CHAPTER 25

# Latest Trends in Fisheries

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## SUMMARY

It has been assessed that the current trends of fisheries are by far causing a significant impact on the fisheries and the marine and wildlife. In this chapter it describes how this industry has matured from the old ways of fishing to the new technologies of fish farming and sustainable fishing. It also discusses the historic roles of fisheries, their technologies and issues associated with fisheries. It addresses the problems of fishing crises, loss of ecological systems, and climate change issues that affect marine lives and the means of sustenance for the fishing populations. Chances can be found by methods of sustainable fishing like MPAs and reducing by-catch besides innovations in artificial intelligence and robotics that create a new effective and sustainable world for fishing. All these technologies and techniques enhanced the fisheries sector from not only an efficient production point of view but also livelihood. Finally, the chapter reiterates the importance of international cooperation and responsible and sustainable management of these issues to help secure the world's fisheries' future.

## INTRODUCTION

From piracy of whaling vessels to modern technological fish farming the relationship between man and fisheries has always evolving. Today, one is therefore observing that change happening at a much faster rate. What is referred to as fisheries is catching fish as an occupation, an industry or during some seasons. In the past decades, fisheries management has been accompanied by certain changes due to the introduction of new technologies, the impact of the environment and the consideration of economic factors (Kuparinen & Merila, 2007). Of course, in order to provide further specifics, let us first define the differences between fisheries and aquaculture. Aquaculture practices fishes and other aquatic species by cultivating under controlled systems and fisheries uses fishing systems to harvest fishes from the natural aquatic systems. Aquaculture delivers fish and seafood that are efficient and beneficial all the time and in contrast; fisheries are based on natural sources of fishes and may have adverse effects on the environment and other species (Gilman et al., 2022).

This chapter provides an account of the current state and challenges of the fisheries sector and also looks at the future prospects and prospects of the sector to make a sustainable future. Fisheries are the source of food, income and living for millions of people internationally but fishing is a big challenge due to over request, water pool degradation, global warming, and volatility. To address those challenges, this chapter examines the background of fisheries management, the state of world fish stocks, and the ways and means, whereby application of modern technologies might assist in making the Fisheries subsector more sustainable and productive (Heino et al., 2015).

### Historical background

Some places have managed fisheries for a long time. Most of the world's fish come from the wild in the marine and freshwater. For example, New Zealand had rules about not wasting fish and giving the first fish to the sea god. In the 1800s, Norway made laws to control fishing in the Lofoten area. "Local groups decided how to divide the fishing areas among the boats. In Europe, the government started to protect the fish resources in the 1900s, after a conference in London. Two British researchers wrote an important book about the fish in the North Sea.

All U.S. states and Canadian provinces have fisheries agencies and their workers follow the laws for both freshwater and marine fisheries. After some time away from fisheries management, Beverton said he was not happy with his earlier work in a paper in 1992. He said his and Holt's work had been used wrongly by fishery experts and managers for 30 years (Heino et al., 2015). However, their work was still the basis for modern fishery management. In 1996, a group was formed to make standards for sustainable fishing. In 2010, another group was made to do the same for aquaculture. A report in 2014 said global fisheries added $270 billion a year to the world economy, but this could go up by $50 billion more if fishing was done sustainably (Atkinson, 1998).

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**Evolution of fisheries science**

About 40,000 years ago, people of the upper Paleolithic period performed many activities and fishing is one of the oldest activities among them. Fishing is influenced by various factors such as society, environment, technology, and politics. These factors evolve fishing from a survival activity to a business and recreational activity. Fishing has also influenced many civilizations, as evidenced by many artistic, religious, and literary paintings of fishing. Fishing evolved through four stages prehistoric, ancient, modern, and contemporary fishing. Each stage illustrated the development of fishing in different ways, tools, and modern techniques and also described the impact of fishing on humans and other aquatic organisms (Heino et al., 2015).

**Prehistoric Fishing:** This is the oldest stage of fishing about 40,000 years ago. Prehistoric people lived near shallow water sources and used spears, hooks, and gorges as simple tools to catch fish. They moved along with the fish as they migrated seasonally and settled there (Heino, 1998). Ancient Fishing: Fishing evolved along with civilizations from 8,000 to 2,000 years ago. Ancient people devised and improved fishing tools such as nets, traps, harpoons, and fish aggregation devices. They also established fishing cultures and traditions, such as art, literature, and religion that celebrated fishing and fish. They exchanged fish and seafood with other areas and explored new fish resources (Heino, 1998).

**Modern Fishing:** This stage of fishing began in the 18th century and to the present era of the Industrial Revolution. The people of the modern era invented new methods and technologies such as sonar, purse seines, longlines, and trawls. They also enhanced fishing efficiency and capacity as well as its social and environmental impacts. They established fisheries management and conservation institutions and policies, such as quotas, regulations, and agreements (Heino et al., 2015).

**Contemporary Fishing:** The present and future challenges and opportunities develop the stage of contemporary fishing. Contemporary people have changed their preferences and practices such as sustainable fishing, recreational fishing, and aquaculture. They are also using innovative approaches such as sensors, artificial intelligence, and drones. They are dealing with complex problems, such as food security, climate change, and overfishing (Killen et al., 2017).

**Current state of global fisheries**

The section presents an overview of production, consumption, trade, and employment in the fisheries sector. It also outlines the main opportunities and challenges for the sustainable development of the fisheries sector. In the latest edition of The State of World Fisheries and Aquaculture1 by the FAO Fisheries and Aquaculture Division, the global fisheries and aquaculture sector's yield was 179.6 million tonnes in 2018. Out of which, humans consumed 156.4 million tonnes. About 59.5 million people including 14% women are directly and indirectly attached to the fisheries sector for employment. The percentage of fish stocks that were biologically sustainable dropped from 90% in 1974 to 65.8% in 2017. The main causes of the decline are illegal overfishing, high demand for fish, ineffective fisheries management, pollution, and climate change (Ovando et al., 2021).

## CHALLENGES AND OPPORTUNITIES OF FISHERIES

As we all know fisheries are an important source of food, income, and livelihood. However, it faces many challenges for its sustainability and future. On the other hand, new opportunities offer hope for the efficiency of fisheries. Here are some challenges and opportunities;

**Challenges**

Overfishing and overexploitation: Overexploitation of fish from the oceans is a major threat to the water and the animals that live there. We take about 90 million tons of seafood from the oceans every year. There are rules to make sure we fish legally and take care of the oceans, but many people do not follow them. Fish stocks are being depleted by unregulated fishing practices, impacting both small-scale and large-scale fishing. Moreover, many fish stocks are harvested at their maximum yield which reduces the productivity of fish and the ecosystem and also causes food insecurity (Garraud et al., 2023).

**IUU fishing:** IUU fishing means Illegal, unregulated, and unreported fishing. This is a major threat to the sustainability of fish as it contributes to the decline in fish stock. It is hard to tackle due to poor governance and inadequate monitoring. It ultimately leads to economic losses and social problems (Tolentino-Zondervan & Zondervan, 2022).

**Climate change and ocean acidification:** Fish sustainability is affected due to the rise in ocean temperature, changing ocean currents, more frequent and intense extreme weather events, and water acidification particularly in susceptible events (Chan et al., 2019).

Pollution and habitat degradation Chemicals, Oil leakage, Plastic, and agriculture runoff are causing massive diseases, depleting habitats, and ultimately mortality of fish. They not only increase the uncertainty of fishers but also harm human health by eating contaminated fish (Tolentino-Zondervan & Zondervan, 2022).

**Governance and policy gaps:** The fisheries sector is supervised by an actor of different institutes at national and international levels. There are gaps and conflicts among governance and policy frameworks of the fisheries sector such as insufficient coordination, cooperation, inadequate data and information, poor monitoring, and accountability (Chan et al., 2019).

**Environmental impact:** By-catch is a term used to describe the unintended capture of non-target species during fishing operations. Unfortunately, bycatch can have a lot of negative effects on the environment, such as reducing the number of fish in the ocean, damaging marine habitats, and decreasing biodiversity. Bycatch in fisheries can be reduced in several ways, such as by using different types of fishing gear, imposing fishing quotas, and creating new fishing technology (Squires et al., 2021).

**Habitat destruction:** It is one of the big issues which is contributing a lot of harm to the environment. Another activity that poses some level of threat to the habitats is the trawling. This is because it erases features and biological formations like spongillis, bryozoa and shell formations which are critical in complexity within the ecosystem. Last but not the least, construction of dams on tidal rivers is also another factor which negatively affect estuarine habitats. This can alter the estuary community structure, water chemistry, food chains and thereby paves way for the elimination of fresh water as well as estuarine habitats (Jan et al., 2023).

**Economic disparities:** There are many factors which can determine the level of economic inequality, for instance, the existence of the few big firms that control certain markets. This may lead to less competition and a greater number of charges that the consumers must pay. Small scale fishers are also affected through overfishing since the fish stock is reduced leading to many negative effects to those fishers. It can also cause growth of the economic discrepancies and problems with the access to markets and resources (Gough et al., 2020).

**Opportunities**

Sustainable fishing of inlands waters: Use of Science based quotas, regulations responsible fishing can contribute to the recovery of the depleted fish resources.

**Aquaculture:** Aquaculture is the food production sector which is fastest growing in the world today and can food secure and nutritionally enrich and bring income to millions of people. It can also reduce the pressure on wild fish stock if done right (Ghose, 2014).

**Technological advancement:** Technology increases the chances of enhancing the fisheries sector since there is an ability to increase the efficiency of the fisher people and other related fishers. For instance, drones, sensors and AI as well as satellite technologies can enhance data collection and monitoring, analytics and block chain can enhance transparency and address IUU fishing besides enhancing efficiency in the management of the resources (Hein, 2020).

**Transparency:** The performance of the fisheries sector as well as the trust of the consumers can be improved by transparency and traceability. For instance, transparency in vessel tracking can assist in fighting IUU fishing, and traceability in supply chains can contribute to ensuring the quality and safety of fish products (Gilman et al., 2022).

**Cooperation and coordination:** All the intricate opportunities and issues could be addressed by the strategic collaboration and integration of all the actors and institutions of the fishing sector. They can help in exchanging the information and the standardizing the policies and regulations as well as coordinating the conflicts (Pinsky and Mantua, 2014).

## TECHNOLOGICAL ADVANCEMENT IN FISHERIES

Modern technologies and innovation are making aquaculture more efficient and sustainable by improving every aspect of the fishery, and how fish are produced, operated, managed, and serviced. The goal of technological advancement is to make fish farming more productive, efficient, safe, and eco-friendly, while also minimizing its negative effects on the environment and society (Lopes, 2022). The fishing industry finds its backbone in technology, essential for its evolution and sustainability. Fishing also faces many challenges such as overfishing, environmental decay, climate alterations, and market instability. To overcome these challenges and meet the growing demand for seafood, technology plays an important role in boosting the industry's efficiency, productivity, and quality (Lucchetti et al., 2023).

Technologies are categorized into two kinds; physical technologies are all about the tools, machines, and techniques that are used to catch, process, move, store, and distribute fish. Information technologies (the systems, software, data, and networks that collect, analyze, communicate, and share information about our fishing activities). In the world of fishing, technologies have many advantages such as; Making our work more efficient, reducing costs, and increasing profits. It also improves our fish quality, ensures safety, and meets all standards. It helps us manage our resources, save fish, and stop overfishing (Squires & Vestergaard, 2013). Technology has played a vital role in the fishing industry's progress, enabling it to become more productive and efficient while also reducing its environmental impact. The history of fisheries technology is marked by several key milestones and innovations that have transformed the industry and made it more efficient and sustainable. Technological advancements have played a crucial role in the development of the fishing industry, with the first fish finder being developed in the 1930s, which used sonar to locate fish in the water.

Integrated system nets are relative newbie that uses sensors to determine the size of captured fish and the species. Drones are being used in the fishing sector in tracking the fishing activities and the cases of illegality (Cooke et al., 2021). Manufacturing fishing tools and equipment such as using synthetic materials in fishing gears, hydraulic equipment in handling fish, the electronical gadgets in fish finding and sensing have been instrumental in the expansion of capture fisheries and aquaculture. Satellite technologies to enable navigation, communication and to monitor fisheries activity on fishing practices, makes them more efficient in their operations (Hein, 2020).

### Modern fishing technologies

There are five modern fishing technologies that proved beneficial for sustainable fishing: There are five modern fishing technologies that proved beneficial for sustainable fishing;

**Satellite technology**

A sustainable approach of assessing the fish stock in the Northwest Pacific using this technology. It employs high tech to gather information on the fishing vessels that engage in the catching of different types of fish such as the satellite images and tracking data of the vessels. Multispecies fishing days and fishing catches were identified by the system with approximately 60% to 90% accuracy which helped when monitoring and evaluating fishery stock. The satellite-based vessel monitoring system (VMS) is also among the satellite applications widely used in fisheries management for tracking fishing vessels. ICES Journal of Marine Science describes how this system was used in a skipjack tuna fishery, for identifying vessels used for catching fish (Saitoh et al., 2011). Sonar is a method of using sound waves to locate objects underwater. It's like a bat's echolocation system but for the ocean. Two ways this is used are to find fish with Echo Sounders and to map the ocean floor with Advanced Sonar Systems (Wei et al., 2022).

**Imaging sonar:** is a technology that uses sound waves to create images that are similar to optical images. It can watch fish in dark and muddy water where visual cameras are useless (Wei et al., 2022).

**Multi-beam forward-looking sonar (MFLS):** helps watercraft and robots navigate safely and recognize targets. Acoustic technology has advanced in recent years with the emergence of high-frequency MFLS, which is now being used for fish monitoring (Wei et al., 2022).

**Drones** are widely used in the current era to assess the targets from high altitude or the places that are inaccessible for human beings. They are extremely useful where access is difficult, and other conditions are unfavorable and difficult to predict. They also reduce time and energy used in operations which would otherwise involve human personnel and shift attention towards managers to deal with other chores (Mohsan et al., 2023).

**Electronic monitoring system**

Fishes using EM as a method of catching them is cheap and also efficient in monitoring catches in fisheries. It employs the use of sensors and cameras on the vessels to take remote fisheries. EM has three benefits: as it reduces on cost, it monitors a larger portion of the fleet, and it monitors fishing better (van Helmond et al., 2020). This assists us in planning and management of disasters, pollution control and combating difficulties met due to pathological external environment (Ullo & Sinha, 2020). In 2015, the AFMA pilot an EM program for three fisheries and contemplates expanding the initiative to up to 23 additional fisheries in the future.The EM system helps with compliance and management by providing timely data on discards, by-catch, and protected species. AFMA requires EM to cover at least 90% of fishing (van Helmond et al., 2020).

**Information and communication technology (ICT)**

Applications have been designed to enable fishers to gain knowledge, communicate with others, locate themselves and for boating assistance (Jivthesh et al., 2022). At present there are 84 smartphone apps developed for commercial wild capture fisheries globally. Modern mobile applications help to gather information, promote personal products, rescue people, and address the people's assembly (Calderwood, 2022). Both usage of recent sales methods and various applications will help fishers increase their revenues and satisfy the commercial needs, as well as reduce their costs. Its usage has increased in the SSF sector through the COVID-19 pandemic since it makes it easier for the fishers (Penca et al., 2021). Indeed, the web and mobile applications may be a great contribution towards safety and being informed. Such apps include weather related and natural disaster alert apps which give out warnings for risky weather events (Jivthesh et al., 2022). A good example of Android application that was created and implemented to help the fishermen's who want accurate weather information are site specific forecasting applications. This app offers the forecast for temperature, humidity, wind speed, and wind direction It also has a 'Remind me' feature that which lets the user to be notified when the weather will change (Hinduja et al., 2022).

**Fishery management software**

Fishery management software is a better-known decision support system which help fisheries managers in making effective decisions about managing fish stocks. There are a multitude of software tools which involve data gathering mechanisms, analysis and mapping, model construction and simulation. Stock assessment is the other decision support system that involves the analysis and interpretation of data that relates to fish populations and their environment. These tools employ statistical models as well as other related methods of data analysis to predict the abundance of the fish stock, its distribution and the effect of fishing on the fish stock (Gilman et al., 2022).

**Communication tools**

Fishermen in India and developing countries are using modern technology to improve their daily activities. Fishermen are using a variety of tools such as radio, wireless sets, computers, the Internet, and mobile phone applications to improve their daily activities. These tools also help them find the best fishing zones, track weather conditions, and locate their vessels.

**Radio communication tool:** Radio communication is a vital tool for fishermen to coordinate with each other and the shore. This helps them stay informed about weather conditions and track their vessel movements.

**Internet-based platforms for market access:** With the help of internet-based platforms, fishermen can now access better markets for their catches, which enables them to sell their fish directly to consumers and get better prices.

**Integration of artificial intelligence (AI)**

The implementation of AI in fisheries is modifying fish growth advancement and health status observation. By using machine learning and computer vision, AI can analyze data from fish farms and make fish farming more sustainable. This data can give fish farmers important information about fish growth, feeding behavior, and environmental factors that influence fish health. This can help fishers indicate diseases, and signs of stress, and help to take preventive actions to avoid losses (Mandal & Ghosh, 2023). AI manages smart monitoring systems that employ sensors, cameras, and data analytics to gather and examine real-time data on water quality, temperature, oxygen levels, and fish behavior. AI spots any deviations from ideal conditions and warns farmers, who can act to maintain healthy fish (Mandal & Ghosh, 2023).

**Robotic fish:** are like underwater detectives that collect information about the environment. They use sensors to detect water quality parameters like temperature, turbidity, dissolved oxygen, carbon dioxide, and more. They can even measure the heart rates of fish. You can connect them to your smartphone and easily collect data. These fish swim independently in the water and monitor all water quality parameters (Verma et al., 2023).

**Robotic turtles:** are artificial turtles that have cameras and sensors to monitor fish and other activities. They are typically used in large culture systems such as cage culture in the sea. Monitoring cages in the sea is a challenging task for farmers, so robotic turtles are a valuable tool for them. In cage culture, various issues can arise, such as net holes, fish mortality, fish disease, fish feeding, and more. Net holes are the primary problem in cage culture, as they can cause fish to escape from the cage and mix with wild fish, leading to interbreeding with the wild population. Therefore, farmers may use robotic turtles to monitor their cages (Verma et al., 2023).

**Robotic fish cage:** The fish farming industry is undergoing a technological transformation with the help of robotics. Innovations like robotic fish cages and autonomous underwater robots are being developed to improve efficiency, monitor water quality, and maintain fish health. The challenges, operations, and applications of these robotic solutions in the fish farming industry are being examined. Robotic fish cages have already been deployed in Puerto Rico and Panama, but the ultimate goal is to deploy fully automated powered Aqua Pods in deep waters in the future. The robotic fish cage can be fully or partially submerged in water and is very strong against strong currents. In normal cages, the main problem is a hole in the net, but in robotic cages, robots examine the cages and repair the net if necessary. In a robotic cage, all fish activities are monitored automatically by robots. Various types of cameras and sensors monitor the cages in a robotic cage. Robotic cages are priced very high (Verma et al., 2023).

**Smart boat:** technology is a USV platform that can be used to monitor water quality. It is a sensor-based technology that is easily accessible to farmers. It is portable and can be easily transported from one place to another due to its lightweight (3 kg) and compact dimensions. The SMART Boat is also used to assess water quality parameters in places where human intervention is less possible, such as water enclosed by high mountains or deep water. Its maximum speed is approximately 40 cm/s, and it can only be used in normal environmental temperatures ranging from 20-25 C (Verma et al., 2023).

**Deep Trekker:** is a handheld, battery-powered underwater remotely operated vehicle that is widely used by aquaculture companies worldwide. It is generally used in rivers, lakes, and oceans for hull inspections, fish health inspections, and fish feeding (Verma et al., 2023).

## SUSTAINABLE AND ECO-FRIENDLY FISHING PRACTICES

Sustainable fishing practices protect fish stocks and the marine environment by maintaining fish populations, reducing environmental impacts, and avoiding bycatch. They use selective fishing gear, limit fishing areas, and boost aquaculture production. Sustainable fishing practices ensure fisheries flourish in marine and freshwater habitats. People have fished sustainably for millennia, and today's practices learn from these cultures (Mooventhan et al., 2016). These methods focus on selectivity, preventing bycatch of unwanted species, and protecting critical habitats. Eco-friendly fishing gear (EFFGs) are a sustainable alternative to traditional fishing gear, supporting the UN Brundtland Commission and the Sustainable Development Goals (SDGs). The FAO's Code of Conduct for Responsible Fisheries (CCRF) defines EFFGs, stressing that sustainable fisheries must consider resource and environmental sustainability, social needs, and human economic needs. Some methods are given below;

### Selective fishing gear

**Fishing Hooks:** Using barbless hooks reduces the chances of entangling unwanted species like dolphins and turtles (Battisti et al., 2019).

**Fish Traps and Pots:** These can target specific sizes of fish. They have escape vents that help undersized fish to flee (Mooventhan et al., 2016).

**Light-Based Fishing:** The disruption to the ecosystem and fuel consumption are reduced by attracting fish with specific light wavelengths (Kaur & Datta, 2021)

### Responsible fishing practices

**Seasonal Rotations:** Based on breeding seasons and fish migrations, moving fishing grounds secures vulnerable populations during critical times (Yulisti et al., 2024).

**Quotas and Catch Limits:** Science-based quotas and catch limits are implemented to avoid overfishing and ensure sustainability (Kaur & Datta, 2021).

### Marine protected areas (MPs)

MPs can significantly boost the fish population when they are designed and managed properly. They can also prove very beneficial for fishers. Here are some key ways MPs attain this;

**Growth:** MPs restrict fish populations in their boundaries where fish grow to their maximum size (Desai & Shambaugh, 2021).

**Habitat and Reproduction:** MPs protect the natural habitat of fish such as coral reefs, mangroves, and seagrass in which young fish feed and adult fish lay eggs safely (Paoli et al., 2022).

**Food Diversity:** MPs increase food availability and diversity for fish population (Schmid et al., 2022).

**Stabe Catch and High Income:** MPs give the facility of more stable and predictable catch to the fishers which ultimately increase the income and stabilize the economy (Püts et al., 2023).

**Examples of MPs**

**Great Barrier Reef Marine Park, Australia:** It covers the world's most expensive coral reef network spreads over 2300 Km. It conserves remarkable marine creatures, such as 1,500 fish species, 411 coral species, and six out of seven species of sea turtles (Niz et al., 2023).

**Galapagos Marine Reserve, Ecuador:** Nearly 138,000 square kilometers of this MPA conserve ecosystems that Charles Darwin's research exposed. It flourishes the species like Penguins, sharks, marine iguanas, and giant tortoises (Castrejón & Charles, 2020).

**Papahānaumokuākea Marine National Monument, USA:** It spreads more than 360,000 square kilometers in the isolated Pacific Ocean which is the world's biggest ocean. Its conserved species are seabirds, whales, dolphins, and other ocean creatures, such as endangered species like the Hawaiian monk seal (Chan, 2020).

**Hanauma Bay Marine Protected Area, Hawaii, USA:** It provides both conservation and recreational benefits. It also provides a secure area for the remarkable restoration of coral reefs and fish populations. It is creating high tourism revenue for the nearby community (Mejía-Mercado & Baco, 2023).

**The Mariana Trench Marine National Monument, USA:** The deepest point on earth is homed in this MPA that covers over 240,000 square kilometers in the western Pacific Ocean. It defends the ecosystem, with hydrothermal vents, seamounts, and deep-sea creatures that are suited to extreme pressures and darkness (Jamieson et al., 2023).

**By-catch reduction techniques**

By-catch Reduction Devices (BRDs) are tools that help reduce the capture of non-targeted species in fishing gear. They are designed to allow the escape of unwanted species, individuals, or endangered species from fishing nets. These devices are usually inserted in a fishing gear trawl in shrimp fisheries, close to the cod-end (Butler & Heinrich, 2007).

**Turtle Excluder Devices (TEDs):** are tools that help reduce the capture of sea turtles in shrimp trawls (Jenkins, 2023). TEDs allow turtles to escape from the net through an opening at the top of the grid while retaining the shrimp in the cod end. Moreover, the TED reduced debris in the codend, improving catch quality and shortening onboard sorting operations, thus increasing fishing time and earnings. Sound deterrents can direct seabirds away from fishing areas (Vasapollo et al., 2019).

**Fish Excluder Devices (FEDs):** are tools that help reduce the capture of non-targeted fish species in trawl nets. They are designed to allow the escape of unwanted species, individuals, or endangered species from fishing nets (Cabral et al., 2014).

**Escape gaps:** are like emergency exits in fishing gear that allow unwanted species to escape. They are usually built into traps and come in different sizes, ranging from 2 to 8 cm in width and 3 to 40 cm in height. Using escape gaps can help reduce the number of juvenile fish caught and increase the average size of the fish that are caught (Flower et al., 2021)

**Monitoring and data collection:** These strategies are tracking bycatch rates which helps in refining fishing practices to further lower the unregulated catch.

## IMPACT OF CLIMATE CHANGE ON FISHERIES

Freshwater environments have an unusually high level of biodiversity compared to their size, even though they're only 0.8% of Earth. They're home to roughly 15,000 types of fish, which is nearly half of all the fish we know (Barbarossa et al., 2021). Human impact and changes in nature have significantly endangered freshwater habitats, leading to considerable declines in the diversity of life within these habitats in the last few decades When we discuss 'climate,' we're talking about the extended weather trends in a specified area involving aspects such as temperature, moisture content, precipitation, and wind intensity. The term 'climate change' as used today encompasses any shifts in the climate occurring for a few decades to millions of years, arising from natural influences, human activities, or a combination thereof. The impact of climate change extends to entire ecosystems and the organisms within them, increasingly posing a significant threat to the global environment, biodiversity, and sustainable human development. This is primarily due to shifts in global temperature patterns, disruptions in the water cycle, and the onset of acidification. Even though

fisheries and aquaculture might be undervalued, the consequences of climate change for these sectors and communities along coasts and rivers cannot be overlooked. Meanwhile, fisheries and aquaculture play a small role in greenhouse gas emissions, they also offer opportunities for mitigation efforts. The projected effects of climate change will have widespread impacts on ecosystems, societies, and economies, escalating pressure on all forms of sustenance and food supplies, including those within fisheries and aquaculture (Cochrane et al., 2009). From 1988 onwards, the IPCC has provided regular, evidence-supported updates on climate change and its extensive political and economic impacts. These updates comprehensively blend the globally agreed-upon understanding of the science behind climate change, encompassing both its origins and effects (Barange et al., 2018).

**Observed alteration in the climate system**

Our understanding of the climate system stems from diverse evidence sources, including both direct and indirect observations, historical reconstructions tracing back thousands of years, recent instrumental observations, and conceptual and numerical models considering radiative and heat budgets. On a global scale, the Earth's typical surface temperature has climbed by more than 0.8 °C since the mid-1800s and is presently advancing at a pace of over 0.1 °C each decade. Currently, there's a higher occurrence of heat waves, yet the reliability of data and certainty levels fluctuate across continents (Barange et al., 2018). Compared to the overall warming pattern of the 20th century, the surface waters in the North Atlantic were cooler between 1900 and 1930, experienced warmth from 1930 to 1960, cooled again from the late 1960s to 1990, and have been warming since 1990 (Frost et al., 2012).

Increased temperatures within inland waters might diminish the quantity and range of wild fish reserves by compromising water quality, raising mortality rates during dry seasons, introducing new predators and diseases, and altering the prey availability for fishery species (Tewabe, 2015). The effects of temperature can vary, showing both positive and negative impacts. While it stimulates growth rates, potentially increasing production per unit area, temperatures exceeding 30 °C hinder feeding, resulting in a decline in the growth rate (Ruby & Ahilan, 2018). Modifications in the timing and patterns of snowmelt are influencing the hydrology of freshwater environments, particularly those sustained by glaciers, snow-fed rivers, and lakes. Over the last century, there has been a recorded temperature rise of 0.2 to 0.7 °C specifically in the deep waters of major East African lakes such as Lake Tanganyika and Lake Malawi. The temperature increase has triggered stronger thermal stratification, hindering the mixing of cold depths and warm surface waters. Consequently, this hinders the upward movement of nutrients, leading to decreased primary productivity within the ecosystem. Both freshwater and oceanic bodies are experiencing noticeable shifts in salinity, oxygen concentrations, and alterations in the flow of currents and circulation (Williams & Rota, 2011). The interconnections between fisheries and their ecosystems are more profound and carry a more substantial impact than the connections typically found in traditional agriculture. The effectiveness of a fishery is directly linked to the vitality and operation of the ecosystems it relies upon for sustenance, shelter, and the dispersal of reproductive elements (Wiese & Nelson, 2022).

**Effects of global warming on fisheries**

**The fact that global warming is real cannot be disputed:** Numerous aquatic ecosystems are witnessing gradual rises in seasonal temperatures, accompanied by increased variability in thermal conditions, and a heightened frequency of extreme heatwaves. As the vast majority of fish are ectothermic, these shifts in climate are expected to strongly influence their physiological functions, affecting them at individual, population, and species levels, and thus on the fisheries they sustain (McKenzie et al., 2021). Three major phenomena have been observed as widespread responses by fish to the ongoing warming of their surroundings; a) latitudinal alterations in the distributions of species, indicated by the migration of temperate and sub-tropical fish towards the poles. b) Alterations in the timing of significant life-cycle events, such as migrations, spawning periods, and the duration of reproductive seasons. c) Reduction in the mean body size, associated with decreases in eventual adult size a heightened representation of younger, smaller individuals within the population (McKenzie et al., 2021). The understanding of the mechanisms governing these phenomena is incomplete, yet it's proposed that they are shaped, at least partially, by the physiological functions and reactions of individual organisms. These responses may indicate either adaptable traits or evolutionary developments (Lefevre et al., 2021).

Global warming significantly impacts freshwater fisheries in various ways;

**Temperature:** As poikilotherms, fish maintain body temperatures that correlate directly with the temperature of the water they inhabit. Their high sensitivity to temperature shifts in their environment prompts fish to relocate to areas where the external temperature aligns with their preferred internal temperature, aiding in the restoration of their optimal temperature range. This "behavioral thermoregulation" As a result, there's a rapid movement toward the poles or cooler aquatic habitats corresponding with the movement of climatic zones toward the poles. From the 1960s onwards, surface water temperatures in lakes and rivers across Europe, North America, and Asia have increased by 0.2 to 2 °C. Higher water temperatures and prolonged durations without ice cover affect how thermal stratification occurs in water bodies. Due to enhanced thermal stability, the stratified period in numerous lakes across Europe and North America has shifted earlier by as much as 20 days and extended by two to three weeks. Temperature can have a dual impact, either positively or negatively. On one hand, it accelerates growth rates, potentially enhancing production per unit area, temperatures exceeding 30 °C can hinder feeding activity and slow down the growth process (Ruby & Ahilan, 2018). This is expected to elevate Net Primary Productivity (NPP), aiding the proliferation of filter feeders. Forecasts indicate the likelihood of decreased natural winter mortality.

**Increasing water salinity:** Climate changes can result in alterations to water salinity levels, causing it to either rise or fall, influenced by multiple factors. The impact of alterations in water salinity varies based on the tolerance levels of organisms and the specific characteristics of their habitat, whether it's freshwater, marine, or estuarine. Anthropogenic climate change is expected to lead to an elevation in salinity within specific freshwater ecosystems (Ruby & Ahilan, 2018).

**Effects of global warming on sex ratios in fishes:** Sex determination in fish species depends on genetics, the environment, or a combination of these factors notably, temperature which represents a vital environmental factor impacting the determination of sex in fish. Changes in temperature during critical developmental stages can lead to imbalances in primary sex ratios in specific species. Genderspecific responses to environmental stress have been identified during the early larval stages before the beginning of gonad formation (Geffroy & Wedekind, 2020).

**Changes in fish distribution – response of the fishery:** Alterations in temperature over extended periods, alongside changes in other oceanic factors, frequently align with observed alterations in the distribution of fish and the functioning of fisheries (Link et al., 2011).

### Adapting fisheries to climate change

Adaptive strategies represent sustained or enduring changes in livelihood methods, in response to a range of stressors, which include the impact of climate change. Like modifications of fishing operations, adaptive capacity building, income diversification, ecosystem-based approaches, community involvement, migration, and application of modern and traditional knowledge systems (Geffroy & Wedekind, 2020).

## FUTURE OF FISHERIES

This chapter examines the evolving world of fisheries, highlighting the integration of technology, the drive for sustainability, and the importance of effective management. It reflects on the sector's current state, its potential for resilience and growth, and the uncertainties it faces. Looking ahead, the chapter underscores the need for a comprehensive approach that encompasses scientific, societal, economic, and environmental considerations. It advocates for collaborative efforts and the adoption of innovative technologies to navigate the challenges and capitalize on the opportunities. Ultimately, the chapter suggests that the future of fisheries is ours to shape through responsible and ethical practices, ensuring a thriving industry for generations to come.

## CONCLUSION

Recent years have seen the fishing industry transform with modernization, sustainability, and tech advancements. The rise of modern fisheries has boosted aquaculture productivity and made fish catching more sustainable. Governments are investing in R&D to push technology further in this field. New tools and analytics have made fishing more efficient, yet the sea monitoring tech hasn't kept up. Automation and robotics could be the answer to better management and environmental issues, while also addressing labor swhortages and boosting the economy. Sustainable fishing is key now, aiming to cut overfishing and protect our seas, especially as climate change heats up waters and disrupts marine life. Looking ahead, it's clear that sustainability, tech innovation, and new aquaculture methods will shape the future of fishing.

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