Time-varying natural mortality estimation in sGSL Atlantic Herring

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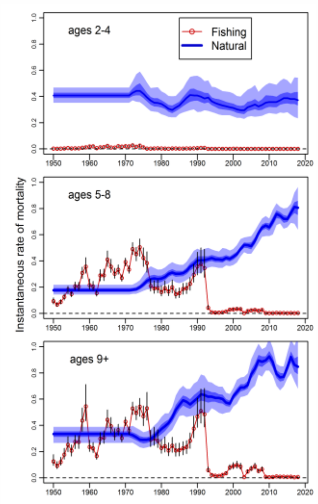
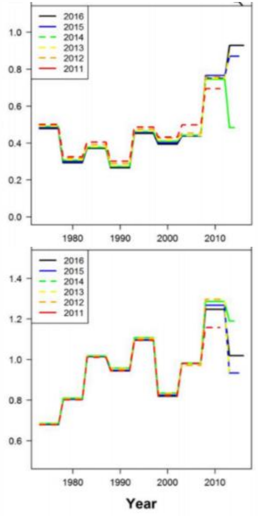
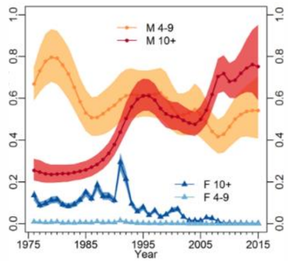
- Why we though it could be done
- Population model
- Results and effects on estimates
- Link to predation
- Filling gaps in predation information
- Challenges & positive points

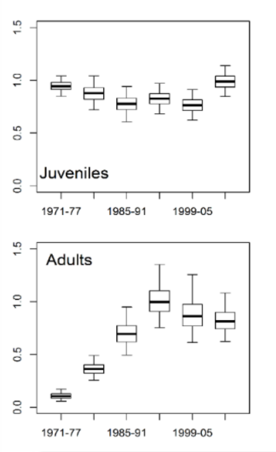
Trends in natural mortality across sGSL species

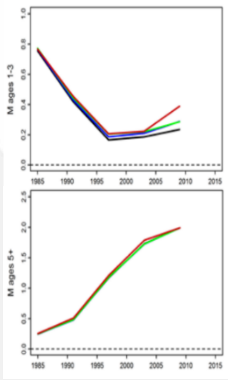
Increase in natural mortality for older fish starting around 1990 is consistent across sGSL species

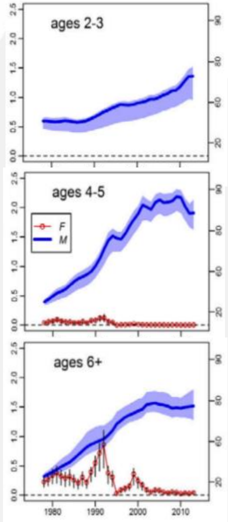










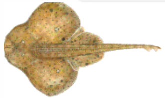


Atlantic cod

Winter flounder

American plaice

Winter skate



Yellowtail flounder

White hake

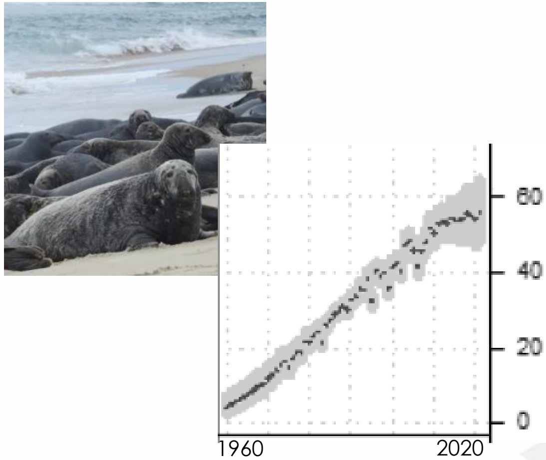
Research to support ecological cause

Potential causes of M

- Unreported catch
- Emigration
- Disease
- Contaminants
- Poor fish condition
- Life history change
- Parasites
- Predation

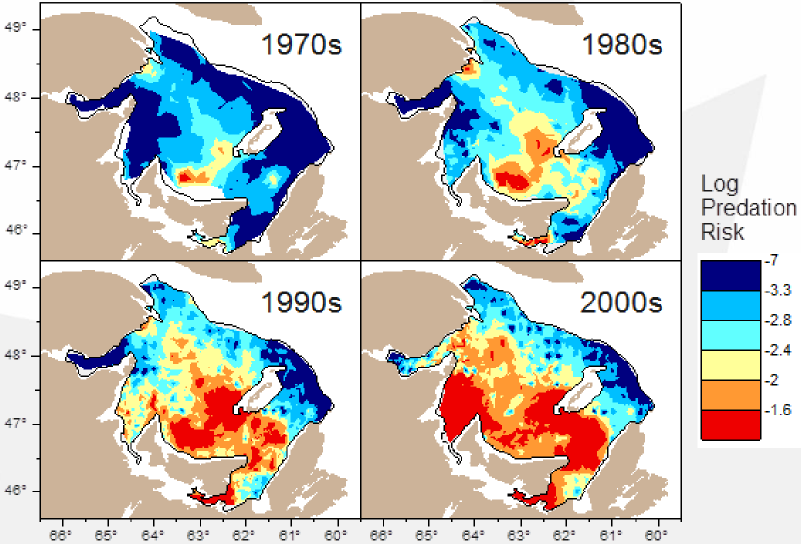
Swain, D., Benoît, H., Hammill, M., McClelland, G., and Aubry, É. 2011. Alternative hypotheses for causes of the elevated natural mortality of cod (Gadus morhua) in the southern Gulf of St.Lawrence: The weight of evidence. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/036: iv + 33 p.

GSL Grey seal abundance



Hammill, M.O., Rossi, S.P., Mosnier, A., den Heyer, C.E., Bowen, W.D., and Stenson, G.B. 2023. Grey Seal Abundance in Canadian Waters and Harvest Advice. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/053. iv + 40 p.

Predation risk by Grey seal

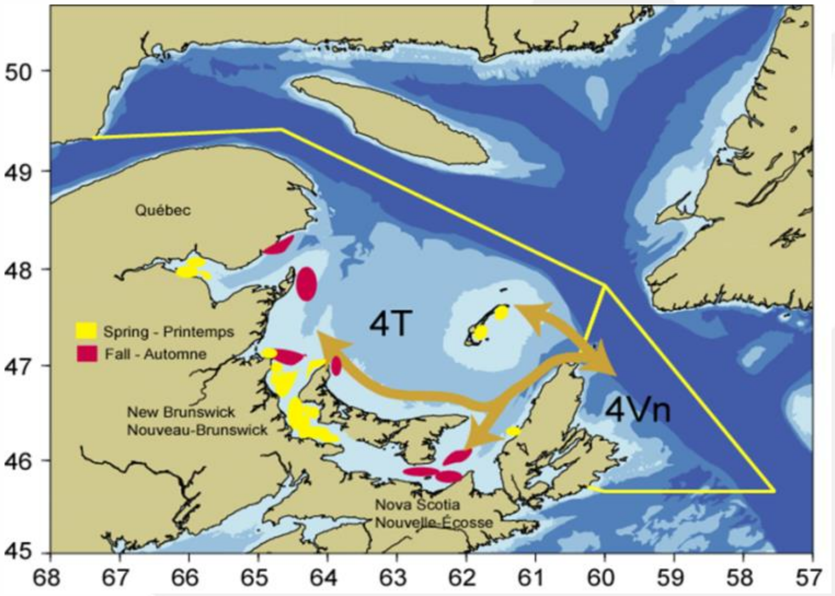


Swain, D., Benoît, H., and Hammill, M. 2015a. Spatial distribution of fishes in a Northwest Atlantic ecosystem in relation to risk of predation by a marine mammal. J. Anim. Ecol. 84: 1286–1298

And many more papers…

Why try to estimate M in sGSL herring

- Also under seal predation
- Other important predators abundance have increased
- Other sources of M unlikely
- Lack of recovery (spring spawners) or declining trends (fall spawners)
- Truncated age compositions (older fish disappearing, unexplained by F)
- Potential to detect predation driven M variations as in other sGSL stocks
- Might fix retrospective pattern



Assessment model

- VPA with time varying CPUE q
- Developped new model from Cod model
- SCA
  - With and without time varying CPUE q (hyperstability)
  - With and without time varying M
- Time varying q an m models were selected as best models
- Model comparison resdoc published with 2020 assessment

- Fishery landings, CAA, WAA
- CPUE in gillnet fishery
- Acoustic surveys
- Trawl surveys
- Multi-mesh gillnet surveys
- Selectivity and maturity inputs

Natural mortality random walk for 2 age groups

$$\log(M_{j,t}) = \log M_j^{init} \text{ where } t = 1978$$

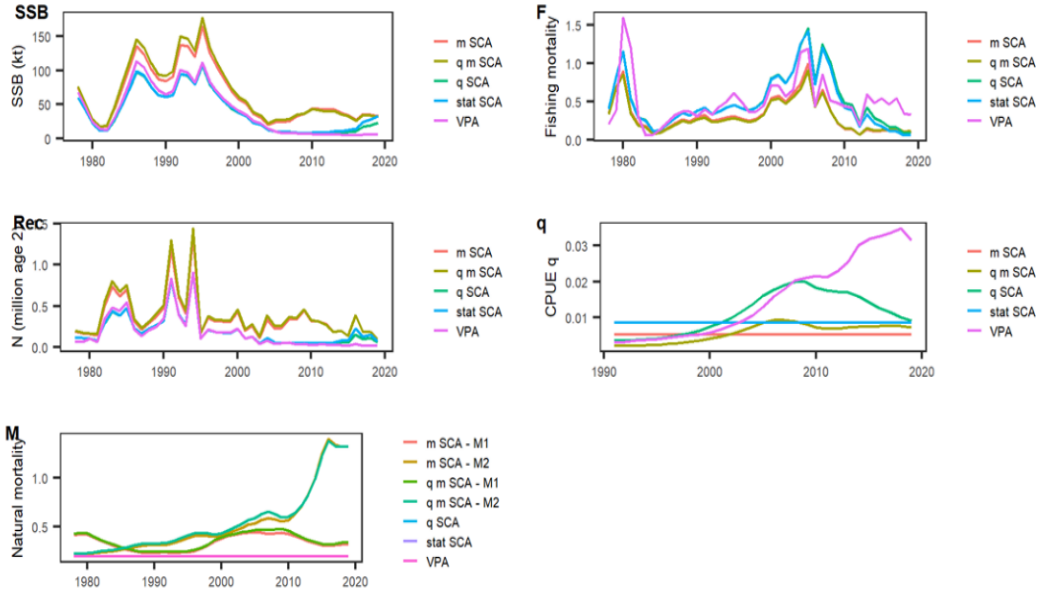
$$\log(M_{j,t}) = \log(M_{j,t-1}) + Mdev_{j,t}, \text{ where } t > 1978$$

$$Mdev_{j,t} \sim Normal(0, \sigma_j^M)$$

$$0.5 \sum_{j,y} (Mdev_{j,t}^2)/(\sigma_j^M)^2 + 0.5 \sum_J \exp(\log(M_j^{init}) - 0.2)^2/0.1^2$$

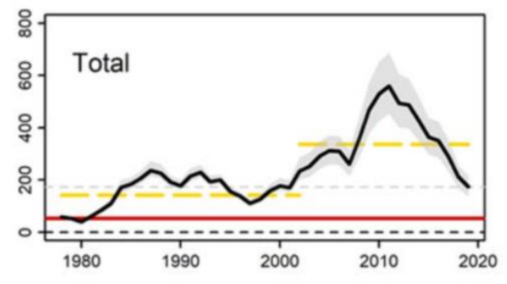
Spring spawning Herring assessment

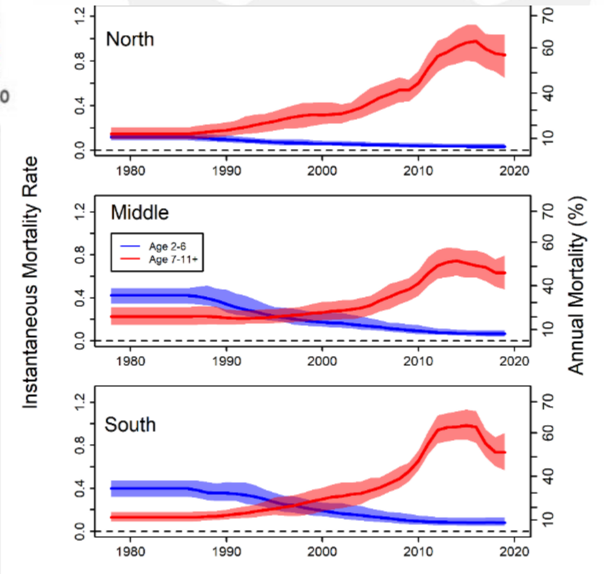
Increased M in older fish from mid 1990s
Change in scale
Change some dynamics
Ex: 2005-2019 qmSCA vs VPA
Better fit to indices
Better fit to age composition
Almost no retrospective pattern



Fall spawning Herring assessment

- Increased M in older fish from mid 1990s
- Population more challenging to assess
- qSCA and qmSCA performed best
- Retrospective patterns still present but now underestimating SSB vs overestimating in the VPA
- New spawning ground acoustic survey (weekly on each ground during spawning season) should help inform SSB estimation and reduce the retro





Major predators

Predator	Annual herring consumption (tons)
Atlantic Bluefin tuna*	13,659
Grey seal	11,220
White-sided Dolphin	10,220
Northern gannet	8,093
Harbour Porpoise	4,390
Cormorants	1,773
Minke whale	1,170
White hake	500
Atlantic cod	Was very important before collapse

Oceana, Keith Ellenbogen

Christine Abraham

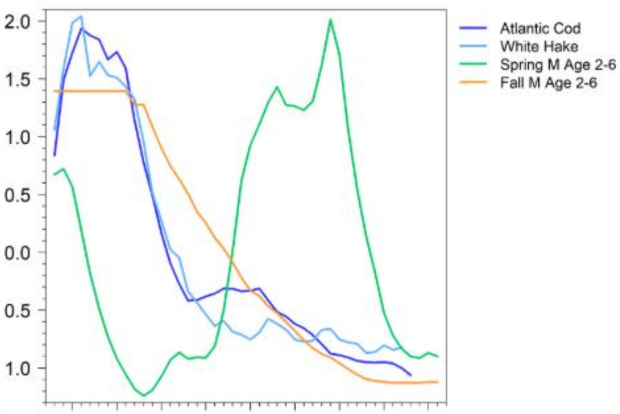
Ocean ecoadventure

Neil Fisher

Gary Taylor

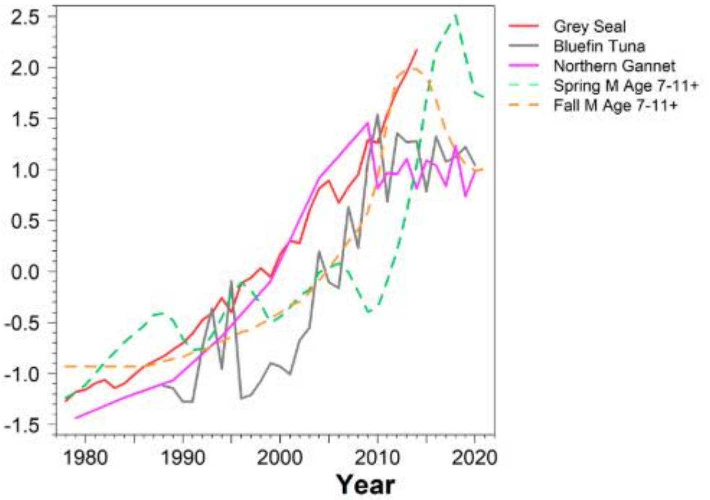
All data except * : Benoît, H.P., and Rail, J. 2016. Principal predators and consumption of juvenile and adult Atlantic Herring (Clupea harengus) in the southern Gulf of St . Lawrence. (September).

Natural mortality and predators



Oceana

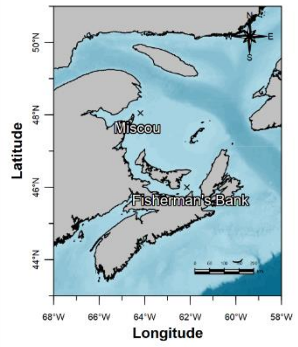
Gary Taylor

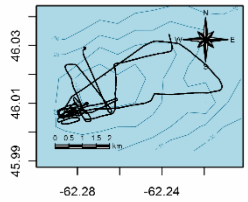


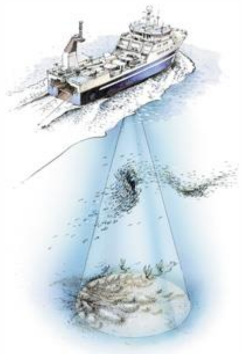
PAULO OLIVEIRA / ALAMY

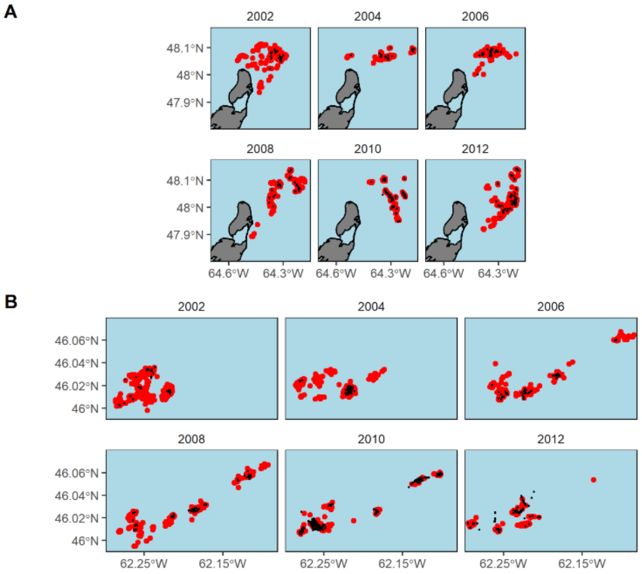
Marie-Ève Giroux

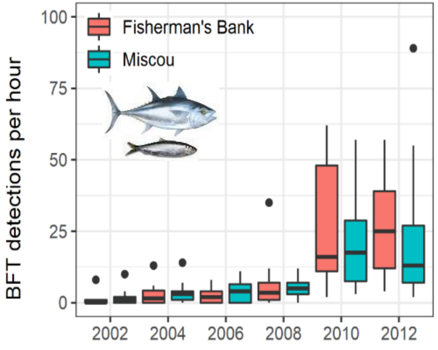
Bluefin Tuna predation – overlap study

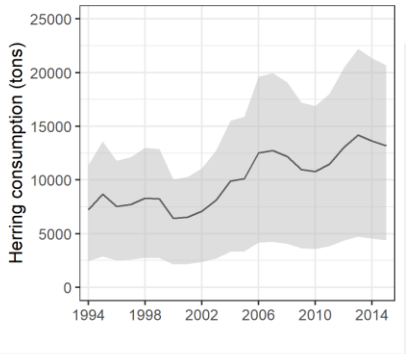






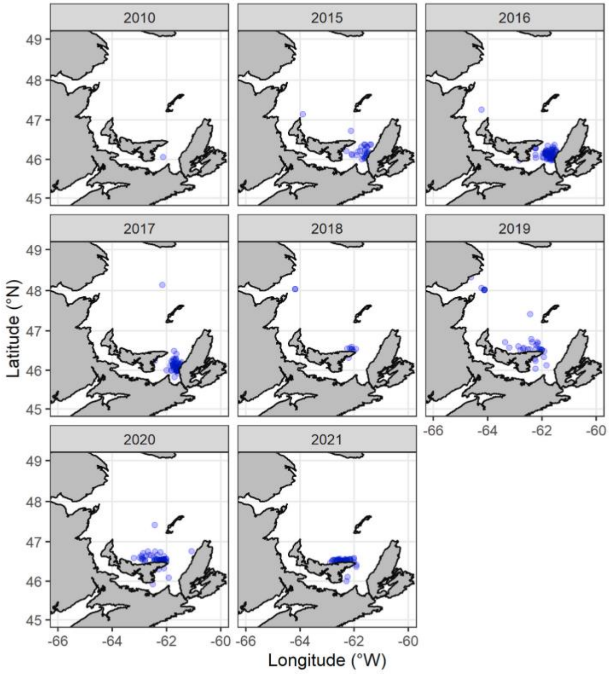






Turcotte F., McDermid J., Tunney T., Hanke A., 2021. Increasing Occurrence of Atlantic Bluefin Tuna on Atlantic Herring Spawning Grounds: A Signal of Escalating Pelagic Predator–Prey Interaction? Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 0:1–13.

Bluefin Tuna predation – diet study



- Published data 2010, 2015:2018
- Stomach sampling 2017:2021
- Visual prey ID
- DNA barcoding

Turcotte, F., Hanke, A., and McDermid, J.L. 2023. Atlantic bluefin tuna diet variability in the southern Gulf of St. Lawrence, Canada. Mar. Environ. Res. **187**: 105949. Elsevier Ltd. doi:10.1016/j.marenvres.2023.105949.

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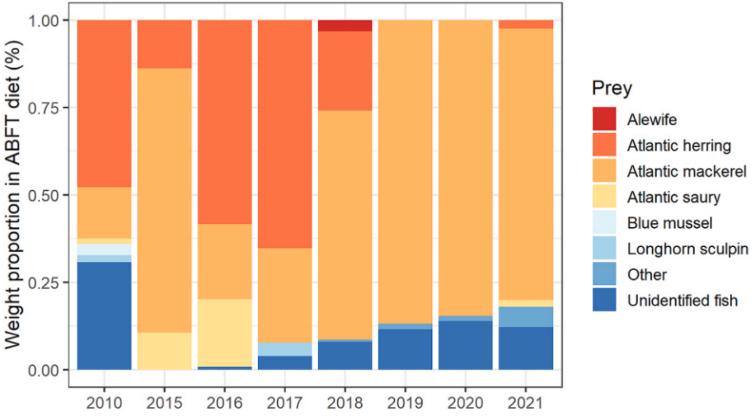
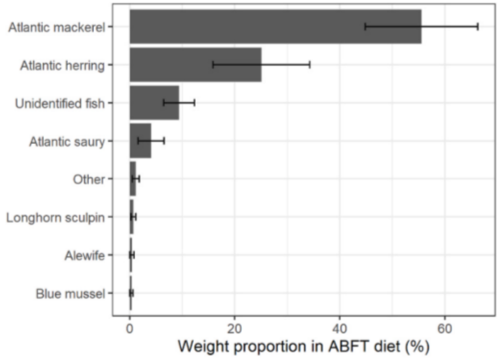


- 2010:2018 roughly similar herring&mackerel % in diet
- Post 2018 almost no herring
- Updated daily meals and daily rates to inform consumption models

Over all years

- 54% mackerel
- 25% herring
- 9% unidentified
- 4% Atlantic saury



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Effects on the assessment

- Explained the disappearance of older fish
- Informed on a long lasting unanswered question about the effect of predators on herring in the context of lack recovery and population decline, and known predation effects on other sGSL stocks
- Helped define cause of decline, define targets and build scenarios of timelines for rebuilding plans
- Industry response was favorable as it reflects what they see on the water and the changes in estimates were accepted as the model is now closer to reality.

- Generated the need to fill knowledge gaps to support findings (bluefin tuna predation)
- Population size scaling was challenging to introduce in assessment meetings
- Projected population trend less responsive to changes in TAC. Made it harder for managers to make recommendations as difference of outcome between TAC options were reduced.

- Challenges remain especially for the fall spawners model but overall, improved the assessment, helped understand the dynamics of the stock and the ecological interactions in the system.