UNEP YEAR eBOOK

2014 UPDATE

FISH AND SHELLFISH FARMING IN MARINE ECOSYSTEMS

UNEP

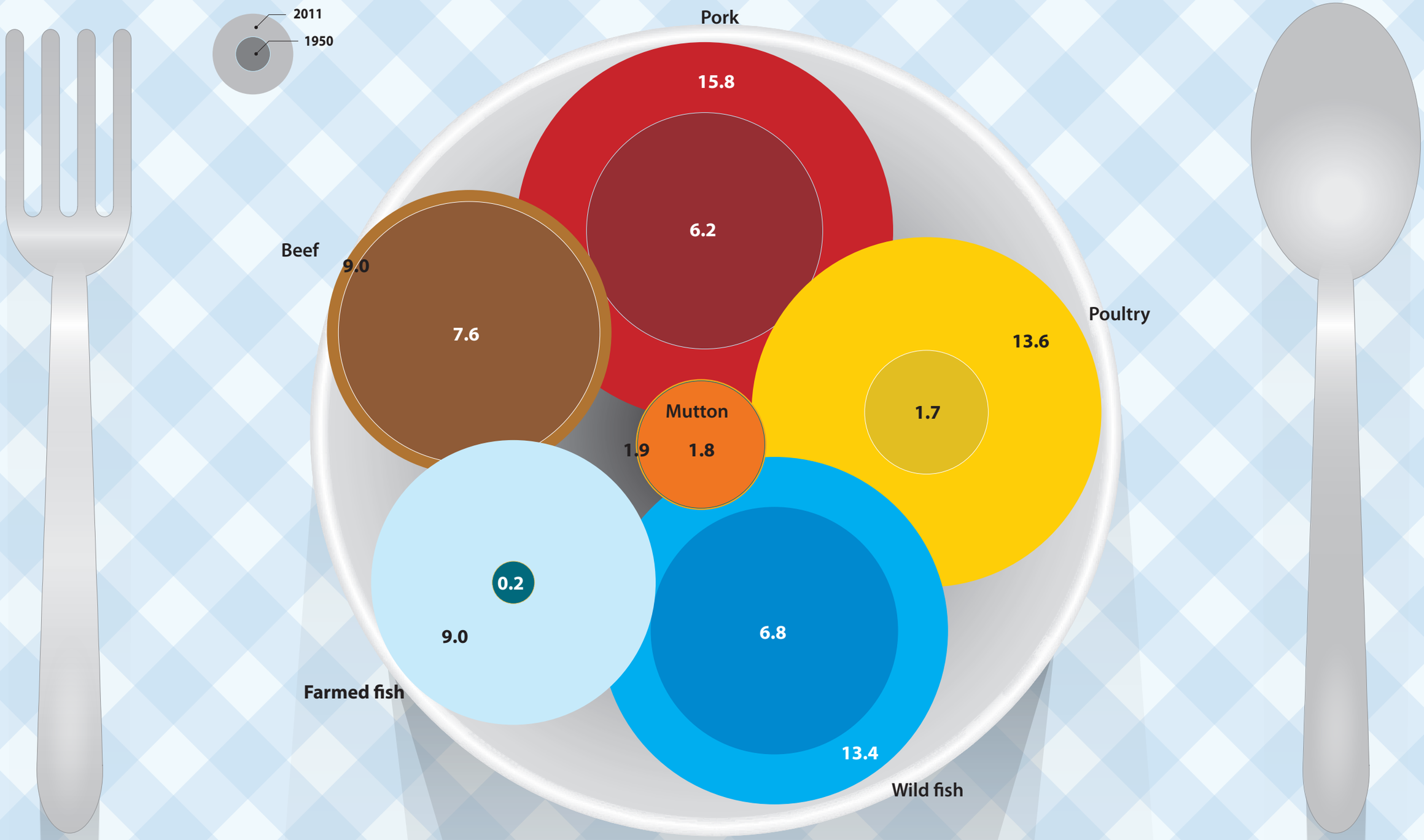
United Nations Environment Programme

1. Marine Fish and Shellfish Farming

Implications for the environment of providing food from the ocean

World animal protein production, per capita

Kilogrammes per year



Helping to feed a growing world population, aquaculture production has increased since the 1950s from 650 thousand tonnes to almost 67 million tonnes **(FAO 2014)**. In the same period, the total marine catch has increased from 20 million to about 80 million tonnes.

Today, aquaculture provides half of all fish for human consumption, and the sector is expected to grow.

Riccardo Pravettoni/GRID-Arendal- 2014

Source: Compiled by Earth Policy Institute from U.N. Food and Agriculture Organization (FAO), FAOSTAT, electronic database, at faostat.fao.org, updated 16 January 2013.

While significant progress has been made over the past decades towards making **marine aquaculture** more sustainable, environmental concerns remain – reflecting this sector's rapid growth. Broadly speaking, fish farms can release nutrients, undigested feed and veterinary drugs, and other biocides to the environment. They can also create conditions that increase risks of diseases and parasites. Farmed fish and shellfish can escape to surrounding waters, which may have negative impacts on ecosystems through genetic regression or introduction of invasive species. In some countries certain forms of shrimp farming have destroyed large areas of coastal habitats, such as **mangrove forests**. Use of fish-based feeds in aquaculture can put additional pressures on poorly managed wild fish stocks and on the marine environment.

Despite these implications for the environment, there is increasing potential for responsibly managed marine aquaculture to provide food from the oceans, particularly in view of increasing pressures on freshwater and terrestrial ecosystems, including those related to climate change.

Investing in Hope: Rusli's Story shows the journey of an Acehnese shrimp farmer, and new hope and income after the tsunami tore through his village.
WorldFish www.youtube.com/watch?v=BOzzxnzAqWQ

For more information, please see the fish and shellfish farming section in the **UNEP Year Book 2006.**

The main systems of marine aquaculture differ in their potential environmental consequences:

Extractive aquaculture is the practice of enhancing production of molluscs. Larvae or juveniles are seeded to the sea bottom or attached to manmade structures, where they grow feeding on (or 'extracting') natural phytoplankton. The detrimental environmental impacts of extractive aquaculture are comparatively low, partly because of the species' low **trophic level.** However, there is a risk that non-native species will be introduced.

Shrimp farming has expanded rapidly in the past several decades. Destruction of coastal habitats, especially mangrove forests, has been attributed in particular to extensive shrimp farming. Other impacts include water pollution by chemicals and pharmaceuticals, eutrophication resulting from releases of nutrients in the form of feed and waste, and salinisation of arable land and freshwater supplies. In many places there have also been social and community impacts.

Marine net pen farming involves rearing fish from the juvenile to harvest stages in net pens. Atlantic salmon is normally farmed in net pens. Environmental impacts include the discharge of waste to bottom-dwelling communities (e.g. cold water corals). The high density of Atlantic salmon in open cages can lead to disease or parasite outbreaks, with potential impacts on wild populations. Escapees can act as vectors and, particularly if genetically modified, affect wild populations' genetic variability. Marine net pen farmed species, which tend to feed naturally on fish, require high amounts of protein as well as, fish meal and fish oil in their diet. This, can impact both terrestrial and marine ecosystems.

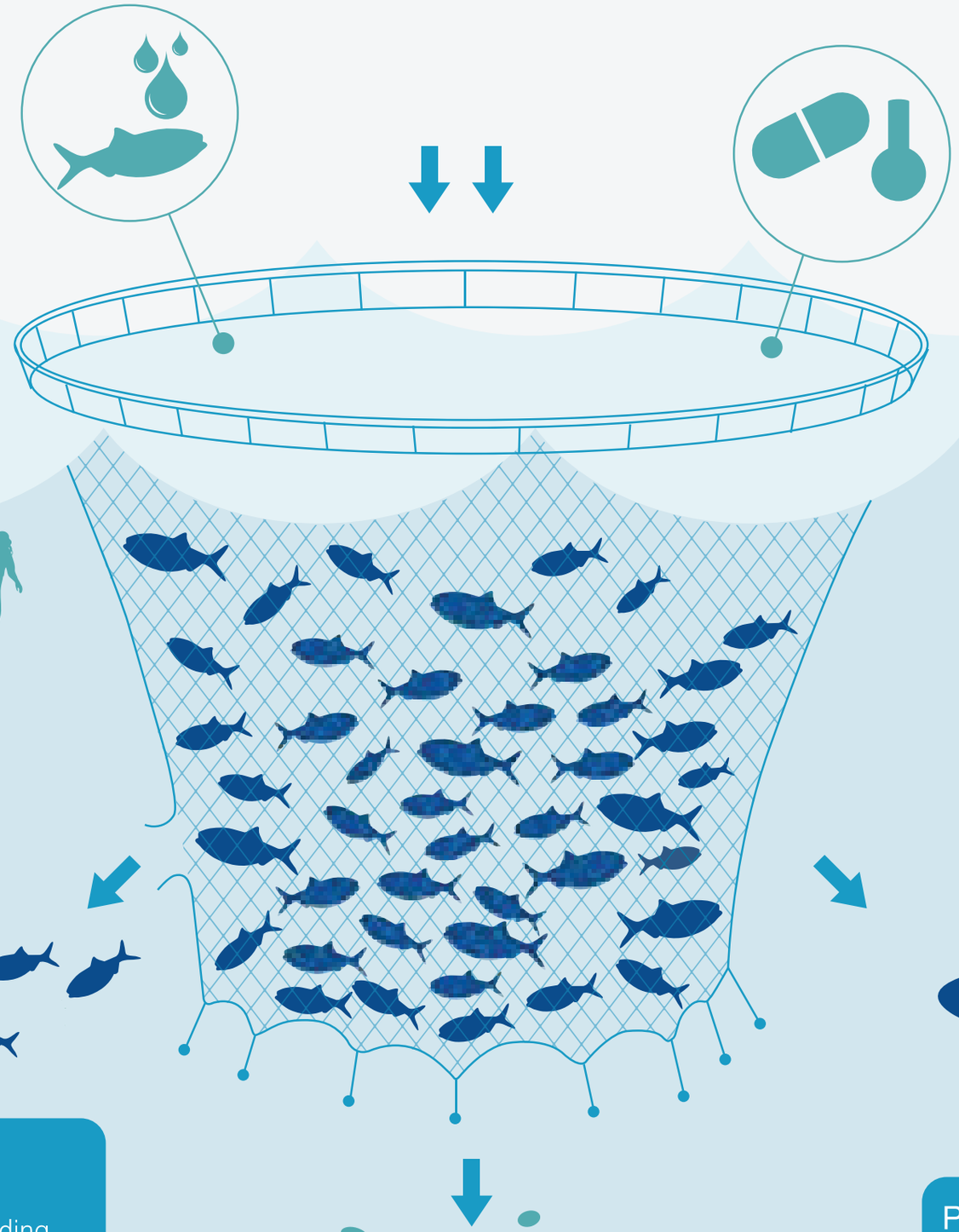
Environmental Impacts of Open-Ocean Aquaculture

FISH MEAL & FISH OIL

Using wild-caught fish to feed farmed fish puts additional pressure on these populations and can impact other wildlife that depends on them for food.

DRUGS AND CHEMICALS

When used, antibiotics, parasiticides, and other chemicals flow out of pens and can affect wild fish as well as the broader marine ecosystem.



ESCAPED FISH

Escaped fish compete for food and habitat, transmit diseases, and prey on and breed with local fish, reducing the health of wild populations.

DISEASE & PARASITES

Disease, pathogens, and parasites can multiply in crowded pens and rapidly spread to wild fish.

FISH WASTE

Fish waste flows out into the ocean, adding potentially harmful extra nutrients to the ecosystem. Uneaten food can also build up on the ocean floor underneath pens, altering the abundance and biodiversity of these communities.

PREDATORS

Seals, sea lions, sharks, birds and other marine wildlife can become entangled in fish pens. The use of deterrents like underwater loudspeakers can alter the natural behavior of predators.

Source: Ocean Conservancy http://tocdev.pub30.convio.net/our-work/aquaculture/assets/pdf/oc_rfts_v11_single.pdf

2. Development of Marine Aquaculture

Increasing production and technological progress

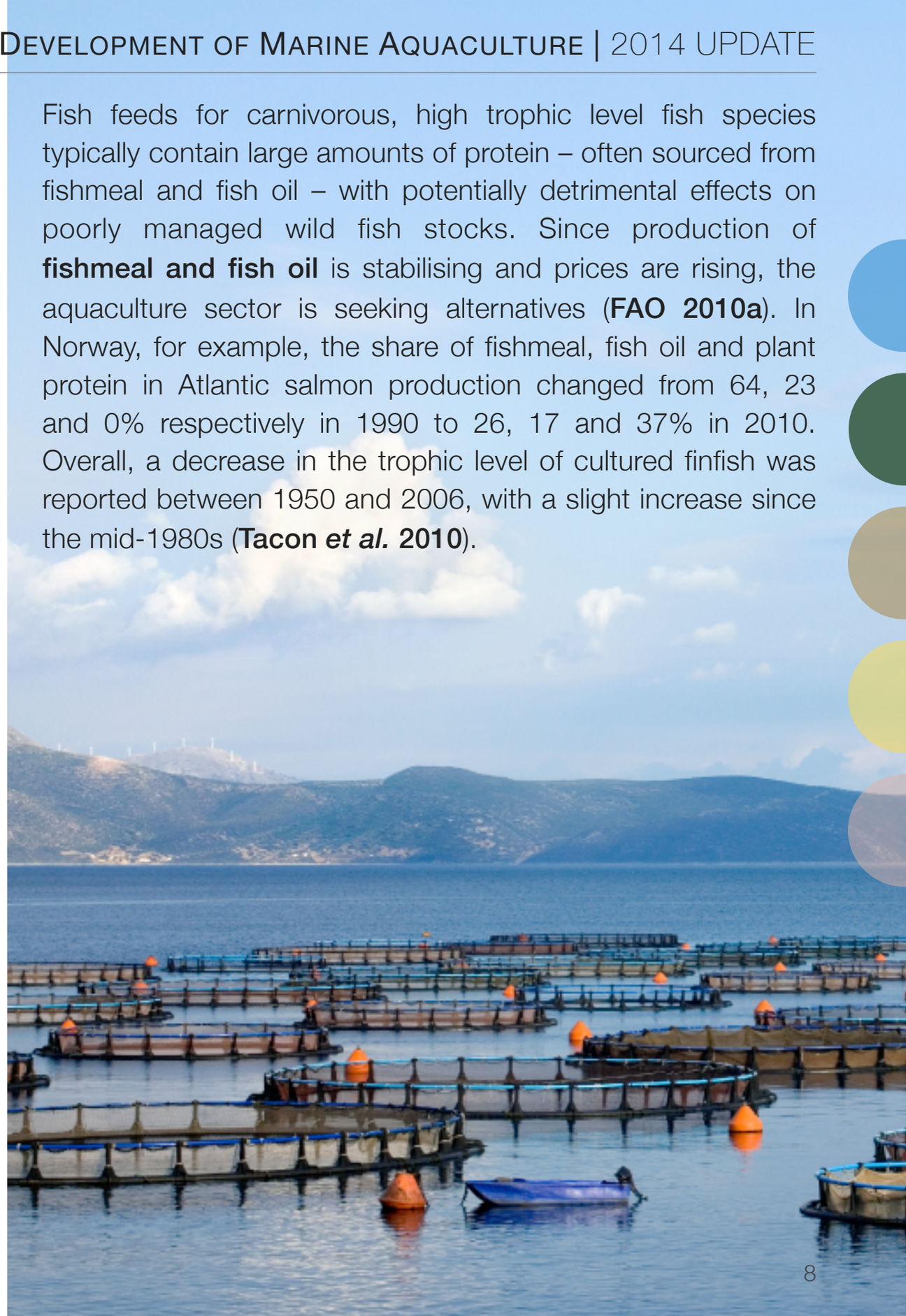
Marine aquaculture production has grown by over 35% since 2004 in total volume. Farmed fish production surpassed beef production in 2012 (**Earth Policy Institute 2013**).

In absolute terms, the greatest growth in fish and shellfish farming has been in Asia. The highest relative growth has taken place in Oceania. While the economic importance of marine aquaculture in **Small Island Developing States (SIDS)** varies, it is low overall. Africa was expected to see a "dramatic increase" in marine aquaculture over the past decade, but this increase has not been realised so far. With the decline in production of tiger shrimp, the size of the sector has shrunk in Africa.

Europe is the only region where the share of marine aquaculture in total aquaculture production is growing. To a great extent, this is due to successful farming of Atlantic salmon, one of the species with the highest production (2 million tonnes globally in 2012). Molluscs also continue to contribute a significant portion of production (over 20%).

Recently there has been notable growth in production of a number of aquaculture species, including groupers, milkfish, Indo-Pacific swamp crab, pompanos, turbot, sole and whiteleg shrimp (*Penaeus vannamei*). Production of whiteleg shrimp overtook that of tiger shrimp in 2003. It requires less expensive feed than tiger shrimp due to a lower protein requirement, and overall production costs are lower (**FAO N.D**.).

Fish feeds for carnivorous, high trophic level fish species typically contain large amounts of protein – often sourced from fishmeal and fish oil – with potentially detrimental effects on poorly managed wild fish stocks. Since production of **fishmeal and fish oil** is stabilising and prices are rising, the aquaculture sector is seeking alternatives (**FAO 2010a**). In Norway, for example, the share of fishmeal, fish oil and plant protein in Atlantic salmon production changed from 64, 23 and 0% respectively in 1990 to 26, 17 and 37% in 2010. Overall, a decrease in the trophic level of cultured finfish was reported between 1950 and 2006, with a slight increase since the mid-1980s (**Tacon *et al.* 2010**).



Aquaculture has been estimated to use 63 and 81%, respectively, of global fishmeal and fish oil. Fish feeds for carnivorous, high trophic level fish species typically contain large amounts of protein – often sourced from fishmeal and fish oil – which could potentially have detrimental effects on poorly managed wild fish stocks. While their shares in feeds are decreasing due to replacement by alternative ingredients, (**FAO 2009a**; **Tacon and Metian 2008**), fish meal and fish oil will continue to be used to meet nutritional requirements but at lower levels (**Nofima 2011**).

Source: IFFO 2010
http://www.iffo.net/node/464

UNIMA and WWF Madagascar are partners on Sustainable Development through eco-friendly fishing, non-intensive shrimp farming and cashew culture.

UNIMA/WWF www.youtube.com/watch?v=wvRI1K5QzNA

Fish processing offcuts have been identified as a potentially important source of high-quality feed ingredient **(World Bank 2013)**, and already provide 25% of all fish meal and fish oil used (**Chamberlain 2011**). Alternatives should not be considered in isolation. For example, replacing fishmeal and fish oil with plants such as soy or rapeseed might have unwanted detrimental impacts on terrestrial ecosystems.

Another important development is the relocation of shrimp farms from tidal mangrove habitats to sites (and natural habitats) further upland (**Stokstad 2010**), using more intensive production patterns requiring greater investments and technical expertise. According to the Global Aquaculture Alliance (**GAA 2011**), today mangrove losses due to shrimp farming have virtually ceased to occur.

3. Marine aquaculture with less impact

A key role for consumers and the private sector

Consumer awareness of, and interest in, more sustainable aquaculture products is increasing. Sector-based activities such as the **Global Salmon Initiative** are important responsive mechanisms that can also support sustainability certification. A number of aquaculture related **certification schemes** have been developed in past years. They include **Naturland**, **the Global Aquaculture Alliance (GAA)** **Best Aquaculture Practices (BAP)** standards, and the **Aquaculture Stewardship Council (ASC)**.

The **ASC** has adopted standards for salmon as well as tilapia, pangasius, trout, abalone and bivalves. It adopted a shrimp standard in March 2014. Many farms have already been certified to these standards. The technical guidelines of the **Food and Agriculture Organisation (FAO)** on aquaculture certification were recently approved at intergovernmental level (**FAO 2011**).

The GAA is an international, non-profit trade association dedicated to advancing responsible aquaculture.

The Global Aquaculture Alliance www.youtube.com/watch?v=Y6py5ZiJVbE

Responsible Farmed Seafood. When done responsibly aquaculture presents a solution to meeting the increasing food demand of a growing global population

WWF/ASC www.youtube.com/watch?v=zpAvBeZnKiA

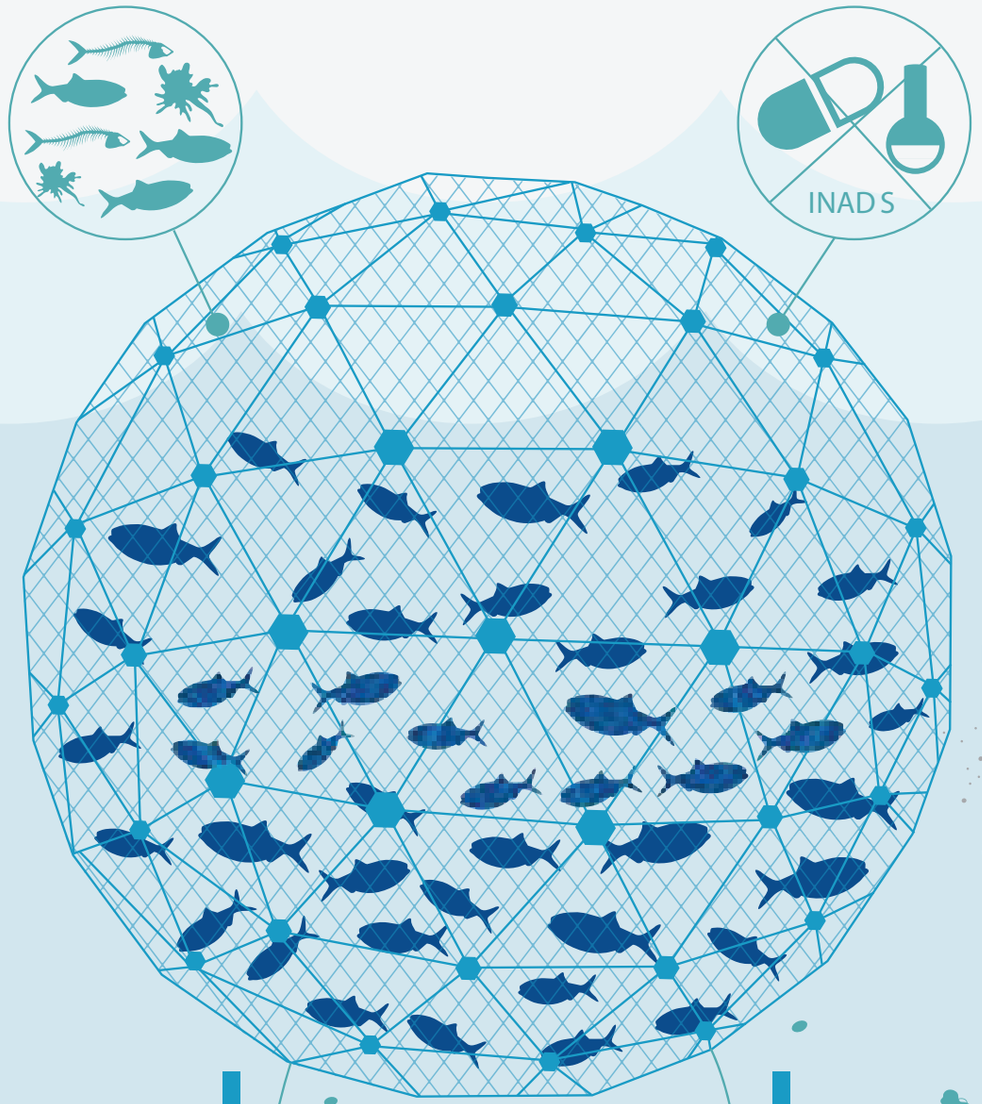
Independent sustainability certification can be a powerful tool that goes beyond improvement of production standards and labelling of certain products to inform consumers. It can also bring about enhanced sector transparency and the provision of better information on impacts. Certification is an effective lever for further development of industry standards and governance mechanisms.

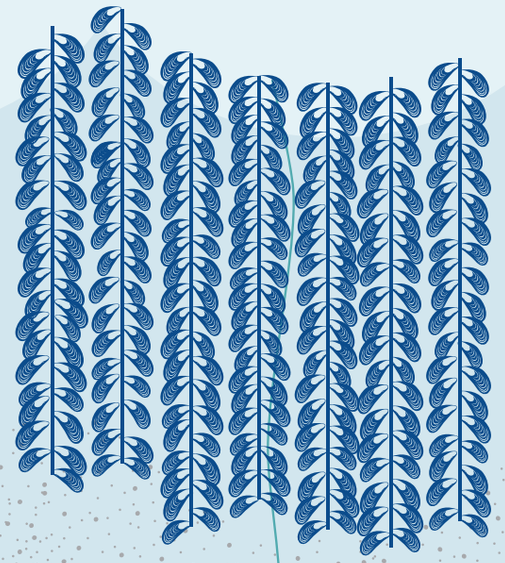
Integrated aquaculture is a practice that combines different kinds of aquaculture (e.g. fish, shellfish and seaweed cultivation) to minimise environmental impacts by creating balanced ecological systems in which, for example, shellfish and seaweeds filter excess nutrients produced by the fish while providing another economic mainstay. This approach is commonly practiced in freshwater environments, particularly in Asian carp farming, but its potential has yet to be realised in the marine environment (**FAO 2009b**). The use in aquaculture operations of offshore structures such as wind farms – which could reduce competition for space – is another approach with great potential.

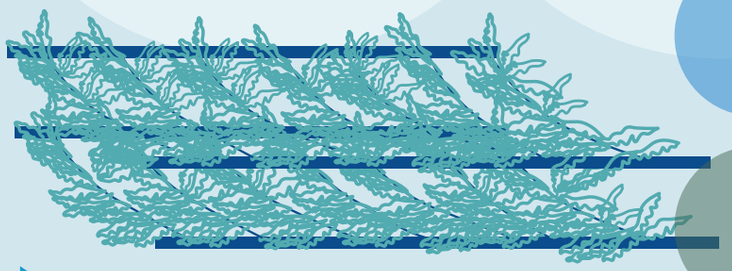
The idea of growing different aquatic species together is an age old concept but new to modern aquaculture in North America and Europe.

AquaNet *www.dfo-mpo.gc.ca/aquaculture/sector-secteur/publications-eng.htm*

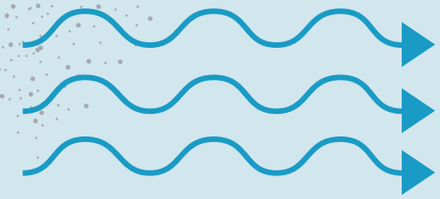
Environmentally Responsible Aquaculture







Seaweeds absorb and capture dissolved inorganic waste and product oxygen through photosynthesis.



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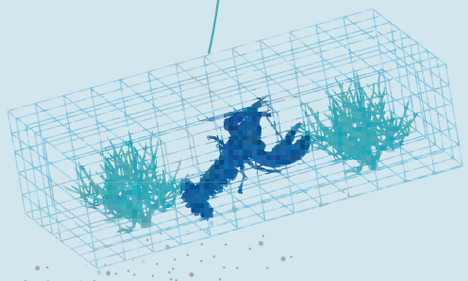
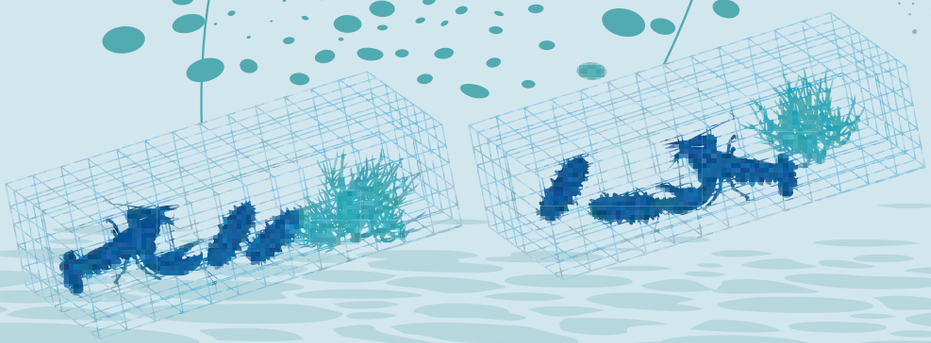
Deposit feeders, like lobsters, sea cucumbers, and sea urc hins, feed on the the excess fish feed and the waste from the fish and mussel systems to recycle waster and minimize sea floor impacts



Suspension feeders, like mussels and other shellfish, recycle organic nutrients and excrete dissolved inorganic waste.



Source: Ocean Conservancy http://tocdev.pub30.convio.net/our-work/aquaculture/assets/pdf/oc_rfts_v11_single.pdf

Significant health related technological advances have taken place in marine aquaculture. For example, **specific pathogen free** tiger and whiteleg shrimp broodstock, or vaccinations of salmon, can reduce the need to use chemicals in farming for disease treatment with their associated environmental impacts. In net pens, wrasses have been used as cleaner fish to treat sea lice (**FAO 2012**).

The increase in the number of **closed aquaculture systems** whose exchanges with natural ecosystems are limited, could potentially reduce the impacts of wastewater and chemicals from aquaculture on water quality (**EPI 2008**).

The **FAO** has published an extensive **series of technical guidelines** which support the public and private sector in taking concrete steps to make marine aquaculture sustainable (**FAO 2013a**).

A significant global contribution to sustainability could be made by shifting from cultivation of high to lower trophic level species, particularly mussels. Further strengthening of the amount of sustainably produced plant ingredients in feeds would help reduce marine aquaculture's environmental footprint. Expanding marine aquaculture further offshore may be an opportunity for food production and development with lower environmental impacts (**FAO 2013b**).

4. Capitalising on Progress

Government support to marine aquaculture sustainability

As marine aquaculture has been experiencing rapid growth, significant technological advances have been made that address some of the sector's environmental impacts. The environmental footprint of aquaculture (including marine aquaculture) is likely to be lower than that of other protein production methods, depending on their particular impacts. However, due to continued growth overall environmental impacts from aquaculture are expected to at least double by 2030 (**Hall *et al.* 2011**). While the private sector's role and responsibility to respond to marine aquaculture's environmental challenges will continue to be critical, governments remain key to promoting and stimulating sustainable practices.

Marine aquaculture cannot be seen as an isolated sector. Its management should be based on (and part of) overall ecosystem-based management, including the use of approaches such as **marine spatial planning** (**FAO 2008**) and **environmental impact assessment** (**FAO 2009c**).

Certification contributes to sustainable production, but has its limits. It can be seen as one approach among many for making aquaculture sustainable.

Wageningen UR www.youtube.com/watch?v=2sHsoVuIsps

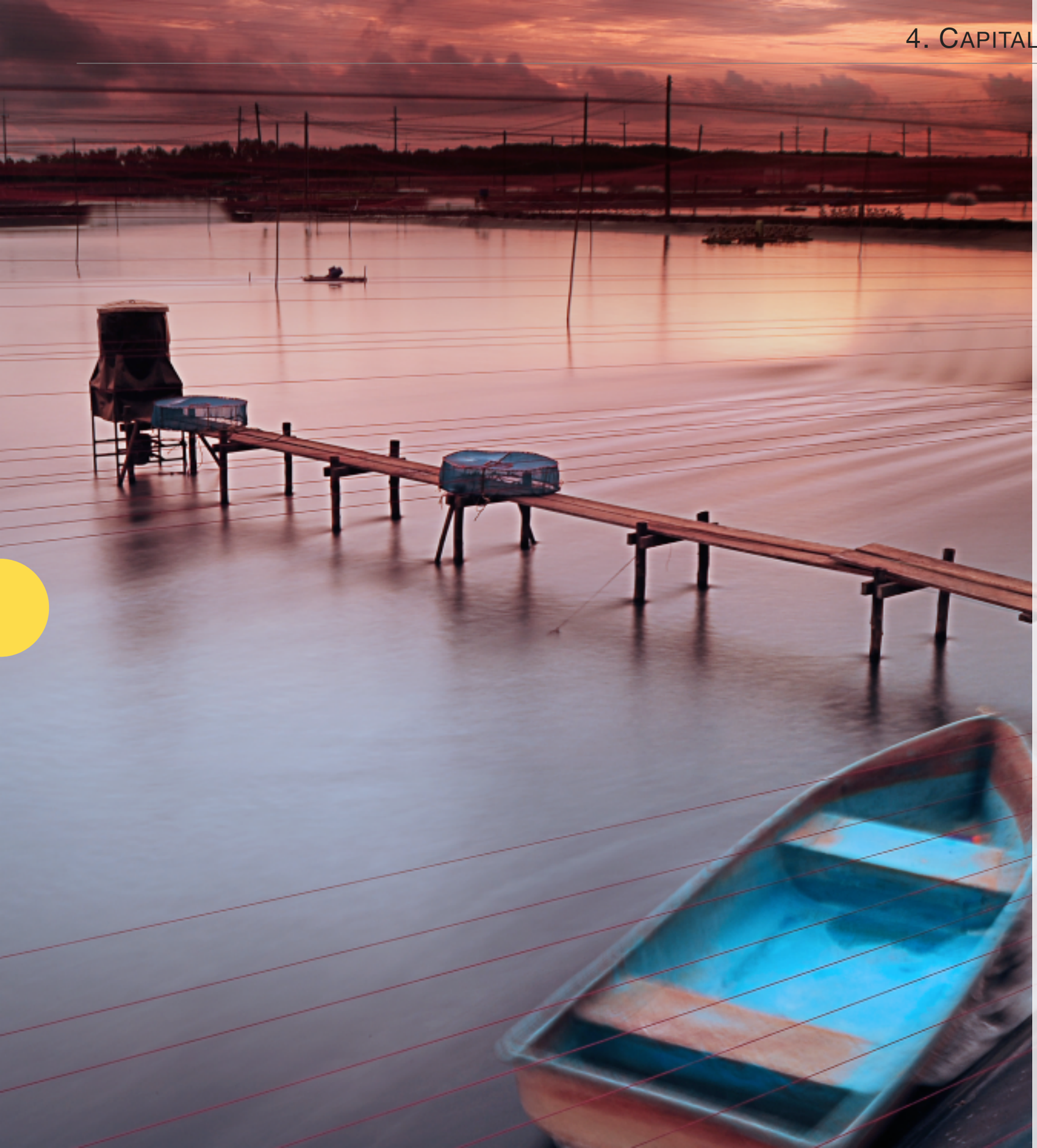
The **FAO** defines an ecosystem approach to aquaculture as "a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems (**FAO 2010b**)." Thus, the involvement of sector and public stakeholders is critical for this approach's success.

Setting operational standards (e.g. for protecting coastal ecosystems or use of chemicals) is important to help ensure a level playing field across the sector. Technical regulations and targeted subsidies for investments in low-impact technology can be an incentive for more sustainable practices. While standards might have to be set nationally, international organisations such as **FAO** – as well as sector roundtables and non-governmental initiatives – should continue to facilitate progress, supported by capacity building and training initiatives that help the marine aquaculture industry develop and embrace best environmental practices.

"Turning points in modern aquaculture" is a historical journey to the major steps in aquaculture development since the Chinese Fan Li two millennia ago.

FAO www.youtube.com/watch?v=4eAXwk2orY0

Stricter regulation can also lead to innovation that drives down costs and impacts, as seen in farmed salmon production. This can be supported by targeted research to strengthen the operational and environmental knowledge base, and to shape cross-country and cross-sector learning networks.



Healthy marine ecosystems are fundamental to reaching development goals – not only with respect to securing food, but also to providing jobs. Marine aquaculture's current impacts and predicted growth call for continued and strengthened efforts towards environmentally sound development of the sector to avoid the loss of important ecosystem services. Technical innovations, the experience and growing skills of aquaculture producers, and improved knowledge of environmental impacts and operational and governance opportunities provide reasons to hope for a sustainable marine aquaculture sector supporting a growing world population with food and livelihoods.

5. Sources, Websites and Credits

Further information about fish and shellfish farming in marine ecosystems

All external links accessed July 10, 2014

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Videos

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FAO www.youtube.com/watch?v=4eAXwk2orY0

Selected Websites

UN Food and Agriculture Organisation, Aquaculture www.fao.org/aquaculture

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Global Salmon Initiative: www.globalsalmoninitiative.org

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Ocean Conservancy, Aquaculture http://tocdev.pub30.convio.net/news-room/aquaculture/

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Mussel farm in the france sea © Gerard Koudenburg / Shutterstock www.shutterstock.com/pic.mhtml?id=98576990&src=lb-27210656

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Alive prawns or white shrimps on hand in front of aquaculture pond © Mati Nitibhon / Shutterstock www.shutterstock.com/pic.mhtml?id=110419187&src=lb-27210656

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BANGPHLI - DECEMBER 23 ; Unidentified workers are catching around shrimp farm, December 23,2009, Samutprakran, Thailand. © think4photop/shutterstock www.shutterstock.com/pic.mhtml?id=161781158&src=lb-27210656

Fish farm plant on Evia island,Aegean sea,Greece.Nature and food industry concepts. © Takis_Milonas / iStock www.istockphoto.com/photo/fish-farm-13247687

Chapter 3:

Shrimp at seafood market in Thailand © amstockphoto / istock www.istockphoto.com/photo/shrimp-at-seafood-market-33004630?st=df2cecd

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A man cast a net to catch his culture prawn with a sun in the background © Mati Nitibhon / Shutterstock www.shutterstock.com/pic.mhtml?id=110133350&src=lb-27210656

A Thai farmer is ready to cast his cast net to catch shrimp in his pond © Mati Nitibhon / Shutterstock www.shutterstock.com/pic.mhtml?id=110421710&src=lb-27210656

Modern shrimp farm long exposure shot © Mati Nitibhon / Shutterstock www.shutterstock.com/pic.mhtml?id=110133341&src=lb-27210656

Chapter 5: Sources and Websites

Many Shrimp in basket for the cook. © Theeraphon / Shutterstock www.shutterstock.com/pic.mhtml?id=139393685&src=lb-27210656

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