

Review

Marine biodiversity and fishery sustainability

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Marine fish is one of the most important sources of animal protein for human use, especially in developing countries with coastlines. Marine fishery is also an important industry in many countries. Fifty years ago, many people believed that the ocean was so vast and so resilient that there was no way the marine environment could be changed, nor could marine fishery resources be depleted. Half a century later, we all agree that the depletion of fishery resources is happening mainly due to anthropogenic factors such as overfishing, habitat destruction, pollution, invasive species introduction, and climate change. Since overfishing can cause chain reactions that decrease marine biodiversity drastically, there will be no seafood left after 40 years if we take no action. The most effective ways to reverse this downward trend and restore fishery resources are to promote fishery conservation, establish marine-protected areas, adopt ecosystem-based management, and implement a "precautionary principle." Additionally, enhancing public awareness of marine conservation, which includes eco-labeling, fishery ban or enclosure, slow fishing, and MPA (marine protected areas) enforcement is important and effective. In this paper, we use Taiwan as an example to discuss the problems facing marine biodiversity and sustainable fisheries.

Key Words: marine conservation, marine fisheries, Taiwan, seafood, sustainability

INTRODUCTION

The ocean covers 70 percent of the Earth's surface area, but it can provide more than 98 percent of the volume of the biosphere. Marine fishery resources are one of the most important animal protein sources for human health, reaching 19 percent of our total protein intake.¹ According to FAO statistics, world fishery production has declined since the 1980s and can maintain only about 100 million tons each year.² Of this, 76 percent is used directly for human consumption. The remaining 24 percent is used for fishmeal, much of it for aquaculture. There are about 200 million people whose livelihood and income depend on fisheries.

In the past, most people believed that marine fisheries were inexhaustible. However, they never thought it might be true only with traditional fishing methods and artisanal fisheries of their time period. After the industrial revolution, and the rapid development of science and technology; modernistic fish-detecting devices and fishing techniques have left fish with no way to hide. The great sea-fisheries have undergone serious overexploitation because of increased seafood demand driven by rapid growth of the human population.³⁻⁶ It is widely believed that the collapse of global fishery resources has been mainly due to inappropriate fishery management and the falling behind of marine conservation in comparison to terrestrial conservation. For example, people will not feel guilty eating tuna, shark, or grouper. But they will if they eat tiger, lion, or hawk. Marine fishery is the only industry left where people are still hunting from the wild. In contrast, agriculture, forestry, and animal husbandry are all industries where people harvest plants they grow or animals they keep in captivity.

FISHERY STATUS IN TAIWAN

In Taiwan, overall fishery production was only 0.2 million tons per year in 1950, but increased to 1.2 million tons by 1990, and 1.3 million tons in 1995 with a value of nearly NT\$100 billion. This led Taiwan to be ranked among the top 20 fishery producers in the world. The catch has decreased continuously since then simply because of the paucity of fishes. Sport fishing, collecting fish and shellfish for the aquarium trade, and illegal fishing using explosives, poisons, electricity, and other destructive methods are gradually destroying the marine ecosystem.

In 1990, 130,000 of Taiwan's households, or approximately 300,000 people, were involved in fisheries. Fishing has contributed greatly to social stability on the island, and fish is an important source of food. However, production began to decline in 1990, especially in coastal and offshore fisheries. These two fisheries combined only account for less than 17 percent of total fishery production (far sea fisheries 58 percent, aquaculture 25 percent — Fisheries Administration, COA) in 2007. Destruction of the marine environment and the degradation of the marine ecosystem are the obvious causes of the decline, especially in the coastal area. The sustainability of marine resources depends on the extent that we effectively protect our marine environment and manage our fisheries.

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TAIWAN'S HIGH MARINE BIODIVERSITY

Taiwan is a relatively small island, but it is rich in marine biodiversity. More than one-tenth of the world's marine species are found in Taiwan. The total number of marine fish species exceeds 3,000.⁷ Comparing Taiwan's land area to the world's total, the marine species biodiversity is approximately 400 times the average number of species in other countries.⁸

The following two factors explain Taiwan's rich marine biodiversity:

- (1) Geographically, Taiwan is located at the northern border of the East Indies—the world's marine biodiversity center, which includes Indonesia, Borneo, and the Philippines.⁹ Taiwan is also located at the apex of the Coral Triangle. Many eggs, larvae, juveniles, and even adults are easily transported to Taiwan waters via the Kuroshio and South China Sea ocean currents.
- (2) Ecologically, Taiwan has various kinds of marine habitats. The island's west coast mangrove forests, estuaries, and sandy barrier lagoons are characterized by sandy bottoms; the northern and southern tips of Taiwan and the islets of Penghu, Hsiao-Liu-Chiu, Green Island, and Orchid Island are characterized by coral reefs; and the east coast is dominated by rocky shores and open ocean (deep sea). Water depth ranges from an average of 50 m in the Taiwan Strait between Taiwan and Mainland China, to a couple thousand meters off Taiwan's east coast. Three main ocean currents—Kuroshio, China Coast Current, and the South China Sea current—flow and intersect in the waters around Taiwan, which results in a water temperature difference of at least 6-7 degrees between northern and southern Taiwan. The dominant marine species thus vary significantly between northern and southern Taiwan.¹⁰

CAUSES OF MARINE ECOSYSTEM DESTRUCTION

Increase in the number of species has not led to a corresponding increase in fishery resources. In fact, the abundance of most species has declined drastically. Many species that were common 20 years ago have now become occasional or rare. Decreasing biodiversity leads to the degradation of marine ecosystems and a decline in fishery productions. The main causes include: (1) overfishing and bycatches, (2) habitat destruction, (3) pollution, (4) introduced species, and (5) natural perturbation.¹¹ The first four causes are related to fisheries and are considered anthropogenic perturbations.

Overfishing and bycatch

Fishing obviously has direct effects on fish stocks. It can alter the abundance, age and size structures, sex ratio, and the genetic structure of the target fish population. The species composition of marine communities is also affected. Non-commercial species (those species that are smaller, less abundant, and less valuable) are discarded. The waste associated with this bycatch problem can reach 9/10 of all harvests, as in prawn (shrimp) trawling.¹² This is the main cause of commercial extinction. Although incidental catches of IUCN-protected species of marine mammals, sea turtles, and sea birds have received much

attention, many long-lived marine species with low fecundity, large pelagic species such as tuna, swordfish, dolphinfish, ocean sunfish, and sharks, and some demersal species such as groupers are still not adequately protected.

Habitat destruction

Species cannot survive and resources cannot be sustained without the habitats necessary for reproduction, feeding, and sheltering during each stage of their life cycles. Unfortunately, Taiwan's natural coastal wetlands are gradually being destroyed by urbanization and the construction of shore-based or near-shore facilities, such as fishing harbors, industrial or recreational, parks, and wavebreaks. The natural coastline of Isla Formosa is going to become "Isla Artificial," surrounded by a man-made concrete coastline if the progress isn't halted. Eventually, the all-important nursery grounds for many economic and non-economic species of marine organisms will be destroyed.

Fishing can also affect habitats, most notably by destroying and disturbing benthic topography and associated communities.¹² Bottom trawlers in Taiwan—nearly 2000 boats in 2001—have damaged the benthic ecosystem seriously. This damage extends to coral reefs. Large-scale mariculture activities (farming of fish, shrimp, and other marine organisms)—especially if they are poorly managed—can also negatively impact marine ecosystems through damage to coastal wetlands and near-shore ecosystems.¹³

Pollution

Marine pollution is caused by organic and inorganic pollutants, including heavy metals, oil, and other toxic substances. Sewage stemming from industry, agriculture, and urbanization, and soil run-offs due to deforestation and unplanned agriculture can also damage marine ecosystems by increasing suspension particles and turbidity in seawater, especially in coral reef areas. Fishery activities can also be a source of pollution. In mariculture areas, the marine ecosystem can be changed through eutrication and the contamination of the water by food, antibiotics, and waste, and through the introduction of diseases and exotic genotypes.¹³

Introduced species

Taiwanese researchers have yet to conduct a survey of alien marine species introduced from ballast waters, but one introduced species, red drum (*Sciaenops ocellatus*), for cage-net harvesting, has been discovered off Western Taiwan.

Natural Perturbation

The source of natural perturbation can be summed up as follows: (1) Strong typhoons can destroy fragile coral species in shallow waters, and consequently impact fish species living in close association with the coral. (2) Cold water masses, which occasionally enter the coastal region in the winter season, can kill marine fishes. This has occurred frequently in Penghu (Pescadores Islands), and occasionally in Kenting, in Southern Taiwan. One recent massive kill of fishes by cold water intrusion happened in 2008.

CONSERVATION STRATEGIES

Natural perturbation is impossible to prevent, but anthropogenic causes are avoidable through enhanced public education, monitoring, and assessment, and through the establishment of effective conservation policies.

Reducing overfishing

Managing single-species fisheries with an explicitly conservative approach could be a first step toward achieving sustainable marine fisheries. A moderate level of exploitation might be a better goal for fisheries than full exploitation. Recreational fishing, diving, and fish watching are less destructive than commercial fishing, and can potentially generate more revenue if managed effectively.

Marine protected areas (MPAs)

The most effective way to protect and rebuild the ecosystem and increase marine resources is to establish more MPAs. It has been shown that the establishment of such protected areas increases the number of fish and other species in nearby waters. The design and implementation of MPAs should convince fishermen that the resulting system will protect their long-term interests. Fishing industry participation in planning also improves operational integrity. Recent calls for protecting 20 percent of potential fishing areas before year 2020 provide a worthwhile reference point for future consideration, and emphasize the importance of greatly expanding the areas currently protected¹⁴.

Although more than 70 marine sanctuaries have been established in Taiwan, they have not been managed or controlled appropriately. These MPAs include 7 wildlife sanctuaries, 3 natural reserves, 26 resource conservation areas, and 12 coastal protected zones. Conservation efforts in these areas are only focused on protecting mangroves, seabirds, and sea turtles, as well as economic species such as seaweeds, lobsters, abalones, and bivalves. Despite the fact that they are not real MPAs and do not protect the entire habitat, artificial reefs built as part of conservation efforts have created more shelters for juvenile fishes, and have reduced illegal bottom trawler fishing within 3 nautical miles of them.

Enhancing public education

Taiwanese people love to eat seafood, but they are loving it to death. The inclusion of many rare and endangered marine organisms on menus is putting them in jeopardy. The government must enhance public awareness through the media to educate people not to catch, raise, and eat rare or protected species. Fortunately, the number of NGOs that actively promote marine conservation in Taiwan is increasing. Also, several large marine aquariums and museums have opened recently, with several more under construction, which allow people to get acquainted with marine organisms. Interpretive exhibits in these museums should go a long way toward increasing public awareness of conservation issues. Whale watching, snorkeling, and establishment of green sea turtle sanctuaries also increase awareness.

Enhance research

Better understanding of the structure and functioning of marine ecosystems is needed, including the role of the habitat and factors affecting stability and resilience. This includes attempting to understand mechanisms at lower levels of the organization (i.e., populations and communities), long-term research and monitoring programs, and the development of trophic ecosystem models. More research is needed on basic taxonomy, ecology, and distribution. These basic data should be integrated using Geographical Information System (GIS) and be made available to the public via the Internet. The biological effects of fishing, such as the alteration of gene pools and population structures as a consequence of fishing, need to be studied as well. More research is needed on the conditions under which MPAs are most effective, and MPAs themselves should be used as research tools. More information is needed on the effects and effectiveness of various management regimes, including rights-based management approaches.

Legislation and Policies

There are four laws governing marine conservation in Taiwan: National Park Law (1972); Cultural Heritage Preservation Law (1982); Wildlife Conservation Law (1989); and Environmental Impact Evaluation Act (1994). Each of these laws provides some legal basis for the protection of the marine ecosystem, but regulations stemming from these laws are rarely enforced. Most previously established sanctuaries and natural reserves have focused on a few endangered or economically important species, not on the habitat as a whole; thus, their benefits can easily be called into question.

Over the past few years, the government and private organizations have recognized the importance of marine conservation and have started to change policies to provide increased environmental protection. However, legislative Yuan has not been able to approve the Law of Coast Management in the past 10 years. People are still eating coral fishes and enjoying tuna and shark fins, ignoring the fact that their resources are declining. Adding more marine species to the aquatic trade red list should prove useful as well.

CURRENT ISSUES

The following current marine conservation issues should be stressed here:

- (1) Marine environmental awareness is much lower than terrestrial awareness—In Taiwan, this problem seems to be even more serious than in foreign countries.
- (2) Economy vs. environment dilemma—Conflict between the construction of the Industrial Complex and saving endangered species, such as the Black-faced Spoonbill and the Chinese White Dolphin.
- (3) The difficulty of establishing new MPAs and marine reserves, and the lack of enforcement.

AUTHOR DISCLOSURES

None

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海洋生物多樣性與漁業永續

海洋魚類是人類最重要的蛋白質來源之一，特別是具有海岸的開發中國家。海洋漁業也是許多國家的重要產業。五十年前，人們仍認為浩瀚的海洋，其恢復力強，人類不可能去改變她，漁業資源亦不會枯竭。半世紀後，大家都同意由於過漁、棲地破壞、污染、外來入侵種及全球氣候變遷等人為因素的破壞，已使得漁業資源匱乏。因過漁所引起的連鎖反應也使得海洋生物多樣性大幅衰退。如果我們再不積極採取行動，四十年後，人類將無海鮮可以享用。最有效的保育措施應是建立海洋保護區、生態系漁業管理、及採取預防原則等。此外，加強宣導教育，包括生態標章、限漁、慢漁、和落實海洋保護區的管理等最為迫切有效。本文乃以台灣為例，討論海洋生物多樣性及永續漁業所面臨的問題。

關鍵字：海洋保育、海洋漁業、台灣、海鮮、永續性