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Characterizing and predicting Aquatic Invasive Species distributions: Reconciling large-scale model predictions with small-scale observations and incorporating climate change scenarios

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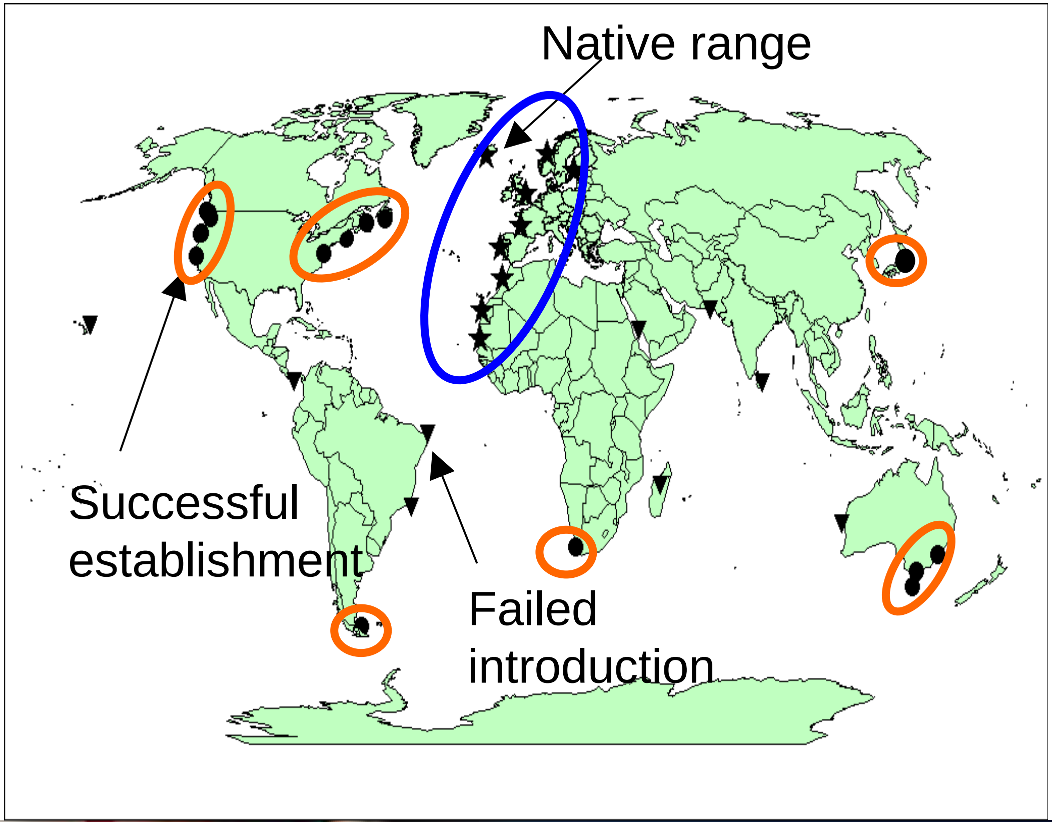
Canada

European Green Crab (*Carcinus maenas*)

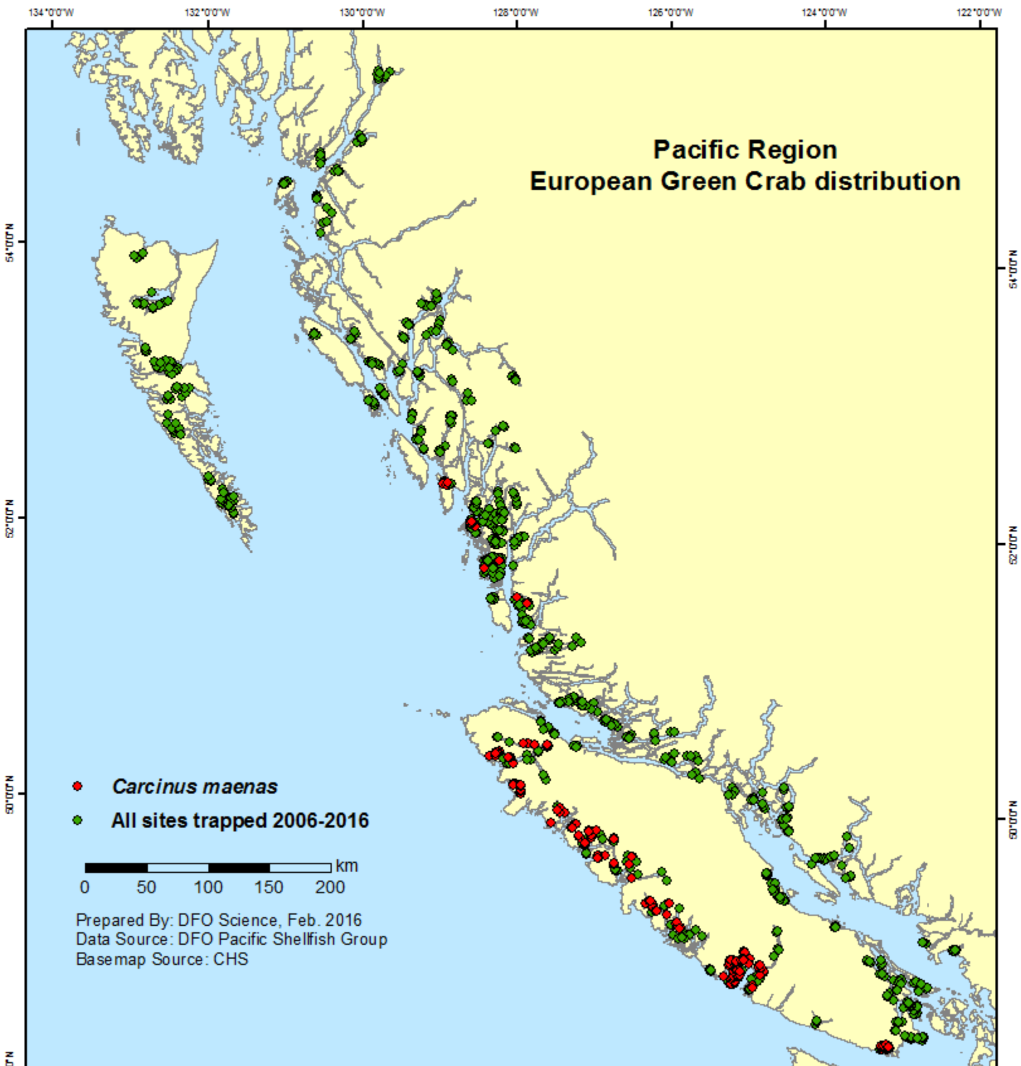


- Ranked on IUCN “100 Worst Invaders” list
- Globally many introductions
- Often negative ecosystem impacts including fisheries and aquaculture

West Coast of North America GC

- Arrived in San Francisco Bay in 1989 (packing material)
- Slowly expanded northward into Pacific Northwest
- Arrived in BC through larval transport during 1998/99 El Nino
- Relatively few public reports after 1999
- No surveys until 2006

Current Green Crab Distribution in BC



- Continue to spread north (larval dispersal)
- Only recently reported from Salish Sea (late fall 2016)
- Managers need to know the potential distribution both now and in the future

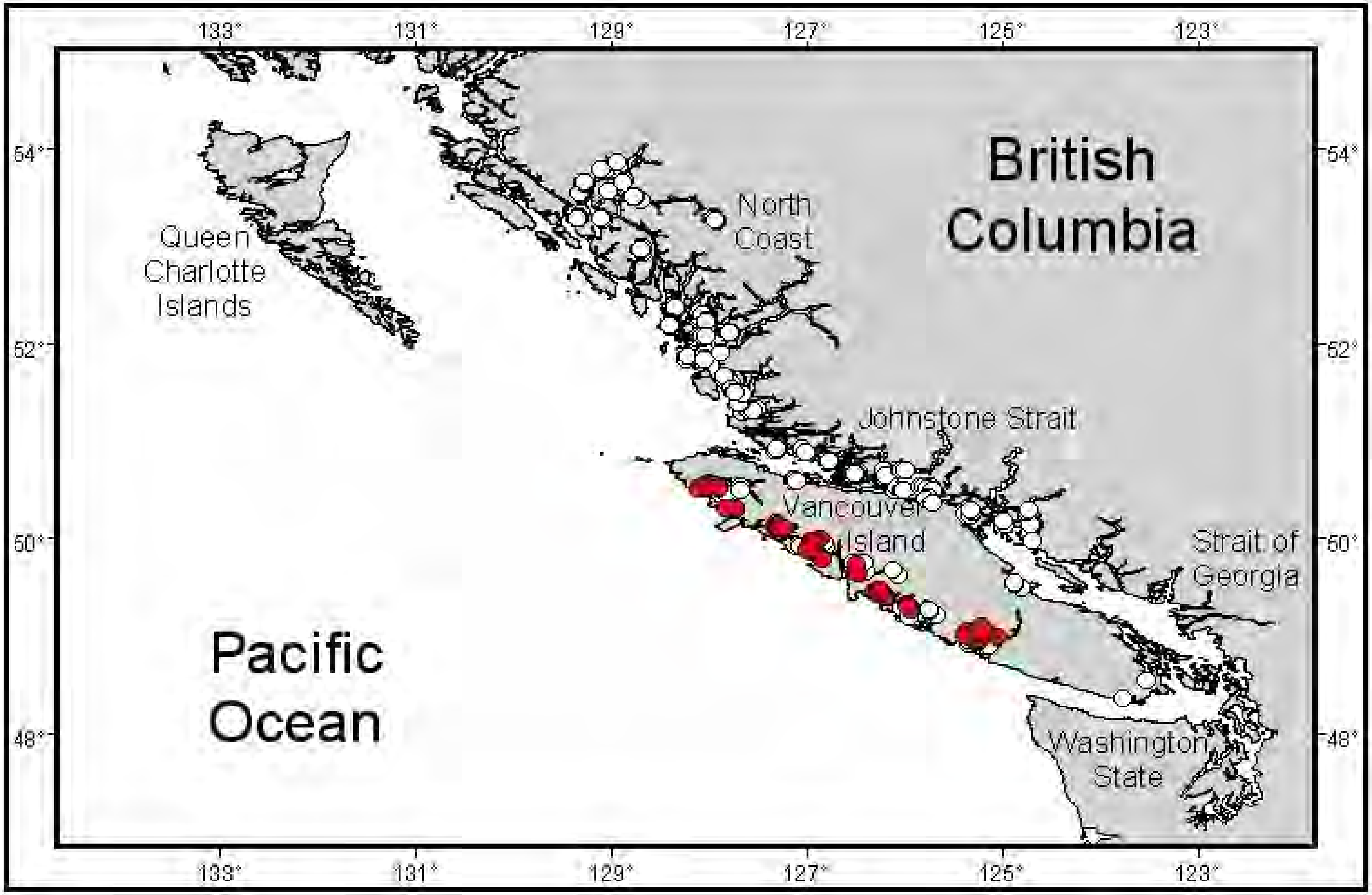
It Is Not Just About Distribution

- Simply knowing an AIS is present in a specific location is of limited utility

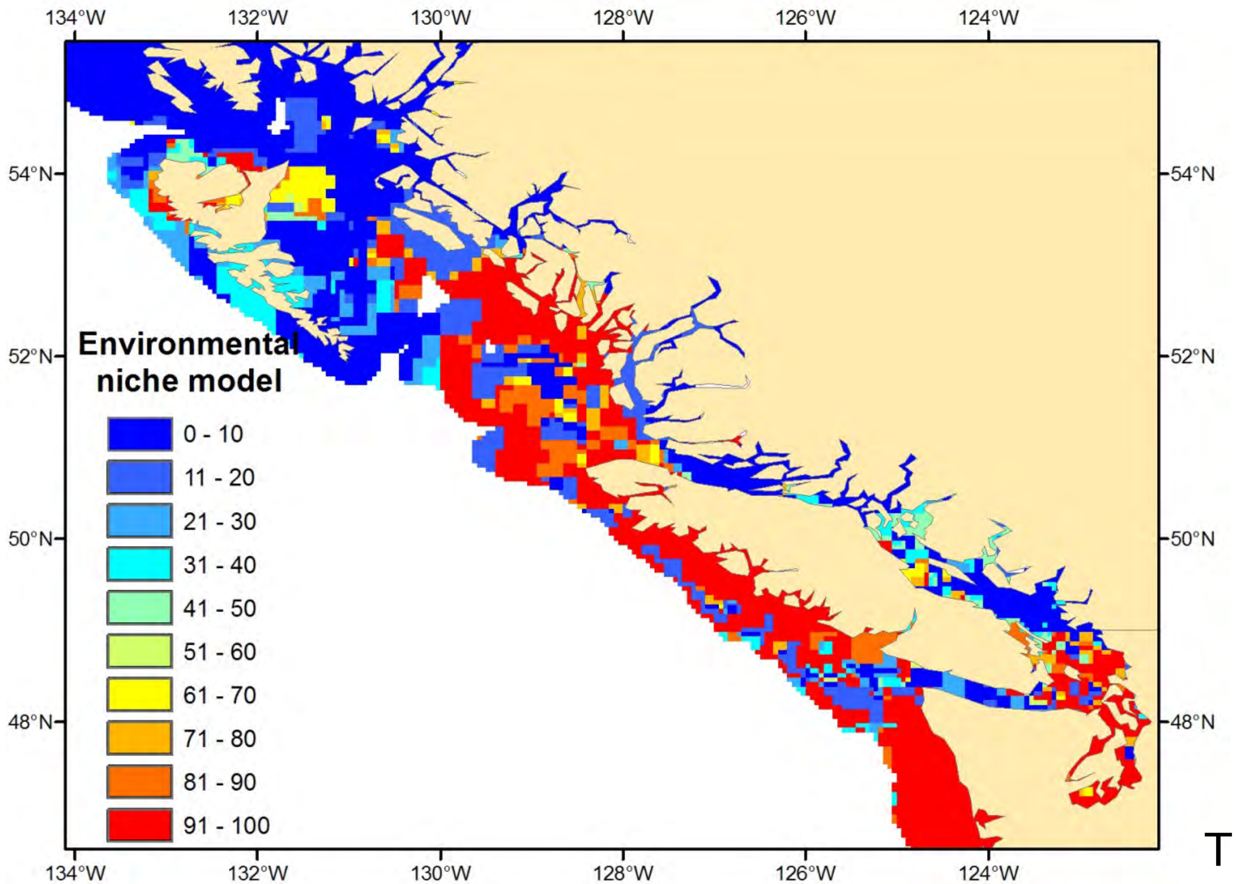
- Managers really want to know where invasion “hotspots” are most likely in order to best utilize limited resources

- Especially true if these “hotspots” are unique (i.e., Salish Sea)

So Where Were We in 2006?



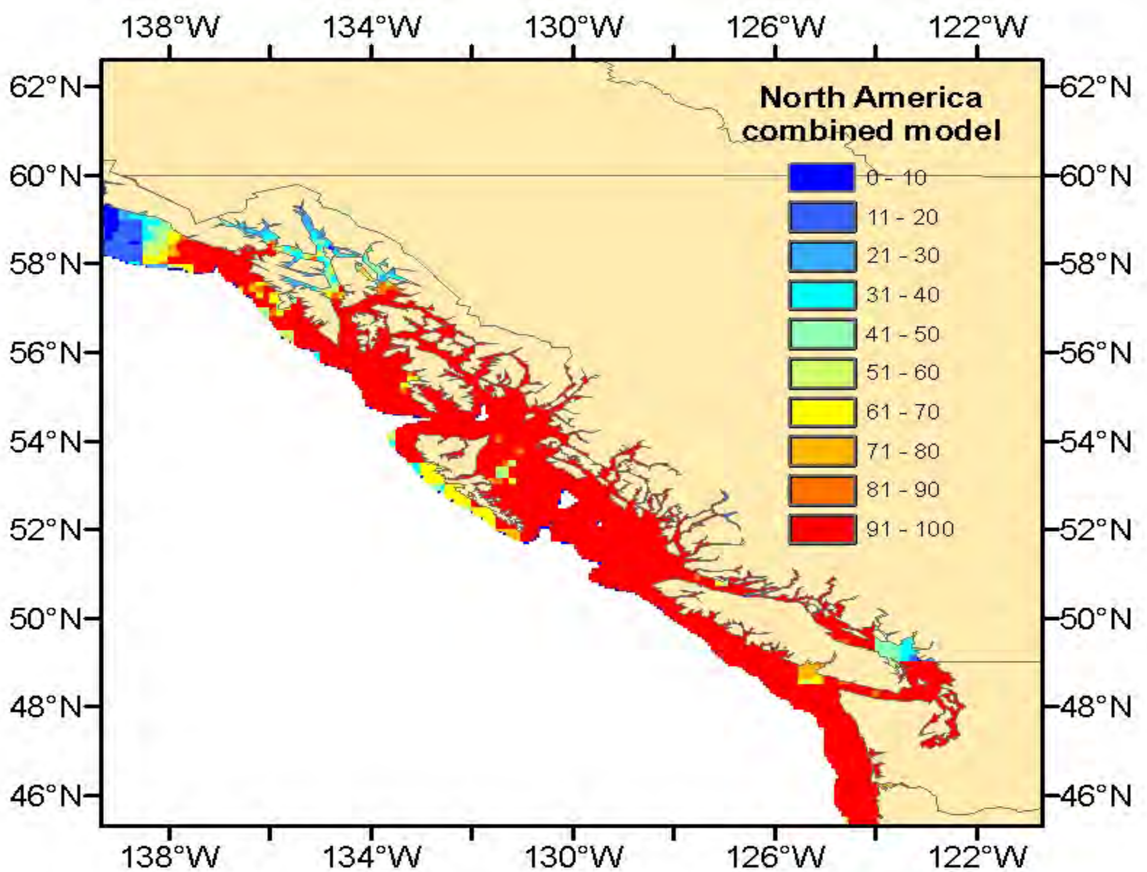
Potential Distribution - 1



- GARP model based on west coast distribution in 2006-07

Therriault et al. 2008

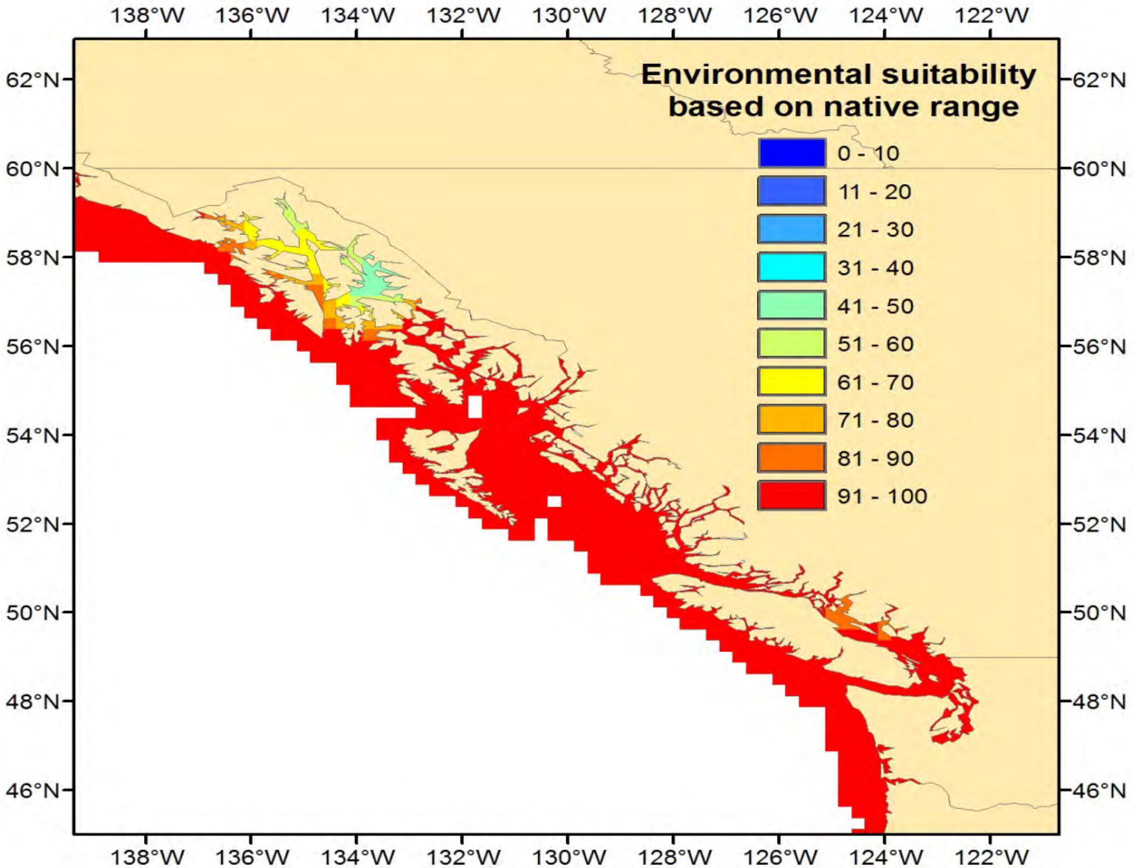
Potential Distribution - 2



- GARP model based on Canadian distribution (both east coast and west coast locations)

Therriault et al. 2008

Potential Distribution - 3



- GARP model based on native range of European green crab

Therriault et al. 2008

Challenges with Initial Predictions

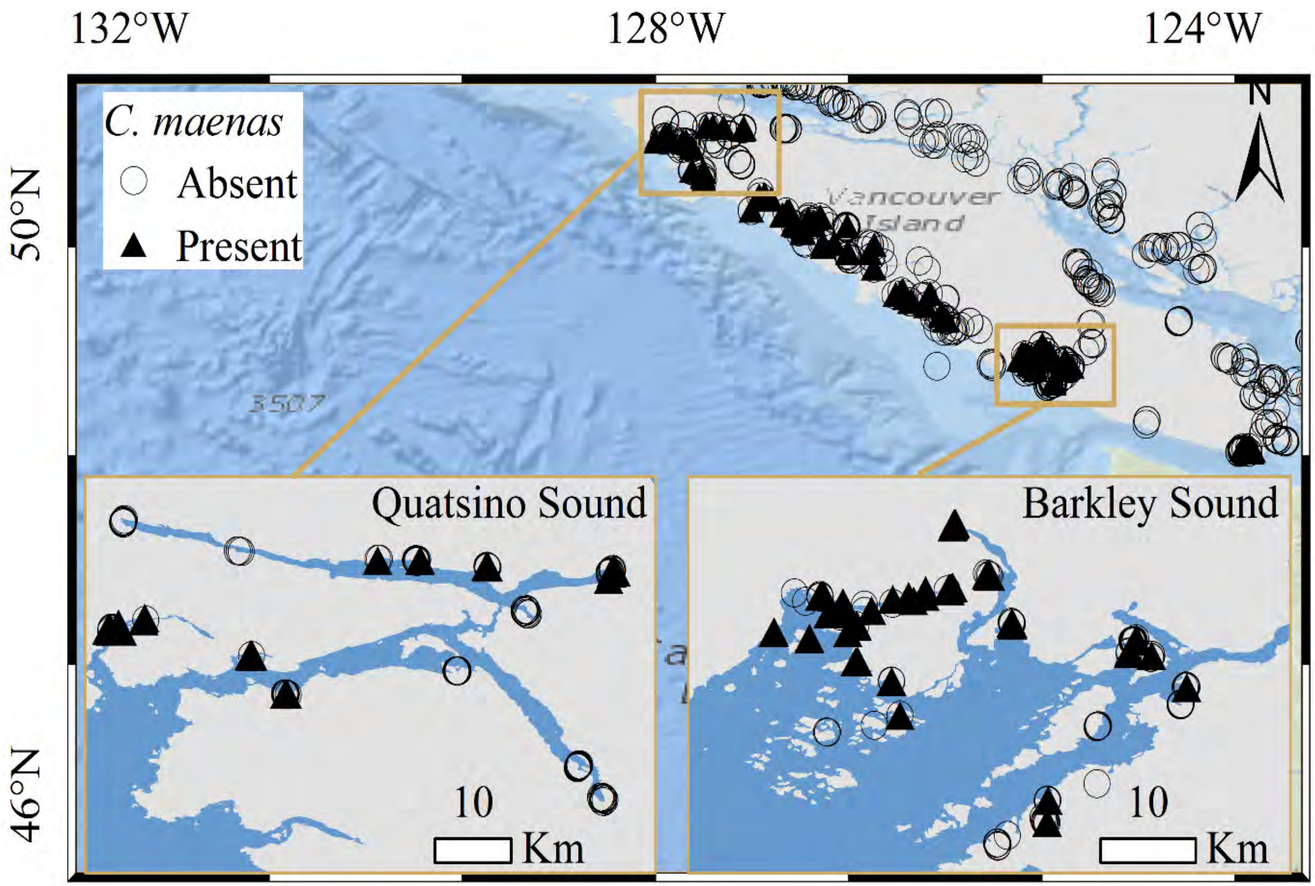
- Not overly informative for AIS Managers (most of BC suitable in all scenarios)
- Differences in abundance (and hence potential impacts) among sites not captured (i.e., hotspots NOT identified)
- So how to move forward?
  - Different variables?
  - Different scales?
  - How to identify the right variables and the right scales?

Factors Constraining AIS Distributions

- For coastal temperate marine species, including AIS, “reproductive success” is constrained primarily by temperature and salinity thresholds for growth, survival, and reproduction

- Additional factors can further constrain AIS invasion success including environmental and biotic (i.e., prey, competition) variables

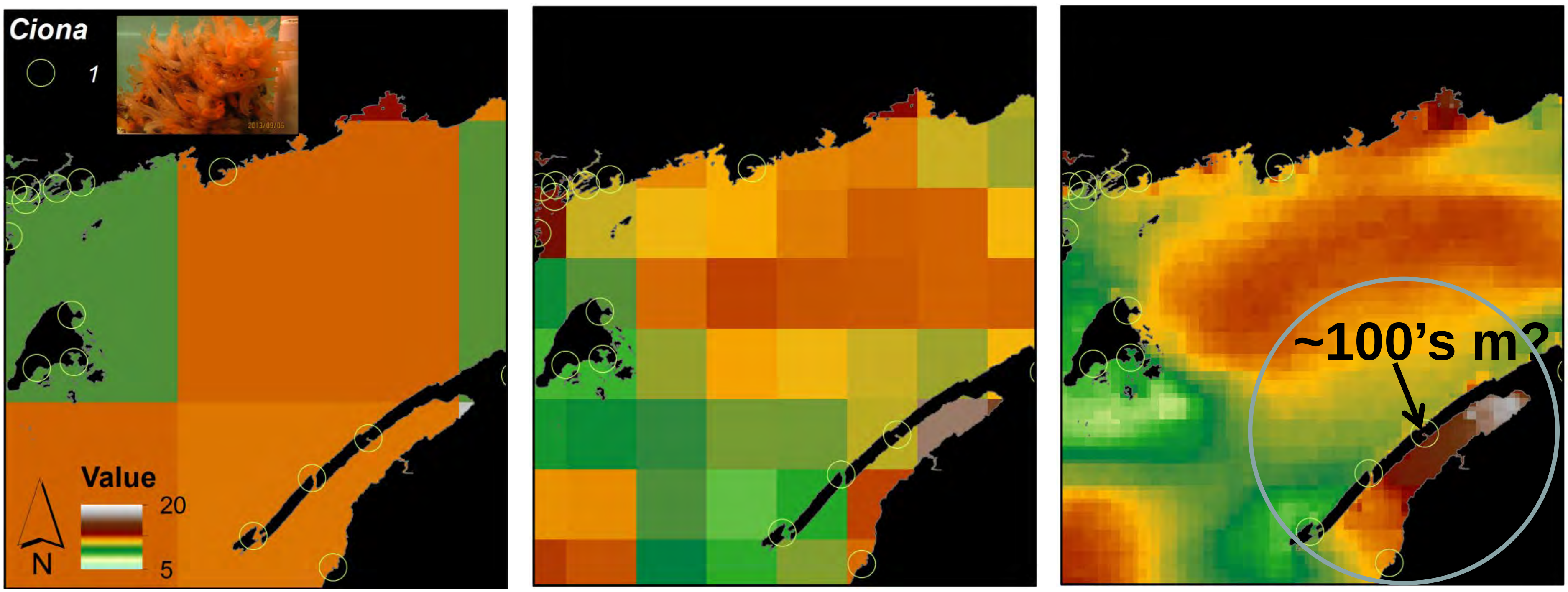
Predictions Using “Enhanced” Data



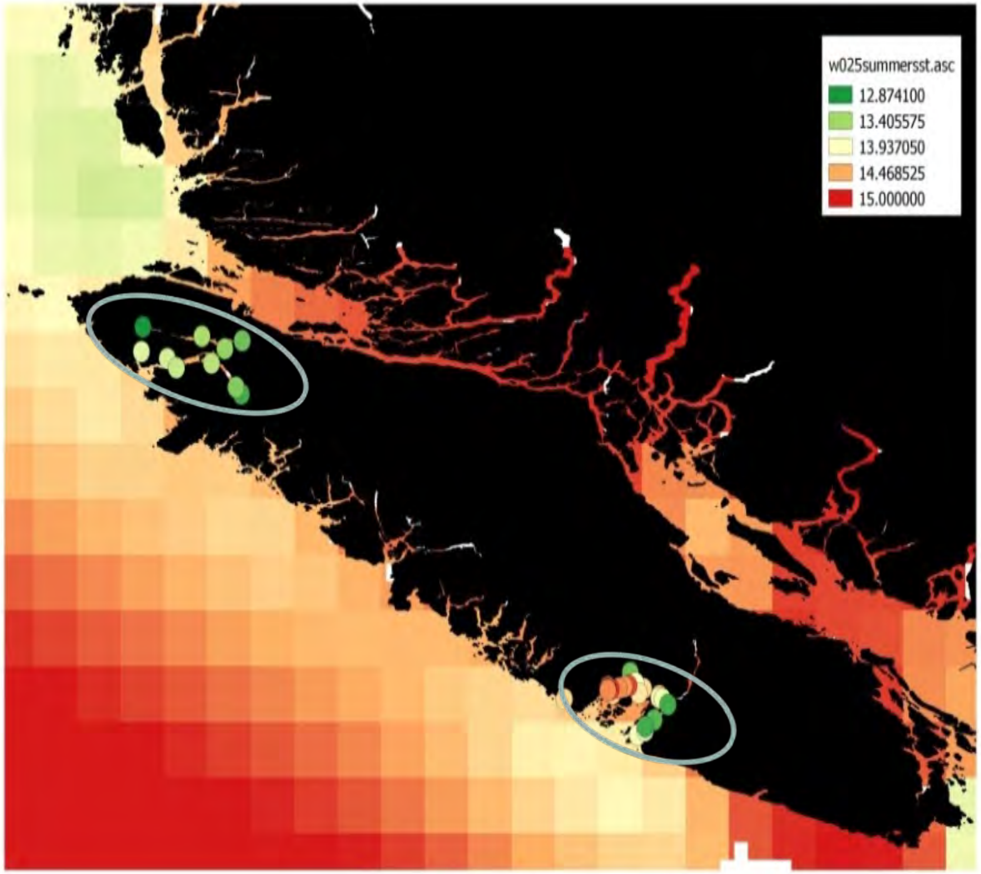
Lowen et al. 2016

But What is the “Best” Scale for Predictions?

~ 64 km ~ 16 km ~ 1 km



Environmental Topography



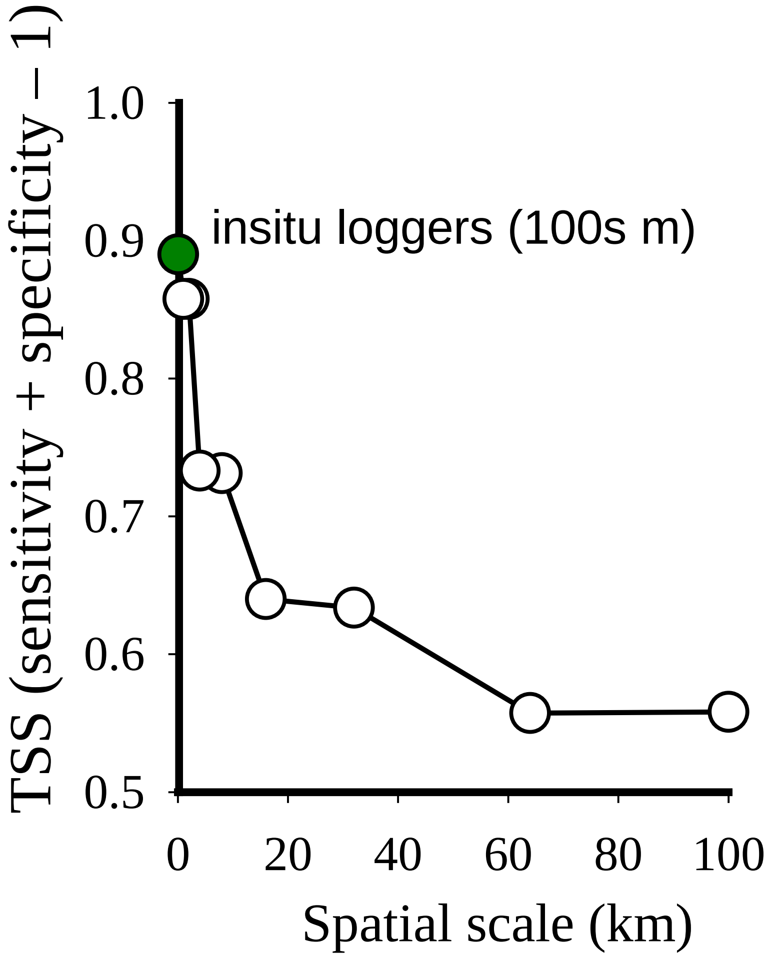
- Summer SST
  - at 25 km (squares)
  - at 100's m (circles)
- Complexity of BC's sounds and fijords with very limited data complicate predictions

So Our “BIG” Question

How does spatial resolution of ecological factors that constrain AIS distributions (e.g. temperature and salinity) influence the probability of accurately identifying suitable coastal habitats for AIS like GC?

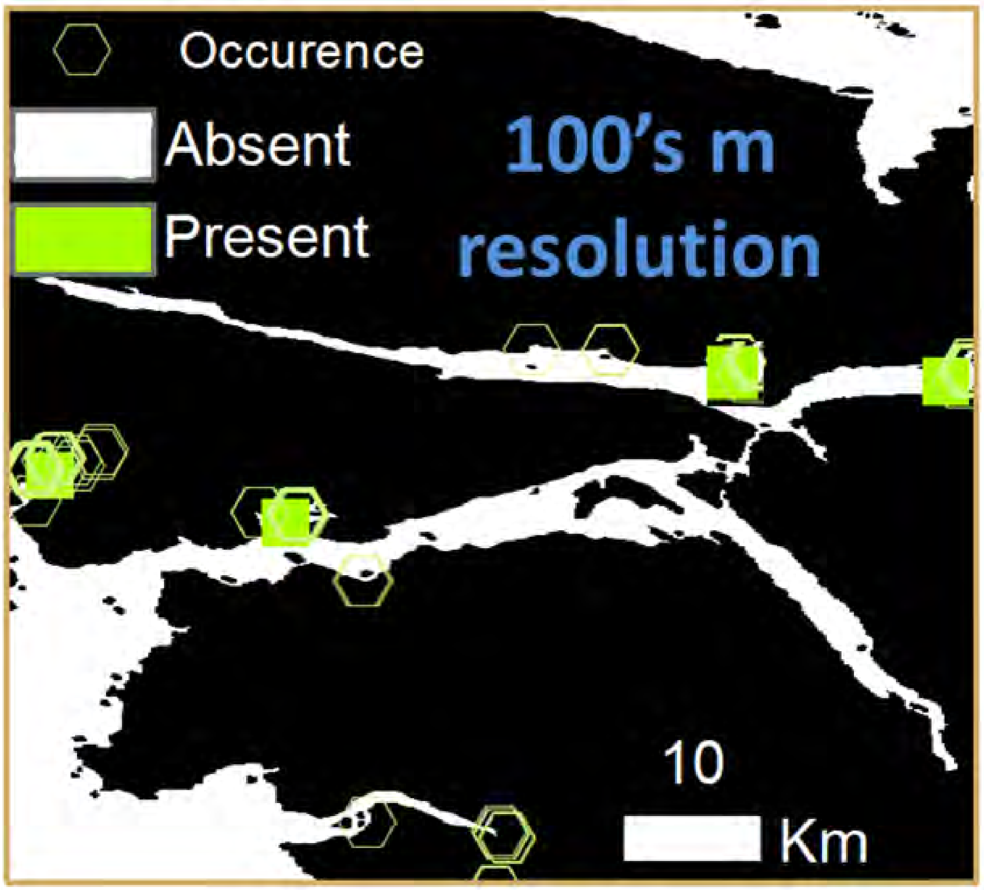
Really this represents a trade-off between relatively fine spatial resolution data that may be required (and unavailable) for predictions and coarser spatial resolution data that may be available but is masking important variation ultimately reducing the utility of predictions

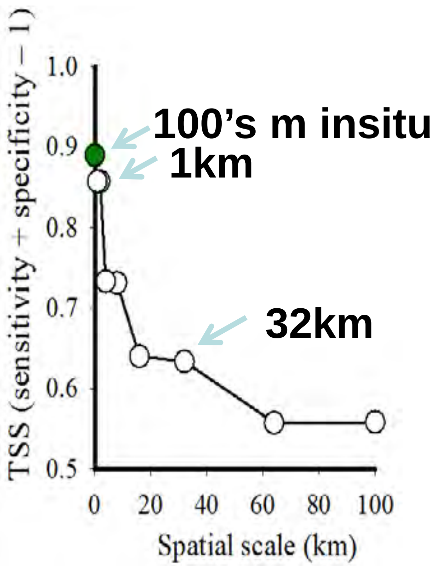
Resolving Observed GC Distributions in BC



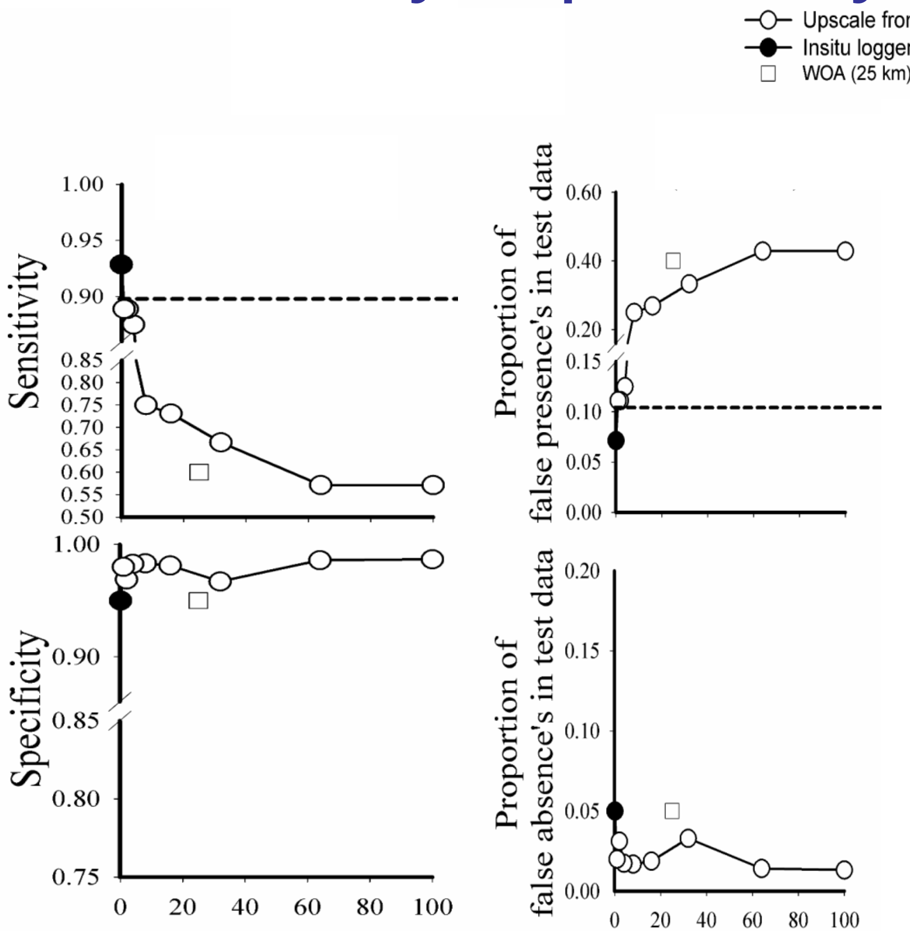
- Used MaxEnt
  - which minimizes relative entropy between environmental and distribution probability densities
- Predictive Power (TSS) decreased with increasing spatial scale

Predictions with Increasing Resolution





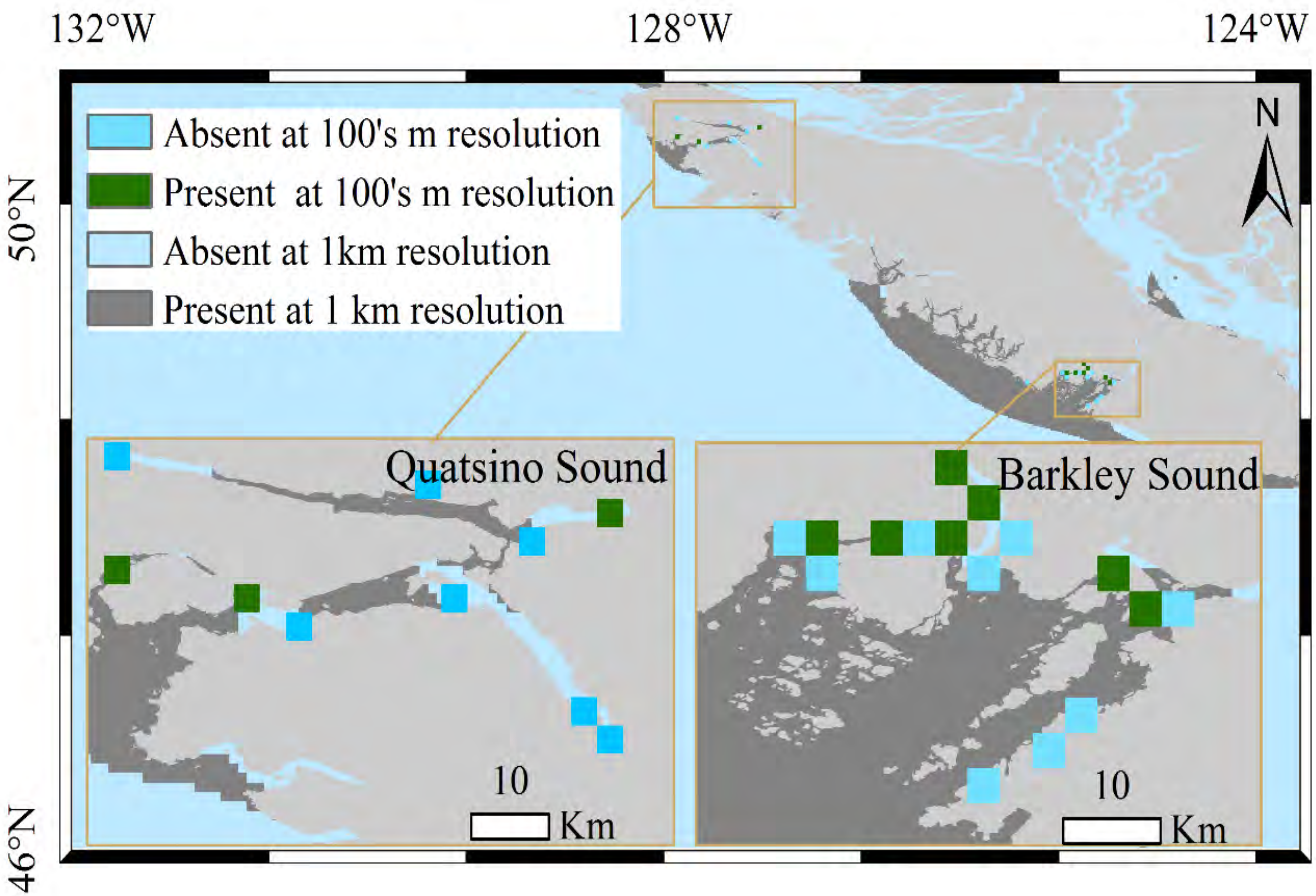
Sensitivity, Specificity and Reliability



Spatial Resolution of Predictors (km)

Lowen et al. 2016

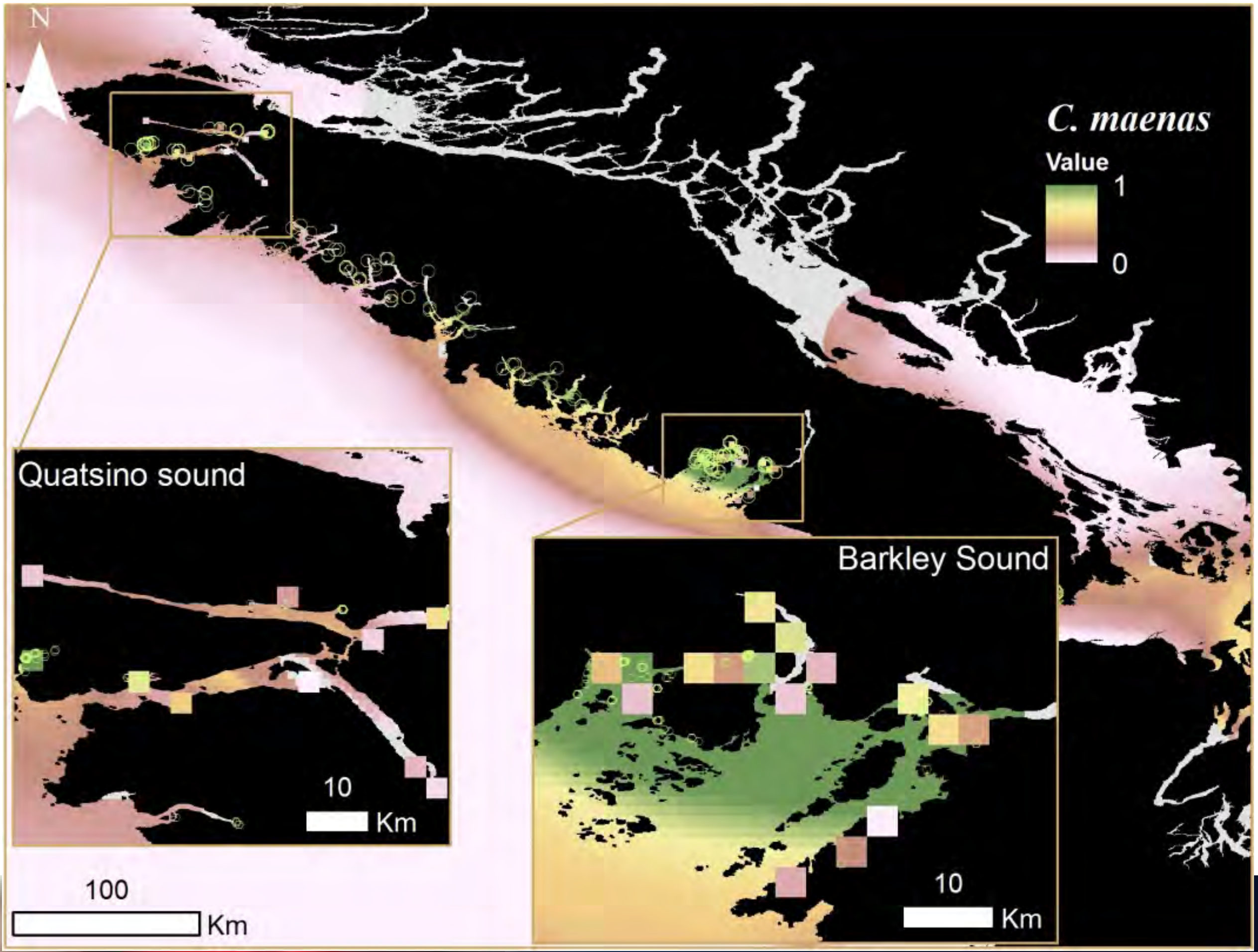
An “Optimal” Resolution for ENMs?



- “Best” predictions at 100s of m but resolution < 4 km was acceptable

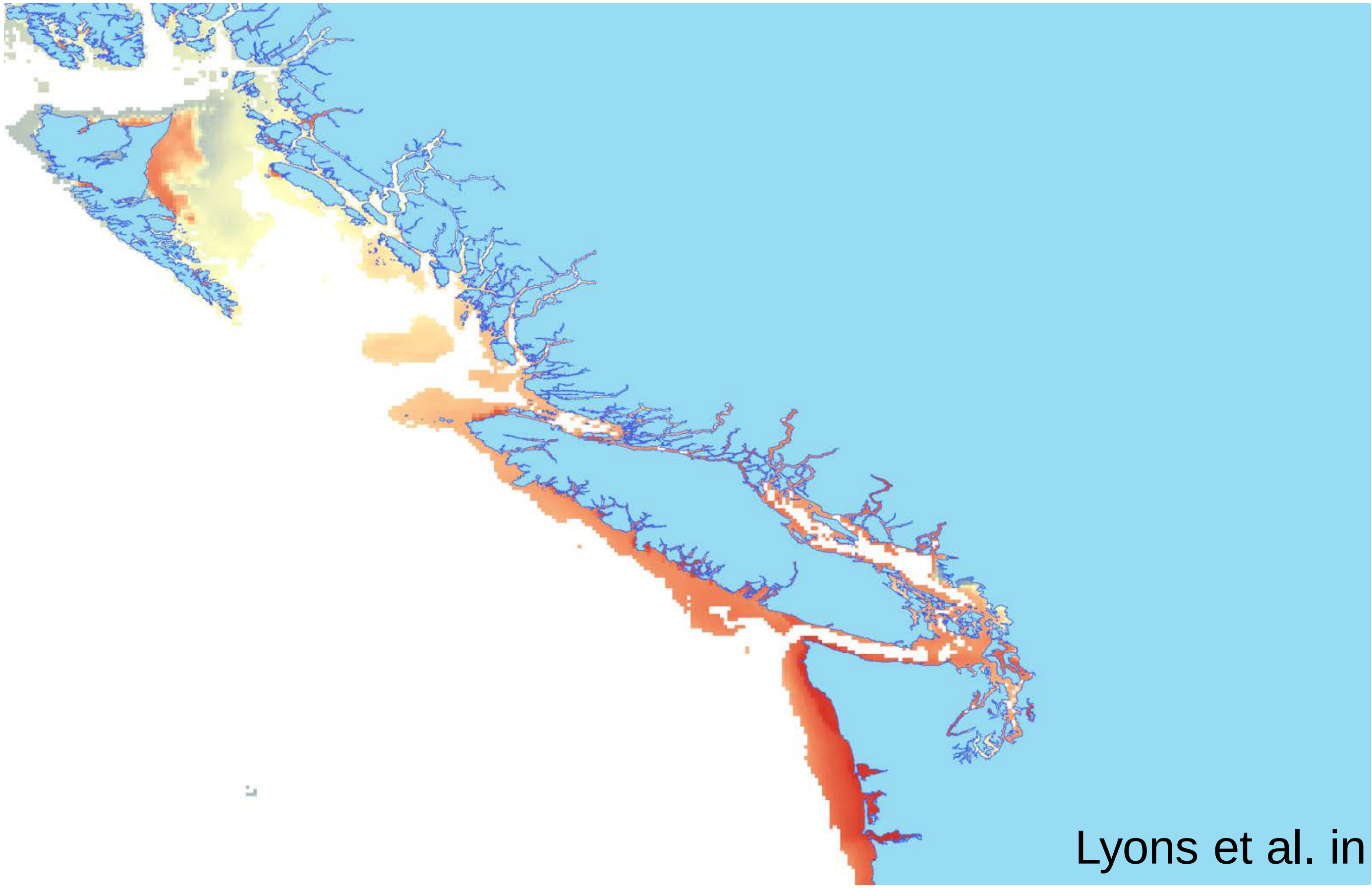
Lowen et al. 2016

But What about the Salish Sea?



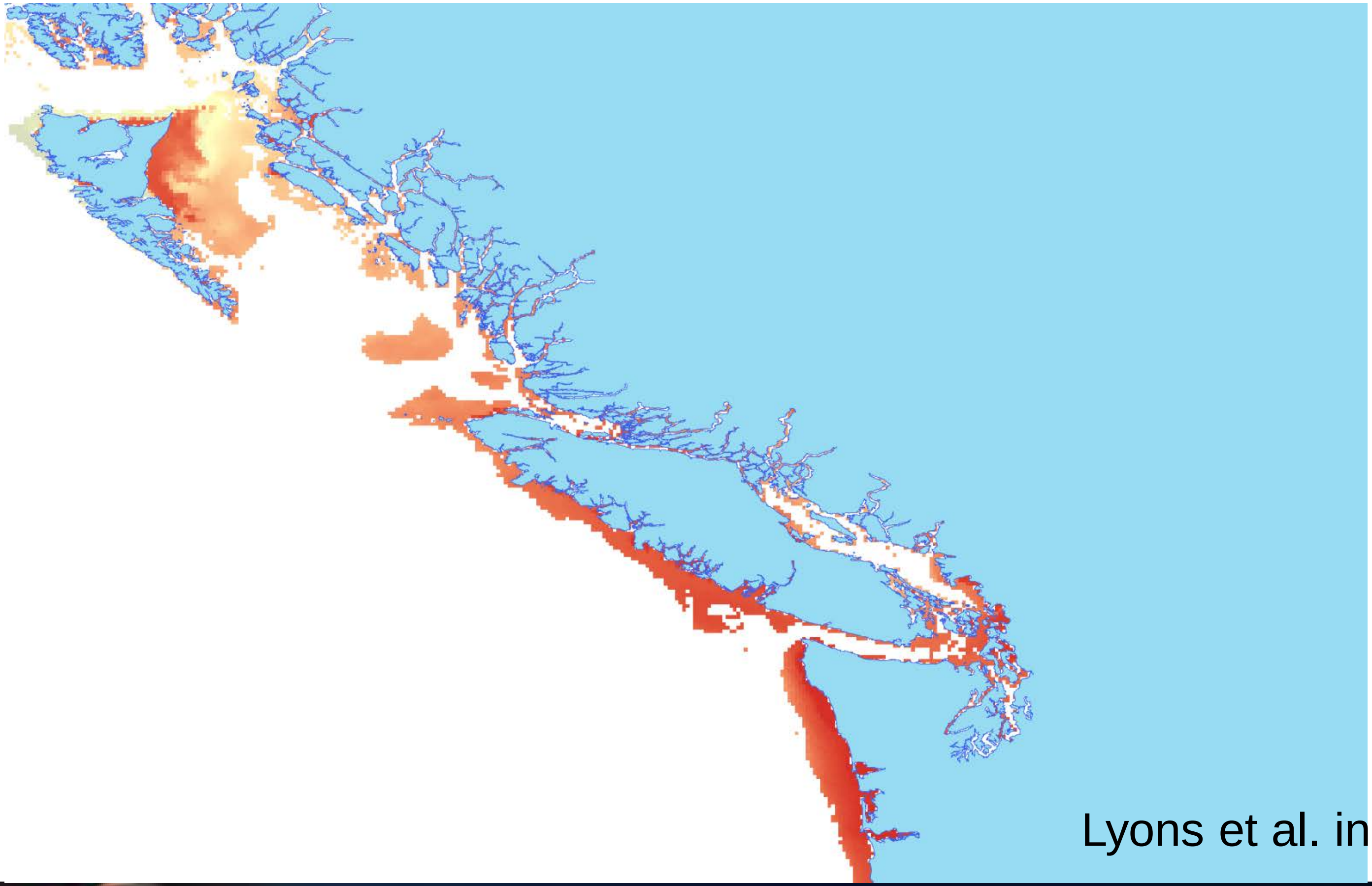
- In fall 2016 GC were detected on US side of Salish Sea
- Additional modeling may help refine predictions

"Updated" MaxEnt Models



Lyons et al. in prep

Climate Projection MaxEnt Models



Lyons et al. in prep

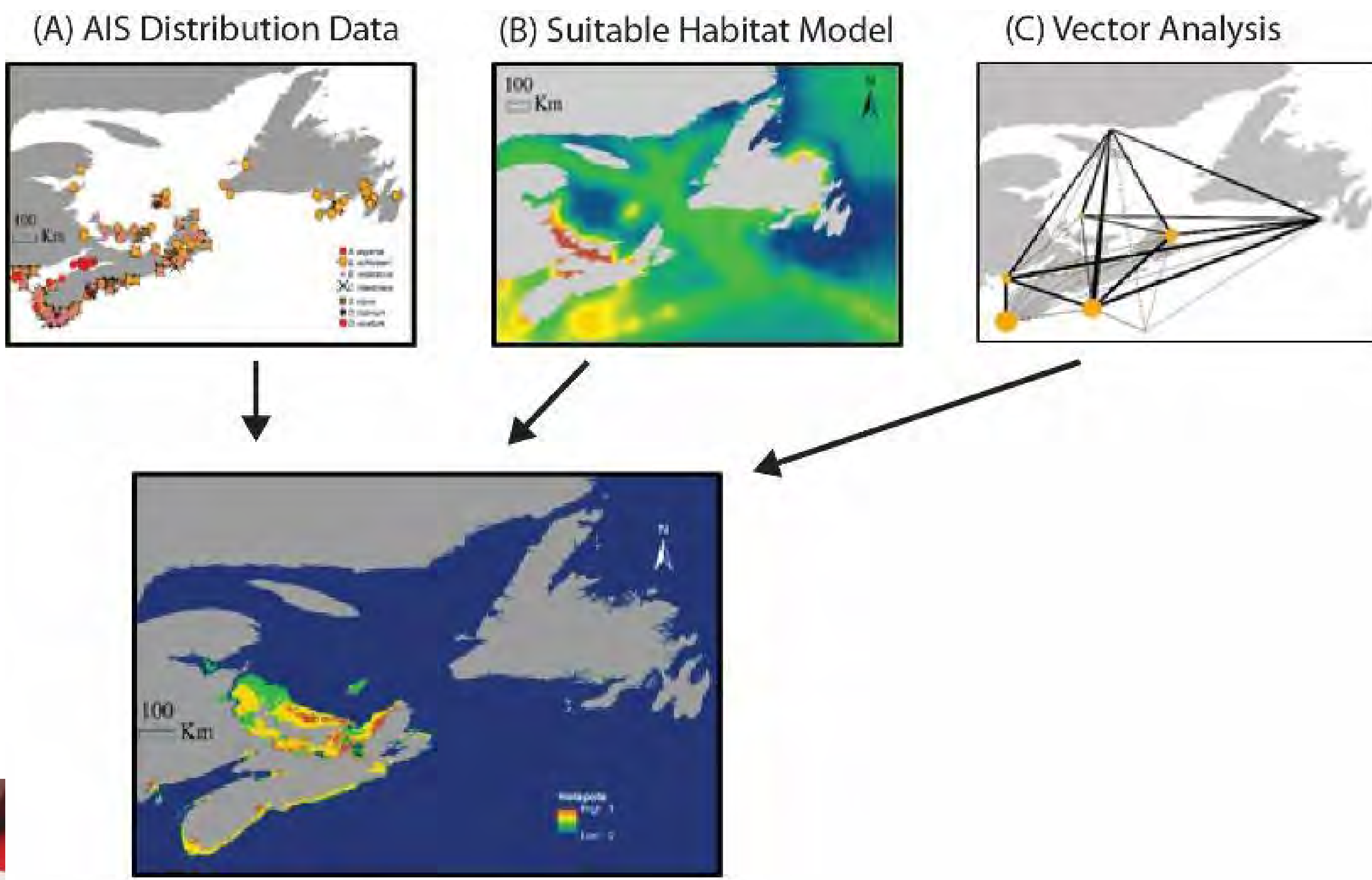
Conclusions

- Probability of accurately identifying suitable habitat for GC increased with spatial resolution of limiting environmental variables but “optimal” scale is likely to differ among AIS
- Suitable habitat for GC exists throughout coastal BC however, in the Salish Sea it is patchy
- Climate change likely to increase amount of suitable habitat for GC in BC

Conclusions (and Caveats)

- Invasion vectors not modeled here (but work is underway on this)
- Climate change is likely to change AIS vectors and pathways in the future
- Technological advancements should allow much higher resolution environmental monitoring data collection in the future

Next Steps


(A) AIS Distribution Data
(B) Suitable Habitat Model
(C) Vector Analysis
100 Km
100 Km
100 Km

Acknowledgements

- All the Green Crab trapping teams
- Funding provided by Fisheries and Oceans Canada's Aquatic Invasive Species Program and the Second Canadian Aquatic Invasive Species Network (CAISN II)