# CHAPTER 27

# OUR FISHERIES AND THEIR MANAGEMENT

## 27. 1. INTRODUCTION

### 27. 1. 1. Fish are Important to Our Culture

From the beginning of human history, people have gotten food from the waters of the earth. Fish are evident in the rituals, art, and legends of almost every human culture. Fish have a played an important role in the development of humanity. Today people place a very high priority on the commercial, recreational, and subsistence harvest of fish.

In addition, the aesthetic value of fish has increased substantially. There has been an increase of water-related activities such as snorkeling. The largest increase has been in the number of people involved in SCUBA diving. Here in Micronesia fish are vital to our understanding of ourselves and to our identity.

*From the beginning of human history, people have gotten food from the waters of the earth.*

### 27. 1. 2. Our Fisheries' Management Authority

Public Law 2-51 mandates the Commonwealth Division of Fish and Wildlife to manage and monitor all fishing-related activity. The Division actively monitors fishing inside the reef for catch levels of reef fish, sea cucumbers, and *Trochus*. It also monitors deep water fishing for bottom fish, pelagic fish, and deepwater shrimp.

The responsibility of the Division to monitor and manage the fisheries resources of the CNMI is becoming increasingly important. The fishery types being exploited are expanding; our islands' populations are increasing; and development is continuing. All these factors place more importance on sound fisheries' management.

## 27. 2. FISH CHARACTERISTICS

Fish represent an important protein source to most of the world's people. Fish have been harvested throughout human history. However, fish aren't just a form of sustenance for the human race. They are also fascinating creatures. They have lived for millions of years, evolving into many interesting forms which have colonized all the waters of the world.

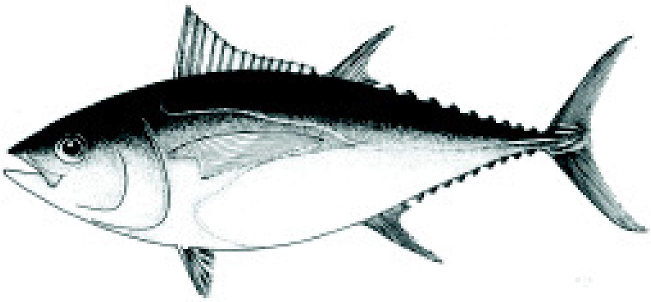
From ponds and lakes to the oceans and seas, fish constitute a significant portion of the earth's biomass. They are an integral part of the world's ecosystems.

## 27. 2. 1. How Many Fish and What Types?

There are estimated to be over 22,000 species of fish worldwide. This number will probably increase as people find more species.

More attention is being focused on the ecological, rather than commercial or subsistence value of fish, so scientists are discovering more species of fish.

All fish can be divided into two classes: the **Class Osteichthyes**, the bony fish, and the **Class Chondrichthyes**, the cartilaginous fish. The vast majority of the world's fish are bony fish. The sharks and rays comprise the cartilaginous fish.



*All fish can be divided into two classes: the Class Osteichthyes, the bony fish...*

## 27. 2. 2. Identifying Fishes

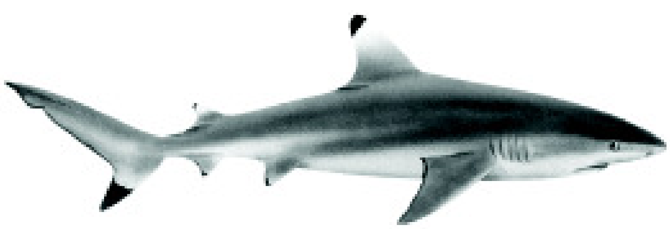
The proper identification of fish is an essential management feature for fisheries. This begins with identification of the **Family** to which the species belongs.

The Family is the primary management grouping. Characteristics and ecological roles, or **niches**, are usually grouped at the Family level. Let's look at the basic morphological characteristics used in fisheries identification.

Counts and measurements are commonly used to identify and classify fishes. Some species of fish require that characteristics of internal organs be viewed for species identification!

For example, Yellowfin and Bigeye tunas have body characteristics that are very similar. The only way to distinguish between Yellowfin and Bigeye tunas is to check the fish's liver for the presence or absence of lines, or **striations**. The Bigeye tuna has them, but the Yellowfin does not.

When identifying a fish, it is often necessary to assemble numerous reference materials. You may need books that show drawings or photographs of fish species. These books may be adequate for some fish, particularly those with unique *morphologies*.



*...and the Class Chondrichthyes, the cartilaginous fish.*

In general, it is best to actually sit down with the fish 'in hand' and compare it to the features shown in the figures. Count the dorsal fin rays, the number of scales on the lateral line, etc. In addition, use photographs for guidance.

Sometimes, we may be lucky enough to have a **dichotomous key** to use. Then, we can follow the key to identify a species based on the measurements and the counts specified in the key. Fish identification is often a complicated, but essential process.

Identification becomes easier as we become more familiar with the forms and characteristics (the things to look for), of certain families and species. Then, identification of the rarer species becomes challenging and fun!

Being able to classify fish into larger, Family groups is an essential tool in fisheries. It is the first step in proper management. This is especially true with respect to reef fish management, for which so many species are present.

### 27. 2. 3. Measuring and Weighing Fishes

The next step is to obtain the length and weight of the fish. This is very important, especially in a new fishery. We measure the length of a fish by what is referred to as **fork length** (fig. 27-1).

This is simply the length of the fish from the tip of the snout (mouth of fish closed) to the *indentation* in the middle of the fishes' tail, the 'fork', in centimeters. Do all fish's tails have a 'fork'?

There are two other measures used to describe fish length. One is the **standard length**, the length from the tip of the snout to the end of the **hyplural** bone (fig. 27-2).

(Ed. note. The hyplural bone is like the backbone of land animals. It is made up of the several vertebrae and protects the fish's central nerve cord. But since fishes have one in their body's middle instead of their back, it is given a different name. Interesting huh?)

This measure is used in **fish systematics,** the study of the classification of fish into families, genera, and species. The other is **total length** (fig. 27-3), which measures from the tip of the snout to the longest point of the tail. As stated, in fisheries' management, we use the fork length for its ease of use.

The weight of a fish is obtained by using a scale, and recording the weight to the nearest tenth of a kilogram.

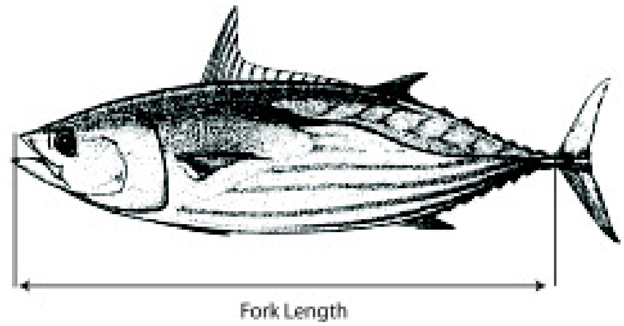



*Figure 27-1, fork length*

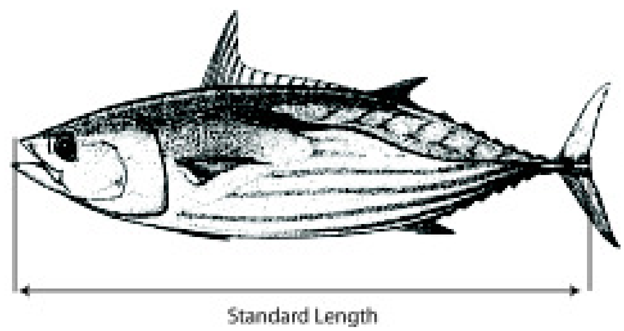



*Figure 27-2, standard length*

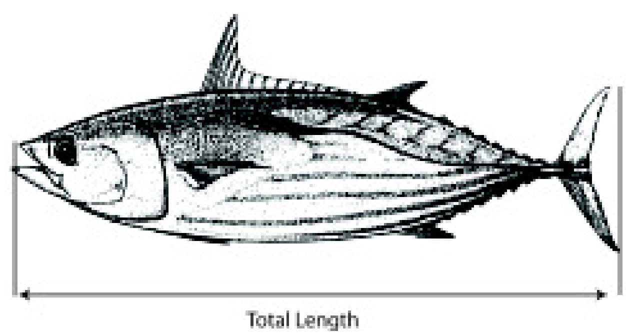



*Figure 27-3, total length*

### 27. 2. 4. Using Measurements to Determine Catch Quantities

When we record both the fork length and weight for all the individuals of a fish species in a catch, we obtain important *data* about that species.

We can produce a mathematical equation that describes the relationship of length to weight for that particular species. If we or the fishermen are pressed for time or if the number of fish is high, this equation allows us to take only lengths of fish.

Then we can estimate the weight of the fish for a particular length. We get a high degree of accuracy using the equation. After we have generated equations for all the fish species being captured, we can estimate the total weight of a catch from length measurements alone!

## 27. 3. FISH ECOLOGY

### 27. 3. 1. Important Questions

One of the most important considerations with respect to fish, or any other organism, is the basic understanding of its ecology. Without such background it is very difficult to make reliable management decisions.

Where does it live? What does it feed on? When does it reproduce? How many young does it produce? Does it protect its young? etc. There are many such questions to consider, some which may be very important, others less so.

### 27. 3. 2. The Fish Food Web

We start here with a basic classification of fish based upon their *feeding modes*. As we've learned, an ecological system can be thought of as the flow of energy.

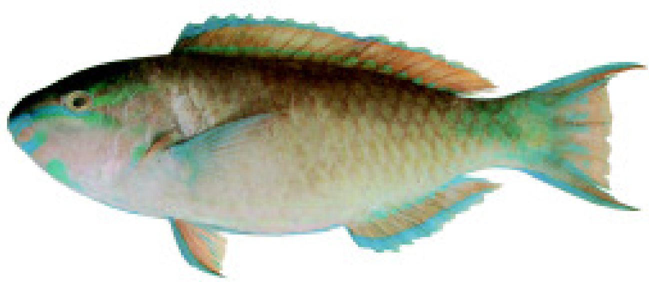
Most of us are now familiar with the term *food web*, and *food chain*. These frequently-used phrases originated in the early stages of ecological study and are still in use today to convey these basic ecological concepts.

### 27. 3. 3. Fish Trophic Levels

Different organisms feed upon each other. This depends upon their ecological feeding role, or **trophic level**.

For example, the energy on earth which drives all life is almost entirely obtained from the sun. Plants have the remarkable ability to capture this energy and transform it into living tissue. Here is where the 'chain' begins.

To generalize the food chain, **herbivores** then feed upon the plants. **Omnivores** feed upon plants and small animals. **Primary carnivores** feed upon the herbivores. Then **secondary carnivores** feed upon the primary carnivores. **Tertiary carnivores** feed upon the secondary carnivores. Finally, **scavengers** feed upon dead and/or decaying plants, herbivores, and carnivores.



*Parrotfish can usually be seen swimming in groups with other herbivores.*

One can only barely imagine how much more complicated this scenario is in actual reality.

At every level of **energy transfer**, that is of one organism consuming all or part of another, some energy is lost. Because energy is the essence of life, life has evolved over millions of years to minimize the amount of energy loss. We're digressing from our objective here, so back to fish. Some examples of *feeding guilds* (or groups) will be given using local fish.

### 27. 3. 4. Herbivore Fishes

Anyone snorkeling or diving on the reefs is familiar with this very common group.

Examples are the Damselfish and Parrotfish. The damselfish can be seen guarding dead coral and rocks covered with algae. They are very *territorial* with a small *home range*.

Parrotfish can usually be seen swimming in groups with other herbivores such as surgeonfish, feeding on algal growth on coral, rocks, and the ocean bottom, or *benthos*. Parrotfish cover a lot of ground and are not restricted to a small area.

### 27. 3. 5. Omnivore Fishes

The Rudderfish (*Family Kyphosidae*), can often be seen on the reef in large schools. They are called GUILI in Chamorro and REEN in Carolinian. They crop off blades of algae and also feed on small invertebrates.

### 27. 3. 6. Primary Carnivore Fishes

Smaller carnivores like wrasses feed on small invertebrates that live in and feed upon algae or seagrass. Small crustaceans and marine worms make up this group of invertebrates. Primary carnivores also eat small fish that hover above coral heads.

### 27. 3. 7. Secondary Carnivore Fishes
Examples of fish that are secondary carnivores are the snappers, emperors, and jacks: TAGAFI, LILILOK, and TARAKITU in Chamorro and Carolinian.

They feed on smaller fish and invertebrates such as crabs and shrimps. They often ambush or stalk their prey, and have large canine teeth for grasping.

### 27. 3. 8. Tertiary Carnivore Fishes
The larger carnivorous fish such as the sharks and larger groupers are tertiary carnivores. The shark that comes to mind immediately is the Tiger shark. It is known for its voracious appetite and its consumption of anything it comes across.

Whatever you can imagine, from human remains to plastic bottles, marine mammals, and turtles, has been found in the stomach of a Tiger shark.

While the Tiger shark pursues its prey, the large, deep-water eight-banded grouper ambushes large fish and invertebrates in the murky depths. These groupers quickly gulp their prey down into their stomachs through their large mouths.

From these examples you can envision the flow of energy in the ocean. It starts from the numerous plants of the oceans such as algae and plankton, and continues up to the higher level carnivores such as the shark and grouper. Think about other examples of fish for the above categories.

*Snappers, Emperors and Jacks are all secondary consumers.*

### 27. 3. 9. Categorizing by Fecundity
In addition to classification by trophic levels, fish can be grouped by other methods. Another way to group fish is by their reproductive method.

Fish are grouped by the number of eggs they produce, their **fecundity**. Fish can have a high fecundity, the ability to produce a high number of eggs, a medial fecundity, or a low fecundity.

### 27. 3. 10. High Fecund Fish
Fish, *broadcast spawners*, can spawn all year around, or spawn only during particular times of the year.

For example, some pelagic fish such as the Wahoo have a prolonged spawning period that extends over the year. Fecundity is very high and females produce up to 6 million eggs a year! Their *eggs* are released concurrently with the *sperm* of males. The resulting larvae are **planktonic**: they drift in the surface currents.

### 27. 3. 11. Low Fecund Fish
On the other side of the spectrum are the Gobies. They are small, benthic fish that dart around in tidepools or scurry across the ocean floor (fig. 27-4). Fecundity is low in these fish.

The male clears an area on the substrate to attract females. The fertilized eggs are placed on the substrate and guarded by the male until they hatch.

Other combinations also exist. There are high fecund benthic spawners. There are also fish, like the Pipefish, that actually keep their eggs in a special pouch on their stomachs until hatching (*Family Sygnathidae*).

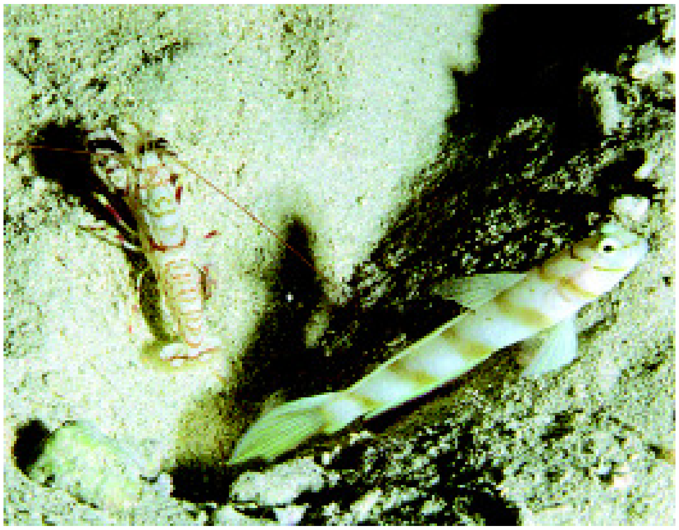


*Figure 27-4, Gobies live in tidepools or on the ocean floor. Recall from Ch. 14 that some Gobies live symbiotically with shrimp.*

## 27. 4. SELECTED FISH LIFE HISTORIES; BOTTOMFISH

### 27. 4. 1. Mafute

The MAFUTE is a member of the ***Family Lethrinidae***. Members of this family are called Emperors. The are closely related to the Snappers (*Family Lutjanidae*) because they are similar in general shape and body characteristics.

The Red-gilled Emperor (*Lethrinus rubrioperculatus*) is a very important traditional food source of our local community (fig. 27-5).

*Figure 27-5, The Redgill Emperor*

Other members of the ***Family Lethrinidae***, such as the LILILOK (*L. olivaceous*) and MATAN HAGON (*Gymnocranius spp.*) (fig. 27-6), are commonly sought in local waters. However, the Red-gilled Emperor is the focus of a major local fishery.

Larger fishing vessels upward of 60 feet make routine excursions one to three times a month to harvest this species. The richest MAFUTE fishing grounds in the Mariana Archipelago are the reefs and banks surrounding Farallon de Medinilla.

MAFUTE are caught with hooks and lines. Each trip, fishing boats typically return with catches exceeding 1,000 pounds. The Division of Fish and Wildlife monitors the catch of MAFUTE on a monthly basis with its port sampling program.

The Red-gilled Emperor is a roving carnivorous predator. It feeds on *benthic fauna* such as sea urchins, crustaceans, and *benthic infauna* including marine polychaete worms and various types of mollusks.

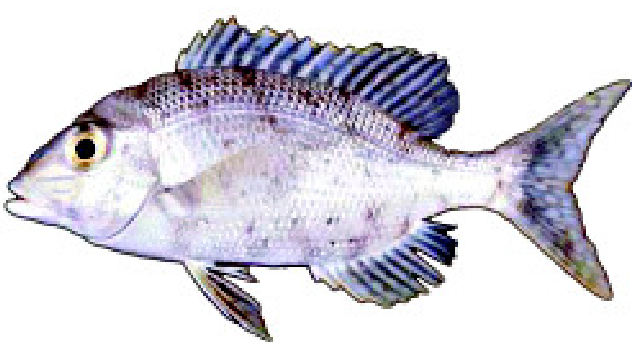


*Figure 27-6, Gymnocranius rivulatus*

MAFUTE inhabit areas with a sandy substrate as well as hard rock pavement. It is the most common emperor outside the reef, occurring at depths from 15 to over 150 meters. The MAFUTE grows to over 40 centimeters. When fishing for MAFUTE, large schools are typically encountered.

### 27. 4. 2. Onaga

Perhaps the most highly prized deep water bottomfish in the Marianas Islands is the Onaga, or BUNIÑAS in Chamorro and KARKAR in Carolinian. A very active fishery for Onaga exists in the Northern Islands. Numerous vessels make 3-4 day trips about four to five times per month.

The Onaga, (*Etelis coruscans*), is a large snapper which possesses a distinctive lyretail (fig. 27-8). It is a carnivorous predator. It feeds upon numerous species of benthic fish and crustaceans.

The depth range of the Onaga occurs from 175 to 525 meters. The larger adults are found in the deeper part of the range, occupying high relief structures as seamounts and pinnacles. Very little is known about the life history of these fish due to their existence at great depths.

They are *broadcast spawners*. Males and females release millions of gametes into the water column, where mixing and subsequent fertilization occur. The Onaga is a *serial spawner*, meaning it can spawn throughout the year. The actual number of spawning episodes in a year is still unknown.

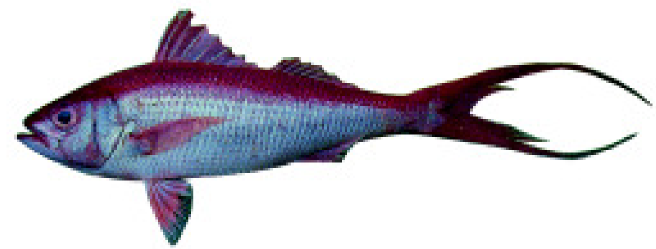


Figure 27-8, Etelis coruscans

Their larvae are planktonic. Juveniles settle down into the adult habitat at an unknown age. Onaga and other eteline snapper larvae are found in oceanic waters. However, other snapper larvae are more abundant over shelf waters.

Because of their restriction to a specific type of limited habitat, species such as Onaga can be easily overfished. The Division of Fish and Wildlife has monitored this fishery over the past two years. It has found that size distributions of Onaga at the island of Sariguan have steadily decreased. Now, the average size of Onaga harvested there is *below the size at sexual maturity* (fig. 27-9). Onaga attain sexual maturity at 66.3 centimeters.

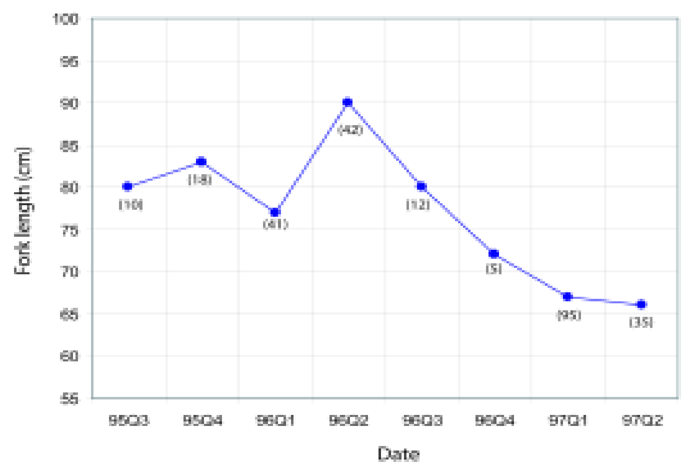



Figure 27-9, Size frequency of Onaga from Sarigan. Data are from sampled cruises through February 1997. Circles indicate mean size and number indicate sample size.

### 27. 4. 3. Eight-Banded Grouper

The undisputed giant of the deepwater realm is the Eight-Banded Grouper (*Epinephelus octofasciatus*). The Latin derivation for the species name is octo = eight, and fasciatus = line or band.

The species has two color phases. During one, the bands are highly visible and during the other the bands are less clear. In general, the larger individuals exhibit the latter color phase (fig. 27-10).

The Eight-banded Grouper is known as the GADAO in Chamorro and ALI in Carolinian. Like the Onaga, this fish, is highly prized by fishermen. It is harvested primarily for export to Japan, where it is considered a delicacy. The Japanese even eat the liver.

The ALI also inhabits high relief habitats from depths of 200 to 550 meters. Unlike the deepwater snappers, the grouper's spawning season is abbreviated. It only peaks for one to two months.

Figure 27-10, The color bands on this Epinephelus octofasciatus are clearly visable.

Studies to determine the fecundity of the ALI have not been conducted. However, scientists believe it has very high fecundity. Scientists have not determined the reproductive biology of this species, but studies show that groupers are *protogynous hermaphrodites*. This means large males that can reproduce are derived from females.

Grouper larvae are most abundant over shelf waters. However, scientists have not yet achieved identification of particular species' larvae.

## 27. 5. SELECTED FISH LIFE HISTORIES; PELAGIC FISH

### 27. 5. 1. Pacific Blue Marlin

The most highly sought sportfish worldwide are the billfish, specifically the marlins. The Pacific Blue Marlin (*Makaira mazara*) is a great prize for any fisherman who lands one (fig. 27-11). They are great fighters. The larger individuals can take up to eight hours or longer to land.

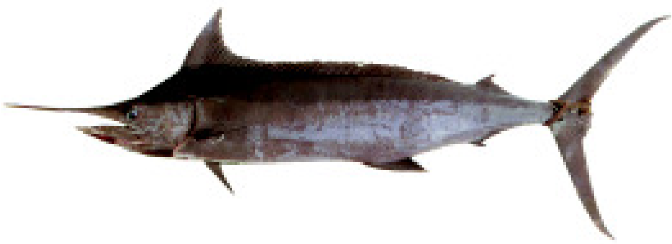


*Figure 27-11, Pacific Blue Marlin*

The Blue Marlin, or BATTO in Chamorro and TAGALAAR in Carolinian, attains a maximum weight of over 900 kilograms (2,000 pounds) for commercial longline fisheries (fig. 27-12).

*Figure 27-12, The Blue Marlin, or BATTO in Chamorro and TAGALAAR in Carolinian, attains a maximum weight of over 900 kilograms (2,000 pounds).*

The sportfish record of 818 kilograms (1,805 pounds) was landed off Hawaii. The second largest Blue Marlin was captured at Ritidian Point off Guam. It weighed 526 kilograms and measured 4.47 meters total length. It is the largest of the billfish species, and it is found primarily in the tropical and subtropical waters of the Pacific and Indian Oceans. Marlins exhibit *sexual dimorphism*, with the females being much larger than males.

The Blue Marlin is the most widely ranging of all the tropical billfish species. Its range is from 45 degrees North to 35 degrees South in the Western Pacific. Being a large pelagic species, billfish travel great distances throughout the oceans of the world. This makes it very difficult to determine and study populations.

Many countries of the world support the capture, tagging, and release of billfish species. This is an attempt to promote the understanding of billfish growth, habitat, and movements.

Tagging opportunities are helping people understand many things about Blue Marlin behavior. It has been recently discovered that Blue Marlin cross the equator and enter into other oceans. These two facts were unknown prior to the advent of large scale tagging in the 1980's. They would not have been discovered without the benefit of tag and release programs.

It is for this reason that the Division of Fish and Wildlife has initiated a billfish tag and release program. The program started in June 1996. The first Blue Marlin in the CNMI was tagged on April 9th, 1997, SSW of Aguiguan.

Billfish species around the world have been decreasing in recent years. Large scale commercial longline fishing and the use of high seas drift nets have caused the decline.

Presently, neither of these types of methods legally occurs in the Exclusive Economic Zone of the CNMI. Any future fishing using such methods must be monitored very closely. We must do this to ensure that local fishermen can still enjoy the challenge and excitement of capturing and landing, or tagging and releasing the Blue Marlin, the most exciting sportfish of all.

### 27. 5. 2. Skipjack Tuna

The Skipjack Tuna (*Katsuwonus pelamis*) (fig. 12-13), is the most abundant species found in the catches of pelagic fishermen. Skipjack tuna is BUNITA in Chamorro and HANGARAAP in Carolinian. Skipjack Tuna comprise over 40% of the world's total tuna catch. It has even surpassed Yellowfin tuna in recent years. Annual landings from the Western and Central Pacific Ocean have ranged from 800,000 to 1,000,000 tons. Nearly half of the worldwide catch is landed by Japan.

Skipjack Tuna are an *epipelagic species* with adults occurring in temperature ranges from 14.7 to 30 degrees Centigrade. The larvae are restricted to temperatures of over 25 degrees Centigrade.

They exhibit a strong tendency to school in surface waters. Skipjack tuna are usually associated with birds, *flotsam* (floating objects such as logs), sharks, whales, or other species of tuna. Flotsam such as logs are rare in our area because of the small land mass that comprises the Marianas. They are also rare due to our isolated location.

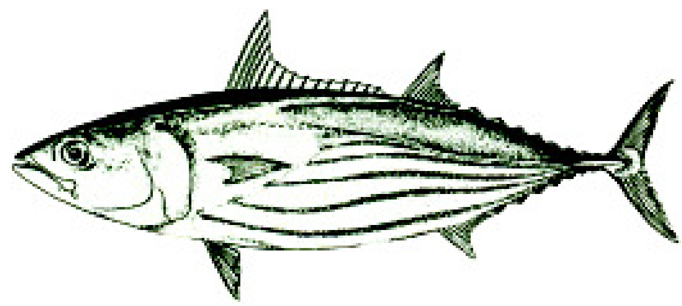


*Figure 27-13, Skipjack Tuna*

Here in the Marianas, schools of Skipjack Tuna are usually located by the presence of birds. The tuna and birds are in pursuit of *baitfish*. Local fishermen take advantage of this tendency to aggregate in surface waters. They use the quickest and most common method of capturing Skipjack, with handlines.

Skipjack Tuna reach sexual maturity at 2-3 years, or about 45 centimeters fork length. This is a relatively young age. In tropical waters they are broadcast spawners and spawn throughout the year. In subtropical waters their peak spawning period is from spring to early fall.

They exhibit a high growth rate. These factors, young sexual maturity and high growth rate, help maintain Skipjack Tuna populations even under heavy fishing pressure, thus helping to maintain high annual yields.

### 27. 5. 3. Mahimahi

The brilliantly colored Mahimahi reaches its peak abundance in the Mariana Islands (fig. 27-14) from January through March. The Mahimahi is called BOTAGUE in Chamorro and HABWUR in Carolinian. It becomes a major target species of local fishermen during this time. A fierce fighter, the Mahimahi is typically taken by pole and line.

Mahimahi (*Coryphaena hippurus*) have a strong tendency to aggregate near surface waters like Skipjack Tuna. They also collect around floating objects. This behavior makes Mahimahi the most abundant species to be found around Fish Aggregating Devices (FADS) (fig. 27-15).

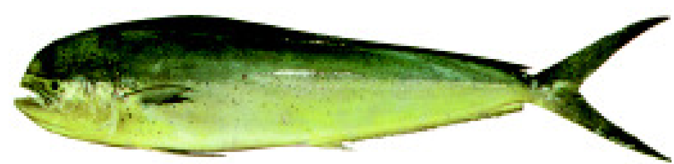


*Figure 27-14,Coryphaena hippurus*

The Mahimahi is also called the Dolphin Fish. It is a protracted spawner like most pelagic species. It is able to spawn throughout the year when environmental conditions are suitable.

The male of the species is easily identifiable by its large, blunt forehead. This body characteristic occurs when sexual maturity is attained.

The Mahimahi is an excellent food fish. It has been successfully raised with mariculture techniques in Hawaii and other parts of the world.

Figure 27-15, A Fish Aggregating Device, or FADS

Siganus spinus, the scribbled rabbitfish, one of the two most abundant species for local fisheries.

## 27. 6. SELECTED FISH LIFE HISTORIES; REEF FISH

### 27. 6. 1. Rabbitfish

Rabbitfish are very important fishes in the CNMI. They are important culturally and as a source of food. The two most abundant species for local fisheries are the Forktail Rabbitfish (*Siganus argenteus*), and the Scribbled Rabbitfish (*S. spinus*).

The former is HITENG KAHLAO in Chamorro and UMWULE in Carolinian. The Scribbled rabbitfish is SESYON in Chamorro and PENUWA in Carolinian. The post-larval stage of both species is MANAHAK in Chamorro.

When the MANAHAK first arrive from the ocean they are tiny, silvery and transparent. Schools of this fish number in the thousands. They usually arrive within a few days of the last quarter of the moon in April or May. They sometimes reappear in October.

At this stage they are considered a highly-prized delicacy. They are prepared by frying or pickling in lemon juice and salt. Eaten right after capture MANAHAK are usually rolled in salt and ground pepper. They are then dipped in spicy *Fina denne* sauce.

Fishermen can be seen all along the beaches of Saipan Lagoon during MANAHAK runs. They also go to Obyan and Lau Lau Bay. They peer into the nearshore waters then quickly casting their *talayas* towards a school.

After having been on the reef for a few days or more, MAHANAK begin to feed on algae. A change in their coloration occurs. At this stage they are known as DAGGE, and are no longer sought after until they attain the adult stage. As adults they are caught primarily by using gill nets and by free-diving with a spear.

When scuba diving or free-diving, adult rabbitfish can often be seen roaming the reef. They feed on algae scraped from the substrate.

Forktail Rabbit fish usually occur in large schools in deeper lagoon areas or on the outer reef slope. Scribbled Rabbitfish are found in small groups on reef flats and in shallow lagoons.

### 27. 6. 2. Squirrelfish and Soldierfish

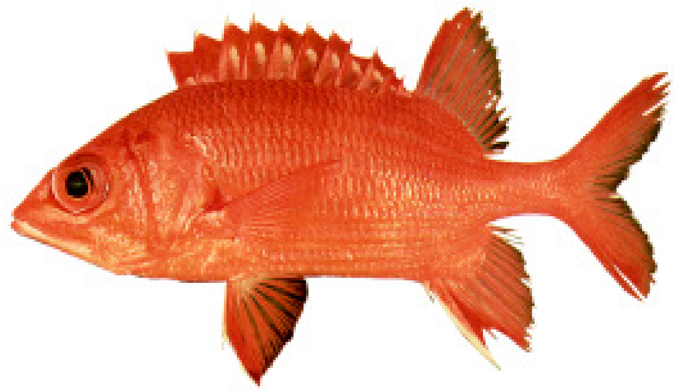
The Soldierfish and Squirrelfish are known as SAKSAK in Chamorro. They are called MWEEN in Carolinian. They are members of the ***Family Holocentridae***. They vary in color from orange to red. These fishes often have white horizontal lines across their lateral surface. Squirrelfish have extremely sharp dorsal spines.

During the day they hover individually or in small groups in or close to crevices, under boulders, and near cracks. At night they venture out to feed on a variety of small fish and invertebrates.

They can often be seen hovering seemingly upside down in caves. Like many reef fish that utilize caves, crevices, or other structures, Soldierfish and Squirrelfish exhibit **geotaxis**. That is, they orient themselves to the surface they are closest to.

Therefore, if they are closest to the top or side of a cave roof or wall, they can be observed seemingly upside down or vertical, respectively. Imagine what direction they must think we are in when we visit caves to observe or fish for them.

These two groups are the most abundant of the nocturnally active fishes on the coral reef. They often comprise a substantial portion of a reef fish catch.



*Sargocentron tiere, the blue-line squirrelfish*

These fishes have large scales, large mouths, and, being nocturnal fish, *very large eyes* relative to their body size. Most squirrelfish and soldierfish attain a maximum size of 25 to 30 centimeters on average. The *Myripritis murdjan* can reach up to 60 centimeters fork length.

Little is known about reproduction in these fish. Scientists think their larvae and eggs are planktonic. Size of settlement to the reef habitat is unknown for most species, as is the size of these fishes at sexual maturity.

### 27. 6. 3. Damselfish

The damselfishes are one of the most successful groups of reef fishes. They are popular *aquarium fish*.

People like them because of their small size, their often bright color patterns, and their hardiness in captivity. There are over 225 species in the ***Family Pomacentridae*** worldwide, representing over 25 genera.

Like many other reef fishes, Damselfish reach a peak and abundance in diversity on Indo-Pacific reefs. Damselfish are most visible hovering around reef structures.

They dart in and out of crevices and holes, or in and around coral heads (fig. 27-16). Many species of Damselfish are herbivores. They can be seen fiercely protecting algae growth on rocks and dead coral.

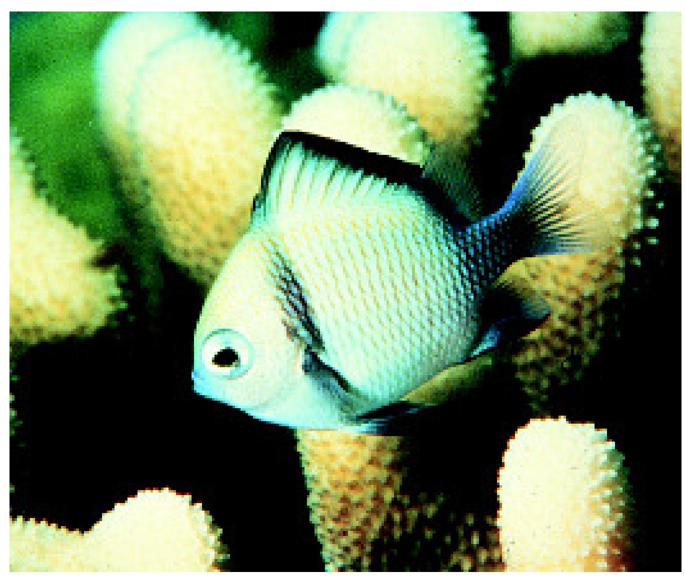


*Figure 27-16, Damselfish*

Damselfish generally *do not* exhibit **sexual dichromatism**. In other words there is no difference in color between the sexes. In some species males may exhibit some temporary color changes during courtship. These changes are not permanent and fade afterwards.

Damselfish commonly spawn periodically throughout the year. There are peaks of activity during early summer.

Spawning behavior has been found to be similar for all species studied. It typically involves selection of a spawning site by the male. The male then prepares the spawning site. Afterwards, there is a *courtship ritual* followed by egg laying and paternal care of the eggs until hatching.

Males spawn with numerous females in a *sequential* manner. This is referred to as **sequential polygamy**. This polygamous behavior is particularly obvious in temporary territorial species. Females from other areas of the reef are attracted to a male's nest. Nests can contain up to 200,000 fertilized eggs from *many* different females!

*The brilliantly colored parrotfishes are some of the most conspicuous fishes on the coral reef.*

*Parrotfish (Family Scaridae) differ in that their teeth have evolved into fused plates. These plates are called a 'beak'.*

Eggs are attached to the substrate by a cluster of fine threads attached at one end of the elliptical egg. Newly hatched larvae are planktonic.

They settle back to the reef 7 to 20 days after hatching. They typically settle at dusk or at night. This helps the larvae avoid predators.

The Trigger for Fish Species Settlement Patterns Back onto Reefs Remains a Mystery
The *factors* that trigger the settlement of fish larvae are *unknown.* Settlement patterns determine the overall distribution of species on the reef.

Scientists still do not know if settlement by larvae is governed by habitat preferences or pure chance. This is an active area of current ecological research.

Do settlement patterns occur *randomly*? Do they result from a *first come first serve* scenario? These are questions that remain unanswered.

Their answer is pivotal to understanding recruitment success. The answers are essential to understanding species abundance and distributional patterns throughout the coral reef. Amazing that we still don't know the answers, huh? Maybe you individually, or as part of a scientific team effort, will find them out.

### 27. 6. 4. Parrotfish

The brilliantly colored parrotfishes are some of the most conspicuous fishes on the coral reef. Parrotfish are closely related to the Wrasses (*Family Labridae*).

Parrotfish (*Family Scaridae*) differ in that their teeth have evolved into **fused plates**. These plates are called a 'beak'. This beak is used to scrape filamentous algae from the surfaces of dead coral and rock.

Parrotfish also eat dead coral rock. They use it to grind algae in their highly muscularized esophagus. They *defecate* indigestible sandy particulate matter which is their waste.

Most parrotfish travel in small to very large groups. They often travel with other browsing herbivorous fish species such as Surgeonfishes (*Family Acanthuridae*), and Rabbitfish *(Family Siganidae*). The majority of parrotfish do not maintain a permanent territory. They wander over the reef in search of food.

Parrotfish sleep at night in holes and small crevices. They surround themselves with a **mucoid veil**. *Unfortunately* (from these fishes' perspective), it is at this time when spear-wielding divers target parrotfish — at their most vulnerable with no means of escape.

Parrotfish are usually striped (in darkish bands with white) when they are less than two inches long. As juveniles, parrotfish are rather drab in color, ranging from gray to brownish to red.

Larger juveniles of both sexes are referred to as the *initial phase*, and are similar in coloration. At this phase parrotfish are referred to in Chamorro as PALAKSE', which means 'slippery'.

Some of the larger females eventually change sex. They develop into males and become brilliantly colored in hues of green and blue. This is called the *terminal phase* and fish in this phase are called LAGGUA in Chamorro.

Like the earlier discussed eight-banded grouper, parrotfish are *protogynous hermaphrodites*. We recall that this means all terminal phase males are derived from initial phase females. Individuals which started out as males do not change color, but will reproduce in some cases.

When spearfishing for parrotfish, divers generally look for the brilliantly colored males in the terminal phase. It is especially easy to find them at night when these fish sleep. Therefore, an indication of an over-exploited population is one with much reduced numbers of brilliantly colored males.

The number of terminal phase males harvested from the less exploited Northern Islands is much greater than those from the heavily exploited islands of Saipan and Tinian.

The Steephead Parrotfish (*Scarus microrhinos*) is LAGGUA in Chamorro and IGAN-WOSH in Carolinian. It is one of the more common species found on the reefs of our southernmost islands (figure 27-17).

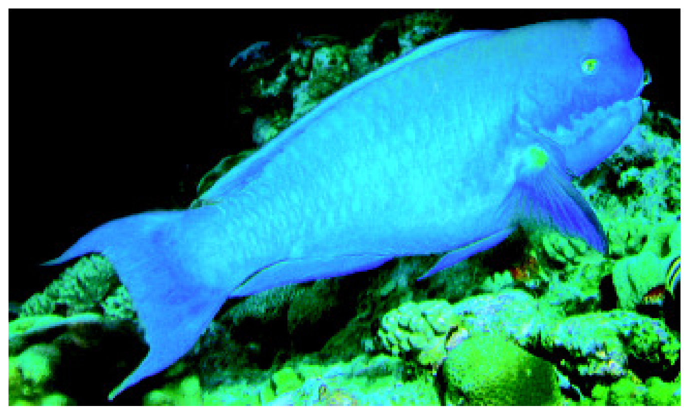


*Figure 27-17, The Steephead Parrotfish (Scarus microrhinos); LAGGUA in Chamorro and IGAN-WOSH in Carolinian.*

### 27. 6. 5. Sharks

The word 'shark' easily conjures up images of innocent swimmers being pulled under water by vicious man eaters. In recent years, the media have focused a great deal of attention toward sharks.

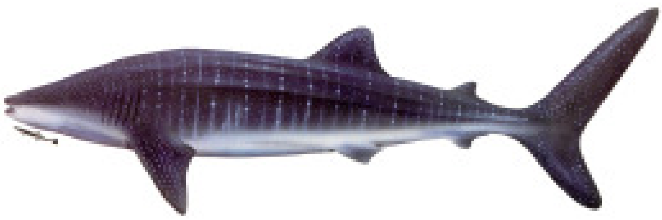
They have mostly illuminated the aggressive nature of a few species. This has negatively influenced people's perceptions about sharks. Recently, there has been a shift in focus to a more balanced exposé of one of the most fascinating of fish.

The HALU'U comprise a vast array of species. Some of them are highly specialized. For example, the largest of all sharks, the Whale shark (***Family Orectolobiformes***), is a suction/filter feeder. It feeds near the ocean surface on small crustaceans, small schooling fishes, and occasionally on larger fishes.

Two other large sharks are filter feeders. They are similar to the baleen whales. These are the Basking shark ***(Family Cetorhinidae)***, and the Megamouth shark ***(Family Megachasmidae)***.

Both feed on small to minute planktonic prey. Other sharks, like the Bullhead sharks (***Family Heterodontidae***), have teeth modified to feed on hard invertebrate prey such as bivalves and crustaceans.

The teeth of sharks are modified **dermal denticles**. These teeth are continuously formed in rows on the inner surface of the jaws (fig. 27-18). When a tooth is lost, the next available, inner tooth replaces it. This keeps these *apex predators* fully prepared to feed.


The largest of all sharks, the Whale Shark (Family Orectolobiformes), is a suction/filter feeder.

Unlike Teleost fish, (fish with bones), the skeletal structure of sharks is cartilaginous, not bony. Also, instead of scales, the skin of sharks is covered with minute (small) dermal denticles pointed towards the back of the fish. These denticles are similar in structure to the shark's tooth.

Because of these structures and their orientation, the skin of the shark will feel rough when you run your hand from the back to the front of the fish. The fins of sharks are covered with the same surface as the rest of the body. Because they are stiff, they cannot be folded to the body like other fishes.

The vision of sharks is limited by water clarity and the degree of light penetration. Sharks, however, have an elaborate system of pores around the head and sides. These pores and a pair of specialized inner ears enable sharks to detect the vibrations and sounds of fish and other animals produced at remote distances.

At closer ranges, the sharks sense of smell is legendary. Sharks are able to identify small traces of blood and other bodily fluids in the water. They can also detect the tiny electrical fields produced by all life forms. This enables sharks to precisely locate prey hidden in the benthos or in the complete absence of light.

There are over 20 some species of sharks found in the waters of our Mariana Islands. Of these, only about 12 can be encountered in our nearshore waters. The most common local sharks seen are those associated with shallow reef environments.

Our three most common species are the Whitetip Reef Shark (*Triaenodon obesus*), the Blacktip Reef Shark (*Carcharhinus melanopterus*), and the Gray Reef Shark (*Carcharhinus amblyrhynchos*).


*Figure 27-18. The teeth of sharks are continuously formed in rows on the inner surface of the jaws.*

All of these sharks are relatively smallish in size, attaining maximum lengths of about 1.8 meters, or 6 feet. The whitetip and blacktip reef sharks are generally shy and flee when approached by a diver. The gray reef shark is also relatively non-aggressive, but is very territorial and will attack if provoked. The gray reef causes serious but usually non-fatal wounds.

The Tiger Shark (*Galeocerdo cuvieri*) is the most dangerous shark in our nearshore waters. It can attain a length of 5.5 meters (18 feet). It will eat almost anything and is known as a 'swimming garbage can'. The tiger shark has discovered, attacked, killed, and consumed divers, not only in our waters but throughout its ecological distribution range.

Fortunately the tiger shark spends most of its daylight hours in depths of over 60 meters (200 feet) deep, where encounters with humans are very rare.

It will enter shallower waters when attracted by dead or dying animals, by garbage, by erratic splashing sounds, or when breeding. It is a *very dangerous* shark. If you ever encounter one, retreat and exit the water as quickly, and 'quietly', as possible.

Shark Fecundity, Gestation, and Oviparity (Egg-birth)
Sharks exhibit a *very low fecundity* compared with most bony fishes. A tuna, for example, produces literally millions of fertilized eggs. However, sharks can produce a maximum of 185 young in some species, with most species producing less than 20.

Female sharks *gestate* and give birth in three ways. The first is by **oviparity**, where eggs are deposited in tough, leathery egg cases in which the embryo develops.

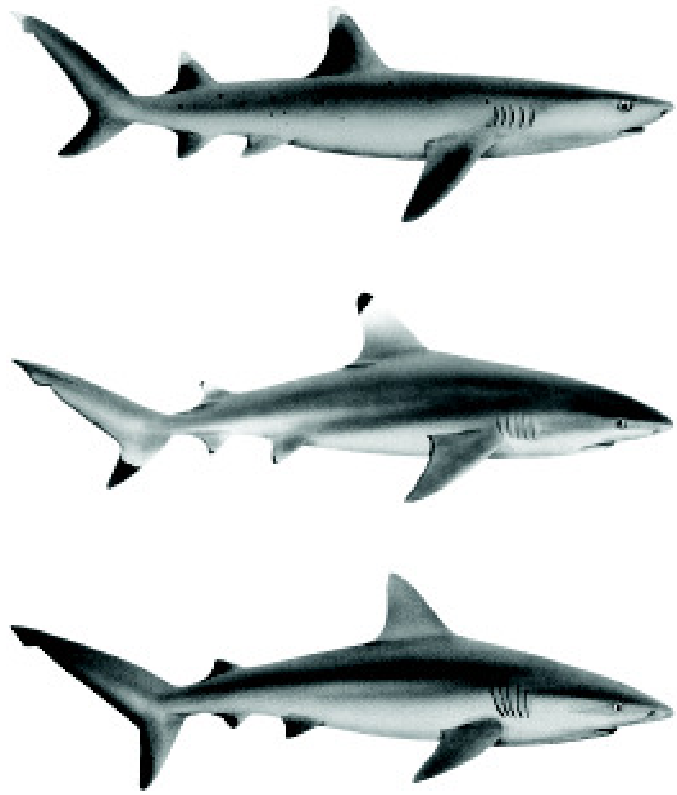
Some species develop within these egg cases in less than a month while others may take up to a year. They then hatch out as miniature adult sharks.

Egg cases are legendary for their toughness, durability, and impervious nature. In one example, an egg case was sent via mail from one researcher to another. It took seven days to arrive, upon which the egg case was placed in water with a tiny shark hatching out some time later!

Ovoviviparity (Egg-live birth)
In **ovoviviparity**, shark eggs stay in the mother shark's ovary long enough to allow substantial embryo development. The eggs are fully self contained units with the embryo and a yolk sac. The eggs hatch within the mother's body and the young sharks exit the mother, "born" live. When the young are born, they must fend for themselves.

Viviparity (Live birth)
**Viviparity** occurs when the nutrition of a young shark's yolk-sac is exhausted. In this case, nutrition is provided via a fluid-passing attachment of the yolk-sac to the maternal uterine wall. This type of reproductive mode is also called **placental viviparity**. Now more developed, these sharks also are live born and more fully able to care for themselves.

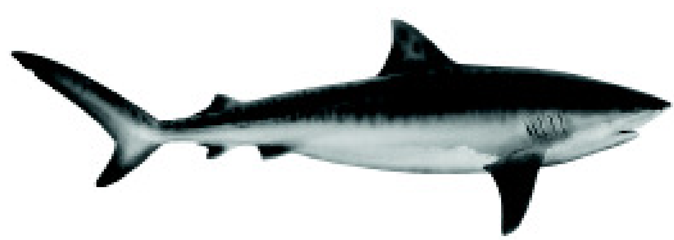
Because of their low fecundity, sharks are *very susceptible* to over-exploitation. Being at the top of the coral reef food web, the *shark* is an integral part of the coral reef ecosystem. It plays a vital role in energy transfer, old and diseased prey removal, and nutrient cycling. Sharks are fascinating creatures. They should not be killed indiscriminately, but respected for what they are.



*Our three most common species are (from top to bottom:) the Whitetip Reef Shark (Triaenodon obesus), the Blacktip Reef Shark (Carcharhinus melanopterus), and the Gray Reef Shark (Carcharhinus amblyrhynchos).*

## 27. 7. FISHERIES' MANAGEMENT: WHY? AND HOW?

### 27. 7. 1. Introduction
The fisheries resources of the world constitute the largest protein source available to humankind. Harvesting of this resource is a multi-billion dollar industry. This industry involves many nations of the world. Almost all nations harvest fisheries resources to some degree.



*The Tiger Shark (Galeocerdo cuvieri) is the most dangerous shark in our nearshore waters.*

Industrialized nations harvest the majority of the fishery catches of our small planet. Consequently, they make the greatest impact on these resources. Often these nations, including our own, fail in their responsibility to protect these common ocean resources.

Economic and political matters often have greater importance in the affairs of nations than does the goal of sustainable fishery management. The wise use of our natural resources, upon which we all depend for food, is not as important to some (nations and companies) as the economic return they may gain by full bore, all out fishing. This reality has resulted in the over-exploitation of our ocean and coastal fisheries, worldwide.

### 27. 7. 2. Managing Fisheries Scientifically and Defining a Fishery

Past Fisheries "Management" Practices

It is hard to find a fishery that has not been degraded by *exploitive-harvesting* practices and little or no real *management*.

*The fisheries resources of the world constitute the largest protein source available to humankind. Harvesting of this resource is a multi-billion dollar industry.*

It is almost impossible to find a fishery that is allowed to be fully managed by fishery management experts. These include fisheries biologists and fisheries managers.

Exploitive fishing practices and "non-management" are, in-fact, resource management at its worst. Unfortunately, and in truth, throughout the world it is the norm. We will begin our discussion of fisheries' management from this alarming view. (Ed. note: *Alarm* here is a good word,,,, there is a serious need for a call to action!)

A Fishery Defined

First, a definition of a '**fishery**' is required. A fishery is the harvest of *any organism* from fresh or salt water. A fishery can be categorized as commercial, recreational, or subsistence.

It follows that a fishery is not solely the harvest of fish, but can also include algae, invertebrates, and mammals. What are some examples of the harvest of algae, invertebrates, and mammals that can be classified as a fishery? Discuss this question in your class.

Fishery management is the monitoring and controlling of the levels of fish harvests by governments. The goal is to make sure that enough fish, of diverse species, and of reproductive ages, always remain for the ecosystem's health in general, and for a catch to always be available to future fishers.

### 27. 7. 3. The Reason to Do So

An obvious reason for us to practice fisheries' management is immediate. Proper management ensures that our resources are harvested at a level that will satisfy the economic and nutritional needs of our people.

It should also guarantee that the resource itself is not driven past a point where it can no longer *sustain* itself.

### 27. 7. 4. Maximum Sustainable Yields

The result of proper management would be a fishery that is sustainable at the highest-most, prescribed level of fishing effort. Expert fisheries biologists and managers can set this level.

This concept is known as the **Maximum Sustainable Yield.** The maximum sustainable yield, or *MSY*, is arrived at by allowing a level of fishing that will maximize the *yield* from the fishery *over the long term*. This is, over many years and decades.

As we can see from figure 27-19, the yield of a fishery does not necessarily increase as the level of fishing effort increases. Why would this be? More fishers. More boats. More poles. More nets, etc. Why not more fish harvested continuously through time?

Instead of increasing the harvest, increasing fishing effort, at too great a level, has a negative impact on the yield.

Fishery development can be encouraged but must be restricted below the point at which the harvests cause a lessening of overall yields.

Determining the MSY Level
It is a bit difficult to explain how scientists arrive at the best harvest number for *MSY* for any particular fishery. Calculations to do so are a bit beyond our purposes here. We should, however, understand that it can mathematically be done.

Through their specialized college classes, fisheries managers are fully trained to do so. We can appreciate some of the elements of the overall MSY formula such as measuring population numbers and understanding population growth and decline factors.

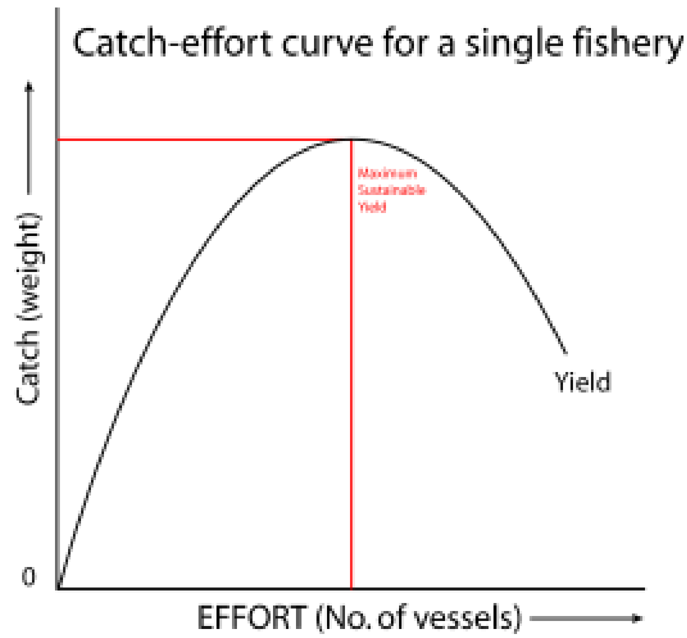


*Figure 27-19 - Catch effort curve for a single fishery*

Categorizing A Fishery; The First Step
To begin, we need to determine what types of information about the fishery are required. A good first step is to categorize the species being harvested. Is it a fish, a plant, an invertebrate, or a mammal?

Categorizing the species will determine our eventual management strategies. Different fishery types have different methods (strategies) of management. Because this chapter is focused toward fish, we will restrict our discussion to fish and fishable stocks.

## 27. 7. 5. Factors Governing Fishable Stocks; Population Factors

Fishable Stocks Defined; a Local Example
What then is a *fishable stock*? Fishable stocks are fishery populations, of a harvestable size, existing at a given location, at any given moment. For example, let us identify the fishable stock of the common Red Gill Emperor MAFUTE near Tinian island today.

Of all of the members of the MAFUTE population (new hatchlings, medium-aged young, and old) presently alive in the waters off Tinian, we would focus only on those individuals that have grown through the planktonic stage.

Further we would focus only on those which have already settled as recruits onto the sandy and hard rock pavement areas of Tinian's patch and fringing reefs. Finally we would focus only on those which have already grown to a desirable catch size.

Catchable size is judged by the fishers who spearfish them or catch them with their hook and lines. (Is that fish worth shooting at? Is it a *keeper* or a *thrower-backer*?)

This smaller, more defined group of the Red Gill Emperor's population, makes up Tinian's MAFUTE fishery's fishable stock. Of course,


*Through their specialized college classes, fisheries managers are fully trained to arrive at the best harvest number for MSY for any particular fishery.*

this stock changes daily as Tinian spear fishers and hook and line fishers catch their take.

It changes naturally as well as new recruits settle and as new MAFUTE spawning occurs. (Don't forget the natural take by sharks, groupers, etc.). The Tinian MAFUTE fishable stock is an *exploited fish population*, here meaning it is used (harvested) by people.

Figure 27-20 displays the dynamics of an exploited fish population. A fish population will *increase in size* by additions of new individuals, recruitment, and by growth of existing individuals.

It will *decrease* through natural deaths, referred to as mortality, and by fishery harvests (yield).

Generating a value for the number, or weight, of a fish stock that can be harvested, the **yield**, while maintaining a self sustaining population, is not easy. Different methods have been developed to obtain numerical values for growth, recruitment, and mortality. Obtaining actual, precise measurements of mortality of a fish stock, for example, is impossible.

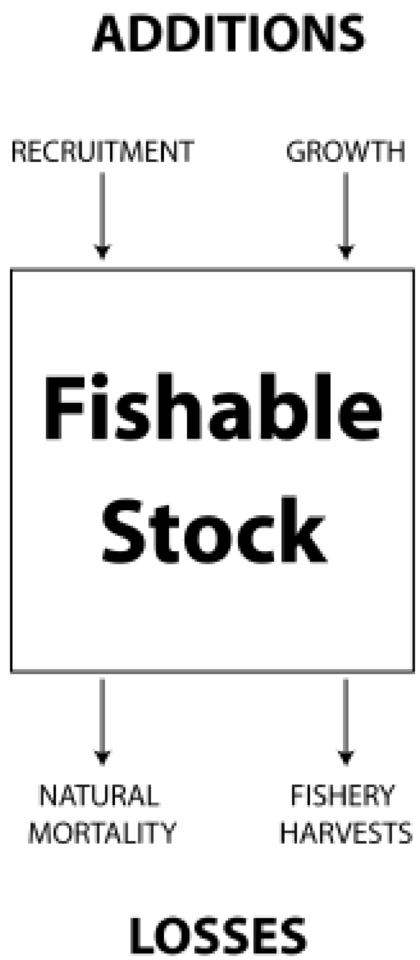



*Figure 27-20. The basic relationships in fishery population dynamics*

Think about the various life stages of a fish. Planktonic species produce millions of fertilized eggs (high fecundity). Each species has a very high mortality during the development of these eggs (loss during embryo development).

This is because some eggs are carried away with currents. These eggs are also a food source for the varied species of oceanic invertebrates, fish, and mammals (baleen whales). Many oceanic (and also reef) species have a diet that consists of planktonic food.

Later in life, the larvae continue to face the same danger of becoming a meal. During early life stages, these types of fish exhibit a very high rate of mortality.

As they grow and become able to swim against currents and avoid predation, mortality decreases. It is easy to imagine how mortality will change as these fishes become older. Fish pass through various life stages, just as people do.

(Ed note: Our common islander-practice of celebrating our newborn children's first birthday has a similar biological life stage connecting element to it. In our not-too-distant past, many babies died from diseases and malnutrition before they reached their first birthday. Those which did so, often had a much greater chance of long term survival. This was recognized and became a matter for celebration. Infant mortality still occurs, but at a much lower frequency than before. OK, sorry for the aside,, back to fish.)

The most important mortality to fisheries biologists and managers is in the size (actually age group) of a particular fish species harvested by a particular fishing method. This is the segment of the species' mortality (—more accurately "yield"), which needs to be estimated.

Unlike land animals, we cannot observe how many fish die of natural causes. Therefore, this needs to be estimated by mathematical models. The same difficulties face fisheries biologists and managers with respect to growth and recruitment.

## 27. 8. EXAMPLES OF OUR LOCAL FISHERIES

We now turn our attention to some local fisheries. The management of these fisheries is the responsibility of the Division of Fish and Wildlife.

The most notable local fishery now in operation is the harvest of bottomfish from the Northern Islands. The bottomfish resources of the Mariana Archipelago were first addressed by the United States Department of Commerce's National Marine Fisheries Service, Honolulu, Hawaii office.

The RAIOMA (Resource Assessment Investigation of the Mariana Archipelago) study occurred from 1982 - 1984. It produced estimates of *MSY* for the entire Mariana Archipelago, including Guam.

In subsequent years there were attempts by local fishers to harvest these resources. These met with limited success. In the early 1990's, two bottom fishing operations targeting the Northern Islands began. One was a charter boat, the *Daiwa Challenger*. The other was a commercial venture, the *Santa Theresa*.

These two operations were the first to successfully harvest the deep water bottomfish resources of the Northern Islands. The *Daiwa Challenger* later became the *CNMI Challenger*, and was owned by the CNMI Government and was later sold to a private party. The *Santa Theresa*, now joined by other vessels, continues to harvest.

The Division of Fish and Wildlife began monitoring our Northern Islands fishery in April of 1995. Typically, the DFW samples a vessel 1-3 times per month, depending upon the number of trips each vessel makes.

The DFW is interested in monitoring three parameters:

1) Total **amount** of fish landed per island.
2) The **length frequency** of the target species.
3) The **catch per unit of effort**, or CPUE, per trip.

The first measure is what we have called *yield*. The RAIOMA study produced estimates of yield for all the islands and selected banks in the Mariana Archipelago. We can now use these estimates to compare with actual or estimated landings.

The second measure is also very important in our monitoring scheme. The *length frequency* data tells us the size distribution of the species harvested.

A fish, like any other animal, reaches an age, or size, when the individual is able to produce sex cells (*gametes)* that are viable, or functional. This is called the *size at sexual maturity*.

You may have heard of regulatory *size limits* for fish. These limits are based on the size at which a particular species reaches sexual maturity. It is essential that each population of fish is allowed to breed before they are captured. If a fish reaches sexual maturity at

*The management of CNMI fisheries is the responsibility of the Division of Fish and Wildlife.*

60 centimeters, then it is important to fish in a manner that will restrict the catching of fish at, or smaller than, this size.

Without management, when a fish population is harvested, the larger fish are usually taken first. As fishing continues over time, the size of fish caught becomes smaller and smaller because the fish are not allowed to reach their maximum size.

This might not have a negative effect on the population. However, it *will* have negative effects if the *majority* of the largest fish in the population are harvested *below* the size at sexual maturity.

When this occurs the fish are not allowed to breed. Population recruitment is much reduced, and this negatively effects population growth.

The third measure is the **CPUE**. This is simply the weight or number of fish captured divided by some measure of fishing effort. There are many ways of measuring fishing effort. For example, managers might want to use the number of fishing days per vessel.

At DFW we measure effort for bottom fishing as the average number of poles and/or fishing lines used per trip. We multiply this by the number of hours the poles and/or lines were used for fishing.

Therefore, the CPUE simply is:

**CPUE = total catch divided by the number of poles used multiplied by number of hours fished.**
We can shorten this relationship by symbolizing the following:

T = total catch
p = # poles used
h = # hours fished
/ = divided by
* = multiplied by

So,

$CPUE = T/p*h$
If we identify the following: $f = p*h$

Thus we obtain:
$CPUE = T/f$

Using symbols greatly simplifies the length of our equation. Managing fisheries involves many mathematical relationships to get estimates of the above measures. Mathematics uses symbols to *communicate* and *condense* definitions and concepts.

### 27. 9. THE FUTURE: BRIGHT OR BLEAK?
The future of fisheries management, here in our Commonwealth, depends greatly upon what WE do now.

It is important to understand that WE are the future determiners of the near term and long term health of our fisheries. It is WE who will decide the direction that fishery resource management here in the CNMI will take. A critical juncture is being approached, and it is up to US to make the right choices. It is up to US to do things properly because WE are the future.

Fisheries can often represent big money opportunities. Big money often translates into pretty hot politics. As a member of our democratic society always remember that you and I both have an equal voice.

With regards to the issue of fisheries management, what direction will you, as one of our island's secondary and post secondary school students, seek to lead our Commonwealth? Would it be towards learning more about and practicing the prudent conservation our precious fishery resources?

Or would it be towards catch-as-catch-can, *trust the fishermen* to "harvest, manage, and conserve" our island's fishery resources at their own economic leisure.

Many references are available throughout the world on how *not* to manage natural resources. Remember our discussion, in earlier chapters, on natural resource economics and the *tragedy of the commons*?

Here in the CNMI we have the opportunity to conduct our management strategy differently — more scientifically. Since most of our ocean resources have not been thoroughly degraded — and most of our coral reef habitats are in fairly good shape — we have the rare opportunity to monitor and manage our fishery resources properly.

How exactly should we manage our fisheries? One option would be to continue to do things 'as usual'. In the not too distant past, this had meant for the average person to do and say nothing — while untrained, though well-respected, island leaders decided how our fishery resources would be harvested. They not only determined how much was harvested but also who harvested them.

Who determines how much will be harvested, and who harvests it, has great bearing in managing resources. Many fishery companies are not conservation-minded and just want to *grab and go*. On the other hand some companies wish to harvest an area's resources over the long term and on a sustained yield basis.

Due to their complexity and fragileness, our natural resources should not be managed by persons who are not thoroughly knowledgeable about them. How wise would it be for a medical doctor, without engineering training, to be placed in charge of a massive building or civil engineering project? Not at all of course. This reasoning is just as true for having one unskilled in fisheries principles placed in charge of managing our island's fisheries.

Fishery biologists and fishery resource managers are expertly trained in the fisheries management field. They are trained in the complex biology, statistics, legalities and other management aspects of their fields. These individuals should be hired, looked to for advice, and called upon to judge fishery permitting issues, and to help guide future program development directions.

Most likely, soon you will join our CNMI work force. You may, in fact, choose to work for a resource management agency. Prepare yourself well. As students of island ecology and resource management, take note that this book includes elements of law, economics, biology, history, and politics (amongst others). Learn as much as you can about each of these resource management-influencing disciplines. Each plays a role.

Study these well now, in this class, and in your future off-island university years. Study hard. Learn well. Go far. Please be sure to come back to help us to better manage our islands' fragile resources and the resources of our nearshore coastal waters.

*Here in the CNMI we have the opportunity to conduct our management strategy differently — more scientifically.*