



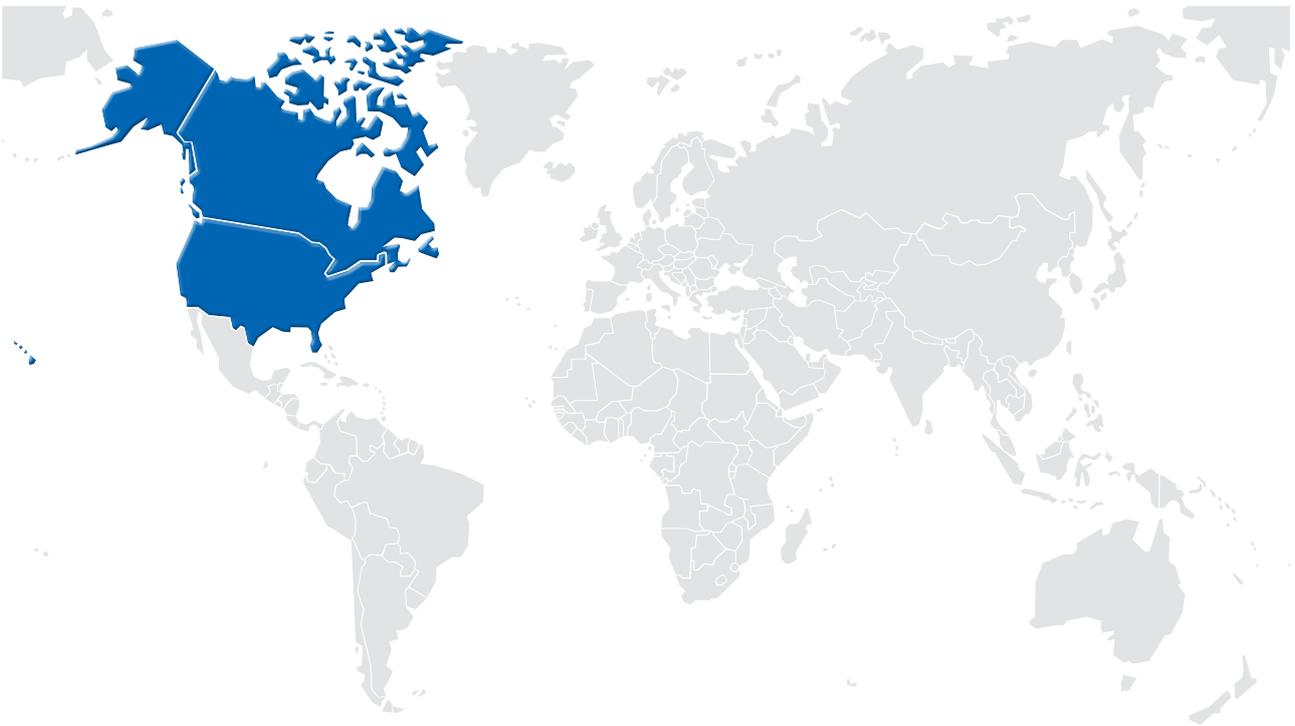
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REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN NORTH AMERICA – 2015



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PREPARATION OF THIS DOCUMENT

The document was written by Brian Harvey, FAO Senior consultant. Xiaowei Zhou, FIAS, developed the main FAO statistical datasets with different levels of details used for the analysis in the document, and provided clarification to specific questions that arose in the course of its writing. The document was edited and formatted in line with FAO house style by Danielle Rizcallah who also assisted in the preparation of the final layout. The author thanks José Aguilar-Manjarrez, Junning Cai, Malcolm Beveridge and Ruth Garcia Gomez of FAO for constructive review of the manuscript.

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ABSTRACT

The review summarizes status and trends of aquaculture development in North America for the period 2010–2015 and concentrates on activities in Canada and the United States of America. Relevant aspects of the social and economic background of each country are followed by a description of current and evolving aquaculture practices (species, methods, amounts and values) and the needs of the industry in terms of resources, services and technologies. Impacts of aquacultural practices on the environment are discussed, followed by a consideration of the industry’s response to market demands and opportunities and its contribution to social and economic development at the regional, national and international levels. External pressures on the sector, including climate change and economic events are described, along with associated changes in governance. The review concludes with an analysis of North American aquaculture’s contribution to the United Nations Sustainable Development Goals, the FAO Strategic Objectives, and the FAO Blue Growth Initiative. Throughout the review, outstanding issues and success stories are identified and a “way forward” suggested for each main topic.

For complementary views on aquaculture in the Region, please see the Report from the COFI Sub-Committee on Aquaculture, Brasilia, Brazil, 3–9 October 2015, available at the following link: www.fao.org/cofi/43341-04a74a5d167de0034251e8eaf83de443e.pdf

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ABBREVIATIONS AND ACRONYMS

AACI	Aboriginal Aquaculture in Canada Initiative
APR	Annual Percentage Rate
BC	British Columbia
BCARP	British Columbia Aquaculture Regulatory Program
BGI	Blue Growth Initiative
BMP	Best Management Practices
CAD	Canadian Dollar
CAIA	Canadian Aquaculture Industry Alliance
CETA	Comprehensive Economic and Trade Agreement
CO ₂	Carbon dioxide
COFI	Committee on Fisheries
DFO	Department of Fisheries and Oceans
ENGO	Environmental non-Governmental Organization
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
FLUPSYS	floating upwelling systems
HADD	Harmful Alteration, Disruption or Destruction
GDP	Gross Domestic Product
GMOs	Genetically Modified Organisms
IHN _v	Infectious Hematopoietic Necrosis virus
IMTA	Integrated Multitrophic Aquaculture
ISA	Infectious Salmon Anaemia
NAFTA	North America Free Trade Agreement
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
RAS	Recirculating Aquatic Systems
RIAS	Regulatory Impacts/Alternatives/Strategies
SDGs	Sustainable Development Goals
SPF	Specific Pathogen Free
TPP	Trans-Pacific Partnership
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
USDA	United States Department of Agriculture

1. SOCIAL AND ECONOMIC BACKGROUND OF THE REGION

1.1 Data sources and area covered

The present review concentrates on developments since FAO (2011a), and draws mainly on statistical and other resources from 2010 to 2015. The primary source for statistical data was an FAO dataset containing data to 2014 (FAO, 2016a). Additional sources of information include published scientific literature, government statistical reports and, occasionally, industry associations. The present review also adds the French territorial islands of St. Pierre and Miquelon, which offer a dramatic social, demographic and geographic contrast to Canada and the United States of America, but whose aquaculture production and prospects do not statistically affect the overall North American picture.

1.2 Status and trends

North America is a very small player on the global aquaculture stage, accounting for less than 1 percent of global production in 2014 and continuing a steady decrease in relative contribution over the last two decades (FAO, 2016). In its review of North American aquaculture to 2010, FAO (2011a) describes Canada and the United States of America (USA) as high-income industrialized nations belonging to the Organisation for Economic Co-operation and Development (OECD), as well as to the G8 and G20 groups of countries with shared interests in global economic development. This picture was unchanged in 2015, as is the interest in both countries in expanding aquaculture production for domestic and export markets. An illuminating arms-length analysis of aquaculture priorities in the two countries is provided by a recent meta-analysis of relevant major decisions, recommendations and agreements, prepared for the 8th Session of the COFI Sub-Committee on Aquaculture in October 2015. The analysis identified an overall North American prioritization of environmental impact, regulatory frameworks, sustainability, partnerships, marketing and access to investment¹.

1.2.1 Population growth

The populations of Canada and the United States of America grew slightly between 2010 and 2015, with the United States of America projected to increase somewhat more rapidly than Canada to 2020 (FAO, 2016a). With around ten times the population of Canada and slightly less area, the United States of America is clearly more densely populated and dominates in economic terms; in terms of resources available for aquaculture, however, the two countries are much more closely matched (see Section 3). The population of St. Pierre and Miquelon has remained stable at just over 6 000 since 2010, and is projected to increase only slightly by 2020.

In Canada and the United States of America, population growth continues to be concentrated in urban areas, which comprise the bulk of domestic markets. The extensive coastal zone in Canada, where most aquaculture operations take place, is home to a relatively small percentage of the total population; most of the remainder occupy a narrow geographic corridor along the southern margin of the country and close to the Canada-United States of America international border – a distribution with important implications for trade between the two countries, including trade in fresh aquaculture product.

1.2.2 Demographics and the workforce

The higher median age and lower fertility rate in Canada mean that its population is aging faster than that of the United States of America. Nevertheless, Canada's population growth rate is expected to remain among the leaders of the G8 countries, primarily because of the relatively higher rate of immigration (Government of Canada, 2016a). Aging of any population has implications for recruitment of workers, researchers and managers in any industry, and aquaculture in North America, which is generally intensive and technology-heavy, will be no exception.

¹ Please see the Report from the COFI Sub-Committee on Aquaculture, Brasilia, Brazil, 3–9 October 2015, available at the following link: www.fao.org/cofi/43341-04a74a5d167de0034251e8eaf83de443e.pdf

1.2.3 Incomes, economies and cross-border trade

North American incomes have continued to increase since 2007. In Canada the median family income (after tax) reached US\$58 785 in 2013 (Government of Canada, 2016c). The comparable figure for the United States of America was US\$52 250 (Government of the United States, 2016a). The economic picture changes when one compares per-capita Gross Domestic Product (GDP) in the two countries. Per-capita GDP in the United States of America has climbed steadily since 1960, except for a transitory dip reflecting the recession of 2008. It stood at US\$55 837 in 2015. In Canada, however, post-recession recovery peaked in 2012, after which per-capita GDP fell to US\$43 285 in 2015 (World Bank, 2016).

Despite the complexities of financing the technology-heavy aquaculture systems common in North America, and in marketing their products, the general economic climate in North America can be considered capable not only of continuing to support an expanding aquaculture industry, but also of responding to external pressures on the sector (see Section 7). Damage to the economies of Canada and the United States of America during the global economic downturn of 2008 seems largely to have been repaired during the period covered by the present review. Extreme fluctuations in global oil prices in 2015 and 2016 are, however, a reminder that the economies of both countries, which are tightly linked to oil supply and demand, will continue to be tested over the decades to come.

Although aquaculture remains a small percentage of overall agricultural output in both countries, the dramatic regional variations noted in FAO (2011a) persist. In the Canadian coastal province of British Columbia, for example, farmed salmon is now the largest agricultural export product; on the Atlantic side of the country, farmed salmon remains the largest crop in the New Brunswick agri-food sector.

In a report published in 2013, the North American fish and seafood market was described as dominated by the United States of America, with that country accounting for roughly 70 percent of seafood consumption by weight. United States of America expenditures outweighed those in Canada by almost 4:1 (Government of Canada, 2016d). Given the much larger disparity in population size (around 10:1 in favour of the United States of America), an increase in per-capita seafood consumption in the United States of America could boost the market for aquaculture products considerably. The United States of America is already the largest by far of importers of Canadian farmed shellfish and salmon; in 2011, for example, exports of Canadian farmed salmon to the United States of America were valued at over CAD\$480² million (Government of Canada, 2016e).

1.3 Important issues and success stories

1.3.1 Issues

The qualified workforce for North American aquaculture continues to grow. In Canada, the proportion of adults with post-secondary qualifications has grown from 60 percent in 2006 to 64 percent in 2011 over the last decade; 21 percent obtained Bachelor's degrees in 2011 (Government of Canada, 2016a). In the United States of America, 14 percent of adults attained Bachelor's degree status, a slight increase over 2006 (Government of the United States, 2016b).

Will these graduates comprise a large enough workforce for an expanding aquaculture industry? Around a dozen institutions offer specialized aquaculture training in Canada; the number of such offerings in the United States of America is considerably higher (FAO, 2009). Yet according to the Canadian Aquaculture Industry Alliance (CAIA), the number of skilled jobs in the industry currently exceeds the number of available qualified Canadian applicants. The current solution is recruitment from outside the country (CAIA, 2016).

² CAD = Canadian Dollar.

1.3.2 Success story

Domination of the North American aquaculture workforce by males in 2009 (FAO, 2011a) appears less striking in 2015, although statistics remain incomplete. Atlantic Canada offers one example of current aquaculture demographics in North America. More than 75 percent of aquaculture employees in the region are under 40 years old, with 40 percent being women (Government of Canada, 2016b). Most aquaculture operations on the continent, although they may be sited on a remote section of coastline, provide good living conditions, competitive wages and reasonable access to nearby cities. The demographic for those entering the aquaculture industry in North America is best described as young, educated and mobile.

1.4 The way forward

The cross-border flow of investment and farmed or manufactured products, which occurs in both directions, is evidence of how tightly linked the economies of Canada and the United States of America are. Consumer seafood preferences and aquaculture governance systems vary considerably between the two countries (see Sections 6, 8) but cross-border trade, enabled by the North America Free Trade Agreement of 1994 (NAFTA) inevitably has a levelling effect on the production and marketing of all agricultural products – including aquaculture products – through adoption of mutually acceptable tolerances and standards.

The challenge for both countries in the coming decades will be to maintain this very significant cross-border trade while developing new markets for the products expected to result from expansion of the industry in both countries. New markets will likely mean new trading partners and new trade agreements (see Section 5).

2. GENERAL CHARACTERISTICS OF THE SECTOR

2.1 Status and trends

The North American aquaculture industry continues to serve both domestic and international markets, and the availability of locations, technology and financing all point to a major role for the continent as a source of aquatic protein in the decades to come. Increasing demand for aquaculture-produced seafood is expected to come not only from a shortfall in wild fishery production (FAO, 2016b) but also from increased consumer demand for seafood in the diets of people in North America, Europe and parts of Asia (Faria, Carolsfeld and Dean, 2016).

Aquaculture in North America is dominated by finfish, primarily Atlantic salmon in Canada, channel catfish in United States of America, and trout in both countries. A smaller segment is dedicated to production of bivalve molluscan shellfish, mainly a number of species of oysters, mussels and clams (Table 1).

Table 1. Production (tonnes) of the main groups of cultured aquatic organisms in North America

Country	Species (Main grouping)	2010	2011	2012	2013	2014
Canada	PISCES	122 842	131 874	140 359	131 079	93 856
Canada	MOLLUSCA	39 499	37 560	42 947	39 109	39 927
Canada Total		162 341	169 434	183 306	170 188	133 783
St. Pierre and Miquelon	MOLLUSCA	...	2	3	5	59
St. Pierre and Miquelon Total		...	2	3	5	59
United States of America	MOLLUSCA	173 635	133 877	168 329	160 458	160 464
United States of America	CRUSTACEA	54 491	55 247	45 340	50 089	65 872
United States of America	PISCES	268 573	208 168	206 717	210 913	199 534
United States of America Total		496 699	397 292	420 386	421 460	425 870
Totals		659 040	566 728	603 695	591 653	559 712

Source: FAO, 2016a.

It is important to note that FAO statistics do not capture the enormous role played by aquaculture in producing young salmon in hatcheries for release into the ocean and subsequent capture in the “enhanced” wild fishery. Production from St. Pierre and Miquelon was not reported before 2011; it is currently reported as mainly mussel culture, with a significant increase in scallop production in 2014.

There were significant decreases in finfish production for both countries in 2014. While Table 1 clearly shows total United States of America production to be three times that of Canada, a comparison of production values reveals a more balanced continental picture. Finfish production tonnage, for example, is substantially higher in the United States of America, but its overall value is much closer to that of finfish in Canada; the explanation lies in the higher market value of the primary Canadian product, Atlantic salmon (Table 2).

Table 2. Production value (US\$) of the main groups of cultured aquatic organisms in North America

Country	Species (Main grouping)	2010	2011	2012	2013	2014
Canada	PISCES	823 353	779 016	783 654	854 480	589 008
Canada	MOLLUSCA	69 679	69 346	81 634	82 795	75 483
Canada Total		893 032	848 362	865 288	937 275	664 491
St. Pierre and Miquelon	MOLLUSCA	...	8	12	20	566
St. Pierre and Miquelon Total		...	8	12	20	566
United States of America	MOLLUSCA	202 708	218 718	253 219	314 910	263 730
United States of America	CRUSTACEA	185 705	216 652	177 585	145 583	201 052
United States of America	PISCES	634 859	669 466	576 478	705 212	678 048
United States of America Total		1 023 272	1 104 836	1 007 282	1 165 705	1 142 830
Totals		1 916 304	1 953 207	1 872 582	2 103 000	1 807 887

Source: FAO, 2016a.

Growth patterns for North American aquaculture have historically varied by species, and the prediction of future trends poses challenges. Although the continent has considerable available resources for expansion of aquaculture as well as technical expertise, production of any given species is strongly affected by market demand and systems of governance that vary regionally in the degree to which they enable or constrain aquaculture growth. These issues will be developed in Sections 3, 4 and 8. Here it is sufficient to point out that the opposition to net-pen culture (also called cage culture) noted in FAO (2011a) continues and has likely increased. Moving the net-pens further offshore is no longer the only accommodation being tested in the industry, with land-based facilities being advanced as ways of adapting to negative public perceptions of net-pen culture. The split between inland aquaculture and coastal/marine aquaculture remains roughly the same in both Canada and the United States of America as was reported in FAO (2011a): Canada’s marine production tonnage is still roughly 14 times that of its inland production, whereas the ratio in the United States of America remains around 1:1.

In contrast to the modest growth of North American total aquaculture between 1998 and 2008 (an annual percentage rate (APR) of 1.8 (FAO, 2011a), production actually decreased between 2010 and 2014 (an APR of -4 percent; FAO, 2016a). The slowdown was somewhat greater in Canada than in the United States of America (-4.7 vs -3.7), a reverse of the trend of the previous decade. Such fluctuations are, however, not uncommon; FAO (2011a) noted the same see-saw pattern between 1998 and 2008, with highs of 24 percent production growth (Canada, in 1999) and contractions of 15 percent (United States of America in 2005). Fluctuations in annual value were even wider. With changing consumer preferences, currency exchange rates, offshore markets, technologies and governance, and especially when the two countries have dissimilar aquaculture species profiles, variability can be expected to continue. The same phenomenon can be seen on a much smaller scale in reported production in St. Pierre and Miquelon. Scallop culture was not even reported before 2014, when it completely eclipsed the culture of mussels (FAO, 2016a).

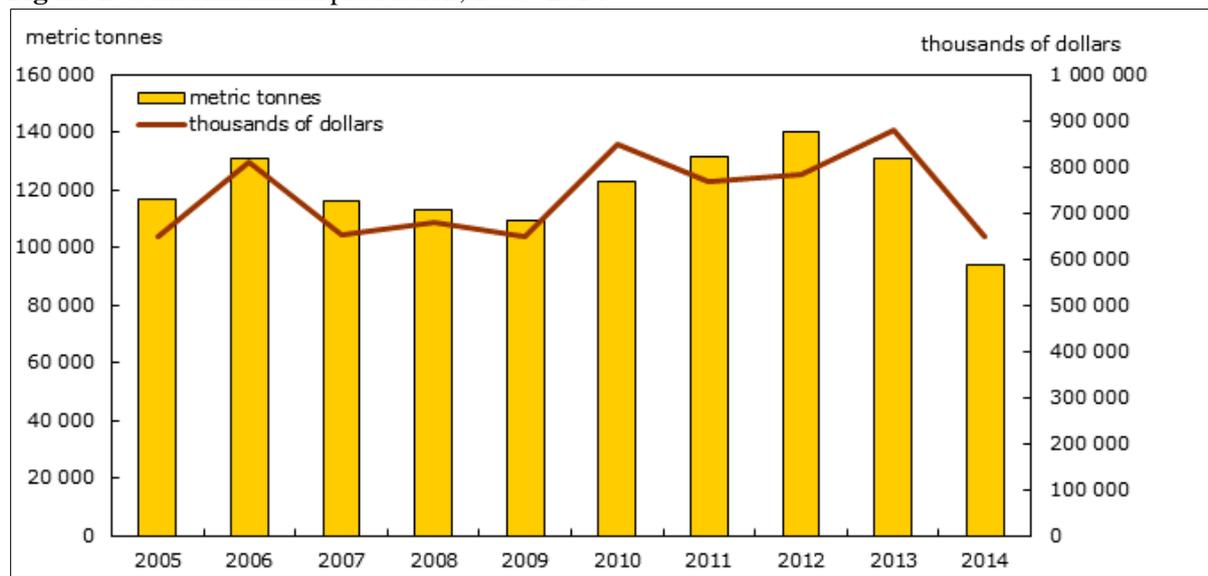
2.1.1 Production quantity and value in Canada

The split between inland and marine/coastal aquaculture in Canada has shifted slightly from the 90 percent marine/coastal reported for 2007 in FAO (2011a) to 94 percent in 2010 and 93 percent in 2014. Operations remain overwhelmingly in marine and coastal sites, and there is clearly no trend in the other direction. This means that the Maritime Provinces (British Columbia in the west and the four Atlantic Provinces on the east) produce most of the product. Aquaculture in Canada is mainly marine and focuses on finfish (mainly Atlantic salmon) and a variety of bivalve molluscs (mussels, oysters and clams).

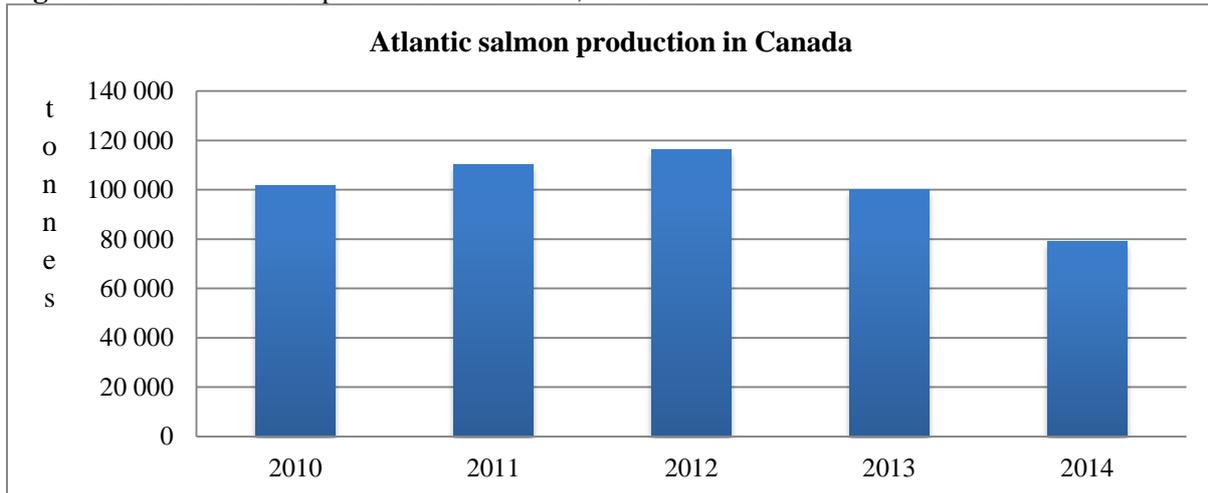
2.1.1.1 Finfish (salmon and trout)

Salmon (mostly Atlantic salmon *Salmo salar*, which is farmed on both coasts but native to the Atlantic only) continues to dominate production, representing 60 percent of total aquaculture production in 2014, and 75 percent of value (FAO, 2016a). British Columbia accounted for 69 percent of salmon farming production in 2014 and farmed salmon is that province's largest agricultural export item. The industry is dominated by a small number of companies, a number of which are Canadian divisions of Norwegian companies. The remainder of salmon production is split between New Brunswick, Newfoundland and Labrador and Nova Scotia. As a whole, however, Atlantic salmon production has declined between 2010 and 2014, for a APR of -6 percent (Figure 4). This is a reversal of the trend reported in the previous North America aquaculture review (FAO, 2011a). The significant drop in 2014 production is related to management of outbreaks of infectious salmon anaemia (ISA) in 2013 in several East coast salmon farms. The disease has also been a significant problem in salmon farms in Norway, Scotland, Chile and the eastern United States of America. Overviews of Canadian finfish production and Atlantic salmon production are shown in Figures 1 and 2.

Figure 1. Canadian finfish production, 2005–2014



Source: Statistics Canada.

Figure 2. Atlantic salmon production in Canada, 2010–2014

Source: FAO, 2016.

A small amount of two Pacific salmon species (coho *Oncorhynchus kisutch* and chinook *Oncorhynchus tshawytscha*) continues to be farmed in British Columbia using the same technologies as for Atlantic salmon.

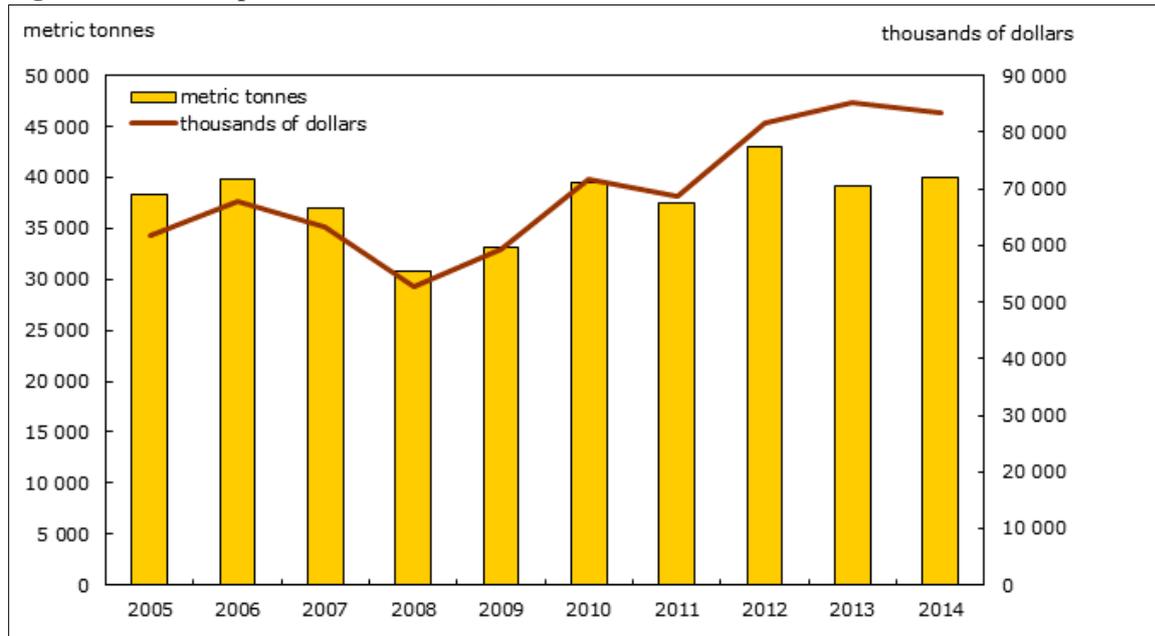
Canada's farmed salmon industry provides more than 10,000 jobs in coastal communities, including aboriginal communities (Government of Canada, 2016g). The technology has matured into a standardized model in which companies maintain their own selectively bred broodstocks that provide eggs for rearing young fish in land-based hatcheries to the stage at which they are capable of transfer to seawater, by truck or by boat, for growout in large floating net cages in coastal areas. Large companies maintain multiple growout sites with suitable temperature, tidal flow and protection from storms and separation from wild salmon migratory routes. Variants on the model mainly represent attempts to reduce environmental effects and build social license; they include land-based recirculating aquatic systems (RAS) and organic product certification. These significant new developments will be discussed in Sections 3, 4 and 7 below.

Trout (includes rainbow and brook trout) continue to be farmed in inland freshwater facilities both for food and for stocking lakes. Half is produced in the province of Ontario. The tonnages of trout have increased steadily but not dramatically since FAO (2011a) and represent a somewhat larger percentage of total finfish production because of the recent decline in Atlantic salmon production. In 2014, trout production amounted to 7 488 tonnes, approximately one-tenth that of Atlantic salmon (FAO, 2016a).

2.1.1.2 Shellfish (molluscs including mussels, oysters, clams)

Overall molluscan shellfish production in Canada has remained essentially flat over the last five years in terms of quantity, with a slight trend toward increase in value (Figure 3).

A different picture emerges, however, if one compares shellfish production on the East and West coasts of the country. Between 2002 and 2012, shellfish aquaculture production remained essentially flat in British Columbia but increased 30 percent in eastern Canada. The very small Atlantic province of Prince Edward Island, with a twentieth of the coastline of British Columbia, still had tripled the shellfish production (Comox Valley Economic Development and Tourism, 2015).

Figure 3. Shellfish production in Canada, 2005–2014

Source: Statistics Canada.

Mussels (several species of *Mytilus* spp.) lead shellfish production in Canada at around 25 000 tonnes in 2014 and are grown on both coasts on tubular mesh “socks” suspended from rafts or longlines. Seed comes from the wild (East coast) or is produced in hatcheries (West coast). Techniques are not as well developed in British Columbia, but innovations in culture systems (e.g. a switch to trays) may stimulate expansion beyond the present relatively small scale. Mussel culture has little environmental impact; like other filter feeders, mussels are well suited to contribute to integrated multitrophic aquaculture (IMTA) systems (Government of Canada, 2016h). Canadian production between 2010 and 2014 has increased around 10 percent over that reported in FAO (2011a). Farm-gate value has, however, increased disproportionately over the same period, rising almost 70 percent between 2009 and 2013.

Oysters farmed in Canada include American/Eastern oyster *Crassostrea virginica* and Pacific oyster *C. gigas* (the latter is farmed only in British Columbia, where it is an introduced species). Pacific oysters continue to dominate by a factor of roughly 2:1. Farmed oysters are Canada’s second most valuable cultured shellfish aquaculture species, with British Columbia the leading producer. Total oyster production has remained steady at around 10 000 tonnes/year since 2010. The Pacific oyster is grown in a variety of suspension culture systems that produce a better product than bottom culture, a move from extensive to intensive culture that is allowing expansion of the industry. Seed are mostly obtained from hatcheries, fed through a nursery stage then transferred to the growout system of choice.

Clam farming is dominated by the introduced Manila clam in British Columbia, with other species grown in the Atlantic provinces. It is a relatively young industry (begun in 1985), whose production of 1 327 tonnes was valued less than 10 percent of that of mussels in 2014 (FAO, 2016a; Government of Canada, 2016f). Seed produced in hatcheries is further grown in nurseries, then planted on prepared subtidal plots. Harvesting is generally by hand. Minus the hatchery and nursery stages, the system is strikingly similar to the “clam gardens” constructed by coastal aboriginal people thousands of years ago (Lepofsky and Caldwell, 2013).

Most shellfish farming companies in Canada are small and generate fewer jobs than do those in salmon farming. As with salmon farming, positions range from skilled jobs in hatcheries to labour-intensive outdoor positions in site maintenance and processing.

2.1.2 *Production and value in the United States of America*

Differences in coastal habitat (type and extent) and water temperature have produced an aquaculture sector in the United States of America whose species composition is markedly different from Canada's. A few species (for example trout, Atlantic salmon and oysters) are shared; most are not. Dominance of high-value Atlantic salmon in Canada means that the aquaculture industry is worth more on a per capita basis in Canada, whose population is a tenth of the United States of America's (Section 1). More species are cultured in the United States of America, but the contribution from lower value freshwater species is still higher than in Canada. Freshwater aquaculture production has been declining since 2009, and 2014 production was 3 percent lower from in 2013. In 2014 the total freshwater and marine industry generated 275 million tonnes valued at US\$1.3 billion. This was still only 20 percent of the value and 6 percent of the volume of total United States of America production of fishery products (National Marine Fisheries Service, 2016).

Marine and coastal aquaculture in the United States of America made up only around 50 percent of production in 2014, compared to over 90 percent in Canada. Marine production in 2014 was valued at around US\$386 million, and has grown at an annual average of 8 percent between 2009 and 2014, with most gains in marine shellfish (Government of United States, 2016c; National Marine Fisheries Service, 2016). Despite clear potential for significant increases in marine aquaculture production in the United States of America, government policies and public opinion have not been favourable. Knapp and Rubino (2016) present detailed arguments for using the tools of political economics to determine what actually influences these policies and perceptions, and how to change them to facilitate an expanded marine sector (see also Section 8).

2.1.2.1 *Finfish*

Although the aquaculture industry in the United States of America is still dominated by culture of the channel catfish (*Ictalurus punctatus*), the decline in its production noted in FAO (2011a) has continued over the past five years. By 2014, production had fallen to less than half of what it was in 2003 (FAO, 2016). The species is farmed mostly in the South, using spawning pond and hatchery-produced fingerlings reared in well-fed earthen ponds. The domestic market predominates, and continues to be impacted by lower-priced imports of farmed pangasid catfish from Asia. Other freshwater finfish farmed at significant levels include (in descending order of tonnage) trout, tilapia and striped bass. Production levels have remained roughly constant since 2010, continuing the pattern of the previous decade, with the most-produced species (trout) at 15 percent of channel catfish output in 2014 (Government of United States, 2016c; FAO, 2016a).

The remaining significant farmed finfish is a marine species, Atlantic salmon, farmed primarily in the state of Maine on the East coast, but also to a lesser extent in Washington State on the West coast. It has maintained roughly constant production since 2004, with a 20 percent drop reported in 2014 (FAO, 2016a). Total Atlantic salmon tonnage stayed below 3 percent of United States of America aquaculture production for the decade. Although its higher value compensates somewhat for lower output, Atlantic salmon value of US\$77 million was still eclipsed by both oysters (US\$136 million) and clams (US\$99 million) in 2012 (Government of United States, 2016c).

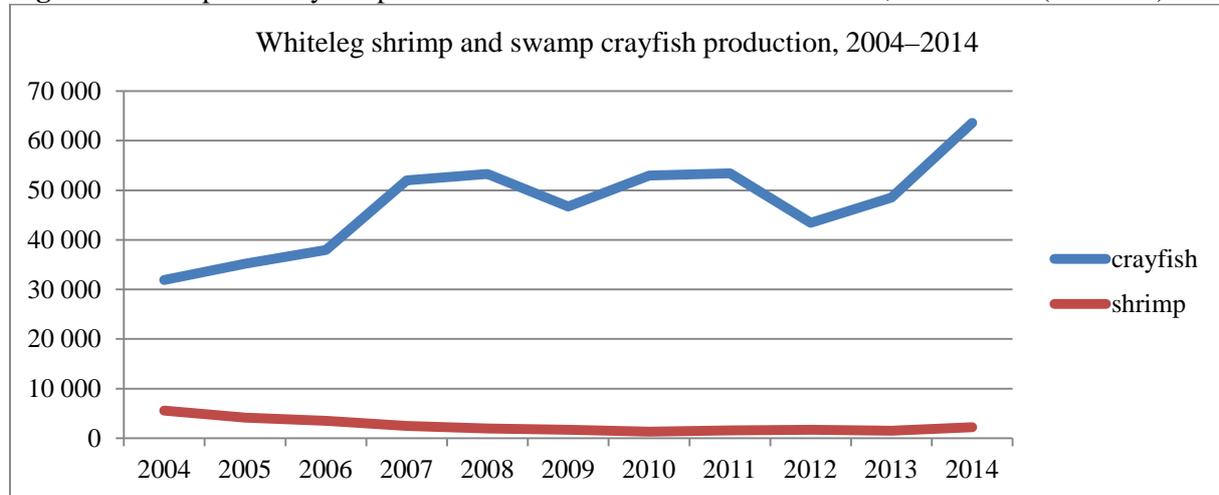
2.1.2.2 *Shellfish including crustaceans*

The bulk of production continues to be bivalve molluscs (oysters, clams, mussels) and crustaceans (shrimp, crawfish). Mollusc culture methods are similar to those used in Canada, although some of the species are different; oysters continue to dominate production, with mussels a distant third. Increases in mollusc production tonnage reported in FAO (2011a) have generally flattened in the last five years. The primary cultured oyster species are the same as in Canada, and similarly split between East coast and Gulf of Mexico (*Crassostrea virginica*; 93 697 tonnes in 2014) and West coast (*Crassostrea gigas*; 29 116 tonnes in 2014). While there is no consistent change in production tonnage since the period reported in FAO (2011a), government data suggest considerable fluctuation in value between

2009 and 2012. Clams included both the Manila clam (3 374 tonnes in 2014) and larger quantities of the hard clam *Merценaria mercenaria* (28 403 tonnes in 2014). Production of both species has remained fairly stable over the reporting period.

Three crustacean species continue to make up the bulk of United States of America production. Whiteleg shrimp, a marine species, is far overshadowed by the freshwater crayfish *Procambarus clarkia*; a second freshwater species, giant freshwater prawn *Macrobrachium rosenbergii*, is a distant third. Dominance of crayfish culture is clearly seen in Figure 4.

Figure 4. Shrimp and crayfish production in the United States of America, 2004–2014 (in tonnes)



Source: FAO (2016a).

The National Agricultural Statistics Service of the United States Department of Agriculture (USDA) census of United States of America aquaculture was updated in 2013. There is clear evidence of expansion of the sector, with the bulk of the increase being in shellfish production. Thus while total sales of aquaculture products in 2013 increased by 26 percent from 2005, the relative increase by finfish (9 percent) was much lower than those of crustaceans (59 percent) and molluscs (62 percent).

2.2 Important issues and success stories

North America's vanishingly small contribution to global aquaculture production leaves little doubt that there is plenty of opportunity for development of the industry. In this wealthy and privileged region, however, "development" is now generally acknowledged to mean "sustainable development." This shift in attitude is behind many of the issues facing the industry today. The major ones are listed below; some will be discussed more fully in later sections of this review. Most apply to the region as a whole, although not necessarily equally.

2.2.1 Issues

Public acceptance. The public demand for "social responsibility" in the siting and operation of aquaculture is most dramatically seen in farming of Atlantic salmon in floating netcages, especially in coastal British Columbia where Atlantic salmon is an introduced species. Spirited ENGO-led criticism of the industry continued during the reporting period, and focuses on environmental effects of the farms, human health effects, and governance related to foreshore rights. In general, industry is now well aware of the requirement of social license for expansion.

Environmental effects. Aquaculture operations can affect wild species (escapes, disease etc.) and their ecosystems (pollution, water withdrawal etc.). Such concerns comprise much of the platform for public resistance to aquaculture in North America.

Shortage of resources. The more densely populated United States of America faces correspondingly

more limitations on available coastal sites. Freshwater resources, especially in agricultural areas could also become in issue as groundwater and surface water becomes depleted (Section 3). Potential for offshore aquaculture will be discussed later in this review. Near-sea level areas are especially susceptible to flooding that will likely be exacerbated by climate change.

Filling market demand. Given the United States of America's size and population, its aquaculture industry is not well developed. The preponderance of freshwater, low value species contributes to a net trade deficit in seafood; high local costs, lack of space and a weak aquaculture lobby mitigate against expansion. Knapp and Rubino (2016) offer specific prescriptions for changing policies and perceptions so as to unlock the country's potential for expanded marine aquaculture.

Competition. Higher North American production costs mean that if the same species can be grown cheaper somewhere else, it will; acceptable "replacement" species can also displace a home-grown product. The decline of channel catfish culture in the United States of America illustrates both scenarios.

Lack of diversification. Canada's aquaculture industry is much less diversified than that in the United States of America, leaning heavily on Atlantic salmon produced for the United States of America's market. So far, the economic argument for diversification in Canada is not strong. Diversification in the United States of America features more species but they are grown at relatively low levels and cannot make up for the country's reliance on relatively low-priced freshwater species. Diversification into more marine species, especially produced offshore, is one option (see also Section 3).

Disease. In the specific case of salmon farming, sea lice infestations continue to pose a significant challenge to the industry (as they do in Europe as well). Concern continues over the potential for recurrences of infectious salmon anaemia outbreaks in farms on the East coast, and its possible appearance on the West coast.

2.2.2 Success stories

Farmed salmon export and certification. Atlantic salmon farmed in British Columbia are more and more being exported to Asia, with major and growing markets in Japan and China (now second only to the United States of America). While this export story is a success, a more interesting one is the case of Creative Salmon, a small Canadian niche grower of native Pacific, not introduced Atlantic, salmon. Creative Salmon has been developing its export market for several decades, and has confronted the challenge of "local social license" by securing organic seafood certification in 2012, the first salmon farming company to do so in North America. This success story touches on most of the issues described above.

2.3 The way forward

North American aquaculture presents a paradoxical picture of opportunity to play a much larger global role constrained by an unusually high level of local disapproval. To go forward, all players in the industry, especially those with head offices outside the continent, need to avoid the fatal errors of underestimating their critics. They must evaluate their critics' claims, respond to those they can demonstrate are unfounded and modify operations in response to those that are well-documented. Industry in North America has many technical options, including RAS systems, multitrophic systems, and significant changes in husbandry. Aquaculture's lack of social license in North America can also be partially remedied by industry's engaging more with partners and stakeholders (this includes communication with the public as well as increasing its lobbying power). Market-related issues of competition and risk-management will benefit from selective and strategic diversification at the species and system levels.

3. RESOURCES, SERVICES AND TECHNOLOGIES

3.1 Status and trends

The focus of this section is on the *needs* of the industry in North America, how they are being met and how they can be met in the future. We are less concerned here with the *effects* of aquaculture or the *external pressures* on the resources; these important topics are dealt with in more depth in Sections 4 and 7. The present chapter takes as its starting point the comprehensive analysis provided in FAO (2011a). Status and trends in access to capital and insurance coverage have not changed significantly since 2010 and are not treated in the present review, which concentrates on technical developments between 2010 and 2015.

3.1.1 Land and water

Access to freshwater, saltwater and associated foreshores continue to be challenges shared by Canada and the United States of America, compounded by major differences in coastline (much longer in Canada), freshwater availability (more lakes and rivers in Canada) and population pressure (coastal development is more extensive in the United States of America). The inescapable conclusion is that the United States aquaculture sector faces more resource challenges than does the industry in Canada. Dominance of freshwater aquaculture in the United States of America (Section 2) may put pressure on the country's comparatively smaller freshwater resources in some areas, but a shift to preferential expansion of marine aquaculture comes up against limited coastal access. This dilemma is unlikely to be solved without major changes in the way marine organisms are farmed.

Even if marine coastline appears to be “available” (that is, currently unoccupied) and satisfies the physical and geographic requirements for finfish or shellfish farming, recent research on the ecosystem impacts of farming has made siting decisions much more complicated. Examples can be found for both sectors in British Columbia, and are relevant to the continent as a whole. In the case of salmon farm siting, public concern about the amplification of sea lice in salmon net cages and their transfer to nearby wild salmon stocks – an issue of major concern in European salmon farming too – prompted a burst of publicly funded research and was a key element in national hearings on declines in wild Pacific salmon. The recommendations (Government of Canada, 2016i) included revising farm siting criteria to reduce contact between farmed and wild salmon. Shellfish aquaculture siting is also under recent scrutiny in British Columbia. Like salmon farming, shellfish farming tends to be concentrated in just a few highly suitable areas. One of these has been the focus of sustained public criticism in recent years, over issues ranging from predator nets on beaches to “unsightly” facilities to carrying capacity.

The spatial limitations on coastal marine aquaculture in North America have meant that suitable sites for salmon and shellfish farming were “colonized” early in the history of the industry. The concept of farmer clusters mentioned in FAO (2011a) and described in Kassam, Subasinghe and Phillips (2011) were developed primarily for small-scale farming in developing countries. They may have some relevance to the opening of new offshore territory to marine farming, in the sense of promoting best management practices (BMP) that are spatially specific and foster an ecosystem approach to aquaculture (FAO and World Bank, 2015). Some North American coastal locations have arrived independently at an informal clustered structure complete with its own regional organization for communication and the setting of BMPs; examples can be found in favoured shellfish-growing areas on the Atlantic and Pacific coasts.

An example from the United States of America highlights availability of freshwater. Compared to agriculture, aquaculture is a very small user of water; for both users, surface water use exceeds groundwater use. Irrigation water use has been flat since 1990, and even declined in 2010; the proportion of groundwater extraction is, however, increasing (Government of United States of

America, 2016d). The seriousness of groundwater limitations can be illustrated by the fact that, in 2016, 30 percent of all water used in American agriculture came from a single aquifer (the Ogallala), now seriously depleted.

3.1.2 Seed

The term “seed”, in aquaculture, refers loosely to the early life stage that is used for growout to harvest size on a farm. The stage of development depends on the culture system; for many species, seed will already have gone through a “nursery” stage before being placed in the final growout surroundings (in shellfish culture, the nursery stage is also referred to as “setting”). For the vast majority of species farmed in North America, seed is obtained from hatcheries, many of which are vertically integrated with growout operations. The United States of America is a key global supplier of specific pathogen free (SPF) shrimp broodstock.

Hatcheries, especially for shellfish, are complex and expensive. For relatively new species or those grown in small quantities, seed supply can still be limiting. This is the case for scallops grown in British Columbia, where there is only one locally owned hatchery.

Reliance on wild seed is limited to new species under development, and in most cases will be aimed at creating a proprietary captive broodstock program. Broodstock programs that rely on access to wild genetic resources (and all such programs inevitably do) face an increasing regulatory challenge in collecting from the wild. This trend is a continuation of concerns about access and benefit sharing from wild genetic resources (Greer and Harvey, 2004). Industries with partnerships with local and indigenous communities will have an advantage in improving broodstock programs in this way.

Although seed production is now sophisticated, supply can be compromised. An example is the inability of United States of America hatcheries to fulfil their orders of oyster seed from British Columbia farmers because of production problems related to ocean acidification in 2014; a large hatchery in Chile had to be contracted instead (Dodd, 2015). Acidification as a result of climate change is a growing risk to oyster farms and will be discussed in Section 4.

3.1.3 Biotechnology

The triploid oyster and mussel seed noted in FAO (2011a) continue to make up a large proportion of the seed used for growout. Shellfish triploidy technology stems from the 1990s. More current biotechnological developments with relevance to aquaculture over the last five years centre on the use of molecular genetics in development of finfish broodstocks, on analysis of interactions between farmed and wild stocks of the same species, and on development of transgenic finfish lines.

Creating or refining broodstocks is being revolutionized by the ability to locate genetic markers for desirable traits like growth and disease resistance. The tools of genomics are now allowing managers to trace the progeny of broodstock to determine how well breeding strategies have worked. The same DNA technology allows farms to monitor any breeding-related genetic diversity loss in aquaculture strains and can also be used to distinguish wild from cultured salmon found in the same waterway or to demonstrate or disprove interbreeding (“genetic pollution”) (Government of Canada, 2016j).

In an update to the discussion of aquatic animal health trends in FAO (2011a), new molecular diagnostic tools are now being applied to identification of disease agents in very high sample numbers as well as to identify distribution patterns of disease agents in hatchery, farmed and wild fish (Genome British Columbia, 2016). A recently developed microarray has also been used to look at impacts of pathogen carrier status (sea lice and IHNV) on wild salmon (Miller *et al.*, 2011).

The transgenic AquaAdvantage™ Atlantic salmon has been under regulatory review by the United States Food and Drug Administration (FDA) for more than a decade. Approval was finally granted in November, 2015 in the United States of America and for commercial sale in Canada by Health

Canada in May, 2016. The company is currently establishing a production facility in Prince Edward Island, on Canada's East coast. The extraordinarily long time to achieve approval underlines the strong societal resistance to "genetically modified foods" in North America, and it remains to be seen in which market the product will succeed.

3.1.4 Feed

The main market for feeds in North America is for finfish. As the largest annual cost associated with culture, feed is a critical area where innovation can bring big dividends. Imports are negligible except for a small amount of specialty feeds imported from Europe. Salmon feeds are manufactured locally or imported; channel catfish feeds are produced in the United States of America.

Reliance on fish meal and fish oil from so-called "forage" fish species such as anchovy is not only vulnerable to declines in meal-fish populations but also viewed as unacceptable in an industry that, in North America at least, badly needs to improve its image. Recent developments have focused on using less fishmeal in feed products, and aquaculture companies are careful to promote advances on this front. The ratio of wild fish input to total farmed fish output fell by more than one-third between 1995 and 2007 (FAO, 2011a). The "fish in: fish out" ratio varies depending on where the target animal is on the food chain, and its calculation remains a matter of scientific debate (Byelashov and Griffin, 2014). The overall ratio of fish harvested for fish meal and fish oil production to quantities of farm-raised fish and shrimp decreased from 0.7 in 2003 to 0.3 in 2012 (FAO, 2014). Restricting fishmeal and oil to diets used for broodstock, larval and final-stage feeding can reduce the ratio, as can replacement of forage fish sources with trimming wastes, plant or even microbial or algal sources. The coming decade will show whether gains for forage fish populations are environmentally offset by losses related to land-based farming of replacement plants like soy and canola (Fry *et al.*, 2016).

3.1.5 Culture technologies

Culture technologies for growing finfish and shellfish in North America are summarized in FAO (2011a). They comprise a variety of freshwater and saltwater hatchery and nursery systems, as well as growout systems including marine and freshwater net pens or cages, ponds, raceways and recirculating systems (RAS) for land-based aquaculture, and rafts, longlines and associated suspension systems for deepwater shellfish culture. The most significant advances in the last five years are in land-based RAS systems, integrated multitrophic aquaculture (IMTA) and offshore cage systems. All relate to the need to produce finfish in the face of reduced coastal availability and public criticism of the environmental impacts of single-species coastal net cage systems (see Sections 2 and 4).

While RAS systems are already well established in inland farming of rainbow trout, the vastly larger Atlantic salmon farming industry has become a much higher-profile candidate for using RAS as a way to eliminate some of the environmental effects of coastal cage culture (Cross, Flaherty and Byrne, 2016). The much higher startup costs, as well as concerns about the carbon footprint of energy used by recirculating systems mean that RAS adoption by the industry is still uncertain. Integrated multitrophic aquaculture (IMTA) is another alternative to single-species coastal cage culture. It seems destined to find its place not in competition with large-scale operations farming Atlantic salmon but as an environmentally friendly provider of higher priced, niche market species.

Offshore culture systems are also in the early stages of development, primarily in the United States of America, where ocean temperatures in the Gulf of Mexico are higher and where coastal tenures are generally harder to acquire or expand. Projects are in development in California and Hawaii; an ambitious strategy for the Gulf of Mexico is described below. Lovatelli, Aguilar-Manjarrez and Soto (2013) report on the technical, environmental, spatial and governance challenges to expansion of offshore aquaculture worldwide, and provide specific discussion of North American cases including offshore mussel culture and a commercial offshore finfish farm in Hawaii. Spatial considerations are

specifically addressed by Kapetsky, Aguilar-Manjarrez and Jenness (2013), again from a global perspective but including numerous examples from North America.

3.2 Issues and success stories

3.2.1 Issues

Finfish and shellfish farm siting. Salmon farm siting is a larger issue in Canada than in the United States of America, but the industry in both countries faces criticism about pollution and ecosystem effects. Impacts on wild salmon from sea lice infestations remain the single largest factor affecting siting decisions in Canada. Fisheries and Oceans Canada (DFO) has now limited salmon farming operations in one affected area until 2020, and siting of all aquaculture operations in British Columbia is now shared between the federal and provincial governments, a regulatory change that industry have had to come to grips with. In the United States of America, increase in the number of droughts will mean aquaculture is competing for an increasingly scarce resource; siting of freshwater farms will become more of an issue. Conflict over shellfish farm siting in North America is at least partially being addressed by research on aquatic carrying capacity and by conflict resolution.

Ocean acidification and shellfish seed supply. Shellfish hatcheries' susceptibility to ocean acidification means that the current model in which large independent facilities supply many small to medium-sized companies is increasingly risky. One option is smaller, floating upwelling systems (FLUPSYS) located directly on farming tenures, thereby spreading out operational risks.

Reliance on forage fish in feeds. Reducing the “fish in: fish out” ratio has become a reliable strategy for deflecting public criticism of industries that farm high food-chain finfish. It is, however, a technically complex issue. The eventual “acceptable” ratio is going to depend both on profitability and on an accounting of gains and losses not only to the farmed fish but also to the ecosystems where forage fish are sourced and where replacement oils are produced.

Alternative growout systems. All of the major proposed “solutions” for netcage system problems are still in the early stages of proof of concept. That the trials of RAS culture, IMTA and offshore technologies are taking place at all is a measure of the seriousness of the problems facing traditional netcage operations, as well as willingness of the industry to contemplate major changes. These innovative approaches may in fact represent a new industry sector, and will continue to rely on government or donor-funded demonstration projects before attracting commercial investment.

3.2.2 Success stories

Kuterra Salmon³ is a land-based salmon farm owned by the Namgis First Nation in British Columbia and seed-funded through grants and donations. Harvest began in 2013; a small amount is presently marketed although the company is not profitable. Its success lies in proof of concept: the operation has great importance for generating data on costs and benefits of land-based farming and is being closely watched by industry, government, academia and consumers. Its experience will undoubtedly be compared to previous industry trials with RAS systems in British Columbia (RIAS, 2015).

Integrated multi-trophic aquaculture is currently represented by a single licensed operation in North America. The company co-produces sablefish, scallops, Native cockle, green urchins, sea cucumbers, and sugar kelp. It has adopted the National Certified Organic Standards for aquaculture; alternative energy components reduce its overall carbon footprint (Cross, 2012). As with Kuterra Salmon, the “success” of North American IMTA operations lies in their contribution to proof of concept for a new technology.

In a recent policy decision, NOAA's Fishery Management Plan for Aquaculture in Federal Waters of the Gulf of Mexico allows for large-scale fish farming in offshore waters and authorizes the agency to

³ www.kuterra.com

issue permits for 10 years for growing native, non-genetically modified and non-transgenic species (NOAA, 2016). The judicial reaction of opponents including commercial fishers and conservation groups (Centre for Food Safety, 2016) suggests that this initiative can be considered a “success story” only insofar as it has advanced the discussion on offshore siting and governance.

3.3 The way forward

The picture of aquaculture in North America as a relatively undiversified and undeveloped industry has begun to change within the last decade as a result of criticism on environmental grounds, as a consequence of geographic restrictions, and in response to opportunities in domestic and international markets. The last five years have seen notable increases in diversification not only in terms of culture systems and feed options, but also of species and products. New species like sablefish, geoduck clam and sea cucumber will be more expensive to produce but will target niche markets, while larger markets (like those for salmon) will demand more and more diversified offerings such as organically certified products and “table-ready” packaging. A nimble industry will put canola-fed, land-farmed salmon in the supermarket; a stumbling one will see its domestically consumed catfish displaced by a competing species farmed in Asia.

4. AQUACULTURE AND ENVIRONMENTAL INTEGRITY

4.1 Status and trends

This section of the review is confined to the effects that aquaculture can have on the environment. These effects can be local or wide ranging. The fact that, in North America, aquaculture is a relatively young industry that is perceived as gradually displacing historic fishing means that criticism of aquaculture on environmental grounds is unlikely to be free of a longing for things to be “the way they were.” In considering aquaculture in North America it is in fact impossible to discuss its various sectors, its socioeconomic backdrop or its need for resources – in other words, the topics of the preceding three sections of this review – without returning constantly to the theme of aquaculture’s “image.” That image is more significant for marine than for freshwater operations.

In North America, marine aquaculture is often seen as the displacer of much-loved traditional fisheries; a familiar claim is that farming has actually caused the steady decline in many wild salmon stocks over recent decades. This is a serious charge casually levelled, and the complex life history of salmon means that evidence for or against it is notoriously difficult to obtain. Farming is also viewed as the despoiler of the environment. There are powerful lobbies on both sides.

FAO (2011a) presented a strong argument for the great strides made by the industry in reducing or eliminating its effects on the environment, and in improving its image regarding “user conflicts” such as the one between commercial fishers and fish farmers. Many of these advances have significantly improved the environmental performance of an industry whose early years featured a scramble for dominance, rapid local expansion and a number of practices, such as heavy antibiotic use, that have since been essentially eliminated by changes in husbandry and by the development of vaccines. The strategies and advances reported in FAO (2011a) remain valid, and include better drug use protocols, more consultation with stakeholders, better systems for reporting and preventing escapes and stringent regulations for introductions and transfers of alien species. User conflicts with commercial fishing are unlikely ever to be completely eliminated, but are less disruptive than a decade ago as better understanding of wild population fluctuations makes it less likely that aquaculture can be considered the main culprit in declines in wild stocks.

The fact remains, however, that a significant proportion of West coast North American aquaculture produces a single, introduced species, Atlantic salmon. To characterize aquaculture’s effects on the environment as “minimal” may thus be reasonable in comparison with other resource-based activities such as oil and gas extraction or forestry, but it does not remove the industry’s need to manage its

environmental image in North America. In North America, aquaculture's critics are not always right, but they are not always wrong. The key environmental effects of aquaculture in North America have already been noted in Sections 1–3 of this report. Those that continue to demand responses from industry and other stakeholders are presented below.

4.2 Issues and success stories

4.2.1 Issues

Sea lice and their control. Sea lice are a problem only for traditional floating salmon farms, but the dominance of the salmon farming industry in North America means the problem is significant. In Norway, a global leader in salmon farming, sea lice remain the foremost technical challenge for the industry. Sea lice is also the only major environmental effect of aquaculture that is also a major cause of financial losses for the companies (the lice debilitate or kill inventory). Reducing the impacts of sea lice therefore has both financial and environmental rewards. Sea lice, whose origin is wild salmon and other species of fish, can be amplified in net pens and released to the environment where they are able to colonize young migratory salmon. Routes of transmission are ecologically and geographically complex and very challenging to study. Despite nearly a decade of management by industry and government, sea lice remain a lightning rod for environmental criticism of salmon farming.

Transmission of diseases from farmed to wild salmon. Bacterial and viral diseases can be amplified in salmon cages and transferred to wild fish, especially at times of migration of juvenile and adult salmon. The issue tends to be controversial, with much resting on the interpretation of screening and identification methods. New technologies for characterization of vectors keep the issue a prominent one for opponents of salmon farms.

Forage fish byproducts in fish feed. This issue remains applicable to all finfish farmed in North America. As noted in Section 2, replacement of forage fish meal and oil with nutrients from plant, algal or bacterial sources will reduce aquaculture's impact on forage fish but needs to be taken in the context of the overall ecological footprint.

Genetically modified organisms (GMOs). In one of the inconsistencies in the environmental criticism of aquaculture, release of triploid oysters and mussels into the environment, and their consumption, have never become issues. The mainstay of oyster culture on the Pacific coast is itself an introduced species, as is the Manila clam; neither have ever occasioned environmental criticism. The genetically modified AquaAdvantage salmon, now cleared for production and sale in Canada and the United States of America, can be expected to meet strenuous market resistance in North America and Europe, based partly on concerns about its escape to the wild, as well as on perceived human health effects.

Offshore farming. The impetus toward offshore net cage farming in North America is both an environmental one and an attempt to fulfil the potential to produce high value marine species in the United States of America. A second rationale, that offshore farms will remove the need to locate net cages and farm services on already-crowded foreshores, has also been advanced. A complicated approvals process has limited progress to a few experimental enclosures. Criticism has taken the form of comparison with coastal net cages as generators of seafloor pollution. A more complicated objection, based on the risk of escapes of the native species that will be farmed, is essentially a concern about dilution of wild genetic resources. Answers to such questions will depend on considerable research into the life history and population genetics of each species; there is unlikely to be a blanket response that applies to all species.

4.2.2 Success story

Finfish aquaculture licenses in British Columbia now contain a requirement for regular monitoring of sea lice infestation levels in all enclosures, in addition to periodic government audits. Monitoring began in 2003 and took its present form in 2010, when the federal government took over

responsibility for aquaculture management from the government of British Columbia. The monitoring program contains a threshold in the average number of sea lice, beyond which treatment is mandatory. Treatment usually involves a biocidal feed additive, currently supplemented, in some farms, with hydrogen peroxide. Sea lice numbers were acceptably low between 2005 and 2015, when a spike reopened the debate over the relative importance of unusually high water temperatures (“natural cause”) vs the ineffective treatment of farmed fish (“salmon farm mismanagement”).

4.3 The way forward

Aquaculture in North America is not limited by access to technologies or investment. Resources currently have some limiting effect in the United States of America, but alternative technologies, including RAS and offshore farms offer solutions. The more important barrier remains the same as was described in FAO (2011a), namely public discomfort with marine finfish aquaculture. How much of this discomfort is legitimate is debatable but the solution remains the same: the industry needs not only to reduce its environmental impact on a technical level but also to continue to engage with its critics, invest heavily in programs that educate the public about its operations, and contribute even more to research partnerships.

5. MARKETS AND TRADE

5.1 Status and trends

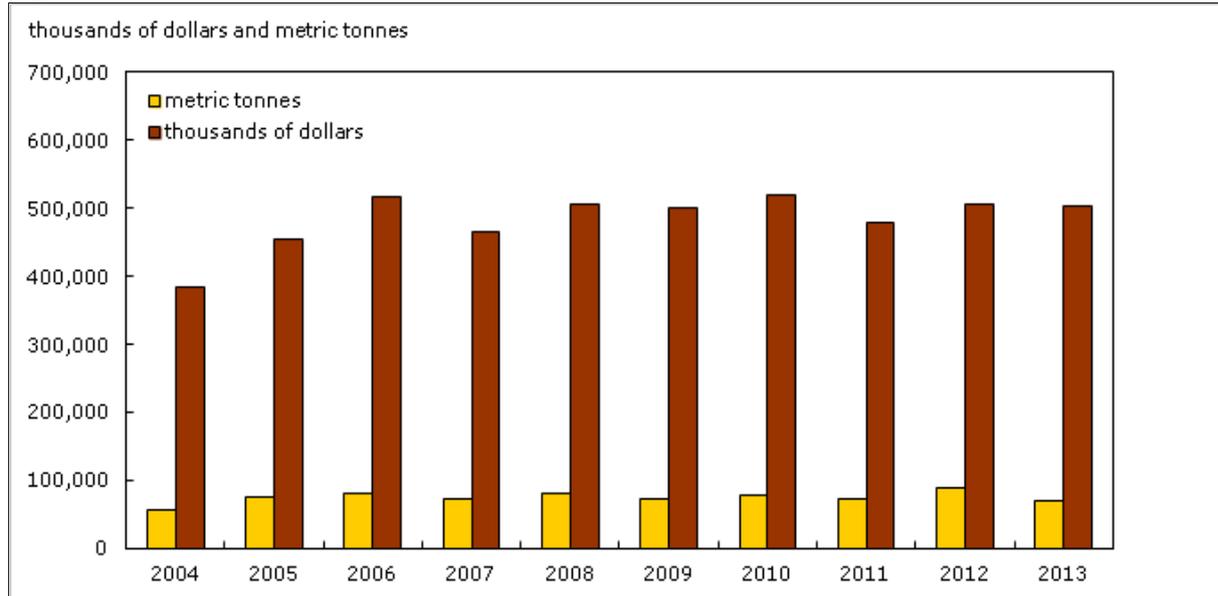
5.1.1 St. Pierre and Miquelon

Mussels represent 20 percent of total 2014 exports from St. Pierre and Miquelon, making them the top export item. It is not clear what percentage of that export is farmed. Total seafood imports are much smaller (Observatory of Economic Complexity, 2016).

5.1.2 Atlantic salmon and channel catfish: a study in national contrasts

Aquaculture accounts for about a third of Canada’s total fisheries value and about 20 percent of total seafood production. The value of aquaculture production has increased by 63 percent over the last ten years, to CAD\$ 962 million in 2013. Eighty percent of British Columbia farmed salmon is exported, and farmed salmon remains Canada’s largest aquaculture export, with the bulk (over 90 percent) going to the United States of America. The total amounts exported, and their values, did not change significantly between 2006 and 2013 (Figure 5). However, exports of farmed salmon products to the United States of America dropped significantly in 2014, from roughly CAD\$473 million in 2013 to CAD\$364 million (Government of Canada, 2016k). Canada remains the largest supplier of shellfish to the United States of America.

The picture for the dominant cultured finfish in the United States of America – channel catfish – is markedly different from that of Atlantic salmon in Canada. Channel catfish farmed in the United States of America is consumed almost exclusively domestically; less than 1 percent is exported. Yet the ratio of imported catfish sales to domestically produced catfish sales has changed dramatically since the period reported in FAO (2011a). The United States of America’s share of all species of farmed catfish sold in its own country has fallen from 80 percent in 2005 through 42 percent in 2010 to 20 percent in 2014 (Hanson and Sites, 2015). The “trade war” in catfish between the United States of America and Asian producers, who are mainly providing alternative species to the one produced in the United States of America, has been well documented (Duc, 2010). Steering customers toward a “buy local” attitude may provide some relief.

Figure 5. Total Canadian exports of farmed Atlantic salmon, 2004–2013

Source: Statistics Canada, International Accounts and Trade Division.

5.1.3 Development of new markets

Taken together, the above snapshot comparisons of the salmon and catfish markets in North America, and the clearly abundant opportunities for aquaculture expansion in North America strongly suggest that the two countries need not only to look for additional export markets, but also to consider carefully how to diversify their own industries in order to respond to market demand. Diversification could include addition of new technologies to grow existing or new species and strains.

The United States of America is now the leading global importer of fish and fisheries products (Government of the United States, 2016e). Its seafood trade imbalance is well known. In contrast, Canada has a trade surplus in aquaculture products which continues to slowly increase (Table 3).

Table 3. Canadian balance of trade in aquaculture products all countries (thousand CAD\$)

	2011	2012	2013	2014	2015
Total exports	500 290	561 674	544 374	445 885	699 838
Total imports	63 854	87 653	113 808	118 805	97 290
Trade balance	436 436	474 020	430 567	327 080	602 548

Source: Statistics Canada and United States Census Bureau.

Yet much of the trade in aquaculture products in North America is between the two North American countries themselves. The North American Free Trade Agreement (NAFTA) encourages this continental exchange, although its status may change following the presidential election in the United States of America in November, 2016. Free trade agreements with other potential purchasers could go some distance to changing the inward-looking character of present North American consumption and trade in aquaculture products. The two most likely candidates are the Comprehensive Economic and Trade Agreement (CETA), between Canada and the European Union, and the Trans-Pacific Partnership (TPP), which would include Canada, the United States of America, Japan and nine other Pacific Rim countries. As of this writing, CETA was formally signed by Canada, the European Commission and the European Council in November 2016. The fate of the TPP has become difficult to predict following the presidential election in the United States of America in November, 2016.

5.1.4 Certification, sustainability and consumer preference

A distinction needs to be made between official organic certification and “sustainability.” Both concepts are increasingly important to consumers not only in North America but also in Europe and, increasingly, in parts of Asia and Latin America. The lone example of organic branding of farmed salmon in North America has been provided in Section 2. There are, however, many certification schemes for sustainability, ranging from rigorous third-party rules to “seals of approval” promoted by NGOs, seafood wholesalers and seafood retailers. It is not clear which carries more weight with consumers; organic certification implies a health benefit, while sustainability implies a concern for the environment. Growing consumer demand for healthy, sustainable seafood (FAO, 2011a) suggests that some kind of assurance will be a key component of any marketing strategy for aquaculture. To date, sustainability branding remains the clear leader as a domestic and export marketing tool.

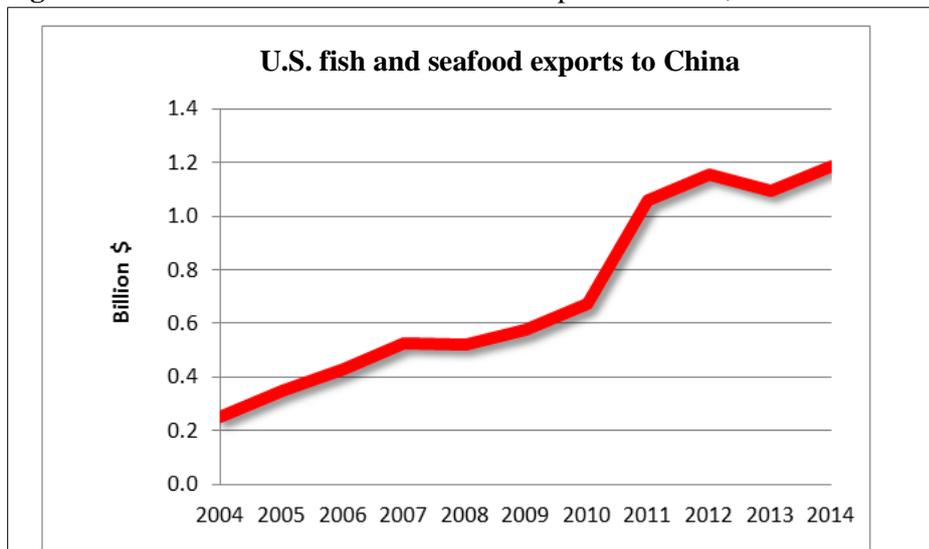
5.2 Issues and success stories

5.2.1 Issues

Neither the CETA nor the proposed TPP trade agreements include China, arguably the largest potential trading partner for many goods, including aquaculture products. For Canada, a bilateral free trade agreement with China remains a subject for preliminary discussion. In the meantime, exports of aquaculture products to China have tripled between 2011 and 2015 and now exceed Canada’s aquaculture exports to Japan (Government of Canada, 2016l). In the case of the United States of America, government seafood trade statistics (which include aquaculture) show not only that the United States of America has a large seafood trade deficit, but also provide food for thought on the direction a “correction” in that trade imbalance might come from. Recent seafood export statistics point strongly to China as a key trading partner. United States of America fish and seafood exports to China have increased 370 percent over the last decade and are expected to soon surpass exports to the European Union (Figure 6; Government of the United States, 2016f). Whether such increased exports could be part of a bilateral trade agreement with China has become more difficult to predict in view of the United States of America presidential election results of November 2016.

Tellingly for aquaculture, the current increase in seafood exports to China is mainly in high-value wild caught product (lobster, Pacific salmon, crab). If aquaculture is to contribute to rising seafood sales in China, it will likely need to provide products that are not farmed in China. Diversification of North American aquaculture, including offshore production of high-end species will become important.

Figure 6. United States of America seafood exports to China, 2004–2014



Source: FAS Global Agricultural Trade System.

5.2.2 Success stories

In the United States of America, the United States Department of Agriculture (USDA) has been developing certification standards for aquaculture for several years. The Canadian General Standards Board's National Standard of Canada for Organic Aquaculture came into force in 2012 (Government of Canada, 2016m). Several products have so far received organic certification, including the farmed Pacific salmon produced in conventional sea cages on Vancouver Island noted in Section 2.3.2, as well as a net cage sablefish farm, a producer of caviar from land-based farmed sturgeon, and a feed company. In keeping with North American market trends, all of the certified aquaculture products in Canada are intended for high-end niche markets. The experience of applying organic standards to aquaculture products in Canada has added North America to the relatively few regions that have embraced what is, after all, a challenging adaptation of agricultural standards to a radically different (and, in North America, relatively new) industry. For consumers who are critical of aquaculture, the fact that organic standards even exist sends an important positive message that could translate into better acceptance of the industry and its products.

5.3 The way forward

The channel catfish aquaculture industry in the United States of America is a major part of the country's production but the product is mainly domestically consumed. Its vulnerability to competition from farmed Asian catfish contains a lesson that Canada must also consider. Both countries have relatively diverse shellfish sectors, but both concentrate their finfish efforts on a single species. Finding new domestic and international markets is part of the answer; the other part is diversification, which in North America will have its own specific characteristics (Cross, Flaherty and Byrne, 2016). The global middle class is growing, and it wants a variety of healthy, higher-end fish presented in a variety of product types.

6. CONTRIBUTION OF AQUACULTURE TO FOOD SECURITY, SOCIAL AND ECONOMIC DEVELOPMENT

6.1 Status and trends

6.1.1 Food security

As in most wealthy developed countries, the relatively high average incomes and living standards in Canada and the United States of America obscure significant disparities. Both countries contain sectors where poverty is endemic. Some of these sectors are geographically defined; others, including aboriginal communities, may be distinguished by race.

For the middle class in North America, food security is not an issue. Aquaculture can however contribute to social and economic development by providing jobs at several levels, as described in FAO (2011a). For poor and disadvantaged North Americans, aquaculture can have a significant impact as a provider of jobs, especially in communities located close to aquaculture operations. A contribution to food security for the poor in North America is technically possible, but the trend toward expansion into new markets, especially with higher-end products, suggests that this contribution will be small.

Some indirect food security benefits can, however, flow from industrial-scale culture of high-end finfish in North America. The argument is frequently made that salmon farming reduces fishing pressure on depleted wild salmon stocks, which have long been dietary and cultural mainstays for coastal aboriginal communities. In North America, management of Pacific salmon harvest is a contentious balancing of allocations between commercial fisheries (which include aboriginal participants) conservation allowances and aboriginal non-commercial harvest. If aquaculture indirectly the latter, food security will increase for aboriginal communities.

6.1.2 *Aquaculture as an employer*

In Canada, the latest figures available for aquaculture employment are for 2010. At that time, the industry “provided” approximately 14 000 jobs, 95 percent per cent of them in rural or coastal areas. Of the total 14,000 jobs, employment on farms, in hatcheries and processing plants accounted for around 5 800 jobs; goods and services industries accounted for 5 600, while the remaining 2 600 jobs were in other retail businesses (Government of Canada, 2016n). There is no significant trend in salaries and wages paid by the aquaculture industry in Canada between 2010 and 2014 (Government of Canada, 2016o). Even in aquaculture-heavy Maritime Provinces, aquaculture employment is strongly regionalized and has virtually no presence in urban centres.

It is difficult to draw comparisons between overall aquaculture employment in Canada and the United States of America because aquaculture is not isolated from other kinds of animal husbandry in the American national occupational census. The World Aquaculture Society (an American professional organization) cites Bureau of Labour Statistics indicating job numbers remarkably similar to those quoted above for Canada (that is, just under 6 000 direct jobs), with a slight increase between 2012 and 2014 (World Aquaculture Society, 2016). By any measure, these are very low numbers of jobs, from which a significant contribution to the national economy cannot be expected. On a tightly defined regional scale, however, 6 000 jobs shared by only a few coastal communities represents an important contribution. An excellent example is afforded by aboriginal communities.

6.1.3 *Participation of aboriginal communities in aquaculture*

The federally funded Aboriginal Aquaculture in Canada Initiative (AACI) supports aboriginal economic development in Canada’s aquaculture sector through three indigenous aquaculture business associations. The greatest potential for aboriginal participation may be found in British Columbia, where there are already many well-established aboriginal finfish and shellfish operations. National aquaculture growth over the next decade is expected to offer significant opportunities to First Nations through investment, joint ventures or partnerships. For British Columbia, one estimate projects creation of nearly 3 500 new jobs for aboriginal people over the next decade (RIAS, 2015).

While there have been notable successes in aboriginal aquaculture ventures involving Atlantic salmon and shellfish, there have also been failures. One lesson learned is that having the biological and physical resources for aquaculture does not in itself guarantee success; social, cultural, technological and educational resources also have to be taken into account. Aquaculture business associations are a step in the right direction in reducing the risk of aboriginal ventures in the industry (RIAS, 2015) and promoting participation in new ventures, including those involving diversification into newer, in-demand species like sablefish, sturgeon and geoduck clam.

6.2 *Issues and success stories*

6.2.1 *Issues*

The long-running salmon farming joint venture between Marine Harvest Corporation and the Kitsoo First Nation (FAO, 2011a) is a good example of aboriginal support for aquaculture but such cooperation should not be assumed to be universal. In British Columbia, many coastal First Nations remain strongly opposed to aquaculture, primarily because of environmental effects of net cage operations. As a result, some First Nations remain on the sidelines, some are comfortable benefitting from employment but do not participate as owners, while others, like the N’amgis First Nation responsible for the RAS system for Atlantic salmon noted in Section 3, have opted for alternative technologies. North American aboriginal communities are not a bloc with respect to aquaculture; their participation will continue to represent individual community decisions.

For coastal aquaculture in North America, land rights affect aquaculture tenures. When coastal areas desirable for finfish or shellfish aquaculture have been identified as traditional aboriginal territory,

and especially when that territory is still subject to legal definition, planning of aquaculture operations has to reflect a complex and fluid situation. This issue is returned to in Section 8.

6.2.2 Success stories

Pentlatch Seafoods is a British Columbia shellfish harvesting company wholly owned by the K'ómoks First Nation. The company has worldwide oyster sales in markets that include Taiwan Province of China, China, and the United States of America. Pentlatch also has clam revenues of over CAD\$1.1 million. The company provides more than 20 fulltime jobs. The First Nation purchased a processing plant in 2013; now known as Salish Sea Foods LP, the plant increased sales to CAD\$3.2 million in its first year of operation. The First Nation has also created Salish Sea Farms LP to cultivate geoduck clam and expand into salmon aquaculture (RIAS, 2015).

6.3 The way forward

Aquaculture can have a significant economic impact in North America through creation of primary jobs (farm worker, processing, management), secondary employment (feed manufacture, equipment manufacture and service, insurance etc.) and the trickle-down effect of general purchasing power. This impact is not significant on a national scale, but can be very important regionally and especially at the community level. Developing the industry thus depends on careful planning at the local scale (for production, processing and transport) and at the international scale (because the products will be mostly for an export market). For non-aboriginal communities, the main benefit from aquaculture development will be economic.

In the case of aboriginal communities that depend on harvest of wild salmon for food security, aquaculture can play a role by reducing pressure on wild fisheries as well as rebuilding wild fisheries through hatchery rearing of young salmon for release to the wild. Aboriginal communities can therefore benefit both directly as producers (economic benefit) and indirectly as consumers (food security benefit).

7. EXTERNAL PRESSURES ON THE AQUACULTURE SECTOR

7.1 Status and trends

There are three main kinds of external pressures on the aquaculture sector in North America. Two of them –climate change and pollution events– act mainly on the natural and physical resources upon which aquaculture relies. These resources have already been mentioned in Section 3. The third category of external pressures is economic, and acts on the industry's ability to fund development and sell products. Economic issues related to aquaculture are discussed in Sections 2 and 5. None of the three kinds of external pressure is confined to aquaculture.

7.1.1 External pressures caused by climate change

The main impacts of climate change on aquaculture have been described in FAO (2011a); a good general reference is Pullin and White (FAO, 2011b). Impacts include changing water temperatures, sea level rise, increase in number and severity of coastal storms, ocean acidification and water quality effects including groundwater salinity.

The direct and indirect effects of higher water temperatures on aquaculture have been well summarized in FAO (2011a). For 2010–2015 and beyond, it is worth noting that planning for offshore aquaculture in the United States of America will need to take rising ocean surface temperatures into account in identifying offshore sites with temperature and circulation patterns that are optimal for each species. Also not covered in FAO (2011a) was the effect of changing ocean conditions on supply of fish meal and fish oil for feeds.

Increase in number and severity of coastal storms may be most acutely felt by shellfish aquaculture operations in the Gulf of Mexico, including the states of Alabama, Louisiana, Mississippi, Texas, and Florida. Coastal populations and ecosystems in the Gulf are also threatened by sea level rise. Storms can affect aquaculture through destruction of infrastructure and sediment deposit. Changes in water quality are also likely to affect seed supply, always a vulnerable link in shellfish farming. As sea level rises, coastal land is lost and eroded, which can also affect freshwater ponds through simple loss of land or through salinization of groundwater.

Ocean acidification has become a more pressing problem for shellfish farms in 2010–2015. The threat is so far mainly limited to the hatchery phase in shellfish aquaculture, where low pH water interferes with the formation of larval shells and leads to increased mortality. Hatcheries from Oregon to Vancouver Island have experienced 70~80 percent mortality in recent years (Svanhill, 2013). The threat is discussed in Section 3.

7.1.2 External pressures caused by pollution events

The pollution events most likely to affect aquaculture are oil pipeline breaches (which can affect freshwater quality), offshore oil rig spills and spills from tankers travelling along coastal routes.

The case of the Deepwater Horizon disaster is instructive. The explosion in the Gulf of Mexico in 2010 caused over 757 million litres of fuel oil⁴ to be released. Many oyster growers and harvesters blame the spill for a sharp decline in oyster production (Digges, 2014). Research results have, however, been equivocal; one report concluded that the effect was indirect, caused by an infusion of freshwater diverted into wetlands to keep oil from sensitive coastal areas (Camp *et al.*, 2015).

If there is a trend in the likelihood of marine oil spills it may be the increased coastal tanker traffic envisaged in plans to ship North American oil and natural gas to Asia. Several such plans are being considered and include deepwater ports in Northern British Columbia. To date, the two most likely candidates are in North coast fjords, where navigational challenges raise the risk of a marine spill. Both plans are the subject of spirited debate; more plans can be expected. Aquaculture operations in the area are limited at present. The closest finfish farming site is the Kitasoo First Nation joint venture in Klemtu (Section 6); another First Nations farm produces scallops farther north. Approval of new shellfish and finfish tenures in the area that could be affected by an oil spill can be anticipated. Not unsurprisingly, opposition to such oil-transport plans focuses mainly on wild fisheries and ecosystems.

7.1.3 External pressures caused by economic events

FAO (2011a) notes the pivotal role played by currency exchange rates in the trade in aquaculture products between Canada and the United States of America (see Sections 2 and 5). The relative value of the Canadian and United States dollar is a fact of life for any industry trading across the border.

Another important economic factor is the increasing consolidation of many aquaculture operations in North America. When such consolidation involves purchase of a previously independent company by a multinational company with similar operations in several countries, global macroeconomic events begin to play a larger role in the health of each satellite, which is now subject to pressures external to its own field of operation. The clearest example in North America is consolidation of Atlantic salmon farming by a handful of European companies, but there are also many examples where investment in a new aquaculture venture has come from offshore. Both of the aboriginal joint ventures mentioned in Section 7.1.2 have investment from foreign sources (in the case of the salmon farm, the partner is Norwegian; in the case of scallop, China).

⁴ Over 200 million US gallons.

7.2 Outstanding issues and success stories

Oil spills and economic downturns can affect many sectors over a very large geographic area. Fortunately, they are also issues of which the public and regulators are well aware, and for which there is some degree of planning and response.

Climate change is harder to predict and far harder to deal with than oil spills and financial collapses. Climate change may pose the greatest threat to aquaculture through ocean acidification, which can affect any organism that secretes a shell from calcium carbonate. The direct effects on shellfish aquaculture are threats to the industry; indirect effects on ecosystems of which shell-forming animals are a part are more widespread and serious.

Since the period reported in FAO (2011a), acidification has increased and its effects on shellfish hatcheries have followed suit. Seed supply is now acknowledged as a major impediment to the development of North American shellfish aquaculture. The efforts of some North American shellfish hatcheries to source shellfish seed from hatcheries in Latin America could be considered a minor “success story”, but they do nothing to correct or even mitigate the fundamental problem.

7.3 The way forward

In the coming decades, survival and expansion of North American aquaculture will demand constant agility in the face of changing ocean conditions, including not only temperature but also weather, circulation patterns, sea level and ocean chemistry. Even the ecosystems within which aquaculture takes place will change, leading to changing interactions with predators, parasites and disease organisms.

Ocean acidification may be the most immediately pressing consequence of climate change for aquaculture in North America. Because its effects vary geographically, short-term fixes exist. In the long term, the only solution is a reduction in global CO₂ emissions. A geo-engineering approach to ocean acidification, namely manipulation of ocean pH by adding calcium carbonate to the ocean, was advanced in FAO (2011a). This proposed “solution” is highly controversial, would have prohibitive mining and transportation costs, and remains completely untested.

8. GOVERNANCE AND MANAGEMENT OF THE SECTOR

8.1 Status and trends

National and provincial/state governments in both Canada and the United States of America have articulated strategies for the development of aquaculture in North America (FAO, 2011a). Between 2010 and 2015, aquaculture governance in the two countries – that is, the bureaucratic basis for action on any development strategies – remained largely the same as in 2005–2010: shared responsibilities between multiple federal and state agencies, a National Aquaculture Act (1980) in the United States of America, and no corresponding specific legislation in Canada. Today, as in 2010, the thrust of aquaculture development in Canada is still toward environmental sustainability. In the United States of America, development is also geared toward sustainability with the added urgency of offshore expansion. Despite the sameness in goals, there have nevertheless been notable challenges to governance that do affect aquaculture. They are described briefly below.

8.1.1 Facilitating the expansion of marine aquaculture in the United States of America

Reference has already been made to the need to unlock the country’s potential for expanded marine aquaculture (Section 2); one example is the recent NOAA strategy for offshore aquaculture in the federal waters of the Gulf of Mexico (Section 3). The implications for changes in governance to facilitate offshore aquaculture are significant, as the immediate legal challenges to the recent NOAA

decision on the Gulf of Mexico make clear. Knapp and Rubino (2016) argue that those changes in governance should flow from a consideration of the political economics of marine aquaculture in the country – in other words, what actually influences policies and public opinion, and what is the role of economic interests.

A reformed governance system that takes these considerations into account will need to consider leasing systems and regulations that the industry currently finds limiting. Governance of aquaculture in the United States of America is fragmented (as it is in most countries), with multiple agencies and levels of government having their own remits. Outcomes perceived as unfavourable to the industry include regulatory “barriers” like the current Alaskan ban on finfish farming and the absence of any enabling regulatory mechanism for marine aquaculture in federal waters. Specific signs of progress include cooperation between the Army Corps of Engineers, EPA and NOAA to create a process to issue permits for aquaculture in the Gulf of Mexico. More generally, Knapp and Rubino (2016) provide evidence for greater stakeholder involvement, moving toward governance based less on confrontation and more on marine spatial planning and consensus.

8.1.2 A change in aquaculture responsibilities in British Columbia

British Columbia is the leading aquaculture producing province in Canada, with heavy concentration in Atlantic salmon farming. In 2010, the British Columbia Supreme Court ruled that finfish aquaculture is a fishery and falls under federal jurisdiction. The British Columbia Aquaculture Regulatory Program (BCARP) was implemented shortly thereafter, and contained sweeping exchanges of responsibilities. Fisheries and Oceans Canada (DFO) is now responsible for most aspects of the aquaculture industry in British Columbia, including site licensing, production volumes, species to be produced, fish health, sea lice levels, fish containment and waste control. Most of these responsibilities were formerly with the province.

The rest of Canada’s provinces and territories continue to develop their own regulations and management practices for aquaculture. They play an essential role in approving site applications, regulating operations and fostering industry development. The Province of British Columbia continues only to issue tenures, license marine plant cultivation, and manage business aspects of aquaculture such as work place health and safety.

8.1.3 Changes to Canada’s Fisheries Act

In Canada, the Fisheries Act is the main federal legislation for aquaculture. The Act establishes a process for assessment of all new aquaculture applications. The two main provisions of the Act concerning aquaculture are habitat protection and pollution prevention. The provision for habitat protection prohibits any aquaculture activities that can result in “harmful alteration, disruption or destruction” (HADD) of habitat.

Changes to the Fisheries Act in 2013 removed the broad protections that covered all fish habitats; the law now only prohibits “serious harm” to fish that are targets of a commercial, recreational or aboriginal fishery, or that support such a fishery. “Serious harm” does include destruction of habitat, but the restriction to fish that are part of a fishery appears to remove significant regulatory hurdles for many kinds of projects, including aquaculture projects. The streamlining of administrative processes called for in FAO (2011a) would here appear to have been accomplished. As of this writing, it is not clear whether the Canadian federal government will restore these lost protections; regulatory uncertainty seems likely to continue to be a feature of aquaculture development in Canada, as it is in the United States of America.

8.2 Important issues

In this review, repeated reference has been made to limitations on expansion of marine aquaculture in North America. The issue is especially acute in the United States, where suitable unexploited coastal locations are in relatively short supply. The move toward exploring offshore aquaculture is a direct

response to such limitations. Once offshore, however, governance changes with the distance from shore and the involvement of more agencies.

Aboriginal participation in aquaculture has frequently been mentioned in this review. Recent changes in governance may provide further support. At the international level, the 2007 United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) noted, in Article 26, that “Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.” It directs states to give legal recognition to these territories. Both Canada and the United States of America support the Declaration.

In British Columbia, few treaties were signed and aboriginal title still exists in many areas. A landmark ruling in 2014 by the Supreme Court of Canada validated aboriginal claim over a significant area in the province and has meant that aboriginal participation in resource development projects is now a primary factor in planning. At present, around 78 percent of British Columbia’s annual production of farmed salmon is harvested from areas covered by agreements with First Nations (RIAS, 2015). Expansion of net-pen production and development of land-based systems is even more likely to involve aboriginal groups as rights and title continue to be clarified.

8.3 The way forward

Expansion of aquaculture in North America will be primarily outward, toward external markets – even if a certain amount of the trade in aquaculture products will remain between the two countries that make up the continent. Planning for aquaculture expansion in the next decade will demand familiarity with a shifting landscape of governance, from local and regional rules through changes in federal and state responsibilities all the way to the negotiation of new trade agreements between countries and the implementation of multinational agreements like UNDRIP.

9. AQUACULTURE CONTRIBUTION TO THE FAO STRATEGIC OBJECTIVES, TO THE SDGS AND TO THE BLUE GROWTH INITIATIVE (BGI)

The FAO Blue Growth Initiative (BGI), endorsed by member countries in 2014, aims to reconcile economic growth and food security with conservation of aquatic resources. Building resilience of coastal communities and restoring the productive potential of fisheries and aquaculture are seen as critical to food security, poverty alleviation and sustainable management of aquatic resources.

The goals and objectives of the BGI apply to coastal fishing and aquaculture, not inland activities. Despite the relatively advanced character of North American coastal aquaculture and the BGI’s concentration in developing countries, BGI goals remain highly relevant to future development in North America. Expansion of the relatively new practice of offshore aquaculture in North America offers a special opportunity to embody Blue Growth principles.

BGI principles are captured explicitly in several of the Sustainable Development Goals (SDGs) adopted by member countries of the United Nations in 2015. Aquaculture in North America can advance a number of these goals as discussed below. Cases where one of FAO’s five Strategic Objectives also applies are noted in the discussion below.

SDG 3: Ensure healthy lives and promote wellbeing. As an alternative to wild capture fisheries, aquaculture is recognized as providing healthy food. In North America, health benefits of cultured seafood are routinely promoted as part of marketing, and FAO (2011a) described both Canadian and American government initiatives for promoting consumption of seafood. The North American contribution to SDG 3 is generic. Also applicable to FAO Strategic Objective 1 (Help eliminate hunger, food insecurity and malnutrition) in the case of some aboriginal communities’ continued access to wild fish.

SDG 5 (Achieve gender equality and empower women and girls) and SDG 8 (Sustained, inclusive and sustainable economic growth, full and productive employment and decent work). Some sectors of North American aquaculture have increased employment for women, and all provide decent work. Both trends can be clearly seen in increased aboriginal participation in salmon and shellfish aquaculture (see Section 6), also relevant to FAO Strategic Objective 3 (Reduce rural poverty). Participation of women in aquaculture is difficult to assess, and complicated by the need to differentiate between direct jobs and indirect ones. The industry also encompasses a broad range of positions, from management and research to field workers and maintenance. A fair indication of women's participation in finfish and shellfish culture may be in Atlantic Canada, where 40 percent of employees are women (Atlantic Canada Opportunities Agency, 2016). The argument that aquaculture creates jobs can in some cases be countered by noting that jobs have been lost in wild fisheries.

SDG 9: Build resilient infrastructure and industry innovation. Section 3 of this review describes the creation of new infrastructure in both finfish and shellfish aquaculture in North America. New developments that respond to environmental and geographic challenges include infrastructure for recirculating, on-land farming systems and satellite shellfish hatcheries. This goal also includes creating the environment for scientific research to further industry, something that is happening steadily in North American aquaculture, especially through creation of industry-government-academic partnerships. As with SDG 5 above, it needs to be acknowledged that aquaculture infrastructure in some cases replaces infrastructure lost as capture fisheries have declined.

SDG 14: Conserve and sustainably use the oceans, seas and marine resources. Aquaculture represents an alternative source of seafood in the face of declining wild stocks; in this general sense the industry contributes to sustainable use of marine resources and is also relevant to FAO Strategic Objective 2 (Make agriculture, forestry and fisheries more productive and sustainable). Caveats to this general statement have been discussed in Sections 3 and 4. Outstanding concerns include dependence on forage fish stocks for feed, especially for finfish that are high on the food chain and highly priced in the market. Interactions between farmed fish, including escapes and disease transmission, also work against any conservation effect of aquaculture. Future developments in North American aquaculture, including offshore oceanic farming, need to be measured against this goal.

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