



Food and Agriculture Organization  
of the United Nations

# Achieving Blue Growth

through implementation of  
the Code of Conduct  
for Responsible Fisheries

Réaliser une croissance  
bleu à travers la mise  
en œuvre du Code  
de conduite pour une  
pêche responsable

Lograr el crecimiento  
azul mediante la  
aplicación del Código  
de Conducta para la  
Pesca Responsable

تحقيق النمو الأزرق  
من خلال تنفيذ  
مدونة السلوك  
بشأن الصيد الرشيد

The background of the entire page is a teal-colored image showing a fishing net draped over the surface of water. The net's mesh is clearly visible, and the water below it has a textured, rippled appearance. The overall tone is a monochromatic teal.

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# The Code of Conduct for Responsible Fisheries

The 1992 United Nations Conference on Environment and Development, more commonly known as the Rio Summit, was instrumental in focusing international attention on achieving sustainable development, with a new interest in safeguarding our natural resources for future generations.

The resulting shift in public debate prepared the way for a long-discussed improved integration of conservation and environmental considerations into fisheries management. The Code of Conduct for Responsible Fisheries was drafted, negotiated, and adopted by FAO member countries to serve this purpose. It served as the basis for the development of the Ecosystem Approach to Fisheries and Aquaculture. The Code recognises the nutritional, economic, social, environmental and cultural importance of fisheries and aquaculture, and the interests of all those concerned with the fishery sector.



The Code of Conduct for Responsible Fisheries provides principles and standards applicable to the conservation, management and development of all fisheries, including:



## Key facts & figures

In March **1991**, the FAO Committee on Fisheries (COFI) called for development of new concepts for responsible, sustained fisheries.

The Code of Conduct for Responsible Fisheries was drafted by **170** FAO member countries.

The Code was adopted unanimously at the FAO Conference on **31** October **1995**.

Numerous technical guidelines for responsible fisheries and International Plans of Action have been produced to support countries with implementing the Code.

States and all those involved in fisheries and aquaculture are encouraged to implement the Code. FAO is responsible for monitoring implementation, and supporting countries in their efforts to implement the Code.



## A blow to IUU fishing: Port State Measures

Illegal, unreported and unregulated (IUU) fishing is believed to represent 20% of total catches per year. Estimates place the dollar figure of IUU fishing between USD 10-23 billion annually. The Code makes clear the important role ports play in supporting its objectives of eliminating IUU fishing. In 2009, a key measure designed to prevent illegally caught fish from ever entering international markets through ports was adopted at FAO: The Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. The Agreement promotes collaboration between fishermen, port authorities, coast guards and navies to strengthen inspections and control procedures at ports and on vessels. Under the terms of the treaty, vessels must request permission for port entry. Port entry and port services must be denied to offending vessels after regular inspections. Twenty-five countries must ratify the treaty in order for it to enter into force. Many countries are advanced in the process prior to ratification, and the international community is hopeful the treaty will soon enter into force – an important milestone in the fight against IUU fishing.

## Responsible and sustainable development of aquaculture

Aquaculture has witnessed spectacular growth since 1995, the year in which the Code was adopted. Aquaculture today makes up over 50% of the fish destined for human consumption, and with an expanding population coupled with an increasing demand for fish and fish products, aquaculture is expected to play an ever greater role in meeting this demand in the future. Two decades ago, the Code laid out important principles to ensure that aquaculture intensification is carried out in a sustainable way, and that planning and policies adequately integrate economic, environmental, social and governance factors. The Code also recognizes that aquaculture development should not impact negatively upon vulnerable populations, noting that ‘states should ensure that the livelihoods of local communities, and their access to fishing grounds, are not negatively affected by aquaculture developments.’ Instruments such as the FAO technical guidelines for aquaculture certification can help ensure that the aquaculture product reaching consumers’ plates has been produced in a manner fully consistent with the principles of the Code of Conduct.



# The Blue Growth Initiative

The Blue Growth Initiative developed from the concept of the Green Economy and is based on the sound principles of the Code of Conduct for Responsible Fisheries. Blue Growth prioritizes balancing the sustainable and socioeconomic management of our natural aquatic resources, with an emphasis on efficient resource use in capture fisheries and aquaculture, ecosystem services, trade, livelihoods and food systems.

The initiative is aimed at reconciling economic growth with improved livelihoods and social equity, and strengthening transparent, reliable and more secure food systems. Blue Growth also places greater responsibility on national and regional policies for protecting living aquatic resources. It aims to create an enabling environment for workers involved in fisheries and aquaculture to act not only as resource users, but also to play an active role in protecting and safeguarding these natural resources for the benefit of future generations.



## Key facts & figures

The “blue economy” concept came out of the **Rio+20 Conference in 2012**, and emphasizes the three pillars of sustainable development – economic, social and environment.

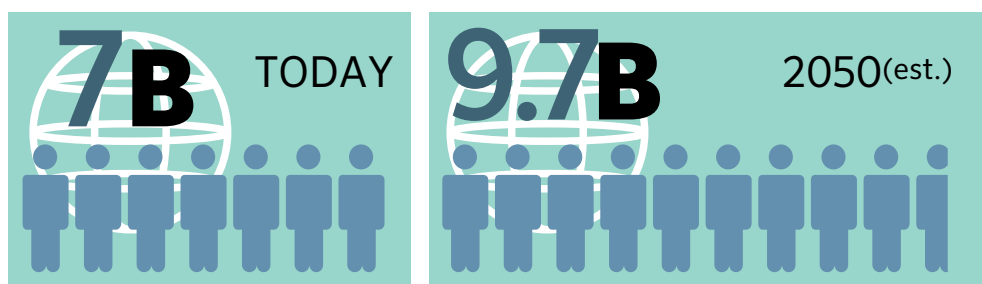
FAO launched the Blue Growth Initiative in **2013** and it featured in high level fora such as at the Global Action Summit in The Hague, the Netherlands.

Blue Growth focuses on **200** million people employed through fisheries & aquaculture and in various sectors along the seafood value chain. A heightened demand for fish and fishery products could translate into increased decent employment opportunities in this sector.

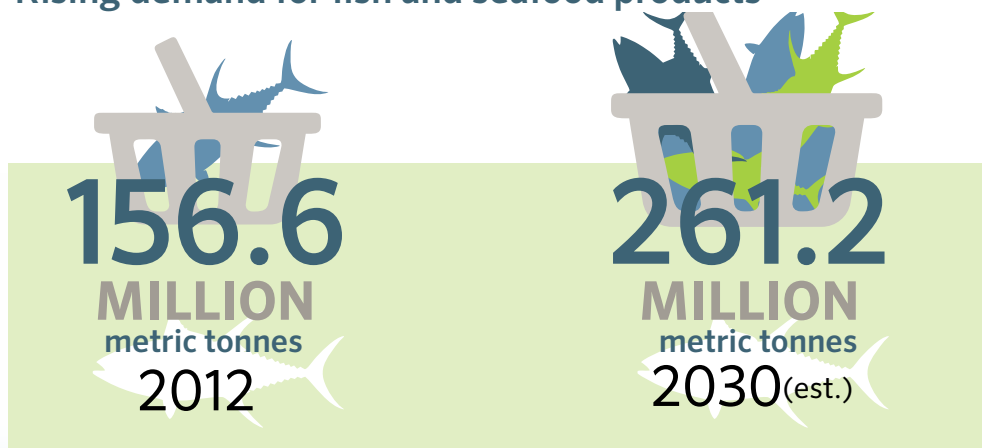
The oceans provide half of the world’s oxygen and **80%** of all life on earth.

Water in lakes and rivers constitute less than **0.01%** of the world’s total water volume, but provide habitat for **41%** of the world’s fish species.

## World population



## Rising demand for fish and seafood products



## Supporting countries in adopting the Blue Growth Initiative

FAO is working to assist countries in transitioning to a blue growth agenda. Priority areas for policy development include eliminating harmful fishing practices and overfishing, instead favoring approaches that promote growth based on resource efficiencies. Such approaches also emphasize the need to generate decent employment and trade opportunities, improve biodiversity conservation, end illegal, unreported and unregulated fishing, and implement measures that foster cooperation between countries and institutions. The Blue Growth Initiative aims to promote investment and innovation in support of food security, poverty reduction, and the sustainable management of aquatic resources.



### Special challenges for inland fisheries

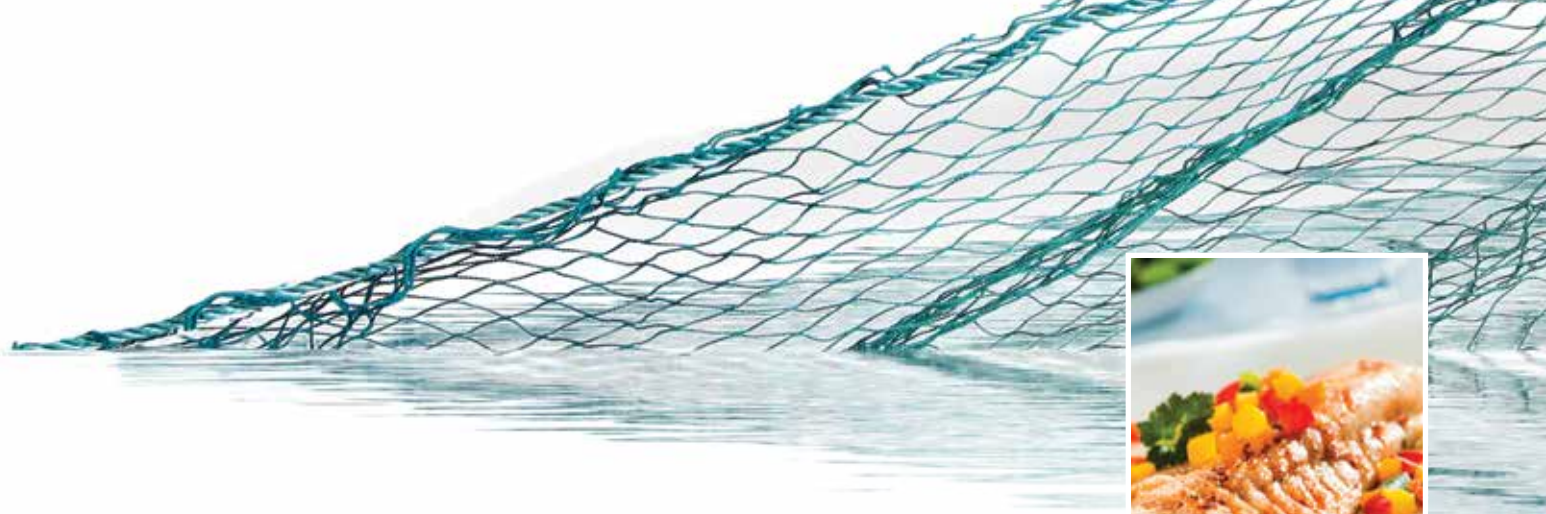
Inland fisheries are an essential element of the Blue Growth Initiative, but with significant challenges.

Fish and other products from inland waters are an essential source of protein, micronutrients, vitamins and omega-3 fats for millions of people, particularly in developing countries, and crucial to the livelihoods of more than 60 million people who depend on inland fisheries. An estimated 71 low-income countries currently produce nearly 7 million tonnes a year, or 80% of global inland capture.

Inland water bodies are frequently impacted by other human needs; competition between inland fisheries and more influential sectors such as hydro-electric, sanitation, transportation and agriculture

is already reducing or degrading inland fishery habitats. Governance is a key challenge to the sector, which is often perceived to have low value and is not often included in national or international policies. Currently, less than half of international or shared inland water bodies have international agreements on their management and only 11% have a mandate covering fisheries management.

The Blue Growth Initiative can play a special role in promoting inland fisheries, especially in bringing together the various stakeholders in integrated water management policies, and ensuring that fisheries management actors are firmly integrated into all multi-stakeholder policies for inland fisheries.



# Fish and human nutrition

Fish plays an important role in fighting hunger and malnutrition. Fish is not only a source of proteins and healthy fats, but also a unique source of essential nutrients, including long-chain omega-3 fatty acids, iodine, vitamin D, and calcium. The multiple benefits of fatty fish high in omega-3s and small fish eaten whole containing nutrients in the skin and bones clearly illustrate seafood's irreplaceable nutritional value.

An increased focus on fish and nutrition aids both developing countries and the developed world. In many developing countries, fish is the main or only source of animal protein, and is essential for providing micronutrients to vulnerable populations. Fish can sometimes serve as a solution to existing health problems. For instance, goiter is found in areas where iodized salt is unavailable, but the consumption of fish and the natural iodine it contains could help reduce these cases. Dietary patterns are also shifting in developed and middle-income countries, and an increasing emphasis on coronary and overall health has led to an increased demand for fish.

## Key facts & figures

More than **3.1** billion people depend on fish for at least **20%** of their total animal protein intake, and a further **1.3** billion people for **15%** of animal protein intake.

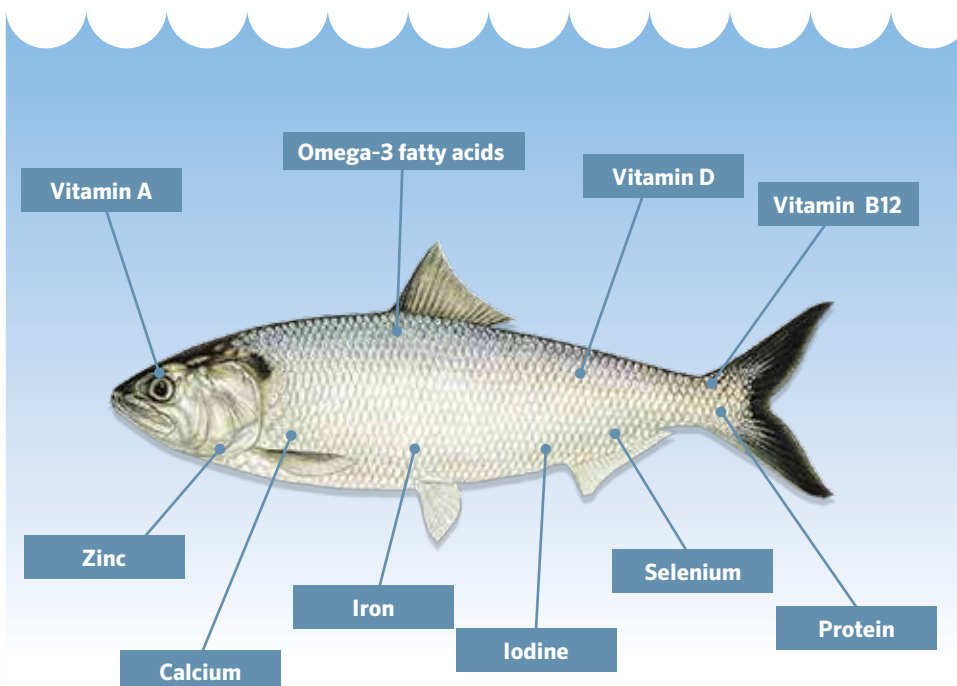
Fish consumption by expectant mothers aids their children's neurodevelopment.

Often undervalued parts of the fish, like the head, viscera, and back-bones make up **30-70%** of fish and are especially high in micronutrients.

Fish consumption has increased from **9 kg** per capita in 1961 to approximately **20 kg** per capita today.

Half of the consumed fishery products derive from aquaculture.

## Fish: Nature's superfood



## Seafood and crucial nutrients for healthy development

Throughout the world, expectant mothers face demanding nutritional needs. The so-called 1 000 day window - from pregnancy to the child's second birthday - is now understood as a crucial time to promote proper nutrition for development, transforming the infant's future prospects and promoting proper physical and mental development. Fish has a crucial role to play in this development.



### Key nutrients in seafood:



#### Long chain omega-3 fats

Mainly found in fish and fishery products, these fatty acids are essential for optimal brain development.



#### Iodine

Seafood is in practice the only natural source of this crucial nutrient. Iodine serves several purposes like aiding thyroid function. It is also essential for neurodevelopment.



#### Vitamin D

Another nutrient crucial for mental development, this vitamin also regulates the immune system function and is essential for healthy bones.



#### Iron

During pregnancy, iron intake is crucial so that the mother can produce additional blood for herself and the baby.



#### Calcium, zinc, other minerals

Diets without dairy products often lack calcium, and zinc deficiency slows a child's development.

### Waste not, want not: How fish bones can supplement traditional diets

The composition of some amino acids, vitamins and minerals in tuna bones used for fish powder, in comparison with maize flour

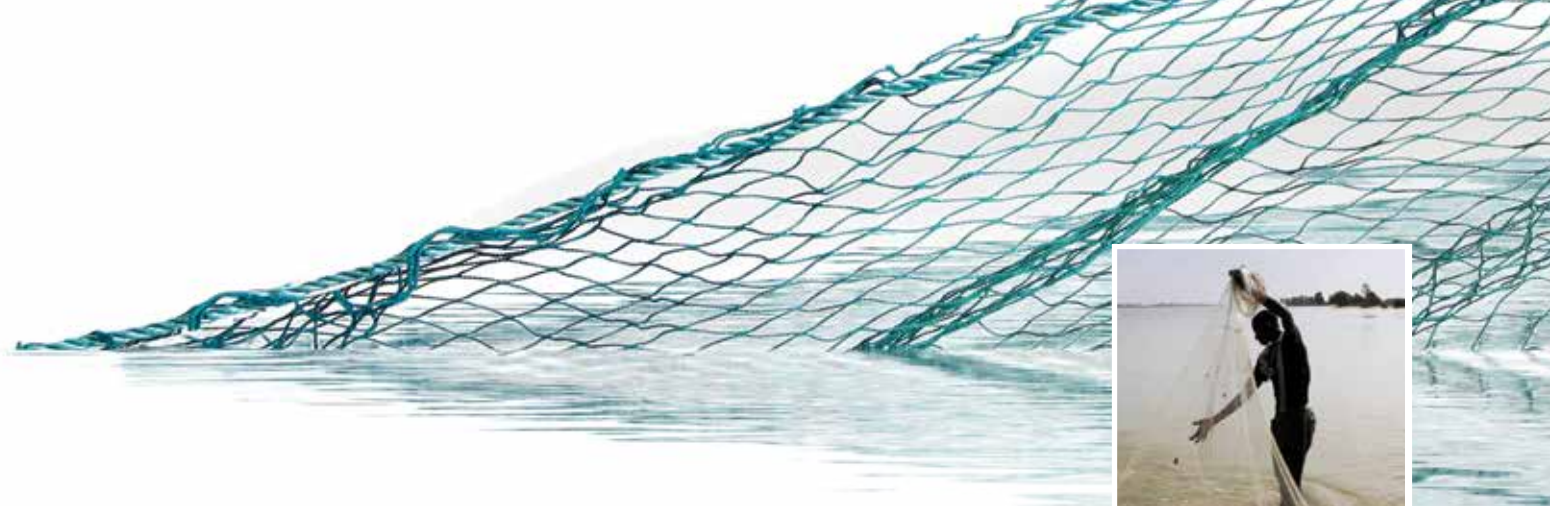
Nutrient	Tuna bones per 100 g	maize flour per 100 g	daily requirement for children
Calcium	10.2 g	7 mg	700 mg/day
Iron	36 mg	2.4 mg	8.9 mg/day
Zinc	8.6 mg	1.7 mg	3.7 mg/day
EPA + DHA	3.1 g	N/A	150 mg/day

Fish products are ideal complements to starch-based diets lacking these nutrients.



### FISH PRODUCTS

Ranging from fish pastes and cakes to dried and fried offerings, seafood products are gaining recognition for their nutritional value. Gaining popularity in African countries like Uganda, seafood powders made from by-products or lake sardines provide missing nutrients to the primarily grain or starch-based diets of the region. In Chile, salmon meat is scraped off frames and heads to produce fish patties and sausages. In many Asian countries fish heads are a highly regarded delicacies.



## Livelihoods and decent work

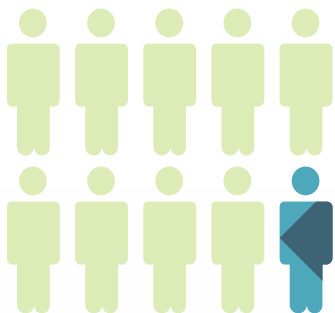
The fisheries sector employs over 110 million people worldwide and feeds billions. Work in the sector is especially important in developing countries, where fisheries and aquaculture provides important opportunities for rural employment and livelihoods. With approximately one-tenth of the world's population relying on fisheries and aquaculture for their livelihoods, improving management in small-scale fisheries is essential for eliminating food insecurity and poverty.

But the sector also struggles to ensure decent work. Many fisheries workers suffer from dangerous work environments, and over 5 million fisheries workers earn less than one dollar a day. The sector must also do more to empower women at all stages of the value-chains. Despite being responsible for over 90% of processing and 20% of primary



fishing activities, women receive limited access to the credit, training, and technology that would make their work more efficient. Too often, children are also working in this sector rather than attending school. Secure livelihoods and decent work are the cornerstones of sustainable and productive fisheries and aquaculture sectors, and at the heart of the Blue Growth Initiative.

Approximately  
**1 in 10**  
**PEOPLE**  
rely on fisheries  
and aquaculture for  
their livelihoods.



## Key facts & figures

**90%** of capture  
fishers operate in small-  
scale fisheries and over  
90% of those fishers live  
in developing countries.

Half of the fisheries  
workforce and over  
**90%** of the processing  
sector are female.

**90-95%** of small-  
scale fisheries landings  
are destined for local  
human consumption.

More than **4,000**  
people from over  
**100** countries  
have participated in  
consultations to develop  
the Small-Scale Fisheries  
Voluntary Guidelines.

Investment in good  
fisheries governance can  
offset economic losses  
from weak fisheries  
governance estimated  
at over **USD 50**  
**billion** annually.

FAO operationalizes the International Labour Organization's concept of decent work in rural areas through the concept of decent rural employment. Here is how FAO's work spreads the four pillars of decent work to fisheries and aquaculture in rural areas.

## The four pillars along the path to decent rural employment:

### STANDARDS AND RIGHTS AT WORK

Agricultural workers and especially fisheries or aquaculture laborers often lack protection from labor laws. Child and migrant laborers are particularly at risk for human rights violations. Women contribute throughout the value chain, but these contributions are largely unrecognized. FAO programmes train women in improving food production, vocational skills, and small-scale agriculture.

### SOCIAL DIALOGUE

Adequate governance and dialogue is difficult to provide when few fishery and aquaculture workers have organized and formal employment, and often lack representation. These laborers frequently rely on organizations that cover other sectors and are not familiar with fishery and aquaculture in order to represent their interests. Supporting cooperatives and recognizing rights to organize at the smallest unit levels could support broader organizational aid.

### SOCIAL PROTECTION

Many fishers work in countries lacking social security, yet the sector remains a dangerous occupation. 24 000 casualties occur annually in the dangerous, and often exhausting occupation of capture fishing. Protecting fishers and their families in times of injury, sickness, or work accidents is essential considering rural communities' dependence on seafood production. Even with social protection programs in place, one may have to navigate bureaucratic issues. In Brazil's Pará state, fisher organizations help women fishers obtain documentation that proves their occupation, thereby allowing them to access benefits if needed.

### EMPLOYMENT GENERATION AND ENTERPRISE DEVELOPMENT

The fact that 5 million fishers earn less than a dollar per day reflects an industry that struggles with infrastructure and development. Wasteful food handling, a lack of investment in new technology, and gaps in data slow the industry's progress and misrepresent its value.



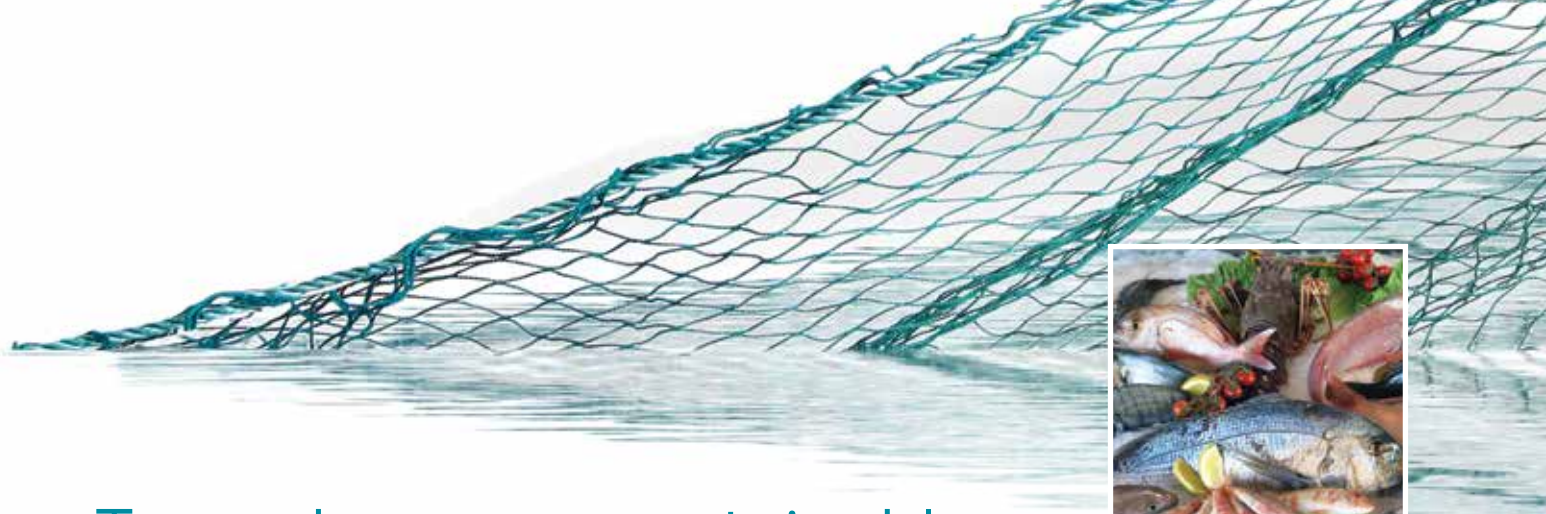
## Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries

The Guidelines are the first internationally agreed instrument for the small-scale fisheries sector.

The Guidelines support investing in health, literacy, and technological education, eradicating forced labor, promoting social security protection, mandating gender mainstreaming, and building fisheries' resistance to climate change and extreme weather.

FAO supports implementation by providing communication materials and performing research to inform policy reform. Parties interested in improving fishers' livelihoods should support their government's implementation and ratification of the Guidelines.





# Towards a more sustainable seafood value chain

The Blue Growth Initiative takes an overall approach to improving sustainable growth and management of aquatic resources, with special attention provided to the seafood value chain. A value chain is the entire process by which a sector or a company adds value to their final product.

By intervening at all stages along the seafood value chain, Blue Growth measures can improve the process, diminish losses and waste, and minimize the carbon footprint while adding value to the final product. At the end of the seafood value chain, consumers can contribute to sustainable Blue Growth through their purchasing choices and their efforts to reduce food waste.



Good governance and strong policies facilitate the implementation of changes throughout the entire value chain. Effective policies are key for everything from job creation and decent employment to efficient resource management, food waste reduction, poverty reduction and providing incentives for investment and innovation.

Influencing policy decisions is also necessary to strengthen the role of women in the seafood industry, and to empower vulnerable communities engaged in small-scale production. The strong focus on policy in the Blue Growth Initiative also applies food safety and processing, labour and transportation policies, and trade measures.



## Key facts & figures

Seafood products are among the most widely traded food commodities – totaling around **USD 145 billion** per year.

**58** million people are employed directly through fisheries and aquaculture.

About **200** million direct and indirect employment opportunities are created along the value chain.

**35%** of fish and seafood is lost or wasted – almost double the figures for losses for meat products.



## Small changes can result in big impacts along the value chain

Simple, inexpensive technologies can have tremendous effects on the value chain, particularly by increasing the earnings of rural fishers and processors. Fish dryers in Burundi were able to double their prices and decrease waste by converting to simple drying racks. More efficient fish smoking kilns in Côte d'Ivoire increased profits for women's cooperatives, improved the health of the women smoking the fish, and met EU standards for dried fish imports. Additionally, the more efficient kilns resulted in lower levels of food loss and waste and reduced the amount of carbon fuel required to produce the product, thereby decreasing greenhouse gas emissions.



## Building a more efficient and sustainable seafood value chain

### Harvesting



- Improve safety and security for workers
- Decrease carbon emissions & adopt appropriate technologies
- Adopt appropriate technologies
- Develop ecotourism
- Eliminate IUU
- Preserve biodiversity
- Improve cold-chain

### Primary processing



- Improve energy efficiencies
- Lower carbon emissions
- Innovate & adopt appropriate technologies
- Recycle food byproducts

### Secondary processing



- Lower carbon emissions
- Improve infrastructure
- Support innovation

### Wholesale



- Improve transport
- Use recyclable packaging
- Decrease food waste
- Improve infrastructure

### Retail



- Reduce packaging and recycle
- Decrease food waste
- Improve transport
- Promote sustainable seafood choices

### Consumer



- Encourage recycling
- Decrease food waste
- Improve nutrition
- Inform about sustainability of seafood & carbon footprint of food

### Post-consumption



- Decrease food waste
- Recycle packaging



# Food loss and waste (Save Food)

The 1 BILLION TONNES of food wasted each year is a tragedy in a world in which 795 million people are still undernourished. Food loss and waste contributes to food insecurity, squanders precious natural resources, and slows economic and social development.

As we struggle to feed the 9.7 billion people expected to make up the world population by 2050, this magnitude of food loss and waste is unacceptable. The SAVE FOOD Initiative is working to link industry, research, governments, and civil society in the crucial fight against food loss.

Combating food loss and waste requires different approaches in different parts of the world. About half of the seafood loss in North America takes place at the consumption stage. In the developing world, most losses are experienced at the post-catch stage, with fish lost in poorly constructed nets, in substandard transport without ice to maintain sanitary conditions, or within inefficient fish processing and storage facilities.

## Key facts & figures

The percentage of fish food losses – **35%** – is almost double that of losses for meat products.

Approximately **25%** of seafood in North America and Oceania is wasted at the consumption stage.

Fish consumption is expanding on all continents, with higher increases expected in Asia and Oceania.



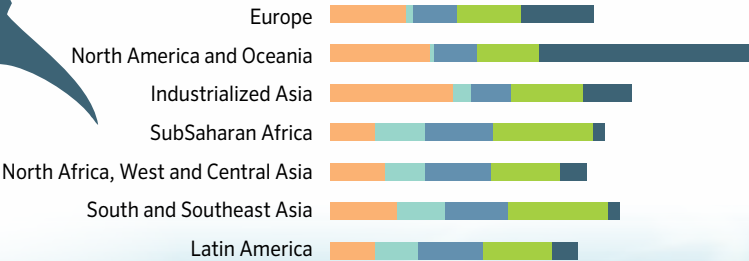
**35%**  
**FISH & SEAFOOD  
FOOD LOSSES**

8% of fish caught globally is thrown back into the sea. In most cases they are dead, dying or badly damaged.



This is equal to almost 3 billion Atlantic salmon.

- Fisheries
- Post-catch
- Processing
- Distribution
- Consumption





In the developed world, increased coordination between fishers, supermarkets, and consumers limits overproduction and wasted fish on grocery shelves. In the agricultural sector, technological innovations such as rice storage facilities in Tajikistan or cold chain development in Bangladesh's milk trade, have allowed for improvements, preserving products' value and safety. There is potential for similar innovations for fish and fishery products.

Food waste translates into emitting an additional 3 gigatons of CO<sub>2</sub> emissions each year to produce food that is never consumed. This level is higher than emissions for any country, except for the US and China.

The blue water footprint (consumption of surface and groundwater resources) of food wastage is about 250 km<sup>3</sup>, three times the volume of Lake Geneva.

Inefficiencies in small-scale fishing and aquaculture operations lead to food waste. This scarcity instigates illegal and unsustainable fishing that harms communities and the environment.

Solutions include spreading technologies like drying racks, policies like fencing off landing beaches to keep production sanitary, communication policies and consulting locals about their needs and fully involving them in policy changes. In one Lake Victoria fisheries site in Kenya, fish landing facilities with ice and cold storage facilities that comply with EU standards have fallen into disrepair because those using the facilities were not adequately consulted and trained in their use and maintenance.



FAO taught women in Burundi to build and use raised racks for fish drying instead of placing them on the sand. Previously, the women lost 15% of the catch to animals or rainwater contamination. Today, the prices of the cleaner, quicker drying fish have doubled since 2004.

Women often participate in less valued post-harvesting operations while men occupy fishing roles. Therefore, economic opportunities for women are valuable, and the women in this project gained greater credibility with their increased earning power. Although men hope to enter this newly lucrative industry, the government supports women's cooperatives through microcredit schemes.



# Ecolabels, certification and sustainability

The demand for fish and fishery products is increasing rapidly. As the annual *OECD-FAO Agricultural Outlook* consistently shows, we are moving to an increasingly fish-protein-based diet. But as consumer patterns change, so do requests for information about the origins of the fish being consumed, and guarantees that they were fished sustainably. Seafood industry experts are increasingly speaking about the consumer demand for 'sea to plate' traceability.

Global standards for fisheries ecolabels and aquaculture certification are relatively new concepts. Ecolabels and certification were developed to: raise consumer awareness that product was caught in a way that has fewer impacts on the environment than other non-certified, similar products; serve as a market-based mechanism designed to influence the purchasing decisions of consumers or procurement policies of retailers, and; provide choices for consumers to support sustainable practices in fisheries through purchase decisions.



## Key facts & figures

Per capita fish consumption reached **20 kg** in **2014**, and is expected to reach **21.5 kg** by **2024**.

Fisheries production worldwide is expected to expand by **19%** between **2012-14** baseline and **2024**, to reach **191** metric tonnes.

In **2005**, the FAO ecolabelling guidelines for marine capture fisheries were endorsed.

In **2011**, the FAO ecolabelling guidelines for inland capture fisheries were endorsed.

In **2011**, the FAO technical guidelines on aquaculture certification were endorsed.

In **2015**, the Global Sustainable Seafood Initiative, a global benchmarking tool based on the Code of Conduct to evaluate third-party certification, was launched in Vigo, Spain.

Environmentally aware, active populations



Seafood retail sector dominated by large supermarket chains, not small fish markets



Consumption patterns based on few seafood species



Preference for processed seafood products that lend themselves to labeling





## Recent market developments The Global Sustainable Seafood Initiative

In 2012, thirty-two private seafood companies and a government agency (GIZ) financed a three-year project to develop a global benchmarking tool to evaluate third-party certification schemes against the *FAO Code of Conduct for Responsible Fisheries*, Certification Guidelines and other FAO instruments. The Global Sustainable Seafood Initiative (GSSI) is modeled after the Global Food Safety Initiative:

- The GSSI benchmarking tool was developed by 3 expert working groups (Fisheries, Aquaculture, and Process);
- FAO and two NGOs sit on the GSSI Steering Board as affiliated partners;
- FAO provides technical expertise on FAO instruments to the 3 EWGs;
- Pilot testing of the tool was completed in mid-2015 with several certification schemes volunteering to participate;
- The GSSI tool was launched in October 2015 at the FAO Conxemar event in Vigo, Spain that celebrated the 20<sup>th</sup> Anniversary of the Code of Conduct for Responsible Fisheries.

### Public ecolabel schemes

A number of countries have developed their own eco-label schemes to replace private third-party certification schemes. This is a trend which may increase in the future, as FAO has been requested to provide capacity building to member governments interested in developing their own national ecolabel scheme.

## What is a Certification Scheme?

Each ecolabel has its own criteria, assessment processes, levels of transparency, different areas of focus. Cost of labelling can vary considerably. Sponsors / developers vary from private companies, industry groups, NGOs, government or a combination.

**1**

### Sets

standards for an ecolabel

**2**

### Certifies

that a fishery and supply chain are in conformity with required standards

**3**

### Accredits

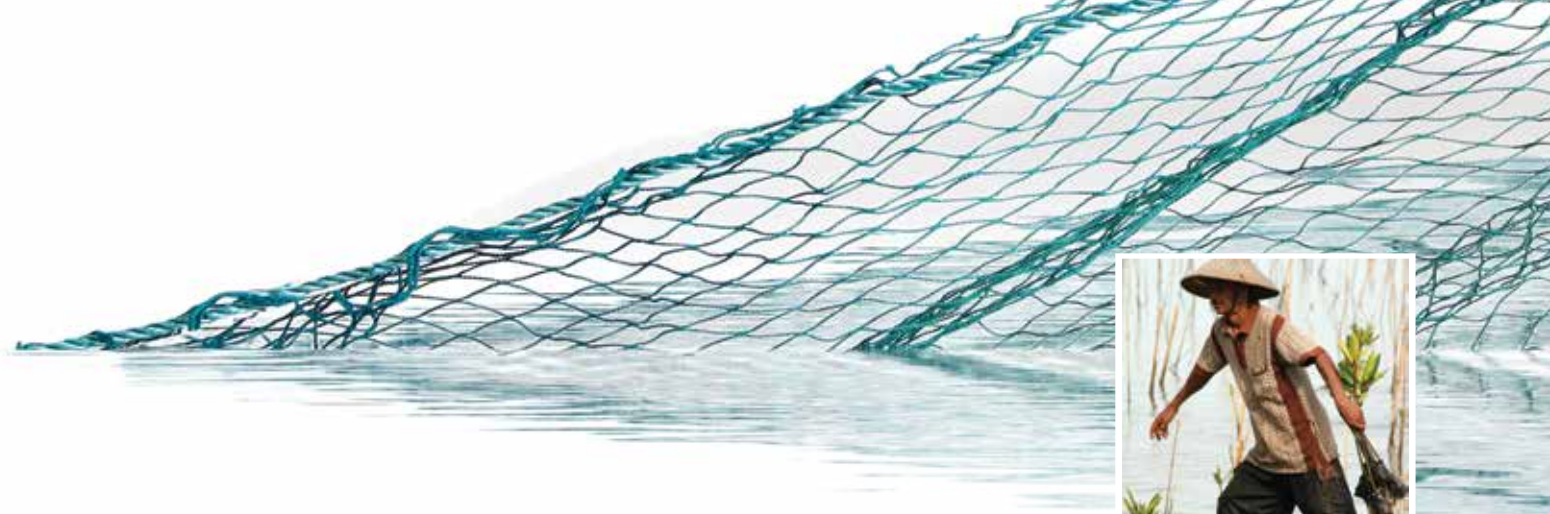
certifying bodies

## FAO Guidelines for voluntary certification

Ecolabelling has been discussed by FAO members since 1997, resulting in the following guidelines:

- Guidelines for Eco-Labeling of Fish and Fishery Products from Marine Capture Fisheries (2005, revised 2009)
- Guidelines for the Eco-Labeling of Fish and Fishery Products from Inland Capture Fisheries (2010)
- Technical Guidelines for Aquaculture Certification (2011)
- Evaluation framework for the Marine Capture Ecolabelling Guidelines (draft not approved by COFI)
- Evaluation framework for Aquaculture Certification (approved 2013)

FAO Certification Guidelines are: consistent with relevant international law (UNCLOS, Fish Stocks Agreement, WTO; voluntary, market driven, transparent, non-discriminatory, and ; recognize special conditions applying to developing countries. FAO Certification Guidelines are intended to provide guidance to Governments and organizations that already maintain, or are considering establishing, labelling schemes for certifying fish from fisheries or from aquaculture.



## Ecosystem services

Aquatic ecosystem services provide essential elements for life: air, food, and water. Every other breath we take originates from the ocean, and approximately 20% of human protein derives from fish, while 40% of rainfall originates from the ocean.

Despite an awareness of the importance of ecosystem services for vulnerable communities, accounting for ecosystem services is not always easy. One example is illustrated by a study in Lami Town, Fiji. The study compared the benefits of constructing a 6 km seawall with that of preserving local mangroves in Lami Town. After completing the costing, researchers discovered that the replacement of the ecosystem services provided to local residents had the wall actually been built would average USD 1 200 annually/per family. This calculation factors in the loss of ecosystem services provided by the trees (including fuel and building materials) and the loss to the families of the fish that thrive in the mangroves.



## Key facts & figures

In **2014**, ecosystem services' value was estimated at **USD 125 trillion**.

**55%** of atmospheric carbon captured by living organisms is sequestered by the sea and blue carbon sinks (peatlands, mangrove forests, seagrass beds, and other vegetated ocean habitats).

Local and indigenous varieties of food may contain over **1 000** times the nutrient content of more common varieties.

Restoring ecosystem services could feed **740** million people, fully one-quarter of the estimated population growth by **2050**.

### The four categories of ecosystem services:



**Provisioning services**- this includes the 20% share of animal proteins consumed by the global population, the freshwater ponds preserved by aquaculture and the algae used by pharmaceutical companies. These services include food, raw materials, freshwater, medicine, and other goods often traded in markets. Some rural communities depend on these services to build their homes and support their families.



**Regulating services**- these manage air quality, water filtration, disease, pest control, and other foundations of ecosystem health. With oceans storing fully 90% of the earth's carbon dioxide, mangroves and coral reefs protecting populations from extreme weather, and wetlands removing waste and pathogens from water, these invisible services are underappreciated but difficult to replace if lost.



**Habitat or supporting services**- these areas provide habitats and preserve biodiversity, by sustaining the plants and animals that support an ecosystem. For example, coral reefs shelter 25% of marine fish species and feed over a billion people. Managing biodiversity is essential for fisheries and aquaculture, particularly when a history of overfishing of many fish stocks has lowered productivity.



**Cultural services** – these services describe the human attachment to aquatic areas, and are essential for economic reasons, such as tourism and social benefits tied to cultural identity and spirituality. Between 220 and 700 million recreational fishers worldwide enjoy their sport, designers draw inspiration from coral reefs and humpback whales, religions celebrate fish harvests, and fishers and fish farmers base their identity on their occupation and way of life handed down through the generations.



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### Sharks - Are fish in the sea worth more than fish in the net?

In the case of sharks, off the island of Palau they are worth much more if left in the sea where shark diving tourism generates annual business revenues of approximately USD 18 million annually (8% of GDP) compared to a one time value of USD 11 000 if the same sharks were caught and sold for shark fin and other high value products on the international market. A study in Palau found shark dive tourism also generated many employment opportunities in related businesses that serviced the diver operations. The government recognized the importance of shark diving tourism and declared the waters around Palau as a shark sanctuary, closing all forms of shark fishing to foreign vessels in its waters.



©FAO/Alberto Conti

### Protecting mangroves and coral reefs in the Bay of Bengal Large marine ecosystems

A 2014 study of the Bay of Bengal Large Marine Ecosystem revealed the ecosystem's diverse benefits. More than 200 000 people harvest firewood, furnish building poles, and produce dyes or paper from mangroves. Moreover, the trees protect 1.5 million people from extreme weather and water pollution, and sequester over 16000 MtC.

Meanwhile, coral reefs attract tourism and create 1.3 million jobs. They protect 700 000 residents from natural hazards. And within these vulnerable communities, the fish caught in mangroves and coral reefs are often the only source of animal protein consumed by poor, coastal families.



# Technology and innovation

Although fishing and aquaculture may evoke images of wooden boats rowed with oars and small fish ponds, the sector today is highly dependent on technology and innovation in order to expand sustainably. Innovation in the sector links global value chains, reduces energy use and provides healthy, bountiful harvests.

Large-scale fishing vessels are now worth millions of US dollars and carry technology developed by scientists and engineers across all sectors. Meanwhile, transformations to aquaculture mean that small pens of the past have transformed into undersea cages, with diameters of over 100 meters and storm-resistant netting, greatly improving the sector's productivity.

In light of the challenge of feeding 9.7 billion in 2050 with finite natural resources, the higher efficiency of production and lower carbon footprint of producing fish compared to other animal food sources renders its role essential.

## Technology and innovation in the aquaculture sector

Aquaculture, the fastest-growing food production sector, provides the potential for meeting increased protein needs. However, the expansion of breeding programs, farmed species, and techniques must be balanced by innovations that analyze risks, ensure fish health, develop sustainable and nutritious fish feeds, and preserve social benefits.



### Feed, Nutrition, and Health

Increased research on the relationships between fish diets, nutrition, and disease has improved the efficiency of feed production and fish health. Enzymes improve fish digestion, and affordable and widely available bone and soybean meal are replacing fish oil in certain fish's diets. Meanwhile, better developed and easily administered vaccines have dramatically lowered the need for antibiotic treatments.



### Environmental

Aquaculture includes the production of aquatic plants, and the Jiangsu province in eastern China has become a major producer of farmed seaweed. China produces over 12 million tonnes of farmed aquatic plants, responsible for over half of global production. Increasing efficiency and fully utilizing their land, some farmers produce power through windmills and solar panels erected in seaweed cultures.



### Engineering Technologies

Cage development and recirculation technologies allow for dense, efficient, and resilient fish farms. One fish farm FAO worked with in eastern China holds 52 concrete raceways which recirculate water and support black bass and grass carp cultivation. The Blue Growth Initiative will support member governments in spreading these technologies to poor rural farmers and fishers.



## Key facts & figures

Global aquaculture production reached a new high in **2012** at over **90** million tonnes.

Since **2014**, for total fish food consumption, species raised from aquaculture became the main source of fish destined for human consumption, and this share is projected to reach **56%** in **2024**.

The fishing industry often benefits from advancements made in other industries. The development of synthetic fibres, improvements in electronic aids and satellite communications have led to improvements in fishing gear, navigation and fish-finding technologies.



The **R/V Dr Fridtjof Nansen** is a Norwegian research vessel operated by the Norwegian Institute of Marine Research, in partnership with FAO. Since it was built in 1974, it has travelled across the world's oceans, but primarily the coasts of Africa, to collect information on marine resources and the health of marine ecosystems. Researchers typically measure ocean temperatures, oxygen levels, chlorophyll and biological processes like plankton production and fish distribution.

The Nansen has rotating teams of scientists, largely from developing countries in the areas being studied on each survey trip.

Onboard a range of advanced technologies include:

- 10 cubic meters of fresh water production each day
- An acoustic doppler current profiler that reflects acoustic beams off particles in the water to measure current speed and direction while calculating for ship movement
- An Echo sounder and transducer that provide a picture of the seafloor
- A CTD system that measures water properties like temperature, oxygen, salinity, and fluorescence
- Accommodation for scientists and crew

The new Nansen, launched in 2016, is replete with seven scientific laboratories, an auditorium, and equipped with modern sonar sensors able to map fish distribution quickly and a remote-control submersible vehicle able to take photos of life on the ocean floor.





## Efficiency and resource use

With global fish production growing at about 3% annually over the last 50 years and outpacing world population growth, and with the increased demand for fish and seafood products by a growing population, the sustainability of fisheries and aquaculture is crucial. Overfished stocks threaten productivity, while inefficient practices and inefficient vessels emit greenhouse gas emissions that contribute to climate change and the health of our oceans.

Responsible for over 90 million tonnes of aquatic plant and seafood production annually, aquaculture provides most of the 3% growth in global fish production. Despite relying on finite resources of land and water and requiring energy to produce feed, aquaculture generates large amount of food while limiting resource use.

### Fuel efficiency in small-scale vessels

Seafood production requires less greenhouse gas emissions than other animal proteins. Fossil fuels have increased efficiency in fisheries and aquaculture through the mechanization of small fishing vessels, which make up 79% of all fishing vessels. Furthermore, small changes like improved vessel design, selecting an efficient propeller, clearing barnacles, and lowering speed can halve fuel consumption.

However, fishers may need government incentives, teams spreading education about fuel-saving, and large-scale projects supporting new fishing technologies to profit from these fuel-saving measures. For example, diesel engines cost more than outboard engines, making adoption unappealing in many developing countries. Nevertheless, a project in Ghana illustrated that the efficient engines covered their cost in under two years. Loan schemes and maintenance training could help overcome the initial price barrier.

## Key facts & figures

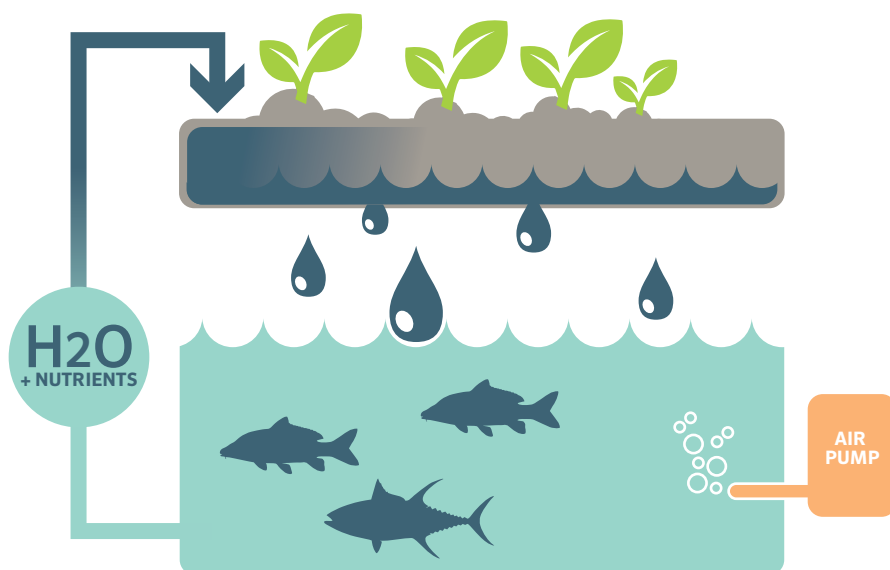
Global capture fisheries consume approximately **41** million tons of fuel per year.

Rebuilding overfished stocks could increase production by approximately **15** million tonnes.

Over half of fishing vessels are engine-powered, but motorized vessels are spread unevenly across the globe. In North America, over **90%** of ships are motorized, while in Africa less than **50%** are motorized.



## The biological components in the aquaponic process: fish, plants and bacteria



## Aquaponics

Aquaponics combines hydroponics, soil-less agriculture, and aquaculture within a closed system. The fish produce waste including ammonia (NH<sub>3</sub>), which bacteria convert into nitrate, a nutrient for plants. The plants uptake the nitrate and other nutrients from the water, purifying it before it returns to the fish tank.

Water efficient, not reliant on fertilizers or pesticides, and implementable in non-arable areas like rooftops or deserts, aquaponics presents economic opportunity and a reliable food source in areas where aquaculture and soil-based agriculture are challenging.

However, aquaponics also requires daily management, electricity, specialized knowledge in fish, bacteria, and plant production, and initial capital. A component of larger sustainability schemes, aquaponics offers an easily adaptable system to provide fish protein, produce, and profits to families and small communities.



In tropical areas, hull fouling – the attaching of barnacles, weed, slime, algae, etc to the hulls of ships – can increase fuel consumption by 7% after one month and 44% after half a year if antifouling paint is not used.



## Resource conservation and adapting to extreme weather in the Philippines: Boat construction post-Haiyan

In 2013, Typhoon Haiyan damaged 30 000 fishing boats, the assets of two-thirds of Filipino fishing communities.

The typhoon also destroyed forests that shelter fisheries and provide boat building materials, so FAO developed a hybrid banca, built by trained local workers, with a fibreglass keel rather than the traditional wooden vessels. However, this new, improved design preserves the traditional boat form.

Innovation that minimizes resource use must still appeal to tradition and be accepted by the local fishing communities.

Further information:  
FI-Inquiries@fao.org  
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