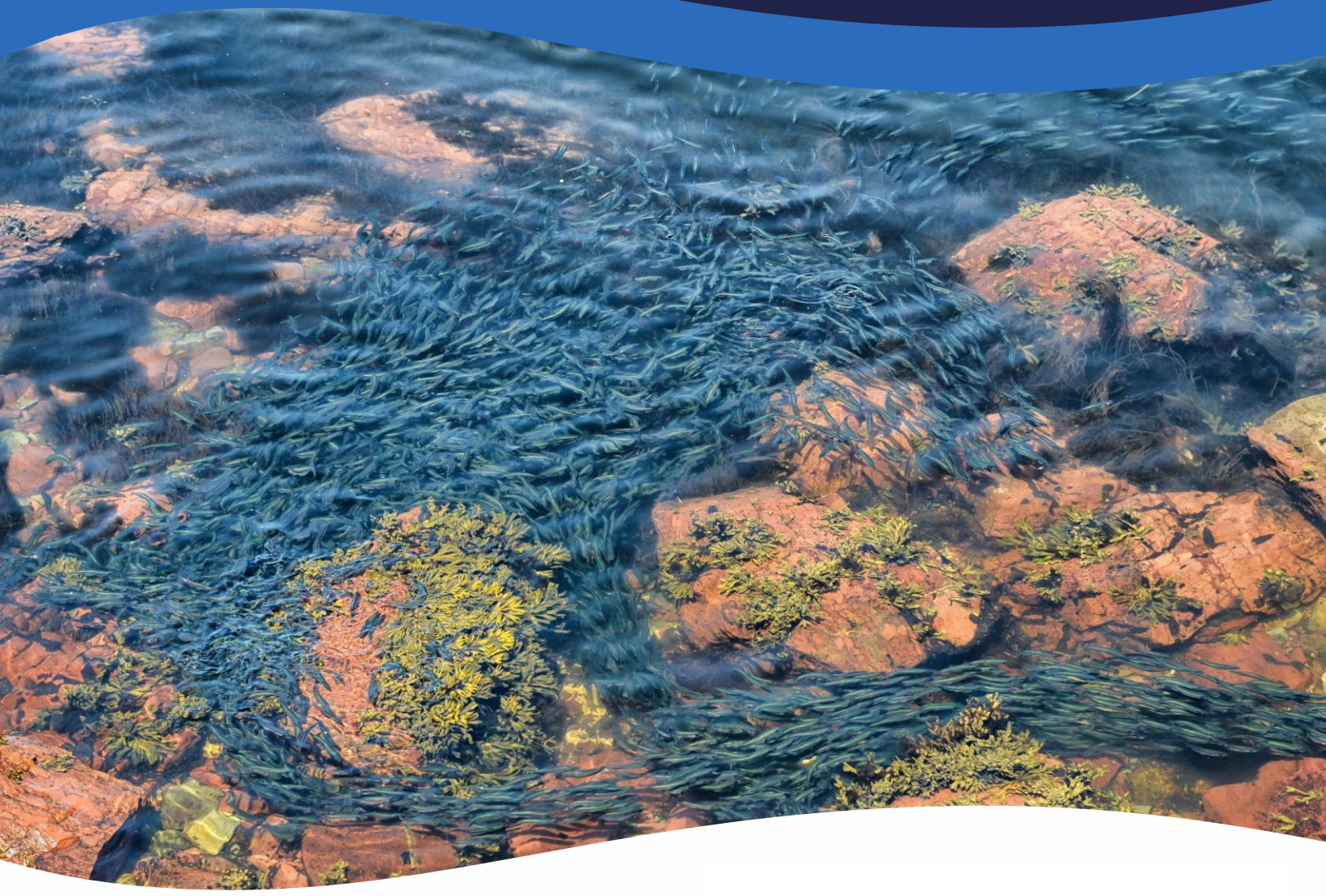
Wednesday, April 14, 2021

SMALL FISH, BIG INFLUENCE: THE CASE FOR REBUILDING CAPELIN



By Reba McIver, Robert Rangeley and Devan Archibald

OCEANA Protecting the World's Oceans

Executive Summary

The foundation of Canada's blue economy is our wild fish populations. Forage fish – the small, schooling fish like herring, capelin and shrimp that feed larger predators – are vital contributors to wild fisheries in Canada. They are targeted directly in fisheries and contribute indirectly as prey to other commercially important fish, like cod, halibut and tuna. While forage fish have large population booms and busts in response to changing environmental conditions, their population dynamics are also influenced by fishing pressure. The most important principle in managing forage fish is that enough must be left in the water to ensure overfishing does not put their populations and their predators at risk.

Off the coasts of Newfoundland and Labrador, capelin is a species of forage fish that serves as an important food source for many animals, including iconic northern cod, humpback whales and seabirds. The northeast Newfoundland and Labrador capelin stock (2J3KL) historically sustained an abundant fishery but collapsed in the early 1990s and today is at only six per cent of pre-collapse estimates, while a fishery continues to operate. The outlook for this stock is dire, and unless Fisheries and Oceans Canada takes immediate action to manage it differently, there will be irreversible harm to capelin and all the animals that rely on them to survive - and little chance for any future capelin fishery.

Oceana Canada recommends that Fisheries and Oceans Canada:

1. **Immediately pause the 2J3KL capelin fishery**
2. **Develop and implement a forage fish-specific management plan to prevent overfishing before resuming the capelin fishery**

The management plan must include:

- A precautionary approach framework;
- A minimum stock size biomass, below which it cannot be fished; and
- A harvest cap, which limits the amount that can be fished.

Rebuilding capelin and establishing a harvest control rule to reduce the risk of future overfishing is an investment in the future fishery and Canada's blue economy. It is not too late to bring our oceans back to abundance. Allowing our fish populations to rebuild will lead to more valuable and long-term sustainable fisheries.

The Importance of Forage Fish

"*Globally, forage fish are twice as valuable in the water as in the net.*"
Lenfast Ocean Program. Pikitch et al. 2012

Forage fish are typically abundant, fast-growing and short-lived species that are a linchpin of marine food webs. These small- to medium-sized schooling fish and invertebrates feed primarily on plankton or juvenile fish and are eaten by larger predators, including seabirds, marine mammals and other fish.

They play a "mesotrophic" role in the ocean – the middle of the food web – transferring energy throughout the ecosystem.

Species include bony fish, like sardines, anchovies, mackerel, herring and capelin, and invertebrates, like krill, shrimp and squid. They support some of the world's largest fisheries either directly as a harvested species, or indirectly as prey to commercially important fish. In fact, forage fish make up between 20 to 30 per cent of all wild-caught fish globally; however, they are mostly processed into fish oil and fish meal instead of landing on people's plates.[2,3]

Forage fish have large population booms and busts that are a response to changing environmental conditions. These fluctuations can cause ripple effects throughout ecosystems, impacting the many species that depend on forage fish. For instance:

- A marine heat wave from 2014 to 2016 in the northwest Pacific Ocean resulted in smaller Pacific sand lances that were less nutritionally valuable, disrupting energy flow in that food web and likely contributing to declines of common murres and larger fish predators.[4]
- Sardine and anchovy population sizes in the California current affect the health of sea lions, flatfish like halibut, as well as dolphins, brown pelicans and other migrating seabirds.[5]

This connection between forage fish and ecosystem health exists everywhere, including off the coast of Atlantic Canada. Capelin's persistently low population size around northeast Newfoundland and Labrador has stalled rebuilding of the iconic and commercially valuable Atlantic cod population there.[6] Globally, research has shown that forage fish are more valuable in the water than in a fishing net because of their important role in energy transfer to predators that are themselves of commercial importance.[7]

While forage fish populations fluctuate because of environmental factors[8] like temperature, food availability and predator pressure, they are also influenced by fishing. Failing to reduce harvests when environmental conditions are unfavourable can result in overfishing, exacerbate natural population busts and slow or prevent the characteristic population booms that bring forage fish populations back to healthy levels.[9,10]

Since it is virtually impossible to influence the environmental changes that affect forage fish, it is essential to reduce fishing pressure when a population is in decline to avoid deep, catastrophic crashes that can take years to recover from.

Global Best Management Practices

A certain amount of forage fish must be left in the water to reduce the risk of overfishing them and reduce the risk to the predators they feed.[9,10,11,12,13] The overarching principle guiding ecosystem-based forage fish management is to keep populations at healthy levels so their natural boom and bust cycles are maintained. This means not fishing them when their total weight, or biomass, is low, and only removing a limited amount through fishing when the biomass is high, thereby reducing negative impacts on the population itself and other fisheries.

Ecosystem-based fisheries management
Marine ecosystems are composed of communities of living organisms that interact with each other and their physical environment.
Ecosystem-based fisheries management goes beyond managing a fishery at the individual stock level, and aims to account for interactions between species, their environments, and humans that need them for food and livelihoods.

There are many examples of good forage fish management that include ecosystem considerations. For example:

- Cod predation is accounted for in the assessment and management of Barents Sea capelin off the northern coasts of Norway and Russia. Fishing is only allowed when the biomass of capelin, after predation, is estimated with high confidence to exceed the boundary below which a stock is considered unfit to support a fishery (a minimum biomass cut off.)[14]
- Pacific sardines off the west coast of the U.S. are similarly managed with a minimum biomass cut off. Harvest levels above the cut off are scaled both by the stock biomass available and recent oceanographic conditions that are known to impact Pacific sardine production. Harvest is capped at 200,000 mt no matter how large stock biomass is.[15]
- In 2020, the U.S. Atlantic Menhaden Management Board adopted ecological reference points,[i] linking the population dynamics of the forage fish menhaden with striped bass, a

[i] Reference points are used to provide management criteria for fisheries. Two basic types of reference points are used globally – limit reference points (LRP or B_{lim} and F_{lim}), which define the point below fishing is no longer sustainable (e.g., Blim is the minimum biomass cut off used in the Barents Sea Capelin fishery), and target reference points (TRP, B_{target}, F_{target}) which represents the ideal status of the stock to sustain a fishery. Trigger reference points are also used in some fisheries, usually set between LRPs and TRPs and are used to signal when management changes are needed to avoid the stock declining to or below the LRP. See a complete

predator that depends on this species and is sensitive to their harvest rates. The reference points are based on models that predict the sustainable level of menhaden harvest that will maintain the bass population at target biomass.[16]

Forage fish have different predator-prey population dynamics and their contributions to the ecosystem are not equal across all species. Therefore, while the principles of forage fish management are generally applicable across species, each individual stock should have dedicated modelling and management plans that reflect the ecosystem in which they reside.[8,17]

Forage Fish Management in Canada

In Canada, all commercially targeted forage fish are subject to precautionary approach management established by Fisheries and Oceans Canada (DFO)'s Sustainable Fisheries Framework, which includes identifying reference points to determine stock status (i.e., critical, cautious or healthy.)[18] Canada's *Fisheries Act*, which was modernized in 2019, now requires rebuilding plans for depleted fish populations.[19]

DFO has a Policy on New Fisheries for Forage Species,[20] which incorporates forage fish-specific management approaches based on the unique and crucial role these species have in their environments. While this policy is only meant to apply to new forage fisheries, its application to existing ones would put Canada in line with forage fish management in other jurisdictions. Although it should be applied retroactively, especially when we see forage fish populations in decline, existing forage fisheries in Canada are not currently subject to this policy specifically designed to account for their important role in the ecosystem.

Capelin

Northwest Atlantic Fisheries Organization (NAFO) area 2J3KL is located around the Eastern and Northern Newfoundland and Labrador shelves ecosystem.[ii] Within its boundaries live two iconic species that are intertwined - capelin, known as a linchpin of the ecosystem, and northern cod, the commercially valuable stock that depends on capelin for food.

definition here. Ecological reference points, like those developed for Atlantic menhaden take into account predator and/or environmental factors for their determination, so the reference points reflect factors beyond the individual stock.

[ii] NAFO is an intergovernmental fisheries science and management body, and the fishing areas in Canada's Exclusive Economic Zones are named in accordance with NAFO's convention area. NAFO area 2J3KL covers eastern and northern Newfoundland and eastern Labrador, from approximately Mary's Harbour to Hopedale. www.nafo.int/Fisheries.

Capelin is a source of food for many other species in this region, including seabirds like puffins and murres as well as marine mammals like humpback whales.[10,21,22,23] They are a short-lived species, reaching two to six years old, with a large proportion of mature individuals dying after they spawn: up to 100 per cent of males and 50 to 75 per cent of females.[24] In the summer, they arrive on beaches and in coastal bays to spawn, which sparks celebrations in Newfoundland and Labrador, known as the capelin roll. Offshore, a historically abundant commercial fishery targeted the 2J3KL capelin stock until it collapsed in the early 1990s.

The boom and bust cycles of forage fish in response to changing environmental factors are normal, but what is unique for 2J3KL capelin is that 30 years after its collapse it has yet to recover. Despite its perpetual collapsed state, a commercial fishery that lands a fraction of the pre-collapse harvests continues to put pressure on the stock.

"*The 2J3KL capelin stock experienced a collapse in the early 1990s, with the annual spring acoustic survey index of largely immature (age two) capelin declining by an order of magnitude from six million tonnes in the late 1980s to less than 150,000 tonnes in 1991.*"
Fisheries and Oceans Canada, 2019 Stock Assessment of 2J3KL Capelin

The stock's recent 2021 scientific assessment indicated that it is in a precarious situation, with its biomass index at only six per cent of its pre-collapse estimate. Compounding this, fish are maturing earlier and spawning later, which is contributing to reduced survival of larvae.[26] Specifically, this year's data shows that the larval index was the lowest on record and was already preceded by six years of lower-than-average larval production.

The impact of the collapse of capelin is spread across the entire ecosystem. The 1990s decline corresponded to changes in seabird feeding patterns and reduced health of seabird chicks.[23,19] Rebuilding northern cod is in part limited by the availability of capelin, a preferred prey.[6] Groundfish like cod and turbot (Greenland halibut) are showing up in research surveys skinny and in poor condition, with less capelin in their bellies than previously seen.[iii]

Whereas capelin stocks in the Barents Sea have boomed after numerous busts in the past 30 years, with each major decline accompanied by a cessation of fishing,[27] the 2J3KL capelin stock has never shown a sustained increase since the collapse in 1991. A direct comparison between capelin stocks is not possible, as different environmental variables affect each one. However, other jurisdictions do stop fishing capelin stocks when the population shrinks, while the fishery for 2J3KL capelin has not stopped since the collapse, and – predictably – after 30 years it has yet to rebound.

Currently this capelin stock has an uncertain population status under DFO's precautionary approach management framework, meaning that there is no confident estimate of the actual number of fish and no reference points to define whether it has a critical, cautious or healthy status.[25,26] Without this, there is no way to determine a sustainable removal level for the fishery.

[iii] From information presented at the 2021 2J3KL capelin stock assessment.

Capelin Management Recommendations

For 30 years, DFO's management of 2J3KL capelin has failed to rebuild a stock that is essential to the larger ecosystem. It is time for a change. Below are Oceana Canada's management recommendations for the 2J3KL capelin stock, in line with global best practices of forage fish management and DFO's own policies.

1. Immediately pause the 2J3KL capelin fishery

While recent quotas may seem small compared to the past, the 20,000 mt allocated to the fishery last year could represent between 0.4-1.3 billion fish.[iv] Because this is primarily a roe fishery, with its main product being eggs, most of the fish are landed directly before they are preparing to spawn. This not only removes the adults from the population, but the potential for any contribution to the next generation they may have made. For a depleted stock stuck in a cycle of poor productivity, removing fish before they can spawn, even if that number of fish is small relative to that consumed by predators, is risky.

As there is no clear or substantiated way to reduce the natural mortality of capelin, reducing fishing mortality is the most direct measure that can influence the stock's total mortality. DFO's precautionary approach to fisheries management commits to "being cautious when scientific knowledge is uncertain and not using the absence of adequate scientific information as a reason to postpone or fail to take action to avoid serious harm to fish stocks or their ecosystems."[18]

As such, Oceana Canada recommends that the commercial fishery be paused until the stock rebuilds.

2. Develop and implement a forage fish-specific management plan to prevent overfishing before resuming the capelin fishery

The amended *Fisheries Act* (6.1(1))[19] states that measures implemented to promote the sustainability of fish stocks shall "[take] into account the biology of the fish and the environmental conditions affecting the stock." In order to develop a management plan for a

[iv] Estimate only: based off a calculation of the average weight of 2-3 year old capelin (which dominate the fishery) weighing between 15-48 g (approximate minimum and maximum average weight at age of Capelin in the DFO surveys from 1989-2018; Figure 6, Mowbray, F.K., Bourne, C., Murphy, H., Adamack, A., Lewis, K., Varkey, D., and P. Regular. 2019. Assessment of Capelin (Mallotus villosus) in SA2 + Div 3KL in 2017. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/068. iv + 34 p.). At 15 g/fish: 20,000 mt = 20,000,000 kg/ 0.015 kg = 1.33 billion fish. If half of these are assumed to be female, and maximum potential fecundity of capelin post-1990s collapse in Newfoundland is 7,616-42,880, the fishery could prevent spawning of 5.1- 28.5 trillion eggs each year. At 48 g/fish: 20,000 mt = 20,000,000 kg/ 0.048 kg = 0.42 billion fish. If half of these are assumed to be female, and maximum potential fecundity is the same as above, the fishery could prevent spawning of 1.5- 8.9 trillion eggs each year. Penton and Davoren. 2013. Capelin (*Mallotus villosus*) fecundity in post-1990s coastal Newfoundland. *Mar Biol* 160**,** 1625–1632. https://doi.org/10.1007/s00227-013-2215-7

capelin fishery once the stock rebuilds, one that accounts for its biology within the ecosystem in which it resides, DFO must:

1. Implement the precautionary approach framework;
2. Identify the minimum biomass cut-off: A minimum biomass of capelin required to sustain itself, considering predation and environmental conditions, below which there is no fishing.
3. Identify a harvest control rule with a harvest cap: The amount or proportion of biomass above this minimum that could be available to a fishery, including the maximum that can be harvested, no matter how high the biomass is.

Despite DFO having a Policy on New Fisheries for Forage Species[20] that provides guidance for stock management, wherein ecosystem-based principles are a primary focus, along with conservation and socio-economic considerations, it does not implement it for existing forage fisheries.

Oceana Canada strongly recommends that management decisions for this stock incorporate principles of the Policy on New Fisheries for Forage Species, which commits to managing forage fish stocks so that the "future recruitment of the target species is not impaired, and that food supply for predators is not depleted."

Benefits of Restoring and Protecting Capelin Abundance

Best management principles for forage fish are in theory straightforward – only fish when the stock is abundant and take less than you would in other fisheries – however, beginning this process for capelin is not easy. A pause in the fishery affects real people and their livelihoods, and currently there is no science to tell us how long the stock may take to recover in the absence of fishing. However, pausing the fishery to reduce pressure on this critically depleted stock is the most direct way we can help the stock rebuild.

Rebuilding the stock and establishing a harvest control rule to reduce the risk of future overfishing is an investment in a future fishery, one that has the potential to be more robust, profitable and sustainable than the status quo.[28]

The benefits of rebuilding capelin in this region would spill over beyond the stock itself, including contributing to rebuilding northern cod and other groundfish fisheries, supporting healthy populations of the seabirds and humpback whales that draw visitors to Newfoundland

and Labrador, and ensuring that the food and celebration associated with the capelin roll each year continues.

"The overall benefits of rebuilding are magnified if we consider the thousands more people in coastal communities who have food, cultural and other social connections to fish stocks."
Sumaila and Teh. 2019. Economic and Social Benefits of Fisheries Rebuilding: Six Canadian Case Studies.

References

1. Pikitch et al. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp. http://www.lenfestocean.org/foragefish
2. Food and Agriculture Organization of the United Nations (2020) The State of World Fisheries and Aquaculture -2020 http://www.fao.org/publications/ sofia/2020/en/.
3. Pikitch et al. 2014. The global contribution of forage fish to marine fisheries and ecosystems**.** Fish, 15: 43-64. 10.1111/faf.12004
4. von et al. 2019. Extreme reduction in nutritional value of a key forage fish during the Pacific marine heatwave of 2014-2016. Mar. Ecol. Prog. Ser. 613:171-182. https://doi.org/10.3354/meps12891
5. Kaplan et al. 2019. A multi-model approach to understanding the role of Pacific sardine in the California Current food web. Mar. Ecol. Prog. Ser. 617-618:307-321. https://doi.org/10.3354/meps12504
6. DFO. 2020. Rebuilding plan for Atlantic cod – NAFO divisions 2J3KL. https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/cod-morue/2020/cod-atl-morue-2020-eng.html
7. Pikitch et al. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp. http://www.lenfestocean.org/foragefish
8. Hilborn et al. 2017. When does fishing forage fish affect their predators? Fish. Res., 191: 211-221. https://doi.org/10.1016/j.fishres.2017.01.008
9. Essington et al. 2015. Fishing amplifies forage fish population collapses. PNAS, *112*(21), pp.6648-6652.
10. Guénette et al. 2014. A review of the ecological role of forage fish and management strategies. Can. Tech. Rep. Fish. Aquat. Sci. 3065
11. Pikitch et al. 2012. The global contribution of forage fish to marine fisheries and ecosystems. Fish.: 15(1):43–64.
12. Cury et al. 2011. Global seabird response to forage fish depletion—one-third for the birds. Science, *334*(6063), pp.1703-1706.
13. Zabel et al. 2003. Ecologically sustainable yield: marine conservation requires a new ecosystem-based concept for fisheries management that looks beyond sustainable yield for individual fish species. Am. Sci. 91(2), pp.150-157.
14. Gjøsæter et al. 2015. A retrospective evaluation of the Barents Sea capelin management advice. Mar. Biol. Res., 11(2): 135-143. doi: https://doi.org/10.1080/17451000.2014.928414
15. PFMC. 2020. Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches. Stock assessment and Fishery Evaluation for 2014. Pacific Fishery management Council. https://www.pcouncil.org/documents/2020/10/2019-cps-safe-june-2020.pdf/
16. Chagaris et al. 2020. Ecological reference points for Atlantic Menhaden established using an ecosystem model of intermediate complexity. Front. Mar. Sci., 7, doi: 10.3389/fmars.2020.606417
17. Pikitch et al. 2018. The strong connection between forage fish and their predators: a response to Hilborn et al. 2017. Fish. Res. 198, 220–223. doi: 10.1016/j.fishres. 2017.07.022
18. DFO. 2009. A fishery decision-making framework incorporating the precautionary approach. https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm

19. Parliament of Canada. 2019. An Act to amend the Fisheries Act and other Acts in consequence (https://www.parl.ca/DocumentViewer/en/42-1/bill/C-68/royal-assent)
20. DFO. 2009. Policy on New Fisheries for Forage Species. https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/forage-eng.htm
21. Rose abd O'Driscoll. 2002. Capelin are good for cod: can the northern stock rebuild without them? ICES J. Mar. Sci. Volume 59, Issue 5: 1018–1026, https://doi.org/10.1006/jmsc.2002.1252
22. Mitchell, E. 1974. Present status of Northwest Atlantic fin and other whale stocks, p. 108-161. In W. E. Schevill [ed.] The whale problem. Harvard University Press, Cambridge, MA.
23. Davoren and Motevecchi. 2003. Signals from seabirds indicate changing biology of capelin stocks. Mar. Ecol. Prog. Ser., 258: 253-261.
24. DFO. 2019. Capelin (*Mallotus villosus*) Newfoundland & Labrador Region Divisions 2+3 (Capelin Fishing Areas 1-11), Integrated Fisheries Management Plan. https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/capelin-capelan/2019/zone-area_1-11-eng.html
25. DFO. 2019. Assessment of 2J3KL Capelin in 2018. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/048.
26. CSAS. 2021. Technical Briefing on the 2021 assessment for 2J3KL Capelin, March 17, 2021. Canadian Science Advisory Secretariat.
27. Institute of Marine Research, Norway. 2020. Topic: Capelin in the Barents Sea. https://www.hi.no/en/hi/temasider/species/capelin-in-the-barents-sea
28. Sumaila and Teh. 2019. Economic and social benefits of fisheries rebuilding: six Canadian case studies. Oceana Canada, https://oceana.ca/sites/default/files/ubc_oceana_economics_of_rebuilding-final.pdf