Managing to Endanger:
Creating Manageable Cod Fisheries in Newfoundland & Labrador, Canada

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Abstract This paper traces the history of the idea that fisheries ought to, and could be, managed. Particular attention is paid to the scientific representation of codfish, the fisherman, and the practice of fishing that enabled managerial interventions into the cod fisheries of Newfoundland and Labrador, Canada. The paper concludes by reflecting on the role the management idea played in the endangerment of cod as a wild species and the destruction of a way of life tied to fishing cod.

Introduction

The discursive spaces and biophysical places of contemporary global fisheries are in disarray. One century of unrelenting industrial harvesting of the sea has led to the extermination and endangerment of marine life that have coevolved with fishing people for tens of thousands of years (Callum 2007; Sharp *et al*. 2008). Fisheries science is increasingly fractured and subdivided over the forms of knowledge and modalities of intervention that make for effective fisheries management. Fisheries experts increasingly emphasize complexity and uncertainty while counselling passive adaptation and coping strategies to transform and reinvent fisheries management. Scientific management is increasingly attacked while Ecosystem-Based Fisheries Management (EBFM) is all the rage. Proposals for new forms of fisheries management change and proliferate rapidly in the contemporary context but the idea of management largely escapes critical engagement. As a way to address this lack of critical engagement, I present a history of how, when and why the management idea entered the northern cod fishery in Newfoundland and Labrador, Canada. I trace out the consequences of cod fisheries management and implicate the management idea in the death of the northern cod fishery.

Imagining, Constructing and Contesting the Manageable Cod Fishery

> Are there any sea fisheries which are exhaustible, and, if so, are the circumstances of the case such that they can be efficiently protected? I believe that it may be affirmed with confidence that, in relation to our present modes of fishing, a number of the most important sea fisheries, such as the cod fishery, the herring fishery, and the mackerel fishery, are inexhaustible. And I base this conviction on two grounds, first, that the multitude of these fishes is so inconceivably great that the number we catch is relatively insignificant;

> and, secondly, that the magnitude of the destructive agencies at work upon them is so prodigious, that the destruction effected by the fisherman cannot sensibly increase the death-rate ... nothing we do seriously affects the number of the fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless (Huxley 1883:6-7).

The natural abundance of codfish and inter-annual landing fluctuations in the cod fishery were not a concern for John Cabot in 1497 when he reported codfish so thick they reportedly slowed the movement of his ship the *Matthew* on the Grand Banks. Close to three hundred years later, Thomas Huxley (quoted above), Darwin's legendary 'bulldog,' could not even imagine the destruction of fecund marine fisheries like the cod. Rather than scarce fish, political and economic uncertainties associated with getting to the fishing grounds and returning without succumbing to unknown waters, storms, war and piracy were the major concerns for Britain after the 'discovery' of Newfoundland. Advances in navigation, boat building, military engagement, war and subsequent treaties helped to tame the uncertainties associated with accessing the cod fishing grounds; however, by the late nineteenth century access uncertainties began to be replaced with new concerns.

Modern industrialization in Europe and the progressive era in the United States created political and economic pressures to maximize the exploitation of the cod as an economic resource adjacent to the island of Newfoundland. Economic pressures also dramatically influenced how and why fishing was conducted in the last half of the nineteenth century. Modern fishing methods, mechanization and the industrialization of processing focused on increasing production and efficiency in the fishery and it required a steady, stable supply of codfish unencumbered by the vagaries of the natural environment, migrating cod, and the subsequent fluctuations in fish landings. In addition, while the dominant scientific and expert consensus up to the end of the nineteenth century echoed Huxley's (1883) belief that marine fish were inexhaustible, experiences in Newfoundland and Labrador and other fishing communities in Europe and North American began to suggest otherwise (Hutchings *et al.* 2002; Callum 2007).

While the influential T.H. Huxley and other fishery experts have become infamous for their belief in unlimited fish abundance relative to fishing impacts, Grant Head (1976) and other scholars of the Newfoundland fishery (Innis 1954; Cadigan 1999a, 1999b; Hutchings *et al.* 2002) have noted that fishers and merchants were concerned about cod exhaustion as early as the eighteenth century. Cod became increasingly scarce relative to Merchant demand in the nineteenth century, and by the last half of the century international debates erupted over the cause of fluctuations in fish landings and the potential for fishery exhaustions. The cod fishery fluctuated wildly in Newfoundland from 1815 to 1836 when landings for merchant exchange declined as cod became increasingly hard to locate and catch in inshore waters (Innis 1954; Hutchings and Myers 1995). This led many fishers to adopt new fishing technologies (jiggers, seines and long line trawls) as opposed to the traditional baited hand line method and to spatially shift their fishing effort north onto less exploited inshore grounds in Labrador and seasonal offshore grounds (Cadigan and Hutchings 2001; Ommer 2002; Bavington *et al.* 2004).

These technological and spatial responses to the decrease in cod abundance, however, were reluctantly adopted and in many cases actively resisted by fishing people in the latter half of the nineteenth century (Innis 1954). The scarcity of fish relative to merchant-demand led to heated debates on what to do about the fluctuations and the possibility that cod abundance may become permanently exhausted (Cadigan 1999ab). Inshore fishers and some merchants complained to colonial administrators and government officials that new fishing technologies, such as cod seines, long-lines and jiggers, were a threat to the moral fabric and the delicately balanced mercantile economic order, and the moral economy of fishing as a unique way of life (Cadigan 2003).[1] These new fishing gears, it was argued, killed and injured both juvenile and 'mother' codfish encouraging viceful fishing practices that resulted in wasteful harm to the fish and growing inequality between fishers using the new fishing technologies and those who could only afford or access the traditional baited hook and hand line gear (Government of Newfoundland 1849; Innis 1954; Cadigan 1999ab). Ongoing declines in landings, and fluctuating catches in the 1850s 'forced the temporary withdrawal of credit by merchants' resulting in extreme poverty and social instability in the outports, creating pressure on the Newfoundland government to actively intervene in the fishery (Ommer 2002:25). The government responded by establishing a fisheries inquiry that proposed laws regarding the size and use of herring seines (herring were used as bait in longline cod trawls), 'and ... an omnibus act to protect the fish – the Rorke Bill of 1863, which was dropped the following year out of fear of falling exports' (Ommer 2002:26). By 1889 a Fisheries Commission was created by the newly established Responsible Government[2] to respond to the ongoing fishery crisis and regulations were instituted to protect immature and spawning codfish, reflecting the suggestions of fishermen who testified to the commission (Hutchings *et al*. 2002:153).[3] While the regulations eventually became statutory law with 'legal precedence over local customs ... the capacity of government to enforce statutory law was limited [and] ... there were persistent violations of the ... regulations' (Hutchings *et al*. 2002:154).

Even with the subsequent development of a Fisheries Department, fishery laboratories, scientific research on cod migration, and even the artificial propagation of cod through a hatchery in Newfoundland, fisheries regulations up to the late 1940s were 'more related to orderly fishing than to conservation or control of total fishing effort and catches' (Vardy and Dunne 2003:108). The regulations that were established by the Newfoundland Fisheries Commission and the first Fishery departments were difficult to enforce and ultimately failed to save profitability in the mercantile capitalist system and outport communities faced a constant threat of hunger and grinding poverty well into the early twentieth century (Ommer 2002).

Fluctuations and failures in the Newfoundland cod fishery and other marine fisheries around the world became a serious problem for governments at the end of the nineteenth century. Flux and uncertainty in marine fish landings spurred demands for a new field of fisheries science to produce instrumental knowledge amenable to long term productivity and stability in landings to ensure the maintenance of economic and social order amidst the uncertainty and change brought on by industrial modernization (Smith 1994). Representations of cod that were fit for the new economic needs of modernity became the order of the day (Apostle *et al.* 1998). As fisheries historian Tim Smith (1994:21) explains:

> The fluctuations in … fisheries posed serious economic, social, and hence political problems, and in each fishery early steps were taken to scientifically study the causes of the fluctuations. The many specific explanations involved four general processes – migration, predation, pollution, and overfishing – each of which has been invoked time and again since the turn of the century to explain fluctuations of fisheries around the world.

Early explanations in Newfoundland for fluctuations in the cod fishery involved a plethora of observations and arguments from natural historians, fishers, merchants, citizens, and government leaders, as the cod fishery became a serious matter of concern (Cadigan 1999ab). Despite a spotty historical record with little evidence of the views of women and other unpublished opinions; the arguments, and explanations that were recorded illustrate a diversity of perspectives on the 'nature of cod', especially on the question of cod migratory behaviour (see Hutchings *et al.* 2002).[4] The public record in Newfoundland and the United Kingdom included debates about the relative contribution of fishing to overall fish mortality, the number of 'races' of cod, the migration patterns of the fish, and the relative importance of pollution and predators, as well as the dangers posed by new technologies such as cod seines, cod traps, jiggers, longlines, and draggers (Government of Newfoundland 1849, 1863).

While these opinions on cod abundance reflected deep concern and experiential knowledge of fish and fishing, they did not produce a type of knowledge that governments could effectively use to solve urgent economic and political problems associated with landing fluctuations and global market instabilities. As early as the 1860s governments began to fund scientists to study the problem of fisheries fluctuations, to test the wide variety of contradictory explanations that had been developing among scientists, fishermen and other citizens, and to deliver practical advice that would help maintain productivity and most importantly, profitability, in the cod fisheries.

Throughout the latter half of the nineteenth century a number of scientists, including the University of Toronto geographer H.Y. Hind in 1876, gave advice on how to respond to the decline of the inshore cod fisheries in Newfoundland and Labrador. Hind, like most other fishery scientists at the time, believed that 'the means for reproduction of the cod resources of Labrador and Newfoundland [were] "inexhaustible" and beyond the power of man to injure' (Hind quoted in Hutchings *et al.* 2002:148). Hind advocated extending the spatial extent of the fishery offshore to allow the recovery of inshore cod fishing grounds. Despite a plethora of reports, royal commissions and scientific studies, the rapid development of the scientific knowledge of fishing in the later half of the nineteenth century resulted in few useful answers to governments. In fact,

> Limitations of scientific knowledge resulted in accounts that ... drew heavily on the experiential knowledge of fishers and others directly employed in the fishery. Their observations of differences in size, colour, condition, diet, migration, and the timing and location of spawning were, of course, mediated by their fishing activities [and] ... were also based upon oral transmission of information between generations (Hutchings *et al.* 2002:142).

Just as isolated rural Newfoundland fishing communities would later be relocated and concentrated to make them amenable to industrial development and legible to a state bent on a modernist vision, so too did the vast and diverse experiential knowledge of fishers and wide ranging natural history knowledge about cod require simplification (Scott 1998). Universal causal laws had to be discovered if governments were to obtain knowledge of cod that permitted control and rationalized industrial use. In order to advance industrial modernization and rationally develop the cod fishery into a profitable industry, governments had to simplify and grasp the reasons underlying the cod fishery fluctuations to get a handle on the unmanageable fecundity of wild fish in the sea and the impact of fishers' actions on cod fish abundance. It would take fisheries scientists close to one hundred years to develop knowledge and causal models of the cod fishery that would permit fisheries management to emerge. The shift from diverse qualitative descriptions and opinions on cod abundance in a natural history mode to a quantitative science founded on statistical laws and population thinking facilitated an understanding of fisheries fluctuations and the emergence of a fully developed cod fisheries management regime.

Constructing the Manageable Cod: From Typological Species to Statistical Population

> [T]he development of population thinking within fisheries biology ... was a wrenching process. It is difficult to imagine after the fact how naturalists actually viewed the organic world prior to this paradigm shift (Sinclair and Solemdal 1988:210).

> [T]o discuss the concept of population ... is a difficult task since for most people the term seems today to denote a natural entity, an issue about which neutral statements can be made, an object open to human control and management (Duden 1992:146).

In 1898 the German fisheries biologist Freidrich Heincke published an influential paper that 'encouraged biologists to consider the population as the unit of study, rather than the species' (Sinclair and Solemdal 1988:201). Heincke borrowed the population concept from human demography to develop a powerful quantitative methodology to distinguish marine fish populations.[5] This focus on quantitative biology was revolutionary in its time and by 1930 population thinking had been accepted by most fisheries biologists, zoologists and wildlife agencies. Fisheries research organizations began to apply population thinking to answer questions surrounding fluctuations in marine fish landings in the 1930s.[6] Even though the precise boundaries of fish populations were difficult to determine and measurements were often restricted by political and practical considerations, the switch from qualitative typological species descriptions to quantitative population analysis permitted the emergence of a demographic paradigm in fisheries biology that held out the enticing possibility of predicting future catch levels based on objective statistical laws. While the process was slow and cumbersome, involving a number of fisheries biologists and economists, Heincke's conceptualization of fish as members of statistical populations set the stage for the development of bio-economic models of the fishery that permitted the emergence of cod fisheries management and what appeared to be a final solution to the costly problem of fluctuations in marine fish landings.

The use of quantitative methodology was a major accomplishment and detour from the traditional work of natural historians and marine biologists who had, according to Heincke, 'a pronounced aversion toward measurements and numbers' (Heincke 1898 quoted in Sinclair and Solemdal 1988:195). Heincke suggested that this pronounced aversion to numbers and mathematical models had to be transgressed if knowledge of nature's laws and the advancement of practical scientific fisheries research were to occur.

> This aversion is admissible when it is a manner of gaining a quick overview about the manifold varieties of organic forms, and is pardonable when the pleasure of the composing artist in the beauty and variety of forms and in his fanciful conceptions is greater than the sense for exploration of the analytical scholar; but this aversion toward measurement and numbers, which at times is heightened into contempt, is incomprehensible, inadmissible, and unpardonable when the scholar demands that his labours be regarded as a contribution to the knowledge of the true laws of nature (Heincke 1898 quoted in Sinclair and Solemdal 1988:195).

Heincke was the first person to apply statistical methods to biological types other than human beings and applying quantification techniques in marine biology led to significant practical advances in knowledge and a quantitative revolution in the field inaugurating the birth of fisheries research as an applied science (Jansen 2000). Heincke found that variability in many of the morphological characteristics of the North-eastern Atlantic herring he studied were distributed following normal curves that accordingly obeyed the laws of probability allowing populations to 'be identified by the use of single characteristics, and individual membership by his method of least squares of combined characteristics' (Sinclair and Solemdal 1988:195). Heincke's call in 1898 for marine biologists to adopt population thinking and embrace measurement and numbers in their research methodology led to the birth of modern fisheries science and made the field crucial for governments interested in solving the fluctuating-landings problem. The development and spread of population thinking in fisheries biology from 1880 to 1930 fundamentally altered how nature was understood and perceived. From natural history and the typological species of Aristotle and Linnaeus that emphasized qualitative descriptions of ideal types, a Darwinian view of the world emerged in fisheries biology that placed the emphasis on variability, evolutionary change and the disciplined analytic search for statistical natural laws.

It was not until after World War II that a theory amenable to fisheries management emerged. By 1950, fisheries scientists had largely abandoned qualitative description and were concentrated on quantitative measurements and the application of statistical modeling tools, not only to identify but also to explain and influence the dynamics of single species fish populations exposed to different levels of fishing pressure. Fish populations were eventually represented as self-regulating systems tending toward equilibrium, whose fluctuations were determined by relationships among interacting variables such as reproduction, individual growth rate, natural mortality and fishing mortality (Wilen 2004). Building on a number of partial theories on the dynamics of fish populations under exploitation, in 1957 Beverton and Holt published a groundbreaking model that allowed scientists to predict future sizes and yields of fish stocks under different catch regimes using readily available data. By assuming that fish populations were reasonably stable over time and that they behaved predictably under moderate levels of exploitation, the Beverton and Holt model permitted the calculation of optimal yields from any fishery (Holm 1996).[7] By controlling the amount of fish killed due to fishing, Beverton and Holt (1957) argued that fish populations could be constructed to produce maximum sustainable yields. No longer was fishing, with all its various techniques, to be seen solely in a positive or negative light, in the influential population dynamics models of Beverton and Holt and other fishery scientists, heterogeneous types of mortality caused by fishing were aggregated and came to be seen as a single *variable* which, if controlled and carefully used, would directly influence the productivity of fish populations and the profitability of seafood commodities.

The statistical description of fish as aggregated members of reproductively separate populations eventually produced models that allowed governments to believe they could finally control fishery fluctuations and pursue socio-economic development goals associated with modernizing and rationalizing fishing as an industry. For the first time in history, cod appeared to be manageable objects – statistically determined aggregations of self-sustaining groups of wild fish that persisted in particular geographical areas over ecological time scales, whose productivity could be influenced by carefully using fishing to kill a specified amount of surplus biomass from separate, identifiable fish populations. Rather than relying on the diverse observations of fisher-folk, complicated and expensive to enforce local fishing rules tied to specific gear types, and the uncertainty of inshore cod migrations, by the 1950s governments were presented with scientific knowledge of cod abundance offshore and quantitative tools to calculate optimal industrial fishing levels. Scientific fisheries management promised to put an end to fluctuating landings and the political and economic problems that accompanied them.

In Newfoundland and Labrador, population-based management units for northern cod were established from 1932 to 1978 by the International Commission for the Northwest Atlantic Fisheries (ICNAF) which later became the North Atlantic Fisheries Organization (NAFO). Debates around the relative homogeneity of northern cod populations, the scale at which statistical data should be collected and how boundaries should be drawn for fisheries management zones were intense throughout the early history of ICNAF and NAFO and continue up to the present. Ultimately, they were determined by pragmatic considerations associated with collecting statistical population data to permit quantitative modeling over time (Halliday and Pinhorn 1990; Lear and Parsons 1993). Despite the presence of scientific evidence indicating complex inshore and offshore migration routes, stock mixing, and diverse spawning patterns, large scale management zones emphasizing enormous aggregated offshore northern cod populations became institutionalized (Halliday and Pinhorn 1990).

While several proposals to redraw cod management boundaries to recognize the existence of separate inshore and offshore cod populations were proposed throughout the 1950s and 1960s, the expense and difficulty of collecting accurate statistical data in numerous small management zones, as well as the significant modeling benefits of maintaining historically consistent boundaries that permitted inter-annual statistical comparison, led to the maintenance of large scale northern cod management zones based ultimately as much on lines of latitude as the life history of cod, their complex stock structures, or their annual migration routes (Halliday and Pinhorn 1990; Hutchings *et al.* 2002) (Figure 1).

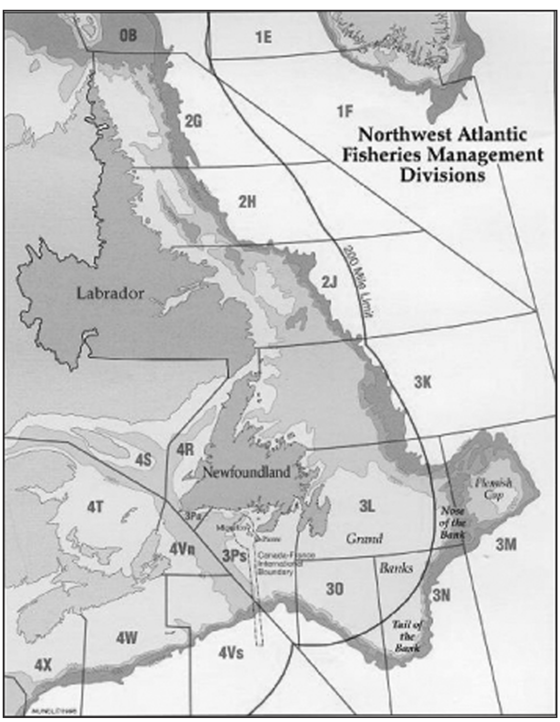

Figure I Northwest Atlantic Fisheries Organization (NAFO) fisheries management zones (MUN 2005).

Fisheries management zones for *Gadus morhua* aggregated inshore and offshore populations assuming that all cod followed capelin in the spring from offshore banks to inshore waters and that all spawning took place randomly within the specified management zones on the offshore banks after cod had migrated back from inshore waters in the autumn (Hutchings *et al.* 2002). The above assumptions allowed northern cod to be conceptually domesticated and grasped, symbolically represented as numbers that could be calculated and manipulated safely in models on land while actual cod swam freely in the wild North Atlantic.

Representing Fish and Fishermen as Elements in Bio-Economic Systems

Population dynamics models were a powerful invention that promised the possibility of not only controlling fluctuations in landings but optimizing the productivity of cod populations. However, the models required actual fishermen and women to adjust their fishing activities to come in line with what the models suggested. To avoid a tragic case of misplaced concreteness, fish, fishermen and fishing had to be made to fit the abstract categories and statistical relationships imagined by fisheries scientists to be universal natural laws. To achieve maximum catches, the population models proposed what was at the time a counterintuitive notion – that less fishing would lead to greater landings over the long term.[8] While fisheries biologists had identified demographic laws and self-organizing feedback relationships among individual growth, reproduction, natural mortality and fishing mortality rates that determined cod population sizes over time, there was little scientific understanding of how fishing people behaved when they hunted for cod.

> The major obstacle for management at this time was that [fisheries models] ... treated the fisherman as an external factor. This would not have been a problem if the fisherman automatically had followed the scientists' advice reducing their efforts to the level where the yield would be optimal. Such was not the case, however (Holm 1996:180-181).

In the 1950s fisheries biologists began to lament the growing competitive element in the fishing industry that made it 'difficult if not impossible for the industries to regulate themselves to obtain a more favorable balance' (Beverton 1952:11). While self-regulating feedbacks between reproduction, growth, and natural mortality had been discovered in fish populations and the impact of various levels of fishing mortality on these variables could be calculated to determine the level of fishing that would result in maximum sustainable yields, the behaviour of the humans that imposed fishing mortality on populations had not been theorized. Economists addressed this problem in the early 1950s by arguing that the costs of fishing and the behaviour of individual fishermen could be quantified and dynamically related to the other elements in population models. The Canadian economist H. Scott Gordon led the way in proposing the integration of fishers' behaviour into biological models arguing that 'the large numbers of fishermen permit valid behavioristic generalization of their activities along the lines of the standard economic theory of production' (Gordon 1953:128). By modeling fishers as rational profit-seeking individuals operating with free and open access to productive fish populations and linearly increasing fixed unit costs for their boats and gear, Gordon developed an influential systems model that illustrated how human fishing activity was 'behaviourized or determined' by interacting elements in a mutually interdependent bio-economic system (Figure 2) (Smith 1994:335). The demographic statistical laws that accompanied population thinking had been joined up with what were assumed to be natural economic laws associated with competitive human behaviour.

This quantitative representational model combines Gordon's assumptions on the behaviour of statistically significant groups of commercial fish harvesters with Schaefer's population surplus production model. The model illustrates how a fish population will develop under different fishing intensities given the assumption that each effort level results in a stable population size and a stable reproductive output. E_{msy} = The level of fishing that produces the maximum output or catch, indefinitely. After the MSY point is passed the fish population's ability to reproduce itself starts to fall and catches decline. E_0 = Under the assumption of free access to the fishery and rational profit-seeking fishermen acting independently beyond any commons, effort will increase up to E_0. Beyond E_0 the economic profits are zero, and there is no economic reason for fishing to continue using any gear. These two extreme statistical data points (E_{msy} & E_0) allow fisheries managers to present what appear to be objective boundaries to guide managerial interventions. If you want to plan for maximum human food supplied you harvest fish up to the MSY, for maximum profits you kill fish up to the MEY (Maximum Economic Yield) level—the point maximizing resource rent. To get to either of these harvest rates or model points, parameters of the model, and actual real fish and fishing people must be changed (Holm 1996).

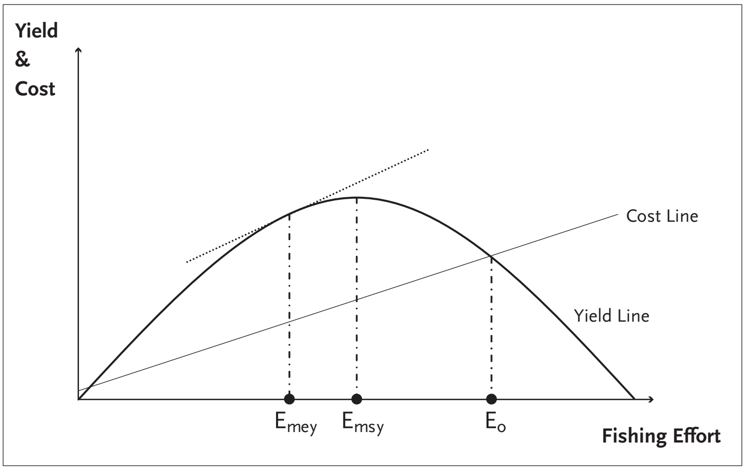

Figure II Adapted Gordon-Schaefer Model (Adapted from Smith 1994 and Holm 1996).

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Gordon's bio-economic model revealed the need for fundamental changes in how fishing was organized and conducted. He argued that the management goal of maximum sustainable yield (E_{msy}), promoted by fisheries biologists, was economically irrational because it did not take into account the costs of fishing nor the need for reasonable profits for those engaged in hunting fish (Gordon 1953). Somewhat ironically in hindsight, it was a Canadian economist, not a biologist, who advised killing less fish, so one could earn more profit off commercial fish populations. Gordon's model also suggested that government regulation would not be needed to avoid over-fishing because fishing effort would eventually regulate itself as rational profit-seeking fishermen realized that the cost of removing fish from sparse populations exceeded the profits they were able to obtain (see Figure 2 – E_o). Gordon argued, however, that both E_{msy} and E_o were suboptimal and he promoted the idea of maximum economic yield (E_{mey}), arguing that the fishery should be controlled and carefully managed to maximize the resource rent – the profits gained from fishing after the costs of hunting the fish and returning them to port were subtracted from their landed value (Figure 2).

The expanding competition in the cod fishery that concerned fisheries biologists in the 1950s, and which formed the underlying assumption of profit seeking human behaviour in Gordon's bio-economic models, was directly tied to the effects of industrial modernization and was contested by inshore fishermen from the beginning. The gradual industrialization of the inshore fishery and the arrival of foreign offshore draggers on the Grand Banks in the post-World War II period dramatically increased the ability to locate and kill codfish.[9] Adding to the competition associated with new fishing technologies was a rapid shift away from the delicately balanced subsistence-merchant economy towards a reliance on wages and cash in an expanding market economy that left fishers and their families with decreasing access to merchant credit and their traditional adaptive strategies associated with occupational pluralism. For those who remained in the modernized fishery, technological abilities and economic pressures to catch fish and turn them quickly into cash before they were killed and sold by someone else threatened to both over-exploit cod populations and result in poor fishers who spent more to win the race to kill fish than they could earn from selling the fish when they returned to shore (Holm 2001).

To obtain the maximum sustainable yields promoted by biologists, or the maximum economic yields advocated by the economists, the fishery had to change. Bio-economic models pointed to several ways that the fishery could be altered to achieve maximum yields (E_{msy} or E_{mey} in Figure 2); however, all of the proposals required fundamental changes to the centuries old Freedom of the Seas law – *Mare Liberum* (Holm 1996).[10] In order to obtain maximum yields, economists argued that fish populations had to be owned as if they were swimming inventories. Without ownership there was no incentive for fishers to act in an economically or biologically rational way and bring their fishing effort in line to achieve maximum yields and profits. Ownership would *produce* the predictable, economically rational fishing behaviour *assumed* in the bio-economic models to exist in the human nature of each and every fisherman. However, economically rational fishing behaviour was impossible to achieve if access was freely available to all to eat and exchange fish. If fish populations were not owned, it was argued, there would be a race to fish, and a tragedy of the commons would ensue.[11] However, if fish populations were owned by a single powerful state actor with the power to exclude others from fishing, maximum economic or sustainable yields could be obtained indirectly through the imposition of resource or effort taxes, or directly by limiting access and effort in the form of quotas, licences or gear restrictions. According to the bio-economic models an unmanaged 'fishery left to itself will always be suboptimal. The structure of the situation thus requires external intervention' (Holm 1996:182).

After one hundred years of state-sponsored fisheries research, by the 1960s scientists had finally provided governments with knowledge of how to profitably control landing fluctuations in cod. By representing fish as statistical populations and developing quantitative bio-economic models, they were able to predict future biomass abundance under a variety of fishing regimes and give advice to governments on the most optimal fishing levels for given biological or economic goals. National governments, however, were unable to implement fisheries management because they did not have the right under international law to take ownership of fish populations beyond their small territorial sea zone that only extended to three miles offshore. The bulk of the cod and other marine fish populations were identified as being located far offshore on the continental shelves up to 200 miles from land. For effective cod fisheries management to exist, the knowledge of scientists had to be connected with vast new territorial powers that granted property rights and ownership responsibilities to the Canadian state.[12]

On January 1st 1977, Canada declared a 200 mile Exclusive Economic Zone (EEZ) off its east and west coasts – overnight the majority of the Northwest Atlantic cod populations fell within Canada's national territory (Lear and Parsons 1993). Canada justified the massive extension of its national territory in the name of creating the conditions for effective fisheries management. If the tragedy of the commons was to be avoided among fishing vessels on the fishing grounds and among states around the international negotiating table, national ownership of the cod populations had to be established beyond three miles. Once ownership was vested in the Canadian State, the knowledgeable scientific representations of fisheries biologists and economists could be linked up with the power of the state to produce effective fisheries management interventions that would put an end to fluctuations in profits and the threat of overfishing (Holm 1996).

While total allowable catch (TAC) limits for northern cod in 2J3KL (see Figure 1) had been introduced by the ICNAF in 1973, they were extremely difficult to enforce, compliance was voluntary, and the ICNAF did not possess the capability or legal right to enforce its recommendations leading to frequent violations of the recommended TAC (Lear and Parsons 1993). Once Canada declared its EEZ, the newly established federal Department of Fisheries and Oceans (DFO) immediately reduced total allowable catch levels and enforced a significant drop in cod fishing activity to permit cod populations to rebuild (Finlayson 1994). DFO eventually established quotas, licences, and gear restrictions for the cod fishery to bring landings in line with TAC levels that would produce maximum yields (Lear and Parsons 1993).[13] Once the foreign fleets had been removed from Canada's EEZ, the Federal and provincial government began subsidizing the development of a domestic offshore cod fishing fleet to permit the development of a year round harvesting and frozen processing industry in Newfoundland and Labrador (Vardy and Dunne 2003). Population survey data from the offshore and predictions of population rebuilding from bio-economic models indicated that huge surpluses of cod would become available to be caught by the 1980s (Finlayson 1994). The rules surrounding the EEZ dictated, however, that any surplus cod which was not removed by Canadian fleets had to be made available to NAFO members.[14] This stipulation encouraged the rapid growth of Canadian fleets to capture as much of the TAC as was feasible.

After declaring the 200 mile limit, Canada had finally created the conditions to implement an effective fisheries management regime. While inshore fishers complained of declining catches in the early 1980s (when cod populations had supposedly recovered) offshore surveys reported increasing catch-per-unit-efforts, indicating that cod populations had rebuilt and were abundant offshore. The complaints from inshore fishers of declining catches were assumed to be caused by changes in cod migratory behaviour, hypothesized to be the result of changes in water temperature and salinity that supposedly were blocking their migration inshore. Furthermore, the bulk of the northern cod populations were assumed to be located on the offshore banks and all indications from scientific surveys and data from the offshore commercial fleet indicated that cod populations were abundant and able to sustain large TAC levels. The abundance of cod offshore led fisheries management efforts to focus on regulating the offshore fleet with the introduction of licensing, quota allocations, gear restrictions, and seasonal limits. Management measures came later to the inshore and received less attention compared to the highly productive, profitable, and tractable offshore cod populations and fishing fleets.

By the 1980s, the development of cod fisheries management had resulted in a 'silent revolution' in Newfoundland and Labrador.[15] All indications were that wild cod, fishermen and fishing had been effectively managed, represented as quantifiable elements in predictable and controllable population dynamics models. The identities of both cod and fishing people as well as the practices of fishing that brought them together had 'been deeply transformed' (Holm 2001:10). The birth and development of cod fisheries management from Heincke's original scientific studies of fish populations in the 1880s up to and including the modern bio-economic models had all occurred in tandem with rapid industrial modernization. The number of people hunting cod fish for a living in Newfoundland, the tools they used, and the numerous sparsely populated outport communities they had once lived in had all dramatically changed.

> [Before fisheries management] ... a major barrier for those who wanted to be fishers had to do with the physical and mental hardships of this occupation. Becoming a fisher entailed the hardening of body and mind to tolerate long working hours and gruelling physical exertions, long periods away from home and family, great risks to personal safety and health. While many fishers nowadays suffer similar hardships, prospective fishers are also forced to cross barriers of a different kind, like the bureaucratic jungle

> of rules and procedures that must be negotiated in order to become owners of fishing vessels and holders of licenses and quotas (Holm 2001:10).

The cod had changed too. Before the advent of fisheries management, cod were understood as a free species embedded in an uncommodified common ocean – nobody owned cod until they were hunted down and pulled onboard a fishing vessel. After the spread of population thinking, the development of population dynamics models and the establishment of the 200 mile EEZ to permit effective fisheries management, northern cod became members of large swimming inventories whose current and future biomass and economic value could be assessed onshore long before any cod were killed by a fisherman or had spawned offshore. Managers in St. John's or Ottawa need not ever set foot on a fishing boat to control fluctuations in landings – by modeling cod populations, fishers and the relationships among them, productivity could be planned into existence from a 'center of calculation' (Latour 1987). The establishment of fisheries management changed the identity of fisherpersons from fish killers, hunting a wild species on the edge of modern society, to professional fish harvesters, licensed owners of cod biomass, attempting to run profitable businesses in the midst of a globally integrated seafood market. The establishment of fisheries management also changed the knowledge that was considered important to enable fishers to carry out the practice of fishing.

> Even if you are a successful fisher, that does not qualify you as a fish expert. After the breakthrough of fisheries resource management, the fish expert is unequivocally a scientist, usually a natural scientist trained in fisheries biology and oceanography. It is no longer the practical knowledge of how to find and catch fish that equals expertise, but the command of scientifically certified methods and models designed for measuring and predicting the size of fish stocks (Holm 2001:11).

However, despite all of these changes and the managerial perception that wild cod had become known populations and that cod fishers interacted with them as if they were predictable economic actors, fisheries management was ultimately based on assumptions that wild cod and fishing people had no interest in or obligation to obey. Natural laws and bio-economic models thought to accurately describe real codfish, fishermen and fishing activities turned out to be fatally inaccurate abstractions.

The Managed Annihilation of *Gadus morhua*

> The population activities launched since the 1960s have turned out to be dreams that brought forth monsters (Duden 1992:155).[16]

> … the Atlantic Canadian groundfish stocks have collapsed, despite the presence of an elaborate stock assessment and management regime (Hutchings *et al.* 2002:140).

In 1988, after numerous scientific studies and governmental inquiries into the northern cod fishery, persistent claims from inshore fishermen that TACs were being set too high (Finlayson 1994), and an independent academic assessment of DFOs stock assessment data (Keats *et al.* 1986), the federal Minister of Fisheries and Oceans ordered an official report to review the estimates of northern cod abundance that had formed the basis of Canada's cod fisheries management regime. The resulting Alverson Report claimed that while northern cod populations had increased since 1977, the stock assessments had massively overestimated the status of northern cod populations in 2J3KL (Figure 2). This shocking admission of error, from a government sponsored report, resulted in a northern cod enquiry called the Harris report which published its findings in 1990. After taking into consideration both the biological and employment implications of a cut in cod landings the Harris report recommended a modest reduction in TAC levels from 235,000 to 190,000 tonnes (Harris 1990). However, 'during the 1992 fishing season it became apparent that there was little left to catch. The situation was far worse than even the most pessimistic projections' (Macgarvin 2002:22). On July 2, 1992 after the Canadian offshore dragger fleet was unable to find enough cod to even come close to meeting their quotas, Federal Fisheries Minister John Crosbie was forced to announce the closure of the northern cod fishery after close to 500 years of uninterrupted fishing activity. The closure of the fishery resulted in massive social upheaval and a significant de-legitimization of DFO's population dynamics models, leading to a plethora of critiques of fisheries management and a reassessment of the assumptions in the models used to manage the fishery.

The careful creation of a world-renowned cod fisheries management system originating with the work of Sars in Norway in the 1860s, Heincke's population thinking at the end of the nineteenth century, the bio-economic systems models of the 1950s, and the declaration of a 200 mile EEZ in 1977 had tragically produced what it was designed to prevent. Rather than bringing stability to fish landings, management had eliminated landings altogether.

Cod are now coming back in Newfoundland and Labrador as a domesticated species. The development of industrial cod aquaculture exemplifies what conservation biologist Gary Meffe calls techno-arrogance, the ultimate outcome of which 'is the increasingly intensive and essentially perpetual management of a multitude of species in a world unfit for their natural existence' (Meffe 1992:354). Without critical attention to the idea of management, real fish and fishermen run the risk of being totally replaced by manageable abstractions.

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Notes

1 Sean Cadigan (2003:15) documents how ' Early nineteenth-century fishers fought to preserve a customary and equitable right of access to fish for all as it became clear that the growing harvesting capacity of the industry threatened the availability of the marine resource for future generations. The preservation of equitable access was an ecological norm of a moral economy that ran counter to the individualistic and accumulative values of a nascent local capitalist political economy.'

2 Newfoundland was granted democratic ' Responsible Government' and political independence from Britain in 1888 and was an independent commonwealth Nation until 1934 when the Newfoundland government requested the United Kingdom to install a ' Commission of Government' ruled by unelected appointed commissioners to rescue Newfoundland from social unrest brought on by bankruptcy associated with the debts the nation incurred during World War I and the economic crisis brought on by the Great Depression that compounded periodic failures in the fishery.

3 The 1890 regulations established by the Fisheries Commission were quite broad and aimed at protecting spawning ' motherfish' and juveniles as indicated by the following quote from the Journal of the House of Assembly, 1890: ' No person shall, in the following harbours in Placentia Bay, namely: Paradise Sound, Boat Harbour, and Roger's Harbour, use any bultow [longline trawl], cod-trap, cod-seine or any contrivance, except hook-and-line, for catching codfish, under a penalty of one hundred dollars, and confiscation of such contrivance hereby prohibitied' (JHA 1890 *quoted in* Hutchings *et al.* 2002:154).

4 While there is ample evidence of a rich discussion of this issue in the press and in government reports of the time, the observations are biased toward those of men, since women's perspectives and observations had little means of written expression at the time. This prevents an understanding of the opinions of those who salted and dried the fish onshore who were predominately women (Bavington *et al.* 2004).

5 In hindsight it is interesting to note that managerially relevant fisheries biology originated by borrowing a methodology from the social sciences at the end of the 19th century. At the end of the 20th century social scientists would complain that their disciplines were not having enough influence on scientific fisheries management.

6 In the book *Imperial Ecology*, Peder Anker (2007) shows how population thinking was encouraged through funding from governments, rich industrial benefactors, the Hudson's Bay Company and other imperial ventures to predict boom and bust cycles in the availability and price of staple commodities like fish and fur bearing wild animals.

7 Beverton and Holt stressed the balanced, steady-state tendencies of fish populations in their population dynamics models and described their approach as relating to the general systems thinking of von Bertalanffy (1950) and the mathematical methods of operations research that had developed out of experiences in World War II (Smith 1994). Beverton and Holt (1957:23) noted that, ' One essential aspect of this synthesis is the recognition of a fish population or community of populations as a self maintaining *open system*, exchanging materials with the environment and usually tending toward a steady state.' Their theory focused on what they termed ' self regenerating population models, adapting a term used by radio engineers to describe a system which ' feeds back into itself' (Beverton and Holt 1957:63 *quoted in* Smith 1994:326).

8 The counterintuitive connection between fishing effort and cod landings was first noticed in Europe when large catches of groundfish species rebounded in the North Sea immediately following the end of the two World Wars. Large catches immediately following the end of conflict, suggested that lowering fishing efforts over the short term could produce larger yields over the long term (Smith 1994).

9 Beginning in the early 1950s factory freezer stern trawlers arrived to fish for cod on the offshore banks as well as in inshore Newfoundland waters, sometimes inside the three mile territorial sea (Hutchings *et al.* 2002). ' Between the 1950s and the late 1960s, the total [reported] catch of Northern cod by all countries almost tripled, reaching an historic maxi-

mum of 810,000 tonnes in 1968' (Hutchings and Myers 1995:58). The 1968 cod landing is often referred to as the killer spike.

10 *Mare Liberum*, or the Freedom of the Seas principle, was codified by the Dutch born Hugo Grotius in 1633 with reference to the freedom of the Dutch to take part in the lucrative marine trade with East India. The principle was first established by the Romans and it gave unrestricted use of non-territorial seas for naval and commercial navigation and fishing in times of peace (Grotius 1633).

11 Hardin's (1968) Tragedy of the Commons argument was extremely influential in cod fisheries management and the warnings contained in his 1968 article appeared to be playing out exactly as he predicted in Newfoundland and Labrador. It is a sad coincidence that 1968 saw the largest landings of Northern cod ever recorded as numerous national fishing fleets competed to land over 800,000 metric tons of cod on the fishing banks off Newfoundland and Labrador.

12 As Petter Holm (1996:182) observes, fisheries management ' builds on a partnership between science and the state. Science must establish the facts: how large are the stocks? Which effort level will give the optimum return? The state must, besides funding science, regulate the fishermen's activities and prevent them from destroying their economic basis.'

13 TAC levels were eventually set at the $F_{0.1}$ level which were originally ' developed in ICNAF as a more conservative replacement for the concept of Maximum Sustainable Yield (MSY) as a management goal' (Finlayson 1994:29). DFO (1988:22 *quoted in* Finlayson 1998:29) defined the concept in the following way: ' ...$F_{0.1}$ is the level of fishing effort at which adding one more boat would result in increasing the total catch by only 10 percent as much as the very first boat to fish that stock... $F_{0.1}$ is a useful idea in fisheries management because it does two things the old 'maximum sustainable yield' did not. It takes some account of the economics of fishing and it leaves a wide margin of biological safety.'

14 NAFO, the North Atlantic Fishery Organization, replaced the ICNAF in 1979 as the lead international agency responsible for Northern cod management beyond the national 200 mile limit.

15 The term ' Silent Revolution' is borrowed from Petter Holm's (2001) dissertation title of the same name. He used the term to designate the revolutionary transformations that followed the introduction of fisheries management into the Norwegian cod fishery at the end of the 1970s.

16 While Duden (1992) is describing human population control programs launched in the developing world, in retrospect the population models applied to Newfoundland and Labrador cod fisheries appear similarly monstrous in their effects.

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