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CAPELIN IN CRISIS: URGENT ACTION NEEDED TO REBUILD ABUNDANCE

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Executive Summary

Capelin are small, fast-growing forage fish that are found across the north Atlantic Ocean. They are a linchpin species for the ocean ecosystem off the coast of northeast Newfoundland (NAFO areas 2J3KL). Capelin transfer energy through the marine food web, from the plankton they eat, to the whales, seabirds and other fish that rely on them for food. They have a unique life cycle, causing wide fluctuations in their population that are usually driven by environmental conditions like temperature and food availability.

The 2J3KL capelin stock collapsed in the early 1990s and has never been given the chance to recover. A fishery is still allowed to operate, which targets female capelin for their eggs (or roe). Roe harvesting means that not only are adults removed from the population before they have a chance to spawn, but the contribution of those larvae to the next generation is lost.

Fisheries and Oceans Canada (DFO) estimates that the capelin population is currently only at six per cent of what it was before the population collapsed. The past eight years have shown below-average larval production, as adult fish mature earlier in their lives and spawn later in the season. DFO uses reference points to determine the health of fish populations, and although capelin lack the reference points necessary to determine its health status under DFO's Precautionary Approach Framework, it is without a doubt a critically depleted population. The Precautionary Approach Framework states that lack of data is not a good enough reason for delayed action to avoid serious harm to the stock, such as closing the fishery. If DFO continues to allow high levels of fishing for capelin, it would be in violation of their own policy.

Oceana Canada conducted new research in 2022 to assign a provisional health status to capelin and other Canadian stocks without reference points. Capelin is overfished according to this assessment and would be considered critical under the Precautionary Approach. Abundance, or amount of fish in the population, is estimated at only 18 per cent of what is needed to support a sustainable fishery, where harvesting can occur without harming the population.

Compounding the depleted state of capelin is the fact that overfishing capelin has consistently occurred for the past three decades. In 2020, fishing was 1.77 times the level that would be considered sustainable for such a depleted stock.

Capelin is in a dire state with a poor outlook for the future unless action is taken to significantly shift their management approach. The actions and tools necessary to recover this critically important little fish are already available to DFO under existing policies.

To recover capelin in northeast Newfoundland, Oceana Canada strongly recommends the following actions:

1. **Immediately close the 2J3KL capelin fishery.**
2. **Invest in capelin research programs and develop a rebuilding plan as required for all stocks under the amended *Fisheries Act*.**
3. **Develop and implement a management strategy that accounts for capelin's role in the ecosystem and with adequate monitoring, prior to resuming the capelin fishery**

Species and Fishery

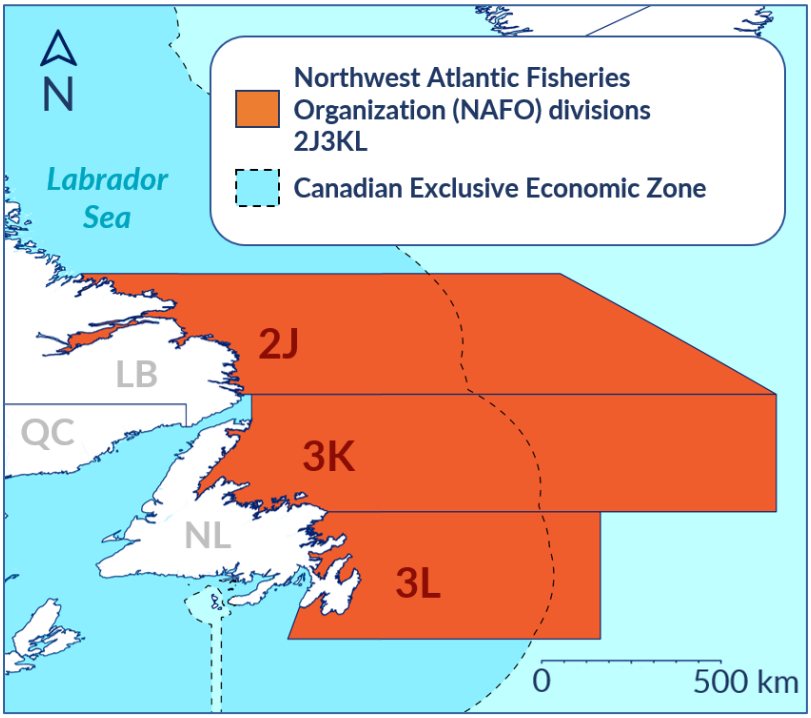
Capelin (*Mallotus villosus*) is widely regarded as a forage fish in the marine ecosystem of Newfoundland and Labrador. Forage fish, which also include species such as sardines, herring and mackerel, are small, fast-growing schooling fish that play an important role in transferring energy from the plankton they eat to the larger species that prey on them.[1]

Capelin support many species in Newfoundland and Labrador, such as humpback whales,[2] seabirds[3] and other fish (See Oceana Canada's 2021 report *Small Fish, Big Influence: The case for rebuilding capelin*). Capelin have been the predominant prey for several economically valuable species in Atlantic Canada, including Greenland halibut and Atlantic cod[4].

At present, low capelin abundance has been cited as a primary limiting factor in the slow recovery of iconic northern Atlantic cod stocks.[5,6]

As with most forage fish, capelin experience natural, wide fluctuations in recruitment and biomass ("boom" and "bust" cycles) driven by the conditions of their environment, including temperature, food availability and predation.[7] High levels of mortality on a forage species during a period where environmental conditions are unfavourable can result in stock depletion, exacerbating population "busts" and preventing recruitment events or "booms" that restore the stock to a healthy level. Given this unique life history characteristic, forage fish require fisheries management strategies that specifically account for and monitor their episodic variation in abundance.

In the waters surrounding northeastern Newfoundland and Labrador (NAFO areas 2J3KL[i]), capelin have been subject to commercial harvest since the early 1970s.[8] Historically an abundant fishery with offshore catches peaking in 1978 at 250,000 metric tonnes, the stock collapsed in the early 1990s, concurrent with the collapse of several groundfish species in Atlantic Canada.



After continued overfishing on a depleted stock, capelin have failed to recover in the last 30 years. Despite this, a large

[i] 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.

fishery is still permitted to harvest the 2J3KL stock. This fishery targets the unspawned roe (or eggs) of capelin, which means that females are removed from the water before they have a chance to release their eggs.

In 2021, nearly 15,000 metric tonnes of capelin were allocated to fishers, which could represent up to half a billion individual female capelin and up to 21 trillion eggs,[i] the majority of which are exported to Asian markets. This type of harvest not only removes reproductive adults from the population, but hampers recruitment by shrinking the contribution of new larvae to the next generation.

Fisheries and Oceans Canada reduced the quota for 2J3KL capelin by 25 per cent in 2021 (from 19,377 metric tonnes to 14,842 metric tonnes). Although this decision received vocal opposition from the fish harvesting community,[9] it was an action taken in response to the stocks persistent lack of recovery and low spawning success. It remained the third largest forage fish quota in Canada, despite that this stock is only a tiny fraction of its former abundance and lacks the formal reference points required to assign its health status under DFO's Precautionary Approach Framework.[10] The Precautionary Approach commits to "not using the absence of adequate scientific information as a reason to postpone or fail to take action to avoid serious harm to the resource." Thus, continuing to put harvest pressure on 2J3KL capelin in the absence of reference points would not comply DFO's own policy, where conservation actions should take precedence when the stock is depleted.

Stock Status under the Precautionary Approach

DFO and other jurisdictions use the biomass that supports maximum sustainable yield (MSY), or **B_{MSY}**, as a reference to assign the health status of fish stocks as either healthy, cautious, or critical. MSY refers to the highest annual catch that could theoretically be extracted from the stock in perpetuity without harming the stock's long-term health.

Upper Stock References (USR) delineate the cautious and healthy zones. USRs are commonly set at 80 per cent of B_{MSY}.

Limit Reference Points (LRP) are the point at which a stock goes from the cautious into critical zone. LRPs are commonly set at 40 per cent of B_{MSY}.

A stock that lacks reference points cannot be defined under the Precautionary Approach and is assigned "uncertain" status.

For more details on the status of Canada's fisheries, visit fisheryaudit.ca

[i] Estimate only: based off a calculation of the average weight of two- to three-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: 15,000 mt = 15,000,000 kg/ 0.015 kg = 1 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 3.8 -21.4 trillion eggs each year. At 48 g/fish: 15,000 mt = 15,000,000 kg/ 0.048 kg = 0.31 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 1.2- 6.7 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

Stock Health and Provisional Status

There was no stock assessment for capelin provided in 2022 due to data limitations stemming from an incomplete annual bottom-trawl survey in 2021. An index of abundance for capelin at the 2021 stock assessment[11] was estimated to be just 6 per cent of pre-collapse levels. The 2021 assessment also showed that capelin were maturing earlier in their lifespan and spawning later in the season, both factors that negatively impact capelin fecundity and larval survival.

A capelin update provided by DFO Science in March of 2022[12] showed that capelin larval production has been below average for the eighth year in a row. DFO is presently unable to estimate the absolute biomass of the capelin stock, and thus is unable to estimate reference points relative to its biomass to determine 2J3KL capelin's stock status and manage it under the Precautionary Approach. Without reference points, it is impossible to determine a sustainable level of harvest for the stock.

Oceana Canada released new research in 2022[13] that assigned a provisional stock status to those Canadian stocks categorized as 'uncertain'. Stock status was elucidated using a method called CMSY++[i], which uses recorded catches, biological information and available indices of biomass to generate reference points and assign health status to stocks previously deemed "data-poor" and ineligible for traditional stock assessments.

This tool has been used on over 2,000 fish stocks worldwide[14] and produces comparable results to other traditional methods of stock assessment.[14,15,16]

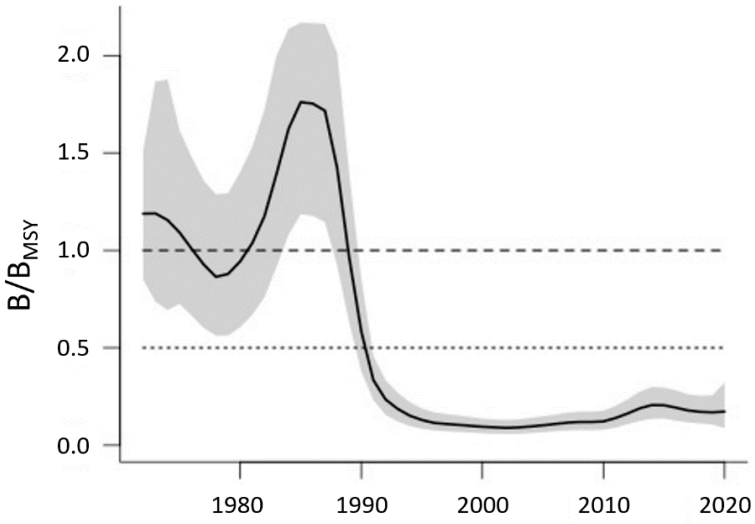


Figure 1: Total biomass (B) of capelin relative to the biomass which supports maximum sustainable yield (B_{MSY}) in NAFO divisions 2J3KL from 1972 to 2020 estimated using CMSY++ methodology.

A CMSY++ stock assessment was conducted for the 2J3KL capelin stock in northeastern Newfoundland. Results are commensurate with what the stock trajectory already clearly indicates: that the stock is far below B_{MSY} and would be considered overfished and deep in the critical status zone, with an estimated relative stock biomass of 0.18 B_{MSY} in 2020 (Figure 1).

In addition, CMSY++ analysis on 2J3KL capelin indicates that the stock is being overfished at current levels of harvest (where fishing mortality, F, exceeds the rate that would produce

[i] Froese, R., Demirel, N., Coro, G. & Winker, H. (2019). A simple user guide for CMSY+ and BSM (CMSY_2019_9f.R). GEOMAR, 1-16.

maximum sustainable yield for the population, F_{MSY}). Despite low overall catches compared to historical levels, a heavily depleted stock such as 2J3KL capelin cannot sustain high enough recruitment that would allow for continued fishing at status quo rates (an effect known as depensation[17]).

In 2020, fishing mortality was estimated using CMSY++ at $1.77F_{MSY}$ and in fact the stock has been in an overfished state for approximately 30 years (Figure 2).

Although natural mortality of capelin is identified as a driver of its persistent collapsed state, reducing fishing mortality such that $F<F_{MSY}$ at the current stock size is the one direct measure that DFO can employ to influence the recovery of the stock. However, 2J3KL capelin have been stuck in a decades-long cycle of poor recruitment, poor productivity, overfishing and low abundance. As such, marginal year-on-year increases in biomass resulting from a lesser harvest will likely be insufficient to bring the stock back to a sustainable size. Thus, it is imperative that commercial fishing on this stock be prohibited until it can rebuild, during which time a rebuilding plan and rigorous harvest management plans must be developed and implemented to ensure sustainability before the fishery resumes.

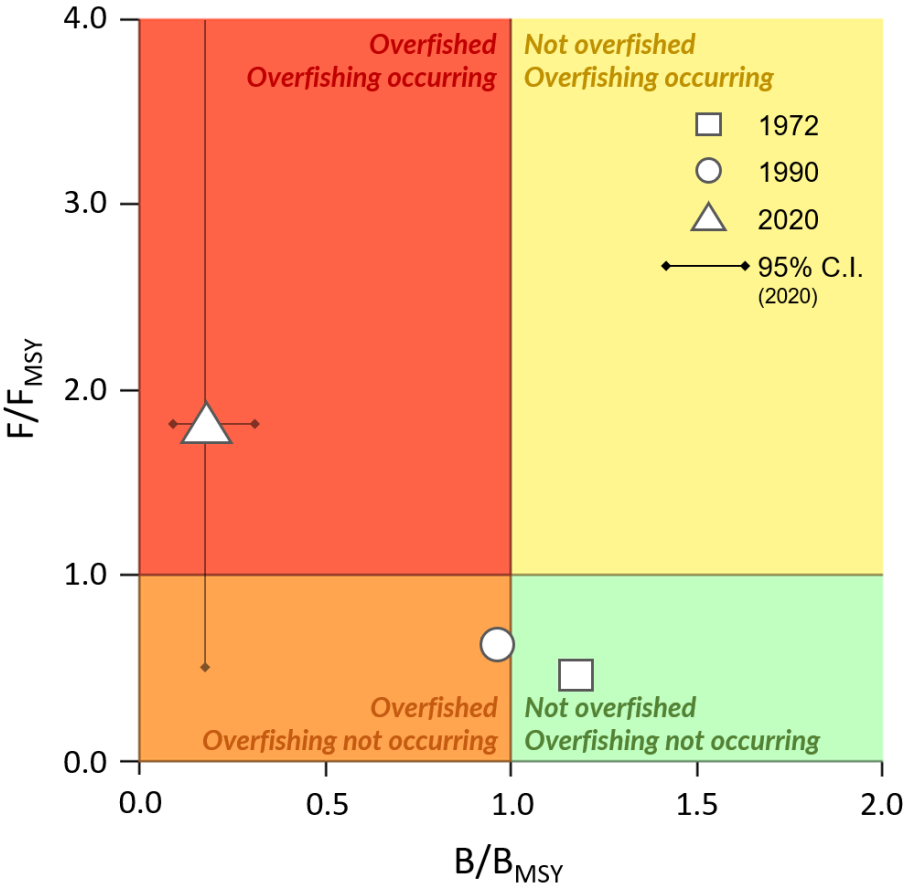


Figure 2: Stock size (B) and fishing mortality (F) for 2J3KL capelin relative to their reference points which support maximum sustainable yield (MSY), estimated using CMSY++ methodology. Shown are estimates for 1972 (square), 1990 (circle) and 2020 (triangle). Overfishing occurs when fishing mortality exceeds maximum sustainable levels (F/F_{MSY} is greater than or equal to 1). A stock is defined as "overfished" when its biomass falls below that which would support a maximum sustainable yield (B/B_{MSY} is less than 1).

A limitation to this approach is that CMSY++, which is based primarily on catch data (and when available, relative biomasses), does not utilize some of the available data for capelin, including larval abundance data or information on the age-structure that is currently used to inform indices of capelin stock health. Further, surplus production models, which are the foundational models used in CMSY++, view populations as a single unit of biomass with uniform growth and mortality rates. While CMSY++ has been proven to be a valuable tool for data-limited scenarios despite this, management actions based on surplus production assessments such as CMSY++ should focus on estimates of biomass and not estimated fishing mortality, which may be underestimated for fish of different age classes.

Forage Fish under the Precautionary Approach Framework

In 2009, DFO established a Policy on New Fisheries for Forage Species[18] which details management approaches specifically designed to support forage species' role in marine food webs. Reflected in this policy, employing a fixed yield approach would not accommodate the natural fluctuations in recruitment and abundance experienced by forage fish stocks. As such, common components of best management practices for forage fish include 1) a **minimum stock biomass** to safeguard recruitment potential, and 2) a **maximum harvest cap** to protect the stock against overfishing when conditions are unfavourable. These management tools have shown success in maintaining or growing forage fish stocks in other jurisdictions and in some Canadian cases, including capelin in the Barents Sea,[19] and Pacific herring in British Columbia.[20]

At present, capelin, along with the majority of forage fish stocks in Canada, continue to be managed in the same manner as single-species stocks, with little attention given to their role in the environment. To facilitate a better outcome for the stock, fisheries managers in Canada must instead source sustainable management practices for forage species from within the existing Precautionary Approach Framework.[10]

For 2J3KL capelin and other forage fish stocks, this policy should be interpreted in such a way that is specifically cognizant of forage species' critical role in marine food webs and its episodic fluctuations in abundance.

A minimum stock biomass to preserve stock productivity and sustain ecologically dependent predators is commonly used internationally to manage forage fish species, including capelin in the Barents Sea.[19] A minimum spawning biomass of 200,000 metric tonnes of capelin in the Barents Sea is preserved each year with 95 per cent probability. In the Barents Sea, capelin have experienced expected natural declines in abundance and recovery to a healthy biomass four times over the past 30 years.[19] Under Canadian policy, minimum stock biomass is reflected in the Precautionary Approach Framework[6] by the Limit Reference Point (LRP). For forage fish, the LRP or proxy value should be set conservatively to account for uncertainties, at a greater biomass than for a stock managed under a single-species approach. The harvest rate would then apply only to the stock biomass that is above the LRP or minimum biomass threshold, and harvesting the stock below the LRP is prohibited.

If fishing mortality is maintained at a high level during a non-favourable year for recruitment, there is a risk of driving the stock back down to unsustainable levels. The Precautionary

Approach Framework[10] already dictates a maximum acceptable removal reference for stocks as "at or below F_{MSY} or some other described metric of fishing pressure". Forage fish management would see a target harvest rate being set below the maximum sustainable removal reference with enough room to allow for the stock to experience its natural 'busts' and 'booms'. The difference between the target harvest rate and a maximum sustainable removal reference would serve as the 'buffer' to reduce the probability of fishing mortality exceeding that maximum rate in a year where stock recruitment is impaired by external conditions.[7]

These principles for forage fish management are already and increasingly in place for some forage fish stocks in Canada managed under the Precautionary Approach framework, namely Pacific herring (*Clupea palasii*). Pacific herring are an important prey species in the Northeast Pacific and support many other species including culturally and economically significant Pacific salmon stocks.[21] Most herring stocks have experienced persistent low abundance and recruitment following decades of commercial fishing. A threshold value of 25 per cent of the estimated unfished biomass (B_0) was established for all Pacific herring stocks in 1996, where harvest rates are set to zero if the stock breached this threshold.[22] In 2017, this cut-off was increased to 30 per cent of B_0 in recognition of the risk of serious harm to the stock and its dependent predators below this biomass. The majority of Pacific herring stocks remain closed to commercial fishing under this management approach, with the exception of herring in the Strait of Georgia, where a maximum harvest cap of 7,850 metric tonnes was put in place in 2021 to reduce the risk of overfishing the stock.[23] Following the closure of commercial fisheries, several Pacific herring stocks which fell below this threshold have seen modest gains in abundance.[20]

The same risk-averse management principles must now be applied consistently to all forage fish stocks across Canada. There are no forage fish stocks in Atlantic Canada that are in the healthy zone under DFO's Sustainability Survey for Fisheries (SSF). Although the 2J3KL capelin stock lacks reference points to officially assign a status, it is incontrovertibly critically depleted, and management requires a decisive change in course to maintain any hope of a future sustainable fishery.

Consequences of Inaction

If Fisheries and Oceans Canada fails to protect and rebuild stocks of 2J3KL capelin, there may be wide-reaching consequences on the surrounding ecosystems, and the people and communities who depend on them.

Many local seabirds including Atlantic puffins and common murres feed on capelin off the northeast coast of Newfoundland, and low capelin abundance has been linked to both decreased egg size,[24] reduced chick condition and increased energy expenditure[25] during the nesting period. Capelin are also a main prey source for humpback whales, and whales tend to follow capelin to their spawning areas.[26] In addition to ecosystem shifts that may be brought on by further declines of 2J3KL capelin, industries like whale-and-seabird tourism, that bring hundreds of thousands of tourists to Newfoundland and Labrador every year, could suffer.

Capelin are an important food source for cod and low capelin abundance has limited the recovery of northern cod stocks in NAFO areas 2J3KL. Formerly worth hundreds of millions of dollars each year, northern cod collapsed in the 1990s and have not shown signs of recovery since. A lack of capelin, a fish rich in oils and fats, in the diet of cod in northeast Newfoundland is

linked to poor cod condition, smaller adult sizes and increased natural mortality.[27] These two species are inextricably linked and a recovery of northern cod is unlikely to be achieved without meaningful increases in capelin abundance. If capelin fail to rebuild, so too will hope for a restored northern cod fishery.

Oceana Canada Recommendations

1. **Immediately close the 2J3KL capelin fishery.**

The 2J3KL capelin stock is in a severe state of depletion, and provisional CMSY++ results indicate that the stock is far into the critical zone, at only 18 per cent of the biomass to support maximum sustainable yield (B_{MSY}). As there is no way at present to manage the natural mortality of this stock, the only tool immediately available to DFO to reverse the course for Newfoundland capelin is an immediate and dramatic reduction in fishing mortality. Consistent with previous closures of Pacific herring, Atlantic herring and Atlantic mackerel fisheries[28] when they reached a critically low abundance, the 2J3KL capelin fishery should be closed and harvest prohibited until such a time that the stock is able to rebuild.

2. **Invest in capelin research programs and develop a rebuilding plan.**

In the early 1990s around the time of many groundfish stock collapses, a prominent research program existed monitoring the conditions and success rates of capelin spawning on seven beaches across northeast Newfoundland, as capelin come to shore to spawn in large aggregations in late spring. Since 1996, however, only one of the seven originally monitored beaches remains annually sampled.[29] Additionally, annual at-sea acoustic surveys only sample in NAFO area 3L, covering less than half of the area this stock occupies. To estimate spawning biomass of capelin with some degree of accuracy, and in turn establish formal reference points to inform the management of the stock, DFO must invest more resources into elucidating the abundance and health of the stock with greater certainty. Reference points informed by science will allow DFO to develop and implement a rebuilding plan for 2J3KL capelin under the Fish Stock Provisions of the amended *Fisheries Act*,[30] to grow the stock to a healthy abundance and safeguard prospects for a future sustainable fishery.

3. **Develop and implement a management plan that accounts for capelin's critical role in the ecosystem and with adequate monitoring, before resuming the capelin fishery.**

Under the revised *Fisheries Act* (6.1(1)),[30] management decisions shall "[take] into account the biology of the fish and the environmental conditions affecting the stock." To account for the ecological role that capelin play in Newfoundland's marine ecosystem, a management plan for 2J3KL capelin must include, along with adequate monitoring of the fishery, the following components:

- A framework that follows the Precautionary Approach where conservation objectives take precedence while the stock is depleted;
- A minimum biomass threshold below which no harvest is permitted, in order to preserve the recruitment capacity of the stock and sustain ecologically dependent predators, and;

- A maximum harvest cap to reduce the likelihood of exceeding sustainable harvest rates in non-favourable years.

These actions adhere to applicable DFO policy including the Precautionary Approach Framework, and for existing forage fish stocks, would satisfy all 5 objectives on DFO's Policy on New Fisheries for Forage Species.[18]

Fisheries and Oceans Canada has the opportunity to stop overfishing capelin and manage the stock in a way that rebuilds them to abundance for the long-term health of the ocean and the coastal communities that depend on it. This government can make a difference by closing the capelin fishery – before it's too late.

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