FISHERIES ECONOMICS

U. R. Sumaila and G. R. Munro, University of British Columbia, Vancouver, BC, Canada

Introduction

Natural resources can be classified into nonrenewable and renewable resources. Minerals and hydrocarbons are examples of nonrenewable natural resources, while forests and fishery resources are examples of renewable resources. The basic distinction between the two categories is whether or not the resource is capable of growth.

Fish, being renewable resources, portray the following characteristics: (1) 'utilization' of a unit of the fish resource implies its destruction, that is, the unit is completely and irrevocably lost; and (2) the fish stock can be augmented again to enable a continuing availability through time.

Thus fish, as for other renewable natural resources, have the special feature that new stocks can be created by a process of self-generation. This regeneration occurs at a natural or biological rate, often related to the amount of original stock remaining unutilized. The essence of fisheries economics stems from these characteristics of fish stocks, coupled with the fact that the rate of biomass adjustment of a fish stock is a function of that stock. Essentially, the central problem of natural resource economics at large and fisheries economics in particular is intertemporal allocation. That is, natural resource economists are mainly concerned with the question of how much of the stock should be designated for consumption today and how much should be left in place for the future.

World ocean fisheries are commonly divided between aquaculture, or fish farming, and capture fisheries, the hunting of fish in the wild. While not denying the growing importance of aquaculture, this contribution will be confined to the economics of capture fishery resources. The economics of aquaculture fisheries, and their links to capture fisheries, demand a contribution unto themselves.

World ocean capture fisheries yield annual catches in the order of 80 million t, which, in turn, have a first sale value of approximately US$80 billion. While these fisheries are but a source of modest employment in the developed world, they continue to be an important source of employment in the developing world. It is estimated that world ocean capture fisheries provide employment – direct and indirect – for upward of 200 million men and women.

There is a clear evidence that the output of world ocean capture fisheries has reached, or is reaching, an upper limit because of the finite capacity of the world's oceans to support such resources (*see* Marine Fishery Resources, Global State of). Scope for increased catch must come through improved resource management. The fact that world ocean capture fisheries may be reaching an upper limit should be no great cause for alarm. What is a cause for alarm is the fact that there is a growing evidence of overexploitation of capture fishery resources, and that the overexploitation has intensified over the past several decades.

Sustainable catch of a capture fishery resource essentially involves skimming off the growth of the resource, or what fishery scientists call the 'surplus production'. If the fish biomass is equal to zero, then its growth, by definition, is equal to zero. If the biomass has achieved its natural equilibrium level (no catch), the growth of the resource will also, by definition, be equal to zero. At some point between these two extremes, the growth of the resource ('surplus production') will be at a maximum, which fishery scientists refer to as maximum sustained yield (catch), it (see Figure 1).While the use of MSY, as a resource management criterion, has been subject to many criticisms, it is still used widely as a reference point.

Using MSY as a reference point, the Food and Agriculture Organization of the United Nations (FAO) periodically assesses the capture fishery resources of the world. If the resource is being exploited at, or near, the MSY level, it is deemed to be 'fully exploited'. If the resource has been driven down below the MSY level, it is deemed by the FAO to have been 'overexploited'. On the other hand, if the resource is above the MSY level, it is deemed to be less than fully exploited. On this basis, the FAO estimates that, in the first half of the 1950s, under 5% of the world's capture fishery resources fell into the 'overexploited' category. By the early 1970s, the percentage in the 'overexploited' category had doubled to 10%. As of 2004, the figure stood at 25%, while another >50% fell into the 'fully exploited' category. Figure 2 illustrates this development vividly. While 'fully exploited' does not mean 'overexploited', there is the fear that many 'fully

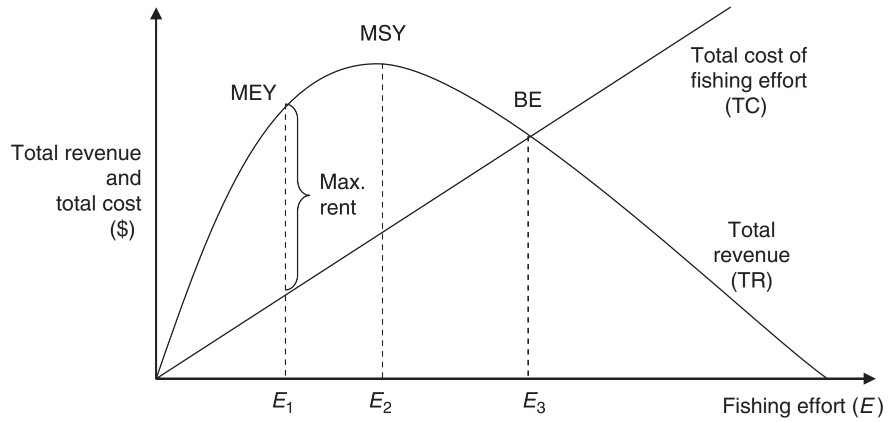

Figure 1 Gordon–Schaefer bioeconomic model (Gordon, 1954). MEY is the maximum economic yield, where economic rent (or profit) is maximized. MSY is the maximum sustainable yield. BE is the bionomic equilibrium, where all rent is dissipated.

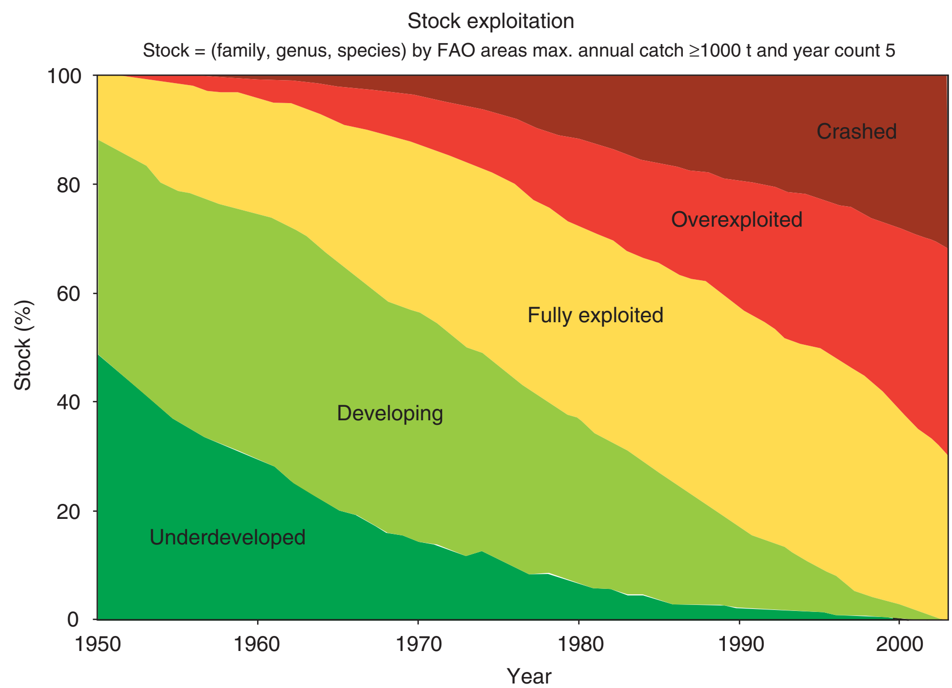

Figure 2 Global trend in the status of marine fisheries resources. Based on FAO statistics to 2003 and the methods and definitions in Froese and Pauly (2003).

exploited' stocks are prime candidates for future inclusion in the 'overexploited' category.

How then did we get into such a situation, and what is to be done about it? It will be argued that economics lies at the heart of each of these questions. This is a view now coming to be held by marine biologists, as well as economists. Having said this, let us immediately follow by stating that economics alone cannot deal with the fisheries management issues at hand. Anyone involved with the questions of capture fisheries management is compelled to acknowledge that the issue is inescapably multidisciplinary in nature. Fisheries economists have no choice but to work closely with marine biologists, legal experts, and sociologists, to mention but a few.

The Basic Economics of Capture Fishery Resources

One can pin the beginning of fisheries economics to the 1950s, when Gordon (1954) and Scott (1955) published their seminal papers. Of course, the seeds of the discipline were sowed as early as 1911. The models developed by Gordon and Scott, which still form the core of the basic economic models of fishing, were essentially static (snapshots) in nature. Further developments of the static approaches were pursued in the 1960s with contributions such as that of Turvey. Basic versions of dynamic fisheries economics models began to be developed in the 1960s and 1970s. Following the pioneering works were a flurry of papers that extended these initial contributions in various directions (stochastic fisheries models, migratory fish stock models, shared stocks fisheries models, etc.).

Central to the economics of natural resources, including fishery resources, is the concept of 'real' (as opposed to financial) capital. Real capital is any asset that is capable of yielding a stream of economic benefits to society over time. Natural resources fall within this definition of 'real' capital. They differ from capital assets made by human beings, only in that they come to us as endowments from nature.

The process of increasing society's stock of 'real' capital, human-made or natural, is a process of positive investment, which involves making a sacrifice today by saving – consuming less – in the promise of greater productive power and output for society in the future. One's stock of 'real' capital can also be reduced, of course – literally consuming one's capital. This, we see as a process of negative investment, or disinvestment.

In the case of nonrenewable resources, the choice is between an investment rate of zero – no exploitation and a negative rate of investment – disinvestment (i.e., mining or depletion). The economics of the management of these resources is concerned with the optimal rate of depletion, through time.

In the case of renewable resources, the options are considerably broader. First, positive investment in such resources is achievable by utilizing less than the growth of the resource. An investment rate of zero in the resource does not involve refraining from exploiting the resource, but rather of utilizing the resource on a sustainable basis.

The economics of capture fishery resource management is thus best seen as a problem in 'real' asset management through time. In an ideal world, society's portfolio of capture fishery resources would be managed to maximize the net economic benefits (broadly defined) from the fishery resources to society, not just for today, but through time. The economics of fisheries management draws upon the economist's theories of capital and investment. In this contribution, we shall do no more than discuss, in general terms, the basic results from the capital theoretic models of the fishery.

Figure 1 describes the basic theory of fisheries economics, which stipulates that fishing cost in open-access fisheries, assumed to be proportional to fishing effort, will continue to increase even though revenues per unit of effort are declining, and that ultimately revenues will decline until they equal costs. The point at which total revenue equals total cost is commonly regarded as the bionomic equilibrium (BE), where both industry profits and resource rents have been completely dissipated.

The Complications: Dealing with Complex Capture Fisheries Problems

Mobility, Visibility, and Uncertainty

Capture fishery resources have always been notoriously difficult to manage effectively. With few exceptions, capture fishery resources are mobile, and are not visible prior to capture. Furthermore, the relevant species interact with one another, as competitors for food sources, or in predator–prey relations, and are, in addition, subject to environmental shocks, all of which are not readily observable, let alone measurable or predictable. Finally, a given stock of a single species may be spread out spatially, and be better thought of as a set of interconnected stocks.

The fact that capture fishery resources are mobile, and are difficult to observe prior to capture, has meant that, in the past, at least, it has been very difficult to establish effective property rights to these resources. This, in turn, has meant that the resources have a long history of being exploited on an open-access, or 'common pool', basis. It has been shown that open-access, and 'common pool' nonjointly managed fisheries result in fishers being faced with a set of economic incentives that are perverse from the point of view of society.

No rational would-be investor will undertake an investment, unless the expected net economic returns from the investment, discounted at an appropriate rate of interest, exceed the current cost of that investment. The sum total of these discounted net economic returns is referred to as the present value of the returns. In open-access and 'common pool' nonjointly managed fisheries, no individual fisher can count on a positive return on an investment in the resource. If a fisher refrains from catching the fish in order to build up the resource, he/she may do nothing more than increase the catch of his/her competitors.

It can be shown that, in such fisheries, fishers will act as if they are applying a rate of discount (interest) to future returns from the fishery equal to infinity.

Tomorrow's returns from the fishery count essentially for nothing. This, in turn, means that the rational fisher is given the incentive to treat the resource as a nonrenewable resource, namely, as a resource to be mined.

What we might term the social rate of discount (interest) never, even in extreme circumstances, approaches infinity. Thus, one can say with assurance that open access or 'common pool' nonjointly managed fisheries will lead to overexploitation, in the sense that the disinvestment in the resources is excessive from society's point of view.

Fisheries economics, to a large extent, is involved in demonstrating the negative economic, and ecological effects (e.g., excessive resource disinvestment) of open-access or 'common pool' nonjointly managed fisheries. It also develops and analyzes approaches for tackling these effects.

Ecosystem-based Fisheries Management

It is agreed that fisheries management, and therefore economic analysis, should properly not be done on a single-species basis, but rather on an ecosystem basis, in which species interactions are explicitly recognized. In general, an ecosystem is a geographically specified system of organisms, including humans, the environment and the processes that control its dynamics. Similarly, an ecosystem-based approach to the management of marine resources (EAM) is geographically specified, it considers multiple external influences, and strives to balance diverse societal objectives. EAM requires that the connections between people and the marine ecosystem be recognized, including the short-term and long-term implications of human activities along with the processes, components, functions, and carrying capacity of ecosystems.

The fact that ecosystems and the EAM are geographically specified implies that for ecosystems that are shared by two or more countries, policies that are transboundary in nature are required to manage them successfully. This is because in such cases, the ecosystems do not respect national borders. Many of the world's 64 large marine ecosystems are shared by two or more countries. For instance, to apply EAM to the management of the Gulf of Guinea Large Marine Ecosystem effectively, policies need to be crafted and adopted by the 16 countries bordering the ecosystem. In terms of policy, getting countries with diverse societal objectives to agree on and implement joint EAMs is certainly a challenge, which must be addressed if EAM is to gain universal applicability. Two ways by which a country's societal objective regarding the use of marine ecosystem resources can enter economic analysis are (1) how the country values market relative to nonmarket values from the ecosystem, and (2) the discount rate applied to discount flows of net benefits over time from the ecosystem.

The economic analysis of a full ecosystem approach to management is daunting at best. Producing analytical results is next to impossible in ecosystem-economic models. As a result, most fisheries economic models continue to be based on single-species biological models. Current economic-ecosystem models have mostly resorted to simulation and numerical models. The economic issues raised by EAM relate to the economics of internationally shared fishery resources, to which we turn in the next section.

Internationally Shared Fishery Resources

The establishment of the exclusive economic zone (EEZ) regime in the early 1980s brought with it the shared fish stock problem. Two broad, nonmutually exclusive, categories of shared stocks have been identified as transboundary stocks (EEZ to EEZ) and straddling fish stocks (both within the EEZ and the adjacent high seas).

Under the 1982 United Nations (UN) Convention, coastal states sharing a transboundary resource are admonished to enter into negotiations with respect to cooperative management of the resources (UN, 1982, Article 63(1)). Importantly, however, they are not required to reach an agreement. If the relevant coastal states negotiate in good faith, but are unable to reach an agreement, then each coastal state is to manage its share of the resource (i.e., that part occurring within its EEZ), in accordance with the relevant rights and duties laid down by the 1982 UN Convention. We refer to this as the default option.

With the default option in mind, economists find two issues that needed attention:

1. the consequences, if any, of the relevant coastal states adopting the default option, and not cooperating in the management of the resource;
2. the conditions that must prevail, if a cooperative resource management regime is to be stable over the long run.

Two aspects of the problem need to be noted. The first is that the state property rights to the fishery resources are straightforward and clear. The relevant coastal states are to be seen as joint owners of the resources. The second is that, with few exceptions, there will be a strategic interaction between, or among, the coastal states sharing the resource in the following sense. Consider two coastal states, I and II, sharing a transboundary resource. The fishing activities of I can be expected to have an impact upon the fishing opportunities available to II, and vice versa. II (I) will have no choice but to take into account the likely catch plans of I (II) – hence the strategic interaction.

In attempting to analyze issues (1) and (2), economists are compelled to recognize such strategic interactions. The economics of the management of transboundary fish stocks is, as a consequence, a blend of the standard fisheries economics applied to domestic fisheries (i.e., fisheries confined to a single EEZ), and the theory of strategic interaction (or interactive decision theory), more commonly known as the theory of games. Economists studying other shared resources, for example, water, the atmosphere, also find themselves compelled to incorporate game theory into their analysis.

There are two broad classes of games, noncooperative (competitive) and cooperative. We draw upon the theory of noncooperative games to analyze issue (1), the default option of noncooperative management. The key conclusion arising from noncooperative game theory is that the 'players' (coastal states sharing the fishery resources) will be driven inexorably to adopt strategies that they know perfectly well will produce decidedly undesirable results. This outcome is referred to as a 'prisoner's dilemma' outcome, after a famous noncooperative game developed to illustrate the point.

With respect to cooperative management, the analysis draws upon the theory of cooperative games. It is assumed that each 'player' is motivated by self-interest, and is prepared to consider cooperating, only because it believes that it will be better off, than by playing competitively. The chief problem in cooperatively managed fisheries is that of ensuring the stability of the cooperative management regime through time.

The effective economic management of transboundary fish stocks, while a demanding problem, is simple in comparison with the management of straddling fish stocks. The management of these resources, of seemingly minor importance in 1982, became a crisis during the following decade, and compelled the UN to mount another international conference – the UN Conference on Straddling Fish Stocks 1993–95.

The root of the problem lay in the High Seas part of the 1982 UN Convention (UN, 1982, Part VII). Straddling stocks are exploited both by coastal states and distant water fishing states (DWFs), the latter operating in the high seas. The drafters of Part VII attempted to balance the Freedom of the Seas, pertaining to the fisheries, with the rights and needs of the coastal states. The resulting articles are models of opaqueness, which left the rights and duties of (1) coastal states, and (2) DWFs, with respect to the high-seas segments of straddling stocks, unclear. The lack of clarity virtually assured that the stocks would be managed noncooperatively. The model of noncooperative management of transboundary stocks proved to be applicable, without modification, to straddling stocks, and to have a high degree of predictive power. It should be noted that the economics of cooperative management of these resources differs substantially from the economics of management of transboundary stocks.

Concrete examples of where game theory may have informed the creation of joint management arrangements are between (1) Norway and Russia in the management of cod in the Barents Sea; (2) the United States and Canada in the management of Pacific salmon; (3) Angola, Namibia, and South Africa in the management of the fishery resources in the Benguela Large Marine Ecosystem; and (4) New Zealand and Australia in the management of the South Tasman Rise Trawl Fishery targeting orange roughy.

Fisheries Subsidies, Overcapacity, and Overexploitation

Economists have long demonstrated that fishery subsidies greatly impact the sustainability of fishery resources. Subsidies that reduce the cost of fisheries operations and those that enhance revenues make fishing enterprises more profitable than they would be otherwise. Such subsidies result in fishery resources being overexploited, as they contribute directly or indirectly to the buildup of excessive fishing capacity, thereby undermining the sustainability of marine living resources and the livelihoods that depend on them. Figure 3 demonstrates how subsidies that lower cost from TC_1 to TC_2, will also lower the bionomic equilibrium from BE_1 to BE_2, thus encouraging the growth of fishing effort from E_3 to E_4.

Not all subsidies, it must be conceded, are harmful. Government expenditures on fisheries management, research, enforcement, and enhancement are classified by the OECD as fisheries subsidies. These subsidies can be seen as being, at worst, neutral in their impact upon resource management. One subsidy that is still being viewed by many fisheries scholars and managers as having a positive, conservationist impact is buyback subsidies. Some economists argue that buyback subsidies, by leading to the removal of economically wasteful and resource-

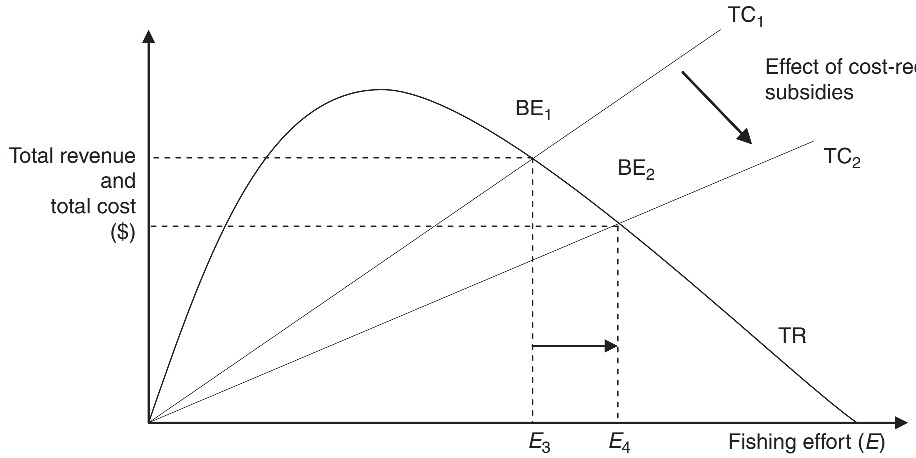

Figure 3 Schematic representation of how subsidies induce overfishing.

threatening excess fleet capacity, make a positive contribution to resource management and conservation. Others, however, argue against the usefulness of buyback subsidies, arguing that these subsidies are basically ineffective, as capital removed by them simply 'seeps' back into the fishery. It has also been demonstrated that even if capital seepage does not occur after a buyback scheme, this class of subsidies could still be ineffective if fishers know beforehand that a buyback scheme will be implemented in the future because they may accumulate more fishing effort than if they did not.

Economics of Illegal Fishing

Illegal fishing is conducted by vessels of countries that are part of a fisheries organization but which operate in violation of its rules, or operate in a country's waters without permission, or on the high seas without showing a flag or other markings. Since those engaging in illegal fishing are mainly economic agents that seek to maximize their profits from the activity, a good understanding of the economics of illegal fishing is important in order to design appropriate measures. Becker's (1968) contribution on the economics of criminal activity forms the theoretic basis for almost all of the contributions in the economic literature on illegal fishing. These contributions argue that criminals behave essentially like other individuals in that they attempt to maximize utility subject to a budget constraint. These models focused on the probability and severity of sanctions as the key determinants of compliance. It has also been shown in the literature that moral and social considerations play a crucial role in determining whether an individual engages in illegal activity or not.

Economics of Marine Protected Areas

Marine protected areas (MPAs) are, as the name implies, designated areas in the ocean within which human activities are regulated more stringently than elsewhere in the marine environment. The protection afforded by MPAs can vary widely, from minimal protection to full protection, that is, no-take reserves. Such areas are carved out to maintain, at least to some extent, the natural environment of the designated area for ecological, economic, cultural, social, recreational, and other reasons.

MPAs and other forms of spatial management are part of the toolkit of fisheries managers. Both theoretical and applied economic analyses are common in the MPA literature. The former focus broadly on obtaining insights into the dynamics and performance of MPAs. On the other hand, applied economic research is oriented toward analyzing specific case studies, both to provide an understanding of particular MPA situations, and to help build a body of case studies that can facilitate a meta-analysis of MPAs.

One of the principal arguments made for MPAs is their use as an 'insurance policy'. It is argued that even if other management measures fail in a fishery, an MPA will ensure a certain minimal level of ecosystem and fish stock health. Thus, many analyses explore the economics of MPAs as insurance policies, and the impact of MPAs within an environment that is prone to structural uncertainty.

Even though MPAs inherently involve spatial considerations, many studies of MPA economics – particularly those with a primarily theoretical focus – are based on aggregated spatially homogeneous models. There has been a recognition of the need for developing spatially heterogeneous models, and progress is being made in this direction, providing needed insights on such issues as the economically optimal placement of an MPA within a certain region, and the desired 'design' of MPAs to optimize economic benefits.

Economics of 'Rights-Based' Management

We will consider three approaches to 'rights-based' or what has come to be known recently as 'dedicated access privileges' (DAPs) management: individual transferable quotas (ITQs), fishers' cooperatives, and community-based fisheries management, sometimes referred to as territorial use rights fisheries (TURFS). One can, in addition, find blends of the three. We argue that there is significant convergence among the three. The most widely used of the three is individual quotas (IQs), usually in the form of transferable quotas (ITQs). The IQ scheme was originally designed to deal with the consequences of ineffectively controlled 'regulated open access' – the race for the fish. Under the scheme, the resource managers continue to set the total allowable catch (TAC), as before. Individual fishers, vessel owners, companies, etc., are then assigned individual shares of the TAC.

Having individual TAC shares, the fishers' incentive to engage in a 'race for the fish' and to overinvest in vessel capacity should be reduced. Obviously, the scheme will not work, if monitoring and enforcement are ineffective.

Of the three approaches, the most studied is the ITQ. Many studies of this approach from around the world show that economic efficiency does indeed improve with the implementation of ITQ schemes. But the role of ITQs with regards to the conservation of the resources and the ecosystems, and ensuring equity in the use of these resources, remains controversial.

Concluding Remarks

In this article, the basic theory of fisheries economics and a selection of topical and central issues in this area are presented. An extensive reading list is provided so that interested readers can dig deeper into the issues discussed in this short piece. The reading list also provides an opportunity to explore other important and topical issues being addressed by fisheries economics, which, unfortunately, could not be covered in this article.

Acknowledgments

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See also

Fisheries: Multispecies Dynamics. Fisheries Overview. Fishery Management. Fishery Management, Human Dimension. Fishery Manipulation through Stock Enhancement or Restoration. Fishing Methods and Fishing Fleets. Marine Fishery Resources, Global State of.

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Relevant Websites

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