ARC Centre of Excellence
Coral Reef Studies

Mapping cumulative impact:

Advances, relevance and limitations to marine management

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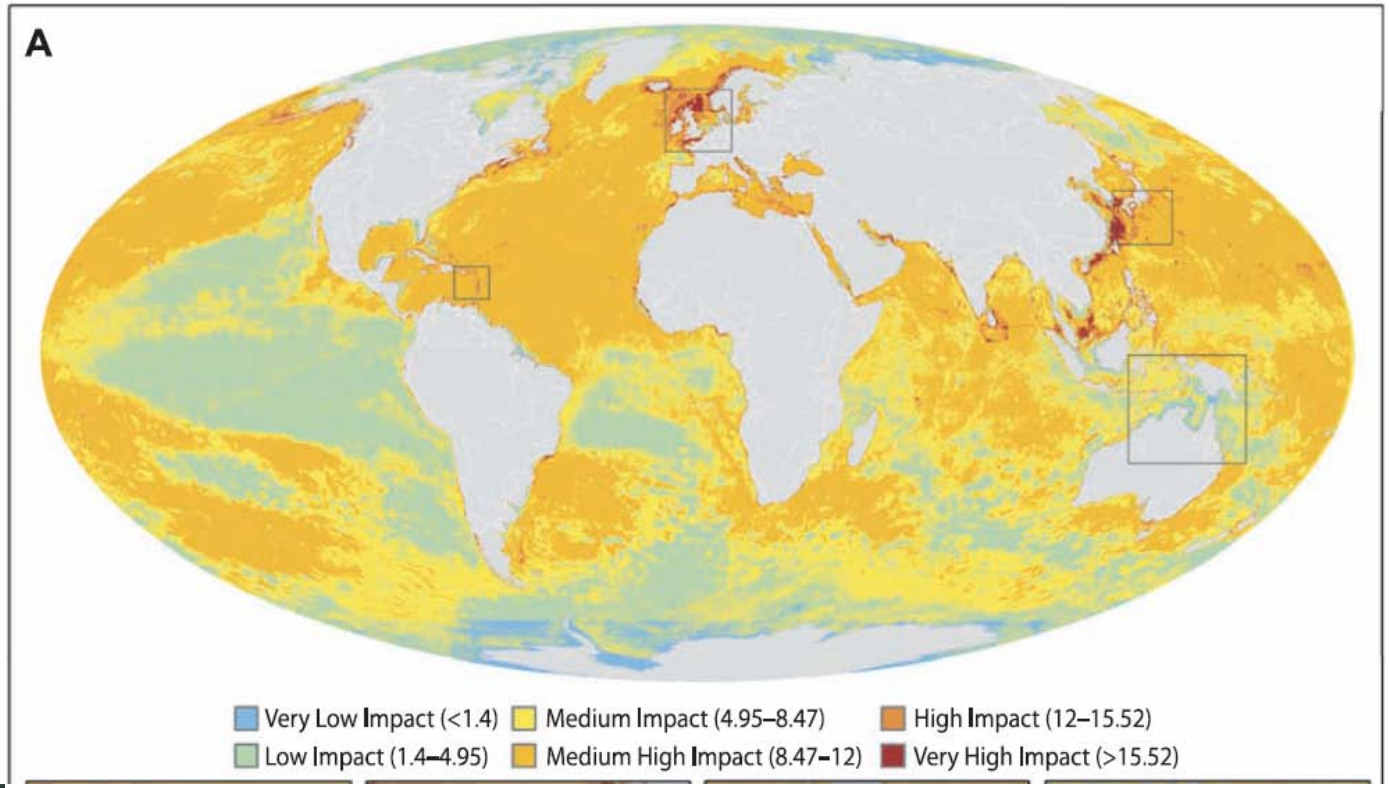
Mapping multiple stressors

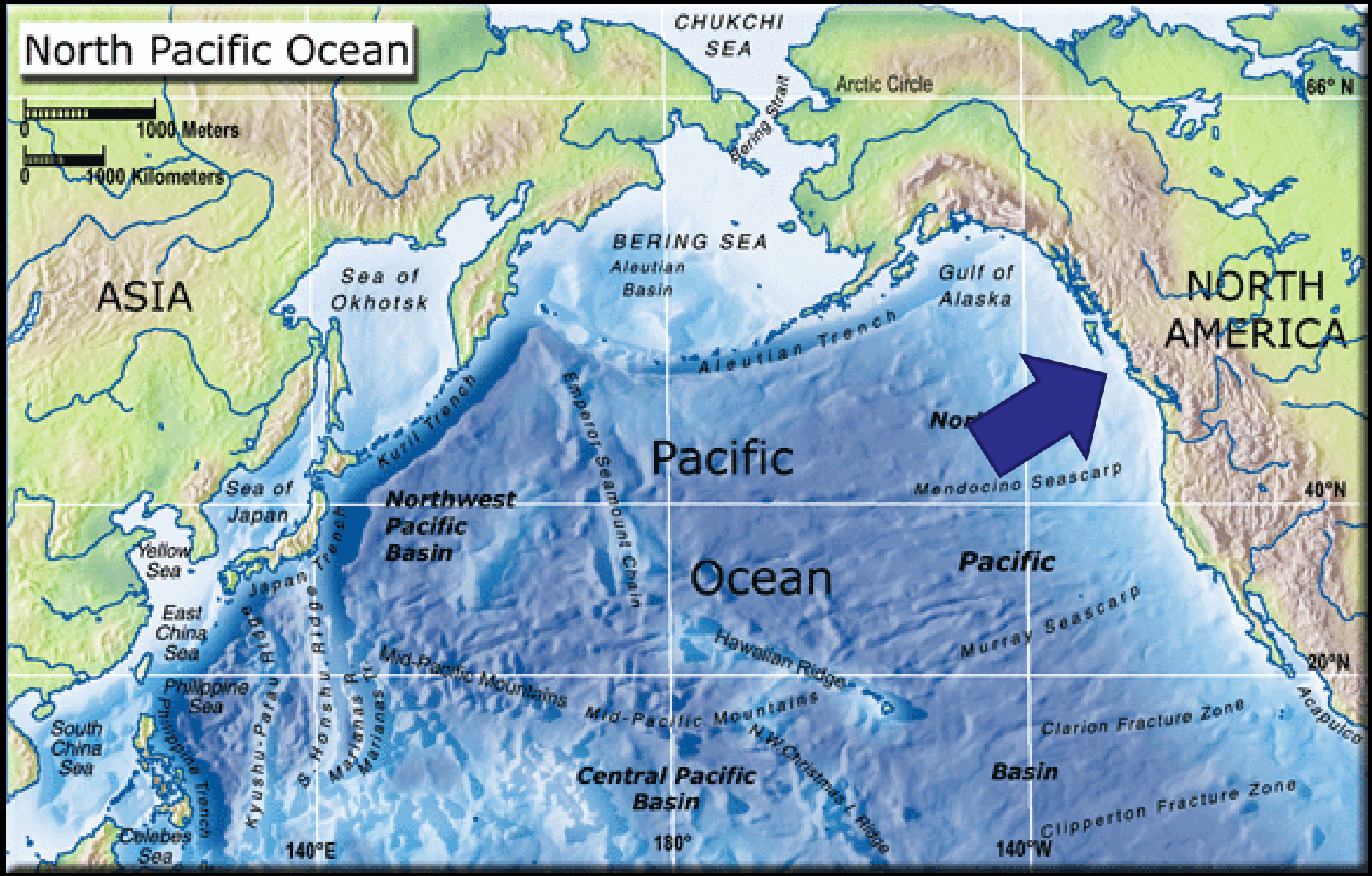
- Global concern about multiple stressors
- A lot of interest in mapping where multiple stressors might be interacting
- Purpose of this presentation: provide an example of methods and data for mapping multiple stressors in a region

ARC CoE for Coral Reef Studies / Marine Photobank

Global stressor mapping



Halpern et al 2008


North Pacific Ocean
0 1000 Meters
0 1000 Kilometers
CHUKCHI SEA
Arctic Circle
66° N
Bering Strait
BERING SEA
Aleutian Basin
Gulf of Alaska
ASIA
Sea of Okhotsk
NORTH AMERICA
Aleutian Trench
Kuril Trench
Emperor Seamount Chain
Pacific
Ocean
Mendocino Seascarp
40°N
Sea of Japan
Northwest Pacific Basin
Yellow Sea
East China Sea
Japan Trench
Ridge
S. Honshu-Ogasawara Ridge
Mariana Trench
Mariana Is.
Mid-Pacific Mountains
Hawaiian Ridge
Murray Seascarp
20°N
Philippine Sea
Philippine Trench
South China Sea
Kyushu-Palau Ridge
Mid-Pacific Mountains
NW Hawaiian Ridge
Central Pacific Basin
Clarion Fracture Zone
Basin
Acapulco
Clipperton Fracture Zone
Celebes Sea
140°E
180°
140°W

Research questions

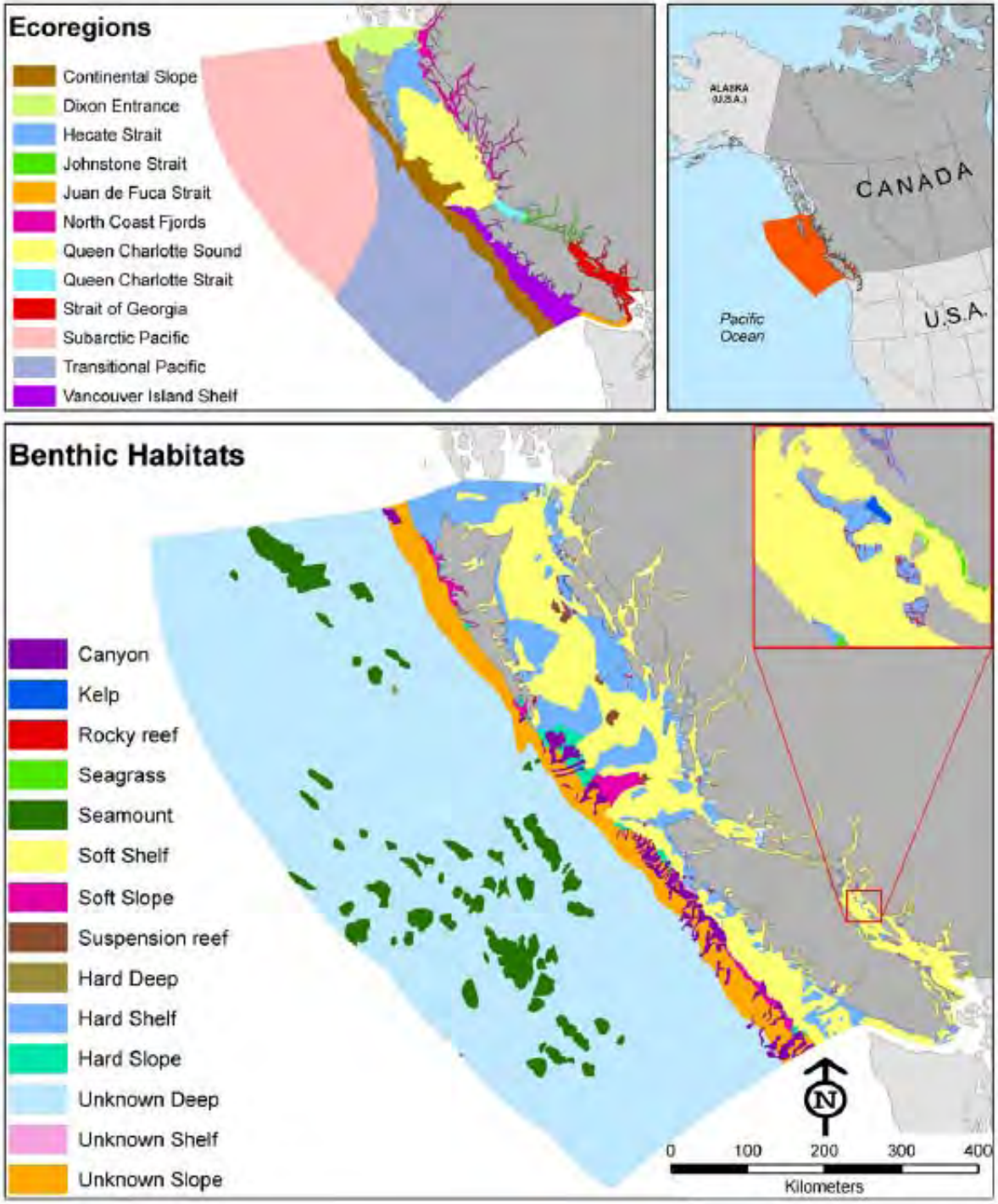
- What are the main human-induced stressors in the marine environment in BC?
- Where are cumulative impacts likely to occur?

Methods

- Methods and data from recent studies (Halpern et al 2008, Ban and Alder 2008)
- Four types of information needed:
  1. Locations of activities, and intensities if known
  2. Stressors resulting from these activities
  3. How far the impacts are felt
  4. How vulnerable habitats are to those impacts

Methods: mapping steps

(a) Assemble Spatial Information on habitats, use and Intensities


Ecoregions
Continental Slope
Dixon Entrance
Hecate Strait
Johnstone Strait
Juan de Fuca Strait
North Coast Fjords
Queen Charlotte Sound
Queen Charlotte Strait
Strait of Georgia
Subarctic Pacific
Transitional Pacific
Vancouver Island Shelf
ALASKA (U.S.A.)
CANADA
U.S.A.
Pacific Ocean
Benthic Habitats
Canyon
Kelp
Rocky reef
Seagrass
Seamount
Soft Shelf
Soft Slope
Suspension reef
Hard Deep
Hard Shelf
Hard Slope
Unknown Deep
Unknown Shelf
Unknown Slope
N
0
100
200
300
400
Kilometers


IPHC


TRITON
8610
Ensenada


OCEANMARINE
EVCO SPRAY


SHELLFISH TENURE
TAKING OR DESTROYING SHELLFISH ON LEASE WITHOUT PERMISSION IS PROHIBITED BY LAW.


Hyundai
Howe Sound
GEARBULK
seaspan
seaspan

Commercial Fishing	Recreational Fishing	Land-based
1. Groundfish Bottom Trawling 2. Groundfish ZN 3. Schedule II 4. Sablefish Trap 5. Sablefish Longline 6. Prawn Trap 7. Shrimp Trawl 8. Crab Trap 9. Red urchin Dive 10. Green urchin Dive 11. Commercial sea cucumber Dive 12. Commercial krill Net 13. Commercial geoduck Dive 14. Commercial scallop Dive/Net 15. Commercial salmon Troll 16. Commercial salmon Net 17. Commercial squid Net 18. Commercial octopus Dive 19. Commercial herring Net 20. Commercial herring roe Net 21. Commercial gooseneck barnacle Intertidal 22. Commercial dogfish Hook and Line	23. Recreational trap fishing (crab and prawn) 24. Recreational diving (dive, diving, scallops) 25. Recreational fishing – unspecified (probably mostly hook and line fishing) **Marine Tourism** 26. Dive sites 27. Kayak routes 28. Motorized boating 29. Fishing and other floating lodges **Aquaculture** 30. Finfish aquaculture 31. Shellfish aquaculture **Marine Transportation** 32. Ports, moorage, ferry docks, marinas 33. Large vessel activity/traffic **Other** 34. Marine disposal sites 35. Logging-related Docks	36. Towns/Human Settlements 37. Pulp and paper 38. Other Industrial 39. Agriculture 40. Mining 41. Logging Related/sediment

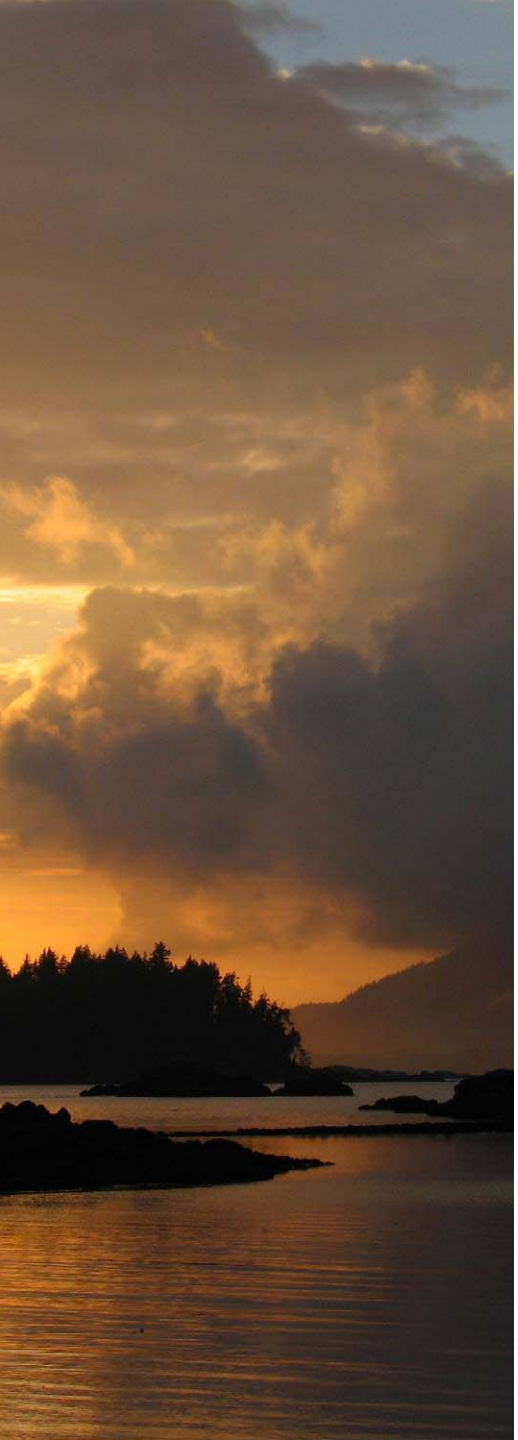
Methods: mapping steps

(a) Assemble Spatial Information on use and Intensities

(b)Identify key stressors resulting from these activities

- Based on literature review that examined which stressors result from activities

(c) Determine the distance to which stressors of individual activities are felt beyond their origin



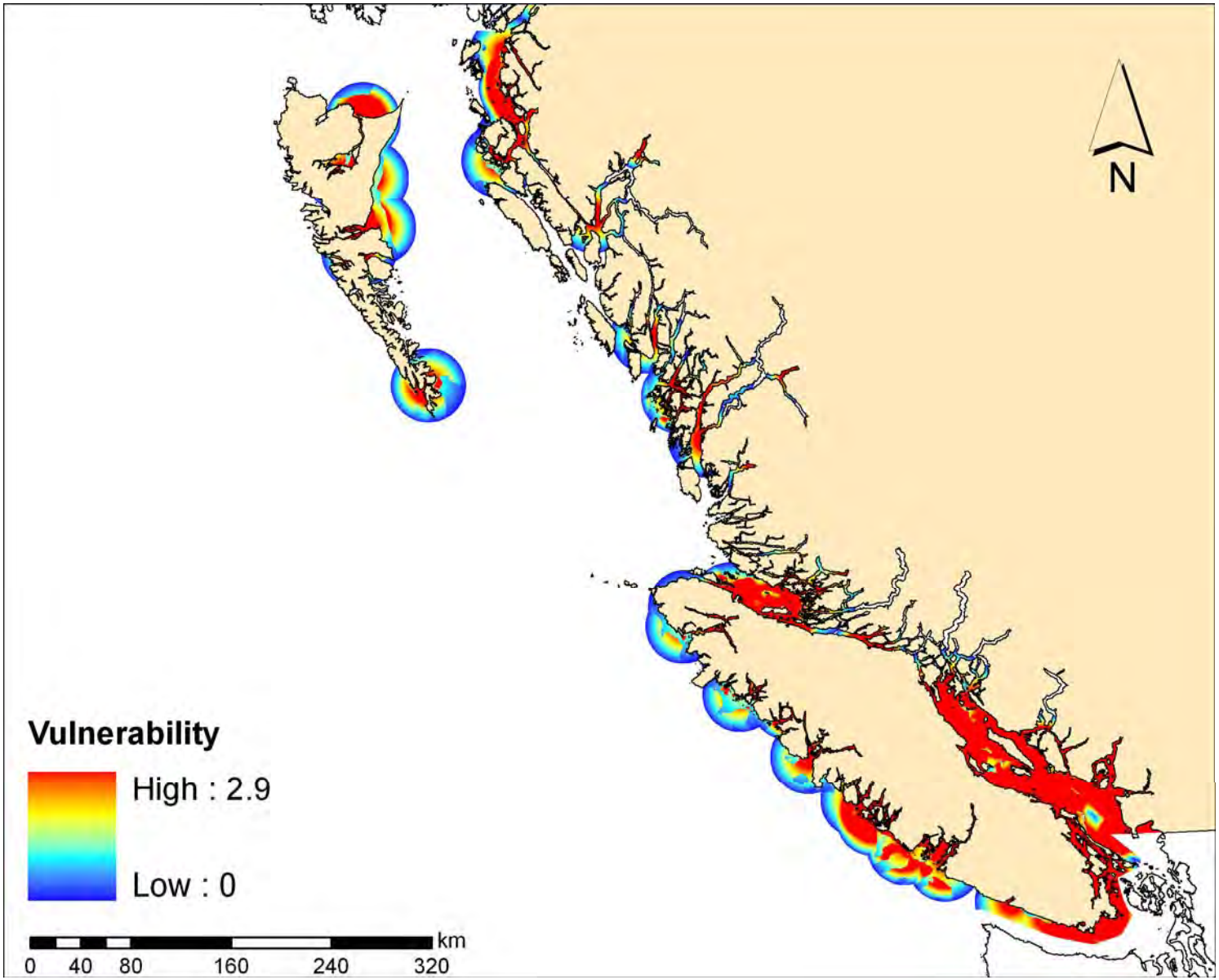
Methods: mapping steps

(d) Apply a sensitivity score that translates the relative impact of different activities on benthic (12 broad types), shallow pelagic (surface), and deep pelagic habitats.
•Taken from Halpern et al. 2008, expert-based

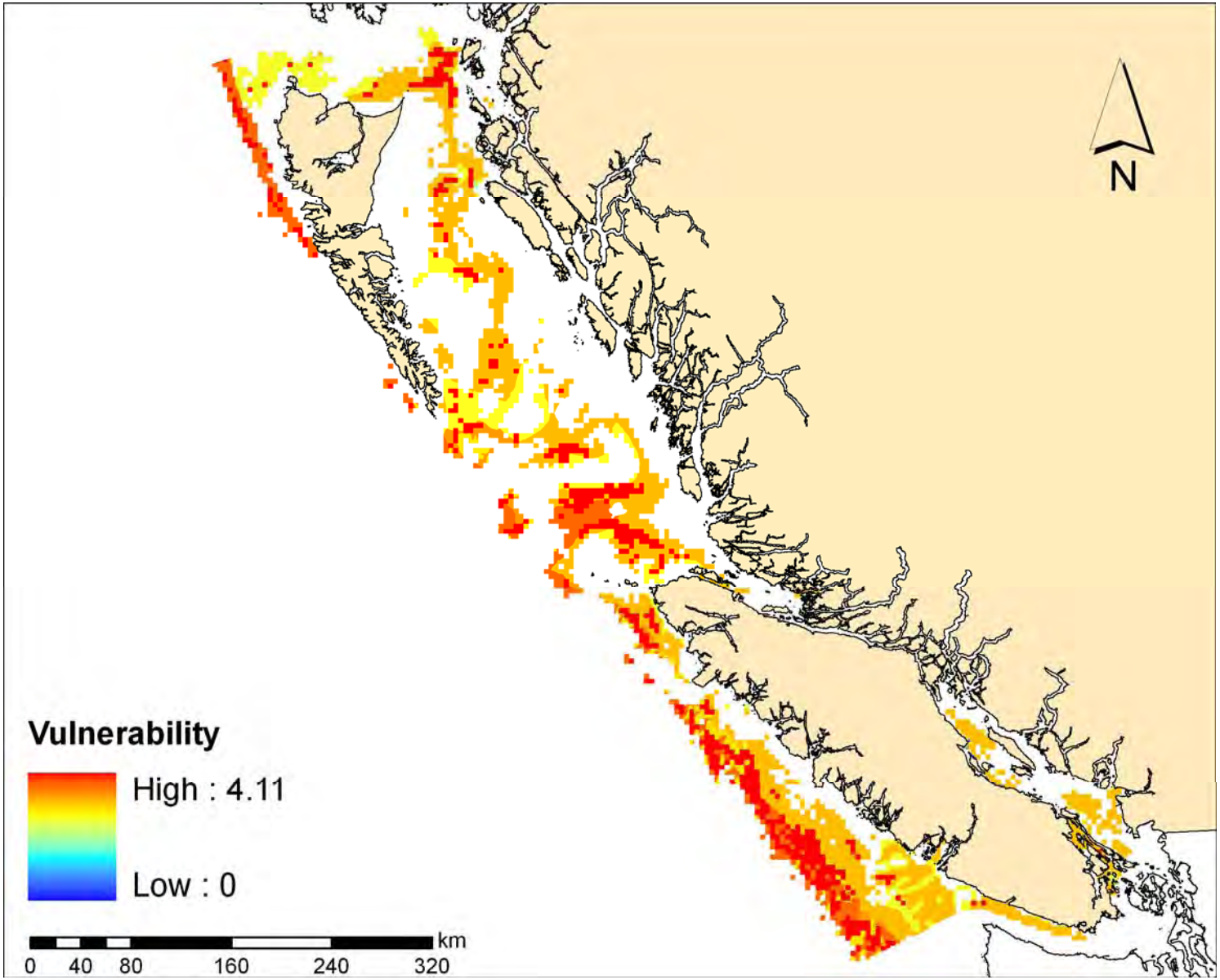
(e) Model a spatially explicit impact score for each activity-habitat combination.

(f) Calculate the cumulative impact of activities – the cumulative impacts is the additive (summed) impacts of all activities over the different habitat types in which they occur.

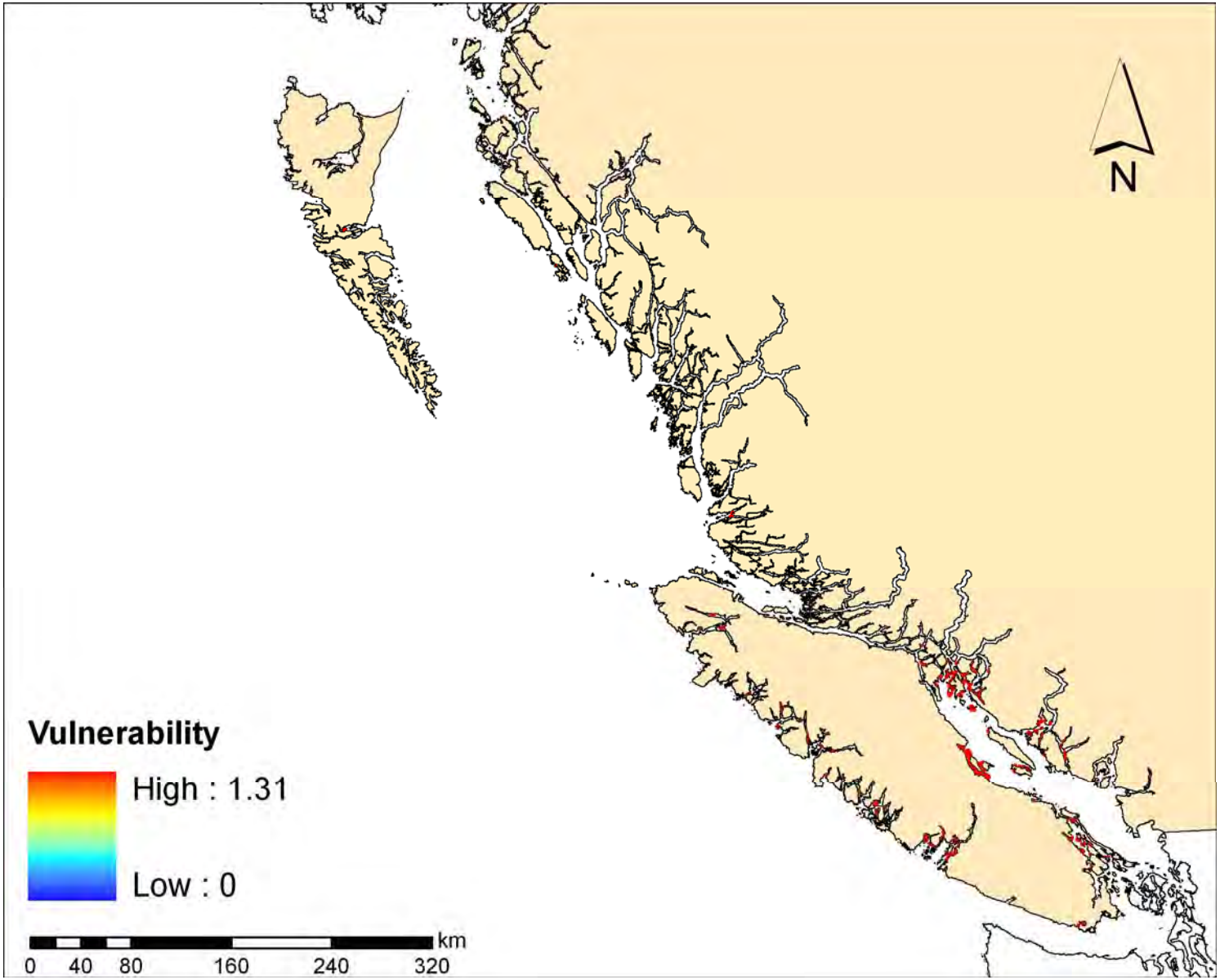
Cities and towns – shallow pelagic



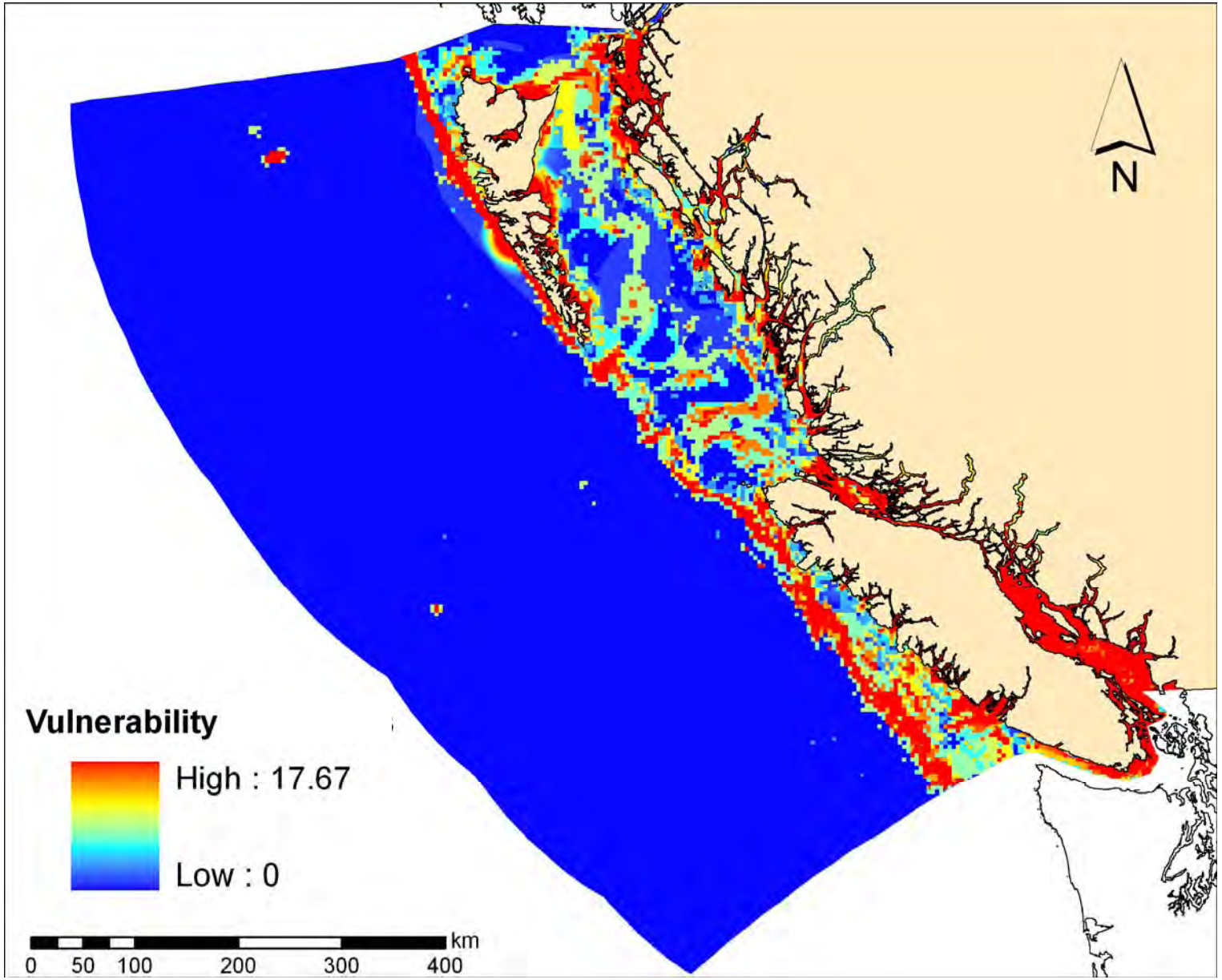
Groundfish bottom trawl - benthic

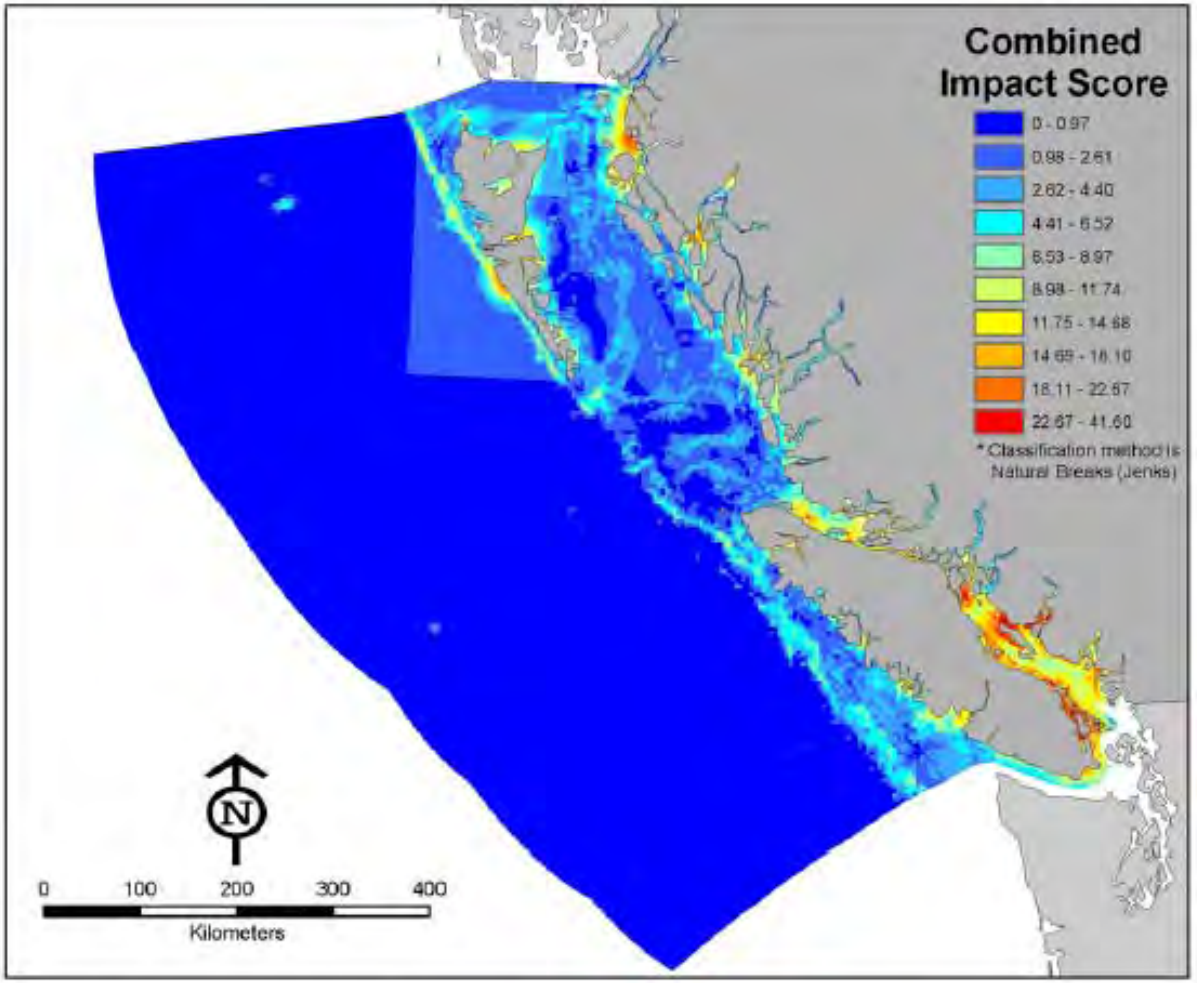


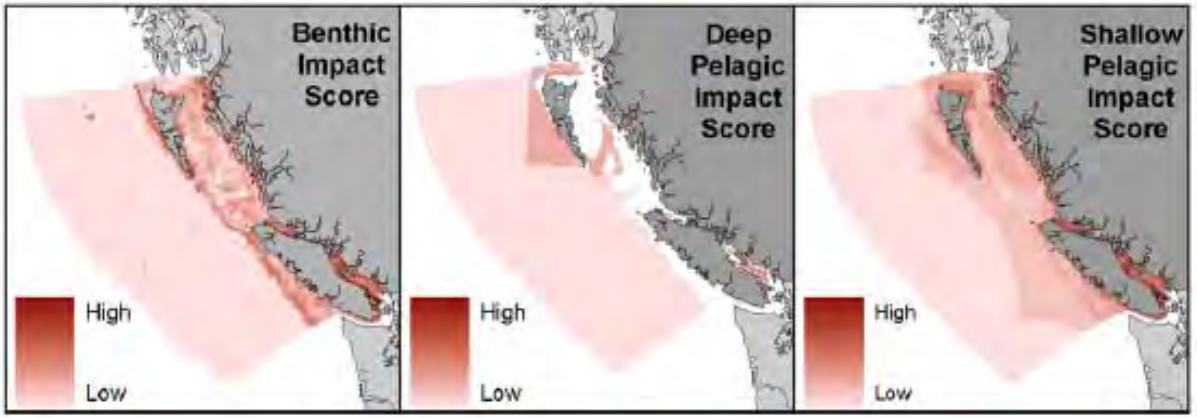
Shellfish aquaculture - benthic

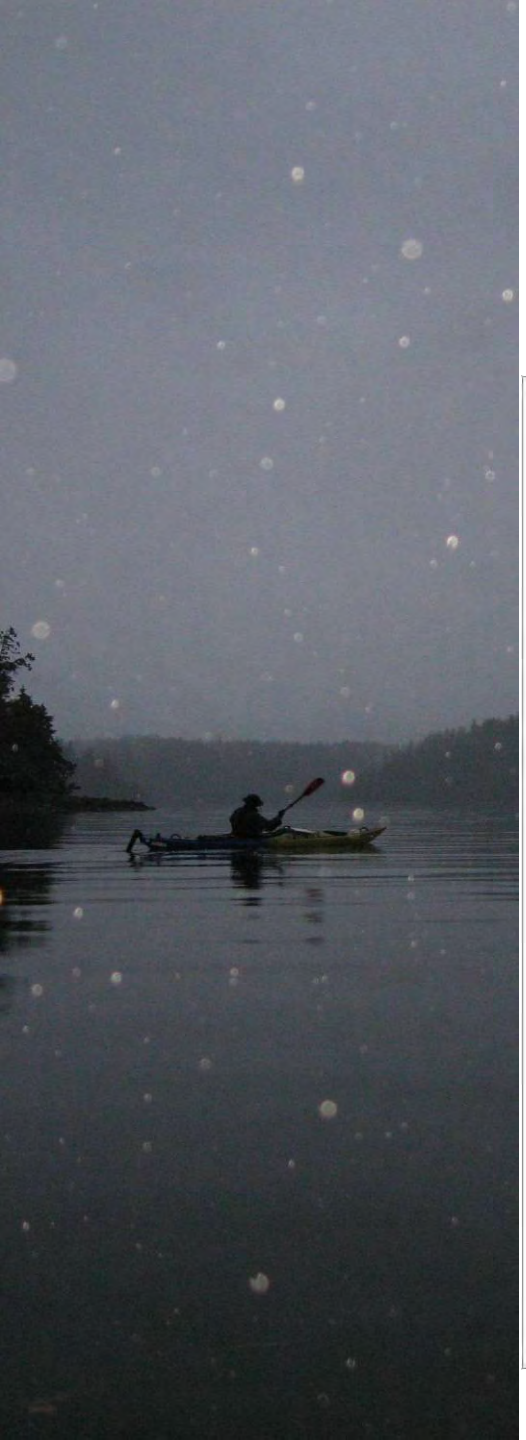


Cumulative impacts: benthic habitats

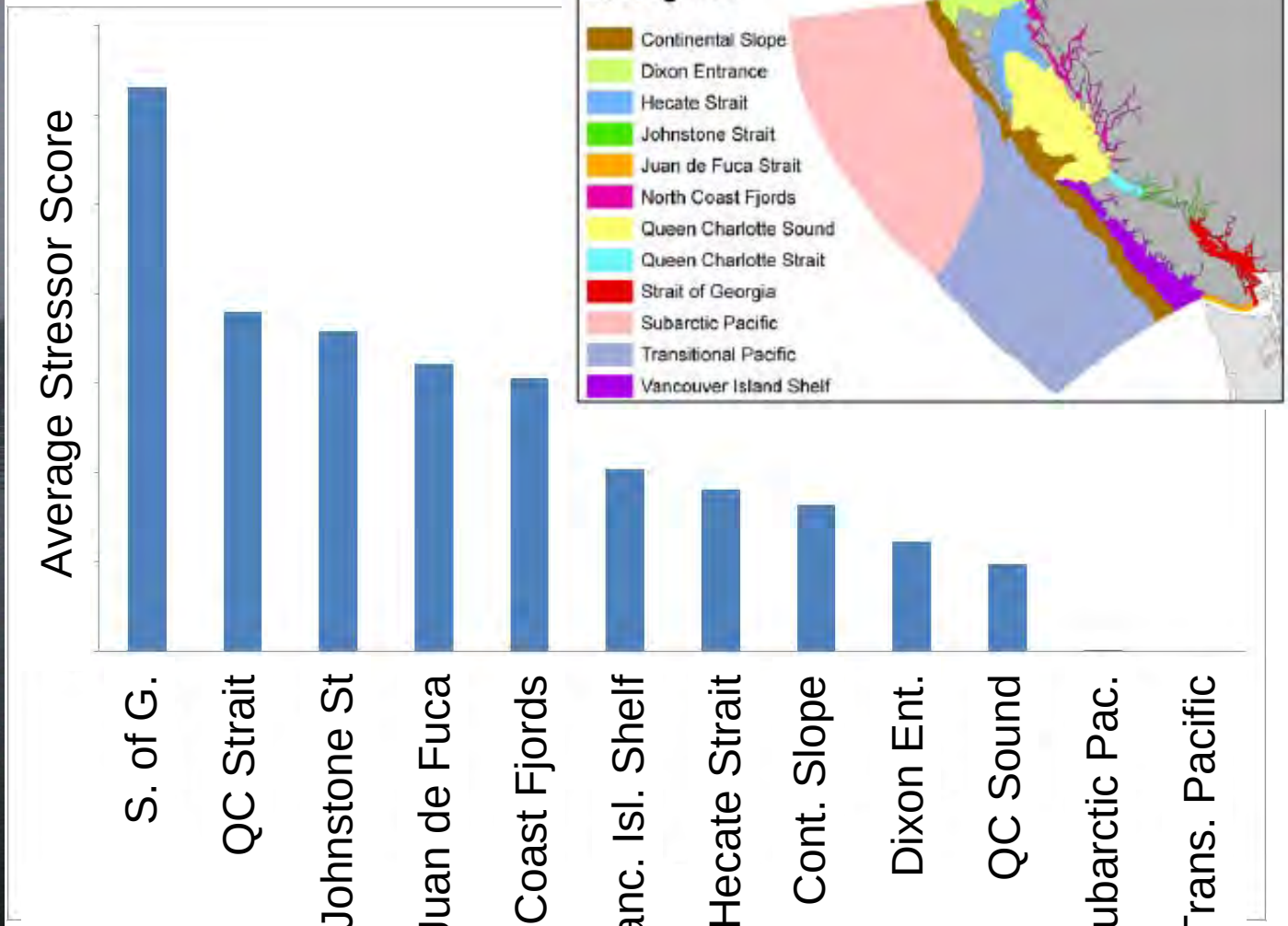


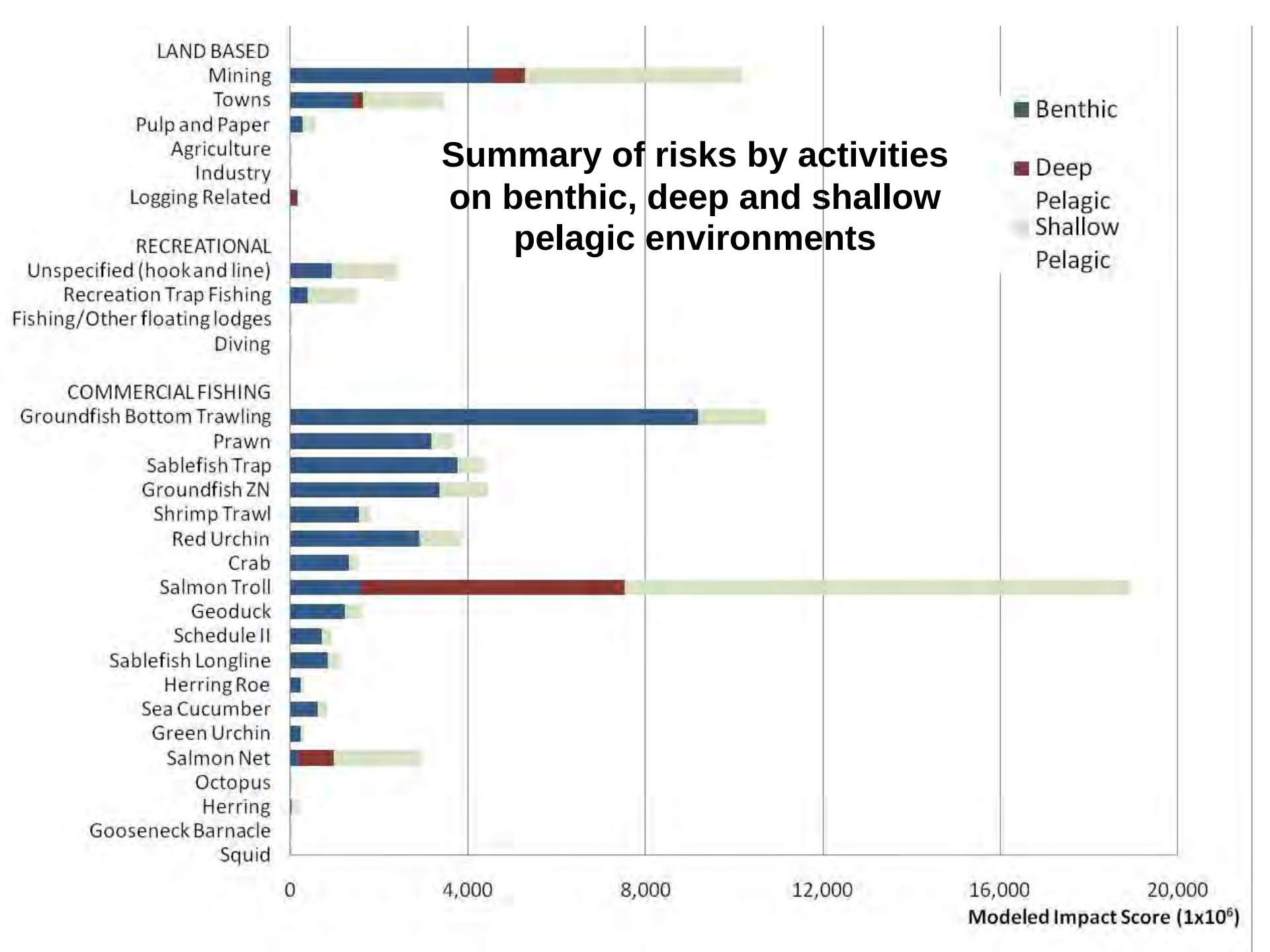

Combined Impact Score
0 - 0.97
0.98 - 2.61
2.62 - 4.40
4.41 - 6.52
6.53 - 8.97
8.98 - 11.74
11.75 - 14.68
14.69 - 18.10
18.11 - 22.67
22.67 - 41.60
*Classification method is Natural Breaks (Jenks)
N
0 100 200 300 400
Kilometers


Benthic Impact Score
High
Low
Deep Pelagic Impact Score
High
Low
Shallow Pelagic Impact Score
High
Low

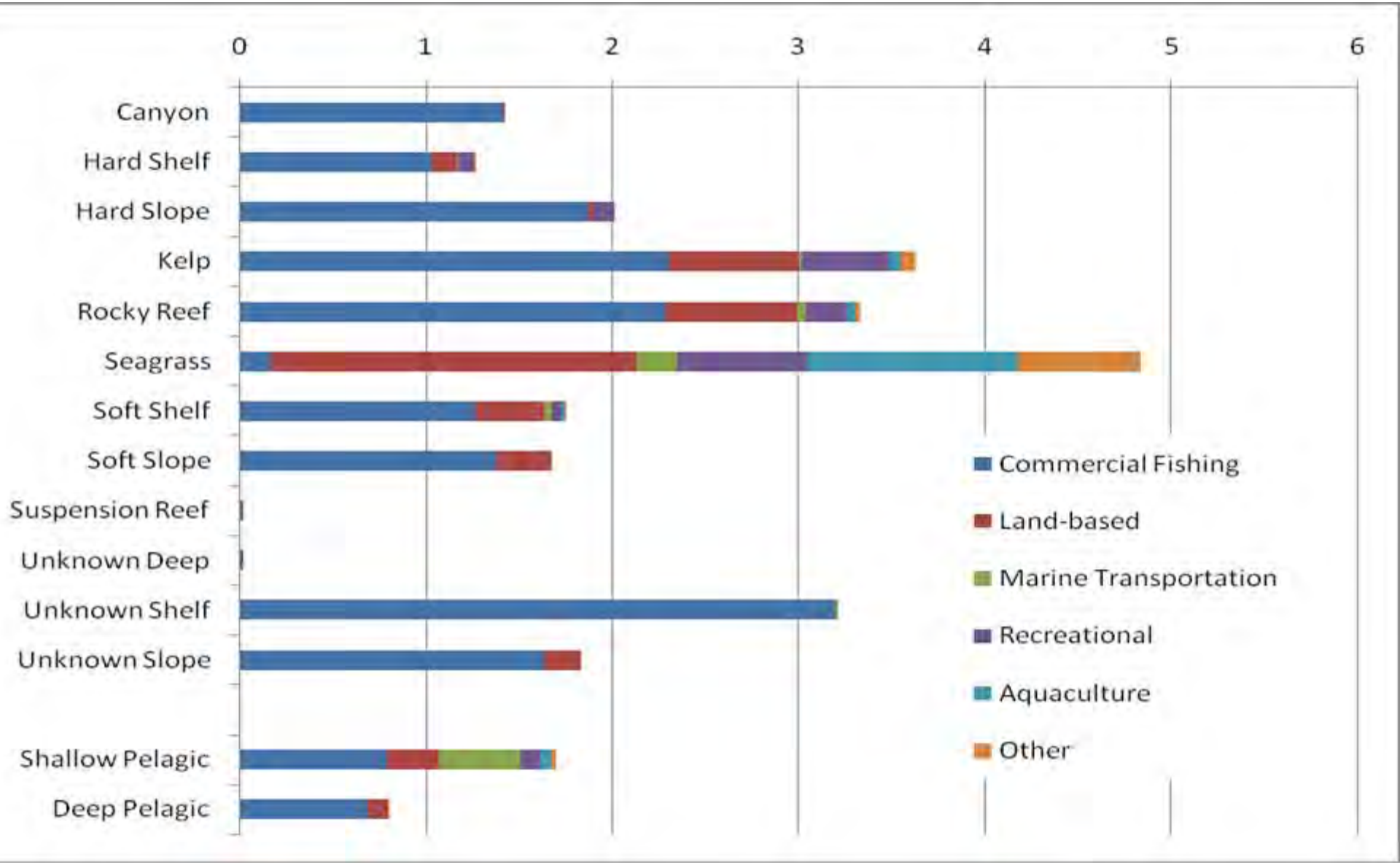


Cumulative stressors by ecoregion, benthic habitats




Summary of risks by activities on benthic, deep and shallow pelagic environments
LAND BASED
Mining
Towns
Pulp and Paper
Agriculture
Industry
Logging Related
RECREATIONAL
Unspecified (hook and line)
Recreation Trap Fishing
Fishing/Other floating lodges
Diving
COMMERCIAL FISHING
Groundfish Bottom Trawling
Prawn
Sablefish Trap
Groundfish ZN
Shrimp Trawl
Red Urchin
Crab
Salmon Troll
Geoduck
Schedule II
Sablefish Longline
Herring Roe
Sea Cucumber
Green Urchin
Salmon Net
Octopus
Herring
Gooseneck Barnacle
Squid
Benthic
Deep Pelagic
Shallow Pelagic
0
4,000
8,000
12,000
16,000
20,000
Modeled Impact Score (1x10⁶)

Summary of risks on habitat types by activities

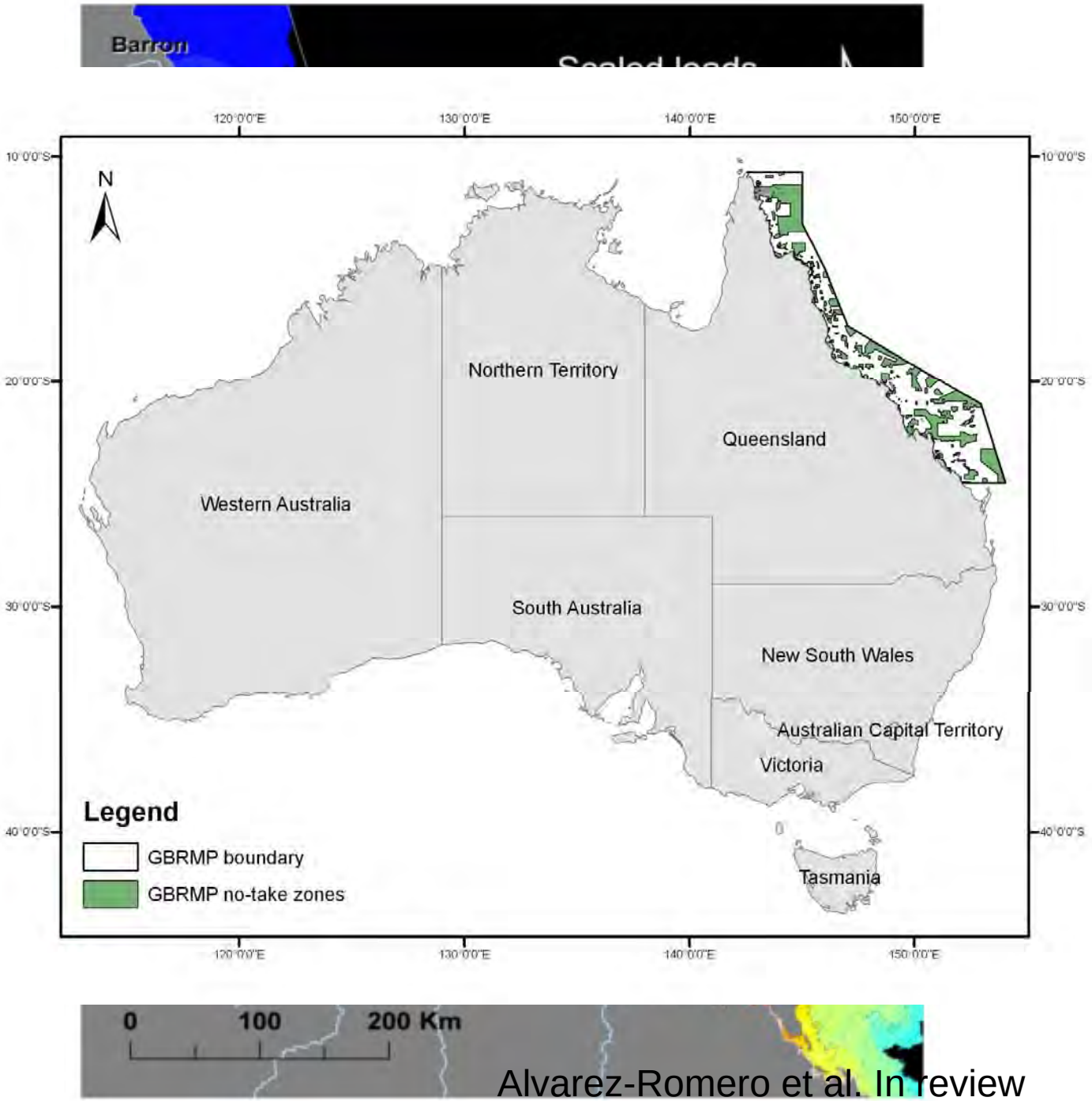


Limitations

- Data availability and quality
- A snapshot in time
- Assumptions – stressors as additive
- Results make sense at a regional scale, but no ground-truthing

Potential improvements

- Improving spatial data
- Use better information about potential interactions of multiple stressors



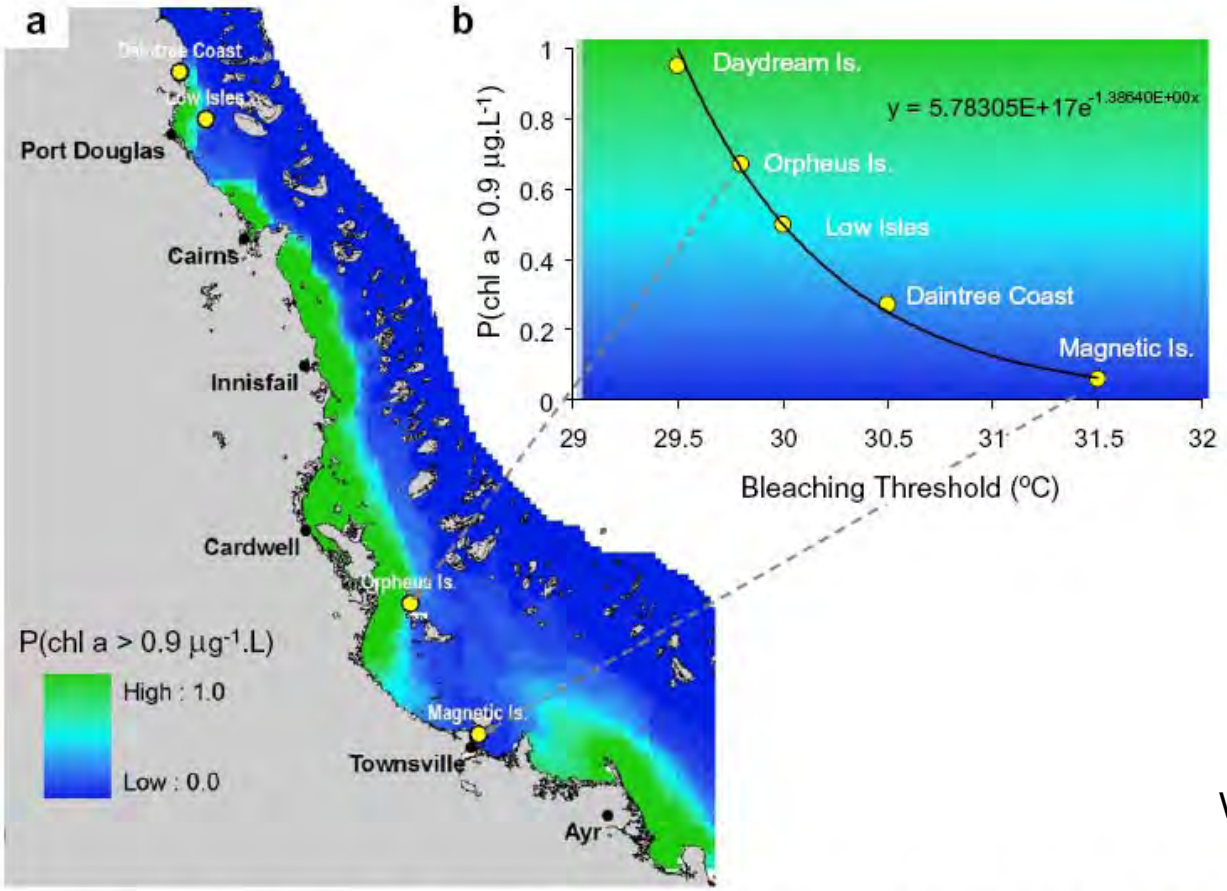
Alvarez-Romero et al. In review

Interactions among stressors

- Use better information about potential interactions of multiple stressors
  - Meta-analyses
  - Expert elicitation
  - Bayesian approach useful – can integrate such information as “prior beliefs”, and update as new information becomes available

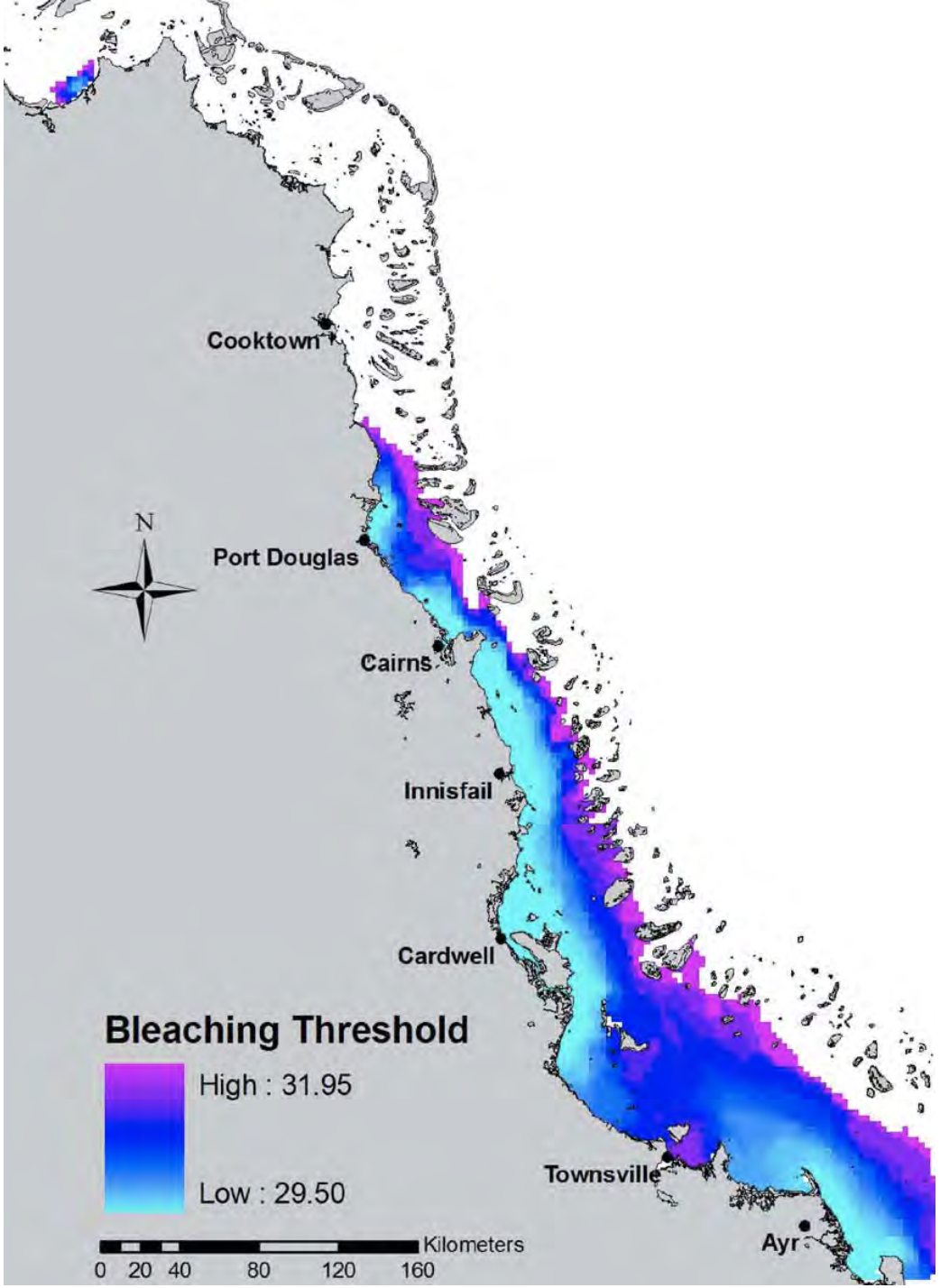
Stressor Interaction Example

- Probability of exceeding a threshold of chlorophyll concentration
- Link between chlorophyll and coral bleaching



Wooldridge, 2009

Fig. 3. (a) Flood plume analysis for the GBR lagoon (1969–2002) showing the annual exceedence probability of Chl *a* > 0.9 µg/L (after Wooldridge et al., 2006), (b) Quantitative spatial link between upper thermal bleaching limits and degree of exposure to nutrient-enriched terrestrial waters.



Wooldridge, 2009

Conclusions

- Informative use of existing data and information
- Baseline for future mapping
- Opportunities to improve mapping approaches
- Need to ground-truth mapping efforts

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.

Thank you

Travel support:

surface ocean solas lower atmosphere study

Research support:

ARC Centre of Excellence Coral Reef Studies

Australian Government
Australian Research Council

JAMES COOK UNIVERSITY AUSTRALIA

Australian Government
Great Barrier Reef Marine Park Authority

surface ocean solas lower atmosphere study

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Xiamen, China
23rd August - 2nd September 2013

- To expose graduate students and young scientists to recent developments and methodologies in the study of biogeochemical and physical feedbacks between the ocean and atmosphere in a changing environment
- First time to be held in Xiamen, China after 5 continuous successful schools in Cargese, Corsica, France

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