Fisheries Management for Fishermen:

A manual for helping fishermen understand the federal management process

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Richard K. Wallace
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4170 Commanders Drive
Mobile, Alabama 36615

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Mr. Jerald Horst
Louisiana Cooperative Extension Service

Mr. Ron Schmied
NMFS Southeast Regional Office

Mr. Bob Jones
Southeastern Fisheries Association

Mr. Doug Gregory
Florida Sea Grant Extension

Mr. Phillip Horn
Clark Seafood

Dr. Phil Goodyear, Fishery Biologist
National Marine Fisheries Service

Mr. James Morris

Ms. Susan Shipman
Georgia Department of Natural Resources

Mr. Chris Nelson
Bon Secour Fisheries, Inc.

Mr. Robert (Bob) K. Mahood, Executive Director
South Atlantic Fishery Management Council

Dr. Robert L. Shipp
University of South Alabama

Table of Contents

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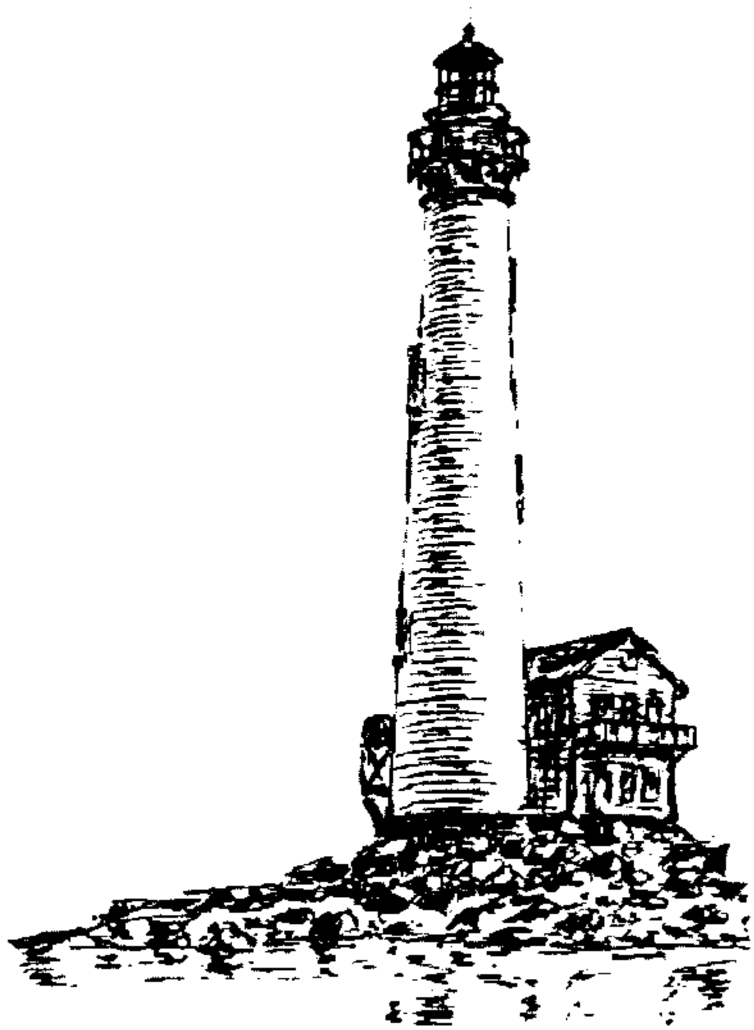
Preface

Fishery regulations have increased dramatically in the last five years. New methods of measuring the health of fisheries have evolved, and the framework in which fishery managers must operate has been more narrowly defined. More than ever, fishermen need to understand the biological basis of regulation as well as the regulatory process. Well-informed fishermen can become an integral part of the process rather than the objects of regulation. The purpose of this manual, therefore, is to unlock the mysteries of fisheries jargon and to explain how regulations are made in the hope that fishermen will get more involved.

Fisheries Management for Fishermen focuses on federal marine fisheries management as mandated by the Magnuson Fishery Conservation and Management Act (MFCMA), more commonly known as the Magnuson Act. Fishery biology principles and the need for public involvement, however, apply to fishery management at the state level as well.



Introduction

WHOSE FISH ARE THEY, ANYHOW?

Many fishermen, frustrated by unwanted regulation, wonder why government officials have the right (or the nerve) to tell them how much they can catch, where and when they can catch it, and how they can catch it. The answer is found in something called "the tragedy of the commons."

Common Property Resources

Hundreds of years ago, community leaders observed that when a resource was owned by the people, no one took any responsibility for maintaining the resource. Human nature being what it is, each person tended to use the resource to the maximum extent. There was little incentive to conserve or invest in the resource because others would then benefit without contributing to the welfare of the resource. In the case of common (public) grazing areas in England, grass soon disappeared as citizens put more and more sheep on the land held in common. Everyone lost as "the commons" became overgrazed and this became known as "the tragedy of the commons."

Tragedy of the commons

To prevent "the tragedy of the commons" most common property resources are held in trust and managed for the people by state or federal government agencies. Fish living in public waters are such a common property resource. The government has the responsibility of managing the fish for the benefit of all citizens, even those who do not fish.

Fish are a common property resource.

So who owns the fish? You do—along with the other 270 million citizens of the U.S. In order for all to benefit from this renewable resource, the fish are managed on the basis of some basic principles. These principles and the regulatory structure are explained in this manual.

Government Management

Managing fishery resources is ultimately the responsibility of elected officials. Elected officials in most states and in the federal government, however, have delegated much of that responsibility to resource agencies that employ people trained in the sciences of fishery biology, economics, and natural resource management. The National Marine Fisheries Service (NMFS) is the federal government agency with primary responsibility for managing marine fish from three miles to 200 miles offshore. Coastal states are responsible for inshore waters and offshore waters out to three miles (nine miles on the Florida west coast and off Texas).

National Marine Fisheries Service

Government Management Structure

The National Marine Fisheries Service is an agency of the National Oceanographic and Atmospheric Administration (NOAA), which in turn is a part of the U.S. Department of Commerce.

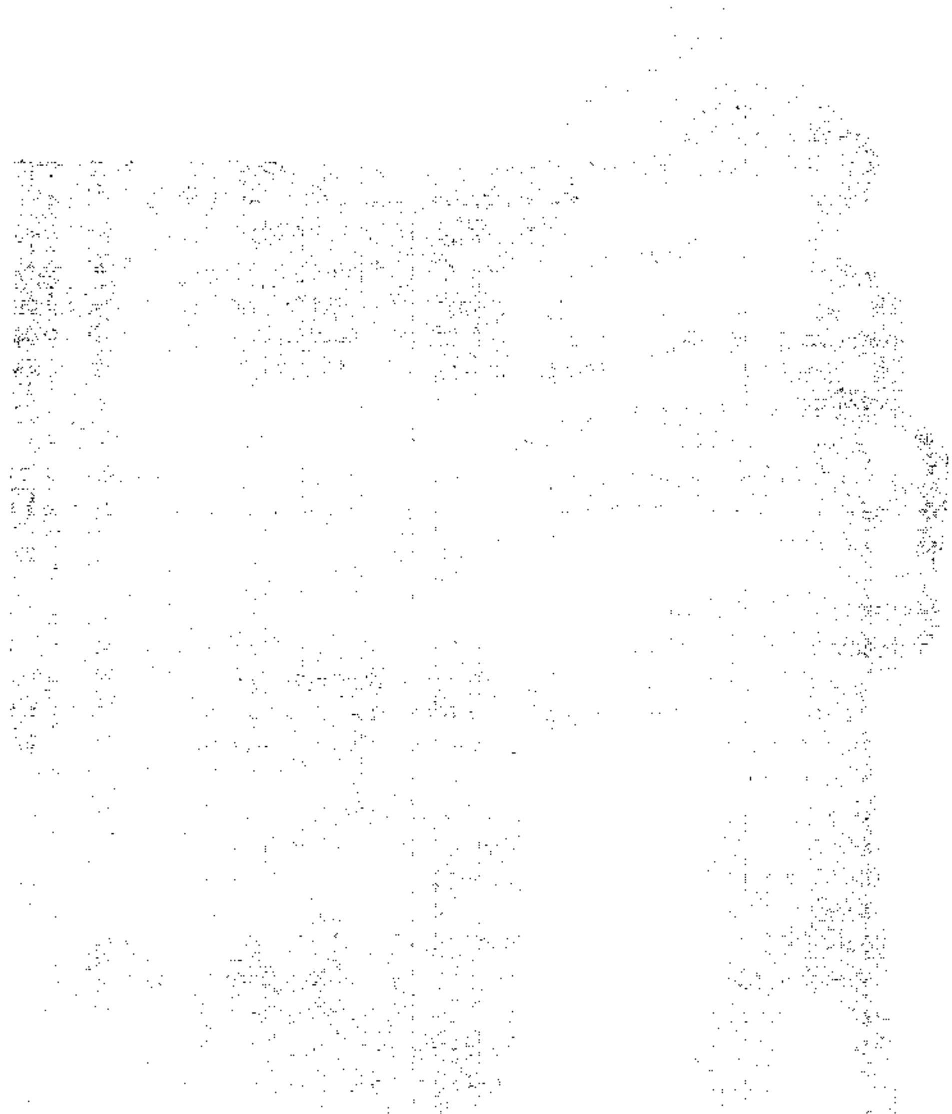
The legislation that directs how the NMFS manages the nation's fisheries is the Magnuson Fishery Conservation and Management Act, also known as the Magnuson Act. The Magnuson Act created eight regional fishery management

Magnuson Fishery Conservation and Management Act

councils to advise NMFS on fisheries management issues. The voting members of the councils include a representative from each state fishery management agency, a mandatory appointee from each state, at-large appointees from any of the states in the region, and the regional director of NMFS. The councils produce fishery management plans (FMPs) with public input that describe the nature and problems of a fishery along with regulatory recommendations to conserve the fishery. After approval by the Secretary of Commerce, regulations that implement management measures in the FMP become federal law and are enforced by NMFS.

Fishery management plans

Part 1 of this manual covers the biological basis for management. Part 2 deals in greater detail with how the councils work and how fishermen can become involved.



Part 1: Fisheries Management and Biology

What Makes Fish and Shellfish a Renewable Resource?

Renewable resources like finfish and shellfish are living things that replenish themselves naturally and can be harvested, within limits, on a continuing basis without eliminating them. The scientific principles behind this renewability are well-known and provide the basis for fish and game management.

Survival

Fish produce more young than can survive.

All animals produce more offspring than survive to adulthood. This is a kind of biological insurance against the natural calamities all animals face. Actually, for a species to maintain itself, each pair of fish only has to produce two offspring that survive to reproduce. Most individual fish and shellfish produce tens of thousands to millions of eggs. Most of their eggs do not survive to become juveniles and even fewer live to become adults.

Surplus Production

This extra production together with the effects of harvesting fish can result in surplus or sustainable production.

Carrying capacity

The theory of surplus production goes something like this. In an unfished population, the biomass (total weight) of fish in a habitat will approach carrying capacity (maximum amount that can live in an area) of the habitat. Furthermore this population will have a lot of older, larger fish compared to a fished population. These fish dominate the habitat and their presence prevents all but a small percentage of the young fish produced each year from surviving to become old fish. When fishing begins, many large older fish are removed. Removal of these older fish and other fish reduces the biomass below the carrying capacity and increases the chances of survival for smaller, younger fish.

The unfished population can be viewed as a relatively stable population with moderate production. The fished population, on the other hand, is a dynamic population with a higher turnover of individual fish as the older fish are replaced by younger, faster growing fish. Some of this new production must be allowed to survive and reproduce to maintain the population. The remaining or surplus production is available for harvest. Surplus production is illustrated in greater detail in Appendix 1.

How Many Fish Can We Catch?

Total allowable catch

The basic goal of fishery biology is to estimate the amount of fish that can be safely removed (total allowable catch - TAC) while keeping the fish population healthy. These estimates may be modified by political, economic, and social considerations. Overly conservative management can result in wasted fisheries production due to under-harvesting, while too liberal or no management may result in over-harvesting and severely reduced populations.

More on Surplus Production

As you may have guessed, surplus production is a complex biological process that is influenced by several factors. These factors merit further discussion.

Carrying Capacity

Fish habitat

One factor is that of carrying capacity. Carrying capacity can be thought of as the amount of fish an area of habitat will support. Habitat that historically supported 100 million pounds of red drum is unlikely to support a lot more or a lot less red drum unless conditions change. For example, if the amount or quality of habitat is reduced, carrying capacity will likewise be reduced.

Habitat Loss

Less fish means less habitat.

There is no question that human activity has altered, and in some cases, reduced fish habitat. Water pollution, loss of coastal wetlands and seagrasses, destruction of spawning areas, and changes in freshwater flows are some habitat alterations that have led to habitat reduction. Unfortunately, fishery managers and fishermen have had little say in habitat alterations. Fishery managers are saddled with managing the fish populations that the habitat can support today, not the fish populations that past habitat conditions supported.

Ever-Changing Carrying Capacity

Carrying capacity is not constant.

Another aspect of carrying capacity is that it changes as environmental conditions change from year to year. The most obvious example of this is found in the brown shrimp fishery of the Gulf of Mexico. From 1980 to 1992 landings were as high as 193 million pounds (1986) and as low as 125 million pounds (in 1983). Most of this variation can be attributed to salinity conditions in the marsh habitat used by very small shrimp. When conditions were good (high salinity), there was more suitable habitat and more young shrimp survived. When conditions were poor (low salinity), there was less suitable habitat and fewer young shrimp survived. The biological principles that cause surplus production are the natural methods that a species uses to increase the population when environmental conditions are favorable.

Summary

Harvesting fish lowers the population below the carrying capacity of the environment. Continued harvest depends on the ability of the population to produce enough offspring to move toward the maximum carrying capacity. Variations in natural conditions can alter the carrying capacity, resulting in good years and bad years for survival of young.

Time Out For a Few Definitions

We have jumped straight into the theory behind renewable fishery resources without too much worry about definitions. We have used words like species and population rather loosely. Biologists define these words as follows:

Species - A group of similar organisms that can freely interbreed.

Population - A group of individuals of the same species living in a certain area.

Stock - A harvested or managed unit of fish.

Fish Stocks

Ideally the various populations of a species would be the units that are managed; however, this is rarely practical and fishery biologists often refer to stocks rather than populations.

For example, Spanish mackerel occur from Maine to the Yucatan Peninsula in Mexico. For purposes of management in the U.S., Spanish mackerel are divided into two stocks. Fish from one stock migrate from Florida northward along the east coast of the United States and the others migrate from Florida into the Gulf of Mexico. The two stocks may represent one or several populations that make up the species. However, current knowledge about harvesting patterns and migration patterns dictates that they be managed as two stocks.

Sometimes more than one species is included in a stock because they are harvested together as though they were one species. In other cases, different species may be managed together for convenience.

More Definitions

Most technical terms are defined within the text where they are used. Additional definitions may be found in Appendix 2.

Summary

A stock of fish is the practical unit of a population that is selected for management or harvesting purposes. In some cases a managed stock may include more than one species.

Stock Assessment

Stock assessment is all of the activities that fishery biologists do to describe the conditions or status of a stock. The result of a stock assessment is a report on the health of a stock and recommendations that would maintain or restore the stock.

Assessment means judging the state of a stock.

Some Basics

Stock assessments often consist of two nearly separate activities. One is to learn as much as possible about the biology of the species in the stock. The other is to learn about the fishing activities for the stock. Historically, the demand for a stock assessment has come after a stock is already in decline. When a stock assessment begins, there may be little or no information on the biology of the species or the fishery. Meanwhile, there is pressure to complete some kind of stock assessment so that the stock can be managed. This leads to preliminary stock assessments which provide for initial management recommendations until more information is available.

A Stock Assessment Based on the Fishery (Catch and Effort)

Landings data

One of the simplest stock assessment methods requires almost no knowledge about the biology of the stock. However, good information about the fishery is required. In this assessment, the manager only needs to look at the history of landings for the stock and the effort expended to catch the stock. The key word here is effort. Landings data (the amount of fish caught and landed per year) alone are not very useful. Landings can fluctuate up and down for a variety of reasons. A trend of decreased landings may be a cause for concern, but the amount of effort made by fishermen to catch the stock tells the real story.

Catch-per-unit effort (CPUE)

In order to account for effort, fishery biologists divide the yearly landings by the fishery effort to calculate the catch-per-unit effort (CPUE). For example, three million pounds of shrimp caught by 6,000 vessel-days of effort gives a catch-per-unit effort of 500 pounds per vessel-day. (Fishery biologists often express effort in ways that are foreign to fishermen. For example, "vessel-days" is an attempt to estimate the total days all shrimpers trawled. In a longline fishery, the effort might be called hook-hours where the number of hooks multiplied by the amount of time the hooks were in the water can be used to estimate effort.) The catch-per-unit effort is directly related to the amount of fish in the stock. A decline in CPUE usually indicates a decline in the stock.

Decline in CPUE usually means trouble.

A number of fisheries have followed a pattern in relation to the catch-per-unit effort. At the beginning of a new fishery, the catch-per-unit effort is high and the effort is low. As interest in the fishery grows, the effort increases, the catch increases and the catch-per-unit effort usually levels off or declines. Finally, as more effort is applied, the catch declines and the catch-per-unit effort declines even more. When both the catch and the catch-per-unit effort decline, it is an indication that the stock is probably overfished. This means too much effort is being applied for the stock to maintain itself. Landings decline despite increasing effort. The obvious solution is to reduce the amount of fishing until the catch-per-unit effort returns to the earlier stages of the fishery.

This seems simple enough. But why isn't this assessment used more often? The reasons include:

- Insufficient landings data.
- Insufficient effort data.
- Fishermen using new technology that make it hard to compare the effort today with the effort of several years ago.

Adequate landings data are often available, but the effort data is usually missing, incomplete or unusable. The other problem is that by the time there is a clear decline in catch-per-unit effort, stocks may be well overfished, even to the point of collapse.

Over-capitalization

If fishing effort is too high, it usually means that there are too many boats in the fishery. Fishery managers call this over-capitalization. This means more money (capital) has been invested in boats than the fishery can support. Over-capitalization can also refer to the ability of fishermen to increase effort without increasing the number of boats. If no new boats are added to a fishery, but each boat doubles its fishing power by carrying twice as much longline or using new technology (sonar, GPS, etc.) the new effort can have the same effect as doubling the number of boats.

Summary of Catch and Effort

Landings data are often used to suggest that there are problems in a fishery. Declines in landings or increases in landings are signals that something has changed in the fishery. In either case, the effort by fishermen to catch the stock must be considered. The catch-per-unit effort is the appropriate way to evaluate changes in catch because CPUE is an indicator of stock abundance. Problems arise in measuring effort over time in a fishery that may have changed from sailboats pulling one net to diesel-powered vessels with sophisticated electronics pulling multiple nets.

Assessment Based on a Little Biology (Age at First Spawning)

When little is known about the biology of a fish stock, one of the first questions asked is, "At what age does the fish spawn?" The second question is, "What proportion of the fish caught are one-year, two-years, and three-years old?" If some of the fish spawn when they are two-years old, and all spawn at age three, and most of the fish caught are two-years old, then there is a danger that too many fish may be caught before they can spawn and replace themselves. This is called recruitment overfishing.

Age and spawning

Recruitment overfishing

Harvesting some fish before they spawn does not automatically doom the stock, but it is something that needs to be evaluated. Declining landings, greater effort to catch the same or smaller amounts of fish, or declines in average size of fish are all signs of possible problems. Determining the age of spawning and the age of fish caught is one step toward management.

When fishermen appear to be catching fish before they have a chance to spawn and there are other signs of trouble in the fishery, the usual management response is to protect small fish. Protection most often comes in the form of length limits or gear restrictions that favor the catch of larger fish. Minimum mesh size limits for gill nets is a gear restriction that allows smaller fish to escape.

Unfortunately, protecting small fish does not necessarily get at the larger problem of overfishing. Remember, recruitment overfishing occurs when more fish are being removed than can replace themselves. Overfishing can still occur on the remaining fish in a stock even when the small fish are protected because small fish produce fewer eggs than large fish.

Overfishing

Fishermen sometime suggest a closed fishing season during the period when a stock is spawning. This would seem logical but the idea is usually rejected by biologists. A fish caught before, during, or after the spawning season is still not available to spawn the next year. As a result, the focus is more on protecting fish until they are old enough to spawn and then determining how many fish can be safely removed without harming the stock. Exceptions to this approach are cases where spawners gather in certain locations and are very vulnerable to being caught in unusually large numbers.

Protect the spawners?

Summary of Age at First Spawning

Knowing the age of first spawning and the age of fish being caught is an important aspect of fishery assessment. Size limits and gear restrictions can be put in place to protect fish until they have a chance to spawn at least once. Protecting small fish, however, still does not guarantee against overfishing.

Information for a More Complete Assessment

Few fish stocks, if any, have been fully assessed. Fishery biologists and managers always wish they knew more about the fish and the fishermen. Full assessment would include some of the following information about the fishery:

1. The kinds of fishermen in the fishery (longliners, rod and reel, netters, recreational, etc.).
2. Pounds of fish caught by each kind of fisherman over many years.

3. Fishing effort expended by each kind of fisherman over many years.
4. The age structure of the fish caught by each group of fishermen.
5. The ratio of males to females in the catch.
6. How the fish are marketed (preferred size, etc.).
7. The value of fish to the different groups of fishermen.
8. The time and geographic area of best catches.

The biological information would include:

1. The age structure of the stock.
2. The age at first spawning.
3. Fecundity (average number of eggs each age fish can produce).
4. Ratio of males to females in the stock.
5. Natural mortality (the rate at which fish die from natural causes).
6. Fishing mortality (the rate at which fish die from being harvested).
7. Growth rate of the fish.
8. Spawning behavior (time and place).
9. Habitats of recently hatched fish (larvae), of juveniles and of adults.
10. Migratory habits.
11. Food habits for all ages of fish in the stock.

Fishery-dependent and fishery-independent data

When the above information is collected by examining the landings of fishermen, it is called fishery-dependent data. When the information is collected by biologists through their own sampling program, it is called fishery-independent data. Both methods contribute valuable information to the stock assessment.

Best Available Data

Even in the best stock assessments it is rare that everything that should be known about a stock is known. Assessments proceed with the assumption that the best available information (data) will be used. Fishermen often disagree with this assumption when they are adversely affected. Fishery managers respond that they are obligated to protect the stocks, and in the case of federal fishery management, are mandated by law to use the best available data.

Best available data and fishermen

The best available data principle sometimes creates a conflict for fishermen. In the past, when managers have asked for more and better data from fishermen, the result has usually been more regulations. The data appear to have been "used against the fisherman." From the managers' point of view the data were used to ensure that the fishery could continue. When fishermen don't provide good data then the fishery will be managed on the data available, which may be incomplete. This can result in overly restrictive management which is wasteful or can result in continued overfishing and declining catches. In either case, fishermen are the losers. It is in the long-term interest of fishermen to provide the best data possible.

Age, Growth, and Death

Any reliable information about the fishing process or the biology of the stock contributes to the stock assessment. Among the basic biological information that fishery biologists find most useful are the age structure of the stock and the relation between fish length and age. Once this is known then important characteristics of the stock such as growth rate and death rate (mortality) can be determined. This information is used to create a picture of the stock which describes the current status of the stock.

Aging Fish

Otoliths

You cannot tell the age of a fish by looking at it. There are too many differences between species and within a species. Fish are normally aged by examining bony parts such as otoliths ("ear bones") that contain a record of growth like rings on a tree. Once it is established that each ring truly represents a year, then the age of a fish can be determined.

Length-at-age keys

The usual procedure is to obtain fish from fishermen or from a fishery-independent sampling program, age them, and then compare the length and weight to the age of the fish. This results in a length-at-age key in which the age of a fish can be estimated from its length. (See Figure 1 in which each × represents the length of an individual fish.) Also, by looking at the change in length and weight from a one-year-old fish to a two-year-old fish etc., the growth rate can be estimated. The more fish that are aged, the better the picture of the stock. However, in the case of long-lived fish, growth usually slows in the older fish and past a certain point, the age cannot be readily assumed by the length of the fish. For example, it would be hard to tell the age of 20-inch fish in Figure 1 because a 20-inch fish could be between 4 and 8 years old. In these cases it is better to age as many fish as possible by the bony parts than to rely on the length, especially in the larger, older fish.

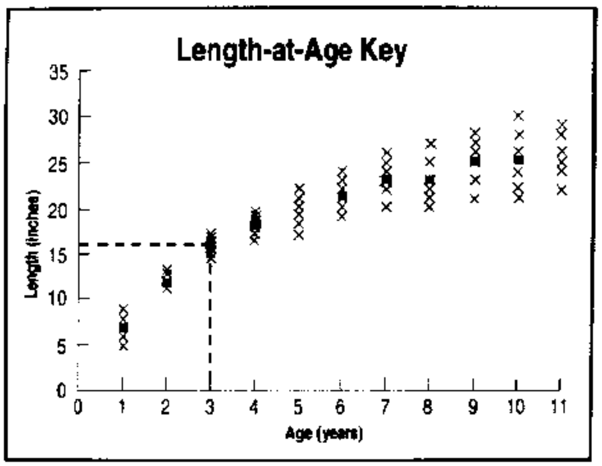


Figure 1

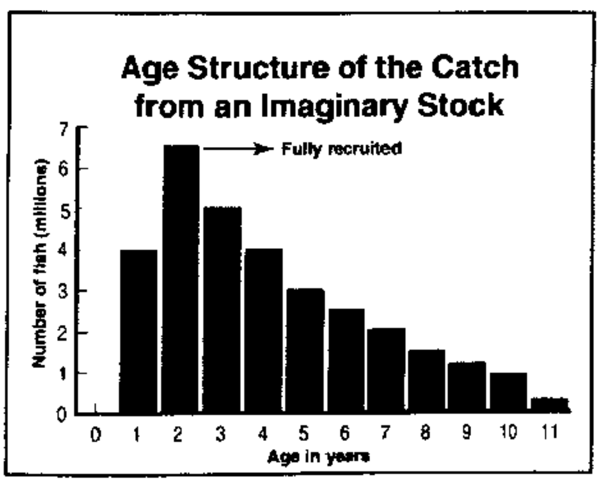


Figure 2

Age structure of the stock

When enough fish have been aged, either directly or indirectly, a picture (catch curve) of the age structure of the stock may be drawn (Figure 2). Note that in this imaginary stock there are more two-year-old fish than one-year-old fish. This does not make sense. We expect that the younger fish will be the more numerous and there will be fewer fish at each subsequent age due to fishing and natural causes. There are several possible reasons why fishermen are not catching one-year-olds in proportion to their abundance. The one-year-olds may not be abundant in the same areas as the older fish, or they may not be caught by the fishing gear, or they may be caught but thrown back. When fishery biologists see a graph like this, they say that the one-year-fish are "not fully recruited" to the fishery while the two-year-olds are considered to be "fully recruited." The first year a fish is readily harvested in a fishery it is referred to as a recruit.

Fully recruited and recruit

A fishery assessment using the abundance of each age group is based on the portion of the stock that is fully recruited to the fishery. It would be desirable to know more about the unrecruited stock between the time of egg fertilization and the age of recruitment, but for many species there is little that management can do that would affect this part of the population. For other species, management could affect water quality, the amount of suitable habitat, or even the death rate (bycatch, power plant entrainment, etc.) to promote greater survival of young fish before they reach harvestable size (are recruited to the fishery).

Management before recruitment to the fishery

More Information From Age Structure

The age structure of a stock is a sort of historic picture of the stock. It reveals something about the current status of the stock as well the past history of the stock. Figure 3 is the age structure of a fish stock in 1986.

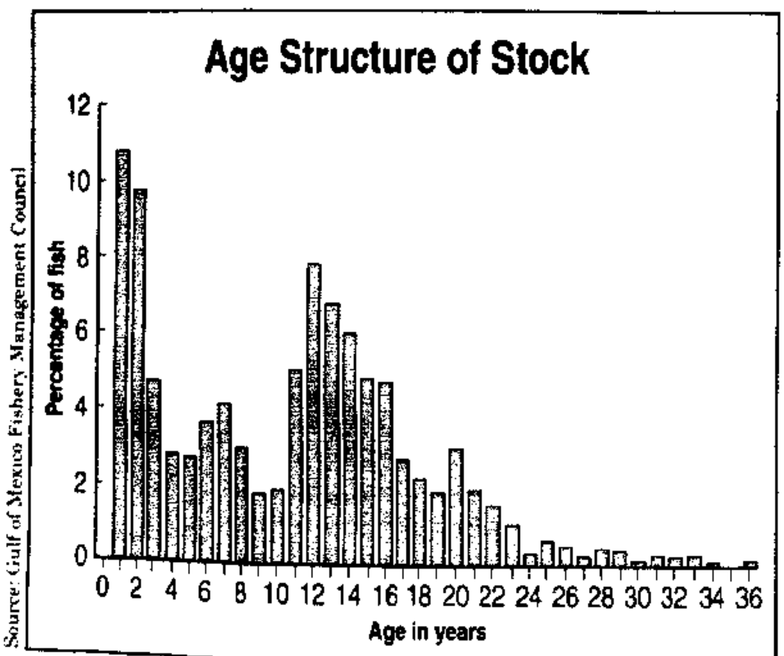


Figure 3

What can be learned from just looking at this graph?

1. The fish are harvested starting at one year of age.
2. The species is a very long-lived fish—up to 36 years old.
3. The number of fish at each successive age (two to three, three to four, etc.) does not follow a smooth downward trend as previously shown in Figure 2.
4. Ages three to 11 appear to be particularly few in number. Eleven-year-old fish were hatched in 1975 (1986 - 11 = 1975). Three-year-olds were hatched in 1983.
5. Even though one and two-year-old fish appear relatively abundant, if we look at the age structure of 12-year-old fish out to 23-year-old fish (hatched between 1974 and 1963) we can see that they have not declined in numbers at the same rate as ages three to 11 appear to have declined. In fact, the number of fish that should have been alive from ages one to 11 can be estimated (See Figure 4) by drawing a line from around age 12 back to age one.

How many age-1 fish might there have been?

6. This backward projection suggests that not only are there not as many three to 11-year-olds as might be expected, but the number of one and two-year-olds may be less than what existed in the 1960s to the 1970s.

Fishery biologists take this kind of pictoral information and quantify it (put numbers on it) in order to further describe the stock and test ideas about the health of the stock.

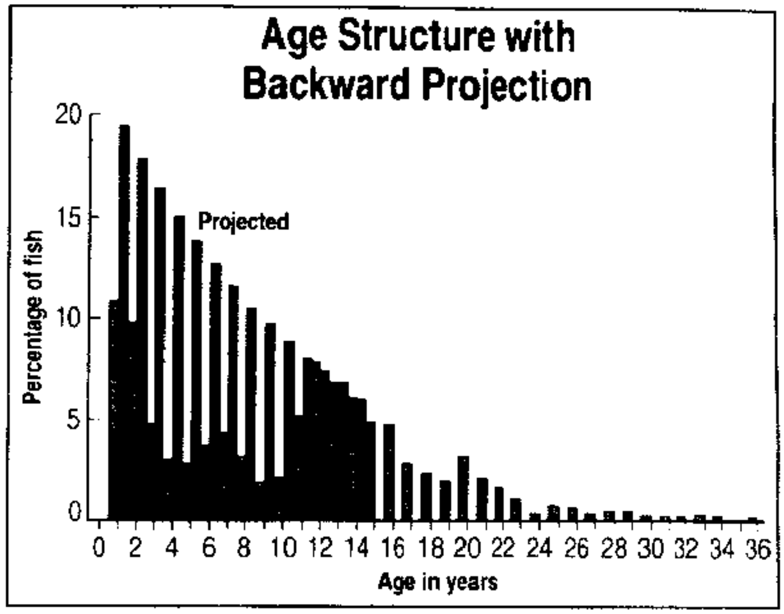


Figure 4

Summary of Age Structure

The age distribution of a stock provides a graphic picture of the stock as it exists today and, in the case of long-lived fish, can reveal something about the past history. The picture by itself does not reveal how much fish can be caught but provides information which leads to the answer.

Mortality and Spawning Potential Ratio (SPR)

Earlier we said the goal of fishery management was to determine how many (numbers) or how much (pounds) fish can be safely harvested from a stock. In simpler terms we want to know how many fish in a stock can die and still allow the stock to maintain itself. Fishery biologists refer to the rate at which fish die as mortality or the mortality rate. If 1000 fish are alive at the beginning of the year and 200 fish die leaving 800 at the end of a year, then the annual mortality rate is 20 percent (200 divided by 1000) and the survival rate is 80 percent (800 divided by 1000). Each year some fish die whether they are harvested or not. The rate at which fish die from natural causes is called natural mortality and the rate at which fish die from fishing is called fishing mortality.

Mortality rate

Natural and fishing mortality

While it is easy to understand these rates as annual percentages, fishery biologists must convert them to something called instantaneous rates to use them in mathematical formulas. As a result, in a fishery management plan you might see statements such as, "The instantaneous fishing mortality rate is 0.67 (F = 0.67)" or that, "The instantaneous natural mortality rate is 0.1 (M = 0.1)." Sometimes the word instantaneous is omitted, but F and M are conventional symbols for instantaneous annual rates. Natural mortality (M) and fishing mortality (F) can be added together to get total mortality (Z). Unless regularly dealt with, these numbers do not mean much relative to our more intuitive understanding of annual percentages. Table 1 gives some examples of annual percentages and the corresponding instantaneous rates (F, M or Z). A more complete table is given in Appendix 3.

Instantaneous rates

Total mortality

Table 1

Annual Percentage	Instantaneous (F, M, or Z) Rate
0	0
10	0.1054
30	0.3567
50	0.6931
80	1.604
90	2.3026

Determining Mortality From Age Structure

The age structure diagrams (Figures 2 and 3) are a picture of the stock at the time the information was gathered. It is often assumed that if conditions remain the same, then as the younger fish grow older they will decline through time at about the same rate as the older year classes appear to have declined. For example, in Figure 2, there are 6.5 million two-year-olds and 2.5 million six-year-olds. It would seem likely that the current crop of two-year-olds will also be reduced to 2.5 million by the time they are six years old. In this case the annual mortality can be estimated by subtracting 2.5 million from 6.5 million to get 4.0 million and then dividing by 6.5 million to get 0.62 or 62 percent mortality. However, this mortality took place over five years, so the average annual rate is 0.62 divided by 5 which equals 0.12 or 12 percent. This corresponds to a total instantaneous mortality (Z) of 0.13.

Fishing mortality and natural mortality

Remember that in a fish population, the total mortality includes the fishing mortality and natural mortality. The above example for estimating total mortality from the age structure does not reveal how much of the total mortality is due to fishing mortality and how much is due to natural mortality.

Estimating mortality

Several methods are used to determine each mortality rate. For example, fishing mortality can be estimated from a tagging study. After a lot of fish from a stock are tagged, the percentage of tagged fish that are caught and reported is an estimate of the fishing mortality. Natural mortality is then calculated by subtracting fishing mortality from total mortality. Sometimes there is no available estimate of fishing mortality for a stock. However, fishery biologists may have a good idea of what the natural mortality might be from studying other similar stocks. In this case, natural mortalities (or a range of possible natural mortalities) can be subtracted from total mortality to get fishing mortality (or a range of possible fishing mortalities).

Spawning Potential Ratio

SPR

Most recent fishery management plans attempt to define a rate of fishing mortality which, when added to the natural mortality, will lead to the rebuilding of a stock or the maintenance of a stock at some agreed upon level. The level being used in many management plans is based on the spawning potential ratio (SPR). The spawning potential ratio incorporates the principle that enough fish have to survive to spawn and replenish the stock at a sustainable level.

Spawning potential ratio is the number of eggs that could be produced by an average recruit over its lifetime when the stock is *fished* divided by the number of eggs that could be produced by an average recruit over its lifetime when the stock is *unfished*. In other words, SPR compares the spawning ability of a stock in the fished condition to the stock's spawning ability in the unfished condition.

SPR example

As an example, imagine that 10 fish survive the first couple of years of life and are now large enough to get caught (recruited) in the fishery. Four are caught before they spawn (no eggs produced), three others are caught after they spawn once (some eggs produced), and the last three live to spawn three times (many eggs produced) before dying of old age. During their lifetime, the 10 fish produced 1 million eggs and the average recruit produced 100,000 eggs (1 million divided by 10).

In the unfished population, 10 fish survive as before. Three die from natural causes after spawning (some eggs produced) and the other seven spawn three times (very many eggs produced) before dying of old age. During their lifetime, these 10 fish produced 5 million eggs and the average recruit produced 500,000 eggs (5 million divided by 10).

The spawning potential ratio is then the 100,000 eggs produced by the *average fished* recruit divided by the 500,00 eggs produced by the *average unfished* recruit and is equal to 0.20 or 20 percent.

SPR can also be calculated using the biomass (weight) of the entire adult stock, the biomass of mature females in the stock, or the biomass of the eggs they produce. These measures are called spawning stock biomass (SSB) and when they are put on a per-recruit basis they are called spawning stock biomass per recruit (SSBR).

SSB

SSBR

In the above example, the weight of fish that contributes to spawning could be substituted for eggs produced to get the SSBR for the fished stock. SSBR (fished) divided by SSBR (unfished) gives the SPR.

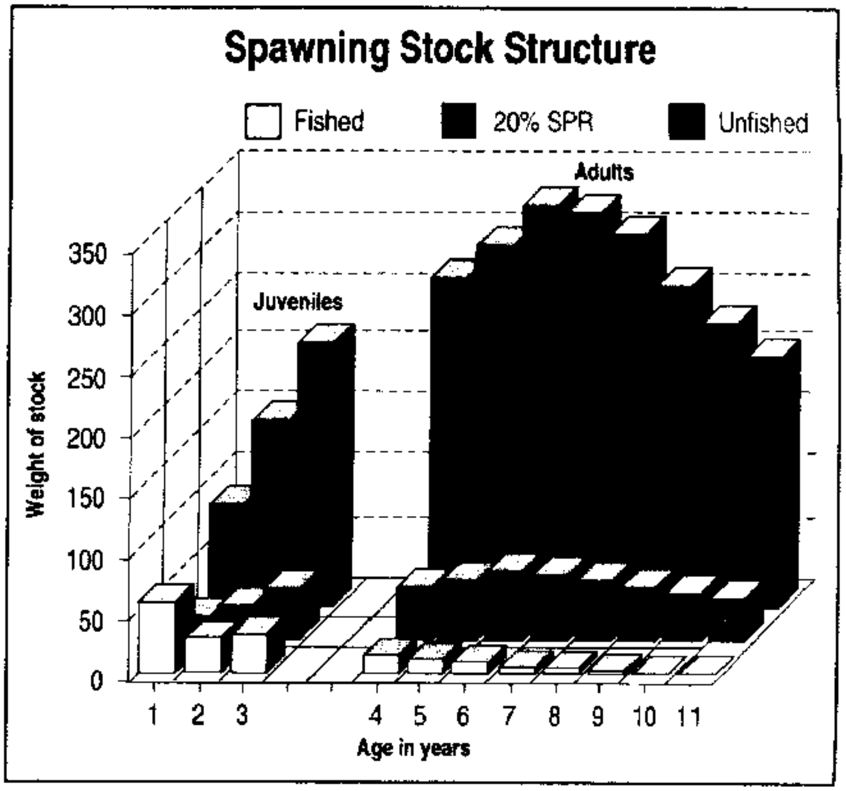


Figure 5

The concept of spawning stock biomass is illustrated in Figure 5. The graph shows the weight (biomass) of a stock at each age in the unfished condition compared to the weight of the stock when SPR = 20%. The adult fish in this stock spawn at age four so only the weight of fish four years and older contribute to the spawning stock biomass.

In a perfect world, fishery biologists would know what the appropriate SPR should be for every harvested stock based on the biology of that stock. Generally, not enough is known about managed stocks to be so precise. However, studies show that some stocks (depending on the species of fish) can maintain themselves if the spawning stock biomass per recruit can be kept at 20 to 35% (or more) of what it was in the unfished stock. Lower values of SPR may lead to severe stock declines.

What should SPR be?

Summary of Mortality and SPR

Fish die from either natural mortality or fishing mortality. Fishing and natural mortality added together equal total mortality. Total mortality can be estimated from age structure graphs. If either fishing or natural mortality can be estimated, then the remaining unknown mortality can be determined by subtraction from total mortality. Once fishing mortality and natural mortality are known, they can be used to examine the effects of fishing on the stock.

One way of looking at the effect of fishing mortality is to compare the spawning biomass of the fished stock to what it would be without fishing. The ratio of the fished spawning biomass to the unfished spawning biomass is called the spawning potential ratio (SPR). If the SPR is below the level considered necessary to sustain the stock, then fishing mortality needs to be reduced.

Virtual Population Analysis (VPA)

Year class

At times, fishery biologists have more information available than is provided by the snapshot of the age structure. Sometimes the number of fish caught from a single year class is known for each year that the year class is fished. Year class refers to the group of fish born in the same year. Using the number caught each year from a year class and the mortality rate, the size of the year class can be reconstructed. For example, if the fish born in 1988 (1988 year class) were first harvested in 1990 and 1,000 fish from the year class were caught during the first year, 900 fish the second year, 800 fish the third year, 700 fish the fourth year, and 600 fish the fifth year (1994), then there had to be at least 4,000 fish alive (1,000+900+800+700+600) in the year class when fishing started in 1990.

If the natural and fishing mortality rates are known or can be estimated, then the number of fish in the year class that should have been alive to produce the catch of fish can be calculated. If 600 fish were caught in 1994, there had to be more than 600 fish alive at the end of 1993, because some would have died of natural causes during 1994 and it is unlikely that fishermen would catch all the fish in that year class (fishing mortality of 100%). For the purpose of illustration, assume that natural mortality equaled 20% and fishing mortality also equaled 20% (remember that these should be converted into instantaneous rates to be mathematically correct). Since a 20% fishing mortality removed 600 fish from the stock, then a 20% natural mortality would remove an equal number of fish (600) from the stock. This means at least 1200 fish were alive at the end of 1993. However, only some of the fish that were alive were caught or died, so there must have been more than 1200 fish alive. Dividing 1200 fish alive by the total mortality rate (20% + 20% = 40%) (1200/0.4) gives 3,000 fish alive at the end of 1993. This process can be continued backward until the total number of fish in the 1988 year class is estimated. The reconstructed year class can then be tested with different rates of fishing mortality to see what the affects might be, or the information can be used in other calculations such as determining the spawning stock biomass.

Other Kinds of Overfishing

So far we have emphasized overfishing that leads to declining stocks. This is often referred to as recruitment overfishing. The name indicates that the mortality rate from fishing is severe enough to affect future recruitment to the extent that catches are reduced and the stock is jeopardized.

Growth overfishing

Another type of overfishing is called growth overfishing. Growth overfishing occurs when the bulk of the harvest is made up of small fish that could have been significantly larger if they survived to an older age. The concern here is that the fishery would produce more weight if the fish were harvested at a larger size. The question biologists must answer is how much bigger or older should the fish get before they are harvested.

Recall the length-at-age graph (Figure 1). The graph is typical of how most fish grow rapidly the first few years and grow more slowly in later years. One approach to getting the most out of a stock of fish would be to harvest them near the point where the growth rate begins to level off. But this approach is too simple because if you recall from our age structure graph (Figure 2), all the time fish are growing their numbers are going down due to mortality.

There are two opposing forces at work in a stock of fish. Growth increases the weight of fish while mortality reduces the number of fish. These forces can be illustrated by following a year class (all fish hatched the same year) as they grow and die over a number of years. Instead of graphing the numbers of fish at each age as before, it is necessary to graph the total weight of the year class.

Year class

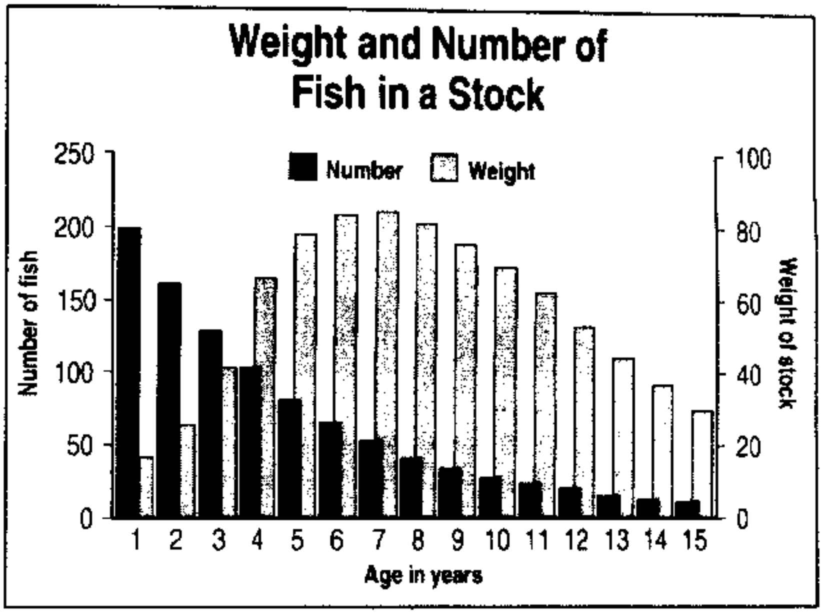


Figure 6

As shown in Figure 6, the weight of the year class is greatest when the fish are 6 to 7 years old. In later years, the death rate overcomes the growth rate and the weight of the stock declines. The point is that even though there are more fish to be harvested at a younger age, there is more weight of fish to be harvested at a later age. The shape of the curve in Figure 6 is determined by the growth rate and the mortality rate. Different rates of harvest (fishing mortality) will give different curves. Using computers, fishery biologists can generate a great number of these curves to make a composite graph called a yield diagram. These diagrams show the harvest (also called yield) that can be expected from different combinations of harvest rates and the age of the fish when they are first captured. As with spawning stock biomass, biologists often like to put the calculations on a per-recruit basis and so the graphs are often called yield-per-recruit-diagrams.

Yield-per-recruit

Another type of overfishing occurs when fishermen catch fish before they reach their maximum price per pound. The idea here is that the catch will have a higher value if the harvest is delayed when there is a premium paid for larger size fish. For example, 50 pounds of 20-to-the-pound shrimp are worth considerably more than 100 pounds of 70-to-the-pound shrimp. As with growth overfishing, the point of maximum value of the stock may be determined. Beyond that point, individual large shrimp may be more valuable but there won't be enough left to equal the value of catches of the more abundant but less valuable smaller shrimp.

Getting more dollars for the catch

Summary of Other Kinds of Overfishing

Management aimed at growth overfishing has more to do with getting the most benefit out of a stock than ensuring the renewability of the stock. This is a legitimate goal for fishery management as long as recruitment overfishing is not a problem.

INDICES

Fishery biologists sometimes employ an index to help assess the general state of a stock. The index is usually an indirect measure of the stock taken the same way at the same time over many years. The index can be compared to the catch in the fishery or other data to see if there is a relationship between the index and the health of the fishery.

Striped bass index

One of the better known fishery indices (plural of index) is the juvenile striped bass index. Since the 1950s biologists have sampled streams surrounding Chesapeake Bay where striped bass spawn and have counted the number of recently hatched fish caught with standardized methods. The index closely follows the decline in the striped bass fishery with a three-year lag (striped bass do not appear in the fishery until they are three years old). An increase in the index is assumed to indicate improvements in the stock.

Red snapper index

A similar index is being used for red snapper in the Gulf of Mexico. In this case, the catch of juvenile red snapper from yearly research cruises designed to sample a variety of fish (instead of a single species) is being used.

Other indices use number of eggs, number of larval fish, or actual counts of fish through aerial, underwater, or acoustic (fish finder) surveys.

When an index is based on the early life history of a fish, it must be remembered that many things can happen to the fish before they are large enough to harvest. Despite some drawbacks, indices are usually easy to understand and can be useful indicators of changes in a fish stock.

Summary of Indices

An index is an indirect (and usually simple) measure of the health of a stock. The measure must be related to other information on the stock to be meaningful.

BYCATCH

Bycatch is all of the animals that are caught but not used. Almost all commercial and recreational fisheries have an associated bycatch. When the bycatch includes endangered species or protected mammals, then regulations are made to reduce or eliminate the bycatch as required by the Endangered Species Act or the Marine Mammal Protection Act.

Bycatch of other valuable species

When the bycatch includes species that are targeted by other fishermen, the bycatch may be included in the overall quota for that species. In this case the bycatch is simply a part of the total allowable catch for that species.

Bycatch of undersized fish

A more difficult problem with bycatch occurs when the bycatch contains undersized fish of desirable species. The undersized fish may be of the same species that the fishermen are targeting but have no economic value at the smaller size. Alternatively, the undersized fish can be the target species for other fisheries when they reach a harvestable size. In these cases, the effects of the bycatch on the stocks are often unknown. However, it is generally accepted that catching large amounts of a stock before it is old enough to spawn or before it has economic value is wasteful and possibly harmful to the stock. Fishery managers try to account for bycatch in their stock assessment because bycatch may be an important cause of mortality.

Bycatch and the Food Chain

The bycatch of species that have no current economic value may present problems that traditionally have not been addressed by fishery managers.

Bycatch of fish with no economic value

The principles of community ecology tell us that each species has a role in the community. Consequently, the removal of an important food item (prey species) through bycatch could adversely affect another species (predator) that eats that item. However, predators often eat a variety of food items. Reduction in the numbers of a single prey species may lead to an increase in another prey species that the predator will readily consume. As we move down the food chain (big fish eat little fish, which eat smaller fish, etc.), the link between prey species in the bycatch and an important predator species gets weaker and the relations less clear.

Predator-prey relations

Food chain

How can a fishery biologist take all of this into account? Understanding all the relations among predators and prey species may be impossible. However, it is generally thought that less bycatch, rather than more bycatch, is probably more desirable for maintaining a balance among the various species in a community. But just as surplus production provides an allowable catch for targeted species, there can be an allowable catch for species of no economic value found in bycatch.

Allowable bycatch?

Allocation

When the harvest of a stock is restricted by management, the different groups of fishermen that use that stock often find themselves in conflict. The conflict occurs because each user group realizes it could harvest more fish if the other group didn't exist or if the other group was restricted even further. These disagreements occur among different kinds of commercial fishermen or between commercial and recreational fishermen.

Conflicts over harvest

The decision as to how much fish each group gets to harvest is called allocation. From a strictly biological viewpoint, there is no fair or unfair allocation. It does not make any difference to the stock who catches the fish as long as the total allowable catch is not exceeded.

Allocation is a political, social, and economic decision usually made by elected or appointed officials. In an attempt to be fair, allocation decisions are often made on the basis of historical catches. If Group A normally caught 60 percent of the landings and Group B 40 percent, then the fish are usually allocated on that basis. Disputes often arise over the accuracy of historical records, particularly when poorly documented fisheries are involved.

Allocation decisions

The determination of total allowable catch and the allocation decisions have not always been separated as described above. However, there is a movement to keep them as separate as possible. With this in mind, fishery biologists determine the total allowable catch based on the scientific information available. Then the fishery management councils (combination of managers and appointees) make the allocation decisions in federal fishery management. Similar boards or commissions are often responsible at the state level.

In theory, the biological decision would not be modified by other considerations, but the regulations and allocations to achieve the target catch would be.

Summary of Allocation

When a fish stock cannot support the unregulated harvest by more than one group of fishermen, it becomes necessary to allocate the catch among the groups. This is not a biological decision but a political, social, and economic decision often based on the historical landings for each group.

Endangered Species and Fisheries Management

The Endangered Species Act passed by Congress in 1973 and the Magnuson Fishery Conservation and Management Act have little in common, yet they are associated in some people's minds. The Endangered Species Act requires all government agencies and private entities to consider whether or not their actions will affect species that are officially listed as "in danger of extinction." The Act prohibits "taking" of listed species, where taking is defined to include almost any activity that will harm the species' chances of survival. For some endangered species, the geographical area necessary for the species to survive is designated "critical habitat" and given special protection.

Misuse of "endangered"

Confusion sometimes occurs when fishing is restricted to rebuild stocks. Harvested fish and shellfish have rarely appeared on the endangered species list (with the exception of several species of salmon). However, in discussing catch quotas or closed seasons, we often hear the media or others making statements such as, "Fishing for red snapper was banned today to protect the endangered fish." Because the word endangered is so closely allied with endangered species, this statement brings to mind images of red snapper becoming extinct if fishing is not halted. What has really happened is that fishermen have harvested their quota (total allowable catch) for the year, and if the management plan is working, they will be able to harvest a similar or possibly larger quota the next year.

Fishermen, however, can be strongly affected by the Endangered Species Act. The prohibition of "taking" makes even the incidental catch of a single individual of an endangered species a federal offense.

Summary of Endangered Species

Fishery management and endangered species regulations are made with separate goals in mind. Fishery management rules are meant to allow the continuing harvest of renewable species. The rules for endangered species attempt to prevent extinction of designated species and to ensure their recovery for long-term survival.

Summing Up Part One

State and federal agencies act as trustees for public resources such as fish. Fishery biologists assess the health of fishery stocks by reviewing available data or conducting new studies. Catch-per-unit effort, indices, age structure, growth rate and death rate are all important elements of stock assessment. The stock assessment naturally leads to recommendations for conserving or rebuilding a stock.

Part 2: The Regulatory Process

Introduction

Part 1 emphasized fishery biology and assessment. Part 2 concentrates on the federal process that follows fishery assessment and leads to fishery management regulations. Not only is this process open to the public, the public is encouraged to participate. Fishermen who understand how regulations are made, and where to go for further information, can become effective participants in this process. Most states also provide opportunities for public comment on state fishery regulations and legislation. Fishermen should be involved at all stages of federal and state management, and not just when they hear that a new regulation is about to take effect. This means helping with data collection, reading fishery management plans, serving on panels and committees, suggesting solutions to management problems, writing letters, commenting at public hearings and attending management meetings. This may be more than most fishermen want to do. The alternative is to leave the management decisions up to someone else.

The Magnuson Act

The Magnuson Fishery Conservation and Management Act (Magnuson Act) empowered the federal government to regulate fishing from three miles off shore (nine miles off the Florida Gulf Coast and off Texas) out to 200 miles. This area is sometimes referred to as federal waters or the Exclusive Economic Zone (EEZ). One of the main purposes of the Act (besides conserving stocks) was to eliminate foreign fishing while developing the U.S. fishing industry.

Federal waters and the EEZ

The Magnuson Act created eight regional fishery management councils that are overseen by the Secretary of Commerce. Each council develops fishery management plans (FMPs) for the stocks in their geographical region. The addresses and phone numbers of each management council are listed in Appendix 4.

Fishery management councils Appendix 4

Who is on the Fisheries Management Councils?

Each council is made up of representatives from the states that are in a council's region as well as several federal representatives. Council members who vote include:

Voting members

1. Each state's director of marine fisheries or equivalent.
2. A person knowledgeable or experienced in recreational or commercial fishing, or marine conservation, from each state who is nominated by the governor and selected from a list of at least three such people by the Secretary of Commerce.
3. At-large members from any of the states in the region and who are selected by the same process as above.
4. The regional director of the National Marine Fisheries Service for the area covered by the council. National Marine Fisheries Service regions do not

Regional offices Appendix 5

coincide with council regions. For example, the Southeast Regional Office of NMFS covers the South Atlantic Council, the Gulf of Mexico Council, and the Carribean Council. Addresses and phone numbers of the NMFS regional offices are in Appendix 5.

Non-voting members

Non-voting members participating in each council include:

1. A regional U.S. Fish and Wildlife Service representative.
2. The Commander of the local Coast Guard district that covers the area.
3. A representative of the Interstate Marine Fisheries Commission for the area (see page 28 for more information).
4. A representative of the U.S. Department of State.

Other Parts of the Council

Council staff

FMP = Fishery Management Plan

Each council has a full-time executive director and a staff to assist in writing FMPs, coordinate council meetings and conduct public hearings. If you call one of the council phone numbers you will talk to someone on the council staff, not a voting member of the council.Council staff will provide the names and phone numbers of voting and non-voting council members as well as answer questions about FMPs.

Scientific Committee & Advisory Panel

Councils also have a Scientific and Statistical Committee and Advisory Panels to help formulate FMPs. The Scientific and Statistical Committee is usually made up of university and government (state and federal) professionals knowledgeable in technical areas such as statistics, fishery biology, economics, sociology, etc. Advisory Panels consist of people knowledgeable in commercial and recreational fisheries or who represent other interests.

Creating a Fishery Management Plan

Most stocks of fish that are managed by the councils already have a FMP in place. The procedure used in developing a plan is outlined in Figure 7. Information from fishery assessment enters the process in steps 1 and 2. The public is involved from the beginning through appointed council representatives, the council advisory panels, and through hearings and written comments.

Fishery management plans contain a great deal of information on the biology of the stock (or stocks) as well as the fishery (landings, gear, fishing grounds, processing, markets, etc). A plan identifies problems in a fishery and proposes management measures in the form of fishing regulations that will correct the problems.

All FMPs must comply with seven national standards specified in the Magnuson Act:

Seven national standards

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield for each fishery.
2. Conservation and management measures shall be based on the best scientific information available.
3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

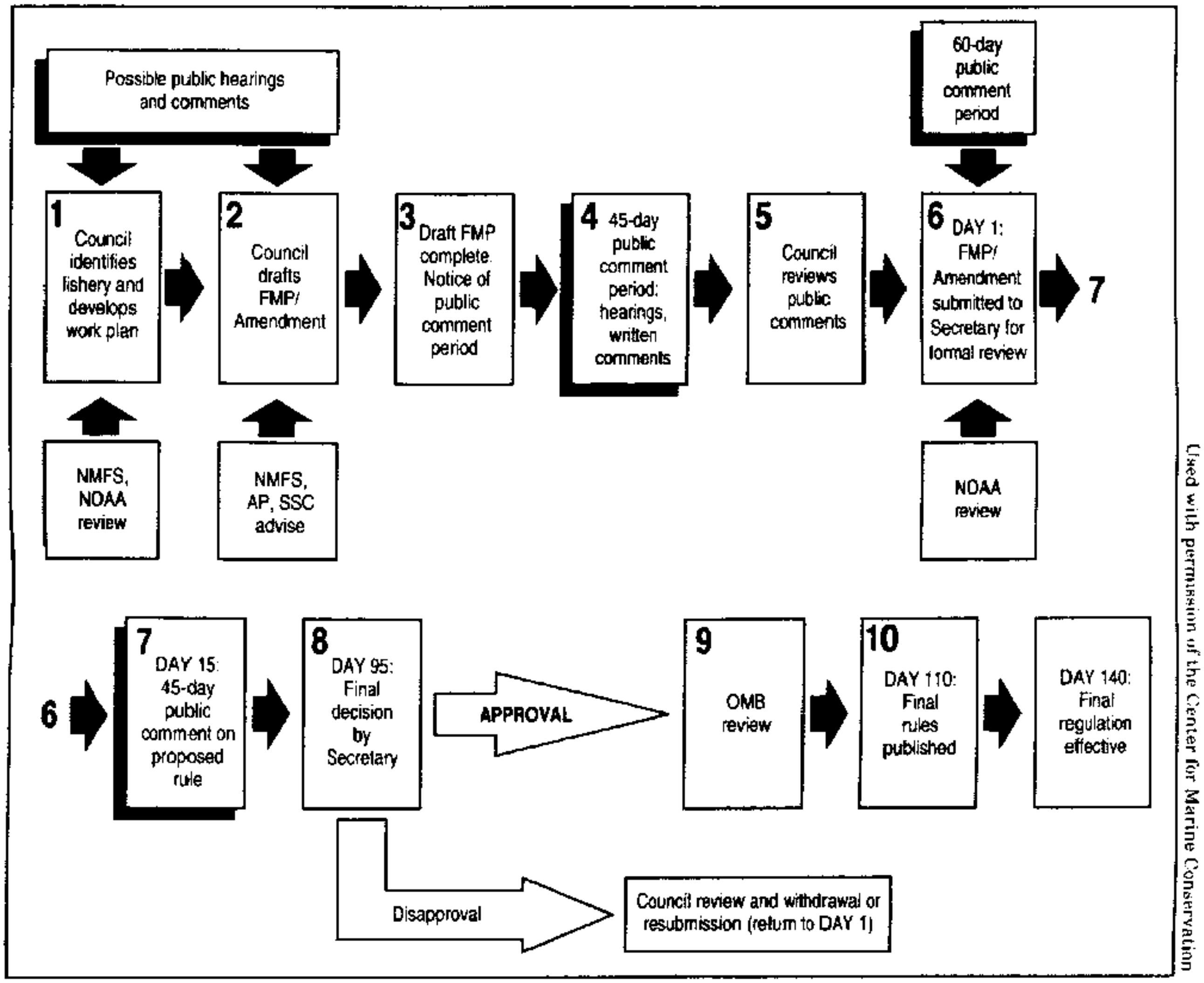


Figure 7

4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (a) fair and equitable to all fishermen; (b) reasonably calculated to promote conservation; and, (c) carried out in such a manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. Conservation and management measures shall, where practicable, promote efficiency and the utilization of fishery resources, except that no such measures shall have economic allocation as their sole purpose.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fishery resources and catches.
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

Overfishing

The first standard (prevent overfishing while achieving optimum yield) is the heart of any FMP. The plan must define overfishing, outline actions to prevent overfishing and, when overfishing already exists, must recommend actions to rebuild the stocks in a specified period of time.

Overfishing may be defined in a number of ways, but it must be **measurable**. Exceeding a certain level of fishing mortality (see pages 11 to 12) or allowing the spawning potential ratio to fall below a specified level (see pages 12 to 13) are two measurable definitions.

Optimum yield

The first national standard also uses the term optimum yield. **Optimum yield** means the amount of fish which will provide the greatest overall benefit to the nation with particular reference to food production and recreational opportunities. Optimum yield is based on the maximum amount of fish that can be harvested safely, but is modified by economic, social, and ecological factors. Food production includes the goals of providing seafood to consumers and maintaining a fishing industry. Recreational opportunities include the importance of the recreational fishing experience and the contribution of recreational fishing to the economy and food supply.

Modifying Plans

Plan amendments

Since most stocks in the Southeast already have a FMP, much of the current council activity involves amending plans. Any FMP can be amended using the same procedure for creating a fishery management plan. While a new FMP is not needed, an amendment must contain any new information that was used to justify the amendment.

Is There a Time Bomb in Your Plan?

Many fishermen are not very familiar with the details of the FMP and amendments that regulate their particular fishery. While they are usually very familiar with the regulations in the plan that are currently being enforced, they may not be aware of plan regulations that can go into effect without new amendments, public hearing, etc.

Monitoring a fishery

Framework for management

Notice actions

This may seem unfair, but consider this. As the councils have gained experience with writing FMPs and managing stocks, they have learned that conditions in a stock and its fishery can change, sometimes rapidly. Furthermore, once an FMP is in place, NMFS and the council are required to monitor the stock to see whether the goals of the plan are being met and to make changes as necessary. Formal amendments are time consuming and may not get through the process in a timely manner. As a result, FMPs usually include a framework for management. This framework may contain language that says something like this: If fishing mortality exceeds some amount then the council will close the season, lower the bag limit, etc. In other words, the council does not have to pass an amendment to implement a regulation if the FMP already specifies reasons for the actions that the council can take. These are called "notice actions" and the councils must notify fishermen through NMFS of the action taken after approval by the National Oceanographic and Atmospheric Administration (NOAA).

Other Ways to Change or Make a Plan

Regulatory amendment

If for some reason the management framework does not cover a problem in the fishery but a regulatory change is needed, the council has two options. One is to pass a regulatory amendment. This is different from a full amendment but still requires some opportunity for public input, and the amendment must be approved by the regional director of NMFS.

Emergency action

The second method is called an emergency action. If the council determines that an emergency situation exists by majority vote, it forwards the decision to the regional director of NMFS where it is reviewed and sent to the Secretary of Commerce. Upon approval and publication in the *Federal Register*, the proposed rule becomes regulation. Emergency regulations are only good for ninety days but can be extended for an additional 90 days. Emergency regulations are usually followed by the amendment procedure to make the change more permanent after public input.

Secretarial plans

The Secretary of Commerce is ultimately responsible for federal fishery management programs. Therefore, the Secretary of Commerce is also authorized to write fishery management plans. Circumstances that call for a secretarial plan are management of highly migratory species or when regional councils fail or are unable to act on a fishery problem in a timely manner.

Council and Plan Details

If you are interested in the details of council membership and the rules that govern the councils, the information can be found in the *Federal Register,* Volume 54 Number 10, pages 1700 to 1720 under the title "Style guide, regional fishery management councils, other applicable law, guidelines for council operations and administration". Similarly, the rules for making fishery management plans are found in the *Federal Register* Volume 54 Number 140, pages 3711 to 3880 under the title "Guidelines for fishery management plans: final rules." Rules for fishery management plans are commonly called the 602 guidelines. These are the guidelines that require a fishery management plan to define overfishing, to specify measures to prevent overfishing, and to establish a program for rebuilding a stock if overfishing already exists.

602 Guidelines

Both documents can be obtained from the fishery management councils or can be read at major libraries.

Summary of the Magnuson Act

The Magnuson Act created eight regional fishery management councils, which with NMFS and the Secretary of Commerce, are responsible for managing fisheries in federal waters. The councils are made up of fishery managers and citizens with fishery interests. Each council develops fishery management plans (FMPs) which include stock assessment information and recommendations for management. The FMPs must define overfishing and must spell out the steps to prevent or correct overfishing. Public input is sought throughout the development of a plan. Plans are approved, implemented, and enforced by the Secretary of Commerce acting through the National Marine Fisheries Service. Councils are required to monitor a fishery after the plan is in place. Changes in the fishery may require amendments to the plan. Management plans may contain a framework for management that describes in advance additional regulatory action that can be taken if the stocks fall below a certain level or fail to reach an agreed upon level.

What Can a Fisherman Do?

The technicalities of fishery assessment and the regulatory process may seem overwhelming. However, there are a few simple steps fishermen can take to begin getting involved.

1. Call the council that is responsible for your region (See Appendix 3).
2. Ask for a copy of the fishery management plan (including amendments) that regulates your fishery.
3. Ask to be put on the mailing list for notices of public hearings, copies of amendments or new fishery management plans.
4. Ask for the name and telephone number of your state's representatives on the council. Also find out who is on the advisory panel that might represent your interests.
5. Read over the fishery management plan.
6. Call your state's representatives on the council. Ask questions. Express your concerns.
7. Contact advisory panel members and find out what their views are.
8. Attend public hearings on specific proposals and make comments or submit written comments and talk with your representative.
9. Continue to keep in touch with the council.
10. Attend council meetings, at least when they are in your area.

A Word of Advice

The council staff, the director of marine fisheries from your state, your state representatives, and the advisory panel members are human beings just like you, not faceless bureaucrats. They will respect your questions and your interest in management if you treat them with common courtesy. Mutual respect can lead to mutual understanding and the possibility of cooperative management.

Enforcement

When a fishery management plan, amendment, regulatory amendment, notice action, or emergency action has gone through the regulatory process and is published in the *Federal Register,* the management measures become federal regulations. These regulations and other NOAA laws are enforced by National Marine Fisheries Service law enforcement agents, the U.S. Coast Guard, cooperating state officers, and other federal agents.

Violations are subject to civil sanctions that include:

- Written warnings.
- Fines issued by Notices of Violation and Assessment (NOVA).
- Forfeiture of seized property including catch, vessels, and equipment.
- Permit sanctions.

Some violations, including but not limited to resisting arrest and interfering with an officer, are subject to criminal sanctions as well as civil sanctions. Criminal sanctions may include fines and/or jail.

Written warnings

Written warnings may be issued by anyone authorized to enforce the laws and regulations that NOAA administers, as well as by the NOAA Office of General Counsel. A written warning will:

1. State that it is a written warning.
2. State the factual and legal basis for its issuance.
3. Advise the fisherman of its effect in the event of a future violation.
4. Inform the fisherman of the right of review and appeal.

Summary settlement

A summary settlement ticket, in which a discounted fine is stated, may be offered to a fisherman in some cases prior to issuance of a NOVA. If the violation is not contested, a fisherman may choose to pay this penalty to swiftly resolve the case without incurring the expense of the legal process. The fisherman forfeits his or her interest in any property that was seized by paying the penalty. If a fisherman chooses not to resolve the case in this fashion, the case will be forwarded to NOAA's Office of General Counsel for issuance of a NOVA.

NOVA

NOVAs are issued by NOAA's Office of General Counsel. A NOVA will contain:

1. A concise statement of the facts believed to show a violation.
2. A specific reference to the provisions of the Act, regulation, license, permit, agreement, or order allegedly violated.
3. The findings and conclusions upon which NOAA bases the assessment.
4. The amount of civil penalty assessed.

The NOVA will also advise fishermen of their rights upon receipt of the NOVA. The fisherman has 30 days from the receipt of the NOVA in which to respond by doing one of the following:

1. Accept the penalty or compromise penalty, if any, by taking the actions specified in the NOVA.
2. Seek to have the NOVA amended, modified, or repealed.
3. Request, in writing, a hearing.
4. Request an extension of time to respond.
5. Take no action, in which case the NOVA becomes final.

Consequences of the failure to pay a penalty that has become final for any reason may include:

1. Denying or revoking fishing permits.
2. Creating a maritime lien against the vessel used in the violation.
3. Filing a collection action in federal district court.
4. Asserting the maritime lien (resulting in seizure and sale of the vessel to pay the penalties assessed, plus interest, non-payment penalty, and an administrative fee).
5. Reporting the debt to the Internal Revenue Service (IRS) for tax offset.
6. Reporting the debt as income to the IRS.

Seizure and forfeiture

Enforcers of the various statutes and regulations administered by NOAA have the authority to seize property, which may include but is not limited to the catch, fishing equipment, and the entire vessel. Property may be seized and held as evidence, and, depending on the law, may be subject to forfeiture to the United States. NOAA's Office of General Counsel issues notices of proposed forfeiture, which:

1. Describe the seized property.
2. State the time, place and reason for the seizure.
3. Describe the rights of an interested person to file a claim to the property.

Fishing permit sanctions

NOAA may also sanction or deny a fishing permit for:

1. The commission of any offense prohibited by any law administered by NOAA (including violations of any regulations, permit conditions, or restrictions) by the permit holder or with the use of a permitted vessel.
2. The failure to pay an assessed civil penalty.
3. The failure to pay a criminal fine imposed or to satisfy any other liability incurred in a judicial proceeding under any of the statutes administered by NOAA.

NOAA's Office of General Counsel issues notices of permit sanctions and notices of intent to deny permits. Both notices set forth the basis for the action and any opportunity for a hearing.

Summary

Management measures in fishery management plans become federal regulations after being published in the *Federal Register*. Violators are subject to civil fines, forfeitures, loss of fishing permit privileges, or criminal penalties

Limited Entry (Controlled Access)

Most U.S. fisheries have always been open-entry or open-access fisheries. Anyone who could afford a boat and the equipment could pursue a living by fishing. The better fishermen caught more fish, made more money, and stayed in the fishery. Less fortunate fishermen came and went. However, the long-term trend in many fisheries has been for more fishermen to enter a fishery than the resource can support. This becomes painfully obvious when fishery biologists determine that the total allowable catch is a lot less than the boats in the fishery are capable of catching.

Not enough fish for everyone

When no boats leave the fishery and everyone fishes as hard as they always have, there are two certain consequences. First, on the average, there will be less fish available per boat. Second, the total allowable catch (quota) will probably be reached in a relatively short time since all the fishermen will be trying to catch as much as they can, as quickly as possible, before the quota is reached. This is known as "derby fishing," which often creates a temporary market glut and lowers prices for the fishermen while creating longer term supply problems for the buyers. The extent of these problems is reduced when the number of fishermen is more in line with the amount of fish available for harvest.

"Derby fishing"

Stock rebuilding

A third problem arises when a fishery has had severe cutbacks in the total allowable catch in order to rebuild the stocks. During the rebuilding period, some fishermen will leave the fishery while others will stick with it and somehow survive the low quotas. If the management scheme is successful, the quota may be raised as the stocks recover. Fishermen who have stuck with the fishery are now ready to harvest the results of their sacrifices. However, in an open access fishery, anyone can join the fishery and reap the benefits. More fish will be caught under the new quota, but the amount per fisherman may not increase due to new or former fishermen entering the fishery as the stocks improve.

An obvious solution would be to limit the entry of fishermen to a fishery. This goes against the grain of the long-standing tradition of open fisheries, yet it is being discussed and implemented in many commercial fisheries both in the United States and around the world.

It should be noted that limited entry has less to do with fishery biology, and more to do with trying to give fishermen the opportunity to earn a living in the face of limited stocks. Limited entry cannot guarantee that fishermen will become wealthy or that all fishermen will be treated fairly.

Kinds of limited entry

There are many forms of limited entry but two basic systems are getting the most attention. These two systems are license limitations and individual transferable quotas (ITQs).

License Limitations

Who gets what?

License limitations would seem to be a straightforward, simple way to limit entry to a fishery. Just decide how much fish can be caught (total allowable catch) and divide it by the amount of fish that would provide an average fisherman with a reasonable living. The result is the number of fishermen that the fishery can sustain and the number of licenses that should be allowed. Unfortunately, most if not all regulated fisheries already have too many fishermen, so someone has to make certain decisions. Which fishermen get licenses? What compensation, if any, should fishermen receive if forced to leave? Should new fishermen be allowed to enter when an existing fisherman leaves? Should licenses be bought and sold on a free market, or should the government control licenses? There are many ways to address these questions, but it usually comes down to perceptions of fairness. Some fishermen may feel that they have been treated unfairly when licenses are limited.

ITQs

Individual transferable quota systems give each fisherman a share of the total allowable catch. Since the total allowable catch can change from year to year, the ITQ is usually a percentage of the total allowable catch. Most ITQ systems include regulations that allow for buying, selling, or leasing the ITQs. Fishermen can increase their share of the catch by buying or leasing ITQs from other fishermen, while fishermen who want to leave the fishery can receive some compensation if there are willing buyers.

As with license limitations, the major issue with ITQs is fairness. Someone must decide who gets the ITQs and how much of the total allowable catch each fisherman will be allowed. Because ITQs have a value, disputes arise about initial allocations and the potential windfall profits that initial shareholders may receive when they sell their ITQs.

Controlling the catch

One important aspect of an ITQ system is specifying how much of the total catch any one individual or corporation can control. Current catch ITQ programs allow as little as 0.5% or as much as 20% of the total allowable catch to be held by one entity.

Fishermen Involvement

When a limited entry system is proposed for a fishery, there may be many good reasons offered for why such a system should be adopted. The problems are in the details of who gets what rights, how the system will be enforced and what it means to you as a fisherman. Fishermen obviously need to become involved in the process that decides the important specifics of a plan. Any plan for limited entry will be subject to a great deal of public debate as fishery managers try to determine the details of what is fair for fishermen.

Proposals for limited entry systems, in most cases, will be addressed as amendments to fishery management plans. Fishermen should be involved from the beginning. This means staying in touch with the council, being aware of new proposals, and letting your representatives know what is good or bad about the system being discussed.

Congress and Fishery Management

Generally speaking, the U.S. Congress does not manage fisheries on a day- to-day or issue-by-issue basis. The regional council system and the National Marine Fisheries Service have been delegated that responsibility. However, Congress can pass legislation at any time that directly regulates fisheries. More commonly, Congress directs fishery management policy through amendments to the Magnuson Act. Additionally, the Act must be periodically reauthorized. The reauthorization process allows for an in-depth review of how well the Act is working and how it can be improved. Hearings are held and Congress debates the merits of many competing interests. Reauthorization provides a good opportunity for fishermen to make their views on federal fisheries management known to their elected representatives.

Interstate Fishery Commissions

There are three regional interstate fishery commissions established by federal law, the Atlantic States Marine Fisheries Commission, the Gulf States Marine Fisheries Commission, and the Pacific Marine Fisheries Commission (See Appendix 6). These commissions are made up of three representatives from each state in the commission's region. The representatives are the head of the state marine resources agency, a member of the state legislature and a citizen with knowledge of marine fisheries appointed by the governor.

Commissions influence state management

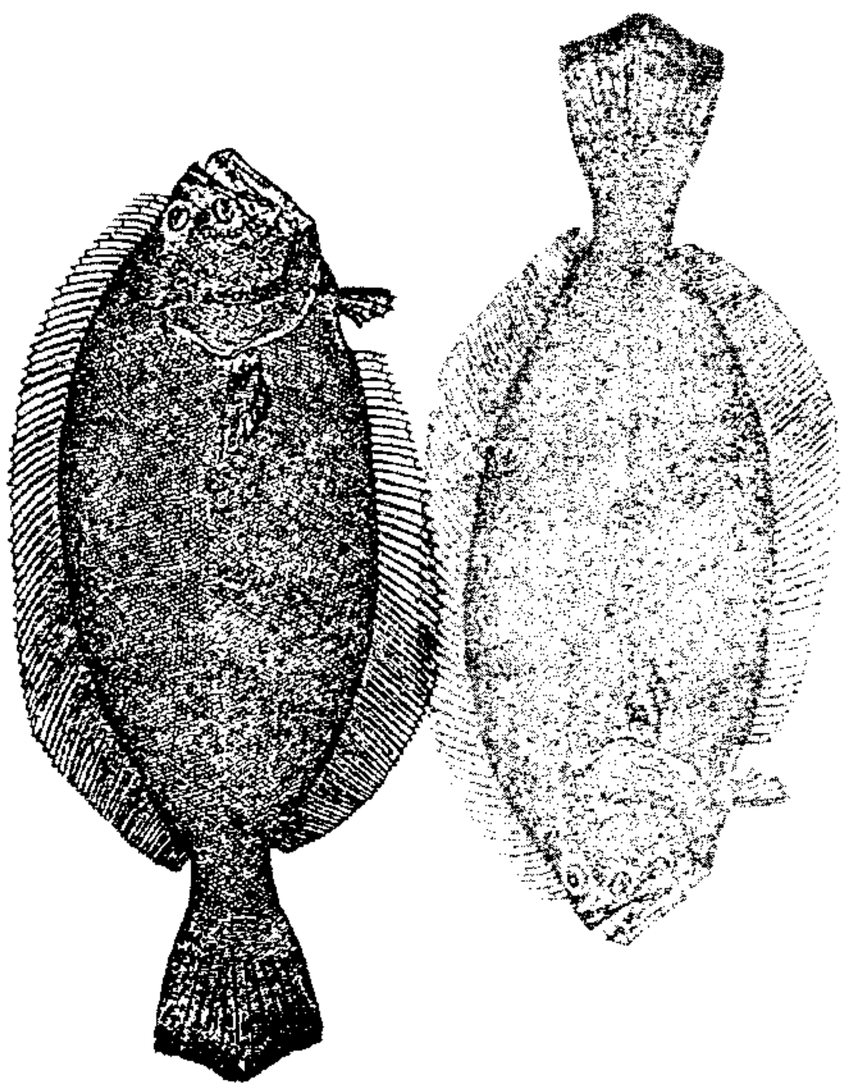
Historically, the commissions have had little power and they functioned primarily to make recommendations for fishery management to the governors and legislatures of their respective states. More recently, the commissions were charged by Congress to promote and encourage management of interjurisdictional marine resources. Interjurisdictional fishery resources are simply fish stocks that cross state and federal boundaries, which means just about all marine fish stocks. This new initiative did not give the commissions any regulatory power but created a stronger process for coordinating regulations among states. This means that regulations proposed at the state level could have originated at one of the interstate fishery commissions.

Atlantic Coastal Fisheries Cooperative Management Act

Passage of the Atlantic Coastal Fisheries Cooperative Management Act in 1993 gave the Atlantic States Marine Fisheries Commission new powers. The commission is required to adopt fishery management plans for coastal fisheries under the Act. The commission then reviews fishery management actions in each state to see if the states are complying with the management measures in the interstate fishery management plans. If a state is not complying with a plan, then the commission must report its findings to the Secretary of Commerce. The secretary can impose a fishing moratorium on a state that is not in compliance until the problem is resolved.

Fishing moratorium

The other two commissions have not been given the same responsibilities, but it seems likely that there will be movement to do so in the future.



Appendix 1: Surplus Production

The concept of surplus production can be illustrated graphically (Figure 1). The straight line 0 to C represents the situation in which the number of offspring increases on a one-to-one basis as the number of adult spawners increases. The arching curved line indicates that as the adult spawners increase the number of offspring increases more rapidly than the number of spawners.

This relation continues until the biomass of spawners begins to approach the carrying capacity of the habitat. This flatter part of the curve (A - C) indicates that additional spawners contribute few new offspring. At point C, the carrying capacity is reached. Spawners and offspring are in balance. Further increases in spawners do not necessarily result in more offspring. The part of the curve to the right of the carrying capacity indicates that the spawning biomass can overshoot the carrying capacity. This results in fewer young surviving and a return toward the carrying capacity.

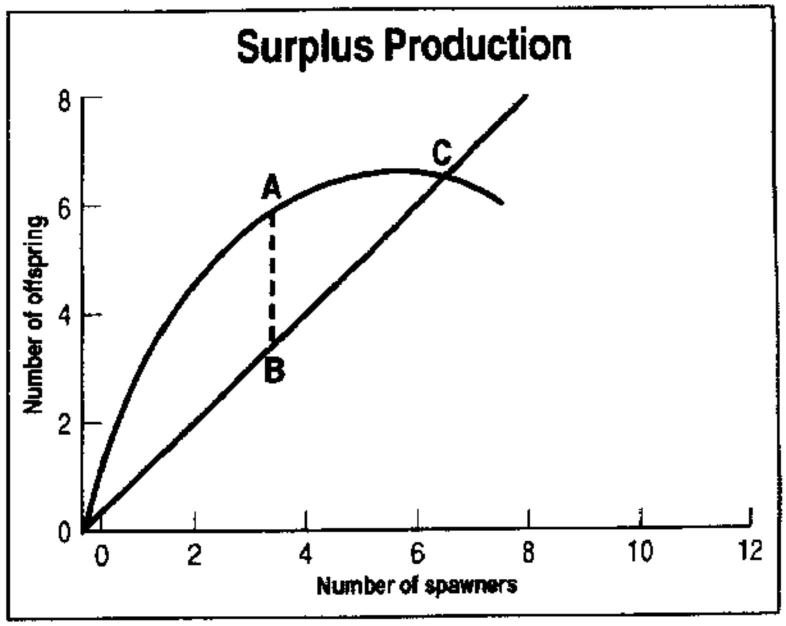


Figure 1

When fishing begins on an unfished population, biomass is close to carrying capacity. As fish are removed (moving to the left along the curve), the population responds by increasing the number of offspring. This increase is represented by the difference between the straight line and the curved line. The greatest increase occurs at point A, the maximum distance (line A-B) between the curve and the 45° straight line. This coincides with the maximum amount of surplus production that might be available from this theoretical population. Removal of more fish by moving to the left of A results in less production. This in itself might not be a disaster if the removal of fish stopped and the population was allowed to rebound (move back to the right along the curve). However, in the real world of fishing, harvesting sometimes continues until both spawners and offspring are removed faster than they can replace themselves.

Appendix 2: Definitions

Defining Fisheries: A User's Glossary

Kenneth J. Roberts, Jerald W. Horst, John E. Roussel, and Joseph A. Shephard
Louisiana Sea Grant College Program
Louisiana State University

A

A - See annual mortality.

ABC - See allowable biological catch.

AP - See advisory panel.

Absolute Abundance - The total number of a kind of fish in the population. This is rarely known, but usually estimated from relative abundance, although other methods may be used.

Abundance - See relative abundance and absolute abundance.

Advisory Panel (AP) - A group of people appointed by a fisheries management agency to review information and give advice. Members are usually not scientists, but most are familiar with the fishing industry or a particular fishery.

Age Frequency or Age Structure - A breakdown of the different age groups of a kind of fish in a population or sample.

Allocation - Distribution of the opportunity to fish among user groups or individuals. The share a user group gets is sometimes based on historic harvest amounts.

Allowable Biological Catch (ABC) - A term used by a management agency which refers to the range of allowable catch for a species or species group. It is set each year by a scientific group created by the management agency. The agency then takes the ABC estimate and sets the annual total allowable catch (TAC).

Anadromous - Fish that migrate from saltwater to fresh water to spawn.

Angler - A person catching fish or shellfish with no intent to sell. This includes people releasing the catch.

Annual Mortality (A) - The percentage of fish dying in one year due to both fishing and natural causes.

Aquaculture - The raising of fish or shellfish under some controls. Ponds, pens, tanks, or other containers may be used. Feed is often used. A hatchery is also aquaculture but the fish are released before harvest size is reached.

Artisanal Fishery - Commercial fishing using traditional or small scale gear and boats.

Availability - Describes whether a certain kind of fish of a certain size can be caught by a type of gear in an area.

B

Bag Limit - The number and/or size of a species that a person can legally take in a day or trip. This may or may not be the same as a possession limit.

Benthic - Refers to animals and fish that live on or in the water bottom.

Billfishes - The family of fish that includes marlins, sailfish and spearfish.

Biomass - The total weight or volume of a species in a given area.

Bony Fishes - Fish that have a bony skeleton and belong to the class Osteichthyes. Basically, this is all fish except for sharks, rays, skates, hagfish and lampreys.

Bycatch - The harvest of fish or shellfish other than the species for which the fishing gear was set. Examples are blue crabs caught in shrimp trawls or sharks caught on a tuna longline. Bycatch is also often called incidental catch. Some bycatch is kept for sale.

C

C/E - See catch per unit of effort.

CPUE - See catch per unit of effort.

Catadromous - Fish that migrate from fresh water to saltwater to spawn.

Catch - The total number or poundage of fish captured from an area over some period of time. This includes fish that are caught but released or discarded instead of being landed. The catch may take place in an area different from where the fish are landed. Note: Catch, harvest, and landings are different terms with different definitions.

Catch Curve - A breakdown of different age groups of fish, showing the decrease in numbers of fish caught as the fish become older and less numerous or less available. Catch curves are often used to estimate total mortality.

Catch Per Unit of Effort (CPUE; C/E) - The number of fish caught by an amount of effort. Typically, effort is a combination of gear type, gear size, and length of time gear is used. Catch per unit of effort is often used as a measurement of relative abundance for a particular fish.

Catch Stream - The catch statistics for a kind or stock of fish over a period of time.

Catchability Coefficient (q) - The part of a stock that is caught by a defined unit of effort.

Charter Boat - A boat available for hire, normally by a group of people for a short period of time. A charter boat is usually hired by anglers.

Coastal Migratory Pelagic Fishes - Several species of fish that live in open waters near the coast, grouped together by the Gulf of Mexico Fishery Management Council and South Atlantic Fishery Management Council for management purposes. This includes king and Spanish mackerel, cobia, dolphin, and little tunny.

Cohort - A group of fish spawned during a given period, usually within a year.

Cohort Analysis - See virtual population analysis.

Commercial Fishery - A term related to the whole process of catching and marketing fish and shellfish for sale. *It refers to and includes fisheries resources, fishermen, and related businesses directly or indirectly involved in harvesting, processing, or sales.

*Added by Wallace et al.

Common Property Resource - A term that indicates a resource owned by the public. It can be fish in public waters, trees on public land, and the air. The government regulates the use of a common property resource to ensure its future benefits.

Compensatory Growth - An increase in growth rate shown by fish when their populations fall below certain levels. This may be caused by less competition for food and living space.

Compensatory Survival - A decrease in the rate of natural mortality (natural deaths) that some fish show when their populations fall below a certain level. This may be caused by less competition for food and living space.

Condition - A mathematical measurement of the degree of plumpness or general health of a fish or group of fish.

Confidence Interval - The probability, based on statistics, that a number will be between an upper and lower limit.

***Controlled Access** - See limited entry.

Council - Indicates a regional fishery management group. The Fishery Conservation and Management Act of 1976 as amended created the regional councils. For example, the Gulf of Mexico Fishery Management Council develops fishery policies designed to manage those species most often found in Gulf federal waters.

Crustacean - A group of freshwater and saltwater animals having no backbone, with jointed legs and a hard shell made of chitin. Includes shrimp, crabs, lobsters, and crayfish.

Cumulative Frequency Distribution - A chart showing the number of animals that fall into certain categories, for example, the number of fish caught that are less than one pound, less that three pounds, and more than three pounds. A cumulative frequency distribution shows the number in a category, plus the number in previous categories.

D

Demersal - Describes fish and animals that live near water bottoms. Examples are flounder and croaker.

Directed Fishery - Fishing that is directed at a certain species or group of species. This applies to both sport fishing and commercial fishing.

Disappearance (Z') - Measures the rate of decline in numbers of fish caught as fish become less numerous or less available. Disappearance is most often calculated from catch curves.

E

EEZ - See exclusive economic zone.

EIS - See environmental impact statement.

ESO - See economics and statistics office.

Economic Efficiency - In commercial fishing, the point at which the added cost of producing a unit of fish is equal to what buyers pay. Producing fewer fish would bring the cost lower than what buyers are paying. Producing more fish would raise the cost higher than what buyers are paying.

*Added by Wallace et al.

harvesting at the point of economic efficiency produces the maximum economic yield. See maximum economic yield and economic rent.

Economic Overfishing - A level of fish harvesting that is higher than that of economic efficiency; harvesting more fish than necessary to have maximum profits for the fishery.

Economic Rent - The total amount of profit that could be earned from a fishery owned by an individual. Individual ownership maximizes profit, but an open entry policy usually results in so many fishermen that profit higher than opportunity cost is zero. See maximum economic yield.

Economics and Statistics Office (ESO) - A unit of the National Marine Fisheries Service (NMFS) found in the regional director's office. This unit does some of the analysis required for developing fishery policy and management plans.

Effort - The amount of time and fishing power used to harvest fish. Fishing power includes gear size, boat size, and horsepower.

Elasmobranch - Describes a group of fish without a hard bony skeleton, including sharks, skates, and rays.

Electrophoresis - A method of determining the genetic differences or similarities between individual fish or groups of fish by using tissue samples.

Environmental Impact Statement (EIS) - An analysis of the expected impacts of a fisheries management plan (or some other proposed action) on the environment.

Escapement - The percentage of fish in a particular fishery that escape from an inshore habitat and move offshore, where they eventually spawn.

Euryhaline - Fish that live in a wide range of salinities.

Ex-vessel - Refers to activities that occur when a commercial fishing boat lands or unloads a catch. For example, the price received by a captain for the catch is an ex-vessel price.

Exclusive Economic Zone (EEZ) - All waters from the seaward boundary of coastal states out to 200 natural miles. This was formerly called the Fishery Conservation Zone.

F

F - See fishing mortality

Fmax - The level of fishing mortality (rate of removal by fishing) that produces the greatest yield from the fishery.

FCMA - See Fishery Conservation and Management Act.

FCZ - See fishery conservation zone.

FMC - See fishery management council.

FMP - See fishery management plan.

Fecundity - A measurement of the egg-producing ability of a fish. Fecundity may change with the age and size of the fish.

Fishery Conservation and Management Act - The federal law that created the regional councils and is the federal government's basis for fisheries management in the EEZ. Also known as the Magnuson Act after a chief sponsor, Senator Warren Magnuson of Washington.

Fishery - All the activities involved in catching a species of fish or group of species.

Fishery Conservation Zone (FCZ) - The area from the seaward limit of state waters out to 200 miles. The term is used less often now than the current term, exclusive economic zone.

Fishery Dependent Data - Data collected on a fish or fishery from sport fishermen, commercial fishermen, and seafood dealers.

Fishery Independent Data - Data collected on a fish by scientists who catch the fish themselves, rather than depending on fishermen and seafood dealers.

Fishery Management Council (FMC) - See council

Fishery Management Plan (FMP) - A plan to achieve specified management goals for a fishery. It includes data, analyses, and management measures for a fishery.

Fishing Effort - See effort.

Fishing Mortality (F) - A measurement of the rate of removal of fish from,a population by fishing. Fishing mortality can be reported as either annual or instantaneous. Annual mortality is the percentage of fish dying in one year. Instantaneous is that percentage of fish dying at any one time. The acceptable rates of fishing mortality may vary from species to species.

Fork Length - The length of a fish as measured from the tip of its snout to the fork in the tail.

G

GLM - See general linear model.

GSI - See gonosomatic index.

General Linear Model (GLM) - A mathematical formula that relates one biological factor to another. Once a mathematical relationship is established, scientists use the formula to predict one factor over another.

Gonosomatic Index (GSI) - The ratio of the weight of a fish's eggs or sperm to its body weight. This is used to determine the spawning time of a species of fish.

Groundfish - A species or group of fish that lives most of its life on or near the sea bottom.

Growth - Usually an individual fish's increase in length or weight with time. Also may refer to the increase in numbers of fish in a population with time.

Growth Model - A mathematical formula that describes the increase in length or weight of an individual fish with time.

Growth Overfishing - When fishing pressure on smaller fish is too heavy to allow the fishery to produce its maximum poundage. Growth overfishing, by itself, does not affect the ability of a fish population to replace itself.

H

Harvest - The total number or poundage of fish caught and kept from an area over a period of time. Note that landings, catch, and harvest are different.

Head Boat - A fishing boat that takes recreational fishermen out for a fee per person. Different from a charter boat in that people on a head boat pay individual fees as opposed to renting the boat.

Histogram - A method of showing data in a graph. The data appear as bars running up and down (vertical) or sideways (horizontal).

I

ITQ - See individual transferable quota.

Incidental Catch - See bycatch.

Individual Transferable Quota - A form of limited entry that gives private property rights to fishermen by assigning a fixed share of the catch to each fisherman.

Industrial Fishery - A fishery for species not directly used for human food. An example is menhaden.

Instantaneous Mortality - See fishing mortality, natural mortality, and total mortality.

Intrinsic Rate of Increase (z) - The change in the amount of harvestable stock. It is estimated by recruitment increases plus growth minus natural mortality.

Isopleth - A method of showing data on a graph which is commonly used in determining yield-per-recruit.

J

Juvenile - A young fish or animal that has not reached sexual maturity.

L

Landings - The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points at which fish are brought to shore. Note that landings, catch, and harvest define different things.

Latent Species - A species of fish that has the potential to support a directed fishery.

Length Frequency - A breakdown of the different lengths of a kind of fish in a population or sample.

Length-Weight Relationship - Mathematical formula for the weight of a fish in terms of its length. When only one is known, the scientist can use this formula to determine the other.

Limited Entry - A program that changes a common property resource like fish into private property for individual fishermen. License limitation and the individual transferable quota (ITQ) are two forms of limited entry.

M

mm - See millimeter.

M - See natural mortality.

MEY - See maximum economic yield.

MRFSS - See marine recreational fishery statistics survey.

MSY - See maximum sustainable yield.

Magnuson Act - See Fishery Conservation and Management Act.

Mariculture - The raising of marine finfish or shellfish under some controls. Ponds, pens, tanks, or other containers may be used, and feed is often used. A hatchery is also mariculture but the fish are released before harvest size is reached.

Marine Mammal Animals - that live in marine waters and breathe air directly. These include porpoises, whales, and seals.

Marine Recreational Fishery Statistics Survey (MRFSS) - An annual survey by the National Marine Fisheries Service (NMFS) to estimate the number, catch, and effort of recreational fishermen. It serves as a basis for many parts of fisheries management plans.

Mark-Recapture - The tagging and releasing of fish to be recaptured later in their life cycles. These studies are used to study fish movement, migration, mortality, and growth, and to estimate population size.

Maximum Economic Yield (MEY) - This is the total amount of profit that could be earned from a fishery if it were owned by an individual. An open entry policy usually results in so many fishermen that profit higher than opportunity cost is zero. See economic rent.

Maximum Sustainable Yield (MSY) - The largest average catch that can be taken continuously (sustained) from a stock under average environmental conditions. This is often used as a management goal.

Mean - Another word for the average of a set of numbers. Simply add up the individual numbers and then divide by the number of items.

Meristics - A series of measurements on a fish, such as scale counts, spine counts, or fin ray counts, which are used to separate different populations or races of fish.

Millimeter (mm) - Metric measurement of length $\frac{1}{25}$ of an inch long.

Model - In fisheries science, a description of something that cannot be directly observed. Often a set of equations and data used to make estimates.

Mollusk - A group of freshwater and saltwater animals with no skeleton and usually one or two hard shells made of calcium carbonate. Includes the oyster, clam, mussel, snail, conch, scallop, squid, and octopus.

Morphometrics - The physical features of fish, for example, coloration. Morphometric differences are sometimes used to identify separate fish populations.

Multiplier - A number used to multiply a dollar amount to get an estimate of economic impact. It is a way of identifying impacts beyond the original expenditure. It can also be used with respect to income and employment.

N

NMFS - See National Marine Fisheries Service

National Marine Fisheries Service (NMFS) - A federal agency—with scientists, research vessels, and a data collection system—responsible for managing the nation's saltwater fish. It oversees the actions of the Councils under the Fishery Conservation and Management Act.

National Standards - The Fishery Conservation and Management Act requires that a fishery management plan and its regulations meet seven standards. The seven standards were developed to identify the nation's interest in fish management.

Natural Mortality (M) - A measurement of the rate of removal of fish from a population from natural causes. Natural mortality can be reported as either annual or instantaneous. Annual mortality is the percentage of fish dying in one year. Instantaneous is the percentage of fish dying at any one time. The rates of natural mortality may vary from species to species.

Nursery - The part of a fish's or animal's habitat where the young grow up.

O

OY - See optimum yield.

Open Access Fishery - A fishery in which any person can participate at any time. Almost all fisheries in federal waters are open to anyone with a fishing boat.

Opportunity Cost - An amount a fisherman could earn for his time and investment in another business or occupation.

Optimum Yield (OY) - The harvest level for a species that achieves the greatest overall benefits, including economic, social, and biological considerations. Optimum yield is different from maximum sustainable yield in that MSY considers only the biology of the species. The term includes both commercial and sport yields.

Overfishing - Harvesting at a rate greater than that which will meet the management goal.

P

Panel - See advisory panel

Pelagic - Refers to fish and animals that live in the open sea, away from the sea bottom.

Population - Fish of the same species inhabiting a specified area.

Population Dynamics - The study of fish populations and how fishing mortality, growth, recruitment, and natural mortality affect them.

Possession Limit - The number and/or size of a species that a person can legally have at any one time. Refers to commercial and recreational fishermen. A possession limit generally does not apply to the wholesale market level and beyond.

Predator - A species that feeds on other species. The species being eaten is the prey.

Predator-Prey Relationship - The interaction between a species (predator) that eats another species (prey). The stages of each species' life cycle and the degree of interaction are important factors.

Prey - A species being fed upon by other species. The species eating the other is the predator.

Primary Productivity - A measurement of plant production that is the start of the food chain. Much primary productivity in marine or aquatic systems is made up of phytoplankton, which are tiny one-celled algae that float freely in the water.

Pulse Fishing - Harvesting a stock of fish, then moving on to other stocks or waiting until the original stock recovers.

Put and Take Fishery - The placing of hatchery-raised fish in waters to be caught by fishermen. There are few marine fisheries that fit this description. Most cases are found in inland streams and lakes.

Q

q - See catchability coefficient.

Quota - The maximum number of fish that can be legally landed in a time period. It can apply to the total fishery or an individual fisherman's share under an ITQ system. Could also include reference to size of fish.

R

RD - See regional director.

RIR - See regulatory impact review.

Recreational Fishery - Harvesting fish for personal use, fun, and challenge. Recreational fishing does not include sale of catch. *The term refers to and includes the fishery resources, fishermen, and businesses providing needed goods and services.

Recruit - An individual fish that has moved into a certain class, such as the spawning class or fishing-size class.

Recruitment - A measure of the number of fish that enter a class during some time period, such as the spawning class or fishing-size class.

Recruitment Overfishing - When fishing pressure is too heavy to allow a fish population to replace itself.

Reef Fish Complex - A term used by the Gulf of Mexico Fishery Management Council to describe the many species of fish found around natural reefs, artificial reefs, ledges, and mud lumps. Snapper, grouper, and tilefish are examples.

Regional Director (RD) - The person in charge of the National Marine Fisheries Service (NMFS) for a given region.

Regression Analysis - A statistical method to estimate any trend that might exist among important factors. An example in fisheries management is the link between catch and other factors like fishing effort and natural mortality.

Regulatory Impact Review (RIR) - The part of a federal fishery management plan that describes impacts resulting from the plan.

Relative Abundance - An index of fish population abundance used to compare fish populations from year to year. This does not measure the actual numbers of fish, but shows changes in the population over time.

Rent - See economic rent.

*Added by Wallace et al.

S

s - See survival rate.

SAFE - See stock assessment and fishery evaluation report.

SEFC - See Southeast Fisheries Center.

SPR - See spawning potential ratio.

SSBR - See spawning stock biomass per recruit.

SSC - See scientific and statistical advisory committee.

Scattergram - A graph that shows how factors relate to each other. This is visual, not statistical, and is used when it is necessary to compare two factors, like fish age and size.

Scientific Assessment Panel - A group of biologist, economists, and sociologists put together by a federal fishery management council to review scientific data on the condition of a stock of fish and the interests of the fishermen and seafood processors who use the stock. Panel members generally come from universities and state and federal fisheries agencies.

Scientific and Statistical Advisory Committee - A group of scientific and technical people giving advice to a council.

Secretarial Management Plan - A term used to describe a plan developed by the Secretary of the U.S. Department of Commerce in response to an emergency, a council's failure to act, *or for highly migratory species.

Selectivity - The ability of a type of gear to catch a certain size or kind of fish, compared with its ability to catch other sizes or kinds.

Simulation - An analysis that shows the production and harvest of fish using a group of equations to represent the fishery. It can be used to predict events in the fishery if certain factors changed.

Size Distribution - A breakdown of the number of fish of various sizes in a sample or catch. The sizes can be in length or weight. This is most often shown on a chart.

***Shellfish** - General term for crustaceans and mollusks.

Slot Limit - A limit on the size of fish that may be kept. Allows a harvester to keep fish under a minimum size and over a maximum size, but not those in between the minimum and maximum. *Can also refer to size limits that allow a harvester to keep only fish that fall between a minimum and maximum size.

Social Impacts - The changes in people, families, and communities resulting from a fishery management decision.

Socioeconomics - A word used to identify the importance of factors other than biology in fishery management decisions. For example, if management results in more fishing income, it is important to know how the income is distributed between small and large boats or part-time and full-time fishermen.

Southeast Fisheries Center (SEFC) - Headquarters for the scientific staff of the National Marine Fisheries Service (NMFS) in the South Atlantic and Gulf of Mexico states. The center is located in Miami, Florida, with smaller laboratories at several other locations.

Spawner-Recruit Relationship - The concept that the number of young fish (recruits) entering a population is related to the number of parent fish (spawners).

*Added by Wallace et al.

Spawning Potential Ratio (SPR) - *The number of eggs that could be produced by an average recruit in a fished stock divided by the number of eggs that could be produced by an average recruit in an unfished stock. SPR can also be expressed as the spawning stock biomass per recruit (SSBR) of a fished stock divided by the SSBR of the stock before it was fished.

Spawning Stock Biomass - The total weight of the fish in a stock that are old enough to spawn.

Spawning Stock Biomass Per Recruit (SSBR) - * The spawning stock biomass divided by the number of recruits to the stock or how much spawning biomass an average recruit would be expected to produce.

Species - A group of similar fish that can freely interbreed.

Sport Fishery - See recreational fishery.

Standard Length - The length of a fish as measured from the tip of the snout to the hidden base of the tail fin rays.

Standing Stock - See biomass.

Stock - A grouping of fish usually based on genetic relationship, geographic distribution, and movement patterns. *Also a managed unit of fish.

Stock Assessment Group - A group of scientists, skilled in the study of fish population dynamics put together by a federal fishery management council to review the scientific data on the condition of a stock of fish. The scientists generally come from universities and state and federal fisheries agencies.

Stock Assessment and Fishery Evaluation Report (SAFE) - A report that provides a summary of the most recent biological condition of a stock of fish and the economic and social condition of the recreational fishermen, commercial fishermen, and seafood processors who use the fish. The report provides information to the federal fishery management councils for determining harvest levels.

Stock-Recruit Relationship - See spawner-recruit relationship.

Stressed Area An area in which there is special concern regarding harvest, perhaps because the fish are small or because harvesters are in conflict.

Surplus Production Model - A model that estimates the catch in a given year and the change in stock size. The stock size could increase or decrease depending on new recruits and natural mortality. A surplus production model estimates the natural increase in fish weight or the sustainable yield.

Survival Rate (s) - The number of fish alive after a specified time, divided by the number alive at the beginning of the period.

T

TAC - See total allowable catch.

TIP - See trip interview program.

Territorial Sea - The area from average low-water mark on the shore out to three miles for the states of Louisiana, Alabama, and Mississippi, and out to nine miles for Texas and the west coast of Florida. The shore is not always the baseline from which the three miles are measured. In such cases, the outer limit can extend further than three miles from the shore.

Total Allowable Catch (TAC) - The annual recommended catch for a species or species group. The regional council sets the TAC from the range of the allowable biological catch.

*Added by Wallace et al.

Total Length - The length of a fish as measured from the tip of the snout to the tip of the tail.

Total Mortality (Z) - A measurement of the rate of removal of fish from a population by both fishing and natural causes. Total mortality can be reported as either annual or instantaneous. Annual mortality is the percentage of fish dying in one year. Instantaneous mortality is that percentage of fish dying at any one time. The rate of total mortality may vary from species to species.

Trip Interview Program (TIP) - *A cooperative state-federal commercial fishery dependent sampling activity conducted in the Southeast region of NMFS, concentrating on size and age information for stock assessments of federal, interstate, and state managed species. TIP also provides information on the species composition, quantity, and price for market categories, and catch-per-unit effort for individual trips that are sampled.

U

Underutilized Species - A species of fish that has potential for large additional harvest.

Unit Stock - A population of fish grouped together for assessment purposes which may or may not include all the fish in a stock.

V

VPA - See virtual population analysis.

Virgin Stock - A stock of fish with no commercial or recreational harvest. A virgin stock changes only in relation to environmental factors and its own growth, recruitment, and natural mortality.

Virtual Population Analysis (VPA) - A type of analysis that uses the number of fish caught at various ages or lengths and an estimate of natural mortality to estimate fishing mortality in a cohort. It also provides an estimate of the number of fish in a cohort at various ages.

Y

Year-Class - The fish spawned and hatched in a given year, a "generation" of fish.

Yield - The production from a fishery in terms of numbers or weight.

Yield Per Recruit - A model that estimates yield in terms of weight, but more often as a percentage of the maximum yield, for various combinations of natural mortality, fishing mortality and time exposed to the fishery.

Z

z - See intrinsic rate of increase

Z - See total mortality.

Z' - See disappearance.

*Added by Wallace et. al.

Appendix 3: Comparison of Annual Mortality Rates and Instantaneous Mortality Rates

Annual Rate (Percentage)	Instantaneous (F, M, or Z) Rate
0	0
5	.0513
10	.1054
15	.1625
20	.2231
25	.2877
30	.3567
35	.4308
40	.5108
45	.5978
50	.6931
55	.7985
60	.9163
65	1.0498
70	1.2040
75	1.3863
80	1.6094
85	1.8971
90	2.3026
95	2.9957

Appendix 4: Regional Fishery Management Councils

States	Telephone No.	Executive Director
	New England	
Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut	617-231-0422	Douglas G. Marshall Santaug Office Park 5 Broadway (Rt.1) Saugus, MA 01906
	Mid Atlantic	
New York, New Jersey, Delaware, Pennsylvania, Maryland, and Virginia	302-674-2331	David R. Keifer Federal Building, Room 2115 300 South New Street Dover, DE 19901
	South Atlantic	
North Carolina, South Carolina, Georgia, and east coast of Florida	803-571-4366	Robert K. Mahood 1 Southpark Circle, Suite 306 Charleston, SC 29407-4699
	Gulf of Mexico	
Texas, Louisiana, Mississippi, Alabama, and west coast of Florida	813-228-2815	Wayne E. Swingle Lincoln Center, Suite 331 5401 W. Kennedy Boulevard Tampa, FL 33609
	Caribbean	
Virgin Islands and the Commonwealth of Puerto Rico	809-766-5926	Miguel A. Rolon 268 Munoz Rivera Avenue Suite 1108 San Juan, PR 00918-2577
	Pacific	
California, Washington, Oregon, and Idaho	503-326-6352	Lawrence D. Six 2000 SW First Avenue Suite 420 Portland, OR 97201
	North Pacific	
Alaska, Washington, and Oregon	907-271-2809	Clarence G. Pautzke 605 West 4th Avenue Room 306 Anchorage, AK 99501
	Western Pacific	
Hawaii, American Samoa, Guam and the Northern Marianas Islands	808-541-1974	Kitty M. Simonds 1164 Bishop Street Room 1405 Honolulu, HI 96813

Appendix 5: National Marine Fisheries Service Regional Offices

Telephone No.	Address
Northeast Region	
508-281-9300	Blackburn Drive Gloucester, MA 01930
Southeast Region	
813-570-5301	Koger Building 9721 Executive Center Drive St. Petersburg, FL 33701
Northwest Region	
206-526-6150	7600 Sand Point Way, NE BIN C15700, Building 1 Seattle, WA 98115
Southwest Region	
619-546-7000	501West Ocean Boulevard Long Beach, CA 90802
Alaska Region	
907-586-7221	9109 Mendenhall Mall Road Federal Building, Suite 6 P. O. Box 21668 Juneau, AK 99802

Appendix 6: Interstate Fishery Commissions

Telephone No.	Address
Atlantic States Marine Fisheries Commission	
202-387-5330	1400 16th Street, NW Washington, DC 20036
Gulf States Marine Fisheries Commission	
601-875-5912	Box 726 Ocean Springs, MS 39564
Pacific States Marine Fisheries Commission	
503-326-7025	2501 Southwest First Avenue Suite 200 Portland, OR 97201

Index