

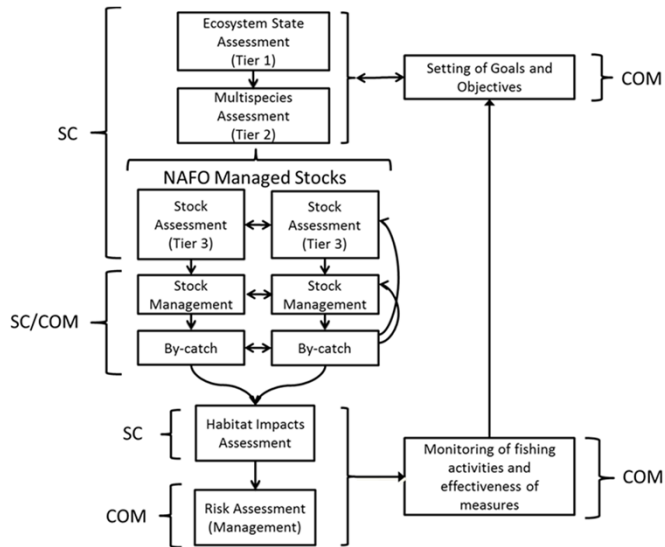
# IMPLEMENTATION OF THE ECOSYSTEM APPROACH FRAMEWORK TO FISHERIES MANAGEMENT



33<sup>o</sup> reunión del Grupo de Trabajo 2 - LDAC  
7<sup>th</sup> March 2024-Brussels

Mar Sacau Cuadrado and Pablo Durán Muñoz  
Centro Oceanográfico de Vigo (COV-IEO, CSIC)

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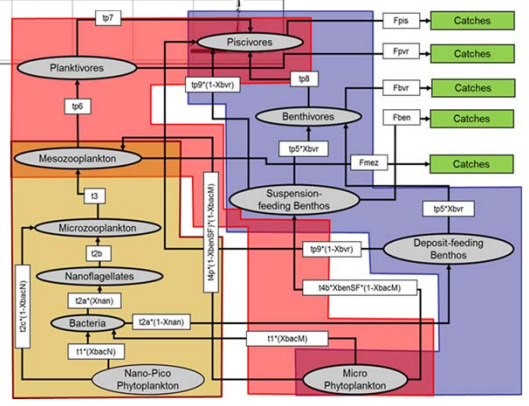
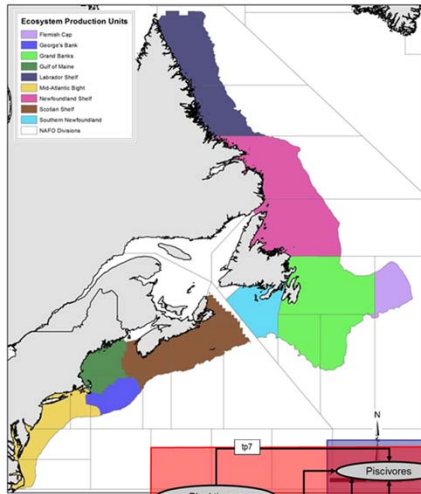


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# What is the NAFO Roadmap ?

3

4



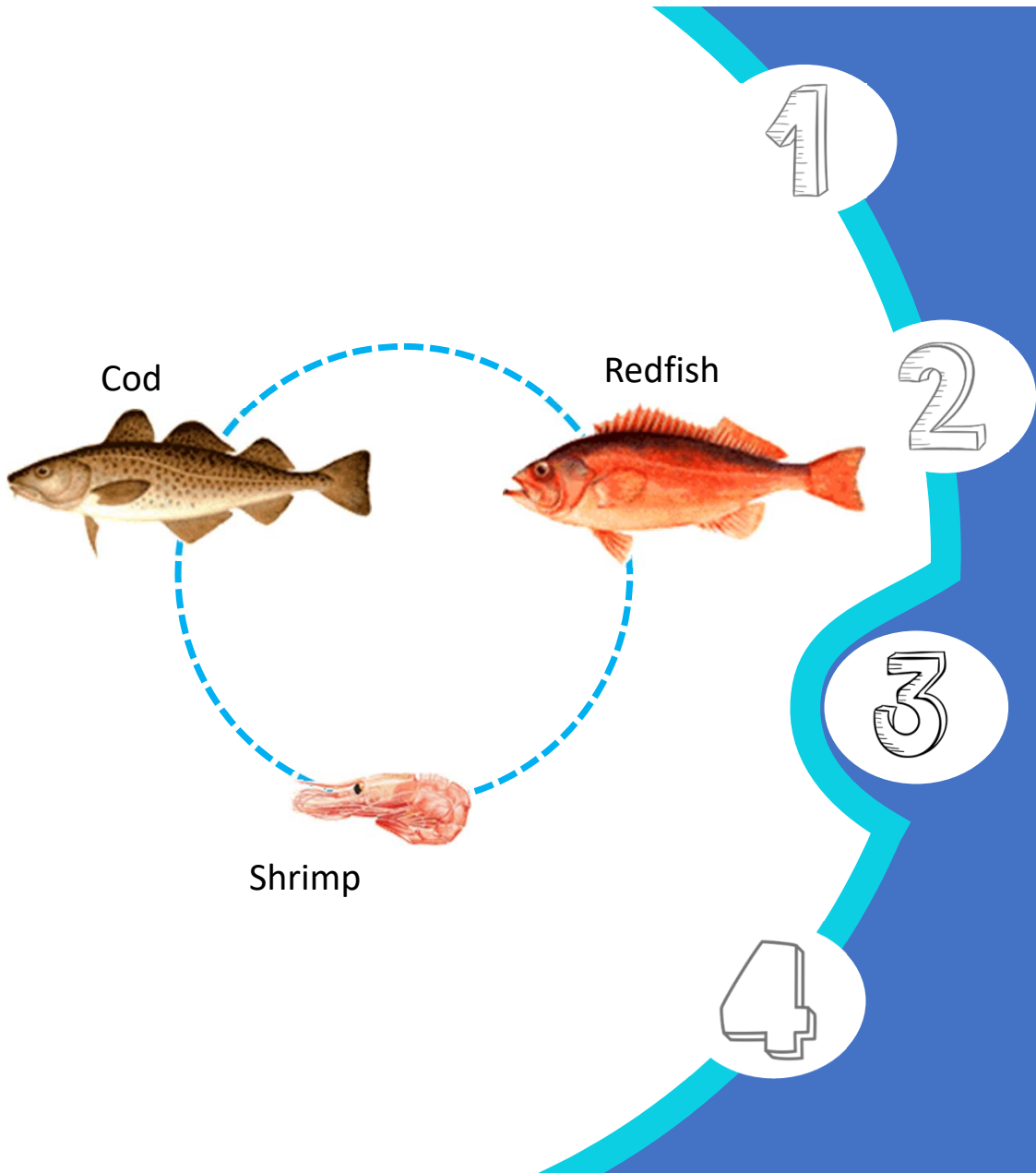
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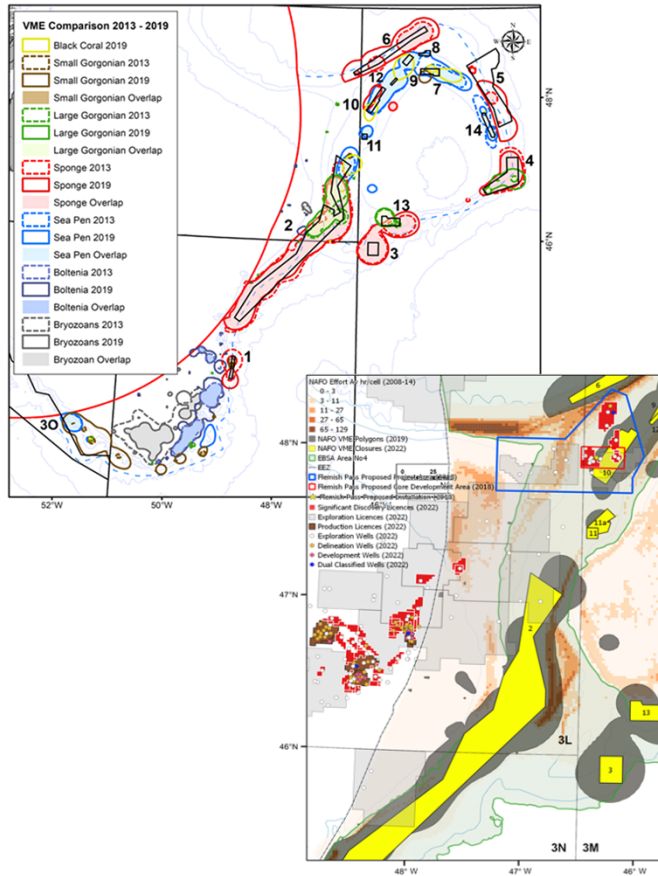
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EPUs; EPP model; FPP and TCI concepts



# Multispecies assessment



1

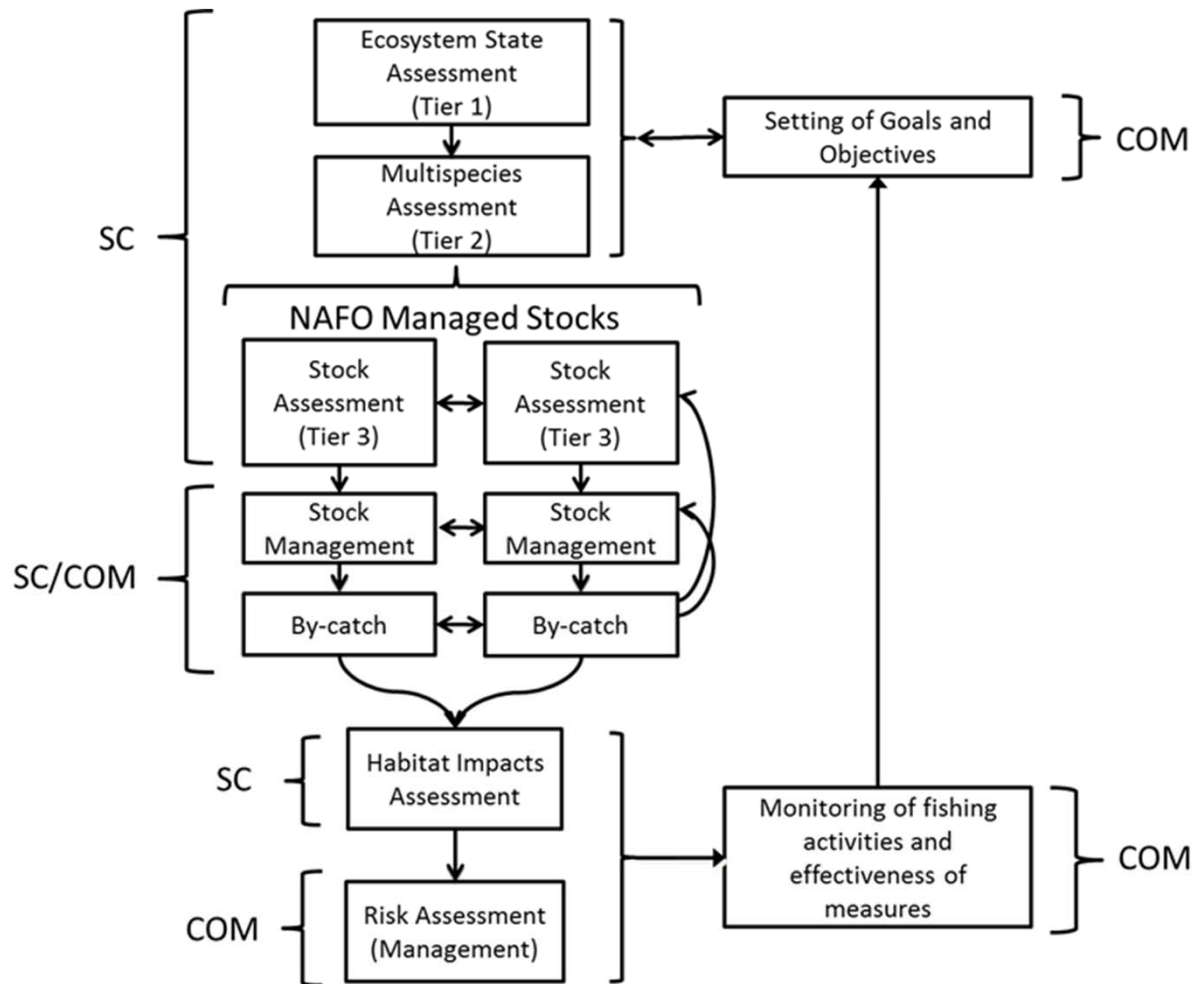
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VMEs; SAI;  
Activities other  
than fishing

# What is the NAFO Roadmap ?



M. Koen-Alonso *et al.* (2019)

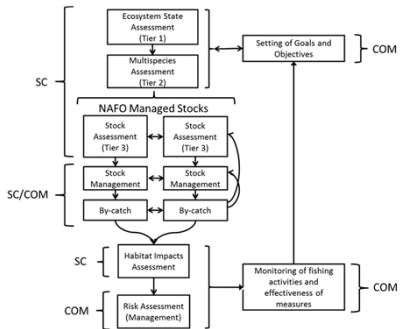
## What is it?

- It is a guiding set of ideas and principles to implement an Ecosystem Approach to Fisheries (EAF)
- It lays out an organizing framework
- It includes both Science and Management
- It is pragmatic
- It is modular

## Core premises

- Objective-driven
- Long-term ecosystem sustainability
- Place-based framework
- Trade-offs in managing human activities explicitly defined

# What is the NAFO Roadmap ?



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1

Productivity State Assessment

Tier 2

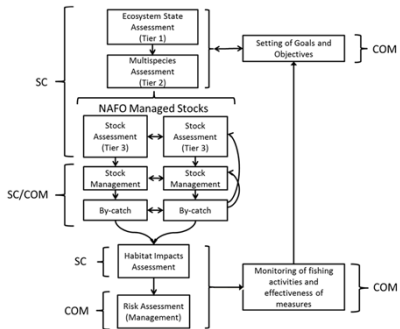
Multispecies Assessment

Tier 3

Stock Assessment

HABITAT IMPACTS ASSESSMENT

# What is the NAFO Roadmap ?



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1

Productivity State Assessment

Tier 2

Multispecies Assessment

Tier 3

Stock Assessment

HABITAT IMPACTS ASSESSMENT



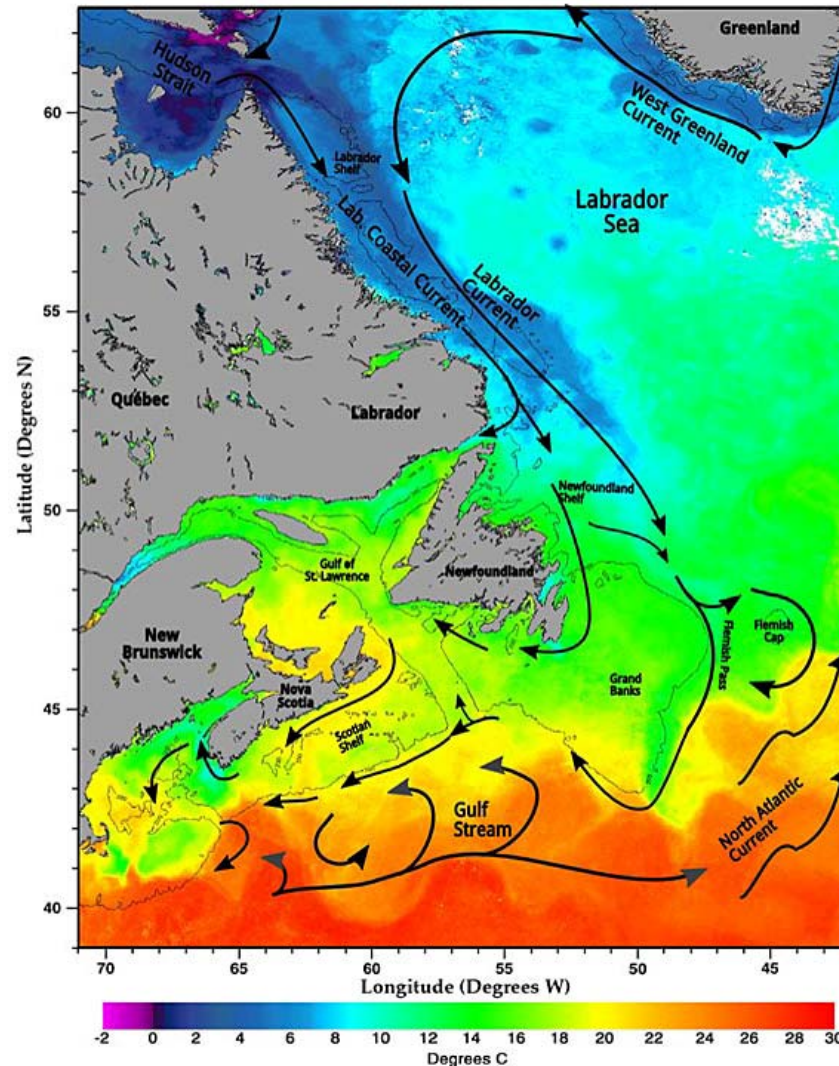
# Identify Functional Ecosystem Units

Ecosystem management requires to define **appropriate management units**.

These units need to:

Reasonably capture a functional ecosystem

Be practical for fisheries management applications



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1 Productivity State Assessment

Tier 2 Multispecies Assessment

Tier 3 Stock Assessment

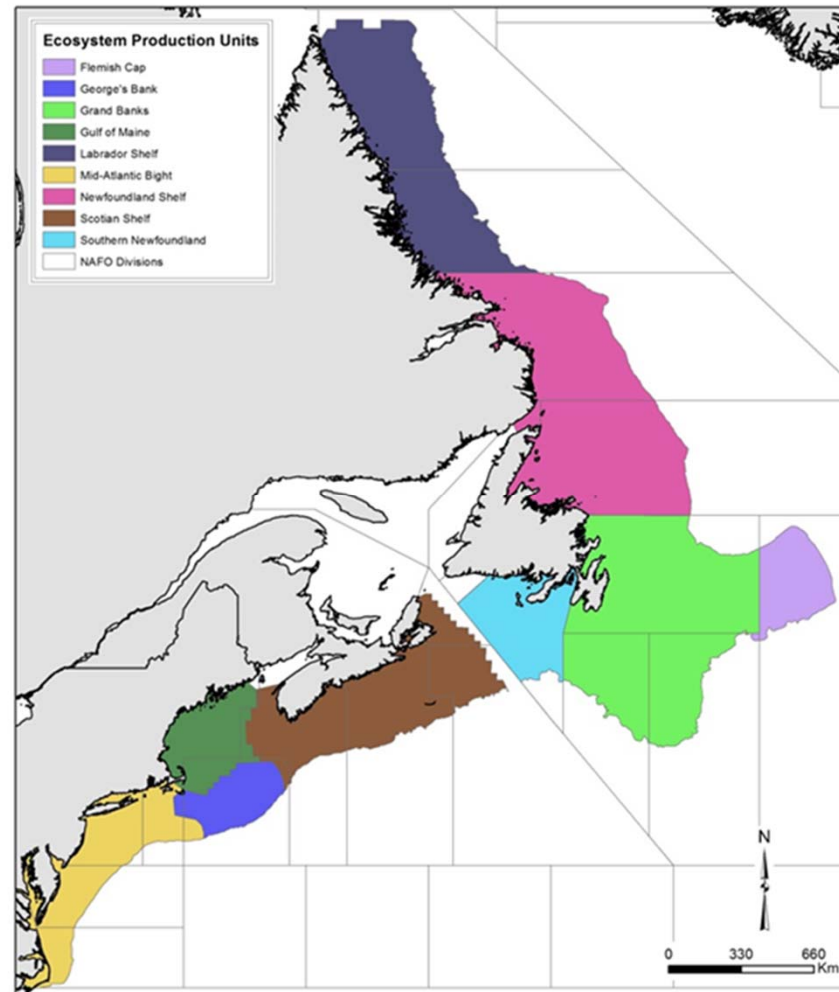
HABITAT IMPACTS ASSESSMENT

**Labrador Current**  
(from N to S)  
**Gulf Stream**  
(from S to N)

# Identify Functional Ecosystem Units

**9** Ecosystem Production Units (EPUs) were defined in NAFO Convention Area

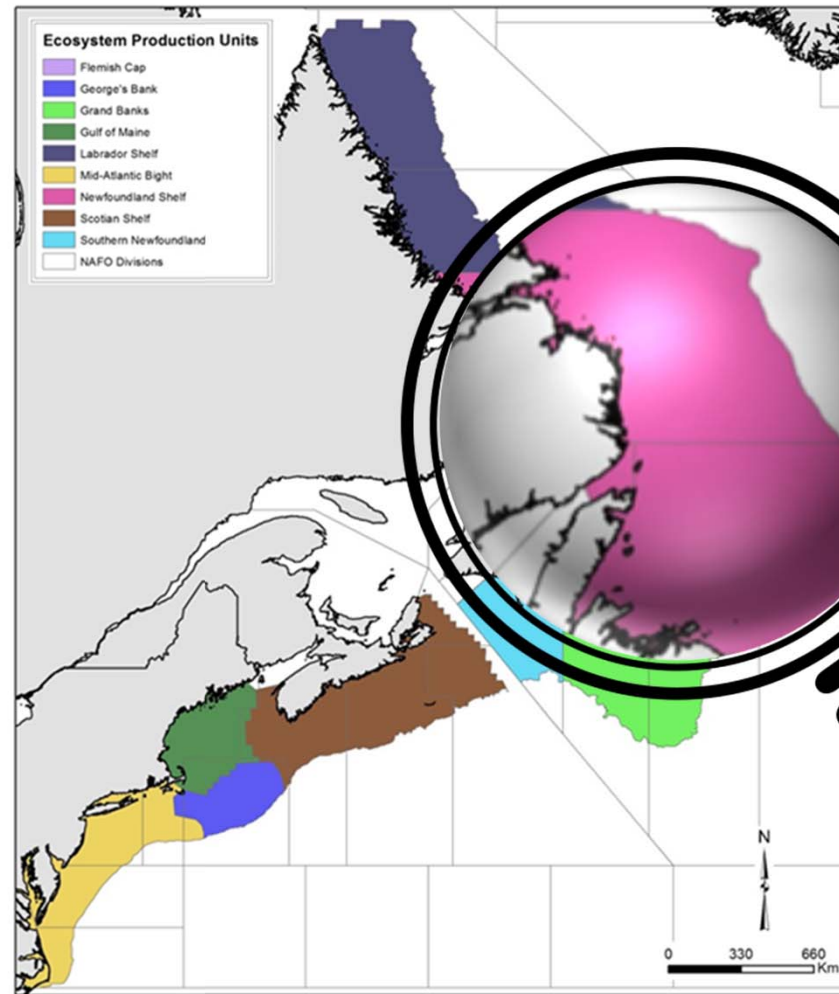
Only **3** used for the analysis of the Ecosystem Production Potential (EPP)



# Identify Functional Ecosystem Units

**9** Ecosystem Production Units (EPUs) were defined in NAFO Convention Area

Only **3** used for the analysis of the Ecosystem Production Potential (EPP)

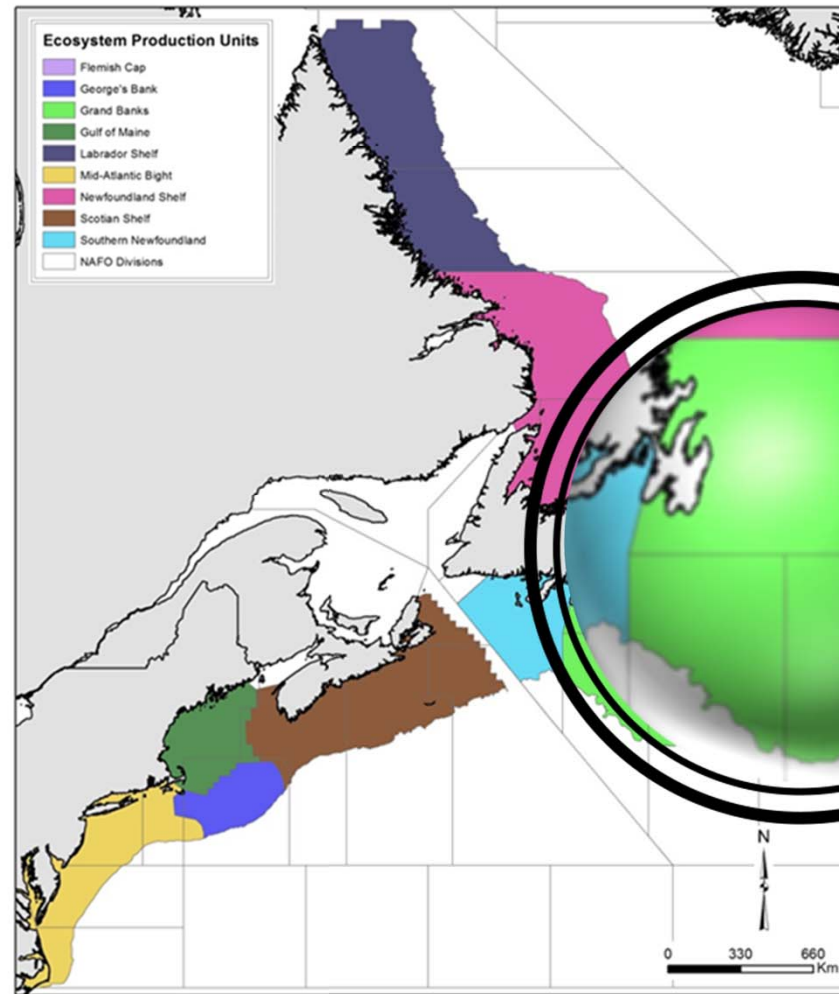


Newfoundland Shelf  
(Divisions 2J3K)

# Identify Functional Ecosystem Units

**9** Ecosystem Production Units (EPUs) were defined in NAFO Convention Area

Only **3** used for the analysis of the Ecosystem Production Potential (EPP)

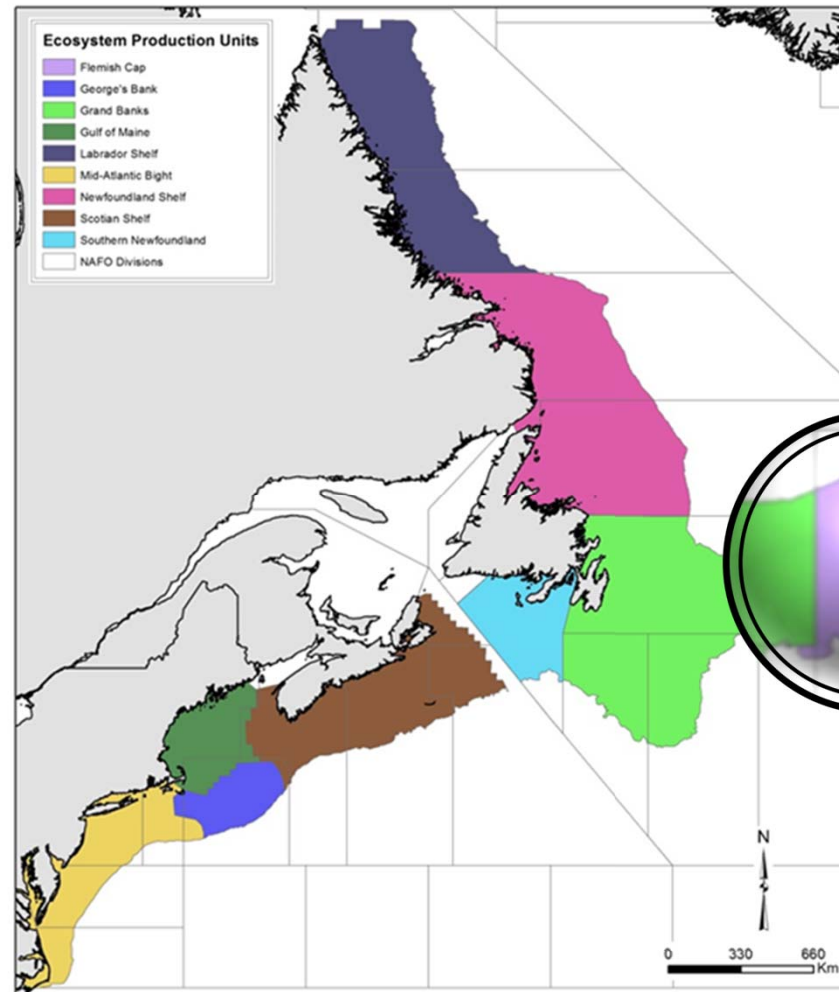


**Grand Bank  
(Divisions 3LNO)**

# Identify Functional Ecosystem Units

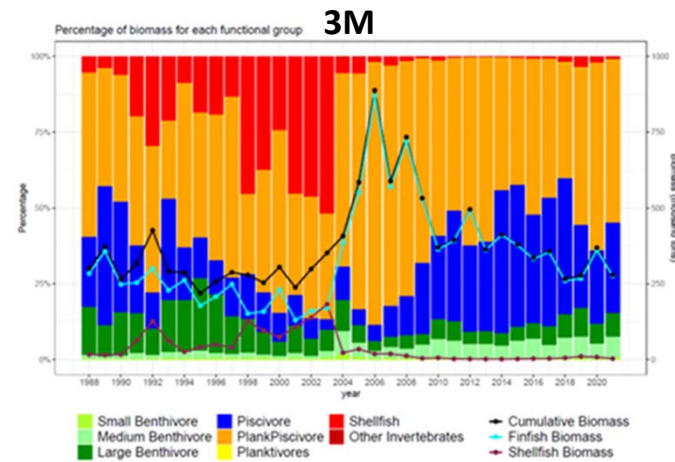
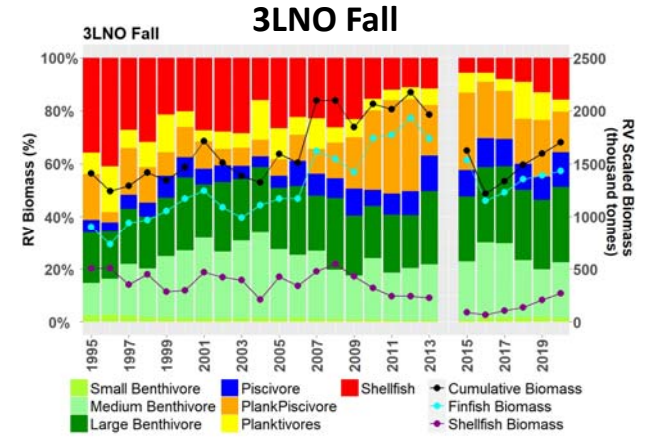
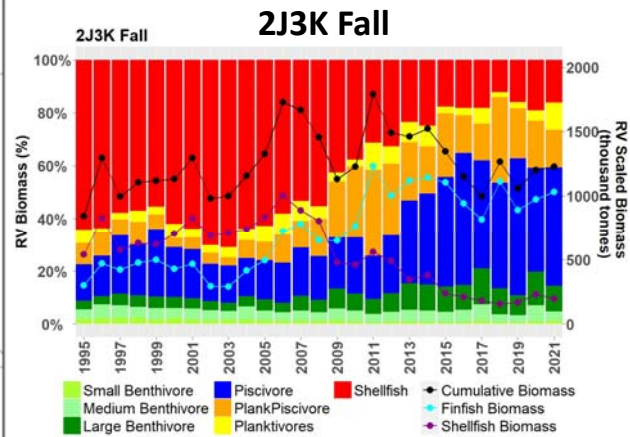
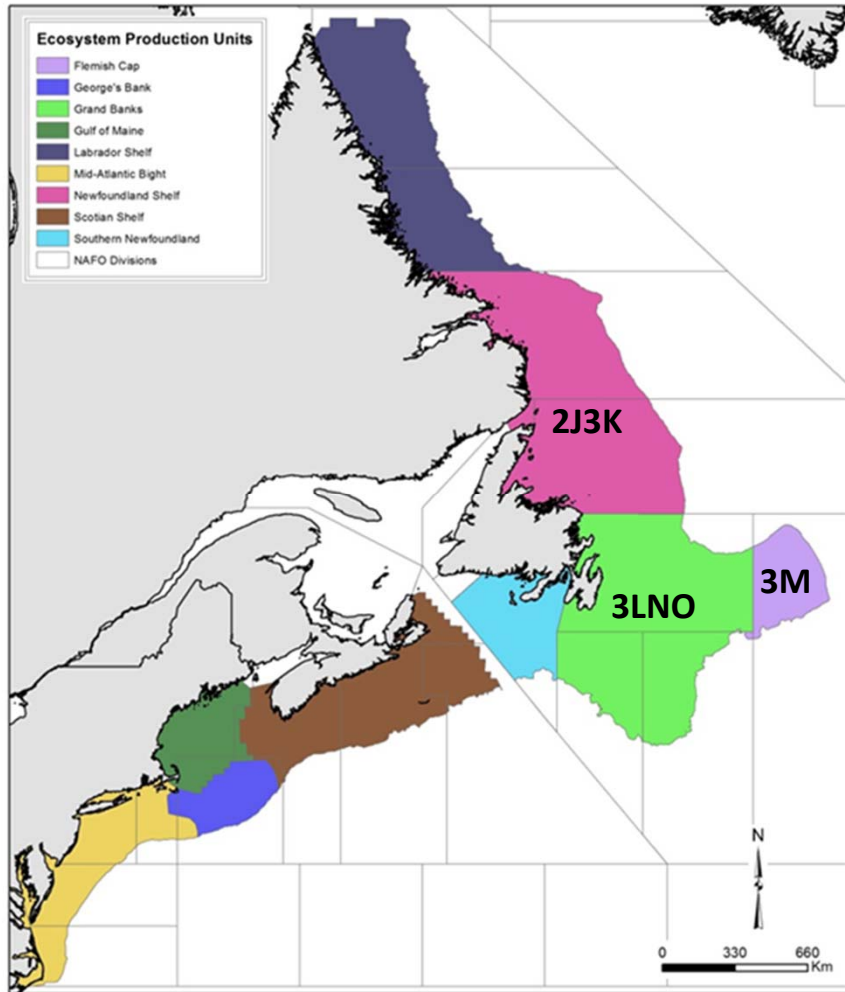
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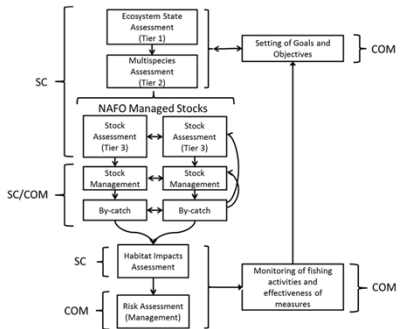
**Flemish Cap  
(Division 3M)**

# Identify Functional Ecosystem Units



Composition of functional groups for the different EPUs

# Productivity State Assessment



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1

Productivity State Assessment

Tier 2

Multispecies Assessment

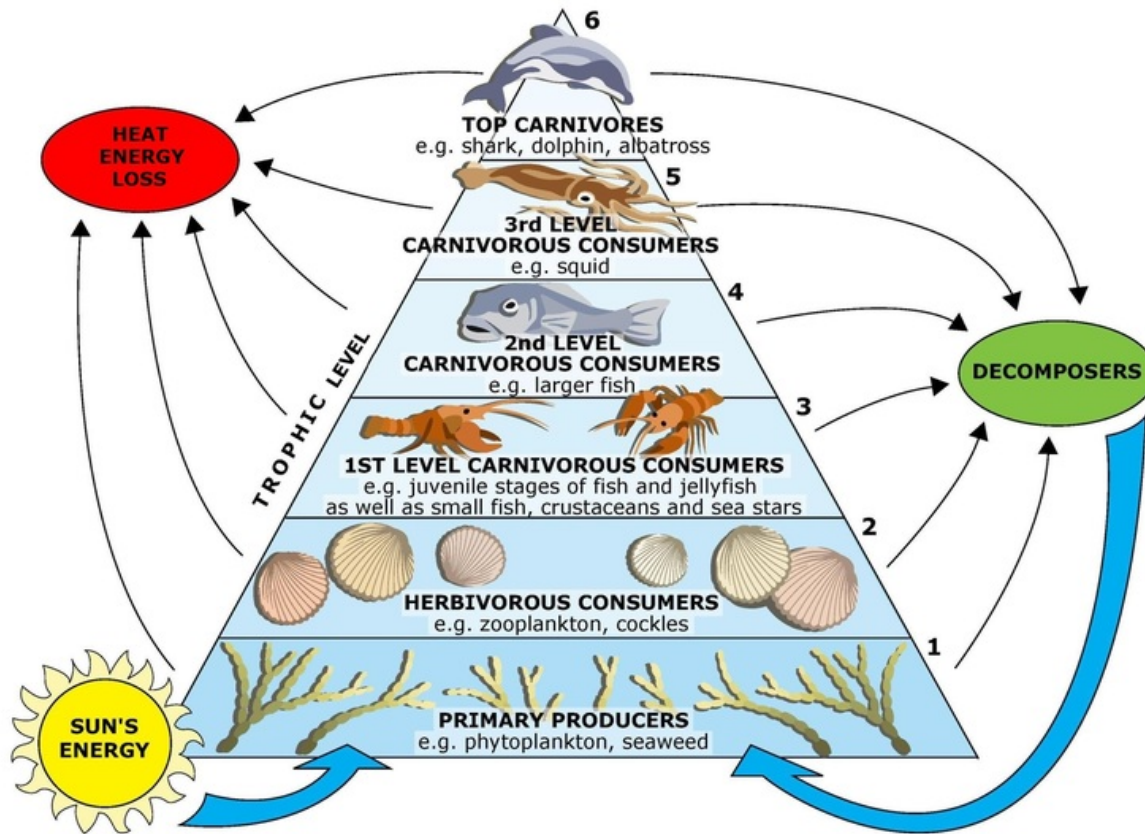
Tier 3

Stock Assessment

HABITAT IMPACTS ASSESSMENT

# Fisheries Sustainability and Ecosystem Productivity

## FOODWEB CONCEPT



At the **ecosystem level**, fisheries sustainability means that we cannot take more than what **ecosystem can produce**.

We can **estimate** how much catch can be **sustainably taken** using **primary production estimates** and some basic **food web modelling**.

The **EPUs** provide the **spatial extent** to consider for these analyses.

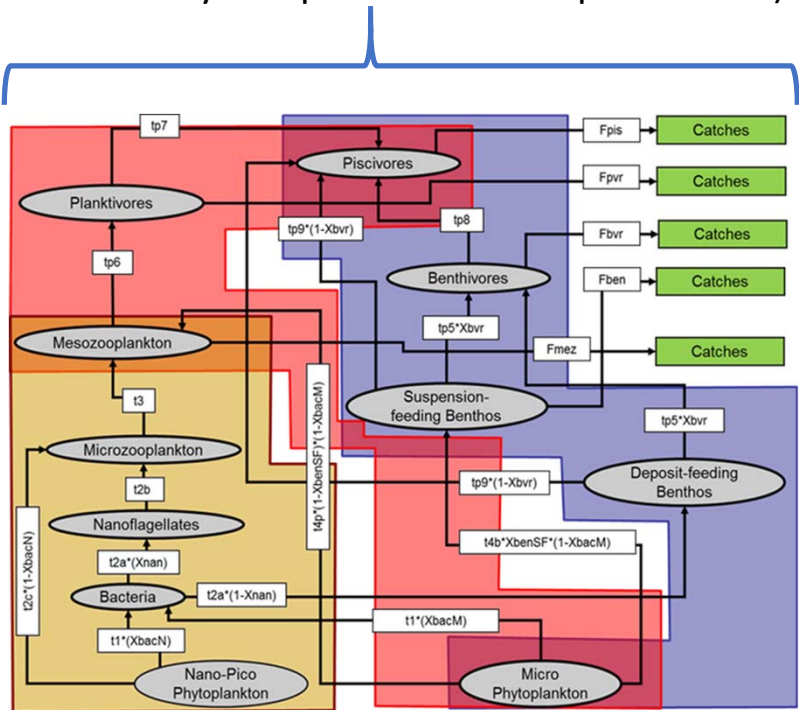
$$\begin{array}{|c|} \hline \text{Primary} \\ \text{Production} \\ \hline \end{array} + \begin{array}{|c|} \hline \text{Transfer efficiencies} \\ \text{\& Food web structure} \\ \hline \end{array} = \begin{array}{|c|} \hline \text{Production at fish} \\ \text{trophic level} \\ \hline \end{array}$$



# Ecosystem Production Potential (EPP) model

## Structure of the EPP model

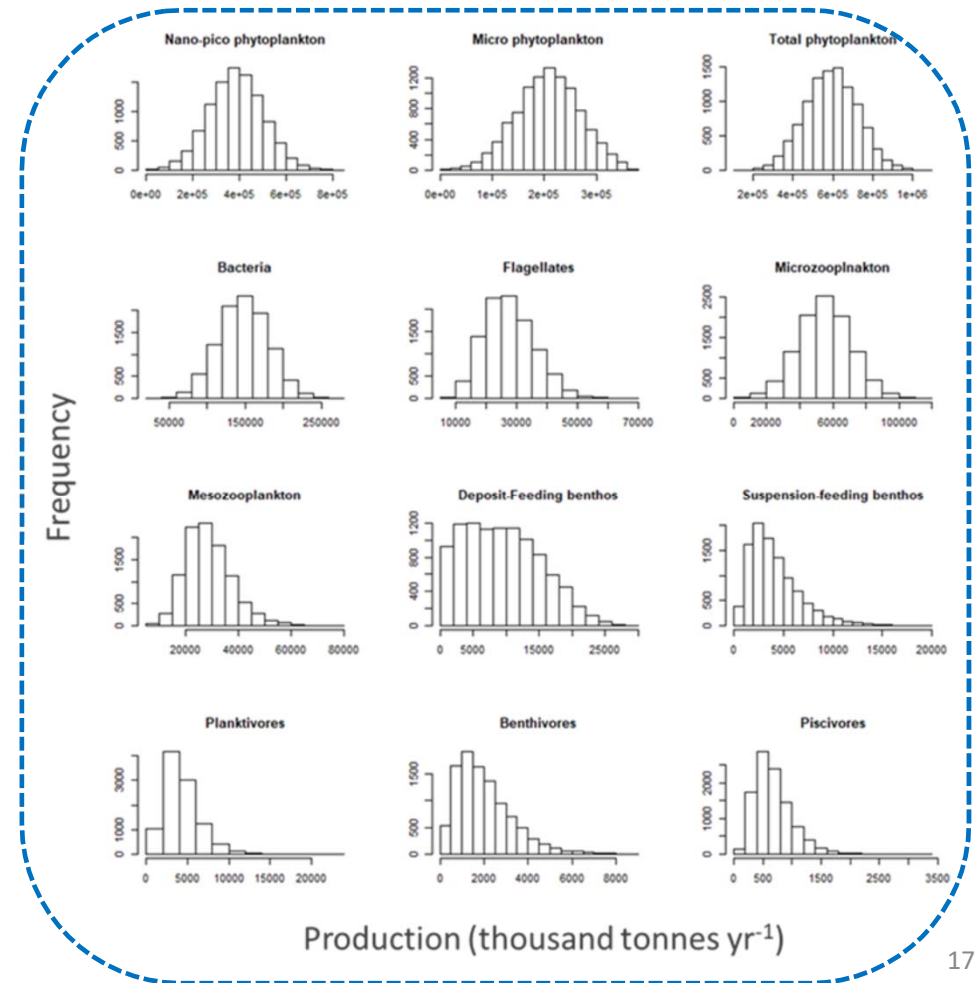
**Monte Carlo simulation:** account for the uncertainty in inputs and model parameters)



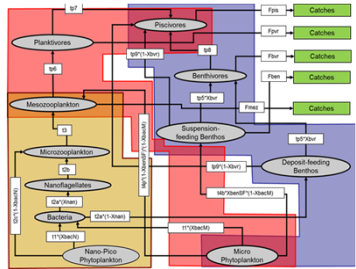
Satellite-derived estimates of primary production

## Estimation of distribution of production of the functional guilds

MODEL OUTPUTS



# Application of the EPP model to fisheries management



EPP model estimates the **potential production of the ecosystem** under the assumption that the ecosystem is fully functional (i.e. its **maximum potential for production**)

## What is a **sustainable catch level** in the context of an EPP model?

In **traditional fisheries science**, the idea of sustainability is often related to the **Maximum Sustainable Yield (MSY)**, which corresponds to the **maximum level of catch that can be annually extracted from the stock** while keeping the stock size at a stable level



Production that can be sustainably taken by fishing is the **FISHERIES PRODUCTION POTENTIAL (FPP)**

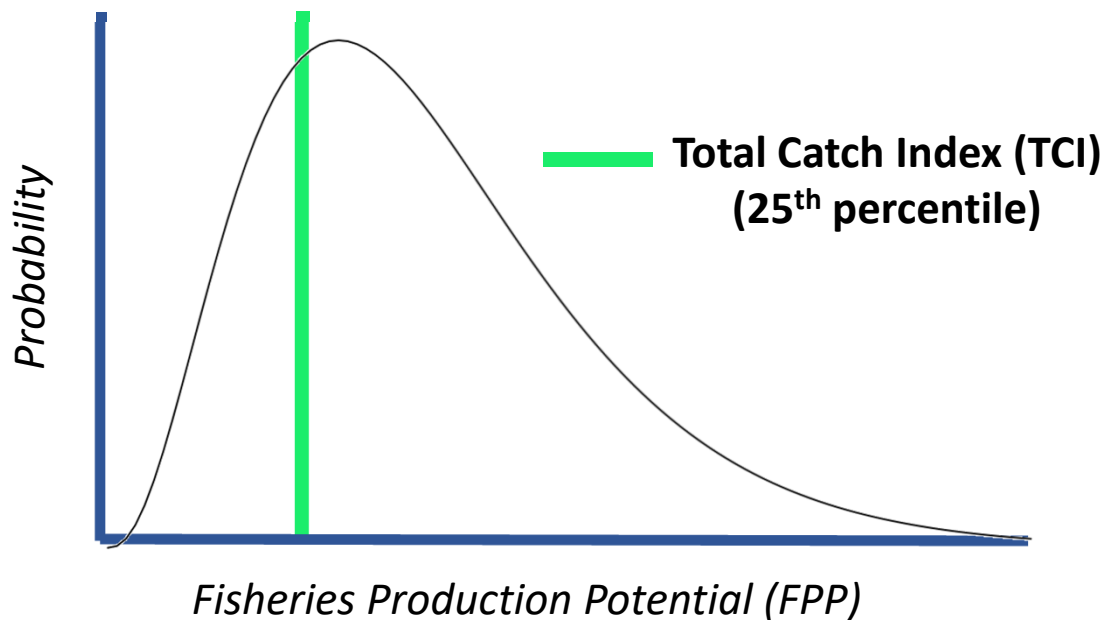
# From FPP to Total Catch Index

FISHERIES PRODUCTION POTENTIAL (FPP)



20% Exploitation Rate  
(sustainable)

If you fish up to **here**, there is a reasonably low probability (25%) of exceeding the maximum catch that the guild can sustain.



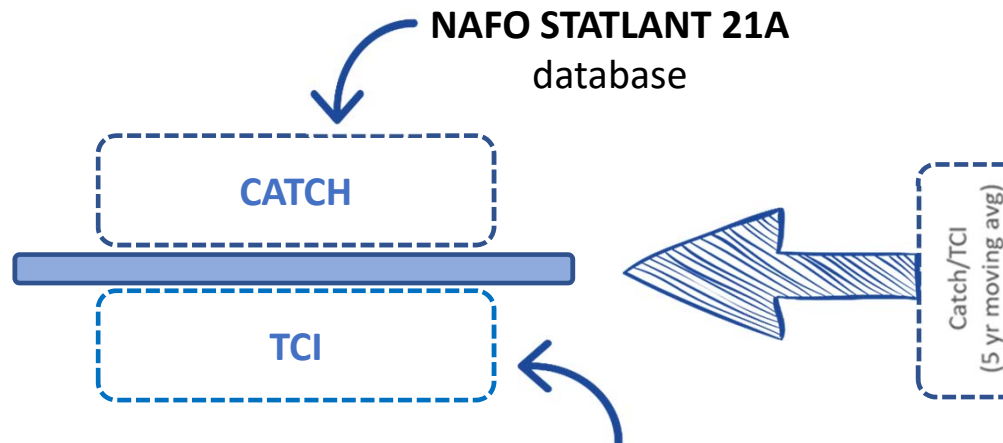
Considering that the **estimated FPP is a distribution**, a way to ensure that the probability of **exceeding FPP is low** is to select the **25<sup>th</sup> percentile** as a reference value.



**Total Catch Index "TCI"**

If **aggregated catches** are kept **below TCI**, the **risk of ecosystem overfishing** would be **low**.

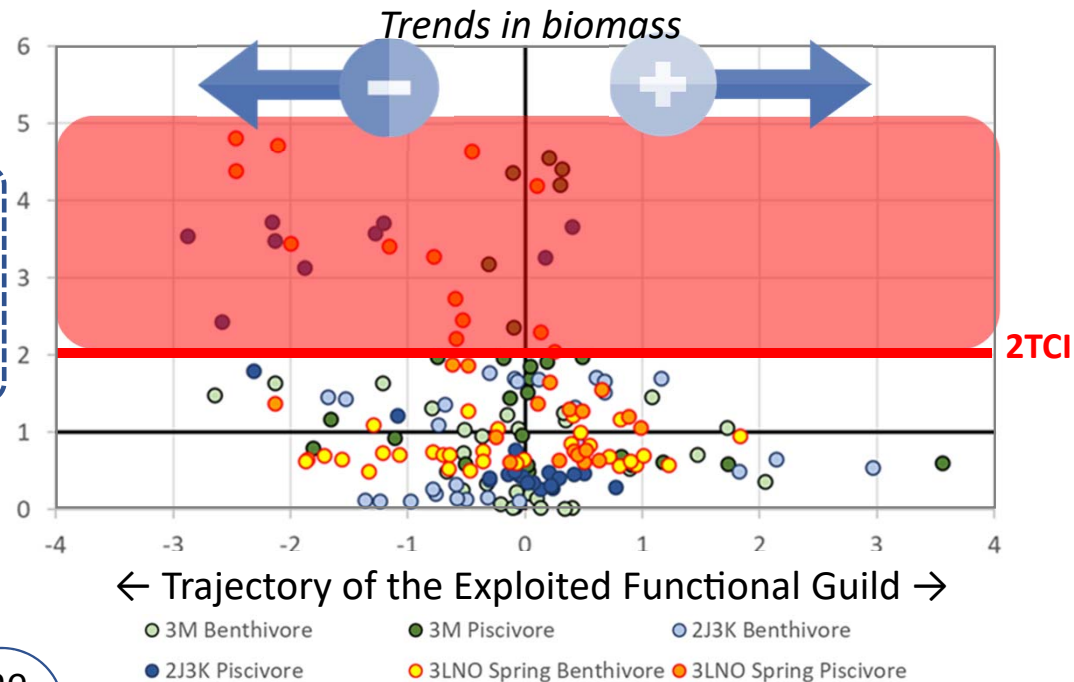
# An Ecosystem Reference Point based on 2TCI



Estimation of the upper limit of sustainability



At the 2022 Annual Meeting, the Commission adopted the “2TCI” as an **ECOSYSTEM REFERENCE POINT** to help inform management decisions regarding the **potential risk of ecosystem overfishing**.



**> 2**

**NEGATIVE trends in biomass**  
**Ecosystem Overfishing**

# TCI Reporting: SSSs and ESSs



## Stock Summary Sheets (SSSs)

- SC (June 2023) developed a template on how to include Total Catch Index (TCI) information in **Stock Summary Sheets (SSSs)**.

### 3M Cod summary table



Convention Principle	Status	Comment
Restore to or maintain at Bmsy	Yellow	Bmsy undefined, B > Blim
Eliminate Overfishing (Stock)	Green	F < Flim
<b>Eliminate Overfishing (Ecosystem)</b>	<b>Green</b>	<b>Total EPU catches &lt; 2TCI</b>
Apply Precautionary Approach	Green	Blim and Flim defined
Minimize harmful impacts on living marine resources and ecosystems	Yellow	Directed fishery, VME closures in effect, effectiveness of bycatch regulations uncertain
Preserve marine biodiversity	Grey	Cannot be evaluated

SSS example  
3M cod

*Line referencing the risk of ecosystem overfishing in relation to the 2TCI ecosystem reference point:*

**Eliminate Overfishing (Ecosystem)**

- Total EPU catches < 2TCI
- Total EPU catches > 2TCI

Text in the **ECOSYSTEM SUSTAINABILITY OF CATCHES** Section of the SSS:

**3M cod** is included in the **piscivores guild** of the Flemish Cap (3M) Ecosystem Production Unit (EPU). Other NAFO managed stocks in this guild and EPU are 3M redfish and 2+3KLMNOPs Greenland halibut. The **Catch/TCI is below the 2TCI** ecosystem reference point (**3M Piscivore Catch<sub>2022</sub>/TCI=0.98**) indicating a **low risk of ecosystem overfishing**.

The TCI information is presented in terms of the **functional guild** of the targeted stocks, and other relevant NAFO- managed stocks within that guild.

This has been **done for all stocks with full assessments in 2023** and it will continue to be rolled out on stocks over time.

# TCI Reporting: SSSs and ESSs

## Ecosystem Summary Sheets (ESSs)

The design of the **Ecosystem Summary Sheets (ESSs)** already included a section for TCI information; this section has been updated to reflect the newly adopted framework and ecosystem reference point.

**GOAL:**  
Provide information useful for NAFO management discussions

### Roadmap Tier 1: Sustainability of Catches at the Ecosystem Level

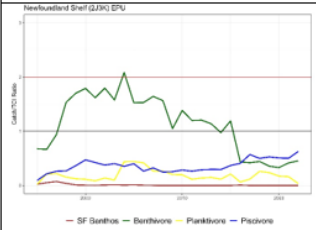
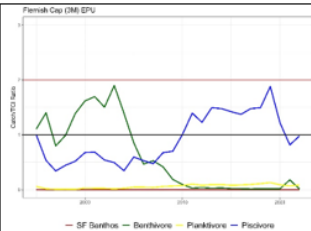
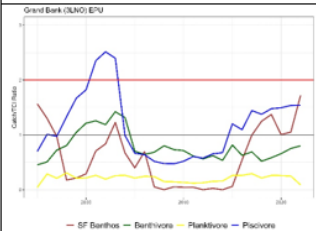
Roadmap Tier 1: Summary Report on Sustainability of Catches at the Ecosystem Level

Since 2005 all Ecosystem Production Units (EPU) evaluated (3M, 3LNO and 2J3K) have shown aggregate catch levels by functional guild which are consistent with the productivity of the EPU and the risk level of ecosystem overfishing.

#### Approach:

Total Catch Index (TCI): This index is an indicator of the level of aggregated catch for a given functional guild (aggregate of species) that is consistent with the current productivity of the ecosystem (ecosystem sustainability). The comparison of aggregate catches with TCI is informative of the risk of ecosystem overfishing.

NAFO has adopted 2TCI as an ecosystem reference point to inform on ecosystem overfishing (EO).



#### Summary:

Previous analyses demonstrated that, during 1960-1995, all the Ecosystem Production Units (EPU) evaluated had experienced sustained catch levels consistent with ecosystem overfishing.

Since 2005 aggregated catches for all functional guilds have been below the 2TCI ecosystem reference point across all EPU.

The catch levels for 2022 indicate a low risk of ecosystem overfishing on the Flemish Cap (3M) EPU and the Newfoundland Shelf (2J3K) EPU, and intermediate risk of ecosystem overfishing in the Grand Bank (3LNO) EPU.

All catch levels are consistent with preventing a high risk of ecosystem overfishing.

#### Risk of ecosystem overfishing:

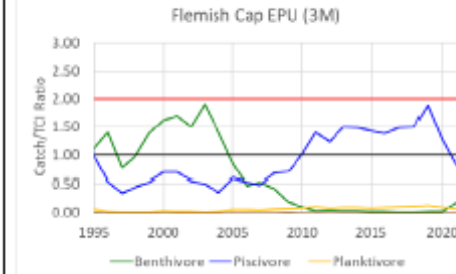
Catch > 2TCI: high risk of ecosystem overfishing

Catch between 1 and 2 TCI: intermediate risk of ecosystem overfishing

Catch < TCI: low risk of ecosystem overfishing

### Details on catch composition in relation to TCI by EPU

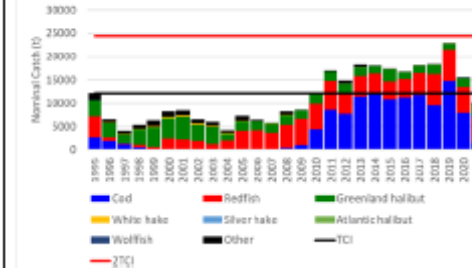
#### Flemish Cap (3M) Ecosystem Production Unit (EPU)



#### Overview

Catches for all functional guilds are below 2TCI, indicating that current fishing levels are consistent with preventing a high risk of ecosystem overfishing.

#### Flemish Cap (3M) EPU - Piscivores



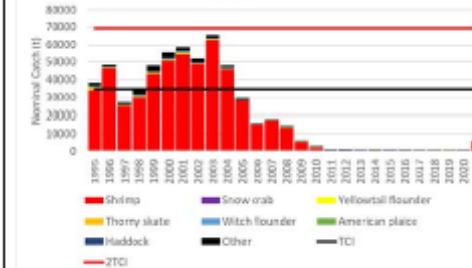
#### Piscivores Guild: low risk of EO

Current 2TCI=24kt

Catches are dominated by redfish, Greenland halibut, and Atlantic cod.

Redfish (3M), Greenland halibut (2+3KLMNO), and Atlantic cod (3M) stocks are managed by NAFO.

#### Flemish Cap (3M) EPU - Benthivores



#### Benthivores Guild: low risk of EO

Current 2TCI=69kt

Catches are dominated by shrimp.

Shrimp (3M) stock is managed by NAFO.

# Considerations for when the 2TCI ecosystem reference point were to be exceeded

## SCIENCE CONSIDERATIONS



**-Reason for exceeding 2TCI.** An increased likelihood of exceeding 2TCI could be related to:

- Stock assessment misspecification: *Can stock assessment be updated/improved? Do some assessments need to be conducted earlier?*

- Ecosystem productivity misspecification: *Can TCI estimates be examined and updated? Is there other reason, like unusually high recruitment, that can explain the excess productivity?.*

**-Horizon for negative impacts:** *How long catches exceeding 2TCI could be reasonably tolerated before impacts would be expected?*

**-Status and trends of the stocks involved:** *Are some stocks declining and other increasing?*

**-Interactions among stocks:** *What are the interactions among the stocks involved?*

**-Incoming TACs:** *Do the stocks involved have already agreed TACs for the incoming years? How do these TACs accumulate?*

## MANAGEMENT CONSIDERATIONS



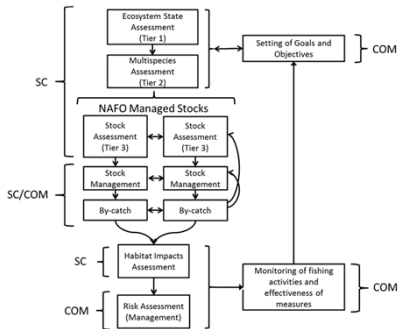
**-Timing of advice in relation to action:** *Should actions be taken immediately?*

**-Horizon of persistence of 2TCI excess:** *How long catches are expected to be over 2TCI?*

**-Trade-offs among stocks:** *What is the best way to prioritize stocks from a management perspective?*

**-Process to evaluate/integrate information.**

# Multispecies assessment



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1

Productivity State Assessment

Tier 2

**Multispecies Assessment**

Tier 3

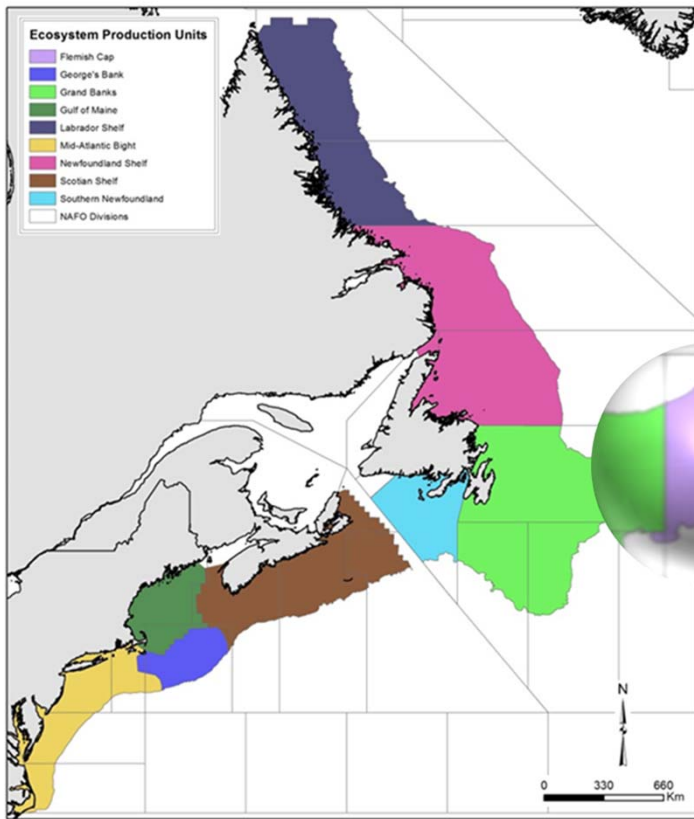
Stock Assessment

HABITAT IMPACTS ASSESSMENT



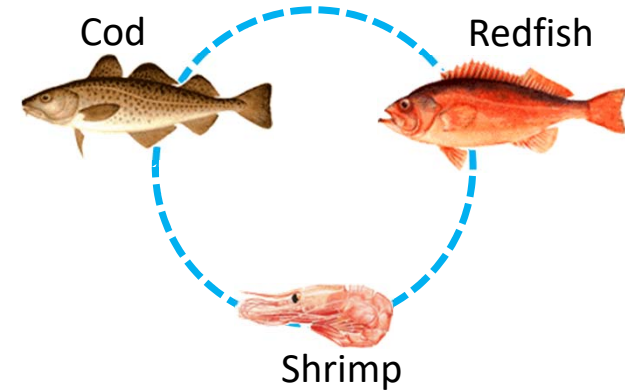
# Tier 2: Multispecies assessment (GadCap model)

## FLEMISH CAP (Div. 3M)



Multispecies model to examine the interactions of Cod, Redfish and Shrimp

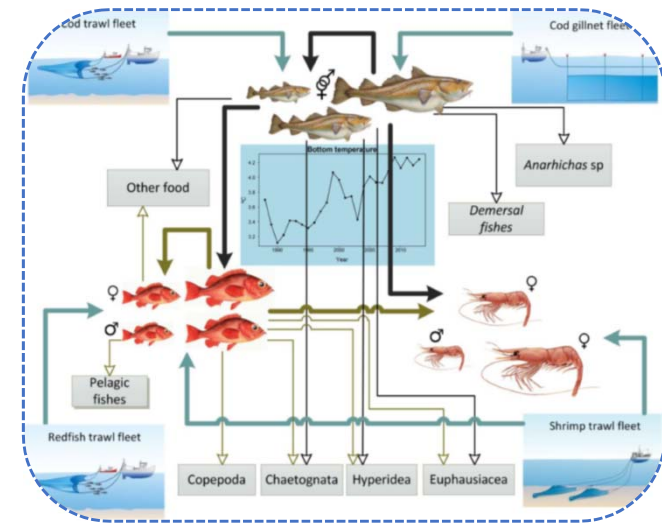
Starting point for the implementation of Tier 2.



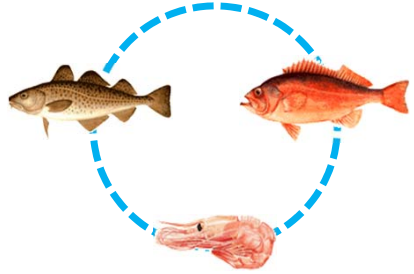
## What was modeled ?



- Effect of fishing
- Trophic interactions (including cannibalism)
- Water temperature



## Tier 2: Multispecies assessment (GadCap model)



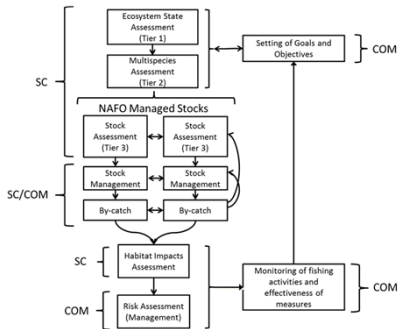
### Some conclusions...



- **Predation** was the explanation to most of the changes in the three species.
- In **shrimp**, both **predation by redfish and fishing** worked together driving the **collapse of the shrimp stock**, with the final contribution of **predation by cod**.
- **Cannibalism** has been the **main source of mortality both in juvenile cod and redfish**.
- Given the **predation interactions between the 3 species and the ecology**, it was **not possible to obtain the MSY for each species** at the same time and for the same year.
- The results obtained in this assessment model **have not yet been used in management**.

The **implementation of Tier 2** is the **next objective** in the workplan as at the present time, only considerations at **the ecosystem** and **stock levels** are in place.

# Vulnerable Marine Ecosystems (VMEs)



IDENTIFY FUNCTIONAL ECOSYSTEM UNIT

Tier 1

Productivity State Assessment

Tier 2

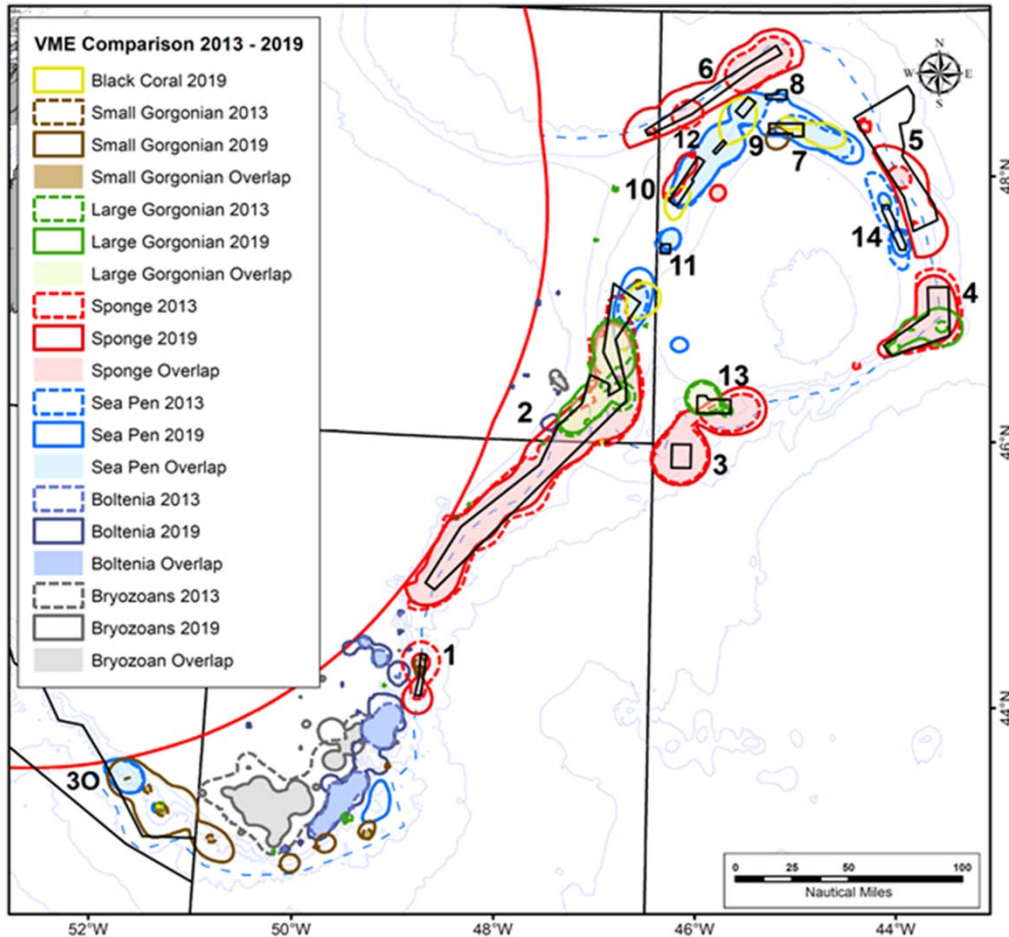
Multispecies Assessment

Tier 3

Stock Assessment

HABITAT IMPACTS ASSESSMENT

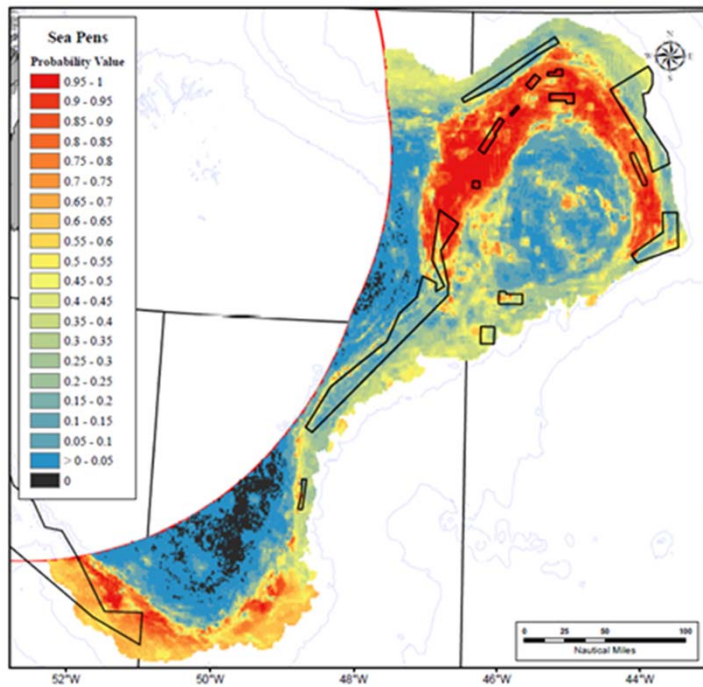
# Vulnerable Marine Ecosystems (VMEs)



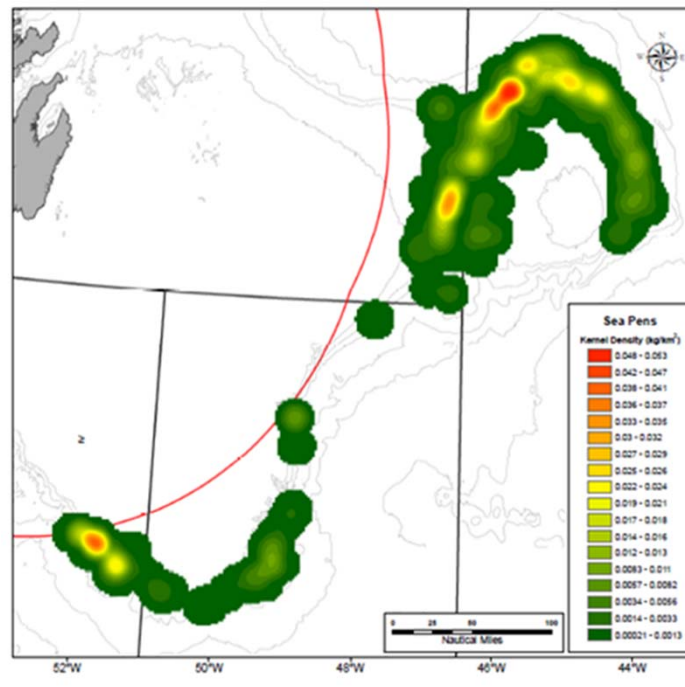
- **Corals and sponges** are typical VME-indicator species, but there are others.
- These habitats are **structurally complex**.
- The key tool used by NAFO to **protect VMEs** are **fisheries closures**.
- VMEs, closures and the risks of Significant Adverse Impacts due to fishing activities within NAFO are **re-assessed every 5 years**.

# Vulnerable Marine Ecosystems (VMEs)

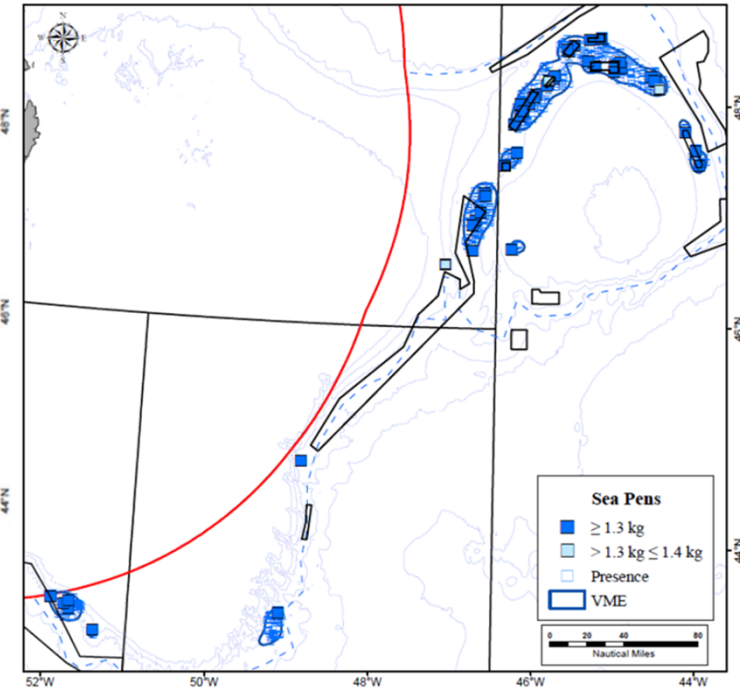
## How VMEs were delineated ? (Example: Sea pens)



*Species Distribution Models*

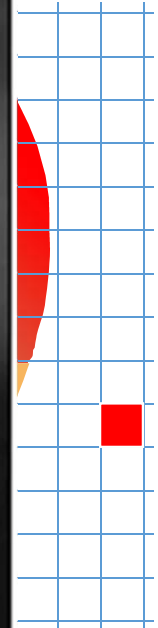
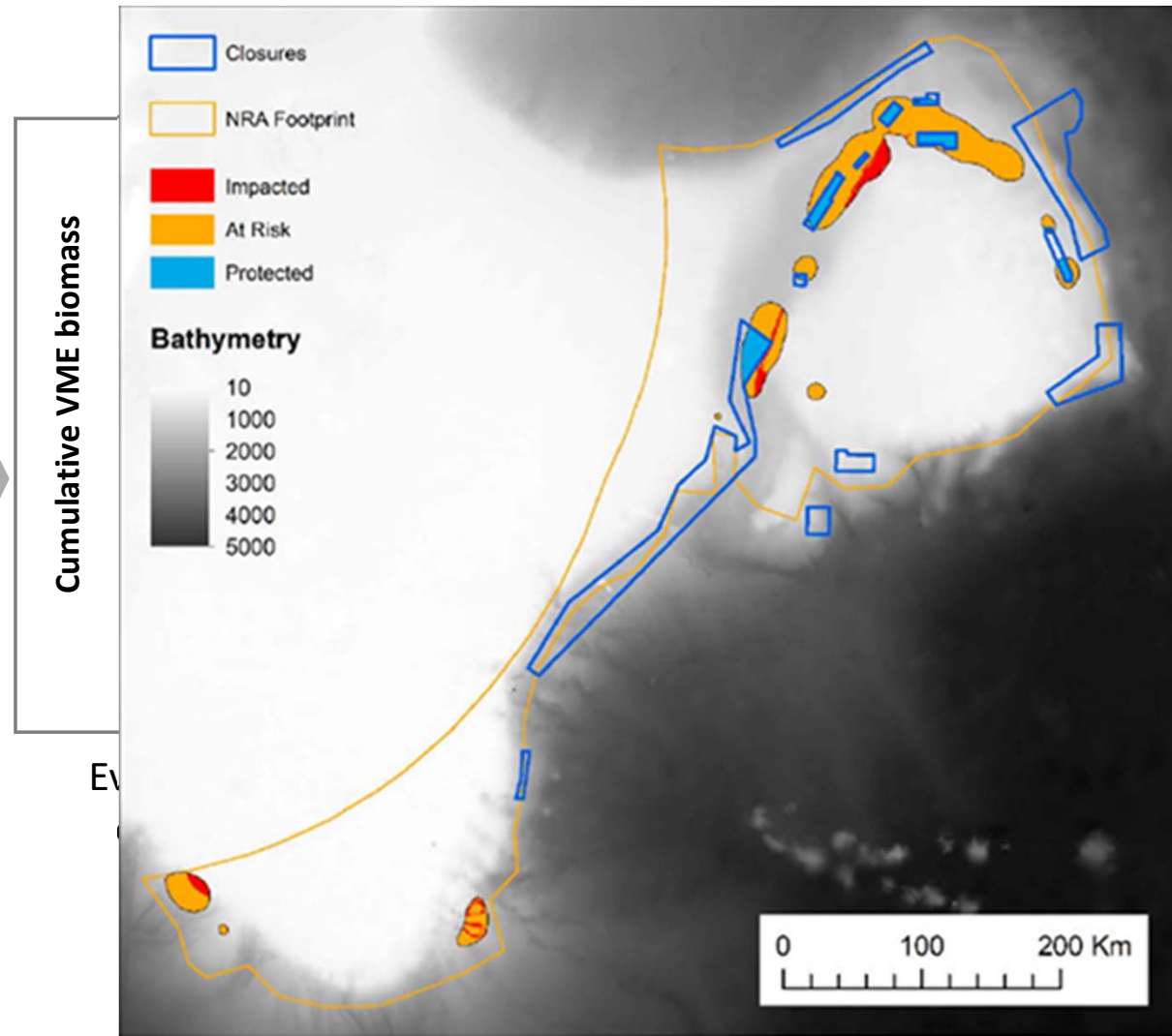
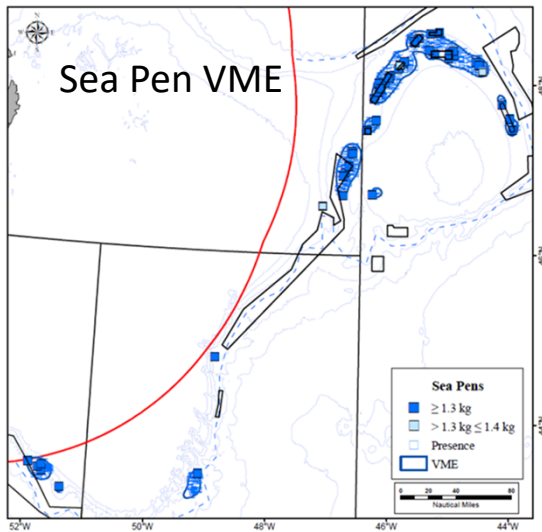
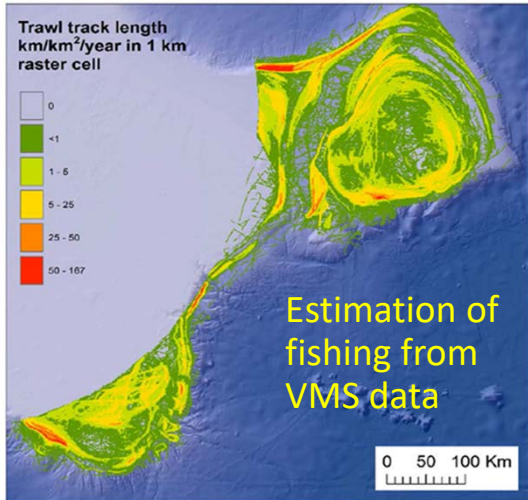


*Kernel Density Estimation*



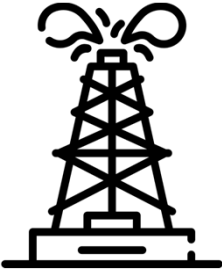
*Sea Pen VMEs (and closures)*

# Significant Adverse Impacts (SAI)

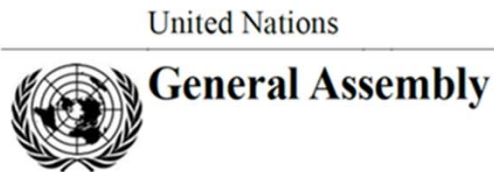


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ct  
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# Activities other than fishing



What is the rationale for studies on *activities other than fishing* in the context of NAFO (e.g. oil and gas) ?



## UNGA Resolution 71/123 on sustainable fisheries

Adopted by the United Nations General Assembly  
(7 December 2016)

184. Notes with concern that vulnerable marine ecosystems may also be impacted by human activities other than bottom fishing, and encourages in this regard States and competent international organizations to consider taking action to address such impacts;



NAFO  
Northwest Atlantic  
Fisheries Organization

## 2023 NAFO Annual Meeting – COM Request #9

The Commission request the SC to monitor and provide regular updates on relevant research related to the potential impacts of activities other than fishing in the Convention Area, subject to the capacity of the Scientific Council.

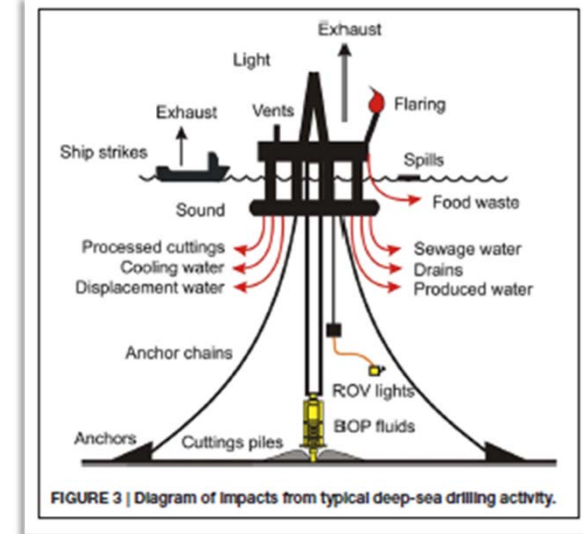


*NEREIDA project was designed to address this COM Request on activities other than fishing*

# Activities other than fishing

As is known from the scientific literature, in addition to the impacts of accidental events (Fisher *et al.*, 2014), routine oil and gas activities can have detrimental environmental effects during each of the main phases of exploration, production, and decommissioning (Cordes *et al.*, 2016).

Environmental effects include, among others, long-term impacts on deep-sea corals (e.g. Girard and Fisher, 2018), as well as impacts on deep-sea sponges and the habitats they form (Vad *et al.*, 2016).



Source: Cordes *et al.*, 2014



Source: C-NLOPB Website



Recent  
accidental  
events

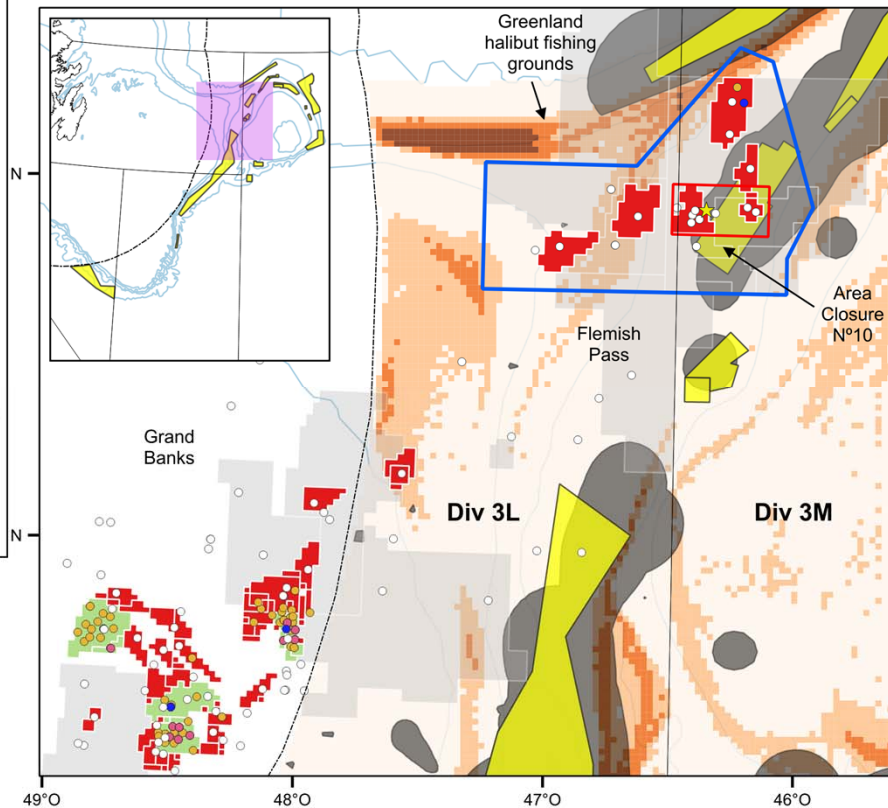
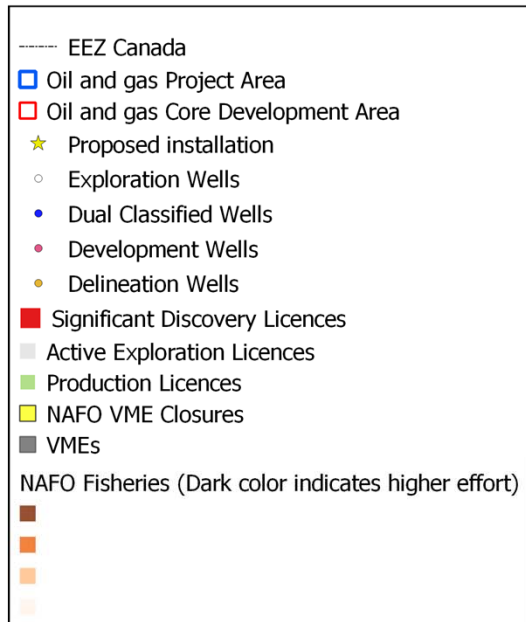
**July 2019:** An oil spill occurred inside Canadian EEZ, but the oil was extended outside the EEZ and into the NAFO RA.

**November 2018:** 250,000 L of oil were released to the environment.



# Activities other than fishing

## Overview of the current situation

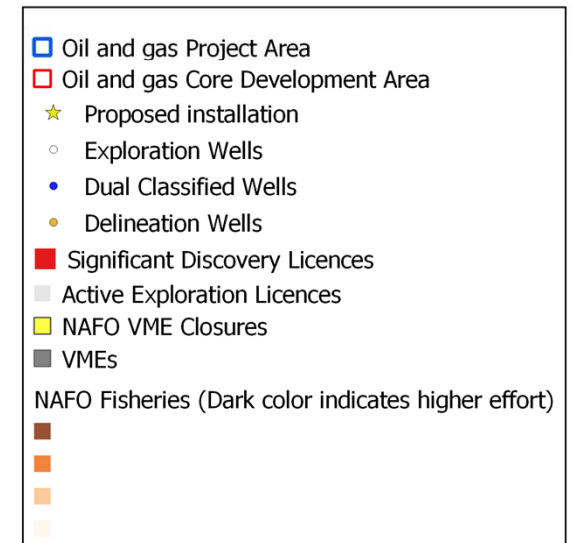
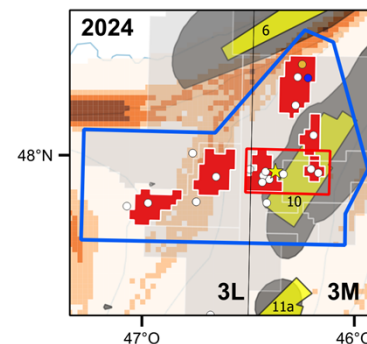
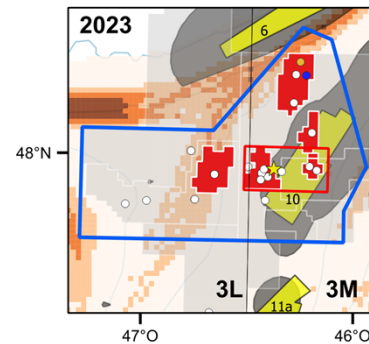
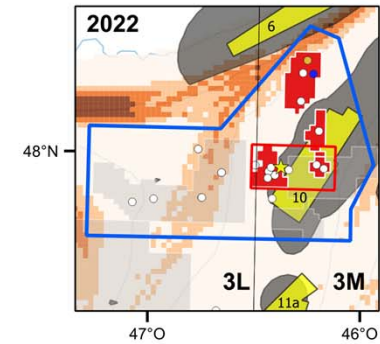
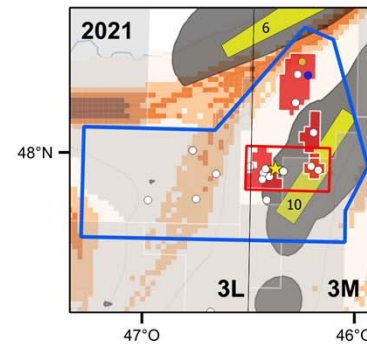
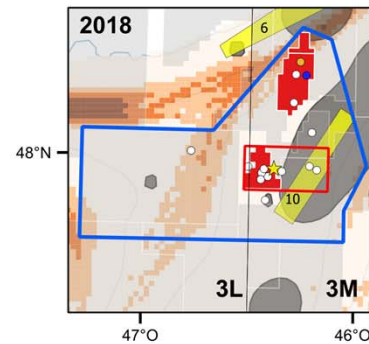


Potential conflicts between different users of the marine space (e.g. oil and gas vs. fisheries) and between users and the marine environment (oil and gas vs. VMEs).

# Activities other than fishing

Increase in the exploration activities (e.g. licenses and wells) in the NRA, especially in Divs. 3LM.

Overlapping with VMEs, closures, fishing grounds and scientific survey sampling area.



# Activities other than fishing

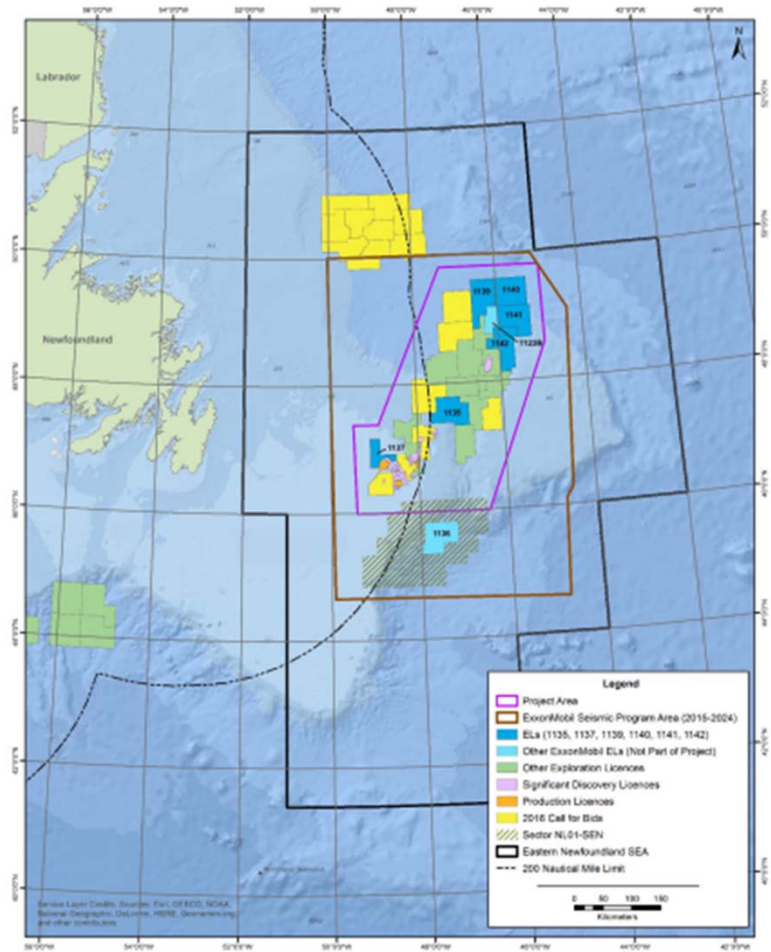
All this information is relevant to develop the Ecosystem Summary Sheets (ESSs)

OTHER CONSIDERATIONS (outside mandate of NAFO Convention)				
Human Activities other than fisheries		S	T	Comment
1	<b>OIL AND GAS ACTIVITIES</b>			As of 2019, there are four offshore production fields on the Grand Bank and intense exploration activities along the eastern shelf break and Flemish Pass. The total area of licenses has increased 8.3-fold from 2014 to 2019. There have been ten reported incidents between 2015 and 2019, with a major oil spill in 2018, and one in 2019 that extended into the NRA. A proposed development project in the Flemish Pass overlaps with fishing grounds. It is expected, based on current exploration leases and development projections that oil and gas exploration activities may increase in the NRA until at least 2030.
2	<b>POLLUTION</b>			Low occurrence and density of litter in 3L and fisheries are the primary source from both NAFO-managed and non-NAFO managed fisheries. Data for 3NO are not currently available. Standardized protocols for litter data collection have been developed and await approval and implementation during EU surveys.

In 2019, information on **oil and gas activities** and **seabed litter** (e.g. from ATLAS H2020 project and García-Alegre *et al.*, 2020) was **included for first time** in the ESS for **Division 3LNO**.

A similar exercise was done later for **Division 3M**.

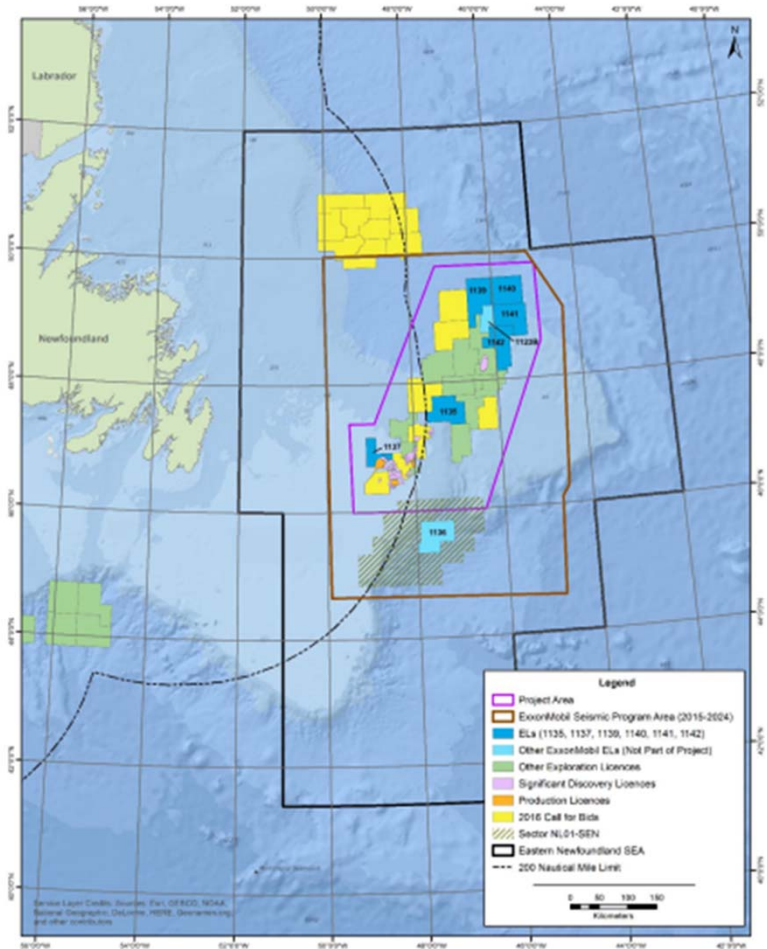
# Roadmap challenges and conflicts



Challenges

Conflicts

# Roadmap challenges and conflicts

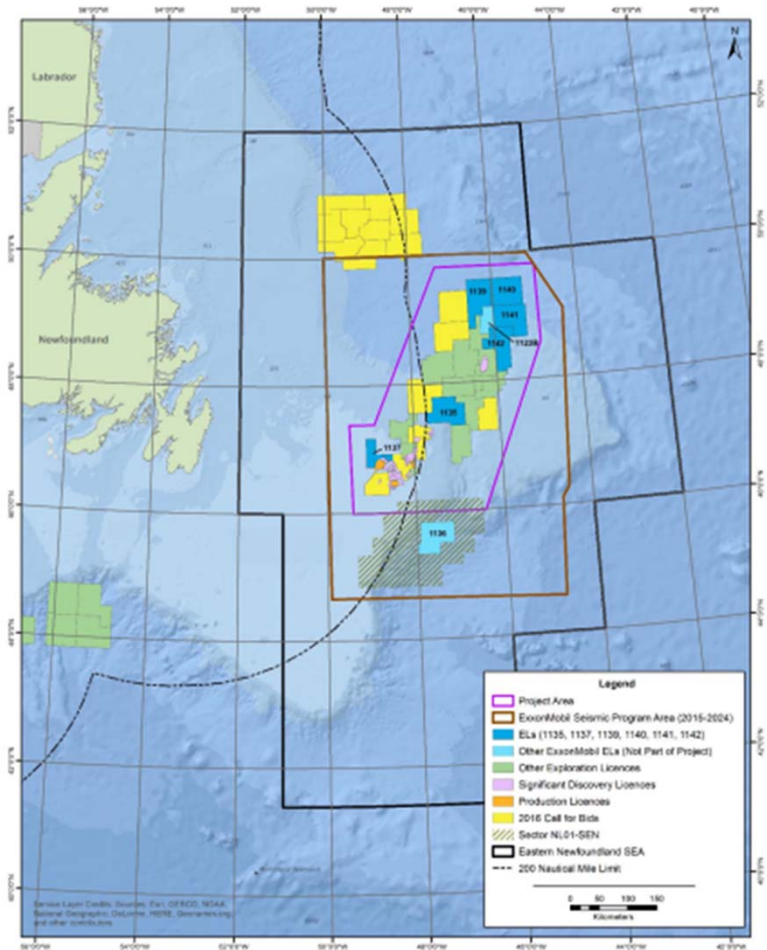


- Continue implementing the Roadmap into management.
- Limited resources and science capacity.
- Coordination and compatibility with coastal states and other international organizations.

Challenges

Conflicts

# Roadmap challenges and conflicts



- Continue implementing the Roadmap into management.
- Limited resources and science capacity.
- Coordination and compatibility with coastal states and other international organizations.

## Challenges

- Oil and gas (realized and potential)
  - Seismic surveys
  - Spills
- Deep sea mining (potential)
- Other human activities (shipping, submarine cables, seabed litter, etc)

## Conflicts

# IMPLEMENTATION OF THE **ECOSYSTEM** APPROACH FRAMEWORK TO FISHERIES MANAGEMENT



Thank  
You!

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