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## Understanding Global Supply Chains and Seafood Markets for the Rebuilding Prospects of Northern Gulf Cod Fisheries

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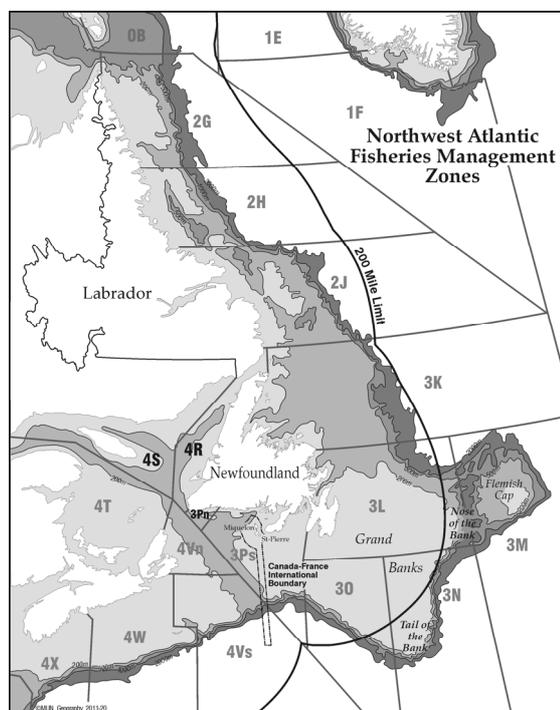
**Abstract:** Although fisheries production and seafood trade are global in scope, with billions of dollars in exports, the rebuilding of collapsed fisheries often focus on national fisheries policy and management measures, with little attention to global supply chains and international consumer markets. Even with two moratoria and two decades of policy changes since the Northern Gulf cod fisheries collapsed in eastern Canada, rebuilding has stalled and the fishing industry and coastal communities continue to undergo challenges with economic viability and resource sustainability. This paper examines and analyzes the global supply chain and marketing dimension of Northern Gulf cod fisheries. Drawing upon fisheries bioeconomics and governance theory, a pre- and post-collapse analysis is undertaken to understand key drivers and institutional mechanisms along global fish supply chains for an effective and successful rebuilding. Findings indicate that the collapse of the cod fishery has cascading effects that go beyond ecosystem changes to new harvesting activities, industry restructuring, supply chain reorganization, new global markets and consumer preference for certified seafood. This suggests that a holistic rebuilding approach is necessary, one that integrates institutional and behavioral changes for both producers and consumers at various scales of fisheries production, political economy issues, as well as cross-scale policies on marine conservation and regional economic development.

**Keywords:** Northern Gulf Cod; pre- and post-collapse analysis; rebuilding; fish chains; eco-certification and seafood trade; backward bending supply; fisheries governance; coastal communities; Newfoundland; Canada

## 1. Introduction

It has been twenty years since the Northern Gulf cod fisheries collapsed in eastern Canada (Figure 1). Despite many rebuilding initiatives and changes in management measures, stock assessments indicate there has been no significant increase in the abundance of Northern Gulf cod stocks bordering Quebec and Newfoundland [1]. Furthermore, there are ongoing challenges threatening the viability of the fishing industry in this region and elsewhere in Newfoundland and Labrador (NL). In this paper, the various changes in seafood production in both the pre- and post-collapse periods are examined for local rebuilding prospects and for long-term resource sustainability. Because of the global nature of seafood production and trade, supply chains have become an important aspect of environmental governance. First, an extensive literature review is undertaken on theoretical developments on fisheries management to underscore the relevance of the supply chain dimension for effective rebuilding. Next, drawing on the fish chain analytical framework and focusing on the harvest and post-harvest stages, seafood production is examined in both the pre- and post-collapse stages in identifying rebuilding challenges and opportunities.

**Figure 1.** Northern Gulf cod stocks (4RS3Pn) in the Gulf of St. Lawrence in eastern Canada.



Before the collapse of the groundfisheries in the early 1990s, Canada ranked second globally as a seafood exporter following the U.S. [2,3]. Total landings and dockside value in 1988 were about 1.7 million tonnes and 1.6 billion CAD, respectively, according to the Department of Fisheries and

Oceans (DFO). In 2006, after the groundfisheries collapsed, landings decreased to around 1.1 million tonnes, with a total production value estimated at 4.2 billion CAD, placing Canada in the sixth place after China, Norway, Thailand, U.S., and Denmark [2]. About two thirds of the total catch is currently landed in Eastern Canada, comprising mostly shellfish and small pelagics and NL contributed about a quarter of the landings in 2006 [2]. Total production value of all fisheries in NL increased to about one billion CAD in 1999, and fluctuated between 900,000 CAD in 2001 and 1.2 billion CAD in 2004. However, production value declined to 830,000 CAD in 2009, due to global fluctuations in fish price, especially for shrimp [2]. According to the 2010 NL Seafood Industry Review [4], total production value in 2010 for both wild capture fisheries and aquaculture reached 942,000 CAD.

The Northern Gulf fisheries in western Newfoundland contributed nearly 12% of the production value in 2004 [5]. Despite this contribution to the economy, stakeholders in the Northern Gulf region are concerned about future economic returns from the fisheries, because of poor resource access, macroeconomic drivers, and changes in fisheries policies [5]. Understanding these complex rebuilding challenges means policy makers must pay more attention to global supply chains and consumer markets as they impact both local economic viability and resource sustainability in the long term. This is an area of research that has been overlooked and very relevant for rebuilding strategies and policy deliberations.

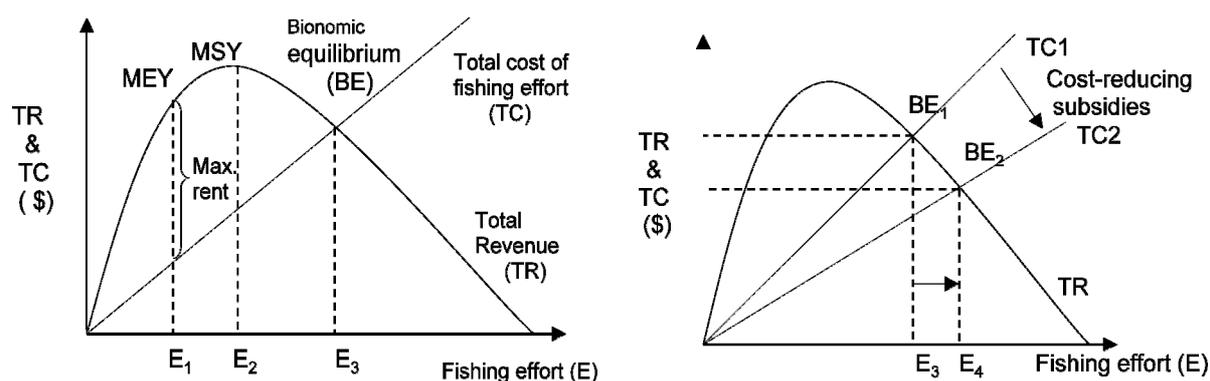
Often, restoration of collapsed fisheries to sustainable levels is undertaken by national agencies using bioeconomic approaches such as input and output control measures, and trade off analysis in meeting conservation reference points. In this context ‘recovery’ focuses on single species and biological reference points such as biomass and maximum sustainable yield target using technical tools and management measures to achieve ecological restoration. For the Northern Gulf fisheries, the 1982 biomass levels have been identified as target reference points. However, despite twenty years of various management measures, less than 10% of this target has been achieved [1] These management tools are insufficient to deal with broader issues about rebuilding, such as sociopolitical and socioeconomic concerns during rebuilding transition (conflicts, livelihoods, and food security). These disconnects in fisheries policy formulation are evident across various scales of seafood production and affects stakeholder groups differently. As has been suggested by Khan and Neis [6], ‘rebuilding’ is different from ‘recovery’ in both theory and practice. Rebuilding concept, which this paper draws upon, treats fisheries as coupled social-ecological entities connected to larger societies and the global economy. It also incorporates attention to intergenerational concerns especially the question of ‘rebuilding for whom’, transitional livelihood issues, predator-prey relationships, and institutional mechanisms to deal with these changes across multiple scales. This paper argues that rebuilding collapsed fisheries therefore require holistic approaches that integrate bioeconomic strategies, in addition to international seafood supply chains, and institutional mechanisms at various spatial scales. A fish chain conceptual approach is offered to better understand rebuilding challenges and opportunities in marine ecosystems, viability and livelihood concerns in the harvesting and marketing sectors, as well as the role of legal and institutional mechanisms in reversing the backward bending supply curve back to sustainable levels and for economic viability.

## 2. Conceptual and Analytical Approach

Historical approaches to understanding the biological and economic interactions in the fishing industry have evolved from a static Gordon-Schaefer bioeconomic model [7,8], to include dynamic optimized models and multispecies approaches [9]. The key contribution of the fishery bioeconomic model lies in its ability to assist in predicting resource use strategies and net economic benefits through time, hence its world wide application. The Gordon-Schaefer model assumes that annual total cost (TC) is proportional to fishing effort (E) and that annual total revenue (TR) is also assumed to be proportional to annual catch or yield (Y). The maximum sustainable yield (MSY), as shown in Figure 2 (left hand side), is a conservation reference point in fisheries management and fundamental in setting harvest rates and rebuilding targets. This bioeconomic model predicts that in a common pool unregulated or poorly managed fishery, E will increase to a point where TC equals TR, referred to as bionomic equilibrium (BE), where rents are totally dissipated. The sustainable resource rent from the fishery is the difference between TR and TC.

As shown in Figure 2 (left hand side), increasing fishing effort beyond  $E_2$  at the MSY level will lead to both economic and biological overfishing. It is argued that lower fishing effort below MSY such as at  $E_1$  provides higher rents at MEY and also promotes conservation goals. In addition, harvesting at a higher rate than the natural growth or replenishment rate would lead to overfishing and stock collapse. Therefore, sustaining the resource and maintaining profits in the longer-term implies keeping harvest rates such that the growth rate is higher than the harvesting rate. This is the crux of fisheries management as practiced in many parts of the world including both developed and developing countries.

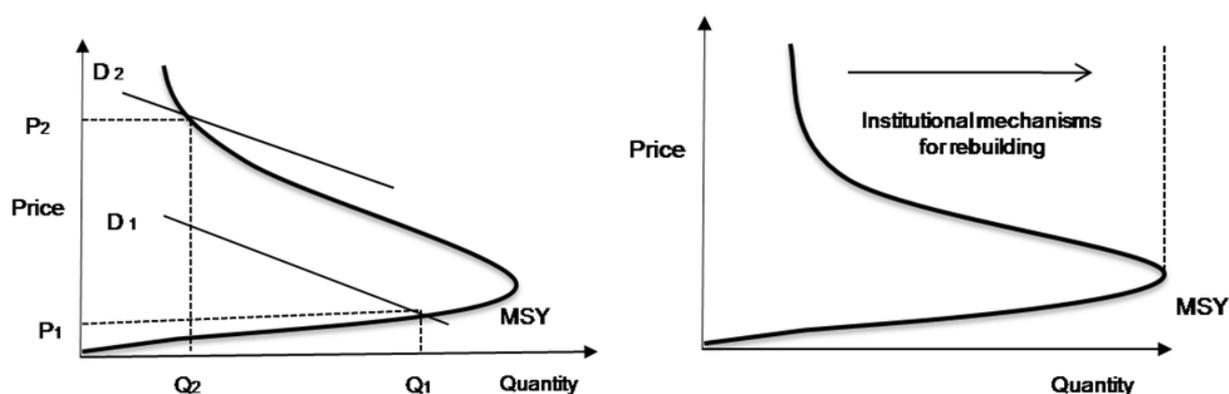
**Figure 2.** Static Gordon-Schaefer bioeconomic model of fisheries (adapted from [7]).



From a sustainability standpoint, the provision of fishing subsidies from governments to the fishing industry especially in capital-intensive fisheries will lead to higher participation and increases fishing effort from  $E_3$  to  $E_4$  as shown in Figure 2 (right hand side). This corresponds to a shift from  $BE_1$  to  $BE_2$  thus leading to further negative consequences for resource sustainability and economic viability [10,11]. However, conceptual approaches to fisheries rebuilding have often focused on stock growth and management measures [12,13], and less on conceptual integration with international seafood supply chains and governance theory in dealing with the human dimension [14–17].

Copes 1970 [18] historically built upon the Gordon-Schaefer theoretical model to incorporate a decision-making component within the context of supply and demand, and potential externalities to the environment, relevant to this analysis. As shown in Figure 3 (left hand side), as fishing increases because of high demand from  $D_1$  to  $D_2$ , the quantity produced will first increase from  $Q_1$  up to the MSY level, and then decline to  $Q_2$ , with corresponding changes in price from  $P_1$  to  $P_2$ . In this context, the long-run supply curve for fisheries may be backward bending owing to the biological constraints on growth and reproduction, and the common pool nature of fisheries [18]. This is due to the social-ecological nature of fishery systems which are highly susceptible to both human-induced and natural shocks and uncertainties, due to their common pool nature and their migratory behavior [19].

**Figure 3.** Backward bending fish supply chains (adapted from [18]).



This scenario is unique to marine seafood production compared to agri-commodities [19] and farmed seafood [20]. For most farmed fish and in aquaculture production, however, the chain is decoupled by controlling environmental conditions through breeding, feeding and enhancing growth through changing cage/pond conditions. In these decoupled situations, the backward bending supply is less relevant as prices are influenced by production cost and the resources are also privately owned [21,22]. In theory, wild captured fish supply chains in well governed fisheries should not be backward bending, as fishing effort will be regulated and monitored relative to natural growth rates [23]. Several institutional mechanisms that could avoid collapse and the dissipation of economic rent have been suggested [18]; including restricting fishing effort, raising taxes, as well as using marketing initiatives to deal with price fluctuations and product substitution. Hence, governance mechanisms and stakeholder support for rebuilding initiatives are thus essential to restore resource supply to its previous MSY level as shown in Figure 3 (right hand side). In this backward bending supply scenario, bioeconomic theory provides a good platform to explore stakeholder concerns across the supply chain, behavioral changes for both producers and consumers, and various types of institutional mechanisms that can deter collapse and sustain fisheries once rebuilt. Moreover, fisheries governance approaches can best complement bioeconomic tools in several ways:

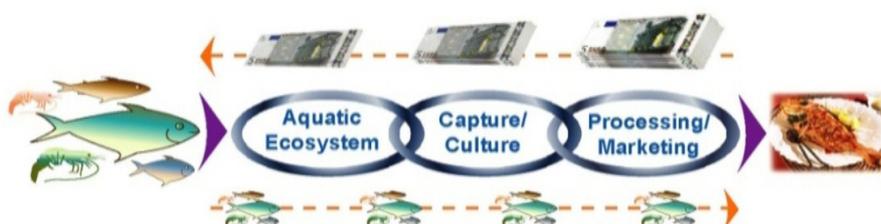
- The analysis of seafood production goes beyond the firm level and considers contributions from community small-scale fisheries and their spill-over and multiplier effects in regional and national economic development [24];

- The meaningful contributions and role of various fisheries institutions (the state, the private sector and civil society organizations) can be negotiated in terms of who pays for management cost and who benefits in the long term bearing in mind demographic changes and future access rights [25];
- Addressing the challenges of political economy issues such as market power, regulatory capture, procedural and distributional equity, as well as institutional structures and path dependencies [26,27].

As mentioned earlier, a rebuilding rather than recovery approach that considers broader socioeconomic and sociopolitical concerns is necessary in achieving effective outcomes for wild captured fisheries. Rebuilding fisheries is a challenging and ‘wicked’ problem because of the multifaceted and multiscaler dimension that lies beyond top down management measures. Because of these unique challenges in governing marine socio-ecological systems, rebuilding fisheries and dealing with endangered species is seen as ‘wicked’ problem [6,28]. Wicked problems in fisheries are understood to be complex and thorny and difficult to comprehend and to solve, as it goes beyond the natural science disciplines to entails the social and policy sciences and engaging on normative principles [29]. In better understanding wicked environmental problems, Ludwig *et al.* [28] highlighted the contribution of various disciplines and the need for multidisciplinary approaches in addressing wicked environmental problems. This paper takes this view and employs a broader governance approach that includes national fisheries management objectives in addition to public policy deliberations and the contribution of civil society, private sector, and community groups across the seafood production chain.

The main aim of this paper is to demonstrate how the lack of attention to organizational and governance complexities along fish supply chains has constrained the opportunities for rebuilding Northern Gulf cod fisheries. Building upon bioeconomic theory [7] and drawing on the fish chain approach [30], this paper examines the dynamics in Northern Gulf cod seafood production, focusing on the capture and marketing stages and their implications for a social-ecological rebuilding [31]. Unlike other approaches that use the ‘chain’ metaphor such as ‘global commodity chains’ or ‘value chains’ used in the consumer goods and food industries [32–35], the ‘fish chain’ focuses on understanding fishery systems specifically and the interaction between both the social and natural systems. It does so through a coupled human-nature approach and looks across the entire production chain from ecosystems to markets, stakeholders, and institutions [35]. The fish chain focuses on three production stages and their interactions: aquatic and marine ecosystems; capture or harvesting operations; and processing, retail, and consumption as shown in Figure 4.

**Figure 4.** The fish chain showing its multiple linkages and interactions (source [35]).



Unlike other agri-commodity chains where production is highly controlled and decoupled from natural phenomena, the fish chain pays attention to natural variability and ecosystem complexity such as predator-prey relations, climate change, and ocean currents. These coupled socio-ecological systems make fish chains very vulnerable to both natural and human induced risks and uncertainties. Fish chains for commercial species such as cod consist of multi-scale inter-linkages and stakeholder interactions in the global seafood marketplace. The fish chain analytical framework integrates ecosystem-based approaches and institutional mechanisms through a suite of instruments that shape stakeholder strategies and consumer behavior for successful governing outcomes [30]. These instruments include, amongst others, conservation measures, fishing regulations, international agreements, subsidies, voluntary measures, rights, consumer awareness and information measures.

The fish chain is a useful approach to understand fisheries rebuilding as it deals with both spatial and temporal scale issues. As seafood is currently the most traded commodity globally by value [3], fisheries production raises questions about organizational complexity and stakeholder interactions at various scales. There are also concerns about illegal and unreported fishing, in addition to “roving bandits” that are involved in indiscriminate fishing activities and habitat destruction especially in regions with ineffective governance systems [36]. Global seafood supply chains involve numerous institutions and stakeholder groups (both local and international), and entails diverse range of species and product types with the potential to affect economic viability and local development [37,38]. This marketing complexity makes rebuilding a much more challenging and a wicked problem to deal with. Moreover, external factors such as trade liberalization and national policy priorities may affect various aspects of fisheries production [17]. The options for policy changes along the fish chain are mediated by historical context such as local institutions, power relations, leadership, innovation and decision-making strategies [6]. Hence, the governing challenges along global seafood chains especially when attempting to rebuild collapsed local fisheries necessitate a move towards holistic approaches that integrate ecosystem considerations, seafood markets, and supply chain governance.

### 3. Methods

A seafood market and global supply chain analysis was conducted for both the pre- and post-collapse periods for the Northern Gulf cod and related fisheries in western Newfoundland. The analysis focuses on trends in fish landings, costs and earnings by fleet types, trade flows across international markets, key stakeholders and their interactions, supply chain organization, consumer preference, retail markets, and institutional mechanisms for rebuilding collapsed fisheries. The stakeholder analysis aims to determine factors that have and are affecting economic viability and rebuilding prospects in this region; focusing on the harvest and post-harvest stages of the Northern Gulf cod fish chain. It also seeks to understand key drivers affecting harvest rates and resource supply, processing requirements and consumer preference for various seafood products. Unlike most seafood market analysis that focuses on investment and profitability for firms [39,40], or costs and earnings for individual boat owners and fleets [41], the approach in this paper combines both these considerations for individual firms as well as for the various fleet sectors by gear and vessel types.

For the first step of this analysis, an archival and document search was undertaken drawing on policy and legal statutes, statistical information on landings and value, seafood market reports,

scientific research on stock status, and government commissioned reports on fishing policy. The second step involved a set of semi-structured interviews with fifty key informants from diverse stakeholders groups located along the fish chain. Unlike other research techniques or surveys that rely on statistical or econometric analysis such as in Roy *et al.* [42], the key informant interviews in this study focused on understanding stakeholders' perceptions of science-policy processes, marketing opportunities, organizational and decision-making approaches that are relevant for effective rebuilding. The interviewees were identified through the literature and document analysis, snow-ball sampling with stakeholders along the fish chain, and relying on community-university research approaches [43].

The interview questions focused on several key issues associated with the capture and processing activities of the fish chain and seafood production (see supplementary information). Notably raw material access, allocation measures, spatial scale of organizations, harvesting and processing policies, marketing chains, distributional networks, and institutional mechanisms. The key informants included six main groups of stakeholders with each key informant having a minimum of 20 years' experience within the fishery to ensure adequate knowledge of the fishery prior to and after the collapse. These groups included: seven scientists and fisheries managers; twelve fish harvesters; eight entrepreneurs engaged in the processing and retail sectors; seven municipal and community planners; ten bureaucrats and other decision-makers at different organizational levels including the federal and provincial governments, industry, and inter-governmental organizations; and six research analysts from consulting, academic, and the media. The results include quantitative and statistical data gathered from scientific research and trade reports, in addition to insightful accounts from key informants along the fish production chain.

#### 4. Results and Analyses

The findings on the changes in the supply chain and marketing aspects of the Northern Gulf fish chain are provided in four sections to illustrate rebuilding challenges and opportunities. These include: (i) challenges in raw material supply and access; (ii) restructuring and organizational changes in seafood production; (iii) concerns about economic viability and community sustainability; and (v) institutional capacity and legislative changes.

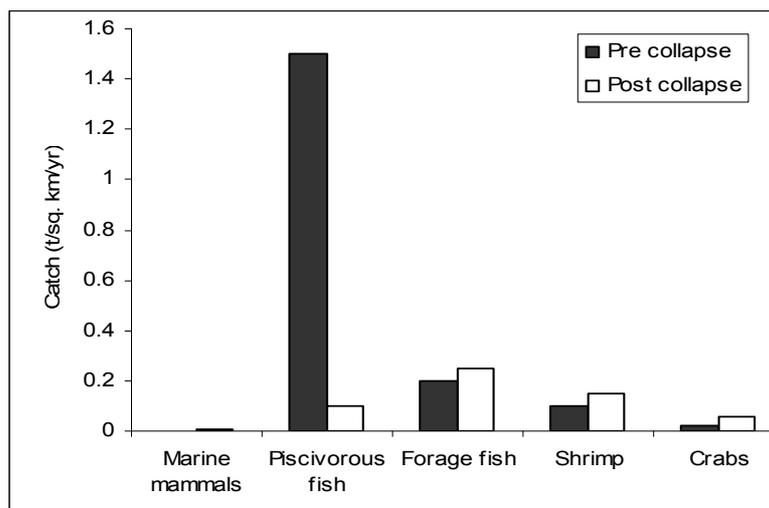
##### 4.1. Raw Material Supply and Resource Sustainability

The current total allowable catch for Northern Gulf cod stocks is 2000 tonnes, which is 2% of the historical maximum attained in the early 1980s. A pre- and post-collapse analysis of ecosystem models [44], stock assessment and policy documents revealed ecological constraints for cod population viability [45], and raw material access in the post-collapse periods. These ecological constraints were corroborated by key informants who identified the following key concerns for resource sustainability: (i) on-going fishing activities for cod and capelin that cod feeds on; (ii) increasing natural mortality due to predation from seals; (iii) seismic activities in the gulf that might affect cod habitat; (iv) concerns about by-catch and discards from other fisheries such as turbot; and (v) institutional inertia and poor stewardship incentives for cod rebuilding.

The cod stocks are currently assessed below conservation limit reference points [45]. In the pre-collapse period, technological development and increasing fishing effort due to capacity enhancing

subsidies towards offshore dragger fleets have been cited as having contributed to the collapse [46,47]. Current predation rates on cod especially by seals, on-going commercial and recreational fishing activities, and potential ecosystem shifts have been identified to affect Northern cod recovery [48,49]. With poor resource supply and livelihood concerns in the post-collapse period, Northern Gulf fishing activities have shifted focus to invertebrate species such as crab and shrimp as shown through recorded landings in Figure 5.

**Figure 5.** Changes in catch for major fish groups in the Northern Gulf (Source [49]).



These changes in target species have affected the organization and distribution of processing infrastructure and been associated with new consumer markets for shellfisheries. These lucrative shellfisheries with less industry participants compared to the pre-collapsed era raises distributional and equity issues especially for the small scale inshore fishers. The higher production value for shellfisheries raises fears about backward bending supply implications, especially in the absence of institutional mandate to stop overfishing and to rebuild commercial fisheries. Further rebuilding concerns about changes in target species, especially for forage fish such as capelin, were articulated by several key informants. According to a community planner in the Corner Brook region: “I can’t see how stocks can recover when we are still fishing capelin and other stuff, how can the fishery recover when we are destroying the very foundation for the [cod] fishery”.

Some fish harvesters in the 4R and 3Pn regions in Newfoundland raised concerns about the small cod they were catching and the corresponding poor prices they received from fish processors. The difference in price, particularly in the 4RS region where gillnets are used raised concerns about discarding and ‘high grading’ of small sized fish and concerns about recruitment overfishing. Management measures for by-catch restrictions vary by gear and species targeted in the Gulf of St. Lawrence. To deal with issues of discarding, some fish harvesters suggested mechanisms to permit trading of by-catch in meeting their quotas, and compulsory or voluntary disclosures. These proposed measures are arguably necessary for compliance, sustaining the resource, and for accurate reporting.

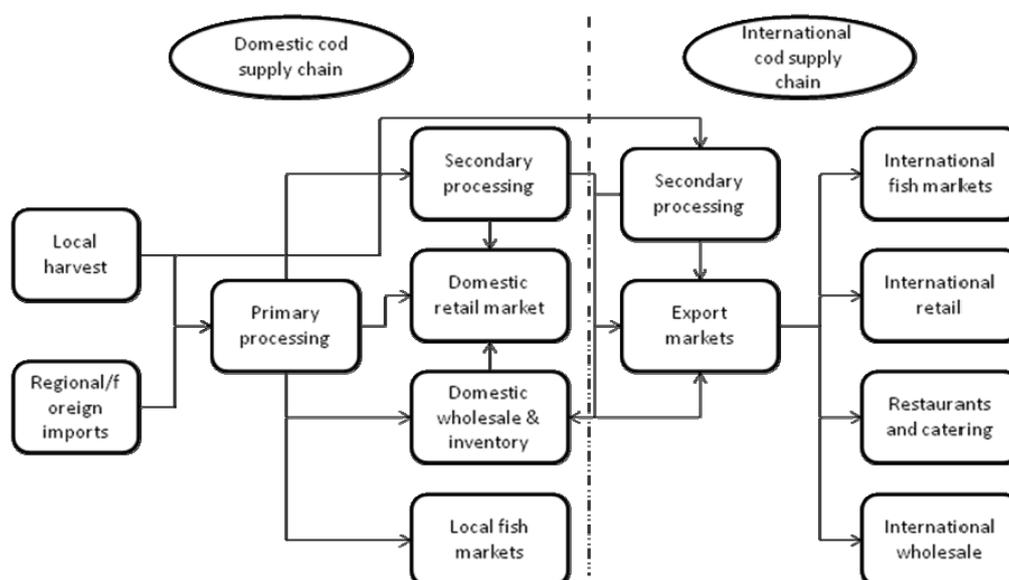
In summary, changes in the ecosystem in the pre and post-collapse periods constrain raw material supply for groundfisheries especially for cod. These changes have triggered a shift in target species to shellfisheries and small pelagic that are in abundance because of regime shift. These changes raise

many other rebuilding challenges such as sustainable harvesting, by-catch and discards, and stewardship from resource users that may influence stock recruitment.

#### 4.2. Restructuring and Organizational Changes in Seafood Production

A review of market reports, in addition to key informant responses, demonstrates major restructuring and organization changes in the post-collapse period of seafood production. The cod supply chain has been restructured and transformed because of resource access and raw material supply, fleet restructuring, and conservative management measures. Using the analogy of global commodity chains [33], the pre and post collapse analysis demonstrate that there is a shift from a producer-driven to a consumer-driven mode of production. For instance, in the pre-collapse period, cod fish chains were characterized by high production volume of mainly cod blocks primarily targeting the US market and mostly influenced by fish merchants [50]. These supply chains entailed primary and secondary processing components, domestic and international, as well as wholesale and retail outlets as shown in Figure 6. The current operational range of the post-collapse cod fish chain is shorter and characterized by poor resource supply due to a lower TACs and stock status and targets mostly local and niche markets in the UK. Most of the supply chain for cod processing has been restructured to meet major fleet capacity reduction programs and corresponding wholesale operations [51]. There have been limits on new licenses for primary processing and a further freeze on secondary processing licenses.

**Figure 6.** Pre-collapse cod marketing and distribution networks to predominant U.S. markets.



The current cod markets are mostly retail-based, shorter in scope, involving less fish chain actors and targeting high end supermarkets in the UK and for local consumption. Only one major cod processing plant has remained in the province, which is also the largest in North America. Total production volume has drastically reduced, with about 39,000 tonnes of groundfisheries landed in NL in 2010, and cod constituted only 24%. The total landed value for the groundfisheries in 2010 was about 50 million CAD [4]. Key informants in the processing and marketing sectors highlighted

numerous changes in the cod fish chain from a producer-driven chain to a more consumer-driven chain that produces high value cod fillets for niche markets and local consumption.

According to FAO statistics, the trend in groundfisheries production has been increasing globally, from less than four million tonnes in the 1950s, peaking up to about 12 million tonnes in the 1980s, and declining to 6 million tonnes in mid 2000s. The composition of species has also changed over the past decade with cod declining as the most landed species in the 1950s and 60s (more than 75%) to less than 25% in the 1990s and 2000s. Currently, hake and Alaskan Pollock constitutes to more than 50% since the 1990s. These global production trends affect local markets and consumer preference as depleted stocks are easily substituted. Alaskan Pollock (*P. polachius*), New Zealand Hoki (*Macruronus novaezelandiae*), Icelandic and Norwegian cod (*Gadus morhua*) have replaced NL cod in the global markets in the post-collapse period [50]. Furthermore, other whitefish such as hake (*Merluccius spp*) and tilapia (*Tilapia spp*) have taken up about 75% of the U.S. market share since 2005, with imports doubling from USD 150 million in early 1990 to USD 300 million in late 2000 [52].

Despite several restructuring and social adjustment programs implemented after the collapse of the groundfisheries, the fishery is still considered overcapitalized [51,53]. For those who hold this view, overcapacity is defined in terms of inputs of fishing effort relative to the resource abundance, measured in terms of capital investments, total revenues, and technological efficiency in both the harvesting and processing sectors [54]. The combined outcomes of overcapacity and poor resource supply amidst industry restructuring were raised by stakeholders as key challenges to be addressed in order for rebuilding to be successful. Furthermore, for most local fishers who have remained in the fishery, the more lucrative shellfishery is a better option due to its higher landed price and production value. According to the 2010 Seafood Industry Review [4], shellfisheries accounted for 60% of total landings and generated 84% of the total landed value (369 million CAD). These changes in product types and consumer markets have ramifications for transitional rebuilding costs and buy-in from industry stakeholder groups.

In addition to predator-prey and ecosystem concerns if cod rebuilds, key informants identified a potential supply glut of cod during the summer harvesting months that could affect profitability. According to one processor, cod stocks caught in summer in places such as western Newfoundland are on their feeding migration and full of capelin. Catching fish at this time affects processing quality and the sale price in the market place. These mismatches between the cod summer harvesting season, poor quality and low market demand often led to 'distress selling' due to high inventory costs [55]. Suggestions for future marketing options from stakeholders included more direct wharf sales to local consumers and towards tourist niche markets in the summer. In both theory and practice, different types of markets (retail, wholesale, *etc.*) will generate a range of price premiums that affect the total revenue. Institutional and management measures through marketing programs and identifying niche markets are central to value addition and generating greater revenue along the chain. The formation of cooperatives was proposed by harvesters for high end sales as formerly practiced in Petty Harbor and Fogo Island in Newfoundland. Other community governance models include the community supported fishery in Nova Scotia (Off the Hook), a local fishery that promotes 'short fish chains' by directly selling to consumers, harvested by gear friendly nets, and supports local fishing entrepreneurs directly [56].

Price setting at the local level and its implications on stakeholder benefits along the supply chain is one of the most challenging aspects of seafood governance. Initial dock side price setting affects revenue distribution and provides opportunities for value addition and marketing programs. Although it is generally agreed that prices are set based on demand and supply, various factors such as scarcity, specie types, farmed or wild, product types or forms, processing requirements, income, and consumer preference do affect prices. The FAO fish price index that uses national trade data, for instance, is not representative across countries let alone regions, the species harvested, and various product forms [57]. However, it is very useful for understanding global seafood market dynamics as well as food policy implication especially in the event of shortages and other uncertainties. For fisheries rebuilding policies, local context matters in setting the institutional stage for buyers and sellers to interact at the national level and to be competitive at the international stage as seafood is the most traded commodity worldwide.

Depending on the socio-political contexts, different price setting models are used for cod and other fisheries in countries such as Norway and Iceland. In Iceland, a computerized auction system are used, whilst in Newfoundland and Labrador a collective bargaining agreement is reached between fishers and processors, and in Norway, a minimum regulated price is set by the state. These various models have implications for cost and benefit sharing along the supply chain for various stakeholders. In fact in NL, there have been suggestions from fish harvesters for outside buyers to compete with provincial buyers for better prices as well as trying fish auctions and direct bidding as practiced in Japan. These suggestions have met some resistance from various other groups especially processors. On-going discussions are underway on how best to deal with price setting that is fair and just for both fish harvesters and processors. Key informants identified local secondary processing, product differentiation and identifying niche markets, branding and eco-certification are potential opportunities to be explored, considering the role of third party labeling initiatives such as the Marine Stewardship Certification (MSC).

The growing reliance on MSC eco-certification as a policy instrument is partly attributed to the globalized nature of food production, chain of custody rules, and the buying power of consumers [58,59]. These eco-certification programs have been partly successful because of consumer awareness campaigns from conservation groups and commitments from retail marketing chains in Canada and abroad (such as Unilever, Wal-Mart, Sainsbury's, Marks and Spencer, Loblaw and Carrefour). Critics have argued that the eco-certification criteria are insufficient, as they neglect social justice and equity issues, in addition to local development and trade barriers [60]. Moreover, the cost of eco-certification is sometimes too high to afford by certain stakeholder groups, raising questions about the credibility and duration of the assessment process and other political economy issues [61]. Out of the 130 fisheries that have been certified by the MSC around the world, only 18 are found in Canada, with several others under assessment [62]. In NL, two fisheries have been certified by the MSC—the Fogo Island Cooperative and the Association of Seafood Producers, both harvesting the Northern Shrimp (*Pandalus borealis*). Recent conflicts amongst these two groups in the Northern shrimp industry certification over price setting have demonstrated how market control can legitimize access over public resource at the expense of society as a whole [27].

Because of the huge investments in shellfisheries processing infrastructure and in eco-certification schemes, there are concerns about the implication of cod rebuilding on ecosystem structure and its

potential impact on the lucrative shellfish trade. The shrimp fishery uses otter trawler vessels under 65 feet, that are owner-operator, has full observer coverage, and the fleets are required to use the Nordmore grate system to reduce by-catch and prevent habitat damage. In a discussion with a key informant about the recovery potential of cod, he remarked:

“...you are going to have to manage it in a very different way than we used to. We have to come up with a new concept...The cod right now is a nuisance, because it’s a nuisance in by-catch. This guy is fishing turbot, but he can’t fish it because of all the [juvenile] cod. The other thing is, he is looking at cod as a predator of small shrimp and crab, and right now they’ve spent tens of thousands in changing from cod to shrimp and crab fishery. They don’t want to go back to cod; *right now cod is a nuisance*” (emphasis added).

In summary, stock collapse brings in another human dimension of supply chain restructuring, which often entails reduction in both capital and labor inputs to meet resource scarcity. Other related issues of new investments in shellfisheries processing infrastructure, substitution and price effects, and political economy issues especially with certification all affect stakeholder notions of rebuilding and the governance challenges it brings.

#### 4.3. Economic Viability and Coastal Community Sustainability

The economic viability of the fishing industry (harvesting and processing sectors) is assessed in terms of operational profits, which depend on total revenue in relation to total costs. The cost structure of fishing operations varies by type of fishing enterprises, capital investments, and fleet types, as well as the number and types of fishing licenses. Interviews with inshore harvesters reveal mixed responses on the viability of fishing enterprises in the post-collapse period. According to one fisher:

“The fishery is going belly up for the small [scale] man. I think if you can afford to be there, you are going to be there. And if you can’t afford to be there, if you can’t afford to spend thirty, forty thousand dollars a year, you aren’t going to stay into the fishery. I’ll be paying off credit card payments until fishing next spring to pay off what I spent in to it this year...I haven’t broke even in the last four or five years...”

Other inshore harvesters interviewed, however, seemed to have viable enterprises. This is primarily due to access to multiple quotas and licenses for lobsters, crab, shrimp, halibut, capelin, and herring. Those who have numerous licenses have better economic performance in their fishing operations. According to costs and earnings survey in 2004 [41], the financial performance of enterprises engaged in shellfisheries is higher for combined crab and shrimp enterprises in the 35-64’ vessel category, than for groundfisheries in the same vessel category. The survey did not take into account debts and seasonal unemployment benefits [51], which have assisted those dependent on the fishery [63]. Key informants identified indebtedness as the biggest challenge in the fishing industry. One key informant, a research analyst, explained: “Debt, it’s our biggest problem, the capital we’ve used in this industry, its huge” referring to issues of ‘capital stuffing’ and investment in fish finding devices and technological improvements.

The types of fishing licenses and fishing enterprise determine crew profits and revenue sharing mechanisms. Although crew sharing arrangements vary from one enterprise to another, there are some indications that a more equitable crew-sharing ethic was adhered to in the pre-collapse era [51]. In the post-collapse period, Schrank [51] documented higher owner shares for skippers sometimes in excess of 100,000 CAD per year; whilst crew members received about 22,000 CAD of which 45% was income from Employment Insurance. As highlighted by one key informant, the change in revenue sharing mechanisms appears to have affected labor markets including particularly the retention of skilled workers in fishing communities and the human capacity to deal with rebuilding challenges.

In the pre-collapse era for the processing sector, larger plants with multispecies licenses mainly for groundfisheries, pelagics, and shellfisheries were economically more successful than smaller plants with few licenses [55,64]. Key informants identified the former Fishery Products International and National Sea Products (High liner) as more successful in acquiring global market share because of stronger marketing strategies and state support. In the post-collapse era, these bigger companies sought to keep their market share by importing groundfish from the Barents Sea to keep their processing operations going in till the early part of 2000 [51,64].

Profits in groundfish products for small processors in the post-collapse era are very low due to competition with cheap substitutes such as Pollock from Alaska and Tilapia from Asia, in addition to consumer demand for certified seafood products. This shift has ramifications for regional economic development especially for fisheries dependent coastal communities. Regarding individuals and fishing households in the Northern Peninsula in western Newfoundland, about 50% of livelihoods in the harvesting and processing sectors have been lost due to the collapse and restructuring measures [5]. For instance, out of the thirty processing plants reported in the pre-collapse period in this region (both primary and secondary), only thirteen remained as of 2010 [4]. This pattern of changes in coastal livelihoods is similar to that in the province as a whole as shown in Figure 7, illustrating numerous closures in number and location of fish processing plants in particular groundfisheries.

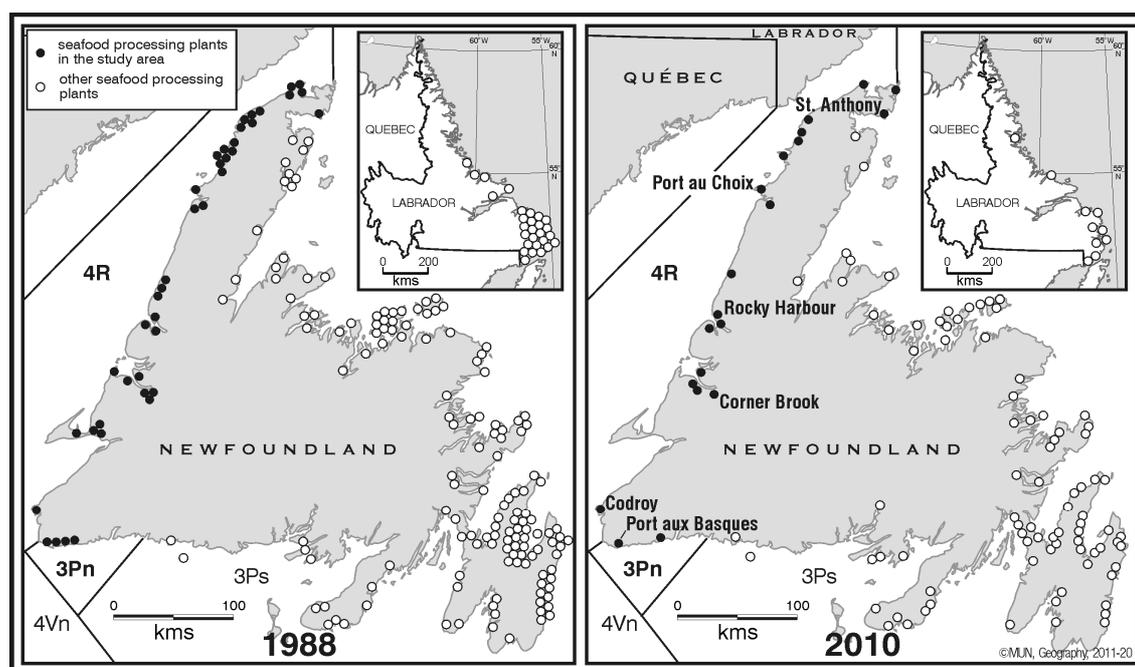
Currently, most of the secondary processing of groundfish including cod is done in low cost countries mainly in Asia and re-exported to Canada [2,3]. Key informants in the processing and harvesting sectors identified only one major cod processing plant and seafood exporter left in the province (located at Arnold's Cove), targeting mostly niche markets in the UK.

In the pre-collapse era, interest rates affected profitability, contributing significantly to a 16% decline in profits in 1989 [39]. In addition to interest rates, exchange rates have also been identified to affect profits for processors, which in turn affect dock site price setting with fish harvesters. In the post-harvest period, key informants predominantly industry stakeholders in the processing and retail sectors expressed concerns about the increasing parity of the Canadian dollar with the U.S. dollar. One key informant, a medium scale processor illustrated this with an example:

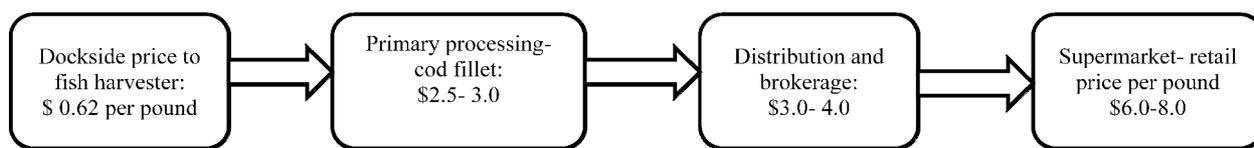
“...the Canadian dollar is up now. That got a reflection in the market place and that got a reflection on the price you pay to the fishermen. I went back about two weeks ago and looked at what the exchange rate was last year; it was 21 cents. Right now we're less than five. That's a big difference. You're looking at probably 18 cents difference on a pound of filets. That's a lot of money. Every hundred thousand pounds of filets is 18,000 dollars.”

These changing global markets and macroeconomic factors impact seafood trade and the viability of local fisheries especially along local supply chains. The current cod recovery strategies pay little consideration for macroeconomic factors in ecosystem restoration and rebuilding efforts and hence provide an opportunity for exploring supply chain strategies beyond national jurisdiction.

**Figure 7.** Number and location of fish processing plants pre- and post-collapse (adapted from [4,65]).



From a value chain perspective in the pre-collapse period, raw material in the form of cod landings contributed to about 62% of plant operating costs; next to labor and wages at 22%, energy at 3%, and profits assessed to be around 13% [55]. Key informants in the processing sector mentioned that a similar cost structure was evident in the current cod fish chain but there has been an increase in packaging, distribution, and brokerage costs. Fish price setting is one of several ‘focal points’ along the fish chain that requires cooperation and negotiation to avoid conflicts as put forward by Schelling [66]. In 2009, a pound of cod at dockside valued at 62 cents purchased from fish harvesters eventually cost about 6 to 8 CAD at the retail end of the chain (Figure 8). Fish harvesters are very concerned about the poor price they receive for their raw material compared to the retail store price they observe sometimes in their own communities. The market prices for cod block fluctuated around 0.90 CAD a pound in the 1980s and steadily increased to 1.25 CAD in 1988; followed by a sharp fall to less than 0.70 CAD in 1989 and gradually increased to a peak of 1.15 CAD in 1991 [50].

**Figure 8.** Post collapse value chain for cod fillet in local markets in Newfoundland.

The *Fishing Industry Collective Bargaining Act* of 1971 governs fish price setting between fish harvesters and processors in NL in both the pre- and post-periods. Following disputes in the early 1990s regarding the dockside price for shrimp, binding arbitration was put in place along with an amendment to institute a price setting panel [67]. The Report on the Standing Fish Price-Setting Panel for 2008/09 on collective bargaining for fish prices showed that out of ten key species, agreement was reached for only five, with further court decisions to be made on the justification of the panel decisions. There are high levels of mistrust amongst stakeholders, mainly between fish harvesters and processors in negotiating fish prices. According to key informants especially harvesters, the cost and benefits are not fairly distributed across the marketing chain and in setting fish prices. Some are opposed to the provincial law against selling directly to consumers or welcoming buyers from outside the province. A fish harvester in Port Aux Choix explained the fluctuating prices:

“We were getting in 1986; we got close to a dollar a pound. That was a good price. Here we are today, 24 years later, we got 37 cents this year...You can’t do that right [?]....We got to look at our expenses and that...we got to have at least 60 cents a pound to survive. Cod should be close to a dollar a pound.”

In the post-harvest period, the retail market price for fresh cod fillet has fluctuated from 5 to 8 CAD in the past five years, with periodic shortage especially in the winter months. The price for frozen cod from the local Sobeys retail store sells for 5 to 7 CAD for a pound in the summer of 2009, almost the same price for imported frozen cod from High Liner. In fact, some Canadian companies such as High Liner outsource their secondary processing to Asia to boost their dividend and to recompense for the rising Canadian dollar.

To deal with the low prices received by fish harvesters, some key informants suggested policy changes to facilitate direct selling to buyers from out of the province or direct wharf sales to local residents. However, fish harvesters are by law not permitted to sell their fish directly to consumers in NL. The rationale for this policy is to ensure quality control through processing requirements, secure local processing jobs, and to ensure accurate catch reporting. The disagreements between harvesters and processors about price setting, and direct sales to either consumers or buyers outside of the province raise concerns for collective action on marketing initiatives.

Economic viability, in summary, is influenced by many factors especially for fish stocks that are in transition towards rebuilding targets. There are tradeoffs between short term cost and long term benefits, which compound issues around equity, debts and debt servicing, conflicts between supply chain actors, and the viability of local economies. All these related issues create more pressure on the fishery resources, especially for resource dependent coastal communities, whose livelihoods are embedded along the fish chain in the region.

#### 4.4. Institutional Capacity and Legislative Changes

Two main concerns were raised by key informants related to effective institutions for rebuilding and sustaining the Northern Gulf cod fisheries: (i) multispecies management strategies and (ii) rebuilding plans and implementation measures. Seafood trade is important for export earnings, food security, and local livelihoods especially in western Newfoundland, one of the most fisheries dependent regions in Canada [68]. However, sustaining the benefits from seafood trade requires strong institutional mechanisms across all three stages of the fish chain. Institutional innovation amongst stakeholders is crucial in strengthening stewardship and marketing policies for reversing the backward bending supply in the event of collapse, as highlighted in Figure 3. Furthermore, governance mechanisms are critical in avoiding path dependencies and exploring options for institutional change [69].

Key informants along the fish chain in both the harvesting and processing sectors showed interest in multispecies harvesting and processing options for economic viability. These suggestions were in response to by-catch and stewardship concerns, which could boost viable operations, through multispecies harvesting plans. Although there are interests amongst stakeholders in various marketing programs, efforts to establish a fish marketing council as recommended under the Federal-Provincial Fishing Industry Renewal initiative were opposed by a majority of processors in the province. According to one small-scale processor who voted against the marketing council “the marketing is not for us, it is for the big processors to inventory their fish in the U.S.”. Despite these marginalization concerns, funding for a marketing council has been approved by both provincial and federal agencies, based on recommendations from a Memorandum of Understanding (MOU) fisheries report [53]. In the event that the marketing council initiative goes as planned, it may create legitimate concerns for the smaller processors who opposed it. Moreover, because the MOU report did not adequately address cod rebuilding and its marketing challenges, it may pose concerns in the light of eco-certification, chain of custody rules, and for environmental groups that promote sustainable seafood. Furthermore, the listings of cod stocks in eastern Canada have been controversial because of buy-in from the fishing industry and livelihood implications [70,71]. The debate have not gone beyond national jurisdictional mandates to include other supply chain actors and partners; unlike other threatened and endangered fish stocks such as tuna that seeks the United Nation’s Convention on International Trade on Endangered Species as an international policy instrument. One of the biggest concerns identified by some conservation minded stakeholders is that the assessment and decisions made by the Committee on Status of Endangered Wildlife in Canada does not take into consideration non- market valuation, discount rates, and long-term intergenerational equity [72,73]. In dealing with intergenerational equity concerns and industry participation, Sumaila and Dominguez-Torreiro [74] have suggested governance approaches that improve the legitimacy for buy-in from resource users and reduction in transaction cost for managers. One key informant, a retired civil servant, pinpointed to the relevance of legislative mandate and institutional mechanisms towards successful rebuilding:

“...we’ve learned next to nothing since the collapse....all I know is that our existing legislation is inadequate...The Americans have had success, and what I like about it, everybody knows what the objectives and timelines are. It has to be taken out of the political hands. Our current system is terrible with the amount of input the industry has... It will never go away unless we have some kind of legislation...”

Such explicit legislative mandates and effective governance approaches could improve compliance and stewardship and support long-term benefits. Moreover, the recent cutbacks in government spending for research and lay-offs involving habitat and environmental management in DFO have raised concerns and protests for long term monitoring and conservation necessary for sustaining fisheries [75].

Other problems to address include illegal, unreported, and unregulated fishing that has exacerbated uncertainties with catch statistics especially as they relate to setting future harvest rates [47]. In the post-collapse period, institutional changes such as dockside monitoring and other policy measures have reduced these potential external threats to the resource and improved shared stewardship in management.

Institutional investments in the form of R&D, resource appraisal, monitoring and control, technical capacity, and reforms through rules, norms and incentives are all necessary for legitimacy, buy-in, and stewardship amongst stakeholders and the general public.

## 5. Summary and Conclusion

The conceptual approach of fish chains and the empirical findings along the Northern Gulf cod fish chain illustrates several reasons for stalled rebuilding and on-going livelihood concerns. Recognizing fisheries rebuilding as wicked problems emphasize the need for better management practices and institutional innovation that are crucial in strengthening stewardship ethics and to reversing the backward bending supply for collapses stocks. The comparative pre- and post-collapsed fish chain analysis underscores four main aspects that make rebuilding such a wicked problem. These challenges range from resource scarcity and raw material supply, to the impacts of restructuring measures on supply chain organization, viability and the livelihood dimension, to institutional capacity and policy reforms. Findings from the Northern Gulf cod region illustrates that paying attention to these multiple factors could support rebuilding of fish stocks and fishing communities; but only if effective institutional mechanisms are put in place to promote conservation, sustainable harvesting practices, and livelihood considerations. This holistic approach and multiple considerations especially on ecological shifts and political economy implications of global supply chains may be difficult to reconcile with the often narrow focus of top down fisheries management departments.

As demonstrated by both key informants and ecological modeling [49], changes in target species from groundfisheries to shellfisheries and pelagic, and a growing seal population raise concerns about changing predator-prey relationships and by-catch issues that may affect cod rebuilding. These interactions in the harvest and post-harvest stages demonstrate that rebuilding goes beyond single species management and reactive restructuring measures to include multispecies and ecosystem considerations, global seafood market dynamics, and community-level concerns. As discussed in the theoretical review, rebuilding the resource and maintaining higher profits in the long term implies the need to keep harvest rates at low levels to avoid the ongoing problems of growth and recruitment overfishing. In practice, increase in natural and fishing mortalities due to high predation rates, on-going fishing activities, and high dependency on the fishery appear to prolong rebuilding especially in the absence of industry buy-in, transitional livelihoods, and effective institutional mandates for conservation.

The findings further demonstrate that economic viability is hampered by raw material supply for cod because of stock collapse, global market competition with other whitefish, and continuous restructuring changes in fishing policies on access and allocation. Moreover, new target species such as shellfisheries comes with professionalization policies that limit access and create wealth for a few harvesters. Restructuring of processing infrastructure towards mechanization in the post-collapse period have limited employment especially in resource dependent coastal communities. Policy coherence between the harvesting, processing and marketing sectors; as well as institutional partnerships on price setting and value addition provides the necessary climate for collective action in rebuilding efforts. In addition to transformative initiatives amongst stakeholders during rebuilding transitions and beyond, institutional mechanisms are also critical in avoiding path dependencies and enhancing economic viability. Recent institutional partnerships in NL and efforts towards eco-certification initiatives for consumer awareness and for encouraging sustainable harvesting policies through chain of custody rules for seafood trade are proving to be effective for sustainable fisheries. Although eco-certification process has its shortcomings [58]; if well governed could provide opportunities for non-state actors especially consumers, NGOs, and the fishing industry to contribute to sustainability practices and behavioral policy changes [76,77]. Effective governance arrangements that involve both state and non-state actors across the entire fish chain are necessary for compliance, stewardship, stakeholder collaboration, and economic viability.

Drawing on the success of fisheries rebuilding such as in the U.S. and other parts of the world, appropriate policy instruments, legislative mandates, and governing arrangements that emphasize robust science and decision control rules within regulatory frameworks, compliance, and stewardship are fundamental to sustaining fisheries [78–80]. The pre- and post-collapse analysis of Northern Gulf cod supply and marketing chain further demonstrate the need to align policy instruments to changing ecosystems, resource supply, fleet and processing capacity, livelihoods and consumer markets in both regional and global contexts. These complex and multiple challenges are best addressed through effective governance mechanisms that deter overfishing, support multispecies rebuilding approaches, and explore diverse policy options with stakeholder groups and local communities on livelihood and marketing issues.

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## Conflict of Interests

The author declares no conflict of interest.

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