# Our coasts, our fish, and our communities in a changing climate: there's good news and bad news….

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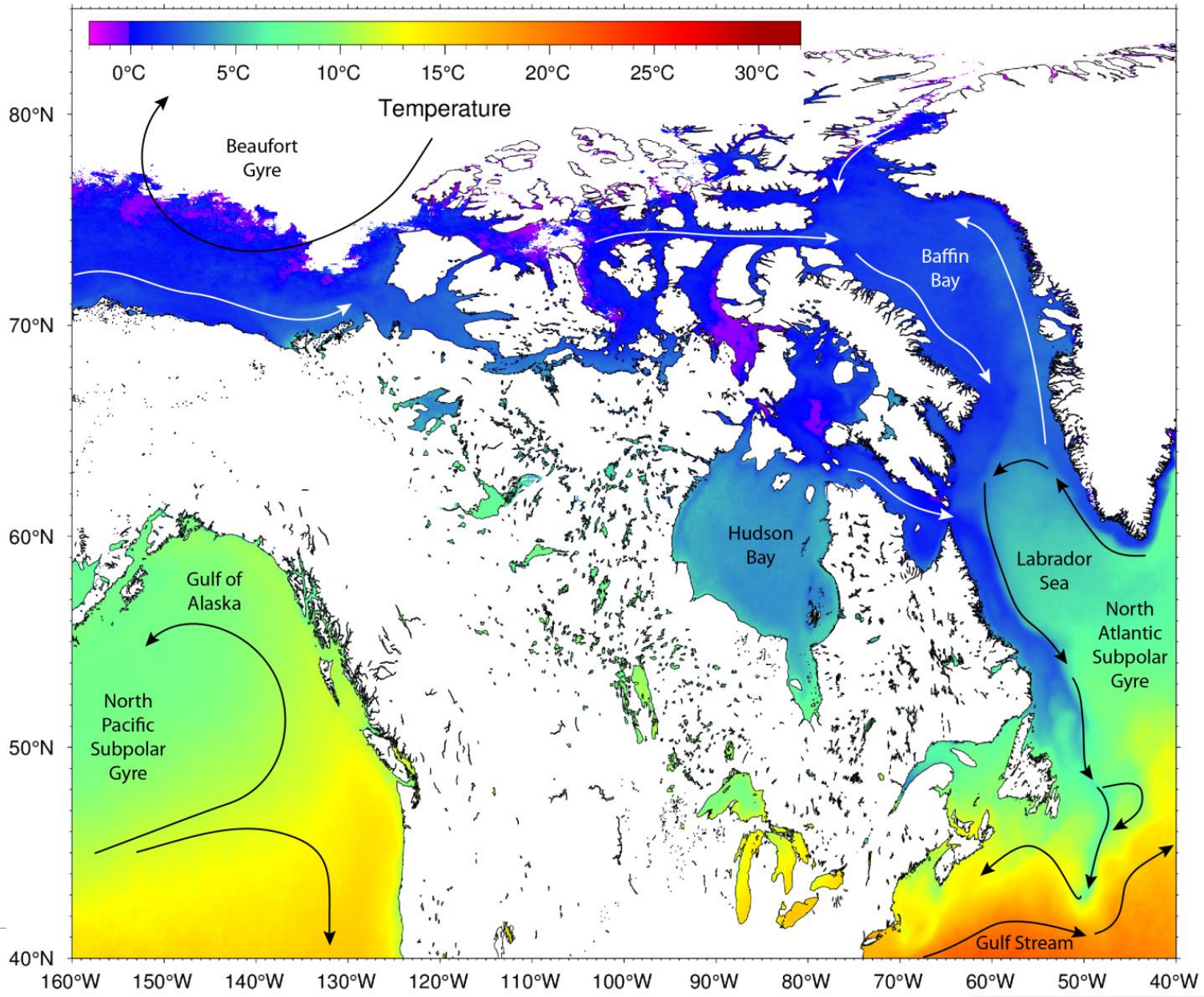
DFO, BIO
March 8, 2018 FSRS

# Outline

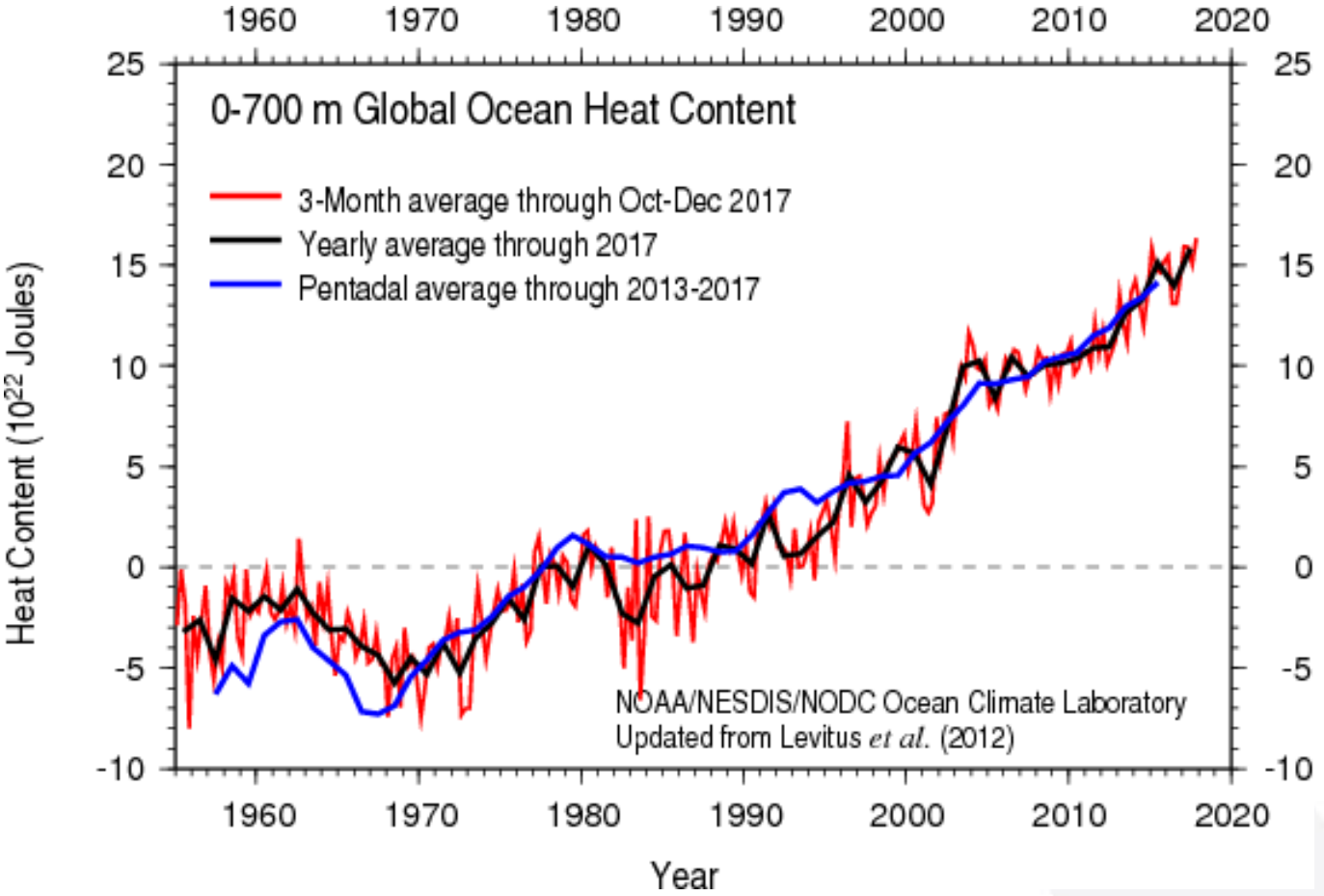
1. Warming trends in Atlantic Canada
2. Preparing for Good/Bad news: Adaptation Plans/Tools
3. Coastal Vulnerability Tool: CAN-EWLAT, CIVI
4. Ecosystem Vulnerability; Distribution shifts (or not)
5. Next steps

->Public website CIVEZ with vulnerability by Economic Zone

# The Physical Setting

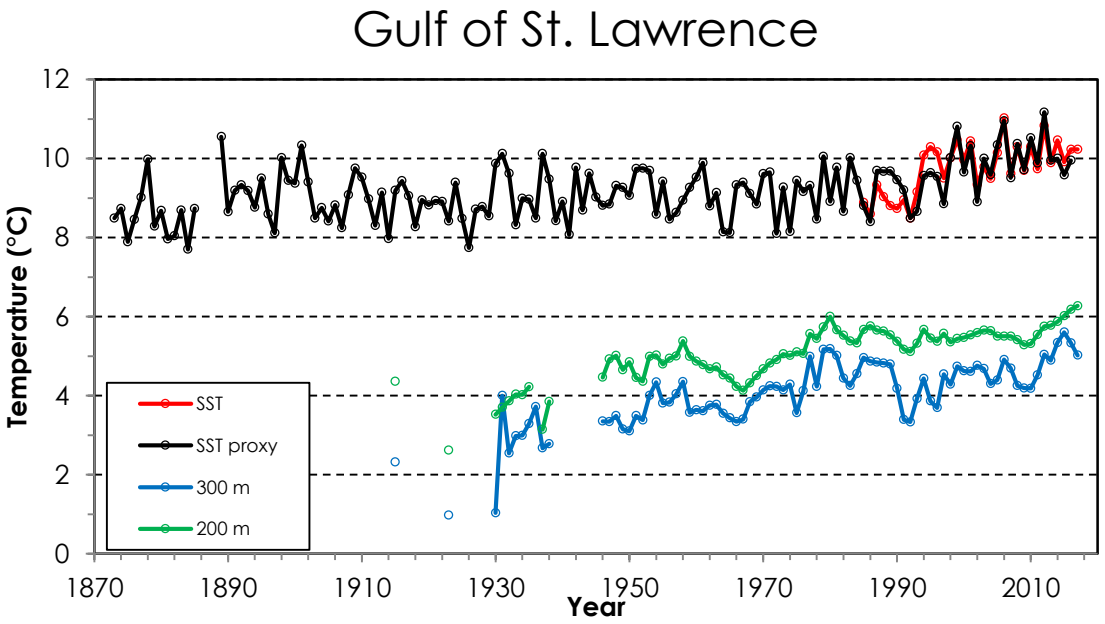


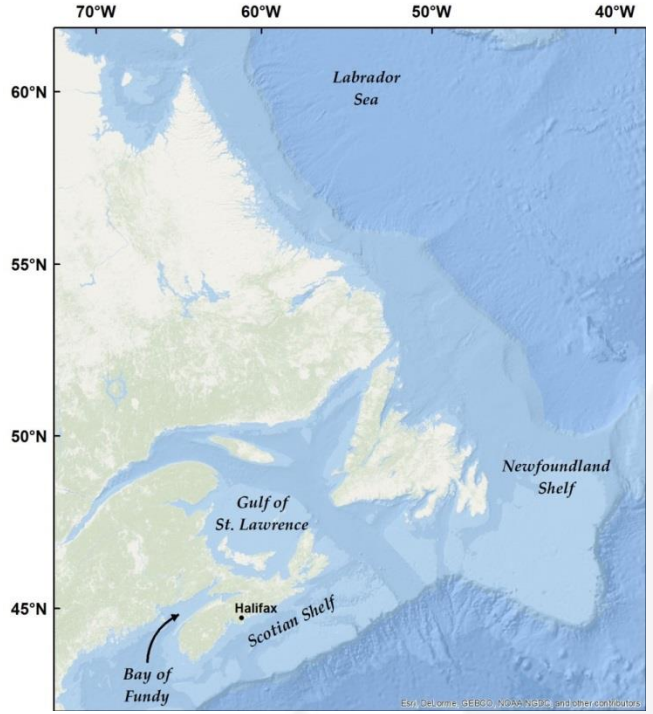
# Global Heat Content of the Ocean




- Demonstrates a strong warming of the global ocean since 1970
- Source: https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/
- DFO contributes to this time series through the International Argo Program http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html

# Temperature (Atlantic Ocean)

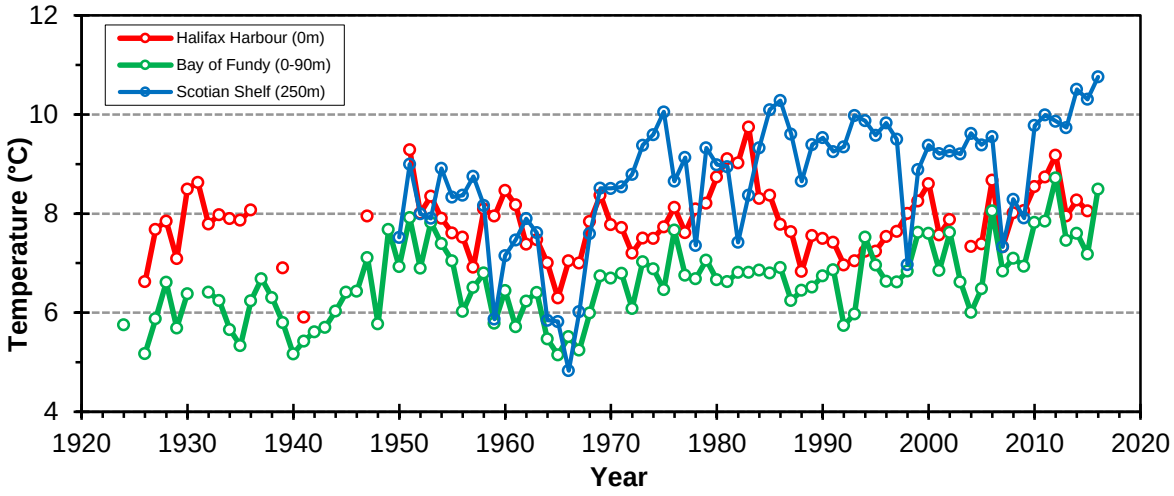


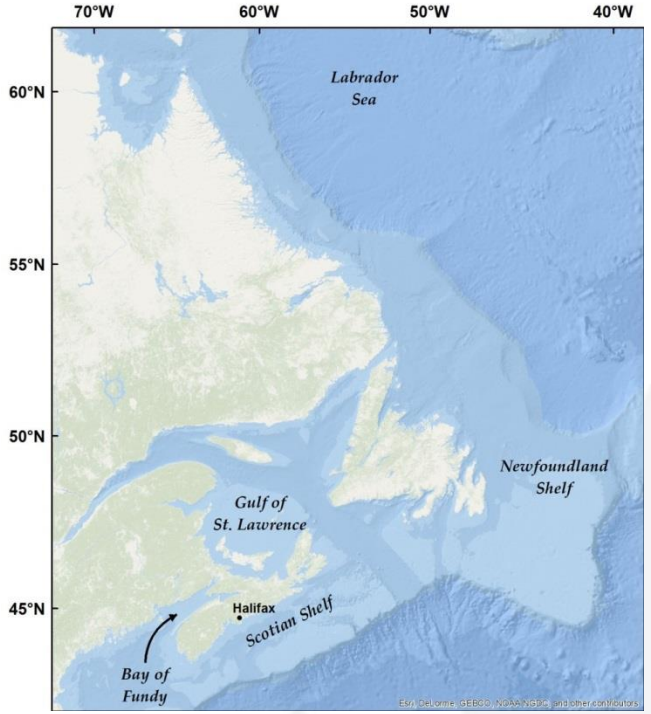




- Gulf of St. Lawrence sea surface temperature (SST) from satellite observations (1985-2017) have been used to generate an SST proxy for earlier years based on recorded air temperatures.
- Ocean temperatures from 200 and 300 m indicate warming in the deep Gulf of St. Lawrence over the past half century at a rate of about +0.2 degrees Celsius per decade.

# Temperature (Atlantic Ocean)

Scotian Shelf and Bay of Fundy

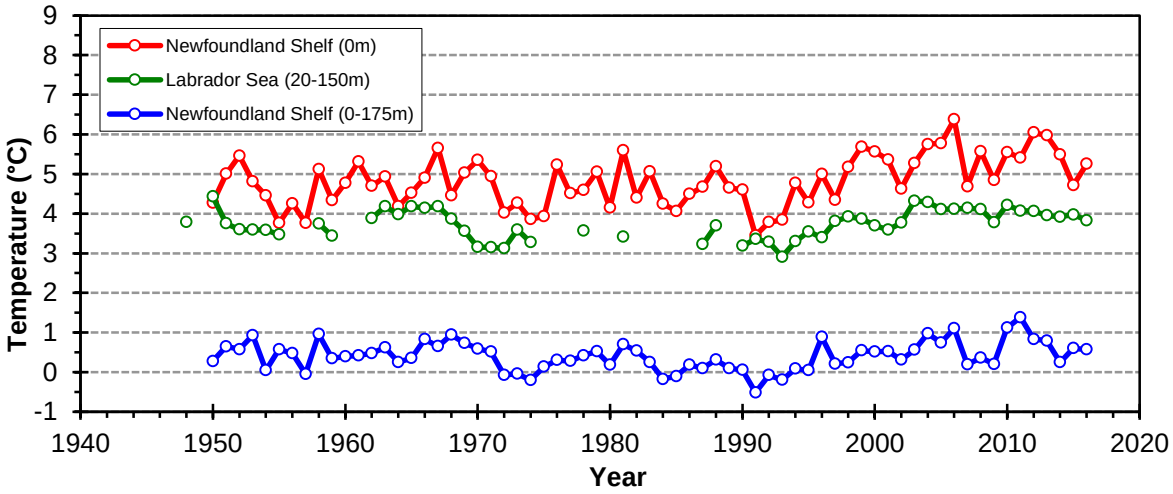


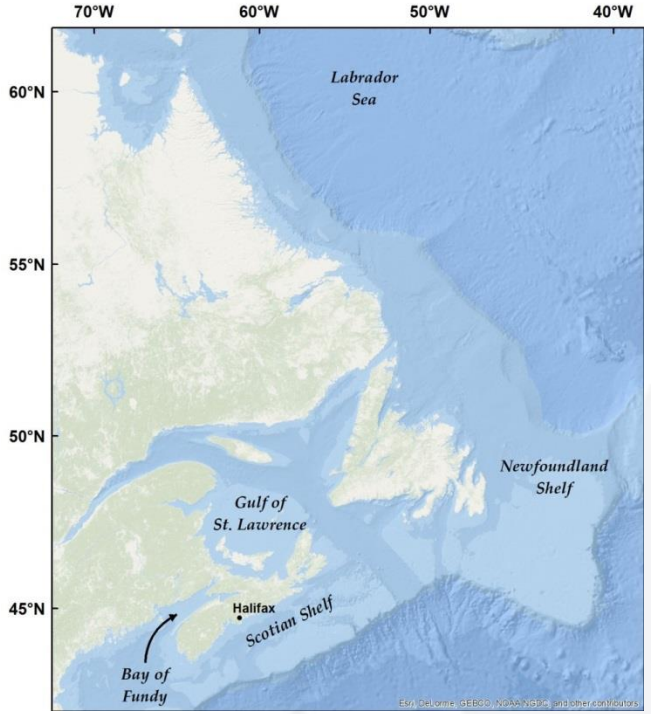




- Sea surface temperature at Halifax Harbour is presented for the period 1926-2016. The long-term trend in this time series is not statistically different from zero.
- Depth averaged ocean temperature (0-90 m) from the Prince 5 station (P5) in the Bay of Fundy (1924-2016) indicates a long-term warming of 0.16 degrees Celsius per decade, which is statistically significant.
- The time series at a depth of 250 m on the Scotian Shelf (1950-2016) indicates strong natural variability with a long term trend of 0.35 degrees Celsius per decade, which is statistically significant.

# Temperature (Atlantic Ocean)

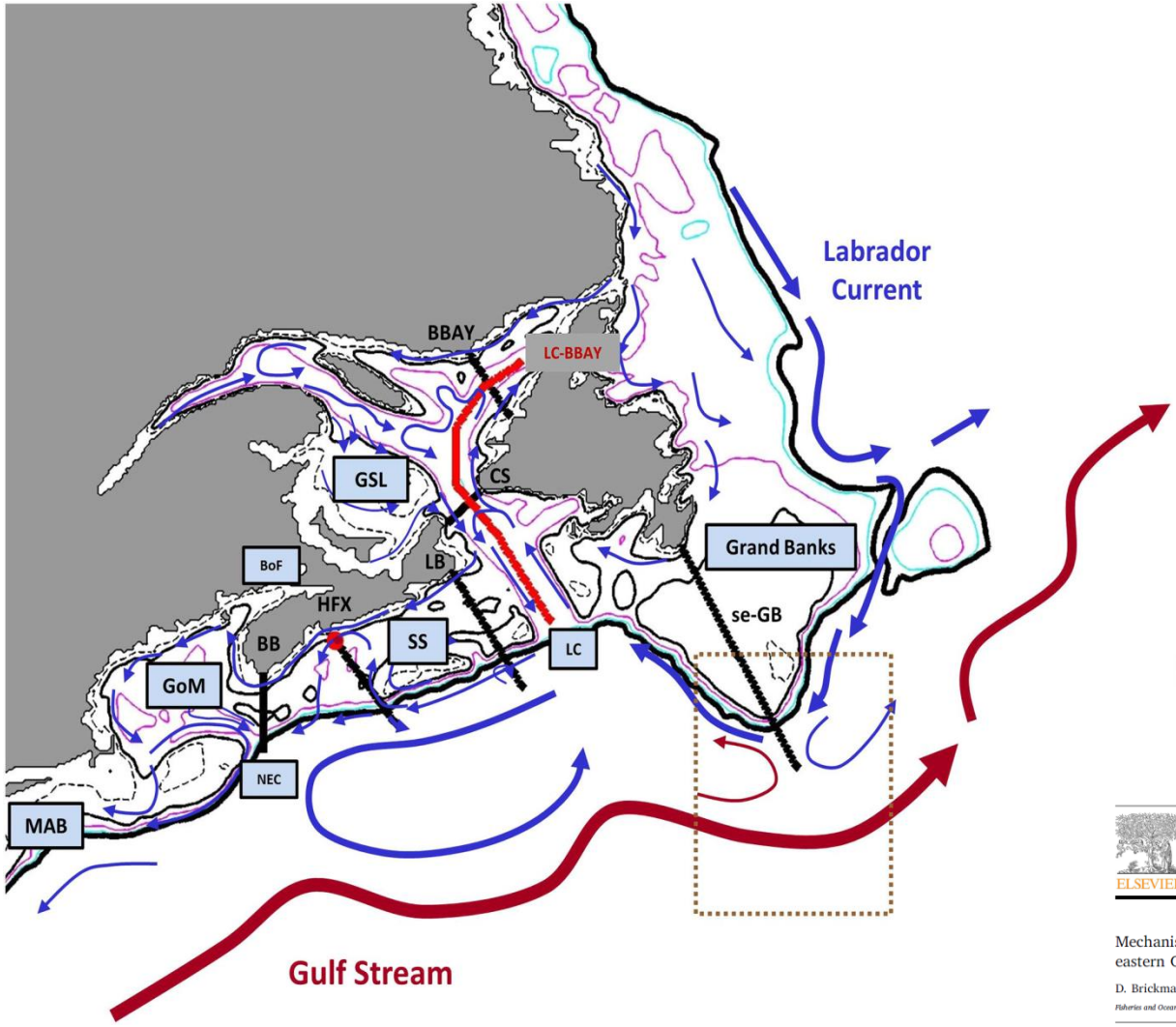
Newfoundland Shelf and Labrador Sea




- Sea surface temperature (at 0m) on the Newfoundland Shelf near St. John's for the period 1950-2016 along with the depth averaged ocean temperature (0–175m) from that site.
- Time series in the upper ocean of the central Labrador Sea basin (20–150 m) is presented for the period of 1948-2016.
- All three time series demonstrate warming in the region from 1990 to present, however, the long-term trends over the whole records are not significantly different from zero.

# Faster rate of warming and extremes in this decade due to Gulf Stream and Labrador Current Competition




Competition at the tail of the Grand Banks between Gulf Stream and Labrador Current. Gulf Stream BLOCKS the cold Labrador water,

Warm eddies form and flow onto Scotian Shelf

SO –over the long term, we are warming BUT it's especially fast in the last decade due to Gulf Stream influence at tail of Grand Banks.


Continental Shelf Research 156 (2018) 11–22

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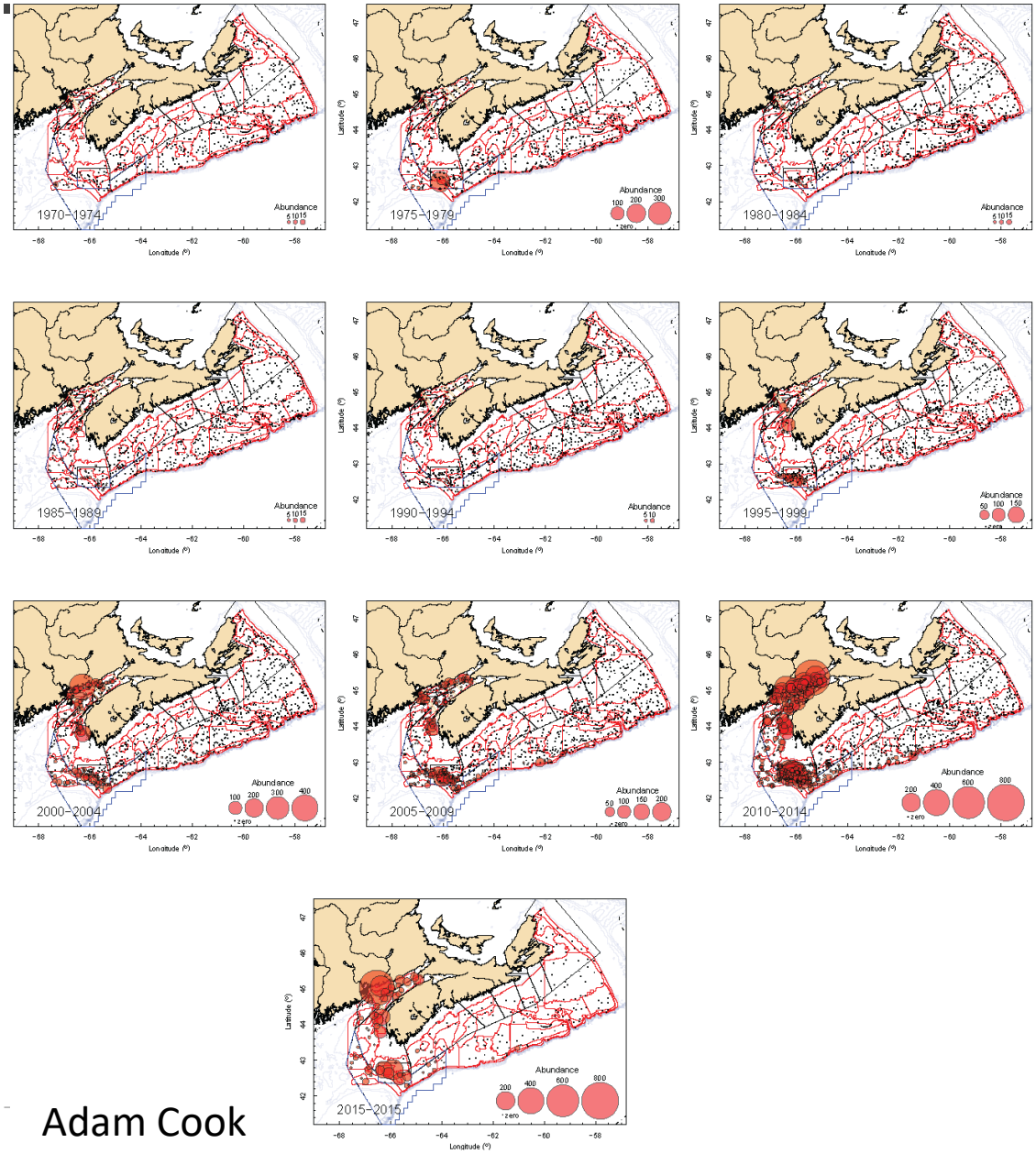
journal homepage: www.elsevier.com/locate/csr

Mechanism for the recent ocean warming events on the Scotian Shelf of eastern Canada

D. Brickman*, D. Hebert, Z. Wang

Fisheries and Oceans Canada, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, N.S., B2Y 4A2, Canada




# Good news…..

## Warmer conditions are favorable to some species. (and fewer predators)

Adam Cook
Brad Hubley

# Bad News....

-Some species prefer colder water (e.g snow crab)

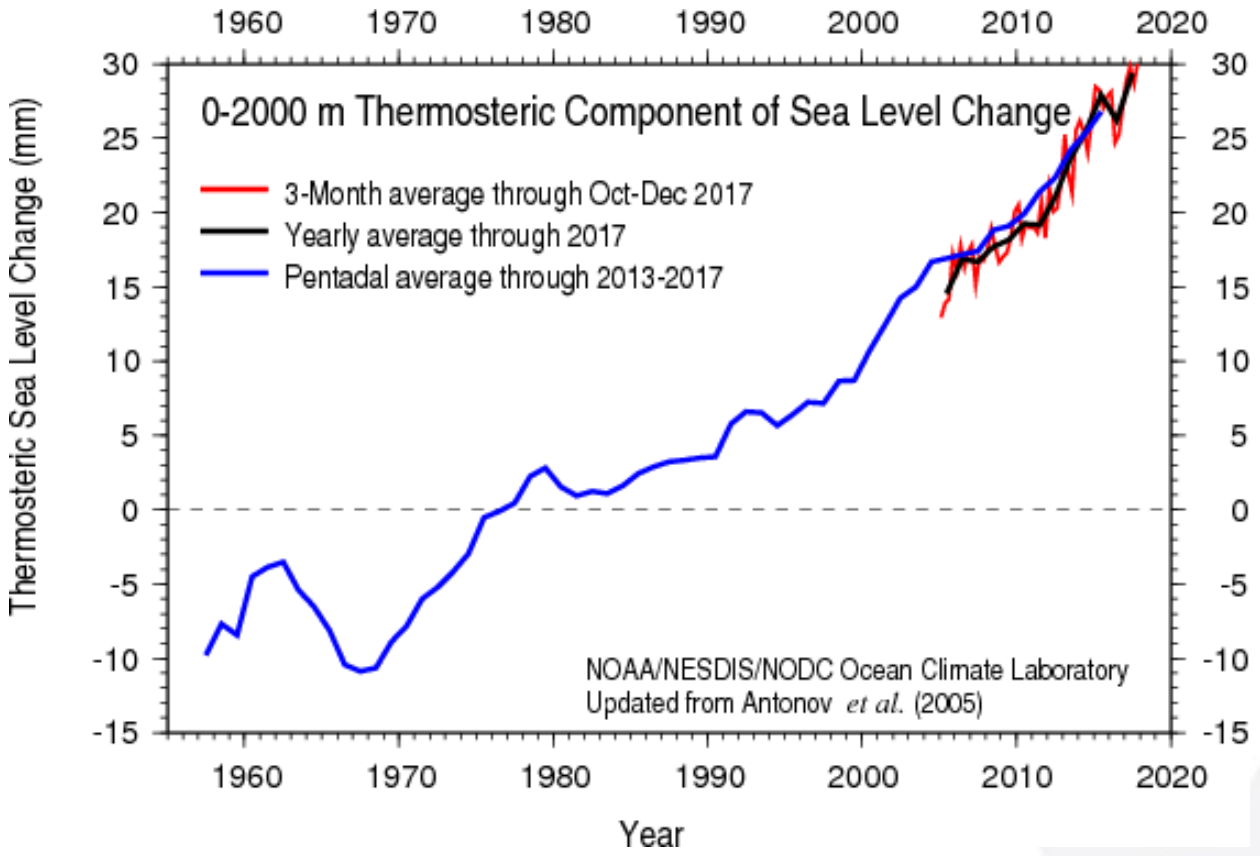
-Sea-level rise/storm surge

... so we need to plan

# Coastal Vulnerability

Knowledge of Impacts of Environmental Drivers can be DIRECT

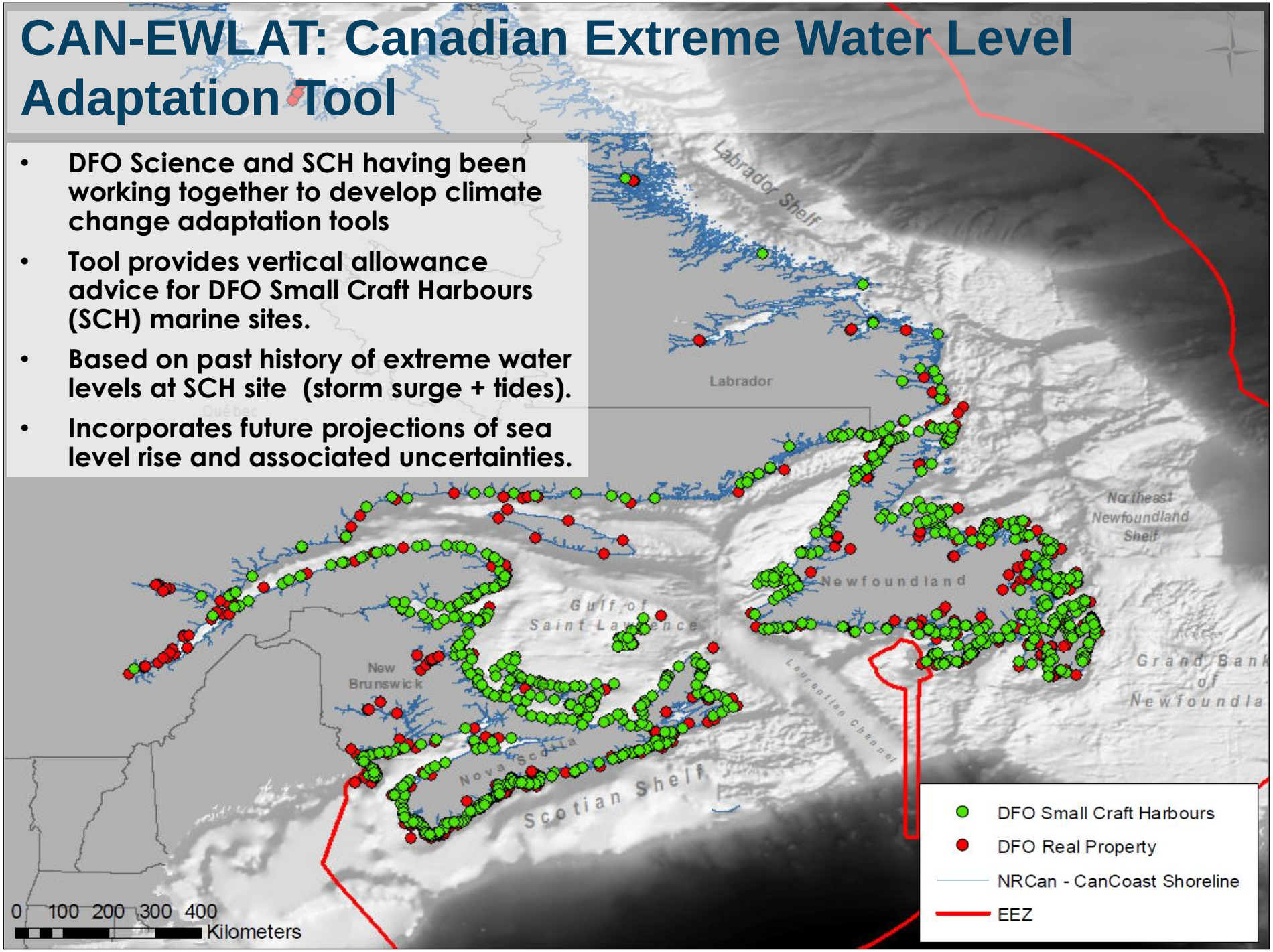
# Global Sea Level Change




- Increasing global sea level since 1970
- Source: https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/
- BUT, the regional trends can be very different compared to the global trend.

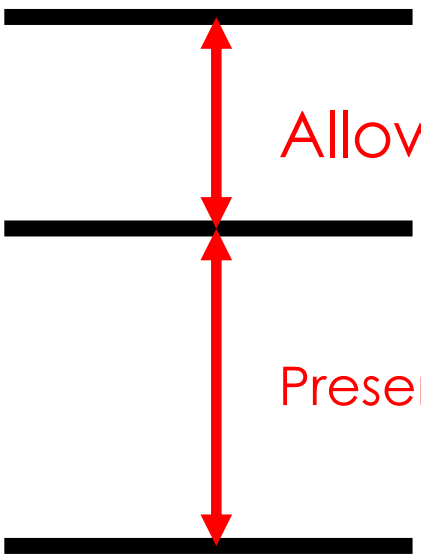
# CAN-EWLAT: Canadian Extreme Water Level Adaptation Tool

- DFO Science and SCH having been working together to develop climate change adaptation tools
- Tool provides vertical allowance advice for DFO Small Craft Harbours (SCH) marine sites.
- Based on past history of extreme water levels at SCH site (storm surge + tides).
- Incorporates future projections of sea level rise and associated uncertainties.



# What is an Allowance?

"Safe" is defined in terms of not exceeding a given frequency of flooding events ("exceedances")




"Safe" height to build with sea level rise

"Safe" height to build without sea level rise

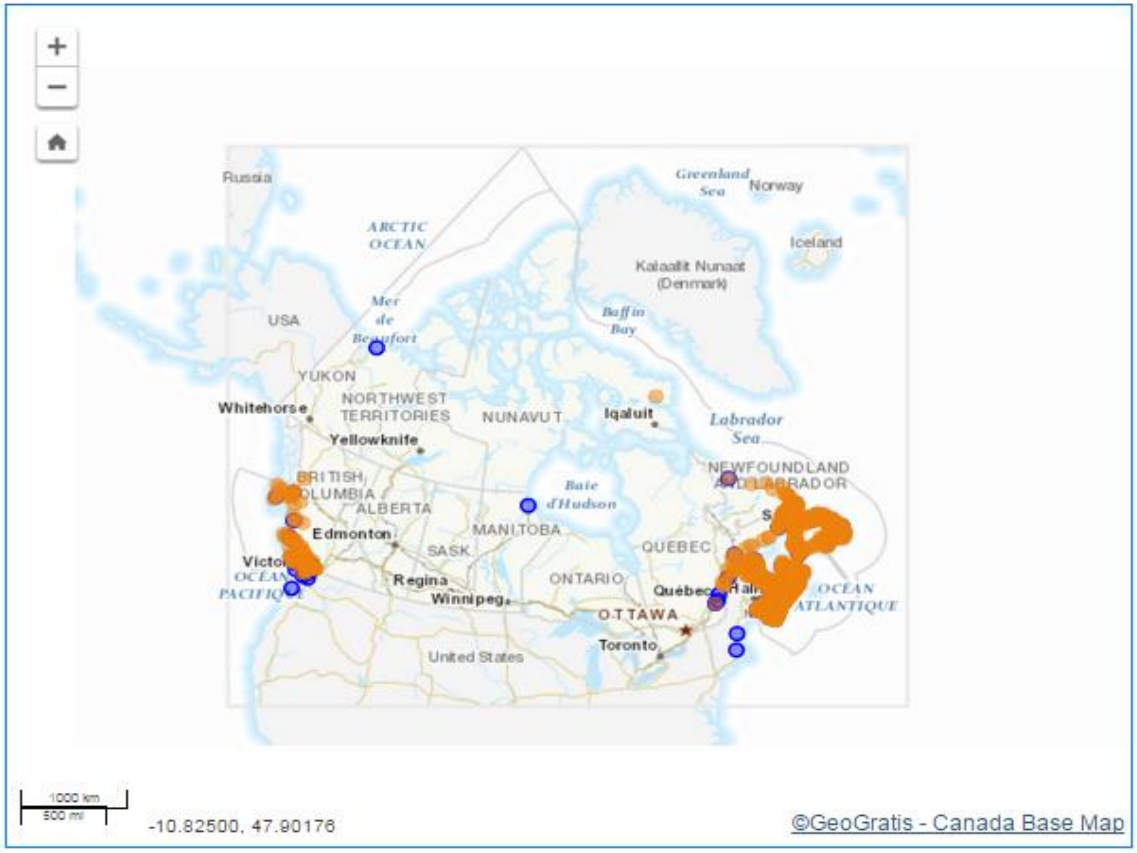
Fixed level or datum

Note: For critical infrastructure, a more conservative approach would be recommended

Li Zhai, Blair J.W. Greenan, John Hunter, Thomas S. James, Guoqi Han, Phillip MacAulay & Joseph A. Henton (2015) Estimating Sea-Level Allowances for Atlantic Canada using the Fifth Assessment Report of the IPCC, Atmosphere-Ocean, 53:5, 476-490, DOI: 10.1080/07055900.2015.1106401

# Canadian Extreme Water Level Adapation Tool (CAN-EWLAT)

▶ Instructions: Map Navigation




## Legend

- Tide Gauge Locations
- SCH Locations

http://www.bio.gc.ca/science/data-donnees/can-ewlat/index-en.php

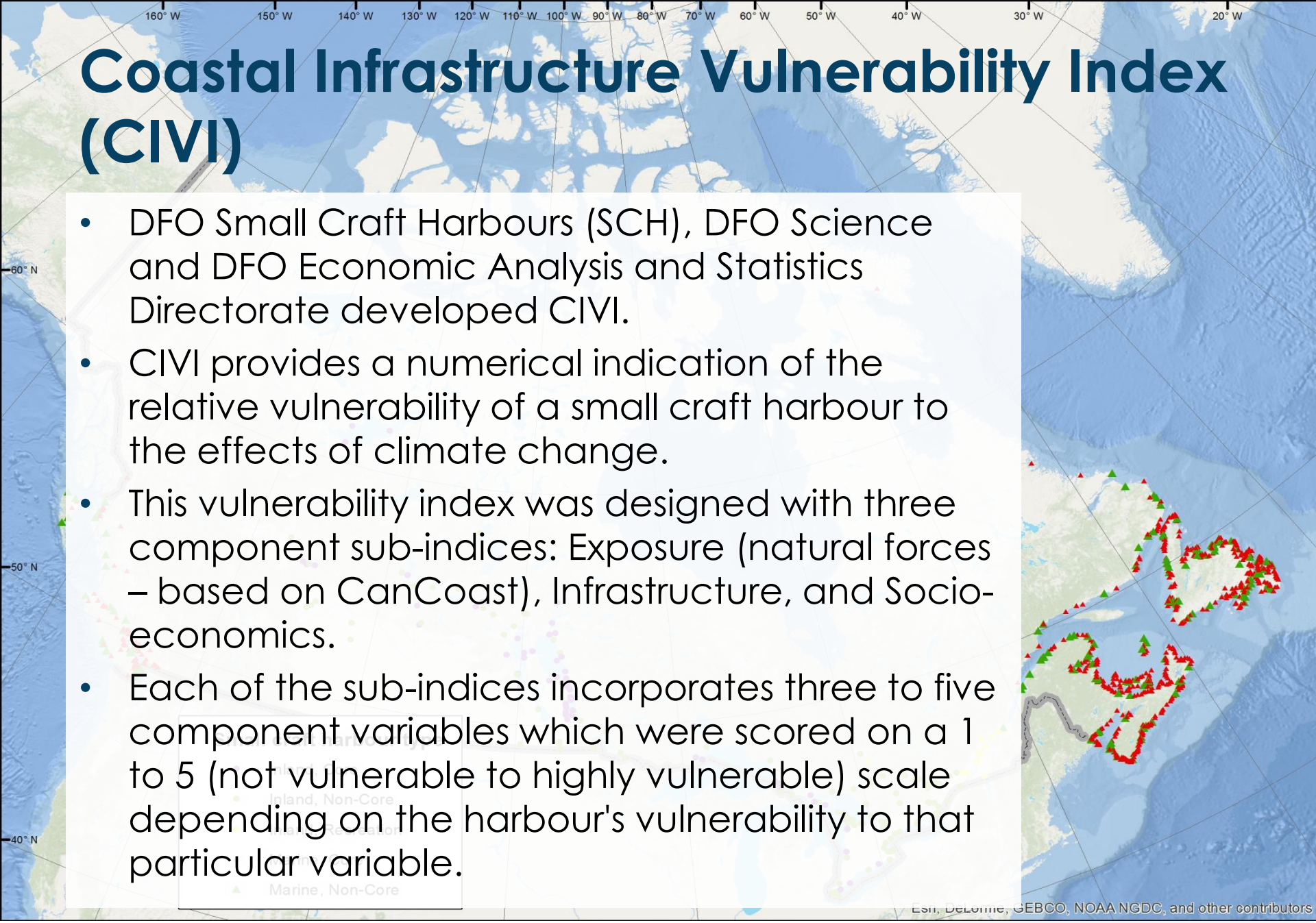
# Ecology Action Centre Partnership

- The Educating Coastal Communities About Sea-level Rise (ECoAS) Project is an initiative designed to translate scientific climate change research into useable information to educate coastal communities within Canada about the need for planning for future sea-level rise impacts. Funded in part by DFO until March 2019.
- **The aims of this project are to:**
  - Help communities learn about sea-level rise and how it affects them
  - Provide access to tools that have been developed locally with the latest climate change information available
  - Illustrate the need for incorporating sea-level rise into future plans

http://sealevelrise.ca/

# Coastal Infrastructure Vulnerability Index (CIVI)

- DFO Small Craft Harbours (SCH), DFO Science and DFO Economic Analysis and Statistics Directorate developed CIVI.
- CIVI provides a numerical indication of the relative vulnerability of a small craft harbour to the effects of climate change.
- This vulnerability index was designed with three component sub-indices: Exposure (natural forces – based on CanCoast), Infrastructure, and Socio-economics.
- Each of the sub-indices incorporates three to five component variables which were scored on a 1 to 5 (not vulnerable to highly vulnerable) scale depending on the harbour's vulnerability to that particular variable.



Bedford Institute of Oceanography

Canada

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Bedford Institute of Oceanography | Science | Outreach | Info for Clients | Facilities

BIO Home → CIVI → Coastal Infrastructure Vulnerability Index (CIVI)

# Coastal Infrastructure Vulnerability Index (CIVI)

Download Data

Environmental Vulnerability

- Coastal Vulnerability
- Environmental Vulnerability
- Socioeconomic Vulnerability
- Infrastructure Vulnerability

High Medium Low N/A

Submit


## Legend

- Coastal Vulnerability
  - High
  - Medium
  - Low
  - NA

Coastal Vulnerability

Filter items

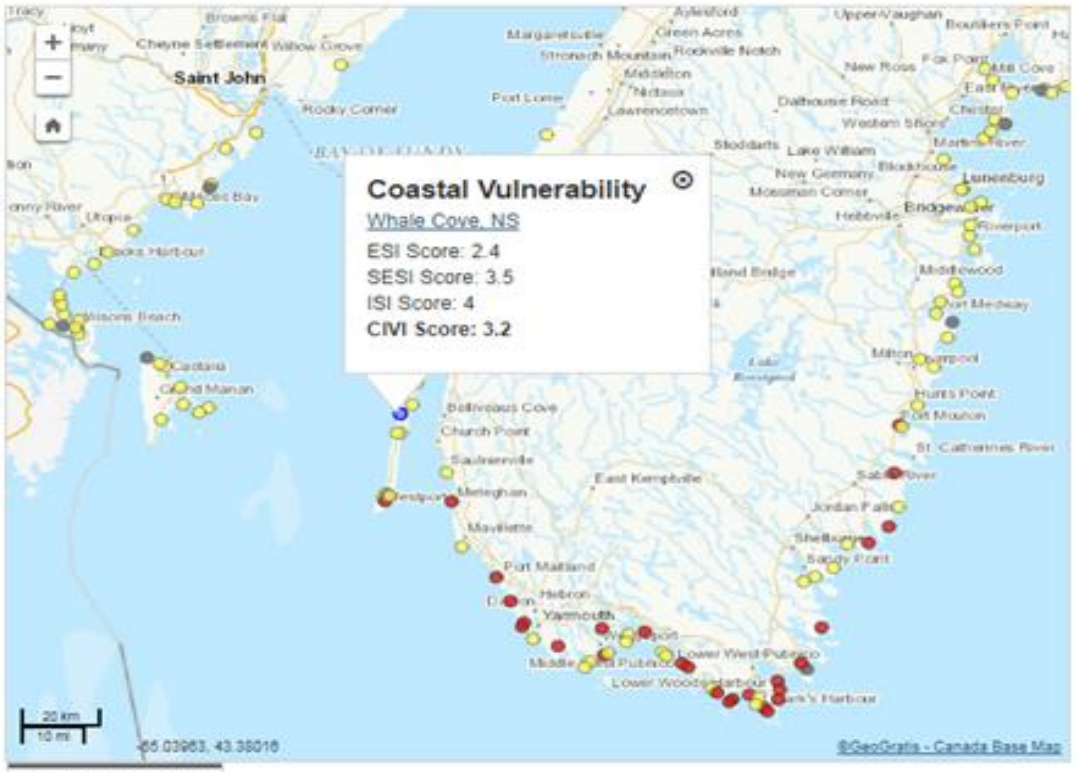
Showing 1 to 10 of 828 entries | Show 10 entries

# Coastal Infrastructure Vulnerability Index (CIVI)

Download Data

Coastal Vulnerability ☑ High ☑ Medium ☑ Low ☑ N/A Submit

▸ Instructions: Map Navigation




## Legend

- ☑ Coastal Vulnerability
- High
- Medium
- Low
- NA

Coastal Vulnerability

Filter items | Showing 1 to 10 of 828 entries | Show 10 entries

Coastal Vulnerability

Zoom to

# Ecosystem Change

Acidification

Warming

Altered boundary current

Stratification

Lower dissolved oxygen

Less ice

Freshening

WordItOut

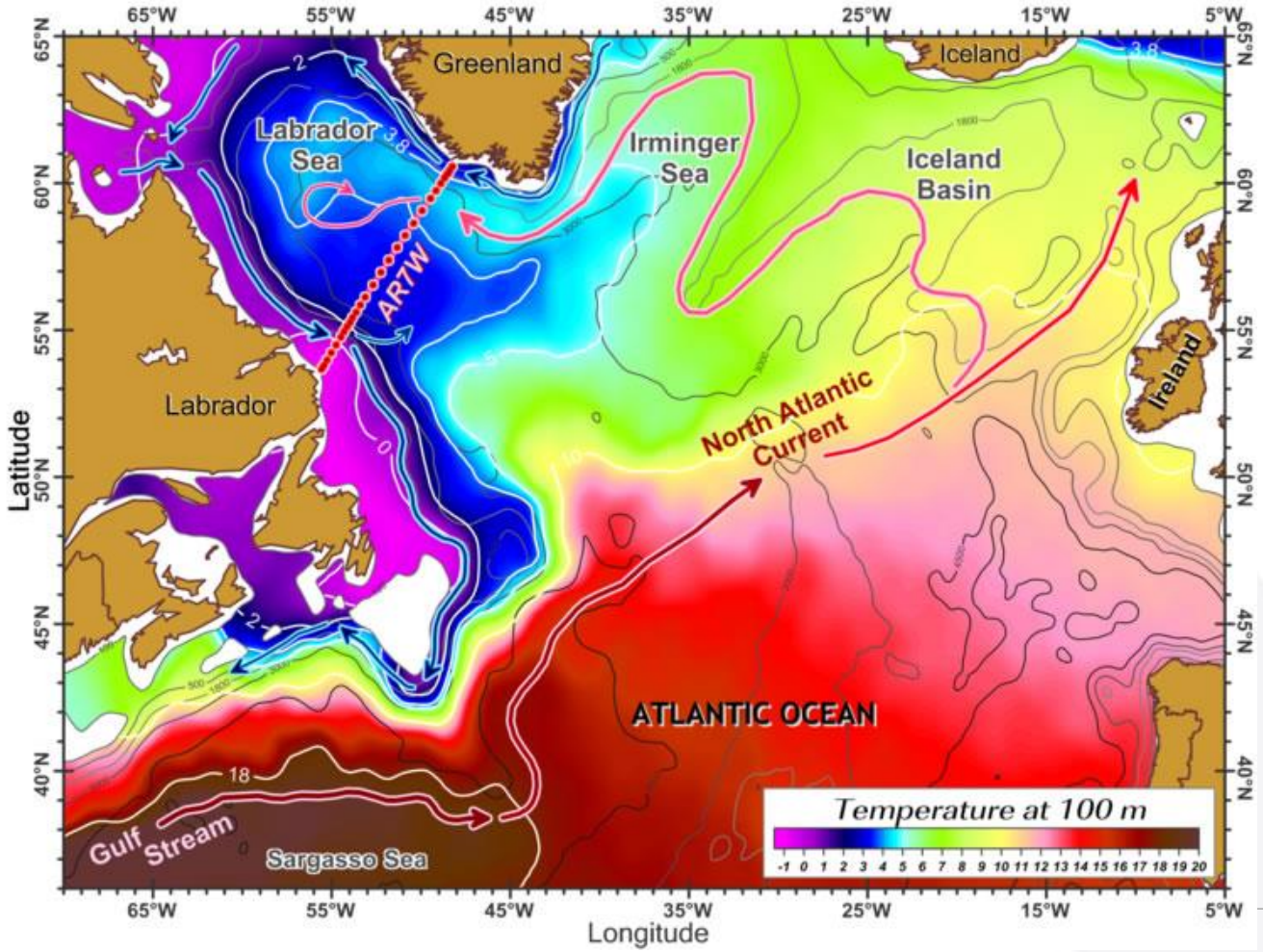
Knowledge of Impacts of Environmental Drivers varies, and can be INDIRECT

Shackell, N.L., B.W. Greenan, P. Pepin, D. Chabot and A. Warburton (Editors) 2013. **Climate Change Impacts, Vulnerabilities and Opportunities (IVO) Analysis of the Marine Atlantic Basin.** Can. Manuscr. Rep. Fish. Aquat. Sci. 3012: xvii + 366 p.

Rave Reviews

…..riveting plots…
….multiple characters with depth….
…. a hot item only getting hotter….

GENERALLY--Southwestern Scotian Shelf is likely to see greater shifts/impact on species near upper thermal limit of their range and even greater impacts if heavily fished (e.g. cod, herring).



# Assessing key fish and invertebrate species vulnerability to warming : Who do we need to worry about?

ICES Journal of Marine Science

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science; doi:10.1093/icesjms/fsv022

## Assessing marine species vulnerability to projected warming on the Scotian Shelf, Canada

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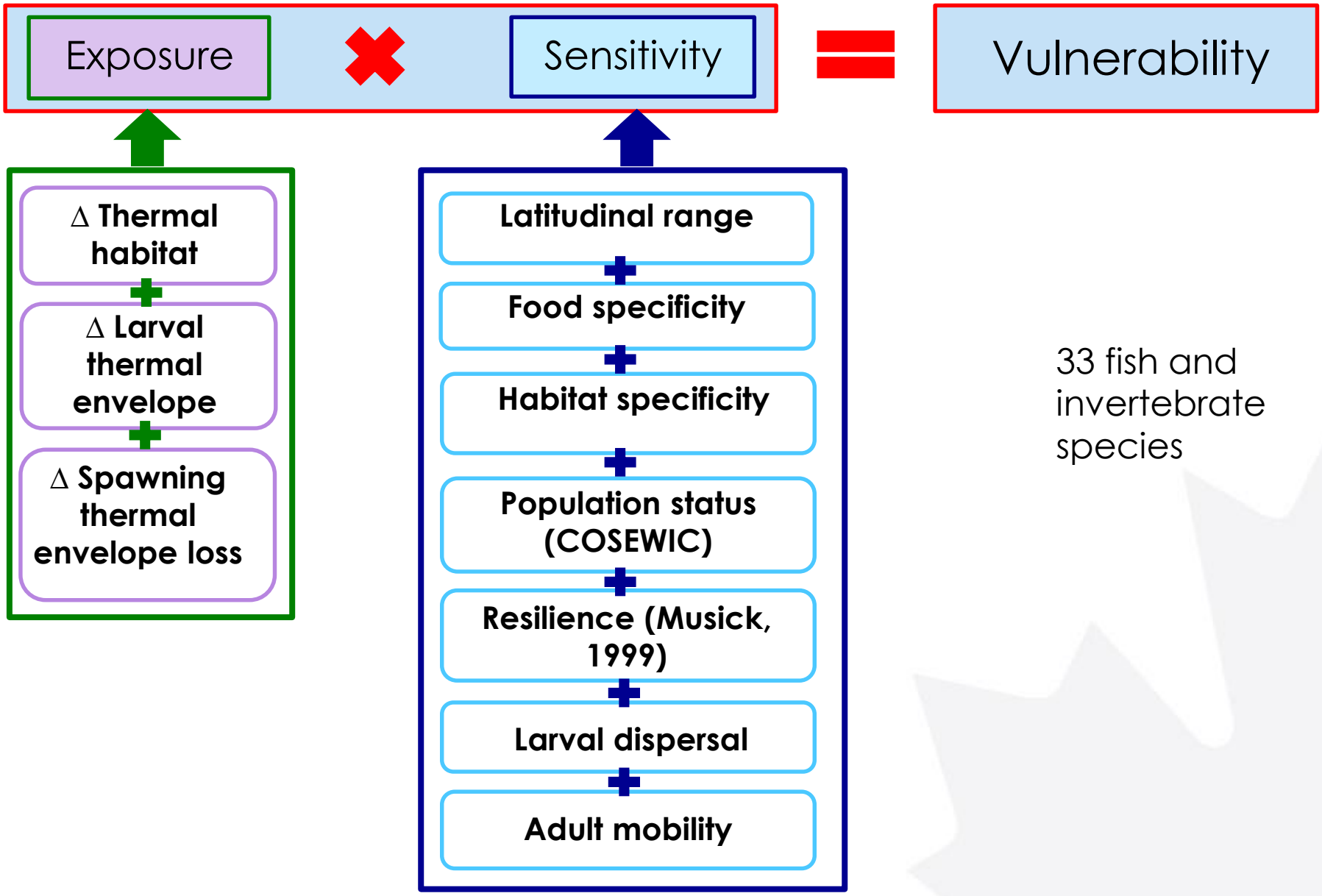
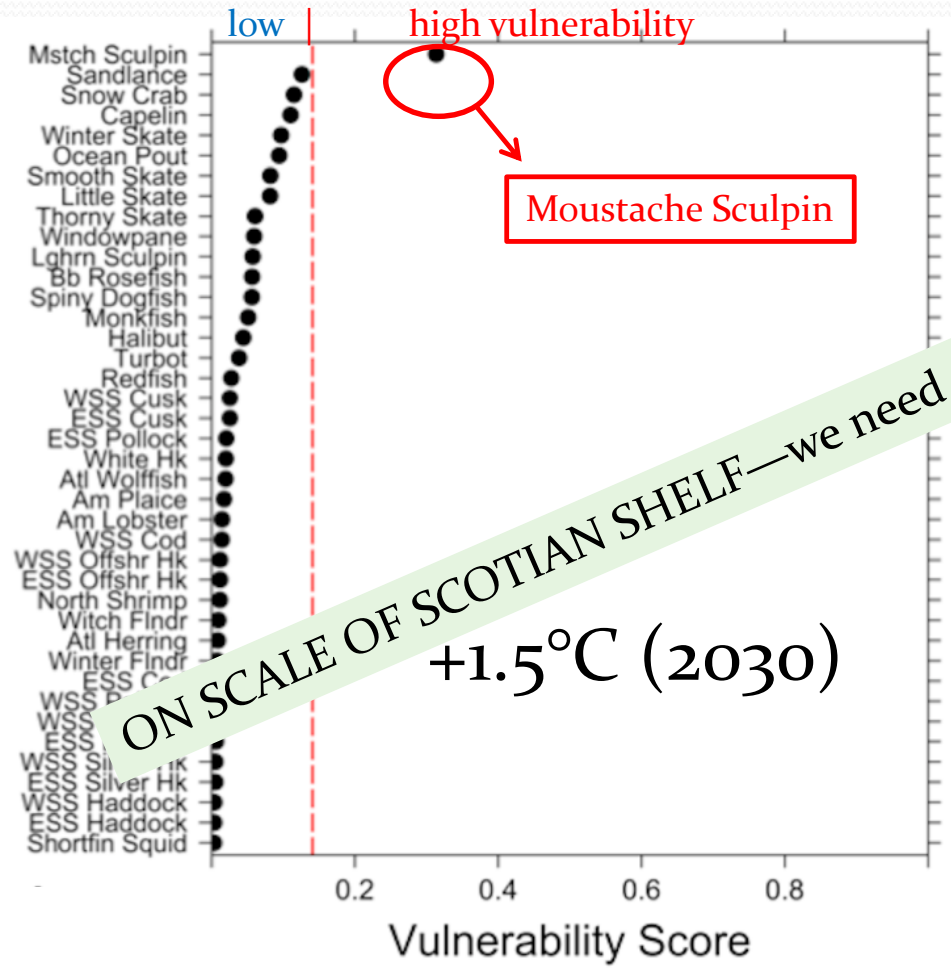
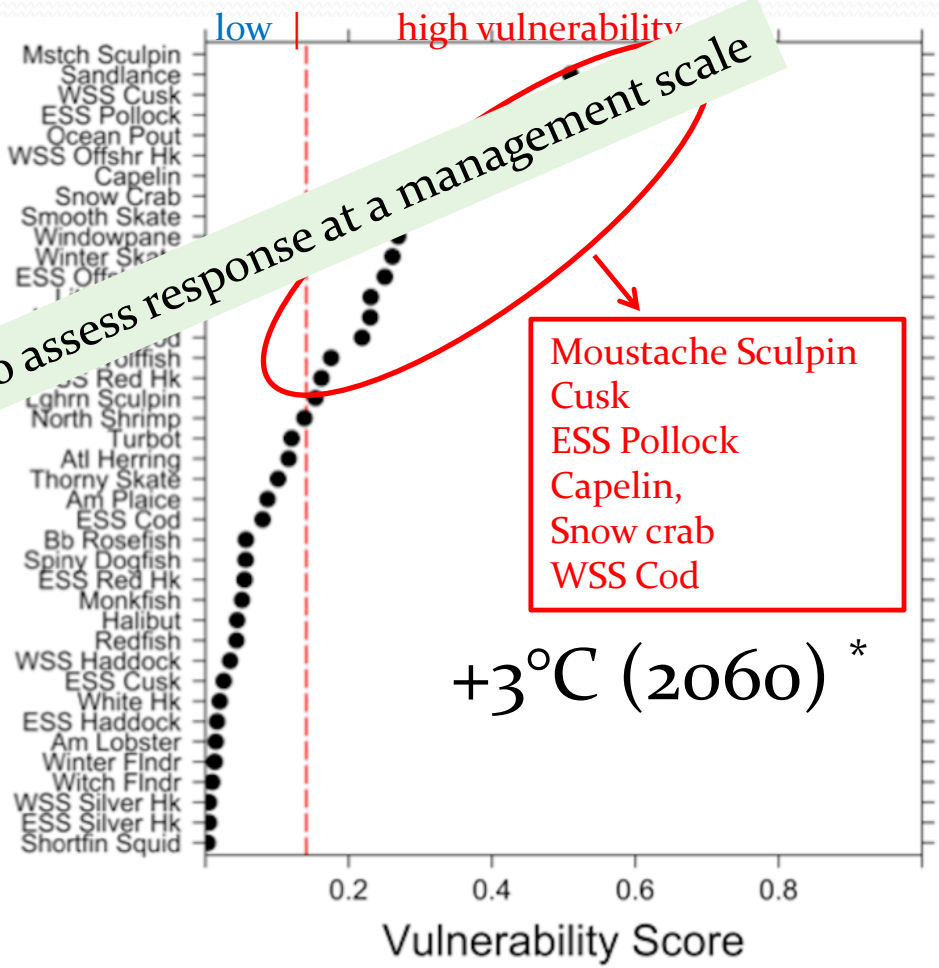
[2]*Fisheries and Oceans Canada, Bedford Institute of Oceanography, 1 Challenger Drive, PO Box 1006, Dartmouth, NS, Canada B2Y 4A2*

**Corresponding author: tel: +1 902 292 0268; fax: +1 902 426 9710; e-mail: c.stortini@dal.ca*




33 fish and invertebrate species

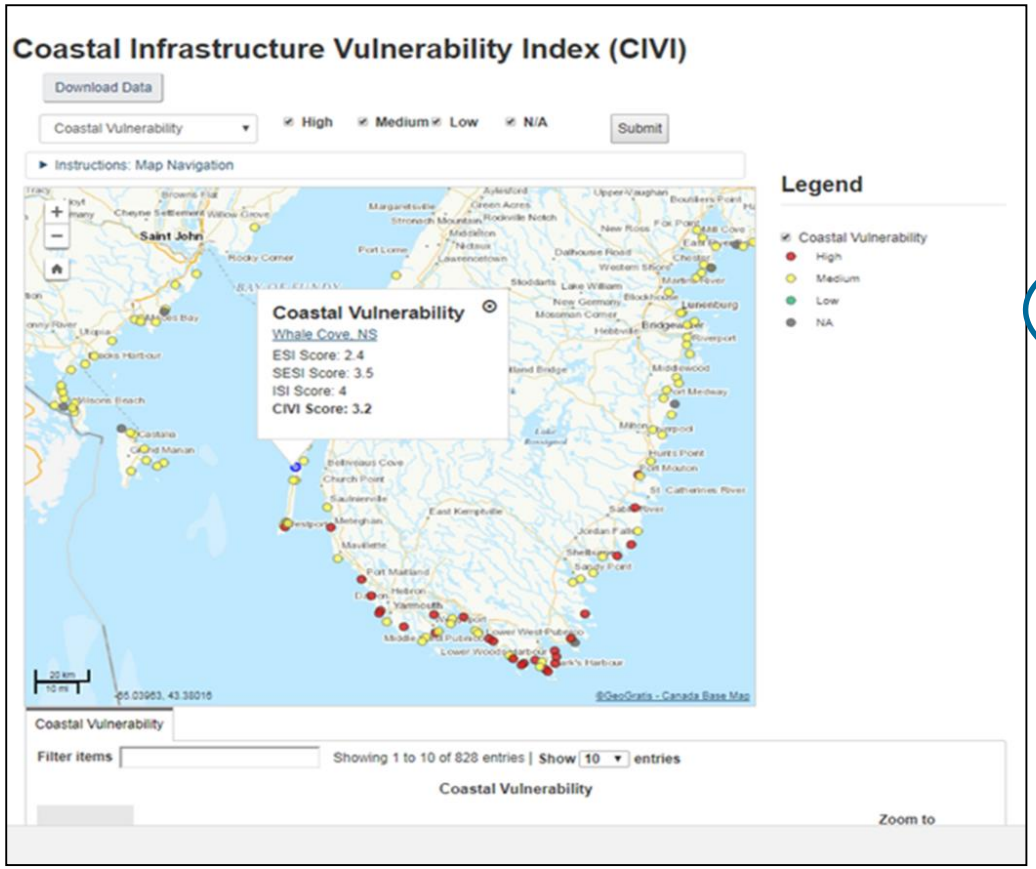


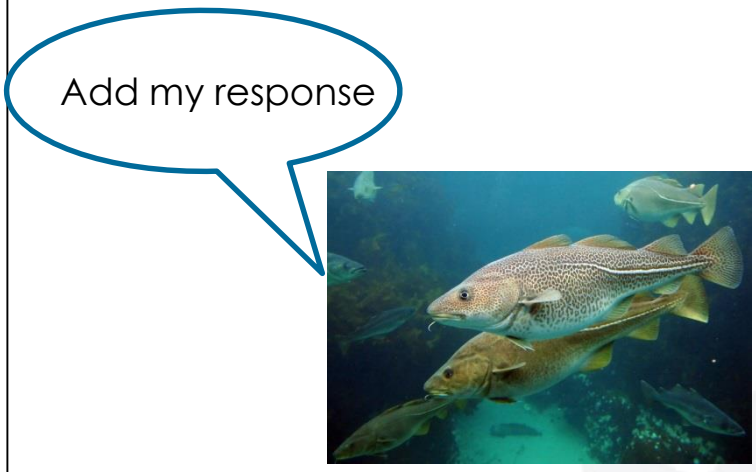

ON SCALE OF SCOTIAN SHELF—we need to assess response at a management scale

* Heat pulse to this degree occurred in 2012

Canada









Next Steps:

**Coastal Index of Vulnerability by Economic Zone-**
(combine fish response assessement with CIVI)

# Coastal Index of Vulnerability by Economic Zone (CIVEZ)

Coastal Infrastructure Vulnerability Index (CIVI)

*Exposure, Infrastructure, Socio-economics*

•Update CIVI database as needed (e.g., harbour condition indicator)

• Explore other socio-economic indicators

Species Vulnerability Assessment

*Exposure (thermal habitat gain/loss)*

*Sensitivity (life history/status)*

- Create Basin-wide Species distribution model for 7spp.
- Use ocean temperature projections as change fields
- Create Thermal Response Change Field=Exposure

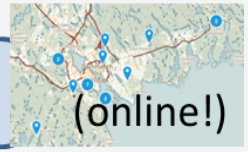
Species Response Assessment

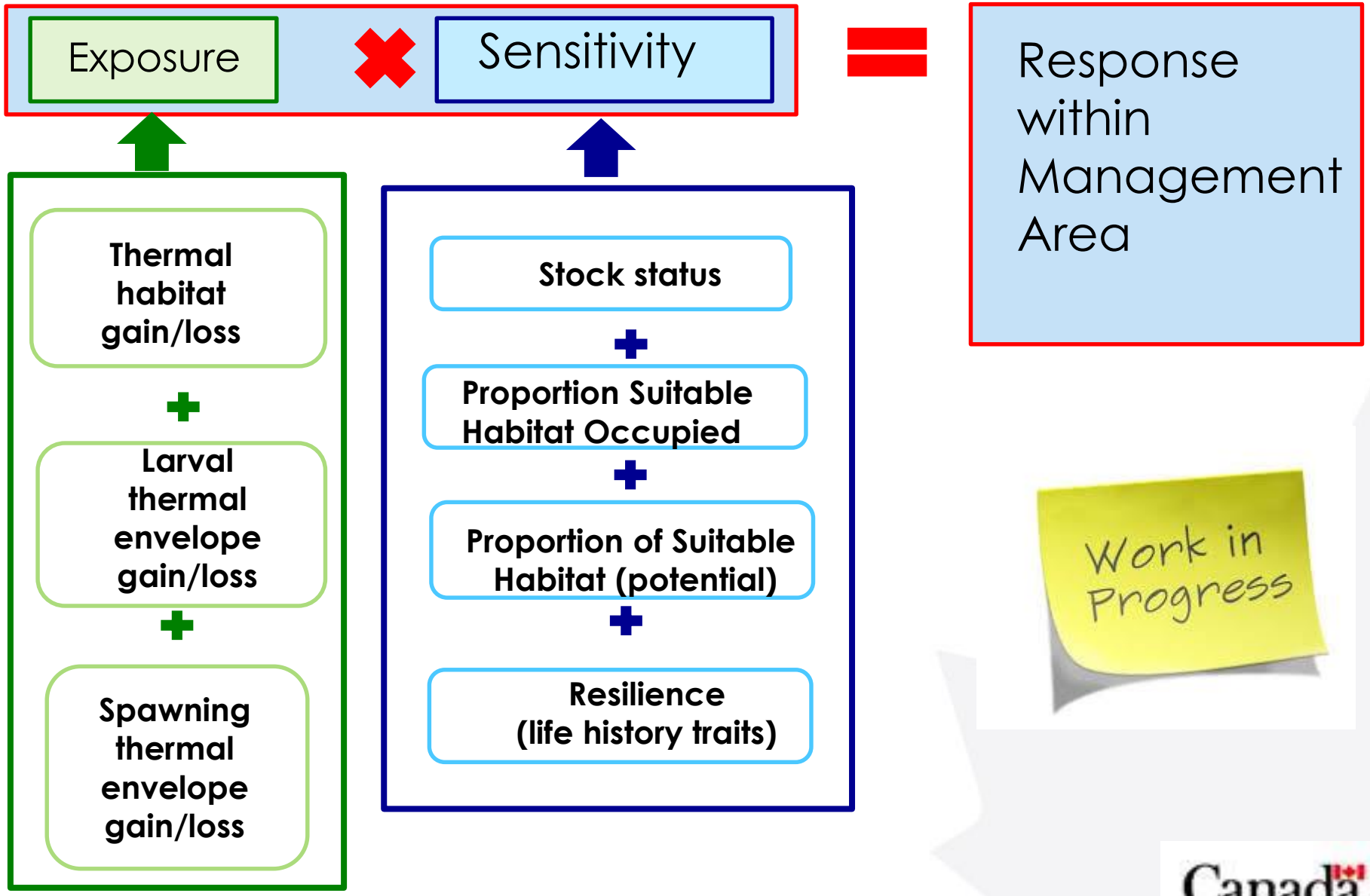
- *Response =Exposure (thermal habitat gain/loss) X Sensitivity (past and current stock status )*

Determine Scale of Economic Zones (EZ)

- Aggregate CIVI indicators by EZ
- Aggregate RESPONSE by EZ

Coastal Index of Vulnerability by Economic Zone (CIVEZ)



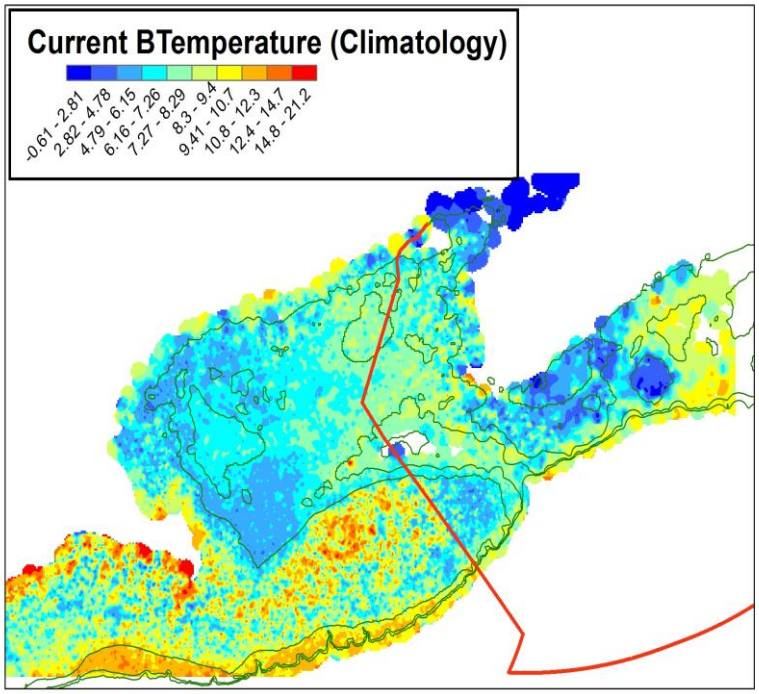

Exposure
Sensitivity
Response within Management Area
Thermal habitat gain/loss
Larval thermal envelope gain/loss
Spawning thermal envelope gain/loss
Stock status
Proportion Suitable Habitat Occupied
Proportion of Suitable Habitat (potential)
Resilience (life history traits)
Work in Progress

# Response Assessment
# ….starting with Exposure-

# How will thermal habitat change?

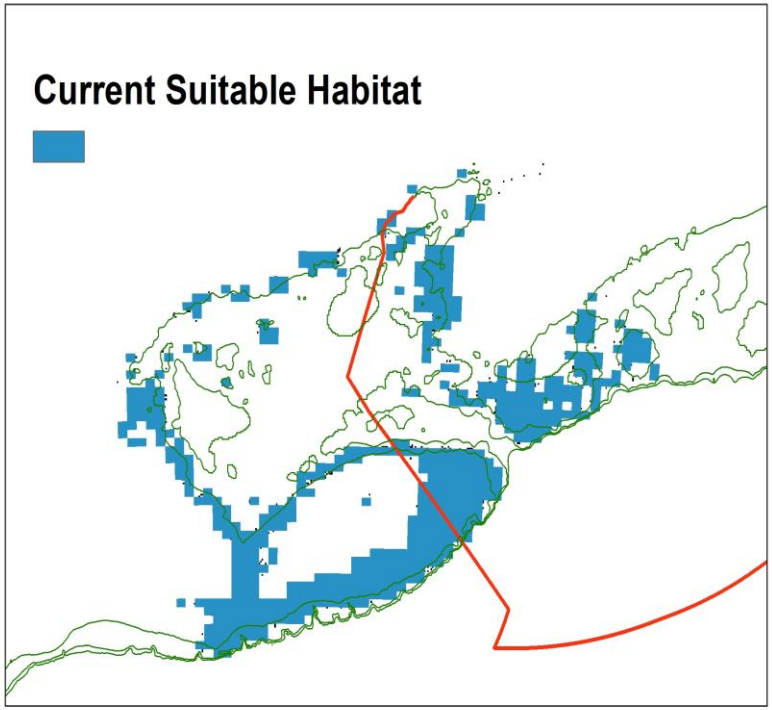
# Prediction of Suitable Habitat in 2055

High Resolution Simulation of Future Ocean Climate in the Northwest Atlantic
(D. Brickman and Z. Wang)



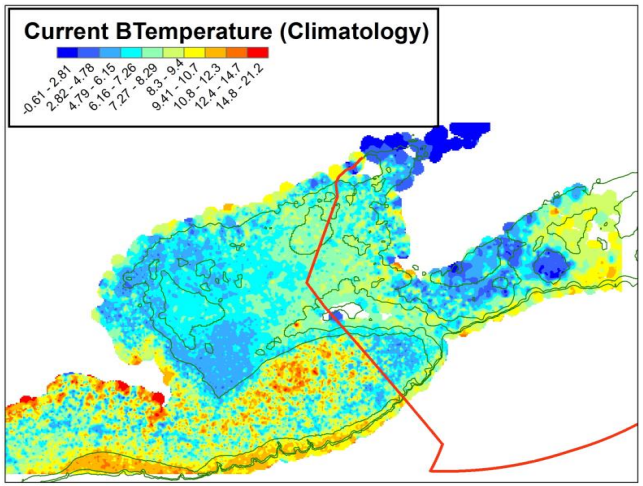

SDM

other variables



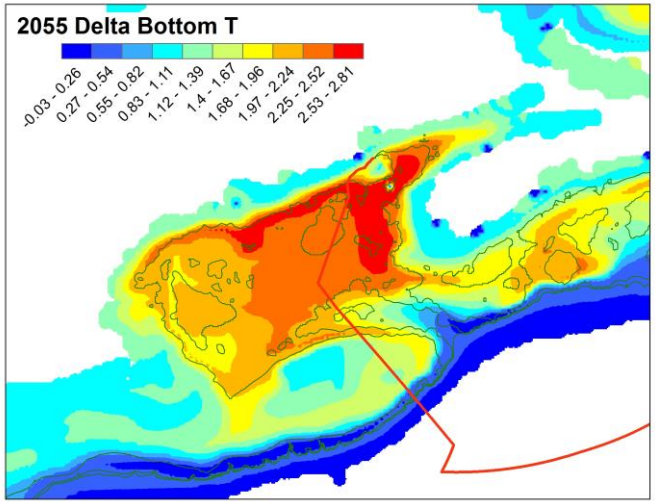

- Species Distribution Model used to identify suitable habitat

**T btm clm**

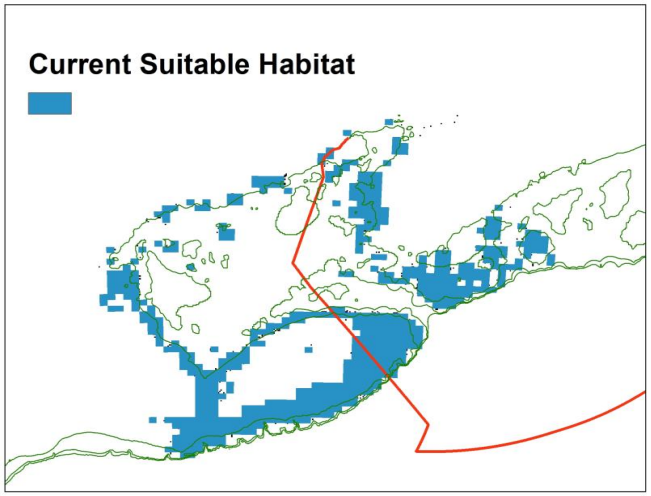



**+**

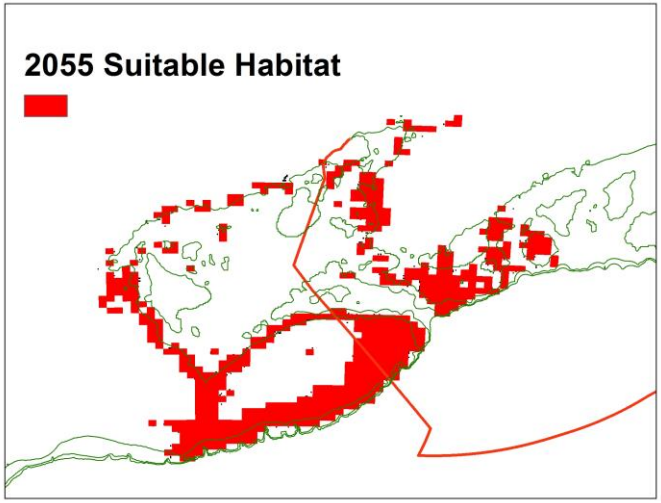
**dT btm**




**SDM**




**compare**




- No significant change in suitable habitat predicted for 2055
- This is because the T increase + the ambient temperature, is still within the window of temperature tolerance for juveniles.

# Preliminary Results for Offshore Lobster

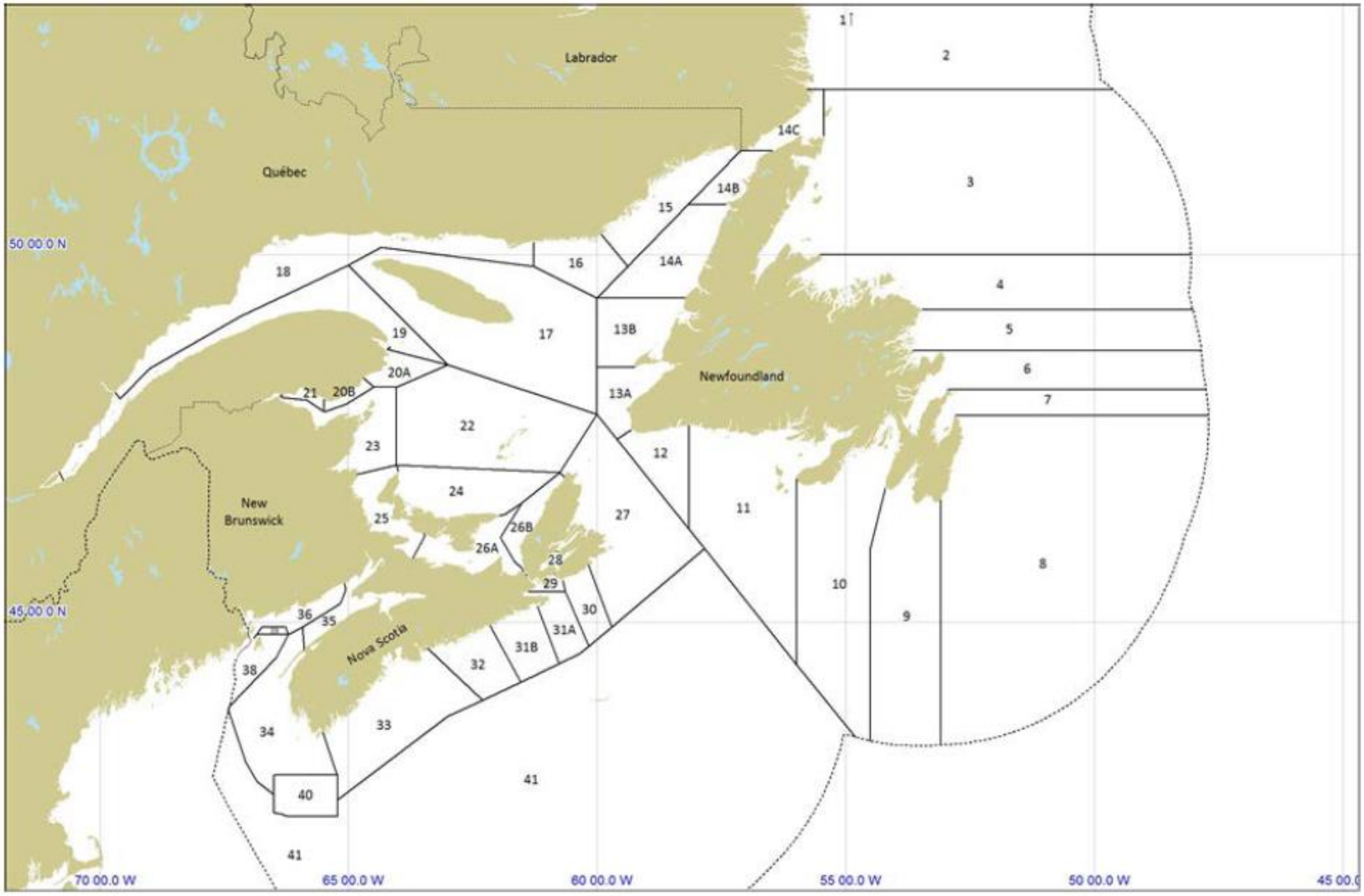
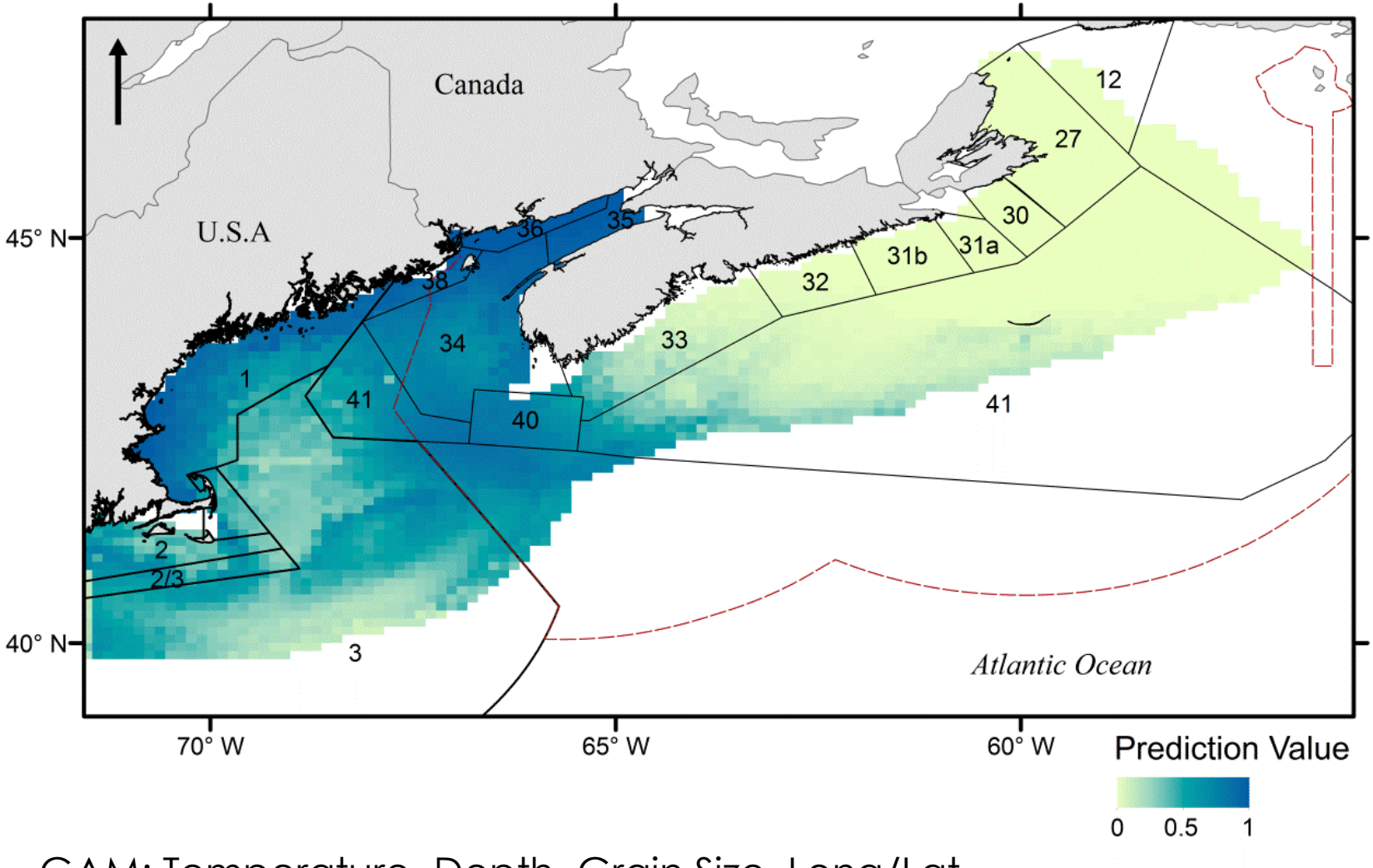



*Figure 1. Map of the Lobster Fishing Areas in Atlantic Canada using the boundaries identified in the Atlantic fishery regulations.*

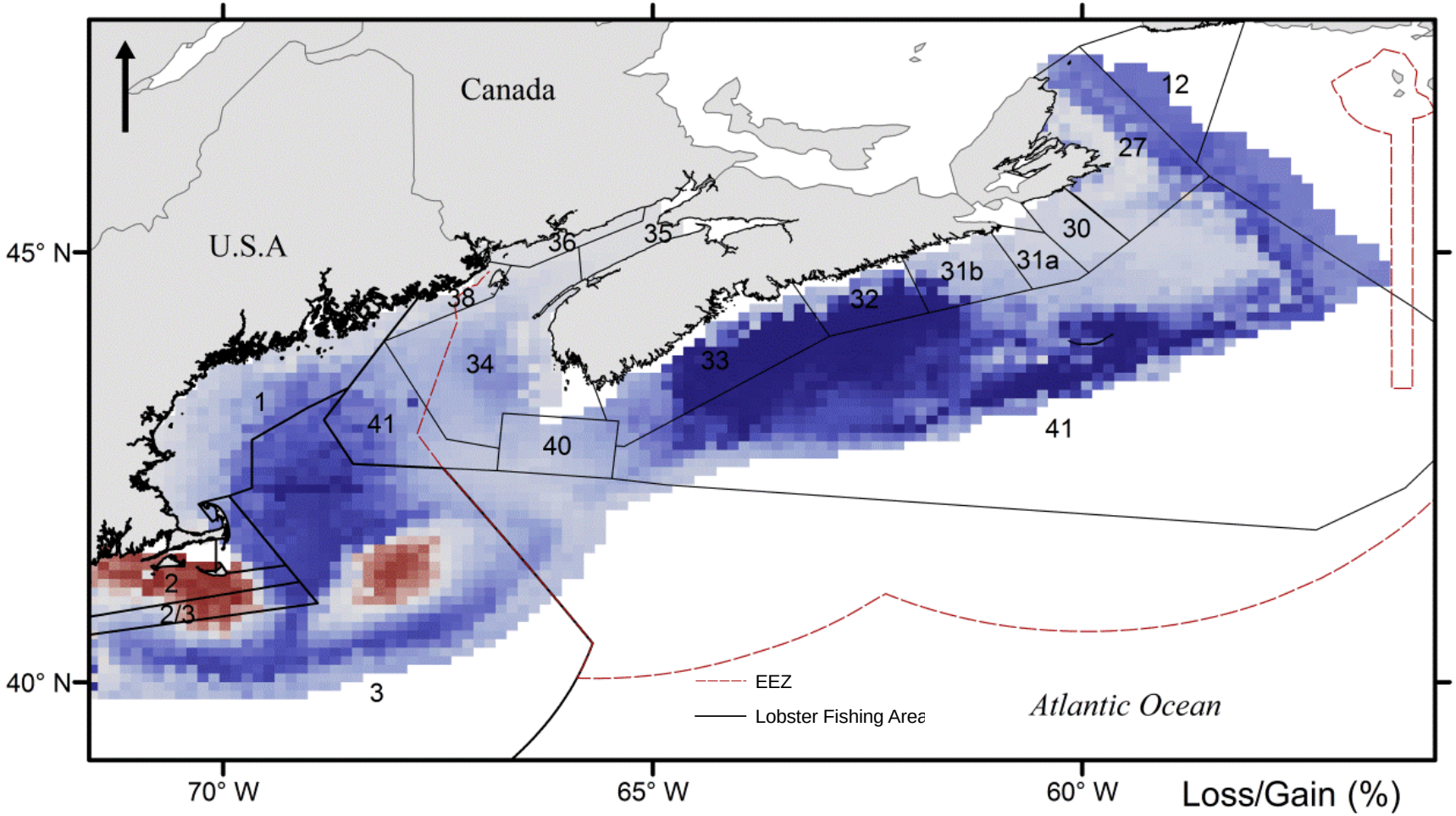
http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2017/2017_065-eng.pdf

# Offshore Lobster Suitable Habitat

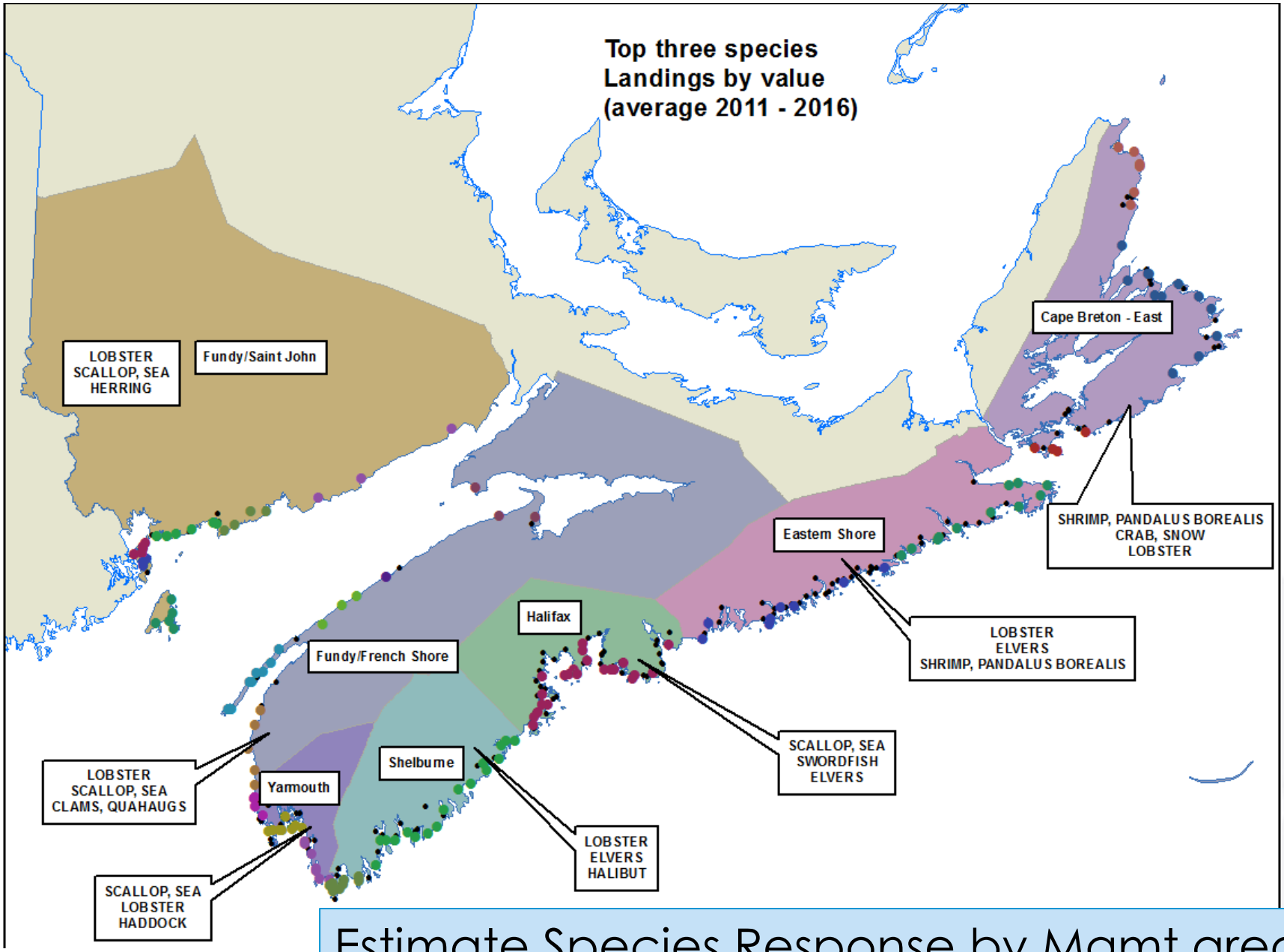



GAM: Temperature, Depth, Grain Size, Long/Lat

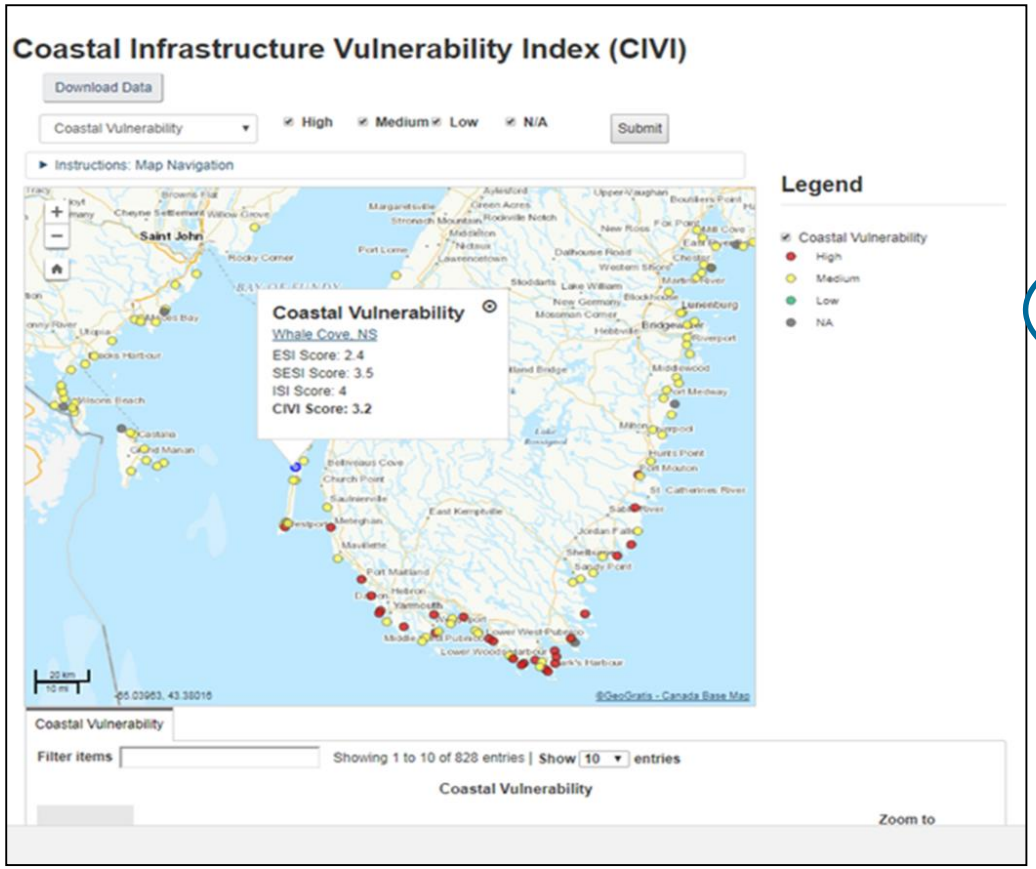
# Offshore Lobster Habitat Gain/Loss (2055)



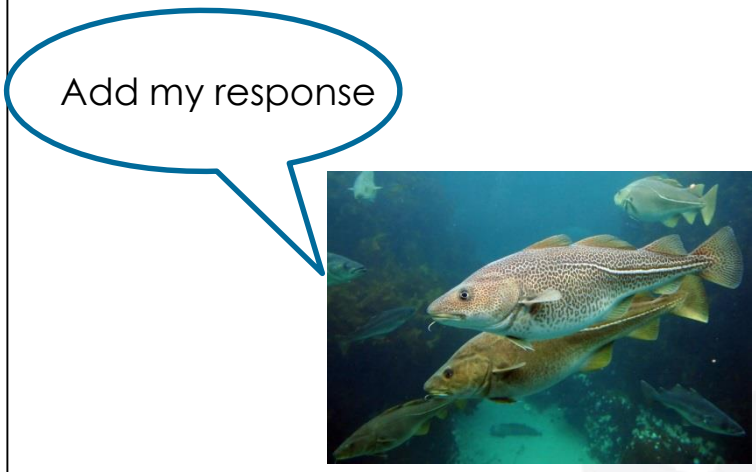

*(Current – 2055 projection)
Current




# Estimate Species Response by Mgmt area -report by Economic Zones









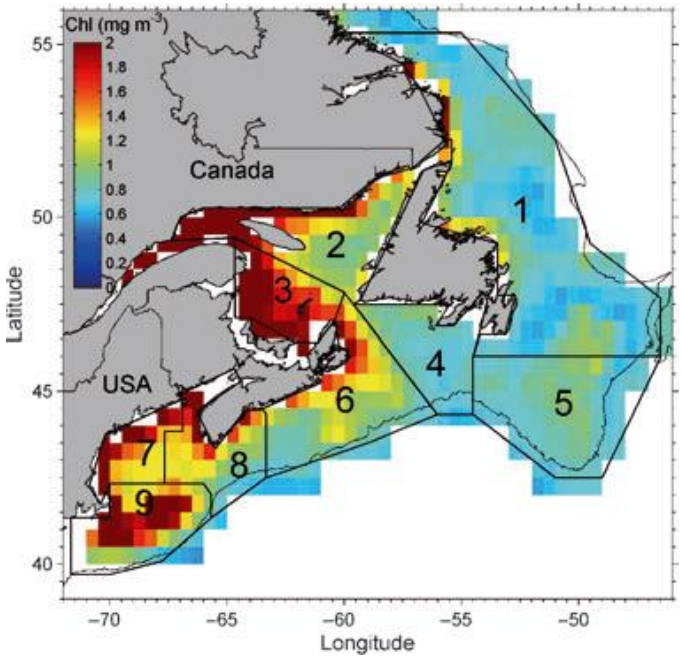
GOAL:

**Coastal Index of Vulnerability by Economic Zone**- (combine fish response with CIVI)

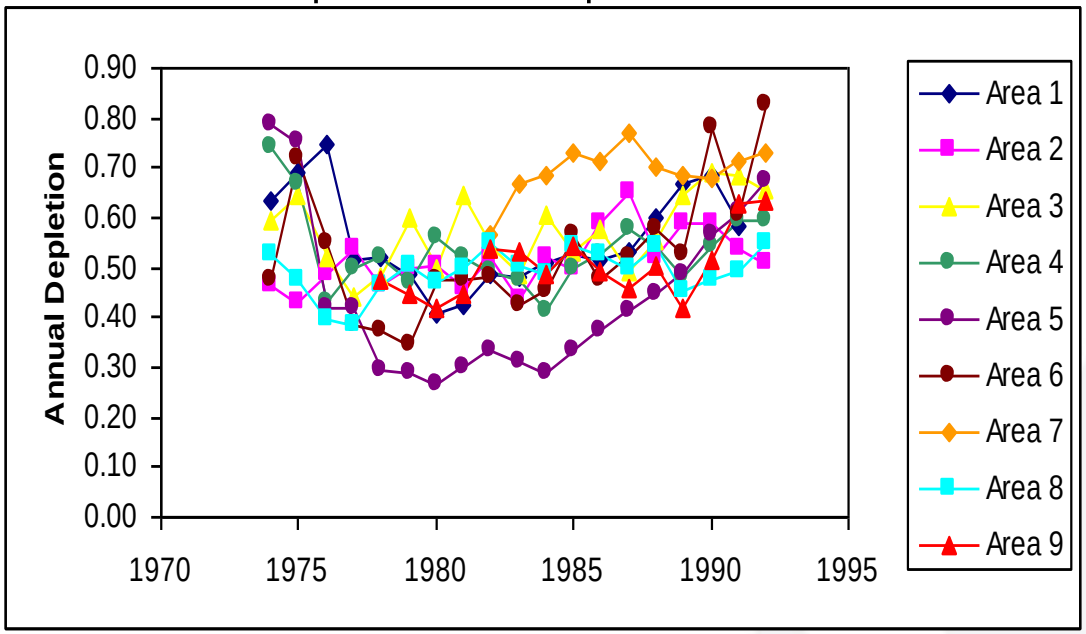
End, questions?

GENERALLY-- Populations overly impacted by other stressors (e.g. fishing) are more likely to be negatively impacted by climate change than healthy populations

**Best Worst Example ➔cod.**




Annual Proportion Depletion of Cod SSB




**Why it matters ->** SNE Lobster in decline, GoM lobster increasing- DIFF is partly because of mgmt measures (throw back large lobster and V-notching)