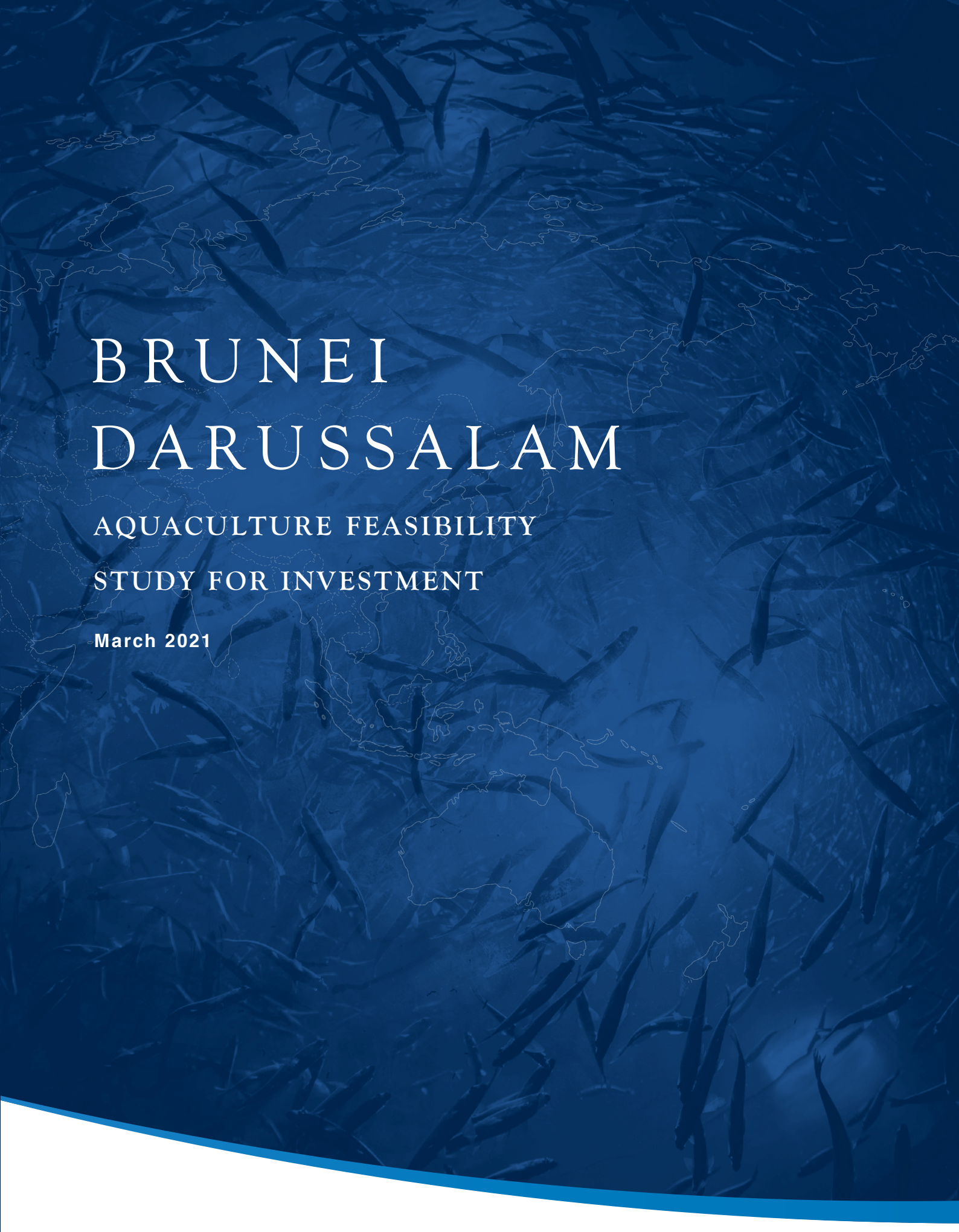

BRUNEI DARUSSALAM

AQUACULTURE FEASIBILITY STUDY FOR INVESTMENT

March 2021

ASEAN-JAPAN CENTRE
(ASEAN Promotion Centre on Trade, Investment and Tourism)

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ACKNOWLEDGEMENTS

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ASEAN-Japan Centre
Secretary General: Masataka Fujita

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LIST OF ACRONYMS

AJC ..... ASEAN-Japan Centre
BEDB ..... Brunei Economic Development Board
BGAqP ..... Brunei Good Aquaculture Practice
BND ..... Brunei dollars
CAGR ..... Compound Annual Growth Rate
CO2 ..... Carbon dioxide
DOF ..... Department of Fisheries
ESG ..... Environment, Society and Governance
EU ..... European Union
FAO ..... Food and Agriculture Organization of the United Nations
FDI ..... Foreign direct investment
FTA ..... Free trade agreement
GDP ..... Gross domestic product
GMP ..... Good Manufacturing Practice
HACCP ..... Hazard Analysis and Critical Control Point
HOB ..... Hygiene on board
IMF ..... International Monetary Fund
IMTA ..... Integrated multi-trophic aquaculture
Kg ..... Kilogrammes
M ..... Metres
MFA ..... Ministry of Foreign Affairs
MT ..... Megatonnes
RAS ..... Recirculating aquaculture system
RKN 11 ..... Eleventh National Development Plan
SDGs ..... Sustainable Development Goals
SEAFDEC ..... South East Asia Fisheries Development Center
UAE ..... United Arab Emirates
UN ..... United Nations

EXECUTIVE SUMMARY

This report provides an analysis and investigation of the fisheries and aquaculture industries in Brunei Darussalam and considers the feasibility of further investment in aquaculture. With the country's aspiration to diversify its economic sources and shift away from the oil and gas industry, the aquaculture industry has great potential as a sustainable and significant industry.

This study is based on collected data from primary interviews with people from the Government and industry in Brunei Darussalam as well as secondary data available online. This report details the landscape of the domestic aquaculture industry and the potential investment opportunities, identified through risk assessments and with suggested practices.

This study concludes that Brunei Darussalam offers an exceptional environment for investment in aquaculture. Specifically, it suggests eight aquaculture products for potential investment opportunities: sea bass, pompano, grouper, sea bream, seaweed, oysters, salmon, and shrimp. These products have seen growing demand across the world, and this demand is expected to continue to grow. In addition, some spin-off industries are also suggested for possible investment, and these include processing facilities, technologies, infrastructure and culturing supplements and equipment, such as seeds, fingerlings and health implements.

This study illustrates investment strategies based on the risk assessment matrix to address issues and challenges identified in this feasibility study. Risks identified in the Brunei aquaculture industry are production risks, environmental risks and market risks.

Finally, in order to fully lubricate FDIs in the fisheries and aquaculture industries in Brunei, it is critical to improve the institutional support—particularly from the Government of Brunei—specific to aquaculture. Further investment policies and incentives pertinent to the aquaculture industry as well as implementing the sectoral regulatory framework provided by the Government of Brunei would contribute to overall institutional development in the aquaculture industry. To attain these, consultations in the process must engage with the current industry practitioners to ensure the holistic promotion of aquaculture industry.

Although this study has some limitations due to data availability, it offers a stepping stone for future Japanese investors and beyond.

CHAPTER I

Introduction

Overview of Brunei Darussalam's economy

Regional and global comparisons

According to the World Bank (2020), the total value of Brunei Darussalam's economy, measured by its gross domestic product (GDP), was $13,469 million in 2019, ranking the country 139th in the world, 44th in Asia and 10th in South-East Asia (Tables I.1, I.2 and I.3). The country's GDP may not be on par with many other countries, but despite this, Brunei Darussalam is considered to be one of the richest countries in the world in terms of GDP per capita (at purchasing power parity), with a value of $61,816 million per capita, ranking 8th in the world just after the United States (Table I.4). The following four tables show the global and regional position of Brunei in terms of GDP and GDP per capita.

【Table I.1】 Ranking of countries by GDP, 2020

(Millions of dollars)

	Country	GDP
1	United States	20,807,269
2	China	14,860,775
...		
137	Mauritius	11,341
138	Moldova	11,241
139	**Brunei Darussalam**	**10,647**
140	Chad	10,510
141	Rwanda	10,428

Source: International Monetary Fund (2020)

【Table I.2】 Ranking of Asian countries by GDP, 2020

(Millions of dollars)

	Country	GDP
1	China	14,860,775
2	Japan	4,910,580
...		
42	Mongolia	13,385
43	Armenia	12,813
44	**Brunei Darussalam**	**10,647**
45	Tajikistan	7,898
46	Kyrgyzstan	7,480

Source: International Monetary Fund (2020)

【Table I.3】 Ranking of South-East Asian countries by GDP, 2020

(Millions of dollars)

	Country	GDP
1	Indonesia	1,088,768
2	Thailand	509,200
3	Philippines	367,362
4	Viet Nam	340,602
5	Singapore	337,451
6	Malaysia	336,330
7	Myanmar	70,890
8	Cambodia	26,316
9	Lao PDR	18,653
10	**Brunei Darussalam**	**10,647**

Source: International Monetary Fund (2020)

【Table I.4】 Ranking of countries by GDP per capita, 2020

(Millions of dollars)

	Country	GDP
1	Luxembourg	112,875
2	Singapore	95,603
3	Qatar	91,897
4	Ireland	89,383
5	Switzerland	68,340
6	Norway	64,856
7	United States	63,051
8	**Brunei Darussalam**	**61,816**
9	United Arab Emirates	58,466
10	Denmark	57,781

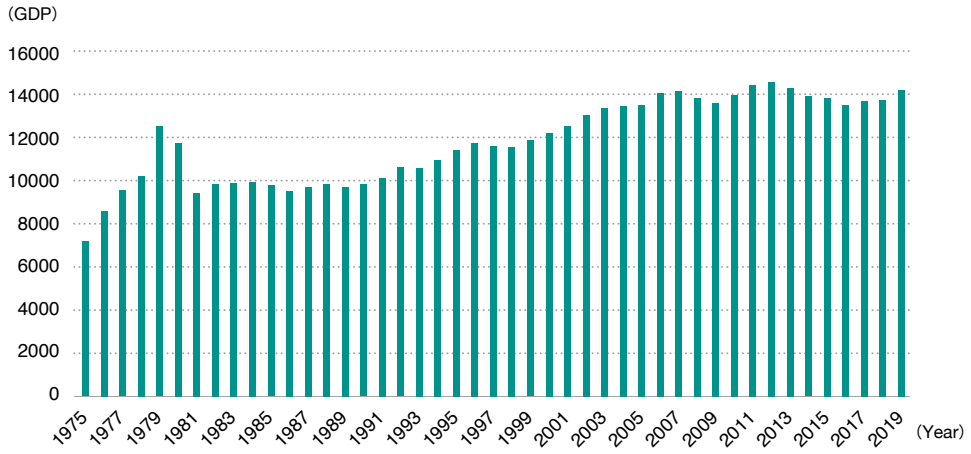
Source: International Monetary Fund (2020)

A. Overview of Brunei Darussalam's GDP and sectoral contributions

Looking at Brunei Darussalam's GDP for 1975–2019 as shown in figure I.1, the country's GDP experienced a fast increase during 1975–1979, which was when the country's oil production peaked. After 1979, it immediately declined for two years due to the deliberate cutbacks that were implemented to extend the life of Brunei Darussalam's oil reserves. Since then, the country's GDP has fluctuated but, overall, has steadily increased from 1980 to the present year.

【Figure I.1】 Brunei Darussalam's gross domestic product, 1975–2019

(Millions of dollars in USD at 2010 constant prices)constant prices)

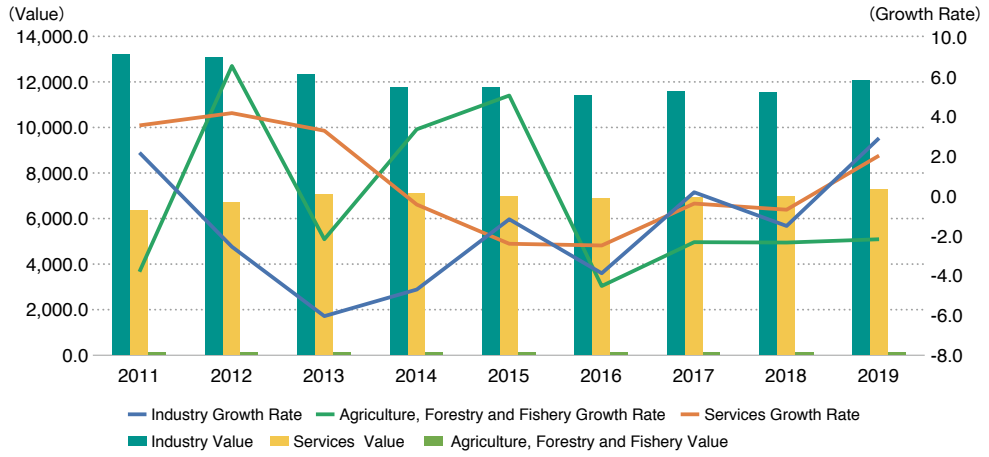


Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

Figure I.2 breaks down Brunei Darussalam's GDP by the type of economic activity contributing to it. In 2019, the biggest contribution came from the industry sector, which constituted 62% of the whole economy. This was also the case in the previous decade, when it comprised 60%–68% of GDP. The reason for this large contribution is due to the oil and natural gas industry, which makes up 40% (2019) of the whole economy. The industry has been Brunei Darussalam's main economic driver since it started production in 1929. The remaining contribution to GDP is from the services sector and the combined agriculture, forestry and fisheries sector. In 2019, the industry sector comprised 37% of GDP, gradually increasing over the previous decade from only 32% in 2010. The last and smallest contribution comes from the agriculture, forestry and fisheries sector. Over the past decade, this combined sector has always contributed less than 1% of GDP.

【Figure I.2】 Value and growth rate of Brunei Darussalam's GDP by type of economic activity, 2011–2019

(Thousands of Brunei dollars at constant 2010 prices and %)



Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

There were varied changes in the growth rate for each type of economic activity contributing to Brunei Darussalam's GDP during 2011–2019, as shown in Figure I.2 and Table I.5. It can be observed that there was a decline in all of the sectors in 2015–2016. This was due to the continued oil price drop, which triggered a recession that started in 2013. After the declining growth of the sectors during the recession, the industry and services sectors started to recover from 2016, with increased growth seen by 2019 when the growth rates reached 3% and 4%, respectively. On the contrary, the agriculture, forestry, and fisheries sector experienced a continuous negative growth rate during 2016–2019 of between –1% and –3%. Given this negative growth, there is a need for continuous support of the sector's development since it offers valuable inputs for Brunei Darussalam as a food resource and food security and in terms of its potential to contribute to economic growth. This support can be made possible through foreign investment.

【Figure I.5】 Actual value and growth rate of Brunei Darussalam's GDP by type of economic activity, 2011–2019

		2011	2012	2013	2014	2015	2016	2017	2018	2019
Industry	"Value (Thousands of Brunei dollars at constant 2010 prices)"	13,248.0	13,064.2	12,327.9	11,790.0	11,786.0	11,439.2	11,612.5	11,570.2	12,055.2
	Growth rate (%)	3.2	-1.4	-5.6	-4.4	0.0	-2.9	1.5	-0.4	4.2
Services	Value (Thousands of Brunei dollars)	6,374.6	6,727.9	7,042.3	7,116.2	7,004.7	6,886.9	6,961.6	7,016.0	7,257.9
	Growth rate (%)	4.9	5.5	4.7	1.0	-1.6	-1.6	1.1	0.8	3.4
Agriculture, forestry and fisheries	Value (Thousands of Brunei dollars)	133.5	144.3	142.6	149.3	158.9	153.2	150.8	148.4	146.3
	Growth rate (%)	-2.6	8.1	-1.2	4.7	6.4	-3.6	-1.6	-1.6	-1.4

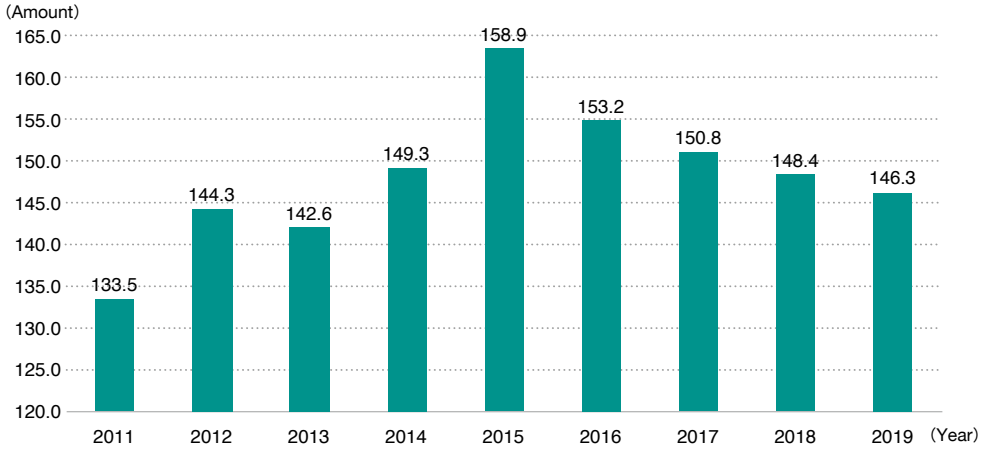
Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy. (2020b)

B. Agriculture, forestry and fisheries sector

Figure I.3 shows the GDP contribution of the combined agriculture, forestry, and fishery sector for 2010–2019. It can be seen that there was a gradual increase in the value in 2010–2015, but after 2015 there was a steady decline due to reduced production output and also the previously mentioned recession during that period.

【Figure I.3】 Contribution of the agriculture, forestry and fisheries sector to GDP, 2011–2019

(Millions of Brunei dollars at constant 2010 prices)

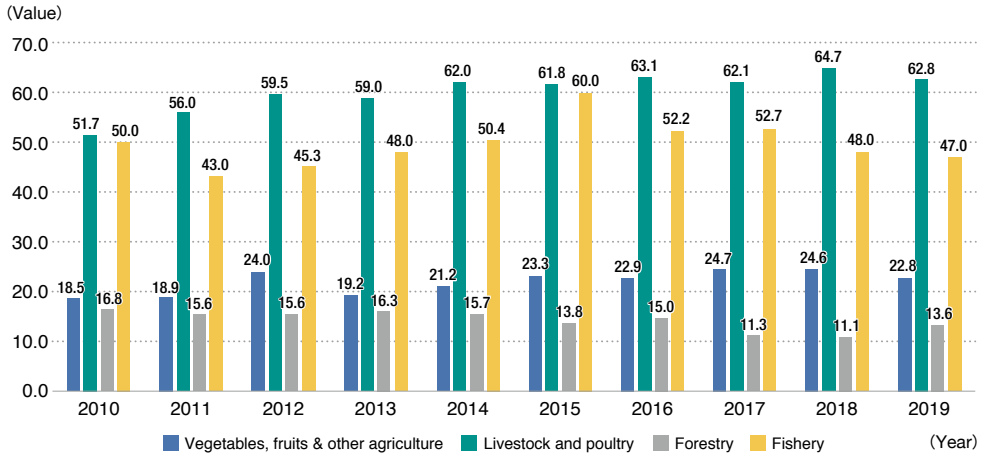


Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

This combined sector is comprised of (1) vegetables, fruits and other agriculture products, (2) livestock and poultry, (3) forestry, and (4) fishery. Figure I.4 shows the breakdown of the individual sectors and their GDP contributions for 2010–2019. It can be seen that the biggest contribution is from the livestock and poultry sector, followed closely by the fishery sector. The remaining two sectors do not contribute as much as the other two but still have considerable production.

【Figure I.4】 Contribution of the agriculture, forestry and fisheries sector to GDP by type of activity, 2011–2019

(Millions of Brunei dollars at constant 2010 prices)



Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

Wawasan Brunei 2035 and Brunei Darussalam's national economic development plan

Wawasan Brunei 2035

Wawasan Brunei 2035 is the long-term vision for the development of Brunei Darussalam. This vision was given consent by His Majesty Sultan Haji Hassanal Bolkiah Mu'izzaddin Waddaulah, Sultan and Yang Di-Pertuan Negara Brunei Darussalam, through the formation of the Council for Long-Term Development Planning. The council was tasked with shaping the future vision of Brunei Darussalam and presenting a detailed account of the technical, financial and strategic requirements needed for it to be realized.

The vision aspires that by 2035, Brunei Darussalam will have developed into a nation that is widely recognized for the accomplishments of its educated and highly skilled people measured by the highest international standards, a quality of life that is among the top-ten nations in the world and a dynamic and sustainable economy with income per capita within the top-ten countries in the world.

Wawasan Brunei 2035 identifies 13 strategies to help achieve this vision and ensure all aspects of development are implemented accordingly and effectively. They are (i) education, (ii) economy, (iii) security, (iv) institutional development, (v) local business development, (vi) infrastructure development, (vii) social security, (viii) environment, (ix) health, (x) religion, (xi) land use, (xii) infrastructure and information and communications technology, and (xiii) human resources planning.

In order to realize this long-term vision, Brunei Darussalam is undertaking the development and implementation of five-year medium-term development plans. These plans continuously build upon the previous accomplishments and set targets that will lead to the achievement of the long-term vision by 2035. Currently, the country is in its 11th National Development Plan (RKN11).

Eleventh National Development Plan (2018–2023)

The Eleventh National Development Plan (RKN11) is Brunei Darussalam's current medium-term development plan for 2018–2023. To contribute to realizing Wawasan Brunei 2035, RKN11 focuses on further developmental efforts for production in the non-oil and gas sector. Thus, the theme of the plan is "Increased Non-Oil and Gas Sector Output as Catalysts for Economic Growth". To support this theme, six development thrusts have been outlined to provide direction for programmes and projects:

- First thrust: improving the quality of teaching and training to produce educated and highly-skilled human capital
- Second thrust: developing human resources in line with industry requirements
- Third thrust: building visionary and *wasatiah* communities
- Fourth thrust: strengthening the sustainable welfare of the people

- Fifth thrust: increasing the output and contribution of the non-oil and gas sector to GDP
- Sixth thrust: strengthening the Government's governance for a conducive business environment

The previous section highlighted Brunei Darussalam's economy and showed that the country's oil and gas sector has been the main source of its GDP and economic growth. But relying on oil and gas is not sustainable economically since it is non-renewable and non-finite and has recently been experiencing a global decline in prices. Therefore, there is a need for the development of other industries with the potential to contribute to Brunei Darussalam's economic development and the achievement of its long-term vision. Thus, increasing the output and contribution of the non-oil and gas sector to GDP was identified as a key thrust.

For improving the country's non-oil and gas sector, the private sector plays a crucial role in assisting micro, small and medium-sized enterprises to thrive and be more competitive with other companies from abroad and, correspondingly, to penetrate the international market. The influx of foreign direct investment (FDI) in the country will also accelerate the growth of the non-oil and gas sector and benefit the country, such as through the introduction of new technology and knowledge transfers, as well as increase productivity and contribute to the skilled workforce.

One of the identified industries under the thrust that has the potential for growth is aquaculture under the agriculture, forestry and fisheries subsector. This industry has grown due to increased productivity and the entry of investors over the past 10 years. Despite this, the aquaculture industry in Brunei Darussalam is still small and has many areas and products that are still to be developed. Hence, there is potential that can be fulfilled by foreign investment, which can further increase the productivity, quality, and competitiveness of Brunei Darussalam's aquaculture products and aquaculture industry.

The rest of the study aims to examine the current situation of the industry, both locally and internationally, in terms of its supply, demand and potential and build upon this information to come up with recommendations for which products are feasible for foreign investors to focus on. The study will also examine the strategies that can be implemented to maximize the investment potential and identify the challenges and risks that may be faced by the industry.

CHAPTER
II

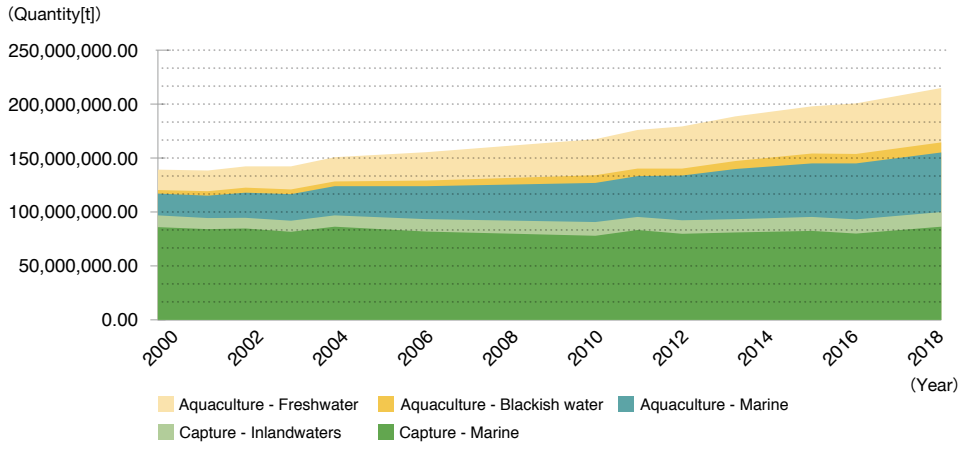
Overview of Aquaculture Industry

Global Situation of Aquaculture

Global Aquaculture Production

Today, aquaculture is one of the fastest growing food production sectors in the world. Through technological development and the needs for food security, the aquaculture industry has opened up many possibilities for sustainable fish production. According to recent data from the Food and Agriculture Organization (FAO) of the United Nations (2020a), world aquaculture production reached another highest record of 114.5 million tonnes in 2018. As a result, aquaculture accounted for 52 percent of fish for human consumption and 46 percent of the total fish production in 2016-2018 (see Figure II.1). Aquaculture's contribution to the total fishery production had a significant increase over the past decades considering its proportion in 2000 being at 25.7 percent compared with 46 percent in 2018 (FAO, 2020a). Specifically, aquaculture production has surpassed that of capture fisheries in the following species; aquatic algae in 1970, freshwater fishes in 1986, molluscs in 1994, diadromous fishes in 1997, and crustaceans in 2014 (FAO, 2020a). Aquaculture will most likely continue to dominate in those species as the aquaculture industry further develop in the future. While marine fishery products are still dominated by capture, there is an increase in production of marine aquaculture in the past two decades. Many companies are shifting their focus to expand aquaculture breeding grounds in order to reduce reliability of wild-harvest capture for the preservation of the ecological balance. This progress of the aquaculture industry has proven the potential for the future and it is projected to continue growing across the world with more varieties in species and products.

【Figure II.1】 Global Capture Fisheries and Aquaculture Production between 2000 and 2018

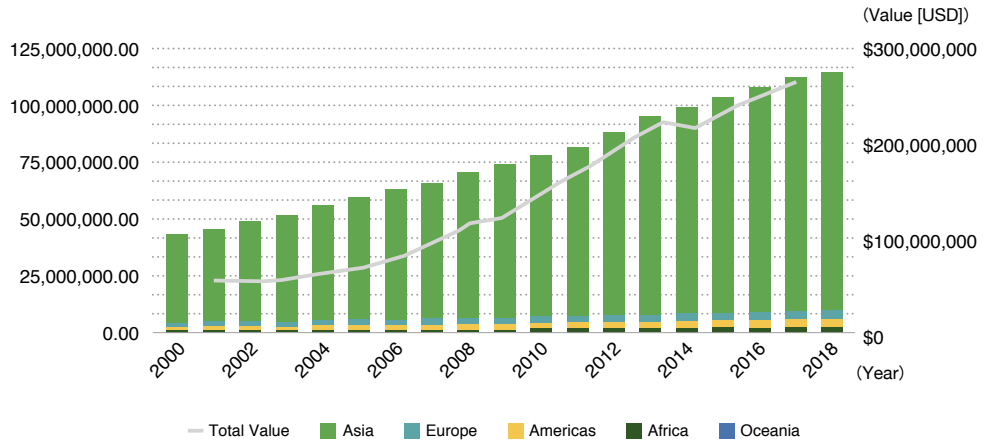


Source: FAO (2020a)

While the development of the aquaculture industry is striking across the world, Asia has been the major contributor for aquaculture production by maintaining around 88% of shares in global aquaculture production for the past two decades (Figure II.2). Other regions such as Africa and the Americas have also increased their share in global aquaculture production from

1.23 percent in 2000 to 2.67 percent in 2018, and 4.39 percent in 2000 to 4.63 percent in 2018 respectively. On the other hand, Europe and Oceania have experienced a marginal decrease in their share for the global total aquaculture production by 2.58 percent and 0.12 percent respectively between 2000 and 2008.

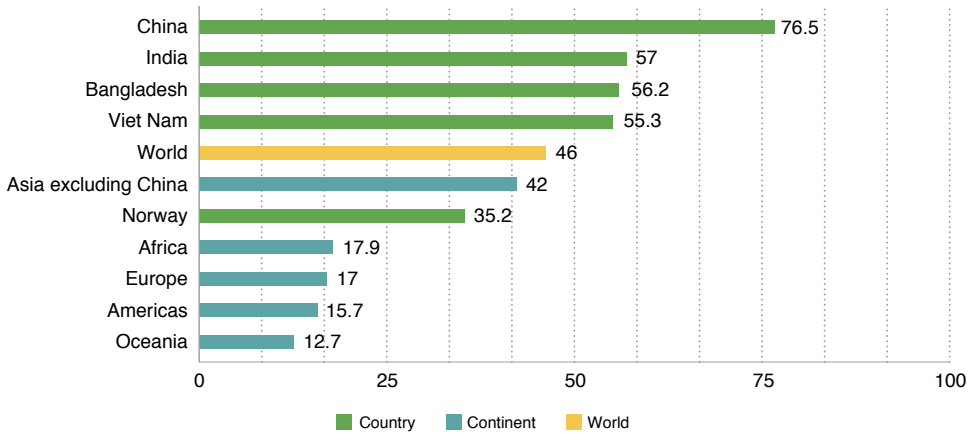
【Figure II.2】 Global Capture Fisheries and Aquaculture Production between 2000 and 2018



Source: FAO (2020a)

The exceptional contribution by Asia largely comes from China, which solely accounts for 57.9 percent of global aquaculture production (FAO, 2020a). China has been prominent in aquaculture activities with 76.5 percent of total fish production coming from aquaculture, followed by 57 percent in India and 56.2 percent in Bangladesh (Figure II.3). However, China's growth rate in aquaculture production has been decelerating in recent years with 2.2 percent in 2017 and 1.6 percent in 2018. Between 2000 and 2018, China's share in world aquaculture production reportedly dropped from 66.4 percent to 57.9 percent (FAO, 2020a). With the growth of other major countries in aquaculture production, China's share is expected to decrease further in the coming years alongside market saturation for staple species as a result of low market prices in those countries (FAO, 2020a).

【Figure II.3】 Aquaculture Production Ration in the total fish production for top 5 countries and continents in 2018.



Source: FAO (2020a)

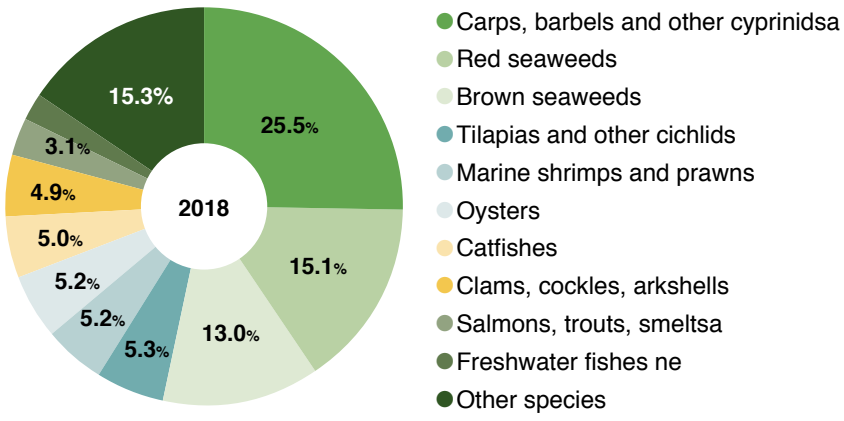
In terms of fish species that are largely cultured across the world, carps, barbels and other cyprinids seem to be the most significant contributor with 29 million tonnes farmed, followed by red seaweeds with 17 million tonnes and brown seaweeds with 15 million tonnes in 2018 (Table II.1 and Figure II.4). While carps, barbels and other cyprinids are cultured in 93 countries, only a few countries are farming red seaweeds and brown seaweeds. The reason why the large quantity of seaweed can be cultured with fewer farming countries could be relatively simple farming environment of seaweed culture with the larger volume of products for each farming. Although Tilapias and other cichlids are ranked 4th for major species for aquaculture, they are the most commonly cultured species with the aquaculture activity across 124 countries in 2018.

【Table II.1.】 Top 10 Global Aquaculture species groups by quantity in 2018

	Country	GDP
1. Carps, barbels and other cyprinids	29 225 694	93
2. Red seaweeds	17 343 783	34
3. Brown seaweeds	14 929 318	14
4. Tilapias and other cichlids	6 031 432	124
5. Marine shrimps and prawns	6 004 353	59
6. Oysters	5 994 895	44
7. Catfishes	5 781 235	89
8. Clams, cockles, arkshells	5 577 541	22
9. Salmons, trouts, smelts	3 555 880	82
10. Freshwater fishes nei	2 545 076	63

Source: FAO (2020a)

【Figure II.4】 Top 10 species groups in Global Aquaculture by share in 2018
[Share of global aquaculture production quantity of all species]



Source: FAO (2020a)

Overall, the global aquaculture production has been significantly increasing in the past few decades. With more varieties of species farmed across the world, the aquaculture production will most likely continue contributing towards fish and seafood production.

Global Demand

The increasing aquaculture production is accompanied by substantial demand in fishery products. For the past 60 years, the average growth rate for fish consumption has been remarkable with 3.1 percent annually, exceeding annual population growth rate of 1.6 percent (FAO, 2020a). In 2018, food fish consumption per capita was recorded at 20.5 kg, which is double the amount of 9.0 kg in 1961. According to the prediction by FAO, the number is expected to further increase by 2030 with 21.5 kg per capita. The main drivers for the growth are pointed out to be a combined high demand through rising income and urbanization, integrated with the expanding fish production and developments in technology, processing, cold chain and distribution channels (FAO, 2020a). Other factors such as shifts in dietary trends for better health, nutrition and diet also play an encouraging role.

Above all, the main source of increasing fish consumption in 2018 was aquaculture with 52 percent in share, another remarkable increase from 19 percent in 1990 (FAO, 2020a). One of the factors behind the aquaculture contribution in fish consumption seems to be its capability of allowing other regions and countries to access the cultured species that are limited to specific areas. The growing dominance of aquaculture in the global fish market has provided more possibility for control over production processes and "vertical and horizontal integration in production and supply chains" than capture fisheries (FAO, 2020a).

Sustainability Challenges

Along with the development of aquaculture in the fishery industry, the environmental challenges faced by aquaculture are highlighted in relation to the '2030 Agenda for Sustainable Development'. The agenda was adopted by all United Nations (UN) Member States in 2015 in order to provide a plan for peace and prosperity for humanity and the planet with its foundation developed under the 17 Sustainable Development Goals (SDGs) (UNDESA, 2021). Among the SDGs, fisheries and aquaculture are involved for the achievement of food security, and economic, social and environmental goals. In particular, SDG 14 - Life Below Water (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) is significant for fishery and aquaculture industries as a fundamental obligation. Achieving the objective will consequently lead to progress across other SDGs.

According to FAO's estimate (2020a), the percentage of fish stocks that are within biologically sustainable levels in 2017 was 65.8 percent, which is significantly lower compared with 90 percent in 1974. One of the major causes of the issue of sustainability derives from overfishing. Every year, an estimate of 35 percent of global fish harvest is either lost or wasted (2020a). Not only does it affect biodiversity and ecosystem to function negatively, but also reduces fish

production in consequence. As these numbers indicate, there is still considerable amount of effort and progress needed in fisheries and aquaculture and many countries and corporations are engaged in its improvement. Based on the UN SDGs Partnerships platform (2021), there have been 2010 actions taken through voluntary commitments and multi-stakeholder partnerships for SDG 14 by stakeholders. Further actions that investors can take in relation to aquaculture sustainability will be explained under the best practice section in chapter IV.

Following the global demand for fish and efforts towards sustainable development, the aquaculture industry holds many possibilities for every country. Brunei is one of the countries that has been promoting the industry for food security and as a possible leading economic source for the country. The current landscape of the aquaculture industry in Brunei will be explored in the following sections.

Fisheries and Aquaculture Industries in Brunei Darussalam

Brunei's Fisheries Sector

Table II.2 shows the percentage contribution of agriculture, forestry, and fisheries sector. Comparing fisheries to the highest contributor, livestock and poultry, Table II.2 shows that there is little difference in the contribution of fishery and livestock & poultry. The fishery sector appear to fluctuate between 31% and 37% whereas the livestock & poultry sector has been within the range of 39% to 44%. But looking at the yearly trend, the livestock & poultry sector has increased from 2015 whereas fishery has been on a downward trend from 2015, with 2019 being the biggest difference between these two.

【Table II.2】 Brunei Agriculture, Forestry, and Fishery percent contribution per sector, 2011 to 2019per sector, 2011 to 2019

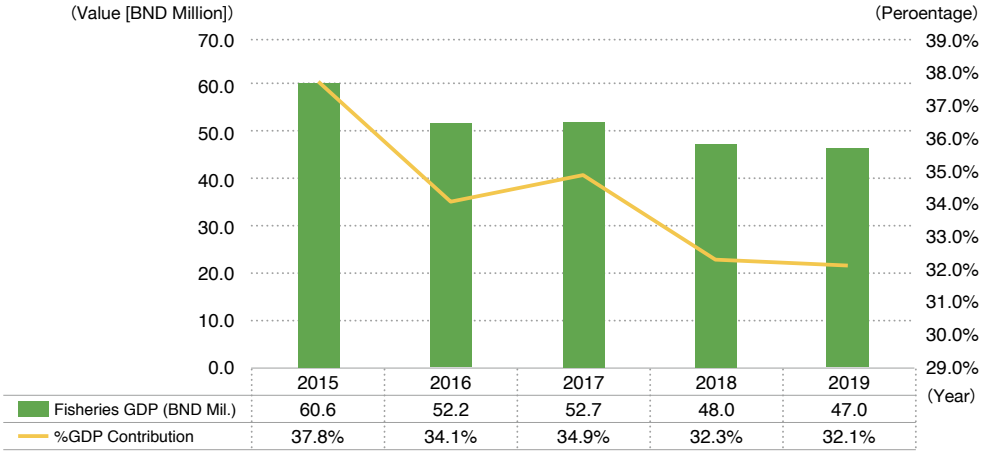
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Livestock & Poultry	42.0%	41.2%	41.4%	41.5%	38.9%	41.2%	41.2%	43.6%	43.0%
Forestry	11.7%	10.8%	11.4%	10.5%	8.7%	9.8%	7.5%	7.5%	9.3%
Vegetables, fruits & other agriculture	14.1%	16.6%	13.5%	14.2%	14.7%	15.0%	16.4%	16.6%	15.6%
Fishery	32.2%	31.4%	33.7%	33.7%	37.8%	34.1%	34.9%	32.3%	32.1%

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

Focusing on fisheries alone, the decrease becomes more evident as show in Figure II.5 where the value has fallen from 60 million BND in 2015 to 47 million BND in 2019 with the

corresponding contribution falling from 37.8% to 32.1%. This shows that except for 2017 where there was an increase in production, the production and share of the fisheries sector has generally declined due to reduced production from the marine capture sub-sector.

【Figure II.5】 Brunei Agriculture, Forestry, and Fishery GDP per type of activity at constant price (2010), 2011 to 2019

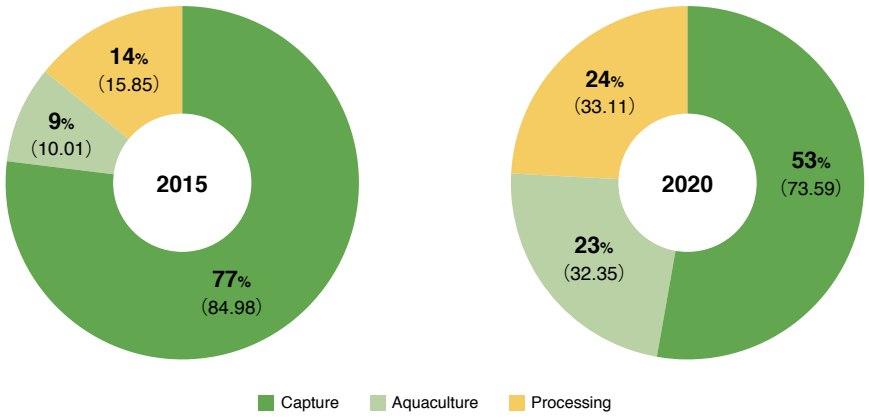


	2015	2016	2017	2018	2019
Fisheries GDP (BND Mil.)	60.6	52.2	52.7	48.0	47.0
%GDP Contribution	37.8%	34.1%	34.9%	32.3%	32.1%

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

The fisheries sector in Brunei Darussalam can be further broken down into three subsectors: (1) capture fisheries, (2) aquaculture, and (3) fish processing. Figure II.6 shows a comparison of the GDP share of each sub-sector to the fisheries sector. From this, it can be seen that aquaculture has shown the largest growth in the past 5 years increasing by 14%. Similarly, the processing industry also increased in the past five years with a 10% growth. On the other hand, marine capture which constitutes the largest share in fisheries has share declined by 25% from 2015 to 2020.

【Figure II.6】 Brunei Fisheries subsector production share, 2015 and 2020

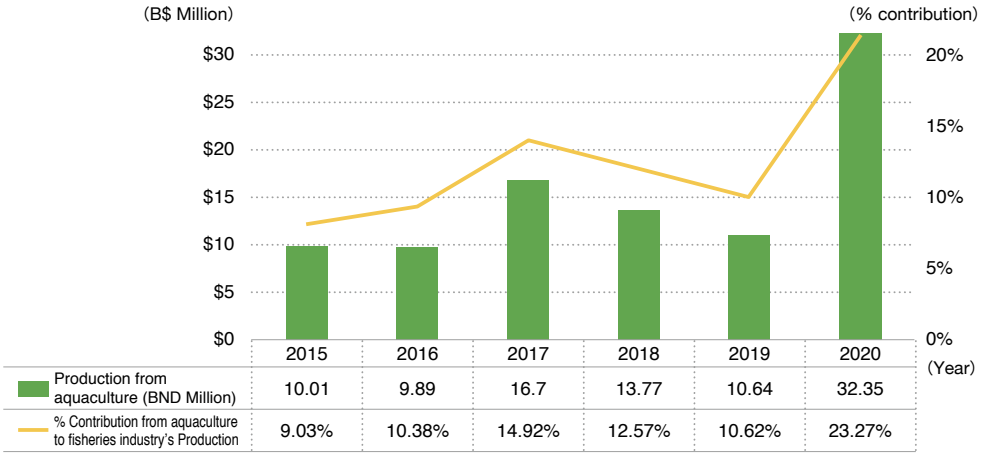


Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

In the yearly production numbers for the aquaculture sector, it can be seen that the rise of value and volume of aquaculture production was not gradual. After the rise in production from

2015 to 2017, despite the decline in 2018 and 2019, there was a sharp revival in 2020 where it increased more than twice of the previous year from 10.64 million BND to 32.35 million BND as shown in Figures II.7 and II.8.

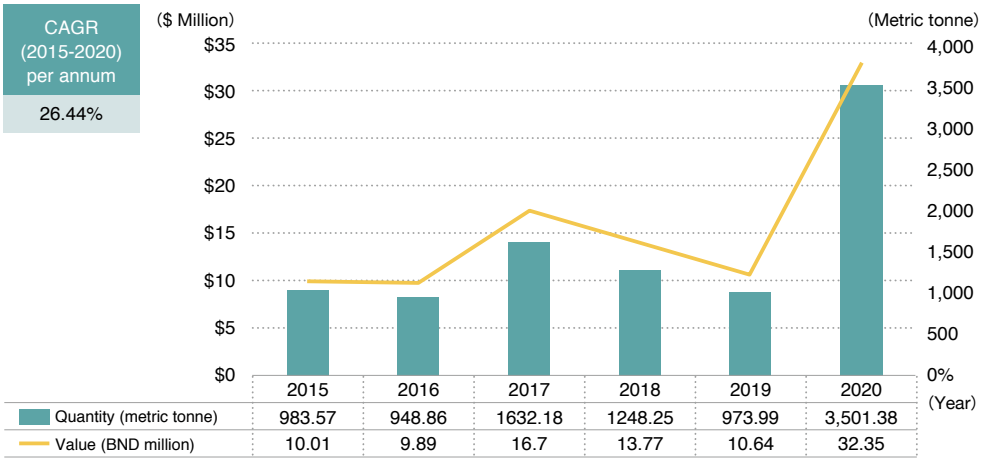
【Figure II.7】 Production value of aquaculture and contribution to fisheries, 2015-2020



	2015	2016	2017	2018	2019	2020
Production from aquaculture (BND Million)	10.01	9.89	16.7	13.77	10.64	32.35
% Contribution from aquaculture to fisheries industry's Production	9.03%	10.38%	14.92%	12.57%	10.62%	23.27%

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020b)

【Figure II.8】 Production volume and value of aquaculture, 2015-2020



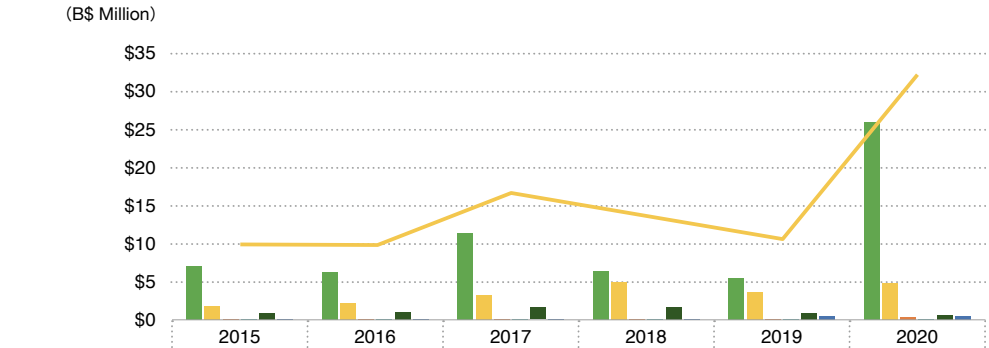
	2015	2016	2017	2018	2019	2020
Quantity (metric tonne)	983.57	948.86	1632.18	1248.25	973.99	3,501.38
Value (BND million)	10.01	9.89	16.7	13.77	10.64	32.35

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020c)[1]

Looking at the same production values from the perspective of the commodity composition that was produced by aquaculture as shown in Figure II.9, it can be seen that marine shrimp has been consistently the largest contributor to the sector followed by marine fish. The most noticeable detail in the graph which has been touched on in the previous sections is the sharp rise in 2020. Looking at the breakdown, marine shrimp has a five-fold rise in a year's time which is the reason why there was a great increase in the production value of the sector.

[1] CAGR (2015-2020) per annum refers to the production value.

【Figure II.9】 Aquaculture Production by type of species, 2015-2020



	2015	2016	2017	2018	2019	2020
Marine Shrimp	7.09	6.36	11.56	6.52	5.51	26.08
Marine Fish	1.85	2.26	3.31	5.1	3.67	4.82
Freshwater Fish	0.07	0.06	0.05	0.09	0.09	0.27
Crab	0	0	0	0.01	0	0.02
Marine Shrimp Fry	0.92	1.03	1.7	1.76	0.84	0.64
Fish Fry	0.07	0.18	0.08	0.3	0.54	0.53
Total	10.01	9.89	17.7	13.77	10.64	32.35

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020c)

Aquaculture Industry Targets

Today, the aquaculture industry has a high potential for contributing to Brunei's economy. The diversification of the economy was introduced as one of the three main goals of Brunei in Wawasan Brunei 2035 and the aquaculture industry has been engaged as an alternative leading industry for Brunei's economy. In Brunei's 11th National Development Plan (2018-2023), aquaculture is included as part of Thrust 5: Increasing output and contribution of non-oil and gas sector to GDP. This contributes to the attainment of the 3rd goal of the plan of creating a dynamic and sustainable economy. The plan lists the following projects as targets for the five years:

- Genetic Development and Selective Breeding Programmes to Increase Aquaculture Industry Productivity
- Development of Sites for Aquaculture Industries
- Programme to Increase Aquaculture Industry Production
- Prawn Breeding Industry Phase 4

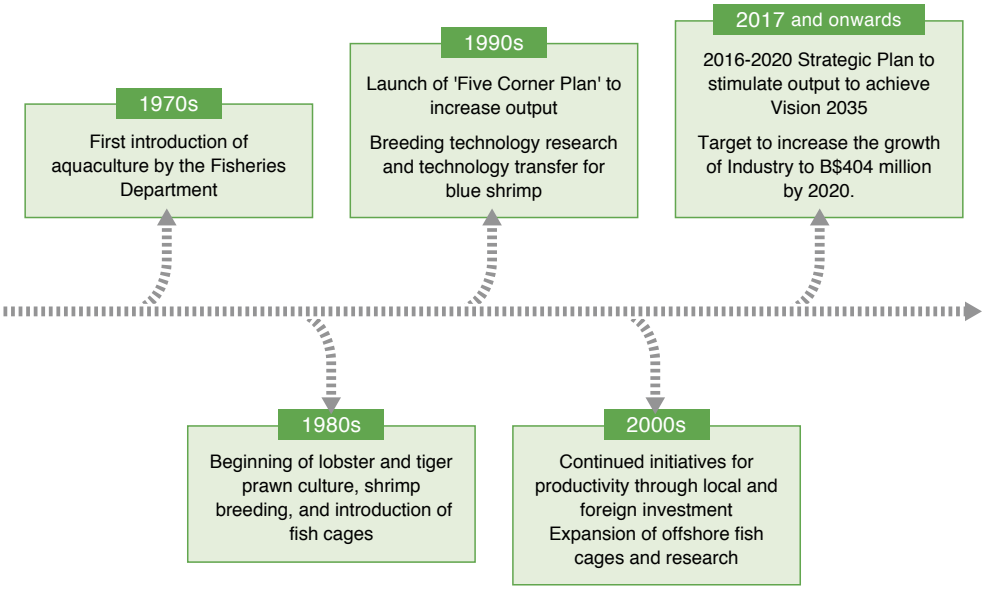
Moreover, the Ministry of Primary Resources and Tourism has stated that the country aims to **increase fisheries output to $404 million BND by 2020**. In order to achieve these aquaculture industry targets; the government of Brunei is promoting export-driven aquaculture activities towards foreign investors. Therefore, the foreign direct investment will be necessary for the development of the industry and Brunei is willing to support or cooperate with foreign investors for the industry.

Overview of the Aquaculture Industry of Brunei Darussalam

1. History

This section of the study will focus on the history of the aquaculture industry of Brunei. The history of the fish and seafood processing industry is also looked at due to its close relation to the aquaculture industry since it provides for raw material input needed to create the products of the processing industry. Despite being relatively young, both industries have gone through various changes and development in the past 50 years (see Figure II.10).

【Figure II.10】 Brunei Aquaculture History



Source: Compiled by the authors

In the era of the 1970s, aquaculture activities were first introduced by the Department of Fisheries through research and expansion carried out at the Sungai Jambu Fish Farm Station, especially in freshwater fish farming such as carp, lampam java, tilapia and gurami.

In the 1980s, the Department of Fisheries began implementing a program to produce lobster seeds and tiger prawn seeds at the Muara Fisheries Station. At the same time, fish farming in cages was first introduced in the Serasa area. Shrimp breeding sites in the pond began to be opened in the area of Kampong Mentiri Brunei Muara, and Kampong Keramut in Tutong District. Meanwhile, fish farm sites in cages were opened in the area of Pulau Kaingaran, Buang Tawardan Tanjong Pelompong to produce sea fish such as selungsong (barramundi), white fish and red fish.

In 1990, the Fisheries Department launched the 'Five Corner Plan', the Fisheries Department's strategic plan to increase the output of the fisheries sector including the commercial aquaculture industry through the marine shrimp farming industry, fish farming in cages, lobster farming and aquarium fish production. To support the development of the aquaculture industry, Meragang Hatchery Center was also built to supply tiger prawn seeds, and selungsong (barramundi) fish fry to entrepreneurs. In 1999, the Department of Fisheries carried out research on the variation of breeding technology and breeding of blue shrimp to

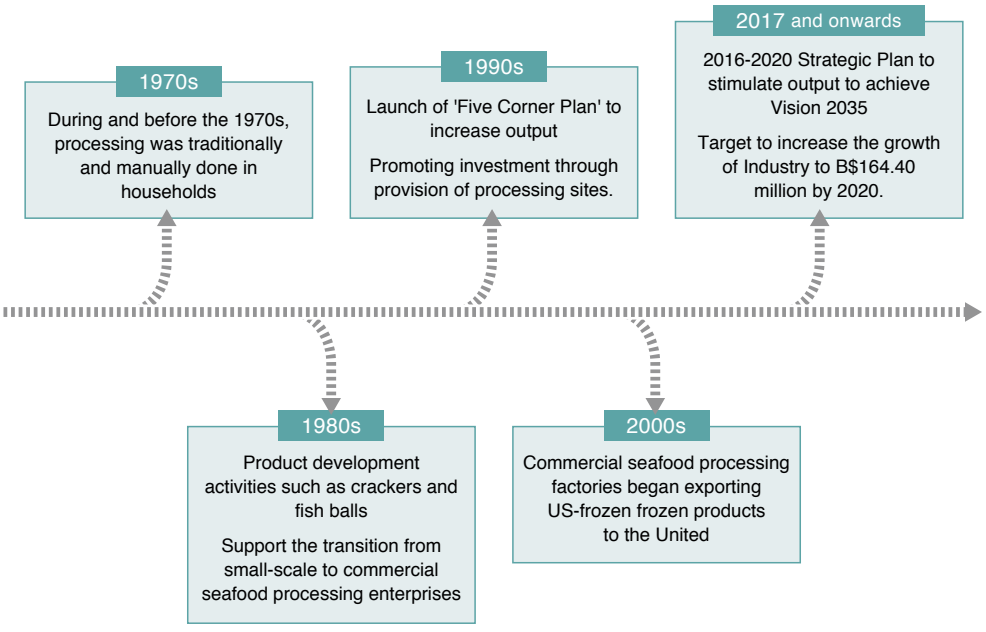
produce disease-free shrimp. As a result of the research, the technology transfer and parent of blue shrimp to private hatching enterprises was implemented to produce and supply disease-free blue shrimp seeds to local entrepreneurs commercially in 2000.

The Fisheries Department continues to actively implement a number of initiatives aimed at increasing the production and productivity of the aquaculture industry through the involvement of foreign and local direct investors with the use of modern technology and export targets. Meanwhile, the Fisheries Department opened a new site for cage fish in the coastal area of Tanjung Pelumpong in 2003, implemented a master quality restoration project and blue shrimp seeds in collaboration with international institutes and continued with the conservation and production of disease-free tiger seeds commercially in 2006, site opening and provision of basic infrastructure for shrimp farming in Sungai Penyatang with an area of 200 hectares in 2007, and fish farming in cages in the offshore area of 18,000 hectares in 2008.

The Fisheries Department Strategic Plan 2016-2020 was launched on 11 January 2017 by Yang Berhormat Dato Seri Setia Awang Haji Alibin Apong, Minister of Primary Resources and Tourism aimed at stimulating increased output of the Catch Industry which will contribute to Gross Domestic Product (GDP) growth, exports and economic diversification towards achieving Vision 2035 by encouraging investment from within and outside the country, and by emphasizing increased productivity, the use of high technology, and a focus on export markets. The target was to increase the growth of Aquaculture Industry products worth B$16.70 million in 2017 to B$404 million by 2020.

Figure II.11 shows that before the 1970s, fish processing activities were done traditionally and manually at home and the tools used were wooden mortars for making belacan (shrimp paste).

【Figure II.11】 Brunei Fish Processing History



Source: Compiled by the authors

In the 1980s, the Fisheries Department began implementing product development activities to make crackers and fish balls to support the transition from small-scale enterprises to commercial seafood processing enterprises. The Fisheries Department strives to assist small entrepreneurs in developing seafood processing enterprises through advisory, technical and demonstration services to introduce appropriate equipment and packaging to produce and improve consistent product quality.

In 1990, the Fisheries Department launched the 'Five Corner Plan', the Fisheries Department's strategic plan to increase the output of the fisheries sector including the seafood processing industry by promoting processing investments by providing processing sites in the Serasa Fisheries Industry area to catalyse industrial growth, building factory to reduce high investment costs, introduce modern equipment for seafood processing and diversify products such as crackers, balls, giggles, liking fish, salted fish, shrimp paste to be marketed either by direct sales or to supermarkets. Some entrepreneurs have moved from their homes to operate in government-provided buildings and industrial sites as well as in commercial buildings.

In the 2000s, commercial seafood processing factories began exporting frozen products to the United States. On December 5, 2016, the Department of Fisheries was recognized as a Competent Authority with two factories allowed to export to European countries.

2. Water Resources and Aquaculture Areas

Having a small territory, the country of Brunei has limited natural water resources available within and surrounding it. Table II.3 shows the different water resources that Brunei has. It has 161 kilometres (100 miles) of coastline facing the South China Sea which ranks its 130th in the world in terms of total coastlines. Beyond this, the country also has an offshore exclusive economic zone spanning 36,600 square kilometres stretching towards the South China Sea.

【Table II.3】 Natural Water Resources of Brunei

Water Resources	Details
Major Rivers	4
Coastline	161 km
Continental shelf	8600 km
Offshore Exclusive Economic Zone	36, 600 sq. km.

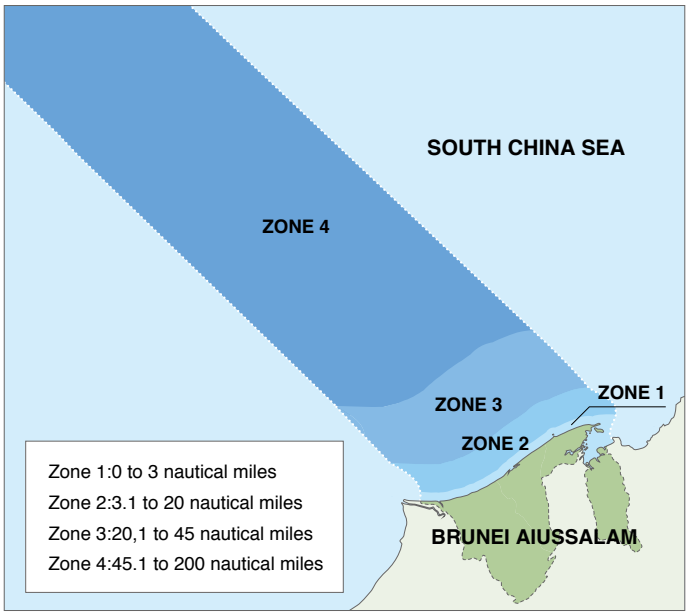
Source: Department of Fisheries, Ministry of Primary Resources (2020a)

Figure II.12 shows the area of Brunei's Offshore Exclusive Economic Zone and the different subdivisions that it has. Zone 1 is from the immediate coastline up to 3 nautical miles. Zone 2 is between 3.1 to 20 nautical miles. Zone 3 is from 20.1 to 45 nautical miles. Lastly, Zone 4 is from 45.1 to 200 nautical miles from the coast. Other than this coastal and maritime water resources, Brunei also has 4 major rivers that drains through the country. The longest is the Belait River that runs 209 km. Next to it are the Tutong River (137 km), Temburong River (98

km), and Brunei River (41 km). This limited water resources in Brunei have made aquaculture an important industry to contribute to the fisheries sector. This limitation is also an impetus for further expansion and investment for aquaculture.

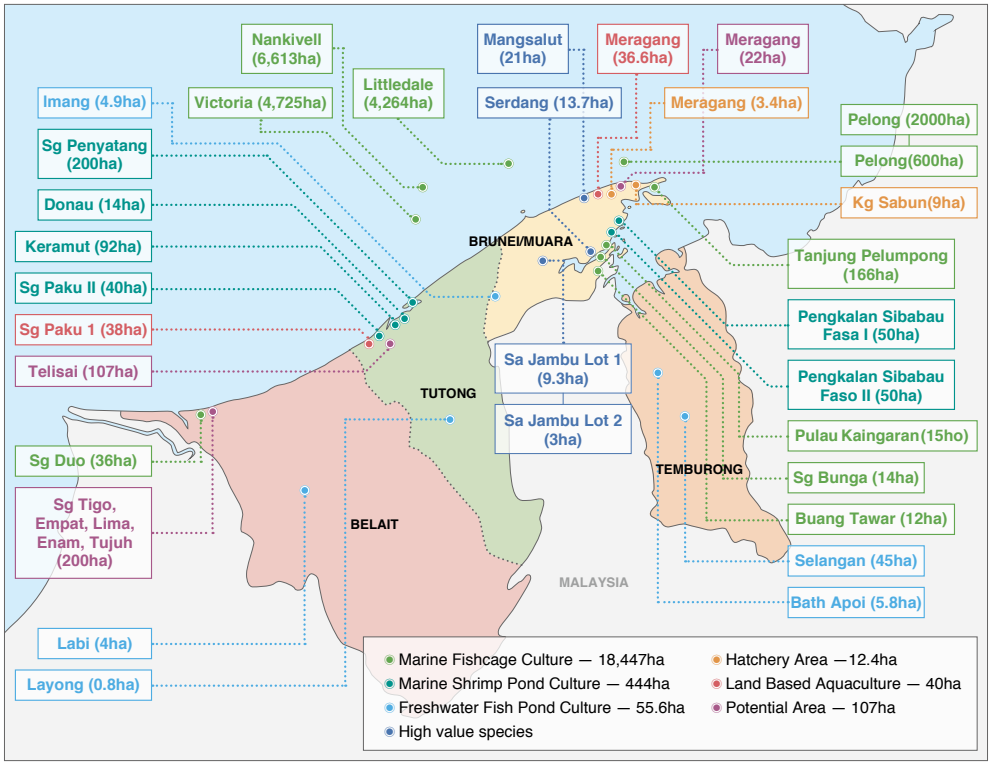
Due to the limitation of water resources for fisheries, aquaculture has been developed and used by Brunei for fish and seafood production. Figure II.13 shows the location of current aquaculture sites in Brunei. These sites can be classified into different types: (1) marine fish cage culture, (2) marine shrimp pond culture, (3) freshwater fish pond culture, (4) high value species aquaculture, (5) hatchery areas, (6) land-based aquaculture, and (7) potential areas.

【Figure II.12】 Brunei's Offshore Exclusive Economic Zone



Source: Department of Fisheries, Ministry of Primary Resources (2020a)

【Figure II.13】 Brunei Aquaculture Sites.



Source: Department of Fisheries, Ministry of Primary Resources

While most of these sites are located near coastal areas and offshore, there are a few which are located inland as land-based aquaculture sites. The largest of these in terms of areas covered are in the marine fish cage capture which in total encompasses 18,447 hectares of offshore water. Next to this although very far in covered area are marine shrimp pond culture and freshwater fish pond culture covering 444 hectares and 55.6 hectares respectively. From this, it can be seen that the aquaculture sector in Brunei is already established but despite this, there are still opportunities for expansion through investment as shown by potential areas where new aquaculture ventures can be placed.

In terms of the companies that are engaged in aquaculture in Brunei, there are several that are operating in the various sites. Table II.4 below summarizes the breakdown of these companies per type of production, location, and number of companies in each location in 2018.

【Table II.4】 Number of companies per type of production for each aquaculture sites in 2018

Type of Production	Site	No. of Companies
Marine Shrimps	Pangkalan Sibabau Fasa 1	3
	Pangkalan Sibabau Fasa 2	4
	KG Keramut	5
	SG Paku Fasa 1	2
	SG Penyatang	1
Marine Finfishes	Tanjong Pelumpong (Inshore)	15
	Pulao Keingaran	14
	Buang Tawar	9
	Sungai Bunga	11
	Sungai Dua	2
Freshwater Fishes	Brunei and Muara District	3
	Tutong District	3
	Belait District	2
	Temburong District	3
Marine Shrimp Fry		2
Marine Finfish Fry		5
Freshwater Fish Fry		4
Total		**88**

Source: Department of Fisheries, Ministry of Primary Resources (2020a)

As of 2018, there were a total of 88 companies engaged in aquaculture activities. Marine finfish production constitutes the greatest number of companies with 51 in 5 sites. Next are those engaged in marine shrimp with 15 companies in five sites. Third are freshwater fishes with 11 companies in four sites. The remaining companies are engaged in marine shrimp fry, marine finfish fry, and freshwater fish fry with two, five, and four companies respectively. Looking at this, the aquaculture industry, represented by these companies despite being established is still relatively small. There is still potential for the establishment of ventures for new commodities and the expansion of current commodities which can be supported by foreign investments.

3. Existing Aquaculture Systems

According to the Department of Fisheries of Brunei, existing aquaculture systems being used in Brunei can be classified into four types: (1) Pond culture, (2) Marine fish farming in floating cages, (3) Offshore cage culture, (4) Recirculating aquaculture system. A brief description of each with advantages and disadvantages of adopting such systems.

Pond culture

Farming through pond culture is the most basic form of aquaculture that is being used in Brunei. This involves the construction of ponds or embankments that is supplied with water channelled from streams or rivers and usual open to be fed by rainwater as well. In Brunei, pond culture is widely used for the production of freshwater fish and prawns.Advantages of using pond culture is that it is the simplest form of aquaculture not requiring complex technology which lowers the capital costs. Being a closed system, it conducts filtering of the water to keep it clean and suitable for fish culture. Secondly, easy access and smooth transport are particularly useful for efficient good delivery. On the other hand, the disadvantage of this is that it uses chemicals like herbicides and fungicides to kill pests and prevent proliferation. Another disadvantage is that being a closed system it needs filtering of the water to keep it clean and suitable for fish culture.

Source: Bizbrunei.com

Marine fish farming in floating cages

Marine fish farming in floating cages at the coastal and inshore areas is common in Brunei as there are abundant water resources including rivers, lakes and the sea. Moreover, the system is used for both marine and freshwater fishes. Rectangular cages are usually implemented in inshore coastal waters and in the Bay of Brunei.The advantage of this system is that it allows for the simplest way to have salt water culture without the need of channelling or pumping salt water from the ocean to the inland. The location of inshore fish cages makes it accessible than offshore systems. The main disadvantage of fish culture in floating cages is the increased chance of introducing invasive and non-native species in the environment which can potentially introduce diseases in the native fish population. Since these systems are located in shallower waters, nutrient and waste would not be easily washed out to the sea, dissolve and may build up in the coastal sea floor.

Source: Newatlas.com and Alamy.com

Offshore fish cage culture

Circular fish cages with a diameter of 18-20 meters is utilised for offshore fish farming by commercial and foreign investors due to high capital and operation costs. On the other hand, the enclosure system such as pen culture is uncommon especially among large-scale farming enterprises or commercial.

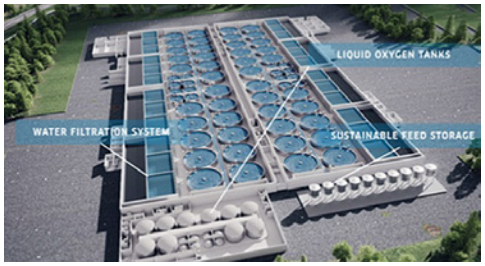
The advantages that this offers include having greater space available for fish culture due to the depth of these areas. Since this is a natural environment for the fish, the temperature is relatively constant (though natural temperature fluctuations occur during the day depending on the season) with little need for adjustment. Unlike inshore cages, the waste from offshore dissolves in the open ocean although accumulation of these at the seafloor may be possible. The disadvantage of this type of aquaculture system is that it is dependent on weather and climate conditions to become viable. It can increase complexity in monitoring fish health due to the size and depth of the cages as well as cleaning the cages. Finally, it is also prone to outside predators caught in the nets and cages.

Source: Investvine and Aquaculture Alliance

Recirculating aquaculture system

Recirculating aquaculture system (RAS) is farming marine and freshwater fishes in concrete and fiberglass tanks. RAS is essentially a technology for farming fish or other aquatic organisms by reusing the water in the production. The technology is based on the use of mechanical and biological filters, and the method can, in principle, be used for any species grown in aquaculture such as fish, shrimps, and clams.

The main advantage of this system is that it is more environmentally friendly since it reuses water and only a little water is introduced to replace evaporated water. The system also allows for the collection of all residue and waste generated through the filtering system which enables better disposal of these. The disadvantage of this is that needs more capital input compared to other systems due to the costs of the filtering system.



Source: Newatlas.com and Alamy.com

Domestic Production and Consumption

Production of Fish and Seafood

The overall fishery production of Brunei in recent years show a positive trend, increasing from $110.84 million BND in 2015 to $139.05 million BND in 2020 (see Table II.5). Among the three subsectors of the fishery industry; capture, aquaculture, and processing, the production of aquaculture especially contributed to the growth from $10.01 million BND (9% in share) in 2015 to $32.35 million BND (23%) in 2020 (see Figure II.6). Given the increasing share of aquaculture from 9% in 2015 to 23% in 2020, the increase in fishery production seems to be driven by the increased aquaculture production.

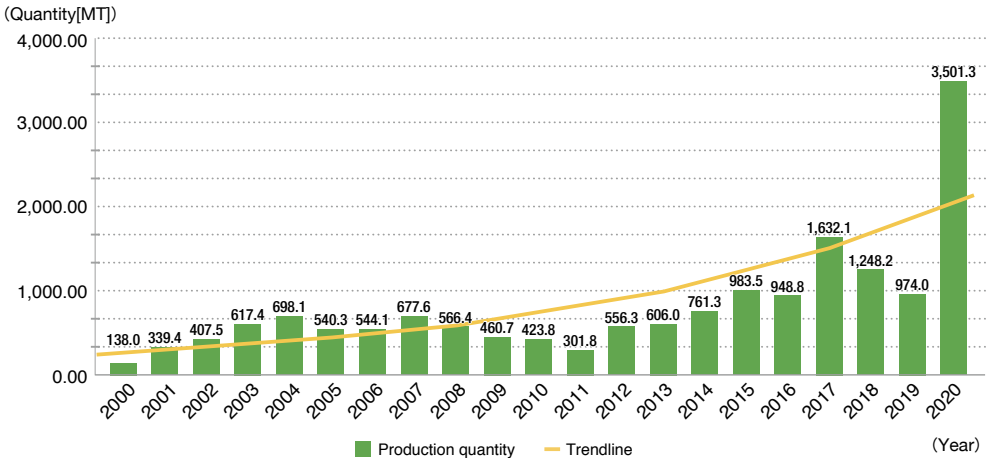
【Table II.5】 Total fisheries industry production between 2015 and 2020.

Year	2015	2016	2017	2018	2019	2020
Value (BND million)	$110.84	$95.34	$111.90	$109.52	$100.15	$139.05

Source: DOF (2021)

As it is clearly indicated in Figure II.14, the aquaculture production in the last decade has been particularly substantial in terms of growth rate. Although the number declined in 2018 and 2019, the production appears to have recovered in 2020 with the highest production quantity at all time.

【Figure II.14】 Production of Aquaculture Industry between 2000 and 2020



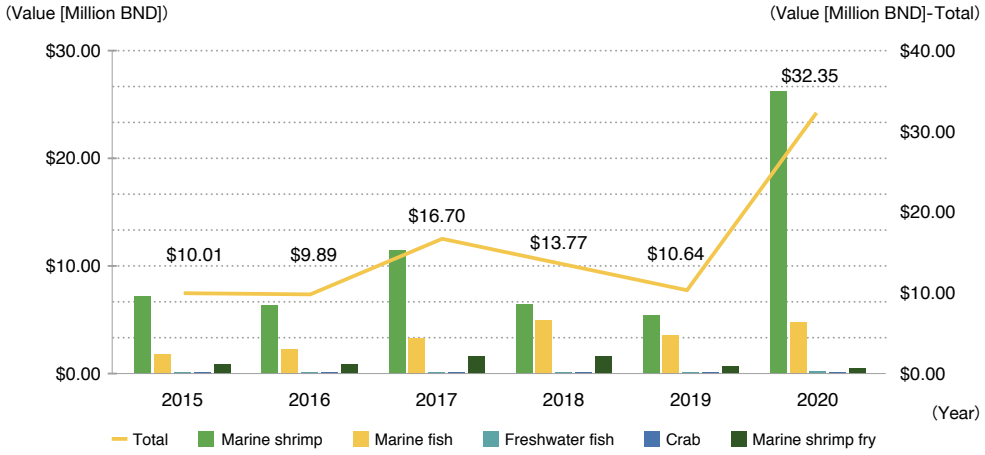
Source: DOF (2020 & 2021)

The fall in aquaculture production in 2018 and 2019 was due to a decrease in marine shrimp production during those years (Figure II.14). Multiple diseases found in blue shrimp have affected the overall marine shrimp production in 2017 (Department of Fisheries, 2021). This was a temporary setback as blue shrimp was the largest contributor for the aquaculture production in Brunei. Despite the fall in marine shrimp in 2018 and 2019, other fish products such as marine fish have shown a more positive trend in the

same years. In terms of specific species that are cultured in Brunei, Figure II.15 indicates a great volume of blue shrimp production in 2018 compared with other species. While other high-value fishes such as grouper and barramundi are also important for the production in Brunei, the volume is still small compared with its amount of blue shrimp. In terms of values, grouper seems to be contributing significantly considering its volume. As it is shown with grouper fish, the high-value fishes can efficiently contribute to the production values even if the volume is rather small.

The issue with diseases in aquaculture remains a critical aspect of biosecurity needs that need to promote healthy and wholesome aquaculture. This point is further reiterated in Chapter IV. [2]

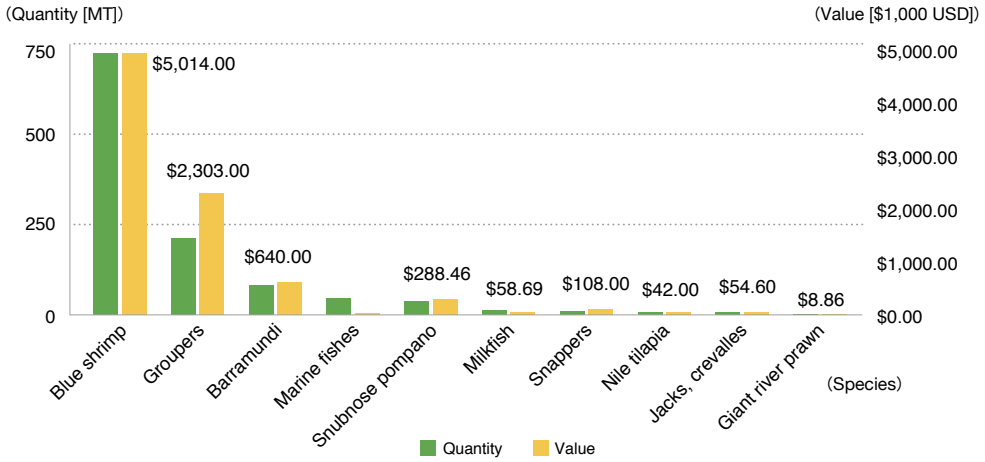
【Figure II.15】 Aquaculture production by types of fish in Brunei between 2015 and 2020



Source: DOF (2021)

【Figure II.16】 Aquaculture Production of Top 10 species in Brunei in 2018

*The value of Marine fishes was unavailable



Source: South East Asia Fisheries Development Center (SEAFDEC, 2020)

[2] Further list of diseases identified is available on the source by Halim (2018).

In the aquaculture industry, "seeds" or shrimp post larvae and fish fry/fingerlings are essential in the main stages to start aquaculture. As of 2018, there are a total of 19 facilities for seed production in Brunei (Table II.6). Similar to the data for aquaculture production by species, seed production for blue shrimp, barramundi, and hybrid grouper have the largest volumes. Essentially, the production of those aquaculture species is successful due to the established seed production facilities for those species.

【Table II.6】 Seed Production from Aquaculture in 2018

Species	Total (million pcs.)	Aquaculture Practices (million pcs.)	No. of operational units and facilities
Tilapias	0.0762	0.0762	3
Catfishes	0.034	0.034	1
Barramundi	0.1629	0.1629	6
Malabar red Snapper	0.0004	0.0004	2
Hybrid grouper	0.0865	0.0865	3
Golden Pompano/Snubnose Pompano	0.03	0.03	2
Giant river prawn	0.03	0.03	1
Blue shrimp	109.96	109.96	1

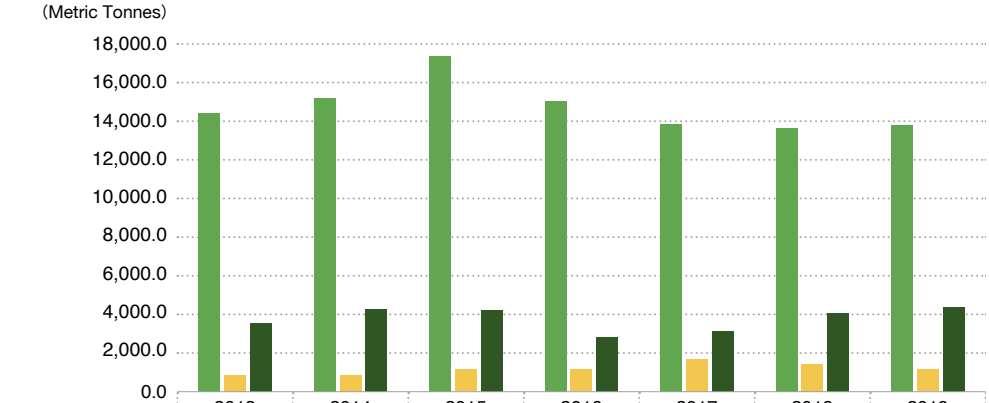
Source: SEAFDEC (2020)

Processing

Fish and seafood processing make up a whole new industry separate from the marine capture and aquaculture. After fish and seafood products are harvested through marine capture and aquaculture, it can either be directly sent into the local market, go through packaging and preparation for exportation, or be sent into facilities to be processed. Processors convert whole fish or shellfish to various other products like fish fillets or steaks, or other items such as frozen products, breaded fish portions, and canned or smoked products. These processed items can be further by secondary processors to heat and serve or ready-to-eat products.

Brunei's fish and seafood industry despite being small has developed from small scale home-based *belacan* (fermented shrimp paste) enterprises before and in the 1970s to commercial scale processing companies of the recent years. Figure II.17 shows the production of Brunei fisheries per subsector in terms of volume produced in the last 7 years. From this, it can be observed that despite large difference from marine capture, the processing industry is the second in terms of the volume produced. The volume produced by the processing industry has fluctuated in the recent years. After the decline from 2014 to 2016, it increased in the next three years with a value of 4,115.9 metric tonnes in 2019.

【Figure II.17】 Production of Fisheries per subsector in metric tonnes, 2013-2019



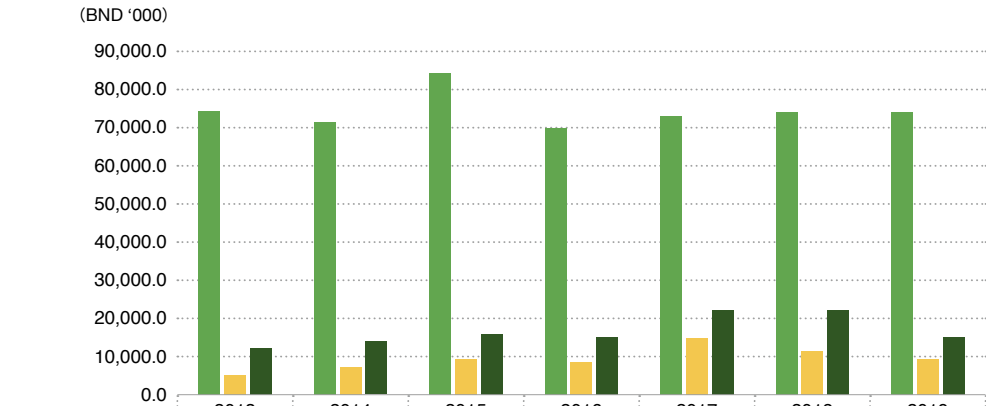
	2013	2014	2015	2016	2017	2018	2019
Capture Industry	14,320.3	15,100.4	17,333.3	14,966.1	13,795.6	13,565.6	13,724.5
Aquaculture Industry	606.0	761.3	983.5	948.8	1,632.1	1,248.2	973.9
Processing Industry	3,325.7	4,068.7	3,983.7	2,645.9	2,963.4	3,852.6	4,115.9

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020c)

On the other hand, Figure II.18 shows the production of Brunei fisheries per subsector in terms of value in BND in the past seven years. While the processing industry is still far second to marine capture, there is a noticeable difference in the trend where processing production has increased steadily compared to the decline in capture fisheries. The value of the aquaculture industry rose up from 2013 to 2015 before slightly declining in 2016. It then continued to increase in 2017 where it peaked at 22,190 million BND. But then, this has declined in the following two years with the value falling to 15,440.1 million BND in 2019.

Despite the size of fish and seafood processing industry in Brunei, in the past five decades, several types of enterprises and companies specifically engaged in fish and seafood processing emerged. Table II.7 shows the number of processors in Brunei per type in 2020 which there were a total of 81 of these processors. These processors can be further categorized into commercial processors, small scale processors, and support industries.

【Figure II.18】 Value of Fisheries per subsector in metric tonnes, 2013-2019



	2013	2014	2015	2016	2017	2018	2019
Capture Industry	74,608.2	71,500.8	84,982.3	70,113.9	73,037.3	73,805.8	74,072.1
Aquaculture Industry	4,872.2	6,992.6	9,055.6	8,688.1	14,919.9	11,713.0	9,268.4
Processing Industry	12,168.0	14,202.0	15,826.0	15,329.0	22,190.0	21,940.0	15,440.1

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020c)

Commercial processors are large-scale processors that produces large quantities of goods. These are further classified into companies producing frozen products, fish crackers, and comminuted fish products (see Table II.7). This type of processor makes up 18.5% of all processors in Brunei. Small-scale processors are enterprises that are producing processed fish at smaller than commercial ones with some using manual labour to produce its products. This is composed of cracker products, ikan liking (marinated fish), belacan (fermented fish paste), salted fish, and lekor. Based on the data from the Department of Fisheries there are 65 small scale processors which makes it the most common type of processor in Brunei. The last type of processor is a support industry which provides goods and services that are needed by the commercial and small-scale processors. Currently there is only one company for the ice processor.

【Table II.7】 Fish and Seafood Processors in Brunei by type, 2020

Type of Processor	Product Produced	No. of Processors
Commercial Processors	Frozen Products	8
	Cracker Products	2
	Comminuted Products	3
	Other Products	2
Small Scale Processors	Cracker Products	18
	Ikan Liking (Marinated Fish)	21
	Belacan (Fermented Fish Paste)	19
	Salted Fish	14
	Lekor (Small Scale)	4
Support Industry	Ice Processors	1
Total of Commercial Processors		15
Marine Finfish Fry		1
Freshwater Fish Fry		65
Total		**81**

Source: Department of Fisheries, Ministry of Primary Resources (2020a)

Domestic Consumption

In terms of fish and seafood consumption, Brunei is one of the highest in the world on a per capita basis. Based on the data from the FAO, in 2013, Brunei ranked 9th out of 150 countries in the world just behind Japan in this statistic at 46.7 kilograms of fish and seafood consumed per person (see Table II.8). The country's consumption has ranged from a low of 19.9 kg in 1965 to its highest at 59.8 kg in 1994 and has consistently been one of the highest.

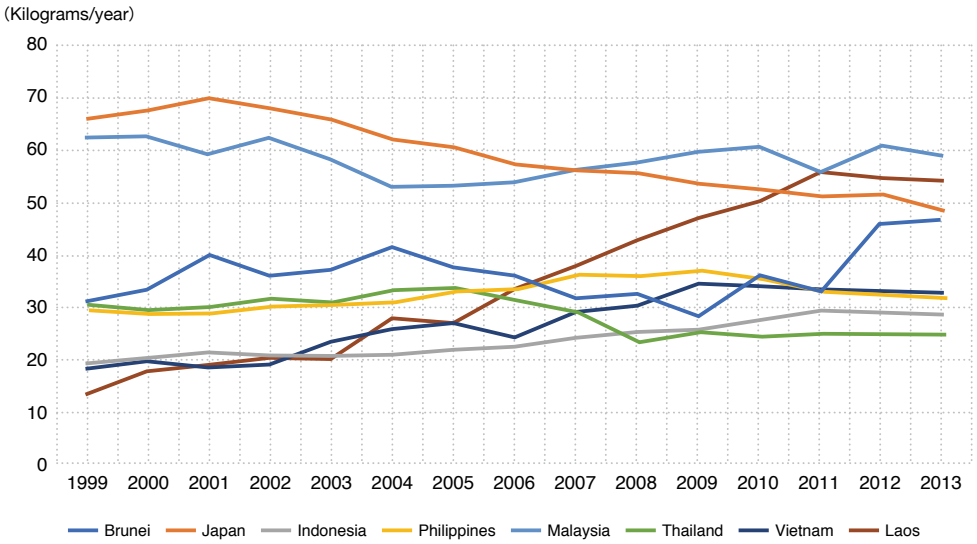
【Table II.8】 Countries with the highest Fish and Seafood Consumption per capita (2013)

	Country	Fish and Seafood Consumption (in kg/person) in 2013
1	Maldives	184.88
2	Iceland	91.92
3	Malaysia	58.97
4	Myanmar	54.39
5	Portugal	53.76
6	South Korea	52.78
7	Norway	52.08
8	Japan	48.6
9	**Brunei**	**46.7**
10	Spain	43.38
11	Cambodia	41.43
12	Bermuda	36.25
13	Fiji	36.09
14	Gabon	35.62
15	China	34.67

Source: FAO (2020a)

Figure II.19 shows the trend of fish and seafood consumption of Brunei compared to Japan and other countries in Southeast Asia. Brunei has the 3rd highest consumption after Malaysia and Myanmar in the region — just behind Japan in Asia. Brunei's Department of Fisheries states that the country's self-sufficiency of fresh fish is more than 80%. To ensure maximum economic gains and at the same time to ensure the sustainability of fishes, the exploitation of the capture fisheries is only up to the "maximum economic yield".

【Figure II.19】 Comparison of Fish and Seafood Consumption, Southeast Asia and Japan [in kilograms per year], 1999-2013



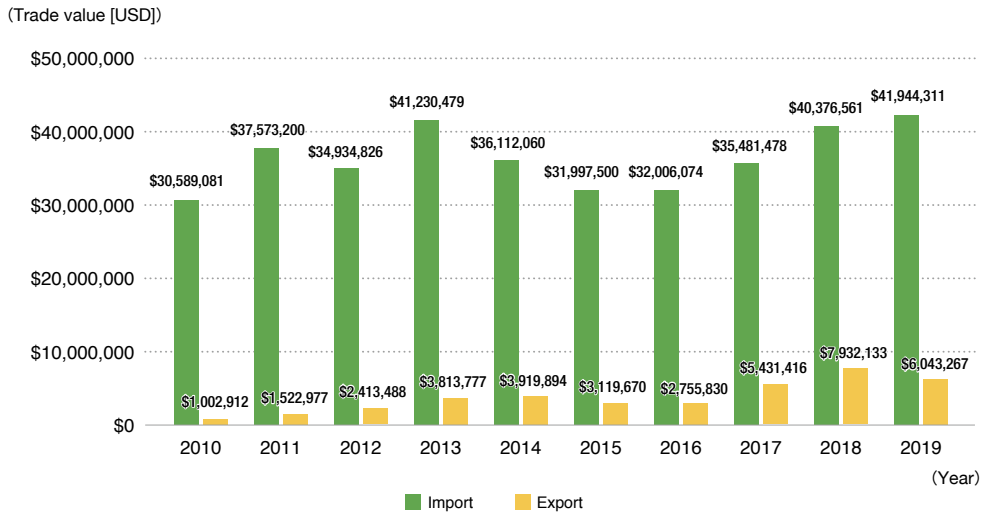
Source: FAO

With this increasing trend in fish and seafood consumption in Brunei, there is a need for increased production for the fisheries sector to steadily provide supply of this commodity. Expansion and investment in the aquaculture industry can certainly help in this area. Also increasing production can provide opportunities for export to nearby countries which also has a high rate of fish and seafood consumption which furthermore emphasizes the potential for investment in the aquaculture industry.

Trade overview

Trading fish and seafood is a significant part of Brunei's economy. As Brunei is one of the top 10 highest fish consuming countries in the world, there needs to be a stable supply for fish and seafood products. As Brunei is geographically small and the fish production is rather limited, most of the domestic consumption is supplied from imported fish and seafood. Figure II.20 emphasizes the significant gap between the values of imports and exports between 2010 and 2019. Although the export value has been increasing in the last decade, the import value has not been reduced. This could imply a heavy reliance on imports for fish and seafood consumption that Brunei is conducting. A possible reason for this is due to the strong marine conservation in Brunei where local supplies cannot keep up with local demand (Oxford Business Group, 2016). This leads to a reason why there needs to be further investment in the aquaculture industry from overseas for developing the export-driven industry.

【Figure II.20】 Comparison of import and export values of fish and seafood in Brunei between 2010-2019



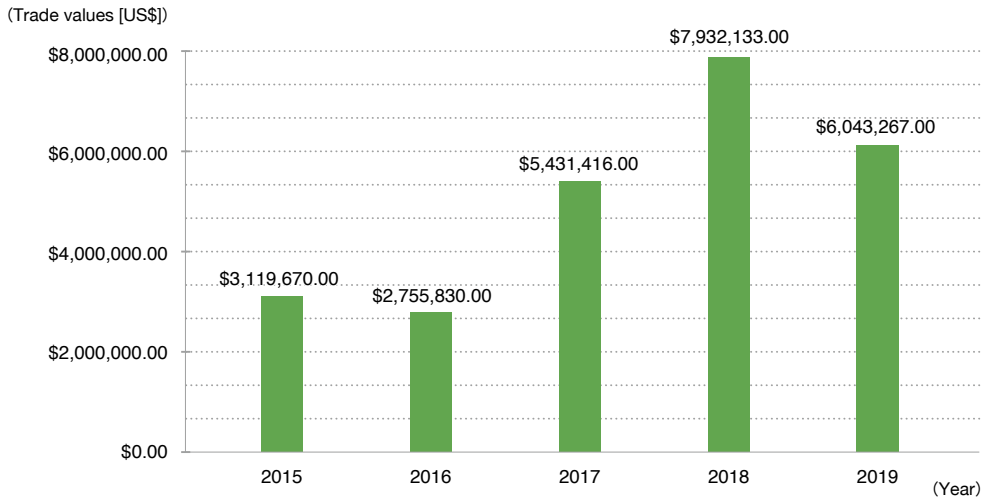
Source: UN Comtrade (2021)

In order to further understand the export and import landscape in Brunei, the following sections will provide the overview of exports and imports.

Export overview

Although Brunei's export values have been rather small and limited compared with its import values, the fishery exports have shown a positive trend in recent years. The export values of fish, crustaceans, molluscs and other aquatic invertebrates reached the highest value in 2018 with $7.9 million USD (Figure II.21). Although the number moderately dropped in the following year with $6.0 million USD, the overall trend in the past few years seems to be positive. While it is not clear what lead to the increase in export value in 2018, it may be related to the growth of fishery production in 2017 where added value in production was reflected in the export value for the following year.

【Figure II.21】 Export values of fish, crustaceans, molluscs and other aquatic invertebrates in Brunei between 2015 and 2019.



Source: UN Comtrade (2021)

Table II.9 identifies the breakdown values of Brunei's fisheries exports by type of commodity in 2019. The largest contributing commodity type is frozen fish which accounts for 42.3% of total fish and seafood exports, followed by live fish with 25.7% and crustaceans with 19.2%. Those three products are the major fish and seafood commodities for exports in Brunei, representing more than 85% of total values. Regarding the crustaceans, 98% of them consist of shrimp and prawns with $1.11 million USD. This is the second largest product group after frozen Skipjack/stripe-bellied bonito which had the value of $1.38 million USD. This shows the large share of shrimp production in Brunei and how they contribute to the economy.

【Table II.9】 Brunei's fisheries export breakdown by type of commodity, 2019

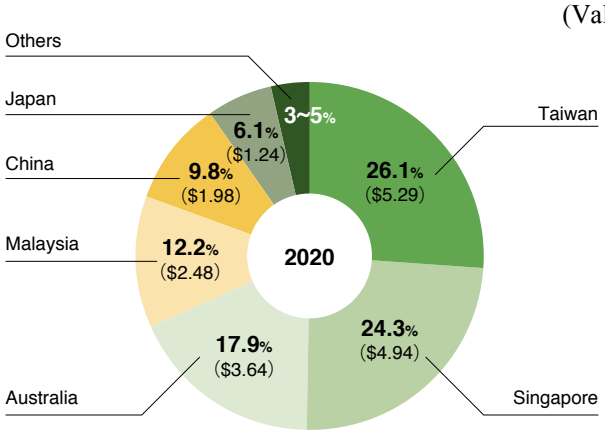
By Commodity Type		
Commodity	**Value (in USD)**	**Share**
Fish, frozen, excluding fish fillets and other fish meat	2.55 million	42.3%
Live fish.	1.55 million	25.7%
Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; crustaceans, in shell, cooked by steaming or by boiling in water, whether or not chilled, frozen, dried, salted or in brine; flours, meals and pellets of crustaceans, fit for human consumption	1.15 million	19.2%
Fish, fresh or chilled, excluding fish fillets and other fish meat	468 thousand	7.8%
Molluscs, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; aquatic invertebrates other than crustaceans and molluscs, live, fresh, chilled, frozen, dried, salted or in brine; flours, meals and pellets of aquatic invertebrates other than crustaceans, fit for human consumption	275 thousand	4.6%
Fish, dried, salted or in brine; smoked fish, whether or not cooked before or during the smoking process; **flours, meals and pellets of fish,** fit for human consumption	22 thousand	0.3%
Fish fillets and other fish meat (whether or not minced), fresh, chilled or frozen	5.63 thousand	0.096%

Source: UN Comtrade (2021)

While some specific products stood out in the export values for the commodity breakdown, export destination countries for fishery products are distributed to a few different countries. Major export destinations largely consist of Asian countries as well as a country in Oceania such as Australia (Figure II.22). Taiwan is the largest export partner for Brunei accounting for 26.1% of total fisheries exports. Countries such as Singapore, Australia, and Malaysia are also significant partners of Brunei, accounting for 24.3%, 17.9%, and 12.2% of total exports respectively. These countries are geographically close to Brunei, enabling more accessibility for export. As previously mentioned, all the major export partners of Brunei including China and Japan consume significant amounts of fish and seafood domestically. Thus, exporting to these countries will ensure the sustainable demand and possibly expand the volume of Brunei's exportations in the coming years.

【Figure II.22】 Major exporting partners of fisheries product in Brunei in 2020

(Value: BND Million)



Source: DOF (2021)

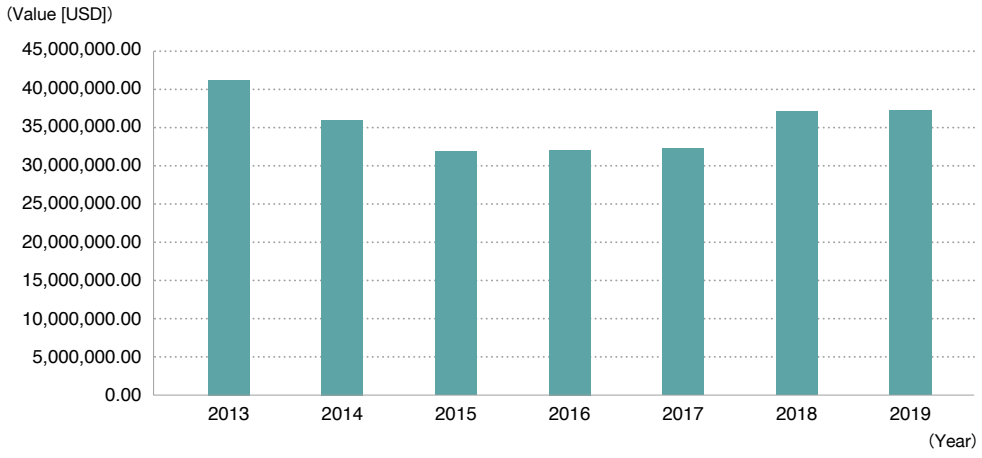
From the data mentioned one may conclude that they hold a lot of capability for expanding the export values and volumes. Although the value of exports has declined in 2019, the overall trend shows a positive growth in the last few years. Brunei already has been exporting to countries with a high demand for fish and seafood and the diversified partners could bring a lot of potential opportunities for Brunei's exports. On the other hand, the relatively small varieties of fish species for both in terms of aquaculture production and exports. This could be further developed as it can limit the diversification of products and market size. The current aquaculture industry is still in the process of development which also implies that there is a wider range of fish products that provides opportunities for local and foreign investors. With that said, the possible products for investment are discussed in chapter IV.

Import overview

As stated earlier, Brunei's fish and seafood import has always outweighed its exports in the past 10 years, compared with the value of total export and import of fish and seafood in Figure II.20. At the highest, the difference went as much as 30 times in 2010, to the lowest at five times in 2018.

Looking at the trend of importation, the value of imported fish and seafood into Brunei has been the highest in 2013 with value of 41 million USD. This then declined in the two following years but has risen up again in the recent four years with a current value of 37 million USD in 2019. In terms of volume of the fish and seafood being imported into Brunei, the trend is similar as shown in Figure II.23. From the graph it can be seen that the volume of imported fish and seafood has increased in the past five years from 2,955.00 metric tonnes in 2016 to 7,141.00 metric tonnes in 2020 which shows an increasing dependence on imports.

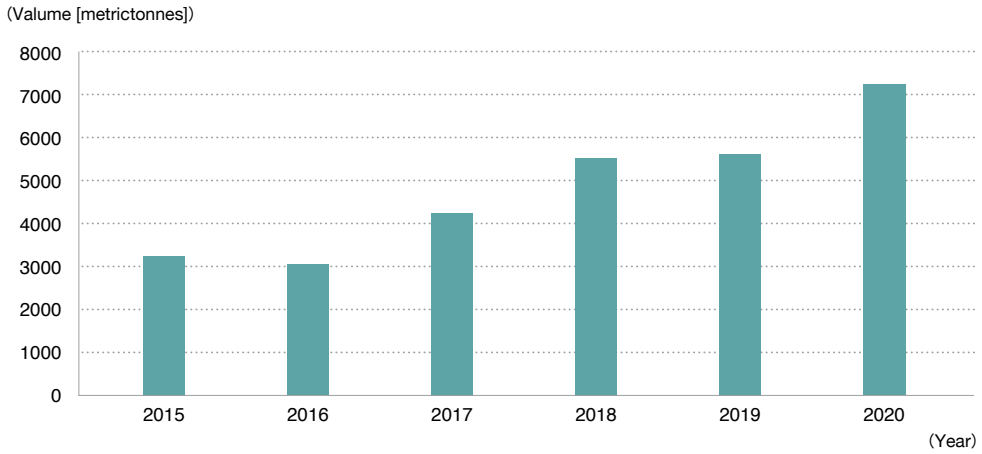
【Figure II.23】 Total value of Fish, crustaceans, molluscs and other aquatic invertebrates in Brunei, 2013-2019



Year	2013	2014	2015	2016	2017	2018	2019
Value	41,230,479	36,112,061	31,997,505	32,006,074	32,401,427	37,004,790	37,329,744

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

【Figure II.24】 Total Volume of imported fish and crustaceans, molluscs and other aquatic invertebrates in Brunei, 2015-2020



Year	2015	2016	2017	2018	2019	2020
Volume	3,139.00	2,955.00	4,226.00	5,469.00	5,566.00	7,141.00

Source: Department of Economic Planning and Statistics, Ministry of Finance and Economy (2020a)

I. Brunei's Importation Partners for Fish and Seafood

Looking at the source of the imported fish and seafood, Brunei is importing it from several countries. Table II.10 shows the breakdown of the 10 countries where Brunei is importing most of this commodity in 2019. Malaysia is the main importation partner with a value of 22 million worth of fish and seafood imported into Brunei in 2019 which makes up 60% of all the importation in that year. The next largest is Singapore at 4.4 million accounting for 12.8%. This is followed by Vietnam (1.79 million), China (1.72 million), and Norway (1.44 million). The rest of the list is composed of India, Indonesia, Chile, Myanmar, and Japan which are importing less than one million. It can be noticed that most of the importation partners are mostly from the neighbouring Southeast Asian region and Asia, with the exception of Norway and Chile.

【Table II.10】 Breakdown of value of importation by country, 2019

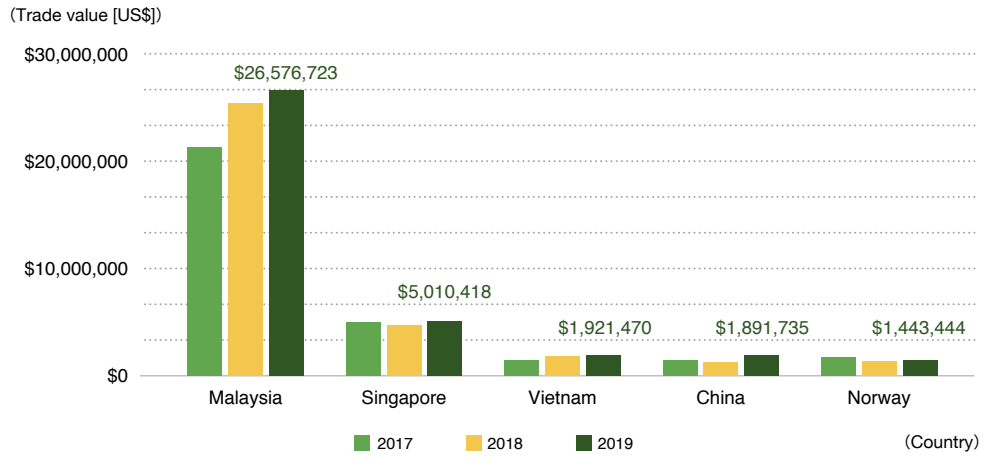
Country	Value (USD)	Share	Country	Value (USD)	Share
Malaysia	22 million	60%	India	857 thousand	2.29%
Singapore	4.4 million	12.8%	Indonesia	778 thousand	2.08%
Vietnam	1.79 million	4.79%	Chile	653 thousand	1.75%
China	1.72 million	4.6%	Myanmar	466 thousand	1.24%
Norway	1.44 million	3.86%	Japan	434 thousand	1.16%

Source: FAO (2020a)

Figure II.25 shows the trend of the importation by value from the top five countries in the last three years. It can be seen that importation from Malaysia, the top importer, has increased

in the last three years. The same trend can be seen in Vietnam. Singapore and China had the same trend where its importation to Brunei decreased in 2018 but then increased in 2019. As for Norway, the amount of importation has decreased in the past three years.

【Figure II.25】 Major import partners (Total Value), 2017-2019



Source: UN Comtrade (2021)

Table II.11 shows the top importation partners of Brunei but in terms of the actual volume of fish and seafood imported by each. From this, it can be seen that Malaysia is still the highest in term of volume with 4,286.78 metric tonnes which accounts for 60% of all imports. This is followed by Vietnam with 760.2 mt. (10.65%), Singapore with 625.98 mt. (8.77%), and China with 373.36 mt. (5.23%). The rest the list is composed of Chile, Myanmar, Norway, Taiwan, India, and New Zealand which are importing less than 200 MT. There are noticeable differences compared to the previous table on values. This might be brought about by the differences of value of the commodities being imported.

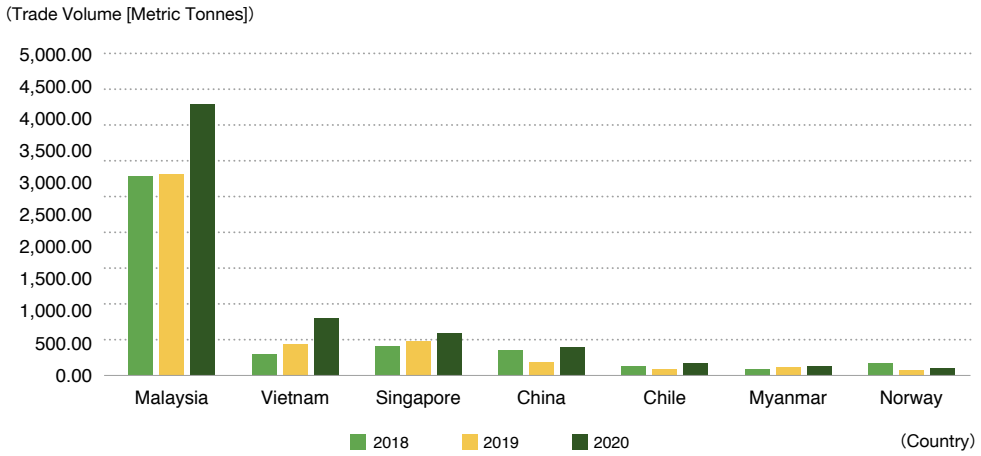
【Table II.11】 Breakdown of volume of importation by country, 2019

Country	Volume (MT)	Share	Country	Volume (MT)	Share
Malaysia	4,286.78	60.03%	Myanmar	165.08	2.31%
Vietnam	760.20	10.65%	Norway	138.07	1.93%
Singapore	625.98	8.77%	Taiwan	132.20	1.85%
China	373.36	5.23%	India	104.06	1.46%
Chile	178.33	2.5%	New Zealand	81.64	1.14%

Source: FAO (2021)

Figure II.26 shows the trend of the importation from the top 7 countries in the last three years. It can be seen that volume imported from Malaysia, the top importer, has increased in the last three years with a large increase from 2018 to 2019. The same increasing trend can be seen in Vietnam, Singapore, and Myanmar. Chile and China had the same trend where its importation to Brunei decreased in 2018 but then increased in 2019. As for Norway, the amount of importation has decreased in the past three years, same with the total value.

【Figure II.26】 Major import partners (Total Volume), 2017-2019



Source: UN Comtrade (2021)

Classification of Fish and Seafood Imports

Brunei's fish and seafood imports can also be broken down into the specific categories of commodities. Table II.12 shows the breakdown of imports by the types of fish and seafood commodities in 2019. The biggest share is from fish (either fresh or chilled) which are valued at 14.8 million USD which accounts for 39% of all imports. Second are frozen fish, valued at 8.43 million USD constituting 22%. Third are crustaceans valued at 3.79 million at 10.1%. Fourth are molluscs valued at 3.63 million USD at 9.74%. The rest are composed by Fish, dried, salted, in brine, or smoked, fish fillets, and live fish which comprises 2.71 million (7.26%), 1.97 million (5.29%), and 1.8 million (5.04%).

【Table II.12】 Importation breakdown by type of commodity, 2019

By Commodity Type		
Commodity	**Value (in USD)**	**Share**
Fish, fresh or chilled, excluding fish fillets and other fish meat	14.8 million	39%
Fish, frozen, excluding fish fillets and other fish meat	8.43 million	22%
Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; crustaceans, in shell, cooked by steaming or by boiling in water, whether or not chilled, frozen, dried, salted or in brine; flours, meals and pellets of crustaceans, fit for human consumption	3.79 million	10.1%
Molluscs, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; aquatic invertebrates other than crustaceans and molluscs, live, fresh, chilled, frozen, dried, salted or in brine; flours, meals and pellets of aquatic invertebrates other than crustaceans, fit for human consumption	3.63 million	9.74%
Fish, dried, salted or in brine; smoked fish, whether or not cooked before or during the smoking process; **flours, meals and pellets of fish**, fit for human consumption	2.71 million	7.26%
Fish fillets and other fish meat (whether or not minced), fresh, chilled or frozen	1.97 million	5.29%
Live fish.	1.88 million	5.04%

Source: UN Comtrade

Table II.12 illustrates different kinds of fish and seafood commodities from other countries. Some of these such as the shrimp and dried, salted and smoked fish are both domestically produced and imported. Brunei's own shrimp aquaculture has been the most productive part of the industry in the recent years yet also the largest imported crustaceans (78% of all crustacean imports).

However, Table II.12 also emphasises the grave food security issue. By promoting aquaculture further, expansion of fish production is possible to meet the local demand and lower impoeshrimp production has the potential to meet the local demand, lowering the reliance on imports. In the same way, dried, salted, and smoked fish have a stark difference in imports and exports with the value of imports are more than a hundred times larger than exports. Expanding the industry on fish processing of these products will increase the potential for exports while decreasing the reliance on imports. Further discussion on each classification focusing the importation partners and specific breakdown of species can be found in Appendix B.

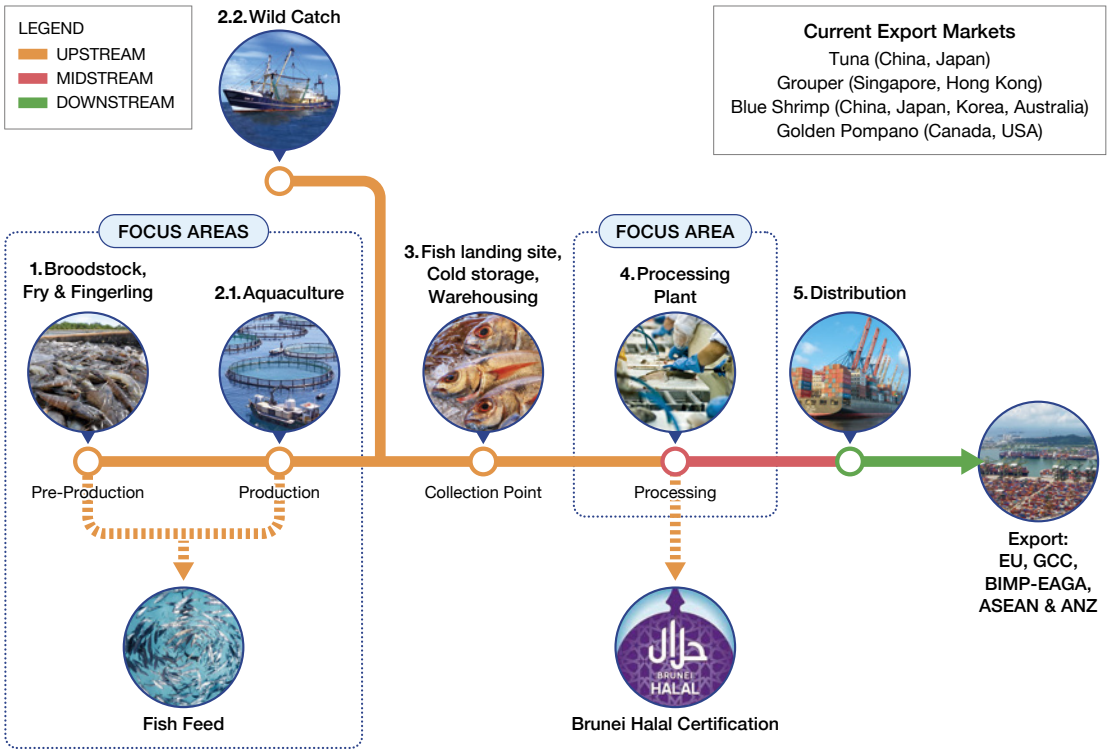
Value Chain Analysis

Overview of Domestic Value Chain

Aquaculture production requires various actors in order to produce and deliver the product to the market and consumers. Given this, the value chains play an important role for creating a mutually beneficial environment for all the actors involved in the process. It seeks to add or create value by assessing each step of the production process to maximize the value of the end product. The efficient functioning of a value chain requires not merely factors of production and technology but also ones such as efficient transport, market information systems and management.

Figure II.27 shows the local fisheries ecosystem in Brunei as identified by the Brunei Economic Development Board (BEDB). It shows the interconnected fisheries industries in Brunei which can also be seen a value chain of fish and sea food products from pre-production, production, processing, and distribution. It also includes inputs and related industries that are important for the aquaculture industry. This includes the development of broodstock fry and fingerlings, feeds, storage, and certification. The BEDB identifies pre-production, production (aquaculture), and processing as key focus areas for development and investment.

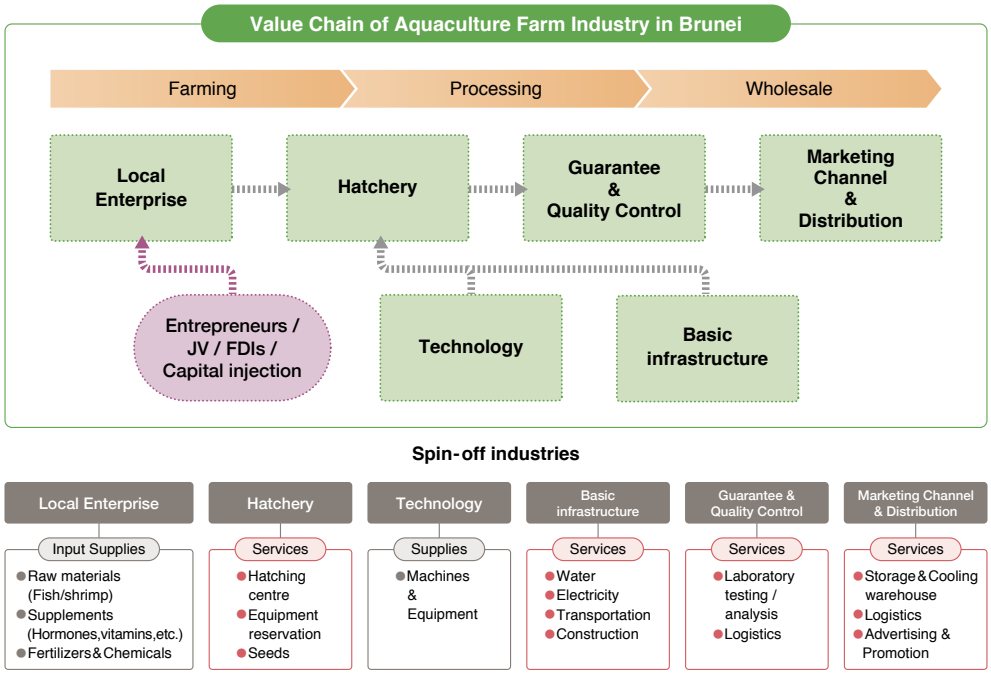
【Figure II.27】 Local Fisheries Ecosystem



Source: Compiled by the authors

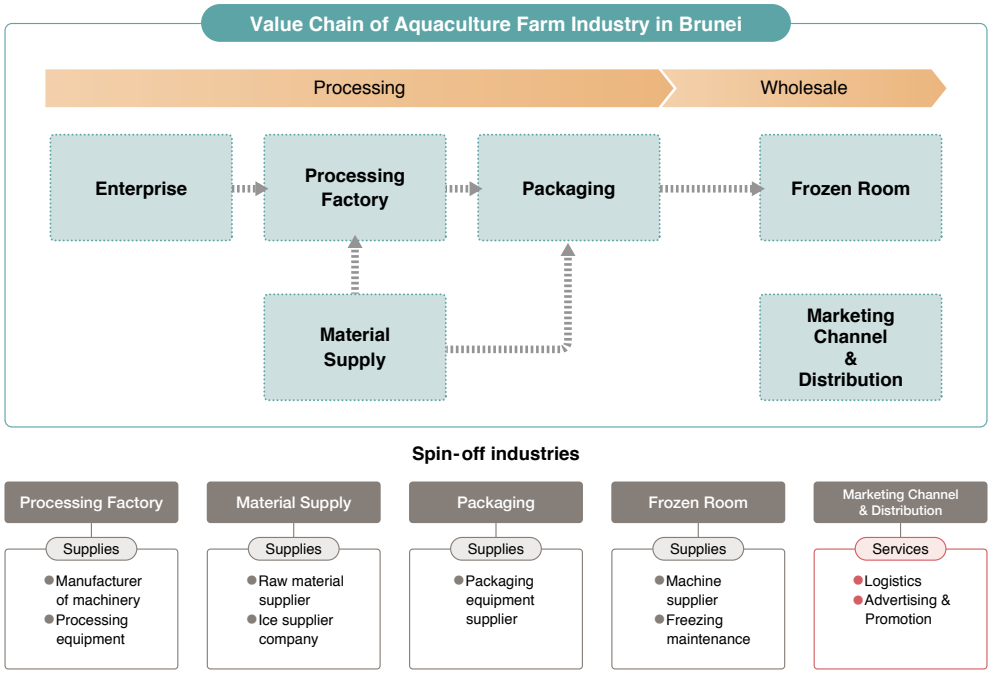
Figure II.27 shows a generalized image of the fisheries ecosystem, specific value chains for specific areas has been developed from the strategic plan of the DOF (see Appendix B for translated detailed information). Figures II.28 and II.29 depict the current value chain and the process of the aquaculture and seafood processing industries in Brunei. It captures the basic flows of the industry and some spin-off industries that are created in the process of production.

【Figure II.28】 Value chain and spin-off industries of aquaculture in Brunei



(This is understood as an output of the study) [3]

【Figure II.29】 Value chain and spin-off industries of seafood processing in Brunei



(This is understood as an output of the study)

Examining the process and actors of Brunei's aquaculture value chain, it has revealed other industries that has developed and contributed to the industry as a whole. Therefore, these spin-off industries, as well as the farming products, will be assessed as investment opportunities in the next chapter.

[3] The authors recognise that the guarantee and quality control section is also part of biosecurity and a major component across all activities, particularly for an export-driven aquaculture industry, compliant with food safety measures required by importing countries. Further strategies are discussed in Chapter IV.

CHAPTER
III

Aquaculture investment opportunities in Brunei Darussalam

Aquaculture investment climate in Brunei Darussalam

Domestic investment

Currently, Brunei Darussalam's domestic investment within the fishery and aquaculture industry is distributed between investment by the Department of Fisheries (DOF) and investment by local aquaculture businesses. Table III.1 shows the investment activities by the DOF and local businesses, which take place in the three sub-categories of facilities, infrastructure, and services.

【Table III.1】 Domestic aquaculture investment in Brunei Darussalam

Department of Fisheries	**Facility** • Suitable sites for operation • Tenancy and licence of fisheries activities
	Infrastructure • Main access roal • Electrical substation • Domestic water
	Service • Site demarcation • Site progress status • Research and development
Local Businesses	**Facility** • Technology
	Infrastructure • Building and ancillary unit • Ponds, cages, and sewerage • Equipment and device • Utilities
	Service • Environmental impact assessment • Technological expertise • Technology transfer

Source: DOF (2021).

Foreign direct investment

II. Investment climate in Brunei Darussalam

Brunei Darussalam has a relatively open economy with an attractive geographic position in South-East Asia and a well-developed infrastructure network. The Government is heavily engaged in encouraging foreign investors to invest in the country and has established several reforms for attracting foreign direct investment (FDI) in priority industries. Moreover, Wawasan Brunei 2035, has emphasized new FDI as a key driver for the country's economic growth.

The major advantages of investing in Brunei Darussalam, especially for the aquaculture industry, lie specifically in the country's favourable FDI incentives, strategic location, high-quality environment, and infrastructure coverage (Invest Brunei, 2021). In particular, a high-quality environment is crucial for aquaculture activities. Brunei Darussalam has not experienced any significant natural disasters in its history and was ranked 8th in the world for air quality in 2018. Moreover, Brunei Darussalam also offers investment-friendly incentives, such as 100% foreign ownership and 99.9% coverage in electricity and water supply. Through these various forms of support, investors can maximize their efforts and outcomes. [4]

【Box III.1】 Brunei Darussalam's FDI incentives

Brunei Darussalam provides various investment incentives based on the Investment Incentive Order (2001) and Income Tax Order (2001).

Incentives:

1. Up to 100% foreign ownership
2. Credible partnerships between the local government and businesses
3. Intellectual property protection
4. Complete facilitation
5. Tax incentives
   - I. 18.5% corporate income tax
   - II. Five-year income exemption for businesses with B$500,000–B$2,500,000 in fixed capital expenditure
   - III. Eight-year income exemption for businesses with more than B$2.5 million in fixed capital expenditure
   - IV. 11-year exemption for any project located in a designated high-tech industrial park

【Box III.2】 Free trade agreements of Brunei Darussalam

- ASEAN-Australia and New Zealand Free Trade Agreement
- ASEAN-People's Republic of China Comprehensive Economic Cooperation Agreement
- ASEAN-Hong Kong, China Free Trade Agreement
- ASEAN-India Comprehensive Economic Cooperation Agreement
- ASEAN-Japan Comprehensive Economic Partnership
- ASEAN-Republic of Korea Comprehensive Economic Cooperation Agreement
- ASEAN Free Trade Area
- Brunei-Japan Economic Partnership Agreement
- Trans-Pacific Strategic Economic Partnership (a plurilateral agreement with Chile, New Zealand and Singapore)
- Trans-Pacific Partnership
- Regional Comprehensive Economic Partnership

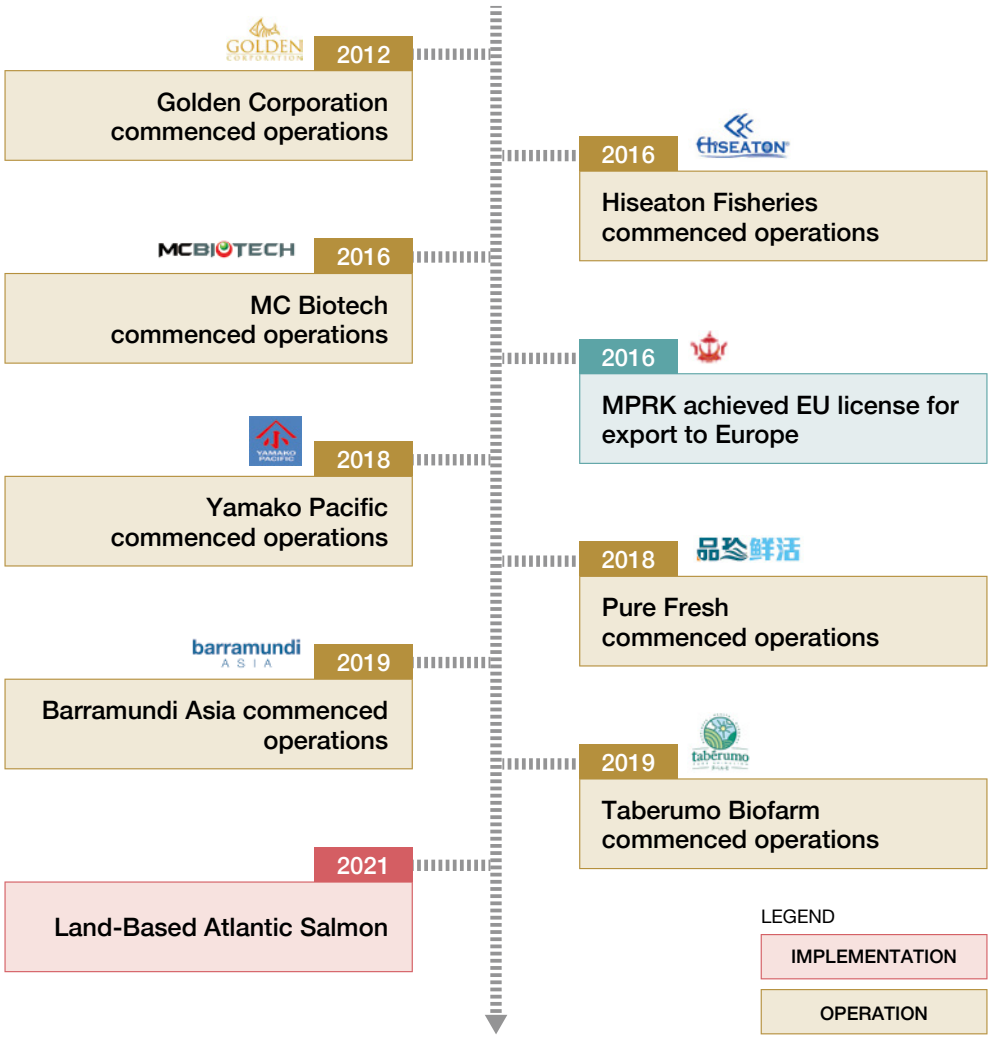
Source: Ministry of Foreign Affairs (2021).

[4] Currently, no aquaculture-specific investment incentives are not identified.

III. Current FDI activities in aquaculture

Over the last few years, there has been increasing investment in the aquaculture industry from overseas companies. Figure III.1 shows the major investment in aquaculture that has been implemented and operated in Brunei Darussalam since 2012.[5] Some of the companies will be explained below with their recent activities and the products they are investing in.

【Figure III.1】Timeline of recent fisheries investment in Brunei Darussalam



Source: Department of Fisheries, Ministry of Primary Resources and Tourism (2021)

I. Golden Corporation Sdn Bhd

Golden Corporation is an FDI company from Taiwan Province of China that has established its operational headquarters in Brunei Darussalam in partnership with Semaun Marine Resources Sdn Bhd (Golden Corporation, 2021). It was invited by Semaun Marine Resources Sdn Bhd (a quasi-government corporate entity since 2002) to develop the Multi-Purpose

[4] Currently, there is neither contract farming nor combination of FDI and contract farming identified from the research.

Marine Resources Processing and Business Centre in Serambangun, Tutong. The company owns three shrimp farms totalling 250 hectares in the Tutong district and three processing plants in the Tutong and Brunei-Muara districts (Kon, 2021).

Golden Corporation is the leading producer for shrimp aquaculture in Brunei Darussalam, and approximately 85% of its shrimp production goes to the export market, while the rest is consumed locally (Lim, 2019). The company already has an integrated value chain, including a brood stock development centre and a shrimp fry hatchery. In 2017, it attained the certifications to penetrate the EU market with the help of the Department Fisheries and is aiming to expand its exports into new markets (Wasil, 2019).

II. Pure Salmon 8F Asset Management

Pure Salmon 8F is a private equity fund management company from Singapore. A memorandum of understanding formalized the intention of Pure Salmon 8F to invest in a land-based farming facility for Atlantic salmon using a recirculating aquaculture system (RAS) with a capacity of 10,000 tonnes of whole-fish equivalent per annum (Undercurrent News, 2019). This is the 12th facility for their development of 260,000 tonnes of salmon in land-based farms in countries such as Bahrain, China, Japan, Lesotho, Poland, and the United States (The Fish Site, 2019). The project will include a hatchery, production units, processing facilities, distribution, and brand management. It is expected to generate 145 jobs and will supply salmon both domestically and regionally.

III. Yamako Pacific Pte Ltd

Yamako Pacific is a joint venture with Japan with a focus on a range of tuna species, from skipjack tuna to yellowfin tuna. It is also involved in the value-added processing of tuna, providing end products such as frozen loin, yellowfin saku and katsuobushi. The company has recently opened a new $2 million tuna processing plant to export sashimi-grade tuna to Japan as well as introduced its first 18-metre fishing vessel (Hazair, 2018). The establishment of its pole and line fishing method has also marked its success in sustainable fishing methods by avoiding damage to the ecosystem in the sea (Rajak, 2019).

IV. Barramundi Asia (B) Sdn Bhd

Barramundi Asia is a Singapore-based company that produces sea bass, also known as barramundi. The Ministry of Primary Resources recently signed an agreement with the company for developing 6,613 hectares at the Nankivell Offshore Aquaculture Site in Brunei Darussalam as well as a 25-hectare processing centre, which will include a hatchery and nursery (Baker, 2019). The aquaculture site is expected to reach 36,000 metric tonnes a year in aquaculture marine fish production by 2032, and the processing centre will enable the country to cultivate its whole sea bass production domestically (Azney, 2019).

V. Hiseaton Fisheries (B) Sdn Bhd,

Hiseaton Fisheries is a Chinese company that established its operations in 2016. The company is essentially involved in marine products, hatching, breeding, acquisition, processing and marketing. The main products the company exports are golden pompano, grouper and barramundi (Hiseaton Fisheries, 2021).

【Box III.3】 Investment credentials in the aquaculture industry in Brunei Darussalam

Brunei Darussalam's Government is interested in further promoting its aquaculture industry through its attractive incentives and environment for foreign investors. The following sections will help direct investors to possible investment areas, including promoting aquaculture industrial areas, aquaculture species and aquaculture-related industries in the country. While the Government is welcome to all sorts of investment, the Department of Fisheries is particularly seeking investors with the following credentials.

1. Export-driven

As Brunei Darussalam currently relies on imports from neighbouring countries for fish and seafood, it is in need of export-driven products with strong market networks.

2. High technology

Brunei Darussalam's aquaculture is still in the development process, and some high-tech equipment and systems, such as RAS, are still uncommon and expensive to incorporate in the domestic environment. Therefore, integrating high technology in the country's aquaculture will open up more opportunities within the industry.

3. High value

The production of high-value species in aquaculture is highly encouraged. High-value species include types of fish such as grouper, pompano and sea bass.

4. Sustainable

Businesses that are engaged in sustainable aquaculture activities are highly encouraged. Sustainable aquaculture will help the overall production and environment of Brunei Darussalam in the long term. Businesses are also suggested to support an environmental protection agenda.

5. Acceptable

Meeting social and religious requirements, such as regarding business conduct, hygiene and quality, is necessary.

6. Best practices

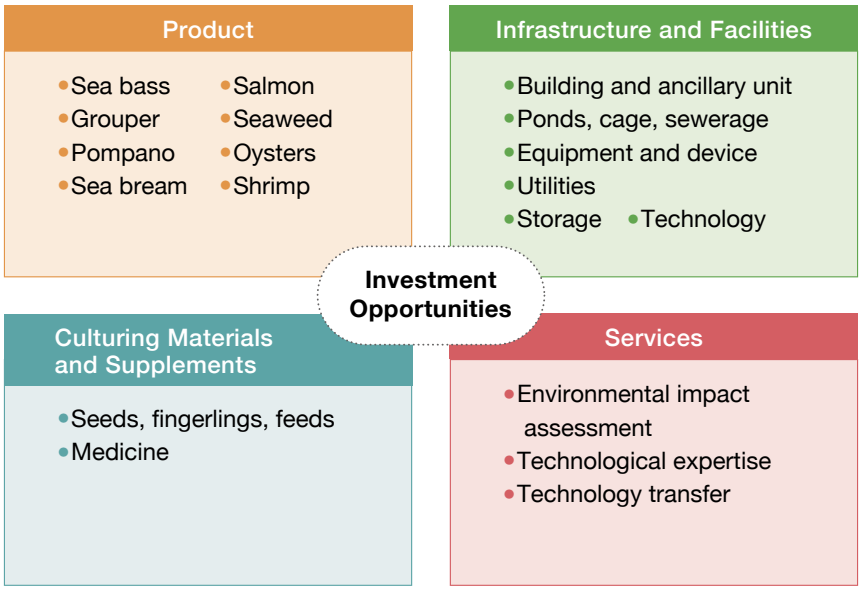
Supporting the implementation of Brunei Good Aquaculture Practices (BGAqP) is important in order to ensure compliance with basic requirements for safety, hygiene and quality standards.

Source: DOF (2021)

Investment opportunities in the aquaculture industry

Potential investment opportunities have been identified through the consideration of domestic investment by local businesses and FDI in Brunei Darussalam's aquaculture industry. Although the opportunities are not limited to those included in Figure III.2, these comprise essential areas for investment in the aquaculture industry. They can be categorized into products, infrastructure and facilities, culturing materials and supplements, and services. There will be an analysis of the possible aquaculture products and spin-off industries for investment.

【Figure III.2】 Potential investment opportunities for the aquaculture industry in Brunei Darussalam

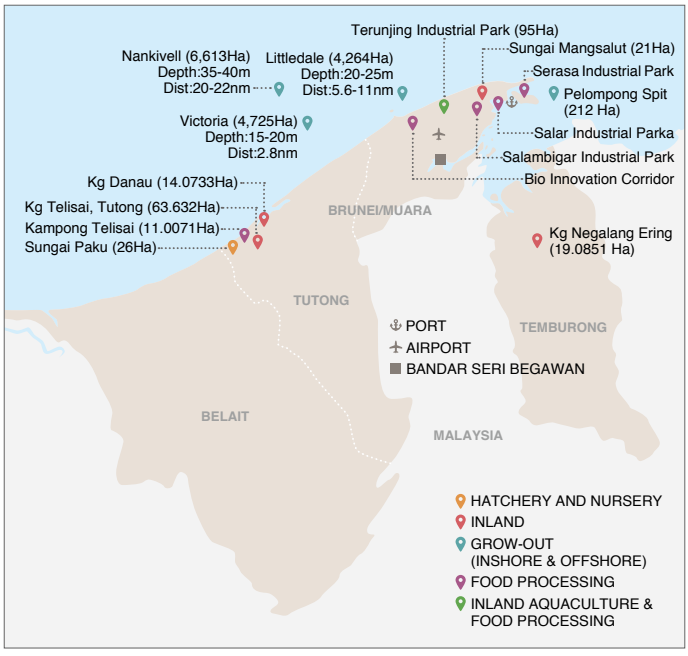


Source: Developed by the authors based on the study

Promoted areas for investment

Aside from the existing aquaculture sites in Brunei Darussalam, which were discussed in the previous chapter, the DOF has identified additional areas that are suitable for the further expansion of the aquaculture industry. Figure III.3 shows the locations of various sites in the country that are available for the expansion of new aquaculture ventures. These are not only limited to sites for farms but also for other related activities necessary for aquaculture. There are five types of sites indicated: (1) hatchery and nursery, (2) inland, (3) grow-out (inshore and offshore), (4) food processing and (5) inland aquaculture and food processing.

【Figure III.3】 Potential sites for fisheries



Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2021).

- **Hatchery and nursery.** There are 26 hectares (Ha) at the Sungai Paku site that are allotted for hatchery and nursery.
- **Inland sites.** There are five inland sites that are available for possible investors. These sites may be suitable for pond and recirculating aquaculture systems. The sites and their sizes are shown in table III.1.

【Table III.1】 Potential sites for inland fisheries (Ha)

Site	Size
KG Telisai, Tutong	63,632.00
Sungai Mangasalut	21.00
KG Negalang Ering	19.00
KG Danau	14,0733.00
Kampong Telisai	11,0071.00

Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2021).

- **Grow-out (inshore and offshore).** There is an allocated sea area of 17,721 hectares by the Department of Fisheries that can be utilized for fish cage culture. There are already existing firms, including AARR Rescan Fisheries and Sea Neptune Aquarius Enterprise, that currently export sea bass, grouper and other varieties to China, Hong Kong (China) and Malaysia. Current inshore and offshore areas are shown in Table III.2.

【Table III.2】 Potential sites for inland fisheries

Site	Size	Depth	Distance
Nankivell	6,613.00 Ha	35–40 m	20–22 nautical miles
Victoria	4,725.00 Ha	15–20 m	2.8 nautical miles
Littledale	4,264.00 Ha	20–25 m	5.6–11 nautical miles
Pelompong Spit	212.00 Ha		

Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2021).

- **Food processing.** Other than aquaculture sites, there are also four industrial parks that are open for food processors and are identified for potential fish and seafood processing investment. These industrial parks are (1) Bio Innovation Corridor, (2) Salambigar Industrial Park, (3) Salar Industrial Park and (4) Serasa Industrial Park.
- **Inland aquaculture and food processing.** There is also one industrial park that has combined space for both aquaculture and food processing. The site is at Terunjung Industrial Park and has 95 Ha of available space for inland aquaculture. This type of site will be attractive for those planning to invest in both aquaculture and the subsequent processing of its products.

All of the above-mentioned areas for aquaculture activities have been chosen based on the targeted species of culture, availability of water resources, availability of land use and size, quality of topography, soil and water, geographical strategy, accessibility, connectivity and climate.

Promoted aquaculture commodities for investment

Due to Brunei Darussalam's aquaculture environment and its location in Southeast Asia, specific fishery products are particularly suggested for investment. These include species that are already in place, those that are upcoming and ones that have not been invested in yet (see Table III.3). Referring to the identified products in the list from the Brunei Economic Development Board as well as ones from the Department of Fisheries, analysis on the market demand and assessment of the suitable farming environments were conducted for each product in Brunei Darussalam. The products under investigation in this report will be **sea bass, grouper,** and **pompano** as high-value species, and products that are growing in aquaculture production, such as **seaweed, salmon, oysters** and **sea bream.** Lastly, the popular species, **shrimp,** will also be explored as it is one of the largest aquaculture products in the country today.

【Table III.3】 Identified aquaculture species for FDI opportunities

Investment in place	Upcoming	Available for new investment
• Grouper • Sea bass • Pompano • Tuna • Blue shrimp • White shrimp	• Salmon • Oysters	• Sea bream • Trout • Eels • Scallops • Tiger prawns • Mud crabs • Abalone

Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2021).

I. Seabass [6]

Market demand

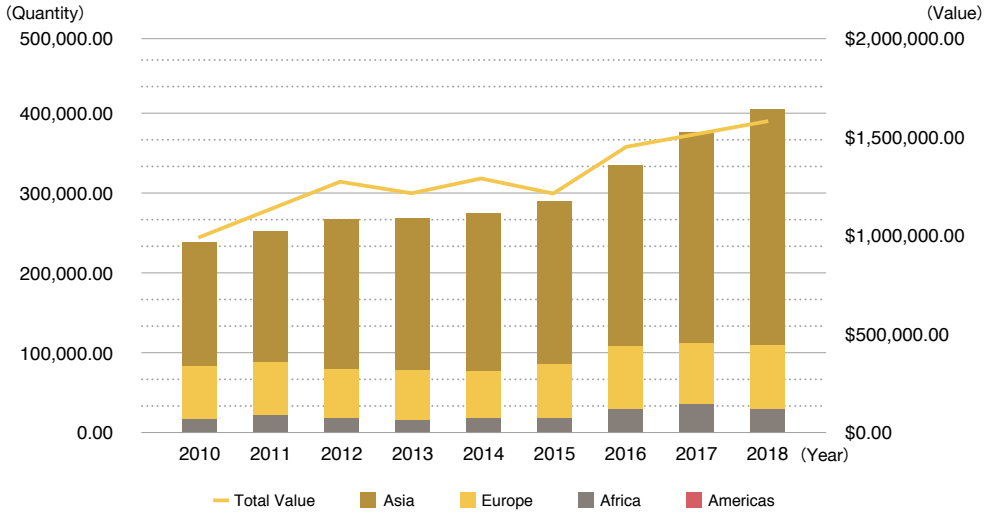
Seabass is a popular fish that is consumed locally from the Indo-West Pacific region to Papua New Guinea and Australia. The sea bass industry has been growing due to increasing demand from Asia, the Middle East, the United Kingdom, and the United States (US), with sales going up in those regions because of the fish's low toxin levels, mild flavour, and high omega-3 content for heart and brain health (Ocean Treasure, 2020). It is also attracting attention as an alternative to salmon as a high-value white-flesh product. As shown in figure III.5, the

[6] Although there are several different species that are called "sea bass", "sea bass" here refers to *Lates calcarifer*, also known as Asian sea bass or barramundi in Australia.

aquaculture production of sea bass in Asia has been increasing significantly since 2016. With the demand for sea bass and its rising production, it can be predicted that the market demand for sea bass will continue to grow.

【Figure III.4】 Global sea bass aquaculture production by region, 2010–2018

(Tonnes and dollars)

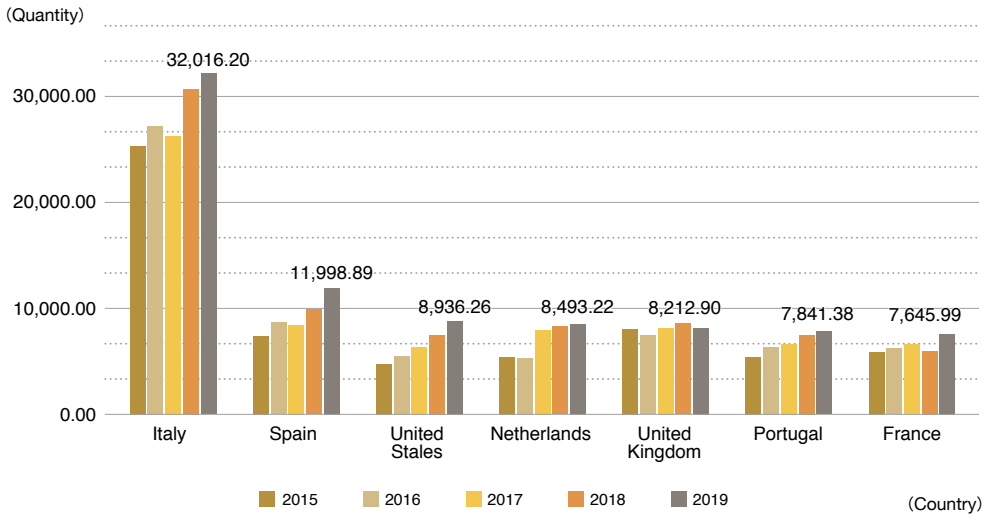


Note: Data for Oceania were unavailable. Source: FAO (2021d).

The major importing countries of sea bass, whether fresh, chilled or frozen, include countries in Europe and the US (Figure III.5 and III.6). Exceptionally, Malaysia has the third-largest imports of sea bass. As "sea bass" in the figures includes different species of sea bass, it seems that European countries mainly import European sea bass from their neighbouring countries, such as Greece and Turkey (Seafish, 2020). Regardless, there is still high demand for sea bass in Europe, which could be another export destination for Brunei Darussalam apart from Asian countries.

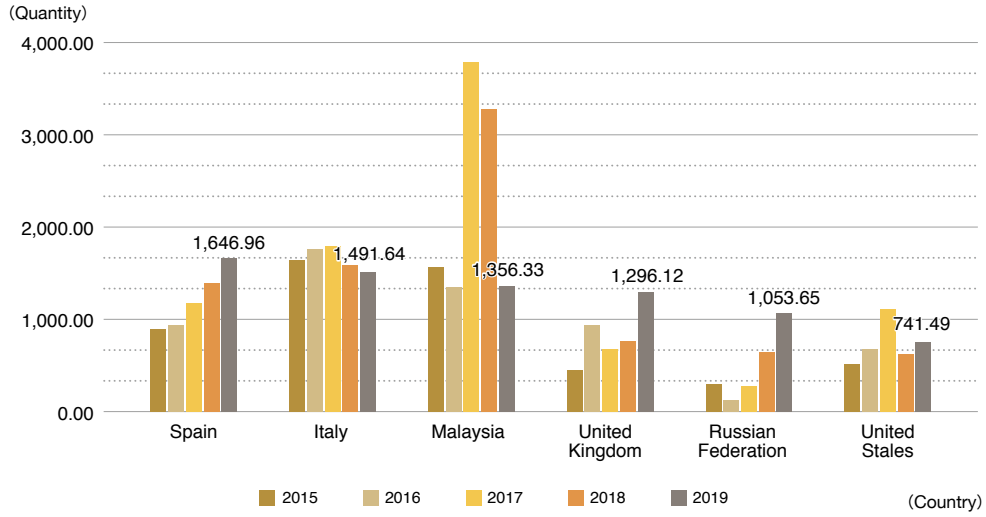
【Figure III.5】 Major importing countries for global fresh and chilled sea bass, 2015–2019

(Tonnes)



Source: UN Comtrade (2021).

【Figure III.6】 Major importing countries for global frozen sea bass, 2015–2019



Source: UN Comtrade (2021).

In Brunei Darussalam, there is already foreign investment in seabass by a Singapore-based aquaculture company, Barramundi Asia, which has started developing its land-based nursery, sea nursery and grow-out farms along Brunei Darussalam's coast. Their sea bass products have been successfully supplied to countries across the Asia-Pacific region, including to Australia, China, the Republic of Korea, Singapore, and Thailand (Lim, 2020). With the increasing demand for sea bass across the region and Brunei Darussalam's trade relations with those countries, there are many opportunities for exporting sea bass.

Aquaculture environment and techniques

Sea bass is a species with catadromous habits that is mainly farmed in Asia (Ocean Treasure, 2020). The many promising features of sea bass come from the assured farming environment of the species. Some of these include its wide physiological and crowding tolerances; the high fecundity of the female fish, which can provide adequate material for seed hatcheries; its simple seed hatchery production; and its rapid growth, with a harvest size of 350 grammes to 3 kilogrammes (kg) in six months to two years (FAO, 2021b). With its hardy and adaptable features, sea bass is also receiving more notice for sustainable aquaculture. Sea bass does not require hormones, antibiotics or chemicals to raise and its diet only requires a small amount of sustainably sourced fishmeal (Australis Barramundi, 2021).

In terms of the techniques that are used for sea bass cultivation, most sea bass are cultivated in cages in freshwater or brackish water ponds, or in sea cages apart from in Australia. With developed technology, Australia is able to use some indoor or closed-systems with recirculation devices (Boeing, 2000). Below are descriptions of the major aquaculture systems for sea bass.

- **Net cage culture.** This is the most common type of culture in South-East Asia, especially in Malaysia, the Philippines and Thailand (Boeing, 2000). In a net cage culture, both floating and fixed cages are utilized, however floating cages are more advantageous in terms of stocking fish qualities as they are usually placed in deeper water, have lower

salinity fluctuations and have better circulation of cleaner water.

- **Pond culture.** Another possible way to farm sea bass is through earthen or lined pond systems. This type of culture has been used in Australia and allows sea bass to be polycultured with other species, such as tilapia in brackish water ponds (FAO, 2021b).
- **Recirculation culture.** This is the most technologically developed method for farming sea bass. Although it is more costly, it enables the stable production of sea bass year-round and reduces environmental issues for aquaculture activity (Boeing, 2000).

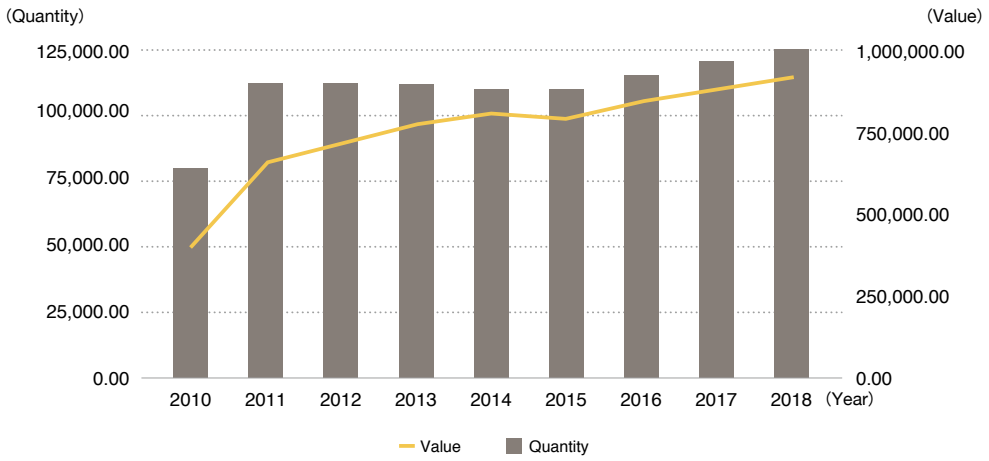
Given the three possible methods for farming sea bass, net cage culture and recirculation aquaculture systems seem to be the best options. While net cage culture is generally more susceptible to environmental conditions, Brunei Darussalam's warm and pristine waters and the low rate of natural disasters in the region will be more suitable for the best practice of cage culture as well as the recirculation culture (Yan and Bejinen, 2019).

II. Pompano

Market demand

Pompanois is a fish that can be caught in most parts of the world, from the Indian Ocean to the tropical areas of North and South America (Xilei et al., 2019). Pompano, like the silver pompano, is a highly valued finfish. Due to the effective farming environments for pompano, such as its fast growth rate, high flesh quality, and its acceptability for commercialized feeds, many South-East Asian countries are drawing their attention to pompano, particularly silver and golden pompano, as a strong player for sea cage culture (Towers, 2011). As shown in Figure III.8, the aquaculture production of pompano in Asia has been growing slightly, particularly since 2016. This is also the case in Brunei Darussalam. Along with increasing market demand, there has been increasing pompano aquaculture in the country since 2016 (Xilei et al., 2019). As pompano is a growing aquaculture product across Brunei Darussalam as well as South-East Asia, it brings great opportunities for investment.

【Figure III.7】 Major importing countries for global frozen sea bass, 2015–2019



Source: UN Comtrade (2021).

Aquaculture environment and techniques

Pompano is primarily known for its wide environmental tolerance and its fast growth. With its high adaptability to the farming environment, it can be successfully grown at a low salinity of about 8% in either ponds, tanks, or in floating sea cage cultures (Damodaran et al., 2019). Because of this, it has indicated that pompano, particularly silver pompano, is a perfect candidate for intercropping with shrimp pond farming. This will allow farmers to diversify their species as well as maximize the benefits of shrimp farming. As shrimp culture is one of the most successful species in Brunei Darussalam, pompano could be a perfect additional fish product for the country's export-driven market. Furthermore, temperature tolerance, which is one of the major environmental obstacles of pompano, is less likely to be a hurdle in Brunei Darussalam. As pompano generally prefers warm tropical waters with a tolerance of 25–29°C (Damodaran et al., 2019), Brunei Darussalam would be a suitable location with the warm waters in its surrounding ocean.

Since pompano has high adaptability in its farming environment, different culture methods can be applied to pompano aquaculture. The major methods for pompano aquaculture are earthen pond culture and cage culture. These are also the methods that are widely used in the aquaculture industry in Brunei Darussalam and, thus, investment in pompano will be suitable for its environment.

III. Grouper

Market demand

Grouper is a high-value fish that is popular around the world. It is popular for being one of the tastiest fish in the ocean as well as having a reputation for good luck and medicinal value (Sadusky, 2017). As there is already established demand from consumers in the regions of Asia and the Middle East where Brunei Darussalam is located, it holds many opportunities for export-driven aquaculture. It has been reported that currently 36 species of grouper and at least 15 hybrids are either in trial or being produced in global aquaculture (Rimmer and Glamuzina, 2019). The major producers of aquaculture grouper are China, Indonesia and Taiwan Province of China, which alone account for 95% of the total farmed grouper in the world. Among the many species of grouper, hybrid-grouper in particular is drawing attention as it has the highest gross margin due to its high survival rate, fast growth rate, and high final sales price compared with other species (Dennis et al., 2020). Another species that has much potential in the market is giant grouper. Giant grouper has a relatively high growth rate and low food conversion ratio, in which 1.4 kg of feed is required for 1 kg of giant grouper, a considerably favourable ratio for the grouper species (Seafood Risk Assessment, 2020).

In Brunei Darussalam, grouper was the second-largest aquaculture product in 2018 with 213.89 megatonnes (MT). A local company, Nur Nabai Aquaculture Sdn. Bhd., has been exporting chilled live hybrid grouper to Hong Kong (China) and Singapore. The products are shipped either by air freight or sea vessels to these destinations from Brunei Darussalam. Based on an interview with Nur Nabai Aquaculture Sdn. Bhd (2021), there is also growing

demand in countries such as China, Japan and the Republic of Korea.

Aquaculture environment and techniques

Despite the fact that grouper is spread in tropical and subtropical seas in the world, most of the aquaculture activity of grouper is undertaken in Asia (Rimmer and Glamuzina, 2019). Considering the fact that groper is a demersal fish that lives in coral reefs, it seems understandable that it is not the most favourable to catch by traditional fishing methods. According to Rimmer and Glamuzina (2019), some unsustainable catching methods that include explosives and poisons have caused harm to the natural habitats. As a result, this has triggered some grouper to be included as near endangered or endangered species. With its growing market demand and environment-related tension, the optimization of grouper aquaculture will fill up the need for more sustainable fishing.

Compared to other high-value species, such as shrimp, grouper is said to be easier to culture with no attended diseases if prudent management is conducted (Pinoy Bisnes Ideas, 2021). In grouper aquaculture, most of the seedstock is supplied through the wild capture of fingerlings, which are in limited availability and in need of development in Asia. While there is still some seed production from hatcheries, they are small and irregular as they require specific feed and environmental requirements. This is also the case in Brunei Darussalam, where resources for grouper aquaculture, such as fingerlings, feed and medicine, rely on imports from overseas. In terms of the systems that are used for grouper cultivation, net cage culture is generally employed, but some coastal species can be cultivated in ponds. According to the SPC Aquaculture Portal (2021), the particular temperature of the water around 26–32°C and salinity of 20–35 parts per thousand are suitable for grouper farming water quality. Moreover, grouper is more competent in small-scale operations and often cultivated in 2x2x2 m to 5x5x5 m cages in Asia. Below are the major aquaculture systems that are used for grouper with a general description of each culture.

- **Earthen pond culture.** Although pond culture is less common for grouper farming, shrimp farmers often use pond culture for grouper for product diversification (SEAFDEC, 2021). Pond culture needs good monitoring to maintain the required water quality, including temperature and salinity (Reddy, 2018).
- **Cage culture.** Cage culture is the most popular method for farming grouper as it is convenient and has a higher production yield and lower investment cost. It is often divided into two different systems, fixed cages and floating cages. The suitable system depends on the location and the investing funds. However, fixed cages are more suitable for water depths of no more than 2.5 m, while floating cages are suited for water depths of more than 2 m (SPC Aquaculture Portal, 2021). In addition, other factors, such as predators and strong winds and waves, should be avoided when choosing the location.

  Brunei Darussalam's warm environment will be suitable for farming grouper. Although the export destinations for grouper in the country are limited at the moment, it seems that the already developed networks for exporting grouper can be further expanded with the growing demand in the world.

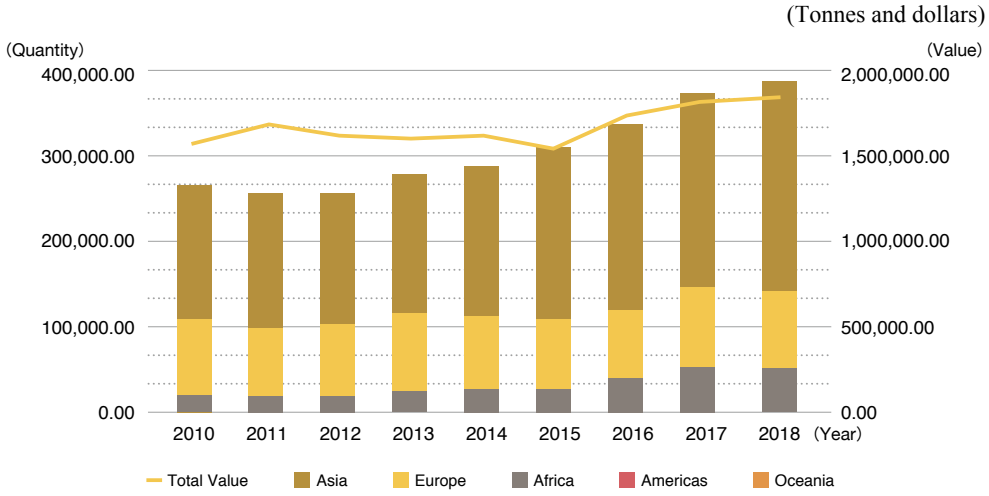
IV. Sea bream

Market demand

As people around the world seek more healthy food products, the demand for sea bream has also been growing in the past years. During 2019–2029, the global sea bream market is predicted to have witnessed a nearly 6% compound annual growth rate (Undercurrent News, 2020). Specifically, the leading countries for the increasing consumer demand are in Europe and North America but also include countries such as Australia. Although the majority of the sea bream products on the market today are processed sea bream, it is expected that fresh sea bream will have positive growth in the coming years as consumers show interest in more healthy seafood.

Figure III.8 shows the aquaculture production of sea bream by region. While Asia is the largest contributor to the global aquaculture production of sea bream, other regions, such as Europe and Africa, are also significant producers. While the aquaculture production of the other discussed species is mostly dominated by Asia, sea bream production seems to have more variation in its producing countries. Moreover, Africa has shown an increasing trend in production during the period alongside Asia's continuing growth.

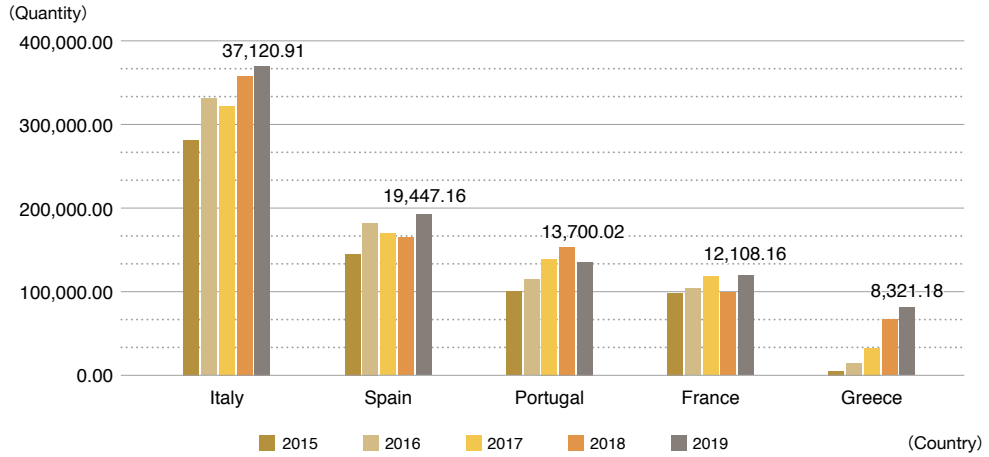
【Figure III.8】 Global sea bream aquaculture production by region, 2010–2018



Source: FAO (2021d).

As the species is popular in Europe, the major importing countries of sea bream also indicate the significance of the product in countries in the region (see Figure III.9). These European countries all show positive trends in the quantities imported. However, Italy, in particular, appears to be the largest importer of sea bream. Although its importing sources are mainly its neighbouring countries, such as Greece (FAO, 2016), Italy could still be a potential destination for Brunei Darussalam if high-quality products are grown.

【Figure III.9】 Major importing countries for global sea bream, 2015–2019 (Tonnes)



Source: FAO (2021).

Regarding the variety of species and market demand, there are many possibilities for farming sea bream in Brunei Darussalam. In particular, the closer high-demand destinations, such as Australia, could be a potential export destination for the species apart from European countries, which are geographically inconvenient for exports. On the other hand, there does not seem to be a huge market in Asia compared with other species, despite the growing demand in other regions. Therefore, this could conversely mean that there are less competition and more opportunities for sea bream for investors in Brunei Darussalam.

Aquaculture environment and techniques

Although the conditions for farming sea bream may differ slightly depending on the specific species, the most commonly farmed species, the gilthead seabream, is rather adaptable. It has the capability of enduring a wider range of temperatures from 12–30 ℃ despite the fact that they are more sensitive to colder temperatures. As a result, there are various ways that sea bream can be farmed, including extensive or semi-intensive methods in coastal ponds and intensive systems in land-based installations and in sea cages (FAO, 2021c). Below are brief descriptions of the culture methods with particular systems:

A. Coastal pond and lagoon culture

The main systems that are used for this culture are extensive systems and semi-intensive systems. While extensive systems rely on the natural migration of fish, semi-intensive systems require more human control of the farming environment. For instance, semi-intensive systems allow farming areas to be fertilized to increase natural food availability.

B. Land-based installation culture

This type of culture generally involves intensive systems with rectangular concrete tanks that may range between 200–3,000 m depending on the size and demands of the fish. This system requires massive oxygen injection in order to endure fish survival.

C. Sea cage culture

Sea cages, which include floating cages and submersible cages, use intensive systems. This is one of the simplest and economical cultures as they do not require energy costs

for pumping, aeration, or post-reading water treatment. However, there can be difficulties with temperature control, which can affect the growing period.

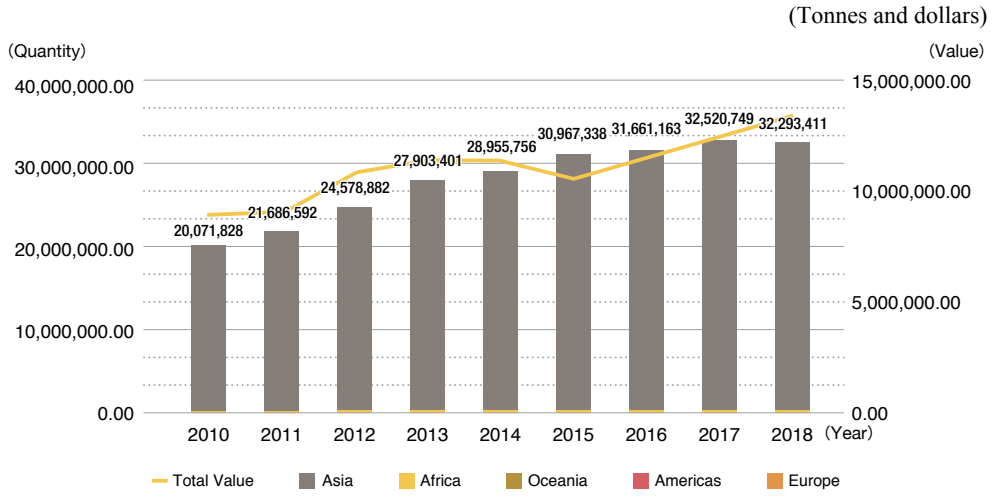
Brunei Darussalam currently does not seem to have a distinct established sea bream culture within the country. However, sea bream still holds many possibilities for the aquaculture industry in Brunei Darussalam. As sea bream seems to be rather uncommon among aquaculture products in Asia, there could alternatively be more opportunities for Brunei Darussalam with the growing demand for sea bream across the world.

V. Seaweed

Market demand

With its high potential to be used in a plethora of ways, seaweed farming has been attracting worldwide attention across different industries. Seaweed is one of the top global aquaculture species, and, in particular, red seaweed and brown seaweed are ranked 2nd and 3rd with 17 MT and 15 MT produced, respectively, in 2018. Today, seaweed is not only used for human consumption in a variety of formats but also for other purposes, including animal feeds, fertilizers, biofuels, cosmetics and medicines. Accordingly, the global seaweed aquaculture production for the last two decades shows an increasing trend of seaweed production with its largest contributor being Asia, which farms more than 90% of the global supply (see Figure III.10). Most of the production comes from Asia as they are the main consumer of seaweed traditionally.

【Figure III.10】 Global seaweed aquaculture production by region, 2010–2018



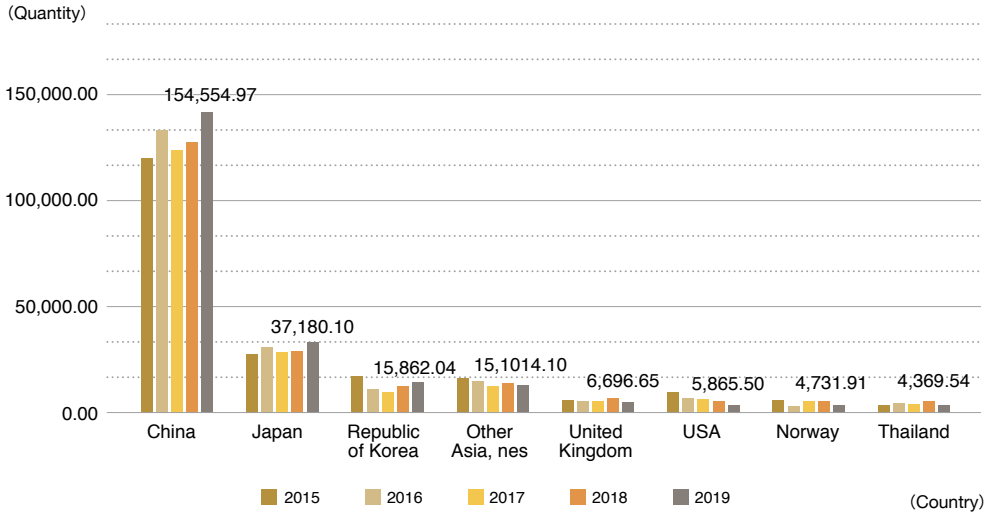
Source: FAO (2021d).

Notably, Figures III.11 and III.12 indicate that China is the largest importer of seaweed for both human consumption and for non-human consumption, with a rather trend over the last five years. While the major importing countries of seaweed that is fit for human consumption primarily consist of Asian countries, such as China, Japan and the Republic of Korea, there is more variety in the major importing countries of seaweed for other purposes. Nevertheless, the geographic location of Brunei Darussalam at the centre of the ASEAN Member States and

in line with the South China Sea, makes it favourable for exporting to high-demand countries, such as China, Japan and the Republic of Korea.

【Figure III.11】 Major importing countries of global seaweed for human consumption, 2015–2019

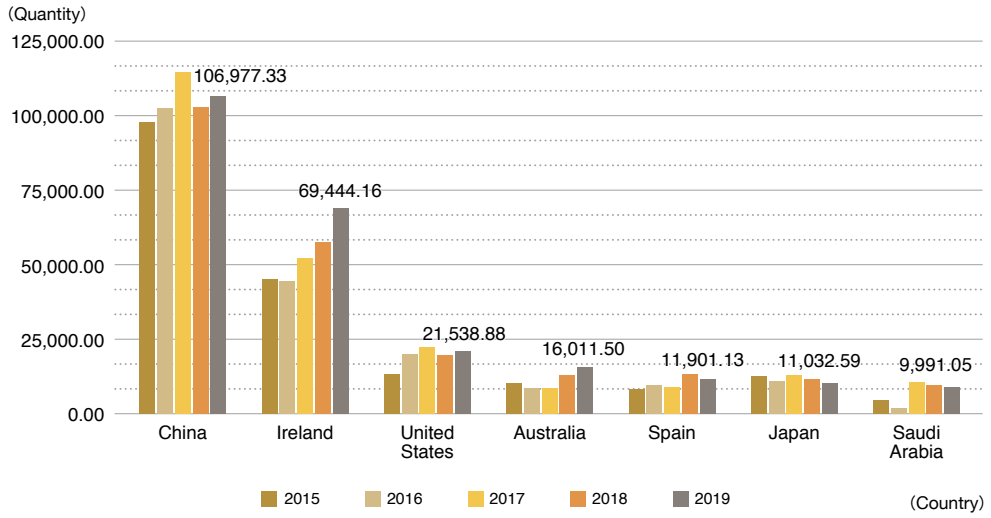
(Tonnes)



Source: UN Comtrade (2021).

【Figure III.12】 Major importing countries of global seaweed for non-human consumption, 2015 and 2019

(Tonnes)

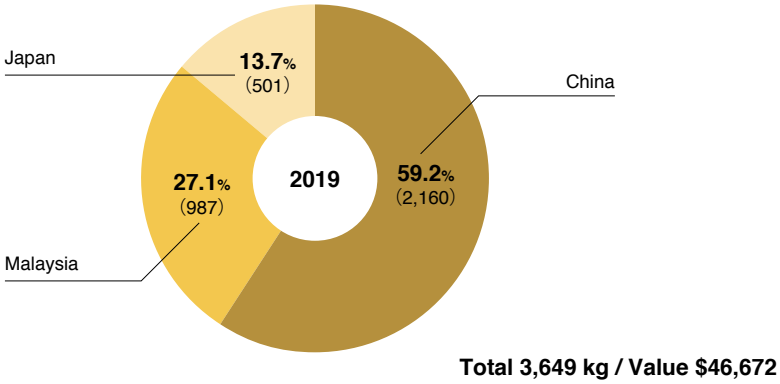


Source: UN Comtrade (2021).

Figure III.13 shows the major exporting partners for Brunei Darussalam's seaweed in 2019. It suggests that the country mainly exports to China, with a share of nearly 60% of the product exported, followed by Malaysia with 27% and Japan with 13.7%. As China and Japan are major importers of global seaweed, the already constructed trade relations for exporting seaweeds are highly beneficial for seaweed exporters.

【Figure III.13】 Major exporting partners of seaweed in Brunei Darussalam, 2019

(Net weight in kilogrammes and %)



Source: UN Comtrade (2021).

Farming environment and techniques

Seaweed farming is often inviting to many farmers because of its relatively simple and cost-effective cultivation methods. It does not require freshwater, fertilizer or much use of land to grow and is only infected by a few pests and diseases (Gro Intelligence, 2016). As seaweed absorbs fertilizer runoffs and carbon dioxide from the ocean to grow, it can contribute to climate change mitigation. Research has supported the finding that it not only absorbs carbon dioxide but can also release carbon that may be buried in sediments or transmitted to the deep sea (Duarte et al., 2017). As a result, this allows seaweed to act as a carbon dioxide (CO2) tank in the ocean. Moreover, seaweed also contributes to the ecosystem of the ocean by consuming nitrogen and phosphorus, which provoke algal blooms that deplete the oxygen when they decompose (NOAA, 2020). These factors indicate both the profitable and sustainable possibilities of seaweed farming. Although there are still areas of development for research in the industry, many scholars are interested in this potential and continue to draw more attention to the industry.

In order to effectively cultivate seaweed, the environmental conditions, such as temperature and solar radiation, are important apart from having adequate salinity and nutrients for the seawater (García-Poza et al., 2020). As seaweed requires adequate sunlight to grow efficiently, Brunei Darussalam's warm climate throughout the year is suitable for seaweed cultivation. According to the Japanese joint venture company, Tavelmout Biofarm (B) Sdn Bhd (Wasil, 2018), depending on the temperature and the amount of sunlight, it takes approximately two weeks to harvest certain types of seaweed in Japan; however, the duration would be reduced by half in Brunei Darussalam. While production in Japan can slow down due to changes in the seasons, Brunei Darussalam's hot and wet climate all-year round enable it to be cultivated and harvested with stable productivity. With clear environmental requirements, there are several possible cultivation techniques for seaweed aquaculture. The major cultivation techniques are noted below with brief descriptions (García-Poza et al., 2020);

- **Onshore cultivation**

  The major systems for onshore seaweed cultivation include line cultivation, net cultivation, floating raft cultivation and tank or pond cultivation. The major advantages of onshore cultivation are the monitoring and the opportunity for real-time adjustments of the conditions. This means that most of the environmental conditions, such as the amount of nutrients, light quality and quantity, control of pH and CO2, and salinity can be adjusted in the most suitable ways. In addition, onshore cultivation is less likely to be affected by natural features, such as tides, waves and wind. On the other hand, onshore cultivation can face the difficulties of having to build expensive infrastructure and the maintenance of the facility along with limited land availability.

- **Offshore cultivation**

  Offshore cultivation can be conducted through various cultivation systems, including line cultivation, net cultivation, floating raft cultivation and rock-based farming. The main advantage of offshore seaweed cultivation is that it is less costly compared to onshore cultivation due to its low installation requirements and maintenance through the use of ropes, lines and nets. However, it faces the disadvantage of being susceptible to extreme ocean conditions, such as strong water movements and nutrient concentrations. Although there are some new systems that can tackle the issues of these ocean conditions with the current technology available, there needs to be further development as these usually have high costs.

- **Nearshore cultivation**

  This is the most common cultivation technique in seaweed aquaculture as it is used in estuarine and near-cost locations with the application of both onshore and offshore techniques. It normally uses line and net cultivation. This type of cultivation is often used as it resolves the issues of onshore access to cultivable land and offshore sea conditions by being near to the land. Moreover, in comparison to onshore and offshore cultivation, nearshore cultivation has the benefits of being less expensive and less labour-intensive.

- **Integrated multi-trophic aquaculture cultivation**

  Integrated multi-trophic aquaculture (IMTA) cultivation is a system that integrates seaweed farming into other fish or mollusc aquaculture in order to solve environmental issues of other aquaculture products by utilising the mechanism of seaweed. IMTA cultivation can overcome problems such as the eutrophication of water from feed supplementation and achieve the stabilization of oxygen, pH and CO2. Lastly, the IMTA system allows companies to diversify their products.

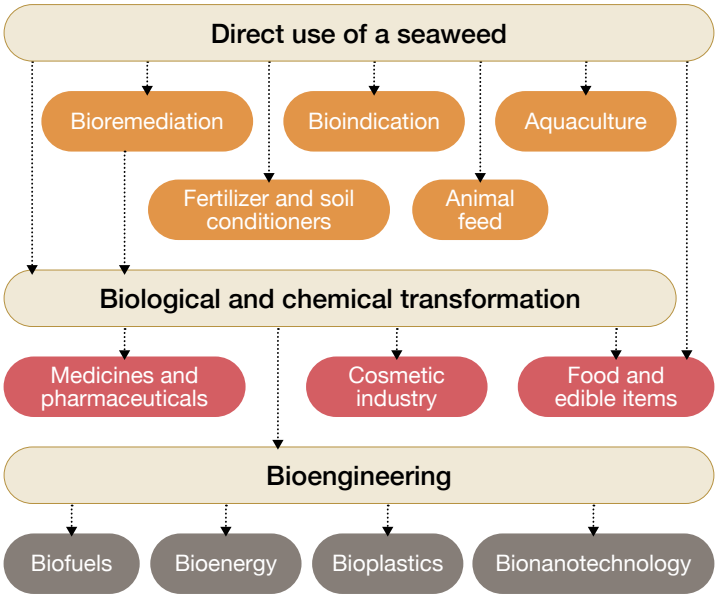
- **Inland culture**

  This is a type of cultivation that uses saline groundwater in the land that has been popularized in recent decades. Some of the systems that are used in saline aquaculture are earthen or plastic-lined ponds, raceways and tanks, which include ones with recirculation mechanics. The merit of saline aquaculture is that it is less costly compared with farming in the ocean because it requires fewer resources as it is located where saline water is available.

【Box III.4】 Different uses of seaweed

As seaweed is becoming an increasingly popular resource because of its variety of uses, there are many possible products that utilize seaweed. Figure III.15 shows multiple uses of seaweed depending on how it is processed.

【Figure III.14】 Multiple uses of seaweed in biomanufacturing



Source: Ditchburn and Carballeira (2019).

Primarily, seaweed can be utilized directly for aquaculture activity as well as the improvement of marine ecosystems through its bioremediation and bioindication capabilities. Another common direct use of seaweed is for agriculture operations, such as in the form of fertilizer, soil conditioners and animal feed. Traditionally, seaweed has been consumed as a food source in Asia. Today the consumption of seaweed is growing across the globe as it is known as a healthy food. People consume seaweed both directly and indirectly. While obvious forms of seaweeds can be raw and processed, including dried seaweed, it is also used in other products by extracting certain substances from it to increase the nutritional, textural and sensorial features of other food products (Roohinejad, 2017). These products include meat, dairy and baked products. The chemicals from seaweed are also used in medicines and cosmetic products because of their organic vitamins and minerals. Lastly, there are several possible uses of seaweed in bioengineering, such as in biofuels, bioenergy, bioplastics and bio-nanotechnology. Biofuels from seaweed, in particular, are drawing attention because of their advantages compared to those from other terrestrial plants. They are three to four times more efficient than those from terrestrial plants, and the sustainable and environmentally friendly cultivation enables the processing of biofuels to be more sustainable if practised correctly. According to the Energy White Paper by Brunei Darussalam's Energy Department (2013), the country has set the goal of achieving 10% of total power generation to be renewable energy by 2035. As the country slowly shifts to more clean energy, biofuels could be a significant source of energy within Brunei Darussalam, and there will be a need for their supply.

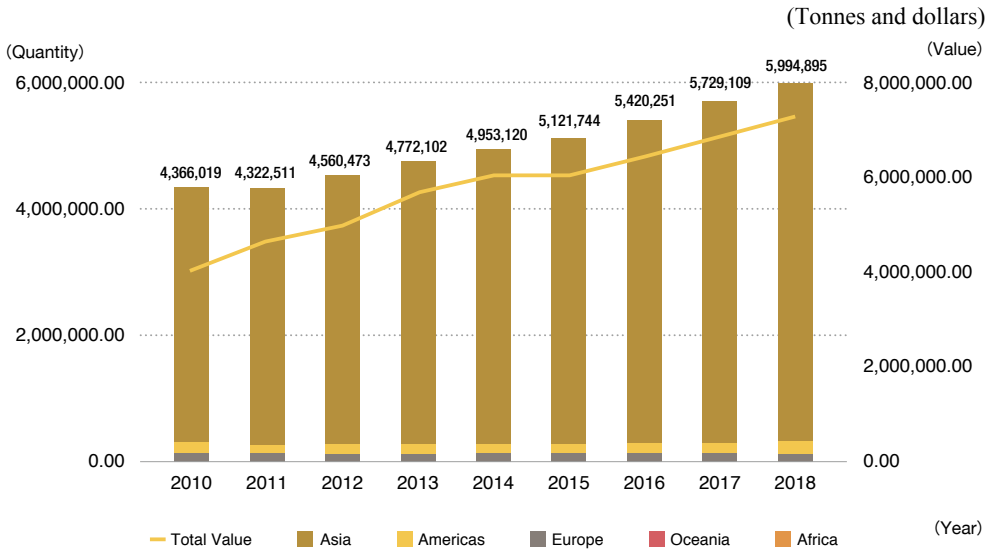
Considering the global demand for seaweed and its variety of uses, seaweed has incredible potential as an aquaculture product. Brunei Darussalam's favourable environment for farming seaweed will allow the product to be recommended as a potential investment opportunity.

VI. Oysters

Market demand

Oysters are the leading species in molluscan aquaculture with one of the longest cultured histories. They have been cultured across all continents and have shown successful trends in increasing production with the blue revolution. As shown in Figure III.15, Asia is the major producer for oyster aquaculture, comprising more than 90% of oyster production by quantity in 2018. This was a huge jump from 1950, when Asia's share in global oyster aquaculture production was only 22% (Botta et al., 2020). The leading nation contributing to this growth is China, which accounts for approximately 80% of the global production. While China has been dominating the supply market for oysters, there is the potential opportunity for producers for high-quality fresh oysters as there is a growing popularity for eating fresh oysters straight from the shell (Spence, 2018). Consequently, the rising popularity of fresh oysters is displayed in the global import data.

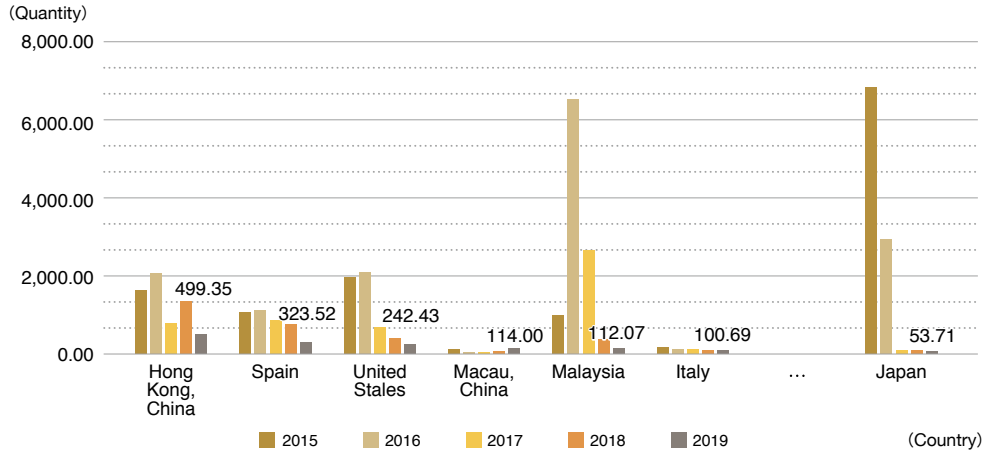
【Figure III.15】 Global oyster aquaculture production by region, 2010–2018



Source: FAO (2021d).

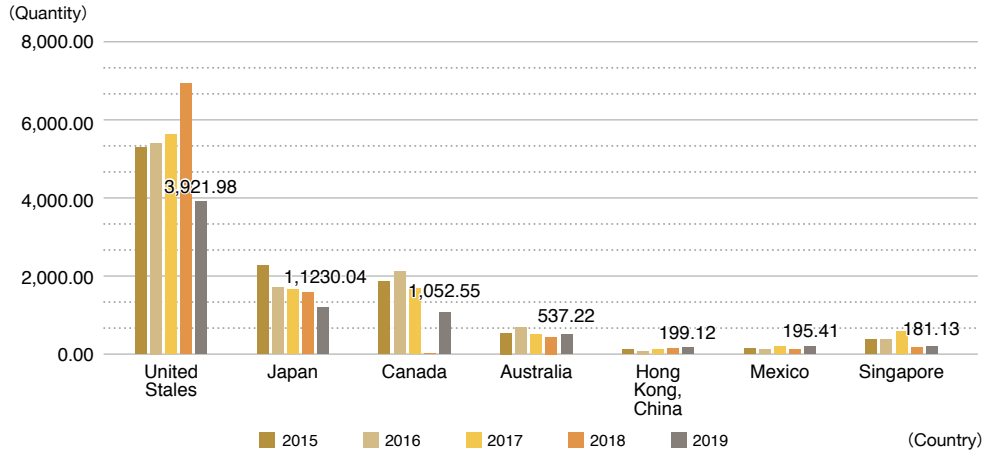
Comparing Figures III.16 and III.17, the volume of imported dried, salted, smoked or cooked oysters and processed oysters shows a sharp decline between 2015 and 2019 for most of the major importing countries. Although the reason behind this is not clear, one of the factors could be that the demand for oysters further shifted from processed products towards fresh or frozen products (Figures III.18 and III.19). Moreover, the major importing countries of non-fresh oysters are mostly located in Asia, while fresh oysters are imported by European countries, such as France and Italy, as well as the United States. China has also been a growing importer in the last few years, with constant growth among the top importing nations.

【Figure III.16】 Major importing countries of global dried, salted, smoked or cooked oysters, 2015–2019 (Tonnes)



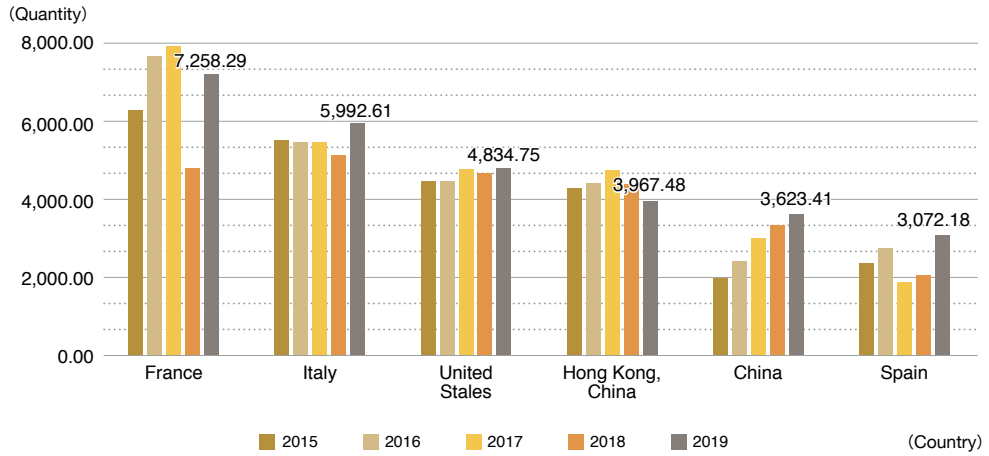
Source: UN Comtrade (2021).

【Figure III.17】 Major importing countries of global prepared or preserved oysters, 2015–2019 (Tonnes)



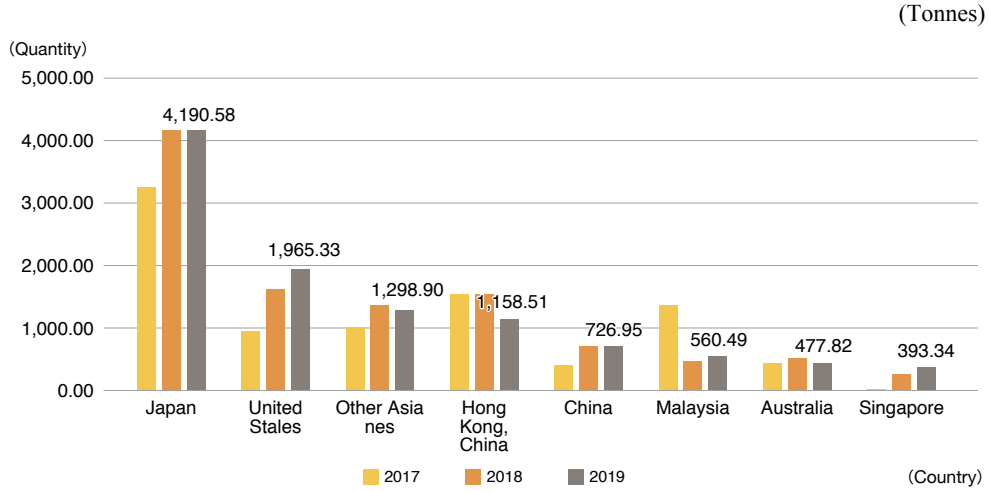
Source: UN Comtrade (2021).

【Figure III.18】 Major importing countries of global oysters, 2015–2019 (Tonnes)



Source: UN Comtrade (2021).

【Figure III.19】 Major importing countries of global frozen oysters, 2015–2019



Source: UN Comtrade (2021).

The growing volume of imports especially in neighbouring countries, such as China, Japan and Singapore, is a great advantage for Brunei Darussalam as they are also the countries that it has concluded FTAs with.

Aquaculture environment and techniques

Oyster farming is almost entirely sea-based. This necessitates the importance of site selection, especially with regards to environmental elements, such as tidal range, water salinity, water depth and pollution levels. For instance, waters in bays and coves are usually preferred for protection from brackish and full-strength seawater, while it is suggested to avoid areas that are prone to flooding or surface run-offs (Garrido-Handog, 1990). Factors such as wave and wind patterns of occurrence and intensity are also crucial for selecting a suitable site. These assessments of the environment are important for choosing culture methods for oysters. According to the FAO (2021a), techniques such as bottom culture, off-bottom culture, suspended culture and floating culture are often used depending on the environment and tradition.

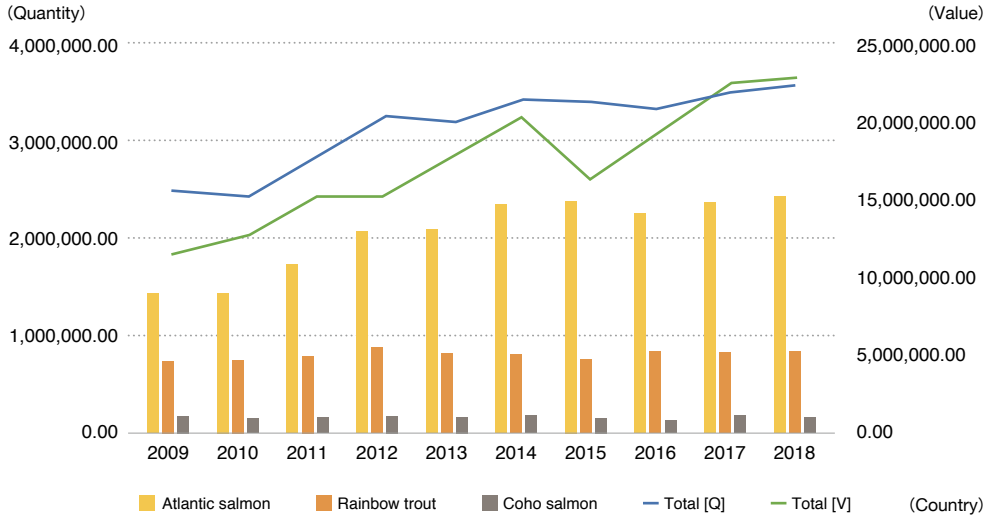
The major advantage of investing in aquaculture oysters in Brunei Darussalam is the comparatively lower frequency of natural disasters, such as tsunami and typhoons. A study of aquaculture oyster production in Miyagi prefecture in Japan showed the serious damage to production following the huge tsunami caused by the Great East Japan Earthquake in 2011, which had not recovered to pre-earthquake production levels even after five years (Okumura et al., 2019). The risks of these natural disasters are much lower in Brunei Darussalam and, thus, it would be ideal for aquaculture oyster production.

VII. Salmon

Market demand

There has been strong demand for salmon, specifically farmed Atlantic salmon, in both developed and developing markets across the world, and it has proven to be a versatile and popular seafood item among consumers. According to the FAO (2020a), the markets for farmed coho salmon, rainbow trout and wild salmon species from North Pacific fisheries have all shown growth. While exports of these species are growing, Atlantic salmon still remains the largest export product in terms of export revenue (see Figure III.20).

【Figure III.20】 Global salmon aquaculture production, 2009–2018 (Tonnes and dollars)



Source: FAO (2020a).

Although Norway and Chile lead Atlantic salmon aquaculture with their profitable and technologically advanced industries, the strong demand for salmon with the possibility of more innovation and markets can allow Brunei Darussalam to invest in the salmon aquaculture industry securely. Currently, there is already an FDI company, Pure Salmon, that is in the process of developing a land-based RAS for Atlantic salmon in the country. Although there are still investment opportunities due to the high market demand for salmon, there may be more competition in the industry.

Aquaculture environment and techniques

The selection of appropriate farming sites for salmon is especially important for cage culture because of its consequences on the environment and natural ecosystems. Generally, salmon farming initially takes place in freshwater environments, and the salmon are then transported to seawater cages (Marine Harvest, 2018). Therefore, factors such as water temperature, salinity, flow and exchange rates, and proximity to other farms are also important to consider when choosing sites. For instance, a temperature range of 8–14°C is ideal for Atlantic salmon as they are cold-blooded animals (MOWI, 2020). This could mean that salmon farming may not be suitable for warm climates. Due to such challenges, more developed and sustainable methods, such as the use of RAS, will be necessary for salmon aquaculture in Brunei Darussalam.

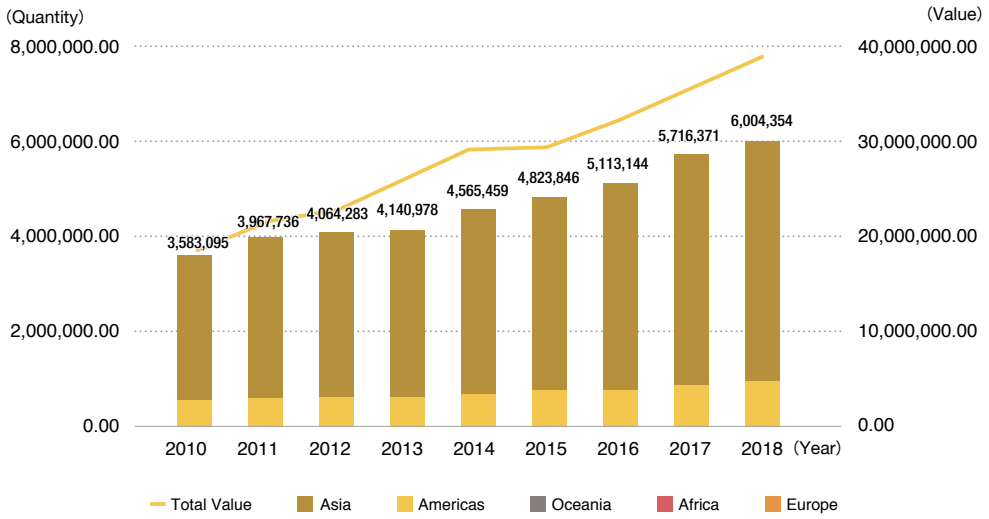
VIII. Shrimp

Market demand

Today, shrimp and prawn are one of the fastest-growing markets in the global aquaculture industry. As indicated in Figure III.21, the aquaculture production of shrimp in the past years has shown significant growth, especially in Asia and the Americas. With the main producing market of shrimp being Asia and Latin America, global trade in shrimp and prawns is estimated at $28 billion per year (FAO, 2020d).

【Figure III.21】 Global shrimp and prawn aquaculture production by region, 2010–2018

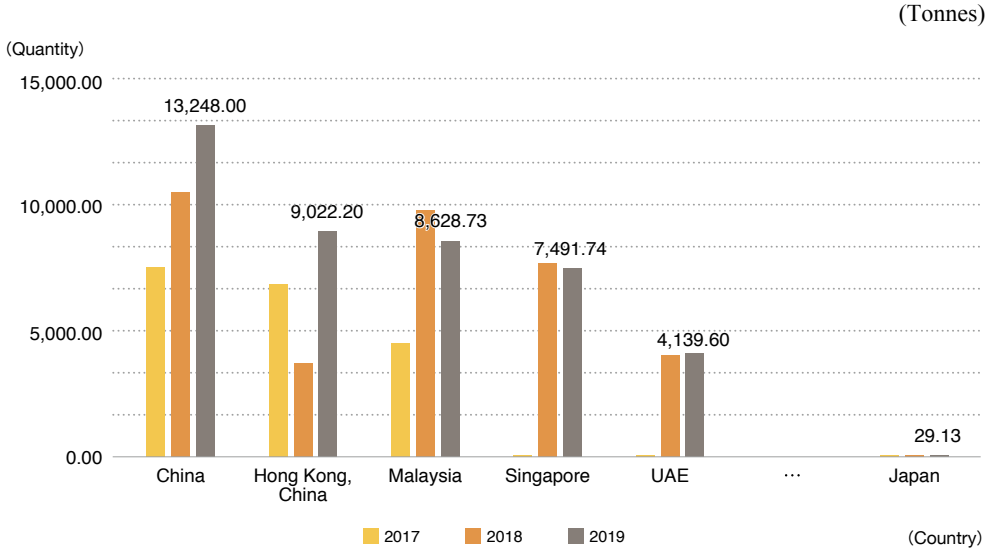
(Tonnes and dollars)



Source: FAO (2021d).

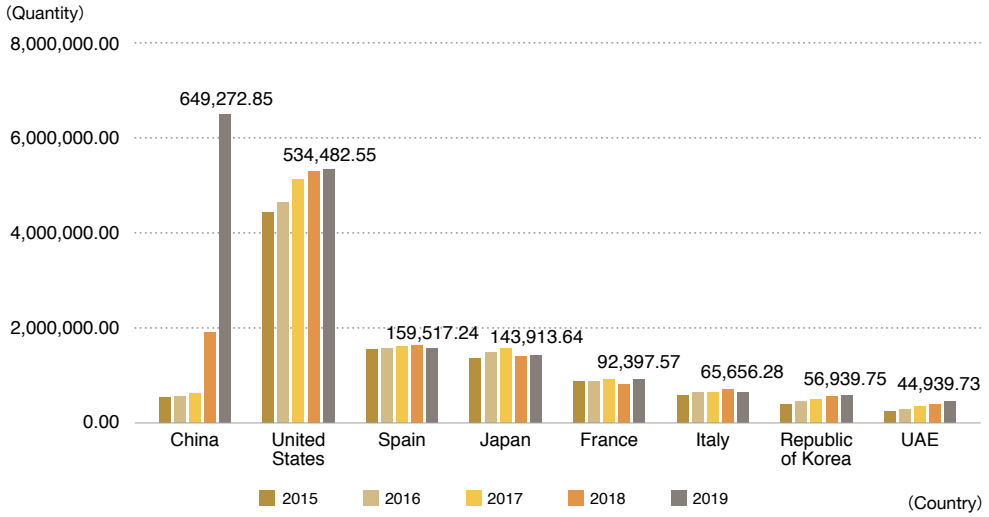
Apart from China and Japan, the major importing countries for shrimp are in Europe and the United States (Figures III.22 and III.23). The demand for shrimp is increasing in the region as there is growing awareness among consumers of it as a healthy source of protein. According to ADROIT (2019), shrimp is one of the cheapest sources of protein compared to other types of seafood available. While many companies will continue to seek expansion in the high-demand markets, some companies are also looking into untouched markets, such as the Russian Federation and Africa. With healthy diets becoming more popular worldwide, shrimp will continue to play a leading role in the global seafood market.

【Figure III.22】 Major importing countries of global fresh shrimp, 2017–2019



Source: UN Comtrade (2021).

【Figure III.23】 Major importing countries of global fresh shrimp, 2017–2019

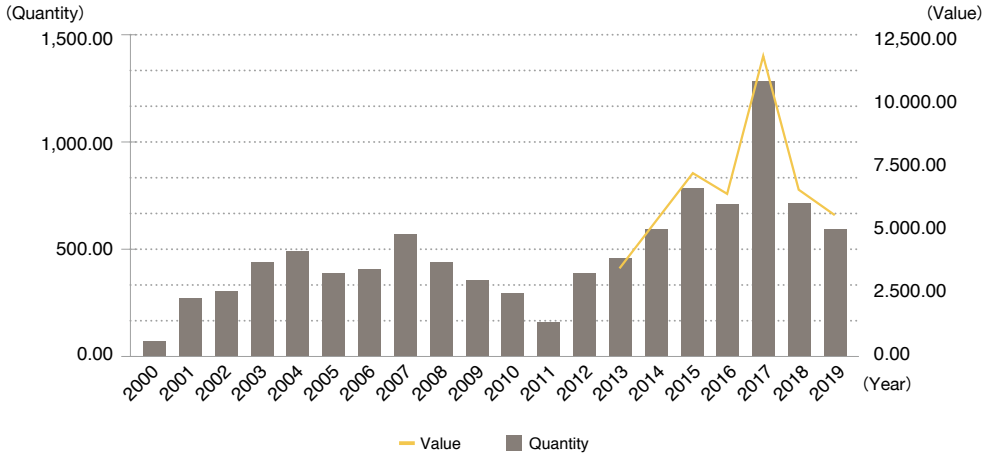


Source: UN Comtrade (2021).

In terms of the domestic landscape for shrimp production, there has been a positive trend, especially over the last decade (see Figure III.24). Despite declines in 2018 and 2019 due to a disease found in blue shrimp, production was expected to recover in 2020. While there are several types of shrimp in the market, most of the shrimp production that is exported from Brunei Darussalam is frozen shrimp. Accordingly, Figure III.25 shows the exporting destinations of the country's frozen shrimp in 2019. As it was the largest importing country, China was also the major partner for Brunei Darussalam's shrimp exportation. Although the United States is still a smaller export partner for Brunei Darussalam, its increasing import volume of shrimp shows the potential for growth in Brunei Darussalam's exports to the country.

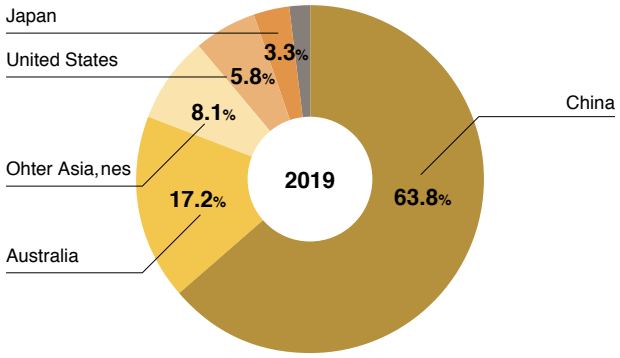
【Figure III.24】 Aquaculture shrimp production in Brunei Darussalam, 2000–2019

(MT and Brunei dollars)



Source: DOF (2020a).

【Figure III.25】 Major exporting partners of frozen shrimp from Brunei Darussalam, 2019



Source: UN Comtrade (2021).

Aquaculture environment and techniques

The farming environment, such as the weather, soil and water quality, plays an important role in the success of shrimp farming. Among the various species, tiger prawns are being particularly promoted by the Government of Brunei Darussalam. They are the largest and fastest-growing shrimp in the world and have stable demand in the market, including in Europe. As tiger prawns are a tropical-to-subtropical species (Reddy, 2019), warm brackish waters, which are present in Brunei Darussalam, are suitable for farming. Although shrimp are rather susceptible to diseases, and this can make farming challenging, the existing shrimp aquaculture investment in Brunei Darussalam demonstrates the potential for shrimp culture. The biosecurity requirements before and during culture needs strict implementation. Another risk is market competition, as there is already substantial investment by other foreign investors. Therefore, assessing the risks and challenges, including the selection of appropriate species, will be especially important for shrimp aquaculture investment.

Promoted aquaculture spin-off industries

Aside from the specific species and products directly produced by aquaculture, there are also other industries related to aquaculture where investment could be made. These are spin-off industries that either give support to aquaculture operation, provide inputs that help fish development or use aquaculture harvests to create value-added products. These include hatcheries for fry and fingerlings, feeds and health implements, infrastructure, technologies and processing.

I. Hatcheries for fry, post larvae and fingerlings

Seeds and fingerlings are the most basic input that any enterprise engaged in aquaculture needs as they dictate what and how much will be produced. Based on an interview with the DOF, it was reported that there are no local suppliers of grouper seeds and fingerlings in Brunei Darussalam, and farmers have to import them from other countries, such as Malaysia.

Importing these from other countries brings several concerns, such as due to the trade restrictions brought about by the COVID-19 pandemic and the added costs of importation. Investors may opt to invest in hatcheries to produce fry, post larvae and fingerlings to have a constant supply for creating a continuous cycle of fish production. When developed enough, these can also be made available for selling to smaller or new aquaculture enterprises or even exported to other countries.

II. Feeds and health implements

Feeds and health implements are important inputs for aquaculture. They are crucial since they greatly contribute to the health of the fish and seafood, which affects the quality of the aquaculture products. Currently, fish feeds and health implements are mainly imported from Singapore and Viet Nam.

At present, Golden Corporation became the first company in Brunei Darussalam to produce fish meal and shrimp feed processed from excess and unmarketable fish, which ensures minimal marine wastage and pollution. Meanwhile, Barramundi Asia partnered with other companies to develop a premium aquafeed for the company. This development provides the benefits of improving the feed conversion ratios and the utilization of more environmentally friendly feed. From this, investing in these inputs is a good option, not only because they are self-sustaining for these companies but also because they will help the local industry to grow once there is an opportunity to expand and provide for local aquaculture.

III. Infrastructure

Infrastructure provides facilities to support aquaculture operations. One form of infrastructure that the industry needs is storage and cold chain facilities. Aquaculture produces fresh products that must be handled properly. Since these products are not immediately sold or consumed, storage facilities are needed to make sure that the quality is maintained before shipping to the final destination. Because of this, it is important for aquaculture investors to simultaneously invest in storage and cold chain facilities together with their aquaculture ventures.

Other than storage and cold chain facilities, the creation or expansion of industrial complexes for aquaculture ventures and related industries is another good yet larger potential investment opportunity. Industrial complexes can help foster the industry by creating an area that is inclusive and inducive for existing and new enterprises. They can enable the faster exchange of goods between producers' storage facilities and processors due to the convenience of being in the same area. This area can also provide spaces that can be rented by smaller and new enterprises, which will help them develop. This can be done in partnership with the Government of Brunei Darussalam to ensure that suitable areas are chosen while strictly following regulations.

IV. Technology

Technology is another set of possible investment opportunities that goes together with the aquaculture industry. Through research and development funding, various areas in the industry can be improved, including but not limited to: (1) breeding and genetics, (2) feeds, medicine and nutrition, (3) sustainable aquaculture systems and (4) markets and consumer demand (World Aquaculture Society, 2018). Funding these can greatly improve the productivity of the industry and help further its development.

Although investors may opt to also focus on improving the current systems that are being used in aquaculture, emerging technologies, like RAS, should also be given attention. There is risk associated with investing in these emerging technologies given the high costs that they come with, but given the demand for a more sustainable industry, they are a notable option. Sustainability in aquaculture and the systems that are associated with it will be further discussed in the next chapter.

V. Processing

The fish processing is another important spin-off industry of aquaculture that should also be considered by investors. Based on data presented in Chapter II there were 88 commercial and small-scale processors in Brunei Darussalam in 2020. These processors produce various products, such as fish crackers, salted fish, marinated fish and shrimp paste.

Looking at the export and import data of one group of processed products, that of salted, dried and smoked fish, as shown in Table III.5, it can be seen that Brunei Darussalam only exports around $22,000 worth of products yet imports around $2.7 million worth of the same products. This shows that there is potential for expansion for these processed fish products to meet export and existing local demand.

【Table III.4】 Value of imported and exported fish (salted, dried, smoked) in Brunei Darussalam, 2019

	Value in 2019
Exports	$22,179.00
Imports	$2,710,757.00

Source: UN Comtrade (2020).

Given this, investors may create their own processing ventures that will complement their investment in aquaculture. Making use of their aquaculture products as inputs will add value, improve the value chain of the aquaculture and processing industry, and diversify the products available in the market. These value-added products have the potential to be exported in addition to being sold locally. Therefore, investing in the processing of fish products is a good opportunity since it could potentially fulfil both local and export demand.

CHAPTER
IV

Aquaculture investment strategies

Approaching sustainability in aquaculture investment for Brunei Darussalam

In Chapter II, it was discussed that the aquaculture industry has a large stake in contributing to Sustainable Development Goal (SDG) 14: life below water. In addition, the Food and Agriculture Organization of the United Nations (FAO) has also stated that aquaculture has the potential to contribute to the attainment of other SDGs (Figure IV.1), including SDG 1 (no poverty), SDG 2 (zero hunger), SDG 8 (decent work and economic growth), SDG12 (responsible consumption and production) and SDG 13 (climate action). However, looking from an investment perspective, how can Brunei Darussalam and potential investors in aquaculture maximize investment in the industry while also contributing to sustainability?

【Figure IV.1】 Most relevant SDGs for the aquaculture industry

Source: FAO (2017).

The FAO reports that fish and seafood is a main food source in the world, with an estimated 3 billion relying on it for their main source of protein. This figure is projected to rise with the increase in the global population in the next 30 years. To add to this, the other main source of animal meat protein, livestock, is facing scrutiny and possible decline due to various health issues and environmental issues, such as carbon dioxide (CO2) emissions and water use. In comparison with marine capture, aquaculture has the advantage of not relying on wild stock while being more productive (Gwilliams-Beeharee, 2020).

Amid this context, investment in aquaculture can take on the demand to supply fish protein in the light of the declining and unsustainable livestock and marine capture resources. Aquaculture is a key source of important animal protein while being sustainable at the same time. In addition, the concept of environmental, social and governance (ESG) has become

a central focus by companies when choosing where to invest their capital, and aquaculture is a good candidate for ESG investment. The reason for this is that there is much room for expansion in the industry, including support of stock health through biosecurity, preventive health implements and quality feeds, which contribute greatly to the industry's productivity. Another reason is the resilience of aquaculture systems in the context of climate change, wherein if the water temperature for one species, such as Atlantic salmon, exceeds its optimal limits, farm rainbow trout may be a better option to manage comparably better in warmer temperatures. This gives good opportunities for Brunei Darussalam and its investors to invest in the aquaculture industry.

However, to be attractive for this kind of investment, the aquaculture industry and its players must be able to do it rightbybeing productive while addressing the issues faced, including fish health and food safety, water pollution, habitat destruction and a range of impacts on wild fish populations. Given this, what are the options available for aquaculture to meet global demand while also generating environmental and social benefits and providing attractive investment opportunities with compelling financial returns? In a guide made by the Nature Conservancy and Encourage Capital (Jones, 2019), three sustainable and financially attractive aquaculture systems were identified: (1) seaweed and bivalve systems, (2) on-land finfish recirculating aquaculture systems and (3) offshore finfish systems.

- **Seaweed and bivalve systems.** Of these three, near-shore bivalve production and seaweed aquaculture offers the clearest environmental value proposition. This type of system does not only require few inputs but has shown positive impacts on degraded habitats by improving water quality, providing habitat for other species and reducing excess nutrients from their immediate environment. The ecological incentives, combined with a growing interest in both species groups for food and non-food uses, create an opportunity to expand production both in scale and geographic scope.
- **On-land recirculating aquaculture systems (RAS).** Land-based RAS may offer an alternative to traditional, near-shore finfish production that is environmentally advantageous since it may enable improved environmental outcomes by physically separating operations from the marine environment and treating wastewater. In addition to this, it allows for higher production density, reduced mortality and greater control over production outcomes.
- **Offshore finfish systems.** Offshore finfish farming has the potential to provide another sustainable and scalable alternative to near-shore aquaculture and is likely to constitute an important subset of overall sector growth. This could avoid many of the impacts that plague near-shore farming by moving activities away from critical habitats and into deep waters with strong currents.

  All of the identified products for investment that were detailed in chapter 3 can fit and can be integrated into these sustainable aquaculture systems. Thus, investors combining these products and systems will be able to maximize their investment potential, resulting in good investment returns while also contributing to sustainability.

Best practices for investing in aquaculture

The previous sections of this study have highlighted the importance and relevance of investing in Brunei Darussalam's aquaculture industry. The country's aquaculture industry has a lot of potential for further expansion and for contributing more to economic development. Investing in aquaculture may seem easy, but pursuing investment does not only entail putting money in the best potential income-generating area or company. There are several considerations and options for exploration.

In some cases, there are unconventional considerations that could be assessed that are actually beneficial not only for the industry but also to the immediate localities. These can be considered as best practices that could be followed by investors to broaden the scope of investment in the industry (see Appendix C for further explanation). This includes investing in small-scale enterprises, investing in research and development, sustainable systems, and technologies, and investing in support and related industries.

Investing in small-scale enterprises

Foreign investment usually goes to large-scale and commercial companies due to their greater and faster rate of return on investment. This is mainly due to the upscaled production approaches and the existing technologies that are available to commercial producers. Related to this is that there is less risk associated since large-scale production is likely to be stable and have measures to respond to risks.

Due to the attractiveness of investing in larger companies, investment in small-scale enterprises that exist in the industry has been minimal at the most. Often, this investment is from donor and development agencies like the United Nations and not from big investors. Various studies have shown that investing in small-scale enterprises is actually beneficial not only to those enterprises but also to the whole industry as well.

In Indonesia, for three years, donor investment helped grow a network of farmers from 47 in 2007 to 2,639 in 2010 and raised the net profit per farmer from $73 to $435 per year. In India, local organizations were established through donor funding to assist small-scale shrimp farmers to help them organize themselves and to reduce shrimp diseases. Participants grew from five volunteers in 2002 to 17,147 in 2011, and $8.9 million in farm gate revenues and $3.52 million in profits were created for 730 farmers generated from just $0.3 million. Meanwhile, in Bangladesh, a USAID-funded project worth $0.5 million for technical and organizational assistance for shrimp farmers created $52.5 million in income and $20.6 million in profits in 2011 for almost 23,000 farmers (Rogers et al., 2013).

From these examples, it can be clearly seen that there are benefits from investing in smaller portions of the industry. Not only does this help small players keep up in production but it also stimulates the local economy, fostering long-term economic sustainability for these businesses and contributing to the value chain of the whole industry. This might not be as attractive for most investors but this is a good practice to consider taking on in the long run as it will open up more possible opportunities as the industry further develops.

Investing in research and development and sustainable aquaculture systems and technologies

The second set of best practices for investing in aquaculture is in ventures that could help improve the efficiency, productivity and sustainability of the aquaculture industry. This includes investing in research and development and sustainable aquaculture systems and technologies (Asche, Roll and Tveteras. 2013).

As mentioned in Chapter II, there are different aquaculture systems being adopted in Brunei Darussalam, which include pond culture, inshore fish cages, offshore marine culture, and RAS. Although investing in existing approaches may seem the best option for investors in aquaculture, it is also a good practice to look into how these can be improved. This can be done by also investing in research and development for these systems, which can focus on various areas like fish breeding, genetics and hybridization, looking at environmental conditions to increase productivity and improve fish health. Through this, investors can help improve the productivity of their investment, which can contribute to improvements in the industry.

Another investment direction that investors may opt for is sustainable aquaculture systems. A sustainable aquaculture system is defined as aquaculture that (1) does not create significant disruption to the ecosystem or cause a loss of biodiversity or substantial pollution impacts, (2) is a viable business with good long-term prospects and (3) must be socially responsible and contribute to community well-being (World Bank, 2014). One of the systems that is considered a sustainable aquaculture system is RAS, which is already adopted in Brunei Darussalam (company undisclosed). While this system involves high costs, there are various investment benefits that can be gained through its adoption. This includes significant cost savings on the freight of fish products by locating production closer to demand centres, fewer biological risks compared to farming at sea and lower environmental compliance and permit costs relative to sea farming. As mentioned in the previous section, this system has also showcased higher production density, reduced mortality and greater control over production outcomes while lessening the impact on the immediate environment. Given this, RAS can be a very viable and sustainable investment option for investors (Jones, 2019).

Investing in spin-off (processing, input and support) industries

While investing directly in the aquaculture industry would be the best option given its potential, industries that support aquaculture and other related industries must be taken into consideration as well. These industries are equally as important as aquaculture since they provide goods and services that are needed to support either the production of aquaculture or make use of its products as inputs to create value-added products.

The fish and seafood processing industry, which was discussed in the previous chapters, is another potential option for investors in aquaculture. As discussed in the previous chapter, expanding aquaculture will benefit existing processors and make possible the creation of new processing enterprises since these can use the aquaculture products as inputs. Processing increases the value of aquaculture goods by transforming them into products that can be readily consumed and sold to the market. Thus, this adds value to the products, improves the

value chain of the aquaculture and processing industry, and diversifies the products that are available in the market and that can be potentially exported to other countries.

Input industries are industries that provide valuable resources that are used to support the production of fish and seafood by aquaculture facilities, including seeds/eggs, feeds and medicine. In an interview conducted with the Department of Fisheries (DOF), it was mentioned that there are no seed producers locally operating in Brunei Darussalam and that the country's supply of seeds is imported from other countries. Given this, it would be a good opportunity for investors to look into fish seed development locally in Brunei Darussalam as this will reduce the reliance on importation. This will also increase accessibility to this input for small-scale and new aquaculture enterprises. Feeds and medicine are other input industries that could be invested in. Both are very important inputs since they are necessary for improving the quality of the products by ensuring the health of the fish and seafood being produced. These inputs can also be included in the investment into research and development. When these industries grow and develop enough, they can not only supply local demand but also have the potential for exporting to other countries as well.

Support industries are ventures that help aquaculture in terms of logistical support, including storage, initial preparation and packaging, and transport. The fisheries statistical report of the DOF indicates that there were only two ice processors in Brunei Darussalam in 2020. Ice is a necessary input needed in aquaculture since it is used to keep harvested fish fresh and chilled before transport. Therefore, increased aquaculture production would generate increased demand for ice processors. Since not all harvested fish and seafood are immediately sold, sent to processors or exported, storage and cold chain facilities are needed to keep fish and seafood chilled or frozen before selling or transport. In connection with this, transport services are another form of logistical support with investment potential since they provide for the easier transfer of aquaculture products from the aquaculture or storage facilities to their destinations. Given these important roles, it would be good for aquaculture investors to consider investing in these support industries.

Challenges faced

Like any other industries, challenges are also present in the aquaculture sector. These challenges pose a threat not only to the existing companies and enterprises but also to future investment in the industry. If these are ignored and left unresolved, they may cause the current industry to stagnate and become unable to produce sufficient and quality products and, hence, not fully realize its potential. These challenges can also determine future incoming investment.

In 2018, Brunei Darussalam's DOF was able to identify various challenges that are currently being experienced by the sector in its strategic plan. These can be categorized into six types: (1) finance and management, (2) supplies and materials, (3) aquaculture methods, (4) facilities, (5) compliance to standards and (6) networks. Other than these challenges, they also identified possible solutions. The challenges and solutions are shown in Table IV.1.

【Table IV.1】 Issues and challenges facing Brunei Darussalam's aquaculture sector

Issues/Challenges	Repair measures
Finance and management	
• Local entrepreneurs lack knowledge and skills in operational management and financial business • Limited financial capital contributions	• Changing the mindset of local entrepreneurs in small-scale enterprises towards intensive enterprises to explore export markets. • Explore business capital (business model) with the participation of local and foreign investors (FDI) through securities capital, contract arrangements and others. This can benefit positively from the aspects of technology transfer and expertise, including investment injections and capital to grow enterprises. The involvement of direct investors also facilitates market access to exports using their existing market networks. • Guide small entrepreneurs in preparing business plans and bookkeeping for any activities related to primary resources and tourism. • Ongoing guidance, dialogue and seminars on entrepreneurial thinking. Commitment to maximizing the use of the sites offered is required.
Supplied and materials	
• Inadequate and inadequate marine supplies	• Encourage the involvement local public investment in business models that are more profitable and powerful by providing or financing agricultural products, such as by guaranteeing the supply of seeds and food to help food and export markets to develop existing businesses.
• Quality of seed supply and stockpiles that needs improvement	• Improve seed quality through the Specific Pathogen Free programme method.
Aquaculture methods	
• Still using conventional methods	• Attract foreign direct investors to invest in Brunei Darussalam and bring the latest technology and use it for commercial purposes. • Technology transfer and knowledge through training, briefings and workshops from government agencies and also FDI through joint ventures with local entrepreneurs through methods such as venture capital, contract farming and others.
Facilities	
• Inadequate basic facilities (water, electricity, communications)	• Opening and advancing new sites by providing basic facilities for seawater and electricity.
• Do not maximize the sites offered	• Improve access to seawater, freshwater and electricity at existing sites.
Compliance to standards	
• Lack of knowledge about food standards, such as Good Aquaculture Practices (BGAqP), and the prevention of diseases as well as compliance with export requirements	• Implementation programmes of Brunei Good Aquaculture Practices, Good Management Practices, Hazard Analysis and Critical Control Point, Hygiene on Board among fisheries entrepreneurs with the aim of making cultural products more productive and competitive as well as ensuring food safety to penetrate export markets. • Programmes to increase the integrity of security and the distribution of aquatic animal health to export companies. • Field certification and accreditation.

Issues/Challenges	Repair measures
Networks	
• Needs strengthening of marketing and marketing networks	• Involvement of direct investors also facilitates market access to export using their existing market networks. • Research and data collection on food markets in selected countries and regions, such as the United Arab Emirates or Europe, etc. • Enacting acts, regulations and guidelines related to export market access. • Using the network of alternative markets in countries that have an existing export market for value-added products, such as Hanif, Ghanim Brunei Halal, etc.

Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2017)

The water quality at aquaculture sites may also pose a challenge to the aquaculture industry. A journal article by Ndah et al. (2017) discussed the water quality assessment of three selected aquaculture sites in Brunei Darussalam: Hazmi Aquaculture, Helif Aquaculture and Pangkalan Sibabau. From the results of the water analysis, only a few parameters were within normal or acceptable levels, including biological oxygen demand, total suspended solids, turbidity, pH and oil and grease residues. Meanwhile, specific parameters at some sites, such as alkalinity, chlorine, phosphate, true colour and other nutrients, were higher than what is deemed safe for aquaculture. Hence, the study recommends stringent implementation of environmental impact assessments, respect of environmental quality standards and regular monitoring and evaluation prior to and during ongoing aquaculture operations.

Other than the challenges in the aquaculture sector, the DOF also identified challenges and possible solutions for the fish and seafood processing sector. This can be categorized into (1) finance and management, (2) processing facility standards, (3) raw materials, (4) packaging and labelling, (5) processing technology and (6) distribution and marketing networks. These are shown in table IV.2.

【Table IV.2】 Issues and challenges facing Brunei Darussalam's fish and seafood processing sector

Issues/Challenges	Repair measures
Finance and management	
• Lack of skilled and knowledgeable local businesses in the fishing industry • Limited financial capital contributions	• Changing the mindset of local entrepreneurs in small-scale enterprises towards intensive enterprises to explore export markets. • Explore business capital ("business model") where the participation of local and foreign investors (FDI) through securities capital, contract arrangements and others. This can benefit positively from the aspects of technology transfer and expertise, including investment injections and capital to grow enterprises. The involvement of direct investors also facilitates market access to exports using their existing market networks.
Processing facility standards	
• Use of factory/premise food standards locally to meet export requirements	• The Department has obtained an EU number for the EU export market • Factory Hazard Analysis and Critical Control Point -element skills

Issues/Challenges	Repair measures
	training courses have been implemented and are ongoing. • Technological courses in processing, packaging, hygiene and food safety for staff and office staff as well as entrepreneurs have been implemented and are ongoing. • Initial preparation and Request for Proposal for seafood production activities have been and are ongoing • Practice of the basic user skills needed to clean the factory processing process has been implemented and is ongoing. • Preparing Standard Working Procedures (SOP) for factory operators has been implemented. • Audit and factory inspections for the processing of export products will be carried out. • Provision of a manual for Brunei Darussalam on hygiene requirements for fish processing establishments.
Raw materials	
• Limited and inconsistent raw materials	• Encourage integrated activities with the industrial and cultural industries to guarantee the supply of raw materials as well as the importation of raw materials if insufficient. • Fully advancing the shrimp breeding site of Golden Corporation Sdn Bhd. • Maximize the use & fully operate the I & II, Telisai I and Kg Keramut aquaculture sites • Developing marine resources in cages.
Packaging and labelling	
• Knowledge in improving the quality of the packaging of products and labelling of packaging to meet the needs of local and export markets.	• Training of factory skill elements of the GMP and HACCP factory elements. • Provision of a manual for Brunei Darussalam on hygiene requirements for fish processing establishments. • Processing technology and hygiene practices and food safety practices
Processing technology	
• Knowledge in the use of the latest freezer technology and its consistent maintenance	• Operation of 100 MT and 20 MT cold storage facilities at the seafood storage and processing building. • Export shrimp processing plant operations.
Distribution and marketing networks	
• Needs strengthening of distribution and marketing networks.	• FD Company has signed a memorandum agreement with UNIMAD Distribution and Aqua Star Australia for distribution in France and Australia.

Source: Department of Fisheries, Ministry of Primary Resources and Tourism. (2017)

Risk management

This chapter explores the possible risks in the aquaculture process. The identified risks, are assessed and suggested approaches for addressing them are provided.

Aquaculture is often perceived as a high-risk industry (IDH, 2018). The major risks associated

with the aquaculture industry can be divided into two categories: production risks or those that occur in the process of farming, and market risks, ones that are related to the market approach.

Production risks

A. Disease. Despite the rapidly growing production of aquaculture in the past decades, disease still remains one of the biggest concerns associated with the aquaculture production process. Infectious diseases have a negative impact not only
A. on limiting production, but also because they result to severe economic loss. In Brunei Darussalam, there was a disease found in blue shrimp in 2017 that caused a decline in shrimp production and exports in the following year.

B. Natural disasters. Aquaculture undertaking is often located in places that cannot avoid natural disasters, whether inshore or offshore. This can include flooding, typhoons and tsunamis in coastal and sea culture, and droughts and floods in onshore culture. These extreme events are more likely to occur in connection with the effects of climate change.

C. Farming environment. The various aspects of aquaculture production that make it operational and productive can also be sources of risk if not managed properly, and this can result in loss of production and decrease in product quality. Farming environment risks include those related to the farming system, such as seed quality, stocking density, feed quality and water quality.

1. Farming system. Depending on the location and environment in which aquaculture takes place, certain systems can be more effective, suitable or successful than others. Failure in the operation of certain systems can bring great losses in production. Measures to address this include the inspection of land and ponds as well as preparing a clean environment prior to farming.

2. Seed quality. Pathogens are most likely to spread into a farm through infected seeds. This is usually a result of the difficulty in removing the pathogens from the seeds. The quality of seed will affect the growth rate as well as susceptibility to diseases.

3. Stocking density. The stocking density determines the productivity and risk of disease. Essentially, higher density provides more yield in crops, but the disease risk is higher, while lower density leads to faster growth and a lower risk of disease.

4. Feed quality. As feed is required for most aquaculture products, the feed quality can largely affect the product quality as well. If the feed lacks enough nutrients with the correct proportions, the risk of nutritional issues arising may increase. The negative impact that the uneaten feed has on the aquaculture water environment is also a rising concern (Kong et al., 2020).

5. Water quality. Water quality is one of the most significant factors in aquaculture. Each species has an optimum temperature and salinity ranges for it to grow effectively and, thus, it is important to adjust these depending on the species and/or carefully choose the site to avoid sub-optimum water quality.

D. Environmental risks

1. Habitat disruption. The development of aquaculture sites has the potential to damage water habitats due to the physical structures that are built in these natural areas. These structures may also disrupt the natural processes in the areas, such as by blocking the currents or sunlight needed by sea life.

2. Chemicals from feeds and medicine. The feeds and medicine that are used in aquaculture contain chemicals that can possibly pollute the immediate environment. This can happen both to closed pond systems leaking into the soil and to open systems directly in the ocean and shore environments. Unwanted residues of some applied chemicals may find their way into the harvested products and affected food safety.

3. Waste produced. As with any animal production system, there is bound to be waste produced by the fish in the aquaculture system. Although this can be cleaned easily in pond systems or in RAS, it presents a risk for open systems that cannot fully filter the water, causing waste to get carried by currents or settle at the ocean floor.

4. Invasive species. Another risk for systems that are located within natural water environments is farm cultured fish escaping and becoming an invasive species that could bring problems to these habitats. This is also possible in closed systems if the escaped fish find a way to water bodies like rivers, lakes and eventually the sea.

Market risks

A. Fluctuating prices. As shown by the sales in Brunei Darussalam, consumer prices for fish and seafood fluctuate according to the demand and supply dynamics as well as influences from the global market.

B. Limited market. Current exporting partners of Brunei Darussalam's aquaculture products have shown a small range of export destinations, mainly limited to neighbouring Asian countries.

C. Competitiveness. Some products are highly competitive in the market where there is already established dominating companies. This can pose a risk for investment if there is not a market for the product.

Risk assessment

Table IV.3 shows the risk assessment guide used to rate the identified risks. Each risk is rated based on two factors, the likelihood of occurrence and the impact of the consequence. The likelihood of occurrence rates the risk on how often it may be likely to occur in course of the investment and operation of aquaculture ventures. The impact of the consequences rates the severity of the impact of the risk not only to the operation of the aquaculture but also its surrounding environment.

【Table IV.3】 Risk assessment guide

			Impact of consequences				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
Likelihood of occurrence	Rare	1	1	2	3	4	5
	Unlikely	2	2	4	6	8	10
	Moderate	3	3	6	9	12	15
	Likely	4	4	8	12	16	20
	Certain	5	5	10	15	20	25

Severity: Low Medium High Extreme

Source: Developed by the authors based on Buczynski (2019)

Each factor will have a five-point ascending rating scale. The descriptions for each point in the scale are described in table IV.4. For the likelihood of occurrence, the lowest rating of 1 means that it can only happen in exceptional circumstances in the investment and operation, while the highest rating of 5 means that it is expected in normal circumstances in the industry. For the impact of the consequences, the lowest rating of 1 means that it will have a negligible impact or damage to aquaculture operation, while the highest rating of 5 means that it will have a catastrophic impact that could mean the loss of income or closure of operations.

【Table IV.4】 Description of the scale of factors for the risk assessment

Rating	Likelihood of occurrence	Impact of consequences
1	Only in exceptional occurrences	Negligible impact
2	Could occur at some future time	Minor impact
3	Might occur at some time	Moderate impact
4	Will probably occur in most circumstances	Major impact
5	Expected in normal circumstances	Extensive impact

Source: Developed by the authors based on Buczynski (2019)

The ratings for each risk were multiplied to result in a risk score that shows the overall severity of the risk. The severity of the risk can be shown in four categories depending on the score, which also determines the level of priority to manage these risks. Those with a score of 1–2 have low severity and priority; scores of 3–6 are moderate risks with medium severity and priority; the third category is 8–16, which is considered to have high severity and priority; and lastly, the highest score ranging from 20–25 indicates critical risks considered to have extreme severity and should be given top priority. Given this rating scheme, the risks are tabulated in Table IV.5 showing the ratings, risk scores and risk priorities of each of the identified risks.

【Table IV.5】 IV.5. Risk assessment of the identified risks

Risk	Likelihood of occurrence	Impact of consequences	Risk score	Risk priority
Production risks				
A. Diseases	3	5	15	High
B. Natural disasters	1	4	4	Medium
C. Farming environment				
• Farming system	3	4	12	High
• Seed quality	3	5	15	High
• Stocking density	3	5	15	High
• Feed quality	3	4	12	High
• Water quality	4	4	16	High
D. Environmental risks				
• Habitat disruption	2	4	8	High
• Chemicals	3	3	9	High
• Waste production	3	3	9	High
• Invasive Species	3	3	9	High
Market risks				
A. Price fluctuation	4	4	16	High
B. Limited market	4	5	20	Extreme
C. Competitiveness	5	5	25	Extreme

Source: Tabulated by the authors [7]

Once in a while, there will be new strains of disease or those passed from invasive species that could potentially proliferate in current fish stocks. In the event that these spread, they can inflict a great deal of production and financial losses to ventures and even to the whole industry. With this, diseases are classified as a high-priority risk.

[7] Risk score is the multiplication of likelihood of occurrence and impact of consequences.

For natural disasters, like earthquakes and typhoons, the likelihood of their occurrence in Brunei Darussalam is low compared to other countries due to its location. Despite this, there is a chance of their occurrence increasing in the near future because of planetary changes such as climate change bringing typhoons. The impact of these is seen as high due to the possible damage to aquaculture's physical structures and the support facilities that are vital for its operations. The rating for this is medium, indicating that it is not a priority but should still be considered when investing in the aquaculture industry.

For the farming environment, there is variation in the ratings of both the likelihood and impact among the identified risks. The likelihood for all these, except for water quality, are seen as moderate since investment going into this type of venture is carefully planned out before the actual undertaking, but making the occurrence of these possible in some unseen circumstances. For water quality, the rating for likelihood is higher since it is a current issue that exists, as mentioned in the previous section. As for the impacts, seed quality and stocking density are seen as really high due to these being the main factors that will determine the productivity of an aquaculture farm and the difficulty of adjustment compared to the three other risks. Overall, all these are considered high priority since they are factors that would impact the productivity and quality of the products that will be produced.

For the environmental risks that could come from aquaculture, the likelihood is generally seen as moderate due to the existing features of the aquaculture systems that deal with these. Pond aquaculture uses lining to prevent water and chemical leakages to the soil and waterways. Meanwhile, RAS uses filtration that cleans the water from chemicals and waste. This issue is more prominent for open water systems, since these are directly located in the ocean and can contribute to the long-term accumulation of chemicals and organic waste. Habitat disruption is rated lower due to the existing proposed sites, which are already allocated and have been considered carefully by the Government of Brunei Darussalam. The impacts of these on the environment are seen as moderate-to-high due to the time it takes for the impacts to show. Habitat disruption is faster due to the direct physical impact it has on the ocean environment, but it would take time for the impacts of the other three to show. All these environmental risks are seen as a high priority due to the increasing demand for aquaculture to be environmentally sustainable.

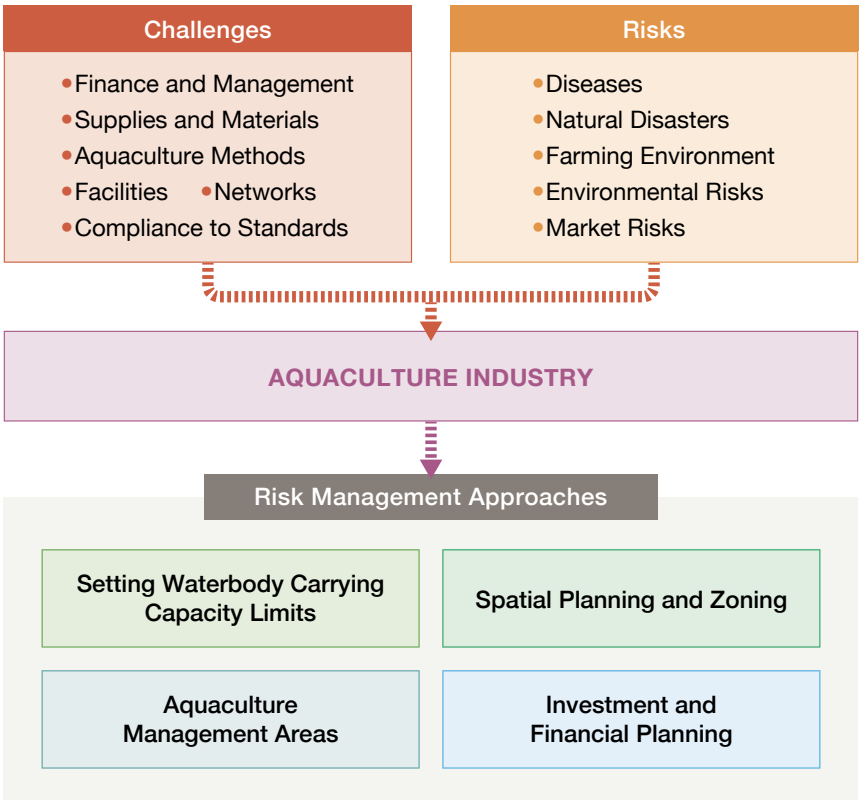
For investors, the market risks are the most important where the return on investment is critical for venture sustainability. The likelihood of all the risks are either likely or certain due to them already being existing conditions. Price fluctuations have been observed for fish and seafood locally in Brunei Darussalam and in the international seafood market, as discussed in the overview chapter. The limited market risk is high due to the fact that Brunei Darussalam's aquaculture industry is still small, and export partners are limited and not yet fully identified. For competitiveness, it was shown in the previous chapter that potential products already have large producers in other countries. Hence, penetrating the market and competing with the existing producers will be a big challenge. The impacts of these risks are considerably high due to the possibility of the aquaculture ventures not realizing their expected returns on investment. If this happens, the failure will be detrimental not only to individual ventures but also the whole industry, its investors and Brunei Darussalam's economy.

Given this assessment, the top priorities for Brunei Darussalam and its aquaculture investors are in the market risks. These will greatly affect the outcome of the investment and whether they will be able to capitalize on the potential or face a loss. Due to the fluctuations in the market prices, changes in demand and supply, and the emergence of new industry players, measures for market risks must be continuously considered and prepared for. Despite not being the top risk priority that has to be dealt it, other risks must be given importance and focus as well. Disease and farming environmental risks must be given the same level of concern since they can both dictate the quality and quantity of products, which will determine the marketability of the goods. For the environmental impacts, with the current call for sustainable business and investment, measures to prevent and provide solutions to the impacts of the aquaculture industry must be put into place.

Risk management approaches

The timing of the risks related to aquaculture may be unknown by the investors and its operators, but risk mitigations measures must always be taken into consideration. From initial conceptualization up to daily operations, there are mitigation measures that can be planned and operationalized. These mitigation measures can also be applied as solutions to existing challenges that the industry is facing. Figure IV.2 shows the possible management approaches that can be used for both aquaculture's challenges and risks.

【Figure IV.2】 Risk management approaches



Source: Compiled by the authors

The figure is a modified compilation of approaches from the Best Practices for Aquaculture Management – Guidance for implementing the ecosystem approach in Indonesia and beyond (Bone, et al, 2018), which was originally developed for the aquaculture industry of Indonesia. Although different from Brunei Darussalam, Indonesia's location and environmental conditions offer similarities. The three main challenges in Indonesia of (1) conflicts with other resource users, (2) exceeding waterbody carrying capacity and (3) disease amplification and transmission are all present or possible in Brunei Darussalam.

To respond to these challenges and risks, the study looked at the ecosystem approach to aquaculture, which was developed by the FAO, and distilled a suite of best management practices that can be turned into risk management approaches and could be actionable for Brunei Darussalam and its investors. These approaches do not target individual issues, but rather are designed to address multiple challenges.

- **Spatial planning and zoning:** the process through which the public and private sectors aim to influence the spatial distribution of people and activities at differing geographic scales.
- **Waterbody carrying capacity limits:** determining the level of resource use, by all resource users, that can be sustained over the long term without harming ecosystems or the provision of ecosystem services.
- **Aquaculture management areas:** waterbodies, or parts thereof, where certain management practices are coordinated across all aquaculture operators in the area, to minimize cumulative impacts and risks.
- **Investment and financial planning:** careful planning of investment and financial decisions to make sure that investment is put into areas and products that would be able to not only provide an exceptional return of investment but also sustainable business practices.

To make the risk management approach more holistic and cover the financial challenges and risks that are most relevant for investors, investment and financial planning are also included as a recommended approach. This can be done by the Government of Brunei Darussalam, working with investors to come up with measures that will make sure that investment opportunities in the aquaculture industry are maximized and managed properly at every stage from initial conceptualization to operation and production.

Future potential: A solution to food security and economic diversification

Investing in aquaculture will bring about not only direct impacts to the industry itself but will also bring positive effects on a bigger scale to Brunei Darussalam. These include impacts on the country's economy, local food production landscape, employment and livelihood, and the creation and expansion of new industries.

Investment in aquaculture will help increase the productivity of the industry. This increased

volume of products projected to be produced by the industry will have various potential economic impacts on Brunei Darussalam. On a macro scale, it is expected to increase the volume of products that are being exported and introduce new products with the potential to be exported globally. This can potentially increase the competitiveness of Brunei Darussalam to become a key player for aquaculture and fish and seafood products. Aquaculture production supported by investment can also contribute positively to the GDP growth of fisheries and the agriculture sector of the country. With the increased local production and processing of aquaculture, reliance on imports for fish and seafood will decrease as well.

The creation and expansion of industries are another potential offshoot that could be created by investment in aquaculture. As discussed in the previous chapters and sections, there are several related and spin-off industries that could benefit from increased aquaculture production and the products it produces. This includes industries for seeds and fingerlings, feeds and medicine, ice processing, storage and logistics, technology development and fish and seafood processing. These industries will also be able to contribute to GDP and potentially be globally competitive as well.

Although the focus of the investment in the aquaculture industry is for exports, it can also contribute to local food production and potentially food security in Brunei Darussalam. Given the country's large fish and seafood consumption, increasing the output of aquaculture can help supply meet this demand. To add to this, the diversification of fish products, which includes processed goods, will increase the choices available to consumers. Another local benefit that can be gained is local employment. The opening up and expansion of new aquaculture ventures will create jobs for people in the country. This will also increase the level of skills of Brunei Darussalam's human resources due to the variety of occupations that would be made available.

Finally, improving the institutional support—particularly from the government of Brunei—specific to aquaculture is an essential stepping stone for Japanese investors and beyond. As explained in Chapter III, currently there is no investment incentive pertinent solely to aquaculture. Where food security and economic diversification are central to the fourth and fifth thrust of the Eleventh National Development Plan (2018-2023), further investment policies and incentives specific to the aquaculture industry as well as implementing the sectoral regulatory framework provided by the government of Brunei contributes to overall institutional development in the aquaculture industry. In this process, consultation and engagement with the current industry practitioners is crucial to reflect the voice of the industry practitioners.

CHAPTER V

Conclusion

This study focused mainly on the potential of the aquaculture industry of Brunei Darussalam for further expansion through foreign direct investment (FDI). To do this, the study looked at the various data regarding the aquaculture industry, both locally and internationally. The current situation of the country's aquaculture industry was examined, including the structure of the industry's landscape, its current players and investment, existing and potential aquaculture sites and systems used, export and import trends, and consumption and value chains. To add to this, the international trends on supply and demand for various fish and seafood species were investigated to see where Brunei Darussalam currently stands and where it could potentially contribute. Based on these analyses, the study has found eight fish and seafood products that have good potential for investment. Table V.1 shows the summary of each product identified.

【Table V.1】 Summary of identified aquaculture products for promotion

Product identified	Characteristics	Market climate	Suitable aquaculture systems/environments
1.Seabass	Advantages • Low toxin levels • Mild flavour • High in omega-3 for heart and brain health • Alternative to salmon Key culturing information • Wide physiological and crowding tolerance • Females have high fecundity	Major producers Taiwan Province of China, Malaysia, Thailand, Indonesia and Australia Major importers Italy, Spain, United States, Netherlands, United Kingdom, Portugal, France, Malaysia and the Russian Federation *Increasing demand in Asia, the United States, the Middle East and the United Kingdom* *Increasing production in Asia*	• Net cage culture • Pond culture • RAS
2.Pompano	Advantages • High flesh quality • Can be intercropped with shrimp Key culturing information • Wide environmental tolerance (low salinity of 8%) • Fast growth rate • Acceptability for commercialized feeds	Major producers China, India, Indonesia, Philippines, Taiwan Province of China, Thailand and Viet Nam *Increasing demand in South-East Asia*	• Pond culture • Floating cages
3.Grouper	Advantages • One of the tastiest fish • Medicinal value Key culturing information • Easier to culture • Not favourable for traditional means due to demersal nature • Most fingerlings are wild capture	Major producers China, Taiwan Province of China and Indonesia *Increasing demand in Asia and the Middle East*	• Pond culture • Net cage culture
4.Seabream	Advantages • Healthy fish option—a rich	Major importers Italy, Spain, Portugal, France	• Coastal pond and lagoon culture

Product identified	Characteristics	Market climate	Suitable aquaculture systems/environments
4.Seabream	source of omega-3 fatty acids Key culturing characteristics • The most commonly farmed species, the gilthead seabream, is highly adaptive to fluctuating temperatures	and Greece *Increasing demand in Europe, North America and Australia* *Highest production in Asia with increasing production in Europe and Africa*	• Land-based installation culture • Sea cage culture
5.Seaweed	Advantages • One of the top global aquaculture species • Various uses, such as in animal feed, biofuel, cosmetics and medicine • Contributes to climate change mitigation and environmental improvement Key culturing characteristics • Simple and cost-effective • Needs adequate sunlight	Major importers *(Human consumption)* China, Japan and the Republic of Korea *(Non-human consumption)* China, Ireland and the United States	• Onshore culture • Offshore culture • Nearshore culture • IMTA cultivation • Saline aquaculture
6.Oysters	Advantages • Leading and longest-cultured mollusc Key culturing characteristics • Entirely sea-based culture • Wave and wind patterns are crucial	Major producer China Major importers *(Salted, smoked, dried)* Hong Kong (China), Spain, the United States, Malaysia and Japan *(Prepared or preserved)* United States, Japan, Canada, Australia and Singapore *(Fresh or chilled)* France, Italy, the United States, Hong Kong (China), China and Spain *(Frozen)* Japan, the United States, Hong Kong (China), China, Malaysia, Australia and Singapore	• Bottom culture • Off-bottom culture • Suspended culture • Floating culture
7.Salmon	Consumption advantages • Versatile and popular seafood item • High value Key culturing characteristics • Initially starts in freshwater but must be transferred to saltwater • Water temperature, salinity, flow and exchange rates, and proximity to other farms must be considered	Major producers Norway and Chile	• RAS
8.Shrimp	Advantages • One of the fastest-growing markets • Tiger prawns are the largest and fastest-growing variety with stable demand Key culturing characteristics • Suitable for warm and brackish waters • Susceptible to diseases	Major importers (Fresh shrimp) China, Hong Kong (China), Malaysia, Singapore and the United Arab Emirates (Frozen shrimp) China, the United States, Spain, Japan, France, Italy, the Republic of Korea and the United Arab Emirates	

Source: Compiled by the authors

Other than these fish and seafood products, investment can also be put into other spin-off industries related to aquaculture. Doing this could support its operation, improve its productivity and make use of its outputs to create more value-added products. The study was able to identify five spin-off industries for aquaculture in Brunei Darussalam.

- **Seed and fingerlings.** The Department of Fisheries has mentioned that there are no suppliers of seeds and fingerlings in Brunei Darussalam. This opens up the opportunity for investors to become key players in providing this important input for the aquaculture industry.
- **Feeds and medicine.** These are another important input needed for aquaculture, which contributes greatly to the productivity and quality of its output. Investing in feeds and medicine specifically aimed at the products being produced in Brunei Darussalam is a viable investment option.
- **Infrastructure.** Like any other industry, vital infrastructure is needed to support the operations of aquaculture. Storage facilities are one of the most important since they allow produce to stay fresh until it is exported, sold or processed. Investing in logistics, utilities and industrial complexes will also help the growth of the industry.
- **Technology.** Technologies in the form of upgraded and new farming systems and research and development on various aspects of aquaculture like breeding, genetics, feeds and medicine are a welcome investment possibility. This will help in increasing production and enable sustainable practices for aquaculture.
- **Processing.** Brunei Darussalam's fish and seafood processing industry is still small and there are opportunities to expand here. Investors may choose to invest in processing along with aquaculture to make use of its produce to create value-added fish and seafood products that can be exported as well.

Given Brunei Darussalam's relatively open economy and strategic geographic location in South-East Asia, it offers several advantages for possible investors in the products and related industries of the aquaculture industry. FDI incentives, a strategic location, infrastructure coverage, a high-quality environment, and low susceptibility to natural disasters make investing in aquaculture in Brunei Darussalam very attractive. However, on the other hand, investing in Brunei Darussalam's aquaculture is not without its challenges and risks. Figure V.1 summarizes the various challenges and risks to the country's aquaculture industry and the applicable management approaches that can provide solutions to preventing these from affecting the industry and its investment.

These approaches offer a holistic approach to the challenges and risks. Even without the occurrence or presence of these issues, these measures should be carried out by investors and players in the industry to further improve the quality of products and increase the competitiveness of the industry. Investors, industry players and the Government of Brunei Darussalam must work together in the pursuit of these measures as this concerns all of them.

To be attractive for investment, the aquaculture industry and its players must be able to be productive while addressing the issues the industry faces in order for it to become sustainable. Given this, there are options available for aquaculture that meet global demand and that can provide attractive investment opportunities and are sustainable at the same time. The three farming systems which fit these criteria are the following:

- **Seaweed and bivalve systems.** This type of system not only requires few inputs but has shown positive impacts on degraded habitats by improving water quality, providing habitats for other species and reducing excess nutrients from the immediate environment.
- **On-land recirculating aquaculture systems (RAS)**. This offers an alternative to traditional finfish production that is environmentally advantageous since it may enable improved environmental outcomes by physically separating operations from the marine environment, treating wastewater and allowing for higher production density, reduced mortality and greater control over production outcomes.
- **Offshore finfish systems.** Offshore finfish farming has the potential to be another sustainable and scalable alternative. It could avoid many of the impacts that plague near-shore farming by moving activities away from critical habitats and into deep waters with strong currents.

Combining these systems with the recommended potential products provides a variety of options for investors. Thus, investors will be able to maximize their investment potential, resulting in good investment returns while also contributing to sustainability.

To add to this, investors are also recommended to engage in various best practices, which will benefit the whole industry. These include (1) investing in small-scale enterprises, which will deliver economic sustainability for the industry in the long-term, (2) investing in research and development and technologies that will contribute to increasing the productivity and quality of fish and seafood products, and (3) investing in spin-off industries, which will support the aquaculture industry's different activities. In the process, it is important to engage with institutions and agencies such as SEAFDEC and the Aquatic Animal Health Services Centre under the Department of Fisheries in Brunei for strengthened institutional capacity. These will help diversify and improve the products, and increase the overall competitiveness of Brunei Darussalam's aquaculture industry in the world.

Finally, improving the institutional support—particularly from the Government of Brunei—specific to aquaculture is an essential stepping stone for Japanese investors and beyond. Further investment policies and incentives specific to the aquaculture industry as well as implementing the sectoral regulatory framework provided by the Government of Brunei contributes to overall institutional development in the aquaculture industry. To attain these, consultations in the process must engage with the current industry practitioners to ensure the holistic promotion of aquaculture industry.

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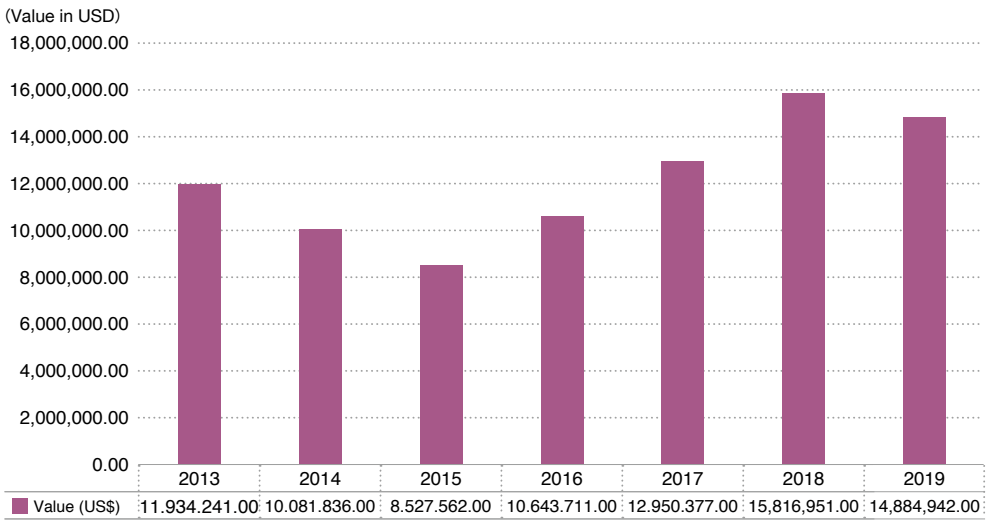
Appendix

Appendix A. Breakdown of Brunei's Fish and Seafood Import per type of product.

Fish, Fresh or Chilled

The highest fish and seafood commodity imported by Brunei is fish which are either fresh or chilled which constituted 14.8 million USD (39%) of all imports in 2019. Looking at the trend of this commodity, it has initially went down then steadily gone up in since 2013. From 11.9 million USD in 2013, the value of this commodity went down for 2 years to 8.5 million USD in 2015. This trend then steadily increased for the next 4 years with a value of 15.8 million USD in 2019 and then went down to 14.8 million in 2019 (Figure A.1).

【Figure A.1】 Value of Imported Fish, Fresh or Chilled, 2013-2019



Source: UN Comtrade

Table A.1 shows the breakdown of the Brunei's top importation partners for fish, fresh or chilled in terms of value in 2019. The highest importer for fish, fresh or chilled is Malaysia which imported 12.4 million USD constituting majority of the imports at 83%. Second highest is Norway which imported 895 thousand USD constituting 6.01% of the imports. The third and fourth are Singapore and Chile importing 822 thousand USD (5.52%) and 425 thousand USD (2.85%) respectively. The rest of the imports come from the countries of Hongkong, New Zealand, China, Myanmar, Thailand, and combined other Asian countries.

【Table A.1】 Top Fish, Fresh or Chilled importation partners, 2019

Country	Value (USD)	Share	Country	Value (USD)	Share
Malaysia	12.4 million	83%	New Zealand	82 thousand	-
Norway	895 thousand	6.01%	China	77 thousand	-
Singapore	822 thousand	5.52%	Myanmar	21 thousand	-
Chile	425 thousand	2.85%	Other Asia	18.1 thousand	-
Hongkong	95 thousand	-	Thailand	16 thousand	-

Source: UN Comtrade

Looking at the specifics of this commodity shown in Table A.2, 75% are a cumulative of all fishes that are not specified in the records. For those which are specifically identified, the top 3 are Pacific salmon/Atlantic salmon/Danube salmon at 1.88 million USD (12.6%), Mackerel at 1.11 million USD (7.49%), and Salmonidae at 349 thousand USD (2.34%). The rest are composed of trout, cod, flat fish, yellow fin tunas, fish liver & roe, and albacore/long finned tunas.

【Table A.2】 Imported Fish, Fresh or Chilled per species

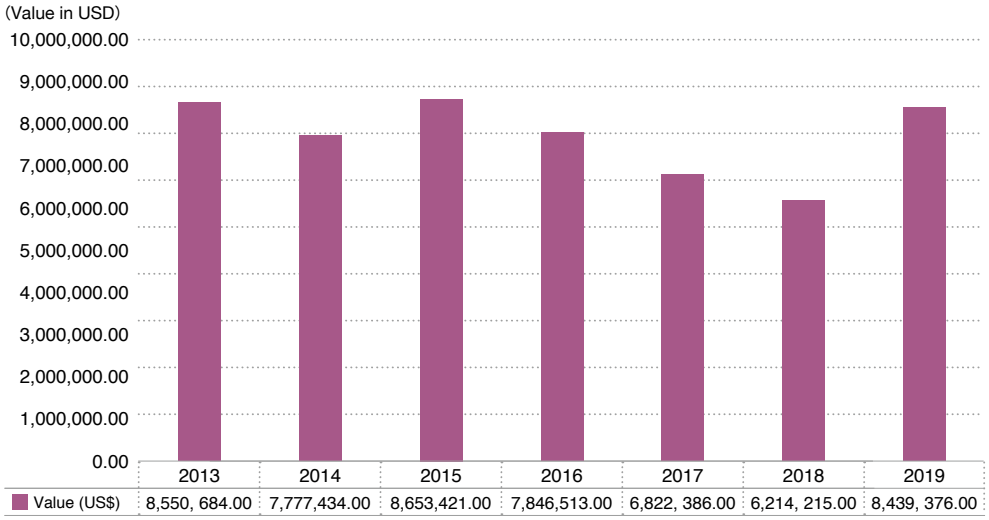
Commodity (fresh / chilled)	Value (in USD)	Share
Fish, n.e.s., fresh/chilled	11.2 million	75%
Pacific salmon/Atlantic salmon/Danube salmon	1.88 million	12.6%
Mackerel (Scomber scombrus / australasicus / japonicus)	1.11 million	7.49%
Salmonidae	349 thousand	2.34%
Trout (Salmo trutta, Oncorhynchus mykiss / clarki / aguabonita / gilae / apache / chrysogaster)	182 thousand	1.22%
Cod (Gadus morhua / ogac / macrocephalus)	28 thousand	0.194%
Flat fish (halibut / plaice / sole)	15.5 thousand	0.104%
Yellowfin tunas (Thunnus albacares)	14.1 thousand	0.094%
Fish livers & roes	5.58 thousand	0.037%
Albacore/long finned tunas (Thunnus alalunga)	2.12 thousand	0.014%

* excluding fillets/other fish meat /livers & roes | Source: UN Comtrade

Fish, Frozen

The second highest fish and seafood commodity imported by Brunei is frozen fish which constituted 8.43 million USD (22%) of all imports in 2019 (Figure A.2). Looking at the trend of this commodity, it has fluctuated up and down in the past 7 years. From 2013 it has went down in 2014 then increasing again in 2015. It then steadily decreased in the next 3 years from 2016 to 2018 where it was at its lowest. After that it, went up sharply almost at the level in 2015.

【Figure A.2】 Value of Imported Fish, Frozen, 2013-2019



Source: UN Comtrade

Table A.3 shows the breakdown of the top importation partners of frozen fish to Brunei in terms of value in 2019. The highest importer for frozen fish is Malaysia which imported 2.84 million USD constituting 33% of all imports of this commodity. Second highest is Singapore which imported 2.02 million USD constituting 23% of the imports. The third highest is Vietnam importing 921 thousand USD worth of frozen fish which makes up 10.9% of this import commodity. The rest of the imports come from the countries of Myanmar, China, Japan, Norway, Indonesia, Chile, and combined other Asian countries.

【Table A.3】 Top Fish, Frozen importation partners, 2019

Country	Value (USD)	Share	Country	Value (USD)	Share
Malaysia	2.84 million	33%	Japan	375 thousand	4.45%
Singapore	2.02 million	23%	Norway	346 thousand	4.1%
Vietnam	921 thousand	10.9%	Indonesia	279 thousand	3.31%
Myanmar	443 thousand	5.25%	Chile	227 thousand	2.27%
China	384 thousand	4.55%	Other Asia	197 thousand	2.34%

Source: UN Comtrade

Looking at the specific species of fish imported in this commodity which is shown in Table A.4, 50% are a cumulative of all fishes that are not specified in records. For those which are specifically identified, the top 3 are Mackerel at 1.29 million USD (15.3%), Salmonidae at 1.11 million USD (13.1%), and Atlantic Salmon at 1.01 million USD (12%). The rest are composed of eels, pacific salmon, cod, yellowfin tuna, skipjack/stripped belly bonito, and tunas.

【Table A.4】 Imported Fish, Fresh or Chilled per species

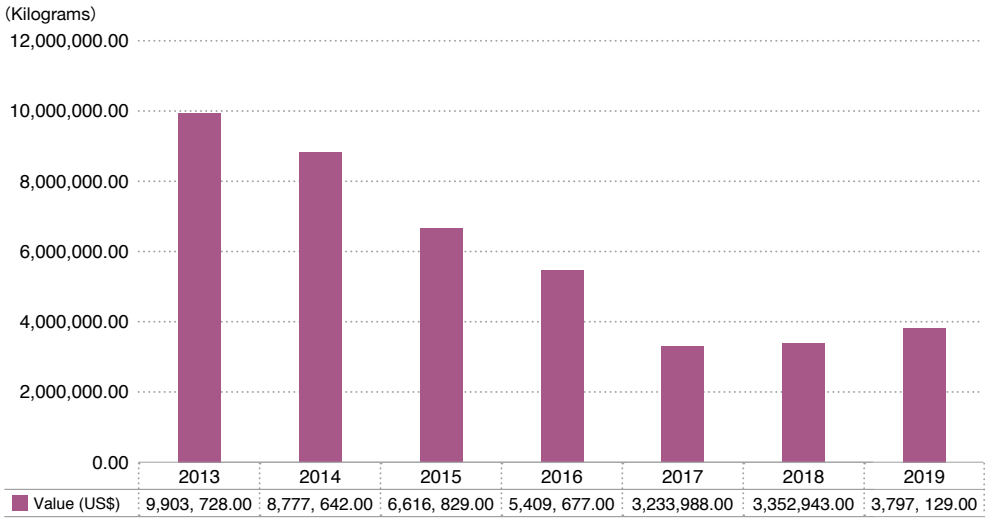
Commodity (fresh / chilled)	Value (in USD)	Share
Fish, n.e.s., (excl. fillets/oth. fish meat /livers & roes)	4.3 million	50%
Mackerel (Scomber scombrus/australasicus/japonicus)	1.29 million	15.3%
Salmonidae (excluding atlantic salmon and danube salmon	1.11 million	13.1%
Atlantic salmon (Salmo salar) **& Danube salmon** (Hucho hucho)	1.01 million	12%
Eels (Anguilla spp.)	222 thousand	2.63%
Pacific salmon (Oncorhynchus gorbuscha / keta / tschawytscha / kisutch / masou / rhodurus)	136 thousand	1.62%
Cod (Gadus morhua/ogac/macrocephalus)	89 thousand	1.05%
Yellowfin tunas (Thunnus albacares)	68 thousand	0.806%
Skipjack/stripe-bellied bonito (Euthynnus (Katsuwonus) pelamis)	65 thousand	0.776%
Tunas (excluding albacore, yellowfin, skipjack, bigeye, bluefin, and southern bluefin)	42 thousand	0.506%

* excluding fillets/other fish meat /livers & roes | Source: UN Comtrade

Crustaceans

The third highest fish and seafood commodity imported by Brunei is fish which are crustaceans which constituted 3.79 million USD (10.1%) of all imports in 2019. Looking at the trend of this commodity in Figure A.3, it has initially gone down then steadily went down since 2013. From 9.9 million USD in 2013, the value of this commodity went down for the next 4 year to 3.2 million USD in 2017. This gradual decrease may be attributed to the increased production of crustaceans like shrimp in the recent years. This then increased a little in the next 2 years with a value of 3.7 million USD in 2019.

【Figure A.3】 Value of Imported Crustacean, 2013-2019



Source: UN Comtrade

Table A.5 shows the breakdown of the Brunei's top importation partners for crustaceans in terms of value in 2019. The highest importer for crustaceans is Malaysia which imported 1.94 million USD constituting half of the imports at 51%. Second highest is Singapore which imported 801 thousand USD constituting 21% of the imports. The third largest is India importing 649 thousand USD at 17.1% of the imports. The rest of the imports come from the countries of Thailand, Australia, Indonesia, Hongkong, Japan, Brazil, and United Kingdom.

【Table A.5】 Top Crustacean importation partners, 2019

Country	Value (USD)	Share	Country	Value (USD)	Share
Malaysia	1.94 million	51%	Indonesia	67 thousand	1.77%
Singapore	801 thousand	21%	Hongkong	16.8 thousand	-
India	649 thousand	17.1%	Japan	7.31 thousand	-
Thailand	168 thousand	4.44%	Brazil	4.72 thousand	-
Australia	131 thousand	3.45%	United Kingdom	4.62 thousand	-

Source: UN Comtrade

Looking at the specific species of fish imported in this commodity which is shown in Table A.6 78% are shrimp and prawns amounting 2.99 million USD. Second highest imported crustacean are crabs amounting to 318 thousand which constitutes 8.38%. Third are frozen crustaceans valued at 204 thousand USD making up 5.38% of the imports. The rest of the imports are composed of lobsters (frozen and otherwise), and rock lobsters and other sea crawfish (frozen and otherwise)

【Table A.6】 Imported Crustaceans per species

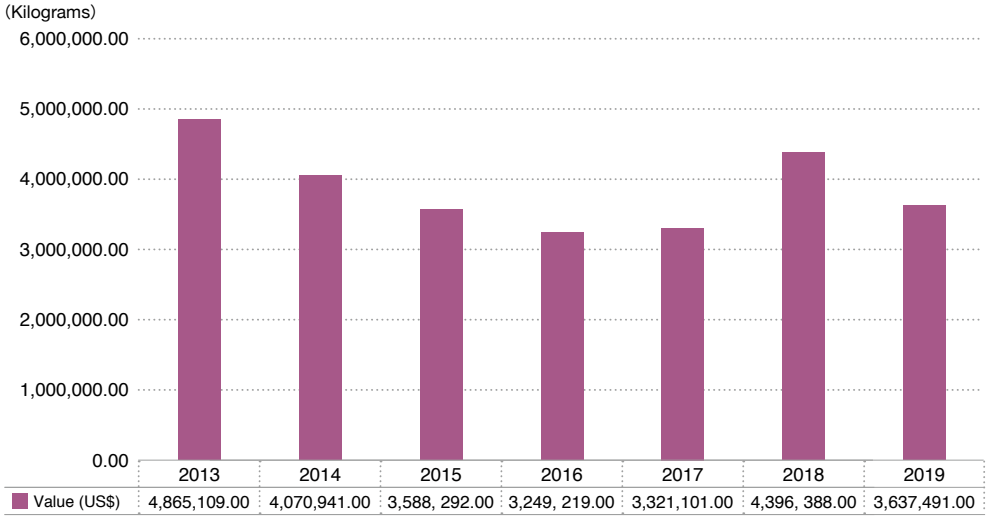
Commodity	Value (in USD)	Share
Shrimps & prawns, whether or not in shell, frozen	2.99 million	78%
Crabs, whether or not in shell, frozen	318 thousand	8.38%
Frozen crustaceans (excl. the above); frozen flours / meals / pellets of crustaceans, fit for human consumption	204 thousand	5.38%
Lobsters (Homarus spp.), whether or not in shell, frozen	139 thousand	3.67%
Lobsters (Homarus spp.), whether or not in shell, other than frozen	90 thousand	2.38%
Rock lobster & oth. sea crawfish (Palinurus spp., Panulirus spp., Jasus spp.), whether or not in shell, frozen	42 thousand	1.11%
Rock lobster & oth. sea crawfish (Palinurus spp., Panulirus spp., Jasus spp.), whether or not in shell, other than frozen	2.18 thousand	0.057%

Source: UN Comtrade

Molluscs

The next fish and seafood commodity imported by Brunei are molluscs which constituted 3.63 million USD (9.74%) of all imports in 2019. Looking at the trend of this commodity in Figure A.4 it has fluctuated in the past 7 years. From 4.8 million USD in 2013, the value of this commodity went down for the next 3 years to 3.2 million USD in 2016. This then increased by 33% at 4.3 million USD in 2018. But then this again decreased to 3.6 million in 2019.

【Figure A.4】 Value of Imported Molluscs, 2013-2019



Source: UN Comtrade

Table A.7 shows the breakdown of the Brunei's top importation partners for molluscs in terms of value in 2019. The highest importer for crustaceans is Malaysia which imported 2.37 million USD constituting more than half of the imports at 65%. Second highest is Singapore which imported 518 thousand USD constituting 14.2% of the imports. This is followed by China importing 391 thousand USD at 10.7% of the imports. The rest of the imports come from the countries of India, Japan, New Zealand, Thailand, USA, Hongkong, and Vietnam.

【Table A.7】 Top Crustacean importation partners, 2019

Country	Value (USD)	Share	Country	Value (USD)	Share
Malaysia	2.37 million	65%	New Zealand	49 thousand	1.37%
Singapore	518 thousand	14.2%	Thailand	30 thousand	-
China	391 thousand	10.7%	USA	23 thousand	-
India	119 thousand	3.28%	Hongkong	21 thousand	-
Japan	51 thousand	3.45%	Vietnam	16.1 thousand	-

Source: UN Comtrade

Looking at the specific species of molluscs imported in this commodity which is shown in Table A.8, 344% are cuttle fish and squid (live, fresh, and chilled) amounting 1.61 million USD. Second highest imports are molluscs & invertebrates (excluding cuttle fish, oysters, scallops, mussels, octopus) amounting to 951 thousand which constitutes 26%. Third are oysters valued at 412 thousand USD making up 11.3% of the imports. The rest of the imports are composed of cuttlefish (other than live/fresh/chilled) scallops incl. queen scallops, mussels, and octopus.

【Table A.8】 Imported Crustaceans per species

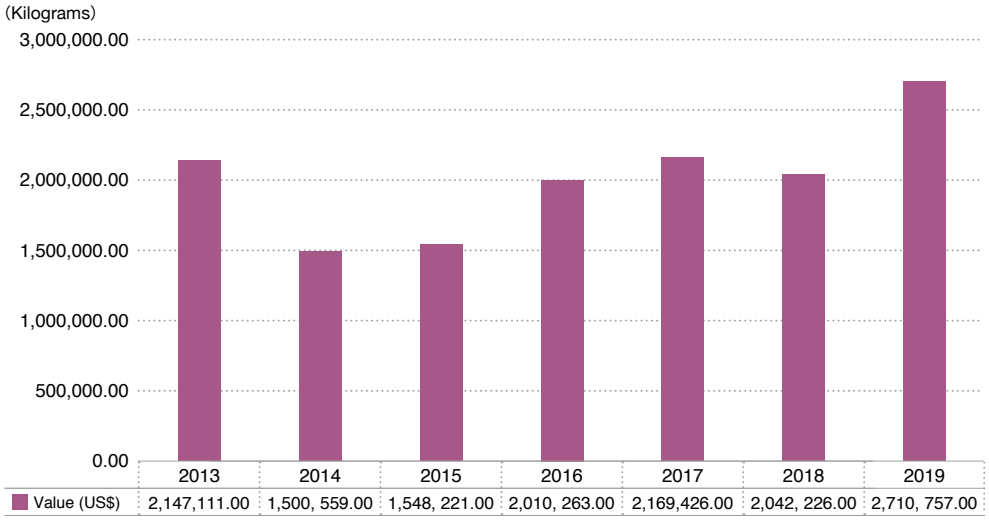
Commodity	Value (in USD)	Share
Cuttle fish (Sepia officinalis, Rossia macrosoma, Sepiola spp.) & Squid (Ommastrephes spp., Loligo spp., Nototodarus spp., Sepioteuthis spp.), live / fresh / chilled	1.61 million	44%
Molluscs & invertebrates (excluding cuttle fish, oysters, scallops, mussels, octopus), frozen/dried/ salted/in brine; incl. flours/meals/pellets of aquatic	951 thousand	26%
Oysters, whether or not in shell, live/fresh/chilled/ frozen/dried/salted/in brine	412 thousand	11.3%
Cuttle fish (Sepia officinalis, Rossia macrosoma, Sepiola spp.) & squid (Ommastrephes spp., Loligo spp., Nototodarus spp., Sepioteuthis spp.), other than live/fresh/chilled	206 thousand	5.67%
Scallops, incl. queen scallops (genera Pecten/ Chlamys/Placopecten), other than live/fresh/chilled	192 thousand	5.28%
Mussels (Mytilus spp., Perna spp.), other than live/ fresh/chilled	190 thousand	5.23%
Scallops, incl. queen scallops (genera Pecten/ Chlamys/Placopecten), live/fresh/chilled	36 thousand	0.993%
Octopus (Octopus spp.), other than live/fresh/chilled	22 thousand	0.625%
Other molluscs & invertebrates, live/fresh/chilled	2.97 thousand	0.081%
Octopus (Octopus spp.), live/fresh/chilled	2.71 thousand	0.074%

Source: UN Comtrade

Fish, Dried, Salted or in Brine, and Smoked

The fifth fish and seafood commodity imported by Brunei are fish which are dried, salted or in brine, and smoked constituted 2.71 million USD (7.26%) of all imports in 2019.(Figure A.5). Looking at the trend of this commodity, it has generally increased in the past 7 years. The value of this commodity went down initially from 2.1 million USD in 2013 to 1.5 million USD in 2014. After this decrease, the value of commodity has steadily increased until 2017, then going down a bit in 2018 then increasing to its highest value in the past 7 years.

【Figure A.5】 Value of Imported Fish (dried, salted or in brined, smoked), 2013-2019



Source: UN Comtrade

Table A.9 shows the breakdown of the Brunei's top importation partners for fish (dried, salted or in brine, and smoked) in terms of value in 2019. The highest importer for crustaceans is Malaysia which imported 2.22 million USD constituting majority of the imports at 81%. Second highest is Singapore which imported 140 thousand USD constituting 5.19% of the imports. This is followed by China importing 94 thousand USD at 3.5% of the imports. The rest of the imports come from the countries of Thailand, Denmark, Philippines, Indonesia, United Kingdom, Netherlands, and Vietnam

【Table A.9】 Top Fish (dried, salted or in brine, or smoked) importation partners, 2019

By Country (2019)		
Country	Value (USD)	Share
Malaysia	2.22 million	81%
Singapore	140 thousand	5.19%
China	94 thousand	3.5%
Thailand	86 thousand	3.17%
Denmark	84 thousand	3.12%

By Country (2019)		
Country	Value (USD)	Share
Philippines	26 thousand	-
Indonesia	21 thousand	-
United Kingdom	18.3 thousand	-
Netherlands	10.2 thousand	-
Vietnam	3.07 thousand	-

Source: UN Comtrade

Looking at the specific type of fish (dried, salted or in brine, and smoked) imported in this commodity which is shown in Table A.10, 57% are dried fish other than cod amounting 1.55 million USD. Second highest imports are smoked fish (excluding salmons and herring) amounting to 468 thousand which constitutes 17.2%. Third are fish other than cod, herring (salted but not dried/smoked, or in brine) valued at 367 thousand USD making up 13.5% of the imports. The rest of the imports are composed of liver ad roes of fish, anchovies, herrings, salmons, cod, and flours, meals & pellets of fish.

【Table A.10】 Imported Fish (dried, salted or in brine) per type

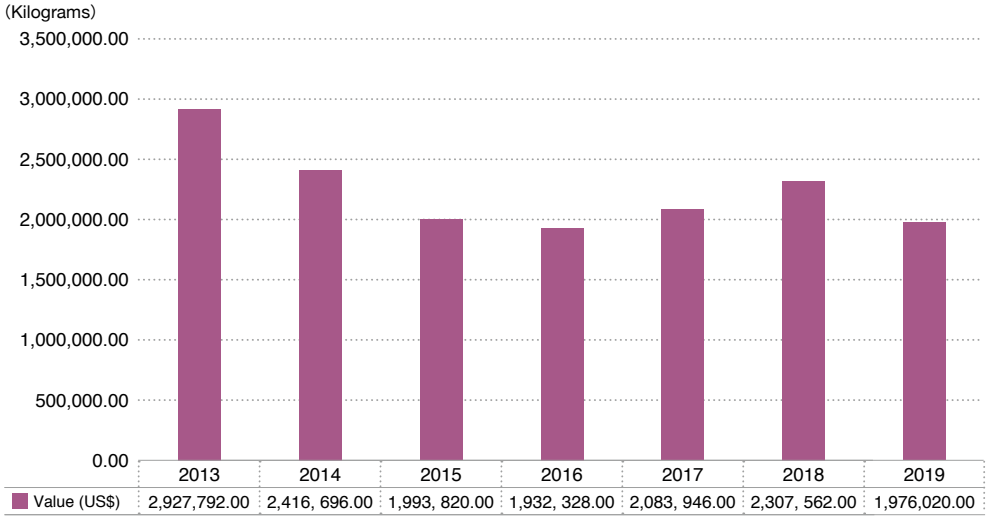
Commodity	Value (in USD)	Share
Dried fish other than cod (Gadus morhua / ogac / macrocephalus), whether or not salted but not smoked	1.55 million	57%
Smoked fish (excluding Pacific salmon/Atlantic salmon/Danube salmon, and herring), incl. fillets	468 thousand	17.2%
Fish other than herrings (Clupea harengus/pallasii), **cod** (Gadus morhua/ogac/macrocephalus) & anchovies (Engraulis spp.), salted (but not dried/smoked)/in brine	367 thousand	13.5%
Livers & roes of fish, dried/smoked/salted/in brine	126 thousand	4.64%
Fish fillets, dried/salted/in brine but not smoked	85 thousand	3.14%
Anchovies (Engraulis spp.), salted (but not dried/ smoked)/in brine	32 thousand	1.19%
Herrings (Clupea harengus/pallasii), smoked, incl. fillets	31 thousand	1.16%
Pacific salmon/Atlantic salmon/Danube salmon smoked, incl. fillets	31 thousand	1.16%
Cod (Gadus morhua/ogac/macrocephalus), dried, whether or not salted but not smoked	10.5 thousand	0.389%
Flours, meals & pellets of fish, fit for human consumption	4.91 thousand	0.181%

Source: UN Comtrade

Fish fillet and other fish meat

The sixth fish and seafood commodity imported by Brunei are fish fillet and other fish meat which constituted 1.97 million USD (5.29%) of all imports in 2019 (Figure A.6). Looking at the trend of this commodity, it has generally decreased in the past 7 years. From 2.9 million USD in 2013, the value of this commodity went down for the next 3 years to 1.9 million USD in 2016. This then increased in the next two years at 2.3 million USD 2018. But then this again decreased again to 1.9 million USD in 2019.

【Figure A.6】 Value of Imported Fish fillet and other fish meat, 2013-2019



Source: UN Comtrade

Table A.11 shows the breakdown of the Brunei's top importation partners for fish fillet and other fish meat in terms of value in 2019. The highest importer for crustaceans is Vietnam which imported 834 thousand USD constituting 42% of the imports. Second highest is Singapore which imported 493 thousand USD constituting 24% of the imports. This is followed by Malaysia importing 282 thousand USD at 12.2% of the imports. The rest of the imports come from the countries of China, United Kingdom, Hongkong, Philippines, Thailand, Netherlands, and other Asian countries

【Table A.11】Top Fish fillet and other fish meat importation partners, 2019

Country	Value (USD)	Share	Country	Value (USD)	Share
Vietnam	834 thousand	42%	Hongkong	67 thousand	3.43%
Singapore	493 thousand	24%	Other Asia	38 thousand	1.92%
Malaysia	282 thousand	12.2%	Philippines	32 thousand	1.63%
China	110 thousand	5.59%	Thailand	30 thousand	1.51%
United Kingdom	84 thousand	4.27%	Netherlands	2.75 thousand	-

Source: UN Comtrade

Looking at the specifics of this commodity (Table A.12), 49% are made of fish meat other than fillets (frozen) valuing at 985 thousand USD. Next are fish fillets (frozen) at 747 thousand (37%), and last are fish fillets and other fish meat (fresh/chilled) at 242 thousand (12.2%)

【Table A.12】Imported Fish fillet and other fish meat, per type

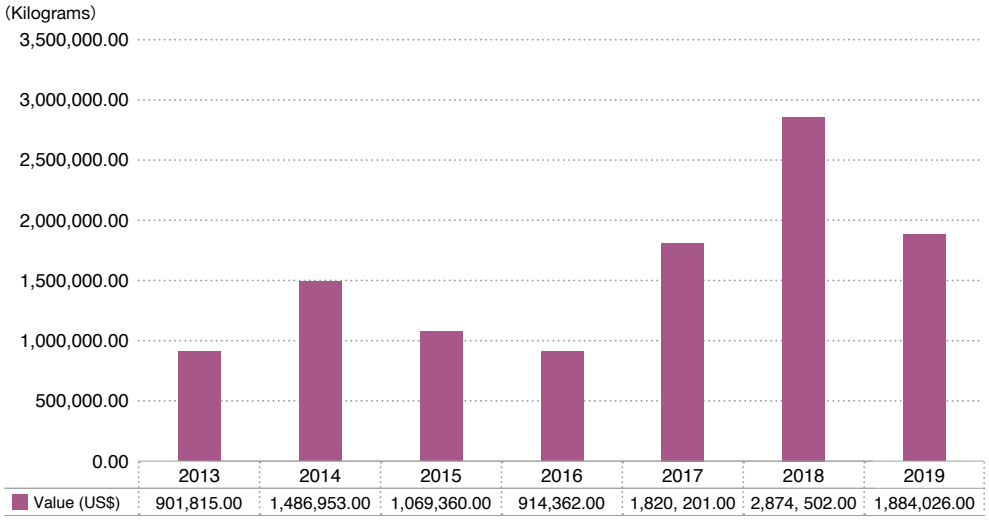
Commodity	Value (in USD)	Share
Fish meat other than fillets, frozen	985 thousand	49%
Fish fillets, frozen	747 thousand	37%
Fish fillets & oth. fish meat, whether or not minced (excl. of 03.02), fresh/chilled	242 thousand	12.2%

Source: UN Comtrade

Live Fish

The seventh and last fish and seafood commodity imported by Brunei are live fish which constituted 1.88 million USD (5.04%) of all imports in 2019 (Figure A.7). Looking at the trend of this commodity, it has fluctuated but generally increased in the past 7 years. From 901 thousand USD in 2013, the value of this commodity increased to 1.48 million USD in 2014 before going down again to 914 thousand USD in 2016. This then increased by a large amount in the next 2 years at 2.8 million USD in 2018. But then this again decreased again to 1.8 million USD in 2019.

【Figure A.7】 Value of Imported Live Fish 2013-2019



Source: UN Comtrade

Table A.13 shows the breakdown of the Brunei's top importation partners for live fish in terms of value in 2019. The highest importer for crustaceans is China which imported 660 thousand USD constituting 35% of the imports. Second highest is Malaysia which imported 511 thousand USD constituting 27% of the imports. This is followed by Indonesia importing 392 thousand USD at 20% of the imports. The rest of the imports come from the countries of Norway, Thailand, Vietnam, Philippines, Singapore, Australia, and other Asian countries

【Table A.13】 Top Fish fillet and other fish meat importation partners, 2019

Country	Value (USD)	Share
China	660 thousand	35%
Malaysia	511 thousand	27%
Indonesia	392 thousand	20%
Norway	201 thousand	10.6%
Thailand	58 thousand	3.1%

Country	Value (USD)	Share
Vietnam	16.2 thousand	-
Other Asia	15.6 thousand	-
Philippines	14.5 thousand	-
Singapore	8.58 thousand	-
Australia	3.38 thousand	-

Source: UN Comtrade

Looking at the specifics of this commodity in Table A.14, 59% are made of live fish not specified in record valuing at 1.12 million USD. Next are live ornamental fish at 549 thousand (29%), next are live trout at 204 thousand (10.8%) and last are live carp at 8.33 thousand (0.442%)

【Table A.14】 Imported Live Fish, per type

Commodity	Value (in USD)	Share
Live fish, n.e.s	1.12 million	59%
Live ornamental fish	549 thousand	29%
Live trout (Salmo trutta, Oncorhynchus mykiss/clarki/ aguabonita/gilae/apache/chrysogaster)	204 thousand	10.8%
Live carp	8.33 thousand	0.442%

Source: UN Comtrade

Appendix B. Ecosystem and Value Chain

Direct translation of ecosystem and value chain tables for fish bleeding, shrimp aquaculture, and seafood processing industries.

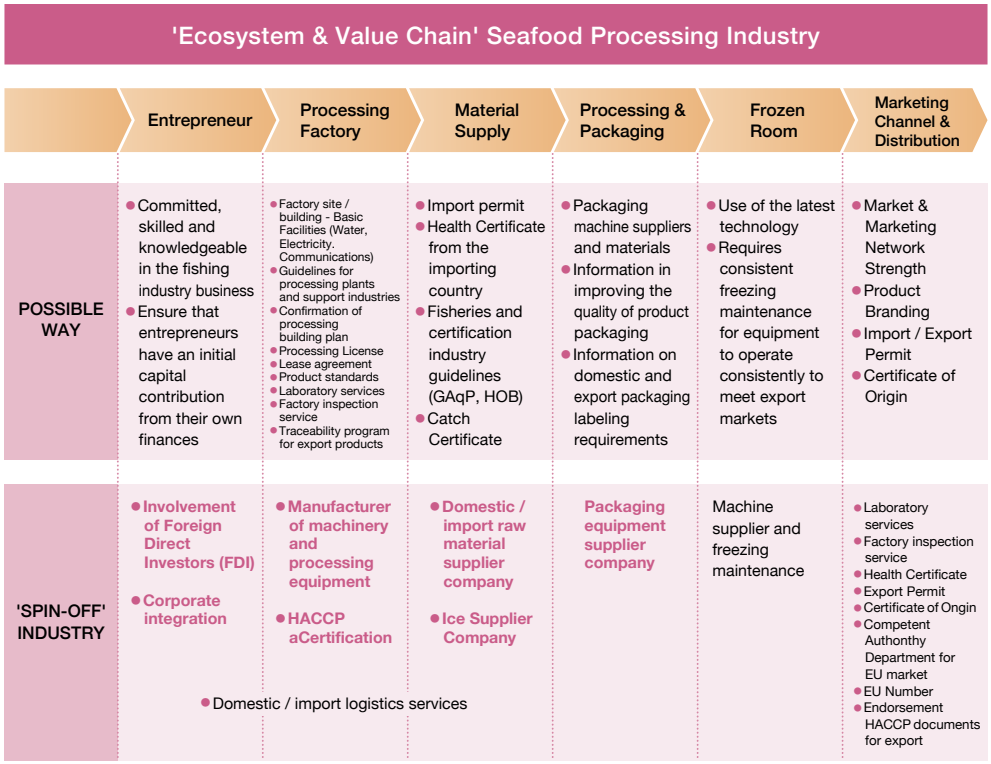
【Figure B.1】 Ecosystem and Value Chain for Fish Breeding and Shrimp Aquaculture Industry

Ecosystem & Value Chain' Fish Bleeding & Shrimp Aquaculture Industry

	Local Entrepreneurs	Hatchery	Technology	Basic Infrastructure	Guarantee & Control	Marketing Channel & Distribution
POSSIBLE WAY	● Entrepreneurs / Local & Foreign Investors (JV& FDIs) ● Capital financial injection	● Provision of Seawater / Freshwater Supply Facilities ● Price Breed Supplies ● Shrimp ● Seedure Livestock Farm License in the pond	● Latest Technology & Innovation ● Applications Financial / Investment ● Resources Technical Expertise/ Skilled Workers ● Certification and Good Aquaculture Practice Guidelines (BGAqP)	● Project Site under the Department of Fisheries news ● Basic Infrastructure ● Water, electricity, roads & telephone lines	● Disease Prevention & Control ● Certification Program ● Display of Manual ● Guidelines International Practices & Procedures	● Product & Cooling Products ● Strength of Market & Marketing Network ● Product Branding ● Print Import / Export ● Certificate of Origin
'SPIN-OFF' INDUSTRY	**Inputs Supply** ● Fish / shrimp food including minced fish ● Supplements. hormones & vitamins, etc. ● Fertilizers & chemicals	**Supplement of Parent Stock** ● Seedlings **Services** ● Hatchery ● Equipment reservation (pool & hatchery)	**Supplies** ● Machines & equipment	**Water supply, electricity and telecommunications** **Transportation and construction services**	**Services** ● Laboratory analysis / testing ● Logistics (land transport)	**Services** ● Storage & Cooling Warehouse ● Logistics (Water Upload & Transport) ● Advertising & Promotion

Source: DOF (2017)

【Figure B.2】 Ecosystem and Value Chain for Seafood Processing Industry



Source: DOF (2017)

Appendix C. Best Practices for Aquaculture Sites and Facilities

• Generic Good Aquaculture Practices

- **Regulatory and non-regulatory compliance –**
  - All aquaculture facilities must make sure utmost compliance with all necessary laws and ensure subsequent review and regular renewal. This includes operational permits, worker health and safety, environmental compliance, and final product safety.
  - Non-regulatory compliance should also be taken into consideration. Included this are producer certification that shows that the facility commits to good practices.
- **Facility siting and design** – selecting sites for aquaculture is a critical aspect must be heavily considered.
  - The area to be chosen must be proper for such industry and must comply with Brunei's national and local land regulation.
  - The site must also be located where it is convenient access to resources and other facilities needed for its operation but must be situated far from areas that could be a source for contamination (e.g., agricultural land that is using pesticides.
  - Design of the facility must also employ features that allow for proper discharge and disposal of wastewater.

- **Source Water –** No matter what form of aquaculture, the source of water is a major consideration.
  - For pond aquaculture, where water is from an external source, the quality should be ensured since it affects the health, quality, and safety of the products. Water sources should be free of organic materials and organisms to avoid possible contamination which can be done by utilizing filtration mechanism and processes.
  - Other than installing filters, periodic testing is also recommended to check if the water's properties are within acceptable levels.
- **Facility Security –** Security does not only mean protecting the facility's physical structure and features, but it also involves ensuring holding, transport, and culture systems be operated and maintained to prevent the escape of animals.
  - Animal intrusion should be prevented to avoid predation of stock and introduction of pathogens and invasive species. This can be done by using exclusion devices such as perimeter fences, pond fences, or netting over ponds.
  - Other effective means are to harass the nuisance wildlife with non-lethal devices such as balloons, aerial noise devices, or noise cannons until the problem abates.
  - Biosecurity is an important aspect as well which can be done by 'cleaning' source water, buying Specific Pathogen Free (SPF) eggs and culture, and setting up appropriate disinfection protocols for farm workers in the facility's entry/exit points. Lastly, access restrictions to medium and high biosecurity zones should be strictly enforced.
- **Animal Health –** It is the utmost goal of the producer to manage the system to reduce the risk of fish health problems.
  - In connection to the source water, water quality and other parameters should be at appropriate levels for the fish that is being raised since each specie has different environmental requirements.
  - Minimizing stress to the fish is included in animal health. Routine monitoring of animal health to develop baseline health indices and subsequent testing can be undertaken.
  - Having a resident veterinarian or one that can be easily contacted will be beneficial to monitor animal health, help administer medicine and supplements, and give overall advice.
  - Fish must be acclimatized first before introducing to a stock to prevent stress to the animal.
  - Development and use of a fish management plan is recommended so as to have a set of steps and protocols to be followed if there would be sudden issues to fish's health.
- **Feed Management –** In aquaculture, fish and seafood would mostly rely on external sources of food through introduced feed to maintain nourishment.
  - It is important to feed the correct nutritional composition, feed size, and feed type (floating, sinking, or slow-sink) to match the species, life stage, and production system being used. Also feed rations are affected by water quality parameters such as

dissolved oxygen and temperature.

- Auto-feeders may be employed to ensure that the amount, timing, and type of feed is appropriate. This involves avoidance of overfeeding by splitting into smaller and frequent rations which can also help in maintaining water quality. Maintenance and cleanliness of the feeding mechanisms should also be observed.
- Feeds must be properly labelled, stored, and checked for expiration

- **Record Keeping –** Records are a significant aquaculture facility good practices component.
  - Maintaining records will help in properly overseeing the operations of the facility. Records include fish inventories (in and out), licenses and permits, cleaning and sanitation, inspections and repairs, feeds, waste management, employee training, employee health, medicine and chemicals.
- **Employee Training –** Employees should be all trained not only in their tasks in the operation of the facility but also on the good practices that is being implemented.

• Production System Practices

- **Recirculating Aquaculture Systems (RAS)**
  - These are systems integrated in aquaculture that is able to recycle or reuse 90 percent or more of the system volume on a daily basis. Using such system will help reduce the wastewater discharged by the facility and ensure that the water in the system is clean and up to expected parameters. This will support in achieving other good practices in water source, biosecurity, and animal health.
- **Raceways –** Traditional raceways are gravity flow-through systems where water flows linearly through a channel and cascades from one raceway unit to another through a system of serial reuse and is then discharged into surface waters.
  - This can be utilized to reduced cost but it is a simpler approach than RAS since it doesn't filter nor recycle water.
  - Raceways should be designed to properly capture the flow and filter debris from entering.
- **Ponds –** Ponds may be classified into either levee ponds or watershed ponds.
  - Ponds should be constructed with ideal dimensions, average depth of 6 feet (1.8m) and minimum shallow depth of 3 feet (0.9m) to allow harvesting and minimization of daily temperature fluctuations.
  - Plastic lining layer and impervious layer of 12 inch (30cm) of compacted clay at the bottom will prevent vertical seepage to the soil.
  - Installation of water pumps capable of delivering about 25 gallons per minute per acre (250 L/minute/ hectare) to replace water lost to evaporation and refill ponds if they are drained at harvest.

- Floating feed is recommended for ponds in order to observe the fish feeding behavior.
- Aeration and proper filtration must also be observed since ponds are a stationary system which may cause stratification and cause stagnation.

- **Aquaponics –** Aquaponics is a system integrated with aquaculture which combines plant production without the use of soil.
  - Dissolved nutrients in the water can be a source of vital nutrient for the plants. This lessens the accumulated waste and puts it into good use.
  - In most system the aquaponic set-up is located at the top of the fish cage and directly feeds on the water. But it is recommended to separate the fish and plant production system to prevent contamination of the plants due to the culture water.
- Cages in Ponds – Cage farming are usually applied to marine aquaculture. But in some instances, cages may be used in ponds where a water source can be used that is not suitable for other aquaculture production techniques.

• Harvesting and Handling

- **Harvesting**
  - Prior to harvest, feed should be withheld for a predetermined number of days to allow for gut evacuation. This enhances the shelf life of the product and reduces the chance for off-flavor in the product due to leaching from the gut.
  - It is also critical to make sure all harvest equipment is in proper working order, that containers for receiving the product are properly cleaned and sanitized, and that sufficient high-quality ice is ready to properly chill-kill the product.
  - All surfaces and utensils that might come in contact with the product must be cleaned and sanitized before processing begins and after each batch of product is processed.
- **Processing**
  - Reduce the temperature of the product as fast as you can using an ice bath or blast freezer, or by spreading the product out in single layers in a refrigerator or freezer.
  - Do not cool the product in big batches.
  - Products should be stored at a temperature of 32 °F(0°C) or colder unless they will be sold immediately. Seafood stored at 32 to 40 °F (0 to 4 °C) will degrade within a few days.
  - Never store product for extended times at a temperature higher than 40 °F (4 °C). Colder temperatures will slow down degradation. To extend shelf life, store product at less than -10 °F (-23 °C) in freezers without defrost cycles.
  - Minimize risk during transportation by ensuring that the transportation vehicle is clean.
  - During transportation, the product should be properly packaged and must be kept frozen or cool to maintain product quality and safety.

Specific Best Practice of Species

Best Practices (Shrimp Aquaculture)

Summary of Best Practices in Shrimp Farming

Physical Farm Set-up

1. External Nursery

2. Central Drain System

Farm Maintenance

1. Sterilisation

a. Pond and Equipment Sterilisation

b. Water Sterilisation

2. Maintain optimum alkalinity level

3. Improving Biosecurity

a. Using pond liners

b. Protect farm with fences

c. Control movement of people and vehicles

d. Place feed and probiotics in a specific storage room

e. Make sure there are labs available in the area

4. Crab and Bird Nets

Tools and Technology

1. Aerators

2. Calibrate all measuring tools

3. Advancing Technologies and tools

Shrimp Management

A. Assess post-larvae (PL) and shrimp health

B. Take shrimp samples regularly

C. Use the baby bucket method for sampling

D. Be aware of moulting

E. Apply probiotics at the right time.

Farm and Industry Management

1. Integrated farming

2. Production Planning

3. Effective management

4. Incentives

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