Environmental Control on the Productivity of a Heavily Fished Ecosystem

Frédéric Cyr

Center for Fisheries and Ecosystem Research Fisheries and Marine Institute of Memorial University St. John's, Newfoundland and Labrador, Canada

Newfoundland

Fisheries Environment in the Northwest Atlantic

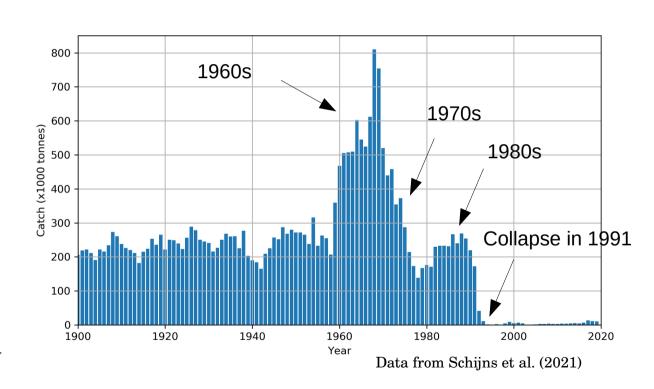
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5 centuries of fisheries ended abruptly early 1990s

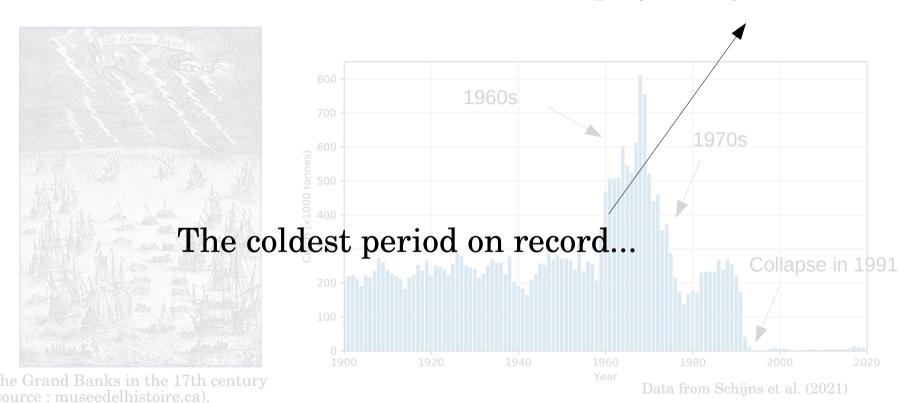


The Grand Banks in the 17th century (source: museedelhistoire.ca).





5 centuries of fisheries ended abruptly early 1990s







Atlantic Zone Monitoring Program [est. 1998]

Proposal for a Northwest Atlantic **Zonal Monitoring Program**

- J.-C. Therriault¹, B. Petrie², P. Pepin³, J. Gagnon⁴, D. Gregory², J. Helbig³, A. Herman², D. Lefaivre¹, M. Mitchell², B. Pelchat¹, J. Runge¹, and D. Sameoto²
- Regional Science Branch Department of Fisheries and Oceans Institut Maurice-Lamontagne 850 route de la Mer. C.P. 1000 Mont-Joli, QC, G5H 3Z4
- Regional Science Branch Department of Fisheries and Oceans Bedford Institute of Oceanography P.O. Box 1006 Dartmouth, NS, B2Y 4A2
- 3 Regional Science Branch Department of Fisheries and Oceans Northwest Atlantic Fisheries Center P.O. Box 5667 St. John's, NF, A1C 5X1
- Marine Environmental Data Services Branch Department of Fisheries and Oceans S1202-200 Kent St. Ottawa, ON, K1A 0E6

1998

Canadian Technical Report of Hydrography and **Ocean Sciences 194**

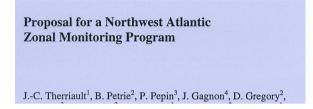


and Oceans

Canadä



Atlantic Zone Monitoring Program [est. 1998]



1. INTRODUCTION

1.1 CONTEXT

Past experience has taught us that fluctuations in the marine environment, either natural or maninduced, can have drastic socio-economic implications for the Canadian population living in coastal areas. One evident example is the potential economic impact of the sea level rise on the inhabited coastal zones. Another is the relationship between environmental variability and the production of marine organisms, which suggests that changes in climate cannot be ignored as an explanation for fluctuations in marine resources.







-- Part I --

A brief history of Fisheries **Environment in the NW Atlantic**

Definition

"Fisheries Environment" refers to the ensemble of environmental and ecological factors affecting particular fisheries and/or ecosystem productivity [personal definition].

t"Climate Fisheries" is a near-synonym but refers to changes in the mean state of the environment (the climate), while Fisheries Environment is more inclusive of both long-term changes and rapid/unexpected fluctuations.



The origin of Fisheries Environment

CONSEIL PERMANENT INTERNATIONAL POUR
L'EXPLORATION DE LA MER

RAPPORTS ET PROCÈS-VERBAUX

VOLUME XX

FLUCTUATIONS IN THE GREAT FISHERIES OF NORTHERN EUROPE

VIEWED IN THE LIGHT OF BIOLOGICAL RESEARCH

BY

JOHAN HJORT

WITH 3 PLATES

"Fluctuations in the yield: a characteristic feature of all great fisheries"

- Hjort, 1914



The origin of Fisheries Environment

[About Newfoundland cod]:

"It is possible that in abnormal years the freezing of the sea farther south than the normal southerly limit might produce disastrous results on baby cod, and in this direction the Canadian inquiries might be of incalculable benefit."

- G.C.L. Howell, 1921

(Ocean Research and the Great Fisheries)

The origin of Fisheries Environment

[About Newfoundland cod]:

70 years before the collapse of the northern cod during the coldest period in the modern records!

- G.C.L. Howell, 1921

(Ocean Research and the Great Fisheries)



The International Commission for the Northwest Atlantic Fisheries (ICNAF) was a key player in Fisheries Environment in the 1960s-70s

93 contributions!

INTERNATIONAL COMMISSION

FOR THE

NORTHWEST ATLANTIC FISHERIES



Special Publication No. 6

ICNAF ENVIRONMENTAL SYMPOSIUM

Held in the Headquarters of FAO,

Rome, 1964

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| SECTION B. | Convener: GLOVER, R.S. Rapporteur: COLEBROOK, J.M.: Effect of the Environment of Pelagic and Early Demersal Stages of Groundfish | |
| SECTION C. | Convener: TEMPLEMAN, W. Rapporteur: MAY, A.W.: Effect of the Biological Environment (including parasites) on the Distribution of Adult Fish | ı |
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1972: second coldest year on record

INTERNATIONAL COMMISSION

FOR THE

NORTHWEST ATLANTIC FISHERIES



Special Publication No. 10

Symposium on Environmental Conditions in the Newfoundland Grand Bank Area in 1972 and their

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ICNAF was dissolved in 1979 and replaced by the Northwest Atlantic Fisheries Organization (NAFO) in the wake of the establishment of the 200 miles EEZs

In 1981:

"whereas under ICNAF the environmental subcommittee provided a forum for bringing together oceanographers and biologists, there is no clear focus on these discussions within the present SC"

SC has four Standing Committees



- Assesses the status of fish stocks
- Assesses the effects on fish. stocks of fishing strategies and management
- Evaluates new methods for fish stock assessment



STACREC

Standing Committee

on RESEARCH

- Compiles and disseminates statistical information on fisheries in the Convention
- Coordinates the planning and execution of international cooperative research
- Reviews and evaluates advances in fisheries science and biology



- · Develops editorial policies and procedures for the Scientific Council
- Reviews the publication process for Scientific Council documents and the Journal of Northwest Atlantic Fishery Science.



In 1981:

"whereas under ICNAF the environmental subcommittee provided a forum for bringing together oceanographers and biologists, there is no clear focus on these discussions within the present SC"

→ 1982 – Creation of the STACFIS Subcommittee on Environmental Research

SC has four Standing Committees

STACFIS Standing Committee on FISHERIES **SCIENCE**

- Assesses the status of fish stocks
- · Assesses the effects on fish stocks of fishing strategies and management
- Evaluates new methods for fish stock assessment





statistical information on fisheries in the Convention

Compiles and disseminates

- Coordinates the planning and execution of international cooperative research
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- Develops editorial policies and procedures for the Scientific Council
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In 1981:

"whereas under ICNAF the environmental subcommittee provided a forum for bringing together oceanographers and biologists, there is no clear focus on these discussions within the present SC"

- → 1982 Creation of the STACFIS Subcommittee on Environmental Research
- → 1994 Creation of STACFEN

SC has four Standing Committees

STACFIS

Standing Committee on FISHERIES **SCIENCE**

- Assesses the status of fish stocks
- · Assesses the effects on fish stocks of fishing strategies and management
- Evaluates new methods for fish stock assessment



- Develops policies and procedures for the collection. compilation and dissemination of environmental information
- · Provides periodic reviews of environmental conditions and advises the Scientific Council on the effects of the environment on fish
- Encourages and promotes cooperation among Contracting Parties in scientific research



- Coordinates the planning and execution of international
- cooperative research Reviews and evaluates advances in fisheries science and biology

Compiles and disseminates

fisheries in the Convention

statistical information on



on PUBLICATIONS

 Develops editorial policies and procedures for the Scientific Council **STACPUB** Standing Committee

 Reviews the publication process for Scientific Council documents and the Journal of Northwest Atlantic Fishery Science.

STACFEN Standing Committee on FISHERIES **ENVIRONMENT**





In 1981:

"whereas under ICNAF the environmental subcommittee provided a forum for bringing together oceanographers and biologists, there is no clear focus on these discussions within the present SC"

In 2024 (43 years later):

"Recommendation that further discussions occur between STACFEN and STACFIS..."



- Assesses the status of fish stocks
- Assesses the effects on fish stocks of fishing strategies and management
- Evaluates new methods for fish stock assessment



- Develops policies and procedures for the collection, compilation and dissemination of environmental information
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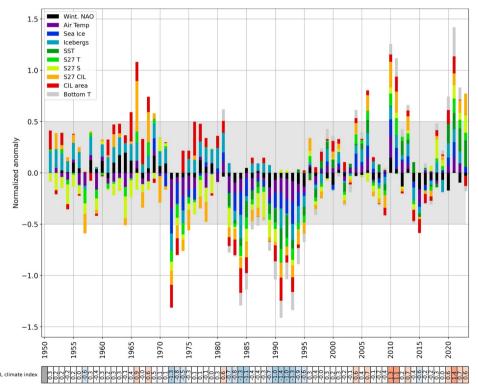


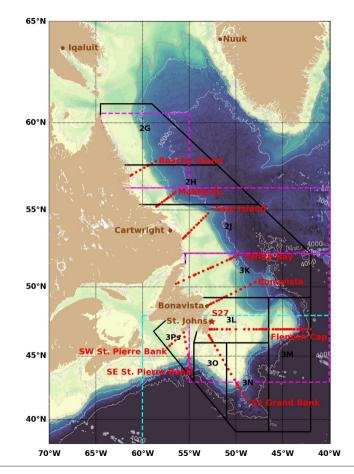


-- Part II --

An Example of Fisheries Environment in the NW Atlantic

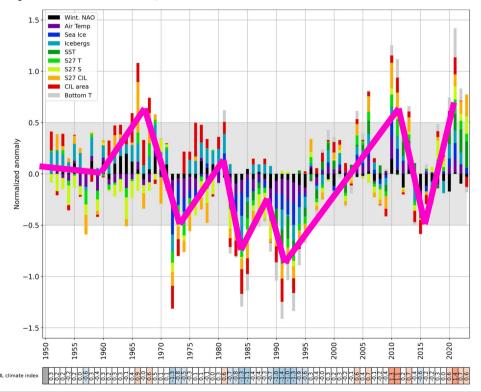
Newfoundland and Labrador Ocean Climate





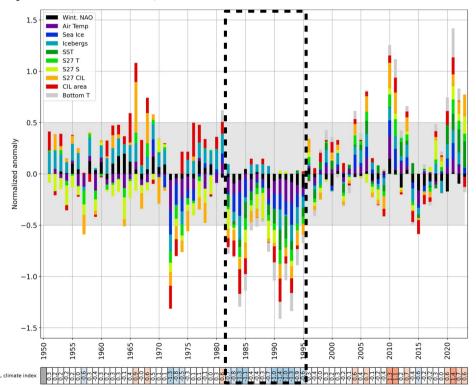


[Cyr & Galbraith, 2021]



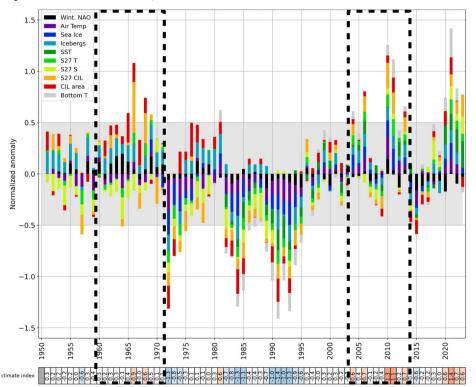
→ Strong decadal variability





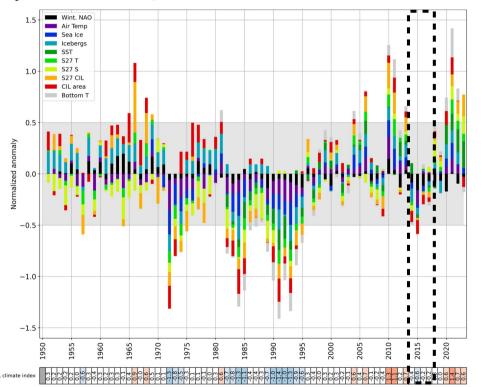
- → Strong decadal variability
- \rightarrow Mid-80's / early-90's was the coldest decade in 70 yr





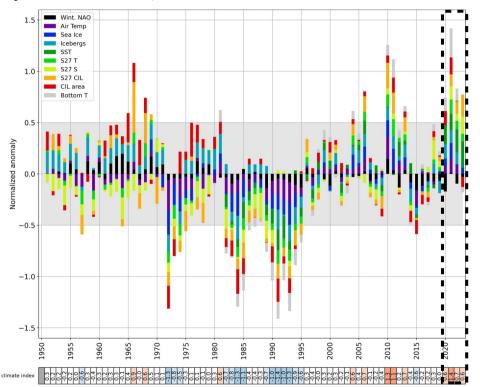
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- \rightarrow The 60's and early-2010's were the warmest





- → Strong decadal variability
- \rightarrow Mid-80's / early-90's was the coldest decade in 70 yr
- \rightarrow The 60's and early-2010's were the warmest
- \rightarrow Recent (2014-2017) cooler period



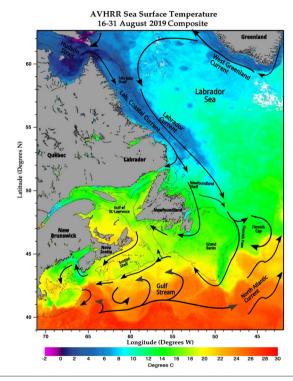


- → Strong decadal variability
- → Mid-80's / early-90's was the coldest decade in 70 yr
- → The 60's and early-2010's were the warmest
- → Recent (2014-2017) *cooler* period
- → Developing warm period since ~2020



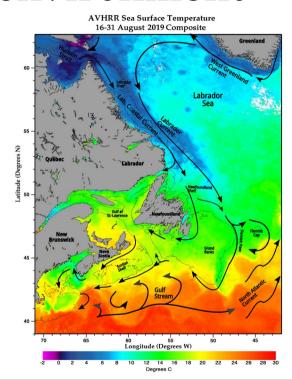
What drive these changes in ocean climate?

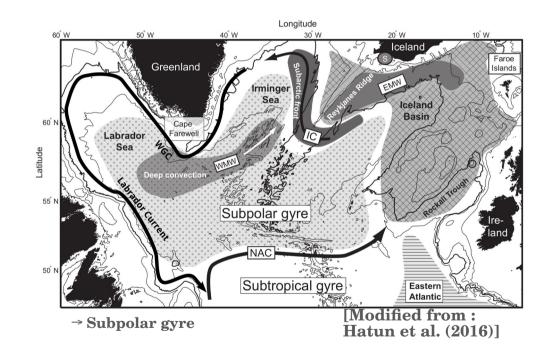
The NL shelf is a naturally variable environment





The NL shelf is a naturally variable environment

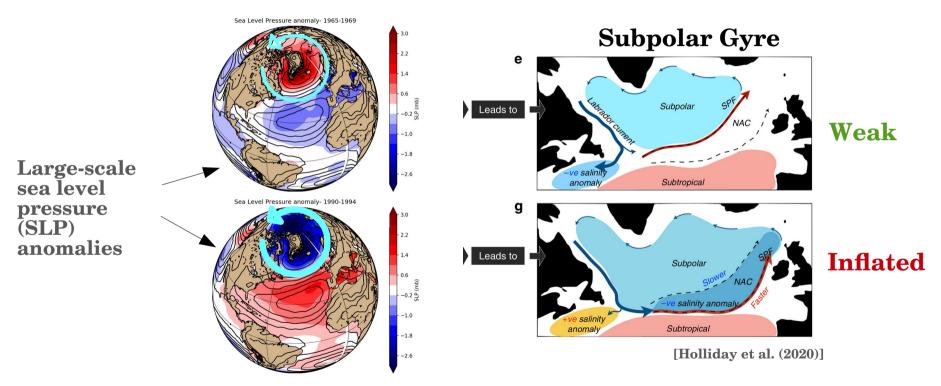








SLP patterns drive the ocean circulation

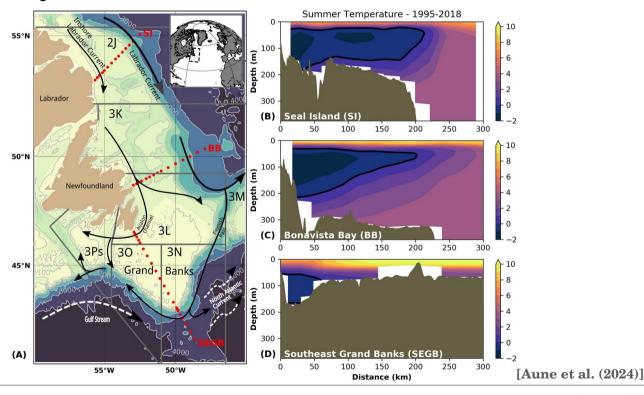






Regional Ocean Climate

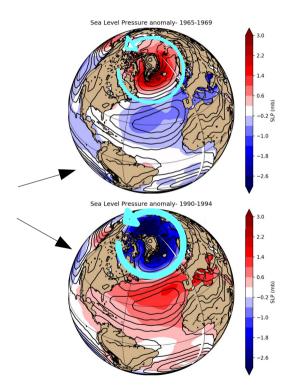
Cold Intermediate Layer (CIL): a key feature of the NL ecosystem

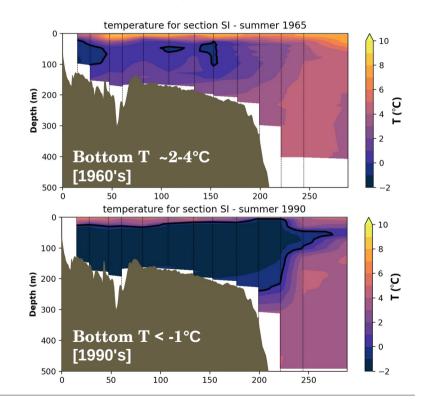




SLP patterns drive the CIL variability

Large-scale sea level pressure (SLP) anomalies

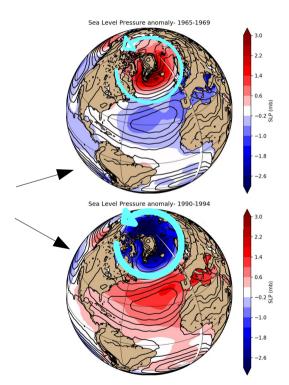


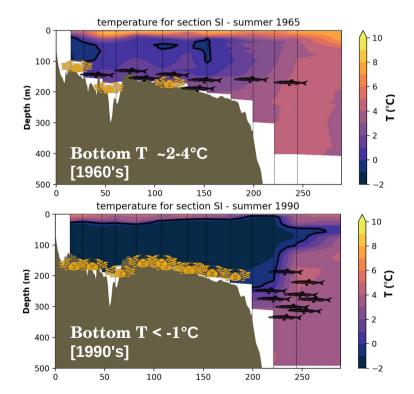




SLP patterns drive the CIL variability

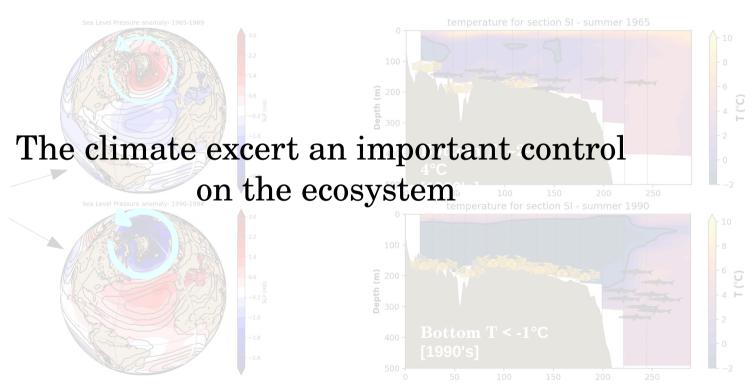
Large-scale sea level pressure (SLP) anomalies





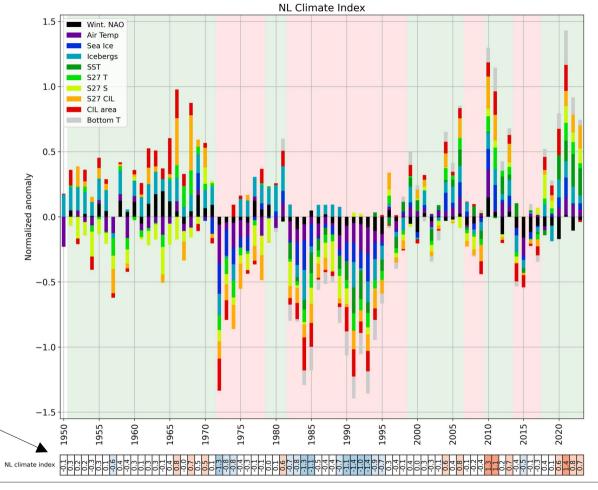


SLP patterns drive the CIL variability



Fisheries and Climate

Climate phases





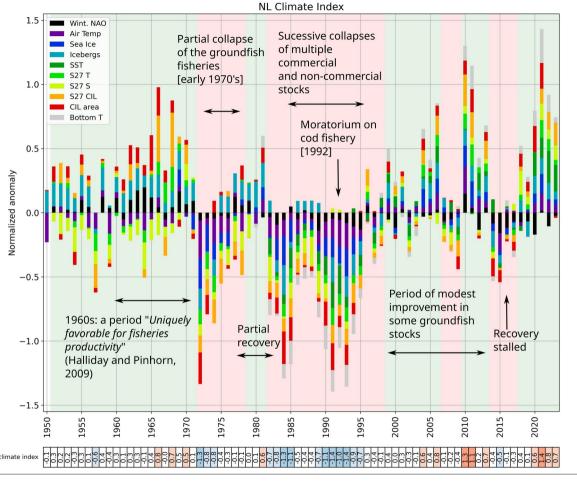


years

A new phase is created when the sign changes for at least 3 sucessive

Climate phases





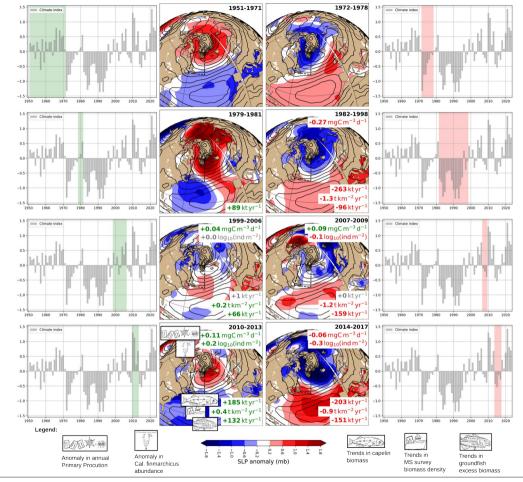


Climate phases



Warmer climate

Positive SLP anomalies above the pole





Colder climate

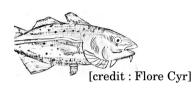
Negative SLP anomalies above the pole



1972-1978 1.5 Climate index 1951-1971 Climate phases Colder Warmer The regional climate is driven by large scale **Negative SLP Positive SLP** atmospheric patterns anomalies above the above the pole pole



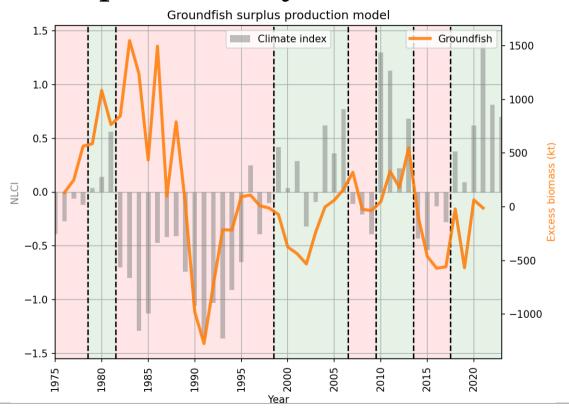




Process error from a groundfish surplus production model converted into "Excess Biomass"

→ changes in biomass not explained by densitydependent effects and subtraction by fisheries

[P. Regular]



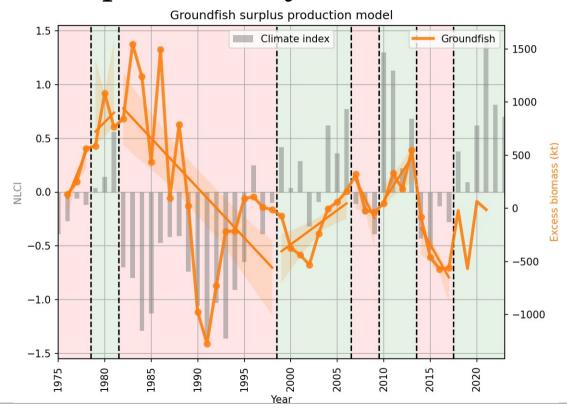




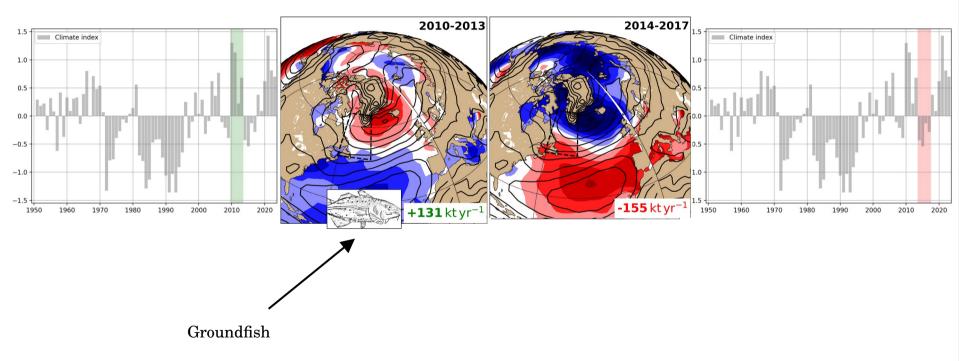
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[P. Regular]

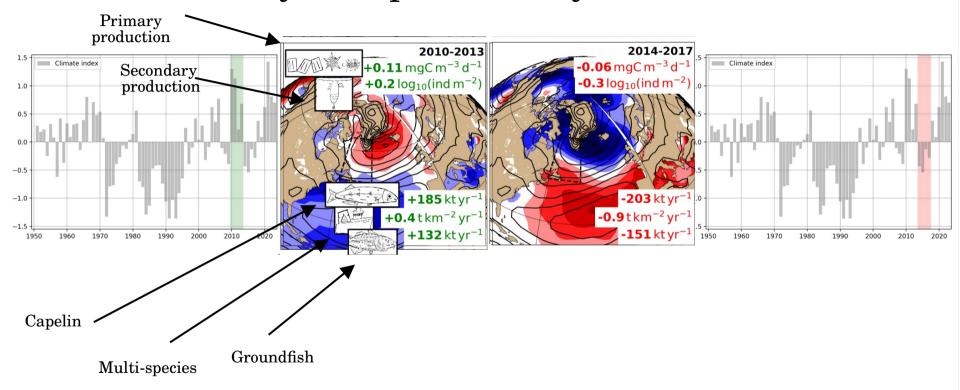






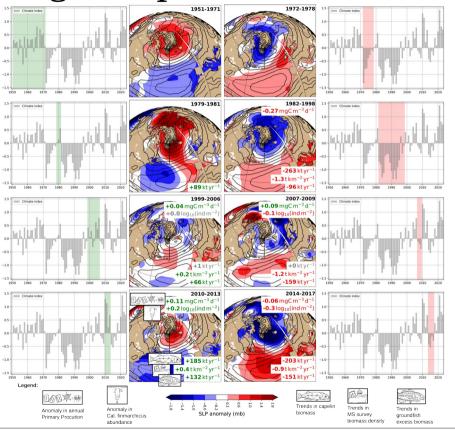






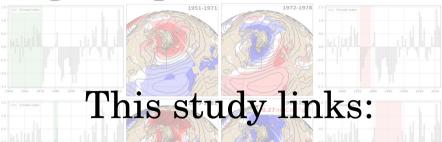


The climate changes in phases

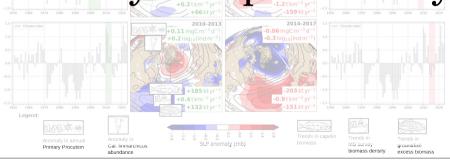




The climate changes in phases



Northern hemisphere atmospheric patterns to NL ocean climate to ecosystem productivity







Article

Environmental Control on the Productivity of a Heavily Fished Ecosystem

Frederic Cyr1 ORCID Email Aaron Adamack1 David Bélanger¹ Mariano Koen-Alonso1 Under review Darrell Mullowney1 Hannah Murphy¹ → available as preprint Paul Regular¹ Pierre Pepin¹ ¹ Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre This is a preprint; it has not been peer reviewed by a journal. https://doi.org/10.21203/rs.3.rs-4108948/v1 This work is licensed under a CC BY 4.0 License



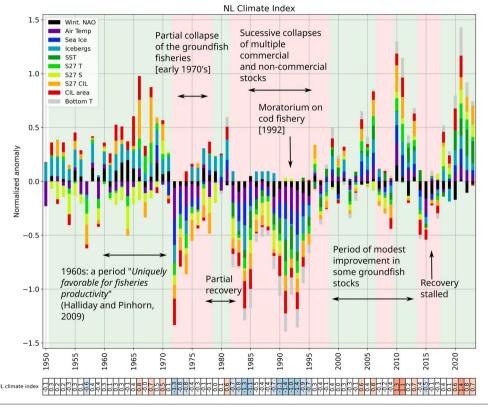


-- Part III --

How to move ahead with Fisheries **Environment?**

Incorporation of climate data into fisheries

management?



Incorporation of climate data into fisheries management?

Hard-coded into harvest control rules



→ « environmentally informed control rule modifies the harvest rate based on average sea surface temperatures »



Incorporation of climate data into fisheries management?

Hard-coded into harvest control rules

or

Qualitative information on climate phase (e.g., El Niño)

OPEN ACCESS | Article

Evaluating robustness of harvest control rules to climate-driven variability in Pacific sardine recruitment

Authors: Robert P. Wildermuth @ M. Desiree Tommasi @ Peter Kuriyama @ James Smith, and Isaac Kaplan @ Publication: Canadian Journal of Fisheries and Aquatic Sciences • 16 November 2023 • https://doi.org/10.1139/cifas-2023-0169

JUNE 14, 2023

Peru's canceled anchovy fishing season seen as necessary trade-off for sustainability

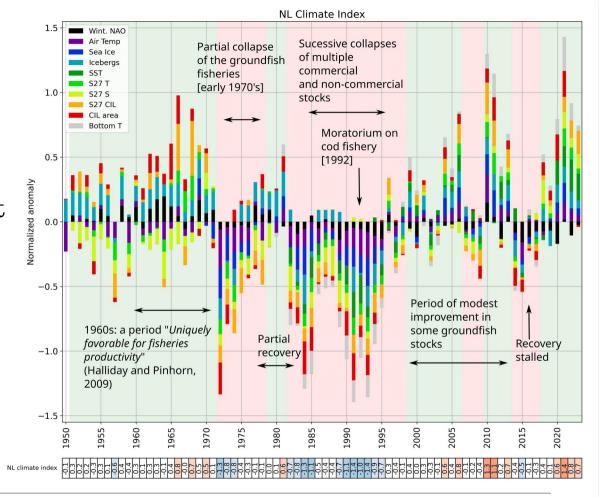
Christian Molinari published in Supply & Trade





Take home message

→ The <u>lack of precise</u>
<u>quantitative knowledge</u> on
the effect of the environment
on fish stocks <u>does not</u>
<u>preclude its integration</u> into
stock assessments
and its consideration in
fisheries management
decisions.











Thank you!

Thank you to numerous colleagues, staff and captains who participated to the data collection since the 1950s

Questions or comments? Frederic.Cyr@mi.mun.ca

@fcyr.bsky.social





