Ocean Warming Effects

NW Atlantic Ocean fisheries catches

Donna Dimarchopoulou[1,2], **Jesús Pineda**[2], **Rubao Ji**[2], **Boris Worm**[1], **Heike K. Lotze**[1]

[1] Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada, e-mail: ddimarch@dal.ca

[2] Biology Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA, ddimarch@whoi.edu

INTRODUCTION

Context: Climate-change induced ocean warming is shifting species distribution from their historical ranges into previously unsuitable environments *(Pinsky et al. 2013 Science 341: 1239-1242)*. This ultimately affects fisheries catches due to simultaneous declines of formerly productive stocks and increases of other stocks in a given area, potentially increasing the risk of fisheries conflict nationally and across borders *(Mendenhall et al. 2020 Mar Pol 117: 103954)*.

Research question #1: Can the signature of ocean warming be identified in fisheries catch and survey data of the rapidly warming NW Atlantic (Canada and US)?

Research question #2: Do the warming signal and level of tropicalization of catches and communities vary latitudinally?

METHODS

Study area: NW Atlantic Ocean – US Mid Atlantic Bight, Gulf of Maine & Georges Bank, and Scotian Shelf, Canada (Fig. 1)

Method: Mean temperature of the catch (MTC) index *(Cheung et al.* 2013 *Nature 497: 365-368)*

$$MTC_{yr} = \frac{\sum_i^n T_i C_{i,yr}}{\sum_i^n C_{i,yr}}$$

$C_{i,yr}$ catches of taxon *i* in year *yr* in the study area
T_i mean temperature preference of taxon *i*
n total number of taxa in the annual catch

Data: Catch & trawl survey datasets (NOAA Fisheries – US National Oceanic & Atmospheric Administration, DFO – Department of Fisheries & Oceans Canada); bottom-associated fishes & invertebrates

Species preferred environmental temperatures (NEREUS database)

Sea bottom temperature (SBT) anomaly (NOAA ship surveys) – Spearman correlations with MTC

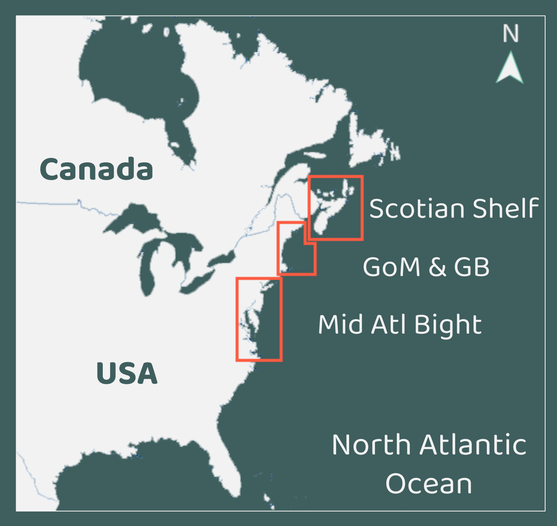

Fig. 1. Map of the three geographical regions of the NW Atlantic included in the MTC calculations.

RESULTS & DISCUSSION

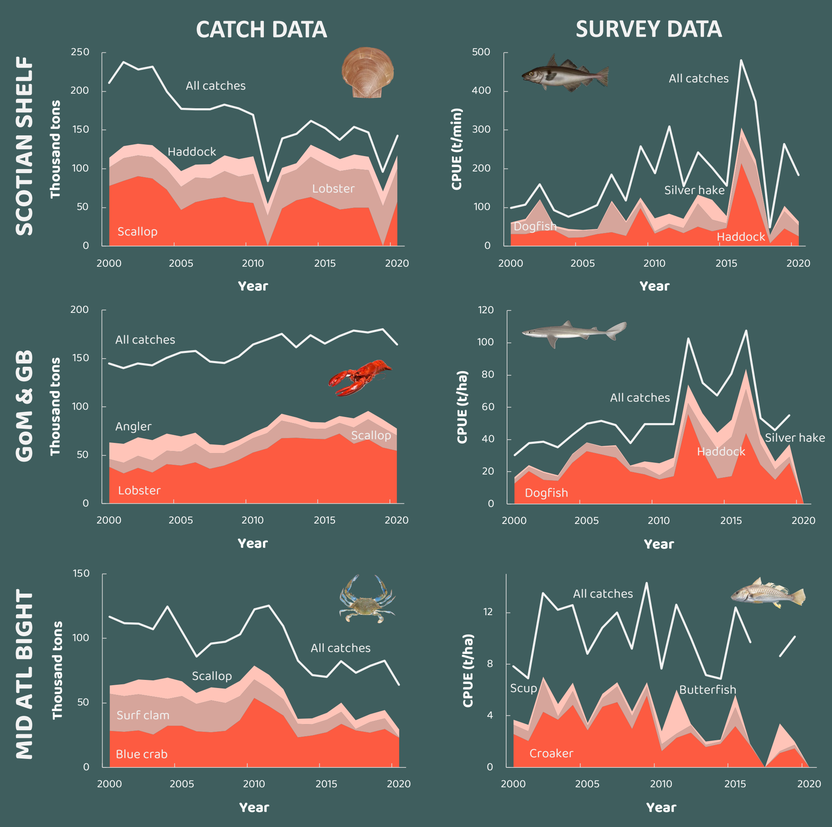

Fig. 2. Overall trends in fisheries catches (left) and survey catch-per-unit-effort (CPUE) data (right) for the three studied regions (white lines) plus the three most abundant species for each region (colors).

#1: Catch trends show overall declines over the past 20 years in the Scotian Shelf and Mid Atl Bight compared to increases in the GoM & GB, while survey data show more variable trends (Fig. 2).

#2: The Scotian Shelf is warming most rapidly (1°C / decade), followed by the GoM & GB (0.9°C / decade), and the Mid Atlantic Bight (0.7°C / decade) (Fig. 3).

#3: Catch and survey data exhibit opposing MTC trends in all three regions (Fig. 3).

#4: The expected increasing MTC trend is shown only in US catches and Canadian surveys but only correlates with SBT in the latter case (Fig. 3).

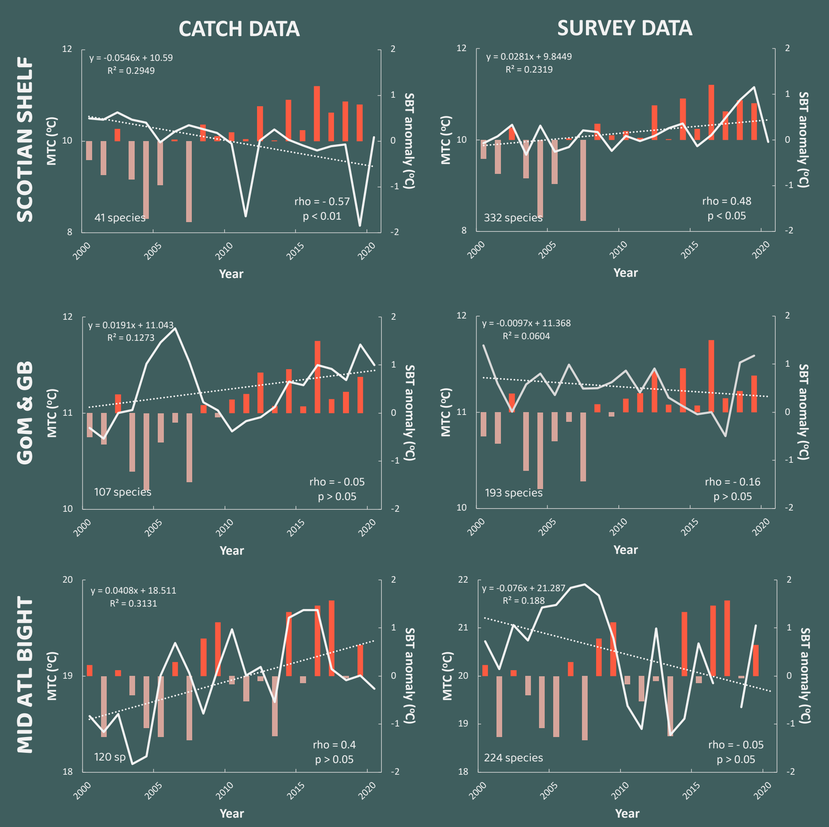

Fig. 3. MTC trends (white lines) calculated using fisheries catches (left) and trawl survey data (right) for the three studied regions, as well as sea bottom temperature anomalies in orange.

- Although the studied regions have been warming, this is not consistently reflected in catch and survey MTC trends. Fish & invertebrate communities are responding to climate change, fisheries management and historical overfishing; this may be blurring the expected MTC signals and latitudinal variability.
- Warming signals in catches may be masked by management regulations, such as the cod moratorium in Atlantic Canada and quotas for summer flounder in the US.
- While fisheries operations may be adapting to changes, species communities may still be resilient to current warming & only reach their thermal maxima in the future.

Luisa Rivera/Yale E360