United States
Mexico
Mongolia
China
Japan
South Korea
Vietnam
Philippines
Malaysia
Indonesia
Papua New Guinea
Australia
Chile
Peru
Colombia
Ecuador
Venezuela
Cuba
Guatemala
Nicaragua
Pacific Ocean
South Pacific Ocean
Bering Sea
Gulf of Alaska
Hudson Bay
Gulf of Mexico
Coral Sea
Map data ©2012 G

A dynamic coastal transition zone

GLOBEC
(http://www.cop.noaa.gov/stressors/climatechange/current/fact-globecpne.html)

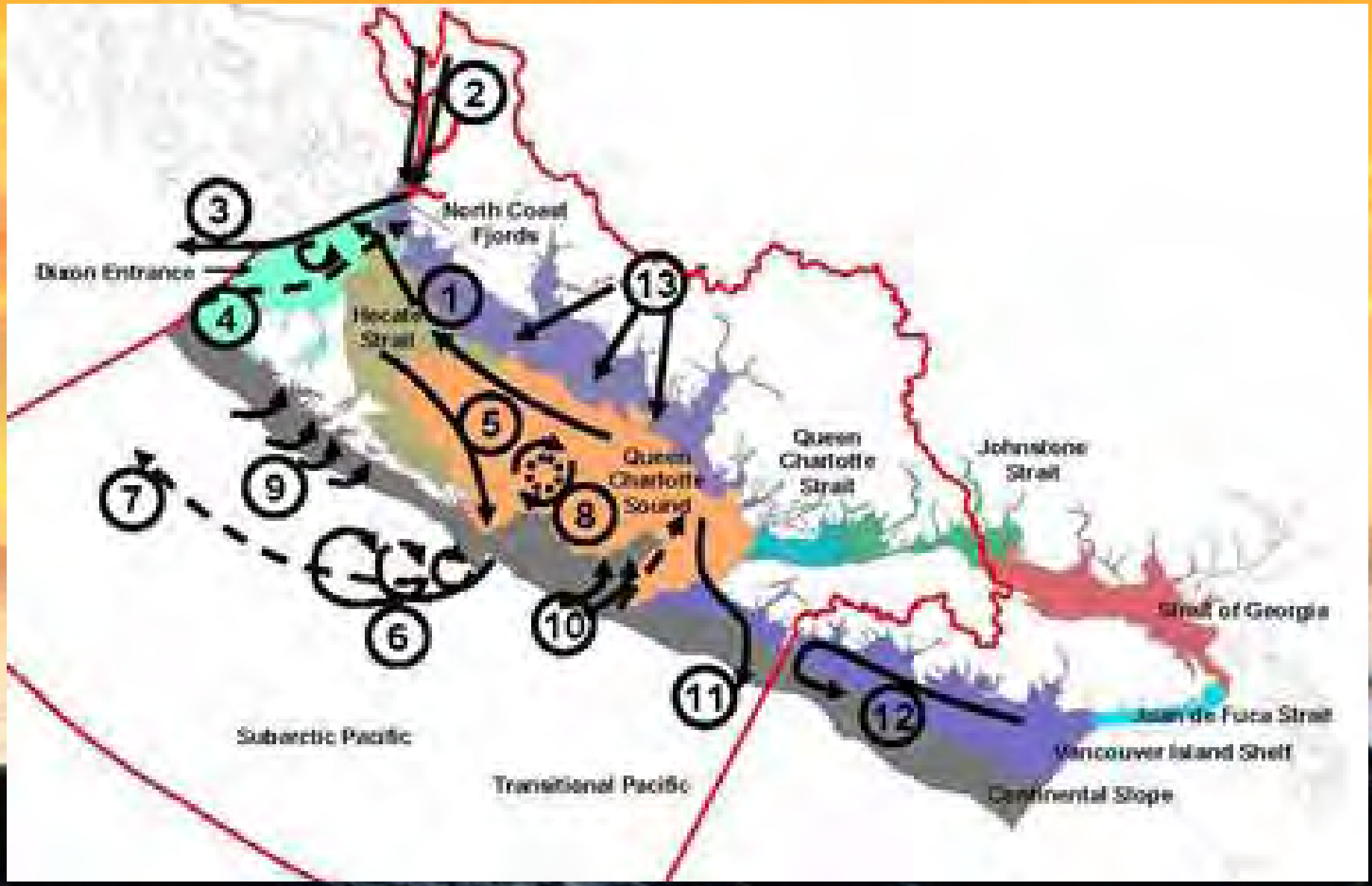
Highly textured: e.g. SST



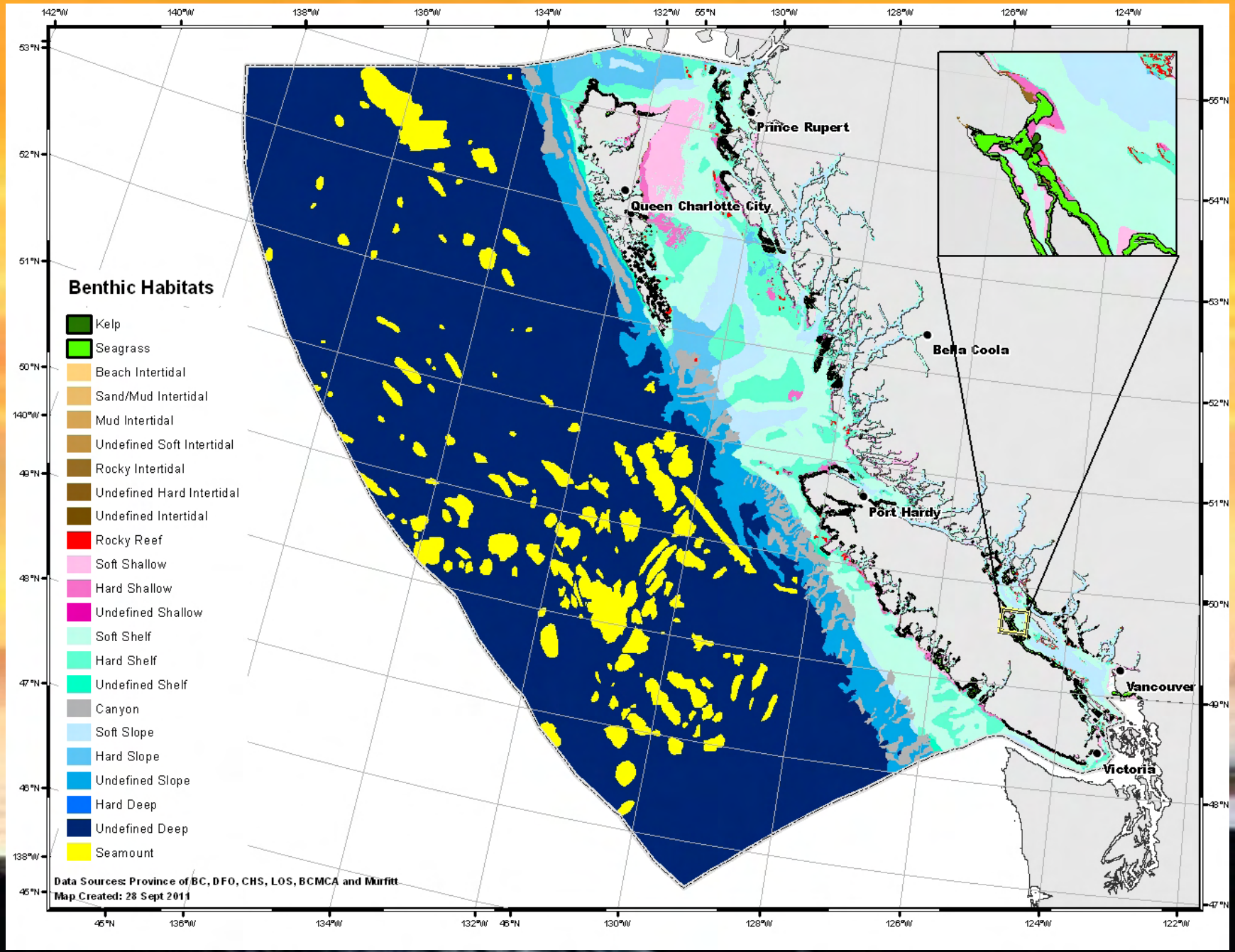
Sea surface temperature (SST) images of observations by AVHRR sensor on NOAA satellites

Perry, R. I., B. Crawford, and A. Sinclair. 2007. Chapter 1. Ecosystem Description. Pages 3-45 in B. G. Lucas, S. Verrin, and R. Brown, editors. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Can. Tech. Rep. Fish. Aquat. Sci. 2667: xiii + 104 p.

Unique features and dynamics

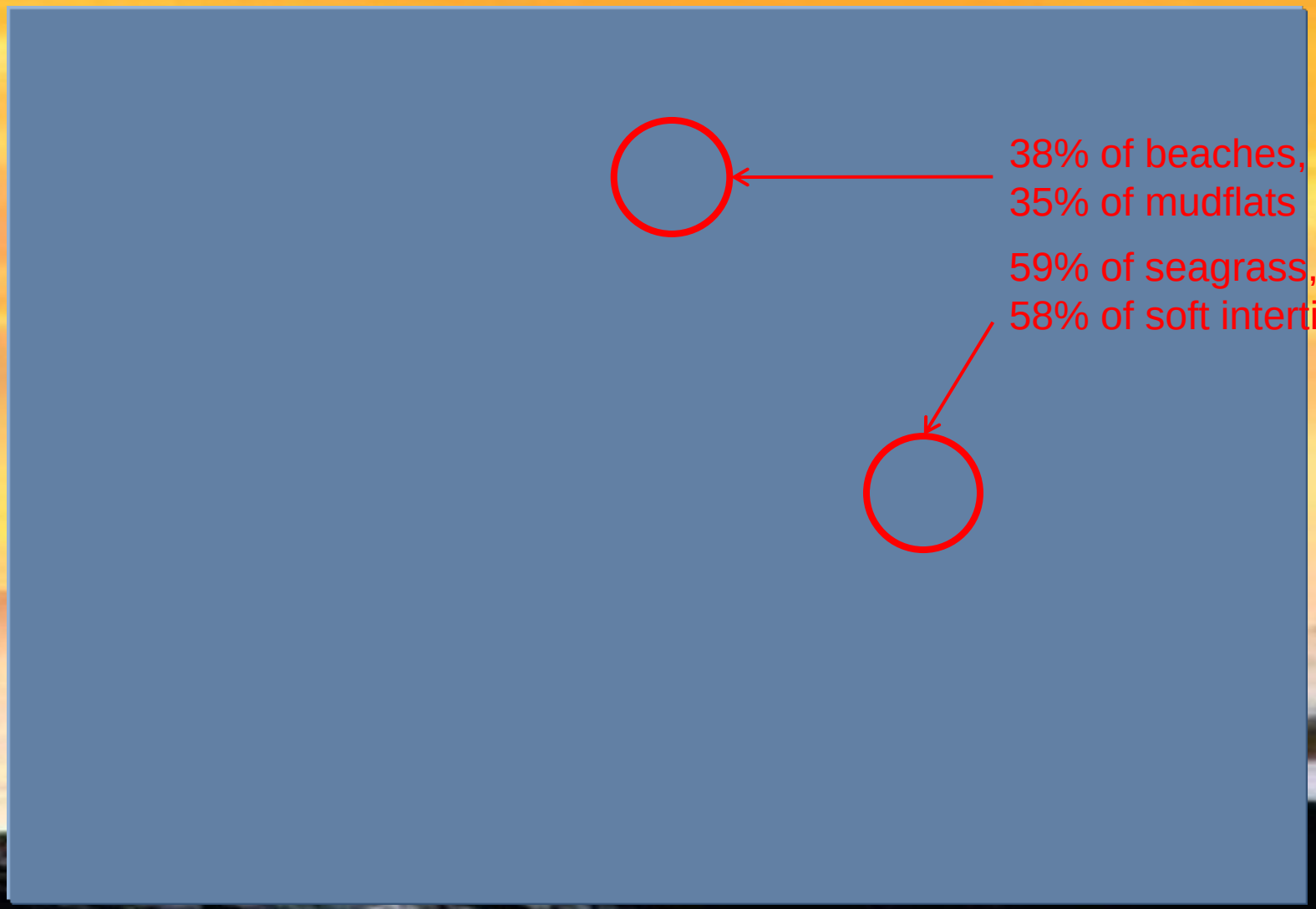


Marine Ecosections of BC

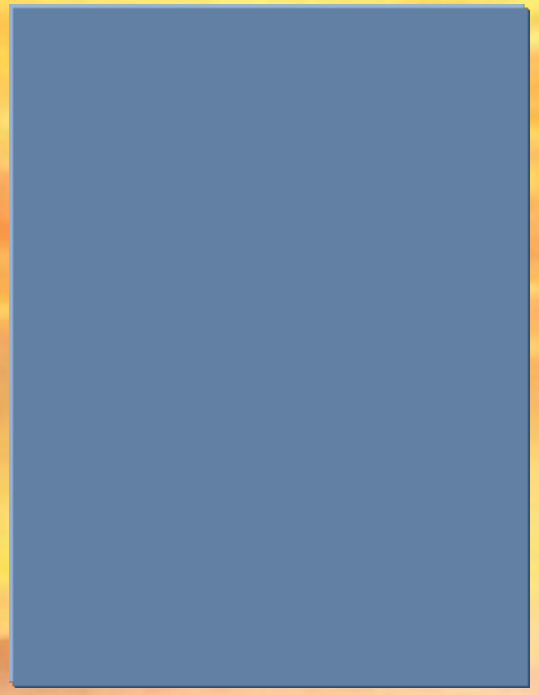

Benthic Habitats
Kelp
Seagrass
Beach Intertidal
Sand/Mud Intertidal
Mud Intertidal
Undefined Soft Intertidal
Rocky Intertidal
Undefined Hard Intertidal
Undefined Intertidal
Rocky Reef
Soft Shallow
Hard Shallow
Undefined Shallow
Soft Shelf
Hard Shelf
Undefined Shelf
Canyon
Soft Slope
Hard Slope
Undefined Slope
Hard Deep
Undefined Deep
Seamount
Prince Rupert
Queen Charlotte City
Bella Coola
Port Hardy
Vancouver
Victoria
Data Sources: Province of BC, DFO, CHS, LOS, BCMCA and Murfitt
Map Created: 28 Sept 2011

Percent of each habitat in each Ecosection of Pacific Canada

Marine Ecosections of British Columbia



Expected physical changes



- Temperature (+)
- Dissolved oxygen (-)
- pH (-)
- Precipitation (+)
- Salinity (-)
- Snowpack (-)
- Stratification (+)
- Sea level (+)
- Storminess (+)
- North Pacific current (+)
- Upwelling (+)
- ENSO (increased frequency?)
- PDO (?)

Types of biological effects

Shifts in species distributions and community structure

- Poleward shift of species ranges
- Changes in phenology
- Mis-matches and re-assembly of communities

Increased occurrence and establishment of new species

- Anomalous occurrences, southern species range expansion
- Invasive species and disease

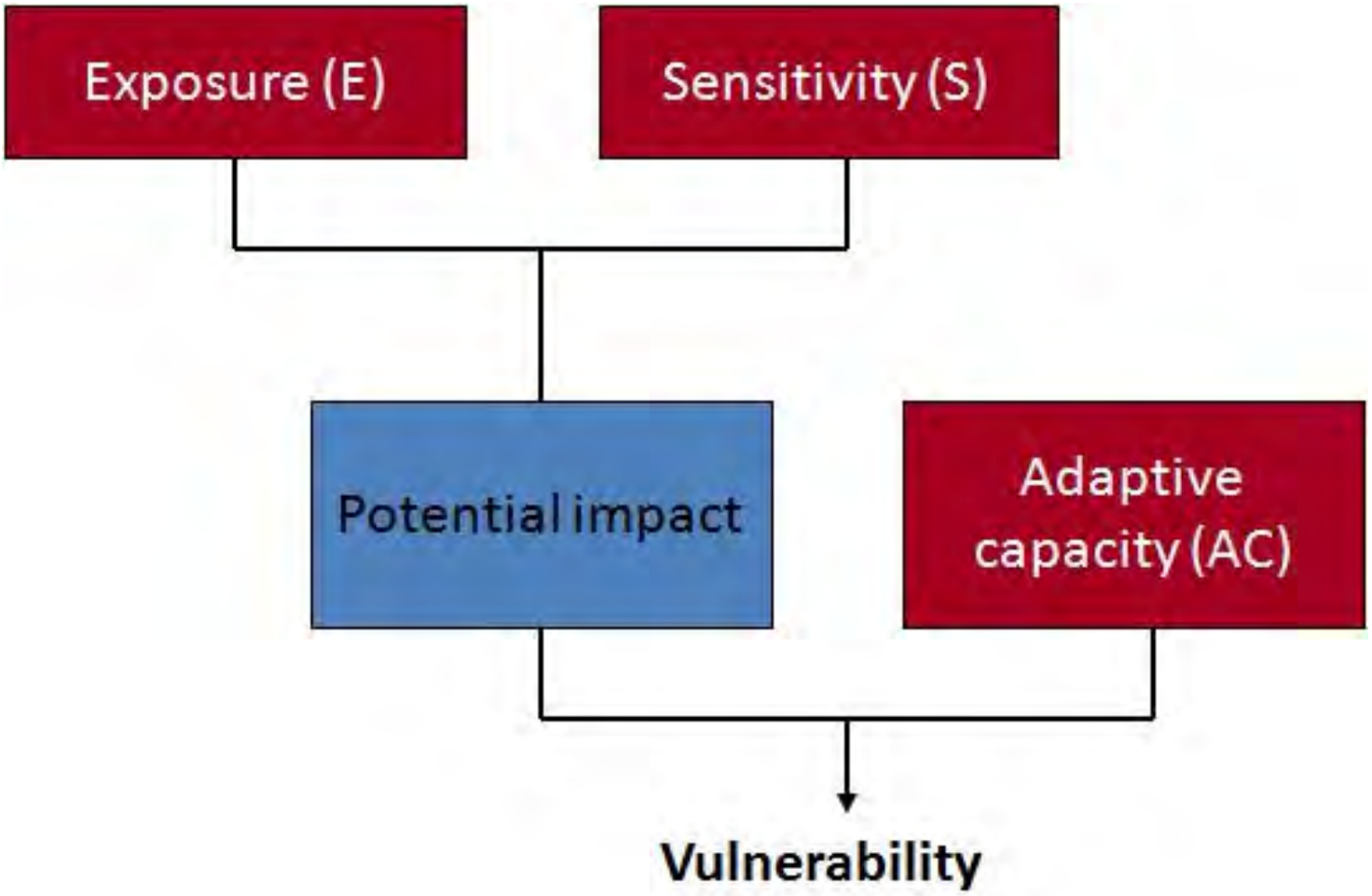
Loss of biodiversity and changes in favourable conditions

- Physiological stress (Temperature, pH, O_2)
- Increased extinction risk
- Effects of exposure to toxins
- Nutrient enrichment and algal blooms

Changes due to Interactions with other stressors

- Increased vulnerability to other anthropogenic stressors
- Decreased resilience to climate changes

Vulnerability



Allen report (2005)

Sensitivities of habitats to three climate change stressors

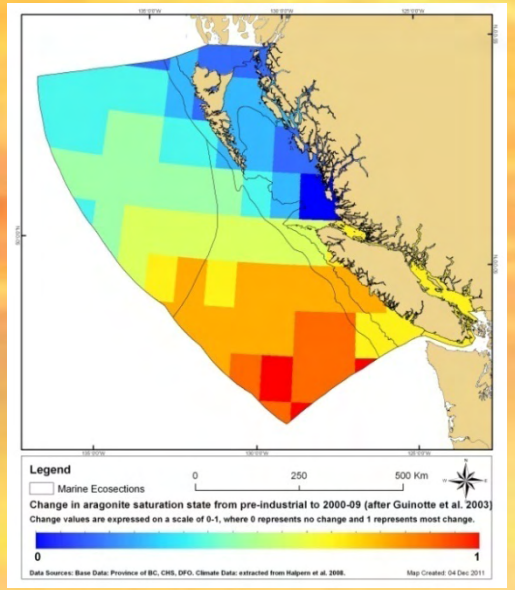
CLIMATE VARIABLE	HABITAT TYPE | BOTTOM TYPE																
	SALT MARSH	MUDFLATS	BEACH	ROCKY INTERTIDAL	KELP	SEA GRASS	ROCKY REEF	SUSPENSION REEF	SOFTSHELF	SOFT SLOPE	SOFT DEEP	HARD SHELF	HARD SLOPE	HARD DEEP	CANYON	SEAMOUNT	SURFACE WATERS	DEEP PELAGIC WATERS
Temperature	1.8	1.8	1.7	3.1	2.9	1.9	2.2	2.2	1.7	0.6	0.5	1.9	1.2	0	1.7	0	2.5	1.9
Acidification	2.4	2.4	1.8	2.7	2.0	2.1	2.2	2.5	2.6	3.4	2.5	2.7	3.4	3.4	2.6	2.6	3.2	2.7
UV light	1.9	1.7	1.8	2.3	1.6	1.5	1.7	1.8	0	0	0	0	0	0	0	0	2.5	0.8

(Tecchio et al. 2010)

Exposure

(Acidification)

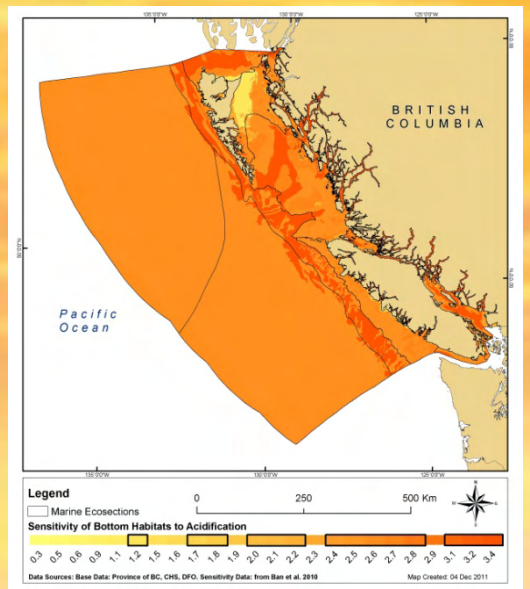
Predicted change in Aragonite Saturation State

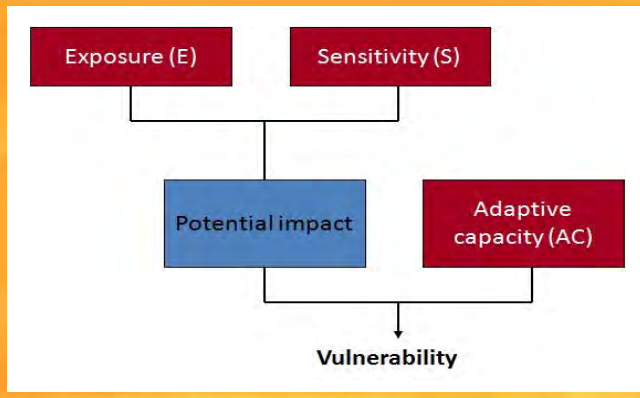


Sensitivity

of Habitat to Acidification

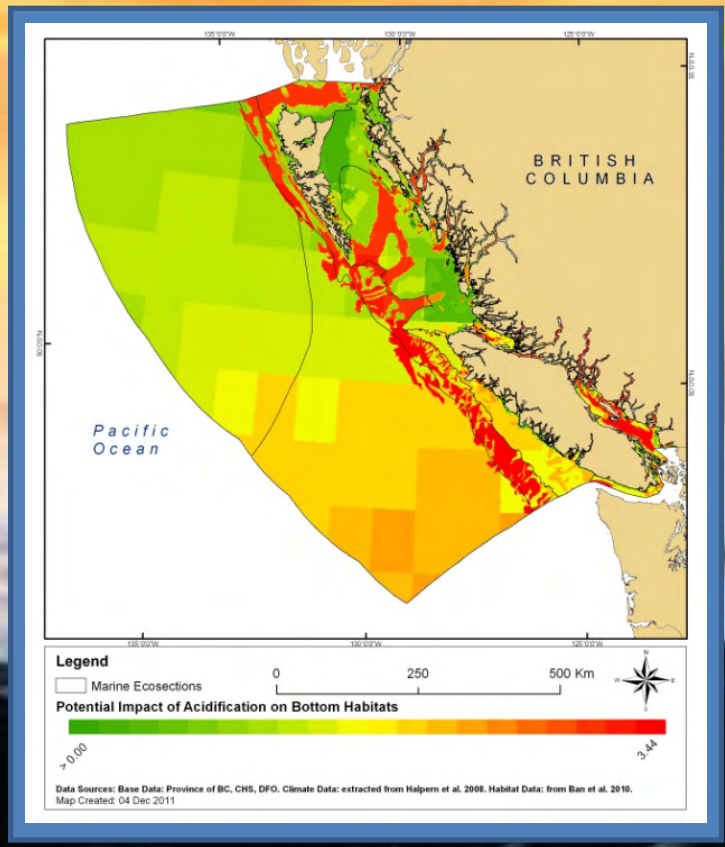
After Teck et al. 2010





Potential Impact

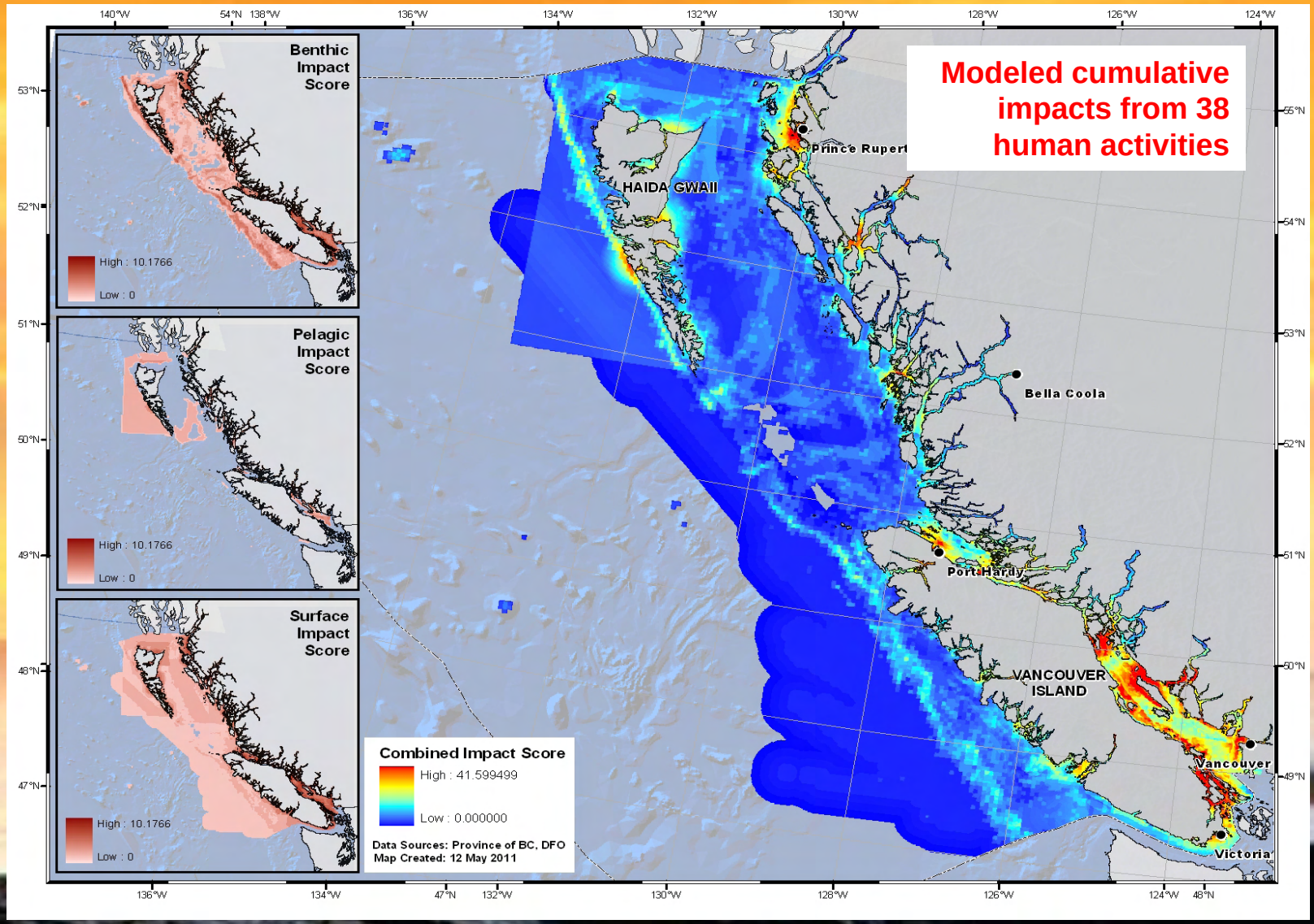
of Acidification on Habitats



Bottom habitats Water column Surface

Mean potential impact on habitats

Incorporating non-climate stressors

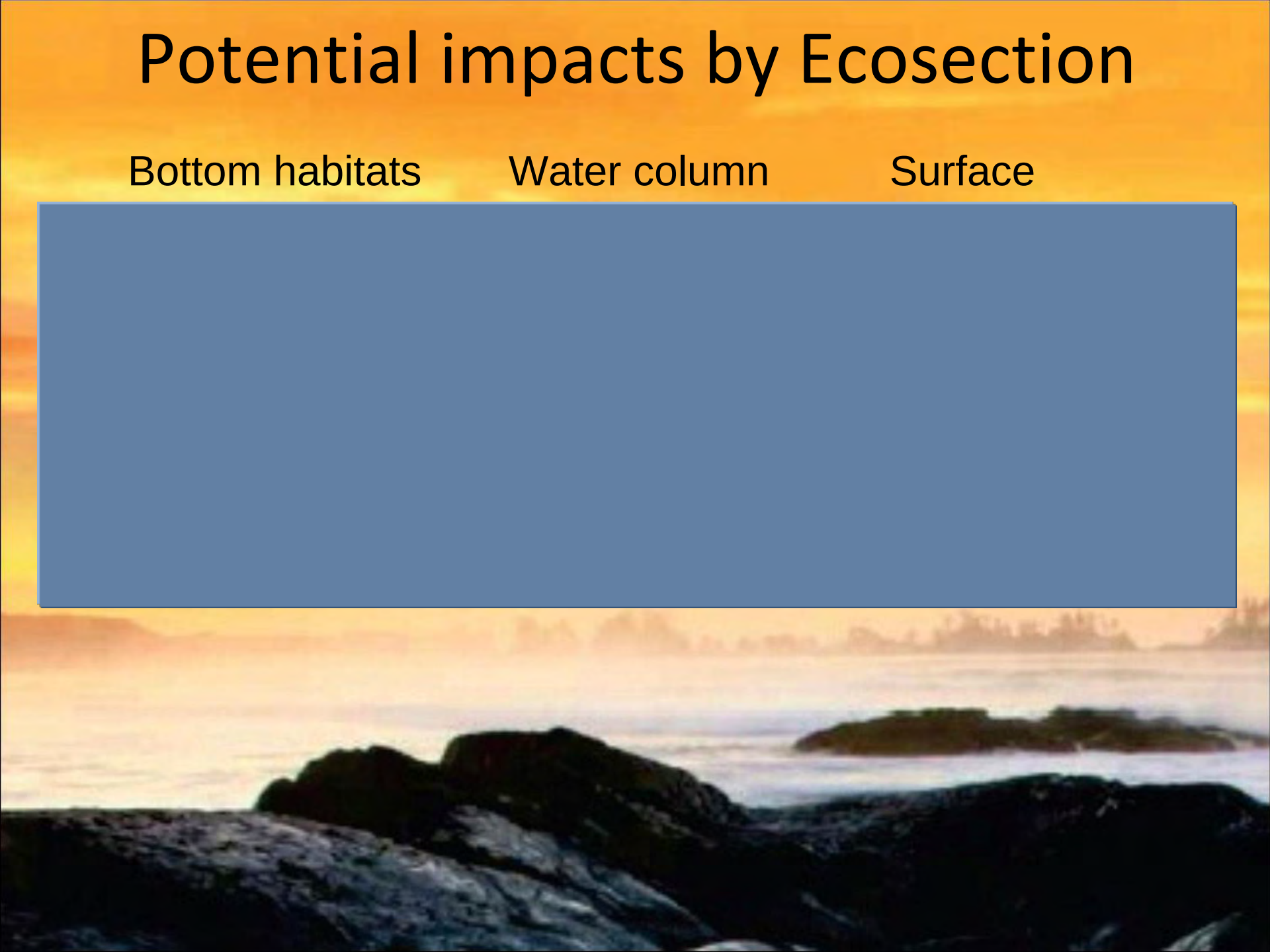


Ban, N.C., H. M. Alidina, and J.A. Ardron. 2010. Cumulative impact mapping: Advances, relevance and limitations to marine management and conservation, using Canada's Pacific waters as a case study. Marine Policy 34: 876–886.

Estimation of vulnerability of habitats to climate change

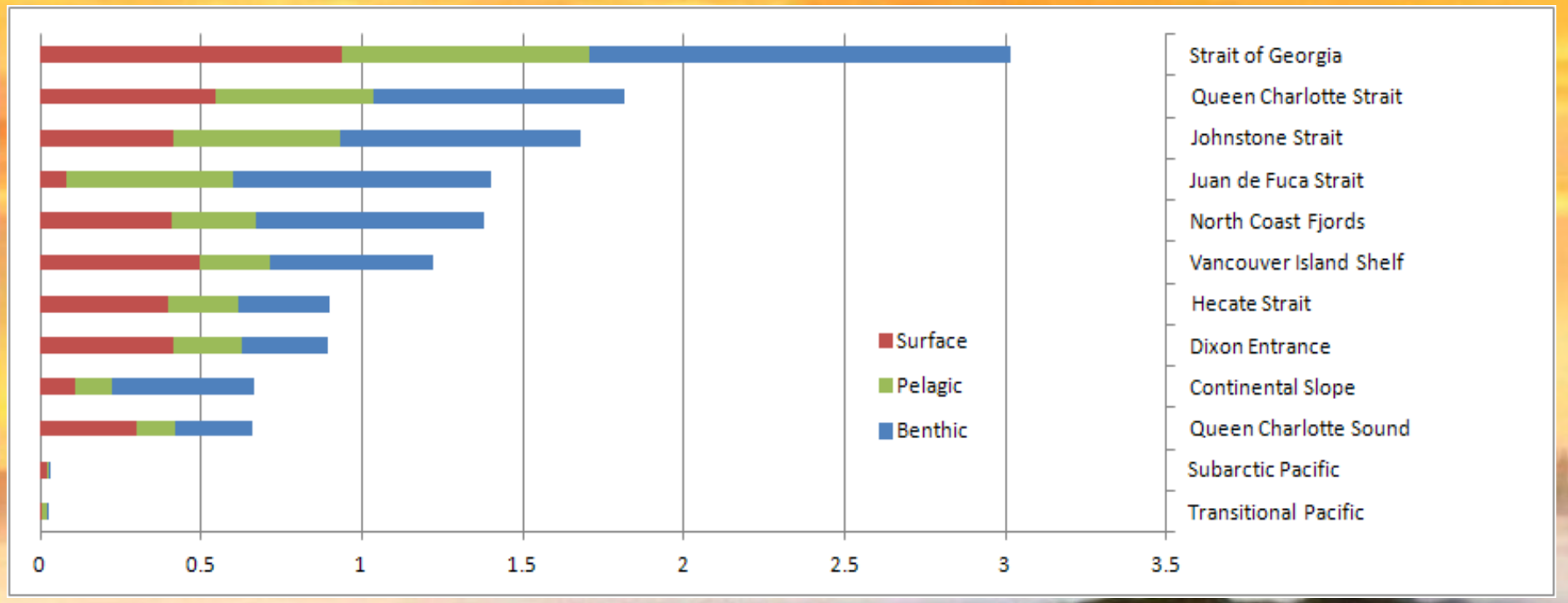
Potential impacts by Ecosection

Bottom habitats Water column Surface



Estimation of vulnerability of Ecosections to climate change

Estimated relative vulnerabilities of Ecosections to climate change



ECO-SECTION	POTENTIAL MAJOR CLIMATE CHANGES	SOME SENSITIVE ELEMENTS
Dixon Entrance	Increase in runoff and stratification. Reduction in salinity and associated changes to the buoyancy driven flow. Ocean warming. Sea level rise.	Larval Gyre (Dungeness Crab), pattern of nutrient entrainment from oceanic water, productivity
Hecate Strait	Ocean warming, Sea level rise, changes in runoff and salinity. May be sheltered from deeper acidic & anoxic waters	Productivity; spawning areas, sedimented shorelines and shoreline dependent species (shorebirds, forage fishes e.g. sandlance, smelt)
Queen Charlotte Sound	Oceanic warming. Intrusion of low anoxic and acidic waters into canyons	Slope communities including invertebrates and fishes, biogenic habitat (coral and sponges)
Vancouver Island Shelf	Oceanic warming. Changes to the nearshore buoyancy driven flow and offshore ocean circulation.	Productivity, neritic and benthic community - northern limit for many southern species
Continental Slope	Acidification and anoxia in the deep layers. Ocean warming. Changes to ocean currents.	Primary productivity, Slope Communities including invertebrates, fishes, structure forming biogenic habitats (corals and sponges). Commercial species including Sablefish

HABITAT	SOME SENSITIVITIES
Intertidal habitats	Sensitive to increasing temperature, freshwater, increased wave heights/surge, sea-level rise
Kelp Forests	Sensitive to Increased temperatures, UV levels, stratification and reduced upwelling, potentially storminess. May be avoured by increased upwelling
Seagrasses	Sensitive to increased turbidity, sediment deposition, changes in flow. May be favoured by increased CO2
Estuaries	Sensitive to changes in mixing and estuarine regimes (flow and timing), freshet timing effects on other species and habitats. Bioavailability of trace metals under acidic conditions
Salt Marshes	Sensitive to salt water intrusion, inundation, sea-level rise, erosion or excessive deposition.
Corals and Sponge Reefs	Sensitive to increased acidification, dexoxygenation, increased sediment transport in nearshore areas. May benefit from nutrient upwelling
Seamounts	Exposed to wide variety of conditions. May be sensitive to a variety of changes, pH, anoxic waters, turbidity
Soft Shelves and Slope	Sensitive to acidification, freshwater input, changes in water chemistry, current dynamics (soft sediment systems)
Submarine Canyons	Acidified and anoxic water and conditions for benthic communities

Qualitative assessed vulnerabilities

- **Oceanographic processes** in areas critical for larval retention and transport that are sensitive to intensification of estuarine conditions (Dixon Entrance, Queen Charlotte Sound Ecosections, Juan de Fuca Strait);
- **Sediment shorelines and other nearshore habitats** that serve as important spawning habitats for forage fishes and are sensitive to erosion and sea-level rise (Hecate Strait, Strait of Georgia, other Ecosections);
- **Biogenic coral habitats in canyons and channels** between slope and shelf areas, which are prime points for exposure to acidic water (Queen Charlotte Sound, Continental Slope Ecosections);
- **Areas where topographically induced upwelling of deeper water** supports productivity and diversity; for example, the shelf break and seamounts where species and habitats would be sensitive to increases of oxygen-depleted and acidic water (Continental Slope Ecosection);
- **Commercially harvested groundfish species**, other non-commercial species and their habitats between 250-400m depth, where increasing levels of oxygen-depleted water are already reducing suitable habitat for these species and will continue to do so;
- Areas considered important as **nursery and juvenile rearing habitats** (estuaries, seagrass, and other nearshore habitats) that would be sensitive to changing physical conditions, particularly temperature, salinity, turbidity, and stratification;
- **Areas through which migrating species transit in large** numbers for part of their life cycle, which will be sensitive to changing physical conditions and/or new predators that arrive as a result of climate changes (Queen Charlotte Strait, Johnstone Strait, some fjords); and
- **Harvested species** that are longer-lived and more resistant to short-term climate variability because they can afford to have long periods of low or no recruitment, but that are more sensitive to longer-term directional change in a given location because they cannot adapt as fast as shorter-lived species (e.g., Pacific Ocean perch, rockfishes, sablefish).

Refining the analysis

- Additional climate variables (downscaled regional projections)
- Regional habitat types
- Regional stressors / pressures / sensitivities
- Improved understanding of Indirect and interactive effects through ecosystem models
- Increased monitoring of changes across scales, relevant indicators

Acknowledgements

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