Teachers' Resource Sheets on

Fisheries management

What is a fishery? ***A fishery* consists of a population or stock of fish or other aquatic species* that is exploited by fishers. A fishery, therefore, includes the exploited species, the fishers and the marketers as well as the ecosystems* in which all aquatic species are components.***

An ecosystem is a biological community of interacting plants and animals (including humans) and the non-living components of the environment.*

A fishery also includes the people, in both fishing communities and government authorities, who manage the fishery.

Why manage fisheries?

All fisheries need to be managed to ensure that fish stocks are not overexploited* and continue to provide benefits to people in the future. With increasing populations and an increasing demand for seafood, a fishery will inevitably be overexploited if it is not managed.

Who manages fisheries?

Fishing communities, government agencies and fishing cooperatives can all manage fisheries. In many Pacific island countries, fishing communities are managing fisheries and are using traditional knowledge to do so. Most national governments have an agency that is responsible for fisheries management.

What are the aims of fisheries management?

The main aim of fisheries management is to ensure that fishing is sustainable. If management is successful, seafood will continue to be available both now and in the future.

Who assesses fish stocks and fisheries?

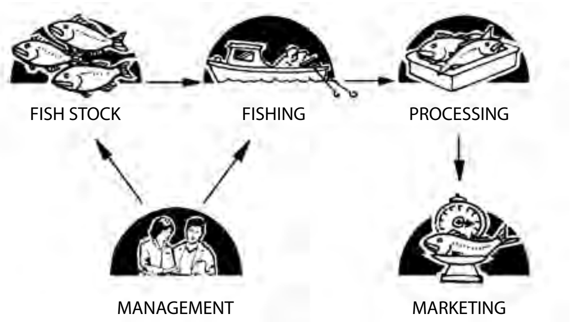
Managers rely on receiving assessments of the health of fish stocks. Sometimes this information comes from fishing communities. More technical assessments are made by scientific staff of government and regional fisheries agencies (see Teachers' Resource Sheet 2: Fisheries assessment).

What or who are we managing?

Fisheries management is mainly about managing people. It often involves preventing people from taking too many fish, using damaging fishing methods and harming the marine environment.

How can we ensure we have seafood for the future?

We have to have rules or regulations to protect our seafood species and the places in which they live. Fishing communities and national fisheries authorities impose many rules and these must be supported by all people.



Fisheries management involves controlling catches from the fish stock, restricting the amount or type of fishing and protecting marine ecosystems.

Manuel Ducrocq © Adecal

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Some general rules are:

- ***Leave small individuals in the sea.*** This allows adult fish to live long enough to breed and produce young fish, many of which will grow and be available to be caught in future years. Many fisheries authorities ban the catch of fish less than a minimum size.
- ***Leave some big fish in the sea.*** Larger individuals produce many more eggs. This is because egg carrying capacity is related to fish volume not length.
- ***Protect plant-eating fish.*** Some fish, such as parrotfish, unicorn fish and surgeonfish, eat seaweeds that would otherwise displace, compete with, or cover corals.
- ***Ban or restrict some types of fishing.*** Restrict the length of gill nets used and ban the use of small mesh nets. Limit the number of fish traps or fish fences. Ban methods such as using underwater torches and spears at night when fish are sleeping (see SPC Community Information Sheet 29: Plant-eating fish).
- ***Ban the use of damaging fishing methods.*** People using poisons and explosives are destroying our resources and our future.
- ***Ban or reduce fishing on spawning* fish.*** Ban fishing in areas where fish are known to gather to spawn* or at times when fish are gathering to spawn. Spawning refers to the act of releasing eggs, which in most fish, are fertilised by males releasing sperm into the sea. Many fish have to gather in large numbers to reproduce successfully (see SPC Community Information Sheet 24: Spawning aggregations)*.
- ***Protect critical habitats.**** All species need places to eat, live and grow. Some species use different habitats at different stages of their lives. These important habitats may include mangroves, seagrass beds and corals.
- ***Set up permanent reserves to protect fish and places in which they live.*** Set up an area where fishing is banned to protect areas including corals and seagrass beds. No-take areas* may allow fish catches to eventually increase in nearby areas.
- ***Protect watershed areas.*** Seek government support to reduce sediments and nutrients* running off the land into rivers and lagoons; these cause damage to many marine habitats (see SPC Information Sheet 27: Nutrients and sediments).

Not all of the above measures are appropriate for all species. Individual information sheets should be consulted for the management options appropriate for specific species.

Fisheries managers recognise that we must manage not only fisheries but the areas in which fish live — this is called an ecosystem approach to fisheries management.

Eric Clua © SPC

Fisheries assessment

To assess something is to examine its status or standing at a given time. In fisheries assessment we are gathering information on the status or health of a fish stock or fishery.* This assessment is used to provide fisheries managers with information that they can use to manage a fish stock.

A fisheries scientist swimming along a transect and counting the numbers of different species within a 5 m wide band over a coral reef.
From King M. 2007. Fisheries biology, assessment and management. UK, Oxford: Wiley-Blackwell. 400 p.

Assessments can range from those made by fishers and fishing communities to more complex analyses made by fisheries scientists. The problem with scientific analyses is that they often require a lot of information and sometimes many years of data collection.

Examples of formal assessments are given in the accompanying guide book. One exercise is based on completing transects* to estimate the size of a population of sea cucumbers on a shallow bank (the diver in the above illustration is completing a transect across a coral reef).

One of most extensive scientific assessments in the Pacific is part of the tuna research programme completed by SPC. Part of this research depends on tagging experiments in which tuna are tagged and released in order to obtain information on their migrations and other biological parameters. An example of using tagging information to estimate the numbers of fish in a population is included in the accompanying guide book. Methods of tagging marine species* are shown in the figure at the back.

However, there are so many species in tropical waters that the individual assessment of each species is a very difficult task. Fisheries managers have to rely on less complex assessments and some of these can be made by fishing communities.

One of the most basic measures of the health or wellbeing of a fishery involves examining changes in fish sizes and catch rates. If fish sizes in catches are decreasing it may suggest that too many large adult fish are being taken from the stock.

Related facts to consider

Coastal waters in the tropics are home to many more species than those in cooler waters. The number of different species decreases with distance away from the equator. For example, big fisheries in New Zealand are based on large numbers of relatively few species whereas a Pacific Island in the tropics has fisheries based on smaller numbers of many more species.

Catch rates refer to the amount of fish caught in a given fishing time; say the number of standard strings of fish, basket of clams, or a number of lobsters caught in an hour of fishing. If catch rates have been decreasing over many years it is likely that too many fish are being taken from the stock.

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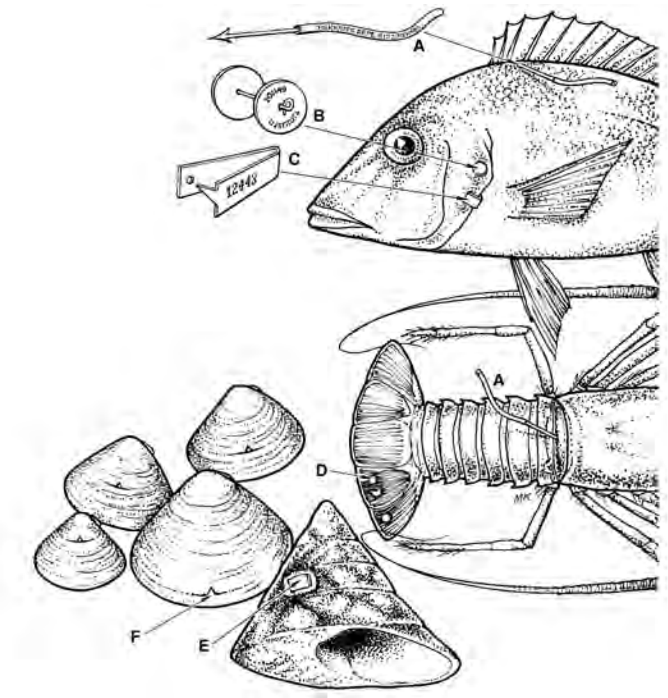
When seeking this information from fishers or in fishing communities it is often easier to ask about catch rates in terms of time taken to obtain a standard catch rather than catch per standard time. That is, for example, the time taken to catch a standard string of fish, a basket of clams, or a number of lobsters.

- If this fishing time is remaining the same, the numbers of fish are probably remaining the same. In this case, the assessment may be that the fish stock is healthy.
- If this fishing time is increasing, the numbers of fish are probably decreasing and management, if any, is not effective. In this case, different or additional management measures should be applied.

This assessment based on information from local fishers has sometimes been called "data-less management" as it is not based on time-consuming and often expensive surveys by fisheries scientists.



Tagged, or marked, marine species. Fish are often tagged with the brightly-coloured spaghetti tag (A) shown inserted between the rays of the base of the dorsal fin. A spaghetti tag is also shown inserted into the muscle of the lobster's abdomen between the covering plates. A disk tag (B) and an opercular clip tag (C) are attached to the gill cover of the fish. The tail fan of the lobster is marked by defacement (D). The trochus has a small printed plastic tag (E) glued to its shell with quick-setting epoxy resin. The bivalve molluscs* have been marked, at some previous date, by filing a notch (F) on the shell margin. After recapture, the increase in distance from the old shell margin to the new shell margin represents growth during the period between release and recapture.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Malo Hosken © SPC

Teachers' Resource Sheets on

Fisheries economics

What is fisheries economics? ***Fisheries economics generally refers to the contribution that the fisheries sector makes to an economy. In economics, we typically discuss the value of fisheries products that are captured, produced or traded and what contribution the fisheries sector makes to an economy in terms of value of production, employment, exports* and government income.***

Fishing and aquaculture are primary production* activities, but the fisheries sector also includes private sector processing and trading businesses and fisheries-related public sector jobs.

How do fisheries contribute to Pacific Island economies?

Fisheries contribute to the economies of the Pacific Islands:

i. by adding to the gross domestic product (GDP)* of an economy. Fishing and aquaculture add to total domestic productivity;

ii. by generating government income from the sale of fishing licences to foreign fishing companies and through taxes that are applied to traded fisheries products;

iii. by creating employment for Pacific Islanders (see Teachers' Resource Sheet 14: Job opportunities in fisheries);

iv. by creating opportunities to export, which is an important source of foreign income and contributes to GDP growth. Government income can also be generated from tax on exports.

Three major fisheries that contribute to Pacific economies

In the Pacific, the three main fisheries include:

i. the industrial tuna fishery;*

ii. small-scale fisheries; and

iii. aquaculture.

The industrial tuna fishery

The industrial tuna fishery refers to commercial fishing* vessels that capture large quantities of fish (mostly tuna) that are sold to canneries or high-value foreign markets. There are four main categories of fishing vessels operating in the industrial tuna fishery (Fig. 1).

Figure 1. Four main categories of industrial fishing vessels operating in the Pacific.

Four species* are of major commercial importance in the Pacific's industrial tuna fishery (Fig. 2).

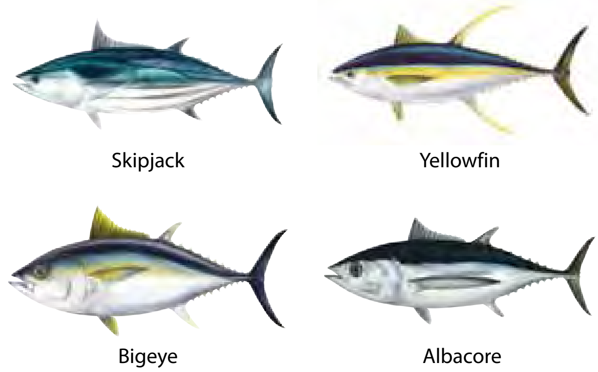


Figure 2. Four main target species* of industrial fishing vessels operating in the Pacific.

Small-scale fisheries

Small-scale fisheries can be subsistence or commercial in nature, supplying fish for local consumption and export markets. They generate income, provide food and make an important contribution to Pacific economies.

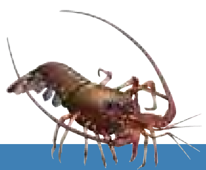
In the Pacific, the main small-scale fisheries that provide food and income to Pacific Islanders include:

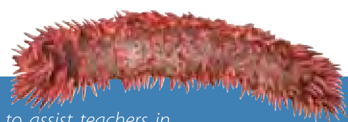
i. small-scale pelagic* fisheries capturing tuna, wahoo, mahi mahi and other pelagic fish;

ii. small-scale coastal fisheries capturing sea cucumber, trochus, reef fish, marine ornamental products and invertebrates;*

iii. demersal fisheries capturing snapper and other deepwater fish; and

iv. sport fishing tourism generating income from charter operations.





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Aquaculture

Aquaculture involves marine and freshwater production systems. Aquaculture plays an important role in food security and income generation for Pacific Islanders. Some of the important aquaculture products that are produced in the Pacific include:

Mariculture	Freshwater aquaculture
Marine shrimp	Tilapia (Nile, Mozambique, or genetically improved farmed tilapia (GIFT))
Pearl oyster	Freshwater prawn
Milkfish	Grass carp
Seaweed	
Marine ornamentals (giant clam, coral, live rock)	
Sea cucumber	

In the Pacific, in terms of income generation, the production of pearls and marine shrimp is the most valuable. In terms of economic contribution, aquaculture plays an important role in boosting domestic productivity (i.e. contributing to GDP), but also by providing foreign income from export of aquaculture products.


Colette Wabnitz © SPC

Businesses in the fisheries sector

There are many different types of businesses in the fisheries sector — some large and some small. Some businesses are involved in production (e.g. fishing vessels, aquaculture farms), some are involved in processing (e.g. tuna canneries, restaurants), while others are involved in the trade (e.g. local market sellers, exporters) of fisheries products.

Irrespective of the activity or size of a business, collectively fisheries businesses are very important to the Pacific Island economies in the sense that, as outlined above, they positively contribute to GDP, employment, exports, food security and tourism development.


Mecki Kronen © SPC

No-take areas

***Why should there be areas where we can't go fishing?** We need to catch fish for food and to make a living. However, the problem is that catch rates, say the number of fish caught in one hour, is decreasing.*

***Why is this happening?** It could be that we have caught too many and there are not enough adult fish left to reproduce and replace the numbers that we catch. Or it could be that we have damaged the environment* in which the fish live or the ecosystem* of which the fish are a part.*

Fisheries authorities and fishing communities are taking steps to manage ecosystems and fishing so that stocks of fish and invertebrates* remain at a sustainable level. Fisheries can be managed in many different ways and these are discussed in Teachers' Resource Sheet 1: Fisheries management.

One of the fisheries management tools commonly used in Pacific Island countries is establishing no-take areas* in which fishing is not allowed. In the Pacific, no-take areas may also be called fish reserves, *tabu* areas or marine protected areas. The term no-take area is preferred because its meaning is clear.

What are no-take areas?

A no-take area is an area in which all fishing or harvesting of marine life is banned, ideally on a permanent basis.

© Francis Hickey

Are there other types of restricted fishing areas?

Other types of closures include an area in which particular fishing methods are banned; for example, the use of nets may be banned even though other less damaging fishing methods, such as line-fishing, are permitted. Another is an area in which the catching of a particular species* is banned; for example, the collection of sea cucumbers may be banned in an area even though the catching of other species is allowed.

In addition there are rotational closures* in which a given fishing area is divided into smaller units which are fished in rotation; for example, if there are three smaller units, fishing is banned in the first area while the other two are open to fishing. The following year, fishing is banned in the second area while the other two are open to fishing — in this example each small unit would have one unfished year to regenerate every third year.

There are also periodic closures, such as those in which fishing is banned for a short time to protect fish during spawning.*

Although these variations are important in managing particular fisheries, it is important to have some permanent no-take areas to provide long-term protection for ecosystems and the species that they support.

What are the purposes of no-take areas?

Most scientists agree that no-take areas provide the following benefits:

a. They protect habitats, plants and animals. In scientific terms, they conserve biodiversity*.

b. They enhance fisheries in nearby areas. They provide places in which fish can grow, breed and spread to other areas.

c. They protect against environmental uncertainty such as global warming. They are more likely to contain less stressed habitats, which would be more resilient to environmental changes.

d. They provide unspoilt areas for income generating ecotourism. Tourists will pay to see well-preserved areas of corals and coral reef fish (however, visitors should keep to marked tracks, or snorkelling trails, in order not to damage reef areas).

Point b) is most important to many fishers who have to obtain seafood on a daily basis to feed their families. The basic aim is to ensure that there are undisturbed habitats and a sufficient number of adult fish to produce enough young to replace the numbers caught.

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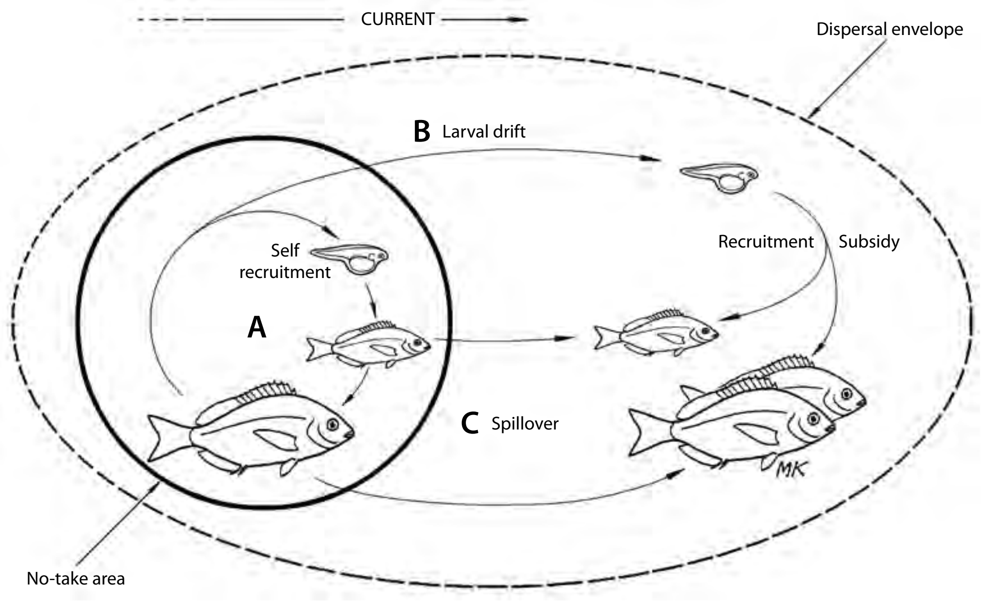
How can no-take areas increase catches?

A fishing community's expectation is that a no-take area will eventually result in improved catches outside the no-take area. In reference to the figure below, the no-take area is represented by the heavy circle.

Fish in the no-take area spawn and produce small larval stages that either A) settle and remain in the no-take area or B) drift with the currents to settle and grow outside the no-take area. Juveniles and adult fish also C) move out of the no-take area as spillover, perhaps due to crowding.

A permanent no-take area is just one way of managing a fishery* but it is an important tool in a toolbox of management controls, some of which are listed in Teachers' Resource Sheet 1: Fisheries management.



Adapted from King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Teachers' Resource Sheets on

Fish anatomy

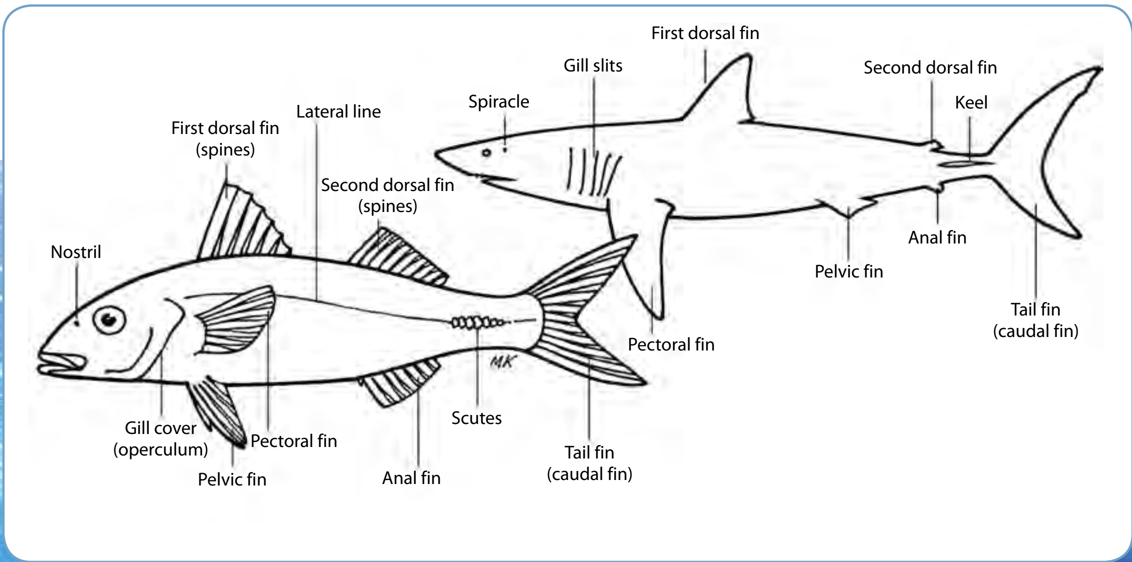
Over half of all animals with backbones (vertebrates*) are fish. There are over 25,000 different species* of fish. Some fish are adapted to eat plants and others to eat meat and they have evolved to fill all available niches* in the marine environment.* Some evolved to hunt on coral reefs and others to swim in the open sea.

External features

Fish have two sets of paired fins, the side or pectoral fins and the pelvic fins. Single fins include the dorsal or back fin, the anal fin and the caudal or tail fin.

Amazing information to think about

Fish appeared on this planet over 400 million years ago. The four limbs of all land-dwelling (terrestrial) animals with backbones that exist today are believed to have evolved from the paired fins of fish.



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Internal features

How do fish stay afloat? They are heavier than water and tend to sink. The two main evolutionary lines, the cartilaginous and the bony fish, have solved the problem of staying afloat in different ways.

Sharks and rays have a light skeleton of cartilage, a firm but flexible type of tissue. They also have a large liver which is rich in the light oil, squalene and fixed pectoral fins which act as paravanes. As a shark moves forward through the water, pressure on the underside of its pectoral fins provides uplift. Thus many, but not all, species of sharks have to swim continually to stay afloat.

The other evolutionary group, bony fish or teleosts, have heavy bones of calcium, but solved the problem of remaining buoyant in a different way. Ancient fish had lungs which evolved into the air-filled swim bladder* of modern bony fish, most of which obtain oxygen through their gills. A small number of fish can gulp air at the surface.

The evolution* of the swim-bladder allowed fish to move away from speed as a way of life. Pectoral fins, no longer required for aiding flotation, could evolve to allow a greater range of movements. Present-day bony fish use pectoral fins to hover, to swerve, to swim backwards and even, in the case of flying-fish, to glide through the air. The ability to take advantage of a variety of ecological niches, to be either bottom-dwelling or pelagic,* has allowed modern bony fish to dominate the waters of the world.

The gill rakers, comb-like structures in front of the gills, sift particles of food from the water which enters the mouth and flows out through the gill slits. The digestive system includes an S-shaped stomach leading to an intestine which is often longer in herbivores than in carnivores. At the junction of the stomach and the intestine, there are often finger-like sacs, the pyloric caeca, whose function may include aiding food absorption.

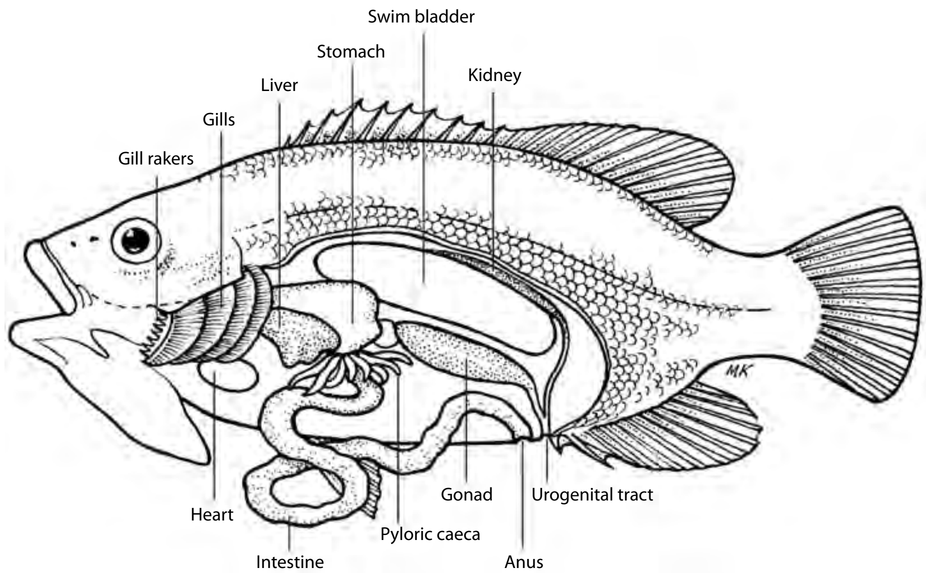
Fish have internal ears with no connection to the outside. Sound waves, travelling through the water and the head, strike dense calcium carbonate "earstones" or otoliths which float in the fluid contained in the inner ear. The otoliths vibrate against sensory hairs in the ear. As the fish grows more layers, these are deposited on the otholiths, which enables them to be used by scientists to estimate the age of some fish.

Many fish produce sounds and this is often reflected in their common English names — drums, croakers and grunts.

And, fish have one sense that we don't have. They have a lateral line which runs down each of its sides. The lateral line is believed to be capable of detecting low-frequency vibrations in the water as well as pressure changes due to different depths.

Fish have gonads* which are usually paired. In most fish, females release eggs into the sea where they are fertilised by sperm released from males. The fertilised eggs hatch to small larvae* (often about 5 mm in length) most of which drift with ocean currents.

After a period which varies from species to species, the larvae change — benthic species settle on the sea floor. The juveniles of many fish species grow in nursery areas, including reefs, banks, bays and estuaries.



The internal organs of a bony (teleost) fish.
Adapted from King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Did you know?

Fish eyes are spherical and have given their name to the photographer's fisheye lens used to take in a field of vision covering up to 180°. The eyes of many fish appear to be capable of distinguishing colours.

Marine food webs

In the sea, as on land, plant material is eaten by herbivorous animals which themselves are eaten by other, usually larger, animals. This flow of material from plants to herbivores* to carnivores* is often depicted in a diagram called a food web* that shows the feeding connections (what eats what?) in an ecological community.

What eats what?

In relation to the food web below, plants include mangroves (1), algae and seagrasses (2). Mangroves are not present in all Pacific Island countries — see Community Information Sheet 25: Mangroves.

But the most important plants in the sea are so small that most are invisible to the naked eye. These are the phytoplankton* (shown greatly magnified at point 3) that, as plants, must live in the sunlit surface layers of the sea.

Corals (4) and giant clams (5) can also use sunlight indirectly because of the plant cells, called zooxanthellae* embedded in their tissues. This relationship between two different living things that advantages both is called symbiosis.*

Larger plants in the sea are eaten by herbivorous animals such as rabbitfish (6) and sea urchins (7).

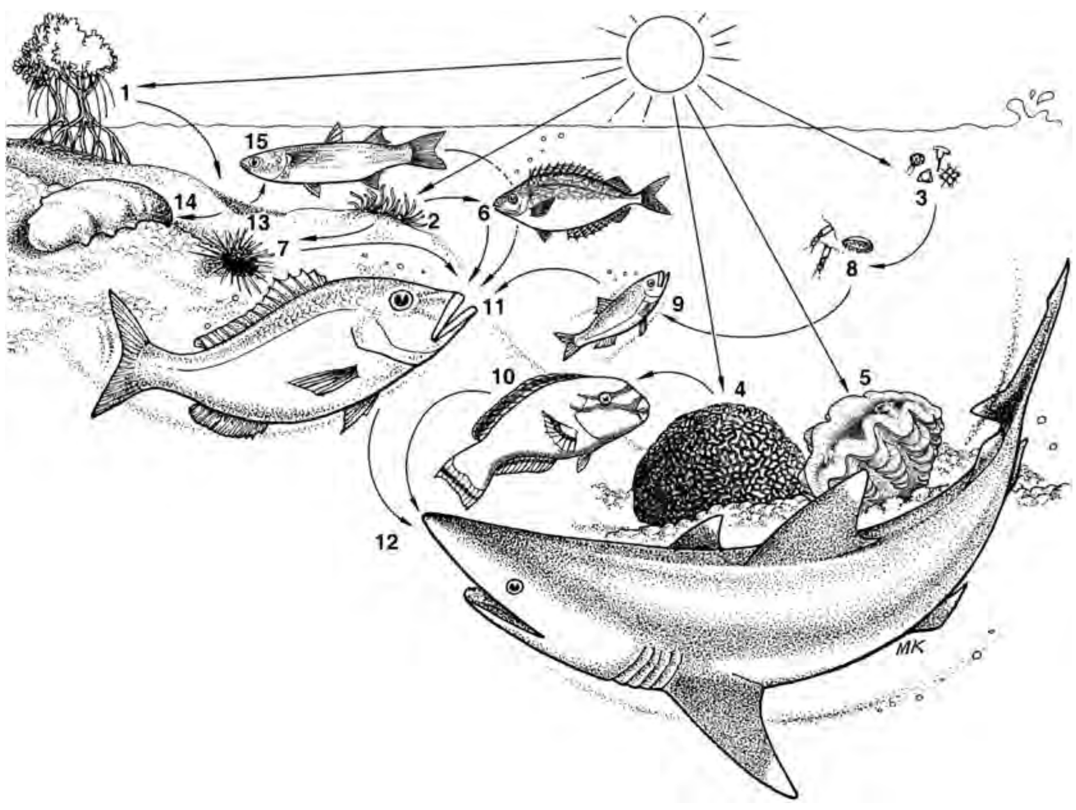
Several larger animals have evolved to take advantage of drifting phytoplankton. Bivalve molluscs,* the cockles and clams, filter out the phytoplankton. But the most important consumers of phytoplankton are the small animals, collectively called zooplankton* (magnified in 8) that drift in the sea and include the larvae* of many marine animals.

Many animals, from barnacles and corals to sardines (9) and baleen whales eat zooplankton. Also, coral polyps trap plankton in sheets of mucus or with their tentacles.

Coral grazers, such as parrotfish (10) feed on algae growing on coral.

Invertebrates* and smaller fish are preyed upon by medium-sized fish including emperors (11) which are preyed upon by large carnivores such as groupers, barracudas and sharks (12).

Bacteria* break down wastes to form detritus* (13), consumed by a wide range of animals such as the sea cucumber (14) and mullet (15).



A simplified, tropical, marine food web.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

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Why are there not many sharks on a coral reef?

Organisms can be thought of as gaining nourishment at different trophic levels* and these may be depicted as the energy pyramid shown below. The first or lowest trophic level in the energy pyramid, the primary producer level, consists of marine plant material including seaweeds (algae), seagrasses and phytoplankton.

Plant material is fed upon by animals at the next trophic level (the herbivore level) which become prey species* for carnivores (the carnivore level). And, as some fish feed on other carnivores, there may be several levels of carnivores.

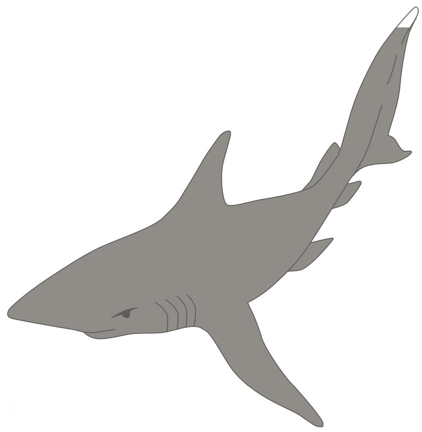
At each level most of the total weight of material or energy (the biomass*) is lost due to the use of energy for respiration, movement and reproduction. As a result, only a small proportion of the food consumed is devoted to flesh growth that may be passed on to the next trophic level. There is, therefore, a large decrease in total biomass of organisms at each succeeding trophic level.

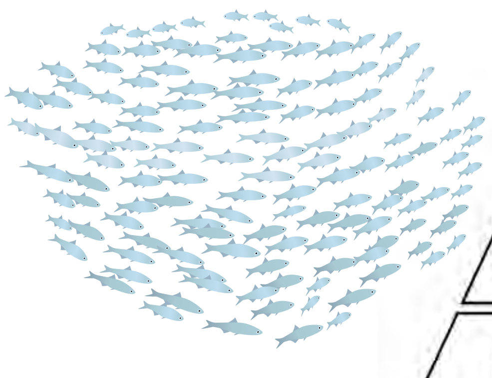
The biomass values shown to the right of the energy pyramid in the figure below arbitrarily assume a 10 per cent level of ecological efficiency — that is, the energy passed from one trophic level to the next. It therefore takes 1,000 kg of plant material to produce one kg of a higher level carnivore such as a snapper.

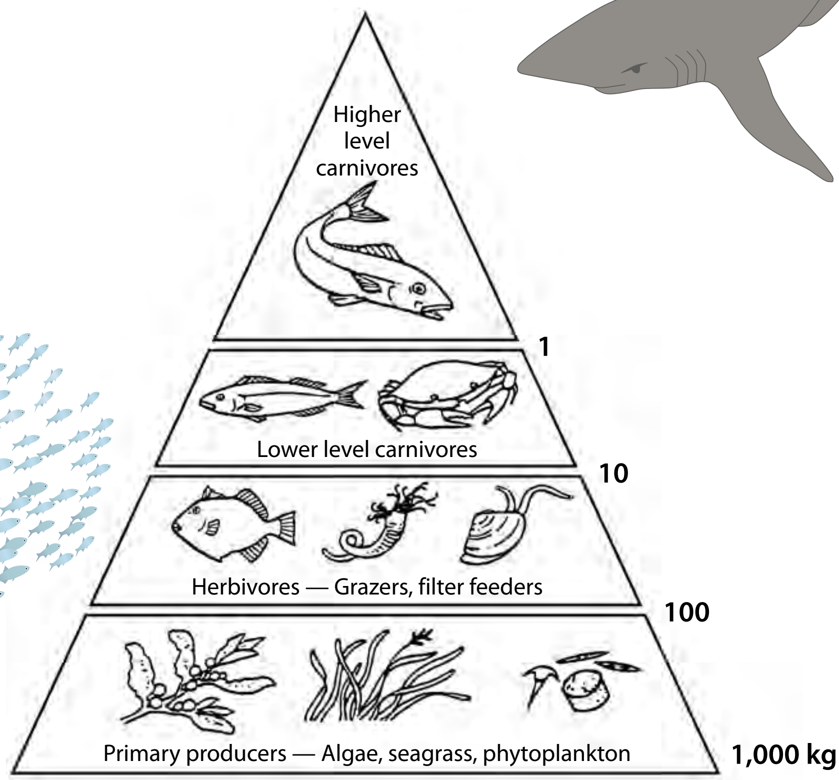
Because of this loss at each succeeding trophic level, animals at high trophic levels are unable to maintain very large populations. A top carnivore such as a large tiger shark is, perhaps thankfully, not common at all and most sharks need to swim over a huge territory to find all the food that they require.

Why we have to look after the sea and its tiny plants?

Life on earth could not exist without plants. Photosynthesis is the process by which green plants use sunlight, carbon dioxide and nutrients* (including nitrates and phosphates) to synthesise proteins,* fats and carbohydrates. Through photosynthesis, plants produce oxygen and food to support all life. Phytoplankton are responsible for half of all photosynthetic activity and produce much of the oxygen present in the Earth's atmosphere — half of the total amount of oxygen is produced by phytoplankton in the sea.*







An energy pyramid. Numbers at the right of the pyramid represent the relative biomass at each trophic level assuming an ecological efficiency of 10 per cent.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Oceanic species

Imagine living out on the surface of the open sea — being hunted by birds from above and by larger fish from below - and with no place to hide!

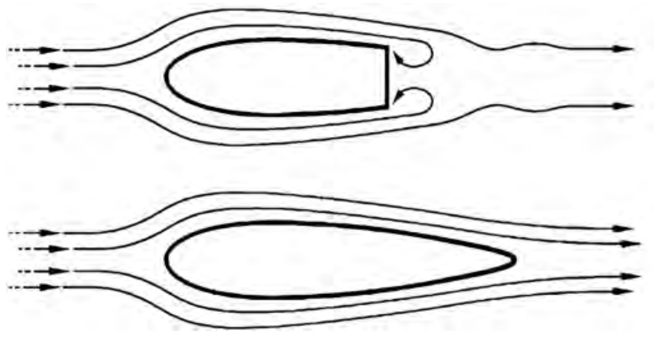
But a few species* have managed to adapt to this difficult pelagic* environment.* The best known of these are the species of tuna, which are distributed over large areas of the Pacific Ocean where they hunt smaller fish. Other oceanic species include billfish*, mahi mahi and wahoo.

Tuna are caught by local fishers often by towing (or trolling) lures behind small boats. Commercial fishing* vessels use longlines and purse seines — these fishing methods are described in Teachers' Resource Sheet 16: Modern fishing methods. Here, we are more concerned with the amazing adaptations of fish that live in the open sea.

Pelagic fish rely on speed to catch their prey and to avoid predators*. And, as water is "thicker" than air (in fact, 800 times more dense* than air), any part of the body that creates friction or turbulence causes a large amount of drag. Compared with travelling through the air, travelling through water is like moving through honey!

In many fast fish, the pectoral or side fins are used as brakes and rudders and fit into depressions in the body when the fish is swimming at speed. The caudal or tail fin, which provides the propulsion, may be shaped like a scythe, with both a long leading edge and a small surface area (a high aspect ratio).

But the shape of the body is most important. The best shape is one of a spindle or tear-drop, called a fusiform shape, as this offers the least resistance or drag when moving through the water. Independently, this fusiform shape has evolved in aquatic mammals such as dolphins and whales. Not so independently perhaps, marine architects have used the shape in designing boats.



Laminar flow* of water past a blunt-ended shape (top), which creates turbulence and drag and flow past a fusiform shape (bottom) which minimises drag.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Life in the fast lane

In addition to their shape, tunas have other adaptations that assist with their fast life. Unlike most other fish, tunas are warm-blooded and keep their bodies at higher temperatures than the surrounding water. A higher body temperature allows increases in muscle power and may account for a tuna's ability to swim at speeds of over 50 kilometres per hour to catch smaller fish. But another oceanic species is much faster.

Which is the fastest animal on the planet?

This is undoubtedly the peregrine falcon, a bird of prey, which can dive at over 300 kilometres per hour. The fastest land animal is the cheetah which can run to catch its prey at over 100 kilometres per hour. But in the sea, the fastest fish is the sailfish.

Bulbous bows?

Have you seen pictures of ocean-going ships below the waterline?

They often have a rounded bulb or bulge sticking out at the bow (or front) just below the waterline. The bulbous bow makes the ship's underwater profile more fusiform and allows water to flow around the hull more easily. Large ships with bulbous bows generally have a 12% to 15% better fuel efficiency than similar vessels without them.

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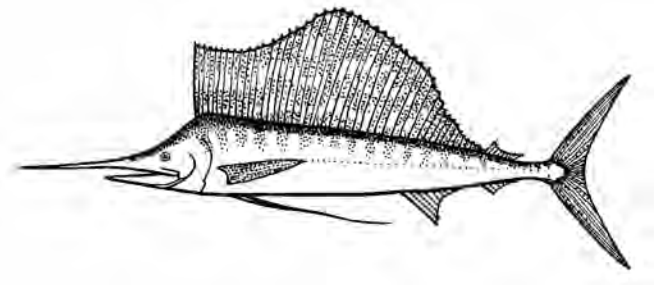
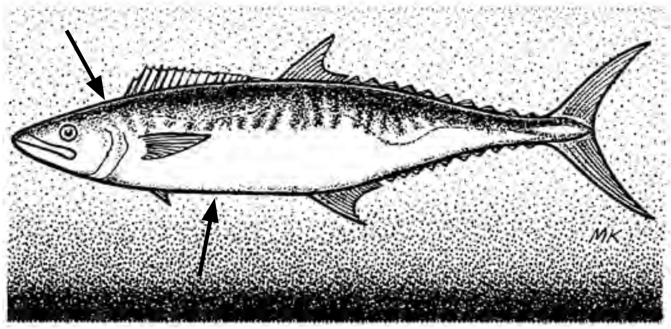




Counter-shading in a pelagic fish.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Sailfish, which can grow to reach 100 kilograms, have large, sail-like dorsal fins more than twice as high as the body is deep. They appear to hunt in groups and their tall blue dorsal fins, cutting through the surface of the sea, are used to herd prey species into a tight ball. The sailfish then move through the ball, slashing from side to side with their long bills to kill or maim the smaller fish. With a timed short-burst swimming speed of 110 kilometres per hour, the sailfish may be the fastest non-flying animal on the planet.

In the open sea, you can swim but cannot hide — or can you?

Most pelagic fish have a very subtle form of camouflage* called counter-shading to avoid predators. Fish that habitually swim near the surface often have dark backs that shade to lighter underparts. To a predator swimming below such a fish, the lighter underparts appear the same shade as the sky and the bright surface of the sea. But to a predator such as a sea bird flying above, the dark back of the fish merges in with the deep blue shades of the sea.

Marc Taquet © FADIO/IRD-Ifremer

Teachers' Resource Sheets on

Bonefish

What is the most valuable fish in Pacific Islands? Tuna, because of its export value? Or emperors — the most commonly caught reef fish? No, it's a fish that is full of bones and not often caught to eat.

Recreational fishers,* who regard bonefish as prized sportfish because of their fighting ability, are prepared to travel great distances to catch them. The fishers buy local food, stay in local accommodation and often pay for local guides.

And because most fishers release bonefish immediately after capture, one fish can be caught and released many times. One bonefish, therefore, has the potential to bring many thousands of dollars to a local community.

The fish

Are all bonefish the same? Evidently not — there are several different species* of bonefish but the one most commonly caught by fishers in the Pacific has the scientific name* of *Albula vulpes*. Bonefish are silver with darker fins and can reach a length of up to 90 cm. The world International Game Fish Association (IGFA)* record is 8.62 kg for a bonefish caught in South Africa in 1962; since then there have been unconfirmed reports of fish weighing more than 9 kg.

Bonefish are named for the many fine bones they contain or for their elusive habits, with names such as grey ghost. In French Polynesia they are called *o'io*, *albule* or "sorte de mulet".

Recreational fishers stalk bonefish as they move across shallow sandy areas hunting shrimps, small molluscs and crabs. Bonefish are caught by fly fishing* — a special method in which fishers use a rod and reel with a line and an almost weightless fly or "lure" to encourage the fish to strike.

Although larger bonefish may swim either alone or in small groups, smaller fish often travel in large schools.* As medium-sized predators,* bonefish are an important link between invertebrates* and larger predators in marine food webs* (see Teachers' Resource Sheet 6: Marine food webs).

Bonefish are generally not preferred as food although they are eaten in some countries such as Hawaii, Kiribati, French Polynesia and the Cook Islands. However, they are highly valued by sports fishers and have the potential to be of great economic benefit to countries in which they are found.

Lifecycle

Bonefish reach sexual maturity between 3 and 4 years of age. In the Pacific, bonefish appear to spawn in deeper water over several months of the year around the time of the full moon.

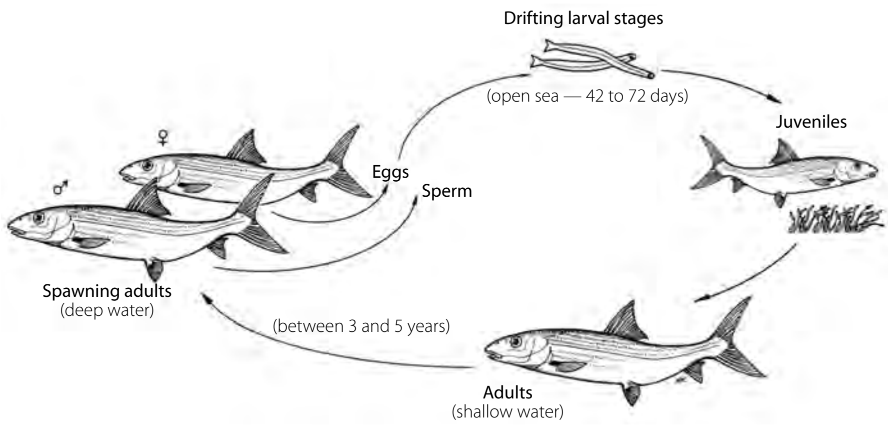
Fertilised eggs hatch into larvae* which drift in the ocean for long periods, perhaps for over two months. Many larvae do not reach areas in which to settle and many others become food for other fish. Only a small number of drifting larvae survive to settle in shallow sandy areas where they grow into juveniles that look like miniature versions of their parents.

Bonefish may live for more than 19 years but are taken by many predators including sharks and barracudas. Their main defences are their cautious behaviour and fast escape speed. For these reasons, fishers find that schools of bonefish are easily frightened or "spooked" and the fish are difficult to catch.

Habitat

Adult bonefish are commonly found in intertidal flats, mangrove areas, river mouths and deeper adjacent waters.

A fish that breathes air? Bonefish can live in waters, such as in warm lagoons and creeks, that contain very little dissolved oxygen — they do this by swimming to the surface and gulping air into a lung-like swim bladder* (see Teachers' Resource Sheet 5: Fish anatomy).



The life-cycle of the bonefish.

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Distribution

Bonefish inhabit tropical and warm temperate waters around the world. They are fished on the east coast of North and South America and the Caribbean. They have been found in several Pacific Islands including New Caledonia, Fiji, Cook Islands, Kiribati and French Polynesia.

Management

All fisheries need to be managed to ensure that fish stocks are not overexploited* and continue to provide benefits to people in the future.

Some managers have imposed direct measures to protect bonefish stocks. In the Cook Islands fishery* in Aitutaki, for example, fishers are required to have a permit and to fish only in designated areas. Fishing in spawning* areas is prohibited from three days before until three days after the full moon.

Most sports fishers release their catch immediately after capture. This type of fishing, called "catch and release", involves fishers returning caught fish to the water as quickly as possible. This practice is likely to protect bonefish from overexploitation.

However, management actions could include protecting important bonefish habitats* including seagrass beds in lagoons and limiting the number of local guides in a given area.

Michel Blanc © SPC

Pearl oysters

A pearl oyster is a bivalve (or two-shelled) mollusc* and is therefore related to mussels and clams. And a pearl is a pearl oyster's way of protecting itself from damage to its flesh.

If a parasite or a sharp grain of sand gets inside its shells, the oyster can cover it with layers of smooth pearl. These gleaming layers around the irritant become a blister attached to the inside of the shell or, much less commonly, a free spherical pearl that can be very valuable.

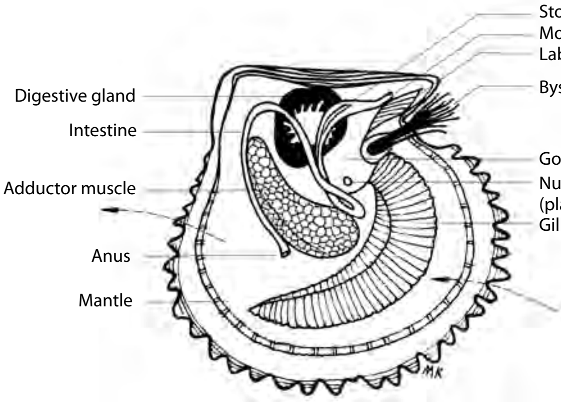
Anatomy

The pearl oyster relies on pumping seawater over its gills. The gills consist of four crescent-shaped flaps covered with fine hairs called cilia, which move water through the inside of the gaping shells. The oyster's gills, like those of a fish, are responsible for extracting oxygen that is dissolved in the water.

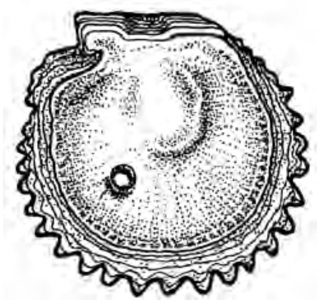
The gills also filter food — microscopic floating plants (phytoplankton)* from the water. The cilia pass the food particles to the mouth, which is hidden under two horizontal lips, the labial palps. The mouth leads into the stomach contained within a brown mass called the digestive gland. Used food passes along an intestine to pass out of an anus, conveniently placed where water currents leave the oyster.

Why is it so difficult to open the shells of a living oyster? The largest muscle in the oyster, the adductor, holds the two shells tightly shut if the oyster is exposed at low tide or threatened by a predator* — although many bivalve molluscs have two adductor muscles the pearl oyster has only one.

Oysters usually have separate sexes and the gonads* in both sexes are creamy yellow in colour. Sperm and ova develop in the gonads of males and females respectively.



A pearl oyster with one shell, one mantle and gill lobes removed. The broken arrows show the flow of water through the shells.



The black-lipped pearl oyster, *Pinctada margaritifera*, with one of its shells removed and a pearl lying on the oyster's mantle.

An amazing living filter

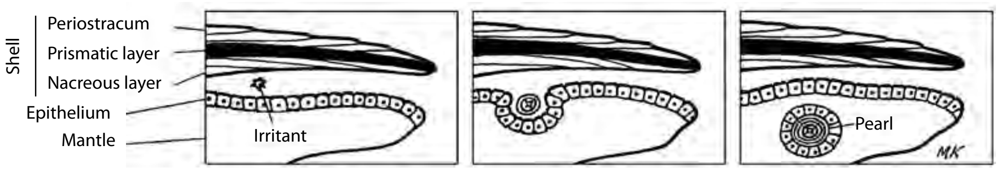
When the pearl oyster's two shells gape open it can pump up to 20 litres of water each hour removing food and gaining oxygen from the sea.

Shell and pearl formation

How does an oyster with two hard shells grow in size?

The oyster's body is covered by the mantle, a fold of tissue, edged with small tentacles. The mantle has specialised cells that produce additional shell material as the oyster grows and can encase irritants with concentric layers of mother-of-pearl or nacre.

A cross-section of a typical mollusc shell is shown in the figure at the back. The shell consists of three separate layers, an outer periostracum, a middle prismatic layer and an inner nacreous layer made up of thin layers of nacre. Iridescent colours are created by light waves reflected from the thin overlapping layers.



Pearl formation in pearl oysters. An irritant between the shell and the mantle is enveloped by the mantle which produces concentric layers around it. Very rarely, a pearl is formed around the object.
From King M. 2007. Fisheries biology, assessment and management. UK, Oxford: Wiley-Blackwell. 400 p.

Pearl farming

In the Pacific region, the black-lipped pearl oyster, *Pinctada margaritifera*, is grown, often on hanging ropes, to produces dark coloured pearls. After growing in the sea for about two years, each oyster has a small bead inserted in it by a skilled technician — a process called seeding.

It takes another two years for layers of nacre to be laid down around the bead and for the pearl to develop inside the oyster. Within a lifespan of 10 years, an oyster can be seeded and produce pearls several times. Many factors affect the success rate, but out of 100 oysters seeded, typically only five will produce a high quality, round pearl.

Management

Management is necessary to ensure that pearl farms continue to be productive and provide benefits to the farmers and the country.

The sites of pearl farms have to be carefully chosen to ensure that sea currents are sufficient to bring food and remove waste material from the oysters as they grow. Farms must be well spaced to avoid poor growth and the spread of oyster disease. As a healthy oyster is needed to produce a good pearl, it is in the interest of farmers as well as government authorities to maintain good environmental conditions.

Freshwater fisheries

10

Although there are very few freshwater fish and invertebrates* in many Pacific Islands, several species* are important food items. Sometimes the production from freshwater fisheries is surprising — in Fiji, for example, the largest fishery* on a single species is based on the freshwater clam,* Batissa violacea *or kai, which women collect from rivers.

Where are freshwater species distributed?

The greatest number of freshwater fish are found in the west of the Pacific Ocean where the high islands of Melanesia, such as Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia and Fiji, have many rivers and lakes suitable for freshwater species.

Where did freshwater species come from?

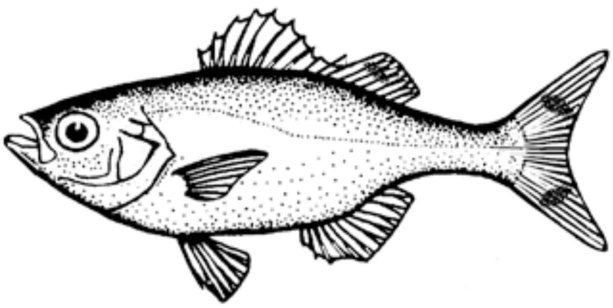
Many freshwater fish are believed to have originated from seawater species that have become adapted, perhaps over many thousands of years, for living in fresh water. A less likely possibility is that their ancestors managed to cross the sea from areas in the west. Perhaps larval stages crossed the sea in pockets of fresh water trapped in rafts of trees blown over during cyclones.

Here we discuss four widely distributed freshwater species — one fish, one prawn, an eel that spends part of its life in fresh water and one introduced species of fish.

Flagtails

Several species of fish called flagtails are found in fresh water across the Pacific. These silvery fish have dark stripes on their tails and belong to the family Kuhliidae. They are variously called *aholehole*, *sesele*, *sakelo*, *ika droka*, *mahore*, *umatari*, mountain trout and flagtail perch.

One particularly large species is the jungle perch, *Kuhlia rupestris*, which grows to 45 cm in total length and 3 kg in weight, and is an important subsistence food, particularly in the interior of the large islands.



i

A hotspot of biodiversity — the Coral Triangle*

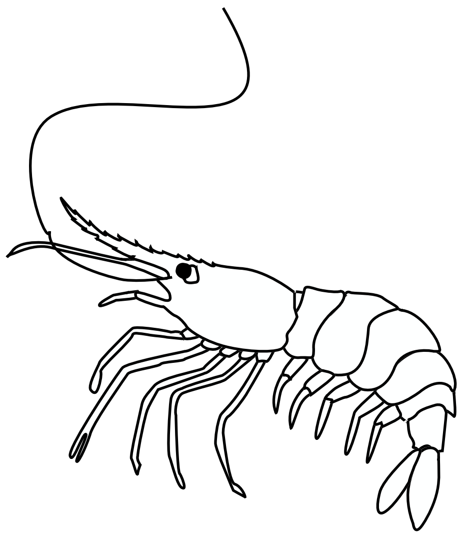
The Coral Triangle (a region comprised of the Philippines, Malaysia, Indonesia, East Timor, Papua New Guinea and Solomon Islands) contains a larger number of different species than most places in the world (it is said to have a large biodiversity).

Many species, including corals and mangroves, appear to have spread out from this area to Pacific Islands. And, because of the difficulty of larval stages reaching far away islands, the number of species decreases across the Pacific from west to east.

Freshwater prawns

Freshwater prawns (*Macrobrachium lar*) are distributed from Africa across the Pacific as far as the Marquesas. Their common names include Tahitian prawn, monkey river prawn, ghost shrimp and glass shrimp.

The prawns are collected as food and there has been some interest in farming them; however, there has been a preference for farming the giant freshwater prawn, *Macrobrachium rosenbergii*.



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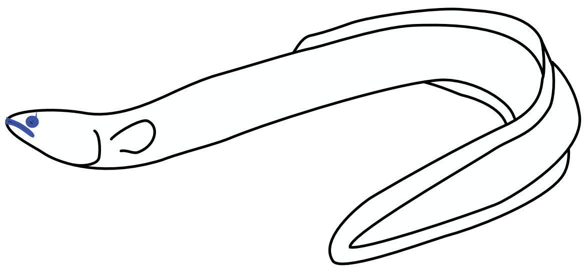
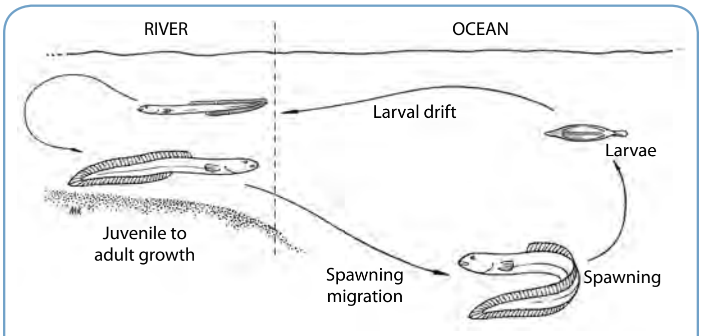
Eels

Eels belonging to the genus* *Anguilla* have a fascinating life-cycle.

The mature adults migrate from the relative safety of freshwater rivers over huge distances to breed in the deep dark sea. Here at the place where they were born, they breed and are then believed to die thousands of kilometres from the rivers where they lived for most of their lives.

The eel larvae* drift with sea currents and change into the colourless small eels known as glass eels as they reach land. After they adjust to fresh water, the eels migrate well into the upper reaches of river systems where they may gain weights of 20 kg.





Anguillid eel life cycle.
Adapted from King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Eel confusion?

The eels described here should not be confused with moray eels of which there are many species living in sea water on coral reefs.

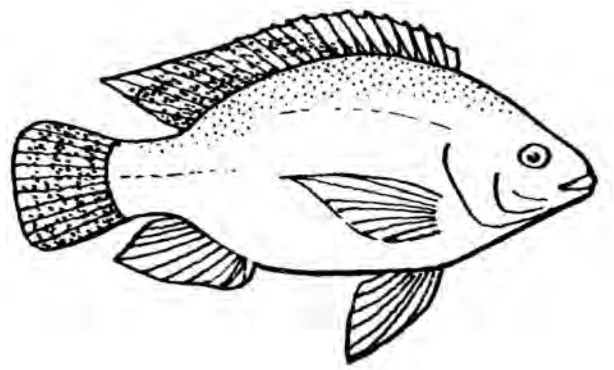
Snake-like eels?

In damp conditions, eels can move around dams and waterfalls by wriggling across land with a movement like snakes.

Tilapia

Tilapia were introduced into several Pacific Island countries from Africa beginning in the 1950s. As the species is easy to breed and eats low-cost foods, the fish was introduced for freshwater fish farming. Tilapia have been farmed in Fiji, Vanuatu, Papua New Guinea and the Cook Islands for many years.

However, the species of tilapia originally introduced to the Pacific was the slow-growing Mozambique tilapia (*Oreochromis mossambicus*) whereas 90% of the tilapia farmed globally today is Nile tilapia (*Oreochromis niloticus*).



Friend or foe?

The introduction of exotic species is not without risk. On one hand, tilapia farming can provide food for local people. On the other hand, introduced tilapia may compete and displace indigenous* freshwater fish.*

Aquarium fish

Many people around the world love to watch colourful fish swimming in a glass tank. And the most popular are those from tropical coral reefs. Many of these fish come from the Pacific Islands.

© Haplochromis

An aquarium is a tank, usually made of glass, in which people keep aquatic species.* A freshwater aquarium is easier to stock and maintain but a marine aquarium is usually much more spectacular, particularly if it contains colourful tropical species.

Where and what species?

The export of coral reef fish, hard and soft corals, giant clams, live rock and a number of reef invertebrates* (such as sea stars, crabs and shrimps) from Pacific Island countries and territories started in the 1970s. It has since expanded to become an important source of income and employment for a number of communities in the region.

Live rocks?

The rock itself is not alive but made up of the calcium carbonate skeletons of long dead corals. However, over time, this rock has been bored into by worms, sponges and bacteria and other marine species. It is considered useful in that it is porous and has a large surface area for bacteria to colonise. The bacteria improve water quality by using nitrogen waste.*

The trade currently operates from many countries including Fiji, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, French Polynesia, Marshall Islands, Tonga, Cook Islands, Federated States of Micronesia, Kiribati and Palau.

According to data collected by SPC, the six most commonly exported species include the following in order of decreasing importance:

- southseas devil (*Chrysiptera taupou*) from Fiji;
- whitetail *Dascyllus* (*Dascyllus aruanus*) from Fiji;
- anemone clownfish (*Amphiprion percula*) from Solomon Islands;
- bicolour angelfish (*Centropyge bicolor*) from Fiji;
- twospined angelfish (*Centropyge bispinosus*) from Fiji;
- sapphire devil (*Chrysiptera cyanea*) from Solomon Islands.

In most countries the collection of marine species for export is a relatively small operation. However, the trade provides employment, mostly in rural communities and contributes to the earning of foreign exchange.

Colette Wabnitz © SPC

The majority of aquarium fish are caught on the reef slope in depths of less than 35 metres, with occasional specimens taken at depths in excess of 50 metres. The fish are generally caught one at a time by experimented divers using scuba and either a small meshed surround net or a hand-held scoop net.

The standard method of packing live aquarium fish for air freight involves placing the fish in a plastic bag or container with clean sea water. The bag is then inflated with pure oxygen and packed in strong styrofoam containers for transport.

The use of damaging collection techniques such as those based on the use of sodium cyanide, quinaldine and rotenone (all of which are fish anaesthetics) is generally banned both by the aquarium fish collectors and governments. The capture of some fish may involve the removal of selected branches of coral. But this damage is minimal and the branches can be re-planted to grow into another colony.

Management

Many Pacific Island countries have or are in the process of developing management plans to effectively develop, monitor and regulate the aquarium fish trade.

The industry is a non-damaging one as only a few selected species are harvested for export. And the most desirable species are small, brightly coloured fish that are generally not sought after for food by local fishers.

The aquarium keepers who buy the fish are often concerned about the possible impacts of taking large number of fish from coral reefs and may selectively source aquarium fish from well-managed operations and from countries with management plans. Some buyers are looking to stock their aquarium with fish that have been grown in aquaculture facilities.

At the moment SPC is working with industry to develop standard best practices that can be effectively and efficiently applied at the local scale by all. The standards are to achieve the following goals:

- the promotion of sustainable fishery* practices;
- the fostering of good fishing and handling practices prior to export; and
- the promotion of good packing practices at export.

Antoine Teitelbaum © SPC

Fish spoilage

Spoilage refers to food becoming unfit to eat. Like almost any other food, seafood must be handled and stored correctly to maintain its quality and to ensure it is safe to eat.

Seafood not handled correctly goes through changes due to the action of bacteria* and enzymes* that make it taste bad and eventually become dangerous to eat. The food is then said to have "gone off" or "gone bad".

Spoilage by bacteria

Bacteria are the usual cause of seafood spoiling. Surface slime, gills and the gut of a living fish contain millions of bacteria. After the fish is caught, the numbers of bacteria increase dramatically and can cause illness and food poisoning. Cooking will kill bacteria but may not degrade the toxins* that they have produced.

What is the only natural food that doesn't go bad?

Most food goes "bad" because of the growth of bacteria and fungi, neither of which can survive in honey. Why? Honey is a very concentrated solution of sugars which draws water out of cells such as those of bacteria by osmosis* — the bacteria therefore shrivel up and die. The ancient Egyptians used honey for dressing wounds and some doctors have started using it again to kill bacteria.*

Spoilage by enzymes

Enzymes are present in all living things and are important in promoting the building of tissues as well as digesting food. After a seafood species* is caught, enzymes continue to work and start to breakdown and soften the flesh.

Histamine poisoning* is one of the common types of non-bacterial fish poisoning. Histadine occurs naturally in many fish including tuna, mahi mahi, marlin and sardines. If the fish is not chilled immediately after capture and not kept at temperatures less than 16°C, histadine is converted to histamine.

Because histamine is not destroyed by heat, even cooked fish will cause reactions that are often severe. Symptoms include allergic responses, a metallic taste, nausea, vomiting, abdominal cramps, diarrhoea, facial flushing and dizziness. Taking antihistamines (found in many hay-fever tablets) will usually give relief.

What does a properly handled fish look and smell like?

Properly handled fish have eyes that are clear and bright, scales or skin that are shiny and red gills that smell seaweed fresh. When raw, the flesh is firm and does not separate easily; when cooked, the flesh does not have a honeycombed appearance.

Stages of spoilage

After being caught, a fish quickly dies and goes through three stages, sometimes known as the three stages of *rigor*.*

Stage 1: (immediately after death) The fish feels soft to the touch. Fish just caught is very fresh and has a pleasant, seaweedy and delicate taste. The fish flesh begins to be affected by the action of its own enzymes immediately after the fish is caught.

Stage 2: (several hours after death, depending on temperature) The fish becomes stiff to the touch. The action of enzymes continues and histamines develop in some types of fish. There are no bad smells but there is some loss of flavour in the flesh.

Stage 3: (a day or more after death) The fish becomes soft to the touch again. Bacteria and enzymes are more active in this stage. The build up of bacteria causes unpleasant smells and the flesh becomes either watery or tough and dry.

The times taken for fish to go through the above stages are highly dependent on temperature. After these stages the fish becomes rapidly spoiled and is likely to cause food poisoning if eaten.

Twice as nice on a bed of ice

After capture, a fish should be covered with a wet bag or palm leaf, or even better, kept on ice. Ideally, fish should be kept on ice from the moment they are caught. At low temperatures between -1°C and +4°C both the action of enzymes and bacteria are greatly reduced and the edible life of fish can be extended to more than a week.

Keep it clean

In addition to keeping fish on ice from the moment they are caught, cleanliness and hygiene are essential to ensure there is little build-up of harmful bacteria and other micro-organisms.

- Wash all fish baskets or containers;
- wash hands frequently while gutting, gilling and preparing seafood;
- wash all work surfaces and utensils used;
- wash fish fillets in clean drinkable water before putting back on ice.

Fabrice Bouyé © SPC

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Teachers' Resource Sheets on

Fish poisoning and ciguatera

Eating fish that hasn't been kept on ice can make you very sick! This is because of the build-up of enzymes* and bacteria* — see Teachers' Resource Sheet 12: Fish spoilage.

But there are other forms of fish poisoning that are not caused by poor handling and are not caused by bacteria. These include ciguatera* fish poisoning and what is broadly called shellfish* poisoning. These forms of poisoning are caused by harmful algal blooms — a dramatic increase in the numbers of very small plants (the phytoplankton)* that float in the sea.

Harmful Algal Blooms (HABs)

Populations of phytoplankton periodically go through massive increases in numbers. These increases are referred to as plankton* blooms and a few species* produce strong toxins.*

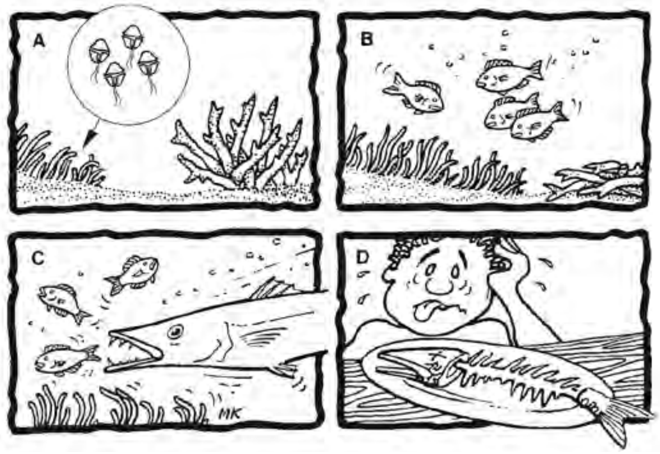
The main culprits are dinoflagellates,* small and very abundant members of the marine plankton; they consist of single cells with two whip-like threads or flagella, which they use to move through the water.

These blooms of toxic species (called Harmful Algal Blooms or HABs) are responsible for fish and shellfish poisoning in humans in many parts of the world.

> *i*
>
> *Myths about recognising fish with ciguatera*
>
> *One common belief is that toxic fish can be recognised by exposing a fillet of the fish to flies or ants — the flesh is regarded as poisonous if the flies avoid it. Another belief is that a toxic fish can be recognised by placing a silver coin on the flesh — if the coin turns black, the flesh is not safe to eat. Unfortunately these tests and many other widely trusted ones, do not work.*

Ciguatera fish poisoning (CFP)

Ciguatera Fish Poisoning (CFP) is common across the tropical Pacific. CFP results from the consumption of fish that have accumulated toxins produced by several organisms including the bottom-living dinoflagellate, *Gambierdiscus toxicus*. The sequence of events leading to ciguatera is shown in the following figure.



A cartoon used to raise community awareness of ciguatera in Pacific Island countries. The sequence of A) to D) is described in the text.
From King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

A The toxic dinoflagellates (shown greatly magnified in the circle) occur as a film on corals and seagrass. Their numbers increase dramatically when there are high levels of nutrients* in the sea — such as during the wet season when nutrients are washed from the land by rain and released from coral reefs damaged during cyclones. Sewage* and agricultural fertilisers entering coastal waters also add to the load of nutrients. Outbreaks of ciguatera have been associated with activities such as harbour dredging and the illegal use of explosives for fishing.

B Small grazing fish feed on the dinoflagellates and toxins build up in their flesh.

C Large predatory fish eat the smaller fish and the toxins become more concentrated in the flesh of the larger fish. By magnification up the food chain, the toxins reach dangerous levels in top carnivores such as some emperors, snappers, trevallies, barracudas, moray eels and large spanish mackerels.

D People eating these usually edible fish suffer from tingling, numbness, muscle pains and a curious reversal of temperature sensations (cold objects feel hot to touch). In extreme cases, death occurs through respiratory failure.

Unfortunately, the toxins cannot be destroyed by cooking or freezing. And in spite of widespread folklore on the subject, there is no reliable, cheap test to determine whether or not a particular fish is ciguatoxic before consumption.

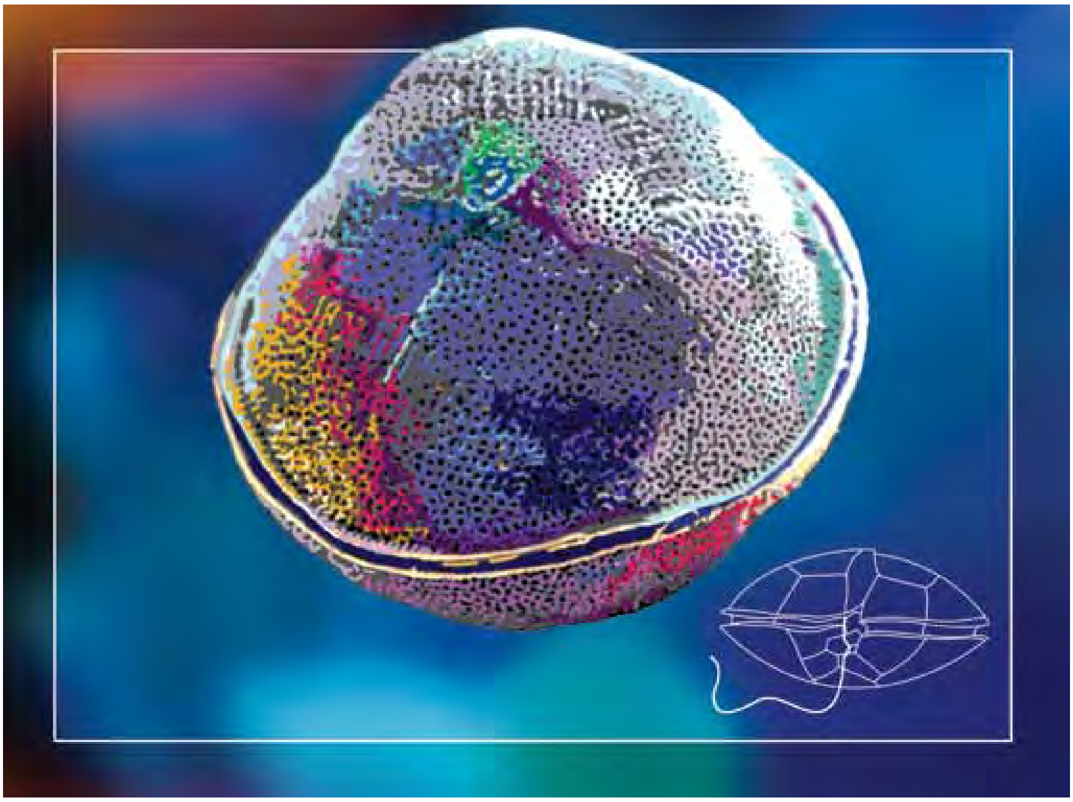
Shellfish poisoning

Other harmful algal blooms cause several conditions collectively called shellfish poisoning. The poisoning is mainly caused by eating filter-feeding shellfish (such as clams, oysters and mussels) that sieve the toxic phytoplankton from the water. Each type of poisoning is caused by different species of toxic phytoplankton and is often named after the symptoms caused.

- The condition called paralytic shellfish poisoning may cause people to stagger about and have trouble talking.
- Neurotoxic shellfish poisoning affects nerves and may cause dizziness, fever and a reduced heart rate.
- Amnesic shellfish poisoning can result in confusion and amnesia (loss of memory).
- Diarrhetic shellfish poisoning is characterised by severe diarrhoea and vomiting.

Marine toxins in the air?

Some HABs toxins can become airborne (as toxic aerosols) because of wave action and cause people swimming and even just walking on the shoreline to suffer respiratory asthma-like symptoms from inhaling the airborne droplets.



Gambierdiscus toxicus
From SPC/IRD Ciguatera field reference guide:
http://www.spc.int/coastfish/en/component/content/article/340-ciguatera-field-reference-guide.html

Teachers' Resource Sheets on

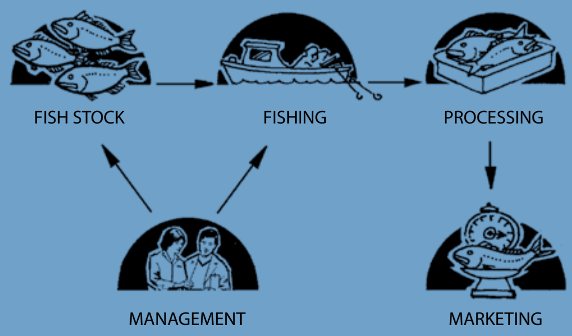
Job opportunities in fisheries

Want a job that is active and interesting? A job that helps to feed families and communities?

Then working in fisheries is for you.

A fishery* is not just about fish. Of course, the fish are most important but there are fishers who catch them, people who process and market the catch and fisheries managers who ensure that fish stocks remain healthy.

Fisheries work is exciting — it can involve inside and outside work depending on your preferences. Some people work at sea and some work in markets and some work on computers. But the work is always varied and interesting. The different types of jobs are discussed under the headings in the above figure.



Management

All fisheries resources need to be managed to ensure that fisheries remain sustainable — that is, they remain capable of providing food forever. Biological and economic data on the resource and the activities of fishers are collected by fisheries scientists, statisticians and economists. These professionals provide information on the status of fisheries resources and suggest policies for development and management.

Fisheries management jobs are available not only with government fisheries authorities but with non-governmental organisations (NGOs). Both of these often work with fishing communities which have much traditional knowledge of fish stocks and the environment.*

Jobs with fisheries authorities are often an exciting mixture of work in the field, the laboratory and the office and usually require university qualifications.

Fishing

Fishers are the people most directly involved in a fishery — both men and women who work on shorelines and at sea on vessels ranging from canoes to large tuna vessels. Any position of responsibility on a larger vessel requires sea-going qualifications.

In more technical fisheries, fishing gear technologists design and build fishing gear and experiment with new methods of catching fish. Some fishing operations, particularly those offshore, are dependent on boat builders providing sound fishing vessels. Trade qualifications are usually required to work with a boat builder.

Young fishers often learn their trade informally from older, more established, fishers. There are, however, training opportunities in many Pacific Island countries — skills in navigation and sea safety are also required. SPC is also involved in fishers training.

Processing

The catch landed by fishers is usually processed — which may range from the simple storage of fish on ice to the technologically more complicated procedures of freezing and canning. In some islands, many people are employed as unskilled or semi-skilled labour in tuna processors and canneries.

Seafood technologists, usually with university training in chemistry, biochemistry or bacteriology, ensure the quality of seafood and work on the development of new products. The development of value-added products, such as smoked fish, is one way of increasing the value of the catch.

Marketing

Marketing may refer to the sale of fish from a local market but, in the case of exported seafood, involves securing overseas sales and transporting the catch to foreign countries. Young people intending to work in this area may require qualifications in small business management and accounting.

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Related activities

Other marine activities include aquaculture, sports fishing and ecotourism.

Aquaculture operations, including prawn, fish and pearl farms, require biologists, technicians, engineers and divers as well as marketing and sales specialists.

Tourism-related activities include working on charter fishing vessels, acting as fishing guides and being part of recreational dive and snorkel tour operations.

Training

Fisheries careers are varied and stimulating. They often involve practical skills, such as seamanship and diving, as well as intellectual skills, such as analysing data with computers; perhaps it is this mixture of active, open-air tasks and stimulating office or laboratory work, that makes fisheries work so interesting.

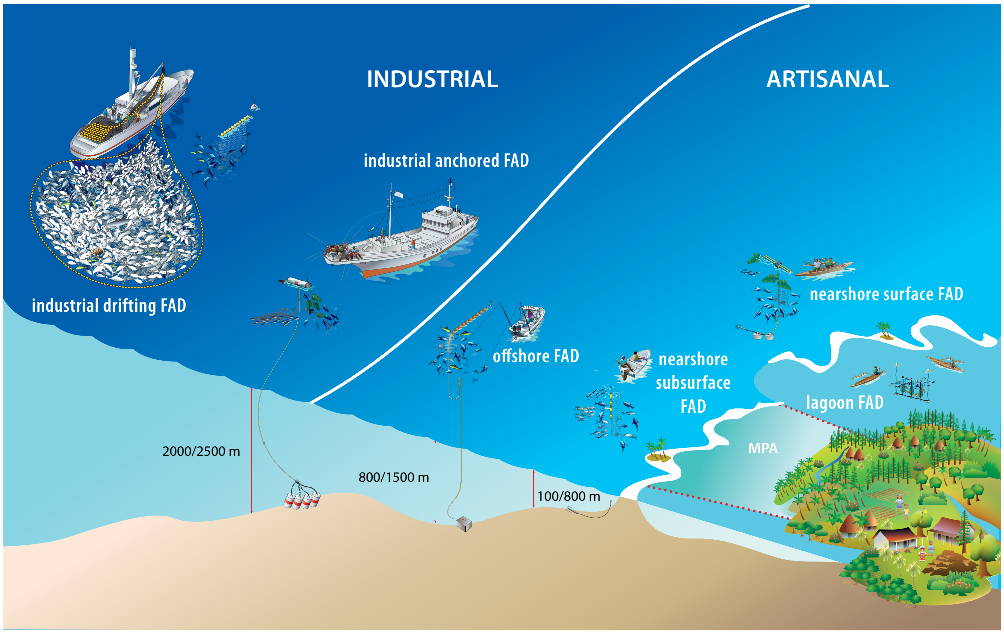
Some careers involve university study while others can be pursued after intensive practical training. Fisheries and marine environmental courses are available at the University of the South Pacific in Fiji and at universities in Hawaii, New Zealand and Australia.

Whichever career in fisheries is decided upon, the student can look forward to entering a life of stimulation and adventure, working with other qualified and highly-motivated individuals surveying, developing, managing and conserving marine resources for the benefit of current and future generations of Pacific Island people.

Aymeric Desurmont © SPC

Fish aggregating devices (FADs)

What are FADs? *Fish aggregating devices (FADs) are drifting or anchored buoys or rafts that attract and aggregate pelagic* fish, making them easier to find and catch. Fishers have long known that fish congregate around naturally occurring floating logs or other debris including dead whales. This aggregating phenomenon is not completely understood and there are several theories to explain it. It is believed that floating objects offer a refuge from predators* and a meeting place for schooling companions (like THE tree in the Ténéré desert, in Africa, where every caravan stops even if there is nothing other than a tree — no water, no food and not even enough shade for all members of the caravan). Another theory posits that because floating objects host a variety of small marine animals, a food chain is established around it and it becomes a feeding place for large pelagic fish. Whatever the cause, knowledge about such aggregating behaviour led to the innovative idea of anchoring something similar to a floating log to attract the fish to a place that can be easily found by fishers.*



FAD types in relation to their use and distance from shore.

Types of FADs and their use

In coastal areas, local fishers or fisheries departments moor FADs on the sea bottom in depths of 50–2,500 metres in order to encourage tunas to gather not too far offshore, where small artisanal fishing vessels can catch them. Anchored FADs improve the catch rate of people who catch fish to feed their families or sell in small amounts at local markets, as well as people who fish as a hobby. They also allow fishing effort* to be moved away from lagoons and reef areas, where resources are both limited and fragile, towards the open ocean where tuna resources are not as sensitive at such scales. The upper part of these anchored FADs can be set under the sea surface (subsurface FADs) or it can float on the surface (surface FADs). When deployed within the reach of paddled canoes, the device is called a nearshore FAD and when moored further offshore, it is called an offshore FAD and its use is limited to motorised fishing boats. Low-cost FADs can also be moored inside lagoons (lagoon FADs) where they attract small pelagic and bottom fish species.*

In the open ocean, operators of tuna purse-seiners also exploit the tendency of large pelagic fish to aggregate around floating objects. They set their large nets around FADs that have been purposely set adrift and are monitored throughout the ocean by electronic tracking beacons. One purse-seine vessel can have up to 100 drifting FADs (d-FADs) equipped in this way. These d-FADs are tools that may be considered to be "too efficient" but getting rid of them would strike a heavy blow to the world's tuna canning industry. In fact, the volume of catches around these d-FADs (by all types of fishing combined) accounts for about 1.8 million tonnes, or 43%, of the 4.2 million tonnes for the three main tuna species worldwide. It has been suggested that purse-seine fishing around d-FADs is leading to catches of small, undersized (juvenile) tunas, unwanted bycatch such as mahi mahi and wahoo and endangered species such as sharks and sea turtles. The use of d-FADs in the Pacific needs to be regulated and monitored to avoid the overfishing of those species.

i

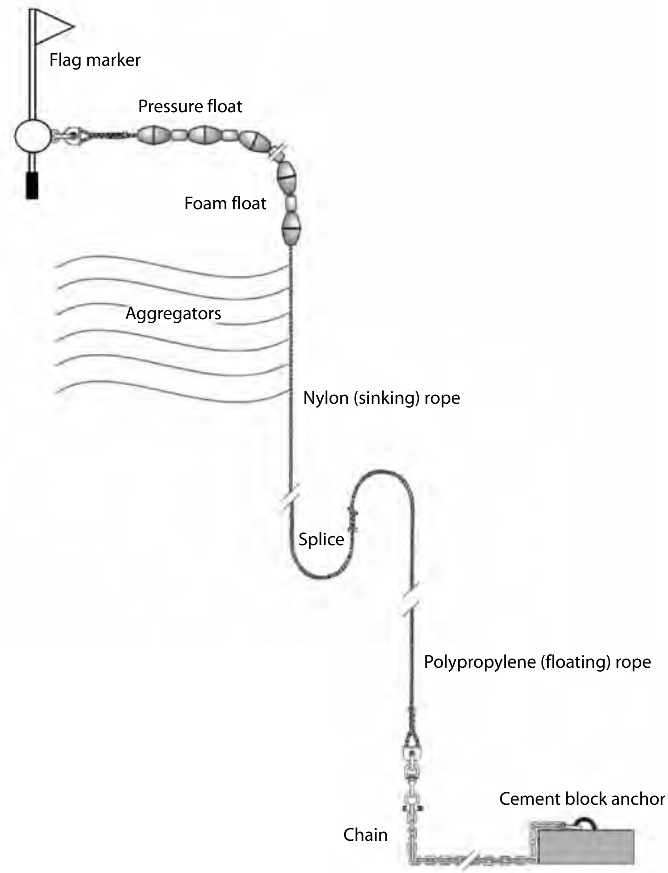
In 180 AD, the Greek poet Oppian of Corycus included, in his treatise on sea fishing "Halieutika", a description of mahi-mahi fishing under the first recorded man-made fish aggregating devices. Those FADs were drifting devices made of bundled reeds and set adrift. Much later on, Southeast Asian countries constructed anchored FADs made of bamboo (called "payaos"), and these are still used today in support of industrial fisheries. With assistance from SPC, Pacific Island countries and territories started to use anchored FADs in the early 1980s.

Artisanal fishers in the Pacific currently catch less than 5% of the tuna caught in the western and central Pacific Ocean and will need to harvest more in future for food security. Anchored FADs are important tools for domestic fisheries development as they can contribute to increasing the share of the tuna catch going to Pacific communities.

A FAD commonly used in the Pacific: the Indian Ocean FAD design

The FAD design illustrated here was first used at Reunion Island, in the Indian Ocean, in the early 1990s. SPC successfully introduced the design in the Pacific during the mid-1990s, with some refinements to the gear configuration. It is still widely used in the region as it is easy to deploy from relatively small boats and is cost-effective (USD 1,500 to 2,500 depending on the anchoring depth, for an average life-span of two years).

Purse-seine catch.



The Indian Ocean FAD design (main components).

Artisanal fisherman displaying a yellowfin tuna caught at a nearshore FAD off Yaren, Nauru.

A cause for concern: sabotage

One of the biggest constraints to successful FAD programmes in artisanal fisheries is vandalism, in which the upper section of a surface FAD is intentionally cut loose by fishers or other boat operators. Jealousy and ignorance are the main causes. To address this problem SPC is promoting the use of subsurface FADs.

Teachers' Resource Sheets on

16 Cook Islands traditional fishing methods

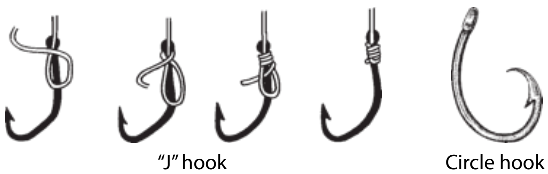
Fishing methods used depend on the targeted species* and the area fished (reef flats, lagoons or open sea). Some of the methods described below are still used but some have been replaced by modern techniques and a change in fishing to a more individual and less community-based activity. Gleaning is still a common traditional fishing method and is described in the Guide to information sheets on fisheries management for communities.

1. Hook-and-line

In the Pacific, hook-and-line gear was traditionally made from natural materials (fibres, wood, bones and shells), but modern materials (nylon and steel) are now used.

Two types of hooks are used:

- "J" hook: fishers must jerk the hook when they feel a fish taking the bait;
- circle hooks: fishers let the fish hook itself (hooks are "self hooking").



Matira or *Takiri*

A line is cast into the water and the baited hook is either kept stationary or shaken. If a lure is used, it is made of shell, feather, metal or plastic. *Matira* is generally done at dawn or dusk.

Target: Small groupers, *ku* (squirrelfish) and *paoa*, *titiara* (trevally)

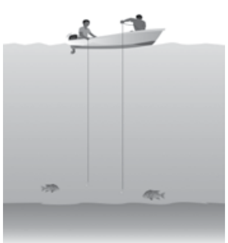
Tiritiri

A handline ending in a baited hook is thrown in the sea and the fisher waits until a fish bites.

Target: Predatory fish such as *titiara*, *urua* (trevally), *angamea* (snapper), emperors and groupers

I'I or drop stone fishing

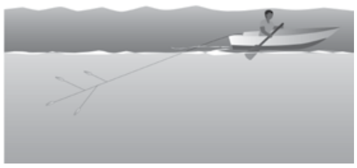
A bait (mackerel scad, bigeye scad or flying fish) and a weight (usually a rock) are wrapped inside a leaf and tied with a slip knot. The package is lowered to the required depth (can be over 300 m) and then the line is jerked upwards. The movement opens the knot and frees the ground bait, also called "chum", around the baited hook.



Target: Deep-sea fish (cods, snappers) and pelagic* fish (tuna, wahoo, marlins…)

Tavere or *Taverevere ku* on canoes

Lines (10 to 15 m long) rigged with three to five hooks are towed or trolled from canoes. *Uru tavake*, or shiny white-strand ropes (made of coconut fiber), are attached to the hooks as lures.



Target: Squirrelfish

Titomo

A small baited hook (using small pieces of fish sometimes mashed and mixed with ground coconut flesh) attached to a short length of line on a rod is used by a diver. Once the fish is hooked it is quickly flicked into a canoe.

Target: *Koperu* (mackerel scad) at dawn or dusk, or small *patuki* (groupers)

Matau tamoe

A thick line is tied to a tree and placed out over the reef. A hook, baited with a live eel, is placed somewhere suitable (such as in a patch of soft coral) to stop it from shifting about with the swell and currents.

Target: Large trevallies

Manga fishing

The gear consists of a monofilament line attached to a bent wire carrying two *tokos* (v-shaped piece of wood), each of them with a straightened steel hook attached to it. Baits consist of fillets of mackerel scad, flying fish or skipjack.

Target: Snake mackerel

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2. Nets

Pokipoki

A V-shaped hand net, made of wild hibiscus bark or coconut fiber, is dipped into the surge channel so that fish swimming past get entangled. The fish are then scooped up using hand nets.

Maroro fishing

At night, flying fish are attracted to a boat by a bright light and caught with a scoop net. Nowadays, fishers use speed boats and a torch attached to a helmet. In the old days, burning dried coconut fronds were used as torches by fishers paddling canoes.

Target: Flying fish or *maroro*

Rau (leaf sweep) fishing

Coconut fronds are tied together to form a "wall" to surround fish schools.* A large number of fishers are involved in this method; some hold the *rau* while others beat the surface of the water with sticks to frighten the fish towards the *rau*. This technique is less and less used due to a shift: 1) towards the use of gill nets and 2) from community to individual fishing methods. The traditional method, involving many people walking on the reef, could cause considerable damage to corals.

3. Spear fishing

Pata spearing

The gear consists of a Y-shaped piece of wood and rubber bands and a metallic spear. Teenage boys use *pata* to learn how to spear fish; nowadays, this method is, unfortunately, also used at night time, with an underwater torch to catch fish sleeping under corals.

Target: *Morava* (rabbitfish), parrotfish, trevally, drummerfish, surgeonfish, goatfish, mullet, snapper, emperor, squirrelfish, lobsters (occasionally at night)

4. Traps

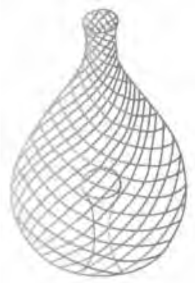
Pa

Stones are piled high and form a wall, which at falling tide intercepts the school and guides it towards a v-shaped apex from which the fish cannot escape.

Target: various types of fish

Inaki

Inaki is a method used to trap freshwater eels. Bait is placed in a plaited basket designed to allow eels to enter the trap but not to exit.



5. Poisoning

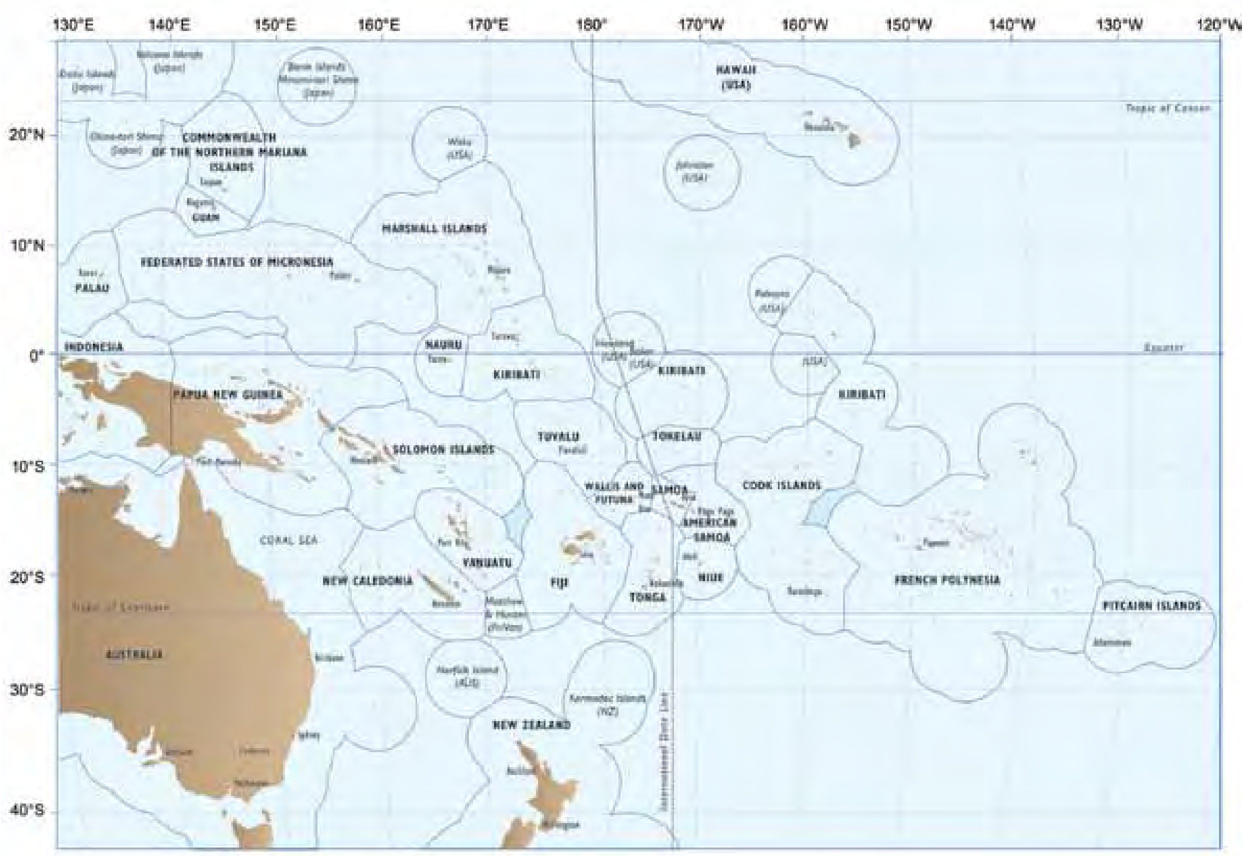
Utu or *Ora papua* fishing

The fruit of the *utu* (*Barringtonia* tree) *Barringtonia asiatica* and the roots of the vine *Derris* sp., *ora papua* were once used to poison fish in coral and enclosed areas. This practice has been banned because it did not only kill the target fish, but also other fish, shellfish,* coral and particularly larvae* in the area.

Teachers' Resource Sheets on

17 Modern large-scale fishing techniques

In the Pacific Islands region, large-scale, or industrial, fishing techniques are almost exclusively used to catch tuna and associated species.* The only exception is the shrimp trawl net fishery* of Papua New Guinea. The main techniques used to catch tuna are: purse seine, longline, pole-and-line and troll.

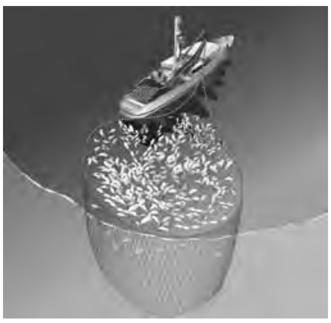


Purse seine

A school* of tuna is spotted while it feeds on schools of baitfish close to the surface. Most of the time, seabirds have also been attracted and dive to feed on the baitfish, making the spotting easier. A huge vertical net (seine) — which can measure up to 1,500–2,000 m long by 120–250 m deep — is quickly set around the school of tuna, and then closed at the bottom to form a purse in which up to 150 tonnes of tuna can be caught at one time.

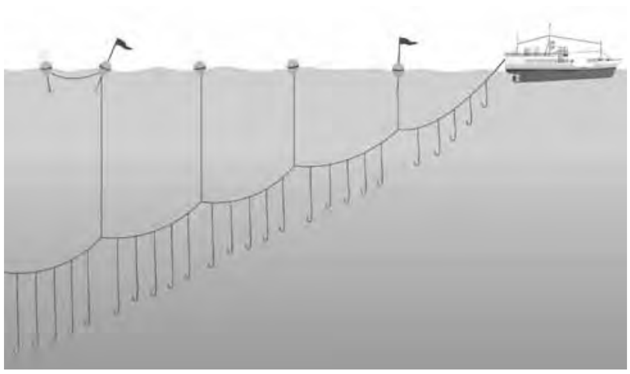
Target: Mainly skipjack and small yellowfin tuna. Most of the catch is for canning and thus ends up in tuna cans one can find in stores all over the world.

About 65% of the tuna catch in the western and central Pacific Ocean (WCPO) region is caught with purse-seine gear — about 1.5 million tonnes in 2011. Most of the purse-seine catch is taken within 5 degrees of the equator.



Longline

A long line, called the mainline, with baited hooks attached at intervals by means of branchlines, is set and allowed to drift for several hours. Large tuna longliners can set up to 3,000 hooks on one line that can measure more than 100 nautical miles. The hooks of a longline are set deep (between 80 and 400+ m), so the fishers cannot see the targeted fish. The choice of the location for a set is therefore made by experience, according to sea surface currents and temperature, season, weather, etc.



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There are two major types of longliners: (1) relatively large (>30 m) vessels that use sophisticated freezing equipment and are often based outside the Pacific Islands, and (2) smaller vessels that use ice or refrigerated sea water to preserve fish and are typically based at a port in the Pacific Islands.

Target: Large yellowfin, bigeye and albacore tunas. The prime-quality yellowfin and bigeyes are often exported chilled to overseas markets for sashimi. Most of the albacore caught by longliners end up in cans.

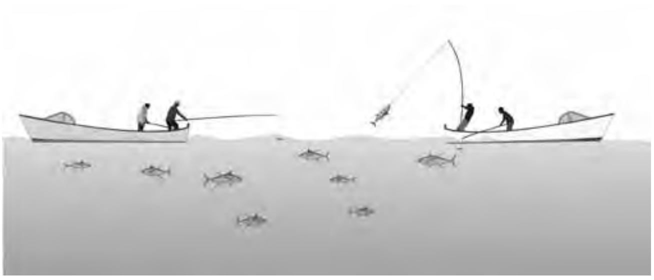
About 11% of the tuna catch in the WCPO region caught with longline gear — about 265,000 tonnes in 2011. Most of the longline catch is taken within 20 degrees of the equator.

Pole-and-line

As with purse seining, a school of tuna is spotted while it feeds on baitfish close to the surface. The pole-and-line boat is brought close to the school of tuna and left drifting while fishers throw small live bait and spray water to mimic the splashing of the school of bait. The idea is to trigger a feeding frenzy in the school of tuna. Fishers stand on the front deck and haul fish with a pole attached to a line ending with a lure and a barbless hook*.

Target: Mainly skipjack and small yellowfin tunas. Most of the catch is for canning or to make a dried product (called *katsuobushi* in Japan) sold to Asian markets.

About 12% of the tuna catch in the WCPO region is by pole-and-line gear — about 275,000 tonnes in 2011. In the 1980s, several Pacific Island countries had pole-and-line fleets, but most have stopped operating due to competition with the more productive purse-seine gear. In the Pacific now, most of the pole-and-line fishing takes place around Japan, and a few boats are still operating in Solomon Islands.



Note:

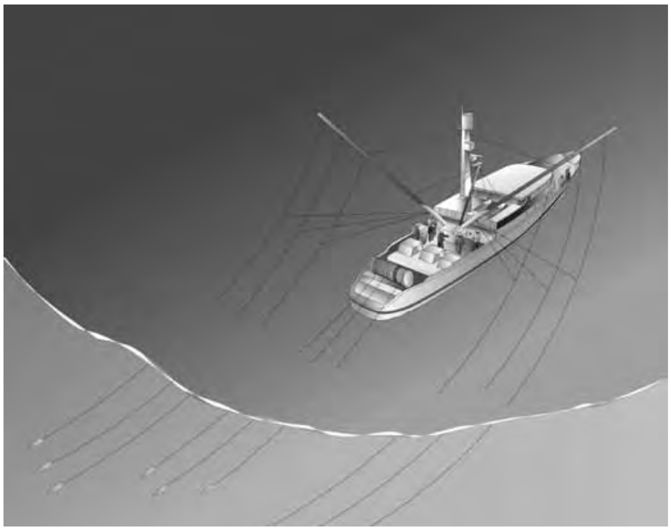
Several small-scale fishing methods and gear types are described in the 'Guide to information sheets on fisheries management for communities', including reef gleaning; spears; portable traps; barrier and fence traps; baited hooks and lines; lures for trolling; as well as cast nets, scoop nets, gill nets, seine nets and ring nets.

Troll

Several lines are trolled behind the boat with lures at the end.

Target: Large-scale tuna trolling boats target albacore for canning.

Gear types other than the three listed above are responsible for about 13% of tuna catch in the WCPO. Large-scale trolling is one of these. It is carried out in temperate waters to the south and north of the tropical Pacific Ocean (mostly south of 25°S and north of 25°N). Trolling in the south results in a catch of about 3,200 tonnes of albacore annually, which is almost exclusively sent to canneries.



Bottom trawl

A very powerful boat drags a trawl net along the bottom of the sea. The trawling can last from a few minutes to a few hours before the trawl net is hauled and emptied on the deck of the boat where the catch is sorted. Because of its lack of selectivity*, this technique harvests a large proportion of bycatch (unwanted species which are caught and thrown back dead into the sea — for example, up to 90% of catch in the shrimp fishery can be bycatch). It is mostly used in places where the seafloor is all sand or mud. It must not be used in coral reef areas as 1) it would destroy the corals and 2) the trawl net would be damaged by the coral heads.

Target: All type of species that live close to the seafloor, such as shrimps and flatfish.

In the Pacific Islands, this technique is only used in the south of Papua New Guinea to catch shrimps.

18

Teachers' Resource Sheets on

Sea safety

Fishing is considered to be the world's most dangerous occupation — estimated in 1999 by the International Labour Organization (ILO) to cause more than 24,000 deaths per year. Although Pacific Island countries have some of the highest sea accident rates in the world, most government fisheries agencies have limited involvement with safety issues. Data are insufficient to statistically demonstrate which activities are particularly risky, but there is a general perception that offshore trolling for tuna in small outboard-powered skiffs is responsible for many, if not most, of accidents at sea.

A typical trolling skiff from Tarawa in Kiribati, a country with one of highest sea accident rates in the Pacific.

What is sea safety?

Sea safety or boat safety means the ability of a vessel to return to port (or more usually the island or village) at the completion of a voyage or trip. A sea safety accident is an event that may lead to a vessel not returning to port.

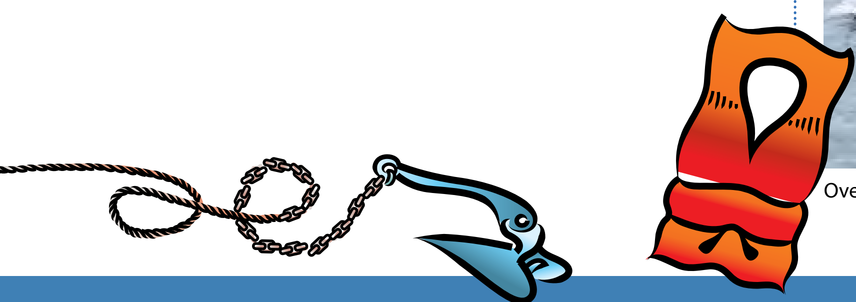
The cost of small boat accidents at sea

In addition to the emotional cost experienced by families and friends as a result of accidents on small boats, regional organisations have tried to analyse the financial cost of sea safety accidents and in particular, the cost of search and rescue (SAR) operations. With 22 island states and territories covering more than 25 million square kilometres of ocean and more than 50,000 small fishing vessels working the nearshore waters of these islands, the exact number of accidents occurring each year is impossible to calculate. What is known, however, are the hourly costs of patrol boats, helicopters and planes that are deployed to undertake SAR. Based on this available information and a case study undertaken for New Caledonia, SPC has estimated that the cost of SAR operations to the region is between 5 and 8 million US dollars per annum. Whatever the exact amount, one thing is for sure, it is a cost the Pacific Islands could well do without!

The causes of sea accidents

Various studies have highlighted the importance of human errors in sea accidents. Despite the scarce data available, we know that most sea accidents in Pacific Islands are linked to mechanical breakdowns (lack of knowledge in outboard motor maintenance and trouble-shooting), losing sight of the island — particularly in atoll countries (lack of navigation skills), running out of petrol (negligence) and bad weather (unsuitable boat design and no pre-departure check of the weather forecast). Overloading of vessels and subsequent capsizing is also a common feature of Pacific Islands' small boat safety.

Overloading of a small transport vessel in Papua New Guinea.



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A world record of survival at sea?

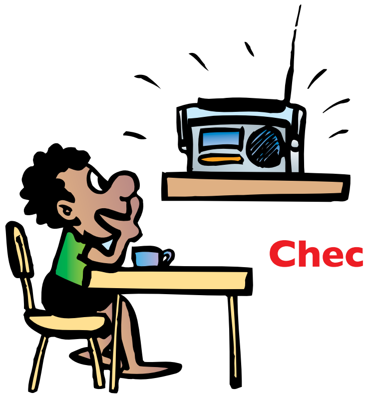
On 18 November 1991, three I-Kiribati fishers left their village on Nikunau for an ordinary fishing trip. Two of them made land again on 11 May 1992… almost six months later, in Samoa! They had survived on rain water and the sharks they could lasso while drifting. This is the longest known drift in the Pacific and possibly in the world. Those two survivors were treated as heroes upon returning home, although the cause of their sea odyssey was pure negligence: they ran out of petrol while fishing. The result was one death and thousands of dollars spent to no avail in searching for their tiny fishing vessel.

A worrisome fact

Most countries in the Pacific do not keep good records of small boat accidents at sea, making it impossible to analyse the extent of the problem and design tailor-made individual responses for countries. The collection and ongoing analysis of data on sea accident should be the first step in the establishment of any national small boat safety programme.

The importance of being prepared

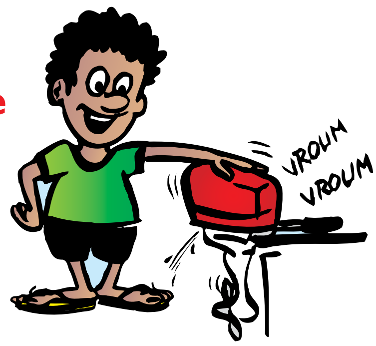
Small boat users, particularly fishers, lack a culture of sea safety. To help change that situation, SPC has released a number of small boat safety awareness materials including two checklists (included in this information package): "Five minutes which can save your life" and a recommended list of safety equipment for small boats. Of particular importance are the things to do before going out to sea:



Check the weather forecast

Tell someone who cares where you are going and when you plan to return

Make sure your engine is working well



Make sure all safety equipment is on board

Teachers' Resource Sheets on

Financial management of a small fishing business

What is a fishing business? ***A fishing business involves capturing fish and marine products with the primary objective of selling them to generate income. Fishing businesses in the Pacific sell many different products[1] in many different forms and in many different markets.[2] Some markets include selling direct at local fish markets; or selling to restaurants, wholesalers, retailers and processors; or to buyers in international markets (export markets).***

Types of fishing businesses

There are two general categories of fishing businesses: commercial and semi-commercial.

Commercial fishing businesses* operate to profit from the sale of fish and other marine products. These enterprises range from small, family-run businesses to large companies that employ staff to help to operate the business.

Semi-commercial fishing businesses are typically informal businesses that usually include fishing for food and income. These businesses are small and are run by a single person or household.

Products sold by a fishing business

Some of the products that are sold by fishing businesses and the form that they're sold are listed in the table below.

Typical products that are sold by small fishing businesses in the Pacific.

Product	Example	Form
Fish	Tuna, wahoo, mahi mahi, grouper, snapper, parrot fish, sardines, mackerel	Fresh (chilled), frozen, whole, filleted, gilled and gutted, cooked, canned, live
Invertebrates*	Prawns, shrimp, sea cucumber, lobster (crayfish), crabs, sponges, trochus	Fresh (chilled), frozen, whole, cooked, shelled, meat, canned
Ornamentals	Angelfish, clownfish, damsels, giant clams, corals, starfish, live rock	Usually live
Seaweed	All types of macroscopic, multicellular and benthic marine algae	Live, dried, chipped, sheets, hydrocolloids
Leisure	Game fishing, fly fishing,* spear fishing	Fishing activities that people participate in for recreation and entertainment

Management of a fishing business

Managers of a fishing business ensure that the business remains viable. A manager of a fishing business is responsible for ensuring that the product being sold meets customer expectations, for ensuring that income is generated and for managing business finances,[3] sometimes with the assistance of an accountant.

Financial management of a fishing business

Costs are usually incurred in the process of generating income. Financial management of a business largely involves ensuring that the income received is more than the costs incurred (income is greater than costs), or maximising income while minimising costs.

[1] A product is a good or service that a business sells to generate income.
[2] The market is the person or business that buys fish and marine products from the fishing business.
[3] Finances refer to the money that a business has, receives and pays.

What is income?

Income refers to the money that a fishing business receives for the sale of its goods and services.

$$\textit{Income per trip} = \textit{Price} \times \textit{Quantity}$$

For example, if a fishing business catches 10 yellowfin tuna, each weighing 10 kg, then the total catch (or quantity) is 100 kg of tuna. If the tuna are sold for \$10 per kg, then the income for that fishing trip is \$1,000 (i.e. \$10 × 100 kg = \$1,000).

Annual income is the sum of the income generated from every fishing trip undertaken over a year.

$$\textit{Total income} = \textit{Income}_1 + \textit{Income}_2 + \textit{Income}_3 + \ldots\ldots + \textit{Income}_n$$

For example, using the above income per trip of \$1,000 and if we assume that we do 100 fishing trips per year and always catch the same amount of fish, we can calculate total income as \$1,000 × 100 trips = \$100,000). The income per trip is not always the same because the catch changes each trip, which is why we need to add income from all trips individually.

What are the costs of fishing?

As with any business, there are costs incurred when generating income. We broadly define these costs as operating costs and fixed costs.

Operating costs are incurred when going on a fishing trip and can include items such as: fuel, bait, ice, gear, crew payments (labour), rations, etc.

Fixed costs (or overheads) are incurred by the business whether or not fishing occurs. That is, fixed costs are the costs that the business has to pay regardless of the number of fishing trips that are completed. Fixed costs can include items such as fishing licence, bank loan repayments, annual vessel maintenance, insurance and depreciation. For example, the cost of a fishing licence is the same whether a business does 10 or 100 fishing trips each year — the cost is fixed.

$$\textit{Total cost} = \textit{Total operating costs} + \textit{Total fixed costs}$$

For example, if a fishing business does 100 fishing trips each year and each fishing trip costs \$500, then our total annual operating cost is \$50,000 (i.e. 100 × \$500 = \$50,000). To operate as a fishing business, the business has to buy a fishing licence (\$1,000), make loan repayments (\$5,000) and pay boat maintenance (\$5,000), so the total annual fixed cost is \$11,000 (i.e. \$1,000 + \$5,000 + \$5,000 = \$11,000). Putting these together, we calculate our total annual cost to be \$61,000 (i.e. \$50,000 + \$11,000 = \$61,000).

What is profit?

Profit is the money that is left over after total costs are deducted from income over a given period. **For businesses to be viable over the long-run, they must be profitable.** If a business is not profitable, then the business spends more money than it makes. Businesses need money (profit) to operate.

Profit = Total income - Total costs

For example, using the total income and total cost figures from above, we can calculate profit, as follows:

Profit and loss analysis

Total income (A)	$100,000	
Total cost (B)	$61,000	
Profit (C)	$39,000	C = A - B

In this example, profit = $39,000, which means that after total costs (operating and fixed) are deducted from total income, we have $39,000 left — this business made a profit for the year.

We can expand the above table to represent a profit and loss statement, as follows:

Detailed profit and loss statement

Total income	Price × Quantity = $10 × (100 kg per trip × 100 trips) **= $100,000**
Operating costs	Cost per trip × number of trips = $500 × 100 = $50,000
Fixed costs	Sum of all fixed costs = $1,000 + $5,000 + $5,000 = $11,000
Total costs	Operating costs + fixed costs = $50,000 + $11,000 **= $61,000**
Profit	Total income - total costs = $100,000 - $61,000 **= $39,000**

Other fields to consider in financial management

Profit is one key component of financial management. However there are many other areas of importance beyond the scope of this sheet. They surround investment expense (e.g. purchase of boat, motor, ice box), managing assets and liabilities (or creditors and debtors, such as banks and customers to whom credit is extended), cashflow, financial reporting, budgeting and decision making.

Michael Sharp © SPC

Climate change and fisheries

Anyone who fishes will tell you that you don't catch the same number or type of fish every time you go fishing! Catch is influenced by the bait you use, where you fish and the tide. It also depends on whether you fish during the day or at night, the prevailing weather conditions and, importantly, the time of year.

In recent years, scientists have identified another reason why the catches of some fish species* change — climate. They have recorded strong relationships between the El Niño-Southern Oscillation (ENSO) and tuna catch. When the southeast trade winds blow more strongly than usual (La Niña conditions), they push the area of warm water in the western Pacific (the Warm Pool) up against Papua New Guinea (Fig. 1). But when the trade winds are weaker than usual (El Niño conditions), the Warm Pool extends far to the east. Changes in the Warm Pool driven by the trade winds affect the catch of skipjack tuna because this valuable species is caught in greatest numbers near the eastern edge of the Warm Pool and the location of this edge can vary in by 3,000 to 4,000 km depending on the strength of an El Niño or La Niña.

The dramatic effect of ENSO on skipjack tuna demonstrates just how profound the effects of climate on fish can be. Based on these observations, there is every reason to expect that global warming, caused by higher concentrations of carbon dioxide (CO_2) and other greenhouse gases in the atmosphere, will also affect other fish species.

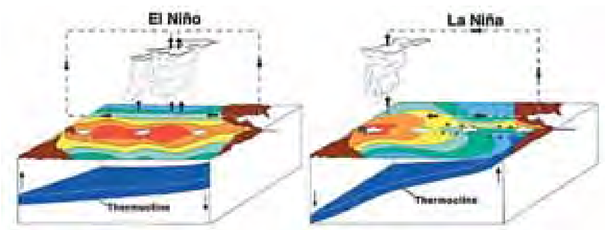


Figure 1. Effects of El Niño and La Niña conditions on the Pacific Ocean (source: SPC).

In considering this, we need to think about two different categories of fish — coastal fish and oceanic fish. Most coastal fish in the tropical Pacific are associated with coral reef habitats (Fig. 2), whereas most oceanic fish are caught offshore (Fig. 3). Most of the oceanic fish we catch are large, highly mobile species like yellowfin, bigeye, skipjack and albacore tuna, but also marlin, wahoo and mahi mahi. These species range widely across the region and are caught as they pass through the exclusive economic zones (EEZs) of Pacific Island countries and territories (the area within 200 nautical miles of the islands).

Coastal fish

The rising sea surface temperature is expected to alter the times of year when coral reef fish spawn and the food available to juvenile coral reef fish during the first few weeks or months of the planktonic (floating) phase of their lives far from shore. Survival during this phase affects how many juvenile fish are available to "settle" back on coral reefs and replenish the fish stocks there. However, climate change is expected to have its greatest effect on coastal fish by altering the coral reefs themselves. As the ocean warms, corals will bleach more frequently — bleaching occurs when warm water stresses corals and they expel the tiny plants (zooxanthellae) within their tissues that provide them with organic compounds (food) by photosynthesis.*

The build-up of CO_2 in the atmosphere also has another negative effect on coral reefs. The CO_2 dissolves in seawater, making the ocean more acidic and reducing the calcium carbonate available to corals to build their skeletons.

The increased coral bleaching and ocean acidification, will progressively degrade coral reefs — they will lose their complex structure and provide fewer places for the fish and prey for fish, to live. Decreases in coastal fish production will follow because not all coral reef fish will be able to adapt to the loss of the shelter and food they need. By 2035, climate change is expected to reduce that catch of coastal fish by 2%–5%, increasing to 20% by 2050.

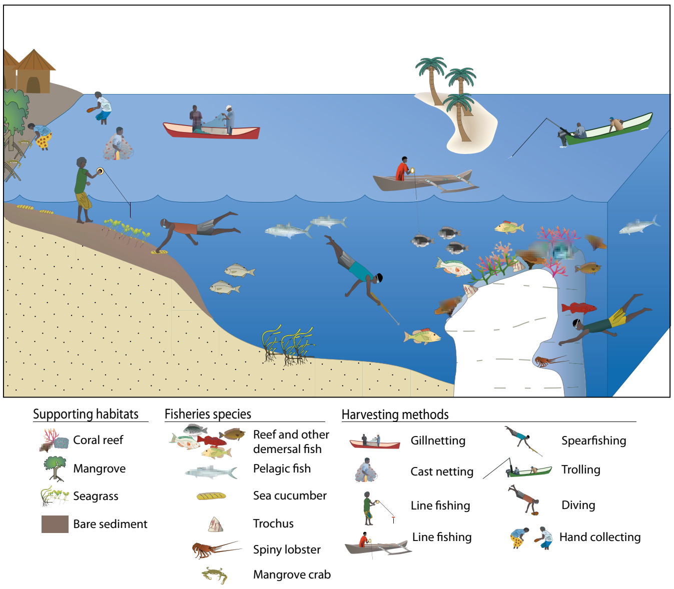


Figure 2. Range of coastal fishing activities in Pacific Islands (source: SPC).

This resource sheet is one of a series produced by the Secretariat of the Pacific Community (SPC) to assist teachers in introducing fisheries topics into school curricula.

Each sheet should be used in conjunction with the Guide to Teachers' Resource Sheets, which contains suggestions for student activities and exercises. All words marked with an asterisk (*) are defined in a glossary in this guide.

SPC
Secretariat of the Pacific Community

Oceanic fisheries

Unlike the effects of climate change on coastal fisheries, some Pacific Island countries and territories may benefit from increased catches of some important oceanic fish as the ocean warms. The reason for this is that there will be a steady increase in the overall size of the Warm Pool — it will extend further to the east under normal conditions. Over time, the distribution of tuna will be more like that observed during strong present-day El Niño conditions.

Pacific Island countries and territories further to the east are likely to receive more requests from purse-seine fishing vessels owned by distant water fishing nations (DWFNs) to fish for skipjack tuna in their EEZs because this fish could well be found in greater abundance there. Increased fishing by DWFNs will add to the revenue the government receives from fishing licence fees. Skipjack tuna could eventually be caught in higher numbers a bit further away from the equator than it does at the moment as sea surface temperature increases to be within the range preferred by this species.

Scientists are still in the process of determining the most likely effects of climate change on the other species of tuna.

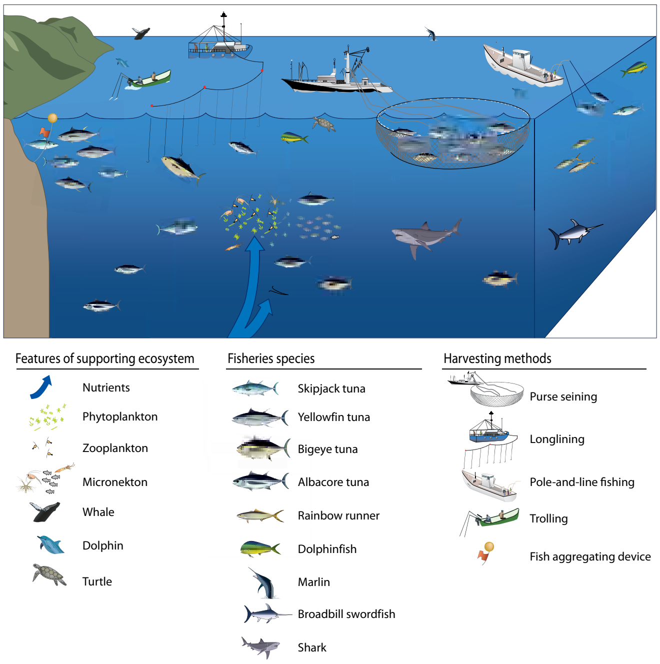


Figure 3. Range of oceanic fishing activities in Pacific Islands (source: SPC).

Interesting fact

Although the body temperature of most fish is the same as the temperature of the water in which they swim, the body temperature of tuna is warmer than the surrounding water. Tuna have a countercurrent heat exchanger that enables them to retain body heat generated as a by-product of metabolism. http://en.wikipedia.org/wiki/Countercurrent_exchange_system