Harvesting

Fishery

Fishery is the enterprise of raising or harvesting fish and other aquatic life. Commercial fisheries include wild fisheries and fish farms, both in fresh water (about 10% of all catch) and the oceans (about 90%). About 500 million people worldwide are economically dependent on fisheries. 171 million tonnes of fish were produced in 2016, but overfishing is an increasing problem causing declines in some populations. Recreational fishing is popular in many locations, particularly North America, Europe, New Zealand, and Australia.

Because of their economic and social importance, fisheries are governed by complex fishery management practices and legal regimes, that vary widely across countries. Historically, fisheries were treated with a first-come first serve approach; however, threats by human overfishing and environmental issues, have required increased regulation of fisheries to prevent conflict and increase profitable economic activity on the fishery. Modern jurisdiction over fisheries is often established by a mix of international treaties and local laws.

Declining fish populations, human pollution in the oceans, and destruction of important coastal ecosystems has introduced increasing uncertainty in important fisheries worldwide, threatening economic security and food security in many parts of the world. These challenges are further complicated by the changes in the ocean caused by climate change, which may extend the range of some fisheries while dramatically reducing the sustainability of other fisheries. International attention to these issues has been captured in Sustainable Development Goal 14 "Life Below Water" which sets goals for international policy focused on preserving coastal ecosystems and supporting more sustainable economic practices for coastal communities, including in their fishery and aquaculture

Definitions

According to the FAO, "...a fishery is an activity leading to harvesting of fish. It may involve capture of wild fish or raising of fish through aquaculture." It is typically defined in terms of the "people involved, species or type of fish, area of water or seabed, method of fishing, class of boats, purpose of the activities or a combination of the foregoing features". The definition often includes a combination of mammal and fish fishers in a region, the latter fishing for similar species with similar gear types. Some government and private organizations,

especially those focusing on recreational fishing include in their definitions not only the fishers, but the fish and habitats upon which the fish depend.

Economic importance

Directly or indirectly, the livelihood of over 500 million people in developing countries depends on fisheries and aquaculture. Overfishing, including the taking of fish beyond sustainable levels, is reducing fish stocks and employment in many world regions. In additional to commercial and subsistence fishing, recreational (sport) fishing is popular and economically important in many regions.

The term *fish*

- **In biology** – the term *fish* is most strictly used to describe any animal with a backbone that has gills throughout life and has limbs, if any, in the shape of fins. Many types of aquatic animals commonly referred to as *fish* are not fish in this strict sense; examples include shellfish, cuttlefish, starfish, crayfish and jellyfish. In earlier times, even biologists did not make a distinction—sixteenth century natural historians classified also seals, whales, amphibians, crocodiles, even hippopotamuses, as well as a host of marine invertebrates, as fish.
- **In fisheries** – the term *fish* is used as a collective term, and includes molluscs, crustaceans and any aquatic animal which is harvested.
- **True fish** – The strict biological definition of a fish, above, is sometimes called a true fish. True fish are also referred to as *finfish* or *fin fish* to distinguish them from other aquatic life harvested in fisheries or aquaculture.

Types

The fishing industry which harvests fish from fisheries can be divided into three main sectors: commercial, recreational or subsistence. They can be saltwater or freshwater, wild or farmed. Examples are the salmon fishery of Alaska, the cod fishery off the Lofoten islands, the tuna fishery of the Eastern Pacific, or the shrimp farm fisheries in China. Capture fisheries can be broadly classified as industrial scale, small-scale or artisanal, and recreational. Close to 90% of the world's fishery catches come from oceans and seas, as opposed to inland waters. These marine catches have remained relatively stable in quantity. Most marine fisheries are based

near the coast. This is not only because harvesting from relatively shallow waters is easier than in the open ocean, but also because fish are much more abundant near the coastal shelf, due to the abundance of nutrients available there from coastal upwelling and land runoff. However, productive wild fisheries also exist in open oceans, particularly by seamounts, and inland in lakes and rivers. Most fisheries are wild fisheries, but farmed fisheries are increasing. Farming can occur in coastal areas, such as with oyster farms, or the aquaculture of salmon, but more typically fish farming occurs inland, in lakes, ponds, tanks and other enclosures. There are commercial fisheries worldwide for finfish, molluscs, crustaceans and echinoderms, and by extension, aquatic plants such as kelp. However, a very small number of species support the majority of the world's fisheries. Some of these species are herring, cod, anchovy, tuna, flounder, mullet, squid, shrimp, salmon, crab, lobster, oyster and scallops. All except these last four have provided a worldwide catch of well a substantial number, with herring and sardines together providing a harvest of over a quarter the size of the species named above. Many other species are harvested in smaller numbers.

Production

Total fish production in 2016 reached an all-time high of 171 million tonnes, of which 88 percent was utilized for direct human consumption, thanks to relatively stable capture fisheries production, reduced wastage and continued aquaculture growth. This production resulted in a record-high per capita consumption of 20.3 kg in 2016. Since 1961 the annual global growth in fish consumption has been twice as high as population growth. While annual growth of aquaculture has declined in recent years, significant double-digit growth is still recorded in some countries, particularly in Africa and Asia.

FAO predicts the following major trends for the period up to 2030:

- World fish production, consumption and trade are expected to increase, but with a growth rate that will slow over time.
- Despite reduced capture fisheries production in China, world capture fisheries production is projected to increase slightly through increased production in other areas if resources are properly managed. Expanding world aquaculture production, although growing more slowly than in the past, is anticipated to fill the supply–demand gap.

- Prices will all increase in nominal terms while declining in real terms, although remaining high.
- Food fish supply will increase in all regions, while per capita fish consumption is expected to decline in Africa, which raises concerns in terms of food security.
- Trade in fish and fish products is expected to increase more slowly than in the past decade, but the share of fish production that is exported is projected to remain stable.

Management

The goal of Fisheries management is to produce sustainable biological, social, and economic benefits from renewable aquatic resources. Fisheries are classified as renewable because the organisms of interest (e.g., fish, shellfish, reptiles, amphibians, and marine mammals) usually produce an annual biological surplus that with judicious management can be harvested without reducing future productivity. Fisheries management employs activities that protect fishery resources so sustainable exploitation is possible, drawing on fisheries science and possibly including the precautionary principle. Modern fisheries management is often referred to as a governmental system of appropriate management rules based on defined objectives and a mix of management means to implement the rules, which are put in place by a system of monitoring control and surveillance. A popular approach is the ecosystem approach to fisheries management. According to the Food and Agriculture Organization of the United Nations (FAO), there are no clear and generally accepted definitions of fisheries management. However, the working definition used by the FAO and much cited elsewhere is: The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives.

Law

Fisheries law is an emerging and specialized area of law. Fisheries law is the study and analysis of different fisheries management approaches such as catch shares e.g. Individual Transferable Quotas; TURFs; and others. The study of fisheries law is important in order to craft policy guidelines that maximize sustainability and legal enforcement. This specific legal area is rarely taught at law schools around the world, which leaves a vacuum of advocacy and research. Fisheries law also takes into account international treaties and industry norms in

order to analyze fisheries management regulations. In addition, fisheries law includes access to justice for small-scale fisheries and coastal and aboriginal communities and labour issues such as child labor laws, employment law, and family law. Another important area of research covered in fisheries law is seafood safety. Each country, or region, around the world has a varying degree of seafood safety standards and regulations. These regulations can contain a large diversity of fisheries management schemes including quota or catch share systems. It is important to study seafood safety regulations around the world in order to craft policy guidelines from countries who have implemented effective schemes. Also, this body of research can identify areas of improvement for countries who have not yet been able to master efficient and effective seafood safety regulations.

Fisheries law also includes the study of aquaculture laws and regulations. Aquaculture, also known as aquafarming, is the farming of aquatic organisms, such as fish and aquatic plants. This body of research also encompasses animal feed regulations and requirements. It is important to regulate what feed is consumed by fish in order to prevent risks to human health and safety.

Environmental issues

Overfishing

Overfishing is the removal of a species of fish from a body of water at a rate that the species cannot replenish, resulting in those species becoming underpopulated in that area. In a Food and Agriculture Organization of the United Nations 2018 report, the FAO estimates that one-third of world fish stocks were overfished by 2015. Overfishing can occur in water bodies of any sizes, such as ponds, rivers, lakes or oceans, and can result in resource depletion, reduced biological growth rates and low biomass levels. Sustained overfishing can lead to critical depensation, where the fish population is no longer able to sustain itself. Some forms of overfishing, such as the overfishing of sharks, has led to the upset of entire marine ecosystems.

The ability of a fishery to recover from overfishing depends on whether the ecosystem's conditions are suitable for the recovery. Dramatic changes in species composition can result in an ecosystem shift, where other equilibrium energy flows involve species compositions different from those that had been present before the depletion of the original fish stock. For

example, once trout have been overfished, carp might take over in a way that makes it impossible for the trout to re-establish a breeding population.

Climate change

The full relationship between fisheries and climate change is difficult to explore due to the context of each fishery and the many pathways that climate change affects. However, there is strong global evidence for these effects. Rising ocean temperatures and ocean acidification are radically altering marine aquatic ecosystems, while freshwater ecosystems are being impacted by changes in water temperature, water flow, and fish habitat loss. Climate change is modifying fish distribution and the productivity of marine and freshwater species. The impacts of climate change on ocean systems have impacts on the sustainability of fisheries and aquaculture, on the livelihoods of the communities that depend on fisheries, and on the ability of the oceans to capture and store carbon (biological pump). The effect of sea level rise means that coastal fishing communities are significantly impacted by climate change, while changing rainfall patterns and water use impact on inland freshwater fisheries and aquaculture.

Maintaining a stable farm for fishing requires one to have tools to ensure the harvesting does not reduce the production. The rate of production should actually be made higher than the rate of harvesting for this to be profitable. The equipment requirements of a project depend largely on the type of rearing to be done and the level of production envisaged. The degree of the use of automation needs to fit within the global context of the project.

Pumping

When it is not possible to have a water supply by gravity, pumping needs to be added to the farm. When pumping is necessary, it is more appropriate to consider extensive or semi-intensive farming under tropical conditions. Water needs for extensive systems are not so high as for the other alternatives described. In these conditions, the water supply should compensate the water lost through evaporation and infiltration into the soil. In a semi-intensive system, a water exchange of 15 to 25% per day has to be accounted for. In order to evaluate exact pumping needs, the calculation will be based on the water requirements of the rearing system, the size of the ponds, on the soil nature (losses through infiltration) and also

the climate (rainfall and evaporative loss). Each case demands a specific study that will determine the type of pumps to be used and their capacity.

Harvest

The equipment for this is the basic (and most used) equipment in fish farming. Nets for harvest must be adapted to the facilities (i.e. the size and depth of ponds). Large mesh nets must be used for harvesting bigger fish while small mesh nets must be foreseen for fry. Nets must be well maintained and be checked after each use, in order to maintain an efficient standard of operation. Not only the condition of the mesh but also floats and ballast must be subject to constant checks.

Aeration

There are two main types of aeration systems used in commercial aquaculture.

Aeration by pulsed air: A blower generates air at relatively low pressure through pipes to air stones or other diffusers. This system is particularly well adapted to small-scale facilities and for fry and small fish since it does not cause damage due to water turbulence.

Aeration by mechanical agitation: There are many different types of aerators (fountain aerator, paddlewheel, and Venturi system) and each has strong and weak points.

Fountain aerators suck the water from the bottom of the pond and throw it into the air as a fountain. This is done very simply by the use of a motor-driven propeller. It is a very efficient aeration system because it takes the water from the bottom that is poor in O2 and creates an important water movement within the pond. The main disadvantage is that it creates waves that can damage the dams of the ponds by erosion and a build-up of heavy silt underneath the aerator, imposing maintenance of the pond structure at regular intervals.

Paddle wheel aerators use motor-driven paddles on floats to throw the water into the air for aeration and create a movement on the surface of the pond. While these might be not seen to be so efficient as the fountain aerator, on the other hand, they offer the advantage of creating less erosion and of not creating turbidity.

The aerators equipped with a **Venturi system** are also very efficient because the system creates an important aeration effect and induces a good gaseous exchange. They can sometimes cause turbidity and create a hole on the bottom of the pond if the flow is badly oriented or if the ponds are not deep enough. The selection of the aeration system needs to be done following the type of facilities being used (earth ponds, concrete pond, size of the facilities etc.) and the rearing conditions applied (density, fish size, etc.)

Fish graders

Fish graders are used to grade and separate fish according to their individual size. This operation is very important because it allows a dramatic improvement in growth performance and improves the overall management of the use of the farm's facilities. If the fish are not graded properly, the smallest ones have difficulty in gaining access to the food *(due to physical competition with larger fish)* and are stressed, resulting in poor growth performance. Since the size of fish pellets is uniform, the fish size must also be uniform. There are two main types of fish grading equipment:

Manual fish graders: They are made of boxes that are fitted with differently sized screens, each relating to a range of physical fish size. It is a very simple system that allows small fish to go through the screen while retaining the larger ones in the box. An advantage of the system is that it does not require any electric energy. However, it generates more stress than an automatic grader that is due to heavier handling of the fish.

Mechanical graders are more sophisticated. Without going into details, it is a machine that is able to grade fish into 3, 4 or 5 different size batches. The system is made of 2 mobile bands or rollers, fixed opposite each other with, a gap between that becomes progressively wider. Fish are conveyed between the bands, being constantly sprayed with water, and they then fall through the gap when the width *(corresponding to their size)* allows it, smaller fish falling through first. Fish are then transferred to the different tanks through plastic pipes by gravity. The main advantage of this system is that the job is done quickly and without excessive damage to the fish. In intensive fish farming, this type of equipment is very interesting to use, especially when temperatures are high and the fish must be handled with care.

As complementary equipment to the fish grader, **fish counters** can also be used, often called "bio-scanners"; it consists of an electronic register/counter that is placed at the end of an outlet of the fish grader. Using this equipment, the exact number of fish is known after the grading.

Fish pumps & fish elevators

This equipment is used to move fish out of the growing units for grading, for loading on a truck or simply for harvest.

Fish pumps function on the same principles as water pumps; they suck fish and water together and pump them out afterwards. All of the movement is done through (flexible) pipe-work. This system is particularly well adapted to floating cage culture.

Fish elevators are based on the concept of the Archimedes screw. This system lifts the water and the fish together.

These two systems are adaptable to a large variety offish *sizes (from few grams to more than 5 kg)* and species. When high production levels are envisaged, this equipment is very useful indeed almost essential. The ratings for this type of machinery can reach 10 tonnes of fish per hour for the biggest ones.

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