OVERLOOKED & UNDERVALUED:

THE ECONOMIC CASE FOR REBUILDING FORAGE FISH

MAY 2024

OCEANS NORTH

SUMMARY

Forage fish are small schooling fish such as capelin, herring, or mackerel that occupy the middle of the food web. They play an essential role in moving energy up and down the food web by eating smaller organisms like zooplankton and being eaten by larger organisms such as other fish, whales, and seabirds.

Historically, they have also been plentiful. Fisheries that target forage fish species are some of the largest in the world, and there are 17 forage fish stocks in Canada that have helped to support coastal livelihoods and local ecosystems.

Unfortunately, only one of Canada's forage fish stocks is considered healthy and more than a quarter are considered critically depleted. Years of mismanagement combined with ecosystem changes and a false sense of endlessly abundant fish stocks have led to these declines. Over the years, Fisheries and Oceans Canada (DFO) has been slow to take action or make decisions that would offer the best chance of returning these stocks to healthy levels.

This is partially due to economic concerns. DFO takes socio-economic information into account when creating management documents, integrated fisheries management plans (IFMPs), and rebuilding plans. However, this information usually consists of short-term evaluations of how the fishing industry is likely to be affected by quota reductions or fisheries closures rather than of the long-term benefits of rebuilding. As a result, **the crucial role forage fish play in the broader marine ecosystem is often overlooked and undervalued**.

In order to estimate the value of leaving forage fish in the water, this study conducted a cost-benefit analysis using the critically depleted herring stock in the Southwest Nova Scotia/ Bay of Fundy area as an example. Four different catch rebuilding scenarios were examined that rebuilt the stock out of the critical zone in 10 years, in line with DFO policy: **1) not allowing any fishing; 2) gradually increasing fishing limits, also known as "stepwise fishing"; 3) "constant catch," where fishing is set at a constant harvest rate; and 4) the "hockey stick," where fishing quotas are adjusted up and down based on the health of the stock.** These were compared against a catch scenario that kept fishing around 2022 levels and did not rebuild the stock in 10 years.

WHAT ARE THE BENEFITS OF FORAGE FISH?

The framework of "ecosystem services" is often used to account for the value of nature alongside the value of extractive industries. Ecosystem services are the benefits that the natural environment provides and can include everything from carbon sequestration and water filtration to nature-based tourism. In addition to the direct commercial fisheries catch value and its contribution directly and indirectly to human consumption, notable contributions of forage fish are: food support to other commercial fish species (predators such as bluefin tuna and cod); support for marine mammals and seabirds (which contribute economically through marine tourism); carbon storage to reduce ocean acidification and atmospheric carbon; and biodiversity value as well as cultural, social, and intrinsic values.[1,2,3,4]

The price of landed herring was set based on the average Nova Scotia price in 2021 and then adjusted to represent 2022 values. The value of herring left in the water was estimated at 66% of the commercial catch value, based on research that suggests the value of the catch is at most 1/3 of herring's total value.

The results of this cost-benefit analysis showed that **a herring stock rebuilt out of the critical zone could be worth at least $402 million under any of the catch rebuilding scenarios** and that they would **result in more herring in the water** compared to a scenario based on recent fishing levels. This would benefit both the ecosystem and harvesters, even accounting for short-term losses due to reduced catches.

When the value of forage fish both in and out of the water is considered, the results can support stock rebuilding and ecosystem-based management approaches that also increase benefits for harvesters over the long term. It is therefore important to understand both the environmental and economic implications so that managers can avoid undesirable trade-offs. Knowing and quantifying the multiple benefits that forage fish provide can help improve decision making and ensure that their role is not undervalued.

1 Pikitch, E.K., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., Steneck, R.S., 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program, Washington, DC, pp. 108.

2 Pikitch, E. K., Rountos, K. J., Essington, T. E., Santora, C., Pauly, D., Watson, R., ... & Munch, S. B. (2014). The global contribution of forage fish to marine fisheries and ecosystems. Fish and Fisheries, 15(1), 43-64. https://doi.org/10.1111/faf.12004.

3 Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Wetlands and Water Synthesis. World Resources Institute, Washington, DC.

4 Konar, M., Qiu, S., Tougher, B., Vause, J., Tlusty, M., Fitzsimmons, K., ... & Cao, L. (2019). Illustrating the hidden economic, social and ecological values of global forage fish resources. Resources, Conservation and Recycling, 151, 104456.

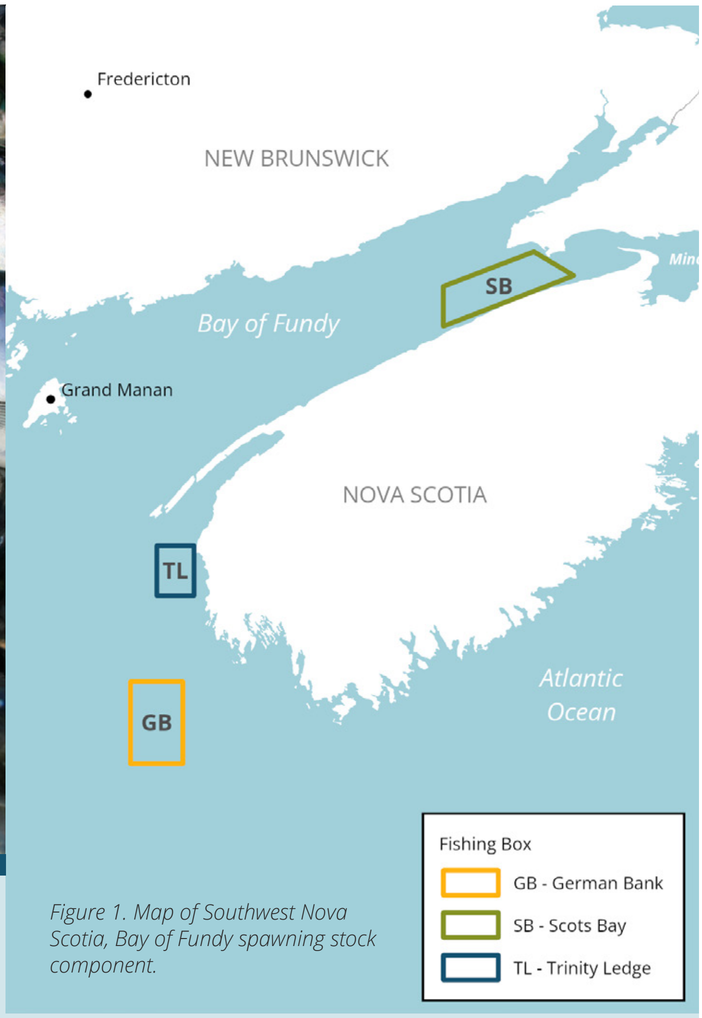


Figure 1. Map of Southwest Nova Scotia, Bay of Fundy spawning stock component.

CASE STUDY:
SOUTHWEST NOVA SCOTIA / BAY OF FUNDY HERRING

For this study, we chose the herring spawning component located in Southwest Nova Scotia/ Bay of Fundy, as it has supported one of the largest fisheries in Canada and herring remains an important forage species for the region. However, the stock has been declining for decades and has been critically depleted since 2017, with reports signalling the need for rebuilding since at least 2001. Although quota cuts have occurred in this fishery over the last six years, they have not been enough to rebuild the stock. The 2023 stock science data suggests a quota of no more than 14,000 tonnes is needed to rebuild the stock out of the critical zone within 10 years, but recent quotas have been set far above that level.

As part of the rebuilding plan process, DFO and stakeholders have been engaged in a management strategy evaluation (MSE). This is a simulation-based way to test potential harvest levels against various uncertainties. These kinds of simulations do not exist for most stocks in Canada, so having one in this case allows us to evaluate economic trade-offs under different harvest scenarios.

Another reason why this stock makes a good case study is that DFO has used its socio-economic importance as a reason to avoid a commitment to full rebuilding—yet DFO has also not provided a recent or long-term socio-economic analysis to support this conclusion. Atlantic herring have been referred to as the "silver of the sea" for their importance in supporting fisheries, economies, and ecosystems; but no valuation of herring's ecological role was considered in DFO's analyses, so this case study aims to address this important shortcoming in understanding the true value of herring.[5,6]

5 Boyce, D. G., Petrie, B., & Frank, K. T. (2019). Multivariate determination of Atlantic herring population health in a large marine ecosystem. ICES Journal of Marine Science, 76(4), 859-869

6 FAO. 2014. The State of World Fisheries and Aquaculture 2014. Food and Agriculture Organization of the United Nations, Rome, 230 pp.

METHODOLOGY

Gardner-Pinfold Consulting conducted an economic analysis for Oceans North to assess the trade-offs between the value of minimizing fishing to rebuild the herring stock and fishing the stock at higher levels, which would jeopardize rebuilding. It considers both landed value and an estimate of herring's value in the water. A cost-benefit analysis was conducted, as these are the assessments used by the Treasury Board of Canada to help resolve complex economic trade-offs involved in resource management decisions.

The study uses the results of a management strategy evaluation, conducted by DFO in partnership with the herring advisory committee members, which provided results to analytically compare future projections of stock health across various rebuilding and non-rebuilding fishing scenarios.

REBUILDING SCENARIOS

In this fishery, the health of the stock is measured by the spawning stock biomass (SSB) calculated through an acoustic index. This is a relative value that represents the total weight of reproductively mature fish in a population. This SSB is compared to a limit reference point, or LRP. When the SSB falls below the LRP, the stock is considered to be in the critical zone of DFO's precautionary approach framework.[7] According to DFO's management framework, when a stock is in the critical zone, fishing should be kept to the lowest possible levels in order to rebuild the stock. The goal of the rebuilding process is to get the SSB above the LRP and out of the critical zone, but the long-term management goal is to rebuild stocks to the healthy zone.

For this herring stock, DFO created different catch scenario models that predicted how rebuilding out of the critical zone could be accomplished within ten years, as per the department's rebuilding policy and legal obligation for stocks under the *Fisheries Act*. Our study evaluated four of these scenarios and compared them against a constant catch of 25,000 tonnes (t). The difference between these scenarios was assessed using a cost-benefit framework over a ten-year rebuilding period. This includes the trade-off with the commercial value that is lost to the industry when quotas are reduced.

7 Fisheries and Oceans Canada. (n.d.). Precautionary approach to fisheries. Retrieved from https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm

REBUILDING SCENARIOS

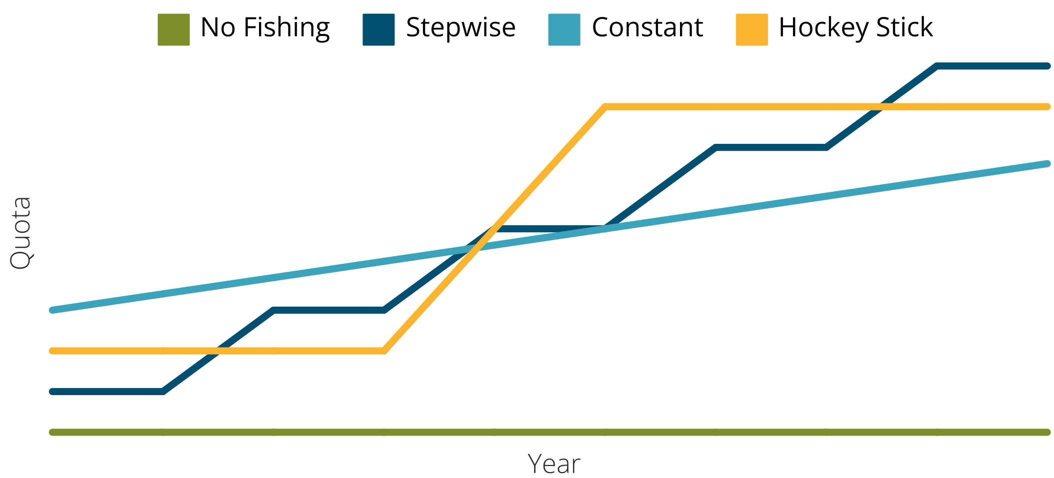


Figure 2. A general illustration of quota over time under the four different catch scenario models outlined below.

SCENARIO 1

NO FISHING

This assumes that no fish are being removed from the water by humans, meaning that there would be no commercial fishery or bycatch of herring from other fisheries. While unrealistic, it allows for comparison against other rebuilding scenarios. DFO modelling indicates this will build the SSB from the current 194,000 t to about **429,000 t** and out of the critical zone after 10 years.

SCENARIO 2

STEPWISE FISHING

The quota can increase in a stepwise fashion during the ten-year rebuilding period if the SSB increases. DFO modelling indicates this will build the SSB to about **319,000 t** and out of the critical zone after 10 years.

SCENARIO 3

CONSTANT CATCH

Assumes that the catch will remain at a constant harvest rate of 4.4%, which will rebuild the stock over the 10-year period. DFO modelling indicates this will build the SSB to about **316,000 t** and out of the critical zone after 10 years.

SCENARIO 4

HOCKEY STICK

Assumes that high quotas are allowed as the stock rebuilds and lower quotas are allowed when the stock is further into critical zone. DFO modelling indicates this will build the SSB to about **285,000 t** and out of the critical zone after 10 years.

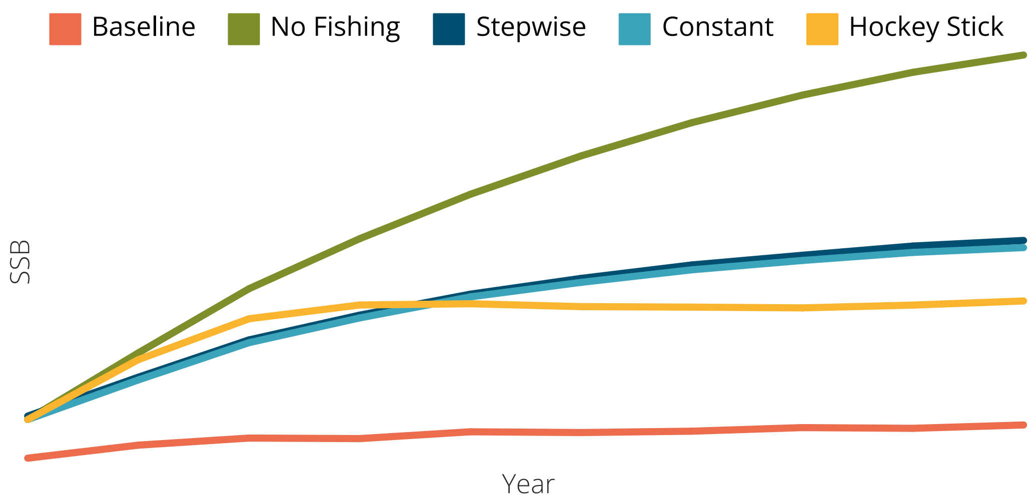


Figure 3. A general illustration of SSB changes over time under the four different catch scenario models.

These rebuilding scenarios were compared to:

Case Study Scenario: Baseline (25,000 t)

Assumes a baseline catch of 25,000 t. This scenario is not expected to rebuild the stock out of the critical zone in 10 years but is similar to recent harvest rates. DFO modelling indicates harvest at this level would not rebuild out of the critical zone and increase the SSB only slightly to 212,000 t after 10 years.

Prices

The price of landed herring in this analysis was set based on the average Nova Scotia price of herring in 2021 and then cost adjusted to represent 2022 values. In order to calculate the price of herring in the water, methodology from Konar et al. (2019) provided an aggregate value of forage fish globally and was used in this case study. Their analysis indicates that the commercial fisheries catch represents at most one-third (33%) of the total value of forage fish. Therefore, a value of 2/3 (66%) of the commercial catch value was assigned to the forage fish left in the water, in this case represented by the SSB value.

The balance of the total value is tied to the supporting role forage fish play as prey for other commercially important fish species, marine seabirds and mammals, and their contributions towards carbon storage and biodiversity. The value used in this case study is considered conservative, as ongoing research will support a better understanding of the full value of forage fish. And while the specific values for herring may differ somewhat from the global average, it provided a reasonable starting point for the analysis and a first look at the potential value of this key forage species in Atlantic Canada.

In Nova Scotia, the average price of herring in 2021 was $2.83/kg when adjusted to 2022 prices, making the total commercial catch worth around $92.4 million. When the SSB value is divided by the SSB weight, the unit value of forage fish left in the ocean is about $1.01 per kg (Table 1). Since the catch price represents 33% of the total value, the value of the herring left in the water was 66% of the total value and equated to $184.8 million.

This provides a unit price that can be applied to stock rebuilding scenarios with increasing SSB over time. A sensitivity analysis using a 20% higher value ($1.21 per kg) and 20% lower value ($0.81 per kg) was conducted since the exact percentage for herring is not known. The forage fish unit price will also change over time depending on a number of factors, including commercial catch price, catch volume relative to the SSB, and the unit prices of other commercially important fish species.

Table 1: Estimated forage fish value for Atlantic herring ($2022)

	Tonnes (000s)	**Value** $	**% of Total Value**	**2021 $/kg in 2022**
Herring left in the water (SSB)	182.7	$184,781,454	66%[3]	$1.01
Catch	32.6	$92,390,727	33%[3]	$2.83

RESULTS

The results of the cost-benefit analysis revealed that a rebuilt herring stock could be worth at least $402 million under any of the above rebuilding scenarios and at a discount rate of 5%.

Importantly, these scenarios **also result in more herring in the water and the potential for higher commercial catches**. The net benefits include those to the ecosystem and to harvesters and account for the short-term losses to harvesters due to reduced catches. Even in scenarios that reduce current fishing effort, **the value of leaving forage fish in the water to support rebuilding is higher than maintaining current fishing effort**.

When valuing forage fish at $1.01 per kg under the different scenarios, scenario 1 (no fishing) produced a net present value of **$460 million** after 10 years. Scenario 2 (stepwise increase in fishing) produced a net present value of **$450 million** and scenario 3 (constant catch) offered the lowest value, at **$402 million**. Scenario 4 (hockey stick) produced the highest value at **$492 milion**. It should be noted that better results were obtained at the 3% lower discount rate, which highlights the value of long-term herring stock recovery and intergenerational equity.

Increasing the unit value of herring by 20% also produced better results and likely better reflects the real value of forage fish in the ecosystem. The results remained positive when the value was decreased by 20%. Similarly, when rebuiliding was assessed over 15– and 20-year timeframes, the results provided higher positive results across all scenarios.

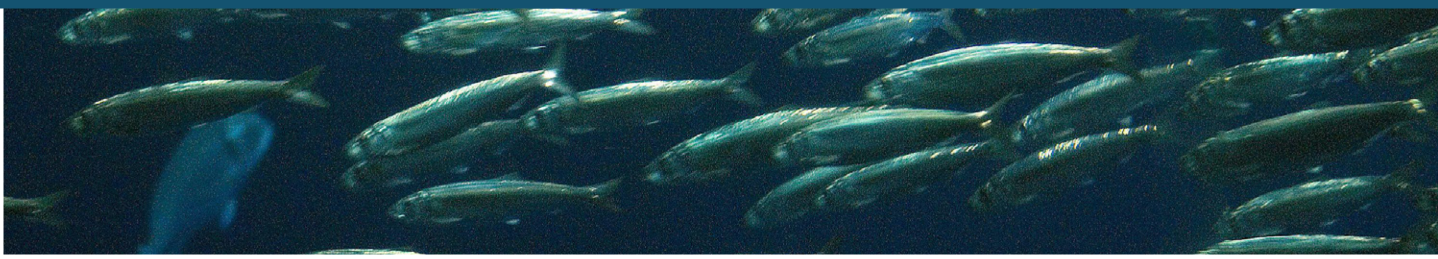
This analysis did not take into account the relative risk of different rebuilding scenarios. For each scenario, the DFO modelling provides probabilities (risks) of the stock not meeting the recovery targets and remaining in the critical zone. Greater risk is associated with higher fishing rates. If this analysis was conducted as a "risk-adjusted" valuation, the value of high-fishing scenarios would be reduced in proportion to the level of risk. This is another way of looking at rebuilding scenarios that considers the broader long-term socio-economic risks rather than just short-term loss due to reduced fishing.

WHAT IS A DISCOUNT RATE?

A discount rate is applied so future values are converted to present values. We place a higher value on money today than we do on money in the future. According to the Treasury Board Canadian Cost-Benefit Analysis Guide, discount rates may range from 3% to 7%, where lower values are preferred for assessments involving environmental, social, and intergenerational issues.

CONCLUSIONS

This case study provides an example of how the value of forage fish in and out of the water can be quantified. In making management decisions without considering this information, DFO is reducing the value of these fish at a loss of millions of dollars.



Our report concludes that when the value of forage fish is considered holistically, the strongest rebuilding strategies are in fact an investment that will result in higher commercial catches of herring, improved catches and stability for other commercial species that depend on herring, and other benefits to important marine species, as well as ecosystem goods and services.

This analysis demonstrates that the continued failure to rebuild depleted stocks is not just an environmental mistake—it's an economic one, too.

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RECOMMENDATIONS

To improve decision making in the future, we recommend that DFO calculate and consider the value of forage fish in the water and:

1. **Make decisions that favour fisheries rebuilding** and long-term economic benefits for industry and communities.

2. **Conduct cost-benefit analyses** to evaluate tradeoffs of short- versus long-term rebuilding and include the results in rebuilding plan.

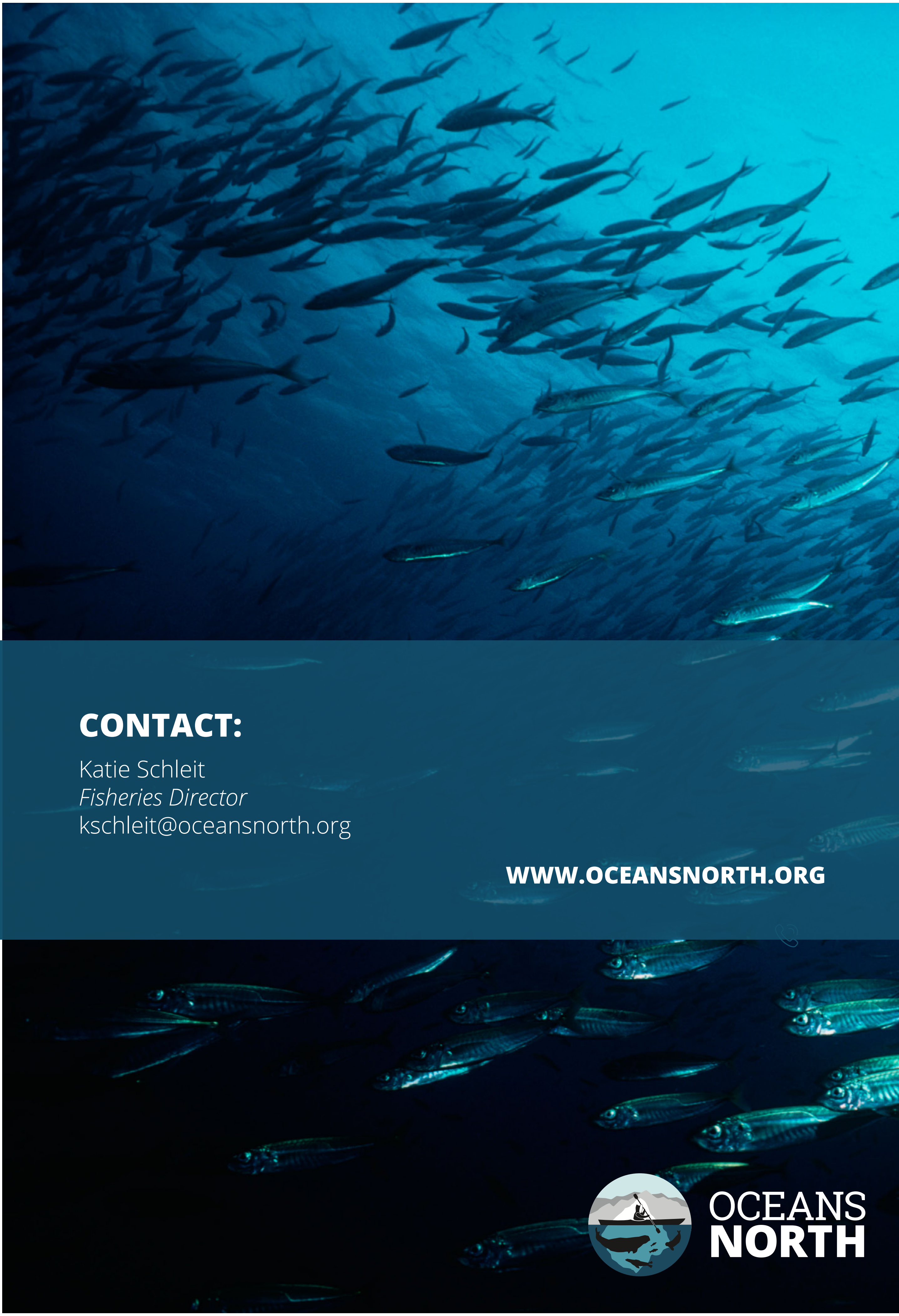
   These will help evaluate the full economic and ecological impacts of decisions, rather than focusing on the short-term risks of minimizing fishing.

3. **Develop bioeconomic ecosystem models** and include this information in stock assessments and IFMPs.

   These analytic tools can help integrate biophysical and economic models to better understand the interactions between fish populations and economic activities.

4. **Conduct economic scenario analyses** at fisheries advisory committees.

   These analyses can help stakeholders prepare for various potential futures by examining multiple economic situations or conditions.



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