Declining marine fish catch: Hightime for "strategic timeout"

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Abstract

It is evident based on the global fish catch data that marine catches are at declining trend and it is accelerated in the last decade. Worldwide, more than 85% of the fish population are overfished. In the early 1990 itself, some of the fish stocks like Pacific Salmon, Atlantic Cod and herring etc have collapsed. The declining fish populations will have a serious impact on the economy and livelihoods of many countries.

Out of >35700 fish species identified in the world (FishBase, 2023); about 20000+ are marine species, 14953+ are belong to freshwater and 5-6% of the total fish population believed to be from brackishwater habitat. In India, there are about 3246 fish species, where exclusively 1569 are marine fishes, 961 freshwater and 15 belong to brackishwater ecosystems. While, 392 species found in both marine as well as brackishwater (Bracki-marine), 108 fishes found in freshwater to brackishwater (Bracki-fresh) and about 201 species found in all three ecosystems (FBM: Fresh-Bracki-Marine) (Source: AqGrisi, NBFDGR 2023). About 220 fish species are commercially important in India. The major landings comprise of sardines, mackerel, cephalopods, ribbon fishes, lesser sardines, threadfin bream, croakers, perches and crustaceans. Though, the estimated potential marine fish resource in is about 4.41 mt, for the last five years, the landings are stagnated and fluctuating between 3.7 mt to 3.9 mt. Though overall landings remain constant and catch in weight is the same, more than 60% of the boat owners are not making profits, because of the reduced average size of fish and increased cost of fishing operations. They are compelled to sell their produce to the throwaway prices to the middlemen.

This is the time to have a 'Strategic Timeout' to review our fishing efforts, fishing gears, mesh sizes, fishing ban periods and fisheries policies. Though fisheries are a state subject, it is the time to have common consensus to have "One Country-One Policy" for marine fisheries management. However, it requires continued action to ensure the long-term sustainability of fisheries by understanding other related issues and their management. This review paper discusses about the management strategies of vast ecosystems through continuous monitoring and stock assessment programs, 'Evolved Management Strategies (EMS)' involving all the stakeholders. It is an effort to connect the diverse perspectives, experiences, and expertise that can assist inform decision-making, drive innovation, and improve outcomes.

Keywords: Overfishing, Stock Assessment, Fish Stocks

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Introduction

The marine environment includes the waters of seas and estuaries, the seabed and its sub soils, and all marine wildlife and its coastal habitats. The marine environment is a vital resource for life on earth. It is a precious asset; a heritage that must be protected, conserved and properly valued. Marine ecosystems perform a number of key environmental functions; they regulate the climate, prevent erosion, accumulate and distribute solar energy, absorb carbon dioxide, provides oxygen and maintain biological control. The seas and oceans are our greatest sources of biodiversity. They cover 71% of the earth's surface and contain 90% of the biosphere. The marine environment is also a great contributor to economic prosperity, social well-being and quality of life. About 70% of the oxygen, we breathe comes from the oceans and 90% of the carbon that is produced on earth ends up in the oceans.

Out of >35600 fish species identified in the world (FishBase, 2023); about 20000+ are marine species, 14953+ are belong to freshwater and 5-6% of the total fish population believed to be from brackishwater habitat. In India, In India, there are about 3242 fish species, where exclusively 1566 are marine fishes, 960 freshwater and 15 belong to brackishwater ecosystems. While, 392 species found in both marine as well as brackishwater (Bracki-marine), 108 fishes found in freshwater to brackishwater (Bracki-fresh) and about 201 species found in all three ecosystems (FBM: Fresh-Bracki-Marine) (Source: AqGrisi, NBFGR 2023). About 220 fish species are commercially important in India. The major landings comprise of sardines, mackerel, cephalopods, ribbon fishes, lesser sardines, threadfin bream, croakers, perches and crustaceans. Though, the estimated potential marine fish resource in is about 4.41 mt, for the last five years, the landings are stagnated and fluctuating between 3.7 mt to 4.1 mt. Though overall landings remain constant and catch in weight is the same, more than 60% of the boat owners are not making profits, because of the reduced average size of fish and increased cost of fishing operations. They are compelled to sell their produce to the throwaway prices to the middlemen.

This is the time to have a 'Strategic Timeout' to review our fishing efforts, fishing gears, mesh sizes, fishing ban periods and fisheries policies. Though fisheries is a state subject, it is the time to have common consensus to have "One Country-One Policy" for marine fisheries management.

Obvious reasons for declining marine fish catches

Overfishing: Globally about 4.1 million (E)[1] fishing vessels were operating in 2020. Though the overall catch remained constant, the catch per unit effort (CPUE) is decreased. In India, there are about 4.44 lakh fishing fleets[2] including 376 deep sea vessels operating

[1] (E): Estimated

[2] ReAlCRaft, GoI, 2023

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all along the Indian coast and producing about 4.13 mt[1]. It is evident based on the global fish catch data that marine catches are at declining trend and it is accelerated in the last decade. Worldwide, more than 85% of the fish population are overfished. In the early 1990 itself, some of the fish stocks of Pacific Salmon, Atlantic Cod and herring etc have declined (Fig. 1).

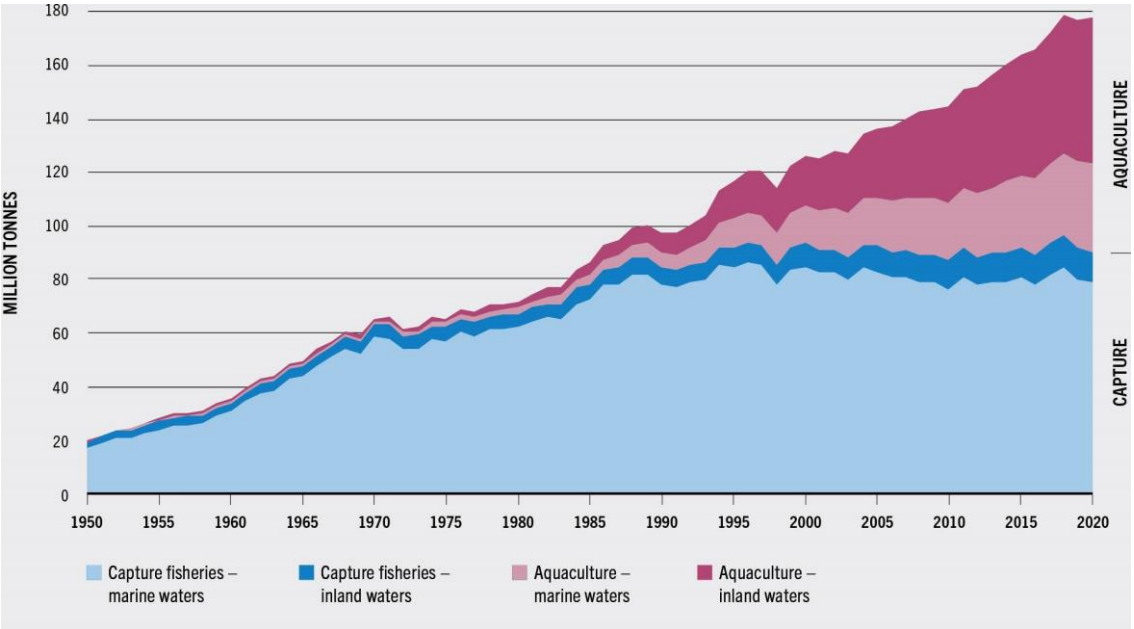

Figure 1: World fish production by year (FAO, 2021).

The declining fish populations will have a serious impact on the economy and livelihoods of many countries. Though the fisheries resources are renewable, due to the increased fishing efforts with the advanced technologies, in many instances, stocks will not be revived or it might take very long periods to retain their original population structures. National and international efforts are on towards the management of these resources. However, it requires continued action to ensure the long-term sustainability of fisheries by understanding other related issues and their management. In some countries, the number of boats on a downward trend in the last two decades, mainly driven by fleet reduction programmes in Europe and China, which started in 2000 and 2013, respectively, and were accounted for in a recent revision of FAO fleet data. In some instances, because of the decreased CPUE, fleet owners are quitting fishing since the fish stocks are declined within the 12 nautical miles (nm). However, some of the countries are promoting dee sea fishing. Even in India, Karnataka state has a target of supporting 100 deep sea boats with 40-60% of government subsidy.

[1] Handbook 2022-23, Department of Fisheries, Government of India

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There is a mixed opinion on increasing fishing efforts and diesel subsidies in India. When the social benefits are larger, there is a tendency to ignore the environmental issues. But its consequences are deadly. So, science must be a guiding force in informed decisions about issues such as overfishing, pollution, climate change, and making of fisheries policies. By relying on scientific evidences and expert analysis, policymakers can make decisions that are grounded in reality and have a greater chance of success (Fig. 2).

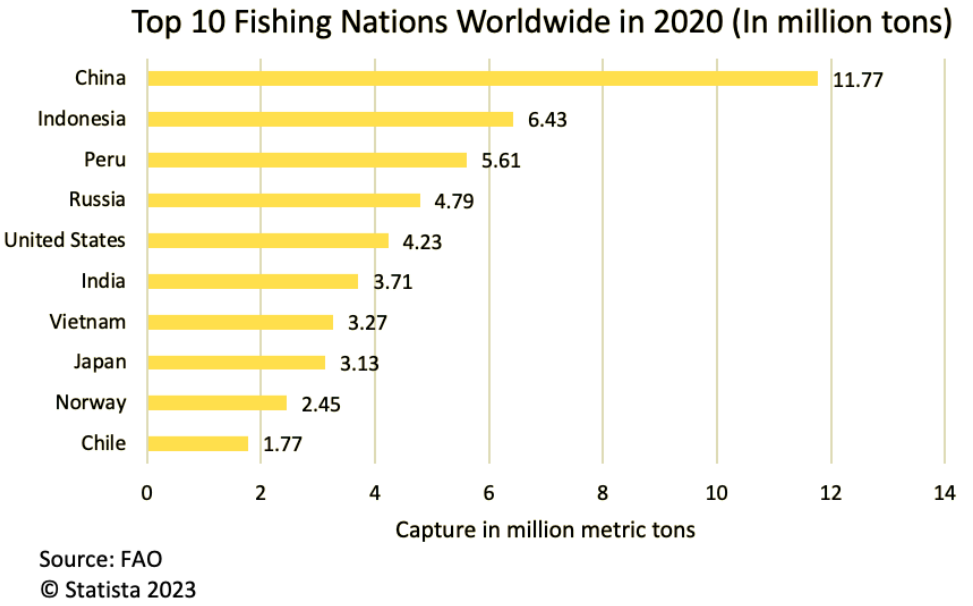

Figure 2: Marine fish production by country. Below picture is showing complete by-catch from the multi-day trawling at Mangalore Coast, India.

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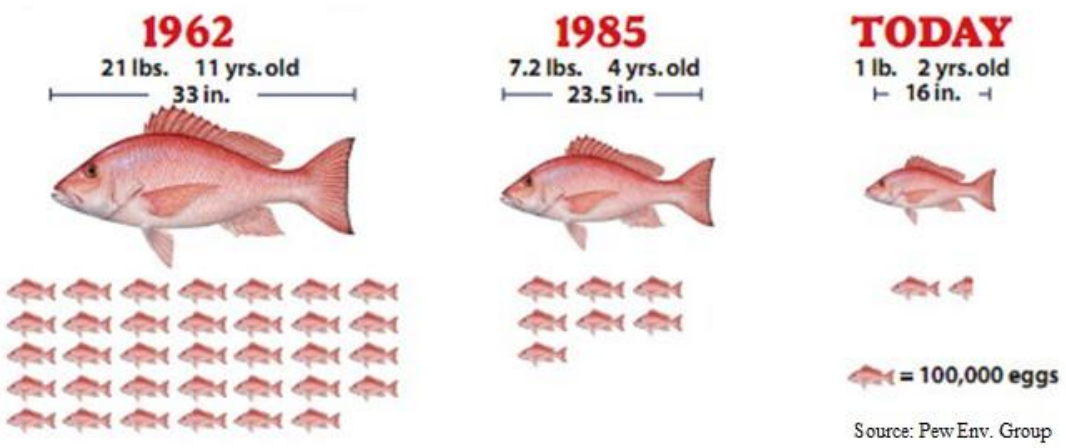
Young fishes at nets

In many instances, overfishing may land more fish with decreased catch per unit effort; but catch may contain more smaller fishes which may not fetch better prices in the markets; eventually goes for fish meal industries. Bycatch proportion in some trawls gone up from 8% to 60%. The catch data still shows better overall production. It is possible that the analysis of catch composition and reduction in average body length and weight over time can provide insight into the consequences of increased fishing efforts. Similarly, if the average body length and weight of the fish in the catch have decreased over time, it could indicate that the population has been heavily fished, and the larger, more mature individuals have been selectively removed, leaving behind smaller, younger individuals that have not yet had the chance to reproduce. The pictorial demonstration of snapper gives better understanding of overfishing and the reduced stocks.

Time to spawn

Although, the red snapper can live up to 54 years, today too few are older than 10 years. Older fish are the best spawners. Since, 1960s, the average weight, age, size and reproductive capacity of snapper have diminished (Pew Environment Group) (Fig. 3).



Figue 3: Stock structure against time with increased fishing efforts.

Habitat destruction

The fishing and breeding grounds are affected due to trawling, discarding of unused nets in the sea, discharge of pollutants, oil spillage and such other activities destroy the marine ecosystems, coral reefs, seagrass beds, and mangrove forests, can also contribute to declining fish populations. The vulnerable coastal region is continuously threatened with anthropogenic pollution destroys the highly productive estuaries, neritic zone and mangrove are which are important breeding grounds and nurseries for many fish species, and their destruction can lead to a decline in fish populations.

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Pollution

Pollution is one of the significant reasons for the declining fish populations. Worldwide, the total volume of oil lost to the ocean environment from tanker spills in 2022 was approximately 15,000 tonnes (t). It is estimated that approximately 2.67 mt of waste oil enter the ocean every year, with over half coming from land drainage and waste disposal; for example, from the improper disposal of used motor oil. In many instances, except in the oil spill area and other chemical disasters, we may not notice the fish kills. But the compounding effects of pollution on fisheries is unfathomable. Chemical pollutants such as pesticides and heavy metals can accumulate in the organs of fish, making them unsafe to eat. Plastic pollution can also harm fish by entangling them or blocking their digestive systems.

Bioaccumulation

Bio-accumulation is the process by which certain substances, such as toxins or heavy metals, build up in the tissues of living organisms over time. This can occur when an organism is exposed to a substance through its food, water, or environment, and the substance is not readily metabolized or excreted by the organism.

- As an organism consumes food or water containing a substance, the substance can accumulate in its tissues and organs. Over time, the concentration of the substance can increase, as the organism continues to consume contaminated food or water. This process can be particularly concerning for organisms at the top of the food chain, such as large predators, as they may accumulate higher concentrations of the substance due to their position in the food chain.
- Bio-accumulation can have serious negative impacts on the health of organisms, including developmental abnormalities, reproductive problems, and organ damage. It can also impact the health of ecosystems, as high levels of toxins or heavy metals in an organism can harm other species in the food chain. Many aquatic organisms have the ability of accumulating harmful substances without affecting themselves. Accumulation levels are higher at the higher trophic levels. This biomagnification will have serious impact on human health.
- Examples of substances that can bio-accumulate in organisms include mercury, which can be found in fish, and polychlorinated biphenyls (PCBs), which were once used in electrical equipment and can be found in some fish and shellfish. To reduce the risk of bio-accumulation, it is important to limit exposure to these substances, through measures such as reducing pollution and monitoring food and water sources for contaminants.

Plastic pollution

Plastic pollution can afflict land, waterways and oceans. It is estimated that 1.1 to 8.8 mt of plastic waste enters

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the ocean from coastal communities each year (Jembeck, 2015). It is estimated that there is a stock of 86 mt of plastic marine debris in the worldwide ocean as of the end of 2013, with an assumption that 1.4% of global plastics produced from 1950 to 2013 has entered the ocean and has accumulated there (Jang *et al*., 2015).

Ghost Fishing: Fishing gear accounts for an alarming amount of plastic pollution in ocean. "More than 50,000 t of plastic from industrial fishing gear pollute the oceans each year—threatening marine life"[1]. Ghost fishing is a term used to describe a situation in which abandoned or lost fishing gear, such as nets, traps, or lines, continues to catch and kill marine animals. This is because about 30-40% of the nets used are discarded in the sea itself. This problem can have significant impacts on marine ecosystems, as it can lead to the unnecessary deaths of fish and other animals, as well as damage to habitats. Ghost fishing can also have economic consequences for the fishing industry, as it can reduce fish stocks and damage gear that is still in use. Efforts are underway to address this issue, including initiatives to retrieve lost gear, improve gear design to reduce entanglement risk, and promote responsible fishing practices.

Global warming

The slow changes in the environment are not noticeable on a regular basis; but their effect is profoundal and in many instances, the consequences are not reversible. It is evident that the carbon dioxide (CO_2) levels in the environment is increasing due to anthropogenic activities. When the CO_2 levels are high in the atmosphere, the atmospheric temperature will also go up. This will change the atmospheric pressure and there by affecting the rainfall pattern, tidal pattern which affects the breeding pattern of majority of the fishes.

CO_2 levels

The increase in carbon dioxide (CO_2) levels in the atmosphere is a significant environmental issue that has been linked to climate change. CO_2 is a greenhouse gas, which means that it traps heat in the Earth's atmosphere, causing the planet to warm. For last 10000 years, the CO_2 levels never gone beyond 300 ppm. Now, it is increased to a level of 421 ppm.

- The burning of fossil fuels such as coal, oil, and gas is one of the main drivers of the increase in CO_2 levels in the atmosphere. When fossil fuels are burned, they release carbon that has been stored underground for millions of years, adding to the amount of CO_2 in the atmosphere. Deforestation and land use changes also contribute to the increase in CO_2 levels by reducing the amount of vegetation that absorbs CO_2 through photosynthesis.
- The consequences of increasing CO_2 levels in the atmosphere are significant and can include more

[1] The Nature Conservancy, 2021

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frequent and severe weather events, rising sea levels, and changes in the distribution and abundance of plant and animal species. These impacts can have cascading effects on all ecosystems and human societies, including economic disruptions, food and water insecurity, and public health risks.

Ocean acidification

The average pH of the oceans is around 8.1, which is slightly basic (alkaline) on the pH scale. However, pH can vary across different parts of the ocean and at different times of the year due to factors such as temperature, salinity, and carbon dioxide levels. Over the past century, human activities such as burning fossil fuels and deforestation have led to an increase in atmospheric carbon dioxide, which has caused the ocean's pH to decrease slightly, a process known as ocean acidification. This can have negative impacts on marine life and ecosystems. The increased temperature of ocean also kills primary producers and upon their decomposition the pH will decrease causing the acidification of the ocean.

Coral bleaching

It is a phenomenon observed where there is a mass mortality of plankton in the coral region and accumulate on the live polyps of corals eventually causing death. This can happen when corals are exposed to stressors such as high-water temperatures, pollution, and lower pH. In coral reef region, coral bleaching takes place due to the decreased pH and accumulation of dead plankton on the live polyps of coral will affect their growth. The death of the primary producers will impact the entire trophic levels. The shoaling fishes will move away from their region. The declined sardine catches in the west coast of India during 2018-22 is attributed to the increased temperature.

Changing rain falls

Global warming increases evaporation in the oceanic area which induces heavy and erratic rain falls. In a given calendar year, there may be a same or more total rains; but uneven distribution of such rains will impact significantly on the food availability, breeding schedule and migration pattern of many aquatic organisms. For last 100 years the average rainfall in India is about 852 mm with standard deviation of 84.7 mm. It is evident that drought years will affect the fish stocks in the nature. It is the time to decide the fishing efforts based on the rainfall of the given calendar year (Fig. 4).

Cyclones and hurricanes

Change in the atmospheric pressure due to high evaporation in the high seas and oceanic area will cause depressions leading to cyclones and hurricanes. These rare events have become more frequent in the recent past and the time lapse between two disasters is reduced. These natural incidents will disrupt the fish population structure and takes very long periods to stabilize (Fig. 5).

In India, the XV Finance Commission had recommended the creation of a

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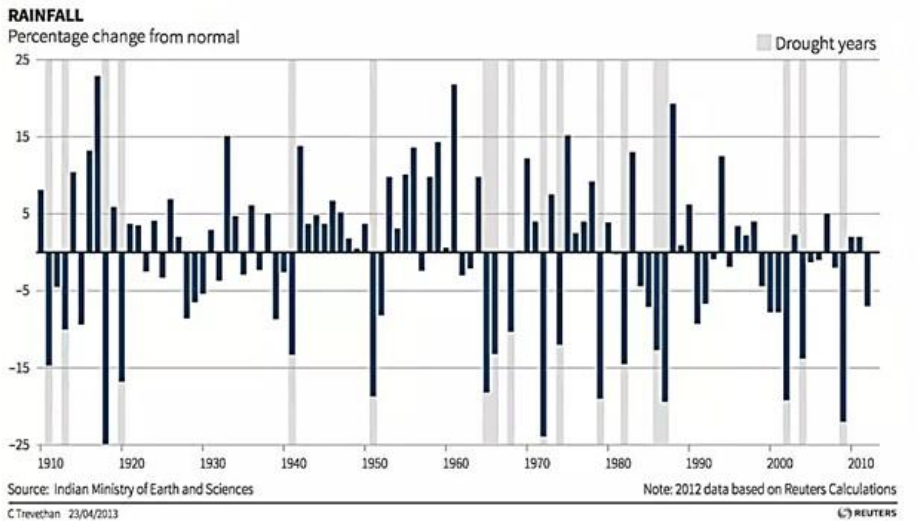
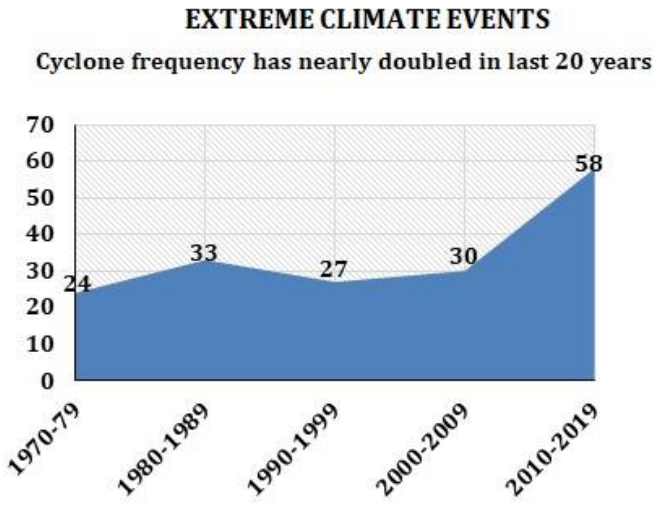
National Disaster Risk Management Fund (NDRMF) and State Disaster Risk Management Fund (SDRMF) comprising a Mitigation Fund at the National and State-levels (NDMF/SDMF), and a Response Fund at the National and State level (NDRF/SDRF) for the award period from 2021-22 to 2022-26. It has also made specific recommendations for 'Mitigation Measures to Prevent Erosion' under NDMF and 'Resettlement of Displaced People Affected by Erosion' under NDRF' (Fig. 6).



Figue 4: India's rainfall and droughts during the year 1910-2010.



Figuer 5: Cyclone frequency and numbers for last 50 years in India.

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Figure 6: Disasters do not occur without giving any prior signs. It is the time to observe nature’s signals.

Strategies for fisheries resource management

The biological principles are universal and region neutral. Science has to be understood in its original form. Irrespective of the governments and governance, management strategies remain same. However, the policies must be evolved involving all the stakeholders. To address declining marine fish catches, it is important to take action to reduce overfishing, protect and restore important fish habitats, reduce pollution, and address climate change issues. This can involve measures such as setting catch limits, using more selective fishing gear, establishing marine protected areas, reducing plastic waste, and reducing greenhouse gas emissions.

It is the protection and preservation of ecosystems of oceans and seas through planned management in order to prevent the exploitation of these resources is warranted than ever before. “It is worth to note that all the issues and causative agents are known to the majority of the stakeholders; but the collective and conscious ignorance is observed”. We may escape the responsibilities; but one cannot escape the consequences for escaping the responsibilities. The nature is giving us enough indications in the form of dead zones in the oceans, loss of biodiversity, ocean acidification, depleting fish stocks, sinking of small islands, plastic pollution which are visible without any trails.

The national and international organizations like UNEP, BOBP, FAOs are providing enough guidelines and road maps. The marine and coastal strategy has been developed by the UNEP Marine and Coastal Ecosystems Branch (MCEB) to focus on priority issues for maintaining marine ecosystems and their services for human well-being. Environmental biologists must be able to connect the dots among marine biology, oceanography, fisheries science, international marine laws, sociology, policy and governance and other related issues to understand the complexes and intensity of the issues

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and draw a tangible strategies to a bring noticeable changes. It constitutes a huge amount of fund and human resources which can be used to achieve greater economic potential. It is the role of environmentalists to educate and make the right people to respond and take necessary actions. The major challenges and issues of concerns related to marine resources are (Fig. 7):

- **Realtime** data collection and processing
- **Monitoring and enforcement** of marine laws and guidelines
- Global governance in the **highly sensitive areas** and **different federal systems**
- Use of **deep-water** resources
- Application of the **ecosystem-based approach**
- Monitoring and assessment of **pollutants and hazardous substances**.

Continuous monitoring and stock assessment programs

Marine ecosystems have to be monitored and assessed on a continual basis. There are scientific tools and artificial intelligence technologies are available which can provide us real-time data.

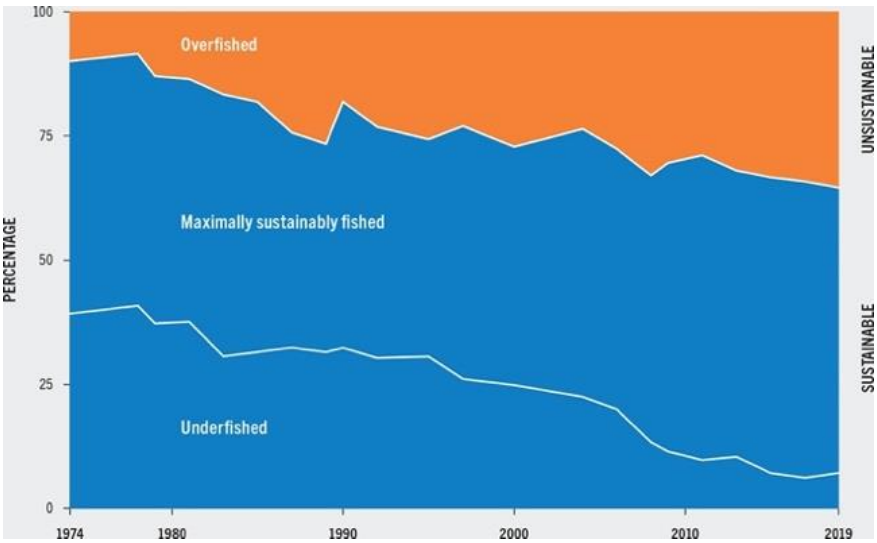

Figure 7: Global trends in the state of the world's marine fishery stocks, 1974–2019 (Source: FAO).

Use of satellites images for observing sea surface temperature (SST) and chlorophyl-a (Chl-a) intensity and correlating with fish abundance is one of the advanced tools to reduce fishing efforts. By analyzing satellite images of SST and Chl-a intensity over time, researchers can identify patterns and trends in these environmental variables that may be correlated with changes in fish abundance. Sample surveys, biochemical analysis of water at different depths, analysing changes in the primary food production and benthos, population dynamics, stock dynamics can be predicted.

Satellite images can also be used to identify areas of upwelling, where nutrient-rich water is brought to the surface, creating productive ecosystems that support high levels of fish abundance. Overall, continuous

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monitoring will provide valuable insights into the distribution and abundance of fish populations, which can be used to inform fisheries management and conservation efforts.

Approaches

The management of vast ecosystems demands 'Evolved Management Strategies (EMS)' involving all the stakeholders as a unit of function. Stakeholders bring diverse perspectives, experiences, and expertise that can inform decision-making, drive innovation, and improve outcomes. Through researchers and development agencies have better understanding of these ecosystems, they must not frame or impose the guidelines. Instead, it must be 'Informed decision-making' which involves a willingness to accept uncertainty and risk by the stakeholders. It is important to recognize that no decision can be entirely risk-free, and that even with the best information available, there may still be unexpected outcomes. The monumental herculean task of surveying, recording and cataloging an immense liquid wilderness can be daunting for managers. Establishing monitoring programs at a large scale enough to appropriately monitor marine communities is frequently cited as a stumbling block to effective management services in marine and coastal areas (Baird *et al*., 2000). But, human ingenuity and established knowledge base is capable of handling stock management issues. The strategies based on the nature of issues are classified as follows for better understanding.

Policies

- Nature FIRST programs
- Ban on destructive fishing methods
- Strict enforcement of Minimum Legal Size (MLS)
- Fishing quotas and restriction of boats
- Mesh size regulations
- Minimizing subsidies
- Setting up of National Marine Environment Conservation Academy
- Integration of organizations and develop common vision, strategy, delivery process
- Prioritization of roles and deliverables in tune with magnitude of the problem
- Declaration of Marine protected areas (MPAs)
- Guidelines on plastic usage and safe disposal in the fishing industry
- Plastic Collection booths can be established at harbors and landing center and it can be incentivized.
- Collection of "Environment Rejuvenation Fund (ERF)" and investing it in the research

Technological issues

- Stock assessment programs for commercially important fish and shellfishes
- Continuous monitoring of marine ecosystems
- Development of suitable technologies for identification of fish shoal and their average size
- AI tools for assessing the ground, fish size and volume

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- New gears for minimizing by-catch
- Developing sustainable fisheries and restoring the populations of endangered species through artificial means
- Viable biotechnological approaches for degradation of oils and fats, control of fouling organisms, control of bloom
- Zero waste technology for fishing boats and companies along the coasts

Management issues

- Educating the industries, publics about conservation issues, pollution and their responsibilities etc.
- Training and capacity building of stakeholders (Fisheries/mining/shipping/aqua sport/capture fisheries)
- Inter-departmental platforms
- Promote development of increased passion, efficiency, transparency, sense of ownership, loyalty, valuable relationship with the environment
- Global linkages – exchange programs and collaborations for strong institutional capacity building

Social responsibilities

As a part of Corporate Social Responsibility (CSR) or Individual Social Responsibility (ISR), the traders of fish meal industry can deny the purchase of the fishes below the MLS. As the World Wildlife Fund (WWF) believes, "Stop buying may stop Killing". There are many special programs around the world working on marine environment conservation. The projects like Green Fins that uses the SCUBA diving industry to educate the public based in South East Asia on the importance of marine conservation. Another focus of conservationists is on curtailing human activities that are detrimental to either marine ecosystems or species through policy, techniques such as, like those set up by the Northwest Atlantic Fisheries Organization. This includes educating tourists that come to an area that might not be familiar of certain rules and regulations regarding the marine habitat. Even at regional levels, there are many organizations like Bay of Bengal Program (BOBP) working on mission is to promote, facilitate and secure the long-term development and utilization of coastal fisheries resources of the Bay of Bengal based on responsible fishing practices and environmentally sound management programs. Wildlife Trust of India, Oceana, Natures' Conservation Trusts and others are working towards these issues. Because of the vastness of the issue, it is difficult to notice the significant changes in a shorter period.

Conclusion

Management and conservation of marine fish stocks is not easy as narrated in the text. The magnitude and complexities of the problems intensifying with time. Its consequences on aquatic life significantly increasing. Though there is a progressive improvement in understanding our stocks through science and technology, efforts on management are insignificant. It calls for

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a “Strategic Timeout” to save our dying seas and oceans. In spite of many international organizations are in place with fairly right aim and objectives, unless there is a people participation as a movement in conserving natural resources, nothing can be achieved significantly. This calls for continuous awareness among different stakeholders, good institutional networks and people participation. Otherwise, we cannot escape the consequences for escaping the responsibilities. Let us work together and conserve our fish stocks.

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