Changing Course:

A New Direction for Canadian Fisheries

Barry Darby

St. John's, NL

September, 2019

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Executive Summary

Changing Course: A New Direction for Canadian Fisheries begins with a look at how the current system of output controls – quota-based management – has failed in recent decades, with ongoing devastating results for fish stocks and coastal economies. The paper points to success stories from both past and present, where basing management on input (the effort invested) rather than output (allowable catch quotas) has resulted in both economic benefits and long-term stock sustainability. It then proposes a major change in management direction, to reflect the lessons learned and offer solutions that will revitalize and rationalize this important sector.

The proposed effort-based management system is described in detail in the body of the paper, covering who can fish, how commercial harvesting should be conducted, and how management tools such as gear regulations, seasons and zones can be used to both maximize net economic returns and ensure stock sustainability. The multiple benefits of this change in course are detailed, the beneficiaries being the fish and the marine ecosystem; the harvesters, communities and nation; and the Department of Fisheries and Oceans itself as it works to fulfil its vital mandate.

The paper then recommends the specific actions that DFO has to undertake to bring about this change in a timely and effective manner. Above all, it must:

- ***ensure that the official mandate of DFO explicitly includes the goal of maximizing the net economic benefit of the fishery to fishing communities and the Canadian economy***,

and

- ***implement the transition from the current system of output controls (quota-based management) to the system of input controls outlined in this paper – effort-based management***.

Other recommendations include bycatch utilization, harvester training and certification, data and information technology, and community involvement. A list of related reading and three Appendices provide additional information.

The result of years of experience in and observation of the fishery, this paper presents a thoughtful analysis of the current situation in fishery management, and a radical and thoroughly practical proposal for positive change.

Part A – Introduction

A1 – The Challenge

The 1992 cod moratorium marked a momentous change date in the Newfoundland fishery. Many previously held beliefs with respect to harvest management were questioned or destroyed. The moratorium and subsequent failures should have taught us many lessons, but it is unclear whether we have learned those lessons or applied them correctly.

In response to this current and ongoing challenge, this paper was honed over several years of work in this area, drawing on well-tested principles and scientific evidence and analysis, some of which is listed in the References.

The following Mission Statement forms the basis for the paper:

> *The purpose of harvesting our ocean resources is to maximize the benefits to Canada's economy and society, particularly the net economic return to the coastal regions, while ensuring the sustainability of the ocean's ecosystem and all the stocks.*

Fulfilling this purpose demands a comprehensive approach that takes into account the economic, social and ecological aspects of a sustainable fishery. It can be envisioned as a 3-legged stool, which can function only if all three legs are strong and stable (see Appendix I). This paper focuses mainly on the economic leg of the fishery, particularly at the level of the harvester – an aspect that has long been seriously neglected in fishery policy.

Over the decades we have accepted a paradigm for how a fishery should be managed – through output controls, notably the application of quotas. But our attempts to make it work have never turned out as planned. The 200-mile limit was supposed to preserve our stocks; the cod moratorium was to end in a few years. New fish plants were established with government help; new and larger boats were built. But as detailed below, the results have been far from what was envisaged. Major anomalies in a paradigm are evidence of the need for a paradigm shift.

This paper suggests that we change our paradigm.

A2 – Background

As noted above, the large commercial fisheries of the NW Atlantic, with the single significant exception of lobster, are managed based on controlling output, principally by allocating quota to various persons or enterprises. This paper will use the term "quota-based management", QBM.

The federal Department of Fisheries and Oceans, DFO, began administering the Newfoundland portion of Canada's waters in the mid 50's. At that time the vast majority of the stocks were in good to excellent condition. Let's assess the results of that management over the ensuing years:

- The enormous northern cod stock was reduced to miniscule levels resulting in the 1992 moratorium.
- It is now 27 years since 1992, and the moratorium is still in place.
- The cod stock in fishing zone 3Ps remained sustainable through the 1990s; yet with all the lessons learned from the northern cod closure, that stock today is a pale shadow of its former self.
- A stock of 300 to 400 kilotonnes of cod has existed in fishing zones 2J3KL for the past 3-4 years. Yet our harvesting rates have been only in the 1-3 percent range, while other countries routinely harvest 20 to 30% from similar stocks.

- The 2018 stock report indicates that several hundred kilotonnes of biomass disappeared from 2J3KL in the past year; no explanation is offered.

Over the years, the Department has been made up of large numbers of highly trained, dedicated and conscientious individuals. The ministers that have led the department are individuals that have proven their skills in other areas before taking the position. How is it possible that such a work force would produce the results listed above?

The answer: the job that DFO is currently tasked with is impossible!

Why is it impossible to effectively, efficiently, and sustainably manage a fishery by basing it on quotas? Setting quotas requires numbers that realistically represent the actual biomass of a given stock. But the Northwest Atlantic is not a fish farm. We don't control the number of eggs laid, successfully fertilized and appropriately fed. We cannot control predation, disease, climate or migration. Moreover, there are inherent statistical errors in any survey sampling, which are especially significant in an ocean ecosystem where fish constantly move, grow, spawn and die. Consequently, we cannot, with any degree of accuracy, determine the total allowable catch, on which the quotas are based. This results in errors with grave implications for management of the stocks. (These and other flaws in the QBM paradigm are outlined in Appendix II.)

Given the multi-layered failures of current fishery policy, what are our options for meeting this critical challenge? There is, in fact, an existing alternative model that works: the lobster fishery – the exception to QBM mentioned above. I maintain that the principles practiced successfully for the past 90 years in our lobster fishery, can and should be applied to our other fisheries, notably to cod.

Part B – A Change in Course – From Quotas to Effort

B1. Effort-Based Management – Principles and Sustainability

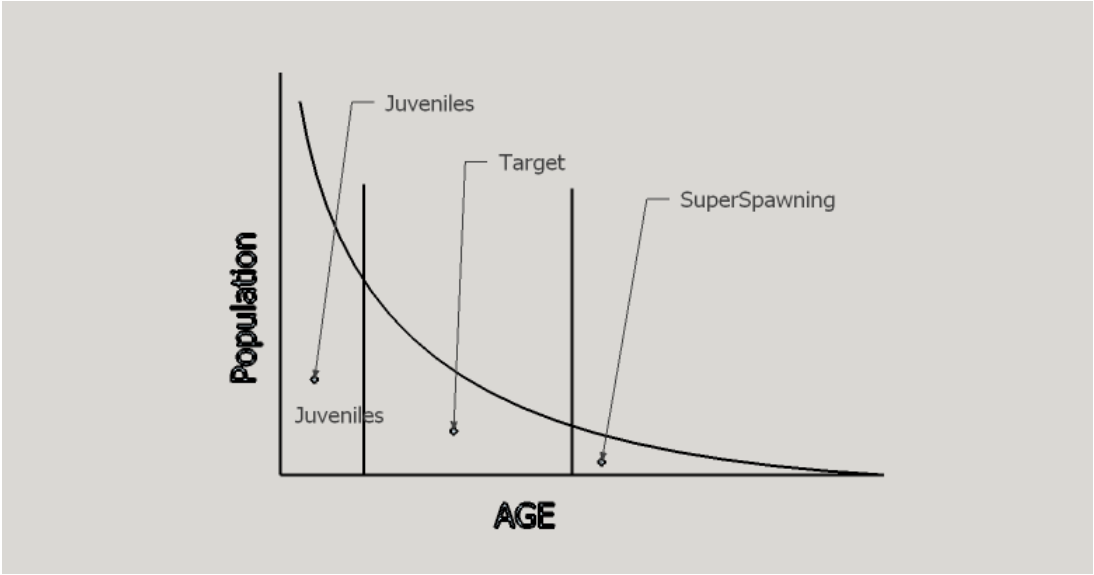
An alternate method of management is through input controls, known as effort-based management (EBM). Instead of trying to calculate the number of fish that could be harvested and assign quotas accordingly, the Department of Fisheries and Oceans (DFO) would define the effort that could be exerted on a stock so that it would remain sustainable. This would mean regulating the number of harvesters, design and type of gear, open and closed seasons, fishing zones, etc. (See details in B4 below.) Notably absent would be any reference to quota.

The principles underlying this alternative paradigm are straightforward:

- the ocean's ecosystem must be kept healthy – in particular, all fish stocks must be harvested at sustainable levels;
- harvesters have "use rights" to sustainably harvest the common resource of the ocean;
- the system must provide positive net economic returns to harvesters and communities;
- implementation and management must be as simple and effective as possible.

Since the sustainability of the fish stocks is the essential foundation for every fishery, how does EBM ensure that sustainability? The ecological basis for maintaining any stock is the protection of young juveniles and of what could be called the "*super* spawning stock biomass" (SSSB) – the relatively few older, larger fish whose prolific annual spawn becomes, in turn, the bulk of the biomass in the generations that follow.

As shown in the graph below relating age and numbers, the younger age classes comprise the largest population of fish – whose numbers decline, through predation and other factors, as the individual fish grow and increase the biomass. The oldest, largest fish – the super spawning stock biomass – are fewest in number, but their superior reproduction capacity provides the greatest source for the growth of the stock. In between are all the fish in the mid-range in terms of age and size; this is the "centre of the biomass", at which harvesting should be targeted if we wish to maximize returns and ensure sustainability.



When the catch comes from the centre of the biomass – a fundamental aspect of effort-based management – the youngest, smallest fish are protected and able to grow, and the super spawning stock biomass is able to continue to replenish the stock.

This principle is supported by recent research that asked: Why do we humans so often decimate our prey species while nature's other predators do not? A study by University of Victoria conservation

science professor Chris Darimont and his colleagues concluded that whereas most predators in nature target juveniles, human predators target mainly adult prey, killing a far greater proportion of the "reproductive capital" of the prey species. Indeed, humans can be considered "super-predators" whose unsustainable practices threaten the survival of the very prey we exploit. This is notably true in the case of fish. To reverse that destructive trend, regulation should aim to mimic the successful approach of natural predators, leaving the older adults to keep reproducing. That is exactly what effort-based management can do.

B2. EBM Success stories: a tale of two fisheries

Has effort-based management been shown to be successful in other situations? Here are two examples from our own waters.

The lobster fishery – Lobster management is the significant exception to the current quota-based management protocol. In the last half of the 1800s and into the first decades of the twentieth century, the lobster fishery was largely unregulated, resulting in a commercial stock collapse by 1924. The Newfoundland government of the day instituted a three-year moratorium, and when the lobster fishery reopened in 1927 it was under an effort-based management system. This resulted in a successful, profitable and sustainable fishery for over ninety years, to the present day.

The lobster management plan contains a number of key provisions:

1. Harvesters are allowed to catch lobsters during a defined season, which is kept relatively the same year over year. This enables harvesters and processers to plan their activities effectively, efficiently and profitably from one year to the next; it also gives the stock and the ecosystem a chance to adapt to this large removal of biomass.
2. The type of gear is specified, with rules regarding number of traps to be used, size of opening and escapement spaces to allow live release of the smallest young.
3. A size limit on the animals harvested means that undersized captured juveniles are returned unharmed to the ocean.
4. The spawning biomass is protected by requiring harvesters to return adult egg-bearing and V-notched animals to the ocean. Most of the harvest consists of lobster that have only that year grown enough to enter the “commercial biomass”. The annual fishing mortality is usually in the range of 80%-90% of that biomass, yet it doesn’t harm the sustainability of the stock.
5. There are no quotas. Harvesters are permitted to catch as much as they can within the constraints of the regulations. This results in more animals being taken when they are abundant and less taken in times of scarcity – an essential objective in fishery management.

The cod fishery – All the elements listed above were present in the cod fishery in the years prior to the 1950s. The constraints were set, not by fishery managers but by the environmental and technological conditions of the time.

1. Many fishing areas were closed during the winter season; bad weather brought further closures; and for religious reasons harvesting was curtailed on the Sabbath, a 14% reduction in effort.
2. There were mainly only two gear types used: cod trap and hook and line. Physical limitations usually limited a small trap crew to two traps, approximately one trap per three harvesters. With hook and line, the maximum number of hooks that could be used was in the 1000 to 1500 range per person per day.
3. Small juvenile fish escaped safely from cod traps by virtue of mesh size. Similarly, hook and line seldom caught very small fish due to bait and hook size.

4. Traps seldom caught much of the super-spawning biomass since those large fish seldom ventured into the shallow water where traps were set. With hook and line, the larger fish, except when they were plentiful, were often defeated in a race for a baited hook by the younger, more agile and hungrier members from the centre of the biomass.
5. There was no quota. Despite this the cod biomass in the early 1960s was higher than it had been for decades despite 450 years of fishing, not only by Newfoundlanders but also harvesters from many other countries, who were allowed within three nautical miles of the coast.

B3. Time and Place – It's Here and Now!

In considering the adoption of an effort-based management system to the Northwest Atlantic fishery, it is important to consider the particular place and time in which we now find ourselves. When we read about the history of the Newfoundland fishery we invariably encounter the concept of this island as a vessel moored on the fishing grounds. It is used to explain why and where we settled, and even why we are the people we have become. The permanent geographical reality of this place gives us, like Iceland, an enormous advantage over more distant states which, if they want fish to feed their populations, must build large and expensive vessels to prosecute a fishery on some distant sea. Although we have not always availed ourselves of this advantage, it is very real.

The other aspect we must consider is time: how different things are now from when the moratorium was imposed in 1992. There have been profound changes in the physical and climatic environment of the NW Atlantic affecting, perhaps permanently, the various stock and their interactions. Knowledge of stock biomass and multiple related factors has also altered greatly in the past quarter century, and many prominent fish scientists now advocate using an ecosystem approach to fish management, rather than trying to manage each stock as a separate entity.

Advances in technology now make it possible to seriously consider management regimes that could not even be dreamed of in the 1990s. Longline technology has advanced greatly, with automated baiting, setters and power haulers. Constant communication with boats at sea is now routine. GPS navigation, fish finders and vessel locators can be installed on even the smallest vessels at quite low cost. All fishing vessels can be equipped with relatively inexpensive radio beacons which will inform managers where every boat is fishing at any time. Applying these changes could transform fishery management and harvesting in very positive ways.

Perhaps the most significant and continuing change over the past few years is our new ability to collect vast amounts of data and then mine it to provide us with accurate and immediate information that will direct our future plans. Collecting catch data on species landed, numbers, their size, the location, etc, will give managers within DFO more accurate information, and, importantly, it will be collected in real time rather than relying mainly on stock assessments and other data from the past. Moreover, the rapidly evolving techniques of "big data" offer ways to analyze, systematically extract and apply information from data sets which – like many in fishery science – are too large or complex to be effectively utilized with conventional methods.

Today there is much greater awareness of the importance of delivering a high quality product to our markets, rather than continuing to ship out the bulk of it in block for much lower prices. It is also now known that in order to ensure top quality through the processing chain, the key is to handle the catch immediately after capture, with each fish bled, chilled, gutted, cleaned and iced within the first hour or so – something it is now possible to do.

The recent surge of aquaculture enterprises also has various implications for our wild fisheries, from changes in the market to environmental concerns.

Today's fisheries should take the key lessons from our past experience and combine them with current scientific knowledge and technologies to implement an effort-based management system that would benefit all involved.

B4. Key Elements of Effort-Based Management

What would a fishery management plan for the 2020s, based on effort, look like? A group of professional harvesters, identified and certified by DFO, would be entitled, by training and experience, to special "use rights" unique to the commercial fishery. Well in advance of a season opening, DFO would define the permitted gear types, seasons, and fishing zones, which, together with the harvester, constitute the main elements of the effort-based management system – the four main levers that would be used to regulate the fishery.

It must be noted that unlike most other economic enterprises, fish harvesting by its very nature does not grant the harvester control of the raw material or of the conditions under which it is accessed. Whatever decisions are needed at the macro level to create and maintain a viable fishery are thus not in the hands of harvesters themselves; policy is by default the responsibility of DFO. It is up to the Department to ensure that harvesters can rely on a viable and sustainable fishery to make a living, support their families and communities, and contribute to the economy and society. Effort-based management is the framework that will enable DFO to carry out this responsibility in partnership with harvesters and the other participants in the sector.

a) Who Can Fish? – The Harvester

A key factor in the implementation of EBM is the identification of the individuals who are entitled to prosecute the fishery. However, the government currently provides no clear answers to the questions: Who is a harvester? How does one become a harvester? What rights does a harvester have? For purposes of effort-based fisheries management, a harvester is a professional who participates in the fishery to make a living, not simply a citizen who sometimes goes fishing.

To enable good management, the professional fish harvester should be identified in a similar way as we identify many other occupations. Numerous examples currently exist within our society in which professional qualifications are based on training and work experience requirements. Registered Nurses and other health professionals have to complete an initial course of training before even entering the work site, and only after a period of internship and successfully passing exams can they enter the work force itself in their specific field. Similarly, the Red Seal Journeyperson process allows citizens to become electricians, plumbers and other certified tradespersons by successfully completing a pre-employment course and a number of years of regulated on-the-job training, concluding with a comprehensive at-arms-length national final exam.

However, there is no such entry system for fish harvesters. A person leaving school today cannot go to their guidance counselor and receive clear information as to how they can become a harvester. This has a number of serious implications for the fishery: it has resulted in too few new entrants into the harvesting sector, and the average age of harvesters continues to increase annually, with devastating consequences for the future. Moreover, the workforce now includes a large number of part-time and under-trained or uncertified individuals, resulting in lower productivity.

Clearly, in transitioning to a new system, many existing harvesters will be automatically grandfathered into professional status, mainly based on age and experience. Current certification would also be recognized.

The federal Advisory Council on Economic Growth notes that due to automation and other factors, “Canadian workers face a rapidly changing economy which will have a profound impact on the nature of work and jobs of the future. To be equipped for this change, there is a critical need for Canada to

rethink our approach to learning, work, and training." Such a rethinking will also give DFO the ability to answer the questions posed at the beginning of this section.

In regard to training, the Department would work with provincial governments to develop training protocols similar to the Red Seal program. In Newfoundland and Labrador, considerable work has already been done by the provincial Professional Fish Harvesters Certification Board and Memorial University's Marine Institute with respect to course content and guidelines for certifications. However, the system currently lacks some key elements necessary to achieving a well trained and certified workforce. Most importantly, it does not provide a pre-employment or entry-level program, which would provide a clear path for citizens wishing to enter this occupation; at the same time it would establish an effective barrier to untrained and part-time individuals. Secondly, the PFHCB operates under provincial jurisdiction, while the assigning of harvesting rights is clearly in the federal sphere.

For the harvesting sector to function effectively as part of a sustainable system, the only individuals permitted to participate in the commercial fishery would be professional fish harvesters. A crucial corollary to this is that every professional harvester would have the explicit right to fish commercially. Ensuring these special rights for professionals is consistent with best practices and with the concept of "use rights" as identified by the UN's Food and Agriculture Organization in *A Fishery Manager's Guidebook*. (Regarding the rights of other Canadians to fish, see Appendix III, The Non-Commercial Fishery.)

b) How Can We Fish? – Gear and Vessel

When managing a stock by effort rather that quota, the type of gear used becomes especially significant. We need to come to grips with the fact that modern technology, combined with the almost unlimited power of today's gear and vessels, enables us, if allowed, to harvest a damaging portion of a stock in a single season, even potentially to destroy it. Effort-based management can ensure that does not happen.

Different gear types and fishing methods will affect a fish stock in different ways, some of which are easy to understand. However, it is difficult to define in quantitative terms the potential effects of a particular type of gear on the stock and the ecosystem – the degree of potential harm from using it, the level of risk of incurring that harm, and the rate at which the harm would occur over time. Although generally those factors are not measurable, it is possible to rank various gear types with respect to the risks their use involves, and have that information guide us in managing this aspect of fishing effort.

First, though, a crucially important paradox: *inefficiency can ensure next year's harvest!* Certain limits on the efficiency of the gear we use can be vital to sustainability. For example, harvesting mackerel with hook and line would be less risky to the stock than using purse seines, and would require less monitoring and supervision; hooks lose their ability to fish as soon as the bait is removed; and cod traps, by their nature, are set in shallow water and therefore catch relatively few large fish (the super spawning stock biomass). These "slow fishing" methods also permit the release of live bycatch and allow for quality-enhancing handling.

We need to ensure positive inefficiencies in our fishing gear so that sufficient stock remains for subsequent years. Where natural inefficiency is absent, we can incorporate it through design and regulation. Setting mesh size in any net allows juveniles to escape; allowing only beach seines for caplin would foster the sustainability of the stock; grates at the opening of otter trawls can have a similar effect; so can closed seasons and closed areas. Such intentional "inefficiencies" have the potential to ensure greater productivity and efficiency in the overall multiyear harvest.

With that in mind, let's examine the various attributes of specific gear types, and consider which ones best contribute towards the goals of maximizing net economic return while ensuring sustainability.

Gear types for groundfish can be roughly ranked for sustainability in the following order. Hand-lining, with its relatively few hooks and limited area, is the least risky, and requires almost zero monitoring

and enforcement; moreover, based on the 450-year history of its use, it does not pose a danger to the sustainability of the stock. Cod traps, with their short season, shallow water, and the fact that their access is naturally limited to much less than 1% of cod's living zone, also pose little risk and require little or no monitoring. Longlining and cod pots, with their greater range and their ability to "go after the fish", require slightly more in the way of rules – seasons, number of hooks, etc. But again, the overall impact of these types of gear is low, and their use could be easily monitored.

Other gear types pose a much bigger risk. The nylon gillnet has the ability to catch large portions of any aggregation that occurs, including the super spawning stock biomass; indeed, the historical record shows gillnets to be a significant danger to sustainability over the long term. Gillnets are also short-lived, and thus costly, and when lost or discarded they add significantly to the problem of plastics in the ocean. They are only slightly less risky than otter trawls and purse seines, because they are not mobile. Otter trawls and purse seines, however, have that mobility, and thus have the capacity to catch the last fish in the ocean before managers would be aware of the fact. Clearly, these last two gear types pose the greatest risk to long-term sustainability.

When applying effort-based management to harvesting, we should start by favouring the least dangerous gear types. For example, groundfish regulations might include allowing all harvesters to handline six days a week all year round; or entitling any five (5) harvesters to operate one cod trap; or permitting each harvester to use a fixed number of hooks per day for a given season.

If conditions warranted, other gear could be allowed on a more restricted and closely regulated basis. For some species, those more dangerous gear types might be the only practical way to harvest a stock: for example, mid water trawling for redfish, or Danish seines for various flatfish.

Some gear types are incompatible with each other: i.e. they cannot be used in the same area at the same time. Longlines, hand lines and cod traps can coexist, but long lines and gill nets cannot. Cod pots would have to have an area separate from any hooked gear, and use of otter trawls would exclude the use of any other type of gear in that area of operation.

Closely related to the harvester's choice of gear is the type of vessel used. Under the current quota-based management system, the fishing vessel is given great importance in the allocation of the resource. Different length vessels have different quotas based on their size. The amount of gear each can use is size dependent, and there are fleet allocations based on vessel size and power. This has led to complexities as vessel owners and builders attempt to meet all the requirements while also maximizing their operating profit and return on their investment. In turn, this may result in overcapitalization and, more importantly, may compromise safety.

We should be building boats to catch fish, not catching fish to pay for building boats. Under EBM, harvesters' "use rights" would allow them, as skilled professionals, to decide what type of vessel they wish to own. They would have the right to choose a boat of a size and design appropriate to their particular situation, according to their assets, abilities and desires. Regulations for vessels would be minimal with respect to harvesting rights; the link between vessel size and harvest allocation would be gone. Safety aspects would of course be subject to Department of Transport rules that apply to all vessels. Specific regulatory requirements for fishing vessels would relate primarily to quality handling capacity, and electronic devices for safety and monitoring purposes. Larger vessels could be equipped with more sophisticated devices measuring, speed, number of tows, etc, effectively establishing an electronic observer on board each ship. Combined with rules requiring that all by-catch be landed and sold, this would make monitoring and enforcement less costly and more effective.

In recent years, we have often opted to invest in large, capital intensive, and ultimately inefficient freezer trawlers like those of other countries. Foreign fleets use such vessels because of their distance from our fishing grounds; however, many countries continue to use smaller boats in their own coastal fisheries. We too should consider keeping our boats small and structuring our harvesting rules to encourage their use.

c) When and Where Can We Fish? – Seasons and Zones

In effort-based management, setting harvesting seasons and defining fishing zones are the two other key elements that enable managers to determine the effort that will be exerted on a stock. Used together and in combination with the elements detailed above, seasons and zones can provide an accurate and responsive basis for management that will lead to both stock sustainability and maximum net economic returns.

The new tools in communication, positioning, monitoring and underwater scanning provide the capacity to establish a more comprehensive and flexible system that can respond promptly to real-time input by adjusting zones and seasons. For example, knowing where every boat is fishing at all times, fishery managers could establish relatively small exclusive fishing zones for smaller boats using either hand lines, long lines or gill nets. Specific gear limits per person per day could be set for a given zone and season. Zones and/or seasons could be sub-divided so that long lines and gillnets could coexist, something that is not possible today.

If real-time data collection detected excessive bycatch in a particular zone, managers could solve the problem by temporarily closing all or part of the zone, changing its boundaries, changing the depth of the water to be fished, discontinuing the use of certain gear or adjusting its design. Seasons for certain species might be set to run concurrently, and rare incidental catches might be allowed.

More carefully defined seasons and zones will enable managers to better deal with spawning aggregations and other times when fish school densely. Given the lessons we must have learned from our past mistakes, it seems to me axiomatic that all harvesting should be forbidden at that time and in those places where fish are spawning. The intensive harvesting on the Hamilton Inlet Bank in the 1970s was a major contributing factor to the demise of our cod fishery – history we must make sure not to repeat.

We have our own success story from the 1800s when the harvesters of Petty Harbour established an exclusive hand-line-only zone. Today as well, community initiatives in regard to local zones and seasons could provide valuable experience and models for effective effort-based management at the level of actual practice.

B5. Benefits and Advantages of Changing Course

A huge range of benefits and advantages can be foreseen if we change course in our management of the fishery. Moving to effort-based management will strengthen all three legs of the sustainability stool (see Appendix I), providing Canada with a healthy marine environment and positive economic and social results for all involved. These benefits will be further enhanced if EBM is combined with other community-supported initiatives to reduce waste, enhance safety and encourage innovation. Simultaneously, DFO's mandate will become increasingly manageable and successful.

The advantages of such a significant shift in fishery management are multiple and intertwined. When fish stocks and the marine environment are healthy and dependable from year to year, the rewards accrue to everyone connected with the fishery and beyond. When harvesters benefit, so do processors, coastal communities and the economy as a whole.

Of course no system is perfect, but some are much better than others. The many advantages of effort-based management are summarized below, roughly grouped into three areas: environmental, economic and social, and administrative.

a) Environmental: Benefits to the Fish and the Marine Ecosystem

Abundance and scarcity are relative, not absolute concepts. At any given time, the sea has as much of a species as it can hold under the prevailing conditions of climate, food availability and predation.

As human predators, we need to be aware of our role in maintaining the best conditions for sustainability – for our own sake as well as that of the fish.

Effort-based management enables us to mimic the sustainable behaviour of natural predators. As noted by Chris Darimont and quoted in Section B1 above, non-human predators target mainly juvenile prey, allowing the adult "reproductive capital" to breed and ensure species survival. By appropriate use of low-capital, intentionally "inefficient" gear, seasons and fishing zones, managers can encourage harvesting the fish at the centre of the biomass. This "hollowing out the middle" preserves the juveniles that will provide for next years' catches; equally importantly, it allows the very prolific larger fish, the super spawning stock biomass, to remain in the ocean.

As a result, when fish are plentiful, that central harvestable biomass is large, and more can be caught without harming the stock; correspondingly, if the stock declines, the regulated limits on effort will limit the harvest, enabling the stock's recovery. In other words, whereas quota-based management encourages extra effort when stocks decline, EBM automatically leads to increased harvests when the biomass increases, and decreased catches when it decreases, helping to ensure the stock's sustainability. In implementing this system, fishery managers using modern methods of data capture and analysis can have a dependable real-time picture of the state of the resource – where fish were caught, their size and age, catch rates, bycatch, etc. This enables the design of timely, realistic and sustainable effort-based management plans that will prevent the kind of past mistakes that have too often resulted in ecological disaster.

EBM will also result in less harm to bycatch species. Under quota-based management, many fish of untargeted species are tangled in gillnets or caught in otter trawls. Current regulations require that these fish and marine mammals, usually dead when caught, be thrown back, despite the obvious fact that the damage has already occurred. With the gear types favoured under EBM, this problem would be minimized; for example, skate caught by handlining can simply be flicked off, still alive; a large mesh at the surface of a cod trap allows salmon or porpoise to escape.

The carbon footprint of the fishery will be reduced with the implementation of effort-based management, which will lead naturally to a shift from power-hungry industrial-type harvesting methods such as otter trawls and purse seines toward hook and line, traps and fish pots. These latter methods generally employ much smaller boats which require less power and less fuel per kilogram of catch, resulting in a decrease in fossil fuel consumption and greenhouse gas emissions.

Ocean plastic is widely recognized as a serious problem, and fishing gear accounts for a significant portion of it. Gill nets in particular are short-lived, sometimes lasting only one season; when lost, abandoned or discarded, they add to this pollution and can even go on fishing as "ghost nets". As otter trawls are abraded with use, millions of tiny bits of plastic enter the marine food chain. EBM will foster the use of long lines and cod traps, which last for years, even decades, thus reducing these forms of ocean pollution.

b) Economic and Social: Benefits to Harvesters, Processors, Communities and Nation

Every harvester knows that there are three main ways to increase their income: catch more fish, get a higher price for the fish they do catch, and reduce their expenses.

More fish: With EBM, harvesters can "fish less and catch more." As explained above, EBM harvesting methods hollow out the middle of the biomass, leaving the super spawning stock biomass to continue reproducing. This allows a higher percentage of the biomass to be caught – in some cases as high as 25 or 30% – whereas with other methods such as gillnets the sustainable catch may be only 10 or 15%. Moreover, when fish are plentiful, harvesters can catch more, without endangering the stock or running up against quota limits often based on inadequate assumptions. And when there is a decrease in the biomass, the lower catches leave more of the stock to reproduce for future harvests.

Higher price: With EBM methods such as hook and line, the speed at which fish are retrieved is slower but continuous. This "slow fishing" enables the harvester to handle each fish individually, bleeding, gutting and icing it within an hour or so of capture – timing that is key to ensuring a top quality product. The story of Fogo Island Fish Inc. demonstrates the success of this approach. With appropriate regulations and defined limits on mesh size, separation distance, etc, the codtrap can produce similar results. This initial step in the quality chain will not only produce a higher price to the harvester upon landing, but better returns all along the chain of production and a superior product for the end consumer.

Reducing expenses: Less expense means more profit. Under EBM, each harvester will have the right to determine the amount and type of effort they will invest, within the rules governing each element of effort. This will often mean lower capital investment in gear and vessel, and lower fuel and operating costs. It will also relieve harvesters of trying to meet cumbersome and sometimes counter-productive vessel requirements that will not be needed under EBM.

Harvest efficiency measures the value of the catch that is left after expenses are paid, expressing that value as a proportion of the total value of the catch. If you catch $1000-worth of fish and spend $200 to do so, your harvesting efficiency is 80%. By taking advantage of Newfoundland as "a vessel anchored on the fishing ground," and using the effort-based management tools of open seasons, gear types, and fishing zones to sustainably maximize both quantity and quality, harvesters can achieve efficiencies of 80%-90%, as they did 100 years ago. This improved efficiency means they get higher net returns from the same fish, and when harvesters collectively make more income, their communities and the economy as a whole benefit as well.

Operating under effort-based management, our lobster fishery harvests 80% to 90% of the stock each year. For cod, Iceland and Norway routinely harvest 20-30% of biomass annually. In contrast, under our quota-based management system, DFO's 2018 stock assessment indicates that we took only 2.5% of our stock. Imagine the economic improvement to Canada and to rural Newfoundland and Labrador if EBM enabled us to increase our catch ten-fold.

By giving harvesters the right to use proven sustainable methods of the past as well as the latest and best in modern technology, effort-based management can substantially reduce the unit cost of removing fish from the ocean, and lead to a higher quality product commanding a better price in the marketplace. This makes for a truly win-win situation for harvesters, processors, the community and the country.

Bycatch currently poses a significant problem for harvesters, who are constantly faced with having to throw back into the ocean high quality protein that represents a portion of their income. That practice is waste, pure and simple; besides the harm it does to the non-target stocks, it lessens the net return to the harvester and the economy. (In one recent trip in 3Ps, an official observer on a Canadian vessel documented the discharge of $70,000 worth of halibut – mostly dead – back into the ocean, in order to comply with the rules.) EBM, combined with rule changes requiring that bycatch be landed, would reduce the amount of bycatch overall, and allow harvesters and processors to make good use of what remained.

With quotas eliminated, EBM will introduce an element of regulated competition into harvesting. The fact that some harvesters, through skill, hard work and an element of luck, will be more successful than others, will be accepted by most, whereas such inequality in the allocation of quotas would be seen as unfair. Equitable competition can encourage best practices, spawn innovation, enhance efficiency and foster a more skilled workforce – all necessary ingredients as we move into the world of the 2020s.

As more and more harvesters realize that they can improve their income by "fishing less and catching more", there should, over time, be a reduction in the over-capitalization of the fleet currently encouraged under quota-based management. The implementation of EBM will lead to a shift from heavily capitalized and industrialized harvesting methods such as otter trawls and purse seines toward greater use of lower-capital gear and vessels.

Opportunities for more jobs in both harvesting and processing will emerge when effort-based management results in a higher percentage of the biomass being sustainably harvested.

Another advantage for processors will be improved predictability, enabling them to better plan their production schedules, based on early notification of seasons, numbers of harvesters and permitted gear. For example, knowing well in advance how many harvesters will be fishing a stock with a particular gear type as of a particular date, and referring to records from previous years, a plant manager can have a good idea of how much product will be available for processing once the season opens. This provides a more realistic basis for planning than the current quota system, and allows them to arrange for staffing, shipping, etc. and prepare their plants accordingly. Similarly, harvesters will have the accurate and timely information they need to plan and prepare their boats and gear.

The effort-based management approach to the fishery will empower coastal communities, helping to reverse the long downward trend that has seen rural areas depressed and depopulated, especially in the years since the cod moratorium. As harvesters and their families gain confidence in their use rights and are able to apply their own experience to both maximize their income and ensure next year's harvest, their communities will likewise regain hope and energy for building a sustainable shared future.

Evidence from areas of the world where fish management has been somewhat successful indicates the importance of local community involvement and input. The knowledge, skills and commitment of coastal people represent a tremendous resource that can be tapped to make our fishery better. Empowering them to take charge and strengthen their local communities will provide benefits on every level.

c) Administrative: Benefits to the Department of Fisheries and Oceans

The change of course from the current quota system to effort-based management will transform the mandate of the Department of Fisheries and Oceans from one that is practically impossible to one that is both workable and cost-efficient.

Management planning will no longer need to be based, as it is in the quota system, on the inherently unreliable estimates of stock biomass, recruitment and mortality and the resulting predictions for total allowable catch. Instead, it will rely on the on the fact that, as explained in the previous sections, managing effort incorporates an automatic responsiveness to the real and ever-evolving situation of the fish in the ocean. With EBM in place, and taking advantage of the advances in "big data" technology noted in B3 above, DFO scientists and managers will be able to base their planning, monitoring, regulatory and enforcement activities on accurate real-time information that is directly relevant to their management mandate.

Regulating effort under EBM will involve less in the way of rules and regulations than the current complex and sometimes conflict-ridden quota system. DFO managers will be able to set harvesting rules well in advance of when the actual fishing takes place, and to communicate the information in a timely manner to all involved. Decisions about vessel and gear type can be made by each harvester within the applicable rules, enhancing compliance and facilitating good relations.

In fact, EBM has the potential to dramatically improve the relationship between DFO and the people of the coastal communities they work with. Instead of DFO's role being perceived as dictating the allocation of scarce resources and imposing restrictions, it will come to be seen as more that of collaborating in the fishing enterprise for the benefit of all. The emphasis will shift from imposition to communication, from enforcement to best practices. The increased sense of ownership and buy-in by harvesters and local communities will naturally help achieve a high degree of compliance, reducing enforcement costs and increasing the Department's effectiveness in carrying out its mandate.

Part C – Charting the New Course – Recommendations

The management of the fishery in Canada's waters is solely and completely under the jurisdiction of the Department of Fisheries and Oceans. Therefore it is only through DFO that any change can be made in the activities of harvesters in the Northwest Atlantic. Implementing the change of course proposed in this paper will require specific legislative and regulatory actions by the Minister and the Government of Canada.

a) Two essential actions

1. First of all, ***the mandate of DFO must explicitly emphasize the goal of maximizing the net economic benefit of the fishery to fishing communities and the Canadian economy***. Ideally, this goal should be included in the Fisheries Act itself, but in any case the Minister must ensure that it is prioritized. The sustainability stool needs all three legs to stand: environmental sustainability can and must be understood in a holistic context which includes the economic and the social. Since only DFO has the managerial authority to implement the necessary measures, the Minister must directly assign to the Department the responsibility for managing the fishery so as to ensure maximum net economic returns as well as preserving healthy fish stocks and marine ecosystems. This will lead to a future fishery with more and better-paid employment, stable communities and increased tax revenues, based on the constant renewal of the ocean's resources.

2. Secondly, and equally essential, ***DFO must be directed to implement the transition from the current system of output controls (quota-based management) to the system of input controls outlined in this paper – effort-based management***. As detailed in the preceding sections, EBM implementation will involve harvester certification; rules specifying what gear is to be used; setting seasons and zones; and mandating certain vessel requirements for quality processes, efficiency, and safety. These elements will work naturally to ensure sustainability and economic returns, eliminating the need for quotas, which have proven to be flawed as a basis for management. This EBM approach should apply to all stocks, but for a few particular species such as redfish, where the only practicable harvesting methods still entail a significant risk to the stock, there could be a need for some flexibility to set catch limits as well as regulating gear, seasons and zones.

The above two actions are the essential ones if we are to apply the lessons of the past and move into the 2020s with a renewed and viable fishery. Unless DFO takes these two crucial steps, the flawed management system that has overseen the failures of the past half century will simply continue to foster the same problematic results.

b) Additional Measures

Training and certification: The Federal Government should immediately enter discussions with provincial governments, harvester groups, training institutions, and existing certifying bodies to develop a training and certification program for professional harvesters modeled on, or part of, the Red Seal Program, "Canada's standard of excellence for the skilled trades."

Bycatch: In keeping with maximizing net economic return and achieving sustainability, the rules for by-catch need serious overhaul. The current default appears to be: "All by-catch is forbidden except where specifically permitted." DFO should change this to: "All by-catch is permitted except where specifically forbidden", and require that by-catch be landed in any case, not discarded into the sea. This will give DFO much better management tools. Because the gear allowed under EBM has a low impact on the stocks, managers will have time, when issues arise, to access the data and react, as outlined in B4c), Seasons and Zones. When by-catch is landed, the data recorded will contribute importantly to stock assessments of some lesser utilized species like skate, wolffish, plaice, etc., assessments that are currently rare and of questionable accuracy. As well, less monitoring and

enforcement will be required, "illegal" landing will be meaningless, and the expense of onboard observers will be reduced.

"Big Data", data collection and information technology: DFO must work with harvesters, processors and information technology experts to build and maintain an up-to-date data collection and analysis system for the fishery as whole, to serve as a key basis for implementation of the management approach outlined in this paper. The rapid expansion of such technologies is already evident in our regular lives, with artificial intelligence, algorithms, machine learning and block chain technology as buzzwords of the future. We must assess the applicability of such technologies to the fishery and ensure that our sector not be left behind.

Other aspects: DFO should work with the provinces to achieve a clear and transparent separation between the harvesting and processing aspects of the fishery. This is vital if the maximum net economic return from harvesting is to be achieved. Iceland and Norway handle this in different ways, either of which is superior to our current practices.

We can also draw on experiences from other countries and our own to explore ways to involve harvesters and their communities in developing local plans and initiatives for their fisheries, building a sense of pride and ownership and strengthening all three legs of the sustainability stool.

Part D - Conclusion

The history of fish management in the Northwest Atlantic has not been exemplary. Few countries come to Canada to learn from our successes. This paper dares to suggest a different style of fishery management that could be a model for others.

We need to change from a system of output controls, quota based management, to input controls, effort based management. The concept is simple to state, but the realities of implementation are more complex. The following two recommendations to the Minister of Fisheries and Oceans are crucial if we are to change course to a more economically and environmentally sustainable fishery:

- ***ensure that the official mandate of DFO explicitly includes the goal of maximizing the net economic benefit of the fishery to fishing communities and the Canadian economy***,

and

- ***implement the transition from the current system of quota-based management to an effort-based management system***.

While this paper reaches into our fishery's rich past for best practices and lessons learned, it is actually very forward looking. These days, automation, advances in gear design, and electronic tools for communications, data capture and analysis, all offer opportunities for improved harvesting and management that our forefathers could never have imagined. We also face new and daunting challenges – species decline, climate change, ocean pollution, and intensified global competition for resources. The time for change is now.

Combining the old with the new in an integrated effort-based management system will enhance our management capabilities and the results we can achieve. Our focus should be on learning from our past mistakes, and taking full advantage of current knowledge and technologies to ensure true sustainability in economic, environmental and social terms.

The goal of fishery management must be to ensure that our marine ecosystems and fish stocks remain healthy for future generations, while providing economic benefits to Canadians and coastal communities. A timely change in course to implement effort-based management will enable us to achieve this goal.

This change requires above all two specific actions by the Minister of Fisheries and Oceans. First, as noted above, the economic goal of maximizing net returns to Canada's coastal economies must be explicitly incorporated into DFO's mandate. Secondly, the Department must be directed to take the steps required to make the transition to effort-based fishery management, as outlined in this paper – an innovative and completely achievable solution to the economic and ecological sustainability problems that have plagued the Atlantic fishery for decades.

At its core this is about economics and society. We went to sea originally to make a living and build communities. We need to keep that ideal top of mind as we develop the policies of ocean harvesting. Changing course as proposed in this paper will dramatically increase the net economic return to Canada's coastal communities, a necessary requirement for a strong stable society. Yet it can only be accomplished in the context of the sustainability of our fish stocks and the ocean ecosystems that support them.

The fishery management plans that we develop now are for the 2020s, and their results will extend far beyond. Let's always keep that in mind as we work to establish a management system for this renewable resource that will ensure its viability over the long term.

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About the Author

Barry Darby grew up on Great Burin Island and in Collins Cove, Burin, on the south coast of Newfoundland. A sixth-generation fisherman, he fished commercially for seven seasons while obtaining a B.Sc and a BA (Ed) from Memorial University. Through the 1970s and '80s he taught math and physics at the College of the North Atlantic, and then became Fisheries Adjustment Coordinator at the St. John's Campus when that Program was established in response to the collapse of the cod fishery.

His longstanding interest in public policy has led to his involvement at the provincial and community levels. He has worked on a range of issues, with a particular focus on the economics and sustainability of the fish harvesting sector. He was active in the labour movement over several decades in a variety of capacities. He has been a director of the Capital Coast Development Alliance (the regional economic development board for the northeast Avalon) as well as of the Public Service Credit Union, and ran as a candidate for the House of Assembly in 1999. Since 2015 he has served on the board of the Wooden Boat Museum of Newfoundland and Labrador, and is an active volunteer at The Rooms. He lives in St. John's.

Appendices

Appendix I – The Three-Legged Sustainability Stool

Sustainability can be defined as ensuring a future where human and other forms of life on earth can thrive. This in turn means meeting the real needs of the present without compromising the ability of future generations to meet their own real needs.

Though the term often refers specifically to environmental considerations, the concept also embraces the economic and social aspects that are vital to human societies. It can be depicted symbolically as a three-legged stool, with the economic, social and environmental legs in balance, keeping the stool strong and stable over time.

In the fishery, this concept can be a touchstone to guide us in decision-making at every level. The stool's environmental "leg" involves ensuring the health and long-term survival not only of the fish stocks we harvest but of the entire complex and inter-twined marine ecosystem they inhabit. The economic leg represents the many ways the ocean's resources generate prosperity and enable people to make a living by harvesting and using those resources. The social leg refers to the coastal communities, the region and the nation – the web of human culture and interaction that the fishery supports and is supported by.

The three legs reinforce each other, and all three are essential to the sustainable fishery stool. If fishery policies neglect the economic leg, the stool becomes unstable, with too few people willing or able to do the work needed to provide the benefits the ocean can offer. Similarly, without the social leg, communities fall into decline and the necessary support systems wither. And obviously, without a healthy marine environment ensuring constant replenishment of the fish stocks we rely on, there is no fishery at all.

From the fishing boat to the fish plant to the desks of the policy-makers, fishery policy and practice must be based on a full understanding of the importance and inter-dependency of the economic, social and environmental legs of the sustainability stool.

Appendix II – Flaws in Quota-Based Fishery Management

In another article I suggested a process to restart the commercial cod fishery. It was based on the "lobster model", an effort-based management system that has been successful for over ninety years. For most other fisheries, DFO uses quota-based management, which has a number of inherent flaws.

1. Quota-based management plans are based on certain assumptions which are subject to numerous potential errors. Setting quotas requires substantial, accurate knowledge of the stock to be harvested before setting the appropriate level of harvest. How large is the stock? What is the level of recruitment? What is the age distribution, etc?

History has shown that our ability to delineate those values in the past has been dismal. We overestimated the amount we could catch in the 1960's, 1970's and 1980's and since 1992 we likely have been underestimating the level of harvesting in some species. This is due in part to flawed assumptions made in calculating quotas and systemic errors that normally arise in making catch estimates.

Some doubtful assumptions are as follows:

a) We assume we know the size of the stock. This is difficult to determine accurately since it is done by survey sampling which has its own built in statistical errors.

b) We assume we know the correct percentage to catch (the optimal TAC). In lobster harvesting we catch over 50% of the available marketable animals annually using effort-based management. No such standard is available for quota-based management.

c) We assume that the "right" fish are caught. Effort-based management of lobster "Hollows out the middle" of a stock, releasing juvenile animals and spawning females. Quota-based management generally does not address this critical factor.

d) We assume that we should get back to historical levels before commencing commercial activity.

e) We assume that the quota available in 2015 is valid even though it is based on data collected the previous year or earlier.

2. Quota-based management encourages harvesters to exert even more effort when a stock is in decline. It should be axiomatic that when a stock biomass declines we should catch less if we wish the stock to remain sustainable. When catches decreased in the 1970s, the companies increased their dragger fleets and inshore fishermen increased the number of nets. Increased effort on 3PS crab this year also illustrates this negative aspect of quota-based management.

Effort-based management will automatically result in fewer fish being caught when a stock declines, and more importantly from a profit prospective, allow more fish to be caught in times of abundance.

3. Quota-based management encourages excessive capitalization of the fleet. Excessive debt reduces profits.

4. Quota-based management is not competitive. While this may have some positive features, they would be outweighed by a regulated competitive fishery which would encourage best practices, enhance efficiency, spawn innovation, and produce a more skilled workforce. In addition it would maximize the overall profit to the harvesting community.

5. Quota-based management may require trip limits which are generally not efficient.

6. Quota-based management has more rules than effort-based management. DFO managers expend excessive human and financial recourses monitoring these fisheries. In addition fishers are subjected to excessive monitoring and enforcement. This brings increased likelihood of fishing violations which also may have social costs. Data from harvesting may be flawed resulting in poor predictions for future quotas. This is especially true when there are a large number of smaller vessels landing at multiple ports. As a result DFO favours larger, less efficient boats simply because it is possible to police them.

7. Quota-based management doesn't target the most appropriate members of a stock. In fact it is generally indiscriminate. In lobster fishing, the gear and the season targets the midrange of the stock. As a result, the young are released alive and the spawning biomass is protected. Effort-based management "hollows out the middle "which improves profitability and sustainability.

8. Quota-based management usually results in intense effort for short periods of time. This is negative for processing plants that would prefer, for economic reasons, to receive their raw material at a more extended and predictable pace. Also, harvesters have a very irregular and unpredictable work schedule. Effort-based management would require fewer process workers with a longer work year.

9. Quota-based management encourages high grading, especially if there is a price differential based on size. As a result fish are dumped, catch data distorted, spawning biomass may be unduly targeted, and general overfishing will result.

10. Quota-based management incorporates a false sense of good management. If the quota is set well below the optimal sustainable harvest, the stock will continue to appear healthy. The downside of this practice is a less than optimal harvest and lower profits. Its aim is to protect the fish but not the fishery.

11. Abundance and scarcity are relative and not absolute quantities. Stock size is prey-dependent. It is possible for a stock to be at its maximum today even though it is only half of what it was years ago due to lower food supply. It is therefore acceptable to harvest from such a stock since it is at a maximum and the remaining stock will have a better chance of survival. Quota-based management doesn't address this fact.

Good fishery management should be designed to maximize the profit from the harvesting of our ocean resources while ensuring the sustainability of the stocks.

Barry Darby

St. John's Telegram, Sept. 12, 2015

Appendix III – The Non-Commercial Fishery

The ocean's wealth is a resource that Canadians hold in common through our government, and all citizens have a right to access it. For economic, social and environmental reasons, however, the bulk of this harvest should principally benefit professional harvesters who have chosen this as their career, and who will have much greater "use rights" than other citizens. The non-commercial fishery will be subject to basic rules such as the use of only a single line, no powered or fixed gear, and individual, boat, and trip limits.

From a fishery management perspective, it is important to acknowledge that the mortality from non-commercial fishing is too small to be of any significance. For cod in 2018 it was less than 1% of the total biomass and less than 10% of the fishing mortality, which DFO identified as only 2.5% of the total biomass in 2J3KL in their annual stock assessment. For other fisheries it is even less – just a small fraction of one percent of total biomass. Regulation of the non-commercial fishery, therefore, has no meaningful role in the management of a sustainable fishery.

However, this harvest has great importance for coastal communities. It represents food security, acknowledges historical rights, and strengthens the societal leg of sustainability's "three-legged stool". It can also contribute economically by drawing visitors and tourists to smaller, "out-of-the-way" places – experiences that are often the highlights of a Newfoundland and Labrador vacation.

Before 1992, the non-commercial fishery required little regulation, and that is probably still true. (Norway's experience provides a positive example in this regard.) If we are to have regulation, it should be as simple and minimalist as possible, allowing coastal citizens to harvest as much as they need for local consumption. As well, relaxing the rules for the non-commercial fishery would dramatically reduce the cost to DFO of providing resources for monitoring and enforcement.