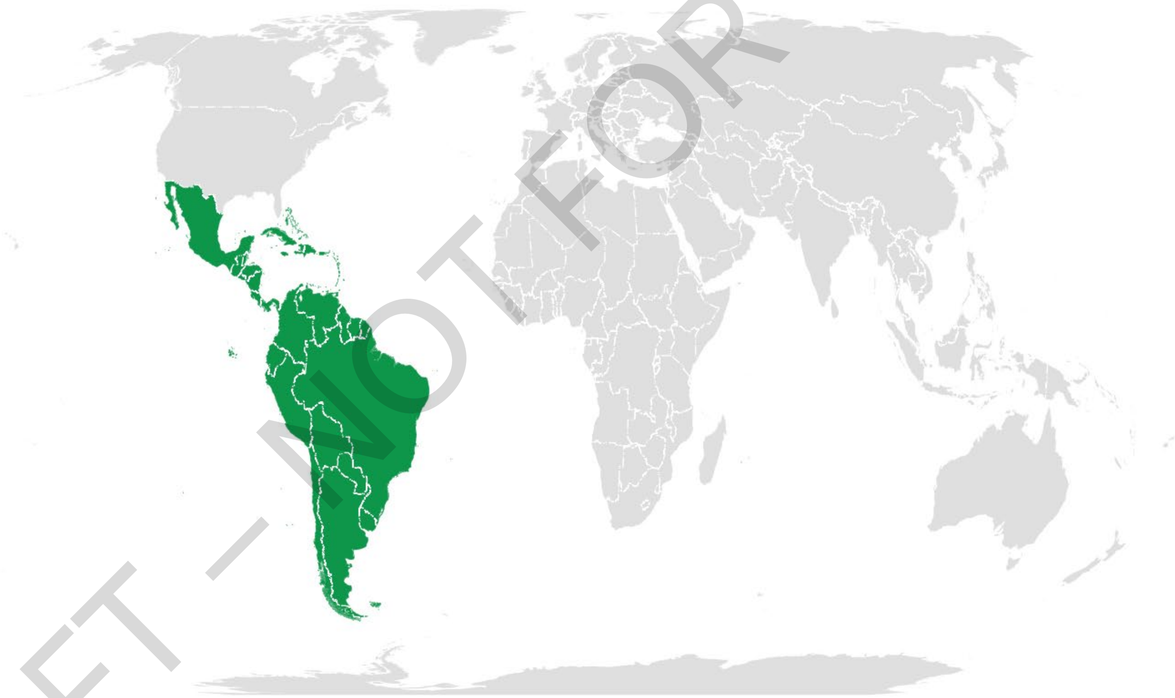
Food and Agriculture Organization of the United Nations

NFIAP/C1232/3

FAO Fisheries and Aquaculture Circular

ISSN 2070-6065

REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN – 2020



FAO Fisheries and Aquaculture Circular No. 1232/3 NFIAP/C1232/3 (En)

REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN – 2020

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2021

FAO. 2021. *Regional review on status and trends in aquaculture development in Latin America and the Caribbean – 2020*, by Carlos Wurmann, Doris Soto & Ricardo Norambuena. FAO Fisheries and Aquaculture Circular No. 1232/3. Rome, Italy.

Preparation of this document

The regional review for Latin America and the Caribbean region was prepared by Carlos Wurmann, Doris Soto and Ricardo Norambuena, FAO Consultants. Alessandro Lovatelli, Aquaculture Officer, FAO Fisheries Division, was the lead review coordinator. FAO Regional Fisheries and Aquaculture Officers, Alejandro Flores, José Aguilar-Manjarrez and Yvette Diei-Ouadi contributed valuable information along with reviewing the document. FAO headquarters colleagues in the Fisheries and Aquaculture Division Xinhua Yuan, Rodrigo Roubach, Melba Reantaso, Ansen Ward, Yolanda Molares, Stefania Vannuccini, Jennifer Gee, Adrienne Egger, Roxane Misk, Xiaowei Zhou, Gabriella Laurenti and Pierre Maudoux are acknowledged for their valuable inputs and review. Also gratefully acknowledged are the following experts that kindly shared their knowledge of the region: Yahira Piedrahita (National Chamber of Aquaculture, Ecuador), Francisco Javier Martinez Cordero (Center for Research in Food and Development, Mexico), Milton Haughton (Caribbean Regional Fisheries Mechanism, Belize), Avery Smikle (Ministry of Agriculture and Fisheries, Jamaica), Alicia Gallardo (Undersecretary of Fisheries and Aquaculture, Chile), Kathleen Allen (FAO Aquaculture Consultant) and three Brazilian experts, João Scorvo, Célia Dória Scorvo and Francisco Medeiros. Brian Harvey and Devin Bartley (World Fisheries Trust) contributed with editing of the document while final editing and layout was carried out by Malcolm Dickson and Chorouk Benkabbour, respectively.

Data used in this regional aquaculture review, derive mainly from FAO fisheries and aquaculture statistics (FishStat sources), including the FAO Yearbook Fishery and Aquaculture Statistics, accessible through online query panels and FishStatJ. A brief description on the collection and consultation of FAO statistical data is provided in Annex 1.

In continuing the global efforts to achieve aquaculture sustainability through dissemination of up-to-date information on the status and trends of the sector, FAO publishes Aquaculture Regional Reviews and a Global Synthesis about every 5 years. This process started in 1995. Previous reviews, along with recordings of the aquaculture review webinars held 26–29 October 2020, can be found here: www.fao.org/fishery/regional-aquaculture-reviews/aquaculture-reviews-home/en/

Abstract

This document reviews the development of the aquaculture industry in the Latin America and the Caribbean region over the past decade. In 2018 aquaculture production in the region amounted to an estimated 3.1 million tonnes of aquatic products (excluding seaweeds) worth USD 17.2 billion at first sale. This food sector is vastly concentrated in a few countries with the combined output from Brazil, Chile, Colombia, Ecuador and Mexico representing over 85 percent of the total regional production. Atlantic salmon, rainbow trout, tilapia, whiteleg shrimp and the Chilean mussel collectively contributed 80.4 percent and 85.9 percent of the regional production by volume and value, respectively.

Marine aquaculture has been the dominant production environment in the region for the past two decades, accounting for 70.1 percent of the farmed output in 2018. Production models vary widely, with a concentration of large-scale companies in Chile, while primarily small- and/or medium-size operations in Brazil, Peru and several other countries. Introduced species remain top on the list among those farmed such as tilapia and the different salmonids both of which have contributed to local livelihoods and employment. Tilapia farming has contributed significantly to food security in many countries of the region while the largest proportion of farmed salmons have been destined to the export markets.

Production prospects remain promising, however the industry requires in general better governance, the adoption at all levels of appropriate technologies and best practices, and renewed efforts to guarantee environmental sustainability and social acceptance as well as competitiveness and foresight to deal with climate and market changes. The small island developing states (SIDS) face additional challenges including limited expertise, high production costs, poor seed supplies, as well as extreme and destructive weather events.

The report discusses issues that require wider regional attention for the aquaculture sector to grow. Key recommendations focus on governance-related improvements highlighting the need for solid sectoral development plans, support policies, and effective rules and regulations. The promotion of a stronger cooperation among the countries in the region as well as further afield on technical matters, species diversification and equal support to small- and large-scale farming operation are identified as key elements to foster investment and help the region gain a solid position among world aquatic food producers.

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Abbreviations and acronyms

AMR	Antimicrobial resistance
AREL	Limited Resources Aquaculture (Acuicultura de recursos limitados)
ASC	Aquaculture Stewardship Council
ASFIS	Aquatic Sciences and Fisheries Information System
BGI	Blue Growth Initiative (FAO)
CAC	Central America and the Caribbean
CAGR	Cumulative annual growth rate
CCRF	Code of Conduct of Responsible Fisheries
CODEVASF	São Francisco and Parnaíba Valley Development Company (Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba – Brazil)
CONABIO	National Commission for the Knowledge and Use of Biodiversity – Mexico (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad – México)
CONAPESCA	Comisión Nacional de Acuacultura y Pesca – México
COVID-19	COronaVIrus Disease 2019
CRFM	Caribbean Regional Fisheries Mechanism – Belize
DNOCS	National Department of Works Against Drought (Departamento Nacional de Obras Contra as Secas – Brazil)
EAA	Ecosystem approach to aquaculture
ECLAC	Economic Commission for Latin America and the Caribbean
ELCSA	Latin American and Caribbean Food Security Scale (Escala Latinoamericana y Caribeña de Seguridad Alimentaria)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária; Ministério da Agricultura, Pecuária e Abastecimento
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FAO-RLC	FAO Regional Office for Latin America and the Caribbean
FAO-SLC	FAO Subregional Office for the Caribbean
FCR	Food Conversion Ratio
GDP	Gross domestic product
GHG	Greenhouse gases
HABs	Harmful algae blooms
HDI	Human Development Index
HPM	Hepatopancreatic Microsporidiosis

IBGE	Brazilian Institute of Geography and Statistic (Instituto Brasileiro de Geografia e Estatística)
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
IIAP	Peruvian Amazon Research Institute (Instituto de Investigaciones de la Amazonía Peruana)
IMTA	Integrated multi-trophic aquaculture
INCAR	Interdisciplinary Center for Aquaculture Research – Chile
INDESPA	National Institute for Sustainable Development of Artisanal Fisheries and Small-Scale Aquaculture – Chile (Instituto Nacional de Desarrollo Sustentable de la Pesca Artesanal y Acuicultura de Pequeña Escala – Chile)
ISA	Infectious Salmon Anaemia
ISSCAAP	International Standard Statistical Classification for Aquatic Animals and Plants
LAC	Latin America and the Caribbean
MAGAP	Ministry of Agriculture, Livestock, Aquaculture and Fisheries – Ecuador (Ministerio de Agricultura, Ganadería, Acuicultura y Pesca – Ecuador)
MPA	Ministry of Fisheries and Aquaculture – Brazil (Ministério da Pesca e Aquicultura – Brazil)
MPCEIP	Ministry of Production, Foreign Trade, Investments and Fisheries – Ecuador (Ministerio de Producción Comercio Exterior Inversiones y Pesca – Ecuador)
NAPs	National adaptation plans
NFIA	FAO Fisheries Division – Aquaculture
NFIS	FAO Fisheries Division – Statistics
NGO	Non-governmental organization
OSPESCA	Organization of the Fisheries and Aquaculture Sector of the Central American Isthmus (Organización del Sector Pesquero y Acuícola del Istmo Centroamericano)
PAHO	Pan American Health Organization
PCR	Polymerase chain reaction
Plan/DAS	National Plan for Sustainable Aquaculture – Colombia (Plan Desarrollo Acuicultura Sostenible – Colombia)
PMP/AB	Progressive Management Pathways for Improving Aquaculture Biosecurity
PNIPA	National programme for Innovation in Fisheries and Aquaculture – Peru (Programa Nacional de Innovación en Pesca y Acuicultura – Perú)

PROCITROPICOS	Cooperative Research and Technology Transfer Program for the South American Tropics (Programa Cooperativo de Investigación, Desarrollo e Innovación Agrícola para los Trópicos)
R&D	Research and development
R&D + I	Research, development and innovation
RAA	Red de Acuicultura de las Américas
RAS	Recirculation aquaculture systems
SBA	Small Business Aquaculture
SDGs	Sustainable development goals
SEBRAE	Brazilian Service of Support for Micro and Small Enterprises (Serviço Brasileiro de Apoio às Micro e Pequenas Empresas)
SERNAPESCA	National Fisheries and Aquaculture Service – Chile (Servicio Nacional de Pesca y Acuicultura)
SIDS	Small islands developing states
SRS	Salmon Rickettsia Syndrome
SUBPESCA	Undersecretary of Fisheries and Aquaculture – Chile (Subsecretaría de Pesca e Acuicultura – Chile)
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USD	United States Dollars
WAPI	World Aquaculture Performance Indicators (FAO)
WFT	World Fisheries Trust
WFP	World Food Programme
WHO	World Health Organization
WWF	World Wide Fund for Nature
WSSV	White spot syndrome virus

Executive summary

This document reviews aquaculture development in the Latin America and the Caribbean (LAC) region over the last decade, focused mainly on the last five years and building on information in previous LAC aquaculture reviews, particularly the 2015 report (FAO, 2017).

Aquaculture in the LAC region resulted in 3.1 million tonnes of fish, shellfish and molluscs (excluding seaweeds) in 2018, worth USD 17.2 billion at first sale. Over the last five years, the quantity of production has grown by an average of 5.6 percent per year, compared to 8.3 percent per year in the period 2000 to 2010. This compares to average world aquaculture growth rates of 4.2 percent per year over the last five years and 5.9 percent over the period 2000 to 2010. The recent reduction in growth rates in LAC region may in part be due to poor governance and public perception or acceptance of aquaculture. Nevertheless, aquaculture contributed 17.9 percent towards total fish production in the region in 2018, compared with only four percent in 2000 and if current trends continue, it is expected that LAC aquaculture production will reach 4.6 million tonnes in 2030.

Apart from some local exceptions, per capita seafood consumption rates in LAC region are low at around 10 kg per year which is approximately half of the global average. Except in Brazil, Cuba and Colombia most aquaculture production is for export. Local eating preferences strongly favour poultry and pork that are cheaper or more accessible than fish and red meat. The growing population of LAC reached 654 million in 2020 with a high proportion of urban residents, but with low average population densities.

LAC aquaculture is highly concentrated in a few countries with the combined output from Chile, Ecuador, Brazil, Mexico and Colombia representing 85 percent to 90 percent of total LAC production. Salmonids and tilapia are the main finfish products, while whiteleg shrimp and Chilean mussels are the main shellfish products. The average value (USD/kg) of LAC aquaculture products is much higher than for all other continents except Oceania. About 70 percent of farmed output is from a few introduced species, although over 90 species were farmed in 2018. Whiteleg shrimp, Atlantic salmon, Nile tilapia, Chilean mussel and rainbow trout, in decreasing order, together contributed 80.4 percent of regional production volume and 85.9 percent of value. Farming has focused on these species and production has increased in recent years, despite efforts towards diversification. Out of 91 species farmed, only 22 resulted in production of more than 5 000 tonnes in 2018. Technology gaps, poor research and development strategies, fragmented public policies, localized markets and marketing issues, as well as relatively high prices have all contributed to this. The small island developing states (SIDS) face additional challenges including inadequate national legal and policy frameworks and support systems, limited expertise, high production costs due to the high cost of inputs and challenges with seed supplies, as well as biosecurity problems and natural disasters such as storms, floods and drought.

Aquaculture growth rates have been highly variable within the region. For example, in Central America, El Salvador, Guatemala and Mexico experienced high growth rates from 2013 to 2018, while growth in Honduras, Nicaragua and Panama has been more modest and production has decreased in Costa Rica and Belize. On a subregional basis, the Caribbean contributed 1.1 percent towards total LAC production in 2018, Central America, 13.1 percent and South America, 85.8 percent by quantity and 91 percent of LAC aquaculture by value. Four countries within each subregion generate 90 percent or more of subregional production: Cuba, Dominican Republic, Haiti and Jamaica in the Caribbean; Guatemala, Honduras, Mexico and Nicaragua in Central America and Brazil, Chile, Colombia and Ecuador in South America.

Marine aquaculture has been the dominant production environment in the region for the past 20 years, accounting for 70.1 percent of production in 2018. Freshwater aquaculture, which grew by 28 percent over the period 2013 to 2018, was mainly due to tilapia farming, while native species, mainly characins, generally showed stagnant or decreased production.

Production models vary widely, with a concentration of large-scale companies in Chile, and primarily small-scale or medium-sized operations in Brazil, Peru and several other countries. The smallest firms usually struggle to remain in business, mostly due to the lack of appropriate policies, technical support and capacity building, as well as market conditions and accessibility. Production prospects are promising, but need to be improved through better governance, the use of appropriate technologies, reinforced efforts to guarantee environmental sustainability and social acceptance as well as competitiveness and foresight to deal with climate and market changes.

Although major disease incidents have affected both salmonid and shrimp farming in the past in LAC region, there have been significant improvements in the adoption of biosecurity measures in recent years, particularly in South America. Also, significant efforts have been made to reduce environmental impacts by decreasing antibiotic use in salmon farming in Chile. More work on biosecurity and related governance is needed, particularly for freshwater farming of tilapia and other species.

Aquaculture contributes significantly to the sustainable development goals (SDGs), but with trade-offs. For example, tilapia aquaculture has contributed significantly to food security in many countries of the region, but expansion of tilapia farming systems has been restricted in several areas due to fears of negative environmental impacts. Farming of salmonids, which are also introduced species and produced mostly for export, has contributed significantly to livelihoods and employment, including for women and residents of remote locations, but has also resulted in significant negative impacts on ecosystem functions and integrity. A large proportion of cultured freshwater native species are consumed within the region, as is the case in Brazil and Colombia, where the majority of production comes from small and medium-scale farms. These contribute directly to local food security, nutrition and livelihoods with potentially lower environmental impacts, but often struggle to make profits and remain in business. Women have benefited from aquaculture in the region especially in post-harvest and processing of export-oriented species such as salmon, shrimp, tilapia and mussels, and with other indirect employment opportunities and services. However, the impacts of aquaculture on employment have not been adequately documented.

Product certification for environmental sustainability and associated better practices has increased in the last five years, enhancing export opportunities but not greatly influencing local and national perceptions of the sector. Nevertheless, in most cases environmental impacts of aquaculture can be adequately addressed, with fish farming performing better than many other food sectors. Recognition of this needs to be made more explicit to help improve social acceptance of aquaculture.

Increasing climate variability and climate change are growing threats in the region. The El Niño Southern Oscillation (ENSO) had significantly negative impacts in 2015 and 2016 on mussel and salmonid production. More frequent extreme weather events in the Caribbean and Central America are a threat to whole countries, including aquaculture facilities. Inland aquaculture is impacted by increasing air and water temperatures, decreasing freshwater availability and water delivery patterns. Droughts have significantly impacted tilapia culture in the dry corridor of Central America and North-eastern Brazil. However, information is still limited regarding impacts and risks. More research has been undertaken on mariculture than freshwater systems, including the risks of changed rainfall patterns, increasing temperatures and wave heights as well as the occurrence harmful algal blooms (HABs). Ocean acidification is also likely to negatively impact mollusc and crustacean farming.

The COVID-19 pandemic has been a significant factor in the LAC aquaculture industry, with largely unpredictable mid to long-term impacts. Travel restrictions and lockdowns have reduced and sometimes stopped production, processing and marketing. Re-direction of exports to alternative markets has sometimes resulted in significant economic losses. Depressed global economies have lowered demand, affecting both large and small-scale producers, but especially the latter. Women are also likely to be most affected, due to reduced processing activities and export sales.

Recommended governance-related improvements include the following:

- Improved long-term sectoral development plans and policies at local, national and subregional levels.
- Improved legislation, rules and regulations (including enforcement).
- Improved and expanded training of government personnel.
- Stronger leadership by authorities, industry and farming leaders.
- Improved LAC country-to-country cooperation for technical development.
- Improved climate change adaptation, environmental considerations, environmental social and economic performance through adequate incentives and training programmes.
- Evaluation of results of governmental and other support programmes, with cessation of under-performing activities.
- Improved enabling national economic and governance environments to foster investment and sustainable aquaculture development.
- Promotion of both small and large-scale aquaculture equally, as they play complementary roles.
- Promotion of diversified aquaculture products and markets, supported by sound research and development (R&D) activities and plans.
- Improvement of aquaculture information and statistics at all levels.

LAC aquaculture sectors need to improve their productivity and competitiveness as they face severe competition in local and international markets. Sustained effort is required to increase the relatively low consumption rate of aquaculture products in domestic markets as well as promote sales abroad. Meanwhile, small to middle-sized farmers need technical innovation and economies of scale to strengthen their competitiveness and access to markets. A permanent process to incorporate new technologies and production methods is required. LAC countries should devote more attention to developing adequate and efficient processes for small-scale operations, open-ocean systems, recirculation system, biotechnology, information technologies, robotics and other important innovations. The region must prepare their aquaculture sectors for new and more challenging sectoral environments. Marine and inland aquaculture zoning and planning is an essential sectoral management instrument, within territorial development, to foster aquaculture potential in a harmonious and sustainable manner.

In summary, production prospects are promising, but they need to be improved through better governance, the use of appropriate technologies and reinforced efforts to guarantee environmental sustainability, social acceptance and market competitiveness.

1. Social and economic background of the region

1.1 STATUS AND TRENDS

1.1.1 Socio-geographic characteristics

The Latin American and the Caribbean (LAC) region includes 50 countries and territories in the subregions of South America, Central America, and the Caribbean (Tables 1 and 2). The South American countries and territories are Argentina, Bolivia (Plurinational State of), Brazil, Chile, Columbia, Ecuador, Falkland Islands (Malvinas), French Guyana, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela (Bolivarian Republic of). The Central American countries and territories are Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama. The Caribbean countries and territories are Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Cuba, Curaçao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Monserrat, Puerto Rico, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint-Martin (French part), Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands and United States Virgin Islands.

In this review, LAC refers to all of this region, although aquaculture production statistics are available for 42 countries only. Overall, the LAC region represents 15.5 percent of the world's surface area, with South America and Central America accounting for the largest proportions within the region (Table 1). This region includes a high diversity of habitats, including some of the world's most significant terrestrial, marine, and freshwater biodiversity hotspots while some of the planet's largest rivers, rainforests, savannahs, deserts, wetlands, mountains, island nations, coral reefs, fjords, extensive coastlines (on the Atlantic and Pacific Oceans) are also found here.

TABLE 1. Geographic description of Latin America and the Caribbean

	Countries		Land Area		Continental Water		Coastline	
	Nº.	% of world	Million km²	% of world	Area (1 000 km²)	% of world	km	% of world
South America	14	7.2	17.7	13.4	268.0	7.8	25 428	3.2
Central America	8	4.1	2.5	1.9	30.8	0.9	15 936	2.0
Caribbean	28	14.4	0.2	0.2	7.1	0.2	14 914	1.9
LAC total	50	26.0	20.0	15.0	307.0	9.0	56 278	7.0
World	195	100.0	132.0	100.0	3 434.0	100.0	805 942	100.0

Sources: The World Bank Group, 2020a; Brinkhoff, 2020.

1.1.2 Population

Latin America and the Caribbean region had an estimated population of 654 million people in 2020, eight percent of the global population, with 66 percent, 27 percent, and seven percent in South America, Central America, and the Caribbean, respectively (Table 2). Brazil accounts for around 50 percent of the South American population, Mexico for 72 percent of the Central America population, and Cuba, Dominican Republic, and Haiti for about 26 percent each within the Caribbean while the remainder is unevenly distributed among the other nations and territories as shown in Table 2. About 50 percent of this population is female, with little variation across countries and subregions.

TABLE 2. Population characteristics of the Latin America and the Caribbean region, 2020

Country/region	Pop. (thousands)[1]	%		Pop. density[2]	% Pop. growth[2]		% Women[2]	% Urban[3]
	2020	LAC	Sub-region	(p/km²)	2010–15	2015–20	2020	2020
South America (total)	**430 760**	**66**	**100.00**	**24.7**	**0.99**	**0.87**	**50.8**	**84.6**
Argentina	45 196	7	10.49	16.5	1.04	0.96	51.2	92.1
Bolivia (Plurinational State of)	11 673	2	2.71	10.8	1.57	1.43	49.8	70.1
Brazil	212 559	33	49.35	25.4	0.88	0.78	50.9	87.1
Chile	19 116	3	4.44	25.7	1.04	1.24	50.7	87.7
Colombia	50 883	8	11.81	45.9	0.99	1.37	50.9	81.4
Ecuador	17 643	3	4.10	71.0	1.54	1.69	50.0	64.2
Falkland Is (Malvinas)	3	0	0.00	0.3	-0.46	4.10		78.5
French Guyana	299	0	0.07	3.6	2.27	2.7.00	50.5	85.8
Guyana	787	0	0.18	4.0	0.48	0.49	49.7	26.8
Paraguay	7 133	1	1.66	18.0	1.36	1.29	49.2	62.2
Peru	32 972	5	7.65	25.8	0.97	1.58	50.3	78.3
Suriname	587	0	0.14	3.8	1.10	0.96	49.7	66.1
Uruguay	3 474	1	0.81	19.8	0.31	0.36	51.7	95.5
Venezuela (Bolivarian Republic of)	28 436	4	6.60	32.2	1.12	-1.13	50.8	88.3
Central America (total)	**179 670**	**28**	**100.00**	**73.3**	**1.39**	**1.23**	**51.0**	**75.4**
Belize	398	0	0.22	17.4	2.25	1.94	50.3	46.0
Costa Rica	5 094	1	2.84	99.8	1.15	0.99	50.0	80.8
El Salvador	6 486	1	3.61	313.0	0.45	0.50	53.2	73.4
Guatemala	17 916	3	9.97	167.2	2.10	1.95	50.7	51.8
Honduras	9 905	2	5.51	88.5	1.83	1.67	50.0	58.4
Mexico	128 933	20	71.76	66.3	1.32	1.13	51.1	80.7
Nicaragua	6 625	1	3.69	55.0	1.33	1.25	50.7	59.0
Panama	4 315	1	2.40	58.0	1.71	1.67	49.9	68.4
Caribbean (total)	**43 532**	**7**	**100.00**	**192.6**	**0.67**	**0.42**	**50.6**	**72.2**
Anguilla	15	0.00	0.03	166.7	1.20	1.00		100.0
Antigua and Barbuda	98	0.01	0.23	222.6	1.22	0.91	52.0	24.4
Aruba	107	0.02	0.25	593.1	0.52	0.46	52.3	43.7
Bahamas	393	0.06	0.90	39.3	1.06	0.99	41.4	83.2
Barbados	287	0.04	0.66	668.3	0.23	0.14	50.5	31.2
Bonaire/S.Eustatius/ Saba	26	0.00	0.06	79.9	3.20	1.30	--	--
British Virgin Islands	30	0.00	0.07	201.6	0.96	0.73	--	48.5
Cayman Islands	66	0.01	0.15	273.8	1.71	1.26	--	100.0
Cuba	11 327	1.73	26.02	106.4	0.18	0.00	50.3	77.2
Curacao	164	0.03	0.38	369.6	1.38	0.53	54.3	89.1
Dominica	72	0.01	0.17	96.0	0.09	0.23		71.1
Dominican Republic	10 848	1.66	24.90	224.5	1.18	1.07	50.0	82.5
Grenada	113	0.02	0.26	330.9	0.63	0.53	49.6	36.5
Guadeloupe	400	0.06	0.92	245.8	-0.29	-0.01	54.0	98.5
Haiti	11 403	1.74	26.20	413.7	1.45	1.28	50.7	57.1
Jamaica	2 961	0.45	6.80	273.4	0.57	0.48	50.4	56.3
Martinique	375	0.06	0.86	354	-0.84	-0.17	54.1	89.1
Montserrat	5	0.00	0.01	50.0	0.28	0.08	--	9.1
Puerto Rico	2 861	0.44	6.57	322.5	-1.14	-3.34	52.6	93.6
Saint Barthelemy	10	0.00	0.02	449.3	0.98	0.38		
Saint Kitts and Nevis	53	0.01	0.12	204.6	0.88	0.76		30.8
Saint Lucia	184	0.03	0.42	301.0	0.57	0.50	50.5	18.8
Saint Vincent and the Grenadines	39	0.01	0.09	729.4	-0.94	1.51	--	53
Saint-Martin	111	0.02	0.25	284.5	0.16	0.33	--	
Sint Maarten	43	0.01	0.10	1261.2	3.13	1.41	--	100.0
Trinidad and Tobago	1 399	0.21	3.21	272.8	0.63	0.42	50.7	53.2
Turks and Caicos Is.	39	0.01	0.09	40.8	1.94	1.47	--	93.6
US Virgin Islands	104	0.02	0.24	298.4	-0.22	-0.10	--	95.9
LAC total	**653 962**	**100.00**	**8.00**	**32.5**	**1.07**	**0.94**	**50.8**	**81.2**
World	**7 794 799**		**100.00**	**59.9**	**1.18**	**1.09**	**49.58**	**56.2**

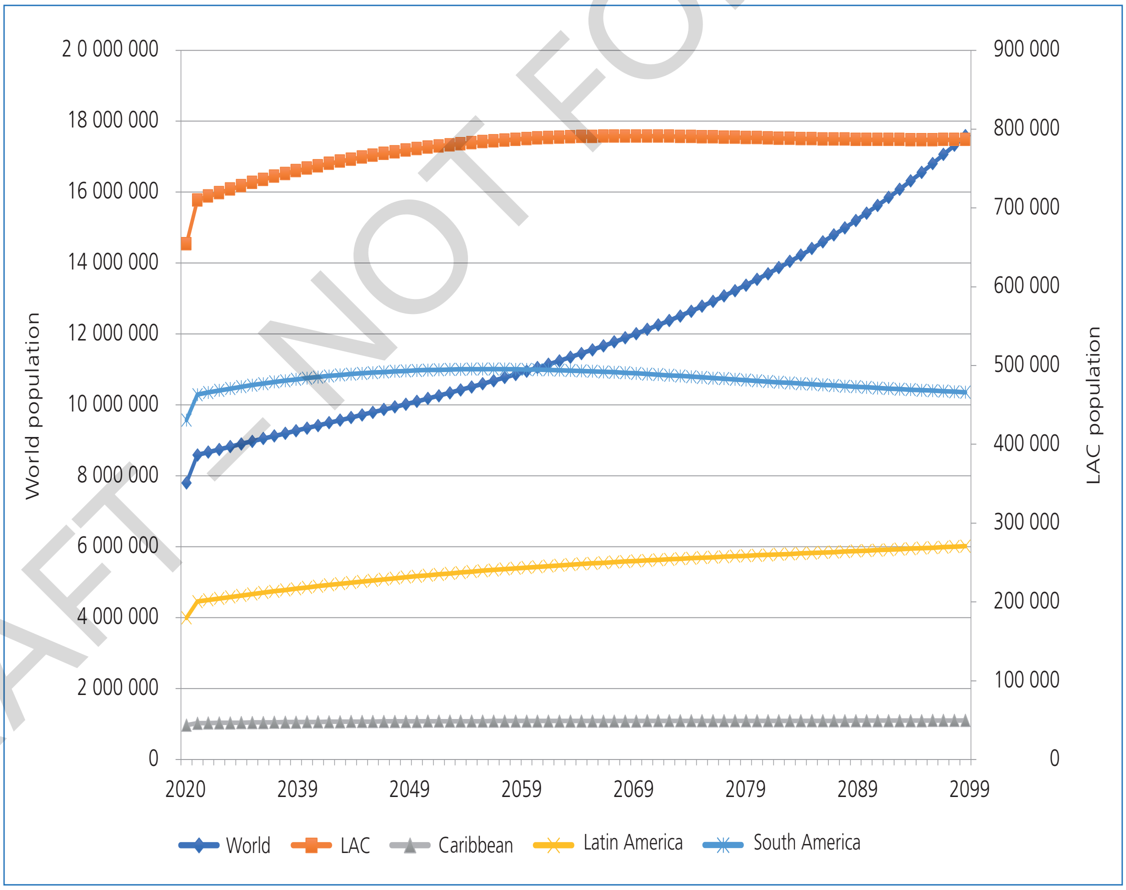
Sources : [1,2](UN DESA PD, 2019a) [3](UN DESA PD, 2018b), [4](UN DESA PD 2019c).

A high proportion of the population in the region lives in urban areas; 81 percent in 2020, compared with a world average urbanisation rate of 56 percent. The LAC population is expected to grow to 706 million by 2030 when the urbanisation rate may rise to 84 percent (ECLAC, 2019). This high proportion of urban inhabitants suggests that the market potential for aquaculture products should continue to grow, especially if relative incomes and fish consumption rates also rise.

The average population density in LAC was 32 persons/km^2 in 2020, ranging from 0.3 to 1 261 persons/km^2 as it includes large, sparsely populated countries and small, densely populated island nations. Meanwhile, subregional averages were 21.6, 108.2 and 316.9 persons/km^2 for South America, Central America, and the Caribbean, respectively and the relatively low average population density in South America is expected to be maintained (ECLAC, 2019). This should, in general, provide room for further aquaculture development. However, development interests of different users are generally clustered around similar areas so zoning, multi-stakeholder negotiations and integrated management plans will be important in all regions.

Population growth rates in LAC are expected to be comparatively lower than world figures and peak around the year 2070, at around 800 million people (Figure 1).

FIGURE 1. Populations in 2020 and predictions to 2100 for Latin America and the Caribbean region and the world



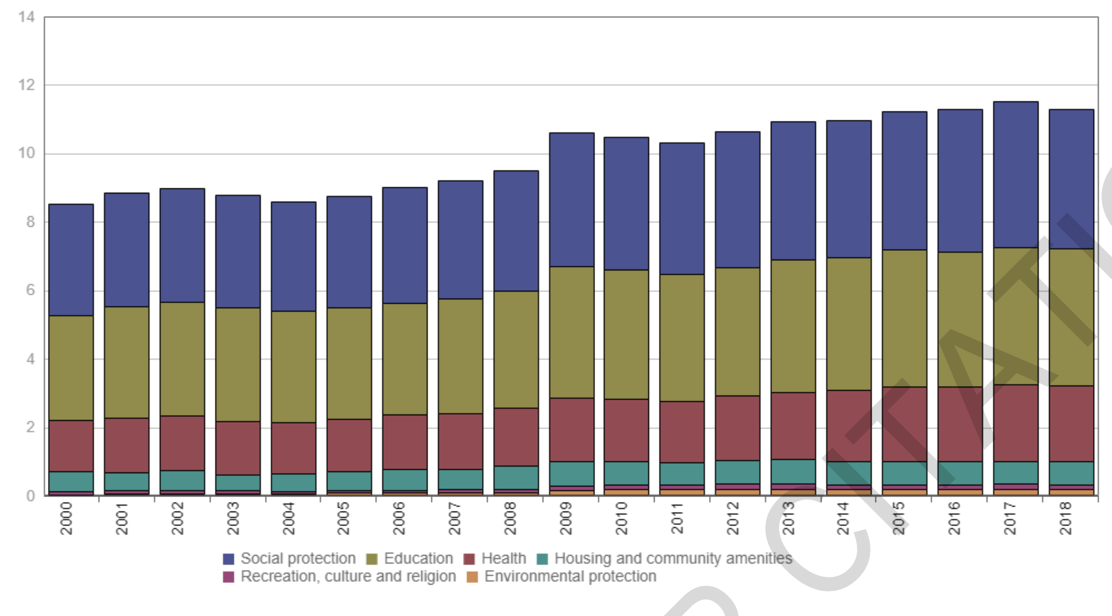
Source: UN DESA PD, 2019d.

TABLE 3. Latin America and the Caribbean average per capita gross domestic product and growth rates, 2000–2018 (2015 USD values)*

Area	USD of 2015, per capita						Mean cumulative growth rate (%)	
	2000	2005	2010	2015	2018	2000–2010	2010–2018	2000–2018
World	**7 769**	**8 540**	**9 218**	**10 105**	**10 689**	**1.7**	**1.9**	**1.8**
Americas	22 148	23 720	24 140	25 613	26 295	0.9	1.1	1.0
Northern America	47 696	51 736	51 737	55 588	58 204	0.8	1.5	1.1
Caribbean	6 643	7 431	7 836	8 125	8 166	1.7	0.5	1.2
Central America	7 267	7 364	7 464	8 122	8 410	0.3	1.5	0.8
South America	6 814	7 341	8 650	9 007	8 503	2.4	-0.2	1.2
Anguilla	20 217	23 798	22 876	22 622	18 991	1.2	-2.3	-0.3
Antigua and Barbuda	12 794	13 802	13 007	13 377	15 158	0.2	1.9	0.9
Argentina	11 577	12 058	14 539	14 853	14 143	2.3	-0.3	1.1
Aruba	30 978	29 975	26 268	27 980	29 014	-1.6	1.3	-0.4
Bahamas	36 048	35 404	31 930	30 380	30 048	-1.2	-0.8	-1.0
Barbados	16 709	17 442	16 857	16 589	16 934	0.1	0.1	0.1
Belize	4 291	4 797	4 756	4 798	4 691	1.0	-0.2	0.5
Bermuda	90 131	100 735	102 808	95 006	98 366	1.3	-0.6	0.5
Bolivia (Plurinational State of)	2 079	2 212	2 547	3 077	3 331	2.1	3.4	2.7
Brazil	6 808	7 321	8 654	8 750	8 445	2.4	-0.3	1.2
British Virgin Islands	55 687	52 034	42 177	38 998	41 864	-2.7	-0.1	-1.6
Canada	37 841	40 910	40 936	43 286	44 668	0.8	1.1	0.9
Cayman Islands	96 322	92 585	78 726	79 794	84 193	-2.0	0.8	-0.7
Chile	8 810	10 372	11 857	13 732	14 358	3.0	2.4	2.8
Colombia	3 886	4 333	5 082	6 085	6 302	2.7	2.7	2.7
Costa Rica	7 636	8 523	10 049	11 393	12 237	2.8	2.5	2.7
Cuba	4 100	5 177	6 701	7 609	7 942	5.0	2.1	3.7
Curaçao		23 268	21 609	19 948	18 568		-1.9	
Dominica	6 177	6 598	7 491	7 392	7 080	1.9	-0.7	0.8
Dominican Republic	3 896	4 294	5 431	6 535	7 537	3.4	4.2	3.7
Ecuador	4 227	4 925	5 351	6 150	6 035	2.4	1.5	2.0
El Salvador	3 009	3 289	3 452	3 713	3 931	1.4	1.6	1.5
Greenland	33 156	36 672	43 402	44 329	47 962	2.7	1.3	2.1
Grenada	7 060	8 700	8 177	9 333	10 383	1.5	3.0	2.2
Guatemala	3 266	3 373	3 612	3 924	4 040	1.0	1.4	1.2
Guyana	2 644	2 748	3 420	4 137	4 438	2.6	3.3	2.9
Haiti	822	738	710	780	783	-1.5	1.2	-0.3
Honduras	1 804	2 004	2 152	2 341	2 516	1.8	2.0	1.9
Jamaica	4 907	5 132	4 880	4 943	5 112	-0.1	0.6	0.2
Mexico	8 611	8 671	8 629	9 298	9 592	0.0	1.3	0.6
Montserrat	9 379	10 765	10 775	11 979	11 955	1.4	1.3	1.4
Netherlands Antilles	22 534	24 166	23 342			0.4		
Nicaragua	1 457	1 590	1 704	2 097	2 137	1.6	2.9	2.1
Panama	6 955	7 815	10 231	13 628	14 894	3.9	4.8	4.3
Paraguay	3 310	3 942	4 793	5 447	5 970	3.8	2.8	3.3
Peru	3 372	3 902	5 115	6 048	6 460	4.3	3.0	3.7
Puerto Rico	27 681	30 258	28 629	28 139	25 822	0.3	-1.3	-0.4
Saint Kitts and Nevis	14 693	16 050	15 927	17 005	17 147	0.8	0.9	0.9
Saint Lucia	7 758	7 978	9 306	9 363	9 852	1.8	0.7	1.3
St.Vincent and the Grenadines	4 993	6 159	6 554	6 901	7 207	2.8	1.2	2.1
Sint Maarten (Dutch part)		28 001	30 624	27 521	23 006		-3.5	
Suriname	5 839	7 061	8 399	8 654	8 308	3.7	-0.1	2.0
Trinidad and Tobago	10 619	15 316	18 116	18 427	16 673	5.5	-1.0	2.5
Turks and Caicos Islands	24 517	26 393	24 672	26 020	28 476	0.1	1.8	0.8
United States of America	48 763	52 912	52 924	56 965	59 729	0.8	1.5	1.1
Uruguay	10 079	10 158	13 373	15 525	16 278	2.9	2.5	2.7
Venezuela (Bolivarian Republic of)	10 284	10 666	11 805	11 055	6 102	1.4	-7.9	-2.9

Source: FAO, 2020c.
* Regional sums include only the countries shown.

FIGURE 2. Social expenditures in selected Latin America and the Caribbean countries* (n=17; percent of GDP)



Source: (ECLAC, 2020a); (* includes Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, the Dominican Republic and Uruguay).

1.1.3 Social indicators

The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development, such as having a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions (UNDP, 2020). In general, countries in LAC region have a medium HDI value (0.55–0.69), a figure that has been improving over the past decade. A few countries in each subregion are ranked as high (above 0.7–0.8) or very high (>0.8), while Haiti, in the Caribbean, four countries of Central America, and Suriname in South America are in the low range (<0.69) (UNDP, 2019).

Latin America and Caribbean governments have generally been slowly increasing their spending on education and social activities as a proportion of total gross domestic product (GDP) (Figure 2), although growth rates have decreased in the latter part of the 2010s (Table 4). The highest proportion of these expenses goes into education, health and social protection, although environmental protection, housing and community services, health, recreation, culture and religion are also included. This increased expenditure will no doubt improve sectoral sustainability and wellbeing of societies but could also increase aquaculture production costs.

1.1.4 Macroeconomics

Gross Domestic Product per person statistics in the LAC region are only showing modest growth and are currently below world average values (Table 3). At times, GDPs have been falling, particularly between 2010 and 2018, resulting in similar average values for all subregions. However, cumulative average growth rates for the years 2010–2018 were higher in Central America, lower in the Caribbean, and negative in South America with significant variations between countries (Table 3), particularly within the Caribbean, as the low populations in small island states make only minor contributions to regional GDP statistics.

As will be discussed later, this may have contributed to the slowdown in aquaculture production growth in recent years. Meanwhile, the COVID-19 pandemic is expected to result in severe GDP cuts during 2020, with an expected loss in the region of minus 5.3 percent (ECLAC, 2020b).

TABLE 4. Foreign Trade Balance in goods and services in selected Latin America and the Caribbean countries, 2000–2019 (Current USD million)*

Country	2000	2005	2010	2015	2018	2019
South America	**-2 842**	**81 369**	**45 742**	**-56 055**	**-16 324**	**-13 971**
Argentina	-1 846	11 806	12 271	-6 393	-11 122	9 833
Brazil	-14 837	30 323	-22 995	-20 784	7 195	-6 104
Chile	1 361	10 701	14 044	-536	-540	-1 022
Colombia	-836	-5 068	-4 536	-20 721	-15 925	-20 421
Ecuador	878	-358	-3 139	-2 708	-1 240	43
Guyana	-104	-207	-531	-340	-452	-559
Paraguay	710	1 091	790	538	473	72
Peru	-1 036	4 822	5 871	-4 912	4 085	2 832
Suriname	0	0	617	0	0	0
Uruguay	-757	335	398	-198	1 202	1 355
Venezuela (Bolivarian Republic of)	13 625	27 923	42 952	0	0	0
Central America	**-18 385**	**-26 106**	**-30 049**	**-43 288**	**-44 222**	**-17 390**
Belize	-172	-90	6	-128	-6	-6
Costa Rica	-100	-460	-698	-476	160	869
El Salvador	-1 774	-2 819	-3 624	-4 122	-5 122	-4 890
Guatemala	-1 689	-4 337	-4 342	-6 364	-7 835	-8 034
Honduras	-884	-1 787	-2 839	-3 552	-4 574	-4 046
Mexico	-11 463	-14 071	-14 439	-23 875	-22 824	-674
Nicaragua	-1 077	-1 446	-1 702	-2 300	-1 217	-609
Panama	-1 226	-1 096	-2 411	-2 470	-2 804	0
Caribbean	**6 101**	**13 559**	**11 432**	**19 761**	**4 808**	**-10 783**
Antigua and Barbuda	-32	-137	-155	-68	0	0
Bahamas, The	-287	-381	-885	-329	-645	0
British Virgin Islands	0	0	0	0	0	0
Cuba	-861	1 141	3 119	2 336	1 909	0
Curacao	0	0	0	0	0	0
Dominica	-39	-67	-96	-72	-277	-218
Dominican Republic	-2 018	-1 803	-5 735	-3 308	-4 238	-4 994
Grenada	-74	-247	-196	4	-11	-12
Haiti	-819	-1 246	-3 272	-2 664	-3 998	-3 451
Jamaica	-1 072	-2 234	-2 413	-2 309	-2 060	-2 158
Puerto Rico	11 423	17 638	20 847	26 402	14 111	0
Sint Maarten (Dutch part)	0	0	0	0	0	0
St. Kitts and Nevis	-99	-53	-155	4	17	49
St. Lucia	0	0	0	0	0	0
St. Martin (French part)	0	0	0	0	0	0
St. Vincent and the Grenadines	-21	-91	-206	0	0	0
Trinidad and Tobago	0	0	0	0	0	0
Turks and Caicos Islands	0	0	0	0	0	0
Virgin Islands (U.S.)	0	1 040	580	-234	0	0

Source: The World Bank Group, 2020b
*Regional sums include only countries shown.

Hunger, malnutrition, micronutrient deficiencies and obesity particularly affect women, indigenous people, Afro-descendants, people with lower incomes and rural families in Latin America and the Caribbean (UNICEF, 2018). The FAO Panorama of Food and Nutrition Security 2017 focuses on the close link between economic and social inequality and higher levels of hunger, obesity and malnutrition in the most vulnerable populations (FAO and PAHO, 2017).

In Latin America, 8.4 percent of women live in severe food insecurity, compared with 6.9 percent of men, while indigenous populations are generally more food-insecure than non-indigenous populations. In ten countries, the poorest 20 percent of children suffer three times more from chronic malnutrition than do the richest 20 percent. Obesity is growing rapidly in the region with an additional 3.6 million people added to this category each year and 60 percent of the regional population (250 million) classed as overweight.

Meanwhile, hunger affects 39.3 million people, 6.1 percent of the regional population. Between 2015 and 2016, the number of undernourished people grew by 200 000 while between 2016 and 2017, the increase was 400 000, indicating a deteriorating situation.

Since 2014, Argentina, Bolivia (Plurinational State of) and Venezuela (Bolivarian Republic of) have experienced increases in the number of undernourished people. The largest increase occurred in Venezuela (Bolivarian Republic of) where 3.7 million or 11.7 percent of the population are undernourished, while there are also high levels of undernourishment in Haiti (5 million, 45.7 percent of the population) and Mexico (4.8 million, 3.8 percent of the population). Meanwhile undernourishment levels in the following eleven countries have not increased; Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, Panama and Paraguay, and levels in Brazil, Cuba, Peru and Uruguay are below 2.5 percent of their population.

Social and economic inequalities are also seen in child nutrition. In Honduras, chronic malnutrition affects 42 percent of children in lower-income families and only eight percent of those who live in higher income categories. In Guatemala, the difference is greater as it affects the poorest 66 percent, but only 17 percent of the children of families with higher incomes. However, there is significant variation across the region.

1.1.5 Trade balance, industries, foreign debt, and fish contribution

The LAC region has a diversity of industries and economies, including resource extraction, agriculture, manufacturing and services, including tourism. In the Caribbean subregion, for example, Guyana, Suriname and Trinidad and Tobago depend on commodities, while Bahamas, Barbados, Jamaica and the Organization of Eastern Caribbean States (Anguilla, Antigua and Barbuda, British Virgin Islands, Dominican Republic, Grenada, Martinique, Montserrat, Saint Kitts and Nevis, Saint Lucia and, Saint Vincent and the Grenadines), rely on services, with emphasis on tourism. Despite these differences, all face the challenges of weak fiscal institutions, crime and violence, slow private sectors, weak development policies and emigration of skilled workers. Recurring natural disasters exacerbate the situation and are expected to increase in frequency with climate change (IDB, 2018).

While data on foreign trade balances are incomplete, Table 4 shows negative foreign trade balances for the period 2000 to 2019 and there are no separate figures available for fisheries or aquaculture. The combined agriculture and fisheries contribution to local GDP figures in 2017 was four percent in the Caribbean compared to 8.1 percent in Central America and eight percent in South America. These contributions were much smaller than the relative contributions from sectoral services and manufacturing.

1.2 SALIENT ISSUES

The economies of Caribbean countries are generally based on services (particularly tourism) or commodities, but all face limitations of weak fiscal institutions, weak development policies, high crime and violence, a rather slow private sector, and emigration of the skilled work force. Natural disasters are expected to increase in frequency and strength which will exacerbate the situation (IDB, 2018).

FAO (2020b) forecasts significantly increased fish consumption in the Latin America and the Caribbean region by 2030 from current relatively low levels. Global fish consumption rates are projected to reach 21.5 kg/person in 2030, (up from 20.3 kg in 2017) and are expected to increase in all regions except Africa while the highest growth rate in per capita consumption is projected for Latin America. Nevertheless, the region is expected to still have the lowest average fish consumption rate in the world (along with Oceania). This predicted pattern of growth is important for aquaculture development within the LAC region, since it will build important export markets as well as increase domestic demand.

Whatever the cause, slow economic development in most LAC countries indicates that aquaculture faces a number of macro-level and micro-level economic challenges that are likely to affect future development prospects. As will be explored further in this report, it is already anticipated that even with promising foreign markets, overall aquaculture production growth rates are likely to decrease in the LAC region.

1.3 THE WAY FORWARD

Aquaculture has the capacity to contribute to economic and social wellbeing. However, mechanisms enhancing its contribution to positive social trends need to be put in place. Aquaculture can and should contribute to food security in LAC, which will be needed as nutritional challenges will definitely increase as a result of the COVID-19 pandemic.

Development and growth of aquaculture in LAC countries will depend on multiple factors (political, economic, social, cultural, human and technological) which must be faced with governance models that sustain activity in the long-term.

It is expected that better sectoral governance throughout the region will offset challenging social, economic and sustainability situations during this decade, helping to increase the contribution that aquaculture makes to regional wellbeing and food security.

2. General characteristics of the sector

2.1 STATUS AND TRENDS

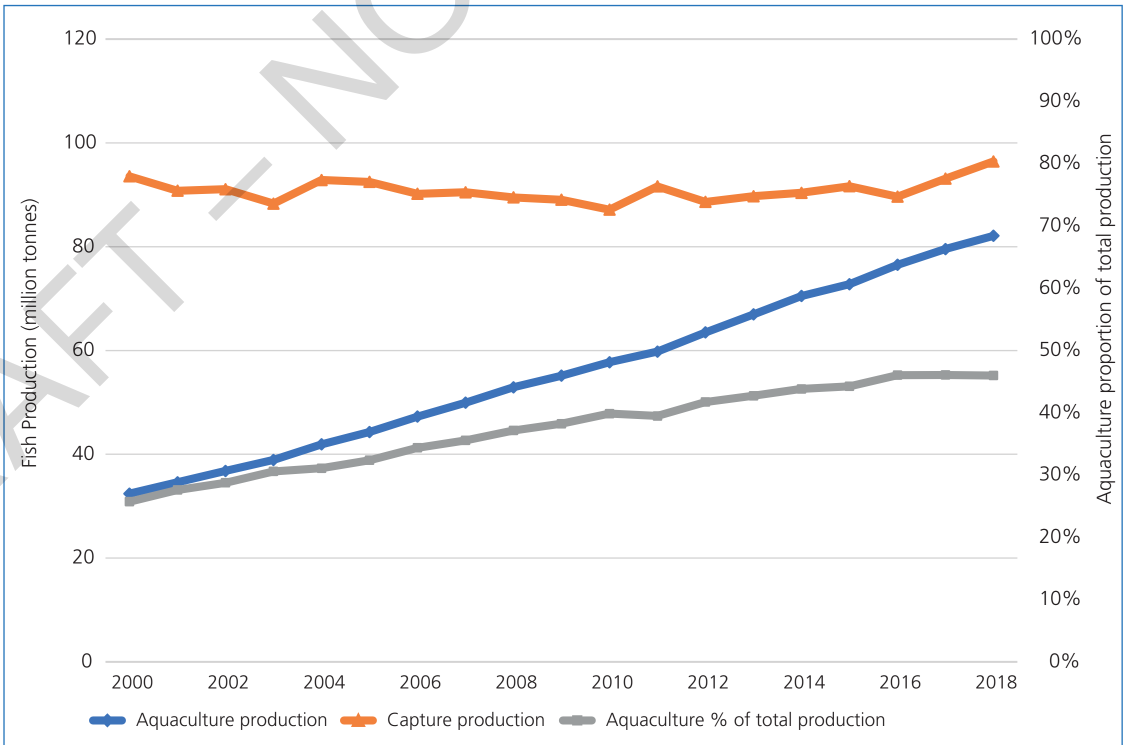
2.1.1 Background

World capture fisheries production has plateaued since the mid-1990s and was estimated at 96.4 million tonnes in 2018. On the other hand, aquaculture production (excluding aquatic plants), has continued to grow to 82.1 million tonnes in 2018, accounting for 46 percent of total production (Figure 3) and 52 percent of fish destined for human consumption.

Latin America and the Caribbean fisheries, largely for small pelagic fish from Peru and Chile, are quite volatile and have generally declined since the mid-1990s (Figure 4). However, in 2018, the wild fishery output increased by 29 percent, reaching 14.4 million tonnes. Meanwhile, there has been steady growth of aquaculture production (excluding aquatic plants) in the region, from 0.8 million tonnes in 2000 to more than 3.1 million tonnes in 2018 (Table 5). In 2018, LAC aquaculture production represented 3.8 percent of global aquaculture production and about 18 percent of the total LAC fish production (Figure 4).

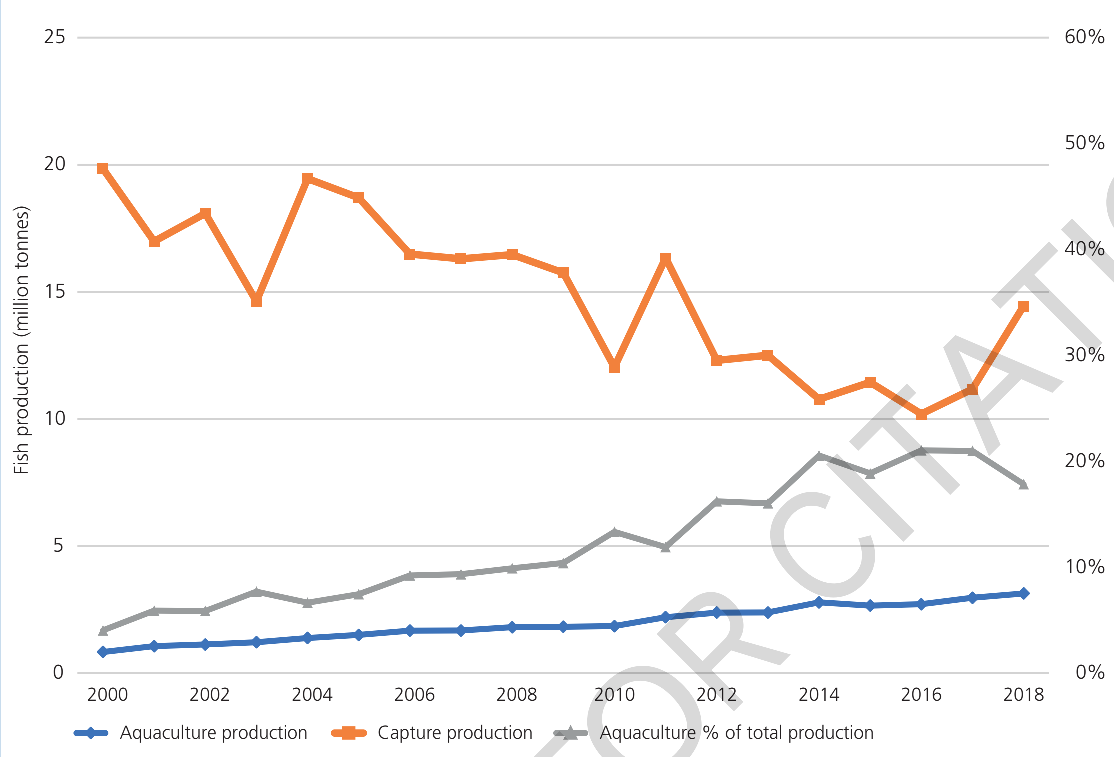
The total value of LAC aquaculture in 2018 was USD 17.2 billion, representing 6.9 percent of global aquaculture value. The great majority of this LAC value was generated in South America (91 percent) while Central America and the Caribbean contributed 8.6 percent and 0.4 percent, respectively. These are 6.2, 0.6 and 0.03 percent of global aquaculture values, respectively (Table 6). Growth in annual value of LAC production from 2010 to 2018

FIGURE 3. World fish production by capture fisheries and aquaculture 2000–2018 (excl. aquatic plants)



Source: FAO, 2020c.

FIGURE 4. Fish production by capture fisheries and aquaculture in the Latin America and the Caribbean region, 2000–2018 (excl. aquatic plants)



Source: FAO, 2020c.

TABLE 5. Aquaculture production in Latin America and the Caribbean by volume and subregion, 2000–2018 (tonnes/year) (excl. aquatic plants)

	2000	2010	2018	2018 % LAC	2018 % World	Compound Annual Growth Rate – (CAGR)
Caribbean	39 705	37 169	34 311	1.1%	0.04%	-1.0%
Central America	88 747	238 858	410 403	13.1%	0.50%	7.0%
South America	710 487	1 579 559	2 694 919	85.8%	3.28%	6.9%
LAC total	838 939	1 855 585	3 139 634	100.0%	3.82%	6.8%
Total World	**32 417 727**	**57 743 941**	**82 095 054**	--	--	--

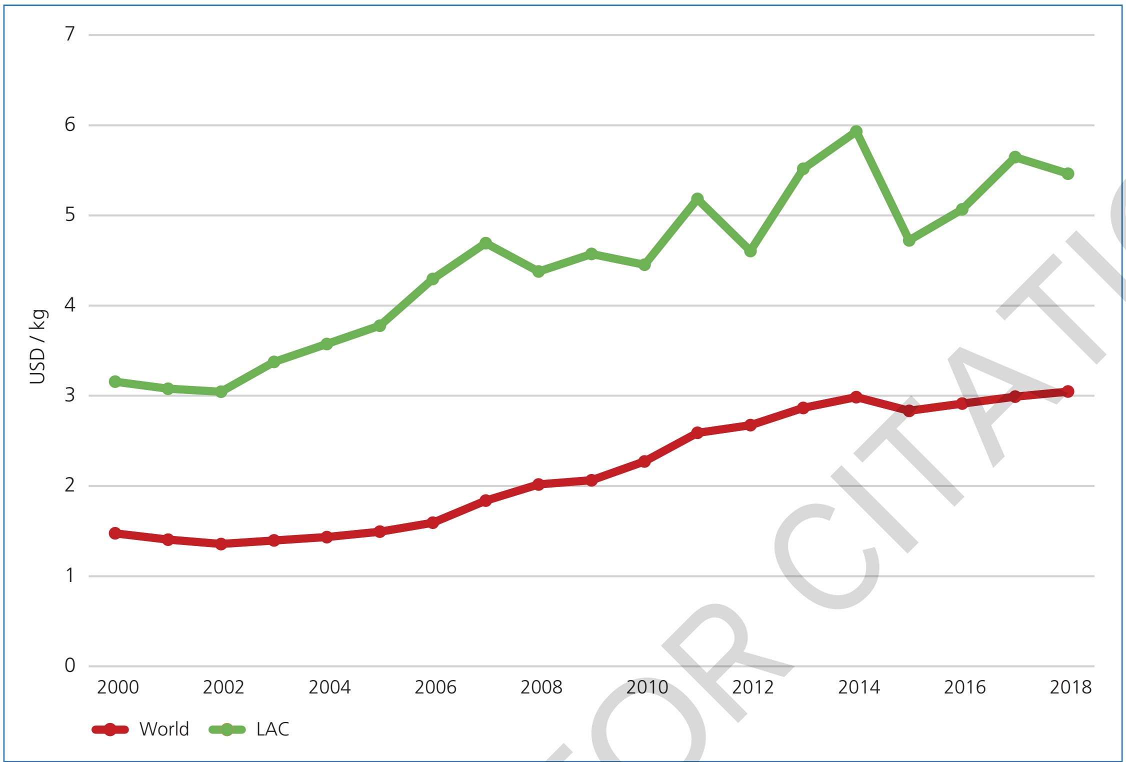
Source: FAO, 2020c.

TABLE 6. Value of Latin America and the Caribbean aquaculture production, by subregion, and comparisons, 2000, 2010 and 2018 (USD 1 000/yr)

	2000	2010	2018	2018 % LAC	2018 % World	Compound Annual Growth Rate (CAGR)	Relative value 2018 (USD/KG)
Caribbean	58 618	66 195	63 838	0.4%	0.03%	-0.5%	1.86
Central America	383 291	871 928	1 473 745	8.6%	0.59%	6.8%	3.59
South America	2 206 372	7 323 943	15 614 462	91.0%	6.24%	9.9%	5.79
LAC total	2 648 281	8 262 065	17 152 044	--	6.86%	9.6%	5.46
Total World	**47 796 466**	**131 214 611**	**250 115 178**	--	--	**8.4%**	**3.05**

Source: FAO, 2020c.

FIGURE 5. Average ex-farm value in Latin America and the Caribbean and world aquaculture (USD/kg)



Source: FAO, 2020c.

was 9.6 percent, similar to the world average of 8.4 percent over the same period[1]. On a subregional basis, South American aquaculture value grew by 9.9 percent per year, Central American aquaculture value grew by 6.8 percent and Caribbean aquaculture lost 0.5 percent of value per year over the same period. The relative average ex-farm value of production (USD/kg) has been consistently high, particularly in South America, which is a distinctive characteristic of the LAC region when compared with other continents (Figure 5).

2.1.2 Latin America and the Caribbean regional aquaculture production

The dominant aquaculture producers in the LAC region in 2018 were Brazil, Chile and Ecuador, who were jointly responsible for 77 percent of total production. Chile alone produced 1.2 million tonnes or 40 percent of LAC aquaculture production (Table 7). These countries and the fourth placed country, Mexico, have retained their relative positions since 2010. The remaining top-15 aquaculture producing countries in LAC were the same as those in 2010, although in different relative positions and included Colombia, Paraguay, Peru and Venezuela (Bolivarian Republic of) in South America, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama in Central America and Cuba in the Caribbean.

The same 15 countries that led the 2018 production rankings were also the top 15 by value, although with somewhat differing relative positions (Table 8). Chilean aquaculture achieved the highest value for its production, representing 61 percent of LAC aquaculture ex-farm value for 2018. Ecuador was second, with 16 percent of LAC value, whereas Brazil was in third place with just under eight percent. These values represent 4.2 percent, 1.1 percent, and 0.5 percent of world aquaculture values in 2018, respectively (Table 8).

[1] Unless otherwise noted, values are expressed as “current” USD equivalents – i.e. the values and exchange rates in the year being reported, without correction for inflation or currency exchange.

TABLE 7. Top 15 aquaculture producing Latin America and the Caribbean countries by volume in 2000, 2010 and 2018 (Live weight equivalent in tonnes/yr; excl. aquatic plants)

Country	Rank 2010	Rank 2018	2000	2010	CAGR 2000–2010	2018	2018 (% LAC)	2018 (% World)	CAGR 2010–2018
Chile	1	1	391 587	701 062	6%	1 266 054	40%	1.54%	7.7%
Brazil	2	2	172 450	411 047	9%	605 000	19%	0.74%	5.0%
Ecuador	3	3	61 311	272 721	16%	539 750	17%	0.66%	8.9%
Mexico	4	4	53 918	126 238	9%	247 192	8%	0.30%	8.8%
Colombia	6	5	61 786	80 367	3%	132 756	4%	0.16%	6.5%
Peru	5	6	6 585	89 021	30%	103 597	3%	0.13%	1.9%
Honduras	8	7	10 053	27 509	11%	65 000	2%	0.08%	11.3%
Nicaragua	12	8	5 435	16 972	12%	29 468	1%	0.04%	7.1%
Venezuela (Bolivarian Republic of)	11	9	13 410	18 225	3%	29 000	1%	0.04%	6.0%
Cuba	7	10	32 780	31 422	0%	28 628	1%	0.03%	-1.2%
Guatemala	10	11	3 963	22 792	19%	28 317	1%	0.03%	2.8%
Costa Rica	9	12	9 708	26 839	11%	20 820	1%	0.03%	-3.1%
Paraguay	17	13	103	2 957	40%	11 536	0%	0.01%	18.5%
Panama	14	14	1 779	6 598	14%	10 445	0%	0.01%	5.9%
El Salvador	15	15	261	4 500	33%	8 600	0%	0.01%	8.4%
Total LAC	--	--	**838 939**	**1 855 585**	**8%**	**3 139 634**	--	**3.8%**	**6.8**
Total World	--	--	**32 417 727**	**57 743 941**	**6%**	**82 095 054**	--	--	**4.5**

CAGR: Compound Annual Growth Rate
Source: FAO, 2020c.

Average annual growth rates in value for the period 2010 to 2018, (not corrected for inflation and currency changes) ranged from minus 5.6 to 30 percent with an overall average of 9.6 percent. El Salvador, Paraguay and Venezuela (Bolivarian Republic of) had particularly high growth rates (Table 8). However, all of these countries still have relatively low levels of production, so small changes in species or an increase in activity of a few large producers has a large effect.

The contribution of aquaculture to total fish production in LAC has increased steadily, reaching 18 percent in 2018 (Figure 4), although in the following eleven countries, aquaculture already accounted for over 30 percent of production: Honduras (86 percent), Colombia (66 percent), Guatemala (62 percent), Costa Rica (60 percent), Cuba (56 percent), Ecuador (47 percent), Paraguay (47 percent), Brazil (46 percent), Chile (37 percent), Nicaragua (35 percent) and Bolivia (Plurinational State of) (33 percent) (FAO, 2020c).

2.1.3. Aquaculture in the Caribbean subregion

Caribbean aquaculture production of 34 311 tonnes in 2018 only represented 0.04 percent of world aquaculture, meaning that it is a relatively limited economic activity across most of the subregion. Moreover, production levels have varied since 2000 and fallen by an average of one percent per year in the period 2010 to 2018 (Table 5).

This subregion consists of small countries and territories depending mainly on tourism with limited natural resources beyond their exclusive economic zone in the Caribbean Sea. Their fisheries tend to be overexploited, to supply growing tourist demand, while there is also competition for physical space. Nevertheless, as fisheries decline, aquaculture aspires to fulfil local seafood needs as well as to generate export revenues or reduce seafood imports. In 2018, Caribbean aquaculture accounted for 18 percent of total fish production in the

TABLE 8. Latin America and the Caribbean aquaculture production values by top 15 countries, in 2000, 2010 and 2018 (excl. aquatic plants)*

Country	Rank 2018 volume	Rank 2018 value	2000	2010	2018	2018 (% LAC)	2018 (% World)	CAGR 2010–2018	Relative value 2018 (US$/KG)
Chile	1	1	1 249 506	3 753 276	10 446 268	60.9%	4.2%	13.6%	8.3
Ecuador	3	2	321 567	1 250 821	2 799 442	16.3%	1.1%	10.6%	5.2
Brazil	2	3	271 294	1 306 956	1 345 833	7.8%	0.5%	0.4%	2.2
Mexico	4	4	226 221	375 130	811 245	4.7%	0.3%	10.1%	3.3
Peru	6	5	37 387	662 598	416 876	2.4%	0.2%	-5.6%	4.0
Colombia	5	6	257 612	261 782	390 667	2.3%	0.2%	5.1%	2.9
Honduras	7	7	51 008	108 465	264 035	1.5%	0.1%	11.8%	4.1
Guatemala	11	8	19 342	130 553	137 251	0.8%	0.1%	0.6%	4.8
Venezuela (Bolivarian Republic of)	9	9	52 807	55 187	121 615	0.7%	0.0%	10.4%	4.2
Costa Rica	12	10	32 715	127 488	98 596	0.6%	0.0%	-3.2%	4.7
Nicaragua	8	11	29 602	64 245	81 021	0.5%	0.0%	2.9%	2.7
Panama	14	12	5 895	31 138	55 591	0.3%	0.0%	7.5%	5.3
Paraguay	13	13	218	5 952	48 638	0.3%	0.0%	30.0%	4.2
Cuba	10	14	33 482	38 985	44 813	0.3%	0.0%	1.8%	1.6
El Salvador	15	15	1 085	9 422	23 857	0.1%	0.0%	12.3%	2.8
Total LAC	--	--	**2 648 281**	**8 262 065**	**17 152 044**	--	**6.9%**	**9.6%**	**5.5**
Total World	--	--	**47 796 466**	**131 214 611**	**250 115 178**	--	--	**8.4%**	**3.0**

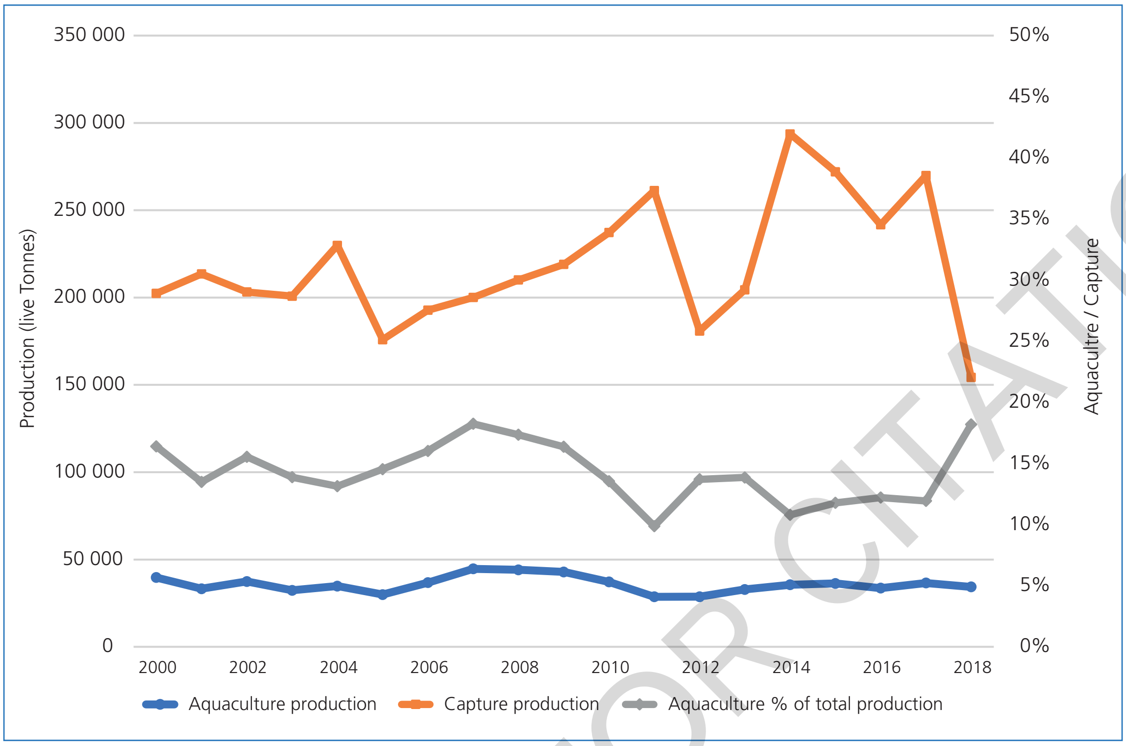
Source: FAO, 2020c.
* Values expressed in 1 000 USD per year.

subregion (Figure 6). However, the relative proportion from aquaculture varied greatly in the years 2010 to 2018 because of fluctuations in capture fisheries statistics.

Despite relatively low production levels, aquaculture makes a significant contribution towards food production and livelihoods in many Caribbean countries (CRFM, 2014). For example, tilapia development projects implemented by FAO were part of the disaster response effort in Haiti after the devastating earthquake in 2010, while aquaponics (growing fish with vegetables in recirculation systems) is also being pursued in several countries. Countries such as Cuba, Dominican Republic and Jamaica have formulated aquaculture development plans, which should lead to increased and more sustainable production in the coming years while many projects are underway, supported by foreign aid or implemented by start-up companies (Ewing-Chow, 2019).

Most of the aquaculture production in the subregion comes from freshwater farms with Nile tilapia (*Oreochromis niloticus*) as the main target species, while there is also a striped catfish (*Pangasianodon hypophthalmus*) project in the Dominican Republic (White, 2019). Shrimp (marine and freshwater) projects intended for export were frequent in the region, but currently do not show significant production, except for a Puerto Rican project in Sabana Grande producing *Macrobrachium rosenbergii* (giant river prawn). Red algae and a red drum (*Sciaenops ocellatus*) project in Martinique (Paquotte, 1998) achieved high enough production levels in marine waters to be registered in the FAO database. The seaweeds, *Gracilaria* and *Eucheuma* are traditionally consumed in the Caribbean and seaweed farming has for many years been considered a good way to provide employment. Saint Lucia was ranked among the top ten seaweed producing countries of the subregion in 2018. This included successful algae production for direct human consumption, rather than only relying on the market for chemical extraction of agar (Atlantic Gold Sea Moss, 2021). Current proposals for marine aquaculture also include "offshore" cobia (*Rachycentron canadum*) farming (Thomas *et al*., 2019).

FIGURE 6. Caribbean fish production from capture fisheries and aquaculture, 2000–2018, (excl. aquatic plants)



Source: FAO, 2020c.

Cuba leads Caribbean aquaculture in terms of production volume. This is primarily based on culture-based fisheries of silver carp in freshwater reservoirs to meet domestic needs. In 2018, Cuban production also included whiteleg shrimp (*Litopeneaus vannemei*), African catfish (*Clarias gariepinus*), and common carp (*Cyprinus carpio*). Current plans focus on using genetically improved tilapia, although recent production levels have been relatively low (IPS CUBA, 2018). Cobia pilot-scale projects have been implemented recently and oyster (*Crassostrea* spp.) farming is included in the newly adopted National Mariculture Strategy for the country (FAO, 2018) where the main objective of aquaculture is to satisfy demand in domestic markets in response to ongoing trade embargos, while also generating income from exports.

Many other Caribbean countries have similar histories of species introductions and variable aquaculture development trajectories. In many cases, national and government goals are complemented by interest in exports by private companies, even though the Caribbean has a long-standing deficit in domestic fish supplies.

Overall growth in Caribbean aquaculture has been negative in the period 2010–2018, with high variability between countries (Table 9).

2.1.4. Aquaculture in the Central American subregion

Central America is the second largest fish-producing subregion in the LAC region, representing 15.5 percent and 13.1 percent of LAC fisheries and aquaculture production respectively. With 410 403 tonnes produced in 2018, the subregion accounts for 0.5 percent of world aquaculture production (Table 7). Both fisheries and aquaculture are growing in this region (Figure 7), with aquaculture production equivalent to about 15.5 percent of total fish production volume in 2018.

TABLE 9. Top 10 aquaculture producers in the Caribbean, 2010 and 2018 (live weight; tonnes/yr)

Country	2010 rank	2018 rank	2010	2018	2018 (% Caribbean)	CAGR 2010–2018
Cuba	1	1	31 422	28 628	83.4%	-1.2%
Dominican Republic	3	2	1 280	2 500	7.3%	8.7%
Jamaica	2	3	3 952	1 616	4.7%	-10.6%
Haiti	4	4	360	1 400	4.1%	18.5%
Martinique	5	5	82	49	0.1%	-6.2%
Barbados	12	6	2	26	0.1%	37.5%
Guadeloupe	9	7	11	24	0.1%	10.2%
Puerto Rico	6	8	17	20	0.1%	2.1%
Saint Lucia	11	9	6	15	0.0%	13.4%
Antigua and Barbuda	16	10	--	10	0.0%	--

Source: FAO, 2020c.

Aquaculture production in Central America grew by an average of 7.0 percent between 2010 and 2018. However, growth rates have varied greatly between the countries of the subregion (Table 10). Mexico accounted for 60 percent of Central American aquaculture production in 2018, coming mainly from whiteleg shrimp and tilapia farming, although a total of 22 species were farmed. Honduras was the second largest Central American producer in 2018, accounting for 15.8 percent of total production, growing only whiteleg shrimp and tilapia. However, Honduran production statistics may be significantly higher, as it seems that processed product weight rather than live weight may have been used when collecting production data. In countries such as Honduras, tilapia and shrimp production are successful export businesses and offer local employment (The Healthy Fish, 2019). Costa Rica, Guatemala and Nicaragua contribute five to seven percent each to the Central American aquaculture total, whereas Belize, El Salvador and Panama contribute less than three percent each. All of these countries primarily produce tilapia and whiteleg shrimp, with cobia farming accounting for 17 percent of Panama's 2018 aquaculture production.

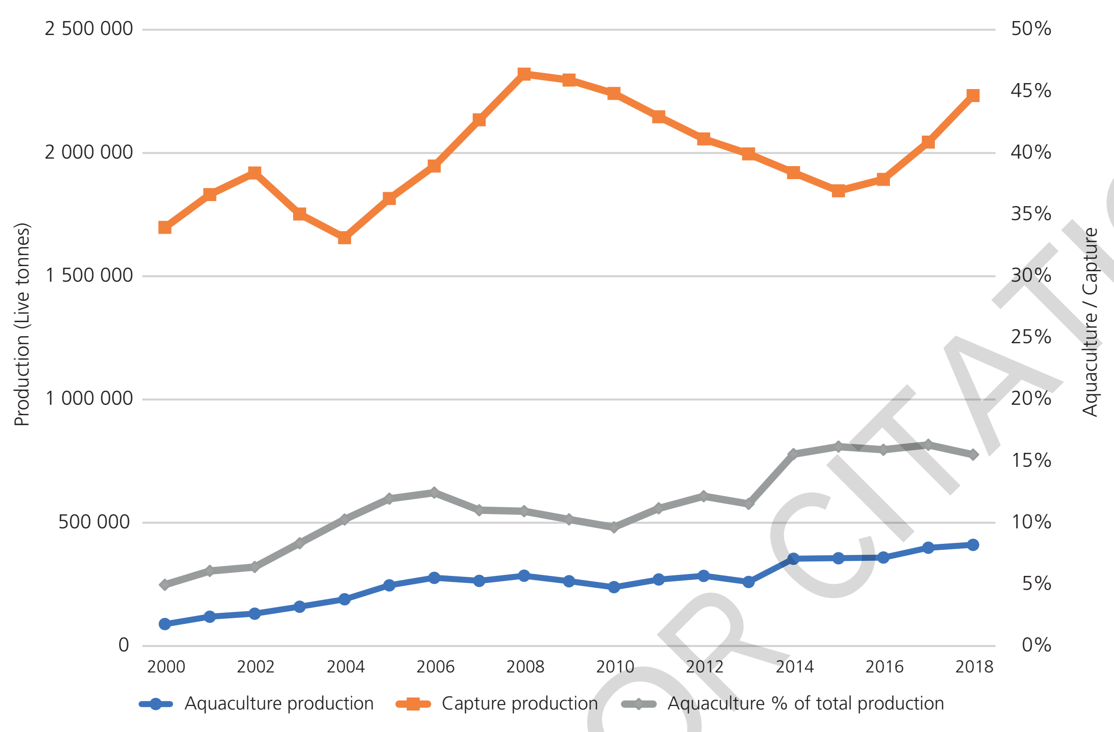
The most significant type of aquaculture business in Central America is large-scale, vertically integrated, private companies, focused on export markets. In both Honduras and Costa Rica, single, large international aquaculture firms export more than 95 percent of national tilapia production, thus concentrating most of the production assets. In Honduras alone, the largest shrimp export company has a shrimp farm covering more than 5 500 hectares.

TABLE 10. Central American aquaculture production by country, 2010 and 2018 (excl. aquatic plants)

Country	Rank 2010	Rank 2018	2010 (tonnes)	2018 (tonnes)	2018 (% Central America totals)	CAGR (2010–2018)	Main species (2018)
Mexico	1	1	126 238	247 192	60.2%	8.8%	WL shrimp, tilapia
Honduras	2	2	27 509	65 000	15.8%	11.3%	Tilapia, WL shrimp
Nicaragua	5	3	16 972	29 468	7.2%	7.1%	Nile tilapia
Guatemala	4	4	22 792	28 317	6.9%	2.8%	WL shrimp, tilapia
Costa Rica	3	5	26 839	20 820	5.1%	-3.1%	Tilapia, WL shrimp
Panama	7	6	6 598	10 445	2.5%	5.9%	WL shrimp, tilapia, cobia
El Salvador	8	7	4 500	8 600	2.1%	8.4%	Tilapia, WL shrimp
Belize	6	8	7 411	560	0.1%	-27.6%	WL shrimp
Total Central America			238 858	410 403	100.0%	7.0%	--

Source: FAO, 2020c.
WL: Whiteleg

FIGURE 7. Fisheries and aquaculture production in Central America, 2000–2018 (excl. aquatic plants)



Source: FAO, 2020c.

There are also many mid-sized and small-scale aquaculture farms throughout the region that provide employment and play important roles in local food and nutrition security. However, official statistical records are weak in many countries of the subregion. OSPESCA carried out the only Central American aquaculture census (excluding Mexico), which recorded around 3 300 farms with various scales of production (OSPESCA, 2012) while more than 56 000 aquaculturists operating more than 9 000 farms were recorded in Mexico (CONAPESCA, 2020). Smaller scale or livelihood-based aquaculture systems are also present but may not be recorded in the FAO database. These include the farming of algae (for export) and small-scale tilapia and characid pond culture for domestic consumption.

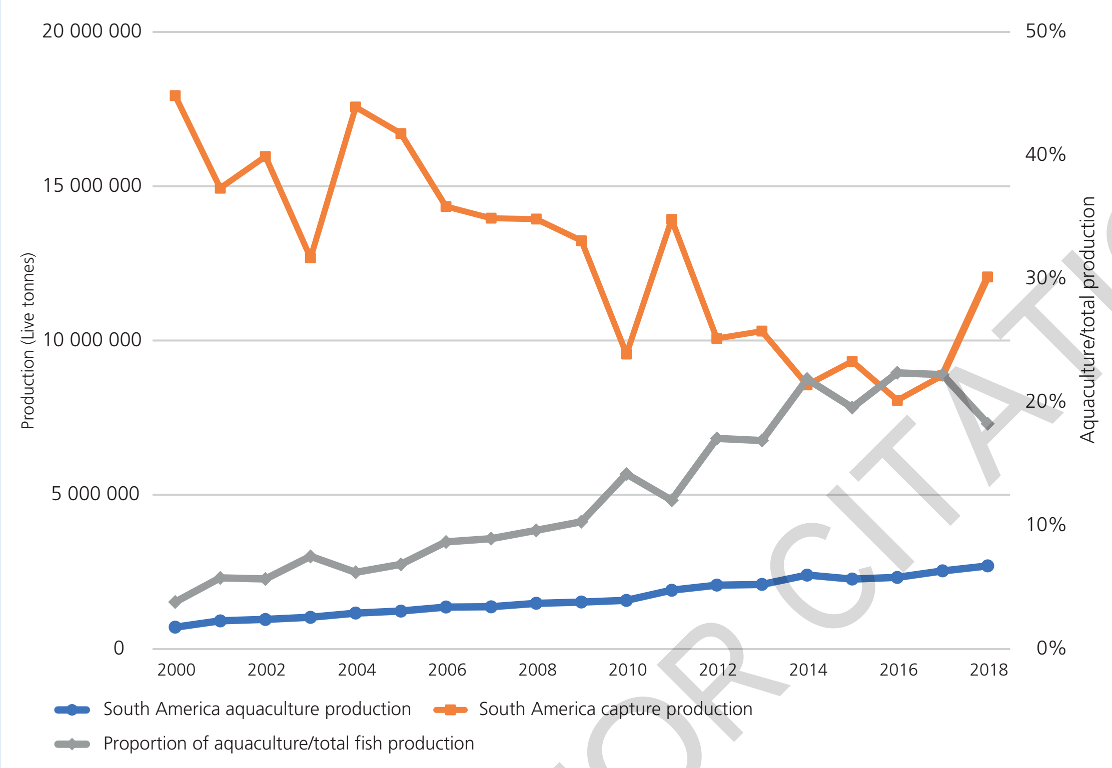
While there has been an overall reduction in the number of mid to large-scale farms, due to consolidation into larger firms and conglomerates, small-scale aquaculture units remain an important part of territorial economies as they provide self-employment and access to fish protein, even though countries of the subregion lack adequate sectoral policies. Meanwhile, countries such as Mexico and Costa Rica, are developing contract-rearing systems for aquaculture, linking small and mid-sized companies to larger, export-oriented aquaculture firms.

2.1.5. Aquaculture in the South American subregion

Aquaculture production in the South American subregion was 2.7 million tonnes in 2018, representing 18 percent of total fisheries and aquaculture production in the LAC region (Figure 8), or 35 percent of total fish production if the anchovy fishery is excluded. There has been steady aquaculture progress across most of the subregion since 2000, while capture fisheries production decreased over the same period.

The average annual growth rate of South American aquaculture between 2010 and 2018 was 6.9 percent, which is lower than in earlier time periods and varied somewhat from year to year (Table 11).

FIGURE 8. South American capture fisheries and aquaculture production, 2000–2018



Source: FAO, 2020c.

TABLE 11. South American aquaculture production by country ranked by 2018 volume compared to 2010 (excl. aquatic plants)

Country	Rank 2010	Rank 2018	2010 (tonnes)	2018 (tonnes)	2018 (% South America totals)	CAGR (2010–2018)	Main species (2018*)
Chile	1	1	701 062	1 266 054	47.0%	7.7%	Atlantic salmon, Chilean mussel
Brazil	2	2	411 047	605 000	22.4%	5.0%	Tilapia, cachama, WL shrimp
Ecuador	3	3	272 721	539 750	20.0%	8.9%	WL shrimp
Colombia	5	4	80 367	132 756	4.9%	6.5%	Tilapia, trout, pirapatinga
Peru	4	5	89 021	103 597	3.8%	1.9%	Trout, WL shrimp, scallop
Venezuela (Bolivarian Republic of)	6	6	18 225	29 000	1.1%	6.0%	WL shrimp, tambatinga
Paraguay	7	7	2 957	11 536	0.4%	18.5%	Tilapia, pacu
Bolivia	9	8	856	3 500	0.1%	19.2%	Trout, cachama, pirapatinga
Argentina	8	9	2 654	3 205	0.1%	2.4%	pacu, trout
Guyana	10	10	488	307	0.0%	-5.6%	shrimp nei, cachama
Suriname	12	11	71	110	0.0%	5.6%	cachama, WL shrimp
Uruguay	11	12	85	102	0.0%	2.3%	Sturgeon
French Guiana	13	13	4	2	0.0%	-8.3%	Fresh water fish nei, cyprinidsnei
Falkland Is.(Malvinas)	14	14	--	--	0.0%	--	n/a
Total South America	**--**	**--**	**1 579 559**	**2 694 919**	**--**	**6,9%**	

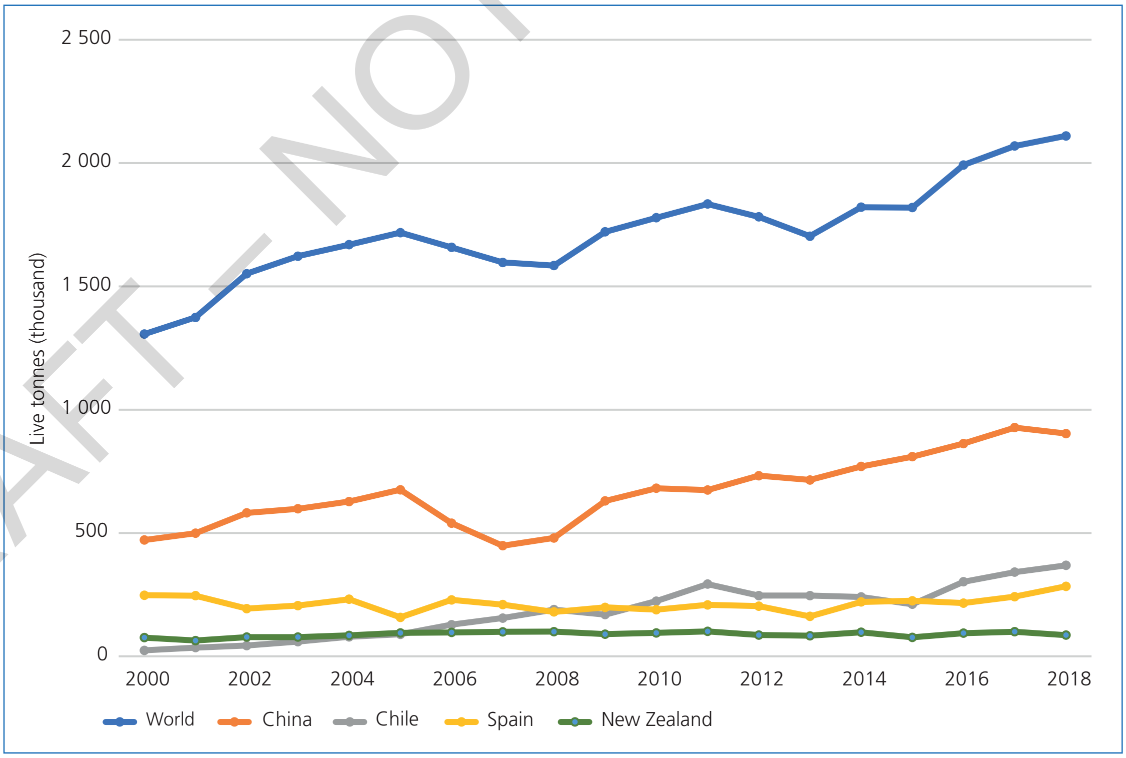
* Species with over 10 percent of country's production in 2018, ordered by volume level
Source: FAO, 2020c

Chile is the leading marine aquaculture country, responsible for 47 percent of all South American aquaculture production in 2018, second only to Norway in global salmon production and to China in global mussel production. The main aquaculture species grown in Chile were Atlantic salmon (*Salmo salar*), Chilean mussels (*Mytilus chilensis*), rainbow trout (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*) intended primarily for exports.

There has been continued consolidation and growth of the Chilean salmon industry, with two major acquisitions worth over USD 800 million during 2018 (FAO, 2019). Production has expanded in the southern Magellan region, as although it is still controversial, it provides an opportunity for antibiotic-free and sustainable aquaculture certification (ASC, 2020). However, production levels are still less than in the Aysén and Los Lagos regions (Chavez *et al.*, 2019). Salmon production has been more strictly regulated in Chile with improved biosecurity after the ISA virus outbreak of 2007 to 2011. This stabilized growth leading to production of almost one million tonnes in 2019 (Cerda, 2019).

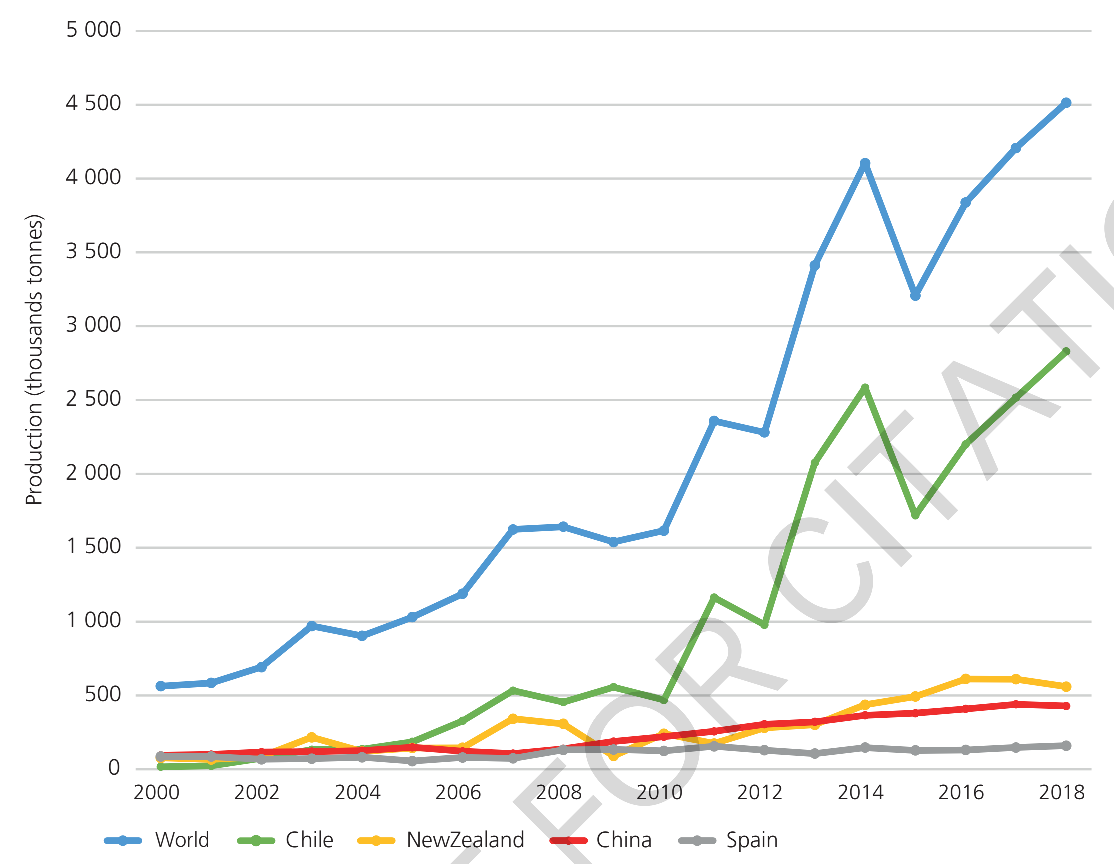
Chilean mussel production has also expanded in recent years, with growth since 2015 seeing it surpass Spain as the second highest global producer (Figure 9). Production has recovered from a period of poor spat availability and phytoplankton supply (Figueroa and Dresdner, 2016; Molinet *et al.*, 2017). Chile is also the largest mussel exporter in the world, and a world leader in terms of value. As shown in Figure 10, the value of Chilean mussels was apparently 63 percent of the world total in 2018, ahead of both New Zealand and China. However, this is likely to be an over-estimate. Chilean mussels are now sold in many countries, but particularly in Europe, Russia and Brazil, sometimes with environmental certification (Mejillon de Chile, 2017).

FIGURE 9. Chilean mussel production volumes and comparisons, 2000–2018



Source: FAO, 2020c.

FIGURE 10. Chilean mussel production values and comparisons, 2000–2018



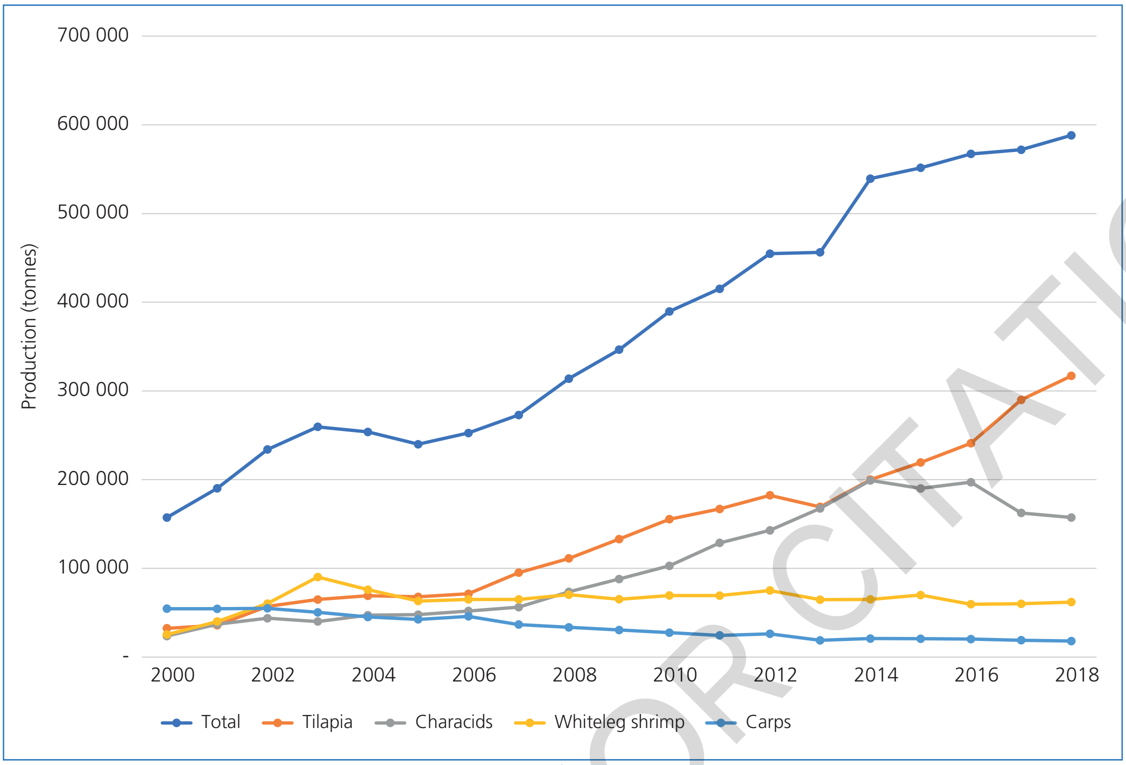
Source: FAO, 2020c.

Brazil registered the second largest aquaculture production volume in South America in 2018 (22.4 percent of the subregional total), mainly of tilapia (the leading species in the subregion), cachama (*Colossoma macropomum*) and whiteleg shrimp, mostly for domestic consumption (Figure 11).

Brazilian aquaculture growth has been modest, as droughts reduced aquaculture output in several states, primarily in the Northeast Region, where water quality and quantity in reservoirs and ponds deteriorated. This was offset by the approval in 2018 of tilapia culture in several north-eastern states, coinciding with the approval of striped catfish culture in some southern states (PeixeBR, 2020). Characid culture volumes declined in this period, apparently due to a combination of drought, disease, processing and market challenges as well as tougher environmental licensing (PeixeBR, 2020). Coincidentally, Chinese characid production also dropped at this time (FAO, 2020c). Meanwhile, shrimp production remained fairly constant with growth limited by recurring disease problems and the government pushing for the opening of markets that were previously closed (Maranghetti, 2017). All three of the main aquaculture products in Brazil are supplying expanding domestic markets. The country also had annual imports of around USD 1.4 billion of fish and fish products in recent years.

The Brazilian Ministry of Fisheries and Aquaculture (MPA) was closed in 2016, with responsibilities for these activities returning to the Ministry of Agriculture as a vice-ministry (SAP) and an ambitious aquaculture production plan for 2015–2020, targeting farmed output of 2 million tonnes by 2020 may have been lost in the process (Prado and Neves, 2015). Nevertheless, wide-spread assistance programmes for small-scale aquaculture production continued (SEBRAE, DNOCS, CODEVSF and state initiatives) as well as research activities supported by EMBRAPA and several state and federal universities throughout the country.

FIGURE 11. Brazilian aquaculture production, 2000–2018



Source: FAO, 2020c.

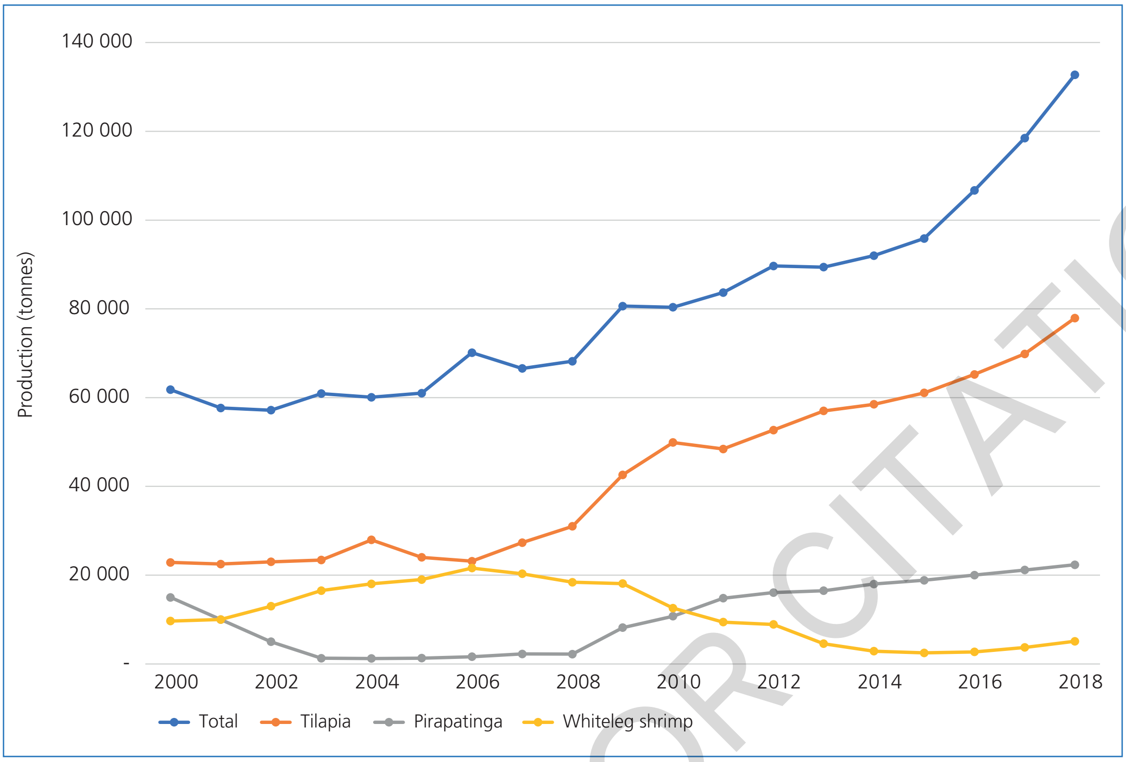
Ecuador was the fifth most important shrimp farming country in the world in 2018 producing over 500 000 tonnes, mainly of whiteleg shrimp for export. This represented 20 percent of total aquaculture production in the subregion (Table 11). Because of the relatively high value of shrimp, Ecuador surpassed Brazil in terms of aquaculture value in 2018 and 2010 (Table 8).

The Ecuadorian shrimp industry recovered remarkably quickly from shrimp viral disease problems and the economic down-turn of 1999 to 2001, becoming the fifth largest global shrimp producer and achieving an average annual growth rate of 8.9 percent from 2010 to 2018. Furthermore, Ecuadorian shrimp farmers have successfully introduced polyculture of tilapia and shrimp, offsetting years of high volatility in the shrimp market.

Ecuador created the Ministry of Aquaculture and Fisheries in 2017, separating the vice-ministry that was part of the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP). However, a year later, the state portfolio was eliminated and merged as a vice-ministry within the Ministry of Production, Foreign Trade, Investments and Fisheries (MPCEIP). Despite this, little has been achieved to promote the development of small and medium-size producers. The development of the shrimp industry is driven by private initiatives, while fish farming is promoted in only a limited manner.

Peru, faced with declining wild fisheries catches over the last 20 years, considers aquaculture as the means by which the fish sector can regain its success. Aquaculture production grew by an average of 14.4 percent per year between 1998 and 2018 although growth slowed down to only 1.9 percent per year between 2010 and 2018, reaching an output of almost 104 000 tonnes in 2018. This was mainly based on trout, shrimp and scallops (*Argopecten purpuratus*), together with tilapia and several Amazonian species. A National Aquaculture Plan was developed (2010–2021) and is still in place, followed by a 2016 General Law on Aquaculture and a 2017 National Innovation Programme in Fisheries and

FIGURE 12. Colombian aquaculture production, 2000–2018



Source: FAO, 2020c.

Aquaculture (Vaque, 2017) funded by the Peruvian Government and the World Bank. This USD 120 million programme is expected to make a substantial contribution to accelerate production growth, diversification and training of personnel.

Colombian aquaculture is based on tilapia and Amazonian fish species. Production showed steady annual growth of six percent from 2010 to 2018 which was tempered by reduced production of rainbow trout and whiteleg shrimp (Figure 12). A National Plan for Sustainable Aquaculture (PlanDAS) was developed in 2014, but its impact is not yet evident in production figures.

Venezuela (Bolivarian Republic of) also experienced a six percent cumulative average annual aquaculture growth rate in 2010 to 2018, based mainly on increased shrimp production. This was most likely facilitated by reduced production costs associated with the country's economic difficulties (Maranghetti, 2017). It is still unknown how this production might be affected by the ongoing uncertainty of the political situation.

Aquaculture in both Paraguay and Bolivia (Plurinational State of), the two landlocked countries in South America, grew at annual average rates of 19 percent in the period 2010 to 2018, but this still represents only modest quantities of farmed fish. In Paraguay, tilapia production plateaued in 2015, whereas pacu culture has grown, particularly from 2016 to 2018, along with small amounts of another characid (*Leporinus* sp.), a native catfish (*Pseudoplatystoma* sp.) and a resurgence of common carp production. Tilapia and combined characids represented 60 percent and 32 percent of 2018 total production, respectively. Bolivia (Plurinational State of) reported particularly robust growth starting in 2014–2015 for both trout and characids, each accounting for 47 percent of total 2018 production. This coincides with governmental and internationally supported aquaculture programmes. The largest and most developed farms are concentrated in the tropical territories of Beni, while less intensive trout farms are largely concentrated in Titicaca Lake and surrounding areas. Increased production has been the result of improved management and expansion of characid culture in response to growing domestic demand.

Argentinian aquaculture is almost entirely freshwater and is relatively undeveloped relative to its potential in both inland and marine environments. Pacu has overtaken trout as the main species in this decade (FAO, 2020c), although mainly cultured by one large firm located in the subtropical north-east of the country. Plans to introduce salmon aquaculture in 2018 to southern waters have met political and social resistance and are likely to be abandoned for now.

Other South American countries such as Guyana, Suriname and Uruguay recorded only minimal amounts of aquaculture production while there was none in Falkland Islands (Malvinas) over the period 2010 to 2018 and less than a tonne produced in French Guyana in 2018. Uruguay has focused on sturgeon production, whereas Guyana is trying to develop cachama, shrimp, tilapia and other species. Meanwhile, other countries contributed less than five percent of total subregional production in 2018 of mixed species including tilapia, shrimp and characids.

2.1.6 Aquaculture species diversity

In terms of species diversity, countries in South America recorded production of 62 species of fish, shellfish and molluscs in 2018, while 33 species were farmed in Central America and 23 in the Caribbean. Only two aquatic plants and a microalga were farmed in the region in significant quantities.

However, only a few species accounted for most of the production with high contributions from introduced species such as tilapia and salmonids (Figures 13 and 14) in addition to species native to LAC waters such as mussels, shrimp, scallops and characins.

In 2013, 80 percent of freshwater aquaculture production concentrated on eight species, whereas in 2018, only four species accounted for 81 percent of production (FAO, 2020c). Tilapia was the main type of fish grown in freshwater aquaculture systems (59 percent of production), followed by characins, salmonids and carps (Figure 13). Nile tilapia was the most important of the four farmed tilapia species (Table 12), while there were 19 species of native characins, even though production concentrated on just three; cachama, pacu, tambaqui and their hybrids (more information on characins in section 2.1.4.5 and table 14).

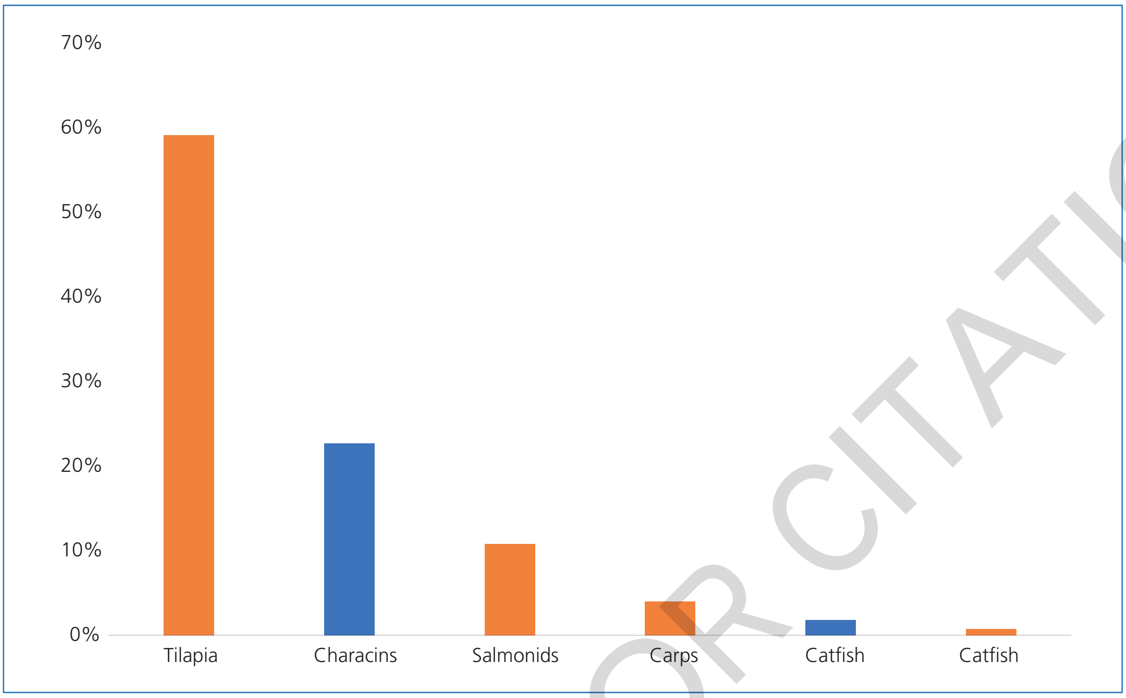
The contribution of introduced species to total inland aquaculture production rose from 67 percent of in 2013 to 75 percent in 2018 (Figure 13). Tilapia has played a key role here as its production continues to grow. However, native species were also important, particularly whiteleg shrimp and the Chilean mussel (Figure 14 and Figure 18). Nevertheless, production concentrated on only a few species. Three salmonids (Atlantic salmon, rainbow trout and

TABLE 12. ASFIS listed tilapia species grown in Latin America and the Caribbean, 2018

Species	2018 Volume (tonnes)	% LAC
Nile tilapia	433 490	78.1%
Tilapias nei	119 482	21.5%
Blue tilapia	1 887	0.3%
Blue-Nile tilapia, hybrid	48	0.0%
Mozambique tilapia	2	0.0%
Redbreast tilapia	--	0.0%
Total LAC	**554 910**	**100.0%**

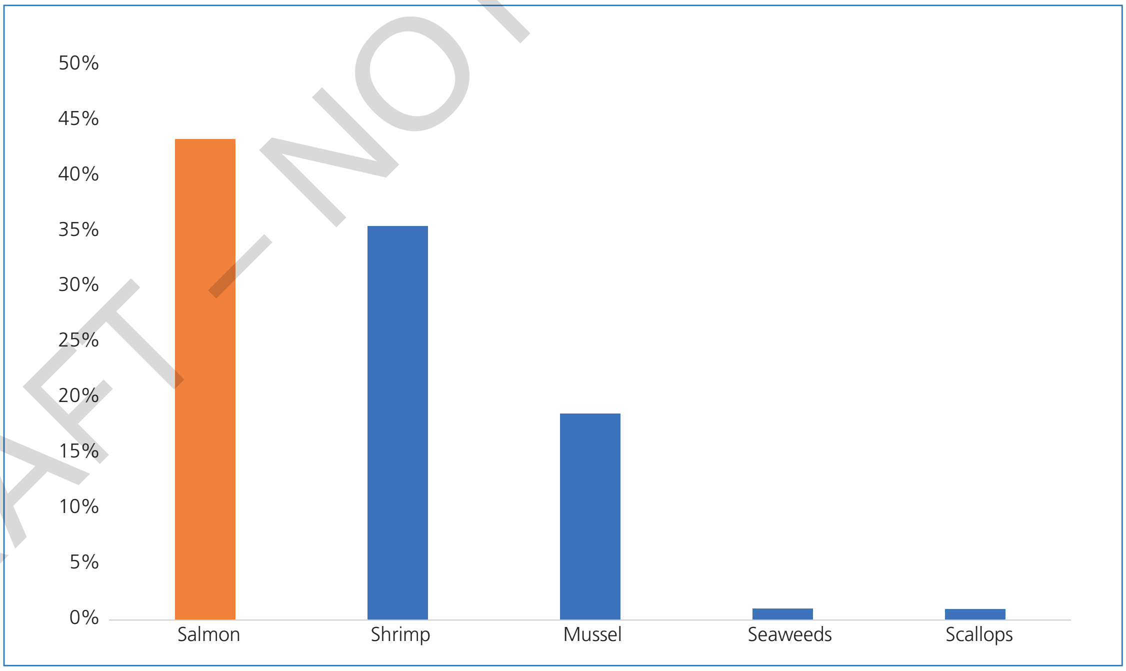
Source: FAO, 2020c.

FIGURE 13. Contribution of introduced (orange bars) and native species (blue bars) to Latin America and the Caribbean freshwater aquaculture (2018 production volumes in %; WAPI group classification)



Source: FAO, 2020c.

FIGURE 14. Contribution of introduced (orange bars) and native species (blue bars) to Latin America and the Caribbean marine aquaculture (2018 production volumes in %; WAPI group classification)



Source: FAO, 2020c.

coho salmon), whiteleg shrimp, Chilean mussel and calico scallop (*Argopecten gibbus*) together accounted for 96.8 percent of 2018 LAC aquaculture production. With the addition of *Gracilaria* seaweed and the South American rock mussel (*Perna perna*) this rises to 99.8 percent of total production.

2.1.7 Salmonids

Salmonid farming in Chile reached 987 thousand tonnes in 2018, with production based on three species: Atlantic salmon (*Salmo salar*) accounting for 74 percent of this total, coho salmon (*Oncorhynchus kisutch*) 17 percent, and rainbow trout (*Oncorhynchus mykiss*), nine percent. This industry has grown rapidly, making Chile the second largest salmon producer and exporter in the world since the early 2000s. After overcoming a disease crisis between 2007 and 2011, the industry went through a restructuring process that involved new expansion and growth. These changes reshaped it in terms of the number of firms, ownership, production levels, location and employment. Regulatory reform and a focus on biosecurity led to a significant increase in production costs over time, which reduced competitiveness (Chavez *et al.*, 2019). However, this was countered by market diversification, efforts to lower costs and entry into Latin American markets, especially Brazil, helped to overcome the crisis. The process was assisted by consolidation of the sector into six to eight companies over the past five years, building economies of scale for production and marketing (Cerda, 2019). Substantial local employment opportunities have been created under this model and product standardization is easier, facilitating export and production. Most marine farm sites produce between 2 000 and 6 000 tonnes in each 12 to 18 month production cycle. A 2018 proposal to replicate the Chilean model in southern Argentina supported by the aquaculture industry and government has stalled, due to public concerns about environmental and social impacts (Evans, 2019).

Cerda (2019) concluded that productivity gains and added value, through technological and productive innovation and decommodification, are essential to maintain competitiveness in the long-term accompanied by adequate governance allowing for sustainable production growth and access to suitable sites. This requires mechanisms that ensure consistent production according to the carrying capacity of the natural environment, and fruitful and positive relationships with the community, thereby maintaining a ‘social license’ to operate. During the last decade, regulatory and institutional changes have facilitated a recovery in competitiveness of the industry. However, maintaining competitiveness and promoting further growth will require significant and continuing innovation requiring greater investment in research and development compared to the worryingly low levels at present.

2.1.8 Mussels

The Chilean mussel farming industry is geographically focused in one southern region of Chile, although Santa Catarina in Brazil is also producing meaningful volumes of a similar species. Unlike salmon, the mussel industry evolved more slowly and is composed mostly of locally owned small and medium-sized producers. It is based on native species, relies on natural spat (vs hatcheries) and in the Chilean case, supplies a large export market, while Brazilian production is consumed locally. Spat collection is essentially small-scale, capture-based aquaculture that has provided an opportunity for many local artisanal fishers. Mussel farming in Chile relies mostly on one species, *Mytilus chilensis*, the Chilean mussel, using long-line production systems in fjords and coastal waters. The industry shares sheltered northern Patagonian seas with salmon farmers but mainly supplies the European market (compared to United States of America and Asian markets for salmon) and has standardized grow-out, harvesting and processing to supply an increasingly demanding market. This is the main reason for substantial value increases over the period 2000 to 2018, despite increased production costs during the grow-out stage.

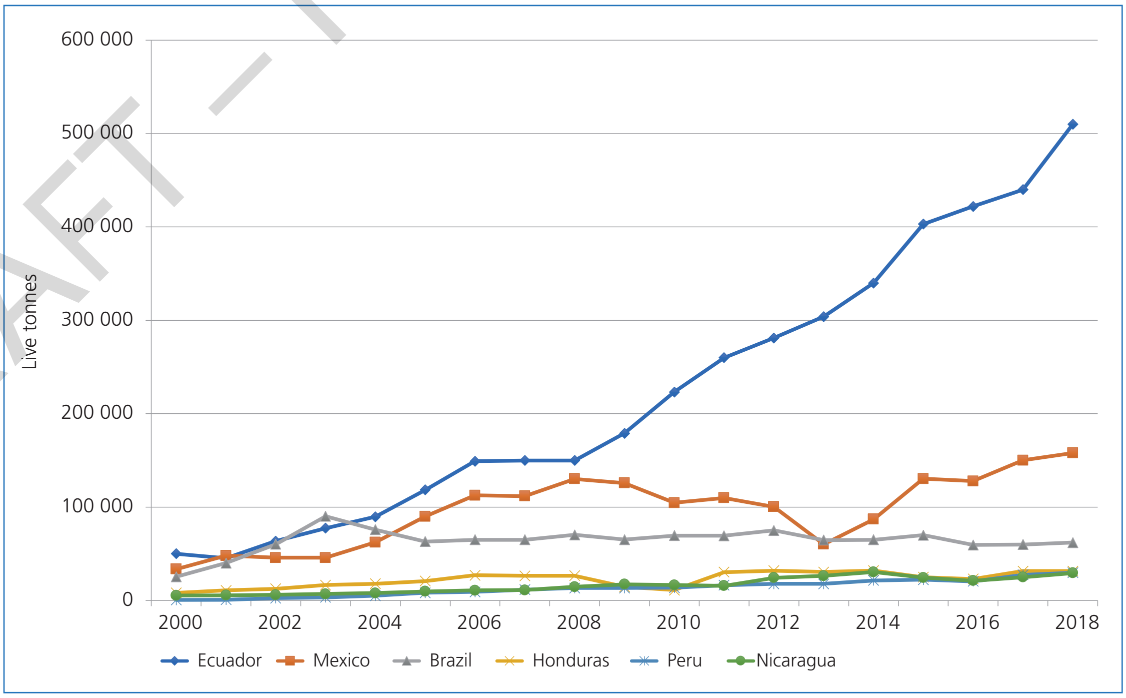
2.1.9 Shrimp

The main shrimp species grown in LAC is *Litopenaeus vannamei*, the Pacific whiteleg shrimp. Native to the Pacific coast from Peru to Mexico, its culture now makes up over 18 percent of world shrimp aquaculture production (FAO, 2020c). Marine shrimp culture in LAC has been dominated by Ecuador (Figure 15), primarily in semi-intensive brackishwater ponds.

The shrimp industry in LAC has rebuilt after a white spot virus epidemic in 1998–2001 that affected the sector in most countries of the region. Despite this, there has been a significant increase in production in more countries, with new systems and environments. Some changes in the LAC region included trials with lower densities, including polyculture with fish (for additional income and environmental benefits), ecosystem-based approaches, probiotic treatments, greater biosecurity, genetic selection for viral resistance, and higher density re-circulation systems, such as bio-floc. There has been investment by governments in disease control programmes and public services (such as electricity supplies), cooperation between farmers, disease monitoring and market dynamics have helped shape current production systems. In particular, Ecuador invested in biosecurity, improved management and environmental certification (Yahira Piedrahita, personal comm., 2020) and recovered quickly from its devastating white spot virus episode. Favourable Chinese markets in recent years, with reduced production in India and supplies from Vietnam, have enabled recent growth (FAO, 2019), although the COVID-19 pandemic has seriously affected shrimp consumption worldwide.

Similarly, Brazil and Colombia implemented government-supported programmes to overcome viral challenges. Both experienced low production growth and are now focused largely on domestic markets. Brazilian import barriers, initially implemented as mechanisms to protect against diseases (Rocha, 2011), more recently served as protection of the domestic market from competition by imports. This has recently been overturned (FAO, 2020d), which may result in re-alignment of the Brazilian shrimp industry, in search of more competitive production methods and better commercial strategies.

FIGURE 15. Production of whiteleg shrimp by Latin America and the Caribbean countries, 2000–2018



Source: FAO, 2020c.

2.1.10 Tilapia

Different species and farmed types of tilapia are grown throughout the LAC region, with first reported production in 1970. The main species reported for the LAC region in 2018 was Nile tilapia (Table 12), followed by tilapias nei (not elsewhere identified) underlining the difficulties in identifying particular species when there has been widespread hybridization. The other species reported were blue tilapia (*Oreochromis aureus*), Mozambique tilapia (*Oreochromis mossambicus*) and redbreast tilapia (*Coptodon rendalli*).

Tilapia is a freshwater fish of African origin that is now farmed throughout much of the tropics and subtropics. There are several genetically improved farmed types and most commercial fish farms grow all-male fish produced through hormone (methyltestosterone) treatment of first feeding juveniles for a short period. Brazil is the main LAC tilapia producer, accounting for 57 percent of regional production in 2018, and 5.3 percent of world production (Table 13). Colombia, Ecuador, Honduras and Mexico complete the list of top five producers in the region. Tilapia production in the LAC region increased by an average of ten percent per year between 2010 and 2018, with some countries (Mexico, Guatemala, and El Salvador) showing substantially higher growth rates over this period (Table 13 and Figure 16). While Brazil is an important global tilapia producer, most of its crop supplies the domestic market, where prices have been higher than those for exports (FAO, 2019).

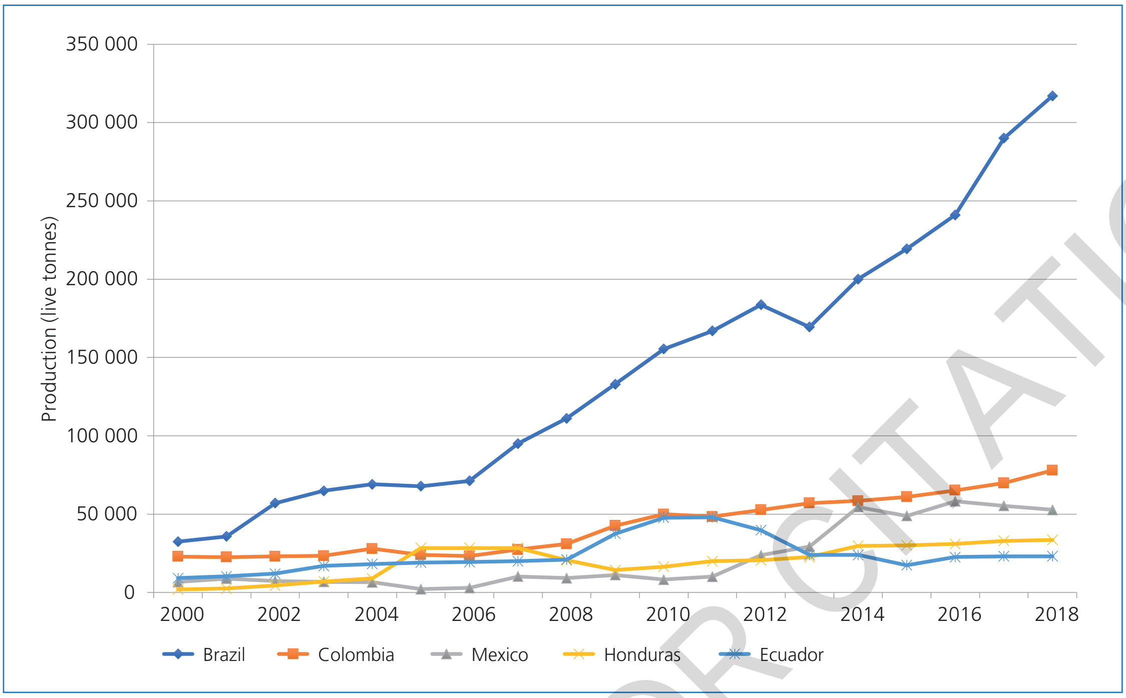
Tilapia farming is commonly promoted for farm diversification or community development in extensive or semi-intensive ponds, either as a monoculture or in polyculture systems, making use of natural feeds produced in ponds as well as a variety of supplementary feeds. More intensive culture is usually carried out in small and large scale, floating cages in freshwater reservoirs, a system that is common in Brazil. Higher intensity is achieved by growing the fish in re-circulating systems of tanks or raceways, often with aeration. Experience with recent droughts in Brazil may drive the industry to more of these high intensity solutions (Dantas Roriz *et al*., 2017). Robust domestic and export markets exist, although price competition from China is challenging. The limited production in Central America primarily targets higher-priced export markets in the United States of America and Europe, with value-added and environmentally certified products (FAO, 2019).

TABLE 13. Latin America and the Caribbean: Top tilapia-producing countries, 2000–2018 (tonnes, live weight)

Country	Rank						
	2010	2018	2010	2018	2018 % LAC	2018 % World	CAGR 2010–2018
Brazil	1	1	155 451	317 000	57%	5.3%	9.32%
Colombia	2	2	49 893	77 933	14%	1.3%	5.73%
Mexico	6	3	8 243	52 748	10%	0.9%	26.11%
Honduras	5	4	16 455	33 500	6%	0.6%	9.29%
Ecuador	3	5	47 733	23 050	4%	0.4%	-8.70%
Costa Rica	4	6	23 034	16 200	3%	0.3%	-4.30%
Guatemala	10	7	846	10 910	2%	0.2%	37.66%
El Salvador	7	8	4 090	7 420	1%	0.1%	7.73%
Paraguay	8	9	2 366	6 912	1%	0.1%	14.34%
Peru	9	10	2 013	3 075	1%	0.1%	5.44%
Other	--	--	6 489	6 162	1%	0.1%	-0.64%
Total LAC	--	--	**316 612**	**554 910**	**100%**	**9.2%**	--
Total World	--	--	**3 494 266**	**6 029 660**	--	**100.0%**	--

Source: FAO, 2020c.

FIGURE 16. Tilapia production in the top five producing Latin America and the Caribbean countries, 2000–2018



Source: FAO, 2020c.

2.1.11 Characids

The characids (*Characidae* family) are a group of freshwater fish with natural distributions in the rivers and flood plains east of the Andes in South America, where they undergo large, seasonal, upstream spawning migrations, called piracema. They have an established reputation in local markets and culture technologies became well established in the early 1990s, including a move into interspecies hybridization facilitated by artificial reproduction. Farming of these species has expanded to most of the neighbouring countries, as well as to Asia in the early 2000s, where the majority of global production took place for several years. In the LAC region, they are grown in 16 countries. The characid group is not well separated in FAO statistics within the ISSCAAP classification used by FISHSTAT, but this problem has been resolved by using the World Aquaculture Performance Indicators (WAPI) 'Characid' category.

Thirteen species recognized in the Aquatic Sciences and Fisheries Information System (ASFIS) (including hybrids) are included in the characid group (Table 14), of which cachama (*Colossoma macropomum*) species and hybrids (also called 'round fishes' in Brazil) are the top five products, representing 92.5 percent of the characid volume grown in LAC in 2018. There is likely to be misreporting in these data, as production and distribution of hybrids is not well controlled and is under-recognized, while there are also regional nomenclature differences.

Brazil accounted for 81.7 percent of LAC characid production in 2018 and Colombia following with 11.5 percent. Growth from 2000 to 2015 was high in Brazil, after which it dropped (Table 15), but still averaged five percent annually over the period. Paraguay, Suriname and Bolivia (Plurinational State of), starting with low total production, showed particularly high growth rates, whereas characid production declined in Ecuador and Guyana.

Characids are primarily grown in earth ponds of different sizes using extensive to semi-intensive feeding systems. Cage culture and intensive culture has been tried but are not yet preferred practices. Both large companies and small farms contribute to this industry, supplying entirely domestic LAC markets.

TABLE 14. Characid group grown in Latin America and the Caribbean, 2018

Species (ASFIS)	2018 Volume (tonnes)	% total LAC Characid	% total World Characid
Cachama	105 777	50.6%	27.0%
Tambacu, hybrid	34 700	16.6%	9.0%
Pirapatinga	26 658	12.8%	6.9%
Pacu	15 853	7.6%	4.1%
Tambatinga, hybrid	10 097	4.8%	2.6%
[Brycon spp]	5 151	2.5%	1.3%
[*Leporinus* spp]	3 842	1.8%	1.0%
[*Brycon amazonicus*]	3 600	1.7%	0.9%
Prochilods nei	3 164	1.5%	0.8%
[*Brycon orbignyanus*]	90	0.0%	0.0%
[*Brycon cephalus*]	89	0.0%	0.0%
[*Prochilodus mariae*]	20	0.0%	0.0%
[*Brycon hilarii*]	--	0.0%	0.0%
Total LAC	**209 040**	**100.0%**	**54%**
Total World	**387 416**	**--**	**100%**

Source: FAO, 2020c

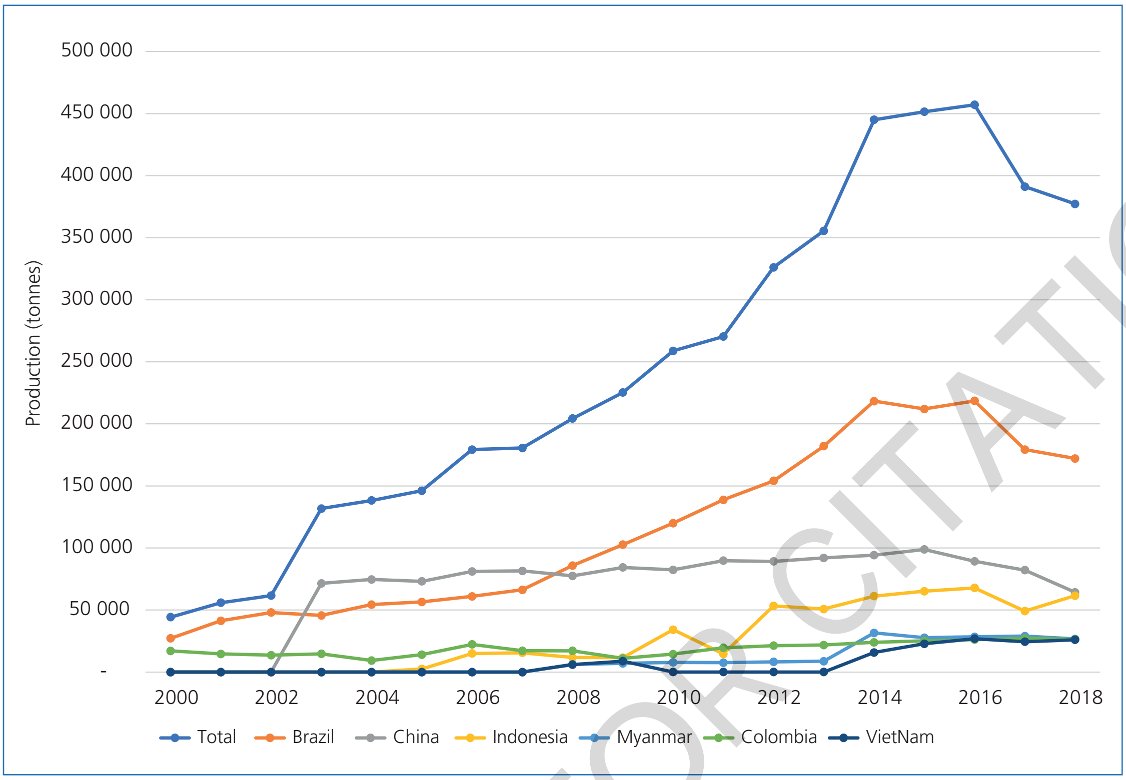
TABLE 15. Characid production in Latin America and the Caribbean countries, 2010 and 2018 (tonnes)

Country	Rank		Volumes (tonnes)		% LAC (2018)	% World (2018)	CAGR 2010–2018
	2010	2018	2010	2018			
Brazil	1	1	112 453	170 700	81.70%	44.10%	5.4%
Colombia	2	2	12 105	23 936	11.50%	6.20%	8.9%
Venezuela	3	3	4 423	4 380	2.10%	1.10%	-0.1%
Paraguay	8	4	362	3 174	1.50%	0.80%	31.2%
Peru	4	5	934	3 017	1.40%	0.80%	15.8%
Argentina	6	6	626	1 911	0.90%	0.50%	15.0%
Bolivia	7	7	374	1 650	0.80%	0.40%	20.4%
Guyana	9	8	116	92	0.04%	0.02%	-2.9%
Suriname	11	9	0	75	0.04%	0.02%	442.5%
Ecuador	5	10	870	40	0.02%	0.01%	-32.0%
Total LAC	**--**	**--**	**132 264**	**209 040**	**100%**	**54%**	**5.9%**
Total World	**--**	**--**	**256 636**	**387 416**	**--**	**--**	**5.3%**

Source: FAO, 2020c

On a global scale, Brazil accounted for 47 percent of total characid production in 2018, with China and Myanmar contributing 17 percent each (Figure 17). Production in both Brazil and China has fallen since 2015, whereas that of other Asian countries continues to grow slowly. In addition to Brazil, the only other globally important characid producer in LAC is Colombia.

FIGURE 17. Global characid production, 2000–2018



Source: FAO, 2020c.

2.1.12 Algae farming

Production of farmed algae in LAC amounted to 22 000 tonnes in 2018, valued at USD 53 million (Table 16). Farmed production accounts for only seven percent of total algae landings locally, meaning that harvesting of wild algae dominates production in the region (292 000 tonnes in 2018). The first record of algae production in LAC region dates from 1970. In 2018, 96.3 percent of LAC algae production came from Chile, 3.3 percent from Brazil and limited quantities were recorded in eight other countries.

Gracilaria seaweed, accounted for 94.3 percent of LAC production and 3.2 percent was Elkhorn sea moss (*Kappaphycus alvarezii*), both of which are red algae.

Farmed algae in the LAC region makes a limited contribution to global production (0.1 percent of volume and 0.4 percent in value). However, the average value of algae farmed in the region in 2018 (USD 2.41/kg) was much higher than the average world price (USD 0.41/kg). Asia was responsible for 99.5 percent of global farmed algae production in 2018 valued at USD 13.3 billion.

Even though regional algae production levels are limited, they have a positive impact on employment levels, particularly for rural farmers in southern and centre-north Chile, a good number of whom depend on these activities for their livelihood. Table 16 shows the basic statistics for LAC's algae production in recent years.

2.1.13 Emerging species

The drive for diversification of species in LAC aquaculture, particularly for culture of local species in South America, has continued for at least ten years. However, in most cases production is still at the pilot-scale level.

TABLE 16. Latin America and the Caribbean production of farmed algae and comparisons, 2000–2018

Region/Species	2000	2005	2010	2015	2016	2017	2018
World Farmed production, tonnes							
Asia	10 487 877	14 726 157	20 008 197	30 831 217	31 474 685	32 442 876	32 231 955
Africa	51 642	81 158	138 329	196 570	139 339	136 763	112 815
Americas	33 577	15 507	12 924	12 756	15 658	17 596	21 984
Oceania	16 424	8 139	12 809	20 406	18 803	13 300	14 040
Europe	6 040	290	2 058	2 899	2 007	2 366	5 396
World	10 595 560	14 831 251	20 174 317	31 063 848	31 650 491	32 612 902	32 386 189
LAC	33 577	15 507	12 924	12 756	15 658	17 596	21 984
LAC farmed production by subregion							
South America	33 577	15 493	12 909	12 687	15 602	17 536	21 914
Caribbean	--	14	15	6	29	34	37
Central America	--	--	--	63	27	27	33
LAC Production of algae extracted from the wild, tonnes							
Totals	**282 246**	**420 127**	**374 076**	**376 845**	**374 595**	**451 899**	**292 367**
Central America	33 555	5 277	1 128	11 331	13 115	8 657	6 750
South America	248 691	414 850	372 948	365 514	361 480	443 242	285 617
LAC/World, %	0.3	0.1	0.1	0.0	0.0	0.1	0.1
LAC Farmed/Totals (%)	**10.6**	**3.6**	**3.3**	**3.3**	**4.0**	**3.7**	**7.0**
LAC Farmed production by country, tonnes							
Chile	33 471	15 493	12 179	11 952	14 863	16 799	21 178
Brazil	--	--	730	730	730	730	730
Mexico	--	--	--	60	24	24	30
Grenada	--	--	--	1	22	18	20
Saint Lucia	--	14	15	2	5	14	14
Ecuador	--	--	--	--	5	5	5
Belize	--	--	--	3	3	3	3
Saint Vincent/Grenadines	--	--	--	1	1	1	2
Peru	11	--	--	2	1	2	1
Saint Kitts and Nevis	--	--	--	1		1	1
Uruguay	--	--	--	4	3	--	-
Venezuela (Bolivarian Republic of)	95	--	--	--	--	--	--
Totals - Tonnes - live weight	**33 577**	**15 507**	**12 924**	**12 756**	**15 658**	**17 596**	**21 984**
LAC Production by species, tonnes							
Gracilaria seaweeds	33 482	15 492	12 180	11 982	14 876	16 755	20 735
Elkhorn sea moss	95	--	700	700	705	705	706
[*Spirulina maxima*]	--		5	--	4	39	451
Eucheuma seaweeds nei	--	14	15	9	32	37	39
Brown seaweeds	--	--	--	--	24	24	30
[*Haematococcus pluvialis]*	--	--	12	--	13	35	23
Giant kelp	--	--	12	2	1	2	2
Aquatic plants nei	-	--	-	40	--	--	--
[*Spirulina platensis*]	--	--	--	4	3	--	--
[*Porphyra columbina*]	--	1	--	--	--	--	--
Spirulina nei	--	--	--	--	--	--	--
[*Sargassum* spp]	--	--	--	20	--	--	--
Spiny eucheuma	--	--	--	--	--	--	--
[*Chondracanthus chamissoi*]	--	--	--	--	--	--	--
Totals	**33 577**	**15 507**	**12 924**	**12 756**	**15 658**	**17 596**	**21 984**

Source: FAO, 2020c

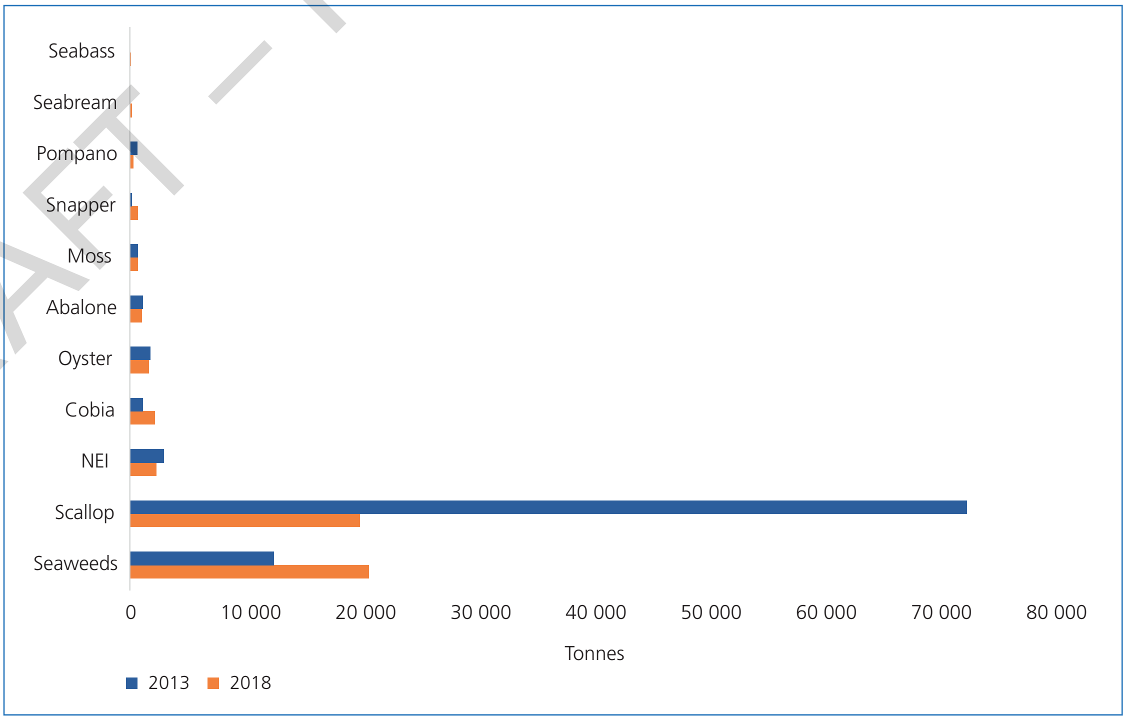
For example, in mariculture there have been increases in *Gracilaria*, cobia (*Rachycentron canadum*) and choro mussel (*Choromytilus chorus*) production, although crops of the latter two are still limited. While a number of recent commercial attempts to culture cobia have failed, one Panamanian company has proven successful and is already exporting. However, reductions in production levels of promising species seems to be more common. For example, there was a sharp decline in production of Peruvian calico scallop (*Argopecten purpuratus*) from 2013 to 2018 while production of Pacific cupped oysters (*Crassostrea gigas*) and mangrove oysters (*Crassostrea rhizophorae*) in Central America and cholga mussel (*Aulacomya atra*) in Chile also declined (Figure 18).

Most recent aquaculture plans (Peru, Colombia, Brazil) identify culture of native species as a priority and promote this as a path to sustainability. South America is one region in the world where development of aquaculture of native species is significant (FAO, 2017), but production advances are slow and still require substantial research investment and better organization. There has been criticism, especially within the industry, of academic research which favours government-supported aquaculture plans rather than investment in applied research. In 2018, Brazil initiated a large practical research development project through their 'Empresa Brasileira de Pesquisa Agropecuaria' (EMBRAPA), focused on tilapia, cachama, cobia and shrimp (EMBRAPA, 2018) including genetic selection programmes for tilapia, cachama and shrimp while other native fish species, like the *Arapaima* and native catfish have also been included.

Spirulina microalgae is produced in Chile and Uruguay for human consumption, while Chile also farms the microalga *Haematococcus pluvialis*, used in human health products and as a pigment in fish diets (FAO, 2020c). The red native alga *Gracilaria* is also grown in a number of countries and brown algae culture is under development in Chile.

The pirarucu or paiche (*Arapaima gigas*) has been considered as a promising aquaculture candidate for several decades. It is a freshwater fish native to the Brazilian Amazon, with the fastest growth rate and best feed conversion yet recorded for any fish (Du *et al.*, 2019) and continues to be a species of interest and investment for aquaculture in Brazil and Peru.

FIGURE 18. Emerging species farmed in Latin America and the Caribbean, 2013 and 2018 (tonnes)



Source: FAO, 2020c.

However, the limited quantity produced declined by 11 percent from 2013 to 2018. The main constraints to scaling up production are obtaining sufficient juveniles, as well as determining nutritional needs and the high cost of feeds. Meanwhile, this species has become invasive in Bolivia (Plurinational State of)) from Peruvian aquaculture escapees and it has also invaded Brazilian areas of the upper Amazon where it is not native, due to the expansion of hydroelectric reservoirs (Doria *et al.*, 2020; MacNaughton *et al.*, 2015).

Over the past decade, significant advances have been made in the culture of cobia (*Rachycentron canadum*), a fast-growing marine fish species with a widespread natural distribution in tropical waters and excellent biological and market characteristics for commercial aquaculture (Benetti, 2008). There was strong interest in the early 2000s, with trial farms in Belize, Brazil, Costa Rica, Colombia and Cuba as well as other parts of the world. However, interest declined somewhat after several failures due to high production costs and disappointing market reception (Urch, 2013). Nevertheless, cobia is still seen as a candidate for large, offshore cage culture in Central America or the Caribbean and culture of this fish continues in Panama, along with a small project in Honduras while it is also part of the EMBRAPA project and is being farmed by a few private firms in Brazil.

Striped catfish (*P. hypophthalmus*) is a major Asian aquaculture product that has seen phenomenal growth in Southeast Asia and is a significant competitor to LAC-produced tilapia, both in domestic and export markets. Given its rapid growth and hardiness, striped catfish has attracted the attention of fish farmers in a number of countries in LAC region, including a farm in the Dominican Republic which produced enough for it to be recorded in 2018 statistics (FAO, 2020c).

Chilean sea bass (*Dissostichus eleginoides*) is a high-value, cold-water, marine fish found in the southern Atlantic and Pacific oceans that is considered to be overfished. Culture technologies for this species have advanced but are not yet at a stage where they are ready to be commercialised. Chilean sea bass culture is seen as a possible alternative to Chilean farmed salmon. Another interesting development in Chile is the establishment of a 200-tonne commercial recirculation farm in the Atacama region due to be completed at the end of 2020 or early 2021 to grow *Seriola lalandi* (yellowtail kingfish) while plans to grow red kingklip (*Genypterus chilensis*), may have to wait until commercial viability has been demonstrated.

There has been continued consolidation of tuna fattening systems in Mexico with production reported as 8 700 tonnes in 2016 (CONAPESCA, 2017). Both bluefin and yellowfin wild-caught juvenile tuna are stocked in ocean cages and fattened for two years on trash fish. However, growth of this industry has been constrained by limitations in the number of concessions and environmental licensing.

In the Caribbean, diversification of farmed species is occurring gradually. However, 97 percent of Caribbean aquaculture volume came from only ten species in 2016. They are Nile tilapia (*Oreochromis niloticus*), Pacific white shrimp (*Litopenaeus vannamei*), silver carp (*Hypopthalmichthys molitrix*) and North African catfish (*Clarias gariepinus*) in Cuba, Belize, Jamaica and Suriname. The species being cultured on pilot scale in the Caribbean region include cobia (*Rachycentron canadum*), dolphinfish (*Coryphaenea*) and red drum (*Sciaenops ocellatus*) in Belize and the Dominican Republic. The species used in projects connected to rural development and poverty alleviation schemes include mangrove oyster (*Crassostrea rhizophorea*) and sea moss (*Eucheuma*, *Kappaphycus* and *Gracilaria* spp.)

2.1.14 Production environment

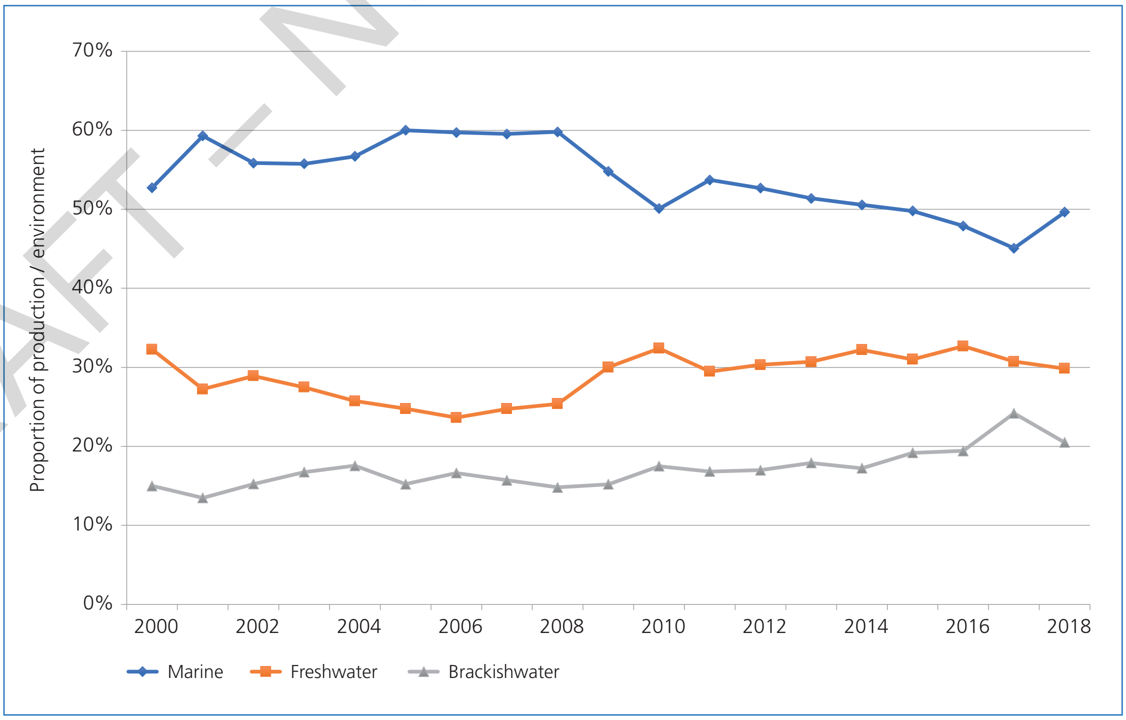
The LAC region has a large diversity of aquatic resources that are used for aquaculture and can be classified into marine, brackish, and freshwater (or continental) environments. Production systems in marine environments accounts for around 50 percent of total production, primarily for Chilean salmon and mussels, making it the largest category. Production in brackish-water systems accounts for 32 percent, mainly comprising Ecuadorean shrimp culture, while around 18 percent of production is from freshwater-based systems, primarily tilapia and characids (Figure 19). This distribution of production by environment contrasts from the global split between production environments where freshwater aquaculture is dominant.

2.2 SALIENT ISSUES

Global and LAC region aquaculture growth rates have been substantially higher than those of other food producing sectors, increasing seafood availability and consumption despite static or declining wild fish supplies. Most of the aquaculture production in LAC is for export markets, with industrial-scale production of only a few species. Meanwhile several countries, particularly in Central America, want to expand these opportunities and a number of South American nations are trying to diversify aquaculture production, particularly with promising native species in response to strong domestic demand.

Advances in technology and competitiveness have allowed LAC countries to compete globally, particularly in the salmon industry. Large aquaculture operations are able to provide standardized, stable supplies of products with cost efficiencies that meet the needs of supermarkets and export markets. However, this also makes it difficult for smaller-scale farmers to compete. The regional (LAC) seafood market also offers increasing opportunities to both large and mid-sized aquaculture companies, as prices of some species such as tilapia, shrimp and salmon are competitive. Meanwhile, smaller companies working in collaboration, have been able to build export opportunities, such as those in the mussel and shrimp sectors.

FIGURE 19. Latin America and the Caribbean aquaculture production by culture environment, 2000–2018



Source: FAO, 2020c.

Disease and climate-related events have had negative impacts on aquaculture development in LAC region, where recent production trends reflect the resilience and response of individual countries to the threats. For example, the rapid recovery of the Ecuadorian shrimp industry from WSSV is attributable to strong government policies and high levels of collaboration.

Governments often target their support to small-scale fish farmers, but not generally in a fashion that is translated into more production, better technologies, long-term sustainability and standards of living. More meaningful support policies for small scale farming are needed with a focus on sustainable results as well as responding to the high concentration of large aquaculture businesses in some countries.

Governments have important roles to play in aquaculture development, by putting in place adequate governance and institutional arrangements, controlling environmental impacts and engaging more people in small-scale farming as well as encouraging large-scale production where local demand and export possibilities allow. Technology must also be improved and updated, incorporating technologies such as recirculation aquaculture systems (RAS) and open-ocean farming. Cooperation among countries in LAC region should be encouraged, particularly through more and better coordinated research and development programmes.

2.3 THE WAY FORWARD

There are many factors that shape and limit the way aquaculture evolves in Latin America and the Caribbean, such as poor governance, lack of technical knowledge, increased competition for land and water, growing concerns about the degradation of environmental conditions, unqualified labour forces and limited economic and community benefits (FAO, 2017).

In this context, there are a few key questions for the development of aquaculture in the LAC region that need to be asked:

- Should large or small-scale aquaculture be promoted in the coming years and in what proportion?
- Should farming systems be intensive or extensive, growing native or introduced species?
- Should foreign or local investment be promoted? and,
- How can further production contribute to reducing malnutrition in the region?

The answers and decisions made in response to these questions will determine the relevance of this activity for the economy and food security of the region. Government actions in this respect should be reflected in long-term policies, plans and programmes (ten to 20 years) that translate into concrete and verifiable results, while international aid and collaboration to assist less developed countries can also help.

Countries such as Chile have concentrated on development of large-scale aquaculture production systems for export, while most other South American countries rely on smaller-scale farming systems. However, Chile is now looking for ways to incorporate small, often family-oriented, fish farming cooperatives into their aquaculture systems while nations such as Brazil are trying to encourage the involvement of larger enterprises that can enhance production and facilitate the availability of seafood in large urban areas that are currently poorly supplied by a myriad of producers and intermediaries. Policies should aim at fostering sustainable aquaculture development benefitting all scales of production, stimulating better interaction and complementary activities to avoid unfair asymmetries and conflict.

Particularly in the case of small-scale farming, intermediaries often take advantage of the poor organizational and marketing abilities of producers, keeping a large proportion of the profits for themselves. This threatens the profitability of the producers, weakening work incentives and severely limiting opportunities for the introduction of better technology.

According to Globefish (FAO, 2020e), Brazil is investing heavily in its production infrastructure in an attempt to compete with China in the frozen tilapia segment driven by the financial and technological capacity of the powerful Brazilian agriculture industry. Additional factors are expertise in selective breeding and good quality fingerlings, large freshwater resources and access to cheap feed, translating into significant competitive advantages as a tilapia producer and exporter. Analysts expect the Brazilian tilapia industry to achieve an increase in production of over 10 percent in 2020, which would take the total tilapia harvest to almost 450 000 tonnes. Almost all Brazilian production is consumed locally, where prices are higher than in export markets.

Most LAC governments have not been able to develop governance schemes that allow for equitable participation of both large and small producers, at a time when each of these actors should receive adequate support, to perform their unique and complementary roles. Small scale aquaculture is an indispensable source of employment in many rural areas, where alternative work is scarce. Furthermore, because coastal small-scale fisheries have often been overfished, aquaculture is often considered as an alternative employment opportunity for fishers (or the family members of fishers) losing their traditional livelihood. Unfortunately, aid schemes for small-scale producers have often taken a paternalistic attitude with short-term projects that cannot deliver the expected results. When support schemes are completed, there is a high level of frustration affecting both farmers and authorities as life almost invariably returns to the initial condition. Government-supported schemes are rarely adequately evaluated, so mistakes are likely to be repeated, with a loss of scarce financial and human resources. In addition, more attention should be paid to large-scale activities, which are the best vehicle to incorporate new technologies, enhance competitiveness at international level and facilitate market supplies to urban centres.

Although LAC fish farming is advancing, this industry faces several challenges if it is to enhance sustainability and competitiveness in a much more globalized world. In fact, some countries seem only partially aware of how difficult it is to compete in an increasingly globalized world, where current aquaculture production businesses will face challenges in the near future. Technology is changing fast; the developed world is better organized and LAC countries will have to resort to a variety of strategies to remain competitive.

Even though aquaculture production in LAC is still highly concentrated on a few species, efforts continue towards diversification with native fish species rather than the introduced species that have dominated so far. However, technological limitations are still hampering further growth throughout the region and the development of credible production systems will still require five to 15 years or more. The introduction of new products to markets will also need significant financial resources and marketing effort, particularly if they are not well known to consumers. Most likely, the full production impact of these new native farmed species will not be felt before the end of this decade or even beyond that date. Nevertheless, large, seafood-importing countries such as Brazil and Mexico have a strong incentive to further promote fish farming and are likely to be among the nations where aquaculture will develop.

Aid programmes to support small-scale aquaculture operations must be re-examined and intensified where necessary. Pilot-scale projects with selected farmers, where the possibilities of success are better, represent a good starting point to enhance effectiveness and produce adequate cost-benefit and social results. Aid schemes should only be extended to wider populations after it has been proved that pilot-scale projects have lasting impacts in their communities.

Large-scale operations, in turn, should also be enhanced and promoted, taking care to avoid monopolistic situations whenever large producers merge. Experience suggests that large-scale producers are likely to continue to internationalize their production systems, installing new farms or buying existing companies in different countries, and combining the farming of different species. In LAC region, the mix of salmonids, shrimp, tilapia and a variety of bivalve species appears to be an attractive option.

Large-scale production also needs more efficient organizational standards and governance to stay competitive both locally and in global markets, particularly with regard to other meat producers and aggressive fish traders from other nations. They require further assistance to be able to innovate continuously and to incorporate state-of-the-art technology and novel managerial skills through tax credits for research and development activities and support to promote their products in international markets. These large operations are needed by supermarkets and other merchants that look for stability, uniformity, predictability, cost efficiency and sanitary assurance in their supplies. Large operations, if vertically integrated, also take the lead in product development, diversification and value-addition including new, fresh or frozen convenience products such as ready-to-eat meals.

Until now, the most successful producers have concentrated on non-native species, and generally on one or a few species only, but the future of farmed production will be based on a wider variety of species, internationalization of operations and the widening of the geographic areas where farming takes place. LAC has the space, the environmental conditions, strong primary agriculture sectors, infrastructure and at least part of the human resources required to advance steadily in aquaculture production, job and wealth creation. However, better governance, and stronger leadership and determination by government, private industry and small-scale producers are required.

Finally, if current trends in aquaculture production continue in this decade, LAC countries could be harvesting between 4.5 and 4.6 million tonnes by 2030. This represents a production increase of around 45 percent from 2018 to 2030, or an average annual growth rate of around 3.1 percent per year, which is well within current rates. For reference, in recent decades, LAC aquaculture production grew by an average of 123 thousand tonnes per year from 2000 to 2018.

However, these projections could be exceeded if countries like Brazil, Chile, Ecuador, Mexico or Peru invested more in their aquaculture industries, exercised better leadership and improved governance. If limitations are addressed, this will benefit local populations through better food security and supplies, enhanced employment and regional development. Similarly, the small islands developing states (SIDS) in the region are refocusing attention on Blue Growth with a view to develop aquaculture in coastal and marine environments.

3. Resources, services and technologies

3.1 STATUS AND TRENDS

3.1.1 Background

The LAC region is endowed with extensive natural conditions suitable for aquaculture, including large freshwater reservoirs and a coastline of more than 72 000 km, a variety of climates suitable for a wide spectrum of species, a wide range of potential ingredients for aquaculture feeds and a large diversity of potential aquaculture species. Specific LAC countries are also global leaders in production of salmon, mussels, shrimp, characids, and other species still farmed in limited quantities. However, the region still relies somewhat on foreign inputs for technologies for the main species and there is much work that still needs to be done to promote and facilitate diversification of production based on local species and knowledge. Substantial service industries have developed in countries with large aquaculture industries, contributing to local economies but the lack of these services is a limiting factor for development in other countries of the region where aquaculture is still at a small scale.

This highlights that there are two equally important aquaculture segments in the region, large-scale, industrial aquaculture and small-scale aquaculture. The former is typically vertically integrated, export-oriented and constantly incorporating technology and management innovations into their business models while the latter has technology limitations and low resilience to shocks, and sells most of its produce in territorial and national markets. Large-scale aquaculture brings hard currency and technology to national economies and leverages local economies while mid to small-scale aquaculture contributes substantially to food availability and employment in rural areas. Each segment should be promoted through specific policies in an enabling environment that includes public services, qualified labour, simplified licensing, access to state-of-the-art technology, fiscal incentives and market opportunities.

Even though aquaculture progress is evident throughout the region, there are several factors that limit further expansion in Latin America and the Caribbean, including poor governance, lack of technical knowledge, increased competition for land and water, growing environmental concerns, lack of skilled labour, and limited credit and insurance access (FAO, 2017).

3.1.2 Natural resources

Although suitable natural conditions for aquaculture of a range of species are available in LAC, successful aquaculture also needs proximity to input services such as seed and feed, markets, a capable workforce, suitable technologies, and a "social license" to operate. The current distribution of aquaculture activities in the LAC region reflects the presence or absence of these factors, sometimes limiting and occasionally boosting aquaculture development.

For example, the Chilean salmon industry was initially focused on a relatively small region of coastal Chile (the Lake Region) selected because of its excellent oceanographic and environmental conditions. It currently works with state-of-the art technology, industry support services and fairly good infrastructure that translates into competitive costs with good managerial practices. A large proportion of smolt production, formerly in lakes, has moved inland with increasing use of recirculation (Quiñones *et al.,* 2019). Marine farming continues in large-scale farms (4 000 to 6 000 tonnes in each 16 to 18 month cycle per farm) with automatic feeding systems and associated technologies. Further expansion of salmon farming south into the Aysén and Magellan regions has been possible using newer technologies and expertise gained from initial development. However, the industry has faced opposition from competing interests along with social challenges and occasionally poor biological performance, generally related to diseases that are difficult to avoid at such large volumes and densities. Meanwhile there were additional challenges from other environmental problems such as heavy nutrient loads and escapes (Quiñones *et al.,* 2019).

Replicating the Chilean model in southern Argentina, despite suitable natural conditions, has been proposed for some time, most recently in 2018, but the concept is proving to be challenging due to social and environmental concerns. People from different sectors of civil society, including environmentalists, scientists, and residents of Patagonia, have opposed an industry model that they say will harm the environment, tourism and the local fishing industry.

Shrimp culture in Ecuador has grown steadily in the past five years with production increasing to more than 500 000 tonnes in 2018, positioning it among the top five global producers. This has been possible through an improved, more sustainable and better coordinated approach led by government and industry, more human resources, robust biosecurity, local hatchery production, improved culture protocols and certification. Meanwhile, further expansion of shrimp farming into mangroves has been stopped due to mangrove conservation programmes.

Most tilapia farming in LAC region is in earth ponds, and a large proportion is small to medium-scale. However, in Mexico, a significant amount of tilapia production from medium-to-large private farms comes from cage systems in dams or lakes, and small to medium-scale cage farming has also increased in some lakes and reservoirs in other countries including Brazil, Colombia and Costa Rica. In Costa Rica, salmon farming companies from Chile and international feed companies have brought in salmon technologies and adapted them for tilapia with increasing success. In Brazil the highest production levels are in the western region of Paraná where, with the use of aerators, fish farmers have increased production densities and improved feed conversion rates (Barroso, Muñoz and Cai, 2018). Meanwhile, expansion of tilapia farming to Amazonian areas has been largely blocked due to environmental concerns and risks associated with introduced species and escapes.

Even though during the last decade most aquaculture growth in the LAC region was from the main species currently being farmed, there has been a clear shift towards research and development to develop technologies for native species, which should translate into production in the late 2020s and early 2030s. However, it is likely that aquaculture expansion will continue on the current path with salmon, mussels, shrimp and tilapia continuing to lead production while production of other, mainly native species of finfish and molluscs, advances at a slower pace.

The farming of some non-fed aquaculture species is likely to increase over the next ten years, as mangrove oyster (*Crassostrea rhizophora*) and the American cupped oyster (*Crassotrea virginica*) are gaining momentum in Cuba, Nicaragua, Honduras and El Salvador through development bank-supported projects.

The continuous decline of Peruvian wild fisheries during the last two decades, particularly anchovy, has led the country to look for alternatives in aquaculture. Massive financial resources have been poured into research and development that should show results in coming years.

Increasing competition for space has slowed production growth of some species, such as shrimp and Atlantic salmon, and will probably continue to do so. A "social license" or public consent to allocate space for new aquaculture projects in a given territory, is increasingly important to the success of aquaculture development and this needs to be supported by public consultation backed up with solid, scientific information (Boyd *et al*., 2020). While improving the socio-environmental responsibility and sustainability of the sector, these public views are often characterized as barriers for further development.

Improved collaborative approaches will increasingly be needed, as are being promoted by the World Wide Fund for Nature (WWF, 2015) supporting producers to implement responsible practices through Aquaculture Improvement Projects. In the same way, WWF encourages large retailers and restaurant chains to adopt responsible seafood procurement policies that call for sourcing responsibly farmed seafood products. In the case of small island states of the Caribbean, where tourism competes for coastal space and freshwater is limiting, both aquaponics (with tilapia and market vegetables) and offshore cages for cobia or other marine fish and shrimp have been promoted in the last five years as suitable alternatives, even though many large-scale farming projects are unlikely to be developed in this area in the foreseeable future.

3.1.3 Human resources

Latin America and the Caribbean experienced a rapid increase in the number of aquaculture research groups as well as aquaculture-related undergraduate and graduate programmes between 1980 and 2000, which coincided with the salmon boom in Chile and the shrimp boom in Ecuador, Central America and Mexico. Aquaculture researchers have contributed to the development of aquaculture technologies, in part through growing collaboration with, and training in, international institutions which allowed for the creation of an important technical critical mass.

A number of regional projects such as the FAO-Italy technical assistance Aquila I and II projects as well as the Spanish-supported Iberoamerican Aquaculture Network significantly contributed to training and applied research in aquaculture, strengthened institutions and led to an expansion of aquaculture. However, a slow-down of aquaculture expansion, falling shrimp prices and other constraints resulted in a drastic reduction of opportunities for aquaculture professionals and consequently a reduction in the number of students and the closure of most of the undergraduate degree programmes throughout the region. Despite this, aquaculture research has continued.

Chilean aquaculture largely benefited from early investment in specialized training, with initial results focused on salmon farming but afterwards, also for mussel farming (Gonzalez-Poblete *et al.,* 2018). Currently the country has several graduate programmes in aquaculture and other specialized training initiatives to support the sector and it has become a hub for the region, increasingly receiving students from other LAC countries. Shrimp farmers from Ecuador and Brazil invested significantly in international exchange and training programmes in the 1990s and 2000s. Domestic training programmes and institutions are also growing in many countries in the region, although they are sometimes subject to funding and organizational problems in volatile economic and political environments. The migration of trained people from the LAC region is also challenging, particularly recently, due to unstable political and economic conditions.

Research and development to support diversification of aquaculture systems towards native species remains a challenge in LAC since initiatives are often discontinued or are not sufficiently comprehensive. There are not enough trained scientists and technicians across the region, particularly for small-scale aquaculture systems. Aquaculture training programmes and development workshops are commonplace but have proved insufficient to address the main limitations. Larger scale farmers can generally afford to hire appropriate local or international technical assistance, but small-scale farmers cannot. Brazil, Ecuador and Peru have robust subsidized technical support and extension services, but not all countries do. Peru, with its recent National Programme for Innovation in Fisheries and Aquaculture (PNIPA) is addressing training with a series of courses and workshops, as well as applied research projects financed through competitive public funds. The same applies in Chile, after the artisanal fishery development institute, INDESPA, was created in 2018 and became active in 2019, aimed at supporting small-scale aquaculture and artisanal fisheries.

Multi-national collaboration and exchanges, particularly within the region, are seen as a way to foster establishment of Latin American aquaculture networks. Recently this has been facilitated and coordinated by the Commission on Inland Fisheries and Aquaculture for Latin America and the Caribbean (COPESCAALC) although with limited impact so far. The Latin American Regional Aquaculture Network established in the 1980s lasted about a decade and was replaced by the Red de Acuicultura de las Américas (RAA – or the Aquaculture Network of the Americas), launched in 2009. The RAA still exists but unfortunately has lost its momentum. The "Programa Cooperativo de Investigación, Desarrollo e Innovación Agrícola" para los Trópicos (PROCITROPICOS) a Latin American network for agricultural technology, is also showing interest in aquaculture (A. Flores, personal communication, 2020). There are other more focused support networks, including multi-faceted developments for agricultural and/or fisheries sectors. For example, Central America has a common aquaculture policy for 2015 to 2025 (OSPESCA, 2015), and progress should be expected for shrimp and finfish. There are also other cases of networks at national level for specific species, such as the Tilapia Mexico Network established in 2014 assisted by WorldFish. Consolidation of these national networks requires stronger commitment from national governments and industry alike.

In November 2019, FAO organized the First Latin American Regional Fisheries and Aquaculture South-South Cooperation Meeting, which was attended by 15 countries and resulted in more than 70 bilateral technical cooperation agreements through which countries with more advanced aquaculture sectors, namely Brazil, Chile, Ecuador and Mexico, agreed to assist developing countries in their areas of expertise. Such activities have just started and should yield results in the coming years.

In general, collaboration for technical support and exchange continues to be based on individual rather than institutional networks. However, international organizations such as the World Aquaculture Society, other professional organizations and FAO try to facilitate technical exchange and collaboration among countries in the LAC region.

While some women participate in aquaculture activities, they are usually more active in fish processing plants and the commercialization of aquaculture products. However, the numbers significant. In Chile, women could make up to 35 percent of the permanent aquaculture labour force (SERNAPESCA, 2019) while a recent analysis based on Chile, Colombia, Paraguay and Peru, provides evidence of the increasing relevance women have in the aquaculture sector, particularly in post-harvest activities (FAO, 2016a). Women's organizations are also contributing to small scale aquaculture projects, for example pacu farming in Bolivia (Plurinational State of) (Peces Para la Vida, 2020). They are also becoming involved in indirect employment and services, ranging from selling food to providing specialized clothing, cage-net cleaning and cage-net manufacture. Aquaculture is also providing new opportunities to women in technical and scientific areas including leadership in innovation and services (AQUA, 2020). However, much more information is needed on employment of women in LAC aquaculture value chains.

3.1.4 Aquaculture feeds

Timely and affordable access to services and inputs including appropriate seed, feed, equipment, machinery, repair and maintenance services are key to a growing aquaculture sector. However, some of these are not available in parts of the LAC region. Meanwhile, the need for local training services is also often cited as a key constraint in national aquaculture plans.

Aquafeeds formulated specifically for finfish (salmon, carp, tilapia, catfish), and crustaceans (shrimp) are generally available (MarketData Forecast, 2020), as are locally manufactured feeds for characid species. Large scale aquafeed producers, including international companies, have been established in many countries, providing high quality standardized feeds for the main aquaculture species. Major advances have been made in the quality of aquafeeds, translating into feed conversion ratios (FCR - food consumed divided by fish weight gain) of one and even less in salmon farming (Biomar Group, 2019). The value of the Latin American aquafeed industry was estimated at USD 12.83 billion in 2018 (MarketData forecast, 2020). Local aquafeed manufacturers and farm-based feeds are also present, particularly in areas where there are small-scale producers whose needs are not being adequately addressed by larger feed companies. In central Bolivia (Plurinational State of) and many Caribbean countries, access to high quality, affordable feed is limited and training in feed formulation and manufacturing is needed. Most farmers in the LAC region complain about the price of fish feeds, which in cases like 'Paiche' in Perú is said to hinder further growth (personal communication, Peruvian Amazon Research Institute (IIAP), July, 2010).

Feeds usually represent between 40 and 60 percent of total aquaculture production costs and these figures increase substantially in small-scale farming, reaching 80 percent in family-owned ponds. Therefore, the price of commercially available feeds determines the economic sustainability of small farmers. As prices for aquaculture feeds continue to rise, larger aquaculture companies often invest in feed production facilities developing more vertically integrated and efficient businesses, while small-scale aquaculture farmers become less competitive and their sustainability is threatened. Research groups throughout the region continue their efforts to identify substitutes for fishmeal and fish oil, as these are among the most expensive ingredients. Meanwhile, a regional FAO-led programme to investigate potential, low-cost, locally available, non-traditional sources of nutrients for aquafeeds is yielding good results for small to mid-sized farmers. For example, in Colombia, farmers in a pilot-scale aquaculture community successfully reduced their use of commercial feeds by more than 50 percent, thus increasing their competitiveness. This indicates that there is still much room for innovation, cooperation and expansion, particularly for small scale aquaculture.

3.1.5 Seed supply

Availability of seed material (i.e. fry, fingerlings, spat and seedling) is crucial to aquaculture and often the development of consistent reproductive techniques has been a key trigger for scaling up farming of particular species (Boyd *et al.*, 2020). This has impacted the development trajectories of most species grown in LAC, as reliance on wild-captured seed still limits production of some mollusc species (Molinet *et al.*, 2017) as well fish such as *Arapaima* where the fry supply comes from the wild. Despite testing and certification, internationally sourced salmon eggs and shrimp post-larvae have been a source of disease, making it important to develop local hatcheries with strengthened biosecurity protocols. For example, salmon egg imports into Chile have substantially diminished in recent years. However, fish seed has continued to be imported in several countries including Bolivia (Plurinational State of), Costa Rica, Guatemala, Mexico and Peru, and shrimp post-larvae are also widely imported from hatcheries within the region including from Ecuador, Honduras and Mexico. At present, the shrimp industry in Ecuador is exclusively supplied with larvae produced in genetic improvement programmes (personal communication, Camara Nacional de la Aquacultura, Ecuador, 2020).

Characid and tilapia hatcheries in Brazil continue to supply neighbouring countries, particularly those still showing difficulties in the early development of the production cycle, posing a risk to the industry if adequate preventive measures are not in place. While viral diseases have not, as yet, strongly impacted production of these species, introduced parasites and diseases are spreading, mostly because of low biosecurity measures (Delphino *et al.*, 2019).

Unless readily available from the wild, as in the case of mussel and scallop farming in Chile or scallop farming in Peru, small-scale farmers rely almost entirely on seed and juveniles provided by third parties, be it private or government-run, as production techniques and installations are not usually available for small-scale farmers. Government hatchery programmes providing subsidized, certified seed are needed in several countries, to support small-scale aquaculture development. At the same time, several government hatcheries have stopped operating in Mexico, as they did not comply adequately with their original aims, although there are new initiatives to reinstate them (Dodd, 2014).

3.1.6 Technology

In general, only larger aquaculture companies take an interest in emerging technologies, such as offshore farming and recirculation aquaculture systems. Nonetheless, zero-water exchange systems such as biofloc have become increasingly popular even among small scale farmers, although the lack of trained personnel, investment capacity and reliable power are often a constraint. Most LAC operations still focus on more traditional production systems. While industrial aquaculture firms should generally have the capacity to adjust, it is important that governments, intergovernmental organizations and international cooperation agencies assist small scale farmers to adapt to new technologies and respond to changing climate scenarios.

Culture technologies in the LAC region range from earth ponds and wooden-framed floating cages, to recirculating systems, raceways and autotrophic (biofloc) systems as well as sophisticated, self-contained, offshore floating cage systems, for salmon, tuna and cobia farming. Mollusc farming mostly depends on wild spat and uses traditional long-lines with an array of bags, ropes or plastic boxes. Closed cycle operations are common in southern Brazil, north-eastern Mexico and Chile, depending on the species.

Globally oriented industries such as those for salmon, shrimp and mussels use internationally validated technologies for large scale production that have been adapted to LAC environments, partly through international aquaculture companies and consultants, and in part through technical exchange and local innovation. However, in some cases, environmental compliance, biosecurity, and quality assurance may need to be upgraded. It is also challenging to devise and access appropriate technology for smaller-scale growers.

Tilapia is grown in a variety of production scales and with different objectives. Culture protocols are standardized and relatively simple, and markets are diverse. Larger companies invest in the latest technology for export markets and more demanding, large-scale, domestic markets. Some countries in the region, including Brazil, Costa Rica and Mexico are working to improve technologies. In the case of Costa Rica, a foreign salmon farming company has brought technology to produce high quality tilapia with important management and environmental improvements (World Aquaculture Society, 2019). In Mexico, the Tilapia Network is bringing together industry, government and scientists to improve technology and practices for small and medium-size farmers (Red Tilapia Mexico, 2019). Genetic quality of broodstock is of particular concern, as growth can be compromised by uncontrolled hybridization and ineffective sex control. As Brazil and Central American countries compete with low-cost tilapia production from China both in regional markets and in the United States of America, they are interested in developing distinctive quality levels, traceability and product differentiation through technological developments in production, processing and marketing. Certification of tilapia has improved export sales from Honduras and Costa Rica to the United States of America.

Pond culture of characids still represents a relatively modest component of LAC aquaculture, using species native to the region and until now serving mainly established domestic markets. The technology used for characids is largely semi-intensive pond culture. Cage culture or other intensive methodologies are not common, though large-scale production in large ponds with aeration is a recent development in the midwestern and northern regions of Brazil, the key areas for characid production. Pond culture of characids continues to be widely promoted for community development. Seed production is well understood, but has resulted in a significant market for hybridized fish, which in turn poses risks to productivity and the environment through escapes of viable individuals. The technology has been adapted to several other native species, largely driven by a demand from fee fishing ponds although it is still at a relatively small scale. Culture of other native fish species has been developed by a private company in Brazil, with pond culture of these and their hybrids increasing (Projeto Pacu, 2000).

Apart from Chilean salmon, most of which is grown in sea water after smoltification, marine finfish culture is at an early stage of development throughout the region. However, technologies and markets have been developed for several native warm water species. For example, bluefin tuna and yellowfin tuna are cultured in offshore cages in Northwestern Mexico but this has grown slowly as environmental licensing is difficult. After several failed attempts to cultivate cobia, a Panama-based international company is currently producing more than 2 000 tonnes per year and has started exporting. Oher marine species such as snook and snapper are being farmed in ponds and cages in Mexico and some Central American and Caribbean countries.

Freshwater culture is likely to continue being the dominant form of tropical finfish culture in the region for some time to come. Offshore cage culture has a long way to go as it is still considered a costly alternative by the local industry. Self-contained recirculating aquaculture systems (RAS) for shrimp culture, as well as biofloc farming, are growing, particularly in Brazil, Colombia and Mexico. Recirculation technology is also important in Chile, where a large proportion of salmon smolt production has shifted to RAS. Land-based aquaculture facilities are increasingly being considered as a more sustainable alternative to open-water fish farms, but there are only a few pilot-scale developments in LAC. Other examples of start-up efforts are the pre-commercial trials fostered by CORFO in Chile to produce yellowtail kingfish (*Seriola lalandi)* and kingklip ("congrio colorado", *Genypterus chilensis*) aiming at establishing innovative culture-based fisheries and aquaculture production in previously unexploited parts of the country (Acuinor, SA, 2020; Colorado Chile, 2016).

3.2 SALIENT ISSUES

Countries that have established solid, export-oriented aquaculture industries such as Chile and Ecuador, have also developed significant private service sectors providing support to their industries. For example, well over 1 000 support enterprises have been established in Chile and the government has a programme that has targeted the export of goods, services and equipment worth USD 500 million to other countries by 2030. Other countries, such as Brazil, Ecuador, Mexico and Peru, have successfully combined private and public support services, including disease diagnostics and market information services. Veterinary services, provision and maintenance of cages, management of plastics and residues, management of mortality and specialized transport of live fish are among the most common services developing in the region and locally produced equipment and raw materials are also being exported to other countries within the region. In Chile, women have entered the services sector; a good example being photoperiod light-induced growth services, created and led by women (Aqua, 2020).

Small-scale producers need government support because of their limited access to managerial skills, improved technologies and marketing expertise. Business models such as contract farming can help them improve productivity, while including them in more complex value chains. Meanwhile, most small-scale farmers work informally perhaps because of remoteness, bureaucratic procedures or to reduce their costs. This not only threatens the ability of regulatory authorities to control sanitary and environmental problems, but it also means that informal farmers are not eligible for technical, financial or social protection. There are a number of programmes to incentivize registration of small-scale farmers in several LAC countries, but this is likely to remain a challenge for the foreseeable future.

With limited financing, restricted human capacity and relatively limited interest in diversification, there is a danger that the LAC aquaculture industry will only advance slowly, while in other parts of the developed world there will be rapid progress through adoption of new technologies such as recirculation systems, offshore mariculture, nano technologies and biotechnology. These trends are backed by massive financial resources, are aimed at diminishing trade deficits in fishery products and are expected to undergo rapid expansion in the coming years. LAC countries could benefit from introducing these swiftly rather than struggling with an uncoordinated species diversification strategy that is making slow progress.

As already noted, not enough is being done to develop research, development and innovation (R&D+I) activities related to fish farming throughout the region. The exception is Peru, where the USD 120 million PNIPA programme (2017–2021), financed by the government and the World Bank, is supporting the most ambitious set of innovation initiatives ever seen in the continent, covering aquaculture, fisheries and governance, with a strong bias towards fish farming. This programme is in its first phase and results have not yet been evaluated to assess if it will go forward to a second phase.

Traditional technical assistance and subsidized approaches, while still in place in some countries, are experiencing a gradual transformation to more capacity-building, self-help extension approaches brought about by the lack of human and financial resources. It appears that these transformational approaches are working in countries like Colombia, Costa Rica and Paraguay, so as these schemes progress and achieve their targets, it is likely that there will be a spill-over effect in neighbouring countries. However, paternalistic approaches are still common, and the development of organizational abilities and managerial skills in small-scale farming needs much more support and attention.

There are many inland, coastal and offshore areas with potential for expansion of both freshwater fish farming and mariculture across the region. Yet, there are clear examples where there is a lack of support to develop large-scale aquaculture activities because of public perceptions influencing political decisions. Environmental risks cannot be denied but they can be mitigated with appropriate planning and management (Lovatelli, Aguilar-Manjarrez and Soto, 2013; Kapetsky, Aguilar-Manjarrez and Jenness, 2013).

In Small Island Developing States, interventions to promote aquaculture have often failed because development strategies have been focused on research or pilot-scale phases, leaving insufficient resources for commercial scale-up or addressing the essential requirements of economic viability, particularly market access, market and value-chain development and competitiveness. A shift towards better governance and the promotion of an adequate business, policy and legal environment to facilitate further investment by private firms is required. Pilot and commercial-scale operations, including research combined with business models and other assistance, training and education programmes may help to test, adapt and demonstrate the economic viability of some of the proposed technologies. Important remaining challenges include the local availability of aquafeeds at competitive prices as well as multisectoral spatial planning to avoid conflicts for resource and space, particularly with tourism.

3.3 THE WAY FORWARD

Even though statistical projections indicate that farmed production should increase over the next decade, the expansion rate will most likely be slower in comparison with former periods, as regional aquaculture will be severely challenged by a wide range of factors including governance issues, imports, more competitive markets abroad and climate-related effects. Sea level rise could particularly affect Caribbean SIDS, as well as coastal lowlands in, Cuba, Honduras, Mexico and Nicaragua. As far as markets for LAC aquaculture products are concerned, stricter quality and sustainability certification will expand in international markets thus demanding better aquaculture practices with higher associated costs. However, being competitive and sustainable is, and will continue to be, central within the region. Governance, in its various dimensions, will also affect regional aquaculture development and will be analysed in more detail in Chapter 8 of this review.

The above calls for two structural changes. Firstly, improving competitiveness in salmonid, tilapia, shrimp and mussel value chains that are already consolidated and successful, and will continue to dominate regional aquaculture throughout the next decade. Secondly, there is a need to invest in research and development on a limited number of promising native species that show the best biological and market potential, to fine-tune their culture technology, draw conclusions regarding their economic viability and if profitable, transfer the technologies to interested farmers. This could be done through private-public alliances to minimize risks.

There is an overarching need for greater involvement with new technologies to avoid losing market share to intensive recirculating aquaculture systems (RAS) or offshore farming operations, threats that were hardly imaginable 20 years ago. New technologies sometimes require large investment, so private-public arrangements could prove effective through transparent and risk-minimizing mechanisms. Integration of small-scale farmers to specific value chains will allow them to access new technologies appropriate to their scale, while contributing production to the overall system.

Countries such as Brazil, currently import substantial amounts of seafood but possess plenty of natural resources for further development of aquaculture. The country has an ambitious long-term plan to boost aquaculture in a sustainable manner, but concrete achievements are not necessarily being obtained as wished. In turn, several other countries also have sectoral development plans, but in almost all cases they now need political will, allocation of financial resources and close collaboration with stakeholders to develop aquaculture to its full capacity in the best interests of their communities. Participation of stakeholders at all scales and inter-sectoral dialogue, are also key to success.

The availability of sites, low population densities and a variety of climatic conditions should make it easier to expand aquaculture in LAC, compared to other regions. However, technological developments such as RAS, open-ocean farming, biotechnology, nanotechnologies and the internet will challenge those comparative advantages, forcing the LAC region to compete with other countries on more demanding terms over the coming decades. There needs to be more efficiency and competitiveness, better science and technology, and better governance.

To increase production of native fish, with potential benefits for small and medium-scale aquaculture, there is a need to fully develop and transfer technologies (Davila-Camacho *et al.*, 2019). Also, important improvements are needed in genetics, feeds, feeding systems and sanitary regulations. Enhancement of human and organizational capacities, together with more direct participation of private entrepreneurs in research and development will also be needed.

In general terms, South and Central America still offer large inland and coastal surface areas for aquaculture development, while Caribbean SIDS are more restricted in inland space, though some like Cuba, Dominican Republic, Haiti, Jamaica and Trinidad and Tobago have not as yet fully used their suitable coastlines, nearshore areas and inland water bodies.

Small Island Developing States and other zones also face challenges posed by high production costs stemming from the lack of locally available, quality feeds for some species (i.e. shrimp and carnivorous fish species) and seed. These are a major hurdle, as it is not yet commercially viable to set up feed mills or hatcheries in some countries, because of the potentially limited size of the market.

Most Central American countries also have to import or transport production inputs over large distances. However, large firms buy large volumes of feed, so prices are competitive. For small scale farmers, it is easier to create economies of scale through organization and consolidation of purchases, and by means of consolidated harvests to be sold in more complex markets.

There are a number of bilateral, national and international fisheries and aquaculture development projects currently being discussed in Central America, some of which are expected to attract funding of USD 50 million to USD 100 million. If these materialize within the next two years, this subregion will become an important aquaculture player. In this context, bivalve aquaculture (chiefly oysters) will become an important new feature of subregional aquaculture.

Countries in Central America could also expand fish farming in the future, given good public policies, better research and development, logistics and services. An action plan to develop the potential of aquaculture in the Caribbean through the Caribbean Regional Fisheries Mechanism (CRFM, 2014) is considering a range of interventions including the strengthening of governance, human and institutional capacity building, strengthening data and information management systems for aquaculture, carrying out surveys on the suitability of aquaculture at the national level, improving access to credit, market studies, particularly for indigenous and locally occurring species, development of alternative feeds, energy, bio-technical and economic aspects of aquaculture and adaptation to climate change and variability. Unfortunately, funds have yet to be secured to implement the plan.

Development of aquaculture in Central America and the Caribbean should also address governance and environmental sustainability, with an emphasis on climate change. Regional cooperation will allow lessons learned in countries like Chile and Brazil to be considered, while deploying future development efforts in other parts of the region and promoting investment, employment and food production. Aquaculture can strengthen the intra-regional market, by covering domestic demand with local products rather than imports from outside the region.

Support schemes between countries in the region should be encouraged and welcomed, to build cooperation in technology, capacity building, human development and sustainability. New means to further support this horizontal transfer of knowledge and technologies should be devised. In many areas, there is a clear need for training and support to create development proposals and national or regional policies and plans.

4. Aquaculture and environmental integrity

4.1 STATUS AND TRENDS

4.1.1 Background

The development of commercial aquaculture in the LAC region has taken place over less than 50 years, with some examples of impressive growth. In a relatively short period of time, the region became a global leader in salmonids and shrimp farming, mostly from large-scale industrial production, as well as mussels and tilapia, produced mainly at medium and small-scale.

Rapid growth has been facilitated by the introduction of species and technologies, facts that have also brought the scrutiny of local and international aquaculture critics who helped publicize the environmental shortcomings of both salmon and shrimp industries. This scrutiny has helped change the aquaculture focus in many parts of the world, including LAC countries, towards environmental sustainability and social responsibility. While large-scale, export-oriented industries have been scrutinized the most, the need to improve environmental performance applies at all scales.

Aquaculture in LAC faces important environmental challenges that must be properly addressed, some of which are now major obstacles for further development. For example, in many states of Brazil, Colombia, Mexico and other countries in LAC there is opposition to culture of tilapia, shrimp and even native fish, as it is felt that these activities might threaten aquatic biodiversity and thus conflict with the Aichi biodiversity targets (Lima Junior *et al.*, 2018; Pelicice *et al.*, 2017). In Mexico for example, the National Commission for Biodiversity CONABIO has recently confirmed the status of tilapia as an invasive species, which strengthens the case for opposition to its culture on environmental grounds. On the other hand, government programmes to promote tilapia farming have been established all over the country for many years, as it is the main freshwater species farmed in Mexico providing work opportunities not only on farms, but also supports important inland fisheries in dams and lakes.

Environmental impacts are often associated with industrial, large scale aquaculture production such as salmonids and shrimp. However, tilapia, trout and native fish farming, even though at small and medium-scales, could have cumulative impacts on the environment.

Even if salmon farming in Chile has brought significant progress to the southernmost part of the country, this activity has faced local and national opposition due to alleged bad practices, well documented environmental issues and negative social impacts (Quiñones *et al.*, 2019). Opposition by NGOs and local populations continues to new salmon farming operations in the Magellan region, the southern tip of Chile. For similar reasons, in Argentina, where aquaculture is poorly developed, there has been strong opposition to a recent attempt to introduce salmon farming in Patagonia (Carrere, 2019).

A potentially unsustainable demand for scallop and mussel wild seed or juveniles for aquaculture fattening is also an unresolved issue in Peru and Chile, respectively. Chile is the largest global mussel exporter, harvesting over 400 thousand tonnes in 2019, with an industry entirely based on wild seed, and there are concerns that mussel beds may not be able to support these levels of seed collection, particularly if spatfall is affected by climate change (Molinet *et al.*, 2017; Soto *et al.*, 2020). Economic factors also come into play as the costs for hatchery production of mussel seed are much higher than the costs for collection of wild seed. Additionally, mussel seed collection is a means of livelihood for coastal fishing communities, with few alternative livelihood options.

Even when aquaculture practices improve, poor public perceptions persist. Negative effects on coastal mangroves of shrimp farming ponds have been solved in some LAC countries through environmental restrictions and improved management (Thompson, 2014). Such measures have also been implemented in Central American countries, although weak surveillance systems make it difficult to enforce. There are a number of shrimp farms surrounding the Gulf of Fonseca (Honduras, El Salvador and Nicaragua) that have adopted, on their own, mangrove restoration programmes within their farms (Gee, 2015).

Salmon cage culture similarly suffers from outdated perceptions on environmental aspects that have been largely solved, such as the use of fish meal in salmon diets. However, recent massive fish escapes have resulted in increased criticism even though some of the escapees are captured by artisanal fishermen (INCAR, 2020).

Environmental regulations for aquaculture have been increasing in the region, especially for industrial aquaculture. However, most norms focus on the potential impacts of individual farms. As almost no ecosystem level assessment has been performed, it is not clear whether farming impacts are significant, especially in comparison with capture fisheries, other land uses, reservoir construction for energy and irrigation, agriculture or urban derived pollution. Opinions on acceptable environmental impacts of aquaculture vary widely. To limit negative opinions, third party certification is a useful approach and has become a significant tool to facilitate access to the American and European markets, an important recent development in LAC aquaculture.

4.1.2 Farming and escapes of introduced species and types

In 2018, farming of introduced species accounted for about 53 percent of LAC aquaculture production and if production of whiteleg shrimp in areas where it is not indigenous are included, that figure is higher. Meanwhile, inland aquaculture also has an increasing share of production from non-native species, mainly due to the expansion of tilapia culture (75 percent of LAC inland production was of non-native species in 2018 compared to 67 percent in 2013).

Escapes from fish farming, especially from fish cages, can be one of the main routes for the introduction of non-native species with potentially severe consequences to local ecosystems. Examples include rainbow trout in most Andean areas in South America and more recently the establishment of chinook salmon in large areas of Chile and Argentina (Soto *et al.*, 2006; Arismendi *et al.*, 2014, Lima Junior *et al.*, 2018). Zaniboni-Filho, Do Santos Pedron and Ribolli (2018) concluded that the most important negative impact of tilapia cage culture in Brazilian reservoirs is that of escapees (Casimiro *et al.*, 2018), followed by eutrophication. While there are no published evaluations of impacts of tilapia escapees in LAC, many documents describe the risks.

Even when farming is small-scale and escapes are not frequent, the risk still exists and can have irreversible effects. For example, the sturgeon, *Acipenser gueldenstaedtii,* has been recorded for the first time in the lower Paraná and La Plata rivers in Argentina (Demonte *et al.*, 2017), no doubt as a result of escapes from small fish farms in Uruguay while *Arapaima* have likewise invaded the upper Amazon basin, as a result of releases from a small aquaculture farm in Peru 50 years ago. Small levels of escapees of hybrid native catfish are likewise endangering the viability of threatened native fish populations (Hashimoto *et al.*, 2016).

Growing native fish has recently been promoted as a safer alternative to introduced species (Davila-Camacho *et al*., 2019) and the culture of some native characid and catfish species is well developed in much of tropical and subtropical South America. However, escapes of non-sterile inter-specific hybrids, or genetically improved types, could contaminate natural populations and constitute a significant threat to their survival by reducing overall reproductive fitness (Hashimoto *et al.,* 2016). Also, while a species may be native to the LAC region, it may become invasive if it escapes into a non-native portion of the region as in the case of *Arapaima* (Miranda *et al*., 2012). Therefore, farming native species is not always safe, and escapes need to be avoided in all circumstances.

4.1.3 Land and water resource uses

Most aquaculture systems have reduced their use of resources and their environmental impacts by using technologies and husbandry procedures that allow intensification. For example, Ecuador has increased shrimp production with better management practices and no further damage to mangrove ecosystems, and in some cases aquaculture companies have contributed to their recovery (Thompson, 2014). Ecuadorian reports in 2019 indicated that local industry recovered around 3000 ha of mangrove (Piedrahita, 2018), although environmental NGOs claim that further major efforts are needed. There have been efforts to reduce shrimp farming impacts on mangroves in Central America, for example in Nicaragua (FAO, 2014) but there are no clear indicators of improvements and for the most part there is not enough information on these issues. Reports also indicate that certain shrimp farming practices can improve conservation of biodiversity, including that of migrating birds (Morales *et al.*, 2019).

Water use depends on the type of aquaculture system. For example, cage culture in reservoirs is not a consumptive water use, although competition for space and pollution need to be considered. The construction of earth ponds to culture characids is increasing in several locations such as tropical areas of Bolivia (Plurinational State of) and Brazil. While this may be considered an improvement to repurposed agricultural land or brownfield sites, forest areas and freshwater marshes could also be affected, with negative ecosystem impacts. Perez-Rincon *et al*. (2017) estimated integrated water footprints of pond aquaculture in Colombia as a measure of water sustainability. They found that tilapia and cachama have similar water footprints of 5.5 and 6.1 thousand m^3 per tonne, respectively, whereas trout have a larger water footprint of 19.8 thousand m^3 per tonne. The tilapia footprint was largely associated with water used in feeds and stored in ponds, whereas those for cachama and trout were more related to nutrient effluents. This type of assessment may become more common to assess actual impacts on water resources and as competition for water by different users increases, technologies can be focussed on reducing these values.

4.1.4 Water quality

Excessive nutrient output from aquaculture has been a long-standing issue, with increasing concern about ecosystem impacts. Benthic ecosystem impacts have been well documented in Chilean salmon farming (Quiñones *et al*., 2019). Significant impacts are often found in intensively used sites farming 2 000 to 6 000 tonnes of salmon per year. Most assessments consider the areas immediately below or close to the cages in the marine environment, while cumulative effects at the ecosystem level are less well known. Quiñones *et al*. (2019) proposed using the cumulative fish biomass produced over the last decade in an area as an indicator of likely eutrophication of ecosystems. Ongoing research in Chile by Soto *et al.* (in preparation) supports the value of such indicators, as some fjords and inland seas are showing hypoxic zones. However, it is not clear how much of this is due to salmon farming or to other factors.

The construction of reservoirs within tropical watersheds in Brazil has increased, along with opportunities for cage culture of fish. In many cases a reservoir may have numerous small aquaculture farms, with little or no monitoring other than temperature and no evaluation of impacts on water quality or sediments (Dantas Roriz *et al*., 2017). Several authors indicate there are changes in phytoplankton, zooplankton and fish composition around cages in different reservoirs, but there are no comprehensive evaluations of environmental impacts. The general perception is that water quality deteriorates (Zaniboni *et al*., 2018) depending on the type of water body and its carrying capacity. There are also numerous reports of the deterioration of water quality and sediments caused by small trout cages in lakes and ponds in the Andean zone of Peru (Vásquez Quispesivana *et al.*, 2016).

4.1.5 Use of antibiotics and pesticides

Diseases caused by bacteria, fungi, parasites and viruses are a frequent occurrence in aquaculture, especially in intensive farming or when biosecurity measures are not in place leading to the use of antibiotics and fungicides. Some antibiotics like florfenicol and oxytetracycline are accepted as permitted medications for use in fish and shrimp farming in particular countries. However, their use is increasingly controlled and generally needs to be reported. For example, monthly volumes of antibiotics are reported for all salmon farming areas in Chile, where they are used to prevent and control bacterial diseases such as the intracellular bacterium *Pisciricketsia salmonis*. The use of antibiotics in the coastal waters of Chile is an important cause for concern regarding potential impacts not only on natural communities and processes, but also due to the likely emergence of antimicrobial resistance (AMR) in humans, (Figueroa *et al*., 2019). Similar issues, although at a smaller scale, have also been reported for trout farming in Peru (Hurtado Torres, 2019), while in Mexico, the use of florfenicol and oxytetracycline has been increasing after the spread of vibriosis, especially *Vibrio parahaemolyticus* (Bermudez-Almada *et al*., 2014).

In some LAC countries, veterinary drugs regulated for farmed animals including cattle, poultry, and swine and for domestic pets are also being used in an uncontrolled manner in the fish farming sector (Figueiredo *et al*., 2012). Yet generally there has been no evaluation of the quantities used or the extent of potential impacts. The use of pesticides to control sea lice in salmon farming in Chile is also a matter of increasing concern, due to potential impacts on wild fauna, including crustaceans and molluscs (Quiñones *et al.*, 2019).

There is a need to understand the combined impacts from different pollution sources (Quiñones *et al.*, 2019). This is probably the case for many watersheds and coastal zones where urban areas, agriculture and aquaculture share the waterbody. A recent study in China (Guo *et al.*, 2019) underscores this problem, and points out the interaction between organic matter and antibiotic retention in sediments. Their findings support a global plea for an integrated "one health approach", in which aquaculture has a significant role not only as a source but also as a target. However, this kind of approach has not yet been considered in LAC.

Health management is one of the main challenges for aquaculture in LAC. According to the FAO Regional Expert Meeting on the Use of Antimicrobials in Aquaculture in Latin America, Challenges and Future Prospects, held in Lima, Peru, in November 2017, there is a need to implement improvements in the application of good productive practices, animal welfare and biosecurity, in addition to increasing the use of preventive measures such as vaccines at the regional level. All actions are associated with sanitary control and consequently with the use of products for the control of pathogens (FAO, 2021). On antibiotics, the needs were to improve the participation of adequately trained veterinary personnel in the clinical diagnosis and the decision to apply antibiotics, train those who apply the indicated treatments, use antibiotic application records and comply with the withdrawal periods (FAO, 2021).

Good practices for feed are also an important issue in the management of AMR, highlighting the limited use of veterinary prescriptions and the use of antibiotics not authorized by the health authority (FAO 2021, unpublished). Due to the impact on environmental and public health, proper management of waste from aquaculture production and the control of contamination of food of animal origin with bacterial agents and antibiotic residues are also relevant (FAO, 2021).

4.1.6 Use of fish meal and oil

There has been ongoing criticism of fish culture regarding the use of fish meal and fish oil in feeds. However, in recent years new feeds have largely replaced these raw materials with plant-based products or other proteins and new technologies have been incorporated that translate into improved FCRs. The best example is salmonid farming and particularly Atlantic salmon, where the use of fishmeal has been reduced by at least 80 percent for most species and sometimes completely replaced (Marine Harvest, 2019 Beheshti Foroutani *et al.*, 2018; FAO, 2020d). The inclusion of fish meal and fish oil in compound aquafeeds for aquaculture has shown a clear downward trend, with more selective use in fingerling rearing and decreased use in grow-out. Industry is also increasingly using fish waste and by-products from capture fisheries and aquaculture as feed sources (FAO, 2020e). Nonetheless, as more carnivorous species are being considered as candidates for aquaculture, such as cobia or snapper, the demand for fishmeal and fish oil is likely to continue.

The use of soy, one of the most important replacement for fish meal in aquaculture feeds, is increasing in LAC as it is being produced in the region, mainly by Argentina and Brazil. However, this may become an issue, if it comes from areas previously covered by tropical forest (see Chapter 7). The high agro-biodiversity of the region offers opportunities to identify high-protein, sustainable alternatives and this should be a focus for aquaculture nutrition research in years to come.

4.2 SALIENT ISSUES

4.2.1 Addressing environmental issues is becoming more important

Over the last ten years, the environmental impacts of aquaculture have become a central consideration for development in LAC region. Public opinion on the subject and more restrictive regulations have shifted the focus away from production, towards the need for reduced environmental impacts and more social benefits. However, integrated sustainability plans that incorporate the environmental impact of all anthropogenic and natural activities, including aquaculture, are still not available.

Bivalve shellfish and seaweed aquaculture represent global opportunities to advance coastal ecosystem recovery and provide substantial benefits to humanity. When managed within a broader ecosystem framework and strategy, aquaculture has the potential to enhance ecosystems and provide increased benefits to humanity, with values potentially returned through a wide range of regulating, provisioning, habitat and cultural ecosystem services. Yet this is not taking place in the region, mainly for market reasons. Seaweed farming still has serious marketing issues associated with low prices and little added value. Shellfish still have low regional demand and export markets have niche conditions, such as that for mussels in Spain and Italy that Chilean mussel producers have managed to fill.

Among the many ecosystem services provided by mangrove ecosystems, their role in carbon sequestration and storage is relatively high compared to other tropical forests. Therefore, there has been global concern about the impacts to mangroves by historical shrimp farming practices that reduced mangrove areas in some LAC countries (Bhomia, Kauffman and McFadden, 2016).

It is challenging to develop responsible aquaculture without having at least some level of impact on biodiversity in some of the most pristine waters of the world. However, fish farming remains an opportunity for improved food security, poverty alleviation and development with lower ecosystem impacts than terrestrial food production systems in most cases. For example, cage culture in Brazilian reservoirs provides an opportunity to deliver animal protein and food security at lower environmental and economic costs than for livestock. There is also great potential to mitigate the environmental impacts of aquaculture by improving spatial planning including defining carrying capacity, improving biosecurity, better aquafeeds and genetic improvements leading to better feed conversion rates, as well as sterile individuals for grow-out.

While having a smaller localized impact, small-scale aquaculture also has the potential for substantial cumulative impact of several small farms within a shared ecosystem, and may not have the resources for improved practices, a fact that deserves further attention as well.

4.2.2 Improving environmental performance through certification

As a response to many of these challenges, aquaculture certification has resulted in significant improvements in the region over the last five to eight years. Product certification in LAC for the main commodities is increasing rapidly, facilitating access to new or additional markets and consumer groups (Table 17). For example, the food service sector in the United States of America, which is of major importance to seafood exporters throughout the LAC region, already works in partnership with NGOs on the sustainable seafood production, relying on different certification programmes (ASC, 2020). Some certifying entities have collaborated with NGOs and have contributed to improving market access.

The highest levels of certification have been achieved by Chilean salmon and mussel farms in the region and this trend has gained momentum is the last five to ten years, followed by shrimp farms (Table 17). In the case of mussels, several companies have been able to meet standards, even if the collection of wild seed still is an obstacle for broader certification, because there is not enough information on the status of wild seed. Certification helps improve individual farm environmental performance and provides consumers with products that are more environmentally friendly, even if they might be more expensive.

Certification has also helped reduce adverse impacts, including the use of antibiotics. It is worth mentioning that the Chilean salmon farming industry has reduced the use of antibiotics through coordinated actions in aquaculture management areas, as well as

TABLE 17. Proportion and number of Aquaculture Stewardship Council certified farms in Latin America and the Caribbean countries, 2020

Country	Percentage of estimated total number of farms by country and species certified by ASC (%)					Number of ASC certified farms
	Salmon	Shrimp	Bivalves	Tilapia	*Cobia/ Seriola*	All species
Brazil	--	--	--	18.6	--	8
Chile	27	--	20.2		--	206
Colombia	--	--	--	9.3	--	4
Costa Rica	--	--	--	NS	--	2
Ecuador	--	10.5	--	--	--	34
Honduras	--	5.6	--	--	--	20
Mexico	--		--	--	6.2	8
Nicaragua	--	NS	--	--		2
Panama	--	--	--	--	6.2	2
Peru	--	--	9.3	--	--	27
Venezuela (Bolivarian Republic of)	--	NS	--	--	--	6

NS - Not specified
Source: Authors' elaboration based on ASC (2020).

through certification schemes. A recent joint venture with the Monterey Bay Aquarium's SeaFood Watch certification programme has set challenging targets for reduced antibiotic use. Certification has also reduced the use of antibiotics in shrimp farming in the region. However, certification of aquaculture products needs to be accessible to all, whether large or small-scale farmers and governments create national programmes aimed at improving aquaculture practices. Once a basic standard is achieved, food safety and sustainability norms should be enacted in line with international standards, to ensure that even small farmers have opportunities to access export markets.

There have also been important efforts in Central America and the Caribbean to implement certification. Belize was the first developing country in the world to achieve ASC certification, with 90 percent of its shrimp farm's output now fully certified (WWF, 2015).

Certified tilapia production is also increasing in Brazil and to a smaller extent in Colombia, Mexico and Guatemala (BAP, 2019). However, certification does not account for ecosystem-scale added impacts of several farms located in the same geographic area (or ecosystem unit), even though joint efforts by different organizations such as the Seafood Watch programme are already under way. There are also experiences with group certification, such as the intervention by ASC to assist small-scale shrimp farmers in Ecuador with better management practices to achieve higher prices and examples of joint ventures between small-scale shrimp farmers and scientists in Ecuador to produce organic shrimp.

As a result of the strong competition with Asian producers, the shrimp industry in Central America has implemented a range of certification schemes to facilitate sales abroad, such as Best Aquaculture Practices (BAP), GLOBALG.A.P., ASC and the European standards ISO 22000 and ISO 14000. Boyd *et al.* (2020) identified two companies with organic production certified by Naturland, one in Honduras and another one in Costa Rica, and many efforts are now in place to advance aquaculture sustainability in the region and elsewhere.

In general, certification in the LAC region works more effectively for export products, as importers are more likely to demand such procedures. Species such as tilapia and other native species in the Amazon are less frequently certified, as they are intended for domestic consumption, where there are fewer restrictions and consumer awareness is less demanding. Certification does not seem to affect local perceptions of aquaculture environmental performance.

4.3 THE WAY FORWARD

The ecosystem approach to aquaculture (EAA) and other strategic integrated approaches provide several tools and better planning frameworks to minimize or mitigate undesirable impacts from fish-farming (FAO, 2010; Brugère *et al.*, 2019). Under the EAA umbrella, integrated aquaculture and integrated multi-trophic aquaculture (IMTA) could play a key role by reducing environmental impacts within the aquaculture farming system (Boyd *et al.*, 2020), while mitigating social impacts and reducing vulnerability associated with monocultures. There is still no commercial application of IMTA in the marine environment in the LAC region even if this concept has been tried experimentally. For now, IMTA does not seem to work at farm scale because LAC still lacks the aquaculture experience of Asia and it is still difficult to have local farmers combine two or more types of production, such as mussels and fish, or algae and fish. However, there is great potential for integrated aquaculture at the landscape scale (Figure 20), to integrate different types of farming systems.

More work is needed on spatial planning, assessment of carrying capacity of water bodies, and evaluation of different production risks and those linked to the ecosystem

(Aguilar-Manjarrez, Soto and Brummett, 2017). In Chile, for example, mussel and salmon farms are located nearby in the same ecosystems (Figure 20) yet each farming system is managed independently with no consideration of mutual benefits. EAA management plans could significantly contribute to balancing nutrients and productivity of these ecosystems and to increasing local and social benefits.

While commercial marine IMTA has not achieved success at a global scale, because it is difficult to account for dispersion and assessment of nutrients, the situation is different in coastal and inland pond farming. In Asia, for instance, the integration of different species with shrimp in farming ponds has been quite successful, especially in China (Chang *et al*., 2020) and this could be tested in the LAC region to increase environmental mitigation, production efficiency and livelihood options in coastal zones.

Research is starting to focus on the management of water bodies and ecosystems where different types of aquaculture and even small-scale fisheries can be combined. In turn, another relevant option, culture-based fisheries, has been practiced in the region with limited results, apart from some tilapia fisheries in Central America.

Other practices such as aquaponics and integrated agriculture-aquaculture could also play an important role in the region, especially in more arid areas. However, farms implementing these production methods are mainly pilot-scale exercises that have not proven sustainable because they lack technical or economic external support. One successful example is in Antigua and Barbuda, an island country with limited space and freshwater resources. Aquaponics of tilapia and vegetables has proven technically and economically viable and has even served as a field school for other island nations of the Caribbean (A. Flores, personal communication, 2020). More efforts are needed to promote these success stories in the region, so they can be analyzed and replicated.

FIGURE 20. Salmon and mussel farms in southern Chile, Chiloé Island, Los Lagos Region

Source: Pablo Carrasco, INCAR

Increased farming of native species could reduce environmental risks of introduced invasive species and improve the public perception of aquaculture (Sosa-Villalobos *et al*, 2016). Culture-based fisheries, which are a common practice in a number of countries of the region such as Brazil, Cuba and Mexico, need to be monitored in terms of the actual impact on the fishery, as well as their impact on the ecosystem.

Recapture and monitoring of escaped fish whether introduced or native is essential, and this is rarely done or reported in the LAC region with the exception of escaped salmon in Chile. Monitoring of escaped fish can help evaluate impact of escapees and implement mitigation measures (INCAR, 2020). Yet comprehensive risk assessments prior to moving species across natural borders or allowing farming of introduced species and hybrids is still not common in the LAC region.

Science, technology and extension to improve farming practices have important roles to play. For example, simply by improving feed conversion ratios (FCRs), environmental footprints, including the reduction of greenhouse gas emissions, can be substantially reduced. The environmental performance of salmon farming has improved significantly through research and technology, with much less nitrogen and phosphorous introduced to ecosystems as FCRs have improved from more than 1.4 to close to one in less than ten years (Hasan and Soto, 2017). Such improvements need to be communicated and replicated in other species. A great challenge for the region is to reduce FCRs for the culture of freshwater species such as tilapia and native Amazonian species since reductions in FCR could lead to significant environmental improvements and economic gains. Research has also provided vaccines, reducing the need to use antibiotics. These contributions need to be recognized, enhanced and continued.

It is essential that all farming activities take into account the physical, ecological, production and social carrying capacities of ecosystems (Ross *et al.,* 2013; Aguilar-Manjarrez, Soto and Brummett, 2017). This remains a great policy challenge, since technical improvements can increase production while ignoring environmental effects.

Spatial planning should be an important basis for aquaculture management within the context of multisector social use of ecosystems and also considering environmental, biosecurity and other risks. However, implementation of this instrument is only useful when applied in concert with other sectors and users of shared ecosystems services. Barragan-Muñoz (2020) explored the situation of coastal zone management in all LAC countries and described different levels of integration towards planning for integrated coastal zone management. However, aquaculture is not mentioned in the review, suggesting a lack of knowledge on the relevance and or potential of the sector in the coastal marine environment and the need to integrate the sector in planning efforts (Theuerkauf *et. al*., 2019).

A study by Oyinlola *et al.* (2018) estimated that there is 72 million km^2 of ocean within the exclusive economic zones of all countries that are environmentally suitable to farm one or more marine species, many of which are already farmed in LAC region and that suitable mariculture areas along the Atlantic coast of South America were identified as some of the most under-utilized for farming. Some of the reasons for this gap relate mainly to poor economic conditions, lack of supporting infrastructure, political instability, limited foreign investment and inadequate value chain linkages.

Another relevant issue is the poor public perception of aquaculture, a fact which has become an increasing barrier for development. However, large scale evaluations on these matters are seldomly performed. One exception is the widespread recognition of the fact that large areas that were once covered by mangrove are now occupied by shrimp ponds.

In most countries, environmental impact assessments and regular monitoring programmes have already been established to control aquaculture impacts, however, they are commonly performed only by individual farms or large industrial operations and do not monitor cumulative impacts of many farms in the same area at the ecosystem level. Permanent monitoring of selected ecosystem indicators or proxies is essential.

Sustainable aquaculture progress in LAC, including the expansion of mariculture, does not seem possible, unless the abovementioned salient issues are properly addressed. Overall, improving environmental performance of the sector requires better governance (Chapter 8 of this review) with strict and well-implemented norms, and adequate monitoring and reporting, as well as incentives and support, especially for small farmers and local communities. All of this can only take place with adequate public-private collaboration.

5. Markets and trade

5.1 STATUS AND TRENDS

5.1.1 Global fisheries and aquaculture production

From 2001 to 2018, the global supply of fish, sourced from both aquaculture and capture fisheries, for human consumption increased from 125.4 million tonnes to 178.5 million tonnes, and the proportion of that supply used for human consumption increased from 78.7 percent to 87.6 percent over the same period. Both the global supply and the proportion used for human consumption far surpass those from previous decades, when much higher proportions were destined to produce fish meals and oils (Table 18).

Fresh and frozen products increased as a proportion of seafood for human consumption from 60.5 percent in 2001–2003 to 69.6 percent in 2016–2018 (Table 18). This has been facilitated by better logistics along the production value chain, higher urbanization in most parts of the world, and more educated and demanding consumers who prefer fresh products. Even if there are no figures available specifically for LAC, it is almost certain that the same trends have prevailed in the region.

TABLE 18. Disposition of world fisheries and aquaculture production, 2001–2018

Disposition of world fishery production	2001–03	2004–06	2007–09	2010–12	2013–15	2016–18
	Million tonnes, live weight equivalent					
Total world fisheries and aquaculture production	126.8	136.1	142.3	149.5	160.7	1 72.4
For human consumption	100.9	110.1	120.2	129.8	142.4	1 52.5
Live, fresh or chilled	49.7	51.6	51.6	51.1	60.8	67.1
Frozen	27.0	30.5	37.8	47.4	49.9	52.9
Cured	11.3	11.9	13.5	14.5	14.7	15.5
Prepared and preserved	13.1	16.0	17.3	16.8	16.9	17.0
For other purposes	25.8	26.0	22.1	19.7	18.3	19.9
Reduction	21.9	21.6	18.2	16.3	14.9	15.9
Miscellaneous purposes	8.1	4.4	4.0	3.4	3.4	4.0

Source: FAO, Yearbook of Fisheries and Aquaculture statistics 2018.

The best estimate for the global ex-farm value2 of fisheries and aquaculture in 2018 was USD 401 019 million, 62.4 percent of which came from aquaculture. In terms of volume, capture fisheries accounted for 54 percent of the 178 million tonnes landed in 2018 when the average value per tonne of aquaculture production (USD 3 047) was 95.3 percent higher than that for capture fisheries (USD 1 560). In contrast, in 2012 the value of aquaculture accounted for only 56.8 percent of the total, with 41.7 percent of the world's total volume (152 million tonnes), and the average aquaculture price per tonne was USD 2 674, exceeding the average value for wild caught fish by 83.8 percent (FAO, 2020e). The proportion of fish used for non-food purposes decreased significantly from 25.8 percent in period 2001 to 2003 to 19.9 percent in 2016 to 2018. This mainly reflected a decline in the proportion that South American fish meal catches contributed to total production.

In terms of end-products, LAC accounted for 29 percent of live, fresh or chilled crustaceans and molluscs produced worldwide in 2016 to 2018, for 30 percent of global fish meals and 32 percent of oils. In other categories, such as prepared and dried/smoked products, the LAC region was responsible for between 0.9 percent and 5.9 percent of world production.

[2] First-transaction values, at farm level, as estimated by the FAO

TABLE 19. Latin America and the Caribbean and global processed fisheries and aquaculture production volumes 2001–2018 (*)

FAO major groups	2001–2003	2004–2006	2007–2009	2010–2012	2013–2015	2016–2018
LAC processed production, thousand tonnes						
Fish oil	407.4	524.2	513.3	415.5	289.0	359.2
Crustaceans & Molluscs, live, fresh, chilled, etc	589.1	770.4	956.6	1 054.7	1 401.4	1 698.4
Fishmeal	2 576.7	2 867.8	2 337.2	1 906.3	1 396.4	1 488.3
Fish, fresh, chilled or frozen	1 464.5	1 572.2	1 545.8	1 521.1	1 569.3	1 495.1
Fish, dried, salted, or smoked	63.8	65.4	47.1	43.7	49.6	41.2
Crustaceans and molluscs, prepared or preserved	30.2	30.2	30.3	30.8	26.1	12.5
Fish, prepared or preserved	554.4	575.9	522.5	475.0	543.3	511.2
Totals	**5 686.0**	**6 406.2**	**5 952.8**	**5 447.1**	**5 275.0**	**5 606.0**
World processed production, thousand tonnes						
Fish oil	970.0	995.6	1 061.9	1 062.0	1 021.4	1 136.4
Crustaceans & Molluscs, live, fresh, chilled, etc	3 519.7	4 006.1	4 464.1	4 873.3	5 645.0	5 816.7
Fishmeal	6 037.1	6 018.0	5 105.8	4 880.6	4 605.7	5 038.1
Fish, fresh, chilled or frozen	18 810.5	21 968.9	25 532.3	29 306.3	32 207.1	33 505.4
Fish, dried, salted, or smoked	4 748.4	4 936.9	5 579.2	6 015.2	6 142.6	6 431.1
Crustaceans and molluscs, prepared or preserved	1 152.2	1 475.4	1 426.1	1 384.2	1 342.7	1 409.9
Fish, prepared or preserved	6 948.2	7 451.3	7 826.1	7 854.9	8 235.8	8 682.7
Totals	**42 186.0**	**46 852.2**	**50 995.5**	**55 376.5**	**59 200.3**	**62 020.4**
LAC relative importance of groups, % of totals						
Fishmeal and fish oil	52%	53%	48%	43%	32%	33%
Fresh, chilled and frozen	36%	37%	42%	47%	56%	57%
Dried, salted, smoked, prepared or preserved	11%	10%	10%	10%	12%	10%
Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
World relative importance of groups, % of totals						
Fishmeal and fish oil	17%	15%	12%	11%	10%	10%
Fresh, chilled and frozen	53%	55%	59%	62%	64%	63%
Dried, salted, smoked, prepared or preserved	30%	30%	29%	28%	27%	27%
Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
LAC processed production to World processed production, %						
Fish oil	42%	53%	48%	39%	28%	32%
Crustaceans & Molluscs, live, fresh, chilled, etc	17%	19%	21%	22%	25%	29%
Fishmeal	43%	48%	46%	39%	30%	30%
Fish, fresh, chilled or frozen	8%	7%	6%	5%	5%	4%
Fish, dried, salted, or smoked	1%	1%	1%	1%	1%	1%
Crustaceans and molluscs, prepared or preserved	3%	2%	2%	2%	2%	1%
Fish, prepared or preserved	8%	8%	7%	6%	7%	6%
Totals	**13%**	**14%**	**12%**	**10%**	**9%**	**9%**

Source: calculations of the study based on figures from FAO. 2020. Fishery and Aquaculture Statistics. Global Fisheries commodities production and trade 1976-2018 (FishstatJ).
(*) Figures do not include algae products

Within the LAC region, 57 percent of the end-product volume in 2016 to 2018 was accounted for by live/fresh/frozen products, ten percent by other food preparations and 33 percent by fish meals and oils. This is a significant change from 2001 to 2003, when meals and oils made up 52 percent, while only 36 percent was classed as live/fresh/frozen products.

During the 15 years ending in 2016 to 2018, world volumes of seafood end-products grew at a cumulative annual average rate of 2.6 percent. This was the result of a 3.8 percent average annual growth in production by developing countries, and a smaller 0.7 percent average annual growth in the developed world. Chinese production of seafood grew by 7.1 percent per year over the 15 year period, while production by LAC decreased by 0.1 percent per year. Africa recorded an average production increase of 4.2 percent per annum, while Oceania grew by 0.4 percent per year, and the Americas, (including LAC) by only 0.1 percent per year, mainly due to the drop in fishmeal and oil production. Meanwhile EU seafood production grew by 0.7 percent per year and the United States of America by only 0.4 percent.

An undetermined but important volume of seafood is sent to other countries for processing, where it can be carried out at lower cost. For example, China receives significant quantities of fish from several countries, and Poland processes Norwegian salmon. Limited amounts of Brazilian seafood have been sent to China for further processing, to be sold in the domestic market upon returning.

Fishmeal and fish oil used for aquaculture feed formulation were originally considered essential for fish, chickens and pigs. A decrease in their availability was thought to threaten the expansion of fish farming. Fortunately, that has not been the case. Through extensive research, they are being substituted by plant raw materials, synthetic amino acids, mineral concentrates and other replacements, without significant impacts on the fish health or growth.

5.1.2 Fish consumption

The overall quantity of fish available for consumption as food for the global population increased at an average annual rate of 3.1 percent from 1961 to 2017, almost twice that of annual world population growth (1.6 %) for the same period, and a higher growth rate than that of all other animal protein foods (meat, dairy, milk, etc.), which increased by 2.1 percent per year. Taking into account population growth, the global per capita food fish consumption rate grew from 9.0 kg (live weight equivalent) in 1961 to 20.5 kg in 2018, an increase of around 1.5 percent per year.

Fish consumption is unevenly distributed in the world and within the LAC region (Table 20). There are also stark differences in annual per capita consumption rates between countries of different economic development levels, with countries in the developed world consuming an average of 24.4 kg in 2017, while developing countries consumed an average of 19.4 kg, and average consumption rates in low-income and food deficient countries were 12.6 kg and 9.3 kg, respectively.

As shown in Table 20, Guyana had the highest per capita fish consumption rates in South America, followed by Peru, while the landlocked countries of Bolivia (Plurinational State of) and Paraguay had the lowest consumption levels in the subregion. Costa Rica had the highest fish consumption rates in Central America, while the rates for Antigua and Barbuda were the highest in the Caribbean and the LAC region. Both South America and the Caribbean had average per capita fish consumption levels of less than half of global average values in 2017, while the consumption rate in Central America was 61 percent of the global average.

TABLE 20. Apparent fish consumption per capita in Latin America and the Caribbean, 2000–2017 (kg/pers/yr)

Country/Year	2000	2010	2017
World	**15.8**	**18.4**	**20.3**
South America	8.3	9.2	9.8
Argentina	8.6	5.8	7.3
Bolivia	2.6	1.8	2.6
Brazil	6.0	8.6	9.1
Chile	12.3	14.2	12.0
Colombia	4.9	5.7	7.1
Ecuador	6.5	8.6	8.6
Guyana	41.7	31.8	25.3
Paraguay	5.5	3.8	4.2
Peru	20.9	22.4	25.1
Suriname	13.9	17.0	17.0
Uruguay	7.8	5.4	9.2
Venezuela (Bolivarian Republic of)	15.5	10.6	9.8
Central America	**8.3**	**10.6**	**12.4**
Belize	15.4	15.2	14.0
Costa Rica	4.2	10.4	18.5
El Salvador	2.6	7.1	6.6
Guatemala	1.5	1.6	3.2
Honduras	2.8	3.1	2.7
Mexico	10.1	12.5	14.7
Nicaragua	4.3	6.4	6.9
Panama	11.0	14.2	14.4
Caribbean	**9.5**	**8.2**	**9.4**
Antigua Barb	45.2	53.7	55.5
Bahamas	35.8	29.8	24.9
Barbados	36.7	39.0	43.0
Cuba	11.4	5.8	5.7
Dominica	40.1	23.8	28.1
Dominican Republic	9.4	7.8	8.5
Grenada	19.2	28.2	27.1
Haiti	2.4	3.9	6.5
Jamaica	19.2	22.5	25.5
St Kitts Nev	37.0	39.9	39.7
St Lucia	29.1	26.6	34.1
St Vincent	16.0	18.5	19.6
Trinidad Tobago	13.2	20.0	23.9

Source: FAO, Yearbook of Fishery and Aquaculture Statistics 2018, Rome, 2020

However, there are positive trends as consumption rates are increasing in South and Central America, while 2017 consumption rates in the Caribbean are returning to levels seen in 2000 with some variability over the years. In Chile, for example, local supplies from artisanal fisheries and apparent fish consumption have been decreasing. However, the country is an important seafood exporter of several products and species. In other countries, fish consumption is rising slowly, reflecting the difficulties of changing food consumption habits, the relative scarcity of coastal fish and high prices. Peru is the only country in LAC where seafood consumption surpasses that of all red meats grouped together (Table 24). Overall, there has been a steady increase in seafood consumption in the LAC region, particularly in younger generations, most probably due to health awareness. If seafood prices are

TABLE 21. Seafood consumption per capita and fish contribution to protein supply in selected countries, 2017

Country	Per capita supply	Protein supply			Fish contribution to:	
		Fish protein	Animal protein	Total protein	Animal protein	Total protein
	kg	g per capita per day			%	%
Argentina	7.3	2.1	65.7	102.7	3.2	2.0
Bolivia (Plurinational State of)	2.6	0.8	31.1	68.5	2.5	1.1
Brazil	9.1	2.5	52.8	90.9	4.7	2.7
Chile	12.0	3.6	45.5	88.6	7.9	4.1
Colombia	7.1	2.1	37.2	72.3	5.6	2.9
Ecuador	8.6	2.4	30.2	66.0	8.0	3.6
French Guyana	10.4	2.5	. . .	. . .	. . .	. . .
Guyana	25.3	7.0	37.9	86.8	18.6	8.1
Paraguay	4.2	1.2	33.6	72.0	3.7	1.7
Peru	25.1	7.3	29.5	78.4	24.7	9.3
Suriname	17.0	4.8	24.8	60.4	19.5	8.0
Uruguay	9.2	2.6	45.1	84.4	5.9	3.1
Venezuela (Bolivarian Republic of)	9.8	2.9	25.3	56.2	11.6	5.2
Other						
World	20.3	5.6	32.2	81.4	17.3	6.8
World excl. China	15.9	4.7	30.4	76.7	15.6	6.2
Africa	9.9	2.9	14.0	62.0	21.0	4.7
Northern America	22.4	5.5	71.5	112.4	7.6	4.9
LAC, Latin Am.&Caribbean	10.5	3.0	42.9	83.7	7.0	3.6
Asia excl. China	17.3	5.3	22.6	70.8	23.4	7.5
China, w/o HK & Macao	38.8	9.1	40.1	101.4	22.8	9.0
Europe	21.5	6.5	58.2	102.6	11.2	6.3
Oceania	25.0	6.6	58.7	81.3	11.2	8.1
Developed countries	24.3	7.2	61.3	104.0	11.8	6.9
Least developed countries	12.6	3.8	13.0	56.9	29.7	6.8
Other developing, excl. China	14.0	4.1	24.7	72.8	16.8	5.7
Low-income, food-deficit countries	9.3	2.7	14.5	62.8	18.6	4.3

Source: FAO, 2020f.

competitive in relation to the prices for other meats, seafood consumption will most likely continue to rise.

Latin America and Caribbean fishery products contributed only seven percent to total animal protein intake in the region and only 3.6 percent to total protein intake in 2017. In comparison, fish supplies 17.3 percent of animal proteins and 6.8 percent of total protein intake on a world-wide basis.

By adding consumption figures per person for bovine, poultry and pig meat, and comparing them with those for seafood, it can be seen (Table 22) that, on a world-wide basis, the red meat per capita consumption rate is around double that for seafood, while in LAC, the rates for seafood consumption are much less, around 21 percent of red meat consumption per person in Central America and the Caribbean, and only around 12 percent in South America.

5.1.3 International trade

The proportion of world fisheries and aquaculture production that was traded internationally in 2018 was 38 percent, which generated revenue for many countries. In the LAC region, the majority of seafood exports come from South America.

Table 23 indicates that global production and export volumes grew more rapidly between 2010 and 2018 than in the period 2000 to 2010. Production by developed nations fell in the period 2000 to 2010 and grew modestly in 2010 to 2018, even though exports kept a much

TABLE 22. Relative importance of global and LAC subregion seafood consumption compared to combined poultry, pig and bovine meat consumption (kg/pers/yr)

Region/Year	2014	2015	2016	2017
World				
Bovine, Poultry, Pigmeat	39.5	39.7	39.7	39.9
Seafood	19.8	20.0	20.1	20.4
Seafood/Other meats,%	50.0	50.4	50.7	51.1
Central America				
Bovine, Poultry, Pigmeat	53.2	54.4	55.4	56.3
Seafood	12.1	12.4	13.0	12.1
Seafood/Other meats,%	22.8	22.8	23.5	21.5
Caribbean				
Bovine, Poultry, Pigmeat	39.6	41.1	42.4	43.4
Seafood	9.5	9.7	9.4	9.5
Seafood/Other meats,%	23.9	23.5	22.1	21.8
South America				
Bovine, Poultry, Pigmeat	79.6	79.9	78.5	79.8
Seafood	10.1	9.7	9.6	9.8
Seafood/Other meats,%	12.7	12.1	12.2	12.3

Source: Calculations of the study based on figures extracted from FAO, 2020b.

more dynamic pace, accounting for 92 percent of production in 2018. Thus, a good part of production increases since year 2000 are associated with developing nations, but there, exports grew at a slower pace than production and accounted for only 26 percent of what was produced. It is also relevant that globalization generates increased competition wherever fish is sold. This fact requires special attention in the LAC region, where a good proportion of fish and fish products is exported, while imports are also increasing. Brazil, for example, already has a high trade deficit in seafood products.

In 2018, total LAC exports (including re-exports) of fish and fish products amounted to USD 21 076 million, and imports totalled USD 5 044 million equating to a substantial trade surplus of USD 16 032 million. Between 2000 and 2018, fish export values more than tripled, while volumes remained unchanged, mainly because of decreasing production and sales of fish meals and oils and increased exports of higher value aquaculture products. Meanwhile, the value of fish imports increased more rapidly than the quantity imported over the same period.

As shown in Table 24, Chile and Ecuador led fish and fish product export values in 2018, mainly because a large proportion of farmed salmonid and shrimp are exported. Peru also stands out, mainly due to exports of fish meals and oils, and Argentina because of capture fishery-based products. Brazil was by far the largest LAC importer of fish and fish products (366 thousand tonnes in 2018 valued at USD 1 356 million), followed by Mexico, Colombia and Chile. On a subregional basis, South America was responsible for most of the LAC seafood trade surplus, worth USD 15 085 million in 2018, when Central America also had a seafood trade surplus (USD 1 267 million) and the Caribbean, which is consistently a net fishery product importer had a USD 320 million seafood trade deficit.

Mexico was the leading seafood exporter in Central America (USD 1 456 million) in 2018, while also being the main importer of fishery products in that subregion. Honduras and Nicaragua were also significant fish exporters, while Costa Rica and Guatemala followed Mexico as the main importers of seafood products in the subregion. Within the Caribbean, only Bahamas, Cuba, Curacao and Grenada had a positive seafood trade balances, while the Dominican Republic and Jamaica were the largest importers of fish and fish products. Evidently seafood exports make an important contribution by generating hard currency for several South American and Central American economies.

TABLE 23. World exports of fishery products, and comparisons with production levels, 2000–2018

--	2000	2010	2018	Variations, %		Avg.annual .growth rates, %	
				2000–2010	2010–2018	2000–2010	2010–2018
World							
Total production (a) (million tonnes live weight)	126	145	179	15.0	23.2	1.4	2.6
Index number, production(2014-2016= 100)	77	88	109	--	--	--	--
Total exports (b) (million tonnes live weight)	47	55	66	15.6	21.4	1.5	2.5
Index number, exports (2014-2016= 100)	78	91	110	--	--	--	--
Total exports as percentage of world production	37	38	37	--	--	--	--
Developed countries or areas							
Total production (a) (million tonnes live weight)	32	28	29	-10.7	3.8	-1.1	0.5
Index number, production(2014-2016= 100)	111	99	103	--	--	--	--
Total exports (b) (million tonnes live weight)	20	23	27	12.2	17.9	1.2	2.1
Index number, exports (2014-2016= 100)	81	91	107	--	--	--	--
Total exports as percentage of world production	64	81	92	--	--	--	--
Developing countries or areas							
Total production (a) (million tonnes live weight)	94	117	149	23.8	27.9	2.2	3.1
Index number, production(2014-2016= 100)	70	86	110	--	--	--	--
Total exports (b) (million tonnes live weight)	27	32	39	18.2	23.9	1.7	2.7
Index number, exports (2014-2016= 100)	77	91	112	--	--	--	--
Total exports as percentage of world production	29	27	26	--	--	--	--

Source: FAO, Yearbook of Fishery and Aquaculture Statistics 2018, Rome, 2020.
(a) The production data (on a live weight basis) exclude whales, seals, other aquatic mammals and aquatic plants; they include aquaculture production.
(b) The international export data, converted to live weight, exclude products obtained from whales, seals, other aquatic mammals and aquatic plants.
The amount of production assigned to "unidentified" countries is included in the world aggregate only.

The largest category of seafood exports from LAC region in 2018 was fresh and frozen crustaceans and molluscs (Table 25), totalling USD 8 029 million, followed by fresh, chilled or frozen fish (USD 7 699 million). Fish meals and canned fish were also important export items. In terms of imports, 50 percent of the value was for fresh and frozen fish, while 23 percent was for canned fish in 2018. The only category where there was a negative trade balance in the LAC region was fish dried, salted or smoked, while in the other six categories, the region consistently shows substantial trade surpluses.

It is important to note that relatively small amounts of exports remain within the region. For the period 2016 to 2018 less than 10 percent of South American seafood exports by value remained within the region, while 22 percent were destined for North America, 21 percent went to the European Union (28), 15 percent to China and 14 percent to East and South East Asia. This high level of diversification is promising for stability and is in contrast to other regions of the world, such as the European Union, where 81 percent of exports are traded within the community and little is exported elsewhere. About 56 percent of South

TABLE 24. Latin America and the Caribbean: Fishery products exports, imports and trade balances, by country, 2000–2018 (USD millions at current value)

Country/Region	Exports (incl. reexports)						Imports						Trade balance		
	Volume ('000 tonnes)			Value (USD m)			Volume ('000 tonnes)			Value (USD m)			Value (USD m)		
	2000	2010	2018	2000	2010	2018	2000	2010	2018	2000	2010	2018	2000	2010	2018
South America Total	**4 957**	**3 843**	**4 753**	**5 217**	**10 028**	**18 157**	**578**	**981**	**1 035**	**638**	**2 411**	**3 073**	**4 580**	**7 617**	**15 085**
Argentina	539	457	479	806	1 337	2 082	42	41	48	84	125	221	722	1 212	1 861
Bolivia (Plurinational State of)	0	0	0	0	0	0	11	8	14	9	10	22	-9	-10	-22
Brazil	58	35	54	239	218	275	201	286	366	324	1 057	1 356	-85	-839	-1 081
Chile	1 069	915	1 326	1 794	3 401	6 794	106	151	178	48	255	432	1 746	3 146	6 363
Colombia	93	60	30	191	180	147	108	123	165	75	260	475	116	-80	-328
Ecuador	264	502	1 097	587	1 789	4 893	4	163	103	2	228	152	585	1 561	4 741
Falkland Is.(Malvinas)	65	100	80	116	261	273	0	0	0	0	0	0	116	261	273
Guyana	22	20	24	51	49	111	2	1	2	2	2	4	49	48	107
Paraguay	0	0	1	0	0	0	1	2	3	2	6	12	-2	-6	-11
Peru	2 711	1 646	1 569	1 129	2 532	3 281	28	115	130	16	163	319	1 113	2 369	2 962
Suriname	16	16	17	41	63	106	2	2	2	6	5	5	35	58	101
Uruguay	78	82	60	110	186	117	8	37	17	12	62	49	98	125	68
Venezuela (Bolivarian Republic of)	43	11	17	153	11	78	67	53	7	57	240	27	96	-228	51
Central America Total	**365**	**443**	**578**	**1 491**	**1 597**	**2 654**	**220**	**308**	**463**	**222**	**771**	**1 386**	**1 270**	**826**	**1 267**
Belize	3	7	3	32	31	22	2	1	1	3	1	1	29	30	21
Costa Rica	33	21	24	118	105	134	20	26	58	20	49	184	98	56	-50
El Salvador	3	19	27	27	78	104	5	25	22	9	43	44	18	35	60
Guatemala	32	35	21	35	98	115	6	32	43	8	75	105	27	23	10
Honduras	13	27	67	189	169	363	6	17	14	16	27	29	173	142	334
Mexico	168	230	321	707	769	1 456	169	188	292	143	530	911	564	239	545
Nicaragua	12	24	41	128	137	297	4	5	7	7	7	17	121	129	281
Panama	101	80	74	257	210	163	8	15	27	15	38	95	241	172	68
Caribbean Total	29	30	43	239	197	265	119	116	162	224	404	585	15	-207	-320
Antigua and Barbuda	0	0	0	0	0	1	2	2	2	4	6	10	-4	-6	-9
Aruba	0	0	0	0	0	0	2	2	3	10	16	27	-10	-16	-26
Bahamas	4	2	3	108	75	74	4	3	4	15	20	19	93	54	54
Barbados	0	0	0	1	1	0	4	5	8	11	18	30	-10	-17	-29
Cayman Islands	0	0	0	0	0	0	0	1	1	1	3	5	-1	-3	-5
Cuba	8	6	8	87	60	74	35	13	18	43	26	40	44	34	33
Curaçao	0	0	24	0	0	37	0	0	2	0	0	13	0	0	24
Dominica	0	0	0	0	0	0	1	0	0	2	2	2	-2	-2	-2
Dominican Republic	2	2	2	3	7	17	29	34	46	53	138	185	-50	-130	-168
Grenada	1	1	1	3	6	8	1	1	1	2	3	3	1	4	5
Haiti	0	0	0	4	7	10	9	13	25	6	20	54	-2	-14	-43
Jamaica	1	1	1	10	10	13	23	26	35	52	90	132	-42	-80	-119
Netherlands Antilles	7	13	0	6	15	0	3	3	0	8	18	0	-2	-4	0
Saint Kitts and Nevis	0	0	0	0	1	0	1	1	1	3	4	3	-3	-3	-3
Saint Lucia	0	0	0	0	0	0	1	1	1	5	7	8	-5	-7	-8
Saint Vincent/ Grenadines	0	0	0	1	0	2	0	0	0	1	2	2	0	-1	0
Trinidad and Tobago	4	4	4	11	11	25	4	9	11	7	28	44	4	-17	-19
Turks and Caicos Is.	1	1	0	4	4	2	0	1	1	2	3	7	2	1	-4
LAC Total	**5 351**	**4 316**	**5 375**	**6 947**	**11 822**	**21 076**	**916**	**1 406**	**1 661**	**1 083**	**3 586**	**5 044**	**5 864**	**8 235**	**16 032**

Source: FAO. 2020. Fishery and Aquaculture Statistics. Global Fisheries commodities production and trade 1976–2018 (FishstatJ).

American imports by value were from countries in the same region, 11 percent came from China and 12 percent from East and South East Asia while other areas such as the European Union (4.3 percent) and other Western European countries (4.4 percent) were also significant sources of seafood imports.

5.2 SALIENT ISSUES

Around half of the LAC import value of fishery products is currently for fresh, chilled or frozen fish, a category that increased 664 percent in value and 209 percent in volume between 2000 and 2018 (Table 25), presenting interesting opportunities for local aquaculture producers. Prepared and preserved fish and different preparations of crustaceans and mollusc are also important import items, suggesting that domestic production of seafood for human consumption is inadequate in most parts of the region. Fish meals and oils are also being imported in increasing quantities, as they are required for feeds for different types of animals, such as salmon, shrimp and chickens. Average import prices in LAC have increased from USD 1.2 per kg in 2000 to USD 3.0 per kg in 2018, while average export values also increased over that period from USD 1.3 per kg to USD 3.9 per kg respectively, indicating that in recent years, there has been a trend to export and import higher-value fishery products.

TABLE 25. Latin America and the Caribbean: Fishery products imports, exports and trade balances, by FAO Major groups, 2000–2018. Volume in '000 tonnes; USD millions at current value

FAO Major Group	2000	2010	2018	2000	2010	2018
IMPORTS		**Volume ('000 tonnes)**			**Value (USD m)**	
Oils	181	83	101	46	100	158
Crustaceans & Molluscs, live, fresh, chilled, etc.	43	70	98	98	234	501
Meals	129	112	107	58	154	163
Fish, fresh, chilled or frozen	297	787	919	329	1 749	2 514
Fish, dried, salted, or smoked	64	83	81	225	483	391
Crustaceans and molluscs, prepared or preserved	6	19	28	30	89	150
Fish, prepared or preserved	196	252	327	297	777	1 166
Total	**916**	**1 406**	**1 661**	**1 083**	**3 586**	**5 044**
EXPORTS (including re-exports)		**Volume ('000 tonnes)**			**Value (USD m)**	
Oils	485	328	318	86	346	555
Crustaceans & Molluscs, live, fresh, chilled, etc.	621	756	1 521	2 684	3 367	8 029
Meals	2 788	1 601	1 484	1 143	2 381	2 272
Fish, fresh, chilled or frozen	1 072	1 192	1 467	2 288	4 261	7 699
Fish, dried, salted, or smoked	25	28	17	118	180	178
Crustaceans and molluscs, prepared or preserved	38	121	150	193	351	682
Fish, prepared or preserved	322	290	418	435	935	1 659
Total	**5 351**	**4 316**	**5 375**	**6 947**	**11 822**	**21 076**
TRADE BALANCE		**Volume ('000 tonnes)**			**Value (USD m)**	
Oils	304	245	216	40	246	397
Crustaceans & Molluscs, live, fresh, chilled, etc.	578	686	1 423	2 585	3 134	7 528
Meals	2 659	1 488	1 378	1 086	2 227	2 109
Fish, fresh, chilled or frozen	775	405	548	1 959	2 512	5 186
Fish, dried, salted, or smoked	-39	-55	-64	-106	-303	-213
Crustaceans and molluscs, prepared or preserved	32	103	122	163	262	532
Fish, prepared or preserved	126	38	91	138	158	493
Total	**4 435**	**2 911**	**3 714**	**5 864**	**8 235**	**16 032**

Source: FAO. 2020. Fishery and Aquaculture Statistics. Global Fisheries commodities production and trade 1976–2018 (FishstatJ).

The most interesting production and trade trends in LAC over the last decade have been the decrease in production of fish meals and oils and the increasing presence of aquaculture products in local exports while the high contribution of fish trade surpluses to generate hard currency, is now more associated with aquaculture than with capture fisheries products. Even without detailed data on the extent to which aquaculture production is exported or marketed within the region it is clear that most aquaculture products from Chile and Ecuador are exported, as well as most production from Nicaragua and Honduras within Central American and Caribbean countries.

Brazil could be the leading aquaculture producing country in South America, however governance problems, poor management and planning have so far prevented the country from achieving this goal. Also, the speed at which seafood demand has risen over the past 15 years, due to social communication campaigns, has surpassed the pace at which the national aquaculture supply has responded, thus stimulating imports. Limited aquaculture and wild fish catches have been responsible for increasing seafood imports in the last 15 or more years, a fact that is likely to prevail in the foreseeable future, unless serious long-term plans are developed, and strong political will and leadership exercised.

Brazil's growth as a tilapia producing country has made it the largest producer of this species in South America, both for exports and domestic consumption. Brazilian whiteleg shrimp production has fluctuated between 60 thousand and 70 thousand tonnes over the past 10 years, but was only 62 thousand tonnes in 2018. There seems to be a shortage of shrimp in the domestic market, but the local shrimp producers' association has fought intensely for many years to avoid imports of wild shrimp from Argentina or from shrimp farms in Ecuador. That fight was lost, and there has been increased inflow of products, forcing local producers in Brazil to improve efficiency and competitiveness.

In Costa Rica, tilapia production decreased between 2013 and 2017 in response to increased competition from low-cost tilapia and striped catfish from Asia. However, in 2018, exports increased by almost 1 000 tonnes compared to 2017, as a result of support from the "Rainforest Tilapia Project", which focussed on higher-priced markets for tilapia (Heinen's, 2019; FAO, 2020e; Rainforest, 2020). Peru, with declining wild fish landings, is set to develop a strong aquaculture sector with the local industry currently favouring inland aquaculture.

Small-scale aquaculture competes with low-cost imports and the demands of larger markets, including supermarkets and other outlets in large urban areas. Government support has seldom focused on strengthening the competitiveness of small-scale production. As globalization progresses, small farmers are threatened with unemployment if they do not meet efficiency standards, even if they are, or should be, the main suppliers of fish in rural areas and small urban markets. Exports also become more difficult because of inefficiencies that affect prices and their ability to compete. It should also be stressed that micro, small and medium-sized farmers are important for rural economies and for local consumption. These farmers sustain what the FAO calls the 'short-distance markets' with fresh product, whose quality is much higher than imported, often untraceable products found in cities. Local farmers support local economies, create jobs and in terms of consumption of seafood are the reason in many rural areas that there is now a fish on the plate of household members once or twice a week, either tilapia or a local freshwater fish, whereas in previous times there was none.

5.3 THE WAY FORWARD

Seafood export volumes in LAC are expected to continue growing, but at a more modest pace in coming years, due to declining growth rates of local aquaculture and sustained declines in capture fisheries. In turn, further growth of imports should be expected in many

LAC countries, associated with more restricted domestic production and improving incomes and education, factors that should boost regional demand for seafood. However, the lack of good data makes it difficult to forecast whether this demand will be met by fishery or aquaculture products.

There should be sustained interest in the region to encourage seafood exports, particularly those from aquaculture, as this activity can provide employment in many rural areas, particularly for small-scale fishers who are displaced from declining coastal fisheries. However, their switch to aquaculture will not be simple and will require not only professional training but also long-term commitment from governments. The CRFM Ministerial Council has directed the Working Group on Aquaculture Development to work along with Member States to investigate the potential across the spectrum of economic models for varying scales and types of aquaculture operations, and to facilitate access to relevant models for both large-scale and small-scale operations that could guide policy-makers and investors.

Countries such as Brazil, with high and increasing trade deficits in seafood products and conducive conditions for aquaculture, should improve their farmed output and could probably lead LAC aquaculture production in the coming decades, if proper governance and adequate leadership are exercised.

The significance of seafood product exports in some regional economies is shown in Table 26. In Ecuador, these accounted for 22.6 percent of the value of all merchandise sold abroad in 2018 and 44.8 percent of agricultural exports. In several other net exporting countries of the region the situation is similar with seafood exports accounting for over 30 percent of agriculture sales abroad, a fact that should stimulate interest in the expansion of aquaculture opportunities.

Increasing levels of fishery imports call for more development of small-scale aquaculture throughout the region, as this sector can contribute substantially to domestic market supply. Until now, a large proportion of domestic seafood supply in LAC came from artisanal fisheries, where landings are diminishing noticeably. Small-scale farming can in due course replace these capture fisheries.

TABLE 26. Latin America and the Caribbean: The significance of foreign trade of fishery products in selected countries, 2018. Values in USD '000

Net Exporters	Exports	Imports	Trade balance	Fishery exports as a % of agricultural exports	Fishery exports as a % of total merchandise exports
Chile	6 794 232	431 557	6 362 675	36.4	9.0
Ecuador	4 892 919	151 667	4 741 252	44.8	22.6
Peru	3 280 816	318 812	2 962 004	32.9	6.7
Argentina	2 082 109	221 168	1 860 941	6.3	3.4
Mexico	1 456 446	911 439	545 007	4.2	0.3
Honduras	363 223	29 315	333 908	13.0	4.2
Nicaragua	297 484	16 581	280 903	12.6	5.9
Falklan Is (Malvinas)	273 035	67	272 968	95.7	…
Panama	162 817	94 987	67 830	33.8	1.4
Uruguay	116 693	49 092	67 601	2.4	1.6
Guatemala	114 780	105 165	9 615	2.2	1.1
Guyana	110 890	3 628	107 262	26.8	8.1
Suriname	105 868	5 215	100 653	56.8	5.0
El Salvador	103 660	43 957	59 703	9.8	1.8
Venezuela (Bolivarian Republic of)	78 319	26 999	51 320	86.1	0.2
Cuba	73 649	40 461	33 188	12.2	2.6
Belize	21 539	857	20 682	11.9	4.8
Net importers	**Exports**	**Imports**	**Trade balance**	**Fishery imports as a % of agricultural imports**	**Fishery imports as a % of total merchandise imports**
Brazil	275 247	1 355 968	-1 080 721	12.7	0.7
Colombia	146 981	474 647	-327 666	7.2	0.9
Dominican Rep	17 168	184 858	-167 690	5.9	0.9
Costa Rica	133 621	183 925	-50 304	8.4	1.1
Jamaica	12 705	131 899	-119 194	12.8	2.2
Haiti	10 463	53 933	-43 470	5.0	1.1
Trinidad&Tobago	25 249	43 943	-18 694	4.8	0.6
Barbados	485	29 610	-29 125	8.1	1.9
Aruba	149	26 627	-26 478	7.6	2.2
Bolivia (Plurinational State of)	0	22 337	-22 337	2.9	0.2
Paraguay	160	11 562	-11 402	1.0	0.1
Antigua&Barbuda	691	9 994	-9 303	6.3	2.0
Saint Lucia	0	7 846	-7 846	6.8	1.1
Turks &Caicos Is.	2 383	6 590	-4 207	5.6	…
Cayman Islands	1	5 308	-5 307	4.2	0.5
St.Kitts&Nevis	286	3 060	-2 774	7.1	0.9
Dominica	7	1 838	-1 831	4.3	0.6

Source: FAO, Yearbook of Fishery and Aquaculture Statistics 2018, Rome, 2020.

6. Contribution of aquaculture to food security, social and economic development

6.1 STATUS AND TRENDS

6.1.1 Food security

FAO (2020b) estimated that one ninth of the global population was undernourished in 2018 and that the LAC region was second only to Africa and Asia in terms of undernourishment rates in 2019. Also, that current levels are likely to get worse by 2030, when the LAC region will become the second most affected region of the world, surpassing Asia due to significant levels of poverty (Table 27). Within the region, data suggest that the Caribbean and Central America are most affected by undernourishment, while South America ranks a little better.

TABLE 27. Prevalence of undernourishment by continent and in the Latin America and the Caribbean region, 2005–2030

	2005	2010	2015	2016	2017	2018	2019*	2030*
World	**12.6**	**9.6**	**8.9**	**8.8**	**8.7**	**8.9**	**8.9**	**9.8**
Africa	21	18.9	18.3	18.5	18.6	18.6	19.1	25.7
Asia	14.4	10.1	8.8	8.5	8.2	8.4	8.3	6.6
Oceania	5.6	5.4	5.5	5.9	6	5.7	5.8	7
North America & Europe	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
LAC region	**8.7**	**6.7**	**6.2**	**6.7**	**6.8**	**7.3**	**7.4**	**9.5**
Caribbean	21.3	17.5	17.3	17	16.6	17	16.6	14.4
Central America	8.1	7.9	7.9	8.6	8.3	8.4	9.3	12.4
South America	7.6	5.1	4.4	4.9	5.2	5.8	5.6	7.7

* Estimated figures

Aquaculture has the potential to support sustainable and resilient food systems, addressing the food security pillars of availability, access, utilization and stability through the provision of healthy food and better livelihoods (FAO 2020c; Little and Bunting, 2016). Although the diversification of global food production systems, including aquaculture, promises an enhanced level of resilience, such promise will not be realized if government policies fail to provide incentives for resource efficiency, equity and environmental protection.

The LAC region had the lowest average annual per capita fish consumption rate in the world in 2018 (9.8 kg), despite areas where fish consumption rates are relatively high such as the Amazon, some of the Caribbean islands, Guyana and coastal Peru (CRFM, 2020). Most countries in the LAC region prefer meat such as beef, pork, and chicken to fish. In 2015, the region apparently consumed only 6.2 million tonnes of fish, lower than all other regions in the world except for Oceania. Nevertheless, FAO (2017) predicts that total fish consumption will grow by 33 percent in the LAC region by 2030 and by 18 percent in the current decade. This would represent the highest regional per capita growth rate in the world and will need to be largely fuelled by increasing availability of aquaculture products.

Evidently LAC freshwater aquaculture contributes more to regional food security and nutrition than mariculture due to the fact that most mariculture production is exported to countries outside the region, while a large proportion of freshwater production, such as tilapia and Amazonian characins, are consumed locally.

Urbanization and a growing, fish-consuming, middle class are expected to support this growth (FAO, 2020d), even though poor governance, difficulties related to access to farming permits and social pressures are key challenges. While most current industrial aquaculture production is exported out of the LAC region, characid and Brazilian shrimp production are already focused on expanding domestic markets, as well as most tilapia production in several countries. Projects for community development generally focus on improving local food security through the provision of fish and livelihoods. While national data or cost-benefit analyses often do not properly assess the final results of these interventions, they most likely also contribute to an increase in fish consumption within the region.

While aquaculture aims to improve food and nutrition security, published evidence is scarce in LAC. In a short study on characid farming in central Bolivia (Plurinational State of), Irwin, Flaherty and Carolsfield (2020), found it difficult to demonstrate differences between aquaculture and non-aquaculture farms based on the Latin American and Caribbean Food Security Scale (ELCSA), but demonstrated increased fish consumption and income within fish-farming families. Little and Bunting (2016) discussed a number of ways in which aquaculture can enhance local food security other than eating the cash crop, including the use of byproducts (water, carcasses or skins) or consuming co-cultured, low-cost fish. Such things are most likely happening but have not been sufficiently documented in the region.

In Brazil, as in many parts of Asia, the small lombari (*Astyanax* spp.), a tetra fish species, is commonly co-cultured accidentally with characids, and is eaten. It has become popular and valuable enough to be registered in the FAO database. Other small fish are commonly found in characid ponds and could likewise be utilized as nutritious food. Many ideas for improving the contribution of aquaculture to food security of poor or low-income people are proposed in development projects in the region and are carried out as pilot-scale projects with selected communities, particularly with women. Unfortunately, formal evaluation of these experiences is not yet available. The peculiarities of each locality, their relatively low monetary value, and the short time frame of most development projects makes scaling up of these ideas challenging.

There are currently pilot-scale projects in Guatemala, Honduras and Paraguay, through which the inclusion of fish in school meals is being promoted. So far, before-and-after comparison of height to weight ratios show that children in Honduras have improved their nutritional condition (A. Flores, personal communication, 2020; FAO, 2020). In Chile, farmed mussels and salmon have been included in school meals in provinces where aquaculture farms are located. These are pilot initiatives where aquaculture farmers' associations have cooperated with the national institution that provides food for school children (SUBPESCA, 2019; Salmonexpert, 2020) and in many cases, this is the only high quality food that poor children have access to.

Aquaculture can also be an important economic driver for local economies. In parts of rural Latin America, it provides self-employment for all family members, as well as cash incomes. Most small-scale fish farmers are also agricultural farmers. This allows them to diversify their cash income activities and risks.

The economic and social significance of aquaculture has increased in at least the top five aquaculture producing countries in South America, and it is expected that its importance will keep growing. Countries with less developed aquaculture industries still need to demonstrate that this activity will have a meaningful impact on their societies and economies, while improving food security. Meanwhile in countries such as Argentina, there is still a lack of interest or awareness because traditional agriculture and fisheries are so well developed and aquaculture has barely caught the attention of authorities or the private sector. In Brazil, with over 8 000 km of coastline, little marine fish farming has taken place so far, a fact that will probably be addressed in coming decades. Perú is also making a shift from declining wild fisheries towards fish farming, so aquaculture is expected to play an important role in job creation and food security.

6.1.2 Employment

Aquaculture-specific employment data are available for the LAC region in The State of World Fisheries and Aquaculture 2018 report up to 2016, but more recent figures (FAO, 2020d) refer only to the Americas as a whole (Table 28). Based on the figures presented in Table 31, and the proportion of LAC employment compared to total employment in the Americas for 2016, it can be estimated that for 2018, employment of fishers and fish farmers in the LAC region amounted to 2.612 million people, out of which only 379 thousand were engaged in aquaculture, while the remaining 2.231 million worked in capture fisheries.

TABLE 28. World employment for fishers and fish farmers by region, 1995–2018 (thousands)

Region/Sector	1995	2000	2005	2010	2015	2018
Fisheries and aquaculture						
Africa	2 812	3 348	3 925	4 483	5 067	5 407
Americas	2 072	2 239	2 254	2 898	3 193	2 843
Asia	31 632	40 434	44 716	49 427	49 969	50 385
Europe	476	783	658	648	453	402
Oceania	46	6 459	466	473	479	473
Total	37 456	47 263	52 019	57 930	59 161	59 509
Fisheries						
Africa	2 743	3 247	3 736	4 228	4 712	5 021
Americas	1 793	1 982	2 013	2 562	2 816	2 455
Asia	24 205	28 079	29 890	31 517	30 436	30 768
Europe	378	679	558	530	338	272
Oceania	460	451	458	467	469	460
Total	29 579	34 439	36 655	39 305	38 771	38 976
Aquaculture						
Africa	69	100	189	255	355	386
Americas	279	257	241	336	377	388
Asia	7 426	12 355	14 826	17 910	19 533	19 617
Europe	98	104	100	118	115	129
Oceania	6	8	8	6	10	12
Total	**7 878**	**12 825**	**15 364**	**18 625**	**20 390**	**20 533**

Note: The regional and global totals have been adjusted in some cases as a result of extended work on the dataset to revise historical data and improve the methodologies applied for estimations.
Source: FAO.

Worldwide, there were about 60 million people working directly in fisheries and aquaculture in 2018, an important increase from 37.5 million in 1995, but a figure that has remained relatively stable since 2010. Aquaculture employment represented 21 percent of this total in 1995 rising to 34.5 percent in 2018 (20.5 million). While total direct employment in LAC aquaculture has been estimated at 379 thousand in 2018, there was probably at least an equivalent amount of indirect employment associated with aquaculture activities, bringing estimated total aquaculture employment in LAC to some 758 thousand jobs. With an average household size of four persons, this means that, around 3 million people may have benefitted from aquaculture and aquaculture-related activities in LAC in 2018, when the equivalent global figure was 164 million people.

Although definitive data are not available, it is thought that the majority of aquaculture employment in LAC is in or related to small or medium-sized aquaculture operations (self-employed or salaried). Flores Nava (2013) proposed two operational definitions for small-scale aquaculture in Latin America, Limited Resource Aquaculture (AREL) and Micro and Small Business Aquaculture (SBA). A large proportion of inland fish farming in Brazil is in the SBA category, which features commercial orientation, while the proportion of AREL was larger in Colombia, Ecuador and Bolivia (Plurinational State of). With the increase in native tropical fish and tilapia farming during the last 10 years it is likely that the proportion of SBA has increased in all countries (Dantas Roriz *et al*., 2017), thus increasing its impact not only on local food security, but also on employment and economic development.

Limited Resource Aquaculture in the LAC region includes subsistence aquaculture, but at times overlaps with SBA. Many of these activities depend heavily on government or international subsidies at some point in their development, even if they aspire to scale up and specialize. Some depend on long-term subsidies to remain active, which may be the only alternative to long-term poverty alleviation. For example, seaweed farming is small-scale and not commercially attractive in many parts of the region but is a significant means of livelihood in some coastal areas and generates enough production volume to be registered in the FAO database. However, the activity continues to be fragile and may be dependent on government support, particularly due to low prices and market conditions where a few large buyers control the market. While official statistics are not reliable, according to a preliminary survey in 15 countries of the region, there are over 100 000 families that depend partially or exclusively on SBA (Flores Nava, 2013). Moreover, SBA accounts for over 60 percent of the total national aquaculture production of Colombia and Bolivia (Plurinational State of), and more than 90 percent of production in Paraguay.

Small-scale aquaculture is also thought to provide particularly good opportunities for empowerment of women and youth (FAO, 2020d). Women work in all sections of the aquaculture value chain, but their opportunities have not kept pace with its growth. Irwin, Flaherty and Carolsfield (2020) determined that Bolivian family aquaculture provided significantly greater income if women and men share decision making, yet there were gender-based wage disparities.

Industrial-level aquaculture is an important source of hard currency in export-oriented countries such as Ecuador and Chile, and its contribution to total exports is significant. According to the National Chamber of Aquaculture of Ecuador, in 2017 the industry generated 100 thousand jobs (direct and indirect) in production and processing and about 200 thousand jobs related to services and support. In the case of Chile, intensive aquaculture is responsible for reinvigorating formerly ailing economies of southern provinces generating 21 462 direct jobs in 2016. Most of these were in processing plants (53.1 percent), followed by marine farms (19.0 percent), hatcheries and smolt farms (12.5 percent) and other activities (15.5 percent). On average, the remuneration rates received by workers in the aquaculture sector are higher than average income levels in Chile (INE, 2019; Cerda, 2019). Additionally, the salmon industry value chain provides work in engineering, manufacturing (e.g. marine rafts, food, nets, packaging materials), veterinary activities and transport services, as well as food and lodging. There is insufficient published information on the indirect economic relevance of the aquaculture sector in Chile. However, the production losses during the ISA virus crisis and El Niño events in 2016 revealed that some cities were highly dependent on salmon farming.

While employing fewer people in proportion to production, large-scale operations contribute significantly to local economies and employment for both women and men. For example, Ceballos, Dresdner-Cid and Quiroga-Suzao (2018), were able to show that salmon aquaculture in Chile created indirect employment in remote regions and had a significant impact on poverty reduction at the local level while support and supply services also provided significant employment. Ramirez and Ruben (2015) reported that 40 percent of the combined salmon farming workforce in Chiloé Island, Chile was female, well above the global aquaculture average of 19 percent (FAO, 2020c). This is also the case in Ecuador, where a large proportion of employment in shrimp processing is for women. Ramirez and Ruben (2015) also underscored that women who are familiar with agriculture work are more likely to perform well in fish farming-related employment, while counterparts that only have knowledge of seafood gathering did not do as well. Thus, aquaculture provides new work opportunities, and will continue to do so as production and value chain activities progress.

While there are increasing employment opportunities in aquaculture across most parts of the region, a proportion of employment may still be informal or temporary, especially regarding harvest, post-harvest and processing activities. However, large scale industrial aquaculture employment such as in salmon or shrimp farming is largely formalized and work safety issues have increasingly been addressed (Watterson *et al*., 2020). Nevertheless, there are still risks. For example, diving accidents have occurred on salmon farms, although the incidence rate has fallen relative to the growth of the industry. A study on diving casualties in salmon farming prepared by the national social security body in Chile in 2015 reported 3 500 divers working for the industry, or about 20 percent of the total number of working divers in the country (Guerrero, Yanez and Jopia, 2015). According to this study, between 2010 and November 2012, there were 877 labour accidents and 55 occupational illnesses associated with divers, while the report emphasized that all divers were covered by health insurance. The study recommended further research and surveillance, although no more recent official information was found after this report. Information on health and occupation hazards in other aquaculture systems and countries is scarce, as shown by Souto Cavalli, Blanco Marques and Watterson (2019) in a review on occupational hazards in Brazilian aquaculture.

6.1.3 Brazilian tilapia culture success story

Tilapia and characid farming in Brazil have made substantial contributions to improving domestic fish consumption and job creation in rural areas. According to Barroso, Muñoz and Cai (2019), by 2013, average annual consumption of farmed tilapia in Brazil increased to 1.39 kg per capita, nearly 80 percent higher than the world average of 0.78 kg and in a country where annual per capita fish consumption rates have been below 10 kg in recent years.

The expansion of tilapia farming in Brazil has had noticeable effects on regional development, mainly in the northeast of the country, where work opportunities are relatively scarce (Barroso, Muñoz and Cai, 2019). Technology training packages helped many people who lack fish farming expertise to become tilapia farmers. Service activities that were created added further employment opportunities, including in equipment and feed manufacturing, hatcheries, processing plants, marketing and distribution, thereby creating new industrial clusters. Employment provided by tilapia farming has helped mitigate rural emigration (Barroso, Muñoz and Cai, 2019). Tilapia farming is now widely practised in almost all regions of the country, in rural areas where alternative jobs are scarce, and malnutrition can be widespread. Therefore, tilapia farming and the farming of several native species have become important in many parts of Brazil, improving income generation, overall food security and the provision of fish for local consumption.

According to the main aquaculture producer organization in Brazil, PEIXE BR (2020), tilapia aquaculture has grown to around 0.7 million tonnes in 2020, compared to production of only 0.4 million tonnes recorded in 2018, making it the species with the highest production in the country. It is being extensively raised in all regions, except in the Amazon. The states with highest tilapia production in 2018 were Paraná, in the south (123 000 tonnes) and São Paulo, in the southeast region (69 500 tonnes), accounting together for 48.1 percent of total national production. The main culture system used in Paraná is excavated ponds, whereas net-pens in reservoirs are used in São Paulo and in the northeast of the country.

Brazil has more than 5 million hectares of flooded areas related to hydroelectric reservoirs alone. In some of these reservoirs new production centres for tilapia farming are being created, using net-pen culture systems. Apart from these reservoirs, tilapia production is carried out in traditional earth ponds while intensive systems such as recirculation systems (RAS), aquaponics, and biofloc systems are still under development. Three types of producers can be identified in Brazil: independent small growers, cooperatives (or other associations) and vertically integrated, large companies. The vast majority of producers are in the independent category, but at the largest scales of production, the cooperatives in the south of the country and the vertically integrated companies in São Paulo, are responsible for a large proportion of production.

In southern Brazil, two cooperatives dominate tilapia production in Parana: Copacol (Cooperativa Agroindustrial Consolata), based in Cafelandia (Copacal, 2020), and Vale, Cooperativa Agroindustrial, based in Pallottine (Vale, 2021). Both cooperatives report production capacities of around 80 tonnes per day. They also grow cereals and oilseeds to produce their own feeds and provide seed (fish fry and juveniles) and technical assistance to members allowing them to control production costs and achieve high productivity. This makes fish farming in the western region of Paraná competitive with fish farming in the state of São Paulo and is an example for the rest of the country in terms of efficiency and organization.

Other case studies on tilapia farming are currently under preparation from countries such as Mexico. The results will become available shortly and will describe the positive impacts of tilapia aquaculture on poverty and reducing the vulnerability of small-scale, rural fish farmers in the Pacific South of Mexico, the region with the highest poverty and food insecurity levels in the country.

6.2 SALIENT ISSUES

Aquaculture in the LAC region continues to contribute to economic and social growth and employment opportunities, through large-scale and small-scale aquaculture due to the increased provision of highly nutritious fish protein and improved livelihood opportunities. This is especially apparent in inland aquaculture, since most tilapia and native Amazonian characins are consumed locally, particularly in Brazil. Aquaculture contributions to food security depend on the type of aquaculture but data on their long-term impacts to food and nutrition security need to be determined.

Aquaculture has had a significant impact on economic activities where jobs are scarce in rural areas of Brazil, Peru, Ecuador, Colombia, Chile and Venezuela (Bolivarian Republic of). Impacts on malnutrition can be widespread especially in countries in Central America and the Caribbean and in some countries in South America. Tilapia and several native species are of paramount importance in many localities, either for self-consumption or income generation.

Promotion of small-scale aquaculture, including of local native species, is part of most aquaculture development plans, including the recent Peruvian programme PNIPA (2018). However, continuity of support programmes and long-term evaluation of the different approaches for poverty alleviation and improved food security are rare. Governments have important roles to play in engaging people in small-scale farming and by encouraging large-scale production where local demand and export possibilities are favourable.

6.3 THE WAY FORWARD

Even if challenges are complex, better leadership, political will and dialogue among the private sector, small-scale producers and governments will create opportunities to further develop aquaculture in the coming decades. Nevertheless, aquaculture will likely not evolve as rapidly as in the past, slowing to growth of four or five percent per year, or less, if more severe impacts of climate change are experienced on top of market issues and the effects of the COVID-19 pandemic.

The promotion of aquaculture to support and improve the livelihoods of small-scale farmers either as self-employed farmers or employees in the value chain will require a new "social contract" that better matches opportunities with the cultures, traditions and environments of local populations. The industry also needs to become more actively involved in environmental sustainability and social well-being, including public relations and the provision of better information to improve the image of aquaculture.

As fishing declines throughout the region, aquaculture is a means of providing alternative livelihoods to coastal fishers. Governments need to facilitate small and medium-scale aquaculture development for this purpose where appropriate, along with transition mechanisms. To date, only a few countries have institutional arrangements in place and urgent action will become necessary in the coming years.

Innovation is one of the most important tools for aquaculture development and competitiveness, and more and better support efforts are needed to promote R&D in this field. Governments need to play a leading role, by developing strategies to facilitate incorporation of new techniques, production systems and innovative raw materials, machinery and/or services. There are several ways authorities can facilitate innovation and development. Most are known but are not necessarily used. Of course, private actors or small-scale farmers or their associations can also lead the way, but most of the time they aim at improving their ability to become more efficient and competitive within their main line of activity, where they feel comfortable. This means committing to long-term R&D processes such as farming new species, or incorporating technology from other areas, with uncertain results and high levels of investment.

Governments can play an important role in promoting R&D, by catalysing innovation to accelerate development, in ways that no other actor can. However, governments do not necessarily take the lead, and instead focus on normative roles, thus creating a vacuum that no other player adequately fills. Governments and their institutions should devise strategies to facilitate innovation and development, directly or through organizations that can make a difference. On the other hand, government-led development processes need to fit the circumstances or they will not gain widespread acceptance. Consensus is required on what needs to be done to move forward efficiently with social approval and legitimacy.

Only through well established and legitimate leadership and guidance can aquaculture move forward more swiftly and contribute decisively to social and economic well-being within the LAC region. Furthermore, governments should also lead the way by preparing more efficient assistance schemes to better serve small-scale producers, through innovative pilot-projects that can produce sustainable change. These issues need to be urgently addressed because global trade and imports put in jeopardy the long-term sustainability of family-oriented farming and the future contribution of aquaculture.

New and more focused financing schemes for small-scale farming are also a must. Well-devised programmes that facilitate the adoption of technology and provide economic stability to these farmers will help to provide growth opportunities for farmers with limited capacity.

The informal nature of a good proportion of small-scale aquaculture producers is also relevant, and governments throughout this region should make their best efforts to solve this problem; otherwise, many producers will remain invisible to aid programmes.

Additionally, for aquaculture to gain more acceptance and political interest it is essential to have better information on its impact on food security and employment, both direct and indirect. Such information could allow better understanding of the role of aquaculture in sustainable development, particularly when compared to other sectors.

7. External pressures on the sector

7.1 STATUS AND TRENDS

7.1.1 Background

Aquaculture in the LAC region is subject to threats from climate variability (variations in the climate that last longer than individual weather events), climate change (variations that persist for a longer period of time, typically decades or more) as well as extreme events (earthquakes, volcanic eruptions, hurricanes and tsunamis). Therefore, it is always important to consider risk-based spatial planning which in most cases is either not done or not implemented (see Chapter 4). Because aquaculture is a newer farming system in LAC than in Asia, for example, there is an opportunity to carry out proper sectoral planning in priority development areas.

Urban development, population growth and intensive agriculture generate nutrient loads and pollution that can affect both inland and coastal aquaculture. Fortunately, most countries in LAC do not have such high levels of urban and intensive agricultural development as regions such as Asia. Climate change, fluctuations in global market demands, political and economic changes and social unrest are likely to constitute the most important long-term external pressures on the sector in LAC, and there is currently a more immediate external factor, the COVID-19 pandemic that will probably have an extended impact.

7.1.2 Climate variability and climate change

The El Niño southern oscillation (ENSO), considered as climatic variability, is a frequently occurring event that can have strongly negative impacts on aquaculture systems in LAC. The El Niño event during 2015 and 2016, one of the strongest in decades, had significant impacts on South American aquaculture, particularly when precipitation sharply declined in some areas and increased in others (Bertrand *et al.*, 2020). This situation helped to predict longer term impacts of changes in precipitation patterns associated with climate change but caused significant losses to Chilean salmon farmers, affected tilapia farmers in Brazil and also shrimp farmers in Ecuador. El Niño has also affected scallop seed availability in Peru and impacted total scallop production in both Peru and Chile (Kluger *et al.*, 2019) due to ocean warming, oxygen depletion and heavy rainfall. The 2015/2016 El Niño caused increased temperatures and reduced precipitation triggering one of the largest harmful algal blooms ever registered in southern Chile with significant salmon losses and also affected mussel exports (Leon-Muñoz *et al.*, 2018).

There is already evidence that climate change will impact aquaculture worldwide in many ways (Dabbadie *et al.*, 2018). As regards inland aquaculture in LAC there are at least two pressing threats, increasing air and water temperatures and decreasing freshwater availability while adaptation measures taken by other sectors, such as energy generation and irrigation, are likely to compound these threats. In most Central American and Caribbean countries, impacts of climate change exceed the response capacity of institutions and communities. More information is needed regarding potential impacts especially at the local level and particularly for freshwater aquaculture compared to mariculture. Further information and analysis are needed to reinforce prevention and strengthen adaptation capacity, including livelihood diversification strategies as well as more effective management measures (FAO, 2018; FAO, 2020g).

Different climate projections and models suggest an increase in warm, dry periods for the Amazon basin, which could reduce water availability and quality, made more acute by deforestation and the expansion of agriculture. In parallel, tilapia and characids can grow faster under slightly higher water temperatures, so there could also be some positive effects on production. However, increased mortalities due to lower oxygen availability and water quality deterioration are also likely to be a threat (Dantas Roriz *et al*., 2017). Hot seasons, intense environmental variations during the day and low water levels due to drought are also important factors that could trigger the emergence of fish diseases and cause production losses. Kubitza (2016) describes critically low water levels in reservoirs used for tilapia farming during the last El Niño event, when precipitation declined sharply. A long-standing drought has been present in Brazil since 2012 (Cunha *et al*., 2019), severely limiting availability of water and affecting water quality in reservoirs and water supply to fishponds. Shrimp producers are also concerned about freshwater availability, necessary to achieve appropriate salinity levels.

Ocean acidification will also affect the production of bivalves and crustaceans, with several scientific reports underscoring potential risks for mussels and scallops along the Chilean and Peruvian coasts (Navarro *et al.,* 2016). Drought, along with reduced water flow from glaciers is affecting Andean trout production in Bolivia (Plurinational State of), Chile and Peru, as well as freshwater delivery into southern fjords and channels that support salmon and mussel farming. The resulting increases in salinity, lower oxygen levels and more sunny days could increase the vulnerability of salmon farming, especially in northern Patagonia. These conditions could increase the impact of sea lice and other parasites that survive better in higher salinities. Changes in climatic conditions could also increase red tides (Soto *et al.,* 2019) and induce lower production of mussel larvae (Soto *et al.,* 2020). Prolonged drought along the "dry corridor" of Central America also limits aquaculture expansion and calls for more resilient culture systems.

In Chile, climate change risk maps have been developed using climate forecasts for the next 30 to 50 years for the most important aquaculture systems, salmon and mussel farming (Soto *et al.,* 2020). This also highlighted the need for improved spatial planning to reduce risks as well as the value of improved management practices to adapt to the new circumstances.

Caribbean island developing states are particularly affected and exposed to floods, increased droughts, coastal erosion and depletion of freshwater resources (Table 30). Damage by extreme events to critical transport infrastructure, such as ports and airports, can have broader consequences for international trade and the sustainable development prospects of these most vulnerable nations (FAO, 2020e). Small-scale operations typical of these countries are particularly sensitive to damage from extreme weather events, changes in ocean conditions and sea-level rise. In Central America, tilapia grown in Costa Rica, Guatemala, Honduras and Mexico (Liñan-Cabello, 2016) and white shrimp grown in Mexico are the most vulnerable aquaculture systems to extreme events and their economic consequences.

7.1.3 International trade dynamics and market demand

Export markets for LAC products are driven by a variety of factors that can affect aquaculture investments, production and value added, including consumer preferences, currency fluctuations and historical trade arrangements. For example, climate-related events reduced shrimp production in India, and the China-United States of America trade disagreement resulted in increased shrimp exports to China from Ecuador in 2019 (FAO, 2020e). Within the LAC region, a long-standing Brazilian ban on shrimp imports for biosecurity reasons has been partially lifted, opening the market for shrimp products from Ecuador and Argentina, thus challenging the profitability and competitiveness of the Brazilian shrimp industry.

TABLE 29. Description and impact of the effects of climate change in the Caribbean and Central America

Region area	Likely Climate changes	Effects on economy and local population
Pacific Central America (Loma-Osorio *et al.*, 2014)	7–10 percent reduction in precipitation and an increase in temperature exceeding 2°C by 2080 in Gulf of Fonseca (shared by El Salvador, Honduras and Nicaragua)	- Water supply systems will need adaptation - Impact on local and national economies - Livelihoods threatened
Gulf of Mexico (Bruyère, 2017)	- Sea level rise - Increased hurricane intensity	- Flood risk for coastal areas and hurricane damage - Impact on local economies
Caribbean Sea Basin (CEPAL, 2018)		- Loss of productive space - Population relocation - Loss of public infrastructure

Source: Modified from FAO, 2020g.

7.1.4 Impact of the COVID-19 pandemic

The COVID-19 pandemic has triggered a public health crisis followed by an on-going economic crisis due to the measures taken by countries to contain the rate of infection, such as home confinement, travel bans and business closures. Although COVID-19 does not affect fish directly, the fish sector is still subject to indirect impacts of the pandemic, altered by changing consumer demands, market access or logistical problems related to transportation and border restrictions, which in turn have impacts on fisher and fish farmer livelihoods, as well as on food security and nutrition for populations that rely heavily on fish (Bondad-Reantaso *et al.*, 2020; FAO, 2020h).

The COVID-19 pandemic has strongly affected both aquaculture production and exports in LAC countries. More than 70 percent of aquaculture production in LAC, namely shrimp, salmon, mussels and some tilapia is destined for export markets. Travel restrictions and lockdowns paralyzed and blocked seafood markets in importing countries such as China, a key destination for Chilean salmon and Ecuadorian shrimp. Thousands of tonnes of salmon did not reach their usual markets during the first months of 2020, forcing the industry to slow production and look for alternative markets, sometimes with significant losses. Shrimp exports from Ecuador were also strongly affected because China was their second most important export destination in 2019 (Torres and Guerra, 2020). Part of the problem was linked to reduced human resources for transportation and marketing in China, but also to lower demand, as many restaurants and related food services were closed. Demand also fell in Brazil which normally imports high volumes of fresh salmon. More importantly, even when the main importing countries open again to fish trade, depressed economies mean it may take some time before demand returns to pre-pandemic levels.

Aquaculture farms have also been severely affected by the irregular delivery of feeds, due to mobility restrictions. This has been particularly apparent in Central American countries where domestic demand for seafood, including aquaculture products, dropped drastically after March 2020. This increased the costs and risks to farmers, as ponds had to be either left unharvested for longer or harvested fish had to be processed and refrigerated until demand resumed (A. Flores, personal communication, 2020). The COVID-19 pandemic poses new challenges to rural women regarding their roles in maintaining household food security, as agricultural producers, farm managers, processors, traders, wage workers and entrepreneurs (FAO, 2020i).

A high concentration of exports to a few destinations poses a significant strategic risk to the sector. The full impact of the COVID-19 pandemic is yet to be determined, but several potential effects can already be described. For example, a reduction in the demand for salmon and shrimp from the United States of America and China was predictable, resulting from slower economies and the effect on seafood demand from sectors such as hotels, restaurants and tourism. Also, alleged contamination of fish and shrimp with COVID-19 in Chinese markets had a negative impact on demand for imports, even as the industry improved sanitary measures and traceability to deal with this issue (Bondad-Reantaso *et al*., 2020). Additionally, there were significant extra costs incurred to adapt to new working practices, with widespread PCR testing of workers, new sanitization procedures in farms and processing plants and increased transport costs.

FAO and ECLAC (2020) recently published a comprehensive bulletin on *Food systems and COVID-19 in Latin America and the Caribbean: Towards inclusive, responsible, and sustainable fisheries and aquaculture*. The bulletin includes key messages, evolution of the state of fisheries and aquaculture, immediate responses to the COVID-19 crisis, COVID-19 as an opportunity to transform fisheries and aquaculture, selected interviews, information resources and key references.

7.1.5 Political and economic volatility and social unrest

Changing economic conditions, the frustration of the less advantaged, a lack of education and civic culture and other causes have resulted in social unrest in several countries of the LAC region, affecting the whole of society, including fish farmers. Insufficient economic and social improvements over the years, as well as continuous changes in policies and government direction have led to instability, frustration and poor investment levels.

Social unrest leads to political change, which in turn means changes in authorities and policies, affecting production, employment and international trade. Social unrest can also affect normal life, through public service strikes as well as in private enterprises. Exporters have to interrupt supplies to foreign and local customers, losing business and credibility and creating a poor commercial image that is hard to recover from.

For example, strikes in late 2019 severely hampered salmon exports from southern Chile, creating conflict with overseas supermarket chains that rely on Chilean supplies. The ability of local producers to honour their contracts have, thereafter, been jeopardized or suspended altogether, causing severe economic damage and unemployment.

7.2 SALIENT ISSUES

More specific information on the causes and adverse consequences of climate variability and climate change on the aquaculture sector is required. In a current review on climate change impacts for specific aquaculture species and systems (Soto, *unpublished*), it was found that there is little specific information on projected threats particularly for inland aquaculture and for LAC in general, compared to North America and Asia.

Also, there is a need to address long-term prevention and adaptation. The political will to fight climate change is at risk, as experienced in the last world climate change summit. Public support for rapid action is essential, but often difficult to materialize into concrete actions.

Conflict over the use of common areas and resources relevant to aquaculture, by traditional fishers, conservationists and indigenous people is likely to increase with climate change. Also, systems that rely strongly on environmental conditions that cannot be managed, such as water, wild seed and natural feed face higher risks with regard to climatic variability and climate change stressors, than do systems that have better control of inputs.

Climate, political and economic environments, the COVID-19 pandemic and market fluctuations are forcing the aquaculture sector in LAC to identify resilience mechanisms for communities and industries.

7.3 THE WAY FORWARD: BUILDING ADAPTIVE CAPACITY

Evaluations of vulnerability, spatial planning, risk assessments and permanent monitoring of aquatic and meteorological conditions are all measures to prevent and mitigate impacts of climate change and other disasters (Aguilar-Manjarrez, Soto and Brummett, 2017; Soto *et al.,* 2018; Aguilar-Manjarrez, Wickliffe and Dean, 2018). Risk mapping can also be useful to plan adaptation. A recent initiative of the Chilean Ministry of Environment has generated a web-based open platform to review climate change risk maps for different food sectors and activities including aquaculture (MMA, 2020). This is becoming an innovative tool for participative planning of adaptation.

Better planning and management of production are probably among the best "win-win" approaches. Soto *et al.* (2019) showed that high salmon production densities can eventually exceed environmental carrying capacity. In most cases, higher densities can magnify the direct and indirect effects of climate change, for example, by increasing the spread of disease and incidence of anoxic conditions. Fish stressed by crowding are much more vulnerable to external shocks, such as those imposed by the COVID-19 pandemic, when farms could not be easily accessed and fish had to remain in their cages or ponds beyond their usual harvest times (Soto *et al.*, 2021) that could be expected to result in greater losses.

Understanding and sharing local and scientific knowledge about environmental trends can be important, while climatic variability and climate change must be taken into account for planning and regulation. Aquaculture must be included in National Adaptation Plans (NAPS), integrated with other uses of water resources and coastal zones. Research on other species and production systems more resistant to climate change are important in better resilience planning. Training of government officers and technical extension leaders is also essential to improve understanding of approaches and methodologies, such as risk and vulnerability assessment, risk communication and adaptation measures.

Better understanding of climate variability and climate change threats and adaptation options is essential. Training material is starting to develop in the region with a focus on local communities and such efforts should be replicated (Barbieri, Aguilar-Manjarrez and Lovatelli, 2020) for aquaculture farmers to better understand risks and their management options and alternative livelihoods.

There is also a need to underscore the relevance of public-private coordination and the key role of risk prevention experts and technicians, as they can guide and help at farm level, processing, and through the whole value chain, while facing unexpected and sometimes catastrophic stressors. This has been particularly relevant to the Chilean industry.

Finally, regarding markets, it is necessary to widen the range of final destinations for aquaculture products to diminish dependency on a few export markets. This should be done through more intense marketing efforts, improved competitiveness and well-organized production processes. Greater efforts are also needed to increase local demand and markets for aquaculture products. The COVID-19 pandemic may offer an opportunity to find local niches and markets for products that were previously exported. This would also increase the contribution of aquaculture to local food security and nutrition.

8. Aquaculture governance and management

8.1 STATUS AND TRENDS

8.1.1 Background

Aquaculture growth rates declined in LAC to an annual average of 6.8 percent between 2010 and 2018, compared to 8.3 percent in the period 2000 to 2010 and 15.9 percent between 1990 and 2000. Even if these figures are still attractive in absolute terms, and exceed world rates over the same time periods, these declines in growth rates need to be taken into account in future expansion plans and inadequate governance could be considered as one of the main factors behind slower growth rates.

8.1.2 The role of government

Only relatively small changes have occurred since aquaculture governance in LAC countries was last reviewed in 2017, reporting on the regional situation up to 2015 (FAO, 2017). Sectoral governance is still dominated by short-term measures rather than sound long-term visions, policies, planning and support mechanisms. Few government officials fully understand the dynamics of aquaculture and have adequate institutional arrangements and regulations in place to manage this industry. Even after 40 years of regional development, aquaculture remains in the shadow of fisheries, which the respective authorities usually consider more important. Aquaculture, despite having great regional potential and proven contributions to employment, exports, food security and nutrition in several countries, is often neglected or poorly serviced. Therefore, new governance structures are needed almost everywhere in the region.

Changes in high level ministerial authorities are common in the LAC region and have recently affected aquaculture governance in several LAC countries including Brazil, Chile and Peru, altering plans, policies and strategies and disrupting previously agreed initiatives. For example, the Brazilian Ministry of Fisheries and Aquaculture has been dismantled and staff were reduced to a minimum within the Ministry of Agriculture. Peru has changed numerous vice ministers of Fisheries and Aquaculture and Chile has been partially immobilized for over two years because of expected changes in the Fishery and Aquaculture Act, while Congress discusses moving fisheries and aquaculture to the new Ministry of Agriculture, Food and Rural Development, a proposal resisted by many.

Overall, the hierarchical level of aquaculture in the political system of many LAC countries is low or it is integrated into multiple-sector ministries. This results in low visibility, reduced budget allocations and only modest inclusion in national development agendas (Table 30).

Granting permissions for aquaculture concessions normally takes several years or is subject to discretionary actions by local authorities. Small scale operators, often working as informal businesses, have difficulty complying with administrative procedures and as a result suffer from involuntary discrimination. In countries such as Chile, there is no clear distinction between small and large-scale producers so small-scale farmers must adhere to rules and regulations which make it difficult for them to start new projects or become legally established. Bureaucracies are slow and complex, and formalities take a long time, are generally expensive and are often difficult to comply with.

Limited funds are allocated for research and development from official funding sources, and private industry provides limited support to diversify farming options or to improve working conditions. Frequent changes in authorities also mean that funding is commonly interrupted, or there are changes in priorities, so that long-term activities to develop new farming techniques, or to facilitate the production of native species, cannot be achieved in reasonable timeframes. Delays bring litigation and frustration. Additionally, government-funded research and development is often focused on scientific publications rather than on practical research that might help solve industry concerns or development needs. Therefore, innovation is fairly limited throughout the production value chain.

Examples of several organizational structures of governments with respect to aquaculture are shown in Table 30.

TABLE 30. Governance structures in selected Latin America and Caribbean countries

	Costa Rica	Chile	Peru	Brazil	Ecuador
Ministry	Ministry of Agriculture and Livestock	Ministry of Economy	Ministry of Production	Ministry of Agriculture, Livestock and Supply	Ministry of Production, Foreign Trade, Investments and Fisheries (MPCEIP)
Department	Costa Rican Institute of Fishing and Aquaculture (INCOPESCA)	Division of Aquaculture of the Undersecretary	Directorate General of Aquaculture of the Fisheries and Aquaculture Vice-Ministry	Fisheries and Aquaculture Secretariat	Vice-Ministry of Aquaculture and Fisheries Undersecretary of Aquaculture
Aquaculture law	Fishing and Aquaculture Law (2005)	Ley General de Pesca y Acuicultura (1991)	Ley General de Acuicultura; Ley de Promoción y Desarrollo de la Acuicultura (2017)	General Fisheries and Aquaculture Legislation, 2009; Decree nº 10.576 of 12/14/2020	Ley Orgánica para el Desarrollo de la Acuicultura y Pesca, 2020
Small-scale aquaculture policies	Law on Small-Scale Fisheries (currently under approval)	Yes			
Development plan	Plano Estratégico de Acuicultura 2019–2013	Política Nacional de Acuicultura (2003)	Plan Nacional de Desarrollo Acuícola 2010–2021 Programa Nacional de Innovación en Pesca y Acuicultura		
Consultative committee		Comisión Nacional de Acuicultura			
R & D		Fisheries Research Institute (IFOP)	IMARPE, FONDEPES, IIAP SANIPES, ITP	EMBRAPA Pesca e Aquicultura	Instituto Público de Investigación de Acuicultura y Pesca (IPIAP)
Informatica			La Red Nacional de Información Acuícola (RNIA)	Brazilian Institute of Geography and Statistic (IBGE)	
Extension services			Direccion General de Acuicultura	SEBRAE, DNOCS, CODEVASF, states and municipal authorities	

Note: Ecuador's data are incomplete. Blank spaces refer to missing or non-applicable information.

8.1.3 The role of industry organizations and non-governmental organizations

Medium and large-scale aquaculture enterprises are improving their organizational structures in several countries to better represent their members and needs as they interface with local authorities. Small-scale producers, on the other hand, either work individually or become members of cooperatives or other organizations that are often poorly managed. They are commonly unprepared to manage fish sales and may be taken advantage of by intermediaries who take a high proportion of profits, limiting opportunities for producers to progress by introducing new technologies.

Environmental NGOs also influence aquaculture development, particularly with respect to sustainability, environmental and social issues. However, opposition by NGOs on environmental or other grounds, often delays the granting of farming permissions, or otherwise inhibits industry development.

The aquaculture industry has largely failed to deal properly with its public image, even when it tries to solve or mitigate sectoral problems. Gonzalez-Poblete *et al.* (2018) found that growth of mussel aquaculture in Chile is particularly inhibited by consumer responses to environmental issues and that improved regulatory action by government and third-party certification systems are re-building confidence.

Aquaculture faces challenges due to real or perceived business impacts on a broad range of issues related to human welfare, for example, working conditions, environmental quality, health or economic opportunity. Aquaculture has social risks and even if it offers employment, some communities have not felt happy with its presence. In South and Central America, perceptions of aquaculture not only affect demand for its products, but can also affect the supply of inputs, especially when local communities are opposed to aquaculture.

8.1.4 Addressing biosecurity through public-private collaboration

Aquaculture businesses are often impacted by disease events, including problems with viral and bacterial diseases and parasites that tend to be more frequent in intensive farming systems or when adequate biosecurity measures are not in place. Most fish and shrimp farming systems, as well as some marine molluscs in LAC have faced disease events in recent decades, sometimes resulting in multi-million dollar losses.

Since 2015, the Chilean salmon farming industry has significantly improved biosecurity measures in response to infectious salmon anaemia (ISA) which had major impacts on production of Atlantic salmon between 2008 and 2011. A major advance was to manage salmon farming areas based on biosecurity indicators (Cerda 2019; Figueroa *et al.*, 2019; Chavez *et al.*, 2019). This new management system also dealt with the presence of parasites such as sea lice and other diseases such as salmon rickettsia syndrome (SRS) by stipulating that production cannot increase unless several biosecurity criteria and their indicators are under control. Stricter norms and compliance assessment systems (Hillman *et al.*, 2020) were also implemented by local authorities.

Shrimp farming in Ecuador has also been developing rapidly as disease outbreaks have been brought under control following the occurrence of white spot disease (caused by white spot syndrome virus, WSSV) in the early 2000s. Shrimp farms in Ecuador have also worked with the government to implement biosecurity measures and sanitary barriers to protect shrimp from hepatopancreatic necrosis disease (caused by a bacterium, *Vibrio parahaemolyticus*) that has affected shrimp farming in Asia and to some extent Central America.

In Central America and the Caribbean, perhaps because of less strict biosecurity measures, introduced, endemic and emerging diseases have been experienced, including a number of shrimp diseases such as WSSV, hepatopancreatic necrosis and a new disease called hepatopancreatic microsporidiosis (HPM), caused by a small microsporidian intracellular parasite (*Enterocytozoon hepatopenaei*) as well as tilapia lake virus.

Addressing biosecurity requires significant resources, strong political will, cooperation between public and private actors and concerted international action when resources are shared by different nations. Strategic planning including spatial planning for health and biosecurity of aquatic animals is of paramount importance, particularly for species with export markets but also for those that are important for food security (Huchzermeyer and Bondad-Reantaso, 2017). Countries must also take into account the need for a systematic and coordinated approach to serious transboundary diseases of aquatic animals (FAO, 2018).

At smaller production scales, biosecurity measures tend to be weaker and there is less assessment of compliance. For molluscs there is little biosecurity in place. However, in Chile, there is a government programme checking for the presence of diseases including those that could affect bivalves.

It is particularly important to have strict biosecurity measures in place to control imports of live products, requesting appropriate certification and making using of quarantine or other methods. In some cases, these should also be taken into account when moving live material (eggs, juveniles, fish seed) between different zones within a country, as diseases can easily be transmitted and disasters can occur. Private sector cooperation has been essential to reduce biosecurity risks in the case of shrimp farming in many countries.

The high dependency on imported trout eggs and shrimp post-larvae is a matter of serious concern in Peru and some other countries and should be addressed as soon as possible. Recent news from Peru indicates that the PNIPA programme might help to solve both issues, with special funds provided by government (PNIPA, personal communication, 2020).

A new initiative called Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB) is anchored on the principles of being risk-based, progressive and collaborative. The PMP/AB offers a co-management approach and greater use of planning processes to bring stakeholders together, thus creating a solid platform for public-private sector partnership and long-term commitment to risk management at the producer and industry levels, as part of a coordinated national approach. (FAO, 2020d; FAO, 2020j).

8.2 SALIENT ISSUES

In most countries, starting up an aquaculture operation is costly and time-consuming. Small producers are at a disadvantage and may be forced to operate as informal businesses making it difficult for them to access services such as government support, financing and technical assistance. Enforcement of regulations and standards is generally poor throughout the LAC region and there could also be instances of corruption to circumvent regulations.

For the past five years aquaculture in Mexico has been growing steadily and it is now recognized as one of the most promising socioeconomic activities with high historic growth rates. However, licensing involves a multiplicity of procedures and requirements while70 to 90 percent of aquaculture production is informal (Cuellar-Lugo *et al.,* 2018). Brazil has experimented with aquaculture parks for tilapia cage culture, where sites are made available for small and medium-scale farmers within regions that have already been licensed for aquaculture development. However, subsequent management of these areas has proven to be challenging.

Poor public perception and a general lack of awareness of aquaculture in local and rural communities creates conflict, particularly with larger farms. At times, the transition into salaried positions from self-employment can be traumatic, causing social conflict and instability. Training on technical procedures and equipment may need to consider low reading and writing skills or illiteracy in several countries. In the case of small-scale farmers, technical advice and guidance may not be available or might not be properly implemented. Most aquaculture plans in LAC call for better support systems, particularly for small-scale producers.

It is also expected that as conflicts with other users of coastal or inland waters and land increase and zonal planning is limited, most large-scale aquaculture production will need to move from their current sites and implement novel technologies such as recirculation or offshore farming, under indeterminate conditions not yet defined by most local authorities. Reclaiming of traditional territories by indigenous peoples is also creating new challenges to aquaculture siting and could lead to complicated negotiations.

These issues across the region will translate into a more challenging governance environment, and consequently into slower development of this industry, unless new energy, better leadership and more resources are devoted to solving the most pressing issues.

There is little doubt that there is an urgent need for Strategic Planning in most if not all LAC countries, to be able to achieve consistent aquaculture development with environmental, social and economic sustainability, and with due consideration for global competition. Otherwise, actions will be disaggregated and not aligned to national or regional goals.

8.3 THE WAY FORWARD

Aquaculture has faced several problems in the LAC region for years. However, improved governance ranks highly in regional priorities including better integration of environmental, social and economic objectives for sustainable development. Improved regulations, well-trained and focused civil servants, political will, leadership and appropriate macro-economic and social environments could help aquaculture regain its dynamism. Research and development needs better support, including collaboration between countries and a more active role for industry. An integrated approach will make sure that longer term views, plans and strategies are put in place and are more resilient in the face of short-term political changes.

In the case of Central America and the Caribbean, the relatively low profile of aquaculture translates into institutional weakness but many countries will be affected by climate change as they are low-lying and small. Adaptation, including ecological, social and economic systems, as well as actions that take advantage of beneficial opportunities are needed (Soto *et al*., 2018). This includes changes in public policies and legal frameworks.

Agreements involving local authorities, industry, small-scale operators, NGOs and other stakeholders in the aquaculture value chain are still weak in most places. Consensus is hard to achieve and there are frequent conflicts when implementing new policies. The region can improve its performance as a well-organized, competitive and meaningful player on the aquaculture world scene, while providing high quality employment and social and economic benefits, especially to local communities. There is a need for more political support, which depends on improved relationships between the aquaculture industry and society.

Emerging farming techniques, such as offshore mariculture, the stocking of coastal waters and closed containment culture of transgenic fish are not yet well understood in the region. Broader consideration of these new dimensions is needed, with new regulations and policies for management of advances that need to be adopted to remain competitive in the global market.

9. Contribution of aquaculture to the FAO strategic objectives, the Sustainable Development Goals, and the Blue Growth Initiative

9.1 STATUS AND TRENDS

The FAO Blue Growth Initiative (BGI) is a system of activities structured around the FAO strategic framework. Its central objective is "*the conservation and sustainable contribution of biological resources and environmental services of marine, coastal and continental ecosystems to food and nutrition security and the alleviation of poverty*". Blue growth attaches special importance to regional and national policies for the protection of ecosystems and the sustainable management of living aquatic resources (FAO, 2015; 2018).

According to FAO (2018), the BGI offers a framework for cooperative action and international synergy to face the challenges of eliminating hunger and poverty in LAC, particularly in the context of macroeconomic volatility and recurring environmental pressures. But aquaculture contributions to the Blue Growth Initiative in LAC, including the expansion of mariculture, would appear to be limited until the problems of environmental and social responsibility, including their public perception, have been addressed. In fact, perceptions of the environmental impacts of aquaculture are becoming an ever-greater obstacle for further development of fish farming in LAC. Nevertheless, aquaculture has important positive impacts in terms of food security, employment, and local development, as well as great potential to increase fish production for food while lowering environmental impacts by using sustainable farming practices.

The UN agenda 2030 and the Sustainable Development Goals (SDGs) are becoming better known in the region and achievement of the goals is gaining interest. However, there is not enough information in the region to quantify aquaculture performance regarding achievements for the different SDGs although some comparative evaluations of environmental and social performance have been attempted at global level for the sector (Waite *et al.*, 2014) as discussed in the latest State of the World Fisheries and Aquaculture 2020 report (FAO, 2020d).

Tables 31 and 32 contain qualitative estimates of LAC aquaculture performance regarding the most relevant SDGs, including SDG 1, to end poverty in all its forms everywhere; SDG 2, to end hunger, achieve food security and improved nutrition and promote sustainable agriculture; SDG 3, to ensure healthy lives and promote well-being at all ages; SDG 5 to provide equal opportunities to women, SDG 6, to ensure availability and sustainable management of water availability, quality and sanitation for all; SDG 8, to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; SDG 13, to take urgent action to combat climate change and its impacts, and SDG 14, to conserve and sustainably use the oceans, seas and marine resources for sustainable development. This analysis should be considered as a preliminary assessment unique to the region. Achievements are qualitatively described using a colour scale with some SDGs clustered, such as SDG 2 and SDG 5 regarding decent labour and economic development with gender opportunities (SDG 8). Although there is information about the increasing role of women in the processing sector (at least for salmon and shrimp) data are insufficient to assess efforts towards gender equity.

TABLE 31. Qualitative evaluation of aquaculture contribution to some SDGs in the Latin America and the Caribbean region (South America, Central America and the Caribbean) using summary description and a colour scale (see below). Some SDGs are combined because there is not enough information to treat them separately. For example, SDG 1, SDG 5 and SDG 8. Blank cells indicate no information.

Species and farming systems (introduced as % of total inland aquaculture is indicated)	**SDG 2** **Contribution to food security**	**SDG 1, SDG 5, SDG 8** **Reducing poverty, increasing decent work**	**SDG 14, SDG 6** **Avoiding eutrophication (water column and benthic ecosystems)**	**SDG 14** **Avoiding biodiversity and habitat losses due to escapees**	**SDG 14, SDG 3** **Avoiding use of antibiotics and other harmful chemicals**	**SDG 13** **Avoiding contribution to GHG emissions**
Tilapia (introduced) farmed in cages in lakes and reservoirs, and in ponds or raceways. 56% in Brazil, 65 % Colombia, 79% Ecuador, 63% Paraguay, 5% Peru 75% in Mexico,>80% in most other Central America and the Caribbean	Relevant-full contribution to local consumption in most countries	Significant contribution to local employment and economic growth	Water quality loss in reservoirs with cage farming	Tilapia is a good invader, but ecosystem impacts not yet evaluated in the region	Antibiotics are often used as prophylactic and for disease treatment with potential risks on ecosystems and humans	Nutrients could increase ponds' and reservoirs' carbon sequestration, but hypoxic conditions can generate GHG
Trout (introduced) farmed in cages in lakes and reservoirs. Introduced, 95% Peru, 45% Bolivia, 20% Ecuador, 15% México, <5% in Chile	Some contribution to local consumption	Significant contribution to local employment and economic growth	Water quality loss in reservoirs due to cage farming	Trout is an aggressive invader already present in most mountain streams in LA; great ecosystem impact	Antibiotics are often used as prophylactic and for disease treatment with potential risks on ecosystems and humans	Nutrients could increase ponds and reservoirs carbon sequestration, but hypoxic conditions can generate GHG
Salmon and trout juveniles (introduced) and adults in land-based hatcheries. Introduced; 100% Chile, 90% Peru	Minimal contribution to local consumption	Some contribution to local employment	Impacts on rivers receiving hatchery water	Escaped juveniles could have some success and cause damage to biodiversity	Antibiotics frequently used in hatcheries	Some contribution especially from energy use
Native Tambaqui, Cachama, Pacu, Pirapatinga (some or all species) farmed in cages and ponds in lakes and reservoirs Brazil, Colombia, Bolivia, Guyana, Surinam, Peru	Full contribution to local consumption	Significant contribution to local employment and economic growth	Water quality loss in reservoirs due to cage farming	Escapes represent some risks of diseases or genetic pollution	Antibiotics are likely being used, but the extent is less clear	Nutrients could increase ponds and reservoirs carbon sequestration, but hypoxic conditions can generate GHG
Pacu and Cachama farmed in places where they are introduced; <5% Panama, Dominican Republic, Aquaculture hybrids farmed in Brazil, Colombia, Bolivia	Full contribution to local consumption	Significant contribution to local employment	Water quality loss in reservoirs due to cage farming	Escape of introduced species and hybrids, competing or genetic contamination of native population	Antibiotics are being used but the extent is not clear	Nutrients could increase ponds and reservoirs carbon sequestration, but hypoxic conditions can generate GHG
Common carp farmed in ponds (introduced) 60% Cuba, 6% Paraguay, 4% Bolivia, <2%in other countries	Full contribution to local consumption			Suspected impacts but with minimal information		
Sturgeon farming in ponds in Uruguay (introduced) 90% Uruguay	No contribution to local consumption	Minor contribution to local employment		Escapees present in Parana and Uruguay Rivers (Argentina-Uruguay)		

TABLE 32. Marine aquaculture environmental and social issues related to SDGs, in Latin America and the Caribbean

Species and farming systems (introduced as % of total mariculture)	SDG 2 Contribution to food security	SDG 1, SDG 8 Reducing poverty alleviation, increasing decent work	SDG 14 Reducing habitat perturbation	SDG 14 Reducing eutrophication (water column and benthic ecosystems)	SDG 14 Reducing biodiversity and habitat losses due to escapees	SDG14, SDG 6 Reducing use of antibiotics and other harmful chemicals	SDG 14 Reducing use of wild seed/larvae with impact to resource	SDG 13 Reducing contribution to GHG
Salmon and trout cage culture in Chile introduced, 67% in Chile	Minor contribution to food in local markets, also due to fishing on escapees and salmon in school diets	Significant contribution to local employment (direct and indirect)	Modification of benthic habitats	Intensive farming impacts on benthic processes and water column; diseases & parasites	Escapees are reported but risks are probably less in the case of Atlantic salmon than with most farmed species	Use of AB to deal with an intracellular bacteria. Potential generation of RAM, risks to humans and wild organisms. Pesticides are also used to control ectoparasites	No use	Excess nutrients often generate hypoxic conditions that could generate GHG
White legged shrimp in ponds, Ecuador, Peru, Mexico Gulf of Fonseca in CAC	Small contribution to local consumption	Significant contribution to local employment (direct and indirect)	Reduced damage to mangroves	Nutrient loads to estuaries and coasts		Some use of AB	No use	Nutrients could increase carbon sequestration but hypoxic conditions could also generate GHG. Relevant loss due to mangrove replacement
White legged shrimp in ponds, introduced 74% Brazil, 100% Venezuela	Significant contribution as shrimp makes it to local markets,	Significant contribution to local employment (direct and indirect)	Reduced damage to mangroves	Nutrient loads to estuaries and coasts	(?) Reported as invader in the Atlantic coasts but impacts unknown	Some use of AB	No use	Nutrients could increase carbon sequestration but hypoxic conditions could also generate GHG. Relevant loss due to mangrove replacement
Native mussels, scallops, in Chile, Peru, Brazil	Minor contribution to local consumption	Relevant contribution to local employment (direct and indirect)	Concerns over habitat deterioration	There are some concerns about impacts on sediments in areas of intensive farming in Chile	Not relevant as mussel seeds are collected from the wild, even though part of scallop seed are hatchery-produced	No use	A strong pressure over natural mussels beds for seeds in Chile	Minimal contribution but shells are taking up Calcium needed to buffer Ocean acidification
Native oysters such as mangrove oysters, Colombia, Venezuela, Brazil, CAC countries	Relevant contribution?	Relevant contribution?					It is not known how much fishing pressure is there on wild seed	

Colour scale describes the authors' estimation of SDGs achievement. SDG 1= Eliminate Poverty, SDG 2 = Eliminate hunger and malnutrition, SDG 3= Provide good health and wellbeing, SDG 6 = Provide and maintain clean water, SDG 8= Provide decent work and economic growth, SDG 13= Stop global warming, SDG 14 = Protect life below water

Very high achievement	Good achievement	Improving achievement	Small achievement	Poor to negative achievements (some negative impacts)	Negative achievement (negative impacts)	Very negative achievement (negative impacts)

Among the environmental impacts, one of greatest concerns is the escape of farmed organisms, especially for introduced or exotic species (see Section 4.1.1; Zaniboni-Filho, Dos Santos Pedron and Ribolli, 2018) while potential impacts on ecosystems due to eutrophication of water bodies are also important.

Tables 31 and 32 indicate that farming in ponds could have better control over some impacts such as eutrophication than cage-based farming systems as inland closed systems provide more options to control outputs and escapes if they are well designed and managed, while cage farming in general presents more risks. Yet inland aquaculture facilities compete with other sector uses and they may also be built in areas with important terrestrial biodiversity. On the other hand, closed inland aquaculture systems, namely ponds, raceways and recirculated systems may employ fewer people and require fewer additional services than floating cages. Therefore, their contribution to SDGs 2 and 5 could be lower than the latter.

9.2 SALIENT ISSUES

Different species and farming systems present trade-offs in the achievement of different SDGs. According to the preliminary analysis in table 31 and table 32, inland aquaculture seems to perform better than mariculture with respect to social SDGs, mainly because of its contribution to domestic nutrition through local consumption of fish, as well as poverty alleviation. This is particularly true of tilapia and characid farming in Brazil and several other countries. Farming of native fish, like characids, could pose a lower risk to biodiversity than farming of non-native species. However, if more farmers start to use genetically-improved types, or hybrids, potential impacts may increase and risk assessments would be required. Mariculture at the regional level, contributes less in general terms to local nutrition and food security, since a large proportion of production is exported. Yet the farming of bivalves such as oysters in northern South America and Central America can have positive impacts on local food security, even though the volume is limited.

Generally, farming of native species contributes to local, national or even regional food consumption for food security and nutrition, and results in limited environmental impacts. These contributions are relevant to achieve key SDGs and corresponding FAO strategic objectives regarding food security, livelihoods and reduced environmental impacts (FAO, 2016b). Nevertheless, the role of tilapia in improved food security and livelihoods is also clear, especially in Central America, the Caribbean and Brazil. In Mexico, the National Commission for Biodiversity has strengthened their environmental viewpoint and taken a position against the farming of tilapia. However, government programmes that support tilapia-based inland fisheries in reservoirs and lakes continue, with significant contributions to local food security (Martinez-Cordero, personal communication, 2020).

Mariculture (salmon, shrimp, mussels) has a role in generating local employment and regional development, often being one of the few, new opportunities for women, particularly in post-harvest processing.

A discussion forum was convened in Mexico City to define the direction and scope of the FAO Blue Growth Initiative in Central America and the Caribbean in November 2017 (A. Flores, personal communication, 2020). Agreements were reached to increase the contribution of fisheries and aquaculture to food and nutrition security and poverty alleviation, as well as towards the sustainable use of fisheries and aquaculture resources, through South-South Cooperation. Aquaculture was recognized as an important productive activity for economies that requires diverse goods and services, contributing to SDG 1 (end poverty) by generating employment and reducing rural poverty, and to SDG 8 (promote sustained growth). The nutritional benefits of aquaculture products have been widely documented, so the sector contributes directly to SDG 3 (ensure healthy life). Efforts to develop climate-smart aquaculture and strengthen the resilience of aquaculture communities to the effects of climate change contribute to SDG 13 (adopt urgent measures to combat climate change).

In Barbados and other Caribbean islands, energy, freshwater and land are limited and expensive. Given these limitations, aquaponics, combining aquaculture with hydroponics has facilitated several important environmental benefits and economic efficiencies, including the supply of tilapia, a protein-rich species for local consumption, as well as high-value lettuce crops for restaurants. With aquaponics, communities can maximize the use of scarce aquatic resources to provide food and nutrition security, while generating work and ensuring livelihoods, thus contributing to SDGs 1, 8 and 14.

9.3 THE WAY FORWARD

There is a need for more comparative information, including data on direct and indirect employment at local and national levels, and more specific evaluation of negative externalities such as impacts on biodiversity, so that each country, locality or region can choose the best aquaculture options to achieve the SDGs.

It is important to be able to compare aquaculture performance with that of other sectors and users of watersheds and ecosystems, since all food systems and other development options have impacts and aquaculture may have advantages (Boyd *et al.*, 2020) compared to other farming systems such as cattle farming (Froehlich *et al*., 2018). The LAC region has diverse ecosystems that generate significant ecosystem services and opportunities for aquaculture, so comparative qualitative tables, such as tables 31 and 32, on the relationship between aquaculture systems and SDGs could become powerful tools for decision-making. This type of analysis could help to make the benefits of aquaculture more explicit, leading to more interest and attracting further investment in species and farming systems that can make the most significant contributions towards SDGs.

However, there are trade-offs while addressing all SDGs. It is difficult to provide optimal solutions as each country and locality faces their own particular conditions. For example, the introduction of tilapia has clearly had an impact on food security and nutrition in the region, but this species poses a permanent threat to biodiversity due to its invasive habits, especially considering the biodiversity uniqueness of parts of LAC. Similarly, it is difficult to balance the reduction of poverty and increasing quality employment with protecting the functions and integrity of ecosystems. Salmon farming has significantly increased employment and development at the local level, including providing opportunities for women. However, it has also resulted in negative environmental impacts. On the other hand, small scale aquaculture initiatives in the LAC region with relevant contributions to livelihoods and with potentially low environmental impact, often struggle to remain in business. The problem is to balance different SDGs, especially when local populations still need to satisfy their basic needs.

The One Health initiative (Stentiford *et al.*, 2020) offers a recent framework for sustainability measures including metrics for comparative evaluations based on policies and norms. Yet to achieve enhanced, sustainable production it is essential to implement measures on the ground through participative management plans, such as those offered by the Ecosystem Approach to Aquaculture and Blue Growth promoted by FAO, based on risk assessments of the different objectives. To be successful, management plans must be designed around meaningful landscape or ecosystem units (Aguilar-Manjarrez, Soto and Brummett, 2017), agreeing with stakeholders on the specific challenges and opportunities. This could generate better understanding, foster their cooperation in effectively enforcing the actions and subsequently increasing the possibility of change.

Another problem is the increasing number of initiatives and acronyms, a fact that can sometimes curtail achievement. Therefore, it is important to consider SDGs and the overarching goals of the UN 2030 agenda, while the FAO Code of Conduct for Responsible Fisheries (CCRF) continues to be an essential framework to support the contribution of aquaculture to sustainable development. A future challenge refers to gathering better information to assess sectoral achievements when compared with other food sectors. This is especially relevant for social aspects including the influence of aquaculture on economic development at the local level, on female employment and on social equity.

Given the climatic and economic uncertainties in the LAC region, it is urgent to address the opportunities and limitations for the sustainable development of aquaculture, an activity which can provide healthy and accessible food, alleviate poverty and provide options for women, youth and indigenous people in rural areas and coastal communities. Increasing the role of aquaculture in food security and nutrition in the main producing countries in LAC is challenging. Technical advances, research and development, innovation, training, cooperation and good governance are essential.

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Annex 1. FAO statistical data

Data used in this regional aquaculture review, derive mainly from the different FAO fisheries and aquaculture statistics (FishStat), accessible through different tools, including the FAO Yearbook Fishery and Aquaculture Statistics, online query panels and FishStatJ (FAO, 2020a; FAO, 2020b; FAO, 2020c). These tools provide free access to fisheries and aquaculture data, including production, trade, consumption and employment for over 245 countries and territories from 1950 to the most recent year available. FAO represents the only global source of fisheries and aquaculture statistics, which are mainly compiled from data submitted by member countries. Statistics received are validated by FAO through adequate quality controls and, in the absence of official reporting, FAO estimates the missing data based on information obtained from alternative sources or standard estimation methods. Estimates also involve disaggregating some of the data received by FAO in aggregated form by species and, in the case of production, also by culture environment.

FAO highlights that data received from countries show different levels of quality in terms of coverage of species, environment and overall national reporting. Inconsistencies may occur in data reported or data are not reported at all. For example, in the case of aquaculture production, FAO has noted that not all the countries have adequate and effective data collection systems set in place. Many countries still do not have a systematically established framework aligned with internationally and regionally accepted standards for data collection from fish farms. In addition, in several countries, the staff responsible for reporting aquaculture production lack the relevant knowledge, support or relevant mechanisms such as specifically designed databases to develop accurate production estimates and improve monitoring and control of the industry. Production data are often estimated through extrapolation by multiplying the area under fish culture by an estimate of average productivity, with adjustments according to advice from key contacts in the industry. Improvements to this problem could, for example, be found by resolving issues related to the fish farm licensing process and devising a system for direct reporting of production, coupled with validation through sample survey by trained enumerators.

Problems occur as well for other typologies of aquaculture statistics. Only a very limited number of countries have a breakdown for farmed vs wild species in their trade statistics and, in addition, many farmed species are often reported in an aggregated form under miscellaneous entries as other fish. The lack of accurate trade data on farmed fish and fish products implies the impossibility to calculate separate consumption statistics on farmed species, with no clear assessment of the nutritional role of farmed species in the countries. In addition, not all the countries have a good collection of employment data in the primary and secondary aquaculture sectors, including insufficient detail on the role of women in the sector, which is captured mainly by ensuring employment data is sex-disaggregated and that all types (part time, full time, occasional time use) are all collected and reported . These data are essential to better assess dependency on the sector and other relevant indicators.

Due to the key role that accurate and timely data play in the management and policy formulation for sustainable aquaculture development, FAO remarks the urgent need for national capacity development in aquaculture statistics systems at several levels, including:

- the legal status, institutionalization and resource allocation;
- development of national statistical standards in line with international standards;
- adequate and stable staffing plus an effective mechanism for data collection, compilation, storage, dissemination and reporting; (FAO, 2020d);
- improvement in the coverage of farmed species in trade statistics, with the clear separation of farmed vs wild species; and,
- improvement in the coverage and accuracy of employment data, disaggregated by sex, occupational status and age.

In continuing the global efforts to achieve aquaculture sustainability through dissemination of up-to-date information on the status and trends of the sector, FAO publishes Aquaculture Regional Reviews and a Global Synthesis about every 5 years, starting in 1997. This review paper summarizes the status and trends of aquaculture development in Latin America and the Caribbean.

Relevant aspects of the social and economic background of each region are followed by a description of current and evolving aquaculture practices and the needs of the industry in terms of resources, services and technologies. Impacts of aquaculture practices on the environment are discussed, followed by a consideration of the response by the industry to market demands and opportunities, and its contribution to social and economic development at regional, national and international levels. External pressures on the sector are described, including climate change and economic events, along with associated changes in governance.

The review concludes with an analysis of the contributions of aquaculture to the 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 is suggested for each main topic.