Overfishing and System Thinking

2021, Vol.2 No.3
© Economics & Management Review 2021
DOI: 10.37420/j.emr.2021.016
https://masonpublish.org

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Abstract

The threat of overfishing has intensified worldwide in recent decades, as fishing technologies advance and demand for seafood soars. It has been proven that solutions for overfishing are challenging. New technologies are under development to avert the potential for major environment deteriorates and financial turmoil. System thinking, which emphasizes interconnection, has been proposed for handling complex systems. System thinking approaches to resolve overfishing have received increased attention. This paper reviews the ongoing overfishing and system thinking approaches to build the foundations for stable, enduringly healthy, and sustainable oceanic ecosystems, aimed at promoting awareness of the increasing importance and urgency of system thinking to more complex social, environmental, and economic problems.

Keywords

Overfishing; Fisheries assessment; System thinking; Marine ecosystem; Climate change

Introduction

One may question whether overfishing and system thinking are connected, and that is positive. System thinking would provide effective solutions for overfishing. In human history, people who live in mountain areas are dependent on what the land produces; people who live in coastal areas depend on seafood for their livelihood. Because the ocean is so big, the health of fish stock was never a concern before the mid-20th century. Fishing technologies were limited so the amount of fish caught was not considerable. As fishing technologies advanced and demand for seafood soared after the World War II, nowadays, advanced technologies make fishing possible in all weather conditions, and fishermen can capture a huge amount of fish anywhere quickly (Gharajedaghi., 2005). So far, most fisheries in the world have collapsed and face overfishing issues. Humans have realized that solutions to overfishing are not easy and straightforward, and new technologies for tacking overfishing issues are highly solicited. System thinking, which emphasizes interconnection, has been proposed for handling complex systems. The superior strengths of system thinking have increased the attention of the approach in resolving the overfishing problems. This paper presents a review of the ongoing overfishing crisis and system thinking approaches to build the foundations for a stable, enduringly healthy, and oceanic sustainable ecosystem, aimed at promoting awareness of the importance of the system thinking approaches.

Overfishing

Overfishing essentially means that the amount of annual fishing exceeds annual fish reproduction, resulting in the decline and eradication of fish populations. There is a threshold for fishing while keeping a sustainable fishery stock. For marine fishing, humans have not exceeded the threshold since ancient times. However, this is not true any more. Two major factors can be blamed for the worldwide problem of overfishing: demand for seafood, and modern technologies being applied to fishing equipment. The second factor is energized by the first. After World War II, many modern technologies were applied to fishing equipment, which was driven by commercial benefits for the rising demand for seafood. Although those technologies realized fishermen's dreams for a massive catch, those technologies make the current level of human's fishing capability surpass the threshold that the ocean can sustain.

It has been well-accepted that seafood is healthier than other meats. The demand for seafood continues to rise. Under such market-driven forces, fishing technologies have rapidly advanced since World War II. (Fritjof, 2012). The traditional small fishing boats were replaced by large commercial factory ships, which is the most revolutionary change in fishing history. The factory ships are well equipped with sufficiently advanced technology, such as depthfinder, sonar scanner (echo-location), GPS (Global Positioning System), advanced communications, and color graphic displays. The factory ships can sail to anywhere in all weather conditions and can operate much longer in fishing seawater. Factory ships allow on-site seafood processes, such as fast-freezing, while fishing. The former Soviet Union established most huge and advanced factory ship fleets. Such a large-scale shift in fishing equipment dramatically increased the hunting amount. The amount of the world fish catch reached a record high in1989. However, the number of fish in the ocean is not infinite. The amount of catch could not go any higher, no matter what technologies are used and how large the fishing fleet is.

One of most famous examples of overfishing happened in Newfoundland, Canada. In 1992, when the cod fishing season began, no cod fish were showing up. The cod fishing industry was forced to idle and became increasingly desperate. In China, overfishing is one major reason one of the world's great fisheries in the East China Sea, Zhoushan Fishery, is being destroyed.

Fishery Management

As overfishing is getting more serious, governments, acting to avert the potential for major environment disaster and financial turmoil, are taking control of catch amount through fishery management. The objective of fishery management is to maximize the amount of fishing possible while minimizing the risk of depleting stocks through overfishing.

Traditional management methods are intended to cap the amount of fishing by initiating various options over the entire fishing operation based on trial and error (Sissenwine1, 2019). The options include enforcing a size limit, reducing the length of the commercial fishing season, switching targeted fish stock, imposing restrictions on fishing equipment, and issuing catch quotas. However, all those options are not working well. For instance, limiting the size of a particular fish that can be caught could cause a scenario in which runt genes

are favored. These traditional management methods are often blamed for late actions only after a crisis of fish depletion has occurred. In the United States, a newly modified system, called Individual Transferable Quota (ITQ), defines the quota for targeted fish stock as flexibly transferable property rights that are distributed to fishermen, who are entitled to use, rent and sell them. In the days and years ahead, ITQ could gradually change the size of fishing fleets and the population of fishing professionals, and it could help establish an appropriate structure for the economy in coastal areas. The structure should be compatible with today's situation of depleted fish stock and advanced fishing technologies that result in less labor. In China, government issues financial aid to encourage fishermen to change their careers.

Marine Fisheries Assessment

Marine fisheries assessment is a job counting fish in the sea, and it is virtually impossible. Marine fisheries assessment is to generate data needed for marine management, because the first step in dealing with the risk of losing fish stock due to overfishing is to quantify the fish stock (Libralato, 2019; Kenneth, 2019). Overfishing is catastrophic. But overprotection of fish stock based on false assessment results is also a nightmare to fishermen and could hurt the economy in coastal areas that are heavily dependent on fishing. However, it is difficult to do an assessment because there is no way to directly measure fish stock.

Traditionally, three assessment methods have been proposed to accomplish this difficult task. Virtual population analysis (VPA) was first proposed to determine the size of fish stock. The principle of obtaining VPA data is that the number of living fish equals the number of fish born minus the number of dead fish. The number of fish born comes from fisheries experts' estimates. The number of dead fish, also estimated by fisheries experts, includes fish that died of natural causes and those caught by fishermen. Only the amount of the catch by fishermen is the result of a statistical computation obtained by sampling the catch from fishermen and identifying the number of each year's fish in the samples through checking a fish's otolith. Research surveying (RS) is the second traditional assessment method, and is based on trawling data gathered by fisheries scientists on randomly picked sites to estimate the annual change in the population of fish. Then, using the estimates obtained by VPA, the series of changes in the population of fish is calculated to find the number of fish. Commercial catch per unit (CCPU) is the third traditional assessment method, which also uses a combination of VPA and the productivity of catch. The productivity of catch is an estimate of the catch a fisherman can get in a working day using the same average efforts. CCPU's basic idea is that a change in productivity is proportional to the change in the population of fish. These annual data of the change together with the estimates from VPA can be transformed into the current number of fish.

All three assessment methods have strengths and weaknesses in terms of cost and performance. VPA's weakness is that the result may not be accurate because it uses a computation of assumption based on another assumption. RS's results are more accurate than those obtained by using VPA, but RS is more costly since the number of surveying sites needs to be large. CCPU has a lower cost than RS, but the results could be less accurate and less independent because the data needed are gathered from fishermen, who may be influenced by commercial interests. Fishery scientists are often frustrated with the inaccuracy of the traditional methods, since these models do not reflect the full story of changes in fish stock.

System Thinking and Solutions for Overfishing

System thinking represents the trend that scientific thinking is moving toward philosophical implications from modern science, including quantum physics (Barro & Basso, 2014). As modernization spreads from the Western world to the Eastern world – a phenomenon called globalization – and science and technology advance, the traditional scientific culture formed by Enlightenment and Newtonian physics and the Copernican revolution of the 17th century prove incapable to solve new problems. The new consciousness that has been fueled by philosophical implications from modern science, including quantum physics, is rising and is capable of providing solutions to social, economic and environmental problems created by globalization. The core of the new consciousness includes holistic worldview, interconnection, and interdependence. The insights of those values are compatible or close to the basic worldview of the Tao of Physics. "Tao" is ancient Chinese philosophy. The problems caused by Western globalization could be solved by the values of the Eastern world.

With traditional scientific culture, everything in the world is seen separately and partly, unless a connection is visible. Traditional scientific culture rose in the 17th century and is based on the worldview provided by Enlightenment and Newtonian physics and the Copernican revolution. The traditional culture fundamentally changed the world. With traditional scientific culture, things are seen mechanically. For instance, wave characteristic and particle characteristic are separate and cannot be with the same object. As the experiment advanced, traditional physics was not able to explain some physical phenomena in the late 19th century. Modern physics was developed to address the new problems.

Modern physics is represented by theory of relativity and quantum physics. Modern physics and Chaos theory were the most advance science that greatly changed the way we observe the world. Quantum physics not only explains new phenomena, but also reveals insights to traditional physics. With the viewpoint of quantum physics, traditional physics approximately describes the specifications of the world. The approximate expression is correct under certain circumstances. The wave and particle characteristics co-exist with light in the world of quantum physics. In the world of Newtonian physics, mass is constant. In quantum physics, mass can be changed with a huge energy exchange (the famous equation E=M*C2), which led to the invention of the nuclear bomb and nuclear power generation plants. The way the world is observed with quantum physics is significantly different from that of traditional physics. The bedrock observing the world with quantum physics is holistic or integral, which is basically more comparable or close to Chinese Tao philosophy.

Traditional and anti-traditional theory has been recursive during the development of physics. In each cycle, when traditional theory becomes dominant, anti-traditional theory is born and rises to address more challenging problems. Newtonian physics and the Copernican revolution were born against the traditional theories at that time and dramatically improved humans' understanding of the world. The biggest impact of Newtonian physics and the Copernican revolution in the following centuries was the industrial revolution and its profound globalization. However, as Newtonian physics was commonly applied to tackle many problems that humans encountered, quantum physics was proposed to address the problems traditional physics could not solve.

As globalization became more intensive, a lot of problems were created, including overfishing, deforestation, climate change, proliferation of weapons of mass destruction, cancer and HIV (human immunodeficiency virus). (Giesecke & Weber, 2004). With those new problems, the traditional scientific culture could not give solutions. The new scientific culture derived from quantum physics is considered to address the new problems. At the core of the new scientific culture is a holistic viewpoint. Tao physics, which was born a couple thousand years ago, is one of traditional Chinese culture. Rather than Western scientific culture seeking a precise description of an object that is impossible in the world of quantum physics, Tao observes objects with integral approaches. Society is as a whole, not a small system, not a small particle. All should be given with love and compassion, which is the basic principle of Tao physics. Importing theory from Tao, every part of the human body is interlinked – some kind of foot problem may indicate a heart problem – and diseases are the result of adaption problem between the human body and the environment, within the central theme of Chinese traditional medical theory. With new scientific culture, small parts depend on large parts, and they are interconnected (Wacks, 2005). Applying this theory to society, small countries depend on large ones. The world depends on each of its smaller parts. Small countries and traditional societies, such as the Pacific islands and Africa, are no longer segregated. They all depend on each other. Hinduism, Budduism, Christianity and Catholic are all dependent. In other words, we need to cooperate, because your life depends on me, and my life depends on you. Take China and the United States, for instance. America needs China for less expensive manufacturing labor and a huge market; China needs American investments and high-tech products such as software and Boeing aircraft.

System thinking also improves the understanding of the ocean and has fostered new comprehensive strategies and solutions for fishery assessment and management. A new emerging assessment method is based on Chaos theory (CT). Chaos theory emphasizes the super complexity of the system. The CT model to obtain statistics regarding the change of fish stock is driven by multiple parameters (factors). These factors could be open and include fishing, pollution, wind, and temperature at the time of the release of a fish's egg and sperm and at the time of the fertilization of the eggs. The thinking behind the traditional assessment methods is linear, mechanistic, and based on a single variable. CT's core is based on system thinking that is based on a holistic, interconnected, and interdependent worldview. A new fishery management method is ecosystem optimization, which is compatible with the CT assessment method in terms of system thinking. Fish stock is an integral part of the ocean. Therefore, ecosystem management is aimed at methods that can improve the health of the entire ocean, of which individual fish are only a part. The ecosystem optimization focuses on the network, relationship, and interactivity of the plants, animals, and environment. One species is an integral part of all species' food chains. Overfishing of one species could cause overpopulation of another, which could, in turn, cause the collapse of the entire ecosystem. The best way to restore the fish stock is to restore the basic ecosystem from its fragile and reversible state. Under ecosystem optimization, consumers are educated about shopping for seafood with environmental protection in mind, using market forces to adjust demand for seafood, so environmentally friendly farm-raised seafood techniques are promoted. In the United States, seafood in market must be labeled with its source, according to law.

Conclusion

The ocean is critical for humankind because it provides highly valuable resources. Most fisheries have

reached crisis levels following widespread overfishing. Overfishing could endanger the entire ocean ecosystem. The object of fish stock assessment is to give necessary input about the health of fish stock so management can select appropriate solutions. Long-standing traditional theories and practices of assessment and management that have a single objective have been problematic. Complicated overfishing problems require innovations for assessment and management, and there is an increasing need to embrace a commitment to integrated approaches. The new culture of system thinking has been fostered by theoretical foundations from quantum physics, biological sciences, and systems theory. "The world we have made, as a result of the level of thinking we have done thus far, creates problems that we cannot solve at the same level of (consciousness) at which we have created them. We shall require a substantially new manner of thinking if humankind is to survive." (Albert Einstein). As the new scientific culture gradually supersedes the traditional scientific culture that is based on a linear, mechanistic worldview, overfishing and other problems produced by intensive globalization could be resolved.

Funding

This paper was supported by the following four projects:

[1] Horizontal project: China (Shaanxi) Pilot Free Trade Zone Xi xian New District Project: "One Belt, One Road" national credit information service system construction ideas and countermeasures.

[2] Shaanxi Provincial Social Science Fund Project: "Research on Tax Planning Strategy for Cross-border Investment of Shaanxi Enterprises under the 'One Belt, One Road' Strategy" [No. 2016D048] .

[3] Shaanxi Province Innovation Capability Support Project: "Research on the Investment Logic and Countermeasures of the Military-civilian Integration Industry Fund Based on the Balance of Interests" [No. 2020KRM076].

[4] Xi'an University of Arts and Science, Xi'an Academy of Social Sciences, Research on "One Belt, One Road" Strategy and Implementation Strategy of Cosmopolitan Metropolis [No. 2018ZDZT05].

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