AQUACULTURE

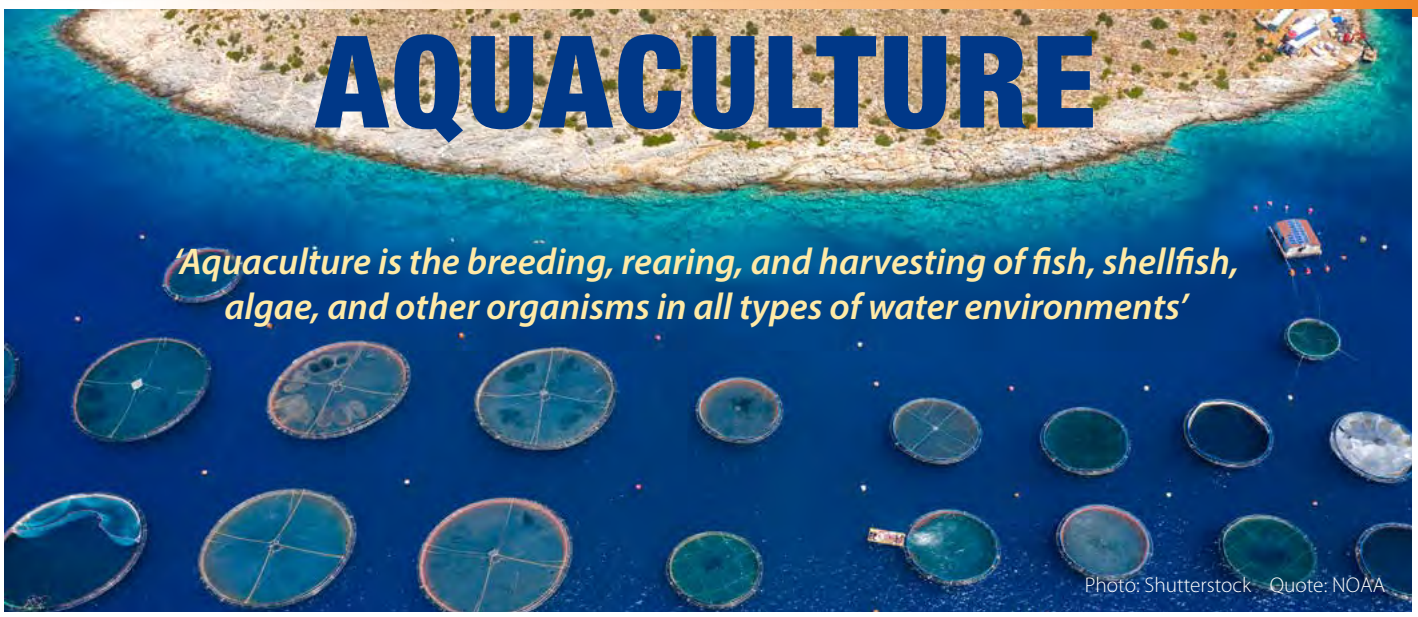


Photo: Shutterstock Quote: NOAA

Lorraine Chaffer, Vice President GTA NSW & ACT

APPROACH 1: Economic Activity (global) – AQUACULTURE
Economic Enterprise (local) – e.g. a salmon, oyster, prawn farm or business

Note: This would suit schools who have a local aquaculture venture e.g. oyster farm they could visit for fieldwork but there may not be sufficient material to focus on that single activity at a global scale.

APPROACH 2: Economic Activity (global) – SALMON AQUACULTURE (or other species)
Economic Enterprise (local) – e.g. a salmon farming business

THE NATURE OF AQUACULTURE

'We must plant the sea and herd its animals, using the sea as farmers instead of hunters'.

Jacques Cousteau

ENGAGE

- Conversation starter: ***Why is aquaculture viewed as both an ecological saviour and an ecological villain of global seafood production?***
- Stimulus: Deep Sea Fish Farming with Geodesic Domes (10 minutes) https://www.youtube.com/watch?v=NSZV_Ikrg0s

  Farms under the sea could feed the world in 2050 (6 minutes) https://www.youtube.com/watch?v=Pm58yVMT3MY

INVESTIGATE

a. Key characteristics

- Aquaculture is the *farming* of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. It involves cultivating freshwater and saltwater species under controlled conditions, in contrast with *capture fisheries*, that harvest wild populations. Farming implies intervention or control over elements of production such as breeding, feeding, containment and protection from predators.
- Aquaculture is one of the world's fastest growing economic activities which, along with capture fisheries, provides *food* to global markets. Aquaculture also provides *feed, fibre, medicinal, cosmetic and consumer products* eg. nutritional supplements and is used to rebuild stocks of species that have been overhunted or harvested.
- Aquaculture has a *long history*, having been practiced for around 4000 years. The Romans (c. 2500 BC), the Chinese (c. 3500 BC) and indigenous peoples in the Americas and Australia all practiced aquaculture.
- Methods of production range from *traditional to scientific and technologically advanced* such as ocean cages with remote feeding systems; scientifically developed fish foods that optimise nutrients and reduce waste; and sophisticated climate controlled indoor facilities.
- *Ownership* of aquaculture ventures varies from small family farms to large Transnational Corporations (TNCs), a feature expected to increase in the future.

b. Diversity

As well as farming a large number of different species in a variety of environments, aquaculture is a diverse activity. It can be:

- *extensive* or *intensive*.
- *subsistence* or *commercial*
- *fresh water* or *saltwater*
- *inland* or *ocean / estuary* (mariculture)
- *'in-situ'* (in bays, estuaries and rivers) or *"ex-situ"* (in tanks, ponds and fish runs).

***Extensive*:** low management, low investment or operating costs e.g. Nile Perch in Lake Victoria

***Intensive*:** human manipulation is prominent and outdoor sites are confined to distinct areas e.g. pearling in Broome, salmon in Tasmania.

***Subsistence*:** exclusively for consumption by the producer or for barter in a local community e.g. fish raised in Asian rice paddies.

***Commercial*:** exclusively for sale e.g. salmon farming in Canada, seaweed farming in Indonesia.

***Freshwater*:** inland rivers and waterways. e.g. carp, eels, trout.

***Mariculture*:** marine plants and animals e.g. prawns, oysters, mussels, seaweed

c. Production

'The Ocean is not a grocery store; we can't continue to take like this without some serious results'
Brian Skerry for the World Economic Forum

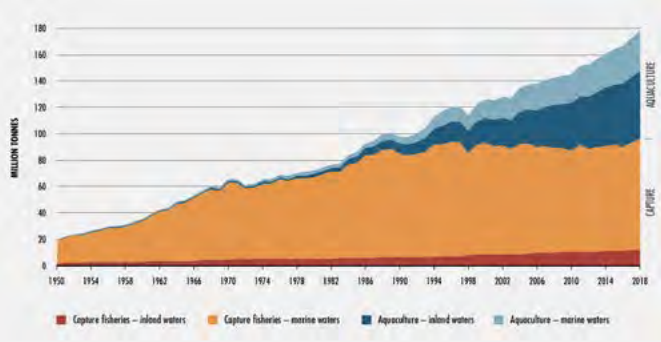
Is our world ready for a blue revolution? A view on fishing and aquaculture from 2009 that still rings true today. TED TALK https://www.youtube.com/watch?v=uk2g9t0KdO4

As human populations and seafood consumption have risen, the global abundance of wild fish has not. Wild harvests have plateaued for over 30 years while aquaculture production has increased globally to meet demand – by 5.3% between 2001 and 2018. (Figure 1). Asia produced 89% of global aquaculture output over the last two decades. Most aquaculture production is finfish (Figure 2) and freshwater aquaculture contributes more than mariculture. Mariculture dominates in Japan compared to China where production is mostly freshwater, however mariculture is increasing e.g. shrimp farming. Other major producers are Egypt, Chile, India, Indonesia, Vietnam, Bangladesh and Norway. (Figure 3)

In Australia the production volume of aquaculture increased by 4% in 2017 – 2018, accounting for 36% of total fisheries and aquaculture production - up from 26% in 2008. The gross value of production (GVP) of aquaculture increased by 5% to $1.42 billion in 2017–18 – the fourth consecutive rise since 2013–14. (Figure 4).

Aquaculture production is projected to reach 109 million tonnes in 2030, an increase of 32 percent over 2018. China's Thirteenth Five-Year Plan (2016–2020) will continue to see a transition from extensive to intensive aquaculture.

Figure 1: World capture fisheries and aquaculture product ion 2018



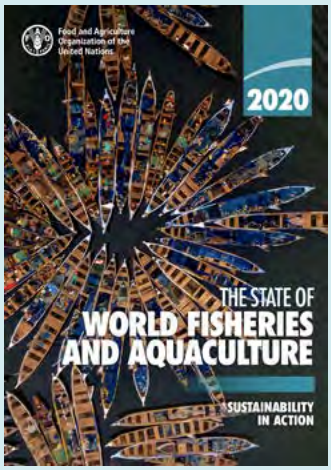
Source: FAO State of World Fisheries and Aquaculture Report 2020 http://www.fao.org/publications/sofia/en/

Figure 2: Finfish

Finfish is the term used to describe a group of fishes, sometimes called true fishes, to distinguish them from other aquatic life whose common names also end in "fish", including molluscs (e.g., cuttlefish), crustaceans (e.g., crayfish), echinoderms (e.g., starfish), and other animals (e.g., jellyfish); or any other aquatic life harvested in fisheries or aquaculture (e.g. shellfish).

Text: https://iss-foundation.org/glossary/finfish/
Image: https://e360.yale.edu/features/can-deepwater-aquaculture-avoid-the-pitfalls-of-coastal-fish-farms

Figure 3: Global aquaculture production



'World aquaculture production attained another all-time record high of 114.5 million tonnes in live weight in 2018, with a total farmgate sale value of USD 263.6 billion. The total production consisted of 82.1 million tonnes of aquatic animals, 32.4 million tonnes of aquatic algae and 26 000 tonnes of ornamental seashells and pearls. The farming of aquatic animals in 2018 was dominated by finfish (54.3 million tonnes).

The farming of aquatic animals in 2018 was dominated by finfish (54.3 million tonnes, USD 139.7 billion), harvested from inland aquaculture (47 million tonnes, USD 104.3 billion) as well as marine and coastal aquaculture (7.3 million tonnes, USD 35.4 billion). Following finfish were molluscs (17.7 million tonnes, USD 34.6 billion) – mainly bivalves – crustaceans (9.4 million tonnes, USD 69.3 billion), marine invertebrates (435 400 tonnes, USD 2 billion), aquatic turtles (370 000 tonnes, USD 3.5 billion), and frogs (131 300 tonnes, USD 997 million).

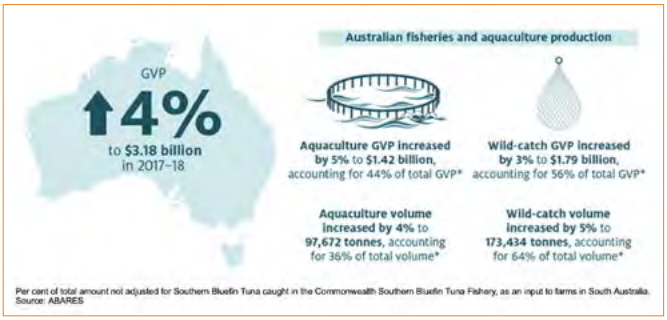
World aquaculture production of farmed aquatic animals grew on average at 5.3 percent per year in the period 2001–2018, whereas the growth was only 4 percent in 2017 and 3.2 percent in 2018. The recent low growth rate was caused by the slowdown in China, the largest producer.

In 2018, inland aquaculture produced 51.3 million tonnes of aquatic animals, accounting for 62.5 percent of the world's farmed food fish production, as compared with 57.9 percent in 2000. Mariculture and coastal aquaculture collectively produced 30.8 million tonnes of aquatic animals in 2018.

Despite technological developments in marine finfish aquaculture, marine and coastal aquaculture produce currently many more molluscs than finfish and crustaceans. World aquaculture production of farmed aquatic animals has been dominated by Asia, with an 89 percent share in the last two decades or so. Among major producing countries, Egypt, Chile, India, Indonesia, Vietnam, Bangladesh and Norway have consolidated their share in regional or world production to varying degree over the past two decades.'

Source: The State of World Fisheries and Aquaculture 2020

Figure 4: Australian aquaculture production 2018



Source: ABARES https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/production-2018#gvp-increases-by-4-in-201718-to-318-billion

d. Consumption

As many parts of the world's oceans face *overfishing by capture fisheries* and popular species become severely depleted, aquaculture has grown increasingly important.

Demand for fish and other aquatic products has risen rapidly over the past 30 years. Australians for example are now consuming 13.5kg of seafood per head per annum (ABARES) compared with 3kg in the 1950's. Seafood prices have risen rapidly as well with increased demand.

Increasing demand for seafood can be attributed to:

- Rising incomes worldwide
- Greater wealth in western countries is increasing the demand for luxury items such as prawns, oysters, crayfish, caviar and crabs
- Newly acquired tastes for fashionable items such as smoked salmon and sashimi and other exotic seafood
- Multicultural influences introducing new tastes for meats such as calamari and sea urchin
- Healthy lifestyles resulting from improved dietary knowledge and demand for fish that is high in protein and essential oils and good fats e.g. Omega 3
- Environmental concerns associated with the production of livestock eg methane emissions, land clearing and climate change

Trade

Seafood is one of the most traded food commodities in the world. Recent increases in seafood trade (4% in 2019) have been mainly driven by farmed species, particularly high-value crustaceans and marine species and lower-value whitefish species traded from Southeast Asia to western countries – a trend expected to continue.

Trade dynamics and routes are likely to change in the future with increasing protectionism, uncertainties in trade relations among trading partners (e.g. Brexit, US-China), the growing aquaculture sector in different parts of the world using new technologies (e.g. land-based and offshore farms), and biological challenges.

COVID-19 has impacted global trade and production in 2020. Projections for the future are based on an assumption of significant disruption in the short run for production, consumption and trade, with a recovery in late 2020 or early 2021.

See Huon Aquaculture illustrative example.

SPATIAL PATTERNS

Aquaculture is a global activity, occurring in almost every country, with Asian countries dominating global production and China dominating in Asia. Generally, higher production occurs in countries with a long history of aquaculture e.g. China and diets incorporating aquatic species e.g. Norway. There is generally less aquaculture production in countries and regions that have large wild catch fisheries e.g. Oceania.

Spatial patterns vary by species, continents and countries due to cultural preferences, biophysical conditions or both. Norway and Chile are renowned for salmon farming that takes advantage of an abundance of cold, high quality water in bays and fjords while shrimp farming is dominated by countries with warmer, shallow bays and inlets such as China, Indonesia and Vietnam.

Other examples of species farmed in different countries

- China: seaweeds and carp and shrimp predominate.
- Japan: yellow tail, bream, salmon, tuna, prawns, oysters, scallops, abalone, algae.
- Russia: sturgeon, salmon, carp, roe.
- North America: catfish, salmon, trout, oysters, prawns (shrimp),
- Europe: catfish, salmon, oysters, mussels, eels.
- Australia: salmon, snapper, oysters, tuna, prawns, pearls, abalone.

See illustrative examples: Seaweed Aquaculture and Huon Aquaculture (Salmon)

For graphs on production, consumption and future projections see:

State of the World's fisheries and Aquaculture 2020 (Document and interactive)
http://www.fao.org/publications/sofia/en/

Prospects for aquaculture by 2030
http://www.eurofish.dk/att/presentations/04-Adrienne.pdf

GTA Bulletin – Vol 52, Special Edition PPT


Source: https://commons.wikimedia.org/wiki/File:Aquaculture_Western_Greece_2004.jpg

FACTORS INFLUENCING THE NATURE, SPATIAL PATTERNS AND FUTURE DIRECTIONS OF AQUACULTURE

BIOPHYSICAL FACTORS

i) Species requirements (Hydrosphere and Atmosphere)

Different species used in aquaculture production require a particular set of *environmental conditions*. Localities that best meet these requirements will have a *competitive advantage*. These conditions will determine where that activity can be located.

The production of *South Sea Pearls* requires sheltered shallow bays with clear warm water. Broome in Western Australia has the ideal biophysical conditions making it the most important pearling centre in Australia. The production of *salmon* requires cold, clean waters, both fresh and salt. Tasmania provides these conditions. When Australia is in drought and Tasmania faces warmer summers production declines. Some aquaculture species require *fresh water*, e.g. yabbies. Others such as shrimp and abalone require salt water. Some like salmon require both environments – the fish hatch in fresh water and grow in brackish water, maturing in saltwater.

Technology is making the impact of biophysical factors less important for some species with production in indoor facilities where computers control environmental conditions and *climate change* is impacting on the viability of some aquaculture activities, especially those in shallow coastal waters.

ii) Water quality

Water quality is one of the most important requirements for successful aquaculture. Pollution can seriously effect production and aquaculture can cause a serious deterioration of water quality. In many areas of the world aquaculture ventures have failed because they have not been ecologically sustainable i.e., they have not maintained the water quality necessary for their survival and have had a disastrous environmental impact and explosion in aquatic diseases. In the past white shrimp farms in China collapsed after they polluted the very water they needed to operate successfully.

iii) Landforms (Lithosphere)

The ideal sites for many maritime activities are flat coastal lands that flood easily or sheltered bays and river estuaries. Figure 5 Inland freshwater lakes and farm dams or village ponds are ideal sites for freshwater species, e.g. Lake Victoria in Egypt and village ponds in China and Japan. Many aquaculture ventures are therefore established in coastal locations or existing lakes and dams.

See illustrative examples: Seaweed Aquaculture and Huon Aquaculture (Salmon)

Figure 5: Coastal bays, inlets and estuaries suit marine aquaculture production

Shutterstock: Salmon farming cages in a coastal estuary

iv) Conflicting water uses

In Asia and South America areas suited to aquaculture are often sites of subsistence rice farming or mangrove forests utilized for resources such as timber and fish. This has resulted in the displacement of traditional farmers and clearing of wetlands.

In coastal areas in the developed world there is also increasing conflict for suitable aquaculture sites with residential, recreational, farming and capture fishing activities. In the Huon Valley estuary in Tasmania landowners claim that salmon aquaculture cages are reducing their property values and sailing clubs are upset about the reduction in the areas within the bays where they can hold regattas.

> 'There are serious constraints on aquaculture's growth. For one, fish farming requires both land and water - two resources in short supply in many areas. In Thailand both these resources have been diverted in recent years to fuel the growth of the aquaculture industry. For example, nearly half the land now used for shrimp ponds in Thailand was formerly used for rice paddies: in addition, water diversion for shrimp ponds has lowered ground water levels in some coastal areas. In China, the concern over loss of arable land has led to restrictions on any further conversion of farmland to aquaculture ponds'
>
> World Resources Institute

ECONOMIC FACTORS

Economic factors are associated with money and capital. As global demand for seafood currently outweighs supply, aquaculture is seen as an economically viable activity for the future as prices are high and supplies are low. This varies on a regional and national scale. Australia imports large amounts of fish to satisfy demand, however, Australia still exports some products such as salmon, pearls and Western Rock lobsters. Peru and Chile are major exporters of seafood.

i) High incomes and profits

There are opportunities to earn high incomes e.g. abalone earns up to $70 per kilogram. Western Rock lobsters can fetch $90 per kilogram and seahorses $1200 per kilogram in the Asian market. For this reason, aquaculture is said to have a very positive economic outlook for the future.

ii) Capital-intensive operations

Set up costs for some ventures are very high e.g. seahorse farms in Tasmania require indoor, climate-controlled facilities and computer monitoring as well as continued research and development. Salmon farms in Tasmania require hatcheries, sea cages and computer-controlled feeding mechanisms. Pearling involves scientific implantation of seeds into oysters – which is carried out in laboratories.

See illustrative example: Huon Aquaculture

On the other hand, yabbies are raised in farm dams in Australia and fish are raised in paddy fields in China. Neither requires huge capital outlays or equipment.

The need for capital equipment affects the spatial pattern of many aquaculture ventures. Europe has the most technologically advanced aquaculture farms because of the level of development means there is capital to invest. In the Pacific Islands aquaculture ventures are largely subsistence activities due to a low level of economic development and lack of investment capital. South Sea pearls are less perfect than "cultured" pearls grown in Australia's northwest around Broome because they involve low levels of technology.

The nature of aquaculture in different parts of the world is a reflection of economic factors. In Asia a significant amount of aquaculture takes place in ponds and dams using ancient techniques such as polyculture. In Australia and Europe, many aquaculture farms use expensive tanks often indoors using capital-intensive equipment and software to maintain temperatures, water flows and filtering.

iii) Exchange rates.

The value of a country's currency can affect the economic viability of aquaculture by affecting demand in other countries. In 2001 the Australian dollar was worth than less than 50 US cents. This meant Australian products were cheaper overseas, so demand increased. In 2012 the Australian dollar rose to over $1.00 US cents to the Australian dollar. This reduced demand for Australian products. In 2020, the Australian dollar fluctuated around 65 – 70 cents to the US dollar.

iv) Economic trade-off in poorer countries

There are some unfortunate *social consequences* of the high value of seafood on global markets.

These include:

- *Poorer countries* have been taking advantage of the high value of seafood by selling it overseas. Unfortunately, countries are often selling one of their main sources of protein and their own population suffer from malnutrition as a result. Many African countries suffer from the commercialisation of traditional fisheries.
- In some *coastal countries* such as Ecuador and the Philippines land has been sold to large TNC's for shrimp farms. Traditional farmers are no longer able to farm rice and huge areas of mangroves have been lost. The consequences have been social as well as environmental (see later notes on environmental factors and sustainability).

v) Economic benefits

The development of aquaculture can have a positive economic impact on a community, a region and a country. In developing countries aquaculture is seen as a means of providing *employment* and important *foreign exchange*. Unfortunately, this often comes at both a social and environmental cost – in Ecuador for example, the environment and indigenous communities were devastated by shrimp farming. In developed countries aquaculture is both a source of employment and a means of satisfying local markets and earning foreign exchange.

Government economic policies such as trade agreements, tariffs and subsidies can impact on the viability of aquaculture activities. Many European Union countries apply tariffs to imported seafood. This means Australian produce cannot compete with locally produced seafoods. This reduces the size of the market available to Australian producers.

ECOLOGICAL FACTORS

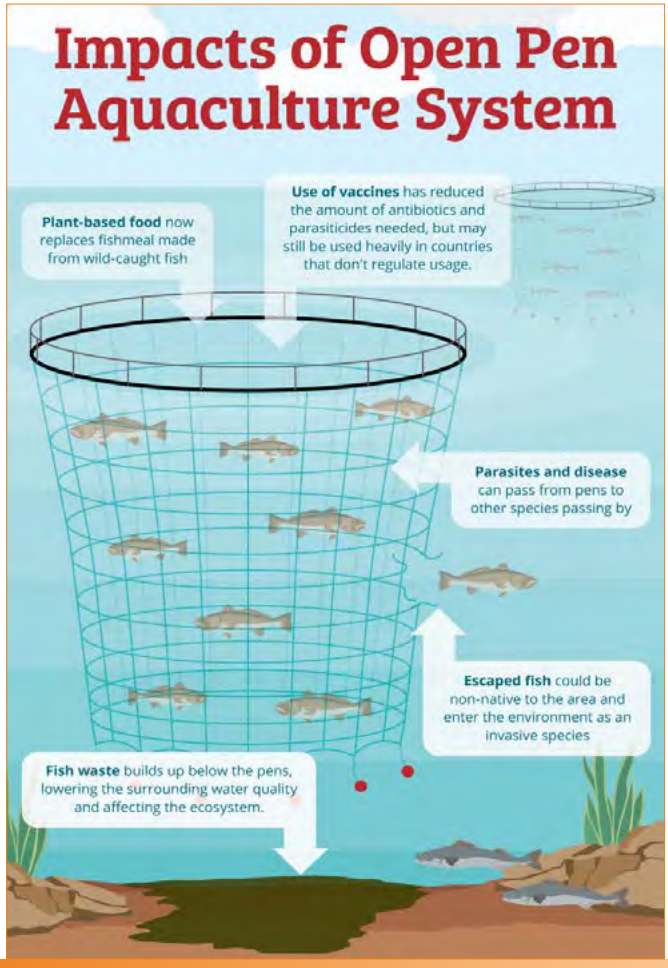
i) Sustainability

The principle behind ecologically sustainable economic activities is that we should use resources to meet the needs of the present without compromising the ability of future generations to meet their needs. The farmers should work with nature rather than against it to ensure the basic ecological processes are not disturbed to the extent that they cannot function in the future.

In the case of aquaculture, the hydrosphere and its maintenance are crucial. The quality and quantity of water must be maintained to ensure the activity itself can be sustained as well as ensuring the survival of any aquatic ecosystems.

A failure to remain ecologically sustainable will impact on the future of the activity, destroying the biophysical environment in the process. Currently, the farming of many species is not environmentally sustainable. Criticisms of aquaculture being ecologically unsustainable have grown in recent years and include the removal of mangrove ecosystems; the use of fish meal (farming the seas to feed the fish); the susceptibility of monocultures to diseases and impacts of escaped species on ecosystems (Figure 6).

Figure 6: Environmental impacts



LEFT: Environmental impacts of fish farming https://www.fix.com/blog/breaking-down-fish-farming/

Salmon cages, Norway. Source: Wikimedia Commons

There are many examples of failed aquaculture ventures because the environment was destroyed.

- White shrimp farms in China. Effluent pollution from these farms destroyed the aquatic environments of the bays and estuaries in which the farms were located. Water quality deteriorated, disease affected the shrimp and production continued to decline resulting in eventual failure. A focus on more sustainable practices is seeing a slow recovery.
- Sea cage farming of salmon has been widely criticised for the amount of nutrients added to the waters around the farms. It takes 100 tonnes of food pellets to produce 50 tonnes of salmon but 20% of the feed falls to the sea floor along with fish faeces.
- Some enterprises use live fish feed or fishmeal harvested from the ocean…not a sustainable practice in our already overfished oceans.

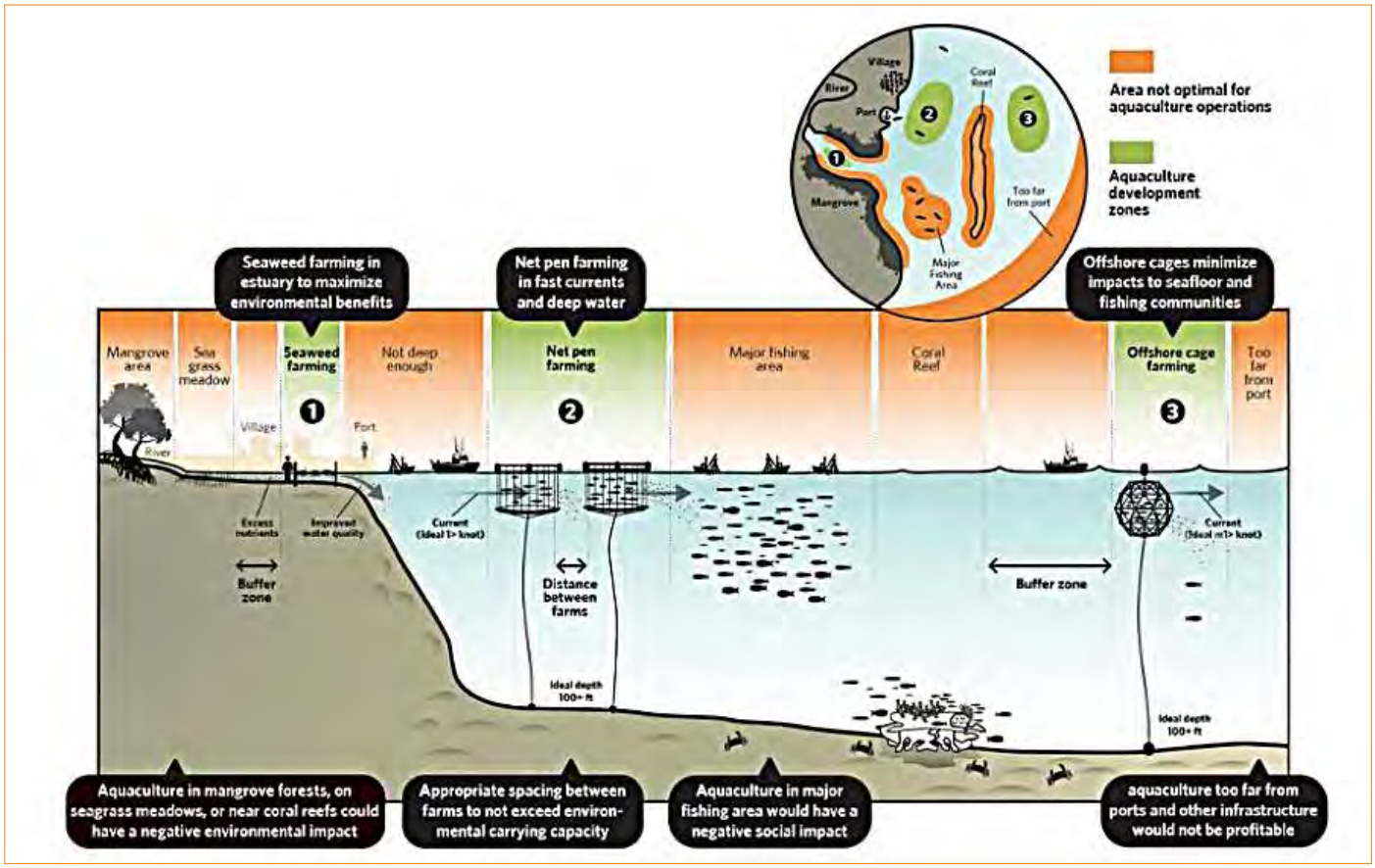
ii) Improving sustainability

There is increasing pressure for aquaculture to be ecologically sustainable and environmentally friendly. People want to know that the seafood they are eating has come from clean waters. Sustainability is not a single technique or practice but encompasses a range of techniques and technologies which vary according to the species farmed. (Figure 7)

Common principles that need to be followed include:

- Determining the carrying capacity of the environment.
- Using techniques that have little effect on the environment.
- Planning for the long-term gain instead of short-term profit.
- Site selection should focus on areas of little biodiversity or less ecosystem importance e.g. mud flats instead of mangrove forests.
- Using settling ponds where waste and nutrients are collected and filtered before water is discharged into the environment.
- Sensible stocking levels.

Figure 7: Aquaculture site considerations for sustainability



Smart Growth in Aquaculture

Siting of aquaculture operations is the first and most critical consideration to minimse negative impacts of aquaculture operations. It is also a critical factor in determining the profitability of an aquaculture operation. To protect the environment and ensure economic growth, aquaculture operations should be sited in optimal locations based on environmental, economic, and social factors.

Source: The Aquaculture Opportunity– https://www.nature.org/en-us/what-we-do/our-insights/perspectives/the-aquaculture-opportunity/
SMART GROWTH IN AQUACULTURE © The Nature Conservancy

Monoculture (one species) is not as sustainable as polyculture e.g. Chinese polyculture pond farming had carried on for centuries using the same ponds because the system includes species that recycle nutrients and reduce wastes.

Many current aquaculture ventures are not sustainable for a variety of reasons the most prominent being over exploitation of the natural environment beyond its' carrying capacity e.g. trying to make large profits quickly by over stocking. Creating sustainable farms is more expensive but with current technology it is possible.

Examples of more sustainable practices include 3D farming, the use of shellfish and seaweeds species to filter wastes, (Figure 8), Integrated Multi-trophic aquaculture (Figure 9) and offshore farming.

Huon Aquaculture in Tasmania is moving to offshore cages to reduce impacts on coastal communities and environments, a move that involves significant investment in infrastructure and technology.

See Huon Aquaculture Illustrative example.

Farming underwater: 3D solutions for land and sea Earthrise (Good animation) https://www.youtube.com/watch?v=yi97si_Wueg

Figure 8: Scallops as water filters

Giant Japanese scallops thrive on fish waste off Canada's Vancouver Island. The farm also uses sea cucumbers and kelp to consume excretions from nearby pens of native sablefish.

Source: National Geographic https://www.nationalgeographic.com/foodfeatures/aquaculture/

SOCIAL / CULTURAL FACTORS

These include features of a society that influence production and consumption of farmed seafood.

i) ***Traditional diets*** like the Japanese rely on seafood as a major source of protein. They are finding it difficult to meet demand from capture fisheries and are relying more on aquaculture and imported seafood. The high incomes mean the Japanese are willing to pay top prices for imported seafood and to invest in aquaculture ventures in other countries.

ii) ***Diet consciousness*** (especially in western cultures) has seen an increased emphasis on low fat and high protein fish diets and a growth in people following 'pescatarian' diets. Increasing knowledge of the benefits of Omega 3 oils in reducing health problems is leading to increased demand for seafood rich in these oils e.g. salmon. Many nations of the developed world are also demanding pollutant free seafood as a part of their increasing health consciousness. Australia's image as a country able to produce "clean and green" seafood has opened markets in Japan.

iii) ***Multiculturalism*** has led to an increased demand for the non-traditional seafoods in many parts of the world. Australia today produces eels, yabbies and seaweeds to satisfy this demand. We are also exporting to parts of the world where these are traditional foods.

iv) ***Socio-economic status.*** In rich countries there is a demand for lobster and caviar. As income levels grow there is increased demand for luxury products. This affects the global spatial pattern as new ventures develop to satisfy the growing demand e.g. Lobster and crayfish farms in Australia.

v) ***Traditional vs modern production methods.*** In China farmers use polyculture to raise several fish species in one pond whereas in Australia and European countries aquaculture ventures tend to be monocultures e.g. a barramundi farm. In the Pacific Islands methods of pearl farming are based on traditional practices where divers free dive to collect oysters grown on lines whereas in Broome, Western Australia methods are much more modern and scientific e.g. scuba.

LEFT: Barramundi farming, Cardwell Qld.. Source: Wikimedia Commons, https://www.fix.com/blog/breaking-down-fish-farming/

TECHNOLOGICAL FACTORS

The use of technology has:

- Made new aquaculture ventures possible.
- Allowed new species to be developed for farming.
- Improved exporting and importing by improving transport.
- Created new employment opportunities and education courses.
- Reduced the importance of the biophysical environment to the location of farms.
- Improved environmental monitoring to ensure the ecological sustainability.

Modern research techniques, new equipment and the ability to create artificial environments in laboratories and indoor facilities has meant an increase in the number of different species of organisms that can be farmed and changed the way they are farmed, e.g. Red Sea Bream in Japan.

The fish are raised from spawn in land-based tanks and hand fed. Eventually they are set free in the ocean. A tower in the ocean emits a feeding signal and food is released through a chute. Nets are then cast after a signal is given making harvesting easy. The fish are fed scientifically formulated food – krill and shrimp – to give them the red colour favourable to consumers.

Technological innovation

3D and Integrated Multi Trophic aquaculture is a modern form of polyculture - with different species farmed down a water column such as below salmon farming cages. Here, species that feed on fish waste eg mussels, are farmed while contributing to improved sustainability of cage aquaculture. These systems are likely to increase in order to promote sustainable practice into the future. (Figure 9)

Progress in *biotechnology* has led to the development of new species through genetic engineering, e.g. At Port Stephens Fisheries Research Centre scientists developed the Sydney Rock Oyster with three chromosomes as opposed to two. This new species cannot reproduce so they concentrate on growth, as a result the oysters reach market size six month earlier and are 27% larger.

Transport technology has opened new global markets e.g. Yabbies' are transported from Western Australia to Europe, and salmon from Tasmania to Japan by chilling and use of refrigerated transport. Products no longer need to be frozen. They can be chilled and arrive fresh to global markets.

The use of technology had reduced the importance of the biophysical factors for many aquaculture activities. Conditions can be reproduced in indoor facilities where conditions such as air and water temperatures and nutrients are computer controlled e.g. Seahorse farms in Tasmania.

The use of technology has increased the demand for highly trained workers such as laboratory technicians and scientists. There is also demand for new research and development with many educational institutions now offering aquaculture courses

Commercial seahorse farming. Source: Wikimedia Commons,

Figure 9: Integrated Multi Trophic Aquaculture (or 3D aquaculture)

Conceptual model for an integrated multi-trophic aquaculture (IMTA) system

The integrated multi-trophic aquaculture (IMTA) system represents a promising new approach to sustainable fish and seafood production. This farming system combines species from multiple levels of the food chain, taking advantage of the fact that wastes from one organism can be a food source for another.

Source: http://www.joycehuiart.com/featured02.php
https://www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/imta-amti-eng.htm

ORGANISATIONAL FACTORS

These factors include the ownership, decision-making and control of aquaculture ventures as well as the structure of organisations. The prospect of huge profits has attracted both large and small entrepreneurs with TNC's often involved. For example, a Thai company, using a major Saudi construction company started a prawn-farming venture in Malaysia.

An *agribusiness* is a single corporation involved in farming, processing and distribution of farmed products. For example, General Foods and Coca Cola have been prominent investors in Ecuador's prawn farming. The aquaculture industry is subject to a lot of bankruptcies, mergers and takeovers often giving a lot of control to one corporation.

Many larger aquaculture companies are vertically and horizontally integrated. *Vertical integration* means the company is involved in many different aspects of the venture, not just farming. e.g. They own processing plants, transport companies, marketing organisations and research facilities. Huon Aquaculture in Tasmania owns its hatcheries and processing plants.

Horizontal integration means they will be involved in other similar farming ventures eg shrimp and salmon farming e.g. Tassal Ltd in Tasmania is both vertically and horizontally integrated company.

These factors influence the spatial pattern of aquaculture through things such as land zoning and licensing of aquaculture farmers. They affect the growth and success of ventures through:

- Tariffs and subsidies
- Import and export licenses
- Research
- Funding / joint ventures
- Environmental restrictions and regulations

In Australia governments are heavily involved at the state level through the fisheries organisations such as the *NSW Fisheries Research Centres* at Port Stephens and Narrandera. At national level they are involved though the work of the CSIRO. Environmental Impact Studies must be carried out before any productive activity can take place. Legislation such as *The Clean Waters Act* required the monitoring of activities that might affect water quality. At a local level Council *land zoning* and *development application* requirements affect present and potential sites for aquaculture.

Government regulations have been enacted to control the taking of brood stock from the wild and their replacement from the stock reared on farms e.g. abalone and bream are raised from wild stock.

'Future mapped out for Tasmania's salmon industry' reports that most of the coastline will be made off-limits to salmon farmers through government zoning but more development is encouraged in high-energy sites. This will impact the nature and location of salmon aquaculture in the state. https://www.fishfarmingexpert.com/article/future-mapped-out-for-tasmania-s-salmon-industry/

Governments across the world are encouraging aquaculture ventures because of the perceived economic benefits. In some cases, they are *partners in aquaculture ventures* e.g. in Tasmania the first salmon hatchery was a joint venture with the Tasmanian government. In Australia the CSIRO is involved in research into potential new species, disease control, environmental monitoring and the development of fish feed. Legislation in Ecuador prohibited the clearing of mangroves for shrimp farming.

SOCIAL, ECONOMIC AND ENVIRONMENTAL IMPACTS

Aquaculture can have a very positive impact on local populations by providing a readily available, high protein food source; employment and improvements in infrastructure.

Negative environmental impacts are the greatest challenges to aquaculture and those receiving the most publicity. Pollution, escaped species and farming the oceans to feed the fish are common complaints

Positive:

- Reducing global demand on capture fisheries
- Satisfying increasing national and global demand for seafood.
- Benefits communities through job creation and businesses supplying goods and services. In 2018 – 20.53 million were engaged in aquaculture.
- Brings tourists – further stimulating the local economies.
- Increasing exports and improve national balance of payments.
- Improving water quality and coastal defenses to natural hazards.

See illustrative examples: Seaweed Aquaculture and Huon Salmon Aquaculture

Figure 10 Benefits of aquaculture for coastal communities

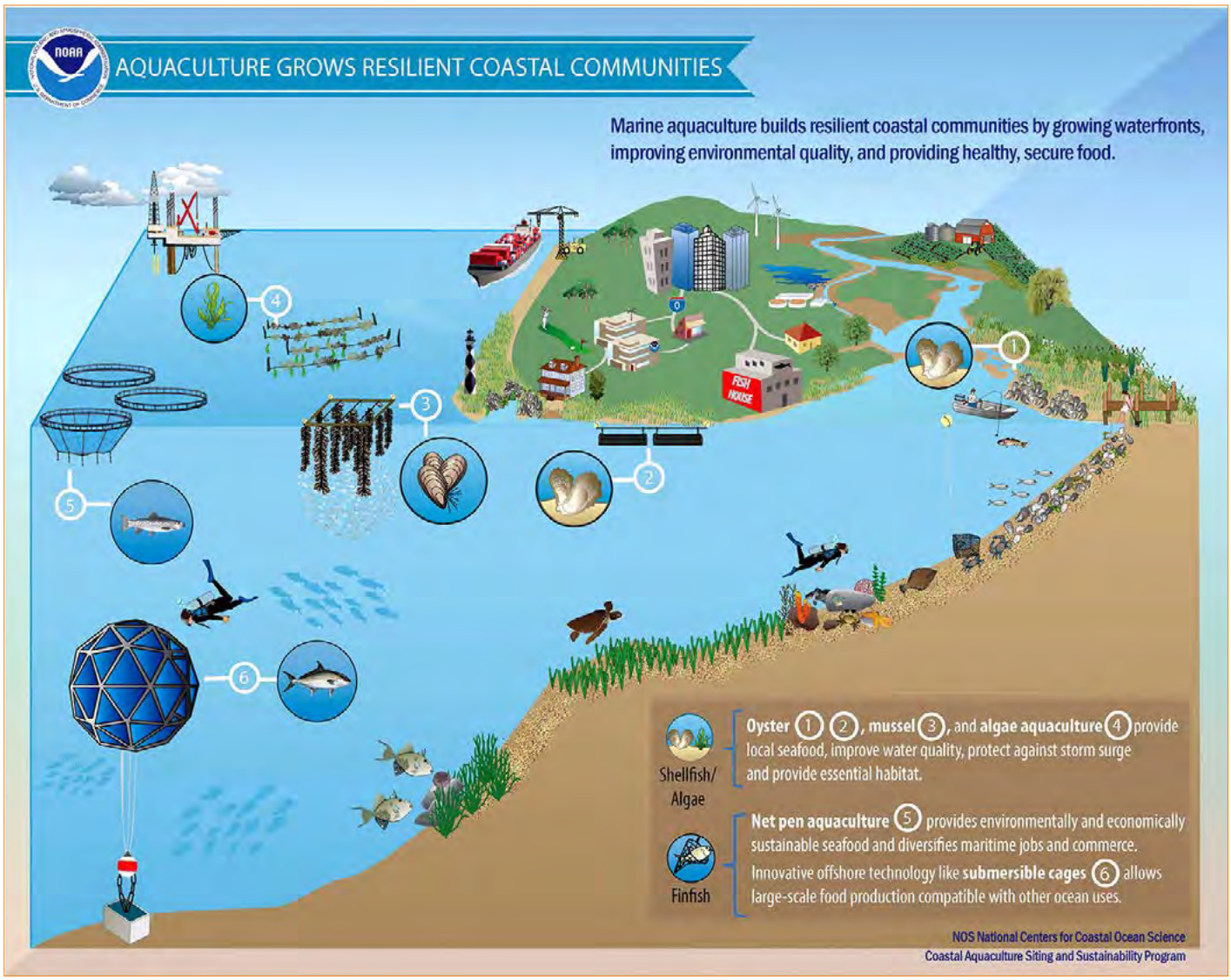


Illustration by Joyce Hui. Source: NOAA https://www.noaa.gov/stories/story-map-farming-in-water

Negative.

- Environmental impacts on coastal ecosystems and species, reduced water quality, noise and poor visual amenity.
- Social upheaval where locals are displaced to make way for fishponds.
- Sale of protein source by people in developing countries. The income is used to buy more carbohydrates increasing malnutrition.
- Can reduce land values in surrounding areas due to operating noise and visual pollution.
- Competes with other economic and social activities eg. Farming and recreation.

The new "blue revolution," which has delivered cheap, vacuum-packed shrimp, salmon, and tilapia to grocery freezers, has brought with it many of the warts of agriculture on land: habitat destruction, water pollution, and food-safety scares. During the 1980s vast swaths of tropical mangroves were bulldozed to build farms that now produce a sizable portion of the world's shrimp. Aquacultural pollution—a putrid cocktail of nitrogen, phosphorus, and dead fish—is now a widespread hazard in Asia, where 90 percent of farmed fish are located. To keep fish alive in densely stocked pens, some Asian farmers resort to antibiotics and pesticides that are banned for use in the United States, Europe, and Japan.

National Geographic: How to farm a better fish – https://www.nationalgeographic.com/foodfeatures/aquaculture/

Globally, expansion into offshore locations is seen as a solution to water quality issues in estuaries and negative impacts on coastal communities at the same time as increasing production and creating employment.

See Huon Aquaculture illustrative example

Source: Shutterstock

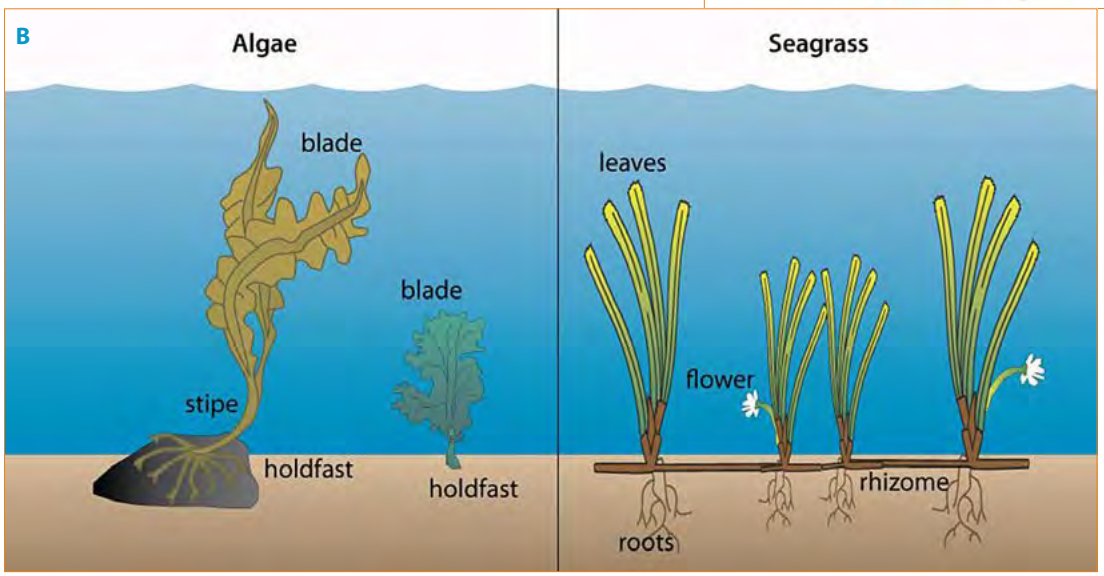
ILLUSTRATIVE EXAMPLE 1: GLOBAL SEAWEED AQUACULTURE

ENGAGE

- Conversation starter:
  Is kelp a socially, economically and ecologically sustainable product of aquaculture?
- Stimulus:
  - YouTube: Kelp Its what's for dinner (6 minutes) https://www.youtube.com/watch?v=0BHfHkOoDGA
  - Belize: Villagers farming seaweed to prevent overfishing https://www.youtube.com/watch?v=lFWiHt0tkng
  - Figure 1: What is seaweed / kelp?
    i. Seaweed is not seagrass.
    ii. Seaweed is algae.

'Algae are classified into three groups: red, brown, and green algae. While some algae have root-like structures called holdfasts, algae do not have true roots or leaves. Like plants, they do photosynthesis, but unlike plants, they are single-celled. These single cells may exist individually or in colonies.'

Figure 1: What is seaweed / kelp?



A: What is seagrass? – https://www.thoughtco.com/what-is-seaweed-2291912

B: Algae vs seagrass – https://ocean.si.edu/holding-tank/images-hide/algae-vs-seagrass

INVESTIGATE

Seaweed aquaculture

Macroalgae have played an important role in coastal communities for centuries with the earliest written record of use in China, about1700 years ago. For centuries, coastal populations harvested seaweeds for food, feed, medicine and industrial uses.

Globally, seaweed is now a highly valued marine resource with an estimated worth in 2019 of around US$9 billion a year. Most seaweed consumption is still for food, with the remainder used for industrial (cosmetics, fertiliser and agars) or feed purposes (such as animal and fish feed).

Seaweed production comes from the harvesting of natural seaweed communities and seaweed aquaculture beds (SAB's). SABs are artificial systems in which seaweeds are attached as germlings to cultivation lines attached to buoys or poles and then allowed to grow until they are of harvestable size.

Spatial patterns of production and consumption

The seaweed industry is undergoing rapid global expansion and currently accounts for ~ 49% of total mariculture production. Exponential growth in the last 50 years has resulted in the increasing value of the industry and growth in employment, particularly in developing and emerging economies.

At a global scale seaweed harvesting and production occurs in a diversity of climates and regions across about 50 countries, dominated by Europe and Asia. Between 2000 and 2014 95% of global seaweed production was in Asian countries. Seaweed aquaculture beds cover extensive shallow coastal areas, particularly in the Asia-Pacific region. The future of seaweed aquaculture is likely to see an increase in the total harvest production following an increase in the number of cultivation areas around the world. In 2019, China was the largest importer of seaweed and the Republic of Korea the largest exporter.

In Australia seaweed imports have increased due to increasing demand for seaweed products. Imports increased by 10,550 tonnes between 2000 and 2017 while exports remain steady. Compared to other countries where seaweed production has developed from a traditional base to commercial production, Australia's industry is in early stages of development and has a mix of harvesting and farming ventures. On the west coast of Western Australia marine algae are produced by aquaculture for beta-carotene and in Tasmania, almost 2,000 tonnes of Undaria or 'wakame' (a delicacy in Japan and the Republic of Korea) was harvested in 2017–2018.

Future directions

Natural seaweed communities and seaweed aquaculture beds (SAB's) have utility and environmental values and are increasingly considered a solution to increasing demands on Earth's natural resources and declining natural environments. The sequestration of CO2, the provision of food and supply of useful chemicals will drive increased demand in the future.

One challenge to the future of seaweed production is climate change. Elevated levels of CO2 and ocean acidification, increased temperatures and rising levels of UVB, affect the performance of seaweeds with impacts varying between species. SAB are considered a valuable contributor to blue carbon, helping to ameliorate increasing anthropogenic CO2 emissions' by increasing the drawdown of CO2. Seaweed is an important component of new initiatives that involve the farming of many species within a column of sea water because of the environmental benefits that increase sustainability.

'Regenerative ocean farming' is another concept linked to seaweed farming. 'It involves growing seaweed and several kinds of shellfish — not just to feed people but to heal the oceans and fight climate change. He said the aim is "going beyond sustainability and using our crops to breathe life back into ecosystems."

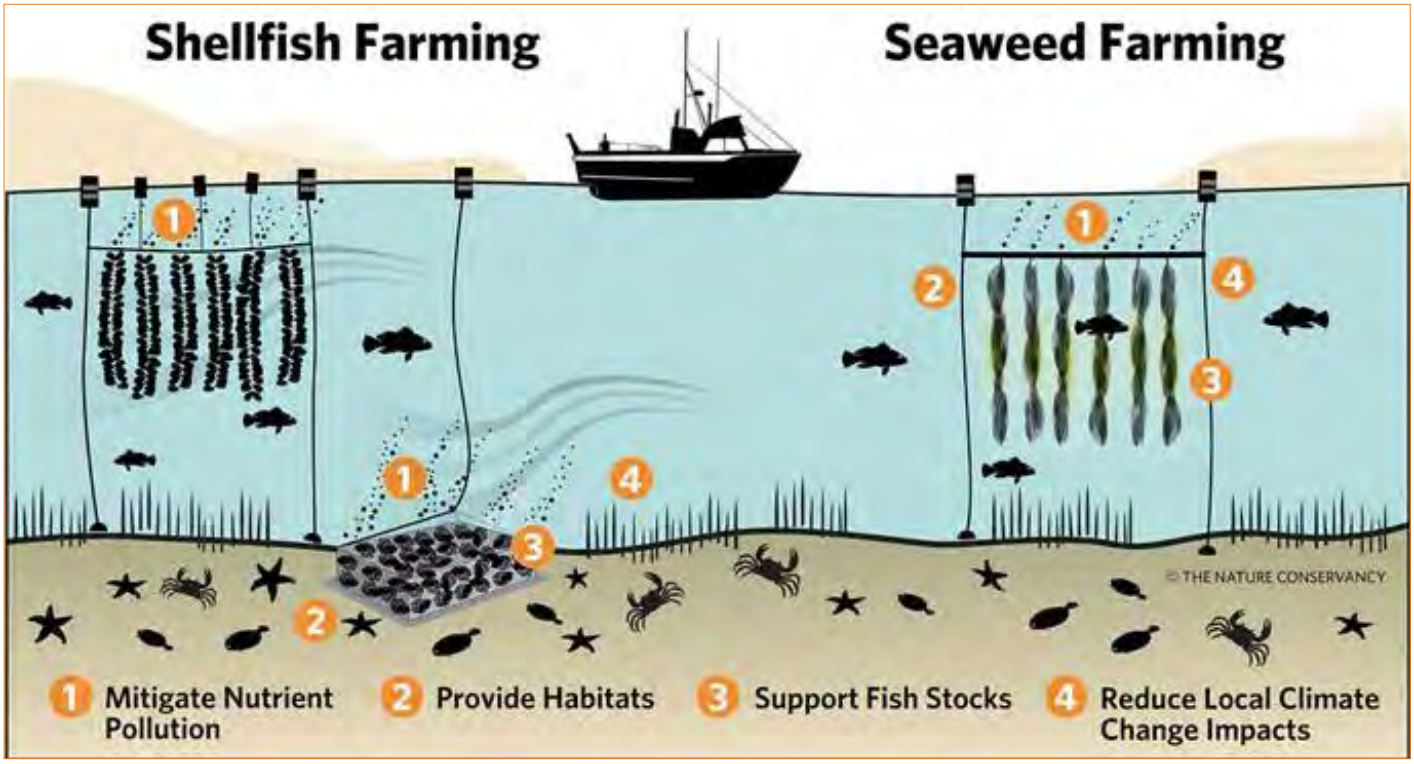
Seaweeds have experienced a renaissance in popularity, prompted in part by the media's take on their applications as 'superfood', with newspapers asking: 'Is seaweed the new kale?', or 'the next superfood?'.

Source: https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1365273

Other challenges to future production include pathogens; epibionts (barnacles, leeches and other marine life that live on the seaweed); grazers and the need to maintain the genetic diversity of seaweeds used in aquaculture.

Seaweed farming, Lembongan. Source: Wikimedia Commons

Figure 2: Seaweed and Bivalve Aquaculture Systems © The Nature Conservancy



Seaweed can contribute to sustainable aquaculture that benefits the environment. Source: Catalysing the Blue Revolution: How Investors Can Turn the Tide on Aquaculture, NATURE – https://www.nature.org/en-us/what-we-do/our-insights/perspectives/how-investors-can-turn-the-tide-on-aquaculture/

Figure 3: 3D Ocean farming

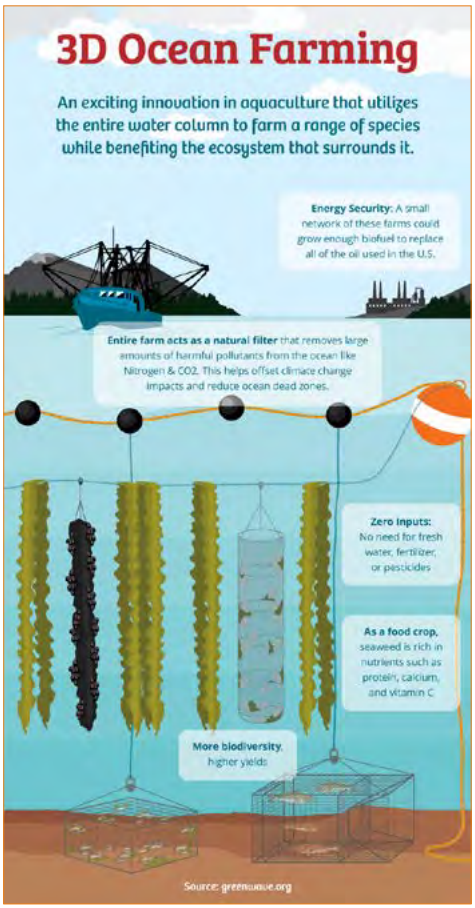
3D Ocean farming

One exciting and new aquaculture method being pioneered right now has been dubbed 3D ocean farming. In these farms, the entire water column is used to grow kelp, scallops, muscles, and oysters, all of which work together to clean our oceans. The farms absorb carbon dioxide and nitrogen from the water, filter out toxins, and could be used as valuable tools to help mitigate the effects of climate change. These farms can be used to grow local food, organic fertiliser, biofuel, and more.

Source: https://www.fix.com/blog/breaking-down-fish-farming/

Figure 4: Low technology, shallow water red seaweed farming in Zanzibar

As the seaweed industry booms, how can we farm seaweed more sustainably?
Credit Leyo /Wikimedia Commons/CC BY-SA 2.5 CH Source: THE WORLD https://www.pri.org/stories/2016-09-24/seaweed-industry-booms-how-can-we-farm-seaweed-more-sustainably



The Environmental Impact of Fish Farming https://www.fix.com/blog/breaking-down-fish-farming/

Figure 5: Satellite view of extensive seaweed farms around Sisan Island, South Korea.

The patchwork of small squares are entire fields of seaweed that are held in place with ropes and buoys to keep the plants near the surface during high tide but off the seafloor in low tide.

Source: NASA Earth Observatory Goddard Space Flight Centre on Flickr – https://www.flickr.com/photos/gsfc/17320902662/in/photolist-soA9UN-soKEa6-KrobV4-hk6iTB-hk4UPe-JTgTpB-hk5o5Y-2iXzsa7-rYNYkz-2c2tDu1-hk6ihr-2c2tJ8E-DLpkBL-s5wdic

ILLUSTRATIVE EXAMPLE 2: HUON SALMON AQUACULTURE (Tasmania)

Huon Aquaculture can be used as an illustrative example of the Economic Activity: Aquaculture, particularly in relation to offshore farming, technological innovation and sustainability OR as a local Economic Enterprise.

There are many layers in the Huon Aquaculture website. This summary is a guide to assist you in finding information quickly

Image source: Shutterstock

Huon Aquaculture began in 1986 when a farming family decided to diversify their Tasmanian cattle and sheep farming enterprises. Salmon are grown in three marine regions: Huon's traditional home – the Huon and D'Entrecasteaux Channel; the unique Macquarie Harbour; and offshore in Bruny Island's Storm Bay. Figure 1

The business has grown into a successful, vertically integrated farming activity that produced nearly 19,000 tonnes of fish (salmon and trout) in the FY2019 and employed over 760 multi-skilled staff (January 2020) located in most states of Australia. Figure 2 Huon employees include biologists, welders, divers, factory hands, accountants, analysts and industry sales and marketers. Huon Aquaculture is recognised globally as a premium producer of fresh and smoked salmon products.

Today, Huon is the only company in Tasmania farming salmon offshore. Prior to ocean farming in Storm Bay, the company closed shallow inshore sites in the Huon River, to reduce the impact of farming operations on neighbours, to improve navigation and safety and reduce environmental impacts.

The following video clips show Huon Aquaculture's operations and directions

YouTube: Get to know Huon (3 minutes, 2015) https://www.youtube.com/watch?time_continue=3&v=17Zfhr8dmGM&feature=emb_logo

LANDLINE: Fish Profit Slump: Managing risks during COVID-19 https://www.abc.net.au/landline/fish-profit-slump:-managing-risks-during-covid-19/12659752?fbclid=IwAR0sK4ePcSNi3kcoD-Ze6eEgZGCeoPMar53NbNOb-U4TeyFwDPDt3IMGNtk

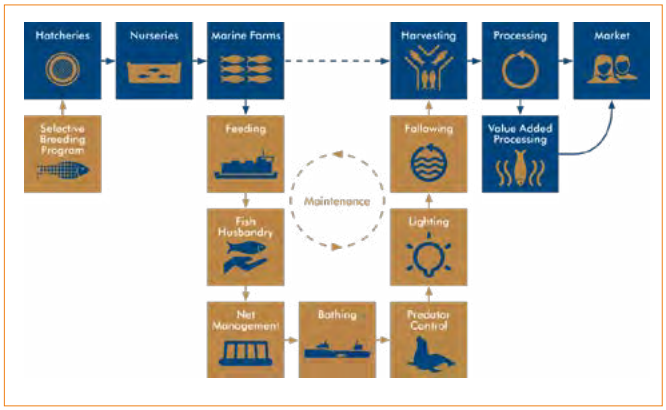
RIGHT: Huon aquaculture https://www.huonaqua.com.au/about/operations/

Figure 1: Huon's marine farm, hatchery and processing facilities

Source: Huon aquaculture https://www.huonaqua.com.au/about/operations/

Figure 2: A Vertically integrated company

Huon Aquaculture does everything from selectively breeding brood stock for egg production, to processing salmon ready for the consumer plate.



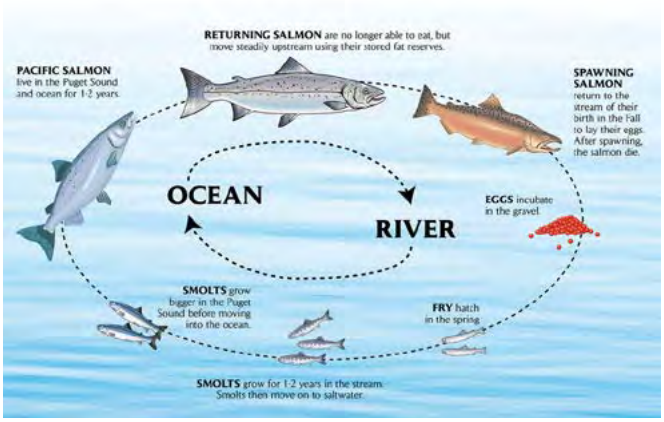
SEE THINK WONDER about wild salmon

Refer to Figure 3 and the YouTube clip about the salmon life cycle.

What are the environmental conditions that need to be replicated to farm salmon?

Figure 3: Salmon life cycle

Atlantic salmon and spend their juvenile phase in rivers before migrating to sea to grow and mature. To complete their life cycle salmon must return to their river of origin to spawn.



Source: http://www.wfpa.org/fish-wildlife/native-fish-amphibians/

YouTube The Life Cycle of the Atlantic Salmon animation (5 minutes) – https://www.youtube.com/watch?v=2fGLzEvWuYA

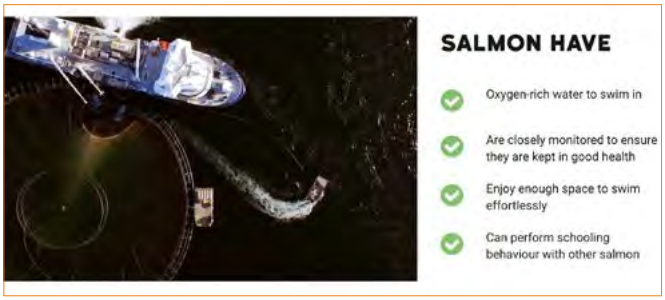
OR

Life cycle of the salmon (6 minutes) – https://www.youtube.com/watch?v=nlSoUXfJEeQ

FARMING OPERATIONS

General introduction and approach to operating including fish welfare – https://www.huonaqua.com.au/our-approach/our-operations/

RSPCA approval – https://rspcaapproved.org.au/rspca-approved-products/farmed-atlantic-salmon



Freshwater Operations

Read about Huon Aquacultures freshwater facilities here – https://www.huonaqua.com.au/our-hatcheries/

Read how a problem led to diversification: Huon caviar – https://www.youtube.com/watch?v=sWBFXbKuYG0

Selective breeding – https://issuu.com/huonaqua/docs/the_huon_story_-_edition_four/s/10345224

Figure 4: Freshwater operations comprise inland hatcheries

Aerial view of the Huon Aquaculture hatchery. Source: https://issuu.com/huonaqua/docs/the_huon_story_-_edition_four/s/10345224

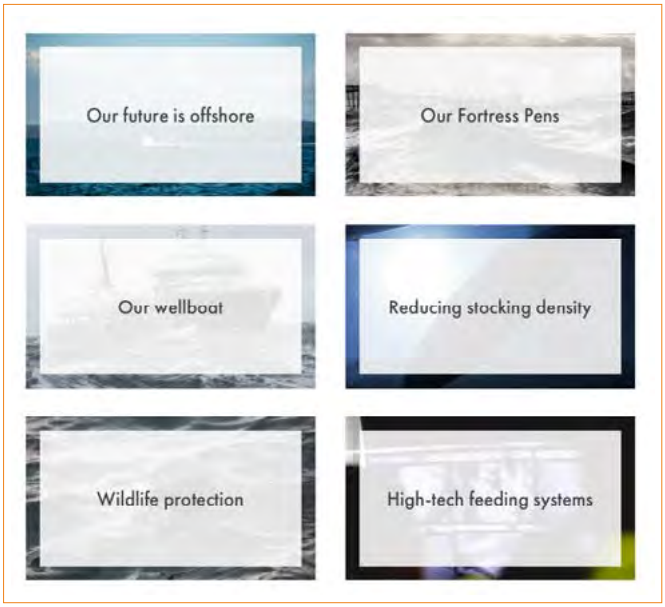
Huon Aquaculture inside a hatchery. Source: https://www.huonaqua.com.au/our-hatcheries/

Offshore operations

Read about different aspects of Huon Aquaculture on the website. Requirements and benefits of offshore sites and how they are selected – https://www.huonaqua.com.au/our-approach/future-fish-farming/offshore-farming/

Aspects of offshore operations

Figure 5: Offshore operations



Screen capture: Huon Aquaculture https://www.huonaqua.com.au/our-approach/future-fish-farming/

YouTube: Offshore operations – https://www.huonaqua.com.au/our-approach/future-fish-farming/

The website contains considerable information on offshore operations including the technology used (fortress pens and wellboats) and link to sustainability.

Sustainability and technology

Huon has a Controlled Growth Strategy (CGS) under which the business has expanded to meet demand and invested in improved freshwater, marine operations and processing. The CGS is guided by six basic principles to achieve sustainability:

- Increasing production to meet growing customer demand responsibly and safely while increasing efficiency of farming practices and improving already high quality of fish
- Improving the health and welfare of fish (RSPCA Approval)
- Improving safety for Huon workers;
- Reducing the company's environmental footprint;
- Continuing to positively participate in the community; and
- Producing world-class salmon products in Tasmania.

Learn more about sustainable freshwater use here: https://www.huonaqua.com.au/our-approach/approach/our-freshwater-use/

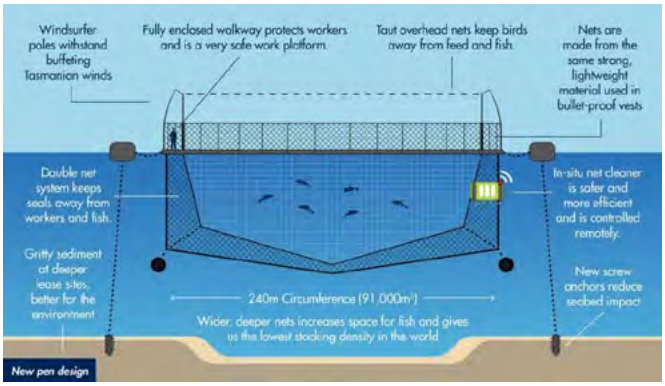
Watch video clips relevant to sustainability

- Large cages to keep stocking density low
- Reducing seafloor waste
- Human and wildlife safety

These clips also demonstrate the application of technology https://www.huonaqua.com.au/our-approach/

To operate on a larger scale and in areas not previously farmed in Tasmania, Huon has used cutting edge technology to innovate and incorporate engineered solutions to enhance production offshore.

Figure 6: Pen design



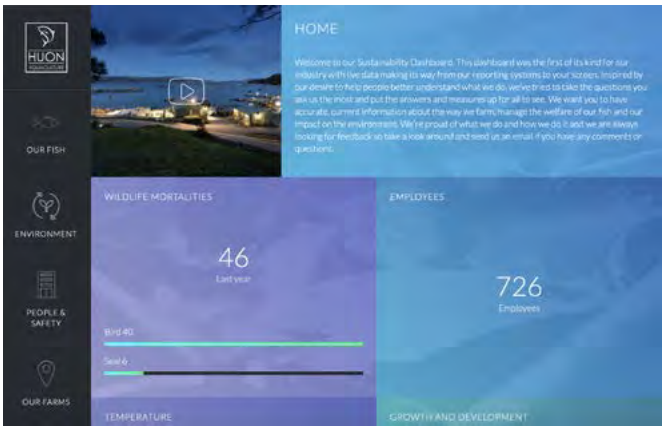
The new pens are a world first in seal and sea-bird protection that will deliver unparalleled safety improvements – for farm workers, for seals, for sea birds, and for the salmon they protect. Read more at https://www.huonaqua.com.au/about/

Figure 7: From the PDF The future of Fish Farming – this image illustrates the importance of technology in meeting production, sustainability and safety targets

Sustainability Dashboard

This online platform shares information about farming operations with the community and public in general in an effort to be more transparent about their business. Data on the Dashboard includes wildlife interactions, temperature and dissolved oxygen data, underwater footage, employee figures, and research spend and more.

Figure 8: Sustainability Dashboard



https://www.huonaqua.com.au/wp-content/uploads/2016/09/Huon-Aquaculture-Future-of-Fish-Farming.pdf

Investigate the interactive sustainability dashboard here: https://www.huonaqua.com.au/our-approach/approach/ethical-farming/sustainability-dashboard/

The future

The future is in offshore farming and the application of technology to remain productive and sustainable.

Read more about the future on the website and linked PDF – https://www.huonaqua.com.au/our-approach/future-fish-farming/

The future mapped out for Tasmania's salmon industry (Political influences) – https://www.fishfarmingexpert.com/article/future-mapped-out-for-tasmania-s-salmon-industry/

The sustainability principles set by Huon Aquaculture are supported through their actions to protest in court government decisions to allow increased operations by rival companies in Macquarie Harbour - on the grounds of environmental impact and carrying capacity.

Several media reports illustrate this story:

Huon Aquaculture takes Tasmanian Government to court over salmon farming in Macquarie Harbour – https://www.abc.net.au/news/2017-02-06/huon-aquaculture-lawsuit-tasmania-government-macquarie-harbour/8244330

Huon Aquaculture loses legal battle against Tasmanian rivals over Macquarie Harbour – http://www.abc.net.au/news/2018-07-06/huon-aquaculture-loses-court-battle-over-macquarie-harbour/9949520.html

All is not perfect

Huon aquaculture do not have a perfect record with fines for breaches of environmental laws in the past.

Huon Aquaculture Convicted of Environmental Breaches – https://tasmaniantimes.com/2020/05/huon-acquaculture-convicted-environmental-breaches/

Escaped Salmon Silence Further Evidence of Self-Regulated Industry – https://tasmps.greens.org.au/media-release/escaped-salmon-silence-further

FACT SHEETS

These Fact Sheets provide more detailed information on many aspects of Huon Aquaculture operations. https://www.huonaqua.com.au/our-approach/fact-sheets/

AQUACULTURE RESOURCES

State of the World's fisheries and Aquaculture 2020 (Document) – http://www.fao.org/publications/sofia/en/

State of the World's fisheries and Aquaculture 2020 (Interactive) – http://www.fao.org/state-of-fisheries-aquaculture

Farming in water: Story map NOAA – https://www.noaa.gov/stories/story-map-farming-in-water

Global aquaculture Alliance – https://www.aquaculturealliance.org/blog/what-is-aquaculture-why-do-we-need-it/

Ocean Matters: The Blue Revolution | Brian Skerry – https://www.youtube.com/watch?v=Zh6VP0AxxxI

ABARES – https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/seafood-consumption-2018

Diversity in species and production

Indigenous aquaculture site Budj Bim added to World Heritage List – https://watersource.awa.asn.au/environment/built-environment/indigenous-aquaculture-site-budj-bim-added-to-world-heritage-list/

Shrimp farming in Australia – https://www.youtube.com/watch?v=n_LEYz_5c4U

Shrimp farm in Japan – https://www.youtube.com/watch?v=9xXANblxqQ0

Feeding 1.4 billion: China's floating fish farms – https://www.youtube.com/watch?v=B4kszhlfvFw

Breeding crayfish under solar panels – https://www.youtube.com/watch?v=byepgkpqjOE

Farm raised Bluefin Tuna – https://www.youtube.com/watch?v=m4r9XC6Ta-s

Aquaculture - the Velella Project - Next Generation Mariculture in Hawaii (6 minutes) – https://www.youtube.com/watch?v=-5GnPGuUhm8

Open-ocean fish farmer: Future of food (6 minutes) – https://www.youtube.com/watch?v=BBbB27698Ug

Sustainability and technology

Introductory Video: Sustainable aquaculture (animation) – https://www.youtube.com/watch?v=fu5wvD9iDyU

The future of seafood. A fascinating look at offshore sea cages seven stories high. – https://www.youtube.com/watch?v=eff-Z0NdwzY

Negative and Positive Environmental Impacts of Aquaculture – https://greentumble.com/environmental-impacts-of-aquaculture/

Ocean farming series – https://oceantoday.noaa.gov/every-full-moon/episode16-oceanfarming/welcome.html

National Geographic: How to farm a better fish – https://www.nationalgeographic.com/foodfeatures/aquaculture/

The Future of Ocean Farming: Innovations in Aquaculture – https://www.youtube.com/watch?v=OXOXn_5PtNI

The Aquaculture Opportunity – https://www.nature.org/en-us/what-we-do/our-insights/perspectives/the-aquaculture-opportunity/

Finally! Healthy fish farming in the deep sea – https://www.youtube.com/watch?v=iWIUM1cnnTE

Farming underwater: 3D solutions for land and sea | Earthrise – https://www.youtube.com/watch?v=yi97si_Wueg&t=551s

The Environmental Impact of Fish Farming – https://www.fix.com/blog/breaking-down-fish-farming/

All About Aquaculture: Environmental Risks and Benefits – https://www.talkingfish.org/2012/did-you-know/all-about-aquaculture-environmental-risks-and-benefits

Seafood Watch – https://www.seafoodwatch.org/ocean-issues/aquaculture

ILLUSTRATIVE EXAMPLE: SEAWEED AQUACULTURE

FAO The global status of seaweed production, trade and utiliSation pdf – http://www.fao.org/in-action/globefish/publications/details-publication/en/c/1154074/

The future of seaweed aquaculture in a rapidly changing world. Retrieved from – https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1359678

Seaweed production: overview of the global state of exploitation, farming and emerging research activity. Retrieved from https://www.tandfonline.com/doi/full/10.1080/09670262.2017.1365175

Australian Department of Agriculture, water and environment – https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/australian-seaweed-production

A New Leaf. Seaweed could be a miracle food—if we can figure out how to make it taste good. – https://www.newyorker.com/magazine/2015/11/02/a-new-leaf

Kelp farming is a win-win when it comes to healing the ocean – https://www.penbaypilot.com/article/kelp-farming-win-win-when-it-comes-healing-ocean/65129

The power of Kelp – https://wsg.washington.edu/community-outreach/kelp-aquaculture/

Kelp farming shown to boost marine biodiversity – https://thefishsite.com/articles/kelp-farming-shown-to-boost-marine-biodiversity

Seaweed Farming: Transforming Fishing into Aquaculture – https://www.energyseek.co.uk/2016/09/04/seaweed-farming-transforming-fishing-to-aquaculture/

Fascinating Satellite Photos of Seaweed Farms in South Korea – https://www.thisiscolossal.com/2015/04/fascinating-satellite-photos-of-seaweed-farms-in-south-korea/

Is algae the food of the future? – https://www.youtube.com/watch?v=tAdrNQNP8ew

Seaweed farming at another level – https://www.youtube.com/watch?v=235gbdhaLOE

Is seaweed America's next cash crop? – https://www.youtube.com/watch?v=geziHoX9GWI

Alaska Sea Kelp Farming – https://videos.fisheries.noaa.gov/detail/videos/aquaculture/video/6095673526001/alaska-kelp-farming:-a-new-sustainable-seafood-opportunity?autoStart=true

ILLUSTRATIVE EXAMPLE: HUON AQUACULTURE

Huon Aquaculture – https://www.huonaqua.com.au/our-approach/

The HUON STORY company magazine contains interesting articles that build deeper understanding of Huon's operations and internal and external linkages, including community involvement and connections. –https://www.huonaqua.com.au/the-huon-story-edition-four/

Edition 1 – The use of baseline surveys to assess seabed flora and fauna at potential offshore sites.

Edition 3 – Technology and trialling the integration of kelp into farming operations

Edition 4 – Antibiotic use, innovation and engaging with education providers

Facebook – https://www.facebook.com/huonaquaculture

ASX Media Release for 2019 – https://www.asx.com.au/asxpdf/20190222/pdf/442vnbkp1rpz36.pdf

Tasmanian salmon farm takes to open, wild water in 'fortress pens' built for millions at Storm Bay – https://www.abc.net.au/news/rural/2019-09-04/millions-of-salmon-make-move-to-open-water-in-southern-tasmania/11432492

Huon Aquaculture. Image source: shutterstock_228638236.jpg

LANDLINE: Fish Profit Slump: Managing risks during COVID-19 – https://www.abc.net.au/landline/fish-profit-slump:-managing-risks-during-covid-19/12659752?fbclid=IwAR0sK4ePcSNi3kcoD-Ze6eEgZGCeoPMar53NbNOb-U4TeyFwDPDt3IMGNtk

ABC news: Huon Aquaculture's revenue grew, but the salmon grower still took a hit due to COVID-19 – https://www.abc.net.au/news/2020-09-01/huon-aquaculture-nets-millions-in-capital-in-tough-conditions/12617384

JUST RELEASED

Australian Seaweed Industry Blueprint

"A seaweed industry offers Australia a sustainable, high-tech and high-value new economic opportunity. By investing and fostering seaweed production, we have the opportunity to improve the health of our bays, oceans and reefs, provide jobs in regional coastal areas, produce high-value products for domestic and export markets, and even make significant progress on mitigating Australia's carbon emissions. Development of a seaweed industry will also assist achievement of the National Aquaculture Strategy's target to increase the current value of Australia's aquaculture industry to $2 billion by 2027.

Source: https://www.agrifutures.com.au/wpcontent/uploads/2020/09/20-072.pdf