MARINE AQUACULTURE: IMPACTS AND INTERNATIONAL REGULATION

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1. Introduction

In the last four decades, the aquaculture industry has undergone such a vast global expansion that it is often referred to as the 'blue revolution'. Stagnation in harvests from wild fisheries and overexploitation of certain species as well as steady improvements in fish processing and trade have brought an enormous vivacity to this sector. Recent figures show that by now, aquaculture supplies half of the fish consumed by the human population worldwide.[1] It has become such an important source of food for humans that it could soon replace wild fisheries as the main source of fish for human consumption, just as agriculture once substituted hunting as the source of most of the meat humans eat.[2]

The production of aquatic species is likely to continue to grow in response to the increasing demand for fish and seafood. The rise in the need for fish and fish products is not merely a phenomenon of western countries, but with the improvement of living standards in developing countries, a higher demand for additional sources of protein, particularly fish, seems to go along.[3] Aquaculture is particularly attractive to accommodate that demand because it provides the ability to manage the complete manufacturing process from the raw material to the end product.[4]

The expansion of marine aquaculture has been widely appreciated by economists, governments and scientists. However, the amount and velocity of the growing production has generated issues over the impacts of the aquaculture industry.

This paper will explore the positive and negative impacts of marine aquaculture, focussing on the ecological effects. Subsequently, it will give a review of the key elements of the current international regulatory framework dealing with marine aquaculture. The paper concludes that, since the effects of marine aquaculture are transboundary, it is a truly a global subject that requires discussion on a supranational level.

2. What is aquaculture?

The word 'aquaculture' has as recently as the middle of the 20th century, been used to describe the art, science and business of producing aquatic plants and animals.[5] It can be seen as a type of agriculture, the difference being that the farming does not take place on land but in water. Aquaculture facilities are commonly referred to as fish farms,[6] meaning a place where aquatic plants and animals are grown commercially in ponds, pens, tanks, or other containers.[7] Aquaculture is also known as 'fish farming' or 'mariculture', the latter referring to marine fish farming.

Many types of aquatic animals commonly referred to as 'fish' are not similarly biologically classified. That applies for example to shellfish, crayfish and jellyfish. In aquaculture, the true fish are often denoted as finfish to distinguish them from these other organisms.

The Food and Agriculture Organization of the United Nations (FAO) defines aquaculture as:

> the farming of aquatic organisms: fish, molluscs, crustaceans, aquatic plants, crocodiles, alligators, turtles, and amphibians. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated.[8]

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[1] Food and Agriculture Organization of the United Nations (FAO), *The State of World Fisheries and Aquaculture 2008* (2009) <http://www.fao.org/docrep/011/i0250e/i0250e00.htm> (accessed 1 April 2010).

[2] C Duarte, N Marbá and M Holmer, 'Rapid Domestication of Marine Species' (2007) 316 *Science* 382, 383.

[3] A Powers, 'Farming the Ocean' (2007) 22 *Natural Resources & Environment* 45, 45.

[4] H Glenn and H White, 'Legal Traditions, Environmental Awareness, and a Modern Industry: Comparative Legal Analysis and Marine Aquaculture' (2007) 38(1) *Ocean Development and International Law* 71, 72.

[5] R O Parker, *Aquaculture Science* (Delmar, 2nd ed, 2000) 3.

[6] In this paper, the words 'aquaculture' and 'fish farming' are used as synonyms.

[7] C Park, *A Dictionary of Environment and Conservation* (Oxford University Press, 2007).

[8] FAO, *CWP Handbook of Fishery Statistical Standards* <http://www.fao.org/fishery/cwp/handbook/J/en> (accessed 1 April 2010).

Thus, the term aquaculture covers a wide range of activities. Marine ranching and stock enhancement are considered to be forms of aquaculture as well. Ranching differs from other forms of aquaculture in that a population of a fish species (eg salmon) is held in captivity for the first stage of their lives, then released, and later harvested or caught as adults.[9]

Present day aquaculture is a highly diverse activity in terms of the modalities, species grown and intensity of operations.[10]

2.1. Location of aquaculture operations

Aquaculture is a truly global production industry, with nearly 180 countries reporting some level of aquaculture activity.[11] However, the worldwide expansion of aquaculture has not been homogeneous across all countries.[12] With some countries contributing a large proportion of global fish production, others are still in the process of developing their industry or just producing small amounts for local markets.

Aquaculture operations can be distinguished according to the different environments in which they take place. Various species, for example carp or trout, are raised in freshwater, such as lakes, rivers or reservoirs. Cultivation of aquatic creatures also occurs in brackish water such as in coves, bays, lagoons or fjords, in which the salinity may lie or generally fluctuate between 0.5 percent and full strength seawater. In mariculture, the end product takes place in seawater, like fjords, inshore and open waters and inland seas in which the salinity generally exceeds 20 percent. At present, most aquaculture production of fish, crustaceans and molluscs takes place in inland waters (61 percent by quantity and 53 percent by value).[13]

Aquaculture is practiced in coastal areas, mangroves, wetlands, natural and artificial ponds, and in artificial structures that re-circulate water. Currently, most marine fish farming is done in coastal areas.

2.2. Products

Aquaculture operations include the production of more than 240 species, from 94 families (this includes 146 fish, 53 molluscs, 30 crustaceans, and 9 plant species) in a wide range of production systems such as ponds, tanks, raceways, and cages.[14] Generally, shrimp and salmon are the main farmed fish. Other species of international economic value are crab, tilapia, molluscs, sea bass and sea bream.[15] In marine operations, the production often consists of high-value finfish and shrimp. However, production in this environment also involves a large amount of relatively low-priced mussels and oysters. The spectacular growth of salmon farming during the last few decades and the resulting drop of salmon prices[16] have motivated fish farmers to launch farming of other marine finfish species, including Atlantic cod, Atlantic halibut, Pacific threadfin, mutton snapper and bluefin tuna.[17]

Aquaculture products are mainly used for human consumption, but also for fish and pet food, fish oil, stocking wild populations, ornamentals (for aquariums), and bait.

2.3. Production methods

Aquaculture facilities can range from small-scale backyard ponds and hatcheries, to large high technology industrial operations employing thousands of people and producing several thousand tonnes of aquatic organisms per year.

[9] Department of Environmental Affairs and Tourism (South Africa), *Draft Guidelines for Marine Ranching in South Africa* (2006) <http://www.mcm-deat.gov.za/mariculture/Ranching%20Draft%20guidelines%20Dec%202006.pdf> (accessed 1 April 2010).
[10] The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), *Assessment and Communication of Environmental Risks in Coastal Aquaculture* (2008) FAO, 3 <http://www.fao.org/docrep/010/i0035e/i0035e00.htm> (accessed 22 April 2011).
[11] F Asche, K Roll and S Tveterås, 'Future Trends in Aquaculture: Productivity Growth and Increased Production', in M Holmer et al (eds), *Aquaculture in the Ecosystem* (Springer, 2008) 275.
[12] Glenn and White, above n 4, 71.
[13] FAO, above n 1, 17.
[14] K Grigorakis, 'Ethical Issues in Aquaculture Production' (2010) 23 *Journal of Agricultural and Environmental Ethics* 345, 346.
[15] L McDorman and T Ström, 'Aquaculture and the Multilateral Trade Regime' in D VanderZwaag and G Chao (eds), *Aquaculture Law and Policy: Towards Principled Access and Operations* (Routledge, 2006) 355.
[16] From the mid 1980s to 2004 the price for Atlantic Salmon fell 75 percent: Asche, Roll and Tveterås, above n 11, 277.
[17] R Goldburg and R Naylor, 'Future Seascapes, Fishing, and Fish Farming' (2005) 3(1) *Frontiers in Ecology and the Environment* 21, 21.

Molluscs, for example, are usually produced along coastlines where wild or hatchery-reared seed are grown on the seabed bottom or in suspended nets, ropes or other structures.[18] Freshwater fish such as carp is farmed in land-based ponds, often in cooperation with agricultural systems. Shrimp are commonly grown in coastal ponds.[19] Production practices of finfish vary widely. While the majority of finfish is farmed in floating net cages, ponds, tanks or other cages are also used.[20]

Aquaculture can be arranged into two basic categories. Extensive fish farming means that fish are reared in nets or cages in their native habitat, such as lakes, rivers or oceans. Mussel farming is an example of an extensive production method, where simply a rope or a stake is needed so that the mussel fry can attach to it and then grow without further interaction by the farmer.[21]

Intensive fish farming refers to the containment of fish in ponds or tanks, where nearly all of their nutrition is provided by the fish farmer. Fish feed depends on the species. Some fish require a vegetarian diet, some are fed zooplankton and carnivores such as salmon will only eat smaller fish.

Commercial farms usually use intensive and semi-intensive methods to produce medium to high-value species for regional or global markets, whereas small-scale family and cooperative farms rely on extensive and semi-intensive practices to produce low-value fish for household subsistence or local markets.[22]

3. Impacts of aquaculture

Before determining the regulatory efforts, it is important to regard the relevant social, economic and environmental aspects of aquaculture. Opinions on aquaculture differ widely between stakeholders such as scientists, environmentalists and fish farmers. Where some endorse the 'blue revolution' and see aquaculture as a key issue in food security and as an alternative to wild fisheries, others claim that aquaculture causes pollution and dangers to food health and animal welfare. Since it certainly is one of the most rapidly growing and complex areas of the global food basket, its impacts deserve to be examined.

3.1. Positive aspects

3.1.1. Food source

Aquaculture has been widely held up as a panacea to the problem of providing a growing world population with sufficient amounts of protein.[23]

The question if mankind will succeed in feeding the growing human population is old and persistent. However, fish has not been part of this concern until recently. Mankind has long regarded the oceans as a vast inexhaustible reservoir of fish, ready for human exploitation.[24] Only in the middle of the last century, marine scientists were recognised by a larger audience when they affirmed that wild fish stocks were finite and could be exploited to depletion. These concerns became serious later, when the overfishing of wild stocks became apparent.[25]

At present, the situation of the world's fisheries can be described as highly problematic. The global fish consumption has doubled in the last half century.[26] Figures of the Food and Agriculture Organization of the United Nations (FAO) for the year 2000 show that fish plays a crucial role in the supply of protein for humans in developing countries. Of all animal protein consumed, fish protein provides around 19 percent in Africa, 21 percent in China and 23 percent in Asia. In regions not fully urbanised, the rate is even higher. For example, in the Philippines, the population acquires 53 percent of essential animal proteins by eating fish.[27]

[18] R Naylor et al, 'Effect of Aquaculture on World Fish Supplies' (2000) 405 *Nature* 1017, 1017.
[19] Ibid 1018.
[20] Ibid.
[21] Asche, Roll and Tveterås, above n 11, 272.
[22] Naylor et al, above n 18, 1018.
[23] S De Silva, 'A Global Perspective of Aquaculture in the New Millennium', in R Subasinghe et al (eds), *Aquaculture in the Third Millennium: Technical Proceedings of the Conference on Aquaculture in the Third Millennium* (FAO, 2000) 431.
[24] Goldburg and Naylor, above n 17.
[25] FAO, above n 1, 153.
[26] S Wilson, 'Sustainable Aquaculture: An Organizing Solution in International Law' (2003) 26 *Thomas Jefferson Law Review* 491, 496.
[27] FAO, *Aquaculture: Not Just an Export Industry* (2003) <http://www.fao.org/english/newsroom/focus/2003/aquaculture.htm> (accessed 6 April 2010).

Along with the population growth and extremely efficient industrial fishing fleets, depletion of wild stocks becomes a widespread phenomenon. The FAO reports that 60 percent of the commercial stocks are overfished.[28] The situation seems to be even more serious for certain species that are fished solely or partially in the high seas. All evidence suggests that the world's oceans have probably reached their maximum wild capture potential.

Aquaculture can play an important role in bridging the gap between supply and demand for fish protein. It may help release pressure on wild stocks and can prevent overfishing, which leads to the depletion of many of the aquatic species now widely farmed.[29]

As recent figures show, without aquaculture the current global amount of fish consumption would be unthinkable. In 2008, the production of farmed Atlantic salmon was approximately 600 times the harvest of wild fish.[30] Seventy five percent of the world's Tilapia supply comes from farming.[31]

3.1.2. Other products of aquaculture

Fish farming provides more than food for human beings. A wide range of products is obtained by aquaculture and used in a variety of commercial goods, such as pharmaceutical products, fertiliser and animal food, including feed for aquaculture operations.

In future, aquaculture may even play a significant role in improving the earth's atmosphere by reducing carbon dioxide. There have been activities to implement a method for capturing carbon from the air and sequestering it as a system to fight global warming.[32] The method, usually referred to as 'iron fertilisation', involves dissolving tons of iron over stretches of barren ocean areas to stimulate an algae bloom. Since the Kyoto Protocol increased pressure on participating states to reduce carbon dioxide emission, several international studies have been carried out in this field.[33] However, there are still obstacles to overcome before algae farming using the iron fertilisation method can be conducted in significant quantities.[34]

Another product relating to algae which might gain importance in future times is biodiesel. Algae are well-adapted for being used in the manufacturing of biodiesel since they perform photosynthesis with a superior rate of efficiency.[35] Several governments promote this process of creating energy, thus we can expect further efforts in this direction.

Furthermore, aquaculture installations can provide new niches for wild populations of aquatic organisms or seabirds that tend to use them as habitats and relate their living and their feeding to them.[36]

3.1.3. Economic growth

Aquaculture is one of the fastest growing food production industries in the world. The international trade of aquaculture products provides important chances for economic development.[37] Ninety percent of global aquaculture production takes place in developing countries and a significant proportion in low-income food-

[28] FAO, *The State of World Fisheries and Aquaculture 2006* (2007) 7 <http://www.fao.org/docrep/009/a0699e/a0699e00.HTM> (accessed 1 April 2010).
[29] Goldburg and Naylor, above n 17.
[30] North Atlantic Salmon Conservation Organization (NASCO), *Aquaculture, Introductions, Transfers & Transgenics* <http://www.nasco.int/aquaculture.html> (accessed 9 April 2010). Moreover, 'wild' salmon stocks are not entirely wild since wild salmon populations have been supplemented by hatcheries. An estimated 4.4 billion salmon fry were released worldwide in 2001: Goldburg and Naylor, above n 17, 22.
[31] World Wildlife Fund, *Global Aquaculture Sustainability Standards Completed for Tilapia* (2009) <http://www.worldwildlife.org/who/media/press/2009/WWFPresitem14387.html> (accessed 13 April 2010).
[32] Powers, above n 3, 46.
[33] See for example Ocean Biogeochemistry & Ecosystems Research Group, *Project Crozex*, National Oceanography Centre, Southampton <http://www.noc.soton.ac.uk/obe/PROJECTS/crozet/> (accessed 8 May 2011).
[34] For a recent and comprehensive overview on this topic, see C Bertram, 'Ocean Iron Fertilization in the Context of the Kyoto Protocol and the Post-Kyoto Process' (2010) 38(2) *Energy Policy Volume* 1130.
[35] German Federal Ministry of Education and Research, *Mikroalgen - die Energiequelle der Zukunft* (2008) <http://www.bmbf.de/_search/searchresult.php?URL=http%3A%2F%2Fwww.bmbf.de%2Fde%2F12360.php&QUERY=algen> (accessed 2 April 2010).
[36] D Roycroft, T Kelly and L Lewis, 'Birds, Seals and the Suspension Culture of Mussels in Bantry Bay, a Non-Seaduck Area in Southwest Ireland' (2004) 61(4) *Estuarine, Coastal and Shelf Science* 703, 703.
[37] McDorman and Ström, above n 15, 376.

deficit countries.[38] With the growing demand for fish products, aquaculture becomes more and more an economically significant factor in these countries, generating jobs and export revenues.[39]

In countries like Indonesia, aquaculture plays an important role in increasing income for traditional small-fish farmers.[40] In other regions, such as Chile, aquaculture is not conducted by single farmers but by global operating companies, using large, factory-like facilities.

3.2. Concerns

The concerns related to the negative impacts of marine aquaculture depend on a range of factors.

3.2.1. Impacts on marine environment and biodiversity

The environmental interactions of fish farming differ in nature and degree with the aquatic organisms produced. Some effects are localised, whereas others occur cross-boundary. However, changes in local marine ecosystems can influence the ocean ecosystem as a whole.[41]

3.2.1.1. Destruction of habitat

Generally, aquaculture is regarded as being responsible for destroying fragile marine ecosystems. In particular, effluent discharge from chemicals used to control diseases and nutrient pollution is a serious concern.

Commercial farming requires certain operational practices such as feeding and medication, which harm the water quality and thus the biotope aquaculture organisms share with other species. Aquaculture facilities produce vast amounts of pollution by dumping organic matter resulting from fish metabolism (faeces, excretion, and mucus), feed losses (uneaten feed) and antibiotics. Even in developed countries, the waste from aquaculture facilities is rarely treated.[42] The way marine facilities are constructed does not stop these substances from reaching surrounding waters. Furthermore, aquaculture activities may impact not only the water resources of the country where the farming occurs, but the water resources of other countries with abutting coastal areas or countries close enough in proximity to be negatively affected.[43]

Common feeding practices result in about 85 percent of phosphorus, 80 per cent of carbon, and 52–95 percent of nitrogen input into fish cages being lost into the wider environment because of feed wastage, fish excretion, faeces production and respiration.[44] Therapeutants and vitamins add to that influx. Studies have revealed that there is a sizable accumulation of solids from the feed in the bottom sediments under and in the vicinity of fish farms, reaching out up to one kilometre into the seabed and lasting for several years.[45] In the immediate neighbourhood of aquaculture sites, this causes high levels of oxygen demand, anoxic sediments, toxic gas production and reduced benthic diversity in low energy areas.

The rapid growth of the aquaculture industry is contributing to ecological concerns. For example, the US National Oceanic and Atmospheric Administration (NOAA) has announced the goal of establishing a maritime aquaculture industry of $5 billion annually by 2025.[46] The corresponding quantity of farms will produce nitrogen equivalent to the amount discharged by untreated sewage from approximately 17.1 million people for one year.[47]

To run most profitably, farms are often equipped with a high density of stock that generate vast amounts of waste. Even in non- secluded areas of the ocean as the Exclusive Economic Zones (EEZs) or high seas, accumulation of sewage on the seafloor can harm marine biodiversity.

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[38] FAO, *Technical Guidelines for Responsible Fisheries No. 5: Aquaculture Development* (1997) 3 <http://www.fao.org/fishery/ccrf/publications/guidelines/en> (accessed 8 April 2010).
[39] Wilson, above n 26, 498.
[40] Powers, above n 3.
[41] Wilson, above n 26, 501.
[42] D Hopkins, R Goldburg, and A Marston, 'An Environmental Critique of Government Regulations and Policies for Open Ocean Aquaculture' (1996-7) 2 *Ocean & Coastal Law Journal* 235, 237.
[43] Powers, above n 3.
[44] R S S Wu, 'The Environmental Impact of Marine Fish Culture: Towards a Sustainable Culture' (1995) 31(4–12) *Marine Pollution Bulletin* 159, 159.
[45] Ibid.
[46] United States Department of Commerce, National Oceanic and Atmospheric Administration, *Aquaculture Policy* <http://aquaculture.noaa.gov/pdf/18_docaqpolicy.pdf> (accessed 12 April 2010).
[47] Goldburg and Naylor, above n 17, 25.

The method in which mariculture facilities are constructed also raises environmental concerns. Typically, farms use floating pens anchored to the seabed, which require bottom dredging and thus have a negative effect on these vital ecosystems.[48] The materials and the paint used may pollute the sea with toxic chemicals.[49] The maintenance of the cages with the use of chemicals such as antifoulants, and pesticides add to environmental loadings.[50]

Furthermore, the facilities may be located in areas where their presence can harm the natural environment. Shrimp farms in Southeast Asia often result in the destruction of host environments. Farming in this region often takes place in coastal zones consisting of vast mangrove woods which are essential for healthy populations of many wild fish.[51] Shrimp aquaculture in Thailand and Vietnam has destroyed vast acreages of woods, eliminating flora and fauna and producing foul water.[52]

3.2.1.2. Food web interactions

Negative impacts of aquaculture not only threaten the environment, but other areas as well. There are several secondary impacts on other production systems. As aforementioned, aquaculture is promoted by its advocates as being a solution to the problem of food shortage in a growing world population. However, to meet that target, the aquaculture industry will have to change its focus since present day fish farming does not contribute to growth of aliments efficiently. [53]

This is mainly due to the fact that carnivorous species such as salmon and shrimp need to be provided with protein. The manufacture of fish feeds is mainly based upon fish meal and fish oils, which are not renewable resources. The amount of other species to be fished to feed carnivorous farm stock fish disproportionally exceeds the amount of farmed fish produced: it requires a minimum of three kilograms of food fish to earn one kilogram of farm fish. It is obvious that farming carnivore species thus may have a negative effect on wild stocks. Fisheries for fish food contribute to the problem of stock depletion, lessen the amount available to wild fish, and interfere with food webs. The problem is highly significant since 25 percent of farmed fish worldwide is salmon.[54] If this kind of farming expands, aquaculture will only supplement, rather than provide a substitute for wild fisheries.[55] Farming plant-eating fish such as tilapia and filter-feeding creatures such as scallops, mussels and oysters, however, produces a net increase in the world's supply of fish.

The growing production of carnivore fish such as salmon and sea bass and thus the increasing amount of fish meal needed leads to far-reaching consequences. For example in 2001, 17–20 million tons of wild caught fish,

[48] M Connolly, 'Thinking Globally, Acting Locally: Cleaning up Global Aquaculture through Eco-Labelling in the United States' (2005) 26 *Public Land and Resources Law Review* 121, 129.
[49] Powers, above n 3, 46.
[50] R Gowen and N B Bradbury, 'The Ecological Impact of Salmonid Farming in Coastal Waters: A Review' (1987) 25 *Oceanography and Marine Biology Annual Review* 563; H Ackefors and M Enell, 'The Release of Nutrients and Organic Matter from Aquaculture Systems in Nordic Countries' (1994) 10 *Journal of Applied Ichthyology* 225; P Read and T Fernandes, 'Management of Environmental Impacts of Marine Aquaculture in Europe' (2003) 226 *Aquaculture* 139, 140.
[51] Mangroves are salt-tolerant trees and shrubs that grow in the shallow tidal waters of estuaries and coastal areas in tropical regions. Their muddy waters, rich in nutrients from decaying leaves and wood, are home to sponges, worms, crustaceans, molluscs and algae, and provide shelter for marine mammals, snakes and crocodiles. They act as fish nurseries and help feed life further out to sea: Our Planet, *Mangroves and estuaries* <http://www.ourplanet.com/aaas/pages/eco06.html> (accessed 5 April 2010).
[52] Powers, above n 3, 46.
[53] As the following table illustrates, traditional animal husbandry may, in some cases, be a more efficient provider of animal protein and thus an appropriate way to feed a growing human population.

Production system	*Industrial energy input required to produce one joule of edible protein*
vegetable crops	2 – 4
sheep farming	10
mussel culture	10
cod fisheries	20
chicken farm	22
cage farming of rainbow trout	24
semi-intensive shrimp aquaculture	40
cage farming of Atlantic salmon	50

Source: J Larsson, C Folke and N Kautsky, 'Ecological Limitations and Appropriation of Ecosystem Support by Shrimp Farming in Colombia' (1994) 18(5) *Environmental Management* 663.
[54] K Wyman, 'Property Rights in Environmental Assets: Economic and Legal Perspective' (2008) 50 *Arizona Law Review* 511, 513.
[55] Goldburg and Naylor, above n 17, 24.

such as anchovies, sardines, and capelin were fed as fish meal to 17.7 million tons of aquaculture fish.[56] Small fish farmers around the world producing mainly for local markets will suffer from depletion of small fish stocks. It is unlikely that they will be able to keep up in the cutthroat competition for fish.

A further concern in relation to food web interactions is the safety of fish feed used on farms. Protein products have been found contaminated by various substances including antibiotics. [57] Moving up the food chain, these substances become more potent and pose a threat to human consumers' health.[58]

3.2.1.3. Introduction of non-indigenous organisms

Further concerns critics of aquaculture frequently cite are related to the escape of aquaculture organisms from farms, which happens frequently. Taking Norway as an example, estimates of the minimum number of escaped salmon vary between 200 000 and 500 000 fish annually.[59] Reasons for escapes are technical failures, towing of cages, handling errors, predators, and damage by floating objects or boat propellers.

Aquaculture can also cause the introduction of non-native and hybrid species into the marine host environment. Escaped fish will transfer parasites and diseases and compete with wild fish for mating, food and other natural resources. Typically, farm fish are raised to be voracious - which is an advantage for the escapees over wild fish. Occasionally, through escapes some species are introduced into a region which is not the natural habitat of those species. This can have fundamental effects on the balance of the respective ecosystems. As for example in Chile, before fish farming, salmon was not part of South American fauna. Since vast volumes of that carnivore have been unintentionally released into the open seas, the food chain has been severely impaired.[60]

Another aspect is genetic contamination. Farm-raised fish may be less healthy and vital, so that interbreeding with wild stocks affects the gene pool negatively. The aquaculture industry has also initiated studies concerning transgenic fish, i.e. fish that has been genetically modified to improve characteristics appropriate for farming. For example, North American scientists have generated transgenic Atlantic salmon, which possesses either antifreeze protein genes or a growth hormone gene construct.[61] The introduction of that fish in natural habitats will have a tremendous impact and the consequences to wild stocks are difficult to predict.

3.2.1.4. Impacts on marine mammals and birds

In Chile, the growing number of salmon farms has caused increased mortality of sea lions. They accidentally get caught up in nets of aquaculture operations or are intentionally shot by farmers. The same has been observed from birds attempting to prey on farm fish in Australia.[62]

In Scotland, acoustic devices are used to deter predators from nets. These devices may expel sound sensitive whales and dolphins from a much larger area and thus their natural habitat.[63]

3.2.2. Conflicts with other uses of the oceans

The wide spread of aquaculture operations can raise conflicts with other uses of the sea. Navigation lanes have to be kept clear of obstructions.[64] More important, the area fish farming takes place in is often equally valuable for

[56] Ibid 23.
[57] Powers, above n 3, 46.
[58] H Babcock, 'Grotius, Ocean Fish Ranching, and the Public Trust Doctrine: Ride 'em Charlie Tuna' (2007) 26 *Stanford Environmental Law Journal* 21, 21.
[59] L P Hansen and M Windsor, 'Interactions Between Aquaculture and Wild Stocks of Atlantic Salmon and Other Diadromous Fish Species: Science and Management, Challenges and Solutions' (Norwegian Institute for Nature Research (NINA) Report 34, October 2006) NASCO, 8 <http://www.nasco.int/pdf/reports_other/conveners_report.pdf> (accessed 9 April 2010). Similar numbers are quoted for the state of Washington: M Schatzberg, 'Salmon Aquaculture in Federal Waters: Shaping Offshore Aquaculture through the Coastal Zone Management Act' (2002) 55(1) *Stanford Law Review* 249, 256.
[60] For more information, see the film *Salmonopoly* (Directed by W Huismann and A Schumann, Anaconda International Films for WDR, 2009).
[61] For detailed information, see G Fletcher et al, 'Gene Transfer: Potential to Enhance the Genome of Atlantic Salmon for Aquaculture' (2004) 44(11) *Australian Journal of Experimental Agriculture* 1095; D Moodie, 'Transgenic Fish' in D VanderZwaag and G Chao (eds), *Aquaculture Law and Policy: Towards Principled Access and Operations* (Routledge, 2006) 421; S Venketesh, C Dayananda, 'Properties, Potentials, and Prospects of Antifreeze Proteins' (2008) 28(1) *Critical Reviews in Biotechnology* 57.
[62] Greenpeace, *Challenging the Aquaculture Industry on Sustainability: Technical Overview* (2008) 19 <http://www.greenpeace.to/publications/Aquaculture_Report_Technical.pdf> (accessed 22 April 2010).
[63] Scottish Executive Central Research Unit, *Review and Synthesis of the Environmental Impacts of Aquaculture* (2002) The Scottish Government, 30 <http://www.scotland.gov.uk/Resource/Doc/46951/0030621.pdf> (accessed 22 April 2010).
[64] W Howarth, 'Global Challenges in the Regulation of Aquaculture' in D VanderZwaag and G Chao (eds), *Aquaculture Law and Policy: Towards Principled Access and Operations* (Routledge, 2006) 23.

traditional fishing or conservation. Industrial aquaculture facilities that are supposed to run economically and efficiently require a large amount of space, which will then be lost to other uses. Especially near coastal areas, aquaculture competes with recreational uses of shores and ocean. Noise, odour and visual impacts can pose a significant nuisance. Tourism in particular is driven by the desire to have extensive, uninterrupted ocean views. Aquaculture cages or mussel rafts typically have large surface structures, so that there is a possibility of conflicts occurring in coastal areas.[65]

Moreover, aquaculture could have other negative effects on traditional fishermen. Critics fear that traditional fishermen will lose access to offshore fishing grounds and that the value of their harvest will decline due to the supply of low priced farmed fish.[66] Traditional fishing communities could thus experience an economic deterioration.

3.2.3. Concluding remarks

The high seas can no longer be regarded infinite and indestructible as they once were. They have been used as a huge dumping ground since the beginning of industrialisation, but now societies of developed as well as less developed countries recognise the need for a change. The oceans have endured a lot of contamination from vessels, land-based activities and offshore operations. With aquaculture being a new source of pollution from a recently enormously increasing industry, impacts to the fragile marine environment and biodiversity have to be monitored carefully.

4. Regulation of marine aquaculture

This chapter discusses the international framework for marine aquaculture, outlining key instruments and initiatives.

The regulation of marine aquaculture is not confined to aquaculture-specific legislation. Where relevant provisions are not specifically provided, they may exist in other regimes. Looking at international regulation, mariculture is mainly affected by two regimes of law: law of the sea and international environmental law.

At the end of this chapter, the paper will discuss the prospect of an opportunity for effective regulation of aquaculture by non-governmental initiatives.

4.1. Law of the sea

International law of the sea is primarily determined by the provisions of the United Nations Convention on the Law of the Sea (UNCLOS) of 1982, which became effective in 1994.[67] The treaty was aimed to establish;

> a legal order for the seas and oceans which will facilitate international communication, and will promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment.[68]

The UNCLOS provisions on the protection and preservation of the oceans are widely acknowledged as generally applicable rules of customary international law.[69] Thus, although the US is not a party to UNCLOS, it has recognised most of its provisions as binding.[70]

Aquaculture per se is not outlined in the convention, since the topic was not recognised as being of international significance at the time of its enactment. However, the convention has a holistic approach when saying in its

[65] T Dempster and P Sanchez-Jerez, 'Aquaculture and Coastal Space Management in Europe: An Ecological Perspective' in M Holmer et al (eds), *Aquaculture in the Ecosystem* (Springer, 2008) 91.
[66] Babcock, above n 58, 23.
[67] The treaty incorporates, modifies and expands on the law of the sea contained within the 1958 Geneva Conventions: the *Convention on the Territorial Sea and Contiguous Zone*, opened for signature 29 April 1958, 516 UNTS 205 (entered into force 10 September 1964); *Convention on the Continental Shelf*, opened for signature 29 April 1958, 499 UNTS 311 (entered into force 10 June 1964); *Convention on the High Seas*, opened for signature 29 April 1958, 450 UNTS 11 (entered into force 30 September 1962); and the *Convention on Fishing and Conservation of the Living Resources of the High Seas*, opened for signature 29 April 1958, 559 UNTS 285 (entered into force 20 March 1966).
[68] *United Nations Convention on the Law of the Sea*, opened for signature 10 December 1982, 1833 UNTS 3 (entered into force 14 November 1994) Preamble ('UNCLOS').
[69] P Sands, *Principles of International Environmental Law I: Frameworks, Standards and Implementation* (Manchester University Press, 1995) 294.
[70] For a discussion of the recent ratification debate, see the Pew Environment Group, *Pew Campaign to Ratify Law of the Sea* <http://ratifylawofthesea.org>.

Preamble 'that the problems of ocean space are closely interrelated and need to be considered as a whole' and that it 'takes into account the interests and needs of mankind as a whole'. Thus the scope of the convention is sufficiently broad to include certain aspects of aquaculture.

4.1.1. Maritime jurisdiction

When discussing regulation of aquaculture in ocean waters we have to distinguish between the varying areas operations can take place. The convention divides the oceans in several jurisdictional zones, which are subject to different legal regimes: the territorial sea, the exclusive economic zone, the continental shelf and the high seas.

4.1.1.1. Territorial sea

Primarily, marine aquaculture sites are constructed in coastal regions, thus in the twelve mile zone of the territorial sea where the coastal state has sovereignty.[71] Legislation concerning aquaculture is therefore mainly national law.

4.1.1.2. Exclusive economic zone

However, as mentioned above, we can expect a higher amount of fish farms to be situated in offshore waters, i.e. in the EEZ or in the high seas. The EEZ was originally introduced to cope with the increasing claims of exclusive rights in respect of fisheries which more and more states have raised in the second half of the 20th century.[72] The EEZ extends from the outer limit of the territorial sea to a maximum of 200 nautical miles from the territorial sea baseline.[73] It is optional for a state to establish its EEZ, and several states have not made use of that possibility. However, 104 signatories to UNCLOS and the US have declared an EEZ.[74] The rights of the coastal state in that zone do not amount to complete sovereignty, but to control and exploit all natural resources in and of the seabed and superjacent waters.[75] Thus UNCLOS only gives a coastal state jurisdiction and sovereign rights over economic activity, marine scientific research and environmental matters in the EEZ.[76]

This includes:

> the right to construct and to authorize and regulate the construction, operation and use of ...
>
> (b) installations and structures for the purposes provided for in article 56 and other economic purposes;
> (c) installations and structures which may interfere with the exercise of the rights of the coastal State in the zone and installations.
>
> 2. The coastal State shall have exclusive jurisdiction over such ... installations and structures, including jurisdiction with regard to customs, fiscal, health, safety and immigration laws and regulations.[77]

UNCLOS leaves the terms 'installations and structure' undefined. Regarding aquaculture sites as moored ships[78] does not incorporate their method of construction and functionality. If we have a look at the meaning of the term 'structure',[79] aquaculture facilities, being constructed as whole units with a significant size, qualify as structures.

The installations and structures have to be constructed because of a particular purpose. Additional to 'other economic purposes', Article 60 refers to the purpose defined in Article 56

> of exploring and exploiting, conserving and managing the natural resources, whether living or non living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds.[80]

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[71] R Long, *Marine Resource Law* (Thomson Round Hall, 2007) 267.
[72] I Brownlie, *Principles of Public International Law* (Oxford University Press, 7th ed, 2008) 200.
[73] UNCLOS art 57.
[74] T Rosen, *Exclusive Economic Zone (EEZ)* (2008) Encyclopaedia of Earth <http://www.eoearth.org/article/Exclusive_economic_zone_(EEZ)> (accessed 14 April 2010).
[75] UNCLOS arts 55 and 60.
[76] S Kaye, 'Threats from the Global Commons: Problems of Jurisdiction and Enforcement' (2007) 8 *Melbourne Journal of International Law* 185, 185.
[77] UNCLOS art 60.
[78] J-F Pulvenis de Séligny, 'The Marine Living Resources and the Evolving Law of the Sea' (2010) 1 *Aegean Review of the Law Sea and Maritime Law* 61, 90.
[79] Defined as 'a whole constructed unit, esp. a building' in T Deverson and G Kennedy (eds), *The New Zealand Oxford Dictionary* (Oxford University Press, 2005).
[80] UNCLOS art 56(1)(a).

Aquaculture is not specifically mentioned as an applicable purpose, nevertheless it is included.

UNCLOS provides no definition of the term 'natural resources'.[81] Aquaculture operations in the oceans comprise usually of cages, nets or ropes. The farmed species are placed there as well as the fish feed, so that the only local resource used for farming is the seawater itself. Article 56 names the 'natural resources ... of the waters', and consequentially, aquaculture does not exploit the 'natural resources' of the oceans. However, aquaculture operations evidently are an economic activity. Thus constructing installations for aquaculture purposes is covered by Article 60.

As a result, one can conclude that UNCLOS grants states a right to construct aquaculture facilities in their EEZ. Furthermore, the coastal state may ban other states from constructing aquaculture facilities in its EEZ, since aquaculture is not subject to the freedoms 'of navigation and overflight and of the laying of submarine cables and pipelines, and other internationally lawful uses of the sea related to these freedoms'.[82]

Article 60 specifies certain conditions and limitations on the use of artificial operations that are applicable to aquaculture facilities in the EEZ. Around structures, the coastal state may establish reasonable safety zones in which it may take appropriate measures to ensure the safety both of navigation and of the structures.[83] The aquaculture operations may not interfere with sea lanes essential to international navigation.[84]

Furthermore, structures have to be removed once they are abandoned or no longer in use. Partial removal is permissible, provided that publicity is given regarding the depth, position and dimensions of any unremoved facilities.[85] This provision has been criticised for being insufficient and requiring a revision in future conventions.[86] In contrast to the 1958 *Convention on the Continental Shelf*[87] the word 'entirely' is omitted, therefore the removal of the structure may not be carried out completely. The reason for the alteration is that, when using the terms 'installations and structures', Article 60 was intended to regulate the construction of oil rigs and platforms. These installations can reach large dimensions that make it impossible or very cost extensive to entirely remove them.[88] Since 1998, the Offshore Installations – Guidelines of the International Maritime Organization require that 'no installations should be placed on any continental shelf or in any EEZ unless the design and construction is such that it makes entire removal upon abandonment or permanent disuse would be feasible.'[89] However, these guidelines are only recommended for consideration, do not have the status of international law and, therefore, are not binding on states.[90]

Aquaculture facilities are not comparable with oil platforms in size or weight, thus the removal provisions do not fit in respect to them. Therefore, the current legislation needs a revision to accommodate aquaculture operations.

4.1.1.3. Continental shelf

The extended continental shelf is the zone beyond the 200 nautical mile limit, stretching out to 350 nautical miles of the baseline or 100 nautical miles from the 2 500 metre isobath.

The exclusive rights to exploit the natural resources in this zone refer solely to 'non-living resources of the seabed and subsoil together with living organisms belonging to sedentary species.'[91] Thus, beyond the EEZ, the coastal state only has an exclusive right to the resources contained within the seabed in the area of the continental shelf.

When aquaculture takes place in the water bodies above the seabed - as is the common farming method for finfish - one could opine that a state cannot derive any rights from the provisions regarding the continental shelf.

[81] The definition in art 133 refers solely to the 'Area', i.e. the seabed, ocean floor and subsoil: UNCLOS art 1 (definition of 'Area').
[82] UNCLOS art 58(1).
[83] UNCLOS art 60(4).
[84] UNCLOS art 60(7).
[85] UNCLOS art 60(3).
[86] U Jenisch, '10 Jahre neues Internationales Seerecht – Eine Bilanz des UN-Seerechtsübereinkommens 1994 –2004' (2006) 2 *Natur und Recht* 79, 84.
[87] *Convention on the Continental Shelf*, opened for signature 29 April 1958, 499 UNTS 311 (entered into force 10 June 1964).
[88] B A Hamzah, 'International Rules on Decommissioning of Offshore Installations: Some Observations' (2003) 27(4) *Marine Policy* 339, 345.
[89] *Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone*, International Maritime Organisation, Resolution A.672(16) (19 October 1989) annex art 3.13.
[90] Gao, Z, *Current Issues of International Law on Offshore Abandonment* (The Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee, 1997) 10; Hamzah, above n 88.
[91] UNCLOS art 77(4).

However, Article 80 of UNCLOS provides that 'Article 60 applies *mutatis mutandis* to ... installations and structures on the continental shelf'. Since *mutatis mutandis* means 'with the necessary changes',[92] the provisions on the continental shelf are of major relevance if a state has not established an EEZ. In that case, it can basically exercise the same rights concerning artificial structures and operations on its continental shelf.[93]

The question is if the 'necessary changes' enable the rights relating to aquaculture in the EEZ to apply to the continental shelf as well. There has been no discussion of this subject in literature so far; in practice the problem has not occurred yet. When determining the UNCLOS regime of the continental shelf, the answer is negative. Article 78 determines that:

> The rights of the coastal State over the continental shelf do not affect the legal status of the superjacent waters or of the air space above those waters.

In light of the fact that aquaculture operations are not taking place in or on the seabed but rather in the waterbodies above, the rights of other states aiming to construct aquaculture facilities seem not to be restricted. Moreover, the exclusive right to construct installations on the continental shelf derives from the background of oil platforms. Unlike oil drilling, aquaculture does not require any resources of the sea or seabed itself. In this respect, mariculture can be compared to facilities producing energy from the water. However, in contrast to the provisions applying to the EEZ, the Articles on the continental shelf do not provide the specific sovereign right 'for the purpose of ... production of energy from the water'.[94] This aspect is adding to the view, that a state cannot have an exclusive jurisdiction relating to aquaculture sites on the continental shelf.

In conclusion, the coastal state is not granted the exclusive right to build structures in its continental shelf zone, and has no accompanying exclusive jurisdiction. Other states may erect aquaculture sites without the coastal states consent.

4.1.1.4. High seas

The term 'high seas' applies to all parts of the sea which are not included in the internal waters, the territorial sea or in the EEZ of a state.[95] In this area, the 'freedom of the high seas' can be enjoyed. This concept is recognised in Article 87 of UNCLOS;

> The high seas are open to all States, whether coastal or land-locked. (...) It comprises, inter alia, both for coastal and land-locked States:
>
> (d) freedom to construct artificial islands and other installations permitted under international law, subject to Part VI

Thus the construction of installations such as aquaculture sites constitutes a part of the freedom of the high seas. However, it does not in any way subject the used part of the seas to state sovereignty.[96]

This freedom, however, must comply with the requirement of Article 116 that due regard shall be paid to the interest of other states. Moreover, Articles 117 determines:

> All States have the duty to take, or to cooperate with other States in taking, such measures for their respective nationals as may be necessary for the conservation of the living resources of the high seas.

Considering marine aquaculture, this provision can be interpreted such that operations in the high seas have to be carried out without harming wild stocks.

4.1.2. Environmental control

UNCLOS not only deals with legal regimes of the oceans but also addresses aspects related to environmental law which also are of importance to mariculture. It is intended to conserve the seas as a source of food and to secure them from pollution.[97] With the adoption of UNCLOS, the freedom of polluting the oceans has expired.[98]

[92] B Garner (ed), *Black's Law Dictionary* (West Group, 9th ed, 2009).
[93] M Nordquist et al (eds), *United Nations Convention of the Sea 1982: A Commentary* (Martinus Nijhoff Publishers, 1993) vol II, 60.15(b).
[94] UNCLOS art 58.
[95] UNCLOS art 86.
[96] UNCLOS art 89.
[97] U Jenisch, 'Seerecht und Klimawandel: Herausforderungen für Schifffahrt, Offshore-Industrie und Seerecht' (2008) 30 *Natur und Recht*, 227, 230.
[98] Ibid.

Article 118[99] can be interpreted in a way that it requires states to ensure that their farming practices do not threaten wild stocks or interfere with their conservation.[100]

The main chapter dealing with issues of the marine environment is Part XII of the convention.[101] The provisions addressing the marine environment contain preventive and oppressive measures, arranged in seven subsections, referring to global and regional cooperation, monitoring and environmental assessment, legislation, enforcement, and safeguards. The convention's subject of protection is the marine environment including 'rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life'.[102] The latter phrasing has been interpreted as being an allusion to the precautionary principle,[103] which is based on the central scheme that scientific uncertainty should not be used as an excuse for not taking conservation and management measures.[104]

Article 192 imposes an obligation on the parties to protect and preserve the marine environment. Signatory countries are confronted with the task to take all measures necessary to prevent, reduce, and control pollution of the marine environment, using the best means necessary within their capabilities.[105] Thus, the convention demands not the same level of measures to be taken by all states. In respect of the diminished economic and technical possibilities of developing states, it does not request the same efforts as from developed states.

The term 'pollution of the marine environment' is defined in Article 1(4) as:

> the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.

Regarding the impacts of aquaculture, aquaculture operations can cause such pollution. Thus, the environmental controls of Part XII of UNCLOS require the states to consider the environmental impact of aquaculture operations on the marine environment.

The actions that states shall take must deal with all sources of pollution.[106] Pollution from mariculture sites is not directly addressed in Article 194 since mariculture pollution is not caused by land-based sources or through the atmosphere, and not produced by vessels or by the installations and devices of the nature referred to in Article 194(3)(c) and (d). Aquaculture is also not an activity that falls in the category of 'dumping' as defined in the convention:

> (a) 'dumping' means:
> (i) any deliberate disposal of wastes or other matter from ... platforms or other man-made structures at sea;
> (ii) any deliberate disposal of ... platforms or other man-made structures at sea;
>
> (b) 'dumping' does not include:
> (i) the disposal of wastes or other matter incidental to, or derived from the normal operations of ... platforms or other man-made structures at sea and their equipment.[107]

Chemical and biological substances that are introduced to waterbodies by aquaculture operations cannot be described as deliberate disposal. In fact, the pollution results principally from feeding, medication, maintaining facilities, excretion of aquaculture organisms and escaping of alien species into habitats, thus incidental during the normal operation of aquaculture sites as stated Article 1(5b)(i).

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[99] UNCLOS art 118:
> Cooperation of States in the conservation and management of living resources:
> States shall cooperate with each other in the conservation and management of living resources in the areas of the high seas. States whose nationals exploit identical living resources, or different living resources in the same area, shall enter into negotiations with a view to taking the measures necessary for the conservation of the living resources concerned. ...

[100] Powers, above n 3, 59.
[101] UNCLOS pt XII 'Protection and Preservation of the Marine Environment'.
[102] UNCLOS art 194(5).
[103] Jenisch, above n 977.
[104] G Moore, 'The Code of Conduct for Responsible Fisheries', in E Hey (ed), *Developments in International Fisheries Law* (Kluwer, 1999) 96.
[105] UNCLOS art 194.
[106] UNCLOS art 194(3).
[107] UNCLOS art 1 (5).

However, the enumeration of sources of pollution is not exclusive,[108] and because of the fact that the implementation of offshore aquaculture was not foreseen at the time of the convention's consultation, pollution from installations such as aquaculture operations may be included in the scope of marine environment protection. Article 196(1) states explicitly that:

> states shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto.

Offshore aquaculture can be paraphrased as a recent technology, so that this provision can be interpreted in a way that states are required to prevent the negative ecological impacts of aquaculture.

According to Article 193, signatory states maintain the sovereign right to exploit their natural resources but must do so in a manner that conforms to their environmental policy and their duty to protect the marine environment. The convention recognizes the significance of national environmental policies in the exploitation of natural resources.

Articles 207-213 UNCLOS provide a catalogue of requirements for states to adopt laws and regulations relating to the pollution of the marine environment. The measures are classified according to the different sources of pollution. Article 218 is the sole provision that can be applied to aquaculture.

> Article 218: Pollution from seabed activities subject to national jurisdiction
>
> 1 Coastal States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising … and from artificial islands, installations and structures under their jurisdiction, pursuant to articles 60 and 80.[109]
> 2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.
> 3. Such laws, regulations and measures shall be no less effective than international rules, standards and recommended practices and procedures.
> …
> 5. States, acting especially through competent international organizations or diplomatic conference, shall establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine …

The Article's superscription is misleading when referring only to seabed activities. The diction, however, makes it clear that pollution from aquaculture sites is included in the scope of the provision.

The last paragraph of Article 218 is linked to Articles 197-203, which require states to seek cooperation on a global or regional basis directly or through competent international organisations. The cooperation shall include setting regulatory standards, notification in case of pollution, contingency plans, research and technical assistance to developing states.

Article 214 states that signatory countries shall enforce the laws adopted in accordance with Article 208 and take all the measures necessary to implement the legislation addressing environment protection. To safeguard the obligations that the convention imposes relating to the preservation of the marine environment, several provisions regarding liability have been adopted. According to Articles 235 and 304, states are 'responsible for the fulfilment of their international obligations' and 'shall be liable in accordance with international law'.

Furthermore, states must ascertain that activities within their jurisdiction or control do not cause pollution damaging the environment of other states.[110] Action must be taken to ensure that damage or hazards are not transferred from one area to another, or one type of pollution transformed into another.[111] The prohibition to shift pollution to other countries can gain importance where the coastal state remains inactive although emissions imperil areas belonging to a neighbouring state.[112] Such incidents may lead to international disputes that are subject to the UNCLOS dispute settlement provisions.[113]

[108] UNCLOS art 194(3), where the term 'inter alia' is used.
[109] Emphasis added.
[110] UNCLOS art 194(2).
[111] UNCLOS art 195.
[112] Jenisch, above n 977.
[113] UNCLOS arts 279 – 299.

Articles 204-206 deal with the monitoring and environmental assessment of the risks. In particular, states shall keep under surveillance the effects of any activities which they permit, or in which they engage, in order to determine whether these activities are likely to pollute the marine environment.

4.1.3. Concluding remarks

Generally, the requirements set by UNCLOS can be described as being often weak and lacking in comprehensive protection of the marine environment. The provisions frequently use terms such as 'shall endeavour', 'promote', or 'in accordance with their capabilities' that leave a wide scope for interpretation and thus do not impose strict obligations, but merely express vague efforts.

Especially when it comes to monitoring and environmental assessment, the convention leaves legislative gaps, when saying that states 'shall ... endeavour, as far as practicable, to observe ... the risks or effects of pollution of the marine environment.'[114] This provision does not address the worries marine aquaculture raises. Offshore aquaculture is a recent development that needs research and monitoring comprehensively. Using new techniques such as genetically modified organisms or introducing unknown problems to the oceans, such as vast amounts of faecal waste resulting from high density of stock, aquaculture requires close and widespread observation and control, a responsibility from which states cannot abdicate. In general, regulatory regimes on monitoring are one of the key issues for international environmental treaties can unfold their full potential.[115] For developing states which are not able to accomplish that task, competent international bodies must be created and granted the respective rights.

UNCLOS has been described as being of constitutional character and as a major contribution to the establishment of a legal framework for the protection and preservation of the marine environment.[116] This is certainly true. However, there have been many developments since its enactment that have not been acknowledged by revision of its provisions. The unforeseen enhancements in science and technology have revealed gaps in that legal regime. The convention is not comprehensive and flexible enough to meet the new challenges raised by mariculture. It focuses on territorial sovereignty, but the sea is an ecosystem that is not delineated by international borders.[117] Thus the necessity for a more precise and detailed regulation in this respect is urgent.

4.2. International environmental law

Although it is a rather new discipline, having arisen only in the last 100 years,[118] international environmental law now covers a vast range of issues. Treaties dealing with the exploitation of deep sea bed resources to space exploration have been arranged to avert, alleviate or compensate for all matters of environmental mischief.[119]

The oceans have been described as 'the only truly 'international' area on the planet, representing an expanse beyond the territorial boundaries of all nations'.[120] Thus it is not surprising that the protection of the seas is a key issue in international environmental law.

4.2.1. Stockholm Declaration

The 1972 Declaration of the United Nations Conference on the Human Environment – better known as the Stockholm Declaration[121] – states the two opposing objectives that environmental law has to cope with:

> Principle 21
> States have ... the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

[114] UNCLOS art 204(1).
[115] D Ardia, 'Does the Emperor Have No Clothes? Enforcement of International Laws Protecting the Marine Environment' (1997-8) 19 *Michigan Journal of International Law* 497, 517.
[116] Ibid 534.
[117] Wilson, above n 266, 505.
[118] The first case of international recognition, demonstrating that states may be liable for its pollution to another state, was the *Trail Smelter Case (U.S. v Canada)* (1941) 3 R. Int'l Arb Awards 1905; the first international document concerned with environmental issues was the *Stockholm Declaration* of 1972, below n 121.
[119] Wilson, above n 26.
[120] Ardia, above n 1155, 499.
[121] *Report of the United Nations Conference on the Human Environment*, UN Doc A/CONF.48/14 (16 June 1972) ('Stockholm Declaration').

This provision is considered the 'cornerstone of international environmental law'.[122] Environmental law before the Stockholm Declaration left unprotected gaps: for example, protection of the high seas presented a special problem. Since the high seas are not the territory of any state, harming them did not mean a breach of state responsibility. Hence, Principle 21 brought a fundamental change.[123]

4.2.2. Rio Declaration

The Rio Declaration on Environment and Development of 1992, produced at the 1992 United Nations 'Earth Summit' comprises of 27 principles intended to promote sustainable development around the world.[124] It expressly adopts the precautionary principle and includes the customary obligation not to cause transboundary harm.[125]

Moreover, at the Earth Summit, the Convention on Biological Diversity (CBD)[126] evolved. This is a legally binding instrument committing governments to protecting the earth's biological resources and it affects some elements of aquaculture relating to introductions of alien species and other externalities. As part of its implementation, the Jakarta Mandate of 1995 calls for sustainable mariculture operations and emphasises the importance of incorporating community-based coastal resources management.[127] The recommendations include installing a monitoring programme and preferring local rather than alien species in farming.[128]

4.2.3. Résumé

International environmental law is generally weak in respect to mariculture. The provisions are composed fairly broadly, are unspecific, and do not recognise the special requirements which are necessary to prevent pollution of marine aquaculture.

The growing significance of the precautionary principle in international environmental law can be appreciated since this approach perfectly fits mariculture, a development that is too new to predict all its ecological impacts in detail and with scientific proof, but where harm to the oceans due to current production methods seems most likely.

4.3. Intergovernmental organisations addressing aquaculture

Supranational legal regimes directly addressing the issues related to aquaculture have only come to the fore in the past fifteen years. Since then, the international recognition of the role of institutions and legal systems in controlling, enabling, and encouraging responsible aquaculture has steadily been increasing.[129]

4.3.1. FAO

4.3.1.1. Regime of the Code of Conduct

The duty to cooperate on a global basis in formulating international rules and standards established by Articles 197-201 UNCLOS motivated the creation of the Code of Conduct for Responsible Fisheries (the Code) by the Food and Agriculture Organization of the United Nations (FAO), which was unanimously adopted on 31 October 1995 by the over 170 member governments of the FAO Conference. The Code presents a framework for the regulation of all living aquatic resources.[130] It is voluntary and does not create in itself any legal obligations. In 1997, it was expanded and contains now a section on aquaculture that aims to provide principles and standards applicable to the conservation, management and development of aquaculture activities.

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[122] Sands, above n 69, 186.
[123] A Schwabach, International Environmental Disputes: A Reference Handbook (ABC-CLIO, 2006) 90.
[124] *Report of the United Nations Conference on Environment and Development*, UN Doc A/CONF.151/26 (Vol I) (12 August 1992) annex I ('*Rio Declaration on Environment and Development*').
[125] *Rio Declaration on Environment and Development*, UN Doc A/CONF.151/26, annex I, principles 2 and 15.
[126] *Convention on Biological Diversity*, opened for signature 5 June 1992, 1760 UNTS 79 (entered into force 29 December 1993).
[127] M B Mokhtar and A Awaluddin, 'Framework for Sea Ranching' (2003) 13 *Reviews in Fish Biology and Fisheries* 213, 216.
[128] See generally, Secretariat of the Convention on Biological Diversity, *The Jakarta Mandate – from global consensus to global work: Conservation and sustainable use of marine and coastal biological diversity* (2000) Convention on Biological Diversity <http://www.cbd.int/doc/publications/jm-brochure-en.pdf> (accessed 20 April 2010).
[129] Glenn and White, above n 4, 73.
[130] Long, above n 71, 269.

The Code stresses on the precautionary approach in the marine environment[131] and emphasises the growing importance of aquaculture for economies and food security when calling on states to 'consider aquaculture ... as a means to promote diversification of income and diet'.[132] The provisions compel states to promote responsible aquaculture through control and regulatory actions.[133] The Code requires that aquaculture be based on the best scientific information and ecologically sustainable plans that allow the rational use of resources shared by aquaculture and other activities.[134] Specific provisions of the Code address the issue of genetic resources used in aquaculture and requests states to minimise the effects of escaped farmed fish on wild stocks.[135] Furthermore, the Code requests states to cooperate with their neighbours as well as on an international basis.[136] The Code aims to encourage sustainability on the production level. States should promote practices in support of rural communities and local farmers.[137] The use of chemicals and the disposal of waste should neither endanger human health nor the environment.[138]

In addition to the Code, the FAO has drafted guidelines for aquaculture development.[139] These guidelines have no formal legal status but include suggestions on how to implement Article 9 of the Code in national legislation. Furthermore, the FAO has recognised that it is essential to know and understand the status and trends of global aquaculture as a basis for policy-making and thus prepared a 'Strategy and Outline Plan for Improving Information on Status and Trends of Aquaculture'.[140]

4.3.1.2. Résumé

In conclusion, it can be said that the Code addresses more issues concerning aquaculture than UNCLOS, and in more detail. It deals with a wide range of impacts of aquaculture, including environmental, social and human health aspects. However, the regulation has some gaps. For example, a requirement to monitor genetically modified fish more closely and to notify other states when those species are used in open waters, where the danger of escape is significant, is desirable. Moreover, the Code is mainly concerned with aquaculture in areas under national jurisdiction.[141] Operations in the high seas are thus excluded.

Furthermore, the Code's weakness lies in the fact that it only provides soft law. Since it is not mandatory, the Code is often criticised as being less effective than binding international law. Moreover, the language of the Code is vague and extensive.[142] It is formulated too generally, without providing precise assistance for the implementation into national law.

However, the intention behind the Code was to create a document that can serve as a template for domestic regulation. Especially in countries where environmental legislation is underdeveloped, stakeholders require a starting point to be able to generate local regulations on aquaculture.[143] The Code acts as a guideline for creating legislation while leaving the freedom which is necessary for implementation in differing ecological, social and economic backgrounds.[144]

Therefore, even if the Code is voluntary, its existence may result in an improvement of quality control in aquaculture operations, since it is 'a powerful motivational force linked to necessity to gain competitive advantage, one form of which resides in product quality assurance'.[145]

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[131] FAO, *Code of Conduct* art 7.5.1.
[132] FAO, *Code of Conduct* art 6.19.
[133] Read and Fernandes, above n 50, 149.
[134] FAO, *Code of Conduct* arts 9.1.2 and 9.1.3.
[135] FAO, *Code of Conduct* arts 9.3 and 9.3.1.
[136] FAO, *Code of Conduct* arts 9.2 and 9.3.2.
[137] FAO, *Code of Conduct* art 9.4.1.
[138] FAO, *Code of Conduct* arts 9.4.5 and 9.4.6.
[139] FAO, Technical Guidelines for Responsible Fisheries No. 5: Aquaculture Development (1997); No.5 Suppl.1: Good Aquaculture Feed Manufacturing Practice (2001); No.5 Suppl.2: Health Management for Responsible Movement of Live Aquatic Animals (2007); No.5 Suppl.3: Genetic Resource Management (2008) <http://www.fao.org/fishery/ccrf/publications/guidelines/en> (accessed 8 April 2010).
[140] FAO, *Strategy and Outline Plan for Improving Information on Status and Trends of Aquaculture* (2008) <http://www.fao.org/docrep/011/i0445t/i0445t00.htm> (accessed 8 April 2010).
[141] FAO, *Code of Conduct* art 9.1.
[142] R Bratspies, 'Finessing King Neptune: Fisheries Management and the Limits of International Law' (2001) 25 *Harvard Environmental Law Review* 213, 235.
[143] Wilson, above n 26, 509.
[144] Ibid 510.
[145] Read and Fernandes, above n 500, 149.

4.3.2. Maritime organisations

Several international maritime bodies have initiated frameworks such as codes of practice or resolutions relating to marine aquaculture. The International Maritime Organization (IMO), however, which is a United Nations body acting globally, has not yet implemented legal instruments that deal exclusively with aquaculture. Most intergovernmental organisations concerned with marine jurisdiction are limited to particular regions or subjects.

Regional Fisheries Bodies (RFBs) play an important role in regulating the seas. Some have real management powers and make decisions on allowable catches and technical management measures whereas others have a purely advisory role and promote the collection of statistics, information exchange and scientific analysis.[146] Not all of these organisations have put responsible aquaculture on their agenda, but some attempt to govern their member states' aquaculture activities.

4.3.2.1. NASCO

A good example of a RFB involved in aquaculture initiatives is the North Atlantic Salmon Conservation Organization (NASCO), which was established as an intergovernmental organization in 1984 and currently comprises six members.[147] In 1994, it adopted measures to protect wild stocks from the impacts of aquaculture salmon, known as the Oslo Resolution. Since this regime did not achieve the desired results,[148] NASCO developed the Williamsburg Resolution in 2003, which includes the precautionary principle and drafts more detailed schemes to minimise the impacts of aquaculture.[149] The Williamsburg Resolution requires member states to implement action plans to reduce the escape of farmed fish to a minimum.[150] In several annexes, it provides detailed guidelines which include technical instruments, such as river classification, exclusion zones, and operation methods. Thus, the Williamsburg Resolution addresses the impacts of aquaculture more specifically and accurately than all the other supranational regulations discussed in this paper. However, since it is not mandatory, its implementation into national legislation through the member states leaves a lot to be desired.[151]

4.3.2.2. OSPAR

Another legislative instrument regulating international cooperation on environmental protection is the Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention), comprising of fifteen signatory nations. The most important measure initiated by OSPAR affecting marine aquaculture is known as PARCOM Recommendation 94/6 on 'Best Environmental Practice for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use'.[152] Its provisions are generally targeted at measures to reduce the use of toxic substances and medicines in fish farming, and to limit the disposal of toxic antifoulants to the sea.[153] In 2000, an OSPAR study revealed that these recommendations have not been adopted very successfully.[154] However, in its current report, the OSPAR Commission reaches the conclusion that there is no need for the development of additional programmes and measures since it regards the marine aquaculture industry as too diverse to apply anything but a case-by-case approach.[155] Thus, OSPAR gives the impression that it has resigned from further promoting the sustainable development of aquaculture.

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[146] For a comprehensive list of RFBs and their instruments see FAO, *Regional Fishery Bodies (RFB)* <http://www.fao.org/fishery/rfb/en> (accessed 22 April 2010).
[147] Canada, Denmark (in respect of the Faroe Islands & Greenland), the European Union, Norway, the Russian Federation and the United States of America. Iceland left in 2009 because of financial considerations, but has signalled that it intends to re-enter when its economic situation improves.
[148] Long, above n 71, 269.
[149] North Atlantic Salmon Conservation Organization (NASCO), *Resolution by the parties to the Convention for the Conservation of Salmon in the North Atlantic Ocean to Minimise Impacts from Aquaculture, Introductions and Transfers, and Transgenics on the Wild Salmon Stocks* (adopted on June 2003 at NASCO 20th annual meeting) ('*The Williamsburg Resolution*') <http://www.nasco.int/pdf/agreements/williamsburg.pdf> (accessed 6 April 2010).
[150] *Williamsburg Resolution* art 5.
[151] United Kingdom, Royal Commission on Environmental Pollution, *Turning the Tide: Addressing the Impact of Fisheries on the Marine Environment* (2004) 137.
[152] Full text available at the OSPAR Commission website <http://www.ospar.org/documents%5Cdbase%5Cpublications%5Cp00023_BEP-E.pdf> (accessed 6 April 2010).
[153] Read and Fernandes, above n 50, 148.
[154] Long, above n 71, 269.
[155] OSPAR Commission, *Assessment of Impacts of Mariculture* (2009) 43 <http://www.ospar.org/documents/dbase/publications/p00442_Impacts%20of%20Mariculture.pdf>.

4.4. The need for international regulation

A variety of regulatory frameworks concerning aquaculture have been adopted throughout the world. Many countries manage the aquaculture sector through some form of national regulation (eg licensing associated with design, geographic or operational conditions). However, the regulation has been criticised as being often only ad hoc, as an answer to specific problems or concerns,[156] or not being comprehensive enough and neglecting sustainability aspects.[157]

A comprehensive framework which provides security for farmers as well as the tools for aquaculture development and considers other stakeholders' interests sufficiently has not even been achieved in the most developed countries. Considering this, international legislation and its enforcement cannot be overrated. Moreover, international bodies not only play a significant role in enforcement of law but also in its creation.[158] Many treaties have been initiated by the work of international organisations.[159] Because aquaculture is a global issue, a supranational environmental agreement is desirable.[160] Regulation should be carried out at the global level rather than at a regional level to provide the essential consistency of law.[161] States are required to evaluate development strategies consistent with principles of environmental responsibility by raising such issues in international forums.[162] Successful aquaculture regulation involves reconciling the interests of aquaculture participants, the communities in which they are based, and the consumers. [163] Without policy and legal coherence, the development of aquaculture will be thwarted and cannot reach its full potential.[164]

The international environmental treaties have been criticised for generally being unable to provide the necessary monitoring and enforcement tools in practice.[165] International bodies which are assigned that task are incapable of performing it, since they frequently lack a sufficient budget; their duties are not precisely defined. Further, many treaties are not self-executing and thus they depend on the assistance of the parties themselves.[166] However, developing countries are often not equipped with the technological or financial capacity to successfully enforce environmental regulation by themselves.[167] International organisations are an important factor in filling that gap.

Marine aquaculture faces the problem that states have not created an international body or mandated an existing organisation to monitor operations and enforce international environmental law. Since a large proportion of aquaculture activity takes place in developing countries, an international observation of marine environmental issues becomes even more important. The FAO with its voluntary Code of Conduct can only be the first step.

4.5. Eco-labelling

Another scheme of implementing, monitoring and enforcing marine environmental regulation is utilising the assistance of non-governmental organizations. NGOs habitually have the ability to focus and direct pressure onto states. They certainly provide a rather cost-effective way of enforcement to the international community.[168] A particularly persuasive method to promote and enforce sustainable aquaculture operations could be eco-labelling.

Eco-labelling means placing a label 'on a product to inform consumers that the product is less environmentally harmful than similar products, either based on the actual product characteristics, the production and process method used in its manufacture, or both'.[169] To be awarded an eco-label, the producer must abide by the respective certification scheme, which usually comprises detailed rules and principles that take into account best

[156] GESAMP, above n 10, 6.
[157] For example, Chile: A Schmehl and S M Wack, 'Umweltfragen des Wachstums der Fischproduktion: Das Recht der Aquakultur in Küsten- und Meeresgewässern' (2009) 10 *Zeitschrift für Umweltrecht* 473.
[158] Ardia, above n 1155, 544.
[159] 'International Environmental Law Developments in the Law' (1990-1) 104 *Harvard Law Review* 1484, 1586.
[160] Connolly, above n 48, 133.
[161] Pulvenis de Séligny, above n 78.
[162] Wilson, above n 26, 501.
[163] GESAMP, above n 10.
[164] N Hishamunda, 'Global Trends in Aquaculture Development' in D VanderZwaag and G Chao (eds) *Aquaculture Law and Policy: Towards Principled Access and Operations* (Routledge, 2006) 38.
[165] Ardia, above n 1155, 511.
[166] S Anderson, 'Reforming International Institutions to Improve Global Environmental Relations, Agreement, and Treaty Enforcement' (1994-5) 18 *Hastings International and Comparative Law Review* 771, 780.
[167] K Goldberg, 'Efforts to Prevent Misuse of Pesticides Exported to Developing Countries: Progressing beyond Regulation and Notification' (1984-5) 12 *Ecology Law Quarterly* 1025, 1030.
[168] Ardia, above n 1155, 559.
[169] Connolly, above n 48, 130.

farming techniques, optimal feeding regimes, environmental sustainability, welfare of the fish and other issues related to aquaculture.

Such certification of aquaculture products has the potential to significantly improve the sustainability of production practices. Eco-labels are a powerful tool in controlling buyers' demand. There is an increased awareness of sustainability issues among consumers that influences purchase decisions. Certified producers can mark their products with the label, signifying that the products meet the production standards laid down in the certification guidelines. Both fish farmers and the environment can profit from labelling. Producers gain better access to markets and receive price premiums for labelled products whilst incentives for adoption of improved environmental production methods are provided.[170]

Friend of the Sea (FOTS), a small NGO based in Italy, runs a certification programme for sustainable aquaculture.[171] Naturland is a major certifying organisation for organic agriculture and also has a certification scheme for organic aquaculture.[172] The Soil Association is a UK-based organization which campaigns for and certifies organic agriculture.[173] Other certification methods have not adopted sustainability as the baseline but best practices in general. The Global Aquaculture Alliance (GAA) is the primary global trade association that certifies aquaculture production and processing facilities with the label 'The Best Aquaculture Practices Certified (BAP Certified)'.

However, these schemes can only be seen as a starting point since they require improved elaboration to meet all concerns related to the negative impacts of aquaculture. They are merely representing particular stakeholder interests, lack in transparency and propose weak ecological and socioeconomic standards.[174] Furthermore, they usually focus on particular species, leaving consumers confused.

The World Wildlife Fund (WWF) is going to launch The Aquaculture Stewardship Council (ASC) in 2011, which will create an eco-label for farmed seafood as well.[175] Its aim is to draft standards for responsible, sustainable aquaculture for twelve aquaculture species. With over 2000 participants in the Aquaculture Dialogues, ranging from scientists to governments and NGOs, it ensures the best possible stakeholder participation. Thus, the eco-label has the potential to be applied and accepted by both producers and consumers of aquaculture products.

5. Conclusion

The consensus is that aquaculture is an activity with a remarkable potential for human benefit. However, a healthy environment is essential to the wellbeing of the human population. With 71 percent of the earth covered by oceans, it is obvious that preserving the seas is vital to achieve that goal. Therefore, instruments have to be found to facilitate aquaculture development in a way that respects the competing concerns.

There are no perfect solutions to the tensions surrounding aquaculture. Since aquaculture operations occur in diverse modes, that creates particular difficulties when drafting regulations or guidelines which meet the requirements of all the stakeholders. A regime is required that allows the industry to prosper but, at the same time, safeguards the wild stocks so as to maintain the social and economic benefits. The aim is finding a balance between aquaculture development and environmental protection. Adequate legal and policy frameworks on an international level are an effective ingredient to act as a compass in aquaculture development. Certainly, that is not an easy task, but if it is done well, it could help to safeguard marine resources for future generations.

[170] Environmental Law Institute and The Ocean Foundation, *Gold Standard for Sustainable Aquaculture Ecolabel Design: Technical Report* (2008) Environmental Law Institute, 1 <http://www.elistore.org/reports_detail.asp?ID=11296> (accessed 13th April 2010).
[171] Friend of the Sea, *Friend of the Sea Certification Criteria Checklist for Aquaculture Products: Marine Aquaculture* (1 April 2010) <http://www.friendofthesea.org/public/page/EN%20-%20Marine%20Aquaculture.pdf> (accessed 21 April 2011).
[172] Naturland, *Naturland Standards for Organic Aquaculture* (2010). <http://www.naturland.de/fileadmin/MDB/documents/Richtlinien_englisch/Naturland-Standards_Aquaculture.pdf>, (accessed 21 April 2011).
[173] Soil Association, *Aquaculture* <http://www.soilassociation.org/LinkClick.aspx?fileticket=pM14JxQtcs4%3D&tabid=353>.
[174] Greenpeace, *Assessment of the Friend of the Sea Fisheries and Aquaculture Certification Programme* (2009) <http://www.greenpeace.org/raw/content/international/press/reports/friend-of-the-sea.pdf> (accessed 13 April 2010); Greenpeace, above n 62; Environmental Law Institute, above n 171, 41.
[175] For further information, see the Aquaculture Stewardship Council website <http://www.ascworldwide.org>.