

Ocean frontier assemblages: Critical insights from Canada's industrial salmon sector

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Abstract

The ocean frontier has become central to a range of new and emerging strategies aimed at realizing the potential of the ocean economy. The purpose of this paper is to critically examine the configuration of the ocean as a frontier and its role in transforming marine spaces through the case of salmon aquaculture in Canada. To this end, we engage with 'frontier assemblage', an analytic that is developed from scholarship on agrarian and extractive resource frontiers in Asia. We use this approach to identify and extend three interrelated conceptual sensibilities. First, we use 'frontierization' to suggest that ocean frontier spaces are not only articulated at leading edges. Instead, frontierization happens at indeterminate sites, including those that have undergone earlier rounds of capitalist resource extraction. Second, we explore how ocean frontier resource extraction is assembled in ways that are indeterminate, but not radically open. Using the case of salmon aquaculture in Newfoundland, we show how resource extraction could have been 'otherwise'. Third, we critically assess the promissory politics that are key to the ocean frontier. We argue that the frontier assemblage analytic—and the sensibilities we use—provides an approach to critically assess strategies aimed at realizing the 'untapped' resources of the ocean frontier.

KEYWORDS

aquaculture, Canada, frontiers, ocean economy

1 | INTRODUCTION

Like the space race decades ago, there is another frontier at our doorstep that, despite having all the tools to unlock its potential, remains vastly under-utilized. The ocean's economy is growing and the world is begging to notice ... Canada can lead the blue economy (Moran, 2016).

The idea that the ocean represents a frontier is not new (Rozwadowski, 2018). Yet the configuration of the ocean as a frontier has become central to recent global, regional and national strategies that are aimed at developing the marine economy (Childs & Hicks, 2019; Choi, 2017; Silver et al., 2015). In these strategies, some of which are connected closely to the idea of the Blue Economy, and the ocean is framed as a space of untapped resources ready for extraction, commodity production and capital accumulation [e.g., Department of Fisheries and Oceans (DFO), 2021]. Indeed, recent policy formulations see the ocean as 'a space of *opening*' (Steinberg, 2018, p. 237, emphasis in the original), and they aim to 'harness' the ocean's massive resource potential to support global economic growth (Barbesgaard, 2018; Satizábal et al., 2020; Winder & Le Heron, 2017). The Canadian province of Newfoundland and Labrador (NL) and its salmon aquaculture industry provides an excellent illustration of how the ocean-as-frontier has become a way of 'unlocking' the economic potential of marine resources. In a context where environmental challenges, public protests and moratoria on new licences are slowing salmon aquaculture expansion elsewhere in Canada, Newfoundland is widely described as the leading edge of the salmon aquaculture frontier in Canada and, perhaps most dramatically, as 'the last frontier for salmon farming growth' (Sapin, 2019, p. 1). Indeed, this most easterly Canadian province has now positioned itself as open for business in direct contrast to other provinces where public pressure and environmental problems have led to moratoria on new licences or commitments to phase out open net pen aquaculture altogether, as is the case in parts of British Columbia (BC) (Sapin, 2019). The Newfoundland case of salmon aquaculture, which we explore in more detail below, provides a revealing illustration of how the ocean frontier has become the basis on which the marine environment is being shaped and reshaped for resource extraction and capital accumulation.

Much of the critical scholarship on the ocean frontier has drawn productively on Jason Moore's (2015) commodity frontier approach. Indeed, the commodity frontier framework—with its emphasis on capitalism 'as a way of organizing nature' that exhausts but then continually seeks out new frontiers of ecological surplus (Moore, 2015, p. 14)—has proven to be a very effective way of exploring capital accumulation through wild capture fisheries (Campling, 2012; Campling & Colás, 2021) and its complex relationship to a rapidly emerging industrial aquaculture sector (Ertör & Ortega-Cerda, 2019; Saguin, 2016). The work on industrial aquaculture is theorized as 'a spatial and sectoral frontier to industrial capture fisheries that enrolls new places, practices and environments in fish production' (Saguin, 2016, p. 588). Through Moore's framing, the rapid expansion of industrial aquaculture illustrates capital's efforts to find new frontiers for the production of fish through commodity widening and then subsequently through commodity deepening as production intensifies at existing sites. This work has also revealed the deep social transformations that have followed from commodity widening and deepening (see especially Saguin, 2016) and the 'blowback' from systems of production that lead inevitably to ecological crises (Bustos-Gallardo & Irrázaval, 2016; Irrázaval & Bustos-Gallardo, 2019).

The scholarship on industrial aquaculture, drawing on Moore's framework, has emphasized commodity widening and commodity deepening as key to how this sector is producing new frontiers for appropriation in countries like Turkey, the Philippines and Chile. Somewhat less developed in this research is what Moore (2015, p. 63) identifies as a 'repertoire' of strategies that are critical to the production of frontiers 'that cannot be reduced to economic relations but are enabled by a mix of science, power and culture'. Moore (2015, p. 63) acknowledges that his mix of science, power and culture represents a 'blunt instrument' but argues that these are crucial to the production of commodity frontiers and thus, to the broader analysis of capitalism as a world ecology. Significantly, they provide the basis for acknowledging the role of science and technology in creating the conditions for ecological surplus at particular historical conjunctures (Baglioni & Campling, 2017; Neimark & Healy, 2018).

In this paper, we hope to ‘sharpen’ the repertoire of strategies that Moore identifies as critical to frontier appropriation by engaging with a complementary approach to resource frontiers. We suggest that the frontier assemblage approach (Cons & Eilenberg, 2019) and the sensibilities we identify and extend in the case of industrial aquaculture in Canada provide a way of highlighting this aspect of Moore’s framework. Frontier assemblage is a heuristic that builds on a long tradition of research on capitalist agrarian transformation in Asia (Barney, 2009; Peluso & Lund, 2011; Tsing, 2003). It is offered as an approach to critically examine how sites are transformed for the extraction of resources and the production of commodities (Cons & Eilenberg, 2019). Frontier sites are made or ‘assembled’ to make them ready for investment and resource extraction. The elements that make up a frontier assemblage are both



FIGURE 1 Canadian Province of Newfoundland and Labrador

material and discursive: they depend, of course, on land, water or mineral resources, but they also involve erasures that render frontiers as vacant, ungoverned and ready for exploitation. As Rasmussen and Lund (2018, p. 388) argue, frontiers 'happen *in and to* space ... frontiers *take place*'. Frontier making is always incredibly disruptive particularly for local groups and ecologies. Access to nature remade as resources is often enclosed leading to dispossession; property and other governance relations are broken down and remade for external benefit; and relations of power and authority are transformed (Peluso & Lund, 2011). Given the violence and social disruption associated with frontier making, resistance and conflict often follows this process.

We use and build on the framing of a frontier assemblage as a 'meso-scale heuristic device' (Barney, 2009, p. 149) through three interrelated sensibilities. Our approach emphasizes the making of frontier spaces at ocean sites not always found at fronts or leading edges; the assemblage of ocean and other resources for extraction; and the promissory politics of associated with the ocean frontier. These sensibilities have been drawn from the frontier assemblage approach and extended through an engagement with critical approaches to resource extraction (Kama, 2019; Valdivia et al., 2012), and scholarship on the political economy of industrial aquaculture (Bustos-Gallardo, 2017; Bustos-Gallardo & Irrázaval, 2016; Ertör & Ortega-Cerda, 2019; Saguin, 2016). Through our analysis of industrial aquaculture using the frontier assemblage approach, we aim to provide critical approaches to contemporary strategies that aim to open up the ocean for resource extraction and capital accumulation, a contribution that we hope addresses Havice and Zalik's (2018, p. 211) recent call for 'robust interdisciplinary social science approaches to the ocean frontier'.

Our analysis of ocean frontier assemblages draws on a range of research methods that include published literature and secondary sources on salmon aquaculture across Canada, as well as fieldwork in aquaculture production sites in Newfoundland in 2018 and 2019. Our ongoing research in Newfoundland has focused on the South Coast of the island, the centre of industrial salmon production in the province (Figures 1 and 2). Our research has involved detailed analysis of secondary sources including reports and archival material held by the Centre for Newfoundland

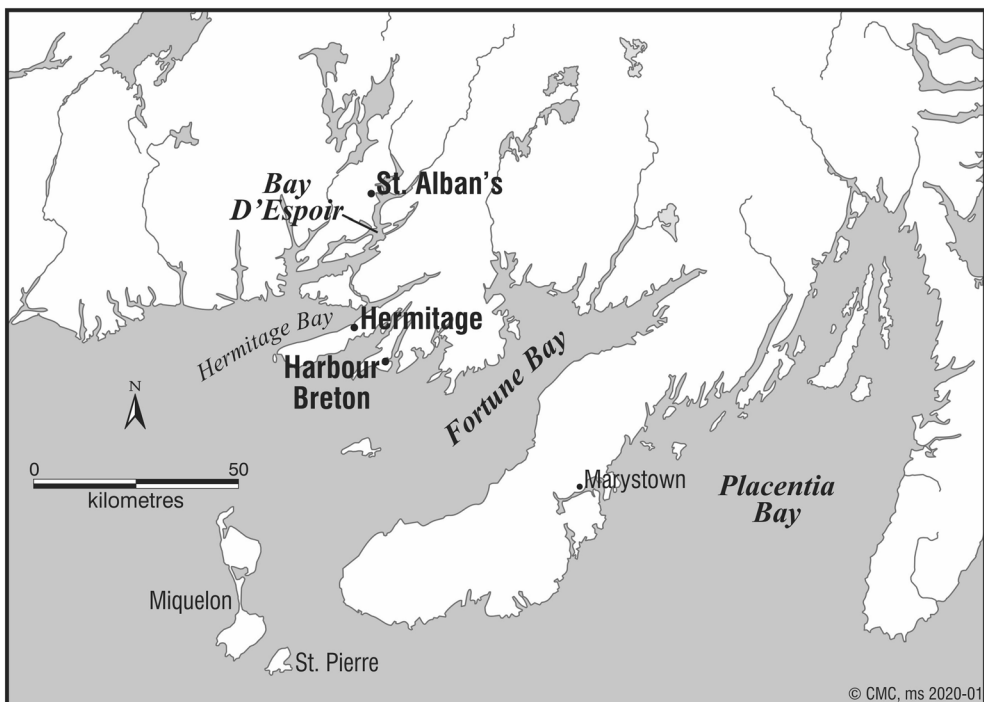


FIGURE 2 Coast of Bays, Newfoundland, Canada

Studies at Memorial University, industry and other news reports, industry conferences, and industry data. We also draw on several periods of field work on the South Coast that involved initial consultations with community, industry and fisheries union representatives followed up by 19 face-to-face semi-structured interviews with community leaders (e.g., mayors), company representatives and aquaculture workers on the South Coast in 2018 and 2019. The face-to-face interviews were focused on gaining insights into salmon aquaculture development and its economic and social impacts in the region.

We begin our paper by providing a more detailed exploration of the frontier assemblage approach, and we extend it by drawing on allied approaches to capitalist resource extraction and by engaging with an existing literature on the political economy of industrial aquaculture. In the sections that follow, we explore the three methodological and conceptual sensibilities—frontier spaces, resource assemblages and promissory politics—which provide a way of critically examining how the ocean frontier is reshaping marine socioecologies for extraction and capital accumulation with important implications for coastal livelihoods. We end the paper by situating our specific analysis within broader debates on ocean frontiers.

2 | FRONTIER ASSEMBLAGES

The frontier assemblage analytic builds on a long and outstanding tradition of critical scholarship on agrarian transformation and resource frontiers in Asia (Peluso & Lund, 2011; Tsing, 2003). It extends this work by adding commodity production to the more conventional concern with resource extraction, and it aims to reveal the complex material and discursive processes that are involved in the making of frontier spaces (Cons & Eilenberg, 2019). In this section, we identify several key themes in the formulation frontier assemblages that are relevant to resource extraction and commodity production in the marine environment. We also engage with recent critical literature on resource extraction and industrial aquaculture to extend the analytical value of this approach for our specific case and for broader analyses of ocean frontier assemblages.

Scholarship on frontier assemblages draws on a longstanding and critical understanding of the term ‘resource’. Resources, in this approach, are not seen as natural, external objects waiting to be discovered and turned into useful commodities. The transformation of resources is, instead, understood as an achievement secured through scientific, social and cultural work (Moore, 2015; Valdivia et al., 2012). This approach to resources helps to denaturalize resource extraction by revealing the socio-material practices that allow resource extraction to happen (Bakker & Bridge, 2006; Moore, 2015; Richardson & Weszkalnys, 2014). As Li (2014a, p. 589) has argued, ‘what we call a “natural resource” is a provisional assemblage of heterogeneous elements including material substances, technologies, discourses and practices’.

The term ‘assemblage’ carries with its epistemological and methodological consequences (Li, 2014a). Assemblage signals that the heterogeneous networks that hold successful resource extraction together require ongoing work, they are temporary and they are fragile and vulnerable to falling apart (Valdivia et al., 2012). Using the term assemblage for resource extraction and frontier making leads to questions such as: how is the network of materials, people, culture and politics held together in a way that facilitates resource extraction? And it allows for a key reflection: could the resource assemblage be arranged differently? These two questions are especially relevant to our analysis of salmon aquaculture. The development of this industry on the South Coast of Newfoundland was by no means certain, other options for resource development were considered but set aside, and the industry currently faces considerable environmental challenges associated with what Watts (2016) has called ‘frontier precarity’, which involves systems of resource extraction that amplify risks and push socioecological systems to breakdown (cf. Irarrázaval & Bustos-Gallardo, 2019).

The term assemblage points to indeterminacy, but this does not mean that resource extraction through frontier assemblages is radically open. The materials that are brought together in resource assemblages are not infinitely malleable. Power dynamics are important and places have their own histories and geographies that shape how resources

can be assembled. The power dynamics associated with resource extraction are often refracted through what Kama (2019) has called 'geo-social' scientific knowledge practices that determine whether resource extraction is deemed feasible at particular sites. These knowledge practices are, however, not neutral, and they are vulnerable to dispute and challenge. In our analysis of salmon aquaculture development in Newfoundland, we attend closely to the knowledge practices that shaped the trajectory of resource extraction, with implications for other frontier assemblages in the marine environment.

The frontier usually signals a space or territory that is at the margin of state control, and frontiers are tightly interwoven with colonialization practices. Scholarship on frontier assemblages suggests that frontier making does not necessarily happen at an edge or a margin. Rasmussen and Lund (2018, p. 390) have argued that frontier spaces 'are not reserved to borders, fringes or edges, but may well emerge in the midst of state space'. This view of frontier spaces is consistent with the indeterminacy associated with assemblage thinking, and it underlines the importance of seeing frontiers as sites that are made rather than discovered. It also means that the same geographical location may experience more than one round of frontier making. In Rasmussen and Lund's (2018) formulation, frontier making or 'frontierization' is an iterative process that may be followed by territorialization, and then potentially by other rounds of frontier making. Middleton's (2019) analysis of cinchona, the tree that provides a natural source of quinine, provides an example how the Darjeeling region in India has gone through more than one round of frontierization. He proposes the term 'recursive assemblage' to refer to the way in which the heterogeneous elements of a frontier are assembled again, yet in a different way and for a different purpose. His work aims to challenge the idea that frontiers are 'one-and-done formations—born of boom, exhausted of life, and left for dead', and he is interested in showing how the 'remains of a dying frontier may be assembled anew' (Middleton, 2019, p. 196; also see Rubinov, 2019). This attention to frontierization as a process is particularly relevant to industrial aquaculture as it often follows on from the ruins of a severely depleted wild capture fishery or other capital-intensive resource booms (Saguin, 2016). Frontier making is also critical to broader formulations around strategies such as the blue economy and blue growth, which present the ocean as untapped and 'resource-ful', ignoring earlier rounds of colonization, resource extraction and environmental ruin.

Frontier making and frontier assemblage, similar to resource making, is both material and discursive. The discursive elements aim to render frontier spaces attractive to capital for investment, resource extraction and accumulation. Yet the discursive elements that help make up resource assemblages are not only aimed at convincing external capital. They may also be aimed at local populations who are offered an imagined future of development, jobs and prosperity associated with resource extraction (Cons & Eilenberg, 2019; Li, 2014a). In this way, the assembling of a resource frontier often involves a promise for local groups, who may be seeking the potential benefits of becoming a part of new economic flows associated with resource extraction.

The promise of jobs and other economic benefits for coastal groups is seen as a key outcome of harnessing the resources of the ocean frontier. In national and international policies and programmes, the opening of the ocean frontier promises jobs, economic growth and sustainable communities. Ocean-based food production also promises to address global food shortages in a context of rapid population growth [Childs & Hicks, 2019; Organization for Economic Cooperation and Development (OECD), 2016]. In our analysis of salmon aquaculture frontiers in Canada, we will argue that the *promise* of economic prosperity is a key element of the ocean frontier aimed at remote coastal groups that have experienced dramatic depopulation, declining services, deteriorating connections to larger centres and high levels of unemployment (cf. Silver, 2013). Salmon aquaculture development in Canada, for example, promises new connections to larger centres, jobs and vibrant coastal communities (Manning & Hubley, 2015), even though farmed salmon production is known to be capital intensive with technical innovations often aimed at reducing the dependence on labour (Asche & Bjørndal, 2011).

Our analysis of salmon aquaculture in Canada, framed within broader concerns around the ocean-as-frontier, draws on an approach that emerges from a long tradition of agrarian frontier resource development in Asia. Using a framework developed in and through Asian scholarship is notable given that this is a region that has tended to be a receiver of northern concepts and ideas, rather than as source of theory and conceptualization (Wilson & Rigg, 2003).

We argue that the frontier assemblage approach has value and purchase beyond Asia because it addresses the problem of resource extraction in a context where interventions are justified through a logic of the frontier, and it allows for a critical assessment of these interventions. While we have drawn on the frontier assemblage approach for our analysis, we have also engaged and adapted it by drawing on allied work in critical resource geography and, as we discuss in more detail below, by drawing on existing work on the political economy of industrial aquaculture framed through commodity frontiers. This has allowed us to develop and refine the three sensibilities we have used—the spaces of ocean frontiers, assemblage and promissory politics—and make them relevant for a critical assessment of resource extraction on the ocean frontier.

3 | SALMON AQUACULTURE IN CANADA'S OCEAN FRONTIER

Farmed fish, shellfish and plants are produced in every province and territory in Canada. Although there are more than 45 different species of fish, shellfish and algae cultivated, the dominant farmed species is Atlantic salmon, the majority of which is farmed in BC (Manning & Hubley, 2015). At the global scale, Canada is the fourth largest producer of farmed Atlantic salmon, behind Norway, Chile and Scotland [Food and Agriculture Organization (FAO), 2020]. Aquaculture, and especially industrial salmon aquaculture, is seen as an important opportunity for export revenues and job creation (Manning & Hubley, 2015), but the industry also faces mounting opposition from communities and non-governmental environmental groups (Young et al., 2019).

In the sections that follow, we draw on our analysis and development of the frontier assemblage approach to explore salmon aquaculture in Canada. We draw on our detailed research in NL to examine how this framework provides new insights into aquaculture development, and we pay specific attention to the South Coast of Newfoundland, widely considered to be Canada's 'last' salmon aquaculture frontier (Figure 1). Our focus is on three key conceptual and methodological themes: (1) the spaces of aquaculture frontiers, (2) assembling aquaculture resource frontiers and (3) the economic and social promises of the ocean frontier.

3.1 | Aquaculture frontier spaces

One reading of Canada's industrial salmon sector is that the salmon aquaculture frontier has been moving west to east over the last 40 years. Salmon production started about the same time on both Canadian coasts but took off quickly in the 1980s in Canada's most western province, BC, and this province is now the country's largest producer of farmed salmon. Following the rapid growth of salmon production in BC in the 1980s, new sites of production have been opened on Canada's east coast with significant production in Nova Scotia, New Brunswick and most recently on the island of Newfoundland. Statistics on salmon production support this west to east shift of the industrial aquaculture frontier. Production volumes of salmon breached 20,000 mt in BC 1991. This same production figure was reached in New Brunswick in 1999, in Nova Scotia in 2001, and in NL in 2013 (Manning & Hubley, 2015). As production has shifted eastward, there is also evidence to suggest that earlier frontiers of industrial aquaculture may be closing (cf. Ertör & Ortega-Cerda, 2019). Environmental problems, with industrial salmon aquaculture linked to sea lice and diseases combined with public pressure and protest action, have had a significant impact in limiting the expansion of salmon aquaculture in Canada, but especially in BC. In BC growing public concern and protests by Indigenous groups led to a decision in 2018 to phase out 17 fish farms by 2023 (Thomas, 2018). More recently, the governing Liberal Party of Canada, in the run up to national elections in 2019, announced a commitment to phase out net pen aquaculture altogether by 2025. Rather than shutting down salmon aquaculture production, the Party has proposed a shift to land based salmon production in BC in closed containment systems. In Nova Scotia, pressure by environmental non-governmental organizations and community organizations led to a moratorium on new salmon aquaculture licences in 2013, which has recently been lifted.

As we noted in the introduction to the paper, NL is considered to be Canada's last frontier for salmon aquaculture. In this province, aquaculture development has been strongly supported as a way of addressing high rural unemployment and a declining, oil-dependent, economy. In 2017, the NL government, which is responsible for licence allocations and also provides direct financial support to the industry, announced a new aquaculture strategy as part of a larger plan to stimulate the economy and create jobs. For aquaculture, the 'Way Forward' plan committed itself to more than doubling salmon production to 50,000 mt by creating new opportunities and 'removing barriers to support aquaculture sector growth' (Newfoundland and Labrador, 2017, p. 2). The provincial government also committed itself to making more coastal water available for aquaculture production, and it has identified a range of different public funding mechanisms for new and existing commercial aquaculture enterprises. Indeed, in its response to the Liberal Party commitment to phase out sea pen aquaculture in BC, the NL Minister of Fisheries openly encouraged companies to move east, saying publicly that 'we suspect that we have become a very attractive climate for investment' (Roberts, 2019). The idea that NL is 'open for business' has also been aggressively pursued by the Newfoundland Aquaculture Industry Association (NAIA), the organization that represents the aquaculture industry in the province. The director of NAIA recently noted, 'We're one of the few places on Earth where there is room for expansion using traditional techniques [i.e. open net pens] for growing salmon' (cited in Sapin, 2019, p. 2). Newfoundland's open for business approach to aquaculture appears to have played a role in attracting significant new investments by two of the largest salmon farming companies in the world, Norwegian-based MOWI (formerly Marine Harvest) and Grieg.

The west to east shift of salmon production appears to suggest a moving frontier of aquaculture development associated with socioecological crises and capital seeking new ecological surpluses for salmon production. However, aquaculture development in Canada, and elsewhere, is likely to be more uneven and less linear than a moving frontier metaphor might suggest (cf. Ertör & Ortega-Cerda, 2019). For example, even though BC has imposed a moratorium on future licences and appears to be shifting towards some form of closed containment technology, the local aquaculture industry is not necessarily closing. In a Canadian Aquaculture Industry Alliance (CAIA) report that examined the total area of ocean space currently leased compared with the total area available, it estimated that BC was only using 0.8% of the potential area available for aquaculture production [Canadian Aquaculture Industry Alliance (CAIA), 2017]. Rather than a closing frontier, the national body representing the aquaculture industry in Canada positions BC as having ample space for new production sites. Similarly, in Nova Scotia, a 2013 moratorium on new salmon licences was recently lifted, which has in turn attracted new applications for licences from Cermaq, a company that also operates in BC. In Cermaq's public announcement of its intention to apply for licences in Nova Scotia—licences that would allow it to produce up to 20,000 t of salmon—it noted that the province's 'pristine waters' and 'relatively untouched coastline is seen as an area of opportunity by the global salmon farming industry' (Withers, 2019, p. 1). At the same time, although the NL government presents itself as Canada's new frontier for aquaculture investment and development, the province may not be entirely 'open for business'. There have been ongoing and important challenges from environmental NGOs including the financially powerful Atlantic Salmon Federation (ASF). The ASF – together with other local angling associations and regional environmental NGOs – has led several successful court challenges against the NL province's decisions to release aquaculture projects from environmental impact assessments. In 2016, for example, the ASF took the provincial government to court for releasing Grieg from having to undertake an environmental assessment for a project that will be one of the largest salmon farming operations in Canada (Rigby et al., 2017). The ASF won the case and Grieg was subsequently forced to go through a formal environmental assessment. The ASF, together with its environmental and NGO allies, continues to mount court challenges to new salmon aquaculture developments, much to the consternation of government and the salmon industry (e.g. Adey, 2018).

In our analysis of salmon aquaculture development across Canada we trouble the idea that this resource frontier has shifted from west to east, enclosing older frontier sites and opening new ones as the leading edge of resource development moves eastwards. Our analysis supports instead the idea of frontierization articulated by Rasmussen and Lund (2018): sites where aquaculture development has been longstanding and where the frontier has ostensibly

closed - as is the case in Nova Scotia - continue to be presented as ready for investment and resource development thanks to the frontier narrative of 'pristine waters' and 'untouched coastlines'. At the same time, Newfoundland, the site that positions itself as the new frontier for aquaculture development, may not be so open given strong and successful court actions by conservation groups and angling associations. The frontier is a powerful way in which the ocean can be made ready for investment, including for salmon aquaculture, but these frontier discourses are subject to contestation and struggle. In this way, the idea of frontierization - as a verb rather than frontier as a noun - works well as a heuristic to explore salmon aquaculture in the Canadian context.

In the next section we focus in more detail on salmon aquaculture production in one part of Eastern Canada. We emphasize the material challenges associated with this industry, the role of contested knowledge practices, and the impact of new technologies and state support. Our aim is to denaturalize resource extraction and to show how development in this marine environment may have been otherwise. Our focus is on the South Coast of Newfoundland where we are exploring, through detailed and ongoing fieldwork, the emergence of industrial salmon aquaculture.

3.2 | Assembling salmon aquaculture in NL

The South Coast of Newfoundland—specifically the region known as the Coast of Bays—is the main area for the production of Atlantic salmon on the island of Newfoundland (Figure 1). In 2016, production volumes exceeded 25,000 mt, and the value of salmon aquaculture was over CAD\$250 million dollars (Newfoundland and Labrador, 2016). The Coast of Bays was long identified as a region suited to aquaculture in general and specifically to salmon farming (NAIA, 1998). Its deep fjord like bays, strong cold-water currents, long coastline, an existing infrastructure for fish processing, a hatchery and a ready workforce thanks to high levels of local unemployment, all made it an ideal site for salmon aquaculture development (Couturier & Rideout, 2018; Figure 2). Indeed, this was the finding of a report produced in the early 1980s to assess the potential of the Coast of Bays for aquaculture based on a tour of other aquaculture production sites in Atlantic Canada. The report found that the Coast of Bays had a significant 'natural advantage' over other sites in Atlantic Canada (Vardy, 1984). A Provincial government report published around the same time noted that if 'only a small proportion of suitable inshore sites are exploited for aquaculture, there is the potential for a major rural industry in Newfoundland' (Aggett, 1981, p. 2). Finally, a detailed feasibility study of aquaculture based on environmental and market considerations recommended that 'future efforts relating to this study should be focused on the Newfoundland south coast with the prospects of culturing Atlantic salmon' [Marine Sciences Research Laboratory (MSRL), 1980, p. 2]. Considering the most recent salmon production statistics from the South Coast of Newfoundland, it seems that the 'natural bounty' of the Coast of Bays identified in these early reports was fully realized.

Yet the argument that the Coast of Bays' resource bounty in the form of sheltered bays and clean water made it an ideal site for salmon aquaculture naturalizes resource development and fails to reveal the considerable environmental, economic and social challenges producers faced in establishing commercial production for salmon in this ocean frontier. In her influential contribution to the processes of assembling land as a resource, Li (2014a) provides a set of questions that follow from an approach that *denaturalizes* resource extraction (also see Richardson & Weszkalnys, 2014; Valdivia et al., 2012). The questions are as follows: what are the assembled elements that makes resource extraction possible?; how is the assemblage made durable?; and, third, why does resource development 'take this form and not another?' (Li, 2014a, p. 590). This last question is particularly relevant to the South Coast as we consider in some detail why and how salmon aquaculture was assembled in the region over other competing farmed fish and shellfish species.

The potential of salmon aquaculture on the Coast of Bays seemed promising given consultant reports produced in the late 1970s and early 1980s (MSRL, 1980; Taylor, 1975). At the same time, these reports identified several significant environmental obstacles. Chief among these was low winter water temperatures that are lethal to salmon.

Unlike other fish that live in cold waters, Atlantic salmon are unable to withstand water temperatures below -0.7°C , which commonly occur not only on the South Coast of Newfoundland, but right across Eastern Canada (Saunders, 1989). Sea ice and high winds presented additional challenges to aquaculture cages on the South Coast of Newfoundland that were relatively fragile in the face of what one research scientist called the 'seasonal violence of the North-west Atlantic' (Pepper, 2003, p. 23). These oceanographic conditions meant that salmon could not be grown in the ocean through a winter season, which was required for the fish to reach a market size of between 4 and 5 kg. The sheltered and deep bays in and around the Bay D'Espoir region of the South Coast did offer a potential opportunity for salmon production (Figure 2). In these bays, sea ice conditions were less dangerous, and water temperatures were less severe. Nonetheless, early experiments showed that the water in these bays was more suited to sea trout than the much-preferred Atlantic salmon (Couturier & Rideout, 2018). One option that was explored was to use these deep bays as overwintering sites for salmon, which then spent the rest of their time in deeper marine environments (Apold et al., 1996). This elaborate strategy required that the cages be towed back and forth between deeper ocean sites and sheltered bays, a task that could take 6 h or more. This practice did not, however, lead to substantial salmon production due to the very high mortalities in cages that were towed between summer and winter sites. Scientists from Canada's Federal Department of Fisheries and Oceans (DFO) suspected that salmon were stressed by the towing of the cages and the subsequent change in environment, which in turn made them susceptible to lethal disease outbreaks (Pepper, 2003). An additional problem facing producers interested in farming Atlantic salmon was federal regulations that required salmon aquaculture to use local sources of broodstock (Saunders, 1989). This requirement affected salmon aquaculture producers across Atlantic Canada, who were required to source broodstock from local rivers using wild salmon populations. The problem for Newfoundland salmon aquaculture producers was that local rivers tended to be populated by salmon that were smaller than 'market size', and they tended to mature earlier, which negatively affected the quality of the flesh (Couturier & Rideout, 2018). Fish buyers typically rejected salmon that matured early because of its impact on salmon flesh.

Given the socioecological obstacles to salmon production, it is perhaps not surprising that a detailed three-volume report released in 1990, produced by a group of nationally recognized consultants in Vancouver and St John's, came out strongly against salmon aquaculture in Newfoundland (DPA, 1990). The report was described as the 'most comprehensive of its kind yet to be undertaken in the aquaculture sector in Canada', and represented 'a realistic basis for the early appraisal and projection of the economic viability of aquaculture in Newfoundland' (DPA, 1990, p. 3). The report's view on salmon aquaculture was unambiguously negative. The group of expert consultants found that the potential for salmon aquaculture was severely limited, given environmental considerations, and they strongly recommended that public funding for salmon farming be discontinued. The obstacles identified were well known to industry players and included low winter temperatures, frequent storms, and access to high quality raw material including feed and broodstock. Given these challenges, the consultants predicted a total stock loss for salmon producers once every 5 years. Finally, they pointed out that the favourable market window for salmon markets that had existed in the 1980s, which had driven much of the interest in salmon aquaculture in Atlantic Canada during this period, was now closed; they predicted that global market conditions for salmon going forward were poor. Instead of salmon, the panel of consultants recommended government support for mussel aquaculture, which was better suited to the local environment, more sustainable, generated more employment opportunities, and was complementary to existing wild capture fisheries in the region (DPA, 1990).

The consultants' recommendations were ignored by the private sector and by various levels of government who continued to see promise for salmon aquaculture on the South Coast of Newfoundland [e.g., Aquaculture Working Group (AWG), 1994], in spite of the obvious socioecological challenges. Instead of shifting to mussels, existing aquaculture companies on the South Coast consolidated into a larger entity (SCB fisheries), hoping to turn their fortunes around through a larger and vertically integrated structure focused on salmon production (Couturier & Rideout, 2018). The new consolidated company used the restructuring exercise to seek new rounds of provincial and federal government funding and loan guarantees to help support this new venture. It was enormously successful in this regard: from the early 1990s, the company received almost CAD\$10 million in direct support and loan

guarantees from the Province and a further CAD\$7 million from a range of federal government sources (Auditor General, 2001). In spite of this enormous investment of public funds, the company failed to build a sustainable salmon production enterprise. By the late 1990s, the financial status of the company was so precarious that the NL government intervened by appointing its own staff to manage the company. In spite of this intervention, the province finally lost hope in the enterprise and decided to write off its significant loans and grants to the company. The province subsequently arranged the sale of the company to a local consortium of fisheries interests and businesses. The Auditor General of the province was forced to admit in 2001 that it was unable to recover any of the CAD\$10 million in loans and grants provided to the company (Auditor General, 2001).

Despite the significant economic loss, renewed efforts to establish salmon aquaculture along the South Coast was still in play in the early 2000s by a local Newfoundland company. Significantly, the company began to experiment with production outside of the deep bays in the Bay D'Espoir where salmon aquaculture had largely failed. They established production in Fortune Bay, in South Coast sites that were widely considered to be too cold for salmon aquaculture (Figure 2). However, the technology used and the approach to salmon production was substantially different, drawing from the experience of producers in more established sites in New Brunswick and from new developments in aquaculture technology. They used deeper nets, higher quality feeds and management techniques that were suited to farming salmon in colder waters (Couturier & Rideout, 2018). The company was also permitted to import higher quality broodstock from New Brunswick (Saunders, 1989). The litmus test for this new company was 2003, one of the coldest winters on record on the South Coast. In spite of these conditions, the company was able to maintain the fish through the winter and eventually produced market ready fish for regional markets. This success led to significant interest from outside of NL and specifically from New Brunswick companies seeking to expand production (Couturier & Rideout, 2018). The local company that had now established that salmon production was possible on the South Coast given new technologies and practices was subsequently bought out by a New Brunswick based company, and their success in turn attracted additional outside capital. With these new investments, production statistics for salmon in Newfoundland rose from around 2000 t in the early 2000s to as high as 25,000 t by the mid-2010s (Newfoundland and Labrador, 2016).

One way of analysing the development of salmon aquaculture on the South Coast of Newfoundland's ocean frontier would be to suggest that technology and human ingenuity was able to overcome significant environmental obstacles. Yet from a frontier assemblage sensibility, what stands out is how salmon aquaculture was continually favoured in spite of decades long socioecological challenges, company failures, significant fish mortalities and millions of dollars in provincial and federal government support. Salmon aquaculture was also favoured over other options, articulated most forcefully in 1990 by consultants who argued convincingly for other farmed species that were not only ecologically more sustainable but also promised more jobs in places where these were desperately needed (DPA, 1990). Why then did resource development take the form of salmon aquaculture and not another farmed species?

Assemblage thinking is helpful in the context of salmon resource development because it asks us to attend to the materials, technologies and capital that are involved in resource extraction in frontier sites (cf. Choi, 2019). Although we do not have the space to explore these in great detail as they relate to our case, these include the scientific and technological infrastructure established by the federal government for salmon aquaculture in New Brunswick from the early 1980s, and later on the South Coast of Newfoundland during the late 1990s and 2000s (Anderson, 2007). This infrastructure included government-funded corporate growth initiatives, scientific research, veterinary expertise and support, demonstration farms focused on salmon production, tours of salmon production sites in Norway, and detailed advice to prospective salmon producers (Cook, 2016). Some of the technological breakthroughs in salmon production—somewhat ironically given their current role in opposing salmon farming—came from powerful non-governmental organizations representing recreational anglers who supported salmon aquaculture based on the hope that farming salmon would replace the need to harvest wild salmon commercially, thereby protecting wild stocks for recreational anglers (Saunders, 1989). All of these groups and organizations in Canada had strong connections to Norway and Norwegian technology for fish biology, broodstock, feed and cage design. There

were also individuals who worked across Canadian sites and between Canada and Norway who championed salmon aquaculture in Newfoundland in spite of the environmental challenges (Anderson, 2007). An additional motivation for salmon over other fish species were the extraordinary profits that were enjoyed by salmon producers especially during the 1980s (Barton & Fløysand, 2010) and the promise that the market for farmed salmon was unlimited. Assembling aquaculture development on the South Coast was indeterminate—it could have been otherwise (cf. Fløysand et al., 2010; Li, 2014a)—but in a context where technology, state funding, markets, and profits were associated with salmon aquaculture, resource development has followed this path in spite of other options and significant environmental obstacles.

3.3 | The promise of the ocean frontier

We noted earlier that while frontiers are assembled to attract capital, and enclose territory and remake nature into resources, local communities are also promised benefits associated with frontier development as ways to allow entry into these spaces and places. In this way, the discursive elements of frontier assemblages may be directed at both capital and local groups (Li, 2014b). The promise of aquaculture resource development has been an important theme in the academic literature on Canadian aquaculture (Marshall, 2003; Milewski & Smith, 2019; Volpe & Shaw, 2007) and is a key theme in government publications and in national and regional aquaculture association reports on the industry (CAIA, 2017; Manning & Hubley, 2015; Newfoundland and Labrador, 2017; Nova Scotia, 2015). In this section, we briefly review these studies before considering in more detail the results of our own field research in Newfoundland on the promise of the aquaculture resource frontier.

Although salmon aquaculture development is promoted on the basis of its ability to create jobs and economic opportunities in remote coastal communities, the secondary literature has been highly critical of this promise. In the mid-2000s, Volpe and Shaw conducted a detailed analysis of employment in the BC salmon farming sector. Between 1997 and 2003, they showed that although production volumes of salmon rose by 100%, the overall wage and salary bill dropped by 29% (Volpe & Shaw, 2007). The jobs that were created also tended to be concentrated in larger coastal communities, and not in the very remote resource-dependent communities who needed jobs the most. In New Brunswick, similar results of increased production alongside decreased number of jobs and wages have also been reported (Knott, 2016; Marshall, 2003), despite the promises made and the continued reporting by government and industry of the benefits of aquaculture to rural communities in these provinces. Milewski and Smith (2019) cite data from Nova Scotia where employment numbers have remained static since the mid-1990s in spite of a 10-fold increase in the volume of production. In NL, in the mid-1990s, the government predicted an increase in employment in aquaculture to 1500 direct jobs associated with projected increases in sale volumes to CAD\$60 million (Newfoundland and Labrador, 2016). The most recent statistics for salmon production are over CAD\$200 million, far more than anticipated, but the number of jobs created has been far less with only 424 direct jobs recorded in official reports (Newfoundland and Labrador, 2017). There has been a consistent pattern across Canada where dramatic increases in salmon production volumes and values have not been met by corresponding increases in employment or wages.

The employment figures associated with salmon aquaculture suggest that it generates relatively small numbers of jobs overall in Canada, even in a context of very significant increases in production volumes. Yet salmon aquaculture continues to be described as central to job creation and social sustainability for remote coastal communities. In 2019, for example, an external consultant to the government of NL predicted that the salmon aquaculture sector could generate 7000 additional jobs by 2030 as production volumes increased to 100,000 t of salmon a year (McKinsey & Company, 2019). The evidence across Canadian jurisdictions suggests that these figures are wildly overstated: technological advances and improvements in salmon production have allowed producers in the past to dramatically expand production without having to increase employment numbers. Given ongoing technological developments in the salmon aquaculture sector, that often are aimed at saving labour, there is no reason to

suggest that the relationship between production volumes and labour in this sector will change (Asche & Bjørndal, 2011).

The impact of technological developments helps explain why the promise of significant numbers of jobs linked to salmon aquaculture development may not be met, but this is not the only reason why we might be pessimistic about the promise of this ocean frontier industry to provide significant and much needed employment in coastal communities. Drawing on research and fieldwork in Newfoundland, we provide additional insights into why the promise of substantial numbers of employment opportunities may not be realized with salmon aquaculture development given the way in which this resource is assembled.

As we noted earlier, salmon aquaculture development in Canada is promoted for its role in providing jobs in remote coastal communities where unemployment levels are high. Yet a paradoxical development in coastal communities in New Brunswick, Nova Scotia and Newfoundland has been the contracting of precarious and temporary international migrants who are used to fill positions in aquaculture production and processing, in spite of high levels of local unemployment (Knott, 2016; Marschke et al., 2018). Migrants are hired through Canada's Temporary Foreign Worker Programme (TFWP), a system that was designed to allow employers to secure labour in a context of regional or local labour shortages (Knott, 2016). The use of temporary foreign workers is well established in Atlantic Canada fish processing facilities even though the programme has been widely criticized for its role in incorporating migrants into exploitative relations with employers. Temporary migrants under this system are tied to one employer, and so are captive and immobilized, which often results in labour arrangements that have been accurately theorised as unfree (Knott, 2016; Marschke et al., 2018; Knott & Marschke, 2021). The hiring of temporary migrants across the economy, and in aquaculture, has highlighted the problem of how employers are using labour shortages as a way of accessing temporary foreign workers, particularly in New Brunswick (Knott, 2016; Knott & Marschke, 2021), but also almost certainly in other fish processing and aquaculture operations elsewhere in the region. These practices have implications for local workers as they increase the precarity of their work, and they allow companies to overstate local employment opportunities as 'good jobs', instead of improving working conditions and wages in order to address labour shortage issues (Knott, 2016; Knott & Neis, 2017). Temporary foreign workers have also been directly linked to aquaculture in Newfoundland: the announcement of a large development for aquaculture infrastructure in Newfoundland in 2018 came with the statement from a co-owner of the project that 'immigrants would be needed to fill new jobs' (CBC, 2018). Although the statement was quickly retracted in response to local public outrage, it nonetheless points to the role of temporary workers in new and existing aquaculture development in Canada, with potential implications for the number and quality of jobs available to local communities.

Our fieldwork on the South Coast of Newfoundland has revealed several additional insights into the problem of salmon aquaculture's promise of employment and economic benefit for communities in the ocean frontier. First, the problem is not only that the number of jobs may be lower than expected or hoped but also that the work is structured in ways that allows workers to live away from production sites, in larger settlements in Newfoundland, or even in other parts of Canada. Contracts for aquaculture workers including divers and other employees are often structured on an 8 day on, 6 day off schedule, similar to the situation that exists in remote mining communities in Canada and Australia (cf. Storey, 2010). These arrangements mean that workers do not need to live in remote coastal areas like the South Coast and can instead commute from larger settlements in the province or elsewhere. Indeed, South Coast aquaculture production sites in Newfoundland are only 2 h away from the much larger town of Grand Falls Windsor, a city that is now promoting itself as the 'gateway to aquaculture', 'perfectly centred' in the middle of Newfoundland to serve aquaculture production sites across the province (GFW, 2019). Living in Grand Falls Windsor and other larger locations away from the South Coast provides workers and their families with the social, educational and recreational infrastructure and its benefits that exist in larger urban centres. At the same time, these work arrangements, and the possibility of drive-in-drive out labour mobility, means that the employment benefits of resource extraction may not be realised in remote coastal sites where production happens, an issue that has been identified in other countries with intensive aquaculture production (O'Higgins et al., 2019).

A second problem relates to the spin-off industries that support aquaculture production, which are often identified as indirect and additional employment and income opportunities that are generated with salmon aquaculture (e.g., Manning & Hubley, 2015). Whereas the South Coast of Newfoundland has several spin-off industries that support aquaculture, the number of secondary enterprises supporting the production of 25,000 t of salmon produced in this region is far less than might be expected given this volume of production. One reason for this is that large and vertically integrated aquaculture companies have concentrated feed and value added processing facilities in specific locations across Atlantic Canada. As Milewski and Smith (2019, p. 3) argue, this means that 'very few communities have hatcheries, processing facilities, corporate administration offices, and net or feed manufacturing operations in addition to grow-out operation'. The uneven distribution of economic benefits associated with salmon aquaculture production has been a key theme of research in countries like Scotland where the concern has been that the economic benefits are centralized, but the ecological costs are borne by remote coastal regions (O'Higgins et al., 2019). On the South Coast of Newfoundland, there is an additional concern: the development of a very large aquaculture production site in Placentia Bay, east of the Coast of Bays, will be supported by a very large 'cold water aquaculture hub' that will provide services for the province's salmon aquaculture industry (Figure 2). Communities on the South Coast are justifiably concerned that the development of this cold water aquaculture hub, which aims to be the 'service centre of all aquaculture in Newfoundland and Labrador' (Maher, 2019, p. 1) will attract companies away from the South Coast together with the jobs that they provide to local residents. In other words, communities on the South Coast are justifiably concerned that local companies will move to Placentia Bay where they can be part of a larger group of local and international companies servicing salmon aquaculture in Newfoundland.

The third issue has to do with the ecological challenges that appear to be intensifying for salmon aquaculture production. In the early development of salmon aquaculture in Newfoundland, producers seemed to be relatively unaffected by sea lice and salmon diseases that currently plague producers elsewhere in Canada and globally. Yet that situation has changed dramatically in the last 5 years. In 2013, one local producer experienced a devastating outbreak of infectious salmon anaemia (ISA) that had a dramatic impact on production volumes. Salmon production in Newfoundland in 2014 decreased by 85% compared with the previous year (Newfoundland and Labrador, 2016). Most recently, in late 2019, there was a mass die off of farmed salmon on Newfoundland's South Coast. More than two and a half million fish, or 25% of the province's total annual production, died through a combination of high water temperatures, algae blooms, fish handling practices for sea lice and low oxygen levels (Marine Institute, 2020). The challenge of mass mortalities and die offs continues to be a problem in the industry: mortalities for 2020 were 67% of the total number of fish harvested in that year (Huffman, 2021). One of the main companies involved in the sector has since announced a major restructuring and reorganization of the industry in Atlantic Canada in response to these production challenges.

The impact of these die-off events is a problem for all workers associated with aquaculture, but it is particularly serious for processing workers in the industry, who make up the majority of the industry's workforce. In the wake of these recent die-off events, processing workers on the South Coast face the prospect of not having work for years. Those promoting aquaculture often speak of its advantage of more stable production and work compared with wild capture fisheries, which may face significant fluctuations harvests within and between years. Yet recent events on the South Coast suggest that aquaculture is not immune to resource fluctuations, with equally disastrous impacts on workers and communities (cf. Bustos-Gallardo & Irrázaval, 2016).

The point of this section has been to provide additional critical insights into the promise of the ocean frontier as it relates to industrial salmon aquaculture. Our analysis adds new knowledge to the problem of limited employment outcomes, and we contribute to existing analyses of labour and restructuring in salmon aquaculture (Bustos-Gallardo, 2017). Our work in Canada questions the promises made by public agencies and the private sector that support salmon aquaculture on the basis of its economic role in remote coastal communities. Yes, salmon aquaculture has significant economic benefits, but for who? We argue that the benefits of resource extraction may be increasingly disconnected from some of the local communities that are supposed to benefit from these activities. This is in part because of labour saving technologies, but we are also suggesting an additional set of concerns related

to labour mobility and work regimes, the structure and organization of industries that support production, and ecological problems in production, all of which raise critical questions about whether those groups closest to the site of extraction will benefit from this form of ocean resource development that generates significant wealth for the industry. A consequence of these processes is that the benefits of salmon aquaculture may be increasingly 'decoupled' from place (Stoll et al., 2019). Instead, as Bustos-Gallardo (2017) has argued convincingly in the context of Chile's salmon industry, what seems to be emerging is resource extraction in the marine environment that operates like an enclave economy, with only limited benefits to local populations and an extraction logic that tends to exclude other options besides salmon for using the marine environment to support sustainable livelihoods.

4 | CONCLUSION

Our aim in this paper has been to provide critical insights and to offer critical approaches to contemporary strategies and developments that are framed around the ocean-as-frontier. We build on existing scholarship that has productively used Moore's capitalist world ecology framework to analyse industrial aquaculture. We hope to have shown how the frontier assemblage approach provides a mesoscale, complementary set of sensibilities to research on commodity frontiers and the marine environment. Through our detailed analysis of salmon aquaculture in Canada, and specifically in Newfoundland, we argue that our use and development of the frontier assemblage approach provides an important and critical lens through which to examine how the marine environment is currently being configured as an untapped resource ready for capital investment and accumulation. In doing so, we hope to have responded to Havis and Zalik's (2018) recent important intervention and their call for ongoing critical analysis of the ocean frontier.

We identify and develop three conceptual and methodological themes from this field of scholarship that we have put to work in analysing salmon aquaculture development in Canada. First, we confirm that ocean frontier sites are not only at edges or fronts, but across the marine environment, including at sites that have experienced more than one round of resource extraction. Our engagement with the idea of frontierization—frontier understood as a verb rather than a noun—helps us explain how a province like Nova Scotia, that has had decades of salmon aquaculture development, can be described as having a pristine undeveloped coastline ideal for salmon production. And it provides a way of accounting for the significant opposition from non-governmental organizations in Newfoundland and Labrador to government and industry practices that underpin frontier making. The attempt to assemble frontier spaces can be a powerful force for capitalist investment in the ocean, but it is also open to contestation by civil society organizations. Second, our detailed analysis of the salmon case in Newfoundland reveals that the forms of extraction and production that are assembled in ocean frontier sites are indeterminate, but they are not random. The evidence we provide questions salmon aquaculture development in cold water ocean sites as a natural outcome of a region's biophysical bounty. Instead, drawing on archival and secondary sources, we have denaturalized salmon aquaculture development in Newfoundland by stressing the considerable environmental challenges facing capital in establishing successful production in spite of huge public investments, bankruptcies and significant salmon mortalities. Our analysis highlights the role of (contested) knowledge practices and the role of government financial support, private companies and new technologies. We also stress contemporary socio-ecological challenges with salmon aquaculture and the impact on workers and communities, a situation documented in detail by Bustos-Gallardo (2017) in their work on Chile. Finally, we focus on the problem of promissory politics. We question the promise that the development of the ocean frontier will lead to sustainable jobs and thriving coastal communities. A key concern is the potential of enclave like systems of production and accumulation where resource extraction happens yet with limited economic benefits to local coastal communities, despite the significant economic gains enjoyed by capital.

Our analysis comes at a time when the marine environment is increasingly being presented not only as a new frontier of economic growth and development (OECD, 2016), but also as a vehicle for a 'blue recovery' in the wake

of the COVID-19 pandemic. The ocean-as-frontier, as Belton et al. (2020) have recently argued, is facilitating the building of new alliances that aim to mobilize ocean resources and justify new rounds of extraction and commodity production (also see Satizábal et al., 2020). We share a concern with scholars focused on the political economy of the marine environment in how these discourses and material practices frame the ocean as a site of accumulation and growth that promises much in terms of contributing to global food security, sustainable jobs and thriving coastal communities, but is likely to fall far short of meeting these commitments (Belton et al., 2020; Childs & Hicks, 2019; Choi, 2017). Like other scholars, we are also sceptical of the strong claims that are made that opening the ocean frontier will lead to new investments that are able to reconcile economic growth and environmental sustainability (Ertör & Hadjimichael, 2020; Irrarázaval & Bustos-Gallardo, 2019; Satizábal et al., 2020). Drawing from our case of industrial salmon aquaculture, we argue that the frontier assemblage heuristic as we use it here provides a critical framework through which to challenge existing forms of resource extraction on the ocean frontier which we hope will open up the possibility for imagining a different and more just relationship between the ocean and the coastal communities it supports.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

- Adey, J. (2018). Another aquaculture project, another court battle for N.L. government? *CBC News*, November 09, 2018.
- Aggett, D. (1981). Provincial involvement in aquaculture in Newfoundland, 1970–1980, and proposed activities for fiscal year 1981–1982, Programme Planning and Review, Government of Newfoundland and Labrador, St John's.
- Anderson, J. M. (2007). *The Salmon connection: The development of Atlantic salmon aquaculture in Canada*. Halifax: Glen Margaret Publishing.
- Apold, W., Sutterlin, A., & Couturier, C. (1996). South coast region aquaculture strategic plan, Report submitted to the Department of Development and Rural Renewal. Government of Newfoundland and Labrador: St John's.
- Asche, J., & Bjørndal, T. (2011). *The economics of salmon aquaculture*. Oxford: Wiley-Blackwell. <https://doi.org/10.1002/9781119993384>
- Auditor General. (2001). Aquaculture program. Auditor General Report of the Government of Newfoundland and Labrador, St John's.
- AWG. (1994). A discussion paper on the future of the Newfoundland and Labrador aquaculture industry, Prepared by the Federal/Provincial Aquaculture Working Group, Government of Newfoundland and Labrador, St John's.
- Baglioni, E., & Campling, L. (2017). Natural resource industries as global value chains: Frontiers, fetishism, labour and the state. *Environment and Planning A*, 49(11), 2437–2456. <https://doi.org/10.1177/0308518X17728517>
- Bakker, K., & Bridge, G. (2006). Material worlds? Resource geographies and the 'matter of nature'. *Progress in Human Geography*, 30(1), 5–27. <https://doi.org/10.1191/0309132506ph588oa>
- Barbesgaard, M. (2018). Blue growth: Saviour or ocean grabbing? *The Journal of Peasant Studies*, 45(1), 130–149. <https://doi.org/10.1080/03066150.2017.1377186>
- Barney, K. (2009). Laos and the making of a 'relational' resource frontier. *The Geographical Journal*, 175(2), 146–159. <https://doi.org/10.1111/j.1475-4959.2009.00323.x>
- Barton, J., & Fløysand, A. (2010). The political ecology of Chilean salmon aquaculture, 1982–2010: A trajectory from economic development to global sustainability. *Global Environmental Change*, 20, 739–752. <https://doi.org/10.1016/j.gloenvcha.2010.04.001>

- Belton, B., Little, D. C., Zhang, W., Edwards, P., Skladany, M., & Thilsted, S. H. (2020). Farming fish in the sea will not nourish the world. *Nature Communications*, 11(1), 1–8.
- Bustos-Gallardo, B. (2017). The post 2008 Chilean salmon industry: The example of an enclave economy. *The Geographical Journal*, 183(2), 152–163. <https://doi.org/10.1111/geoj.12204>
- Bustos-Gallardo, B., & Irarrázaval, F. (2016). “Throwing money into the sea”: Capitalism as a world-ecological system. Evidence from the Chilean salmon industry crisis, 2008. *Capitalism Nature Socialism*, 27(3), 83–102. <https://doi.org/10.1080/10455752.2016.1162822>
- Canadian Aquaculture Industry Alliance (CAIA). (2017). *Sustainable, diverse and growing: The state of farmed seafood in Canada, 2018*. Ottawa: Canadian Aquaculture Industry Alliance.
- Campling, L. (2012). The tuna ‘commodity frontier’: business strategies and environment in the industrial tuna fisheries of the Western Indian Ocean. *Journal of Agrarian Change*, 12(2), 252–278.
- Campling, L., & Colás, A. (2021). *Capitalism and the sea: The maritime factor in the making of the modern world*. London: Verso.
- CBC. (2018). Immigrants needed to fill jobs at Marystown aquaculture hub, says Paul Antle. CBC News, October 4, 2018.
- Childs, J. R., & Hicks, C. C. (2019). Securing the blue: Political ecologies of the blue economy in Africa. *Journal of Political Ecology*, 26(1), 323–340.
- Choi, Y. R. (2017). The blue economy as governmentality and the making of new spatial rationalities. *Dialogues in Human Geography*, 7(1), 37–41. <https://doi.org/10.1177/2043820617691649>
- Choi, Y. R. (2019). Profitable tidal flats, governable fishing communities: Assembling tidal flat fisheries in post crisis South Korea. *Political Geography*, 72, 20–30. <https://doi.org/10.1016/j.polgeo.2019.03.006>
- Cons, J., & Eilenberg, M. (2019). On the new politics of margins in Asia: Mapping frontier assemblages. In J. Cons & M. Eilenberg (Eds.), *Frontier assemblages: The emergent politics of resource Frontiers in Asia* (pp. 1–18). Wiley: London. <https://doi.org/10.1002/9781119412090>
- Cook, R. H. (2016). Aquaculture research and development at the St Andrews Biological Station, 1908–2008. In J. Hubbard, D. J. Wildish, & R. L. Stephenson (Eds.), *A century of maritime science: The St Andrews Biological Station* (pp. 156–178). Toronto: University of Toronto Press. <https://doi.org/10.3138/9781442617278-014>
- Couturier, C., & Rideout, K. (2018). Sustainable aquaculture production. In C. Keske (Ed.), *Food futures: Growing a sustainable food system for Newfoundland and Labrador* (pp. 303–346). St John's, Canada: ISER Press.
- Department of Fisheries and Oceans (DFO). (2021). Blue economy strategy engagement paper, Fisheries and Oceans Canada, Ottawa.
- DPA. (1990). Aquaculture development strategy, Volume 1, Report prepared for the Department of Fisheries, Government of Newfoundland and Labrador, St John's.
- Ertör, I., & Hadjimichael, M. (2020). Blue degrowth and the politics of the sea: Rethinking the blue economy. *Sustainability Science*, 15, 1–10. <https://doi.org/10.1007/s11625-019-00772-y>
- Ertör, I., & Ortega-Cerda, M. (2019). The expansion of intensive marine aquaculture in Turkey: The next-to-last commodity frontier? *Journal of Agrarian Change*, 19(2), 337–360. <https://doi.org/10.1111/joac.12283>
- Food and Agriculture Organization (FAO). (2020). The state of world fisheries and aquaculture: Sustainability in action, Food and Agriculture Organization of the United Nations, Rome.
- Fløysand, A., Haarstad, H., & Barton, J. (2010). Global economic imperatives, crisis generation and local spaces of engagement in the Chilean aquaculture industry. *Norwegian Journal of Geography*, 64(4), 199–210.
- GFW. (2019). Perfectly centred: The gateway to the aquaculture industry in Newfoundland and Labrador, <https://www.gatewaytoaquaculture.com/>, accessed 5 January 2021.
- Havice, E., & Zalik, A. (2018). Ocean frontiers: Epistemologies, jurisdictions, commodifications. *International Social Science Journal*, 68(229–230), 219–235. <https://doi.org/10.1111/issj.12198>
- Huffman, J. (2021). Salmon death rates still high in Newfoundland 18 months after Mowi meltdown, *Undercurrentnews*, 9 April 2021.
- Irarrázaval, F., & Bustos-Gallardo, B. (2019). Global salmon networks: Unpacking ecological contradictions at the production stage. *Economic Geography*, 95(2), 159–178. <https://doi.org/10.1080/00130095.2018.1506700>
- Kama, K. (2019). Resource-making controversies: Knowledge, anticipatory politics and economization of unconventional fossil fuels. *Progress in Human Geography*, 44(2), 333–356.
- Knott, C. (2016). Contentious mobilities and cheap (er) labour: Temporary foreign workers in a New Brunswick seafood processing community. *Canadian Journal of Sociology*, 41(3), 375–398. <https://doi.org/10.29173/cjs28256>
- Knott, C., & Marschke, M. (2021). ‘Flagpoling’: Inter-provincial mobility of international migrants within Canada's temporary foreign worker program. *International Migration*, 59(2), 25–40. <https://doi.org/10.1111/imig.12713>
- Knott, C., & Neis, B. (2017). Privatization, financialization, and ocean grabbing in New Brunswick herring fisheries and salmon aquaculture. *Marine Policy*, 80, 10–18. <https://doi.org/10.1016/j.marpol.2016.10.022>
- Li, T. M. (2014a). What is land? Assembling a resource for global investment. *Transactions, Institute for British Geographers*, 39, 589–602. <https://doi.org/10.1111/tran.12065>

- Li, T. M. (2014b). *Land's end: Capitalist relations on an indigenous frontier*. Duke: Durham. <https://doi.org/10.1215/9780822376460>
- Maher, D. (2019). Marystown shipyard sold to Paul Antle's Marbase for \$1 million, *The Telegram*, 27 September 2019, St John's.
- Manning, F. and Hubley, E. (2015). An ocean of opportunities: Aquaculture in Canada, Volume 3, Standing Senate Committee on Fisheries and Oceans, Ottawa.
- Marine Institute. (2020). A review of the 2019 Newfoundland and Labrador South Coast Cultured Atlantic Salmon Mortality Event, Report submitted to the Department of Fisheries and Land Resources, Government of Newfoundland and Labrador.
- Marschke, M., Kehoe, C., & Vandergeest, P. (2018). Migrant worker experiences in Atlantic Canadian fish processing plants. *The Canadian Geographer*, 62(4), 482–493. <https://doi.org/10.1111/cag.12466>
- Marshall, D. (2003). *Fishy business: The economics of salmon farming in British Columbia*, Canadian Centre for Policy Alternatives, Ottawa.
- McKinsey & Company. (2019). *Economic growth strategy for Newfoundland and Labrador, recommendations to the government of Newfoundland and Labrador*. New York: McKinsey & Company Consultants. <https://bit.ly/34UgQ9E>
- Middleton, T. (2019). Frontier 2.0: The recursive lives and death of cinchona in Darjeeling. In J. Cons & M. Eilenberg (Eds.), *Frontier assemblages: The emergent politics of resource frontiers in Asia* (pp. 195–212). Wiley: London.
- Milewski, I., & Smith, R. E. (2019). Sustainable aquaculture in Canada: Lost in translation. *Marine Policy*, 107, 1–8.
- Moore, J. W. (2015). *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. London: Verso.
- Moran, K. (2016). The ocean economy: Canada could be a global superpower. *The Globe and Mail*, 10 October 2016, Toronto, Canada.
- MSRL. (1980). Bay D'Espoir aquaculture feasibility study, A report prepared for the Bay D'Espoir Development Association and the Newfoundland Department of Fisheries, Marine Sciences Research Laboratory, St John's.
- NAIA. (1998). Bay D'Espoir area leads the way in aquaculture production. *Newfoundland Aquaculture Review*, 1, 25–27.
- Neimark, B. D., & Healy, T. M. (2018). Small-scale commodity frontiers: The bioeconomy value chain of castor oil in Madagascar. *Journal of Agrarian Change*, 18(3), 632–657. <https://doi.org/10.1111/joac.12231>
- Newfoundland and Labrador. (2016). *Seafood industry year in review*, Department of Fisheries, Land and Resources, Government of Newfoundland, St John's, Canada.
- Newfoundland and Labrador. (2017). *The Way Forward on Aquaculture, Sector Work Plan*, Department of Fisheries, Land and Resources, Government of Newfoundland, St John's, Canada.
- Nova Scotia. (2015). *Aquaculture strategy: Creating sustainable wealth in rural and coastal Nova Scotia*. Halifax: Government of Nova Scotia.
- Organization for Economic Cooperation and Development (OECD). (2016). *The ocean economy in 2030*. Paris: OECD publishing. <https://doi.org/10.1787/9789264251724-en>
- O'Higgins, T., Alexander, K., & Graziano, M. (2019). Mismatches in spatial scale of supply and demand and their consequences for local welfare in Scottish aquaculture. *Anthropocene Coasts*, 2(1), 61–278.
- Peluso, N. L., & Lund, C. (2011). New frontiers of land control: Introduction. *Journal of Peasant Studies*, 38(4), 667–681.
- Pepper, V. (2003). Bay d'Espoir Atlantic salmon aquaculture: Experience with early maturation. *Bulletin of the Aquaculture Association of Canada*, 103, 23–26.
- Rasmussen, M. B., & Lund, C. (2018). Reconfiguring frontier spaces: The territorialization of resource control. *World Development*, 101, 388–399. <https://doi.org/10.1016/j.worlddev.2017.01.018>
- Richardson, T., & Weszkalnys, G. (2014). Introduction: resource materialities. *Anthropological Quarterly*, 87(1), 5–30.
- Rigby, B., Davis, R., Bavington, D., & Baird, C. (2017). Industrial aquaculture and the politics of resignation. *Marine Policy*, 80, 19–27. <https://doi.org/10.1016/j.marpol.2016.10.016>
- Roberts, T. (2019). No appetite for fish farming in BC? Look east, says NL fisheries minister, CBC News, 1 October 2019.
- Rozwadowski, H. (2018). *Vast expanses: A history of the oceans*. Chicago: University of Chicago Press.
- Rubinov, I. (2019). Growing at the margins: Enlivening a neglected post-Soviet frontier. In J. Cons & M. Eilenberg (Eds.), *Frontier assemblages: The emergent politics of resource frontiers in Asia* (pp. 99–116). London: Wiley.
- Saguin, K. (2016). Blue revolution in a commodity frontier: Ecologies of aquaculture and agrarian change in Laguna Lake, Philippines. *Journal of Agrarian Change*, 16(4), 571–593. <https://doi.org/10.1111/joac.12114>
- Sapin, R. (2019). Atlantic Canada may be the last frontier for salmon farming growth. *Intrafish News*, 30 September 2019.
- Satizábal, P., Dressler, W. H., Fabinyi, M., & Pido, M. D. (2020). Blue economy discourses and practices: Reconfiguring ocean spaces in the Philippines. *Maritime Studies*, 19, 1–15.
- Saunders, R. L. (1989). Salmonid aquaculture: Present status and prospects for the future. In A. D. Boghen (Ed.), *Cold water aquaculture in Atlantic Canada* (pp. 53–68). Moncton: The Canadian Institute for Research on Regional Development.

- Silver, J., Gray, N. J., Campbell, L. M., Fairbanks, L. W., & Gurby, R. L. (2015). Blue economy and competing discourses in international oceans governance. *The Journal of Environment and Development*, 24(2), 135–160. <https://doi.org/10.1177/1070496515580797>
- Silver, J. J. (2013). Neoliberalizing coastal space and subjects: On shellfish aquaculture projections, interventions and outcomes in British Columbia, Canada. *Journal of Rural Studies*, 32, 430–438. <https://doi.org/10.1016/j.jrurstud.2013.10.003>
- Steinberg, P. E. (2018). Editorial: The ocean as frontier. *International Social Science Journal*, 68(229–230), 237–240. <https://doi.org/10.1111/issj.12152>
- Stoll, J. S., Leslie, H. M., Britsch, M. L., & Cleaver, C. M. (2019). Evaluating aquaculture as a diversification strategy for Maine's commercial fishing sector in the face of change. *Marine Policy*, 107, 1–10.
- Storey, K. (2010). Fly-in/Fly-out: Implications for community sustainability. *Sustainability*, 2(5), 1161–1181. <https://doi.org/10.3390/su2051161>
- Taylor, V.R. (1975). A preliminary assessment of Newfoundland near-shore areas as potential sites for salmonid aquaculture, Internal Report Series, No. NEW/I-75-5 Newfoundland Region, Fisheries and Marine Services, Environment Canada, St John's.
- Thomas, M. (2018). Farms in Broughton Archipelago will be gone by 2023. CBC News, December 14, 2018.
- Tsing, A. L. (2003). Natural resources and capitalist frontiers. *Economic and Political Weekly*, 38(48), 5100–5106.
- Valdivia, G., Himley, M., & Havice, E. (2012). Critical Resource Geography: An Introduction. In M. Himley E. Havice & G. Valdivia (Eds.), *The Routledge Handbook of Critical Resource Geography* (pp. 1–27). New York: Routledge.
- Vardy, D. (1984). Aquaculture tour report. Bay D'Espoir Development Association, Conne River Indian Band Council, and the Department of Rural, Agricultural and Northern Development, Government of Newfoundland and Labrador.
- Volpe, J. P., & Shaw, K. (2007). Fish farms and neoliberalism: Salmon aquaculture in British Columbia. In C. D. Gore & P. J. Stoett (Eds.), *Environmental challenges and opportunities: Local-global perspectives on Canadian issues* (pp. 131–158). Toronto: Edmond Montgomery.
- Watts, M. (2016). Accumulating insecurity and manufacturing risk along the energy frontier. *Risking Capitalism: Research in Political Economy*, 31, 197–236. <https://doi.org/10.1108/S0161-723020160000031012>
- Wilson, G. A., & Rigg, J. (2003). 'Post-productivist' agricultural regimes and the South: discordant concepts? *Progress in Human Geography*, 27(6), 681–707.
- Winder, G. M., & Le Heron, R. (2017). Assembling a blue economy moment? Geographic engagement with globalizing biological-economic relations in multi-use marine environments. *Dialogues in Human Geography*, 7(1), 3–26. <https://doi.org/10.1177/2043820617691643>
- Withers, P., 2019. Global salmon farming company eyes \$500m expansion along Nova Scotia coast, CBC News, 3 April 2019.
- Young, N., Brattland, C., Digiovanni, C., Hersoug, B., Johnsen, J. P., Karlsen, K. M., & Thorarensen, H. (2019). Limitations to growth: Social-ecological challenges to aquaculture development in five wealthy nations. *Marine Policy*, 104, 216–224. <https://doi.org/10.1016/j.marpol.2019.02.022>

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