The History and Evolution of Salmon Aquaculture Siting Policy in British Columbia

by

DANIEL GALLAND
B.Sc. Civil Engineering
(Instituto Tecnológico de Estudios Superiores de Occidente, México, 2000)

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Abstract

Salmon aquaculture is the rearing of salmonids for commercial purposes. These practices are typically carried out in saltwater farms located in coastal waters. The process of siting these facilities requires identifying and selecting areas that are economically, socially and environmentally suitable to locate them. Siting salmon aquaculture facilities has become a controversial resource management issue in British Columbia (B.C.), where distance-based criteria ultimately determine the location of these facilities.

This thesis focuses on providing insights and concepts to inform and examine the salmon aquaculture facility siting process in B.C. It is argued that regulatory processes and outcomes in the context of a new industry could respond to mechanisms and factors that shape governmental agendas, illustrating how policy can behave reactively rather than in a precautionary manner. In this case, the outcomes of such reactive policies are reflected in siting criteria that yield implicit environmental and socio-economic disadvantages and trade-offs. This way, siting criteria derive from expert judgements based on best available information while their associated uncertainties may lead to consider less-desirable sites while underestimating or overestimating risks, and overlooking important regional objectives, cumulative impacts and stakeholder values.

The thesis further suggests that the future evolution of the salmon aquaculture facility siting process in B.C. could benefit from siting processes that have already been developed and implemented by other sectors. Different lines of reasoning that deal with processes of public negotiation, analytical decision-making and a systems' approach are explored as ways by which the salmon aquaculture facility siting process could evolve in the future toward creating more comprehensive policy.

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1. Introduction to the case

Salmon aquaculture is the rearing of salmonids for commercial purposes. This research is concerned with the grow-out phase of salmon aquaculture in British Columbia (B.C.), which is almost entirely carried out in saltwater farms located in coastal waters. Siting criteria ultimately determine the location of salmon aquaculture facilities. The focus of this thesis is how such criteria have evolved and what they entail.

Siting refers to the process of identifying and selecting areas that are economically, socially and environmentally suitable to locate certain types of facilities. In general, facility siting is an exceptionally complex problem associated with new (and controversial) industries such as salmon aquaculture. In B.C., siting fish farms has become an increasingly contentious issue given the environmental, socio-economic and cultural contexts associated with the industry.

1.1. Context and need for the study

Siting salmon aquaculture facilities has become a controversial resource management issue in B.C. The federal and provincial governments introduced siting criteria several years after the industry was established and during a process of rapid expansion. Siting fish farms became gradually more complex from environmental and socio-economic perspectives as numerous stakeholders reacted to this process. To date, there is no harmonization of siting criteria between policy makers or agreement between stakeholders about their meaning.

Significant environmental and socio-economic concerns have created conflicts between policy makers, resource users and other stakeholders. At the same time, conflicting interests between levels of government have led to conflicting interpretations of the criteria and complicated the siting process. Therefore, the expansion of the sector has been limited (assuming that salmon aquaculture is a viable industry, capable of growth). The provincial government currently seeks to make siting criteria more flexible while the federal government does not want to relax regulations. Issues concerning the integration of biophysical, socio-economic, political and cultural components still need to be resolved. Also, the lack of a clear procedure for making siting decisions and considering alternative perspectives are important challenges.

The current salmon aquaculture siting criteria deal with biophysical aspects from the perspective of how to avoid further environmental damage (e.g., sites should be located at least 1 km away from salmon bearing streams) or with socio-economic questions from the perspective of how to avoid further conflict with other resource users or stakeholders. These criteria are fraught with disadvantages and implicit trade-offs that need to be clarified in order to address the problem.

It is argued that the salmon aquaculture industry in B.C. is regulated by siting policy that has responded to factors that shape governmental agendas. These factors describe how regulations can behave reactively rather than in a precautionary manner. In addition, siting policy has been designed under a site-by-site approach. The outcome is reflected in criteria that may overlook important regional objectives, cumulative impacts and stakeholder values.

1.2. Fundamental objective and research questions

The fundamental objective of this research project is to explore the salmon aquaculture facility siting process to provide insights that clarify the evolution, determination and use of siting criteria. Three research questions related to the aforementioned context are posed and explained in the following sections.

1.2.1. How has salmon aquaculture siting policy evolved in B.C.?

This research question arises from the need to understand how siting policy has originated and evolved in the context of an industry that is relatively recent and where initial planning approaches neither projected an accelerated expansion nor conceived significant potential risks (which were almost unknown in B.C. at the time when the industry was first established there). It is expected that examining the factors that shaped siting policy processes and outcomes will offer insights for future policy decisions.

Chapter 3 addresses this question in detail. First, section 3.1 proposes a conceptual framework comprised by mechanisms and factors that may shape policy in general. Thereafter, section 3.2 delves into the different salmon aquaculture policy outcomes that dealt with siting matters. Each policy outcome is analyzed based on the proposed framework.

1.2.2. What are the rationales, disadvantages and implicit trade-offs of siting criteria?

Understanding the rationales, disadvantages and implicit trade-offs behind the establishment of siting criteria is important for informing future courses of action that are able to integrate expert judgments, technical information and stakeholder values. Section 3.3 delves into the origin, evolution, purpose and rationale of relevant criteria, placing emphasis on six out of a total of fifteen existent siting criteria. Section 3.4 discusses some of the implicit disadvantages concerned with the establishment of criteria and analyses some of the major trade-offs associated with the buffers that constitute siting criteria.

1.2.3. How could the salmon aquaculture facility siting process evolve in B.C.?

This research question is concerned with suggestions regarding how the current facility siting process could evolve in the future toward creating more comprehensive policy. Facility siting could be approached from different perspectives. Often, locating a fish farm in coastal waters may only consider the perspective of how to find the most suitable site in terms of fish production. However, because the real problem is much more complex (from environmental and socio-economic perspectives), the facility siting process may also benefit, for instance, from negotiation or analytical decision-making processes. Chapter 4 suggests and describes three processes that consider how salmon aquaculture facility siting in B.C. could evolve.

1.3. Research sequence and methods

A vast literature review was conducted that included the most comprehensive official document concerned with the salmon aquaculture industry in the province (i.e., the Environmental Assessment Office Salmon Aquaculture Review), other studies that discussed stakeholder perspectives on the industry (i.e., Net Loss, Leggatt Inquiry) and the history of the industry itself (i.e., Sea Silver). This literature provided an overall introduction to the salmon aquaculture situation in B.C. as well as an overview regarding some of the major problems associated with the industry.

A particular case regarding siting criteria was identified from a GIS exercise performed by the Living Oceans Society (Leggatt Inquiry, 2002), where over 90% of salmon aquaculture sites located in the Broughton Archipelago (the most aquaculture-intensive region in the province) were found to violate at least one criterion. The first two research questions of this thesis emerged from this situation.

Two types of interviews were then carried out. The first set was undertaken with government officials (policy makers) of the federal Department of Fisheries and Oceans and the provincial Ministry of Agriculture, Food and Fisheries. The aim of these interviews was to clarify the origin, evolution, purpose and scientific rationale (if any) behind siting criteria. These interviews yielded information on policy outcomes concerned with siting matters, perspectives regarding the role of siting criteria and important historical facts. A second set of interviews was undertaken with individuals associated with the industry (i.e., Stolt Sea Farm) and research organizations (i.e., Aquametrix and Living Oceans Society). These interviews were based on a questionnaire specifically developed to clarify their values and interests.

A conceptual framework regarding the evolution of siting criteria was developed based on factors that may play a role in the setting of agendas, which is the means by which issues get typically addressed from a policy-maker perspective (Kingdon, 1995). Inductive reasoning concerned with the salmon aquaculture case strengthened this framework. An analysis concerned with each siting policy document followed. The suggested factors were then applied to each policy outcome, including a general and a more detailed analysis with respect to six relevant (and controversial) criteria. The disadvantages and implicit trade-offs associated with siting criteria were also deduced.

Finally, as a response to the research outcome and analysis from chapter 3, a new question was posed concerning how the salmon aquaculture facility siting process could evolve in B.C. Facility siting literature associated with other industries was analyzed to understand how they had managed their siting issues. Important concepts were identified in three different processes which could help the salmon aquaculture industry adapt its own siting process.

1.4. Outline of remaining chapters

The remainder of this thesis is comprised by four chapters. Chapter 2 provides an overview of the history and evolution of the salmon aquaculture industry worldwide and in B.C. This provides a description of historical and current production quantities and values, the overall production process, alternative technologies, the regulatory framework in the province and inherent risks associated with this industry. Moreover, an introduction is given to the facility siting problem, comprised by its dimensions, objectives and typical mechanisms.

Chapter 3 introduces the conceptual framework on which the research is founded. Factors that have contributed to shape the evolution of salmon aquaculture siting policy are introduced and a thorough analysis concerned with relevant siting policy outcomes in B.C. is presented. Finally, the chapter explores the purpose, rationale, disadvantages and implicit trade-offs regarding the establishment of siting criteria. Policy-maker and stakeholder views on this subject are also presented.

Chapter 4 describes three processes that could be considered when thinking of how the facility siting process could evolve in B.C. The first one refers to a public negotiation process that has been previously used by other sectors. A second process approaches facility siting from an analytical decision-making perspective to find best sites. Finally, a third process examines fish farm sites as sub-systems that are embedded in and should adapt to broader and more complex systems. The chapter concludes with ideas toward integrating siting perspectives to develop a more comprehensive facility siting process.

The fifth and final chapter provides general conclusions regarding the scope and outcome of this research. Emphasis is placed on the three general research questions. Additional suggestions and recommendations with regards to possible future research steps are also provided.

2. Overview of the salmon aquaculture industry and the siting problem

This chapter provides a brief review of the history and evolution of the salmon aquaculture industry focusing on B.C. The first section discusses historical facts associated with the growth and development of the industry at a global scale and in the province. The second section provides an overview of the industry in B.C., placing emphasis on the production process, current and alternative technologies, the regulatory framework and the risks that have given rise to public concerns. The third section introduces the siting problem by discussing its social and environmental dimensions, addressing important siting process objectives and describing typical siting mechanisms. The chapter concludes with the lessons learned throughout the three sections and their relevance to this project.

2.1. Origins of the salmon aquaculture industry

The genesis of the aquaculture industry dates back to 4000 BC. Archaeological evidence has shown that people of Mesopotamia reared fish in ponds at that time. Their techniques were adopted and improved by other cultures including the Egyptians,[1] Greeks and Romans (Keller & Leslie, 1996). Moreover, cultures inhabiting the world's eastern hemisphere also developed sophisticated fish farming techniques during the same period of time. For instance, carp are known to have been spawned and reared about 5000 to 2500 years ago in China (Landau, 1992).

The term aquaculture has been subject to several definitions. Amongst the most common ones are "the large-scale husbandry or rearing of aquatic organisms for commercial purposes" or "the art of cultivating the natural produce of water" (Landau, 1992).

[1] An Egyptian bas-relief from 2500 BC shows men removing tilapia from a pond (Keller & Leslie, 1996).

2.1.1. Contemporary salmon aquaculture history worldwide

In general terms, salmon aquaculture[2] is the practice of raising salmon for human consumption. The first endeavours to culture salmon intensively from juvenile stages to commercial distribution and marketing were carried out during the late 1960s and early 1970s. Norway pioneered contemporary salmon aquaculture practices and successfully harvested Atlantic salmon (*Salmo salar*) since the early 1970s. Scotland took the lead in salmon production during the first years of the industry.[3] However, since 1974 and until most recent data (FAO, 2003), Norway has been the leading farmed salmon producer.

Several other nations entered the salmon aquaculture market during the following decade. Global farmed salmon production surpassed 10,000 tonnes in 1981 and as technology, farmed stock and feed quality continued to improve, production quantities grew exponentially exceeding 200,000 tonnes by the end of the decade (Figure 2-1). Norwegian production continued growing significantly and produced over 60% of the world's farmed Atlantic salmon until 1986 (45,000 tonnes).

Parallel to the Norwegian fish farming expansion during the 1980s, the industry also evolved in Scotland, Chile and Canada (B.C. and the Atlantic coast provinces), and to a lesser degree in the Faeroe Islands, Japan and the United States. Norway continued to be the most important producer until Chile's strong growth in farmed salmonid production during the 1990s. Chile's production has impressively grown to the extent that farmed salmon quantities have practically equalled those of Norway.[4] In recent years, Norway and Chile together have accounted for over 70% of the world's total salmonid production from traditional floating marine net-cage systems. And together with Scotland, B.C. and the Faeroe Islands, production rates account for over 90% of the world's total production

---

2 The terms salmon aquaculture, salmon farming, finfish aquaculture and fish farming are used interchangeably throughout this thesis. It is important to note that the term 'salmon ranching' refers to a different culture method where salmon are released into the natural environment, followed by their entire development at sea, and finally their subsequent return to freshwater for harvesting.

3 From 1970 and until 1973 Scotland produced 1074 tonnes of Atlantic salmon while Norway harvested 465 tonnes (FAO, 2003).

4 Norway produced 509,000 tonnes of farmed salmon in 2001 versus Chile's 503,000 tonnes during that same year (FAO, 2003).

(FAO, 2001). The remaining 10% takes place in Australia, France, Iceland, Ireland, Japan, New Zealand, Spain, Sweden, Turkey and the United States (off the coasts of Washington State and Maine).

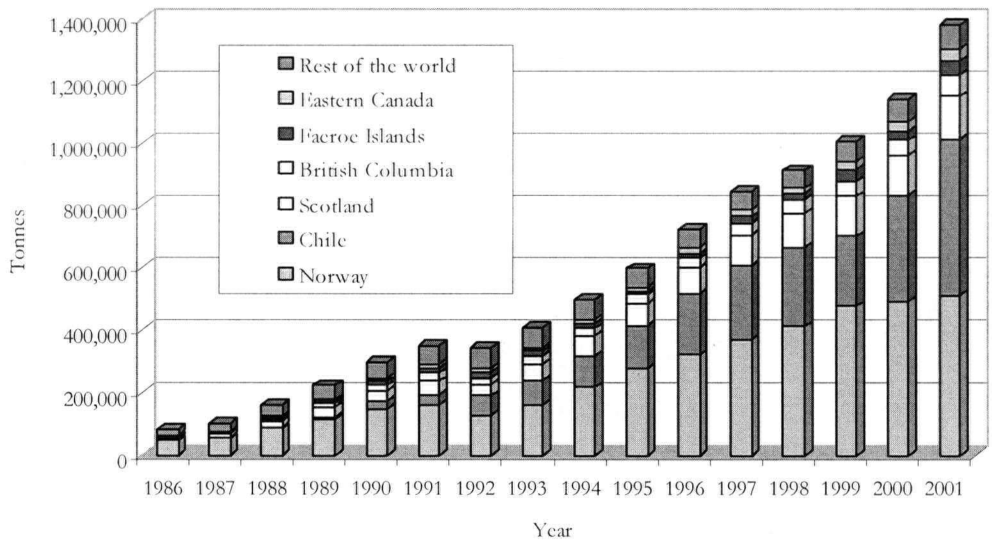

Figure 2-1. Worldwide salmonid production quantities by country (in metric tonnes), from 1986 to 2001 (FAO, 2003).

The industry in Chile grew to become the second largest producer of farmed salmonids, and is a main actor in international markets for salmon and trout. Beneficial environmental and social conditions have contributed to the achievements of the sector in that country. For instance, Chilean regions where aquaculture has been developed are typically sheltered and biophysically favourable. Moreover, the relatively low population density within those regions, low labour costs, inexpensive feed based on locally-produced fish meal, and the relatively few constraints that the government has placed to the expansion of the industry, are all important factors that have largely contributed to such growth (Bjorndal & Aarland, 1999). In contrast, other jurisdictions with less favourable biophysical or socio-political settings have developed the industry under more limiting conditions.

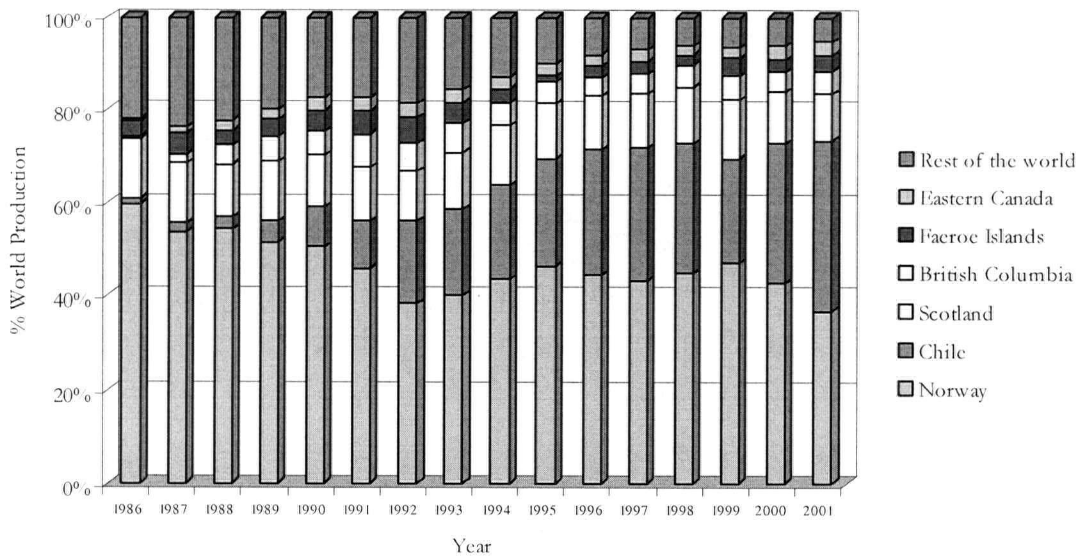

Figure 2-2. Worldwide farmed salmonid production quantities by country (in %),[5] from 1986 to 2001 (FAO, 2003).

Atlantic salmon (*Salmo salar*), Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tshawytscha*), and Rainbow trout (*Oncorhynchus mykiss*) are the most important farmed salmonid species. Atlantic salmon have become the preferred farmed salmonid species in most jurisdictions throughout the world mainly due to market preferences and cost advantages. In addition, Atlantic salmon are characterized by faster growth rates and a greater tolerance to higher stocking densities (EAO, 1997a).

The global production rates of both Coho salmon and Rainbow trout have been quite similar, with Rainbow trout production exceeding that of Coho salmon only recently. Chinook salmon production has remained somewhat modest with respect to the other three farmed salmonids on a global scale. For instance, in 2001, chinook production just reached over 20,000 tonnes while almost 1,000,000, nearly 200,000 and 150,000 tonnes of Atlantic salmon, Rainbow trout and Coho salmon were generated, respectively (Figure 2-3).

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[5] Production of salmonids in this graph comprises the types of most typically farmed salmonids: Atlantic salmon, Coho salmon, Chinook salmon, and Rainbow trout (Source: Fishstat+, *ibid.*).

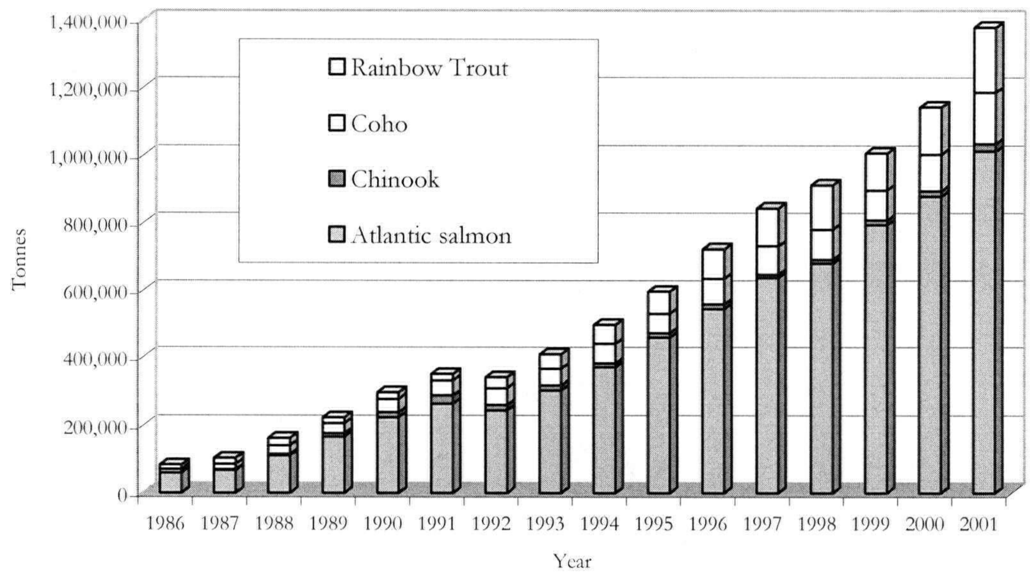

Figure 2-3. Worldwide salmonid production quantities by species (in metric tonnes), 1986 to 2001 (FAO, 2003).

At present, the aquaculture industry is characterized by global integration that has created intensive market competition across borders and continents. The industry has been influenced by an emerging international trend of organizational challenges. The extent by which globalization has influenced the salmon aquaculture industry is quite remarkable. Small-scale, locally-controlled farms have virtually disappeared while few multinational corporations dominate the entire farmed salmonid marketplace.[6]

Furthermore, the value of salmonid production has exponentially increased to the extent that the industry has become a multi-million dollar business (Figure 2-4). Altogether, current production values exceed 3.5 billion USD (FAO, 2003). In B.C., salmonid production values went beyond 250 million USD in 2001 (FAO, 2003).

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[6] B.C.'s salmon aquaculture industry clearly illustrates this fact. By 1988 there were 101 companies operating in the province (EAO, 1997a). Ownership of small farms shifted to larger corporations in subsequent years. A total of 16 companies owned all sites that remained operating by 1997. Currently, three Norwegian multi-national corporations (Stolt Sea Farm, PanFish and EWOS) together own 74 sites while the Dutch multi-national Nutreco owns 15 sites. Norway and Holland account for two-thirds of a total of 135 sites that operate in the province (LWBC, 2002; Living Oceans Society, 2003).

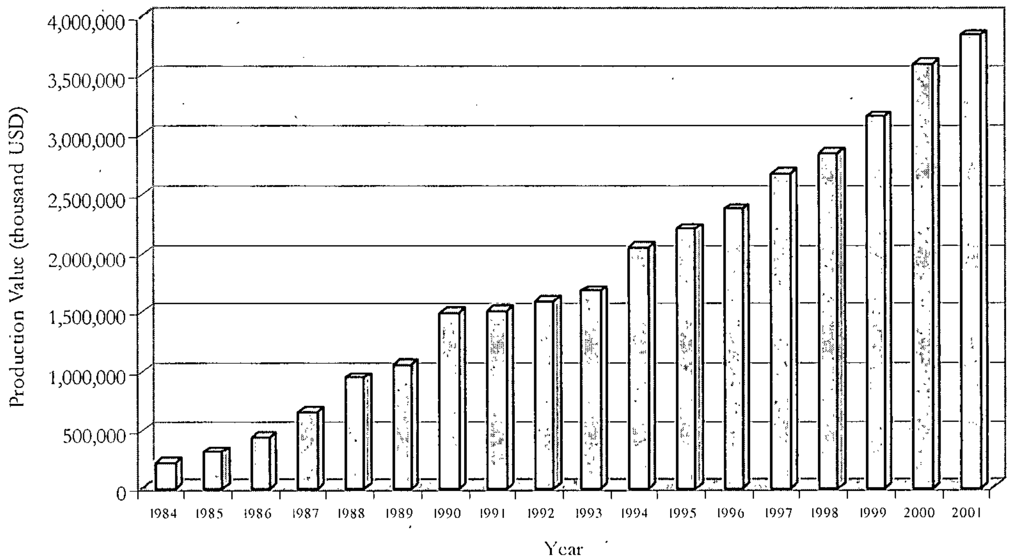

Figure 2-4. Worldwide salmonid production values (in thousand USD), from 1984 to 2001 (FAO, 2003).

2.1.2. Salmon aquaculture history in British Columbia

The 1970s[7]

The salmon aquaculture industry was introduced to the province in the 1970s. The first attempts to farm salmonids were undertaken by a forestry firm, *Crown Zellerbach*, in 1971. The company initiated an aquaculture project receiving federal and provincial government approvals to farm Chinook salmon and hybrids of Rainbow and Steelhead trout. However, the final permits were not granted and, because these species had been obtained from a foreign hatchery, the federal Department of Fisheries and Oceans (DFO) ordered to deport the fish. Soon after, the corporation shut down their initial test site.

DFO granted the first B.C. aquaculture license to *Moccasin Valley Marifarms* to site a farm next to the Sechelt Peninsula in the Sunshine Coast by mid-1972. This local firm designed its own net-pen technology and relied on Coho salmon eggs from government hatcheries,

[7] This section draws heavily on Keller & Leslie (1996) for historical facts.

because imported eggs were outlawed by the federal government at the time. During the same year, a foreign-owned company, *Union Carbide Canada Ltd.*, showed interest in aquaculture investment and placed an order with DFO for several million eggs to be delivered during the subsequent year. The provincial government objected to this proposal and decided not to issue a license. Union Carbide ended up cancelling their project.

There were ten more aquaculture licenses granted to both locally-owned and foreign companies during the rest of the decade. Projects were attempted in multiple locations along the west and east of Vancouver Island,[8] as well as on several mainland inlets. Local species (Chum, Sockeye and Coho salmon) were the first to be farmed. Chum and Sockeye were the specialties of the federal Pacific Biological Station (PBS) at Nanaimo, B.C., who provided the companies with hatchery eggs. Both species proved commercially unviable while Coho and Chinook were prevalent until the introduction of Atlantic salmon in the following decade.

In summary, the major factors that made salmon aquaculture projects in the coastal waters of B.C. unsuccessful during the 1970s were the failure to attract financial interest, lack of governmental support, isolation of sites and deficient technology. However, an important shift occurred during the following decade on all four matters.

The 1980s[9]

Regulations, foreign investment and production rates associated with the salmon aquaculture industry in the province underwent considerable changes. Both the federal and provincial governments began to make aquaculture policy more explicit in terms of permit and license processes. The regulatory process became rather complex, requiring farmers to obtain licenses from DFO and permits from the then provincial Ministry of the Environment, foreshore leases, environmental assessments and development plans. In addition, had any other federal agency or provincial ministry with a stake in the evaluation process objected to a certain application, it was likely to be derailed.

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[8] Interestingly, during the same decade and as part of a large project, the founder of a college in the northeast of Vancouver Island encouraged the Nimpkish Indian Band of Alert Bay to acquire fish farming skills and began growing coho salmon in 1977 after receiving a license (Keller & Leslie, 1996).
[9] This section draws heavily on Keller & Leslie (1996) for historical facts.

By the early 1980s, the main inlets of the Sunshine Coast became the preferred location for aquaculture investment given the optimal biophysical conditions of the area and their relative proximity to the mainland markets. Aquaculture investment in the area was being strongly encouraged by the Economic Development Division of the Sunshine Coast. At that same time, in Norway, a moratorium on new farms that had been in place since 1977 had limited the dimensions and capacities of salmon farms, therefore imposing stringent control on the expansion of the industry in that country.[10] It was then that Norwegian corporations looked overseas for investment opportunities and considered B.C. a suitable location to expand.

Given the lack of explicit regulation and the changing political climate in the province at the time, Norwegian firms envisioned the possibility of developing much larger farms than in their own country. Also, they invested in the Canadian market to minimize their own taxes in Norway. In 1984, the Conservative party came into power in Canada and new policies were established and implemented, encouraging foreign investment in different sectors. A delegation of Norwegians then visited the B.C. coast to survey the potential for investment in the area. Several corporations that were financed by the aquaculture subsidiary divisions of two major Norwegian banks,[11] sited their farms on the B.C. coast in 1985 (Keller & Leslie, 1996).

Once salmon farms were actively operating in the Sunshine Coast and there was promise of considerable expansion in the province, both fishers and community organizations began raising environmental concerns associated with impacts of fish farm waste, including overfeeding and faeces. Little was known about the long-term effects of a large-scale aquaculture industry then and neither testing nor research had been planned for the future expansion of the industry.

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[10] Gary Caine. Ministry of Agriculture, Food and Fisheries (MAFF). Courtenay, B.C. April 2003. Personal communication.
[11] Bergen Bartz and Christiana (Keller & Leslie, 1996).

While most salmon farmers in the province were entirely unaware of the risks held by particular types of diseases in their farms, plankton blooms emerged,[12] giving rise to multiple water quality concerns. Universities and other research groups began to study harmful algal blooms (HABs)[13] while local farmers dealt with diseases such as the bacterial kidney disease (BKD) and vibrosis, both of which had no controls at the time (Keller & Leslie, 1996).

The risk of disease and greater environmental concerns increased significantly when DFO allowed the introduction of Atlantic salmon eggs to some farm sites in the mid-1980s. While this species was considered more desirable due to faster growth rate and substantial economic appeal, its introduction to the B.C. coast had the potential for the spread of sea lice,[14] which had already generated outbreaks resulting in massive fish kills in Scotland and Norway.

The industry continued to expand to other areas located on the west, east and northeast of Vancouver Island. The industry had a gold-rush vision for development. Then, a massive bloom of phytoplankton (*Heterosigma carterae*) occurred on the Sunshine Coast in the summer of 1986 which killed an estimated 100,000 fish and led to recommendations that suggested moving fish farms into less exposed locations.[15] Soon after this event took place, pressure from fishers resulted in the first moratorium on issuance of farm leases. An inquiry led by David Gillespie was then conducted, resulting in recommendations for improving and monitoring the industry. By 1987, an Atlantic salmon importation policy was established and the industry began to switch from Coho and Chinook production to Atlantic salmon.

Controversy increased with respect to several environmental and socio-economic aspects during subsequent years and a disastrous crisis struck the industry. Fishers reported declines

[12] Despite being the staple of the marine food chain, these microscopic organisms exponentially increase whenever there is underwater accumulation of nutrients that deplete oxygen. Plankton become then a peril to the survival of aquatic organisms. The natural decay process of plankton creates hydrogen sulphide (H_2S) and methane (CH_4), which cause the death of marine life.
[13] Specific types of phytoplankton (e.g. diatoms such as *Chaetoceros*, or flagellates such as *Heterosigma carterae*) that cause death of marine life and humans.
[14] External parasites that feed on the skin and mucous of salmon
[15] Research carried out at the University of British Columbia focused on the origin of the bloom and whether fish farms had been the cause of high nutrient levels. This work concluded that there was no particular

in wildlife in areas near fish farms on the Sunshine Coast. The unconsidered problem of fish predators (e.g., seals, sea lions, river otters, etc.) in farms arose and quickly worsened, causing fish farmers to apply unsustainable control measures. The disposal of morts (dead farmed fish) as well as issues of infected egg and smolt supplies also arose. For instance, an epidemic of furunculosis[16] hit several fish farms after the importation of Scottish eggs. Consumers were alarmed about ingesting antibiotic residues from farmed salmon. The Norwegians (who owned 40% of the B.C. salmon aquaculture industry by 1988) cut off further investment. A price collapse in salmon also took place, causing serious financial difficulties and contributing to the closure of farms, particularly from Prince Rupert to the Sunshine Coast. By the end of the decade, there were 185 small salmon farms operated by more that 100 companies.

The 1990s

The industry went through a considerable restructuring process during this decade. Most companies relocated their farms and moved north to regions such as Campbell River and the Broughton Archipelago. Although few firms stayed on the Sunshine Coast, the industry mostly shut down there.

The beginning of the decade was not easy for the industry. Harsh climatic conditions from wind and rainstorms impacted several fish farms in their new locations while phytoplankton blooms remained a problem. These damaging biophysical conditions coupled with the low salmon prices at the time caused production to decrease in 1992 compared to the previous year (Figure 2-5). Despite the introduction of Atlantic salmon some years before, most companies continued to farm Chinook salmon until a major switch to the imported species came about in 1993. From that year onwards, Atlantic salmon production prevailed over other salmonid species.[17]

evidence of farm contribution to phytoplankton bloom. However, it was recommended to relocate fish farms in areas with better biophysical conditions (Keller & Leslie, 1996).

[16] Disease caused by a bacterium that produces an enzyme that inhibits immunity-producing cells.

[17] Atlantic salmon currently accounts for over 80% of overall farmed salmonid production.

Fish farms became large in size and many were purchased by transnational corporations. The number of small, family-owned operations radically decreased. The total number of companies in charge of aquaculture operations dropped to only a few.[18] With this trend, plus the fact that mechanical procedures became automated, fewer companies yielded fewer jobs. The provincial government continued to encourage Norwegian investment. In terms of location, farms predominantly concentrated off the coasts of the provincial mainland and east coast of Vancouver Island (Broughton Archipelago, Johnstone Strait, The Narrows, and Queen Charlotte Strait) and to a lesser extent along the west coast of Vancouver Island (Clayoquot and Barkley Sounds, and the northwest coast), where they remain.

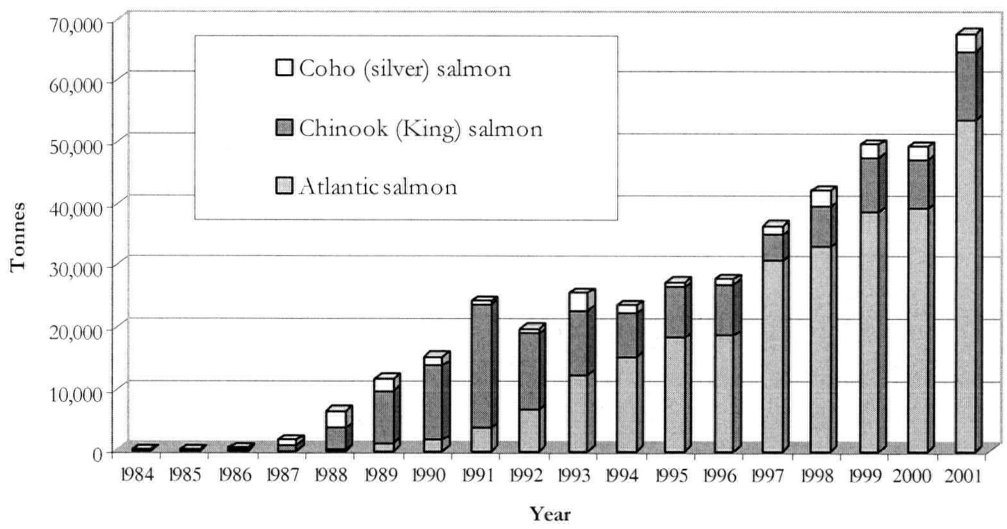

Figure 2-5. Salmon production quantities in British Columbia by species (in metric tonnes), from 1984 to 2001 (FAO, 2003).

A moratorium on the issuance of aquaculture tenures was imposed in April 1995, when multiple concerns and conflicts made it necessary to review an array of environmental issues and policies. The Environmental Assessment Office (EAO)[19] was then established to carry

[18] The total number of farms declined to 80, operated by only 17 companies in 1993.
[19] The EAO established a Technical Advisory Team of experts to perform reviews and recommendations on all 5 issues. The final outcome was compiled in the overall Salmon Aquaculture Review (SAR).

out an evaluation of five major issues[20] associated with the industry as determined via broad public consultation (EAO, 1997a). The final outcome was revealed in the Salmon Aquaculture Review (SAR) in 1997, which consisted of five detailed volumes that addressed the above-mentioned issues. The general conclusions of the review declared that salmon farming presented a low overall risk to the environment. However, the SAR acknowledged continuing concerns and the need for more in-depth ecological research given the significant gaps that existed in the scientific knowledge on which they based their conclusions.

The 2000s

The magnitude of B.C.'s salmon aquaculture industry remains relatively small compared to the global industry.[21] Nevertheless, the industry accounted for about 15% of the province's total agricultural production in 2000 and within a few years has grown to be the province's largest agricultural exporter (B.C. Salmon Farmers Association, 2003). The moratorium on aquaculture tenures ended in September 2002 after seven years. Since then, different companies have applied for new aquaculture tenures but only relocations have been approved. DFO and MAFF are still undergoing a process of finalizing a 'harmonized application package' where both agencies need to agree on siting criteria and other issues.[22]

A scenario of risks, issues and concerns associated with salmon aquaculture is likely to remain if the industry continues to operate with its current net-cage technology. Moreover, the development of the industry in the province has also generated social controversy as fish farms and their ecological footprint interfere with the way of life of certain First Nations groups, local communities and other resource users, some of whom are in opposition to industrial aquaculture. This fact makes the B.C. case distinctive from several other aquaculture-intensive jurisdictions.

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[20] a) Impacts of escaped farmed salmon on wild stocks; b) Disease in wild and farmed fish; c) Environmental impacts of waste discharged from farms; d) Impacts of farms on coastal mammals and other species, and e) Siting of salmon farms.
[21] About 67,700 tonnes in 2001, representing less than 5% of the total global salmonid production (FAO, 2003).
[22] Jennifer Nener. DFO. Vancouver, B.C. March 2003. Personal communication.

Marine grow-out sites in B.C. are currently located in the protected waters of the Strait of Georgia and the inlets of Vancouver Island's west coast. The former region includes areas adjacent to Campbell River and Desolation Sound, as well as the Johnstone and Queen Charlotte Straits. Most of these farms grow Atlantic salmon. Vancouver Island's west coast aquaculture areas mainly comprise the Clayoquot Sound (west-central region) and Quatsino Sound (northwest region) which also grow Chinook and Coho salmon.

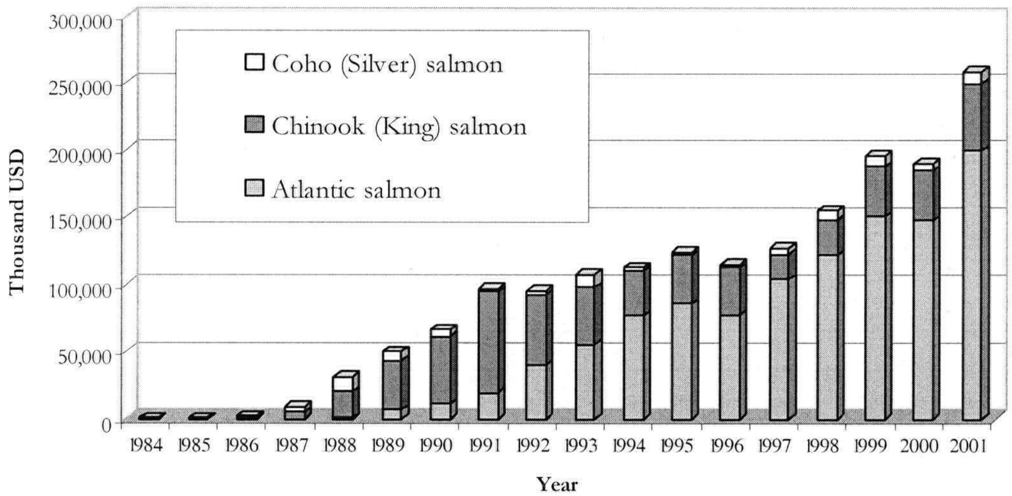

Figure 2-6. Salmon production values in British Columbia by species (in thousand USD), from 1984 to 2001 (FAO, 2003).

2.2. Current salmon aquaculture in British Columbia

2.2.1. Production process[23]

B.C.'s salmon aquaculture technology and its production process are, in essence, identical to those followed by other aquaculture-intensive countries. The production process is comprised by the following six stages.

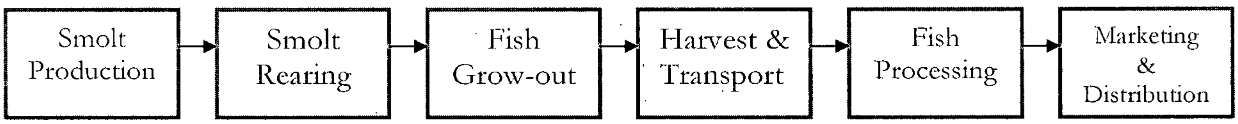

Figure 2-7. Fish farming production process stages (Tyedmers, 2000)

Smolt production comprises the (artificial) spawning, incubation and hatching of eggs that are collected from broodstock.[24] Hatching is typically carried out in land-based hatchery facilities.[25] The eggs (harvested from broodstock) are selected depending on their growth potential, feed conversion and maturation rates, and disease resistance. Once selected, they are combined with milt taken from males and placed in incubation trays (for approximately one month) to reach fertilization. Eggs are hatched over a three to five month period. Once they have reached a certain weight called the 'eyed' stage, the fertilized eggs are transferred into freshwater rearing tanks where they are intensively fed to become smolts.

Smolt rearing is usually carried out either in hatcheries or lake-based, net-cage sites.[26] From a cost-effectiveness perspective, it is more convenient to rear smolts in lake-based facilities

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23 This section draws on Tyedmers (2000), Keller & Leslie (1996), and the EAO's Salmon Aquaculture Review, Volumes 1&3 (1997).

24 Female salmon.

25 Hatcheries are commonly located where freshwater can be either diverted from nearby streams or tapped from pure underground supplies.

26 Pacific salmon and a large percent of Atlantic salmon used to be directly transferred from hatcheries into marine net-cages. However, throughout the years, the B.C. aquaculture industry has found that if kept longer in freshwater environments, smolts become larger and thus have higher survival and faster growth rates when entering saltwater systems (Tyedmers, 2000).

than it is to grow them in hatcheries because lakes have lower capital and operating costs. When smolts reach a stage at which they are capable of living in seawater, they are transferred to floating marine net-cage systems via floatplanes, tanker trucks or well-boats suspended from helicopters (Keller & Leslie, 1996).

Fish grow-out is typically carried out in floating marine net-cage systems where fish are reared to market size. A traditional farm is generally comprised of a system of suspended and interconnected pens within a rigid framework anchored to the seabed.[27] There are typically 10 to 30 cages in a farm, usually arranged in two rows. Additional infrastructure is commonly located next to the farm itself, which mainly consists of feed storage sheds and houses for farm staff. These constructions are either located on land or on floating platforms adjacent to the net-cage system.

Biophysical factors ultimately determine the success or failure of finfish marine grow-out sites. Good tidal flushing and shelter are considered to be key factors in attaining success. However, many other factors eventually determine whether a site has optimal biophysical properties. First order factors[28] are fundamental to fish health and their production. They cannot be mitigated by other means. Second order factors[29] largely influence the long term viability of a site. Finally, third order factors[30] are those that threaten the operational feasibility of a farm (MAFF, 1987).

Fish stocking densities vary according to the species under cultivation. For instance, the average stocking density for Pacific salmon is about 8 kg/m^3 *versus* 10 kg/m^3 for Atlantic salmon. Salmon aquaculture farms should also be fallowed.[31] Ideally, several sites are set aside for smolt intake to leave each site uncultivated for a period of time (usually a year) between crops. The objective of this action is to lower disease transfer risks from previous crops (Ellis, 1996).

[27] A variety of materials (steel, aluminium, wood or plastic) are used to construct these systems. In B.C., typical net-cages and their frameworks are made out of galvanised steel and, more recently, plastic.
[28] Water temperature, dissolved oxygen, salinity and phytoplankton.
[29] Pollution, currents, depth, site physiography and hydrology.
[30] Predators, marine plants, fouling organisms and wind and wave action.
[31] Fallowing is the process by which farm activity is rotated between tenures to allow recovery from adverse environmental impacts (Ellis, 1996).

Harvest and transport take place after fish spend between one and two years in marine net-cages, when they weigh between 2 and 5.5 kg (Tyedmers, 2000). Typically, live fish are harvested on-site. The fish are pumped from net-cages into boats[32] and transported to processing centres, where they are brailed from the ship's hold into a receiving tank. Harvest time is usually determined by several external (economic) factors, such as market conditions.

Fish processing typically takes place in shore-based plants located at suitable distances from fish farms. Salmon are graded according to specific physical properties such as texture and colour. They are processed into gutted, head-on form, and shipped in boxes containing ice (Ellis, 1996).[33]

Finally, fish are marketed in a cleaned, fresh and head-on fashion (Tyedmers, 2000) and thereafter distributed according to proximity and demand.[34]

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[32] In B.C., the great majority of sites can only be accessed either by water or air. For obvious economic reasons, marine vessels are the main means of transporting farmed salmon to processing centres.

[33] In the Pacific Northwest, gutting and boxing functions are carried out at distribution centres (Ellis, 1996)

[34] Due to proximity and high demand, most of B.C.'s salmon production has been exported to the U.S. In general, exports in previous years have accounted for over 80% of B.C.'s total salmon production (B.C. Salmon Farmers Association, 2003). In response to U.S. market demands, there has been a shift to value-added production, which tends to be labour-intensive. Also, to a lesser extent, foreign brokers conduct overseas sales, particularly to Japan.

2.2.2. Current and alternative technologies[35]

Industrial aquaculture is largely dependent on the technology associated with the containment of fish and attached structures. Floating marine net-cage systems have been, by far, the predominant type of aquaculture technology employed by the industry throughout its years of operation in B.C.

Several alternative technologies have been researched and developed by countries with intensive salmon farming industries (e.g., Norway and Scotland) as well as non-intensive ones (e.g., Germany, Japan, the U.S. and Iceland) since the 1980s (EAO, 1997d). Environmental and economic disadvantages associated with typical net-cage technology have driven proponents to explore alternative technologies.[36] For instance, land-based systems have been developed due to concerns and government financial incentives.

The main characteristics associated with the current floating marine net-cages and alternative technologies are described in the following paragraphs.

Floating marine net-cage systems

A traditional floating marine net-cage farm is generally comprised of a system of suspended and interconnected pens within a rigid framework anchored to the seabed. There are typically 10 to 30 cages in a farm, usually arranged in two rows. Several other structures are located next to the farm.[37] An array of cage designs with varying dimensions is currently in use by the industry. The typical structural design is square (15m by 15m) with a net depth of 10m.[38]

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[35] This section draws heavily on the EAO's Salmon Aquaculture Review, Vol. 4, 1997.

[36] Environmental concerns refer to impacts on the natural environment and cultured salmon themselves. Economic matters have restricted increase in the total number of sites and improvement of efficiency in current culture practices. These aspects have become key incentives in the search of alternative technologies as more intensive practices and profits (i.e., increasing the total number of sites, stocking densities, growth rates and levels of fish health) are being sought (EAO, 1997d).

[37] These buildings include feed storage sheds and floating houses serving as dwellings for farm staff. They are either located on land or on floating platforms adjacent to the net-cage system.

[38] However, these dimensions may vary, measuring 10, 20 or 30m on the side and 15 or 20m depth. Recently, different designs have been adopted but square net-cages continue to be the most common structures.

This type of system offers several advantages, such as low capital investment requirements, easy mode of operation and the allowing for incremental change in production capacity with little alteration of the facility (EAO, 1997a). However, the many disadvantages[39] that contribute to the current controversy could outbalance the aforementioned benefits.

Land-based systems

Land-based saltwater systems are perhaps the most complex and sophisticated type of salmon aquaculture technology. They are composed of several structural elements.[40] A recirculating technology component makes these systems promising and attractive.[41] Most benefits are mainly environmental, both for farmed salmon grow-out and the surrounding marine environment. The farmer can more easily control the physical, chemical and biological factors, which improves the management of the temperature, oxygen levels, plankton blooms and so forth. Negative effects on the marine environment are considerably minimized or even eliminated.[42] Similarly, if wastewater and sludge treatment facilities are incorporated, the discharge of residues and their associated impacts are significantly reduced.

According to industry affiliates,[43] government subsidies would be required before land-based systems would be viable substitutes for grow-out operations. Even so, experience from some other countries, particularly Scotland, suggests that not only economic, but also technical feasibility of these systems are questionable (EAO, 1997d).

Siting this type of facility can also be a limiting factor. There are physical requirements such as the dimensions of the land, topography, proximity to saltwater that meets determined quality standards, and the need for access to 'vital' infrastructure, such as roads and power

[39] The numerous environmental risks discussed elsewhere in the Salmon Aquaculture Review (1997) are a result of using net-cages as grow-out systems for salmon aquaculture.
[40] Pumps, pipelines, saltwater ponds, effluent structures, tanks and site buildings comprise the basic land-based infrastructure.
[41] Recirculation technology is, however, a leading constraint from an economic standpoint as it substantially increases the capital costs and operating complexity of facilities (mainly due to energy and oxygenation requirements).
[42] For instance, fish escapes into the wild and the possible interaction of farmed fish with wild marine mammals and other aquatic species are virtually eliminated.

lines. In addition, siting land-based facilities would require a different legislation that could be very restrictive.

Closed circulating systems

These systems mainly resemble typical floating marine net-cage systems. The structures that distinguish them from the latter are their closed-wall cages, composed of a variety of materials such as polyester or fibreglass. Water recirculation and aeration are essential requirements.[44] Waste collection systems can be added at the bottom of the cage and used to pump out solid matter (EAO, 1997d). Wastewater and sewage require further treatment (which resembles the type of processes and infrastructure employed in land-based systems).

Effective control of the farmed fish environment is the major benefit associated with this type of technology, which in turn translates into a higher quality product. Problems related to external biophysical factors (plankton blooms, fluctuating temperatures and pathogen exposure) are considerably decreased or even avoided, while impacts on the marine environment are also significantly reduced.[45] However, strong environmental,[46] economic[47] and technical[48] constraints remain and have not allowed the expansion of this technology (EAO, 1997d).

Offshore systems

Also known as 'open marine systems', these structures are located between a few hundred meters and a few hundred kilometres from the shore and are exposed to more severe environmental conditions. Cultured fish are exposed to higher water quality and less interaction with predators. A wide variety of offshore systems have been designed to date.

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[43] Gary Robinson. Stolt Sea Farm. Campbell River. December 2002. Personal communication.
[44] The use of aeration is dependant on stocking densities.
[45] E.g., the closed walls associated with these systems do not allow for predators to interact with farmed fish.
[46] For instance, pumping water through the system leaves the potential to disperse fish pathogens into the marine environment. In addition, waste continues to be disposed of in the marine environment and the visual impact of these structures has the potential to generate conflict with tourism and nearby communities.
[47] High capital investment and operating costs greatly exceed those of net-cage systems.
[48] High energy use (involving pumping and water recirculation) translates into high economic and environmental costs.

Infrastructure, operation and serviceability are considerably different from typical net-cages in sheltered waters.(EAO, 1997d).

Environmental and economic benefits[49] are a function of the type of design employed as well as the relative distance from the shoreline. Offshore systems present fewer conflicts with adjacent landowners and some competing coastal resource users but more conflicts with offshore resource users. Contrary to land-based systems, the most relevant constraints associated with offshore structures are *technical* in nature. Given their exposed location, these systems require more sophisticated engineering that is less vulnerable to harsh weather conditions from storms and wind. These systems also present complex logistical problems, such as maintenance, servicing and monitoring (EAO, 1997d). As far as siting is concerned, regulations, permitting requirements and government policy are uncertain or do not exist.[50]

Conclusion

The disadvantages associated with floating marine net-cage systems have caused controversy and led to questions about the viability of this industry in the province. Alternative finfish aquaculture technologies aim toward controlling environmental impacts, improving efficiencies in culture methods, and enhancing opportunities to site salmon farms in locations that result in reduced coastal use conflicts.

However, important constraints (mainly economic) associated with salmon aquaculture alternative technologies still outweigh benefits. The factors that may lead to the adoption of any alternative technology largely depend on economic requirements that are not currently met. This fact explains why all intensive salmon farming countries still rely on typical net-cage systems to carry out their operations.

[49] Economic benefits of offshore systems are directly related to water quality. Major concerns in near-shore facilities usually involve nutrient loading and parasite exposure as well as benthic smothering, which translate into fish losses. In offshore systems, advantageous water quality would mean a higher-quality product given the appropriate flushing and overall healthier environment.
[50] In the B.C. case, siting regulations concerning salmon aquaculture apply uniquely within the province. Locating pens offshore within federal jurisdiction would require a new legal regime.

Current siting criteria are designed to minimize the impact of fish farms on the marine environment and reduce the interaction with competing coastal resource users. While current technology may be economically feasible, the level of attainment of these objectives with respect to land-based, closed, and offshore systems is still questionable. For instance, land-based systems may have important environmental benefits but are restricted by technology costs, land availability, and conflicts with neighbouring property users. In the case of offshore systems, benefits would be largely perceived by major population centres rather than small coastal communities.

2.2.3. Regulatory framework

Since B.C.'s salmon aquaculture industry first began to operate in the 1970s, it has faced an unclear identification of regulatory responsibilities and little policy guidance. Competition with other existing users led to conflict and distrust, and insufficient consideration was allocated to potential impacts related to environmental values. Farm practices generally improved over the years, but the absence of clear standards, consistent performance, strict enforcement of regulatory requirements and meaningful public participation in siting decisions have continued to generate criticism.

The industry is currently regulated by several provincial and federal bodies. Their respective roles often overlap and their responsibilities and regulations could be somewhat complex (EAO, 1997c). The federal government has responsibility for the conservation and management of the fisheries resource and is the regulatory authority for farmed fish health, food safety and public health, conservation and protection of wild fish stocks and habitat, and navigational safety (OCAD, 2003). The lead federal agency is the Department of Fisheries and Oceans (DFO).

The province has authority for overall development and management of the industry, including location, size and development of farm sites, reporting requirements and monitoring operations. The lead entities are the Ministry of Agriculture, Food and Fisheries

(MAFF)[51] and Land and Water British Columbia (LWBC).[52] The province has overall responsibility for issuing aquaculture operating licenses and leasing Crown land (MAFF, 2000).[53]

To establish new salmon aquaculture operations or relocate existing facilities, applicants must obtain an aquaculture license issued by MAFF in compliance with the *Fisheries Act.* A review process based on biophysical suitability and technical viability is then carried out by the ministry. The license is valid for a one-year period, with an option for renewal. The holder must comply with aquaculture development plans, rear certain kinds of species and consider sensible precautions to prevent escapes. License applications are also reviewed by DFO under the Canadian Environmental Assessment Act (CEAA) screenings. A license is given only with MAFF and DFO approval.

Furthermore, proponents need also apply to LWBC for Crown land tenure under the *Land Act*[54] since aquaculture operations make use of public aquatic resources.[55] The review process considers riparian rights, navigation requirements, aboriginal interests and environmental and social concerns (LWBC, 2004). Besides being contingent on the approval of federal and provincial bodies, siting decisions also depend on local governments who regulate local land use via zoning (QP, 2004).

51 Amongst its multiple licensing roles, MAFF is responsible for licensing and monitoring aquaculture (finfish, shellfish and marine plants), and licensing all fish processing plants, fish buying stations, fish vendors and brokers. MAFF is also the provincial government's lead agency to deal with the federal government on aquaculture-related matters. As the agency that licenses aquaculture operations, the ministry controls most operational aspects of salmon aquaculture.

52 LWBC is responsible for evaluating land allocation and management applications with respect to the best management practices and guidelines established by other agencies, as well as initiating referrals for applications which cannot be adequately addressed through best management priorities or established guidelines.

53 Together with the Ministry of Sustainable Resource Management (MSRM) that is responsible for issuing foreshore tenures for aquaculture operations, water and waste legislation to allocate water for fish hatcheries and regulate waste discharges, and the Ministry of Water, Land and Air Protection (MWLAP), MAFF and LWBC manage inland fisheries and aquaculture activities under the authority of several acts such as the federal *Fisheries Act,* provincial *Fisheries Act, Wildlife Act, Forest Practices Code Act, Land Act, Water Act, Fish Inspection Act* and the *Waste Management Act* (EAO, 1997c).

54 There are three different forms of land allocation for aquaculture: investigative permits, licenses of occupation, and leases. These last 2, 20 and 30 years, respectively (LWBC, 2004)

55 The so-called sub-aquatic lands such as bays, harbours, estuaries and inland waters where most aquaculture sites operate are within the boundaries of the province.

2.2.4. Risks

The risks currently faced by the salmon aquaculture industry in B.C. relate to environmental and, to a lesser degree, human health impacts. Environmental risks are associated with fish health and impacts on the surrounding biophysical environment. These include genetic damage to wild stocks, fish escapes,[56] exotic diseases introduced by imported Atlantic salmon eggs, and waste discharges[57] (EAO, 1997a).

Human health risks arise from the consumption of both wild and farmed fish. For instance, wild salmon that First Nations and coastal communities rely on for subsistence may be under risk of acquiring disease that could be passed on to humans. Also, farmed fish may contain antimicrobial drug residues that pose risks to consumers.

2.3. Introduction to facility siting

Siting refers to the process of identifying and selecting areas that are economically, socially and environmentally suitable to locate certain types of facilities. Facility siting is an exceptionally complex problem associated with new and controversial industries such as salmon aquaculture. The process involves high-stakes decisions but there is a lack of expertise among stakeholders and policy-makers that can lead to different interpretations and difficult understanding of such concerns (i.e., the interaction of environmental, socio-economic, political and cultural contexts associated with the industry).

Siting criteria could be created using expert judgements and technical information. Criteria usually consist of a set of standards or rules on which judgements or decisions can be based. The extent of their success fully depends on a complex process that is continually refined by policy-makers and stakeholders.

[56] Fish escapes may induce the transmission of parasites and pathogens from farmed to wild stocks and therefore could provoke epidemics.
[57] Waste discharges can provoke smothering and organic overload under cages.

2.3.1. Dimensions of the facility siting problem

Siting controversial facilities such as landfills, incinerators, and chemical and nuclear power plants, has been a problem since the 1970s. To date, siting these types of facilities continues to raise intense public opposition due to potential health and environmental concerns.[58] The general public has become increasingly aware of the inherent social, environmental and human health risks and uncertainties associated with these types of facilities (Kunreuther, 1993). Similarly, communities have grown more sceptical of government authorities and industry. Disagreements about values and objectives have inevitably arisen while considerable challenges to enhance siting processes remain. Two major dimensions (social and environmental) have been identified as critical to the facility siting process as they are believed to be the roots of siting issues (Keeney, 1980).

The social dimension

Significant social aspects are inherently associated with siting contentious types of facilities such as hazardous waste deposits, nuclear power plants, and more recently, marine-based aquaculture facilities. Such aspects may be associated with *multiple stakeholders and objectives, risk perceptions, concerns, uncertainties about impacts and intangibles.* Their degree of relevance is a function of the site in question.

Multiple stakeholders (and therefore multiple objectives) surround the siting question. For instance, stakeholders may involve federal, provincial and local governments, industry, research organizations, First Nations groups, specific communities, other resource users, and the general public, amongst others. Each party has its own set of values and interests, which translate into different objectives.

Fundamental objectives are a function of stakeholder values and interests, as well as socio-economic, political and environmental conditions. For instance, the fundamental objectives of site proponents (e.g., industry, a state or provincial government) could ultimately relate to economic revenues and jobs. At the same time, the fundamental objectives of site opponents (e.g., local communities, a local government, or interest groups) could focus on short and long-term health impacts, aesthetics, reduced property values and risk concerns. Industry objectives may strongly influence the desirability of a site while the degree of impacts, risks and uncertainties inherent to site operations could shape the objectives of stakeholders who are opposed.

A site's value to a stakeholder is a function of his fundamental objectives which may be opposed to other stakeholder objectives. Deciding which objectives will take priority during the decision-making process and final outcomes is an issue. Value trade-offs are unavoidable as the share of some groups may be only improved at the expense of others. Based on this premise, it is essential to minimize and balance such trade-offs during and after the facility siting process.

A multiple-objective scenario inevitably gives way to diverse perceptions of risks and uncertainties, which generate different attitudes.[59] Stigma, an extreme case of perceived risk, illustrates the enormous differences in perspective that may exist among stakeholders (Gregory, *et. al.*, 1996).[60] In siting controversial facilities, stigma can be associated with the operations or purpose of the site.[61]

Another aspect of the social dimension of siting is uncertainty about impacts. The prediction of phenomena associated with future implications of sited facilities could be inaccurate. An

[58] The effects of this resistance are reflected on phenomena such as NIMBY (Not In My BackYard) and LULU (Locally Unwanted Land Use), (Kunreuther, 1993), which have expanded into water-based facilities such as the case of finfish aquaculture open-net cages in the coastal waters of some aquaculture-intensive jurisdictions.

[59] The public and scientific community are influenced by emotions, diverse paradigms, worldviews, ideologies and values (Slovic, 1987). Wisdom and error are present in attitudes and perceptions.

[60] Stigma can be based on social perceptions of particular risks associated with places, products or technologies. In the context of siting, stigma is directly associated with the technology in place. For instance, a certain technology that is supported by a specific industry may be perceived by other parties as catastrophic. In such technological contexts, extensive media coverage plays a crucial role in the intensification of stigma (Slovic, *et. al.*, 1994). The general public experience such technological hazards via the news media, which typically document threats and disasters occurring elsewhere (Slovic, 1987).

[61] Stigma is prevalent in perceptions of nuclear plants (e.g., Chernobyl). This gives way to public opposition in jurisdictions that intend to site nuclear plants in relative proximity to them. Similarly, it happens in siting new hazardous waste facilities aimed at treatment, disposal and incineration (Kunreuther, *et. al.*, 1993). In the case of salmon aquaculture in B.C., the media has played a critical role in moulding perceptions and creating stigma in terms of environmental risks, impacts and human health implications.

open treatment of uncertainty allows stakeholders to consider the most and least important factors and sources of disagreement in a problem, and to plan for probable unforeseen events (Morgan, *et. al.*, 1990). Historically, decisions taken by industrial sectors and societies have considerably disregarded significant uncertainties (Keeney, 1980). Thus, identifying and effectively addressing uncertainties is essential.[62]

Finally, there is the question of intangibles. Some socio-economic objectives can be measured in defined units like jobs or dollars. However, other aspects are difficult to measure in tangible terms. These may include the social disruption of psychological and moral impacts on local or nearby communities (Keeney, 1980),[63] or the aesthetic disruption of a setting.

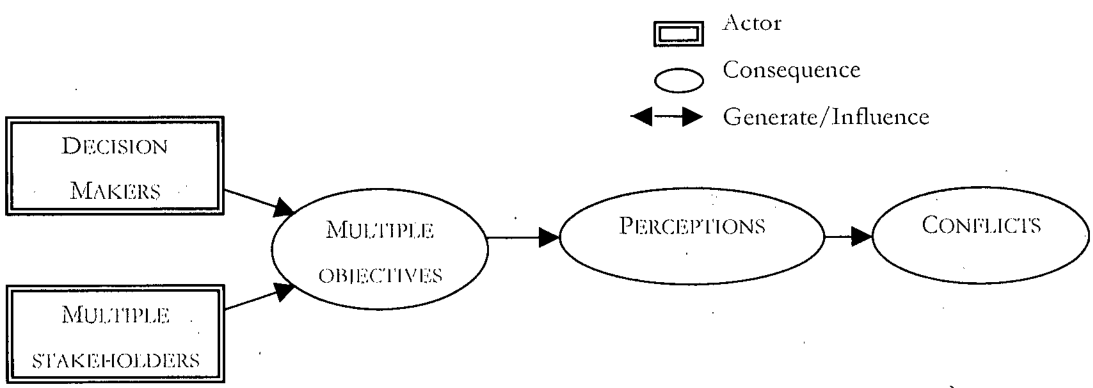

Figure 2-8. Siting controversial facilities: The social dimension.

[62] The major uncertainties of the B.C. salmon aquaculture industry are associated with the 5 major issues pointed out by the SAR in 1997.

[63] For instance, the impact that a multi-national corporation may have on aboriginal communities when introducing some type of industry into their territories may ultimately generate a degree of social disruption that is difficult to assess.

The environmental dimension

The environmental dimension of the facility siting problem is comprised by two major issues. The first one relates to searching for locations that are environmentally suitable for the facility's own purposes; that is, the appropriate biophysical and spatial considerations make the site a suitable location (Keeney, 1980). The second issue is the potential for impacts on the ecosystems where the facility is located. In practical terms, this can be addressed with environmental impact assessments or studies, designed to identify and predict impacts on the biogeophysical environment, human health and well-being, and to interpret and communicate information about the impacts (Munn, 1979).

Identifying an environmentally-suitable location is a crucial step in the facility siting process. First, a region (e.g., an inlet) is chosen; then numerous potential sites give way to a final selection. Several biophysical criteria need to be met. For instance, proponents of an energy facility may consider environmental variables such as topography, climatic conditions, wind directions, and so forth. Similarly, proponents of a waste disposal facility must regard water levels and soil composition, among other environmental variables. Proponents of a marine-based aquaculture facility would be concerned with water temperatures and currents, dissolved oxygen levels, depth and site physiography, hydrology, salinity, and interactions with flora and fauna, among others (MAFF, 1987). These factors are measured to determine the viability of a site.

This environmental dimension explores the impacts that a particular site may have on biophysical systems. In principle, ecosystem considerations could be addressed via environmental impact assessments that incorporate risks and uncertainties. Numerous ecological considerations that consider the influences and interactions amongst organisms and abiotic substances[64] need to be similarly addressed. This is particularly important in the case of net-pen fish farms, which are in direct contact with the environment.[65]

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[64] Interactions amongst and between the four basic components of ecosystems: abiotic substances, producer organisms, consumer organisms and decomposer organisms.
[65] The degree of impact on ecosystems is determined by the negative alteration of the biotic (i.e., flora and fauna species) and abiotic environments. In the case of salmon aquaculture, these impacts are mainly generated by fish escapes, the environment of fish farms, wastes and predator control practices. Fish escapes are a major concern given the existing potential for genetic and disease interactions with wild populations, which may

It is difficult to predict how other systems will respond to aquaculture disturbance gradients, which extend beyond the net-pen structure. Sites could therefore be considered elements of complex systems that are interconnected and influence one another.

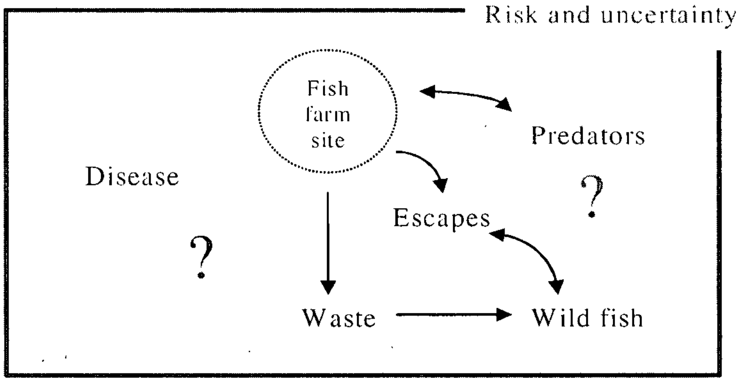

Figure 2-9. Siting controversial facilities: Ecosystem considerations and ecological interactions.

2.3.2. Siting process objectives

The siting decision-making context seeks not only to attain viable outcomes but more importantly, to develop a sound methodology. Understanding the objectives of the siting process is fundamental to addressing issues and could lay the foundation for an appropriate siting procedure. Practicality, quality analysis and perception of the analysis could be essential objectives to guide a suitable and fair process (Ford, *et. al.*, 1979).

translate into deleterious effects on wild salmon stocks. The overcrowded and stressful environment of fish farms has an inherent potential for disease, not only on farmed fish themselves, but also on wild populations and other marine species. The amounts of waste (i.e., fish faeces and unconsumed fish feed) that accumulate below fish farms have the potential to create water quality concerns (e.g., build-up of hydrogen sulphide (H_2S) and methane (CH_4), eutrophication, algae blooms, and oxygen depletion) that may translate into deleterious effects on benthic communities. Finally, marine mammals, birds and other species that are targeted as predators are also at risk via common predator control practices (e.g., shooting, poisoning, harassment or the use of acoustic deterrent devices).

Practicality is based on having the required expertise to successfully go through an entire process that is cost-effective to implement. Interdisciplinarity makes this objective easier to attain by minimizing costs, effort and time.[66] *Quality analysis* means each part of the process (e.g., establishing siting criteria) should be clear and justified. The data and expert judgements used in the process need to be clarified as they reflect perceptions and interpretations. *Perception of the analysis* is crucial to stakeholders. The siting process deals extensively with socio-political issues that generate multiple perceptions. Several values, such as *understandability*, *accountability* and *moral concerns* could impact such perceptions in a positive manner. Understandability is achieved when any particular stakeholder can assimilate the siting process clearly. Accountability addresses stakeholder concerns. Finally, moral concerns relate to fairness, equity, legality and rationality of the process.

2.3.3. Typical siting mechanisms

Site identification and selection mechanisms have been used by other industries in the process of identifying and selecting sites. The salmon aquaculture industry uses screening to a large degree as a typical siting identification mechanism. This section discusses some of the characteristics of these mechanisms.

Screening: The identification mechanism

Screening models have been used to identify candidate sites associated with nuclear or hazardous waste facilities. They entail three basic steps: selection of a region of interest, identification of candidate areas and selection of candidate sites. *Selecting a region of interest* depends on political districts, service or geographical areas that may ultimately benefit the operations of the facility in question. Screening criteria may be used to *identify candidate areas* and *select candidate sites* once the region of interest has been chosen. The criteria are usually constituted by *buffers* (for measuring purposes) and *attributes* (that define what is acceptable or unacceptable for a site to be considered as 'potential'). There are also weaknesses associated with screening criteria, such as inconsistency amongst criteria, implicit assumptions and

[66] Interdisciplinarity is characterized by the participation of several fields of study. It comprises careful effort to

value judgements and the application of oversimplified criteria. In combination, these shortcomings could lead to the rejection of good candidate sites. A detailed example given in the following chapter illustrates the disadvantages associated with screening criteria.

Evaluation procedures: Selection mechanism

Candidate sites must be evaluated for selection using site-specific data that relate to socio-economic and environmental considerations. Typically, evaluation procedures such as cost-benefit analysis, dominance or site rating are followed in the absence of sufficient data and make use of implicit assumptions while oversimplifying value judgements (Keeney, 1980). In consequence, they may be impractical, of questionable quality, and show a bias toward economic objectives while neglecting uncertainties.

2.4. Conclusion

This chapter sought to support the further arguments of this thesis by offering a preamble that highlights the background and constitution of the industry. Understanding the overall structure and actors associated with salmon aquaculture in B.C. is of significant value in identifying the factors that determine the development and progression of siting policy.

A general overview regarding the origin and evolution of the world's salmon aquaculture industry with particular emphasis on B.C. was described in the first section of this chapter. The worldwide and provincial production quantities and values illustrate the (exponential) growth pattern that has guided the industry. Global competition suggests this pattern will continue.

The second section of this chapter addressed the overall setting of the industry in the province. The production process and current technologies clarify the important risks concerned with the current controversy. Moreover, the regulatory framework and its most significant players are introduced, since the interaction between these means and actors

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interpret and translate research findings between different sciences or paradigms (Vedeld, 1994).

determines siting policy evolution. The subsequent chapters of this thesis will seek to argue how salmon aquaculture siting policy has evolved in B.C.

Finally, the third section introduced the siting problem via its social and environmental dimensions, which in combination determine the degree of complexity concerned with facility siting. The facility siting process could benefit from understanding the considerations explained by these dimensions. Siting objectives are also suggested to guide the facility siting process.

3. Factors affecting the evolution of salmon aquaculture siting policy in B.C.[67]

This chapter proposes a conceptual framework based on specific factors that attempt to explain how policy evolves in the context of new industries. The framework was developed under the theoretical basis of governmental agenda setting, which describes how problems come to be addressed from a policy perspective (Kingdon, 1995). Inductive reasoning was used to strengthen the argument for each of the proposed factors for the salmon aquaculture case in B.C. Such factors appear to influence (to different degrees) the evolution of siting policy associated with salmon aquaculture facilities.

The main argument of this chapter asserts that regulatory processes and outcomes in the context of a new industry may respond to factors that shape governmental agendas. This response illustrates how policy can behave reactively rather than in a precautionary manner. In addition, the outcomes of such reactive policies (i.e., siting criteria) may yield implicit environmental and socio-economic disadvantages and trade-offs that need to be clarified.

Section 3.1 discusses the conceptual framework that includes two siting mechanisms. Each mechanism is composed of series of factors and interactions, which attempt to explain how policy is likely to evolve in a new industry. Section 3.2 describes the evolution of salmon aquaculture siting policy in B.C. The proposed conceptual framework is applied to each policy outcome (document). Section 3.3 delves into the origin, evolution, purpose and rationale of relevant criteria, focusing on six out of a total of fifteen existent siting criteria. Section 3.4 discusses some of the implicit disadvantages and trade-offs concerned with the use and constitution of criteria. Section 3.5 characterizes stakeholder and policy maker views regarding the current state of siting policy. Finally, the last section draws general conclusions concerned with the lessons learned from the chapter.

[67] The term 'policy' is defined as "a definite course or method of action selected to guide and determine present and future decisions." For the purposes of this work, 'policy' is used interchangeably with terms such as 'regulations', 'criteria' and 'guidelines'.

3.1. Conceptual framework: Factors that influence the evolution of policy

This section outlines the conceptual framework developed in this thesis to explain the evolution of policies for siting salmon aquaculture facilities in B.C. The proposed framework is founded on two mechanisms (agenda setting and incrementalism) that attempt to describe the evolution of policy. Each mechanism is a function of three different and independent factors. The general concept of the agenda setting (AS) mechanism was drawn from the political science literature (Kingdon, 1995). The incrementalism (IM) mechanism has been similarly adopted but changed to reflect specific factors affecting salmon aquaculture siting policy evolution.[68] Both mechanisms and their related factors attempt to explain why policy may respond reactively rather than in a precautionary manner. An explanation of both AS and IM, with their associated factors, is given in the following section.

Governmental AS is a function of focusing events (FEs), indicators (INDs) and feedback (FB) (Kingdon, 1995). The dynamics of these factors depend on environmental, socio-economic or political issues and have the potential to create and constantly shape policy outcomes in the form of guidelines, criteria or regulations. IM is a function of scientific evidence (SE), other jurisdictions' leads (OJLs) and borrowing existing policy (BEP). These factors typically shape existing policies on an individual basis. Altogether, the six policy evolution factors may influence policy independently or simultaneously via expansion, adjustment or replacement.

It should be noted that, in principle, all factors are ultimately associated with AS. Besides FEs, INDs and FB, the factors associated with IM also have the potential to influence AS in a direct way. In other words, the progressive incremental growth of policy itself may well have been originated via AS. However, for the purpose of this analysis and to offer a clearer emphasis, all factors are addressed separately.

The following diagram summarizes the policy evolution factors, mechanisms and outcomes (regarding salmon aquaculture *per se*) that constitute the proposed conceptual framework.

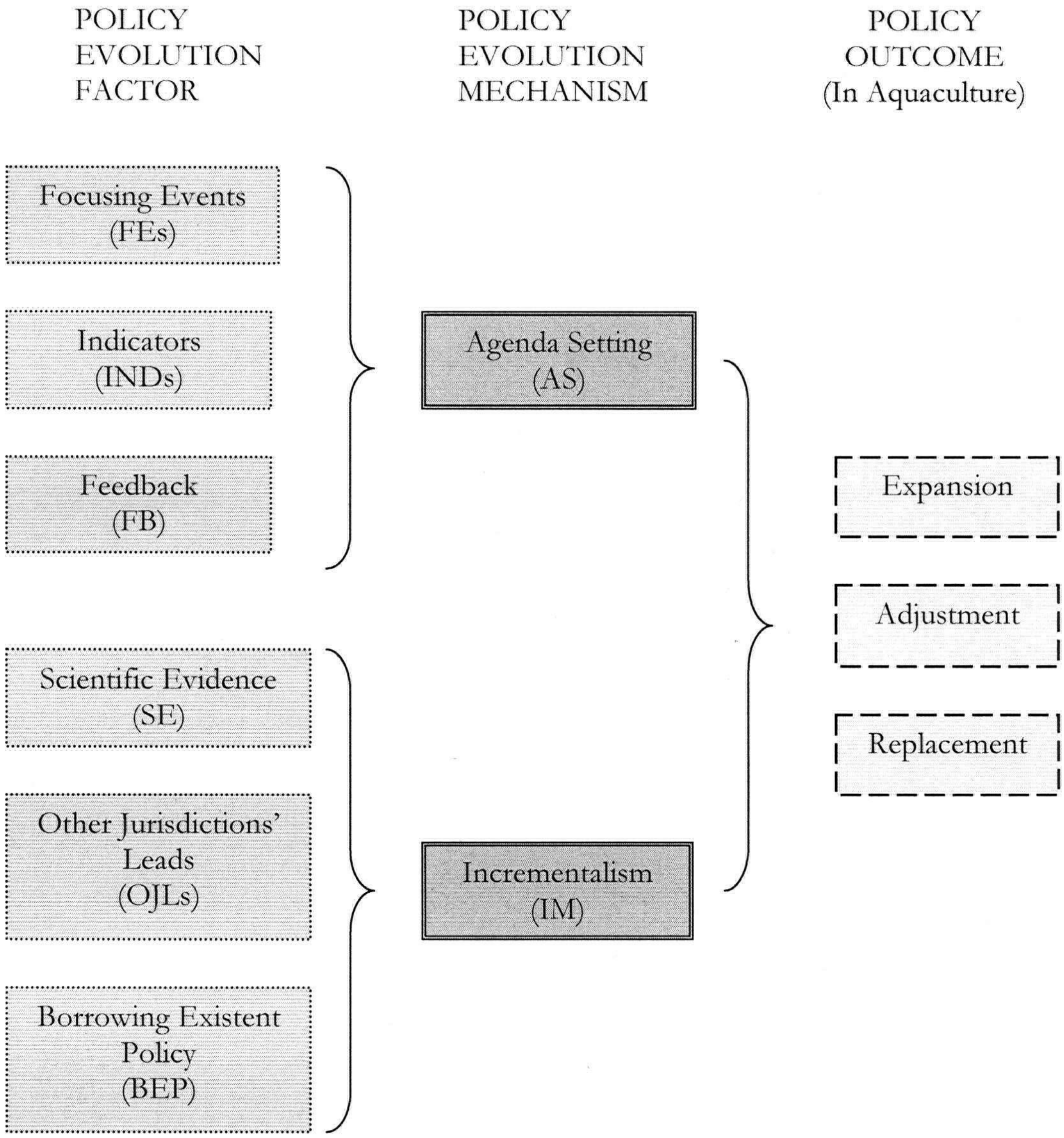

Figure 3-1. Conceptual framework explaining the evolution of policy.

In this conceptual framework, the evolution of policy associated with a new industry is activated by some environmental, socio-economic or political issue (or a combination of these). The recognition of such issues may occur in the form of FE (e.g., an environmental disaster or socio-economic crisis). INDs are the elements that show the magnitude of the event and are objective manifestations of FE. Finally, FB, which may be a stream of

[68] The terms 'incrementalism' (IM) and 'progressive incremental growth' are used interchangeably throughout this thesis.

complaints from stakeholders, is a subjective manifestation of FEs. The dynamics that occur among these three factors have the potential to shape policy in the form of expansion, adjustment or replacement.

The three factors associated with the IM mechanism also have the potential to modify existing policy but on an individual basis. In other words, SE, OJLs and BEP, do not interact with each other, but may work to create similar outcomes. These factors may also trigger the creation of policy.

The following diagram attempts to explain the dynamics of policy evolution factors. Note that there is a particular interaction between SE and INDs. The former is usually represented in the form of the latter, activating the evolution of policy. A description of each policy evolution mechanism and factor is given in the following section.

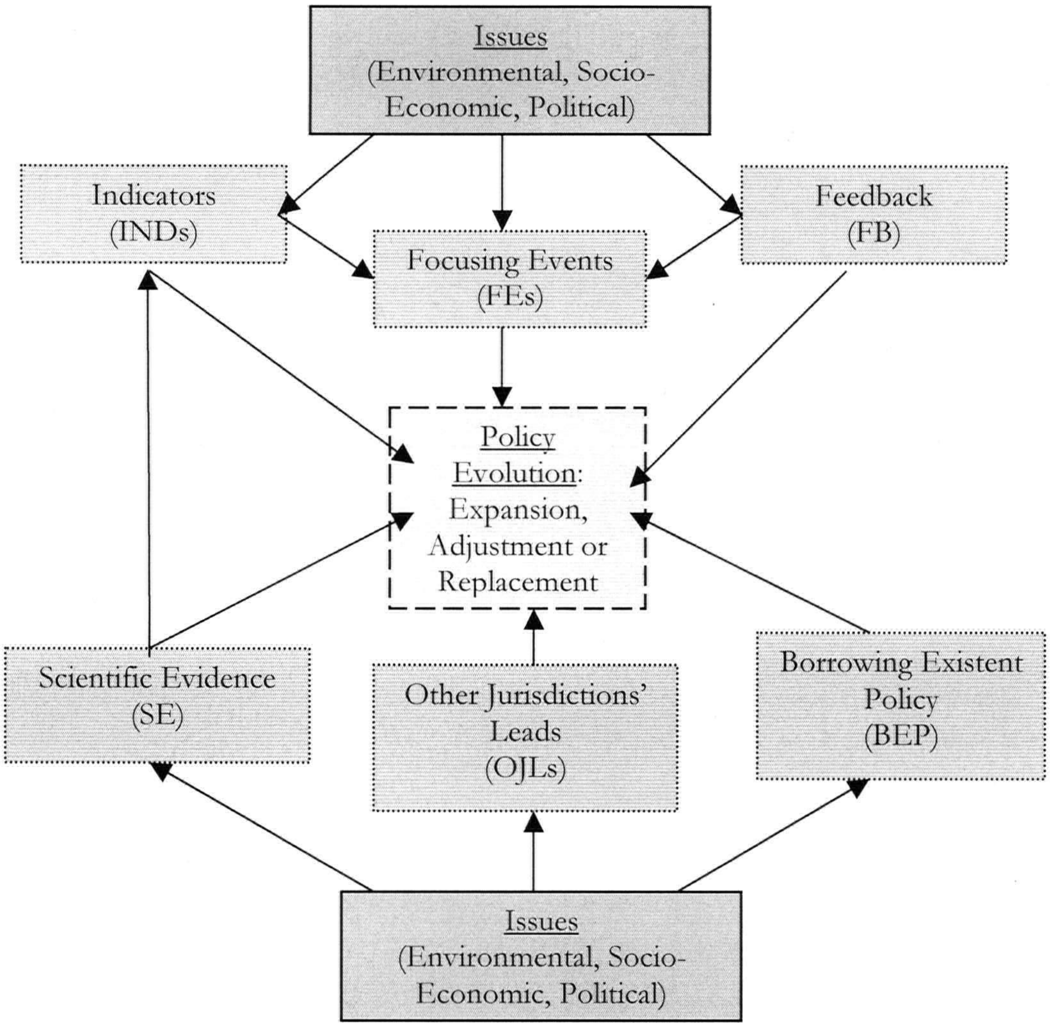

Figure 3-2. Dynamics and interactions between factors that influence the evolution of policy. Arrow suggests 'influence' from A to B.

3.1.1. Policy Evolution Mechanism #1: Agenda setting[69]

A governmental agenda is the list of matters to which officials pay attention at any given time. Participants and processes ultimately define how and why subjects take precedence (or do not) on a given agenda. In brief, this course of action characterizes AS.[70] Participants may be from inside the government (e.g., the prime minister's cabinet or civil servants) or outside

[69] This section draws heavily from Kingdon, J.W. (1995). Agendas, Alternatives and Public Policies.

the government (e.g., interest groups, academia, consultants, the media, the general public, etc.). The processes that determine how prominent a matter is on the agenda are the recognition of problems, the occurrence of political events[71] and the involvement of visible participants.[72] The recognition of problems depends on how participants (in and around the government) learn about them. This learning can occur via FEs, INDs and FB. The first part of the proposed conceptual framework of this study focuses on the first AS process (i.e., recognition of problems) and its factors (FEs, INDs and FB) as conceptual indicators that explain policy evolution.[73]

Focusing events (FEs)

FEs are associated with happenings inside or outside a specific industry that are concerned with the industry itself and that may have the potential to impact its policy processes. Disasters and crises are typically FEs. These two phenomena are often interconnected. Disasters usually take place during a short period of time whereas crises last longer, sometimes as a result of a disaster, i.e., the consequences of a disaster may give rise to a crisis. However, this process may also occur the other way around. For instance, a crisis may not be regarded as such until it turns into a disaster. Kingdon (1995) argues that, generally, human health-related issues are top priority on agendas in the sense that they (directly or indirectly) affect everybody.

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70 "AS is a predecision process that narrows the set of subjects that could conceivably occupy the government's attention to the list on which they actually do focus." (Kingdon, 1995).

71 The occurrence of political events takes place when there are swings in national moods, elections that shift political parties to power and bring new ideologies to governments, and pressure from interest groups (Kingdon, 1995).

72 Visible participants (e.g., the prime minister, his high-level appointees, members of parliament, political parties, the media, etc.) are the actors who determine AS. However, so-called hidden participants (e.g., academic specialists, researchers, consultants, analysts, etc.) may also influence AS by affecting alternative solutions to problems. On a national scale, the most important agenda setters are the prime minister's cabinet and the main members of parliament.

73 It must be noted, however, that the recognition of problems is strongly linked with the occurrence of political events and the involvement of visible participants. Its level of influence on policy ultimately depends on the interconnectedness and synergies that are achieved between the three processes.

Indicators (INDs)

INDs describe the magnitude or show change in a particular condition (Kingdon, 1995). The larger the magnitude or change, the higher the probability to attract attention and therefore influence policy. INDs are inherently interconnected with FEs and FB in the sense that they reflect an objective measure of the former and are prone to subjective constructs regarding the latter. INDs can comprise both qualitative and quantitative values, such as the occurrence (or frequency) of a particular disease or the cost of a facility or program.

Feedback (FB)

FB simply refers to 'formal or informal' means by which officials come to know about a specific problem or condition. Formal means are assessments, evaluations or studies. Informal means could be streams of complaints from specific stakeholders. Moreover, FB can be importantly influenced by INDs. The combination of both factors can determine the level of significance of a FE.

3.1.2. Policy Evolution Mechanism #2: Incrementalism

IM makes reference to changes associated with existing policy that proceed gradually via independent factors during a specific period of time.[74] In other words, IM is a mechanism of progressive policy growth. Policy-makers may generate "small, incremental, marginal adjustments" (Kingdon, 1995) to existing policy via three independent factors: SE, OJLs and BEP. Any factor may have the potential to shape policy via expansion, adjustment or replacement.

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[74] This second mechanism is defined as "the enactment of changes in small increments" (Kingdon, 1995).

Scientific evidence (SE)[75]

SE encompasses the products of research in a given field. It is via this factor that the scientific community plays an indirect role on public policy-making.[76] SE may influence the expansion, adjustment or replacement of policy by providing qualitative or quantitative INDs. For instance, a significant scientific discovery is capable of generating a strong policy response if a specific 'policy window' is open at that moment.[77]

The way in which a jurisdiction reacts to a scientific discovery may vary according to the interaction of ideas, domestic interests and political institutions associated with the jurisdiction.[78] Ideas demand either severe or weak measures that lead to policy change. Interests are mainly driven by economic goals, which interact with ideas. Finally, political institutions ultimately determine the relevance of scientific research according to existing legislation and regulatory history (Harrison, 2002).

Other jurisdictions' leads (OJLs)

This factor may be considered (in some instances) a feasible and timesaving approach to developing policy, particularly when a jurisdiction is largely unfamiliar with a new industry. The global expansion of markets has helped establish industries in new regions that may not be familiar with them. This phenomenon creates the need for new regulations. Adopting or adapting the regulatory leads from other jurisdictions where an industry has existed longer could therefore be convenient.

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[75] This section draws heavily from Harrison, K. (2002). Ideas and environmental standard setting: A comparative study of regulation of the pulp and paper industry.
[76] For detailed information on a case study revealing scientific impacts on public policy-making, see Harrison, K. (2002). Ibid.
[77] "An open 'policy window' is an opportunity for advocates to push their pet solutions or to push attention to their special problems" (Kingdon, 1995). Policy windows are opened by events that occur under the agenda setting processes of 'problem recognition' or 'occurrence of political events'.
[78] Harrison, K. (2002). Ibid. In the pulp and paper industry the evolution of regulatory processes in several jurisdictions was impacted simultaneously. In this case, the discovery of dioxins (considered the most toxic chemicals known to humankind, causing severe health impacts such as cancer) in pulp mill effluents and paper products was a cause of remarkable policy shifts in Sweden, Canada and the U.S.

Adoption could be seen as the straightforward acceptance and implementation of another jurisdiction's policy. Adaptation, however, is a process of framing, shaping or moulding policy according to a jurisdiction's own biophysical, socio-economic and political systems. In principle, the adoption of regulatory standards may bring about significant risks as systems are never identical in two jurisdictions. Adapting policy according to specific biophysical, socio-economic and institutional spheres may be more sensible.

Borrowing existent policy (BEP)

This concept was developed inductively based on this particular case study. New industries may borrow existent policy from a different industry when they lack a solid policy structure or when they must comply with policies that affect other industries. This factor may be a function of the relationship between both industries in terms of activities or biophysical locations.

3.2. Evolution of salmon aquaculture policy in B.C. and its impact on siting

The factors examined in the previous section conceptualize the single or combined ways by which policy associated with a new industry may (reactively) evolve over time. This section explores the salmon aquaculture industry in B.C. to apply the proposed conceptual framework. Salmon aquaculture has generated conflict and controversy in the province during the past two decades. The siting issue has been a key issue in the debate. The industry started without a defined siting policy or planning schemes. Throughout time, the salmon aquaculture facility siting question has therefore been subject to numerous reactive policy shifts.

The unfolding sections describe the evolution of salmon aquaculture siting policy in B.C. The description given for each policy document (i.e., study, review, inquiry or report) includes the document's purpose and outcome, historical facts that led to its development, actors involved, and the policy evolution factors that may have played a role in determining the document outcome.

The following figure illustrates (in chronological order) the policy outcomes that directly or indirectly influenced salmon aquaculture siting matters in B.C.

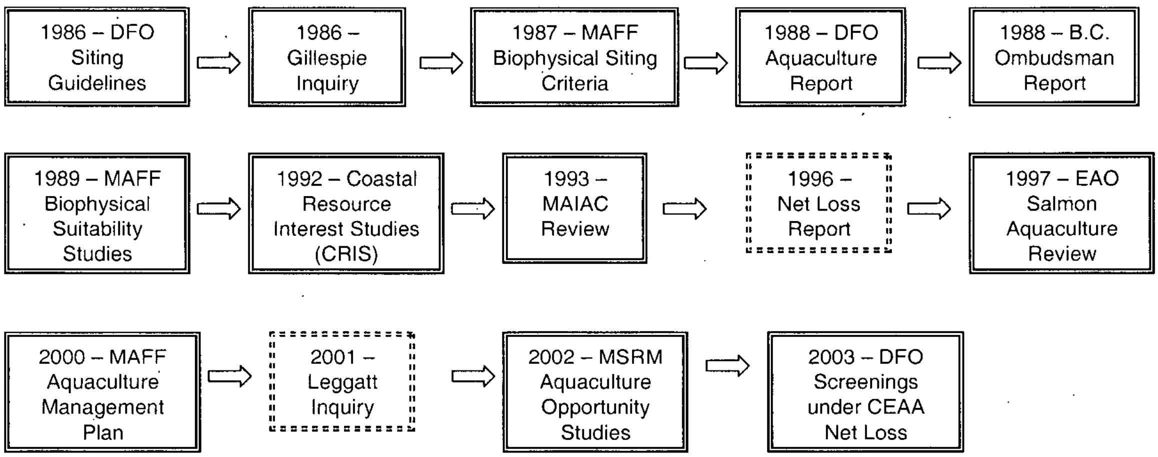

Figure 3-3. Chronology of studies, reviews, inquiries and reports that have influenced siting matters (including siting criteria, guidelines or recommendations)[79] relevant to the salmon aquaculture industry in B.C. Bold and dotted textboxes refer to government and non-governmental documents, respectively. The only two documents that have been entirely devoted to siting regulation *per se* are the DFO Siting Guidelines (1986) and the MAFF Biophysical Siting Criteria (1987), which together marked the origin of siting policy in the province. The rest have addressed the salmon aquaculture topic in general.

[79] The terms 'criterion', 'guideline' and 'recommendation' are different by definition. Criterion refers to a standard, rule, or test on which a judgement or decision can be based. A level of stringency is innately attached to this concept. On the other hand, a guideline is a statement aimed at determining a course of action, implying guidance without being compulsory. In the context of salmon aquaculture policy in B.C., MAFF has historically interpreted the three terms as 'guidelines', while DFO in B.C. regards them more as 'criteria'.

3.2.1. DFO Guidelines for Development and Operation of Aquaculture and Fish Processing Facilities (1986)

When the industry was first introduced to the province in the 1970s, salmon aquaculture in B.C. was largely unregulated in terms of siting farms. In 1986, DFO developed a set of guidelines "to prevent impacts to fish and fish habitats and to avoid conflicts between aquaculture and fishery activities." This policy outcome delivered siting criteria developed for marine fish rearing facilities, hatchery facilities and fish processing centres, and became the foundation for the further development of siting criteria. Nevertheless, this original set of criteria was neither published nor enforced.[80]

The problem recognition process of AS played a role in the origin of siting policy, which was originally issued in the form of guidelines (i.e., as recommendations, therefore not enforced). A combination of FEs, INDs and FB occurred simultaneously because the industry was rapidly expanding but ignoring potential environmental risks and uncertainties.

A massive bloom of phytoplankton occurred on the Sunshine Coast, which is the coastal area where most salmon farms had been operating since the industry originated and began to expand (Keller & Rosella, 1996). This FE coupled with a decline of marine wildlife in proximity to fish farms attracted the attention of fishers, the general public and interest groups. Moreover, increasing conflicts between resource users highlighted a second FE at the time. Streams of complaints (FB) associated with these two FEs indicated a need for new siting policy (Stinchcombe, 2000). An important IND at the time was the loss of an estimated 100,000 farmed fish. At this time little was known about the potential impacts of a large-scale aquaculture industry (Keller & Rosella, 1996).

The combination of political events in both Canada and Norway during the same period of time opened a policy window. The Scandinavian country accounted for over 60% of the world's salmon aquaculture production at the time and had been regularly investing in B.C (Keller & Rosella, 1996). A moratorium on new farms had been put in place in Norway since

[80] Wayne Knapp. DFO. Vancouver, B.C. March 2003. Personal communication.

1977.[81] Restrictions on the dimensions and capacities of Norwegian salmon farms had become rather stringent, limiting the industry's growth for several years. Moreover, because Norway was focused on aquaculture development policy geared toward expansion and profit maximization, investing in another jurisdiction was necessary to expand their production rates and avoid economic losses.[82] As a result, B.C. was seen as an optimal location given the industry's similar growth-oriented vision at that time. Similarly, the political agenda in Canada placed strong emphasis in foreign investment. The combination of both Norwegian and Canadian government agendas (i.e., the politics stream and visible participants on this matter) in association with the 'problem recognition' process and its related factors importantly influenced the origin of salmon aquaculture siting policy in the province.

Finally, BEP also played a role in shaping this initial siting policy document. A particular criterion was originally borrowed from the Canadian Food Inspection Agency's (CFIA) Sanitary Shellfish Regulations that applied to wharves, marinas, and other nearshore based facilities.[83] The BEP factor was adopted from this set of guidelines. A more thorough description of specific criteria is given in section 3.3.

3.2.2. The Gillespie Inquiry (1986)

A moratorium on the issuance of leases and licenses was imposed in 1986 as a result of the abovementioned FEs, INDs and FB, which included public concerns associated with health risks. A provincial inquiry was then conducted, which lasted less than three months. There was an outcome of 52 recommendations covering several aspects of the industry. The siting question was only addressed from the perspective of resource user conflicts and no particular guidelines were suggested. The inquiry's overall conclusions placed emphasis on stronger regulation and more stringent environmental standards for the expansion of the industry. The moratorium was lifted soon after the release of this inquiry.

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[81] Gary Caine. MAFF. Courtenay, B.C. April 2003. Personal communication.
[82] Gary Caine. Ibid.

A stream of complaints from a coalition of critics (comprised mainly by fishers and community organizations) constituted the main source of FB. These advocacy groups strongly opposed the introduction of Atlantic salmon and dreaded the impacts of fish farming on the benthic environment. Clearly, this FB scenario along with its associated INDs was the reflection of a 'social crisis' that needed immediate attention.

Besides FE, the evolution of B.C.'s siting policy at this point was partially influenced by OJLs. A guideline that dealt with an optimal separation distance between fish farms (800m) was taken by the provincial government from Norwegian standards and used from the early 1980s until the Gillespie inquiry concluded.[84] The Norwegian criterion had its foundation on a rural planning exercise to promote socio-economic development by keeping communities close to each other.[85] It is clear that in Norway the fish farming industry was being established under a socio-economic development scheme where little science was being used to determine siting policy. However, in B.C., the standard was adopted for the purpose of environmental protection. As a result of the Gillespie Inquiry and the social and environmental scenarios in the province, a 3000-m separation distance was later adopted. This was an almost four-fold increase from the previous 800-m buffer.

The use of OJLs in policy setting prior to this inquiry brought about a high concentration of farms on the Sunshine Coast, creating unfamiliar risks that resulted in the aforementioned disasters and crises because the area's carrying capacity was considerably surpassed.

3.2.3. MAFF Biophysical Siting Criteria (1987)

A series of biophysical factors that are necessary for fish farm sites were scientifically determined by MAFF in 1987 (Caine, 1987). This document basically addressed 'good' areas

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[83] This criterion states that "Net pens shall not be located within 125m from inter-tidal fish beds and 125m from all other wild shellfish beds where there are, or is the potential for recreational, native food fish or commercial fisheries."
[84] Gary Caine. Ibid.
[85] Gary Caine. Ibid.

to site salmon farms based on optimal biophysical factors for grow-out operations. It was aimed at environmental protection as well as biophysical suitability.[86]

These criteria meant the provincial government's reaction to the surrounding controversy at the time. However, most importantly, criteria marked the birth of a planning process. While not adopted as strict regulations, criteria became a reference framework to locate sites in Campbell River and the Broughton Archipelago, after the industry left the Sunshine Coast. Similarly, this document became the foundation upon which biophysical suitability studies (BSS) were carried out two years later. This way, a combination of policy initiatives began to shape the facility siting process.

The development of SE was the main factor that triggered the development of MAFF's biophysical siting criteria. Until the release of these criteria, siting policy had merely focused on preventing impacts on fish and, more importantly, on avoiding user conflicts. The primary emphasis of siting policy was therefore socially driven. With MAFF's criteria, a planning and a scientific approach were used together for the first time. This was also a first example of precautionary action.

The need for scientific research was urgent due to environmental impacts combined with numerous environmental uncertainties. The recognition of an environmental problem by policy-makers was activated by the series of FEs, INDs and FB that essentially led DFO to develop their guidelines and Gillespie to undertake the inquiry. In this case, it was the provincial government's turn to take action.

[86] Priority factors (those affecting fish health and growth) include water temperature, dissolved oxygen levels, salinity, and absence of phytoplankton. Secondary factors (influencing long-term viability of a site) consist of pollution, currents, depth, site physiography and hydrology. Other factors such as predators, marine plants and fouling organisms, wind and waves, snowfall and freezing, are also considered for the operational feasibility of fish farms.

3.2.4. DFO Aquaculture Report / Memorandum of Understanding / Ombudsman Report (1988)

Several aquaculture policy events took place in Canada in 1988 that were relevant to the salmon farm siting issue. DFO released a report called "*Aquaculture Canada: Report of the Standing Committee on Fisheries and Oceans*". The report suggested the establishment of fair site selection procedures that, in addition to DFO and MAFF representatives, would include members of Indian and Foreign Affairs and Indian Bands with coastal claims. The siting perspective of this federal report was mainly stakeholder-oriented to address resource user conflicts. At the provincial level, this proposition was addressed within the land tenure application process.

Furthermore, the federal report also recommended a resolution of the outstanding issues between federal and provincial governments in aquaculture-intensive provinces. In B.C., this recommendation originated a "*Memorandum of Understanding on Aquaculture Development*" between the government of Canada and the B.C. government.[87] The Memorandum of understanding (MOU) clarified the delineation of responsibilities between the two levels of government. The provincial government was given full responsibility to determine where and how aquaculture was to be carried out, while DFO retained the accountability for navigation, habitat protection and fish health.[88] This response was mainly reactive to conflicts regarding aquaculture policy between both levels of government and made clear their positions with respect to aquaculture industrial development.

Soon after the MOU was released, the B.C. Ombudsman[89] published a report titled "*Aquaculture and the administration of coastal resources in British Columbia*" in response to public complaints on the lack of administrative fairness when granting tenures for foreshore leases (Office of the Ombudsman, 1988). This report was a product of FB with respect to

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[87] The Government of Canada and The Government of B.C. "*Canada-B.C. Memorandum of Understanding on Aquaculture Development.*" September 6th, 1988.

[88] Environmental Assessment Office. 1997. Salmon Aquaculture Review. Volume 3. Discussion Paper: "*Siting of Salmon Farms.*" Some of the topics addressed by the MOU include research and development, education and training, provincial licensing and regulation, federal regulation, co-ordination between parties, dispute resolution, compliance and inspection, and feed egg supply, among others.

[89] One who investigates complaints and mediates fair settlements.

environmental, socio-economic and political events, and offered siting recommendations from a stakeholder conflict resolution perspective. The outcome of this effort stressed the need for sound planning by creating an integrated coastal resource management framework that highlighted community planning and control as well as prioritizing public participation at all stages of the planning process (Office of the Ombudsman, 1988).

The B.C. Ombudsman report addressed both DFO's resource user conflict resolution approach and MAFF's biophysical siting criteria. The outcome of both the Gillespie Inquiry and the B.C. Ombudsman report influenced the creation of BSS and CRIS during the following years.

3.2.5. MAFF Biophysical Suitability Studies (1989)

These comprehensive studies were carried out and published by the provincial government to assist the industry in locating good sites by evaluating the biophysical capability of large coastal areas. BSS addressed the siting question in response to the Gillespie Inquiry recommendation regarding a Coastal Resource Interest Studies (CRIS) program. Provincial waterways for the net-cage rearing of salmon species were assessed in this study by weighing the natural adversities and attributes of the environment for siting.[90]

The AS mechanism *per se* coupled with SE on biophysical criteria importantly influenced the design and implementation of BSS. Although not directly reflected in a final policy outcome, BSS are largely a product of progressive incremental growth (IM), because they are based on previous policy outcomes. The FEs that occurred in previous years included the Gillespie Inquiry recommendation regarding the need for planning attention on the Sunshine Coast and Johnstone Strait areas.[91] BSS became relevant to land use planning and allocation during

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[90] Province of British Columbia. Ministry of Agriculture and Fisheries. 1989. *"Biophysical suitability of the Sunshine Coast and Johnstone Strait/Desolation Sound areas for Salmonid Farming in Net Cages".* Aquaculture and Commercial Fisheries Branch.

[91] BSS were carried out for these two areas at first, and thereafter for numerous sounds and inlets located on the west of Vancouver Island. Sites were rated for biophysical capability based on MAFF's biophysical criteria.

subsequent years. Overall, the studies were the outcome of a combination of previous initiatives that evolved in less than half a decade.[92]

3.2.6. Coastal Resource Interest Studies (1992)

CRIS were started in response to the Gillespie Inquiry soon after the release of this document and were published in 1992. Prior to the release of CRIS, farm sites were being determined on a one-by-one basis under the BSS outcome.[93] At first, CRIS studies were not conducted in a planning context and therefore neither contemplated the comparative capability of the coast for various uses nor regarded the relative ecological or economic values associated with each use of an area (Minister's Aquaculture Industry Advisory Council, 1993). The main outcome of these studies was in the form of maps, which indicated the suitable areas to site farms from the perspective of preventing conflicts with other resource users. While not the most optimal solution to address a multiple-objective problem, the studies provided a valuable source of information on coastal interests at the time.

CRIS have been updated and evolved into comprehensive coastal plans that address aquaculture capability from multiple perspectives. The studies are based on the idea of pursuing an asymptotic (open-ended) process that is constantly refined. From a policy evolution perspective, CRIS were the outcome of the IM mechanism *per se* (without particular reference to any of its factors), as they are based on previous policies and recommendations.

3.2.7. The Salmon Aquaculture Review (1997)

The Salmon Aquaculture Review (SAR) was an exceptionally comprehensive study carried out by the Environmental Assessment Office (EAO) on behalf of the provincial government

[92] The Aquaculture regulation under the Provincial Fisheries Act was published in 1989 as a response to a recommendation from the B.C. Ombudsman report. Interestingly, this enactment made no reference to the siting question whatsoever and has remained unaltered on this respect.
[93] In the early 1990s, MAFF was receiving almost one tenure application per week, most of which were approved (Gary Caine. MAFF. Courtenay, B.C. April 2003. Personal communication.)

(MAFF and the former Ministry of Environmental Lands and Parks) as a reaction to FEs that generated important FB in the form of environmental and socio-economic concerns. The review was also a response to a second moratorium on the issuance of new farm licenses imposed in 1995.

The siting issue and four other environmental concerns[94] were exhaustively addressed in the report. Fifteen siting criteria were established (EAO, 1997a). The criteria contained separation distances (buffers) between external (environmental and social) settings and fish farms, which became a topic of attention in light of their constraining and ambiguous nature.

For the first time in the history of salmon aquaculture in B.C., available sites for farms near the provincial coastline became very limited. The fifteen siting criteria were published under the title of "recommended salmon farm siting criteria", which aimed at "(i) locating salmon farms at sites with intrinsic biophysical capability and socio-cultural suitability (to prevent or reduce negative impacts and conflicts), and (ii) promoting successful production of healthy farmed salmon" (EAO, 1997). Several siting criteria were adapted from the first set of recommendations submitted by DFO in 1986. Moreover, socio-economic proximity criteria (mainly aimed at avoiding conflicts with First Nations reserves, recreation and tourism, fisheries, private residences and cultural and heritage sites) were explicitly incorporated to the list. Such aspects had never been formally stated in the form of policy. Since then, these criteria have been adopted and interpreted differently by DFO, MAFF, the industry and an array of stakeholders. This situation generated a great deal of controversy. Moreover, the SAR also alluded to the biophysical criteria developed by MAFF in 1987, adopting them as "site selection considerations." These fall more into the 'guideline category' than compulsory criteria to be followed by the industry.

The FEs that originated this review were in essence very similar to those that generated the Gillespie Inquiry, except their magnitude was greater due to the multiplication of fish farm sites. All policy evolution factors (except BEP) influenced the development of this review. The IM mechanism *per se* produced the addition of all socio-economic criteria. SE influenced one criterion. OJLs did not influence the siting criteria outcome, but were addressed in a technical paper as a means of comparison with B.C. criteria (EAO, 1997d).[95]

3.2.8. MAFF Commercial Finfish Aquaculture Management Plan (2000)

To a great extent, MAFF's criteria resemble those developed by the SAR in 1997. Despite the fact that proximity buffers remained unaltered, the wording of several criteria was modified to decrease ambiguity.[96] This set of criteria is currently applied to evaluate applications.

It can be argued that these criteria were a product of IM itself. The wording of certain criteria was only adjusted (e.g., by adding the phrase "in consultation with DFO and the province," at the end of sentences). There were two important reasons for the enactment of these criteria. First, the ambiguity of former guidelines had generated misunderstandings amongst the two levels of government and industry. Second, the forecasted lifting of the 1995 moratorium on farm leases, which did not occur until September 2002.

3.2.9. MSRM Aquaculture Opportunity Studies (2002)

The provincial Ministry of Sustainable Resource Management (MSRM) introduced a mapping approach in 2002 to support new siting and relocation of fish farms. The Aquaculture Opportunity Studies (AOS) are based on previous provincial policy, namely MAFF's biophysical criteria (1987) and the Commercial Finfish Aquaculture Management Plan (2000). From a policy evolution standpoint, AOS are a result of progressive incremental

[94] Impacts of escaped farmed salmon on wild stocks, disease in wild and farmed fish, environmental impacts of waste discharged from farms, and impacts of farms on coastal marine mammals.
[95] Siting criteria comparisons were made with Maine, New Brunswick, Ireland, Washington, Norway, Scotland and Iceland regarding boundaries (low tide), minimum depths, distances between farms, critical fish and ecologically sensitive areas, oceanographic considerations, performance of Environmental Impact Statements and zoning criteria. However, this comparative study did not have any impact on siting criteria.
[96] Kirk Stinchcombe and Claire Townsend. MAFF. Victoria, B.C. February 2003. Personal communication.

growth. At the same time, the overall mapping outcome attempted to incorporate stakeholder (industry, First Nations, local governments) interests and values.[97]

The AOS regional maps identify priority areas to site salmon aquaculture facilities. The so-called "Opportunity Areas" (OA) are divided into OA1 and OA2, which show "good" and "limited" biophysical rankings based on MAFF's biophysical and current siting criteria.[98] A sound advantage of these maps is that they explicitly recognise caveats and limitations. For instance, the AOS carried out for B.C.'s North Coast acknowledges the "poor levels of resource inventory and unreliable salmon capability information."[99] Moreover, these studies point out that companies still need to carry out site-specific studies to meet all siting requirements.

3.2.10. DFO screenings under the Canadian Environmental Assessment Act (2002)

This guide comprises DFO's most recent marine finfish aquaculture requirements. The Canadian Environmental Assessment Act (CEAA) screenings[100] are fully site-specific and divided into environment, production, resource information and management plans (DFO, 2002). Siting criteria appear to be consistent with MAFF's Commercial Finfish Aquaculture Management Plan although ambiguity remains regarding their interpretation.[101]

CEAA screenings are the federal response to the lifting of the seven-year moratorium on aquaculture licenses that occurred in September 2002. Besides complying with siting criteria,

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97 Memorandum to John Willow (Business Programs LWBC) from John Bones (Coast and Marine Planning Branch MSRM). March 2002.
98 Examples of this maps can be retrieved from MAFF's website: http://www.agf.gov.bc.ca/fisheries/siting_reloc/aos.htm
99 Memorandum to John Willow. Ibid.
100 CEAA screenings resemble an environmental assessment requiring consideration of the following factors: environmental effects (and cumulative effects) of the project (malfunctions or accidents), comments from the public received in accordance with CEAA, measures that are technically or economically feasible that would mitigate any significant adverse environmental effects, and any other matter relevant to the screening, comprehensive study, mediation or assessment by a review panel.
101 a) Claire Townsend. MAFF. Victoria, B.C. April 2003. Personal communication. b) Jennifer Nener, Wayne Knapp and Allison Webb. DFO. Vancouver, B.C. March 2003.Personal communication. As the wording of criteria continues to be ambiguous and both levels of government have different mandates, the interpretation is subject to variation.

these screenings demonstrate extreme precaution as further stringent requirements are demanded during the license application process (e.g., stream and watershed surveys, benthic habitat surveys, water quality and circulation pattern studies, and so forth). As of late 2003, no new licenses have been granted to aquaculture developers given the demanding nature of these federal screenings.[102]

3.2.11. Summary Table: Factors that have influenced the evolution of salmon aquaculture siting policy in B.C.

Regulatory Event	Siting Objectives	Reactive to
a) DFO Guidelines (1986)	Prevent impacts on fish Avoid resource user conflicts	FEs, INDs, FB, BEP
b) Gillespie Inquiry (1986)	Avoid resource user conflicts	FEs, INDs, FB, (OJLs)
c) MAFF biophysical siting criteria (1987)	Environmental suitability	SE, (FEs, INDs, FB)
d) Ombudsman report (1988)	Mediate resource user conflicts	FB
e) DFO aquaculture report (1998)	Address resource user conflicts	FB
f) MOU (1988)	Define positions between levels of government	FB
g) Aquaculture regulation (1989)	Did not consider siting issues	AS
h) Biophysical suitability studies (1989)	Attributes and natural adversities of the environment for siting facilities	AS, IM
i) Coastal resource interest studies (1992)	Produce maps to show the areas suitable to site farms from the perspective of preventing conflicts with other resource users	IM
j) Salmon Aquaculture Review (1997)	Locate salmon farms at sites with intrinsic biophysical capability and socio-cultural suitability to prevent or reduce negative impacts and conflicts Promote successful production of healthy farmed salmon	AS, IM FEs, INDs, FB, SE, (OJLs)
k) Provincial Aquaculture Management Plan (2000)	Same as SAR. Only applies to the siting of new tenures	IM
l) Aquaculture Opportunity Studies (2002)	Support new siting and relocation of fish farms by identifying feasible "opportunity areas"	FB, IM
m) Federal CEAA Screenings (2002)	Provide new precautionary measures for fish farm license approval	IM

Table 3-1. Evolution of siting policy: Summary Table. Acronyms: [AS: Agenda Setting; IM: Incrementalism; FEs: Focusing Events; INDs: Indicators; FB: Feedback; SE: Scientific Evidence; OJLs: Other Jurisdictions' Leads; BEP: Borrowing Existing Policy]. The parenthesis ( ) indicates 'indirect influence'.

[102] Gary Caine. Ibid.

3.3. Origin, evolution, purpose and rationale behind siting criteria

Siting criteria ultimately determine the location in which new fish farms are established or re-located in the coastal waters of B.C. This section explores the origin and evolution of relevant siting criteria, what they seek to accomplish and the rationale supporting their constitution. Typical siting criteria are comprised by *buffers* (proximity or separation distances) and *attributes* (i.e., environmental or socio-economic settings). An important aim of this section is to describe the foundation of these concepts as applied to the salmon aquaculture case so that judgements regarding implicit disadvantages and trade-offs can be made and assessed.

a) Criterion #1: "No salmon farms within 1-km radius from the mouth of salmon-bearing streams."

The original criterion stated that "a finfish pen farm will not be located within 1-km radius from the mouth of a stream populated by anadromous fish, to minimise disease transmission concerns and protect highly sensitive estuarian fish habitat." Both the federal and provincial governments initially supported it (DFO 1998). The buffer is unsupported by scientific analysis and was determined as a "level of convenience to have cultured stock at a reasonable distance away from wild stocks" (DFO, 1998).[103] The purpose of the criterion was to reduce risk of disease transference from caged salmonids to wild stocks and *vice versa*. The criterion had an overarching impact on the industry's expansion as it is nearly impossible to find a place on these coastal areas where water is not flowing into the ocean.[104]

Furthermore, controversy exists because *"the mouth of a stream holding anadromous fish"* is a rather subjective attribute since the width of a stream varies considerably according to seasonal patterns. DFO regards streams as watercourses with the potential to have fish habitat, whereas MAFF defines them as watercourses carrying a considerable population of

[103] Wayne Knapp. DFO. Vancouver, B.C. March 2003. Personal communication. The workshop was held at the Pacific Biological Station and attended by personnel from DFO's science branch and other federal agencies. Its objective was to determine the adequacy and purpose of siting guidelines as well as the scientific rationale, if any, behind them.
[104] Gary Caine. Ibid.

salmonids.[105] In addition, there is no formal classification of salmonid productivity in regional streams and rivers, and science continues to be unsure about the degree to which the environmental conditions of a site may imprint on cultured salmon (DFO, 1998).

Consensus has not yet been achieved between MAFF and DFO. New salmon aquaculture licenses thus continue to be on hold. The agencies also disagree on where to start measuring the 1-km buffer zone. MAFF regards the edge of a net pen as the starting point to measure a 1-km distance to a salmonid-bearing stream while DFO regards the edge of a tenure as the starting point.[106]

Another factor that underscores the importance of this criterion is that DFO now asks proponents to undertake *salmon stream surveys* to obtain a more thorough description of on-site impacts.[107] However, the temporal scale by which such surveys should be carried out is not specified in the most recent CEAA screenings, a fact that may have implications with respect to the surveys' reliability. An implicit trade-off that emerges from this requirement is that fewer local firms can afford such surveys due to their high costs.[108]

b) Criterion #2: "Net pens should not be located within 1 km of herring spawning areas designated as 'vital', 'major', or 'important'."

This criterion emerged in the SAR as a response to well-documented changes overtime in the health of herring spawn (in part due to low dissolved oxygen concentrations) in relation to their proximity to salmon farms (DFO, 1998).

The purpose of the criterion sought to reduce the direct impact of farms on herring spawn. The 1-km buffer is based on a best guess by policy-makers and is unsupported by scientific evidence (DFO, 1998). Moreover, it has been previously acknowledged that an "appropriate" buffer distance between a fish farm and herring spawning areas varies

[105] Gary Caine. Ibid. Caine argues that refugee streams and resident streams need to be differentiated and defined. He mentioned that "refugee streams relate to those in which fish happen to pass by accident whereas resident streams have a history of consistently returning fish population."
[106] Kirk Stinchcombe and Claire Townsend. Ibid.
[107] Jeniffer Nener. DFO. Vancouver, B.C. March 2003. Personal communication.
[108] Gary Caine. Ibid.

depending on physical variables (DFO, 1998). Controversy regarding the adequacy of this criterion remained until the late 1990s as herring spawn classification was updated after the SAR was completed. It has been previously recommended that "the guideline be reworded to reflect DFO's revised system of classifying herring spawn" (DFO, 1998). The latest version of this criterion now appears under the "sensitive fish habitat" section included in the CEAA screenings. The provincial guidelines have remained unchanged.

c) Criterion #3: "Net pens shall not be located within 300 m of inter-tidal fish beds and 125 m from all other wild shellfish beds where there are, or is the potential for recreational, native food fish or commercial fisheries."

The original guideline put forward a 125-m buffer to separate fish farms from both intertidal fish beds and all other wild shellfish beds. Its purpose was to reduce the concentration of suspended solids and chemicals in waters used by shellfish and to safeguard human health (DFO, 1986). Both buffers were originally borrowed from the Canadian Food Inspection's Agency (CFIA) Sanitary Shellfish Regulations in relation to wharves, marinas, and other nearshore-based facilities (DFO, 1998) and were not derived from scientific analysis.[109] Such distances were selected as buffers as they "seemed reasonable and conservative" (DFO, 1998), most probably under the logic that a salmon aquaculture farm could be regarded as another "nearshore based facility" with respect to shellfish beds.

The SAR recommended a 300-m minimum distance between a farm's perimeter and intertidal shellfish beds. This buffer was derived from scientific analysis carried out at the University of British Columbia (DFO, 1998). The other 125-m buffer from other wild shellfish beds remained unchanged.

[109] Cross, S. Aquametrix Research. Courtenay, B.C. April 2003. Personal communication. Cross indicated that this buffer was derived from a best guess in the 1980s. He added, however, that his group has carried out scientific research based on tidal currents, oceanographic measurements, bioaccumulation of contaminants from farms, and impact on shellfish themselves, which (still in the form of grey literature) have proven that impacts on shellfish beds occur at a maximum distance of 30 to 50m from the edge of a salmon net pen. "Thus, by including a safety factor, the original buffer could be very close to reality."

d) Criterion #4: "Net pens should be located at an appropriate distance from areas of sensitive fish habitat."

The original guideline stated that "*net pens shall not be located over or near areas of sensitive fish habitat*" (DFO, 1986), which refers to spawning, rearing, food supply and migration areas upon which fish and shellfish depend directly or indirectly to carry out life processes.

The SAR modified the wording of the criterion, replacing the terms *'over or near'* with *'appropriate distance'*. The need for a more explicit definition concerning the *'sensitive fish habitat'* attribute was later acknowledged given multiple interpretations from stakeholders and decision-makers (DFO, 1998). Moreover, a 50-m buffer between the farm's perimeter and sensitive habitat was determined via scientific analysis. However, it was later recognized that even a 200-m buffer would prove inadequate under certain physical conditions (DFO, 1998). Consensus has not yet been reached and neither buffer has ever been incorporated into siting guidelines.

Current criteria state that information needs to be provided regarding the location of sensitive fish habitat areas (kelp beds, eelgrass, herring spawn areas, migratory routes, and so forth) that are within 1 km of the farm tenure, as well as the habitat's size or area, depth, seasonality and frequency of use (DFO, 2002).[110] This arbitrary buffer leaves the criterion open to judgment and evaluation.

e) Criterion #5: "Net pens should not be located within 1 km distance in all directions from a First Nations reserve."

The criterion aims to reduce potential conflicts with residents of First Nations reserves and prevent potential infringement of aboriginal rights or conflict with areas of aboriginal interest (EAO, 1997b). First Nations requested that this criterion be increased to a minimum distance of 10 km (EAO, 1997b). The criterion has remained unchanged until now.

[110] Linked to this criterion, a minimum depth of 10m was first suggested in order to minimize impacts on sensitive fish habitat (DFO, 1986). Thereafter, a greater depth of 30m was recommended (EAO, 1997). Finally, the adequacy of a distance greater than 35m was also argued (DFO, 1998), since impacts would be site-dependent according to physical and chemical parameters. There appears to be no scientific evidence related to this specific buffer.

f) Criterion #6: "Net pen facilities must have a minimum of 3 km distance between them."

An unpublished 800-m buffer between net-pen facilities that had been adopted from Norwegian standards at the beginning of the 1980s was the origin of this criterion.[111] It was used by the province until the Gillespie Inquiry was undertaken. A suggested 5-km minimum distance between net pens was then proposed (DFO, 1986). The aim was to minimize risk of disease transfer and prevent cumulative water quality impacts arising from nutrient loading. The buffer was increased after phytoplankton blooms occurred and threat from parasitic sea-lice was imminent in the mid-1980s.[112] Thereafter, the buffer was finally changed to 3 km (EAO, 1997a). It can be assumed that the original suggested buffer of 5 km may have been considered overly conservative, as there is no scientific support for this distance.

The following table shows a summary of relevant criteria including the year each was established, how each was disseminated, their purposes, rationales, and, finally, how each has evolved.

[111] Gary Caine. Ibid.
[112] Gary Caine. Ibid.

Table 3-2. Origin, evolution, purpose and rationale behind siting criteria.

Criteria as of today	*Year*	*Origin*	*Purpose*	*Rationale*	*Policy Evolution Factor*
1. "No salmon farms within a 1-km radius from the mouth of salmonid-bearing streams."	*1986*	*DFO Guidelines*	*Reduce the risk of disease transference from caged salmonids to wild stock and vice versa.*	*Unsupported by scientific analysis. Set as a 'level of convenience'.* *Buffer: Expert judgement* *Attribute: Subjective*	*FEs, INDs & FB: Decline in wild fisheries, phytoplankton blooms, number of fish losses, fishers' complaints, public and interest group concerns, complaints and pressure*
2. "Net pens should not be located within 1km of herring spawning areas designated as 'vital', 'major', or 'important'."	*1997*	*Salmon Aquaculture Review*	*Reduce the direct impact of salmon farms on herring spawn.*	*Unsupported by scientific analysis.* *Buffer: Expert judgement (best guess)* *Attribute: Subjective*	*INDs (& SE): 'Well-documented changes in the health of herring spawn (in part due to low DO concentrations) in relation to their proximity to salmon farms'*
3. "Net pens shall not be located within 300m from inter-tidal fish beds and 125m from all other wild shellfish beds where there are, or is the potential for recreational, native food fish or commercial fisheries."	*1986*	*DFO Guidelines*	*Prevent contamination of shellfish and safeguard human health.*	*Adopted under the logic that a salmon aquaculture fish farm is 'another nearshore-based facility' with respect to shellfish beds.* *Buffers: Both original buffers (125m) are unsupported by scientific analysis. The 300m-buffer derived from scientific analysis performed at UBC..*	*BEP: Buffer originally borrowed from the Canadian Food Inspection Agency's (CFIA) Sanitary Shellfish Regulations for wharves, marinas, and other nearshore based facilities.* *SE: Increased intertidal shellfish buffer from 125m to 300m*
4. "Net pens should be located at an appropriate distance from areas of sensitive fish habitat."	*1986*	*DFO Guidelines*	*Protect important fish spawning, rearing, food supply and migration areas upon which fish and shellfish depend directly or indirectly to carry out their life processes.*	*Buffer: Expert judgement. Changing SE led to a precautionary 1-km buffer based on expert judgements (DFO, 2002) as consensus was not reached.* *Attribute: Subjective as there is uncertainty regarding 'appropriate distance'.*	*(SE): A distance of 50m was determined after the SAR. It was later recognised that even 200m was inappropriate under certain physical conditions (DFO, 1998). Both buffers were not published and the criterion remained unchanged.*
5. "Net pens should not be located within 1 km distance in all directions from a First Nations reserve."	*1997*	*Salmon Aquaculture Review*	*Reduce potential conflicts with residents of FN reserves and prevent potential infringement of aboriginal rights and potential conflict with areas of aboriginal interest.*	*Buffer: Adopted under the logic that 1km is a 'reasonable' distance.* *Attribute: Objective and clear.*	*FB: Conflict with First Nations as they disagree about appropriate buffer distance. FN requested this criterion be changed to a minimum distance of 10km (EAO, 1997b)*
6. "Spacing between farms to be 3 km."	*1986*	*DFO Guidelines*	*Minimize risk of disease transfer and prevent cumulative water quality impacts arising from nutrient loading.*	*Unsupported by scientific analysis.* *Buffer: Expert judgement; 3km set as a conservative buffer 'to reduce sea lice'.* *Attribute: Objective and clear.*	*OJLs: 800m buffer adopted from Norway.* *FE: Increased to 3km, possibly due to IHN outbreaks and sea lice concerns.*

3.4. Disadvantages and trade-offs implicit in current siting criteria

Disadvantages refer to implicit inconveniences, conflicts or costs that may arise from the constitution and use of siting criteria. Trade-offs refer to the need to balance objectives when they cannot be attained all at once. They indicate ways to express one objective in terms of another. Trade-offs ultimately depend on the consequences associated with initial objectives and can be cognitively difficult in that they require comparison between a wide array of dimensions and qualities (Gregory, 2002).

This section addresses the implicit disadvantages and trade-offs behind the constitution and use of siting criteria. The reasoning behind the analysis makes use of the following set of objectives.

3.4.1. Objectives for the salmon aquaculture industry

The following set of objectives associated with the salmon aquaculture industry can help clarify the fundamental goals sought by the sector (McDaniels, 2002). Implicit disadvantages and trade-offs can be deduced through assessing the level of achievement of these objectives.

Fostering the health of the marine environment, refers to minimizing impacts on species (salmon, other fish species, mammals, birds and shellfish) and the marine ecosystem, as well as minimizing adverse environmental impacts on marine habitat both at and near fish farm sites.

Fostering economic benefits, refers to maximizing employment (of residents in small coastal B.C. communities, other B.C. communities and elsewhere in Canada) and income (related to the above-mentioned individuals, organizations and governments).

Fostering social benefits, refers to minimizing adverse impacts on traditional cultural patterns (of resource use and diverse work activities), aesthetics (noise, visual impacts and odours), and other marine uses (recreation and navigation), while fostering community cooperation and cohesion and respecting aboriginal rights.

Fostering adaptive management, refers to a process of learning about minimizing negative environmental consequences, processes (cooperative ventures and regulatory), minimizing costs and maximizing benefits (social, economic and environmental), and state-of-the-art technologies.

Fostering good governance, refers to coordinating aquaculture with the objectives of provincial Land Use and Coastal Zone Management Plans (LUPs & CZMPs), broader community economic development plans, and building social agreement about local siting decisions.

3.4.2. Disadvantages of using current siting criteria

a) Exclusion of potentially suitable sites within a selected region

Eight siting criteria (out of a total of fifteen) utilize *buffers* and *attributes* as means of separating fish farms from various other settings (MAFF, 2000).[113] In this context, a buffer divides a given region into acceptable and unacceptable areas. Buffers can therefore be both inclusive and exclusive, implying that some areas are 'inappropriate' to site a facility. They have the potential to exclude potentially suitable sites within a region of interest.

The buffer (1km) in the following criterion illustrates this disadvantage: *"A salmon aquaculture site should not be located within a 1-km distance of a salmonid-bearing stream."* Consider a hypothetical salmon aquaculture case in which site X adequately meets the remaining 14 criteria but fails to meet this buffer by 20 metres (i.e., site X is 980m away from a salmonid-bearing stream). In another hypothetical case, site Y meets this and several other criteria but by very small margins of, say, 5 metres (e.g., site Y is 1005m away from a salmonid-bearing stream). The outcome of this scenario is that site X is automatically eliminated whereas site Y is regarded as 'potential'. Considering that all 15 criteria are equally important, the outcome associated with site Y is clearly unfavourable. A "better" site is eliminated while a "less-desirable" one is

[113] These eight criteria state that fish farms should be sited at least: i) 1km in all directions from First Nations reserve; ii) 1km from salmonid-bearing streams determined as "significant by DFO and the province"; iii) 1km from herring spawning areas designated as vital, major or important by DFO and the province; iv) 300m from intertidal shellfish beds…; v) 125m from all other wild shellfish beds; vi) 1km from existing or approved proposals for ecological reserves < 1000 ha; vii) 1km in all directions from existing or approved federal, provincial and regional parks and protected areas; viii) 3km from other farm sites in accordance with local area plan or CZMP (MAFF, 2000).

taken into consideration. A major implication associated with this scenario is that the less-desirable site (initially regarded as potential) is less likely to meet the multiple objectives sought by stakeholders and policy makers, and more likely to generate adverse impacts in the long run.

Attributes are similarly fraught with disadvantages. The main reason is their ambiguity. The attribute in the above scenario [salmonid-bearing streams] may be subject to multiple interpretations. Attributes are usually interpreted according to policy-maker mandates or stakeholder interests and values. In the first case, DFO (having a fish protection mandate) considers any single stream or waterway regardless of its dimensions and fish population to be "salmon-bearing." That is, any stream bearing salmon or having the potential of bearing salmon is taken into account even if there exists no evidence of salmon habitat.[114] In contrast, MAFF (having an aquaculture development mandate) would consider only major streams that bear a determined number of fish. At the same time, other stakeholders directly impacted by fish farms such as First Nations or the tourism industry would be likely to support DFO's approach while trans-national corporations would be likely to only regard streams of large dimensions to be 'salmon-bearing'.

b) Exclusion of potentially suitable sites outside a selected region

Selecting a region of interest is usually the first step in choosing a site for facilities. There is possibility of excluding potential sites (with better environmental or socio-economic conditions) outside such regions with the application of siting criteria. This case is typical of salmon aquaculture in B.C. as the industry concentrates to a large extent in two specific regions (the Broughton Archipelago and the Johnstone Strait), which together comprise over fifty percent of the total salmon net cage tenures in the province (Living Oceans Society, 2003).[115]

[114] Jeniffer Nener & Allison Webb. DFO. Vancouver, B.C. March 2003. Personal communication.
[115] The poor biophysical setting under which former aquaculture practices were conducted on the Sunshine Coast caused the industry to collapse and move north to these regions, aiming at better environmental conditions such as uniform year-round temperatures and dissolved oxygen levels, sufficient depth, adequate current speed, and so forth.

c) Multiplication of adverse impacts within a selected region

Adverse social and environmental impacts have continuously arisen since the number of sites multiplied within both regions. The optimal biophysical conditions to grow fish in the Broughton Archipelago and the Johnstone Strait drove the industry to develop intensive aquaculture practices in multiple sites at a time when criteria were not appropriately defined or implemented. Additional implicit disadvantages emerge from using siting criteria including environmental impacts on marine ecosystems and habitats (as their carrying capacity is exceeded), socio-economic impacts (e.g., on First Nations and their traditional cultural patterns, other industries such as tourism, and other marine users), and complicating the co-ordination of the industry with local and regional LUPs and CZMPs.

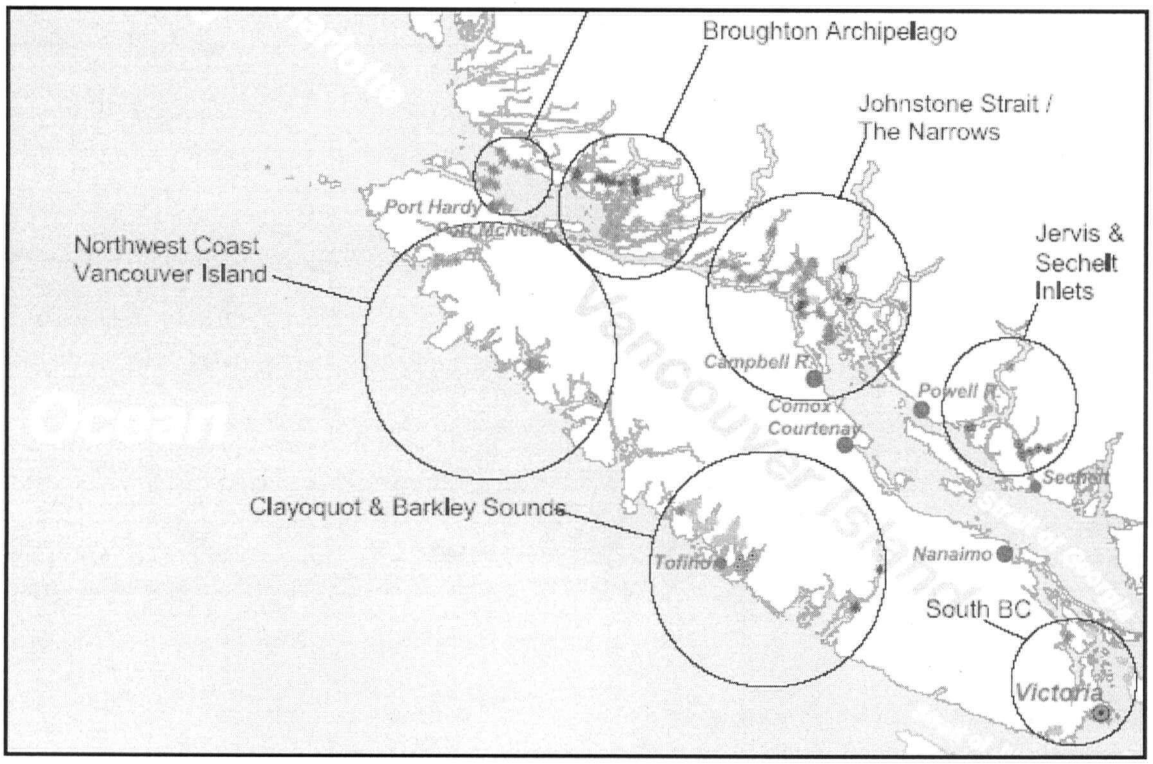

Figure 3-4. British Columbia fish farm tenures (Source: Living Oceans Society, September 2003)

d) Site-specific criteria disregard (biophysical and socio-economic) cumulative impacts and hinder the integration of salmon aquaculture with region-smart plans

Siting criteria are site-specific in the sense that they implicitly identify particular "spots" within a selected region where farms can operate while "minimizing" environmental impacts and resource user conflicts. However, the outcome of such criteria treats sites as independent components within vast systems, disregarding their dynamic interactions and emergent properties.[116] Following this logic, selected sites may simply be used to pursue economic goals and be seen only as biophysical locations with the appropriate conditions to rear fish.

Furthermore, site-specific criteria cannot be conceived as part of an integrated regional planning approach. In B.C., the regions where the largest concentration of farms exists have been physically divided into 'blocks'. The reason behind the "block approach" is that transnational corporations seek "ease of access and cost savings in serving the tenures with manpower and materials" (Ellis, 1996).[117] This approach translates into economic savings and a more suitable fish farm management scheme because travel distances between fish farms and to processing and distribution centres are minimized.

Nevertheless, blocks with a higher concentration of fish farms have a greater risk of adverse environmental impacts (e.g., on marine ecosystems and habitats) and social conflicts (e.g., with First Nations and other resource users). In addition, the use of blocks makes coordination with broader community economic development plans that seek to integrate the industry into the region more complex. Cooperation and cohesion amongst industries are made difficult if one industry dominates an area.

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[116] Emergent properties refer to those that arise only when specific components of systems get engaged.
[117] Over two-thirds of the salmon aquaculture industry are currently foreign-owned by four major corporations: Stolt Sea Farm, Pan Fish, EWOS and Nutreco (LWBC, 2002).

3.4.3. Tradeoffs implicit in current siting criteria

a) Larger buffers leave less area available for salmon farming, but mean greater environmental and social safety

The main trade-off that arises from the use of siting criteria is that larger buffers leave less area available for the salmon aquaculture industry (given the type of existing technology). Buffers act as a constraint on the overall scale and economic potential of the industry, and limit its expansion. A limited number of sites can be projected in each region so economic benefits are constrained to that defined scale.

At the same time, however, larger buffers would mean more safety. Adverse environmental and social impacts are, in principle, decreased with larger buffers. Impacts on marine ecosystems and habitats are obviously decreased because there would be less area for salmon farming. Social impacts on traditional cultural patterns (i.e., their resource uses and diverse work activities), other marine uses (recreation and navigation) and aesthetics (noise, visual impacts and odours) are similarly decreased.

In summary, larger buffers constrain economic potential but lessen environmental and social impacts.

3.5. Characterizing views regarding the current state of siting policy

Policy-maker and stakeholder interviews were carried out to clarify the rationale, purpose and implicit disadvantages associated with salmon aquaculture siting policy in B.C. The exercise assumes the need for more comprehensive siting policy, i.e., one that incorporates scientific evidence as well as values and interests related to conflicting stakeholder objectives.

Multiple objectives are sought by a wide range of stakeholders with different backgrounds, beliefs, assumptions and values. Therefore, to become aware of different perspectives regarding siting criteria is crucial to developing more a comprehensive policy process.

3.5.1. DFO perspectives

DFO's legal mandate concerning salmon aquaculture in Canada specifies the need *"to prevent impacts to fish and fish habitats and to avoid conflicts between aquaculture and fishery activities"* (DFO, 1986). A strong viewpoint prevails amongst the federal department staff interviewed in B.C.[118] Siting criteria are regarded as stringent standards amongst several other requisites for salmon farm siting decisions. Proponents must then strictly comply with the so-called *buffers*. In addition, they believe development of "good" science is the only justification that exists to modify such buffers.[119]

Despite the fact that several siting buffers are unsupported by science, DFO regards all criteria with the same degree of significance and rigorousness. For instance, a 1-km buffer from salmonid bearing streams and a 300-m buffer from shellfish beds are equally considered and applied. However, DFO now acknowledges that some buffers ought to be challenged[120] and that the first step toward a good siting process is to achieve consensus regarding the rationale and science of siting criteria.[121].

3.5.2. MAFF perspectives

The province is mandated to develop and manage the salmon aquaculture industry in B.C. Economic growth is situated as a priority objective and thus the provincial ministries (MAFF, LWBC and MSRM) are more flexible and open to relax and modify siting criteria.

[118] E.g., "The precautionary principle takes the most conservative view from our perspective and we shall continue to follow it." Allison Webb. DFO. Vancouver, B.C. March 2003. Personal communication.
[119] "Scientifically-defensible reasons must back up any possible modifications in current criteria since DFO has to stand to the public." Allison Webb. Ibid. Moreover, the mysterious disappearance of pink salmon runs (that led to empty some salmon farms in the Broughton Archipelago due to pressures from interest groups and further lawsuits from First Nations groups) may have contributed to the more stringent application of CEAA screenings.
[120] E.g., "Shellfish buffers are planned to be looked upon with more flexibility given that there happen to be shellfish beds everywhere around." Allison Webb. Ibid.
[121] Wayne Knapp. DFO. Vancouver, B.C. March 2003. Personal communication. DFO is also working on wild salmon policy and documentation with regard to policy principles and guidelines for general aquaculture, based on extensive public consultation under an ecosystem-based management approach.

For instance, if a particular firm has good fish health management practices, then MAFF would consider to relax the proximity of their net pens to a salmon bearing stream."[122]

The recommendations put forward by the SAR (soon after modified by MAFF in 2000) are perceived as guidelines rather than stringent criteria. As a consequence, MAFF policy makers have indicated that the possibility of a fully-harmonized document (in collaboration with DFO) regarding siting criteria has been scaled back.[123] Siting buffers are mostly perceived as arbitrary values based on common sense and conservation principles.[124] Overall, the first siting criterion is the most important for the province.[125] There is a large degree of willingness to modify existing buffers as the limit possible salmon farm sites.[126]

The provincial government is currently in the process of developing improved siting criteria for finfish farms. However, neither siting buffers nor attributes are likely to change.[127] Moreover, there is an ongoing discussion with DFO to reach agreement on when each buffer should be applied. The intention is not to relax any buffers, but to describe how proposed farm sites will be evaluated using them.[128] This fact may suggest a site-specific scenario, which implies a greater degree of objectivity.

3.5.3. Research organizations' perspectives

The interests and values associated with research organizations ultimately determine their perspectives on salmon aquaculture siting policy. On the one hand, there is the belief that

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[122] Kirk Stinchcombe, MAFF. Victoria, B.C. February 2003. Personal communication. "We would even allow firms to site on top of a shellfish bed if enhancement work is done on a different area."
[123] Claire Townsend. MAFF. Victoria, B.C. June 2003. Personal communication.
[124] Kirk Stinchcombe. MAFF. Victoria, B.C. February 2003. Personal communication.
[125] "The 1-km separation distance from salmonid-bearing streams should only be treated as a guideline, not under a thou-shall-not basis." MAFF regards this buffer only in the case of resident streams as opposed to also refugee streams or watercourses of any other sort (Caine, G. Ibid.).
[126] Gary Caine. MAFF. Courtenay, B.C. April 2003. Personal communication. A good example of openness is a case where MAFF would consider a temporal scale scenario for farm operations, meaning that sites are shut down whenever fish are migrating and re-opened whenever there is no migration.
[127] According to MAFF's website (http://www.agf.gov.bc.ca/fisheries/siting_reloc/govt_man.htm, September 2003), these criteria will reflect the requirements of relevant provincial and federal legislation (CEAA & DFO's Policy for the management of fish habitat will be taken into consideration) and will incorporate new knowledge of physical and biological interactions in the marine environment.

criteria should never be established in the absence of data.[129] This perception implies that siting criteria should only be set on the basis of scientific evidence.[130] Other research entities, on the other hand, have opposite views. Successful siting criteria are perceived to be those that fully maintain the health of the environment and ensure negligible social and biophysical impacts.[131]

3.6. Conclusion

This chapter explored the way that siting policy has been shaped throughout the relatively short existence of the salmon aquaculture industry in B.C. The chapter proposed a conceptual framework comprised by two political science mechanisms (AS and IM) and six policy evolution factors (FEs, INDs, FB, SE, OJLs and BEP) that explain how policy develops and changes over time. It was suggested that policy in general may evolve via outcomes that combine expansion, adjustment and replacement of policy. This analysis showed that the siting policy case associated with salmon aquaculture in B.C. has evolved via the first two [expansion and adjustment].

The policy evolution factors have played different roles during different periods of regulatory action. The AS mechanism and its associated factors (FEs, INDs and FB) influenced the origin and initial evolution of siting policy at a time when social and environmental impacts needed urgent attention (DFO, 1986). SE played an active role in determining optimal biophysical suitability for fish grow-out purposes (MAFF, 1987). FB caused the development of siting documents that aimed at mediating resource user conflicts (DFO, 1988; Office of the Ombudsman, 1988). Finally, the IM mechanism *per se* via expansion and adjustment influenced the moulding of newer policy that largely evolved from initial policies (EAO, 1997; MAFF, 2000; DFO, 2002).

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[128] For example, this may mean a farm could be allowed closer than 1 km to a federal, provincial or regional park, provided it does not interfere with activities of the park's plan (Claire Townsend, pers. comm. May 2003).
[129] Stephen Cross, Aquametrix Research. March 2003. Courtenay, BC. Personal communication
[130] Criteria are therefore developed once factors such as oceanographic measurements, current directions from fish farms, sensitive species found in shallower areas, and so forth, have been reliably determined and consensus has been achieved. Social criteria would then follow this initial process.
[131] Jeff Ardron. Living Oceans Society. Sointula, BC. November, 2002. Personal communication.

Typical siting criteria are constituted by *buffers* (i.e., proximity or separation distances) and *attributes* (i.e., environmental or socio-economic settings delimited by buffers themselves). Implicit disadvantages and trade-offs amongst conflicting objectives arise during a siting process that uses site-specific criteria. In addition, despite the fact that regulating agencies make use of the same *buffers* and *attributes,* the implementation of siting criteria remains subjective. Criteria may be either looked upon as guidelines (recommendations) or as stringent standards developed via precautionary common sense.

Buffers are largely based on risk management principles given the lack of definitive science that supports them. Hence they are imposed in order to manage risks by providing a measure of protection. However, in the end, establishing criteria in the absence of scientific data has led to controversy amongst stakeholders and policy makers.

4. Additional concepts for siting facilities

This chapter outlines and discusses three potential processes associated with facility siting. The first process yields siting decisions using public negotiation based on a procedure developed to site nuclear power plants and hazardous waste facilities in the United States (Kunreuther, 1993). The second process takes an analytical perspective on siting by making use of a decision-making tool that aims to find "best" sites while following a sound siting process. This method has been used by the energy sector in the U.S. (Keeney, 1980). Finally, the third process introduces a perspective where sites are regarded as components or sub-systems that co-exist within more broader and complex systems and are subject to cumulative effects, emergent properties and dynamic interactions. The chapter concludes with lessons learned from these lines of reasoning as applied to siting salmon aquaculture facilities in B.C.

These three processes are, in essence, suggestions for future methods of evolution for the siting process of salmon aquaculture facilities in B.C. A typical approach to locate a fish farm in coastal waters only considers how to find suitable sites that meet siting criteria under optimal biophysical conditions. In addition, as described earlier, the siting process places emphasis on criteria that evolve reactively, constraining the total number of "optimal" sites. Several other disadvantages have been identified with respect to the current approach. The purpose of this chapter is therefore to build on the previous one by suggesting other processes when considering the development of more comprehensive siting process and outcome schemes.

4.1. Siting as a public process of negotiation

The nature of facility siting typically involves different stakeholders and their associated values, interests, preferences and proposed outcomes. Lack of trust and disagreement about values and goals may sometimes be seen as major obstacles from a public perspective. These facts unquestionably generate conflicts and disputes. Negotiation tools and procedures are important to overcome disputes and search for mutual gains.

4.1.1. Facility Siting Credo

The Facility Siting Credo (FSC), a procedure developed for siting purposes *per se*, has proven beneficial in addressing stakeholder conflicts (Kunreuther, 1993). In addition, tools such as the method of principled negotiation may also be simultaneously employed (Fisher, 1980). While not intended as a panacea for dealing with siting matters, the appropriate combination and implementation of siting negotiation procedures and techniques could possibly help assist the marine-based facility siting process from a stakeholder negotiation perspective.

Siting noxious facilities such as landfills, incinerators and hazardous waste sites has been a topic of controversy since the 1970s. The lack of rational, impartial and workable siting procedures easily generated conflicts between stakeholders, decision makers and facility proponents. Research then identified that trust between developers and host communities, public perceptions of appropriate facility design, and public participation were crucial for sound siting negotiation processes and long-term positive outcomes (Kunreuther, 1993). The FSC was then purposely developed to assist facility siting negotiation and to address the main sources of conflict.

The FSC involves six procedural steps: instituting a broad-based participatory process, seeking consensus, working to develop trust, seeking acceptable sites through volunteer processes, setting realistic timetables, and keeping options open at all times. There are also seven desired outcome stages: achieving agreement that the status quo is unacceptable, choosing the solution that best addresses the problem, guaranteeing stringent safety standards will be met, fully addressing all negative aspects of the facility, making the host community better off, using contingent agreements, and working for geographic fairness. The possible relevance of the FSC for siting marine-based facilities such as salmon aquaculture sites is discussed below.

4.1.2. Discussion: Procedural steps

The first three procedural steps are crucial to any negotiation. *Instituting a broad-based participatory process* calls for stakeholder involvement and extensive public outreach, stressing the need for involving affected parties in the siting process while giving them the necessary resources to attain effective participation. Parties can then interact with one another via meetings, workshops or citizen advisory committees. *Seeking consensus* may require considerable time and, in some instances, may not even be possible. In light of this, *working to develop trust* focuses on the necessity for equity considerations associated with stakeholder values, concerns and needs so as to ultimately try to reach for consensus. Principled negotiation may be crucial in attaining consensus while working to develop trust by separating the people involved from the problem, prioritizing interests rather than positions, inventing options for mutual gain and using objective criteria (Fisher, 1980).

The last three procedural steps offer recommendations to the siting process. *Seeking sites through volunteer processes* may be an innovative way to encourage local communities to volunteer in siting a facility near their region. The public process of negotiation largely benefits from this action since conflict minimization and early community involvement toward common goals are expected. *Setting realistic timetables* places emphasis on efficient warnings to give sufficient time to address all possible details associated with facility siting. Finally, *keeping options open at all times* takes into consideration the fact that values may change over time since communities are not meant to have irreversible commitments.

4.1.3. Discussion: Desired outcomes

Achieving agreement that the status quo is unacceptable does not apply to marine-based aquaculture sites. Siting this type of facilities is not as indispensable as siting landfills, incinerators, energy or hazardous waste facilities. However, this first desired outcome does apply to the case of relocating existing marine-based sites that have a negative social or environmental record. *Choosing a solution that best addresses the problem* depends on mutual agreements between stakeholders, decision-makers and developers, on the basis of the socio-economic and environmental considerations. *Guaranteeing stringent safety standards* refers to meeting human health standards from communities being affected by the facility.

Addressing all negative aspects of the facility refers to developing prevention and mitigation measures to deal with social and environmental impacts. *Making the host community better off* makes allusion not only to economic profits but also to social and environmental domains. A sign of social disruption is indicative of failure in the siting process. Similarly, there is a failure when communities receive economic benefits but the process does not give adequate consideration to their local environmental needs. *The use of contingent agreements* also requires prevention and mitigation strategies that refer to response measures for environmental disasters, or conditions under which facilities are to be shut down. Finally, *working for geographic fairness* considers the ethical principle of equity between natural areas and communities as well as consideration of carrying capacity, risks and uncertainties where sites are highly concentrated within a limited area. High levels of uncertainty about ecological dynamics call for precautionary action to achieve an optimal geographical distribution of sites.

4.1.4. Discussion: How can the salmon aquaculture facility siting process benefit from the Facility Siting Credo?

Involving the public in siting decision-making became a question of intense scrutiny in the 1980s (Kunreuther *et. al.*, 1990). Accounting for public values in the siting process was expected to lead to improved decisions. Evidence has shown that both public participation and the building of trust between developers and host communities help deal with conflicting values, objectives, interests and preferences associated with stakeholders and decision makers (Kunreuther *et. al.*, 1993).

From a public negotiation perspective, siting processes associated with marine-based aquaculture facilities may benefit considerably from tools such as the FSC and its implementation in other types of facilities. A negotiation process that is participatory and active is likely to deliver enhanced results in the long run (Beierle, 2002).

The core social factors of a fair and workable public negotiation process aimed at siting any type of (controversial) facility should include public participation, positive public perception and development of trust. Both process and outcome considerations are key ingredients for long-term success, since siting decisions do not only affect a facility's location but also its future management.[132]

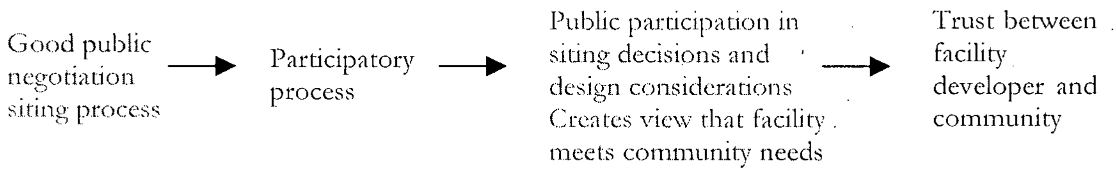

Figure 4-1. Summary regarding siting as a public process of negotiation
(Arrow indicates 'leads to')

4.2. Siting as an analytical process[133]

The need for structured decision-making in siting requires strategies to find 'best' sites. As in other types of controversial facilities, the salmon aquaculture siting process is characterized by substantial structural complexity. Stakeholders and policy makers must address multiple objectives, alternatives, trade-offs, risks and uncertainties, amongst other factors. Siting process objectives therefore become crucial to guide decision-making. Strategies such as decision analysis provide an analytical framework to structure the complexity of the siting problem, taking into consideration both stakeholder values and technical information. Decision analysis is a convenient risk management approach, because it helps to develop a good siting process using more comprehensive siting criteria.

[132] While public negotiation processes related to the planning and management of sites typically take place in the form of meetings, workshops and citizen advisory committees, it is worthwhile to note that the form of participation does not determine process and outcome success (Chess, 1999). Determining specific forms of community participation still remains a challenge. However, more intensive stakeholder-based processes are more likely to result in higher-quality decisions given the addition of new information, ideas and analysis (Beierle, 2002).
[133] This section draws heavily from Keeney, R.L. (1982). Decision Analysis: An Overview. Operations Research. Vol. 30(5): 803-838.

The decision analysis (DA) framework as applied to siting organizes the problem into a structure of possible courses of action, their outcomes, and likelihoods and consequences (Keeney, *et. al.*, 1982). DA techniques were originally designed to aid complex decision-making in the face of risk and uncertainty (Slovic, 1981). In the case of siting, DA intends to provide a rationale on how to create and use criteria for siting facilities by focusing on aspects that are fundamental to all decision problems such as determination of objectives, selection of alternatives, the consequences associated with alternatives and the uncertainties of such consequences (Keeney, 1982).

4.2.1. Decision Analysis: Overall methodology

The overall DA methodology follows four major steps: structuring the decision problem, assessing possible impacts of each alternative, determining values and evaluating and comparing proposed alternatives.

Structuring the decision problem requires determining objectives and performance measures (PMs),[134] followed by generation of alternatives. Multiple objectives are a typical outcome at this stage, making it difficult to generate alternatives that meet the vast majority of objectives with few trade-offs. A hierarchy of objectives based on external circumstances and information is used to generate dynamic alternatives.

The *impacts generated by each alternative* are then assessed in a second stage. Consequences for each alternative and their probability of occurrence are determined. Models such as simulations, systems analysis, management science and so forth are typically used at this stage. The impacts are measured in terms of production, capital costs, competition, financial impacts, quantitative assessment of professional judgement and probabilities.

The third stage comprises the *determination of values and preferences*. Value tradeoffs and risk perceptions are important at this stage. A model of values to evaluate all alternatives is

[134] Performance measures indicate the level of attainment of objectives.

created by the decision analyst and decision-makers to quantify value judgements about consequences. In the end, information on value tradeoffs, equity concerns, and risk perceptions are elicited. Value-focused thinking principles are important at this stage.[135]

Finally, the *evaluation and comparison of alternatives* is carried out to determine the expected utility. The higher the utility, the more desirable the alternative. The alternative with the highest utility will be the one that best meets the objectives that guide the decision. Sensitivity analysis is typically performed at this stage to indicate the sensitivity of a decision with respect to uncertainties of consequences and value structures.

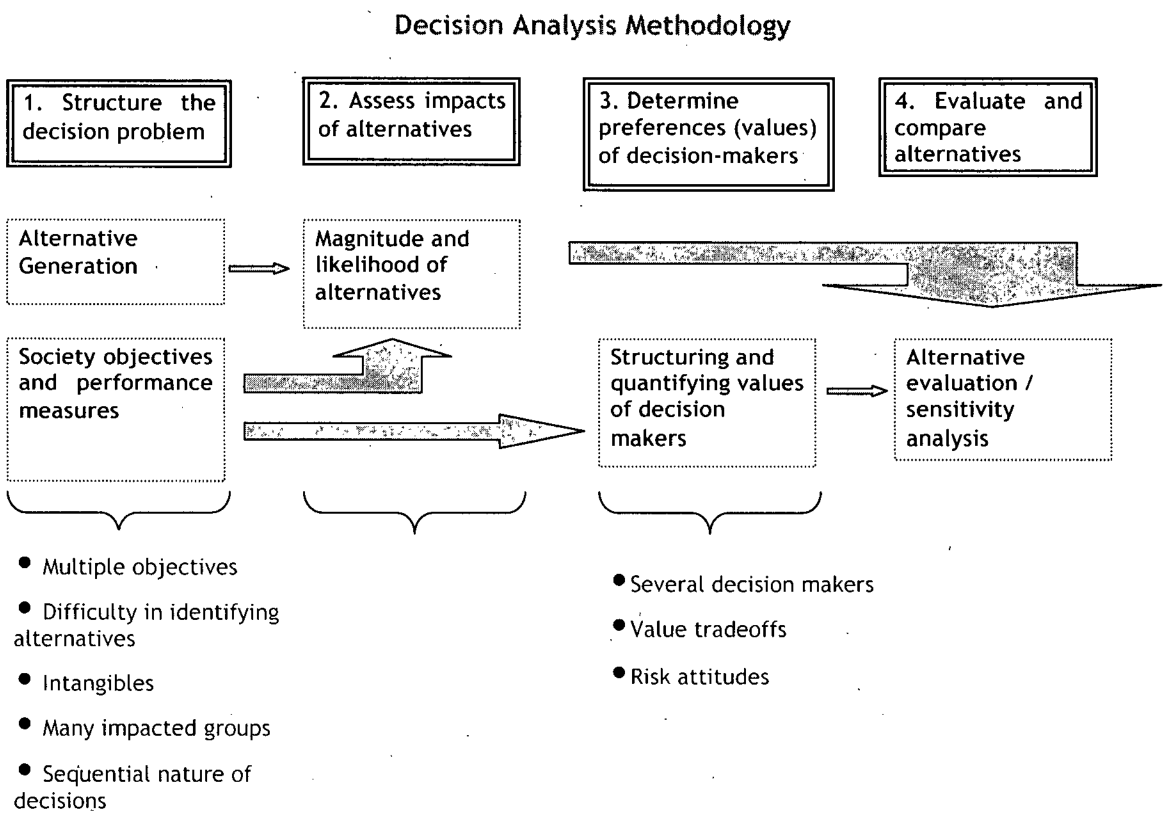

Figure 4-2. DA: Overall Methodology (Keeney, 1982).

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135 Value-focused thinking (VFT) is a proactive philosophy that aims to solve decision problems and to ultimately identify decision opportunities. It is based on a structured methodology that leads to better understanding and articulation of values, which are the driving force in the decision-making process. VFT addresses situations as decision opportunities rather than decision problems (Keeney, 1992).

4.2.2. *Decision Analysis: Siting methodology*[136]

DA as applied to siting decision-making begins with carefully identifying candidate sites. General objectives and their PMs are then put forward. The possible impacts associated with identified sites are detected, described and quantified. Finally, the analysis evaluates the impacts and compares sites to select the most suitable one in terms of stakeholder values and best available information.

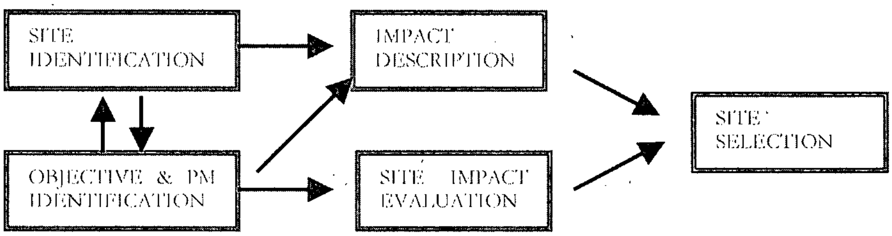

Figure 4-3. Siting decision analysis (Keeney, 1980)

A region of interest is first chosen by narrowing down the location to a specific area. This identifies numerous potential sites. Screening criteria are carefully set and applied under DA screening models, which state and quantify value judgements and indicate the level of attainment of the fundamental siting objectives. This step is intended to result in a series of candidate areas that are homogeneous.

Appropriate candidate sites are identified by incorporating diverse opinions from several experts in different fields (e.g. oceanographers, demographers, geologists, economists, and so forth). Screening models are also applied at the local level. Professional judgements become easier at this stage given the resulting homogeneity of candidate areas.

Siting DA formally specifies objectives and PMs to gauge the degree to which objectives are being attained. The facility siting dimensions discussed in chapter 2 could be an appropriate foundation for establishing objectives. PMs are ascribed to more specific objectives (i.e., sub-

[136] This section draws heavily from Keeney, R.L. (1980). Siting Energy Facilities. Academic Press.

objectives), which in combination indicate the levels of attainment of fundamental objectives. The impacts associated with every alternative are identified and described based on their consequences and probabilities of occurrence. Formal models can be developed and applied to assess consequences and probabilities. The desirability of each possible consequence is quantified to evaluate the previously described impacts. Value tradeoffs, equity and risk attitudes are addressed, while value judgements are made explicit. Values are elicited and clarified in order to assess the alternatives.

Up to this stage, the siting problem could be seen as structured and the magnitude of its associated impacts explicitly determined. The suitability of DA assumptions can be verified at this point. The site selection process is determined via expected utility.[137] All the gathered information is integrated to evaluate alternatives. Sensitivity analysis is then conducted with respect to preferences and impact inputs, to determine the sensitivity of decisions regarding uncertainties associated about the levels of impact. Finally, impacts are quantified, uncertainties are determined and the value structure is explicitly developed.

4.2.3. Discussion: How can the siting process benefit from Decision Analysis?

As a risk management problem, salmon aquaculture involves technical aspects comprised by exposure and effects, and social aspects comprised by risk perception and communication. To responsibly understand salmon aquaculture as a risk problem and develop sensible criteria, its social context needs better understanding. There seems to be a disconnection between public values and public policy. The former are believed to be crucial to determine siting criteria.

The key to DA is the decomposition of a problem into smaller, more workable analytical questions and judgements, and the recomposition to examine the whole problem. A characteristic feature of this type of framework is that subjective judgements are incorporated into the analysis. In that sense, initial emphasis is placed on understanding

[137] Mathematical computation comprising the probability distribution for each site and the utility function.

central values and objectives. DA provides a functional tool for the salmon aquaculture facility siting context because it has features that are innate to complex decision problems, i.e., multiple objectives, difficult identification of good alternatives, intangibles, long-term horizons, risk and uncertainty, impacted groups, interdisciplinary nature, as well as several decision makers, value trade-offs and risk perceptions (Keeney, 1980).

Screening and evaluation procedures serve as tools geared toward reaching specific objectives to address the concerns and multiple challenges of the facility siting problem. Nevertheless, from a more inclusive viewpoint, DA aims at finding best available sites via a logically sound, justifiable and pragmatic decision-making process.

4.3. Sites as components of larger systems

This section describes salmon aquaculture sites as components (or sub-systems) of larger systems. The purpose is to contribute another perspective to the difficult task of developing more comprehensive siting policy. First, the section describes the underlying industrial paradigm that has guided salmon aquaculture in the province. The larger, interconnected and complex systems in which salmon aquaculture sites are embedded and the impacts of facilities on such systems are also explored. Finally, the section argues the need for a regulatory system that is geared toward regional planning of salmon aquaculture management in the province.

4.3.1. Industrial aquaculture

Modern societies are characterized by techno-industrial growth and development based on science. The current techno-industrial paradigm is based on simple and linear laws. This ruling paradigm seems to be embedded in a reductionist model that separates humans from ecological systems. Yet, ecosystems, societies and economies are characterized by complex and non-linear factors and thresholds. This reductionist paradigm has become challenged in recent years by alternative perspectives that approach both natural and social systems based on "Post-Normal Science".[138]

Industrial aquaculture at the global level clearly follows an economic model (i.e., neo-classical economics) that, to a large extent, overlooks ecological science. Profit maximization is stressed in order to compete in global markets. In this sense, priority is given to the amount of fish that are grown and harvested rather than the way in which they are grown or their impact on larger ecological, socio-economic or cultural-ethical systems in which grow-out sites are embedded and dependant upon. This way, "industrial aquaculture concentrates on technological and managerial enhancement, leaving critical system dynamics questions unexplored" (Bavington, 2000). In Canada, this approach is illustrated by DFO's Aquaculture Development Strategy (1995), which focuses on economic competitiveness "to gain stature in world aquaculture..." This approach can easily overlook local and regional-level structures and disregard adverse impacts and consequences on other systems and sub-systems on which the industry depends.

Furthermore, as is the case with several other production-based industries, modern industrial aquaculture focuses on producing maximum output while minimizing capital input. The way in which such economic targets are accomplished tends to overlook the complex relationships that exist between the activities that occur in each site and the larger systems in which they are embedded. Similarly, risks and uncertainty (e.g., potential for unpredictable changes and social conflict) are not sufficiently taken into consideration.

4.3.2. Systems

In simple terms, a system may be defined as a network of functionally interacting and interdependent elements that form a "whole" that is self-contained but yet reliant on inputs from external sources, i.e., other systems. Systems tend to vary considerably in terms of size and complexity. Their activities and boundaries are critical with respect to both factors. In

[138] Post-Normal Science is based on ecosystem processes, ecological economics, and participatory forms of community-based politics in the context of space, time, energy and information. Several authors have

reality, no system exists in complete isolation without the influence of others, albeit a system can be more easily described if viewed in isolation and treated as a closed entity.

A system has connections and interactions with respect to other systems. Emergent properties also arise when specific components of systems become connected or engaged. These properties range from harmless to detrimental, depending on spatial, temporal, energy and information considerations. Salmon aquaculture sites can be viewed as components or sub-systems of larger and more complex systems, namely the biophysical, socio-economic, political, and cultural-ethical domains. An explanation of this argument is given in the following paragraphs. The diagram below illustrates how fish farm sites interact with, influence and get influenced by the broader systems in which they are embedded.

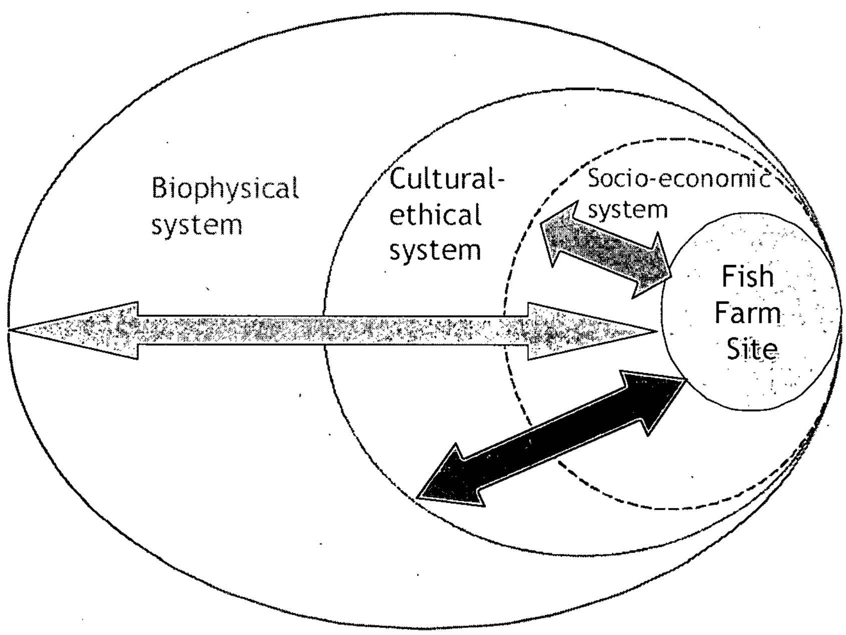

Figure 4-4. Fish farms as elements embedded within broader systems (Bavington, 2000).

Marine-based sites have dynamic interconnectedness with ecosystems (i.e., the biophysical system). An ecosystem refers to any spatial or organizational unit which includes living organisms and non-living substances that interact to produce an exchange of materials

developed these concepts. A description of this can be found on Funtowicz and Ravetz, 1993.

(Southwick, 1976).[139] Ecosystems are comprised by processes that bind organisms together and which influence ecosystem development, structure and function (Schneider & Kay, 1994). The incorporation of salmon aquaculture sub-systems into the structure of ecosystems has the potential to disrupt the natural, self-contained cycles, and the interaction and exchange of matter and energy within elements of ecosystems themselves. In addition, emergent properties introduce a great deal of uncertainty on both spatial and temporal scales. While ecosystems are dynamic, constantly changing and inherently complex, the typical managerial approaches of industrial aquaculture assume a world of simple rules. This results in siting criteria that considerably disregard ecological questions full of uncertainty (i.e., genetic effects and disease transfer, wild fish migration patterns, wastes and water quality, deleterious effects on marine mammals, cumulative impacts and so forth), and the overall ecological footprint of each site on a variety of faraway ecosocial systems.[140]

Fish farms are also immersed within socio-economic and political structures. First, 'intangibles' such as the social identity of individuals and groups (e.g., fishers, local communities and First Nations groups) at the local level are threatened. Significant conflicts in coastal areas emerge (e.g., navigational safety issues, access to traditional fishing grounds, aesthetic concerns, impaired access to coastlines, and so forth) and externalities (social and ecological risks and costs) are also increased as aquaculture practices are privatized and economic profits go almost entirely to trans-national corporations. These cumulative shifts of larger socio-economic structures must be regarded in the development of siting policy.

Finally, modern salmon aquaculture is ultimately governed by a set of assumptions and intellectual models that constitute a complex cultural-ethical system. Its structure is mainly comprised by neoclassical economics (based on growth and industrialization), social democracy (based on individualism), anthropocentric ethics (based on utilitarianism) and a scientific paradigm geared toward reductionism (Bavington, 2000). All these complex and

[139] An ecosystem may also be defined as a "nearly self-contained system, that is, the matter that flows into and out of it being nearly small as compared to the quantities that are internally recycled in a continuous exchange of the essentials of life" (Henry and Heinke, 1996).
[140] The ecological footprint of a fish farm is complex when the feed system is considered. Feed pellets used in a typical farm in B.C. comprise wild fish, agricultural products and antibiotics that are transported over long distances, which require massive energy expenditure in the form of fossil fuels. Tyedmers (2000) performed a comprehensive ecological footprint analysis on this topic.

multifaceted structures and their related functions are themselves subsystems within a vast array of values and cultures that are significantly ignored in the development of siting criteria.

In light of the multiple dynamics between systems, salmon aquaculture siting policy in B.C. could consider the interrelatedness of the systems' structures and functions. To look at salmon aquaculture sites from a systems perspective requires a new vision for managing operations. Most importantly, siting policy would need to be re-structured to consider uncertainties.

4.3.3. Need for regional planning

The salmon aquaculture industry in B.C. is regulated by several provincial and federal entities that have historically created a complex regulatory framework that focuses on a site-by-site approach. As such, current siting criteria have been specifically designed to select sites that, based on expert judgements, minimize environmental and social impacts (while having the appropriate biophysical set of conditions to carry out operations safely). This approach fails to consider cumulative impacts of fish farms on other systems (i.e., environmental and socio-economic) and does not support sound and sustainable regional planning (McDaniels, *et. al.*, 2003).

There is considerable degree of uncertainty about the cumulative impacts that salmon farms have on both the biophysical environment (e.g., wild salmon stocks, other marine species, benthos, and so forth) and human health. Also, cumulative impacts with respect to economic development and social well-being at various scales are uncertain (McDaniels, *et. al.,* 2003). The application of siting criteria merely focuses on the local perspective, leaving the regional perspective nearly unconsidered. Regional effects are not regarded because each site is viewed as an individual and isolated system that needs to be "protected" from the hazards imposed by other external systems.

A regional regulatory approach wherein site-by-site regulations are only considered in special cases is important if regional objectives are to be met. Regional objectives could consider cumulative impacts and other uncertainties. While a regional regulatory scheme may be complex to define, a systems perspective in combination with public negotiation and analytical (decision-making) processes, may importantly contribute to its various phases of development.

4.4. Conclusion: Toward more comprehensive siting policy

The FSC and DA are two well-established lines of reasoning that address the facility siting question. They have been developed throughout the past couple of decades and been implemented by other sectors. The former one looks at siting as a public process of negotiation for gaining agreement amongst stakeholders and decision-makers who are involved in or affected by on-site operations. The latter one portrays siting as an analytical (decision-making) process to find "best" sites through a structured methodology. Both courses of action and their associated procedures have been successfully implemented in hazardous waste and energy facility siting processes, respectively. As such, they could have the potential to be incorporated in the salmon aquaculture facility siting process.

A third line of reasoning envisions sites as components of larger and more complex systems. These systems are biophysical, socio-economic, political and cultural-ethical domains that are filled with highly profound dynamics, multifaceted interactions, emergent properties and uncertainties. The site-by-site approach that currently guides the salmon aquaculture process may find the systems approach to be a complementary strategy. It could allow sites to be adapted to broader systems instead of the current management strategy of adapting systems to sites.

A formal salmon aquaculture facility siting process where multiple stakeholders and policy-makers determine outcome criteria has not yet been designed in B.C. So far, federal and provincial government policy makers have developed criteria on a mostly reactive basis. Siting criteria tend to perform only as standards since they only try to avoid further environmental damage and resource user conflicts. A strategic siting process based on participatory forms of stakeholder involvement, analytical procedures and regional planning under a systems perspective could contribute to creating more comprehensive siting policy. Future criteria could then be founded on stakeholder values, scientific evidence and expert judgements under a regional approach while pursuing the fundamental objectives ultimately sought by the sector.

5. Conclusions

This research project focused on providing insights and concepts to inform and examine the salmon aquaculture facility siting process in B.C. The work explored siting policy evolution, looked at the rationale and disadvantages behind the use of siting criteria and suggested some lines of reasoning to consider when determining the future evolution of the siting process. The following sections briefly describe the findings and lessons learned from each proposed research question.

5.1 Salmon aquaculture siting policy evolution in B.C.

The first research question of the project focused on understanding and clarifying how salmon aquaculture siting policy has evolved in B.C. Based on the analysis of the various siting policy outcomes and interviews with stakeholders and policy-makers, the study showed that several factors associated with two policy analysis mechanisms (agenda setting and incrementalism) played an important role in shaping siting regulation. The origin and evolution of siting policy mainly responded to focusing events, indicators, stakeholder feedback and scientific evidence, and, to a lesser extent, to other jurisdictions' leads and borrowing existing policy.

Salmon aquaculture siting policy largely originated from two documents put forward by DFO (1986) and MAFF (1987). Each addressed the siting question from different perspectives. The study showed that, in essence, the former policy outcome directly emerged from focusing events, indicators and feedback while the latter was a product of scientific evidence. In other words, DFO's guidelines were directly reactive to agenda setting while MAFF's biophysical criteria resembled the birth of a planning process via scientific research. Each policy evolution factor plays a different role. DFO focused on how to avoid further environmental damage and resource user conflicts (thus being directly influenced by focusing events, indicators and feedback) while MAFF placed emphasis on biophysical suitability to find ideal locations for fish farming grow-out sites (an outcome of scientific evidence).

The study also showed that several policies associated with salmon aquaculture in B.C. were developed in 1988 to mediate resource user conflicts. Feedback played an important role in the creation of these reports.

The next siting policy outcome (in the form of criteria) emerged in 1997 in the SAR. The review, as a whole, was a reaction to agenda setting *per se*. However, the siting criteria included in the document emerged from incrementalism via adjustment and expansion. Biophysical criteria were essentially adopted from the first document put forward by DFO eleven years before. Only one particular criterion (i.e., distance from shellfish beds) evolved in combination with scientific evidence. Socio-economic criteria were added to biophysical criteria using the logic of avoiding resource user conflicts. Finally, the study showed that current siting criteria (MAFF, 2000 and DFO, 2002) evolved directly from the SAR without any major modification to their buffers and attributes. Both outcomes were a product of incrementalism.

Furthermore, the study identified that the evolution of siting policy has, for the most part, been *reactive* and ultimately determined by a few government participants. Siting policy is likely to continue evolving reactively via the same factors. Given the disadvantages concerned with reactive policy, a further step based on proactive planning (where environmental, socio-economic and governance goals are equitably met) could possibly contribute to developing more comprehensive policy. Proactive planning toward new siting policy would place equal emphasis to both process and outcome considerations. Siting criteria could then evolve from integrated and fair processes that consider stakeholder values, scientific evidence, and expert judgments under a regional planning approach.

5.2 Siting criteria rationale and implicit disadvantages

The second research question of the project aimed at clarifying the rationale behind and implicit disadvantages of current siting criteria. The study focused on six specific criteria constituted by buffers and attributes. The purpose of each criterion was found to be clear and sensible, usually based on the perspective of avoiding environmental damage or resource user conflicts. The rationale behind siting criteria was found to mainly rely on expert judgements based on risk management. That is, the actual buffers that constitute criteria are not scientifically defensible according to DFO and MAFF policy makers. In general, current buffers may imply "reasonable starting points" or "levels of convenience" to regulate the industry. Furthermore, several attributes could lead to ambiguous interpretation. For instance, the study showed that stakeholders and policy makers could have different views on "refugee and resident salmon bearing streams," "vital, major, or important herring spawning areas," "appropriate distances from sensitive fish habitat," and so forth. Many attributes could therefore be subjective in the absence of a comprehensive definition.

Several other disadvantages were shown to emerge from the way that siting criteria have been constituted and applied. For instance, the exclusion of potentially suitable sites within and outside the regions of interest can occur. Buffers divide regions into "acceptable" and "unacceptable" areas, but this may not reflect the true conditions. Some outcomes may thus result in the selection of less-desirable sites that have more impact on biophysical and socio-economic systems. Moreover, the use of buffers and attributes disregards cumulative impacts. The site-by-site approach by which criteria were designed suggests that each site exists in isolation from others and is independent from the external systems where it is embedded. This fact has unquestionably brought up important environmental risks and resource user conflicts.

5.3 Lines of reasoning associated with facility siting

Three lines of reasoning associated with facility siting were suggested in order to describe possible future evolution of facility siting processes and outcomes that could lead to more comprehensive siting policy. The first line of reasoning approached facility siting as a public process of negotiation, whereby a set of procedural steps guides the siting process through public participation, consensus and trust toward desired outcomes that see most benefits delivered to the local level. Salmon aquaculture siting processes in B.C. could significantly benefit from this procedure as such a participatory form of stakeholder-oriented negotiation has not yet been formally developed or implemented.

The second line of reasoning explored an analytical decision-making approach to find "best" sites, where the problem is first structured using objectives, performance measures and alternatives, followed by the assessment of alternatives, value determination and, finally, comparison of proposed alternatives. "Best" sites are then more justifiable on the basis of stakeholder values, technical information regarding biophysical suitability and additional criteria incorporated to the process. A regional model may largely benefit from this structured process (Keeney, 1980).

A final line of reasoning suggests that sites be viewed as sub-systems that occur within broader and more complex biophysical, socio-economic and cultural-ethical systems (Bavington, 2000). In the current era of globalization, industrial aquaculture has largely concentrated on economic profits and managerial improvements. Critical system dynamics that involve cumulative impacts and other questions of uncertainty have been largely overlooked. Salmon aquaculture siting policy in B.C. could therefore benefit from an alternative paradigm where the industry considers the structure, function and dynamic pattern of organization of the broad, interconnected and interdependent systems in which sites are nested.

The first two lines of reasoning and their associated procedures have been successfully implemented by other sectors that require facility siting processes. Both are thought to be applicable to the salmon aquaculture case given the need for public negotiation and structured decision-making in the facility siting process. While the third line of reasoning does not include a specific design or procedure, it does offer the potential for proactive regional planning.

5.4 Future research steps

The implications of this study suggest future research steps. The development of siting criteria could benefit from new approaches. If buffers and attributes continue to determine future sites (despite their disadvantages and trade-offs), scientifically-defensible criteria would be needed. This would call for intensive research on numerous risks and uncertainties related to wild salmon (i.e., risks of colonization, habitat impact, disease transfer, etc.), shellfish (bioaccumulation, transport of contaminants, etc.), bottom effects on benthic communities, and so forth. Scientifically-based buffers could then determine a number of "best available sites" where fish farms generate the "lowest" environmental and socio-economic impacts. Moreover, attributes would also need further clarification via consensus-based definitions.

However, there seem to be alternatives to buffer-and-attribute based criteria. For instance, the development of a framework that is objective-based rather than distance-based. This approach could also entail the use of value judgements and therefore benefit from public and analytical processes. For instance, in regions adjacent to wild salmon migratory routes, objective-based reasoning would lead to a total forbiddance of sites. In addition to other types of research, the identification and classification of resident streams with a history of consistently returning population of salmon would be needed.[141]. The same reasoning would follow with regards to visual corridors or large parks where tourism activities or conservation practices take place. Instead, sites could be located within areas of lower use and value (both from environmental and socio-economic perspectives). Moreover, sites would also have to be consistent with existent local management plans.

Furthermore, siting criteria disregard the temporal scale that exists in the biophysical environment, i.e., siting criteria only focus on a proximity scale. Research regarding the temporal scale of migration patterns could also offer a new perspective to develop criteria.

[141] For instance, one single stream accounts for almost half the returning population of pink salmon in the Broughton Archipelago. Thus, in that case, sites would be totally forbidden, and stringent criteria would be applied (Kirk Stinchcombe and Claire Townsend. MAFF. Victoria, B.C. February 2003. Personal comm.).

This perspective could consider site closure whenever fish are migrating through the aquaculture-intensive regions.

Another alternative approach would be to use site-specific impact assessments (SSIAs) to ultimately determine site location. In this situation, criteria would be only means toward ends.[142] The outcome of a SSIA considers actual (ecological) footprints associated with each proposed site based on waste impact, risk assessment and safety margins. Significant scientific research would be needed. In other words, SSIAs suggest the creation of criteria that specify when to use siting criteria based on a footprint analysis. An *impact zone* approach could be researched and developed where oceanographic data determine the orientation of sites and, ultimately, the footprint of every fish farm.[143]

The design and development of new schemes that combine siting processes are important actions to determine more comprehensive and sound siting policy processes and outcomes. Thus, each line of reasoning could be scrutinized and adapted specifically to the salmon aquaculture case. The idea of combining these three lines of reasoning may call for "multiple-stakeholder assessment groups." These could benefit from integrated assessments, simulations and qualitative and quantitative studies regarding the integration of sites into current plans.

Sustainable development principles such as precaution, integration, environmental impact assessment, public participation, community-based management, indigenous rights and integrated management planning are essential to modern aquaculture practices (DFO, Aquaculture Law and Policy workshop, 2003). Precaution and integration are relevant to the salmon aquaculture facility siting process *per se*. Precaution takes into account lessons learned from former reactive policy and applies a systems perspective to siting policy processes. Integration refers to enhancing co-operation between and among levels of government and places emphasis on local stakeholder perceptions for siting decision-making purposes. Siting process considerations and outcome criteria should incorporate both principles because a myriad of implications associated with systems dynamics and interactions is likely to remain

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142 Kirk Stinchcombe and Claire Townsend. February 2003. Ibid.

uncertain. This way, an alternative foundation to develop criteria (that considers stakeholder values and risks and uncertainties of cumulative impacts) could benefit from a more integrated siting process that is public (to elicit stakeholder values), and follows an analytical methodology (to determine the "best sites," if any) while considering the broad environmental and social system-level implications.

Finally, a significant solution (although more hypothetical) calls for a shift from intensive aquaculture practices toward more moderate ones. Adverse social and environmental impacts typically emerge in aquaculture-intensive jurisdictions that have ambitious economic goals. It must be acknowledged that great part of the social and environmental problems of salmon aquaculture arise from stakeholder perceptions that there are few benefits compared to considerable ecological risks. Thus, in conclusion, the facility siting process needs to equally focus and balance environmental, social and economic objectives to achieve a more sustainable salmon aquaculture industry in the province.

[143] Aquametrix Research. Courtenay, B.C. April 2003. Personal communication.

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Appendices

Appendix A. Levels of Government in B.C. and their regulatory authority in salmon aquaculture.

Level of Government	Aquaculture Regulatory Body	Regulatory Authority for...
Federal	Department of Fisheries and Oceans (DFO)	• Health of Fish • Food and public health safety • Conservation and protection of wild fish stocks and habitat • Protection of navigable waters
Provincial	Ministry of Agriculture Fisheries and Food (MAFF)	• Development and management of the Aquaculture industry: location, size, development of farm sites, reporting requirements and standards for design, construction and layout
	Ministry of Sustainable Resource Management (MSRM)	• Siting • Waste discharge permits
Municipal	Regional districts and municipalities	• Administer zoning bylaws and permits prepared in conjunction with Official Community Plans and Rural Land Use Bylaws
First Nations		• Resource planning and management? • First Nations in Clayoquot Sound and northern Vancouver Island have agreements with the province that provide for consultation in decisions regarding aquaculture

Appendix B. Regulations that apply on key issues of the salmon aquaculture industry.

Issue	Approach	Regulation	Brief Description
Issue #1: Escaped Farm Fish	*Federal*	• Fisheries Regulations • Fish Health Protection Regulations	
	Provincial	• Wildlife Act Regulations	Requires a permit to traffic in, possess or transport live fish
		• Fisheries Act (Aquaculture Regulation)	Conditions attached to aquaculture licenses: • Development of site specific predator management plans • Prohibiting releasing fish into fresh or tidal waters • Direct the licensee to prevent escapes and to report them
	Policies	• Federal guidelines on screening for hatchery effluents • Land siting guidelines • Introduction and transfer of finfish into and within BC • Special conditions on aquaculture licenses to prevent escapes • MAFF/MSRM protocol agreements	
	Programs	Focused on the impacts of escaped farm fish (Atlantic, Chinook and Coho salmon) on wild fish (steelhead and cutthroat trout, and wild salmon) and their spawning and rearing areas.	
Issue #2: Fish Health	*Federal*	• Canadian Fish Health Regulations	Directed at fish movements (live fish and fish eggs) into the country and across provincial boundaries. A license must be obtained from the Federal/Provincial Transplant Committee
	Provincial	• Wildlife Act Regulations	Prohibits the transport of live fish unless authorized by license or permit
		• Animal Disease Control Act	Requires the licensee to notify of aquatic animals that appear to be diseased (infectious or contagious)
	Policies	• Importation of Atlantic and Pacific Salmon into BC	
	Programs	• Federal/Provincial Fish Transplant Committee • CASH (Cooperative Assessment of Salmonid Health)	

Issue	Approach	Regulation	Brief Description
Issue #3: Waste Discharges	*Federal*	• Fisheries Act	
	Provincial	• Waste Management Act (Aquaculture Waste Control Regulation)	Allow BC Environment to administer the management and disposal of wastes from net cage fish farms operating in marine waters. Fish farm operation using less than 630 tonnes of dry feed per year are exempted from requiring a Waste Management Permit.
		• Fisheries Act (Aquaculture regulation)	MAFF reviews development plans and sets maximum on-site biomass levels in the aquaculture license
	Policies	• Special conditions to Aquaculture Licenses (Provincial Fisheries Act) • Environmental Management of Marine Fish Farms (1990)	
	Programs	• Environmental Monitoring Program for Marine Fish Farms (MSRM)	
Issue #4: Marine Mammals and Other Species	*Federal*	• Fisheries Act • Wildlife Act	
	Provincial	• Aquaculture regulation • Fisheries Act • Land Act	Define specific site predator management plans
	Policies	• Special conditions to aquaculture license (Provincial Fisheries Act) • DFO/B.C. Ministry of Sustainable Resource Management siting guidelines	
Issue #5: Fish Farm Siting	*Federal/Local*	• Local government bylaws and siting guidelines	
	Provincial	• Land Act	Approval to LOCATE. Requires a license or lease. Attempts to prevent or mitigate potential adverse effects. General siting criteria are established through the location of the farm and the management plan for the site
		• Fisheries Act	Approval to OPERATE. Aquaculture license

Appendix C. DFO Siting Criteria regarding Marine Fish Rearing Facilities (1986)

i. A finfish pen farm will not be located within 1-km radius from the mouth of a stream populated by anadromous fish, to minimize disease transmission concerns and protect highly sensitive estuarian fish habitat.

ii. A finfish net pen will not be located adjacent to a Small Craft harbour, DFO wharf or dock in order to minimize possible deleterious effects to farmed salmonids from periodic maintenance dredging operations which may be required. In addition, net pens must be located so as to provide a minimum of 30 metres clearance from the edge of the approach channel to such facilities.

iii. Net pens shall not be located within 125 metres of shellfish beds where there may be recreational, native food-fish or commercial harvests or within 125 metres of existing shellfish culture operation

iv. Net pen facilities must have a minimum of 5-km distance between them regardless of ownership to minimize risk of disease transfer and prevent cumulative water quality impacts arising from nutrient loading.

v. Net pens shall not be located over or near areas of sensitive fish habitat as defined by Section 31(5) of the Fisheries Act

vi. Net pens shall not be located or anchored in an area with a depth less than 10 metres at zero tide to minimize impacts on sensitive, productive littoral fish habitats.

vii. Net pens or fish rearing facilities will not be located in areas where they would interfere with commercial, recreational, or native food-fish fisheries.

Appendix D. Siting and user conflicts recommendations in the Gillespie Inquiry (1986)[144,145]

i. Initiate Coastal Resource Interest Studies (CRIS) program
ii. Immediate initiation of CRIS for Campbell River, Johnstone Strait, Islands Trust and Sechelt Inlet areas
iii. Discontinue issuing aquaculture tenures fronting park and recreation areas
iv. Encourage local government to develop zoning bylaws for aquaculture
v. Establish a minimum distance between aquaculture sites in populated coastal areas
vi. Aquaculture industry should develop a program for providing anchorage, access and emergency assistance to other coastal users

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[144] Review of Salmon Farming in British Columbia. (1993). Prepared on behalf of the Minister's Aquaculture Industry Advisory Council by ESSA Environmental and Social Systems Analysts Ltd.

[145] The provincial government authorised a total of fifty sites and considered additional seventy more at the time of this Inquiry. In addition to DFO's Guidelines in 1986, these events had considerable impact on the industry's regulatory process, including the siting of new facilities. The provincial government issued the first moratorium on salmon aquaculture licenses and appointed an inquiry to the industry, led by David Gillespie. The inquiry prepared a final report on the impacts of salmon aquaculture and outlined a series of recommendations on 10 different issues related to the industry. Various recommendations were included under each of the following headings: government support, information and education, native involvement, fish marketing and processing, marine environment, user conflicts and siting, referrals and advertising, production plans and diligent use, land tenure and the provincial agency approval system. The six recommendations shown here are indicative of a reactive regulatory process and that played a role on the evolution of siting guidelines. The Gillespie Inquiry was prepared in only two months after the first moratorium had been imposed. It was submitted to the Province in December 1986. The moratorium was lifted in March 1987 shortly after the submission of the inquiry.

Appendix E. Ombudsman recommendations regarding siting (1988)[146]

i. Siting consistent with principles of integrated resource management
ii. Siting and operation requirements consistent with the maintenance of environmental integrity. Similarly, aquaculturists should rely on provisions aimed at protecting the quality of their water resource.
iii. Appeal process must be available for all significantly affected parties prior to final grant of tenure.
iv. Recognize authority of local/regional governments to establish areas where aquaculture activities may be limited.
v. Facility design criteria should be developed on a site-specific basis to minimize visual impact.
vi. Internal and external appeal processes for siting and operation should be available to all affected parties.

[146] Review of Salmon Farming in British Columbia. (1993). Prepared on behalf of the Minister's Aquaculture Industry Advisory Council by ESSA Environmental and Social Systems Analysts Ltd.

Appendix F. Salmon Aquaculture Review Recommended Salmon Farm Siting Criteria (1997).

i. No salmon farms within the mouth of all anadromous fish streams.
ii. No salmon farms within 1 km of herring spawning areas designated as "vital," "major" or "important" (DFO classification), with DFO and local consultation required where salmon farms are proposed within areas classified as "sometimes important" or "minor" to determine if standards apply.
iii. No salmon farms within 300 meters of inter-tidal shellfish beds that are exposed to water flow from a salmon farm and which have regular or traditional use for First Nations, recreational, or commercial fisheries. No salmon farms within 125 meters of all other shellfish beds, including commercial shellfish growing operations.
iv. Locate salmon farms an appropriate distance from areas of "sensitive fish habitat" as defined by Section 34(1) of the federal Fisheries Act. (e.g., eel grass beds, kelp beds and rocky reef habitats).
v. Locate salmon farms an appropriate distance from areas used extensively by wildlife for breeding, foraging, and staging, and from traplines. No salmon farms in critical habitats required by red-or blue-listed species.
vi. As guidelines, locate salmon farms in areas that are naturally well-flushed by tides and currents and do not experience heavy natural organic deposition or natural oxygen depletion. Ideally, currents should be predominantly offshore or parallel to shore, and average current speeds should be >10, >5, and >3 cm per second at the surface, mid0depth and bottom, respectively. Natural bottom conditions beneath net-cages should not be more than 70% fine silts and clays. Water depth should be >30 meters with bottom sloping offshore; or >20 meters at locations where sediments will not accumulate due to high tidal flushing. overtime incorporate detailed current data into computer site modelling.
vii. Comply with all requirements of the Navigable Waters Protection Act, as administered by the Canadian Coast Guard. As a guideline, maintain opportunities for boater access to shoreline, which is not part of the Land Act site tenure. No salmon farms at marine anchorages designated on marine charts or by the CBCYC as boat havens.
viii. No salmon farms within the line of sight up to 1 km in all directions from existing or 'proposed' (i.e., approved study areas) federal, provincial or regional parks and ecological

reserves which are less than 1000 ha. Where a salmon farm is proposed at a location that is out of sight from, but within 1 km of, an above-listed protected area that is less than 1000 ha, the acceptability of the proposed farm is to be determined through consultation and reference to the protected area management plan. Where a salmon farm is proposed at a location that is within 1 km of an above-listed protected area that is greater than 1000 ha, the acceptability of the proposed farm is to be determined through consultation and reference to the protected area management plan (recognising that larger protected areas may already provide a sufficient buffer to prevent or minimise adjacency conflicts).

ix. No salmon farms within 1 km in all directions from a First Nations reserve, unless First Nation's consent is obtained. Locate salmon farms to address possible infringements of First Nations aboriginal rights in relation to spiritual and cultural areas, and resources that are harvested for food, ceremonial and economic purposes. Distance of salmon farms from these areas is to be determined in consultation with local First Nations.

x. No salmon farms within the line of sight up to 1 km from an existing residence(s) or recreational property(ies), unless the proposed farm has the support of the residential / recreational property owner(s).

xi. No salmon farms at sites that are "important" for recreation and tourism purposes, as defined through reference to CRIS data, Tourism Resource Inventories, and consultation. Locate salmon farms an appropriate distance from "other" recreation and tourism sites, as determined through reference to CRIS data, Tourism Resource Inventories and consultation (i.e., "other" sites are those that have value and/or are used for recreation and tourism purposes, but which are not classified as "important".)

xii. No salmon farms in areas that would pre-empt important aboriginal, commercial, or recreational fisheries (e.g., seine tie-up spits, gillnet drift areas, trap fishing areas, traditional trawl sites, shrimp and prawn areas).

xiii. Locate salmon farms in conformance with the requirements of the Heritage Conservation Act, based on consultation with MSBTC (Archaeology Branch).

xiv. Site salmon farms in full accordance with approved local government land use/zoning bylaws.

xv. Locate salmon farms in accordance with approved coastal zone management plans and local assessments of environmental carrying capacity.

Appendix G. Salmon Aquaculture Review biophysical siting criteria (1997)[147]

Factor	Chinook	Atlantic Salmon	Comments
Temperature			
Min	> 1 C	> 0 C	
Max	< 20 C	< 25 C	Surface temperature
Optimum	17 C		
Salinity	10 – 36 ppl	0 – 34 ppl	Concern with rapid shifts in salinity
Dissolved Oxygen			
Min	> 5 mg/litre	> 4 mg/litre	Varies with time in feeding cycle
Current speeds			
Average lowest	5 – 7 cm/sec	5 cm/sec	Measured at 15m depth
Highest Max	140 cm/sec	140 cm/sec	Expensive to anchor
Depth			
Min	20m	5m	Less for chinook if other factors optimum
No Maximum			
Wind speed – Max		100 knots	
Waves – Max	3m	3m	Technology dependent
pH		6.5 – 8.2	Freshwater portion of life cycle

[147] Based on information provided by the B.C. Salmon Farmers Association to the SAR.

Appendix H. New Tenure Siting Criteria under Commercial Aquaculture Management Plan (MAFF, 2000)

i. 1 km in all directions from a First Nations reserve;

ii. 1 km from the mouth of a salmonid-bearing stream determined as significant in consultation with DFO and the province;

iii. 1 km from herring spawning areas designated as vital, major or important by DFO and the province;

iv. 300 m from inter-tidal shellfish beds that are exposed to water flow from a salmon farm and which have regular or traditional use from First Nations, recreational, or commercial fisheries;

v. 125 m from all other wild shellfish beds and commercial shellfish growing operations;

vi. Appropriate distance from areas of "sensitive fish habitat", as defined by DFO and the province;

vii. Appropriate distance from the areas used extensively by marine mammals as determined by DFO and the province;

viii. 30 m from the edge of the approach channel to a small craft harbor, federal wharf or dock;

ix. 1 km from existing or approved proposals for ecological reserves <1000 ha.;

x. No salmon farms within the line of sight up to 1 km in all directions from existing or approved proposals for federal, provincial or regional parks, and Marine Protected Areas;

xi. Note to infringe on the riparian rights of an upland owner without consent for the term of the tenure license;

xii. No salmon farms in areas that would pre-empt important Aboriginal, commercial or recreational fisheries as determined by the province in consultation with First Nations, and DFO;

xiii. No salmon farms in areas of cultural and heritage significant as determined in the Heritage Conservation Act;

xiv. Land use planning and zoning to be consistent with approved local government land use and zoning bylaws;

xv. Spacing between farm sites to be three kilometres or in accordance with a local area plan or Coastal Zone Management Plan.

Appendix I. DFO siting criteria based on CEAA screenings (2002)

Stream/watershed survey
* Location of any streams of freshwater bodies within 1km radius and known anadromous streams in the area but beyond 1km

Resource information[148]
Provision of a comprehensive map which illustrates the spatial relationships of farm-site and the siting criteria elements:

Additional detailed supporting information (including information sources) is required regarding the siting criteria and the stated buffer zones. More general information is required for the wider area of the vicinity of a site (a minimum radius of 1 km around the site unless otherwise stated, although a wider coverage of up to 5km would be preferred)

1) Location of other finfish aquaculture facilities (i) within 3km, (ii) if possible, any finfish farms in the general vicinity but > 3km *(names of the operators & sites useful).*
2) Location of harvested intertidal shellfish beds in vicinity (buffer 300m) *(species, location in relation to the site, identification of group(s) harvesting them)*
3) Location of any other shellfish beds or commercial shellfish operations in the vicinity (buffer 125m)
(species, location in relation to the site, size, frequency of harvest)
4) Location of `sensitive fish habitat' such as kelp beds, eelgrass, herring spawn areas, migratory routes, etc., that are within 1km of the farm tenure. Information describing the size or area of habitat, depth, seasonality / frequency of use, etc., should also be provided.
5) Location of site relative to any existing or proposed Federal / Provincial / Regional parks, ecological reserves, or approved study areas in vicinity (buffer 1km)
(details e.g. site name, study group).
6) Location of significant wildlife areas near the site *(distance, details of any breeding / foraging / staging habitats, and the presence of any red / blue-listed species including seasonality / frequency).*
7) Location of areas known to be frequented by marine mammal (within 5km)
(species, seasonality / frequency and type of use e.g. haul-out / breeding area etc).
8) Location of any sites of cultural or heritage significance
(details e.g. location, its nature, site name etc.).
9) Presence and location of any fisheries at / near the site (Commercial / Recreational / Aboriginal).
(details e.g. type of fishery, seasonality, frequency).
10) Description of other present uses of the area surrounding the site (e.g. tourism, recreational boaters, logging etc) *(details, e.g. location, operators, frequency)*

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148 These criteria appear under the "Resource Information" section of the "Finfish Information Checklist: Information Requirements for CEAA Screening," emitted by DFO's Habitat and Enhancement Branch in January, 2002. According to Allison Webb (pers. comm.), this is the document currently used by DFO to evaluate site applications.

Appendix J. Typical Marine Net-cage Systems vs. Land-Based Systems

	Land-based systems[149]	Net-Cage systems[150]
Capital Investment ($)	21-27 million	1.5 million (2002)
Operating Costs ($/annum)	11-13 million	2-2.5 million (2002)
Stocking density (kg/m^3)	30-50	15

A comparison between the capital investment and operating costs of land-based systems and traditional marine net-cages shows that a significant margin between commercial viability and actual costs remains, even if higher stocking densities are allowed in land-based systems.

[149] Source: Simmons Environmental (cited in SAR, 1997d).
[150] Source: Gary Robinson. Stolt Sea Farm. December, 2002. Personal communication.