Basic Information
on the Marine Resources
of the Cook Islands

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Produced by

the Ministry of Marine Resources
Government of the Cook Islands

and

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Introduction

Geography

The Cook Islands consists of 15 islands that extend over 1,500 kilometres of ocean in a north-south direction. The country is located between 156° and 167°W longitude and between 8° and 23°S latitude (central Polynesia), and has a 200-mile exclusive economic zone (EEZ) of 1,830,000 square kilometres.

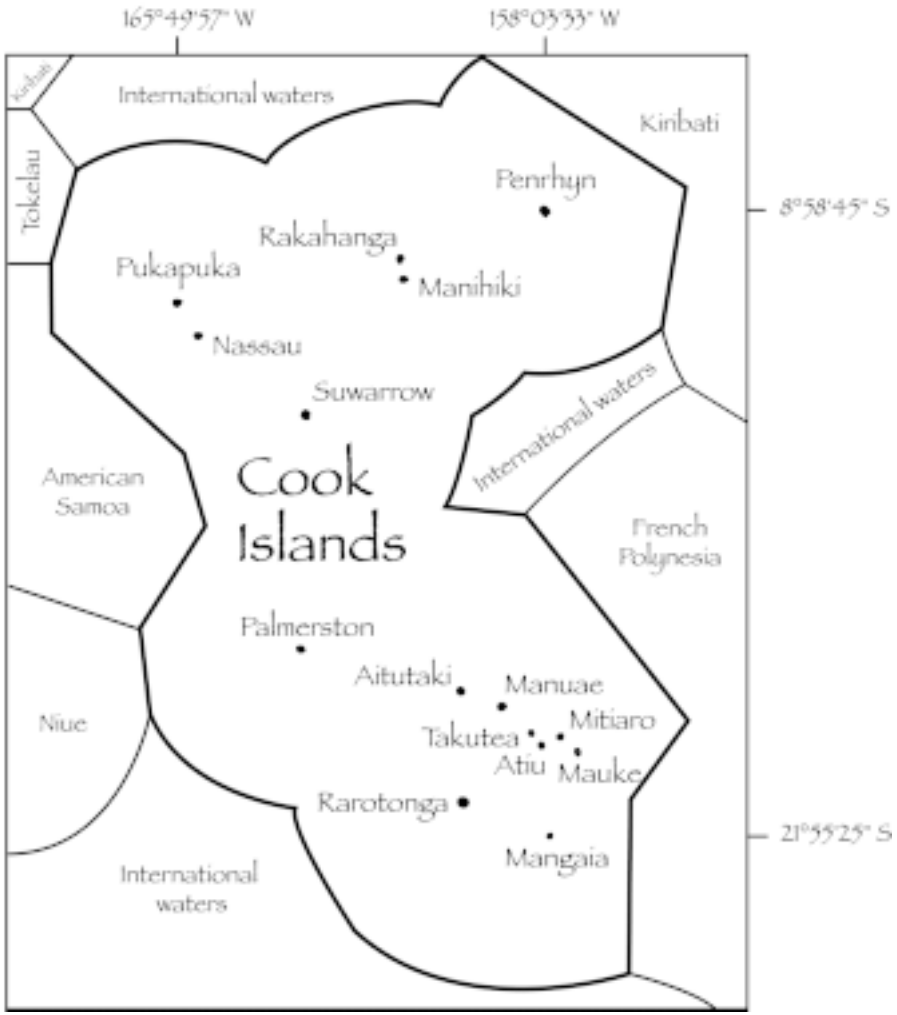
The 15 islands have a total land area of 237 square kilometres. The largest island is Rarotonga (67 square kilometres).

The islands of the northern group are coral atolls as is Manuae in the southern group. The rest of the southern group islands, Mauke, Mitiaro, Mangaia, and Atiu are raised islands with encircling reef platforms adjacent to the coast. Aitutaki is part volcanic island and part atoll, with an enclosed lagoon. Rarotonga is a volcanic island with a narrow fringing reef.

In the southern group, temperatures range from 16°C in August to 32°C during January with an annual average of 25°C. In the northern atolls, temperatures range from 20°C to 37°C averaging 29°C.

Rainfall can vary considerably from year to year, but 200 centimetres per year is considered normal. Winds are predominantly from the south-east, with average speeds of about 15 km/hr. Cyclone season in the Cook Islands is from November to April.

It is thought that the Cook Islands have been populated for approximately 2000 years, a relatively short period of time compared with many other Pacific islands. In 1996, the population was 17,726. Of this, 9,930 (or 56%) live in Rarotonga.



Economy

The economy is mostly based on tourism, offshore banking, and the black pearl industry. Some 50,000 tourists visit the Cook Islands annually. In the last few years, tourism has brought revenues of over 33.5 million New Zealand dollars (NZD). Seventy per cent of all exports from the Cook Islands come from the sea; pearl exports alone make up 60% of all exports. In 1998, pearl exports were valued at 5.2 million NZD; however, the Ministry of Marine Resources estimates that pearl exports were worth over 10 million NZD. Trochus and aquarium fish also bring in income. In addition, the government collects money from licensing foreign-owned, longline tuna boats that fish within the Cook Islands EEZ.

Marine biodiversity and fishing activities in the Cook Islands

The Cook Islands have a high diversity of marine species compared to more temperate waters. In comparison, however, to areas in the western Pacific, such as Indonesia and Papua New Guinea, species diversity in Cook Islands waters is relatively low. Nevertheless, reefs and lagoons in the Cook Islands support a wide range of demersal fish, corals, molluscs, crustaceans, echinoderms and other marine organisms. Beyond the reef, tuna (albacore, yellowfin and skipjack) form part of the Western and Central Pacific tuna stocks, which are the basis of the world's greatest tuna fishery.

Human population and fishing pressure are low in the Cook Islands compared with some Pacific Island countries. The reefs are generally in good condition except for some areas on Rarotonga and Aitutaki where damage has occurred as a result of run-off and coastal development activities. Certain fish species have been heavily exploited through the use of small-mesh gillnets.

Subsistence fishing is important in the Cook Islands, particularly in the northern group. Subsistence and artisanal fishing occurs on Rarotonga and Aitutaki where urban populations and tourism have created a demand for fresh seafood.

Seafood constitutes a major component of the diet of Cook Islanders, especially for people from the northern group. Cook Islanders consume, on average, 47 kilograms of seafood per person per year.

Since the 1980s, a programme of fish aggregation device (FAD) deployment, and improvements to fishing craft gear and techniques have ensured a reasonable supply of tuna and other pelagic species to Rarotonga and Aitutaki markets. At times, however, demand exceeds supply.

Fish aggregating devices (FADs) are floating rafts anchored by rope and chain in deep water several kilometres offshore, which attract fish and make oceanic fishing more cost effective. FADs are also good for tag-and-release game fishing, and if you really want to see sharks, this is a good place to make a SCUBAdive. FADs do not last forever, particularly after a cyclone, and cost several thousand dollars to replace.

A fleet of 70 or more small craft, mostly wooden skiffs from 4.5 to 6 metres and powered by 40 to 80 horsepower outboard engines, conducts FAD-based fishing off Rarotonga.

These vessels, most of which operate on a part-time or occasional basis, are used to carry out a variety of fishing methods, including scoop-netting for flying fish, trolling, mid-water fishing with vertical longlines, and drop-stone fishing. In 1999, 32 tonnes of pelagic fish were caught near FADs, and 26 tonnes from coastal pelagic fisheries, a total value of 160,000 NZD.

Ministry of Marine Resources

The Ministry of Marine Resources (MMR), established in 1984, has three main sections: Research, Economic Development, and Policy and Resources Management.

- The Research Section develops and conducts research programs that are focused on responsible and sustainable management of marine resources.
- The Economic Development Section promotes the increased use of offshore and inshore marine resources.
- The Policy and Resources Management Section sets policy guidelines for the marine sector.

The main office is on Rarotonga and additional offices are on Penrhyn, Aitutaki and Manihiki. MMR staff are also on Pukapuka, Rakahanga and Palmerston.

The Marine Resources Act (1989), amended in 1990 and in 1991 is the major piece of legislation governing fisheries activities in Cook Islands territorial waters and exclusive economic zone (EEZ). Island councils are able to draft regulations concerning the management of their reefs and lagoon.

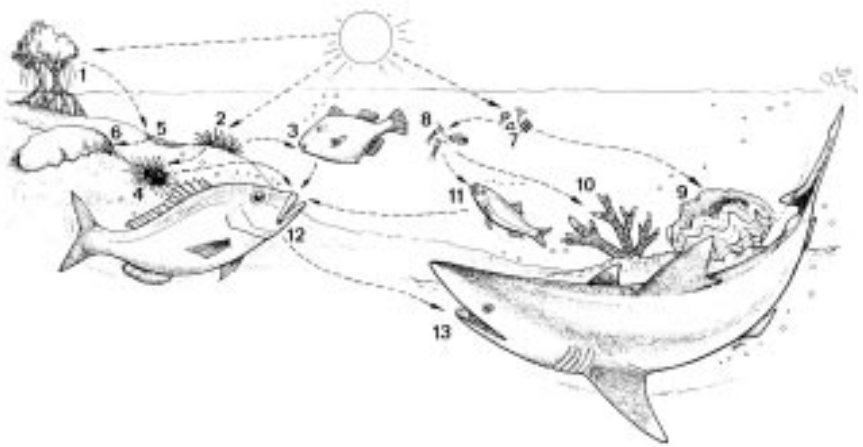
The Marine Environment and Fisheries Resources

Marine Plants

Seaweeds, or algae, are marine plants that form the basis of a complex food web involving all the organisms living within a coral reef ecosystem. Seaweeds are eaten by fish, molluscs, and crustaceans, which in turn are eaten by other, usually larger animals. In addition, seaweeds convert sunlight and dissolved nutrients into energy-rich organic compounds that other organisms can eat. They also produce oxygen that all animals need to breathe, and provide shelter and protection for many organisms.

There are over 100 kinds of seaweed in the Cook Islands. Seaweeds are divided into four types: green, brown, red, and blue-green. Seaweeds have different growth forms. Some encrusting types such as coralline algae help to 'cement' the reefs. Another type, *Halimeda*, is responsible for much of the white sand on the beaches after it dies. This species is found mostly in the lagoon. *Caulerpa* sp. or rimu (sea grapes) is another seaweed found in the Cook Islands and a popular food resource.

Some animals and algae have close relationships. Coral polyps have small algae living inside their bodies, which they rely on for a large



A simplified, tropical, marine food web (from King, 1995)

Plants such as mangroves **(1)** and seagrasses **(2)** use sunlight to produce plant materials from carbon dioxide and nutrients during photosynthesis. Plant materials are eaten by herbivorous animals such as triggerfish **(3)** and sea urchins **(4)**. Plants and wastes from animals are broken down by bacteria to form a pool of organic materials called detritus **(5)** which is consumed by a wide range of animals, including the sea cucumber **(6)**. Microscopic plants (phytoplankton – greatly magnified in **(7)** drift near the surface of the sea, and are eaten by small floating animals (zooplankton – magnified in **(8)**. Some small plant cells (zooxanthellae) live in the tissue of giant clams **(9)** and corals **(10)**. Some animals, including the giant clam, actively pump seawater through their shells to filter out phytoplankton for food. Zooplankton is consumed by small carnivores such as sardines **(11)** and corals. Fish, including emperors **(12)**, eat a wide range of smaller fish, and are themselves hunted by larger animals such as sharks **(13)**.

amount of their food, and clams owe their beautifully coloured mantle to algae that live within their flesh. These relationships are beneficial to all parties: the algae produce food for the clam or coral, which in turn provides, among other things, protection for the algae.

Invertebrates

Invertebrates are animals without backbones. They are generally small and include corals (both hard and soft types), echinoderms (sea urchins, kina, vana, seastars, holothurians), molluscs (octopus, shellfish), worms (Christmas tree worm, flatworms), crustaceans (crayfish, crabs, shrimps) and other organisms.

The Cook Islands Natural Heritage Project estimates about 1500 invertebrate species exist in the Cook Islands.

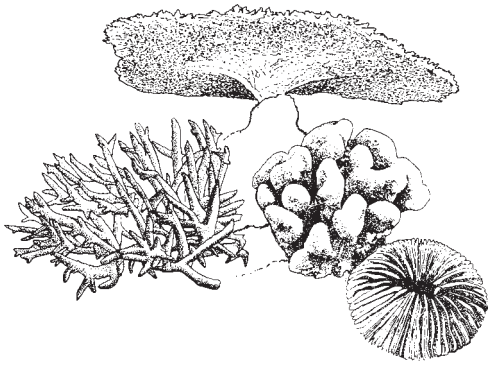
Trochus, clams and pearl oyster are three of the important economic and food invertebrates. Trochus are harvested in Aitutaki for export every year. They are made into buttons and other ornaments. Clams are considered a delicacy in many island communities. Black lip pearl oyster culture is the Cook Islands' second biggest industry after tourism.

Corals

Coral reefs are composed of millions of tiny (one millimetre or so) soft-bodied animals that are closely related to jellyfish and sea anemones. Unlike those animals, however, coral polyps produce a hard skeleton of calcium carbonate.

Soft corals have tiny limestone crystal structures (spicules) embedded in their tissues. The polyps feed on small, usually microscopic, animals called zooplankton that float in the water column. The small stinging tentacles of the polyps are used to spear zooplankton.

Corals also get a large amount of their nutrients from tiny plants (algae called zooxanthellae) that live within the tissue of the polyp. The algae use the coral's waste products, which in addition to sunlight enables them to photosynthesise vital nutrients, which are then leaked into the surrounding tissues of the coral polyp. The relationship is beneficial to both the coral polyp and the algae. Because coral polyps rely on these small plants that need sunlight for photosynthesis, most corals grow in shallow and clear water.



Some common types of corals, from left to right: staghorn coral, table coral (*Acropora* sp.), boulder coral (Porites), and mushroom coral (Fungia) (from King, 1988)

Hard corals are largely responsible for building reefs: when they die their skeleton remains. Coral reefs in the Pacific are the result of millions of years of growth with additional material from calcareous seaweed and shells that are found on reefs.

Only the top layer of the reef is living coral. The northern atolls are built entirely of coral skeletons. Mangaia, Atiu, Mauke and Mitiaro would be much smaller without them, as the Makatea (raised coral) is fossil reef.

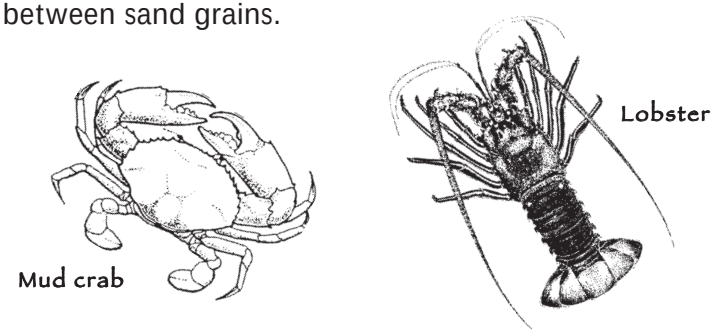
Coral reefs protect the coast by lessening the impact of waves and storm damage. Undamaged coral reefs attract tourists and provide a growing source of income to many local people.

Worms

Although not immediately obvious, coral reefs are riddled with worms. Many species of worms burrow into the living coral. These burrowing types breakdown coral skeletons to rubble and fine sediment. One type of burrowing worm is the colourful Christmas tree worm, which is spiral-shaped. Worms withdraw into their tubes when disturbed.

Crustaceans

Crustaceans have a hard shell covering their soft body. They also have jointed legs that can move in a number of directions (in fact, most crustaceans have 10 legs), and two pairs of antennae. Crustaceans include lobsters, shrimps, crabs, barnacles, and a host of microscopic organisms. Many of these smaller crustaceans live in the water column while others live among seaweed, under rocks and even between sand grains.



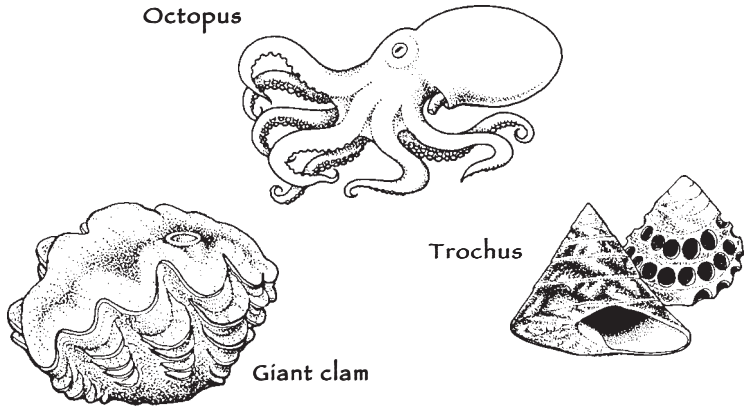
As crustaceans grow, they must periodically moult their shell. During the moulting stage the soft body is exposed and the animal is particularly vulnerable to predators. During this phase, the animal seeks a hiding place for several hours or days until the new shell hardens.

Crustaceans are eaten by Cook Islanders and used for bait. Coconut crabs, land crabs and lobster are favoured seafood on most islands.

Molluscs

There are three different types of molluscs that are important in the Cook Islands:

1) bivalves (e.g. pearl oysters, giant clams, Pacific asaphis),
2) gastropods (e.g. trochus, cowrie shells, turban snail), and
3) cephalopods (e.g. octopus, squid).



Bivalves have two shells, which are secreted by a layer of tissue called the mantle on the outside of the body. The shell grows larger with the age of the animal (often if you look closely you can see where the new growth is added to a shell). Bivalves feed by filtering food particles from the water. Pearl oysters are important in the Cook Islands as they form the basis of the pearl industry. Giant clams are the world's largest known bivalves.

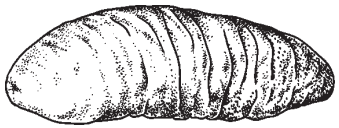
There are two types of gastropods: those that have a single shell (e.g. trochus) and those that don't have a shell at all (e.g. nudibranchs and

patito – sea slugs). Gastropods feed by scraping coral, sand, and plants for microscopic organisms. Some predatory species bore through the hard shell of other molluscs. Trochus is an important subsistence and commercial resource in the Cook Islands.

Cephalopods are the most complex of the molluscs. They have large heads, two complex eyes, and a mouth with many arms (tentacles). Squids have their shells on the inside, while octopus have no shell at all. The nautilus is the only cephalopod with an external shell. When they are frightened, cephalopods (with the exception of the nautilus) squirt a stream of ink that allows them to escape from predators. The ink disperses in the water and obscures the vision of the predator giving the cephalopod time to escape. Nautilus is the only shell that swims rather than crawls.

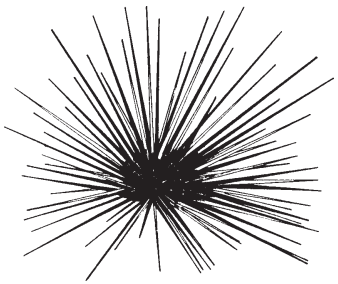
Echinoderms

Echinoderms include all sea cucumbers, sea stars, brittle stars, feather stars and sea urchins. All echinoderms have tube feet with suction cups that hydraulically expand and contract, giving the animal its ability to move about. Echinoderms feed on microscopic organisms that live in the sand or on dead coral.



Sea cucumber

Sea urchin



Rori (sea cucumbers) are important to the marine environment because they scavenge on the reef and turn over the sand on the lagoon floor, preventing the build-up of decaying organic matter that would otherwise be locked up under layers of sediment.

There are eleven species of rori in the Cook Islands. The most common species are the rori matie (green sea cucumber), the rori puakatoro (red surf fish), and the rori toto (sandy sea cucumber). Rori toto have a kind of poison that makes them undesirable to predators. If you rub the skin of this animal you will see a red colour. This blood-coloured substance is a defensive toxin that destroys red blood cells (in fish and in humans). Handling rori toto with cuts on your hands may slow the healing process.

Examples of sea urchins in the Cook Islands are atuke, kina and vana. These animals have spines that move in many directions. The spines serve as a defensive weapon. On the underside of the urchin, the spines are used, along with the tube feet, for movement. The mouth is also underneath and most sea urchins feed on algae, small molluscs and other invertebrates.

Finfish

The Cook Islands Natural Heritage Project estimates that there are between 550-600 species of finfish in the Cook Islands. There are many different feeding, sleeping, territorial habits, and other behaviour to cope with living in the competitive world of the ocean and reef habitats.

Fish use a number of strategies to avoid being eaten by other animals. Schooling is one of these. Many fish swim and feed in large groups, which affords a certain amount of protection against individuals being eaten. For example, if you are a koma or vete in a school of 100, the chances are high that one of the other 99 fish in the school are eaten

instead of you. So if you swim in a school, you as an individual are more likely to survive. Another strategy that some fish (e.g. ku) use is to swim at night to avoid predation (being eaten). In order to see in the dark, these fish have very large eyes.

Some fish such as taputapu (butterflyfish) have black spots on their bodies, often towards the back. In this case, a predator sees the black spot and thinks it's a large eye and that there must be a big fish associated with that eye. Or, a predator might see the black spot and focus on it. If they do manage to get a bite, all they will get is a small piece of tail.

Most kinds of maito, ume and manini (surgeonfish) all have small spikes at the base of their tail that are extremely sharp and can cut a predator who tries to catch it, including humans. The totara (pufferfish) has spines all over its body.

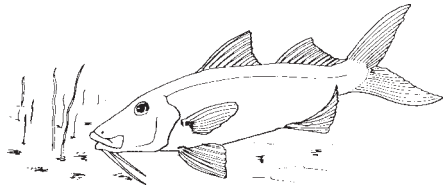
Reef fish

Some of the more common types of fish in the Cook Islands include wrasses, damselfish, groupers, surgeonfish, butterfly fish, snappers, pipefish and parrotfish.

They all have different feeding preferences. Very broadly, some eat only plants (herbivores); most species of parrotfish, surgeonfish and rabbitfish are herbivores. Some, such as groupers and reef shark only eat flesh (carnivores), while other fish such as goatfish and butterflyfish eat both plant and animal matter (omnivores).

Many different fishing methods are used to catch reef fish, including nets, traps, hook and line and spears (see section on 'Common fishing methods in the Cook Islands'). With the exception of a few toxic species, nearly all reef fish are edible.

Koma, Vete (goatfish)

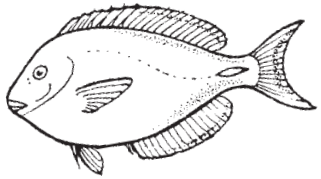


Goatfish are easily recognised by the twin 'whiskers' under their chin. These whiskers are used for feeling in the sand and holes in the reef for food such as crabs and small fish. Like surgeonfish, goatfish are often seen in schools and are sometimes caught in large numbers by gill nets.

Taputapu (butterfly fish)

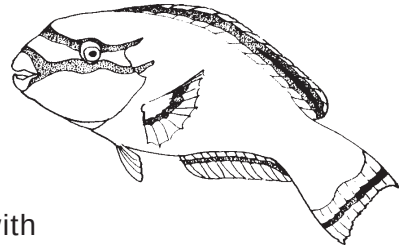
Butterflyfish are very colourful and have numerous patterns and designs. Scientists feel that these colours and patterns aid butterflyfish in recognising and locating members of their own species for reproduction. Most butterflyfish are carnivorous and feed on live coral. Butterflyfish patrol a very specific area of reef or even an individual coral head and are almost always seen in places where there is good coral cover. For this reason, they are used as an indicator of reef health.

Maito, parangi, ume, manini (surgeonfish)



Surgeonfish are one of the most common fish found in the Cook Islands. They get their name from the knife-like blade on either side of the base of their tail. They are generally herbivorous, and feed on algae. Some, including ume (unicorn fishes) feed on microscopic zooplankton. Surgeonfish are one of the known carriers of ciguatera fish poisoning.

Pakati, rai, u'u (parrotfish)

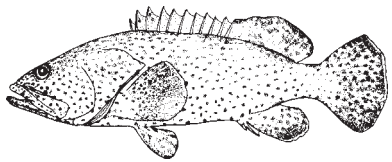


Thirteen species of parrotfish are found in the Cook Islands. Parrotfish feed on the algal stubble that grows on old coral rock. They do this by scraping the coral with their beak-shaped mouth. Scrape marks on corals can be seen and the rasping sounds they make while eating coral are noticeable underwater. Larger parrotfish feed on live coral.

In the Cook Islands, parrotfish are keenly sought after for eating. The island of Palmerston is well known for the large amount of parrotfish fillets it sends to Rarotonga.

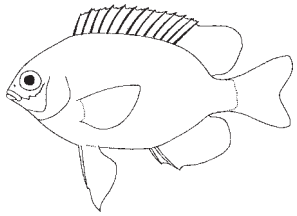
Many islands, however, are experiencing severe declines in parrotfish populations. Rarotonga has five, two-year ra'ui and Aitutaki has four reserves in place that may be beneficial to the parrotfish. However, it is not known how long an individual fish will remain in a given area, or how large that area is, so this form of protection is not foolproof. Aitutaki has responded by banning the use of SCUBA while spearfishing and by placing various limitations on the use of gill nets. Palmerston has responded to declines over the last ten years by placing short-term bans on catching parrotfish.

Patuki (groupers)



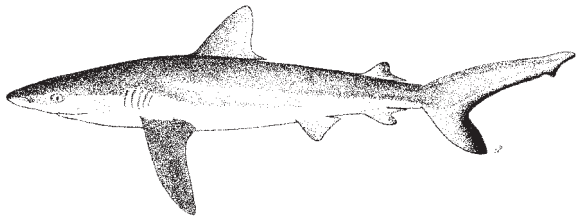
Groupers are some of the largest reef fish; some can reach weights of up to half a ton and live to be several decades old. Most groupers are predators and feed on crabs and fishes. In the Cook Islands, groupers are frequently found to be ciguatoxic.

Katoti (damselfish)



Damselfish are small and colourful, living and feeding in large schools and feeding on various microscopic plants and animals floating in the water. A few species "farm" small patches of algae that they bravely protect, even against unsuspecting humans who swim by.

Sharks



In the Cook Islands the more common sharks are the oceanic white-tip, the ngarara (reef white-tip), the reef black-tip, and the papera (grey reef). There have been occasional sightings of mango iravaru (hammerheads) and whale sharks. Sharks eat fish, squid, octopus, small shrimp-like animals, jellyfish, seaworms, skates and rays, other sharks, turtles, and seabirds. But not all sharks are predators; the two largest sharks, the whale shark and basking shark, are plankton feeders. They have gill rakers, that strain the many tiny creatures that float or swim near the surface of the oceans, including small fish swimming in schools. Whale sharks are the world's largest fish, reaching lengths of over 15 metres and weights of more than ten tonnes.

Sharks have six to fifteen rows or series of teeth, some of these rows are used but others lie beneath a thin membrane and move forward to replace teeth that fall out. It is known that in at least a few species the teeth are replaced every year so that the shark's 'business' teeth

are always new and sharp. Shark teeth are the most efficient cutting instruments known. Whale sharks have 7,200 teeth, each only 3 millimetres high. Apparently, these serve not as cutting instruments but rather as gates to keep tiny fish from escaping. The earliest sharks or shark-like ancestors date back 350 million years. Sharks have changed little since then.

From tagging programs, it has been discovered that sharks do not grow very fast and probably live quite a long time, but no one knows for certain how long. It is very difficult to tell the age of sharks. Very little information is available on shark numbers in Cook Island waters, though sharks are reported to be abundant in the northern group.

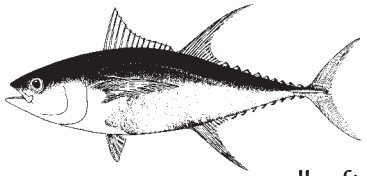
Shark attacks against humans are extremely rare events. World-wide, more than four times as many people are struck by lightning than are bitten by sharks, and millions of people swim, surf, dive or otherwise occupy themselves in the sea without shark trouble. However, by all accounts the tiger shark and the great white shark are dangerous sharks, especially as they frequent areas used by humans.

Sharks use hearing and vibrations to find food and to navigate. Sensory organs, or canals running along the shark's body or scattered about the head, detect vibrations and water displacements, and electrical fields, which are emitted by all animals. Sharks also have a well-developed sense of smell. They have no natural predators (apart from other sharks).

Sharks have cartilage rather than bone. Cartilage is lighter and makes up for the shark's lack of a gas or swim bladder, which most fish have for buoyancy. This means that sharks can change depth rapidly without risking fatal injury, an obvious asset when preying upon other fish. The cartilaginous shark is a supple fish, able to change direction quickly and within a small space, compensating for its inability to swim backward or stop quickly.

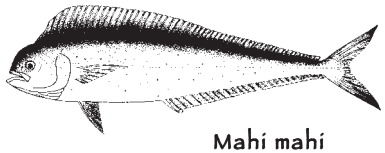
Pelagic fish

Pelagic fish live in the open ocean rather than in nearshore waters. In the open ocean there are no reefs to provide shelter and no large plants to provide food; only a few specialised types of fish, such as tuna, mahi mahi, mackerel, and billfish can live there. Catches by local fishermen mostly consist of yellowfin tuna, wahoo, and mahi mahi. Flyingfish are also a popular pelagic catch.

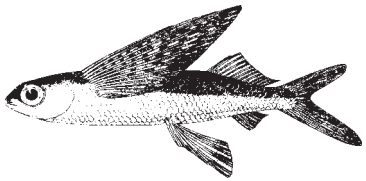


Yellowfin tuna

Wahoo



Mahi mahi



Flying fish

Other animals

Onu (turtles)

Two species of turtle are commonly found in the Cook Islands: the onu taratara or hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*). Both species nest on Manihiki, Pukapuka, Penrhyn, Nassau, Suwarrow and Palmerston Islands, while Rakahanga is a nesting site for green turtles only. Nesting occurs to a lesser degree in the southern islands of Takutea, Aitutaki and Manuae.

Turtles take approximately 25–30 years to reach sexual maturity. At this stage they will swim enormous distances back to the area where they were hatched. Mating occurs near the nesting areas. Around Palmerston this period is from May to August. On Suwarrow Atoll, December to February is the nesting period for turtles. After mating, males migrate back to their feeding areas and females move to their nesting beaches to lay their eggs. It is likely that younger turtles, not yet mature, will remain near one island.

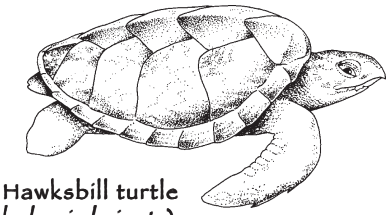
After laying eggs, the female will migrate back to the feeding area. The same female will not usually breed every year, but will wait from two to eight years (a 3-year cycle is common) before breeding again. It is thought that turtles typically live more than 40 years.

Female green turtles return to the same beaches to lay their eggs, year after year. She lays her eggs at night in a nest dug in the sand. Generally she will lay between 90 and 140 eggs. She will lay these in about three to seven sessions, spaced 10 to 15 days apart. The hawksbill females lay more eggs in any one season than any other. Eggs take around 48 to 70 days to hatch, depending on the temperature of the sand. The temperature determines the sex of the hatchlings: if the nest is hot, then most turtles will be female; if the nest is cool, then the majority of the hatchlings will be male.

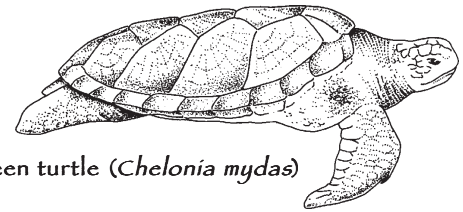
DO NOT DISTURB TURTLE NESTS BECAUSE YOU DECREASE THE EGGS' CHANCES OF SURVIVAL.

Juveniles break through the egg using a pointed tooth. The juvenile who hatches first stimulates the others to do the same. The hatchlings form a big pack and together they climb upward through the sand. A few days later they emerge on the surface.

By hatching together each one increases its likelihood of getting to the water alive. In other words, the chances of their brothers or sisters being caught instead of them are greater. The hatchlings know the direction of the water by its lighter colour, so any lights inland of the nest can confuse them. After reaching the sea, the hatchlings immediately swim for the open ocean where they begin feeding on tiny animals near the surface of the water.



Hawksbill turtle
(*Eretmochelys imbricata*)



Green turtle (*Chelonia mydas*)

Little is known of what happens over the next few years of life. It is thought that they drift for several years in the open ocean, perhaps hiding amongst floating seaweed and feeding on small plants and animals living on the seaweed, before they come to live around reefs and islands.

Small hawksbill and green turtles will feed on tiny animals but older green turtles are herbivores feeding on plants growing in shallow water. Older hawksbills are known to be carnivorous, dining mainly on sponges.

There is no available information on how many turtles use the Cook Islands for nesting, feeding, and resting. Recent information suggests that turtle numbers are declining in most of the islands. Palmerston and Penrhyn may now be the atolls most frequently used by nesting turtles. Because they travel so far to feed and mate, it is difficult to know how much Cook Islands fishermen have contributed to their decline.

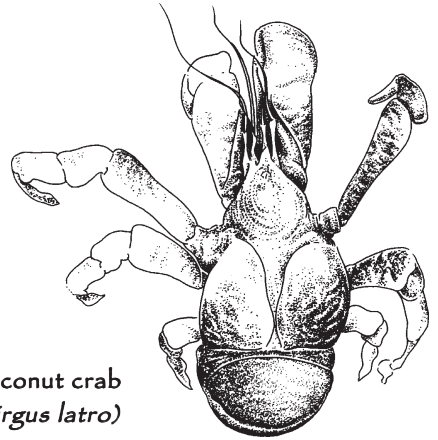
The hawksbill turtle is endangered world-wide and the green is threatened throughout much of its habitat.

Unga, kaveu (coconut crab)

Coconut crabs were once found widely throughout the Pacific. They have now disappeared over much of their previous range. In the Cook Islands, coconut crabs are present on most islands but have become extremely rare where there are many people. Pukapuka, Suwarrow, Mangaia, Takutea, Mauke, Atiu and Palmerston have quite large populations of coconut crabs.

During the day they hide in holes in the sand or under coconut trees and shrubs. At night they forage along beaches and over coral rubble looking for food, but will also forage during the day in areas where there is an abundance of crabs. They eat fruit, rotting leaves and animals. With their massive claws they can open and eat fallen coconuts.

This crab is the largest crab found in the world and spends most of its life out of the water, although they do need to drink seawater from time to time to keep up their salt levels. If you leave an adult coconut crab in the water it will drown.



Coconut crab
(*Birgus latro*)

Coconut crabs grow very slowly and must reach an age of four to eight years before they can reproduce. An adult may weigh up to 4 kilograms and live for over 30 years. As crabs grow they must shed this hard carapace and grow a new, bigger one. Like lobsters, they hide away in a shallow hole for a period of time while the new shell grows and hardens.

Mating occurs from May to September, with a peak in July to August. In Mangaia, the females come out of their burrows several months later in October or November to release the eggs, which they have stored under their tails (abdomen). The female moves to the shore and releases the eggs into the sea. After hatching, the crab larvae

float in the water for four to five weeks before settling. For about nine months they will use an old seashell to live in. They stay close to the water, and gradually develop their own shell and become more like land animals. As they grow they move further inland away from the coast. Because most larval crabs die, coconut crabs increase their numbers very slowly.

Coconut crabs are eaten throughout the Cook Islands. They are considered a delicacy and are generally eaten for local consumption rather than sold for profit.

On Palmerston, hunting for coconut crabs is done at night with the use of flashlights and is reported to be most successful when there is no moon and the ground is wet from a recent rain. Some crabs though can be caught on moonlit nights or during the day by digging up their holes or smoking them out. There are arapo (moon phases) when crabs and lobsters are thought to be most plentiful, these peak periods occur around the new and full moons. The best times for finding coconut crabs is thought to be the three nights following the new moon.

It is not known how many coconut crabs are found in the Cook Islands. People on Palmerston suggest that coconut crabs are becoming scarce on some islets of the atoll, this decline is probably seen throughout the Cooks.

There is no national effort to prevent overharvesting but some islands have protected areas where no marine animals can be taken (including coconut crabs). Suwarrow is a National Park but even so, there are no harvest restrictions on the island.

On Pukapuka, where traditional management is still strong, the villages govern the opening and closing of their motus to the taking of coconut crabs. Harvesting is only allowed at certain times of the year. Even so, today coconut crabs caught today are relatively small.

Because coconut crabs are very slow growing and relatively easy to catch, their populations will quickly decline where they are over harvested. It is up to each island to decide if they want to protect the coconut crab.

Common Fishing Methods in the Cook Islands

Reef-flats, lagoons, fringing and barrier reefs, and the open ocean provide an important source of protein for many Cook Islanders. Fish and invertebrates are harvested from nearshore areas by using gill nets, traps, spears, rod and reel, gleaning and simple hook-and-line gear. Trolling and longlining are methods for catching oceanic species of fish; gear includes trolling lures, multi-hooked longlines, and rod and reel. The choice of gear used largely depends on the type of fish a fisherman or woman is targeting. This section describes some of the more commonly used fishing methods in the Cook Islands.

Hook-and-line

Hook-and-line fishing is one of the oldest methods for catching fish. In the Pacific, traditional hook-and-line gear was made from natural materials: vines, coconut fibre or strong bark from trees were woven into thin fishing lines; hooks were made from strong wood (e.g. the roots of trees), bone, or shell; stones were used for weights. Fishermen and women generally fished from the shore or from simple rafts or canoes.

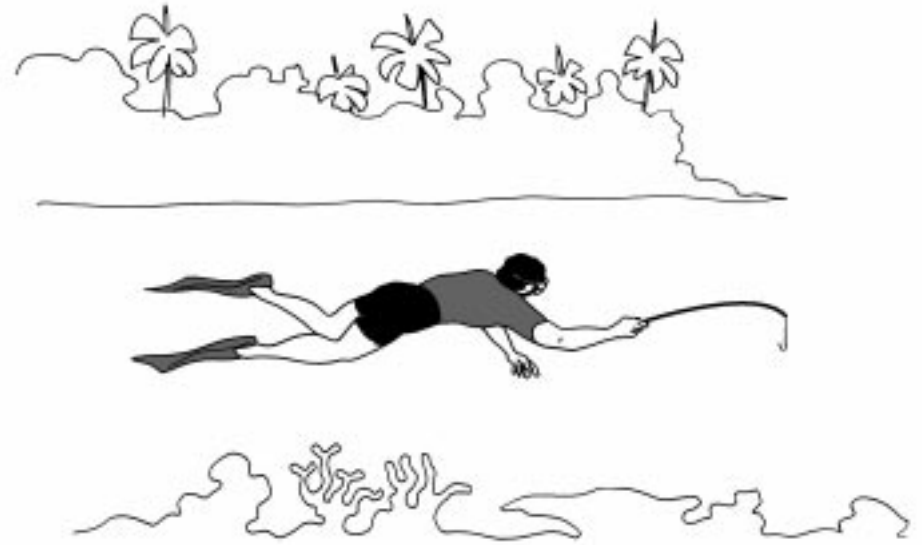
Over time, hook-and-line gear has changed to take advantage of modern materials. Examples include the use of monofilament for fishing line, stainless steel for hooks, and wood or plastic spools or mechanised fishing reels for storing the line.

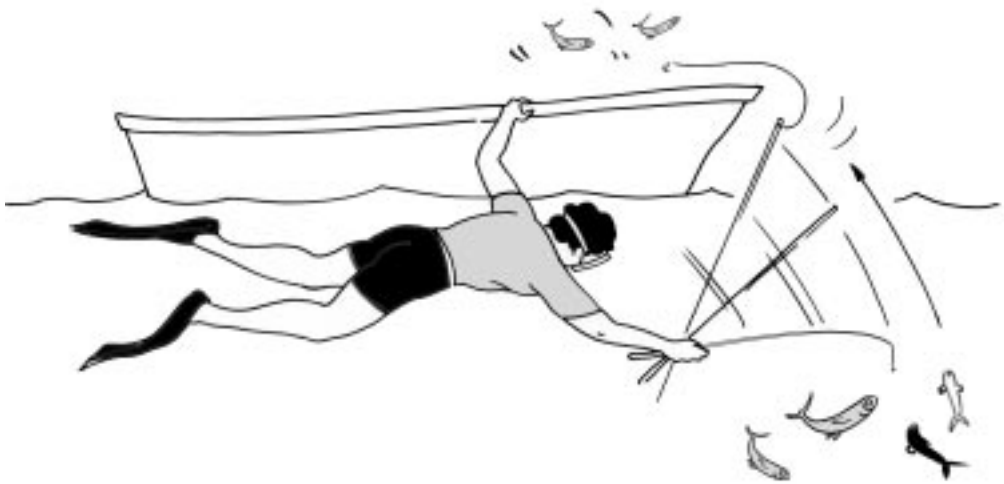
The most familiar type of hook used in the Cook Islands is the "J" and circle hook. To capture fish using a "J" hook the fisherman or woman must jerk the hook when s/he feels a fish is taking the bait. Circle hooks are designed to hook the fish using a rotating action, when the fish takes the hook. Hook-and-line fishing may range from casting the baited hook from shore, fishing off canoes or motorised fishing boats, or from large commercial fishing vessels, capable of setting tens of thousand of hooks in a single fishing trip.

Hook-and-line fishing is considered an environmentally friendly method as it catches primarily target species, inflicts minimal injury to the fish, and causes minimal damage to the surrounding habitat.

Titomo

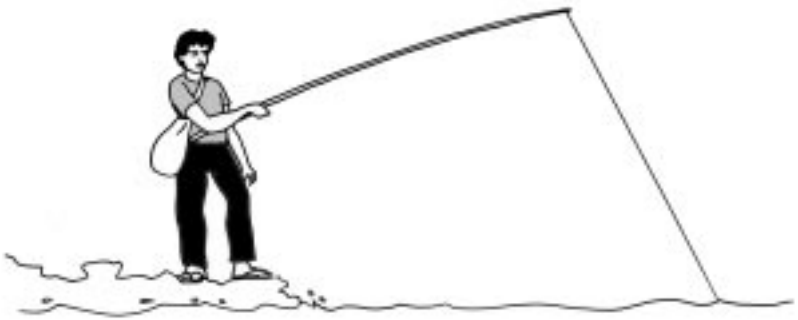
Titomo is carried out while diving. The fisherman has a small baited hook attached to a short length of line (15 to 30 centimetres) on a rod of about one metre. Fishermen using this method target koperu (mackerel scad) at dawn or dusk, or small patuki (groupers). To catch mackerel scad a piece of coconut flesh is attached to a barbless hook. The fisherman uses chum (ground coconut flesh) to attract the fish and then offers the bait to the fish. Once the fish is hooked it is quickly flicked into a canoe.





Matira or takiri

This fishing method uses a two to five metre rod and is done either from boats or from the shore. Fishermen cast the line and keep the baited hook stationary or move it about. The lure is made of shell, feather, metal or plastic. Matira is carried out at any time of the day to catch small groupers, paoa, titiara (trevally) or at night to catch ku (squirrelfish).

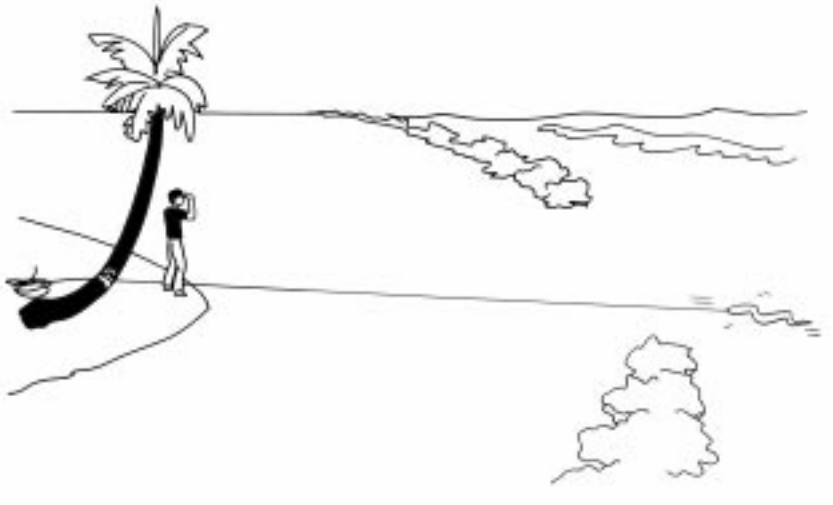


Tiritiri

Tiritiri targets predatory fish such as titiara, urua (trevally), angamea (snapper), mu (emperors) and groupers. The method uses only a handline and a baited hook. The fisherman waits until a fish takes the bait. In some cases, paru (ground bait) is used. On some islands such as Atiu, this type of fishing is done from cliffs near the water to catch trevally.

Matau tamoe

This method is generally used for catching large trevallies. Fishermen tie a thick line to a tree, then walk the line out over the reef. A hook is baited with live eel, to prevent other fish (such as small groupers and triggerfish) from eating the bait. The hook is placed somewhere soft (such as in a patch of soft coral) to stop it from shifting about with the swell and currents. The fisherman either waits or leaves the baited hook over night and checks it in the morning.

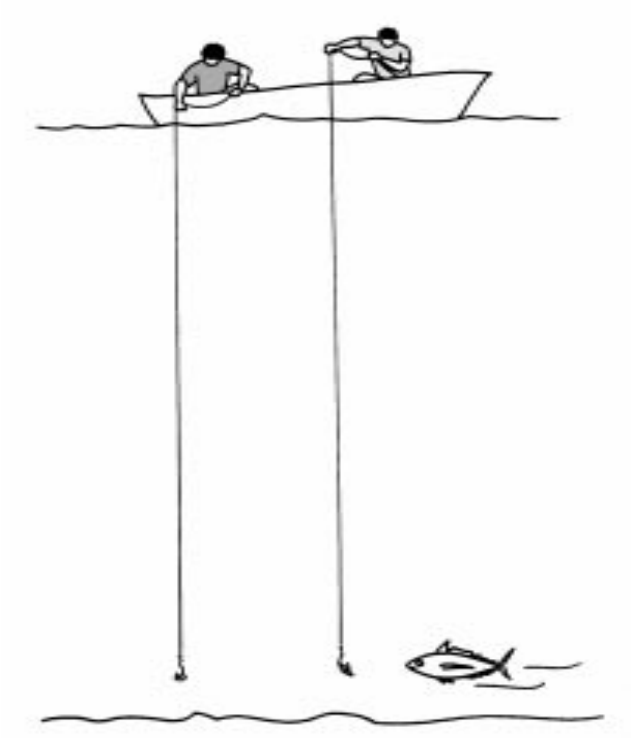


Rod and reel

The modern rod-and-reel method is used for catching both inshore and offshore species of fish. Offshore fishing uses game rods with 15–70 kilogram breaking strain line, while nearshore fishing (lagoon and reef) uses spinning reels with 3–25 kilogram breaking strain line. Game fishing involves dragging baited hooks or lures of various configurations behind boats. Game fishing targets pelagic species such as marlin, tuna, dolphin fish, wahoo and barracuda. Casting involves flicking baits, lures, metal spinners, or flies into the water and reeling them back towards the fisherman. Casting targets trevally, bonefish, and small pelagic species. Traditionally, fishermen dragged pearl-shell lures behind canoes to catch small tunas.

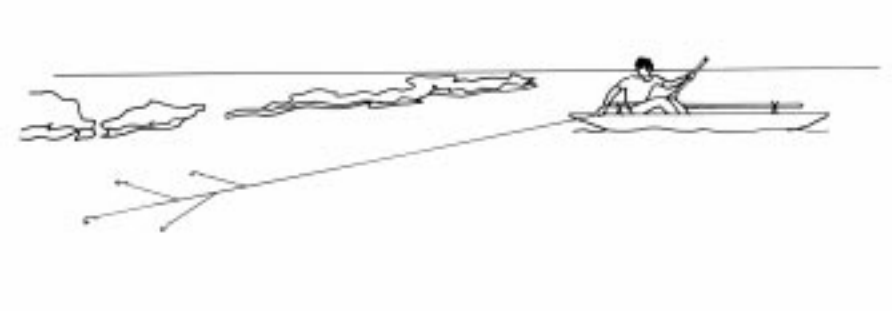
I'i or drop stone fishing

With i'i, a baited hook is dropped to great depths to target deep-sea fish species such as groupers and snappers, and pelagic fish such as tuna, wahoo and marlin. Bait is usually mackerel scad, big eye scad or flying fish. Ground-up bait and a weight (usually a rock) is wrapped inside a leaf with a baited hook and tied with a slip-knot. The package is dropped over the side of the boat and lowered to the required depth and then the line is jerked upwards. The movement slips the knot and freeing the packet of leaves and ground bait.



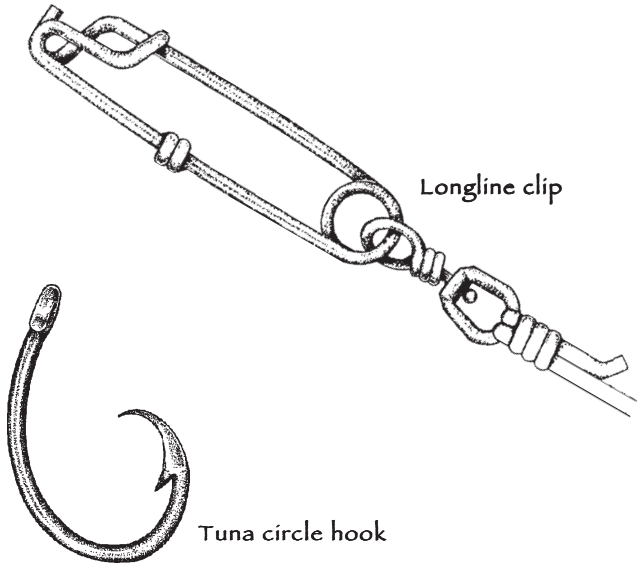
Tavere or taverevere ku on canoes

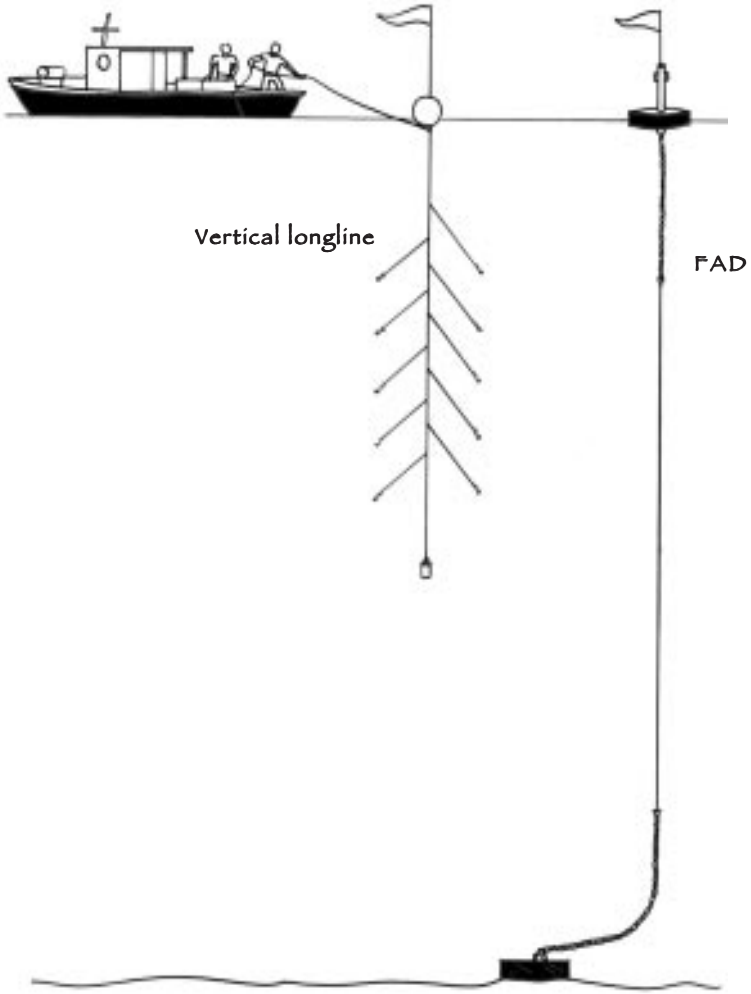
This type of fishing is done on dark nights, generally when the seas are very calm. Fishers go out in canoes and troll (10 to 15 metres in length) rigged with three to five hooks attached directly to the main line. Uru tavake (bird feathers) or shiny white-strand rope (preferably nylon) are attached to the hooks. This type of fishing is similar to modern-day trolling but is done from canoes. The boat is paddled along the reef areas or as closed to reef as possible to catch squirrelfish.



Vertical longline

A vertical longline is generally used to catch tunas. The gear consists of a mainline (between 100 to 300 kg breaking strength) with several branch lines (between 10 to 20) attached to the mainline via quick release clips. Each branch line (or snood) carries a baited hook. A float is attached to the top end of the mainline and a sinker is attached to the bottom end. Fresh bait such as mackerel, sardines, mullet, or flying fish are attached to the hooks. The gear is left to soak for up to two to four hours before hauling. This method is generally used around fish aggregating devices (FADs).





Net fishing

Net fishing is one of the most popular fishing methods in the Cook Islands. Nets are an effective way of catching fish, although there are several drawbacks to using them. Apart from the scoop nets used to catch flying fish, all nets are capable of catching undesirable or non-target fish that may not be eaten.

Gill nets

Gill nets work by snagging fish behind their gill covers (this is where the name 'gill net' comes from). Gill nets are used to catch a number of different reef fish in a lagoon or along a reef edge. Gill nets are made of either monofilament or nylon. A number of floats are threaded onto a line and fixed to the upper portion of the net while a lead line is fastened to the bottom portion of the net. This keeps the net wide open after setting it. The net can be either anchored or dragged along the bottom. The mesh size partly determines which species and size of fish will be caught. Generally, the smaller the mesh size, the smaller the fish that will be caught. If a large mesh net is loosely fixed to the floatline and leadline this will also catch small fish by tangling rather than snagging them behind the gills. Most fishing nets used in the Cook Islands are set in lagoons; common mesh sizes range between 1.5 to 3 inches.

There are two common types of gillnet fishing, 1) set gillnetting and 2) drive gillnetting.

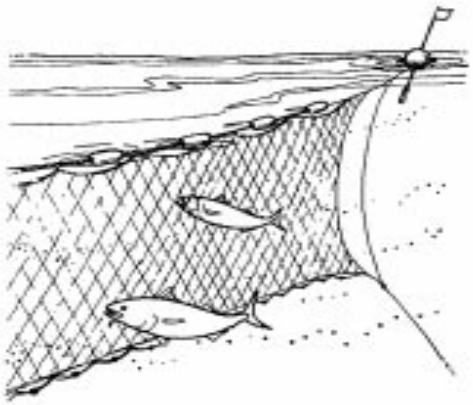
Set gillnet fishing

The gill net is set in the lagoon or along the reef slope and anchored to the bottom at each end. Fish are caught as they try to pass through the net. This method is used to catch many kinds of fish.

Drive gillnet fishing

Fishermen walk along the reef crest, sight and stalk a school of fish, and place the net across the channels (leading from the lagoon to the open ocean) through which the school will try to get away. The school is then chased seaward into the net and trapped. For catching schooling species, such as kanae (mullet), kiokio (bonefish), and ava (milkfish), a long net is used to surround the school. This involves several outrigger canoes or fishers. Fishers beat the water, herd and chase a school of fish towards a half-encircling net. The ends of the net are then brought around to surround the fish.

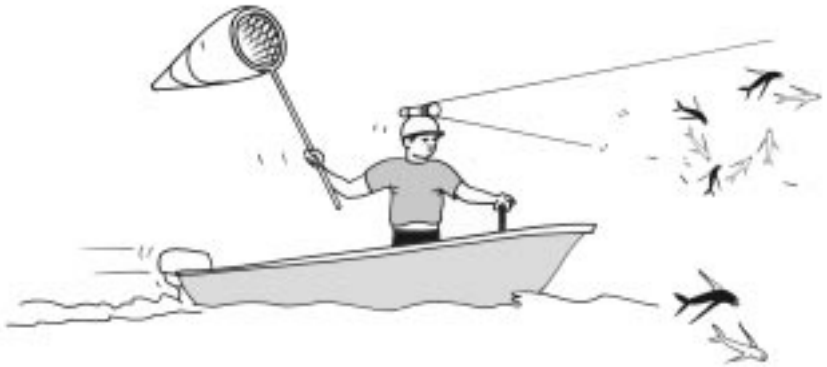
Fish follow natural migration paths. Certain fish species such as the ume (unicorn fish) use these paths to leave the lagoon at particular times of the year. A net is often set across these paths and fishers beat the water and poke under coral, basically driving the fish into the v-shaped net. The nets are then lifted up and emptied into the outrigger canoe. In some instances, such as when large schools of unicorn fish have been trapped within an encircling net, the fishermen will enter the water and spear the fish that have hidden amongst coral.



Set gillnet

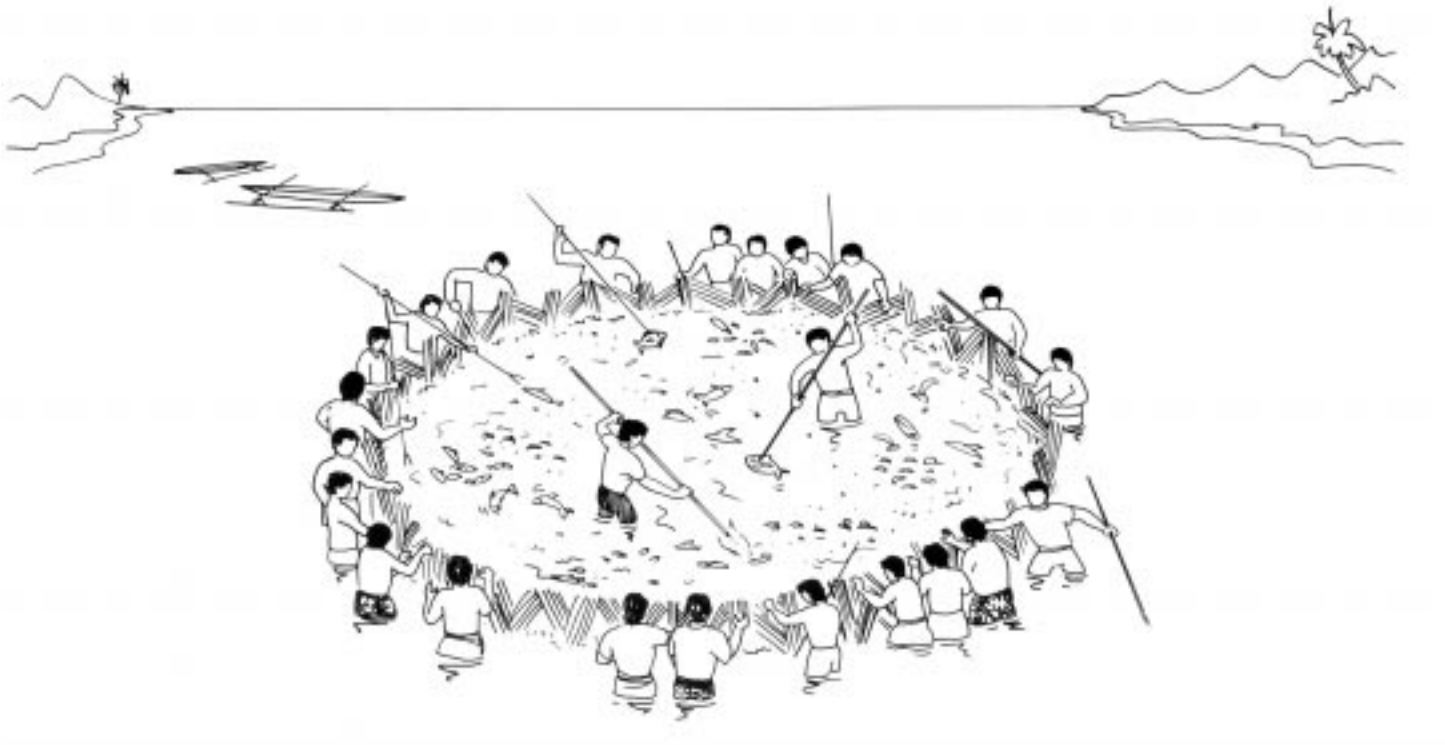
Scoop nets

Scoop nets are used to catch flying fish. The net is attached to a hoop, approximately 0.5 metres in diameter, which is formed either from stainless steel rod or flexible tree branches, 1.5 to 3 metres long. Netting is attached to the hoop so that it tapers towards the bottom. Flying fish are captured using a motorised boat. Bright lamps are attached to a helmet worn by the fisherman especially for scoop net fishing. As soon a school of flying fish is spotted, the fisherman keeps the light trained on the fish (which attracts and keeps them on the surface) and scoops them up. Some fishermen are capable of catching up to 400 maroro on a good night.



Cast nets

Cast netting is done by one person, usually in shallow areas of a sandy lagoon or close to the beach, with little or no rough substrate to destroy the net. This method is used to catch small fish schools. When a school is spotted, the fisher casts the net quickly to avoid scaring the fish and to ensure the net opens fully. A rope is attached to the net apex for retrieving. It takes a lot of practice to use the cast net efficiently.



Rau (leaf sweep)

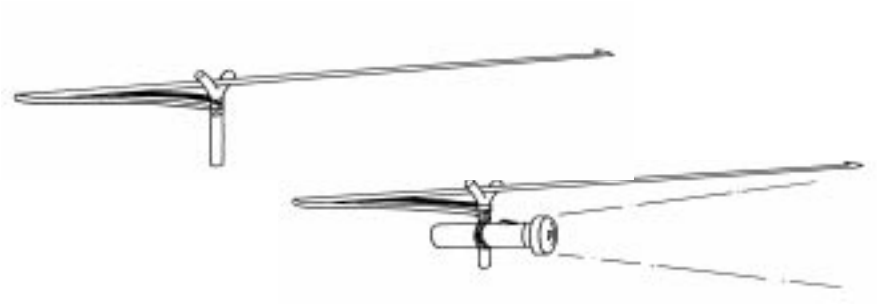
Rau, a traditional fishing method seldom used, is sometimes referred to as a leaf sweep. This type of fishing involved tying coconut fronds together and using them as a "wall" to surround fish schools. *Rau* fishing generally involved a large number of fishermen and women and was done in reef channels and in the lagoon. Due to the modernisation of fishing gear there was a shift from *rau* fishing to gillnetting. The shift followed an increased availability of monofilament gill nets and an increase in fishing activity on an individual rather than a community-based level.

Spear fishing

Traditional spear fishing used a javelin-like wooden spear and was done along the shore or in the surf. The arrival of metal and rubber radically changed the spear, which now has barbed prongs at the end and a quick trigger mechanism.

Pata spearing

Pata spearing is similar to using a slingshot. The gear consists of a "Y"-shaped piece of wood, heavy gauge rubber and a metallic spear. Teenage boys use *pata* to learn how to spear fish; older, more experienced fishermen, use this method at night, with an underwater torch attached to the *pata*. The method is mainly carried out in the lagoon to catch most types of edible fish that venture close enough to be shot.



Throw spearing

Multi-pronged throw spears were once widely used around the Cook Islands. Today, however, their usage is declining. The spear is made of a steelhead with three to five prongs with outward-facing barbs. The shaft is four to five metres long and made from a hard, light local timber such as wild hibiscus.

Throw spearing is conducted on the reef, along the beach, or in the lagoon and is generally done at low tide or on incoming and outgoing tides. This method was traditionally done to catch reef fish such as parrotfish and trevally along surge channels, although fishermen are now using this method to catch mahimahi (dolphinfish).

There are two primary methods that use a throw spear.

1) Reef stalking involves walking along the reef crest and throwing the spear at fish on the reef or in the seaward gutters. This is usually done on an incoming tide, as the fish begin to move up onto the reef. The lower tide makes it easier to walk along the reef crest, and also means that fewer small fish are present that would otherwise spook the target fish.

2) Passage spearing involves standing at the side of a passage, spearing fish as they swim past, generally at dawn and dusk, when fish are moving into or out of the lagoon. The best time is in the predawn after a full moon, when there is sufficient moonlight to see the fish, and on an outgoing tide which forces fish entering the lagoon (against the current) to pass close to the sides of the pass.

Spear guns

Fishing with a spear gun while free diving is like hunting. Spear guns are used both in the lagoon and outside the reef, during the day and night, and are probably one of the most popular fishing gear. Spear guns are an efficient method of catching fish. The gear consists of a spear shaft, handle, trigger mechanism and rubber. Snorkelling gear (fins, mask, snorkel) is used. Morava (rabbitfish), parrotfish, trevally, drummerfish, surgeonfish, goatfish, mullet, snapper, emperor, squirrelfish; lobsters are also occasionally taken at night.

Gleaning

Women and men search the reef during the day or at night, but usually when the tide is going out, or is very low. Most gathering activities use a limited amount of equipment and specialised gear. Generally, a screwdriver, a knife, and a bucket are all that are taken out on the reef when gleaning.

The types of seafood collected on the reef differ from island to island but include some of the following: pa'ua (clam), vana, atuke (sea urchins), matu rori (sea cucumber gonads), rimu (a type of seaweed), ariri (rough turban snail), korori (pearl oyster meat), eke (octopus), papaka (crabs) and mapii (limpet).

Other fishing methods

Traps and pa

Traps are used to capture various types of fish. The pa (coral fence trap) is one of the oldest communal fishing methods. Schooling lagoon fish move out of the lagoon on a falling tide. The stone wall intercepts the school and guides it towards a v-shaped apex where the fish cannot escape.

Inaki is a trap used to catch eels. A plaited basket is baited in a way that allows eels to enter the trap but not exit. Inaki is used to catch freshwater eels.

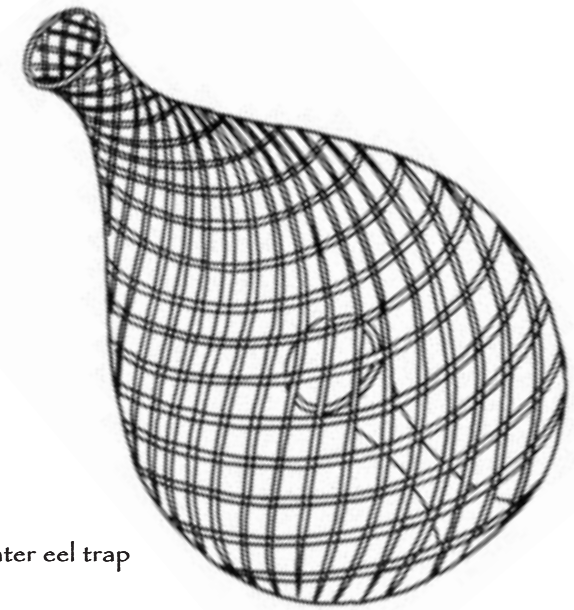
Jabbing

This method is used to catch varo (mantis shrimp) from their burrows. At the bottom of a short stick are some upward-facing barbs with bait at the tip of the barbs. The stick is placed into the burrow. As the shrimp comes to take the bait and retreat back into its burrow, it hooks itself onto the barbs.

Freshwater fishing

Tilapia (*Oreochromis mossambiscus)*, a type of freshwater fish, was introduced into the Cook Islands in 1955 as an additional food source for local people. Tilapia are found in fresh and brackish water on most islands in the Cooks. They are captured using gill nets and hook-and-line gear; hooks are generally baited with earthworms.

Itiki and tuna (fresh water eels) are caught using hook-and-line gear, traps, or by a swift blow with a large knife. Traps, woven from a special vine locally known as pirita, are made into shapes that make it difficult for the eel to escape.



Inaki,
fresh water eel trap

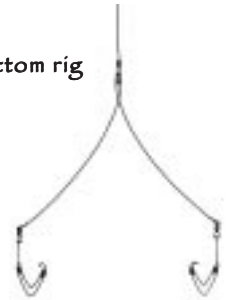
Manga fishing

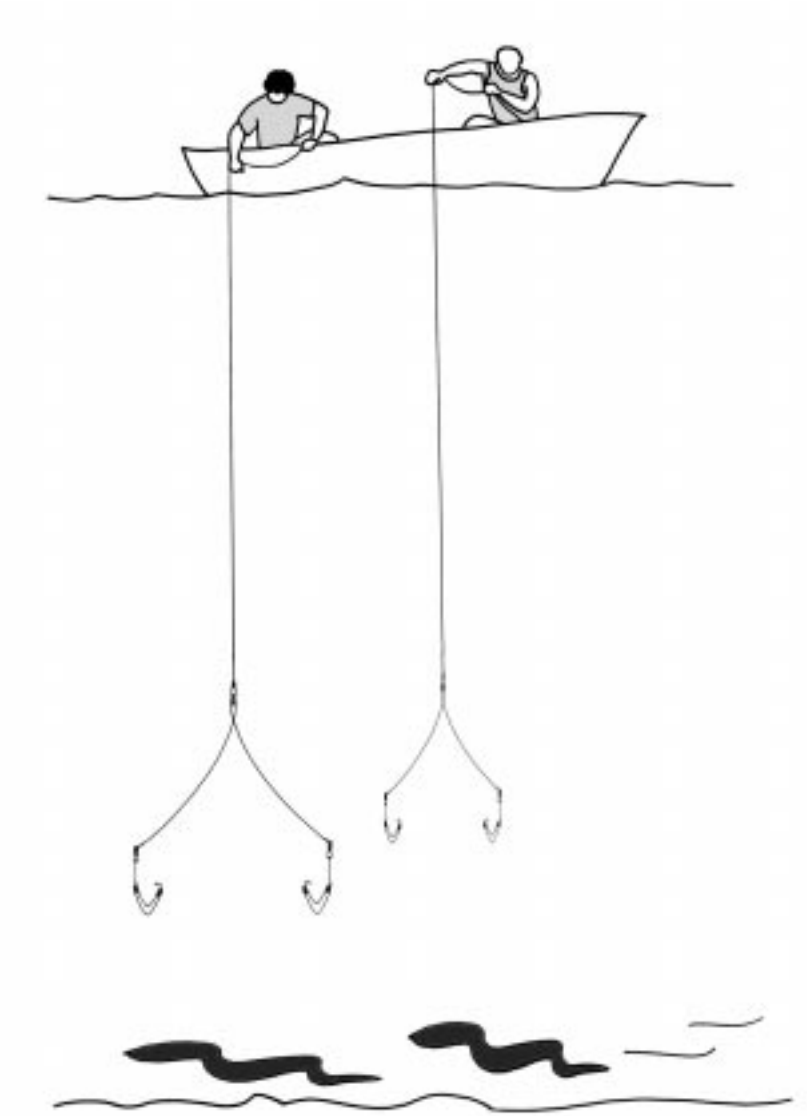
Fishing for manga (snake mackerel) is generally carried out on dark nights. It involves a lot of preparation. Manga is a deepwater species that lives at a depth of 300 metres or more. The gear consists of: a monofilament line attached to a bent wire (similar to a coat hanger) carrying two homemade hooks locally called "toko" (v-shaped piece of wood). Tokos are carved out of forked branches from a very strong, dense hardwood. Each toko has a straightened steel hook attached to it.

Prior to a fishing trip, a fisherman collects several rocks (between 2 to 3 kg) and strips the bark (between 2 to 3 metres) of wild hibiscus branches. During fishing, the fisherman baits the hooks with fillets of mackerel scad, flying fish or skipjack. One end of the hibiscus bark is tied to a rock and the other is tied using a half hitch knot onto one of the hooks. The weight is lowered over the side of the boat making sure there is tension on the line until the hooks enter the water. The baited hooks and weight are allowed to reach the bottom without any tension on the line. When the bottom is reached, the fisherman allows additional slack then quickly hauls in a few metres of the line. This quick action releases the rock and allows the baited hook to sway freely over the bottom.

Toko

Bottom rig





A manga fisherman leaves the shore just before sunset to reach his fishing ground. If the current is too strong at one spot, the fisherman will move to other known fishing grounds. During manga fishing, the fishermen either anchor the boat or use paddles to keep the line at the desired fishing depth. During manga fishing, fishermen usually stay out all night. On most islands, manga fishermen know all the manga fishing grounds and choose their fishing spot according to weather conditions, currents and phases of the moon.

Destructive fishing methods

The fruit of the utu (barringtonia tree) *Barringtonia asiatica* , the roots of the vine *Derris* sp., ora papua, and dynamite were once used to poison, stun, and blast fish. These practices have been banned because they not only kill the target fish, but also other fish, shellfish, and coral in the area. These methods are particularly harmful to larvae and juvenile marine organisms.

Marine Ecosystem and Fisheries Management

Objective of management

Living marine resources are regarded as common property in the Cook Islands. No individual has exclusive rights over them, and anyone in the community has a right to harvest these resources. But, if too many young parrotfish, clams, coconut crabs, or any other animal or plant is taken before it reaches breeding age, it becomes almost impossible for that species to keep its population numbers up.

The objective of marine ecosystem and fisheries management is to allow living resources to continue to exist in numbers great enough for them to maintain their populations, and be a readily available food source for the people of the islands year after year. Sensible management also allows the community and visitors to observe the beauty and complex nature of the marine ecosystem through recreational activities. In other words, various groups including fishers, tourism operators, tourists and locals can all benefit from marine management. Ultimately, it is for these reasons that marine ecosystem and fisheries management is needed.

Management of the marine environment has been practised in the Cook Islands since the ancestors of the present Polynesian populations inhabited these islands. It has been important because of the small areas and limited resources available. Today, although the large majority of islands have plentiful supplies of most of their marine resources, there are some species that need to be managed to prevent population declines. Management is becoming even more important because of the economic, technological and environmental changes occurring as well as changes in the traditional use of marine resources. Income from fisheries is becoming increasingly important, as people have come to rely on cash for purchasing imported foods and goods. More efficient fishing gear (such as gill nets) means that more fish can be caught in less time; and with storing facilities such as freezers, a surplus of fish can be had (that is, more than can be eaten at one time).

Land activities have a major impact on the marine environment. Agricultural pesticides, fertilisers, and erosion from land-clearing activities eventually end up in the lagoon and nearshore waters after heavy rains. These sediments and chemicals affect water quality, and silt smothers the coral preventing sunlight from reaching the symbiotic algae living inside the coral polyp. As a result, the algae can no longer conduct photosynthesis and the coral dies. Other human impacts on the reef environment include anchor damage from boats; rubbish thrown into rivers or the sea or, left on the beach; sewage; and foreshore construction.

In addition to protecting the environment, marine management can provide a means of preventing conflicts between different resource users, and can help ensure that the economic benefits obtained from fisheries are returned to the community.

Marine management tools

This section describes several types of appropriate marine management tools that can be used to manage reef resources. They include limits or restrictions on:

1) fishing gear,
2) the number of users,
3) the size of animals caught,
4) the number of animals caught,
5) closures.

Restrictions on fishing gear

Limits on fishing gear are applied to equipment that are capable of overharvesting marine organisms (e.g. gill nets). The community of Pukapuka has placed a ban on spear fishing to protect groupers.

Spear fishing with SCUBA gear is banned on most islands, and on Manihiki and Penrhyn the use of SCUBA is prohibited for the collection of wild pearl oysters.

Controls on gill nets vary from island to island. On most islands there are no restrictions, while on others, restrictions are placed on:

- mesh size
- length of nets
- time of the day nets can be used
- distance between two separate gill nets
- joining two nets together.

The purpose of controlling mesh size is to allow small fish to escape. Controls on net length allow some fish to avoid the net altogether and make it difficult for fishermen and women to surround schools of fish. Maximising the area between two gill nets also works to allow some fish to escape.

The use of SCUBA and surface supplied air from a compressor (hookah) are prohibited on some islands. Both kinds of gear allow a fisherman to spend longer periods of time under water catching fish, shellfish, and crustaceans. Trochus, clams, pearl oysters, sea urchins, lobsters, sleeping fish and other slow-moving or stationary animals are vulnerable to fishermen using SCUBA or hookah gear. Banning or restricting the collection of slow-moving species using such gear ensures that fishermen do not take too much.

Restrictions on the number of users

Restrictions on the number of fishing boats, number of pearl oyster farmers, licenses, and permits are all ways of controlling overfishing. Pearl farmers are issued a permit, which allows a restricted number of shells to be farmed in a certain area. The number of offshore fishing boats is also limited by licensing arrangements.

Restrictions on the size of the catch

Limits on the size of animal a person can catch ensures that the reef ecosystem maintains a balance of adults and juveniles. If too many adult fish, shellfish, molluscs, crustaceans and other marine organisms are overharvested, then there are not enough individuals left to produce offspring. If too many young are overharvested, then they won't grow to be adults and produce offspring themselves.

Often, larger adults have greater "breeding power" (ability to produce more offspring) than medium-sized adults. It is, therefore, best to catch medium-sized fish and leave the larger-sized animals as breeders. This measure is applied to the Aitutaki trochus fishery. Trochus reach reproductive maturity when the base of their shell reaches about six centimetres in diameter (this is equal to approximately two years of age). A minimum size of eight centimetres is imposed to allow trochus to reproduce before they can be taken from the reef. The maximum size limit for trochus is eleven centimetres and this size limit is imposed to ensure that enough large trochus are left as a breeding population. This maximum size limit also helps maintain a high quality of export shell because the larger and older trochus are normally of lower quality (i.e. value) due to the infestation of shell-boring tubeworms.

Limiting sizes is most effective for marine organisms that are collected by hand, such as trochus, sea cucumbers, and others. Despite the

limitations of this type of management, size limits on fish are still used in many countries and can be effective.

Restrictions on the number of animals caught

Limiting the volume, number, or weight of the catch is generally referred to as a quota. This means fishermen or women, boats, or communities are only permitted to catch a certain number of fish or shellfish. The Aitutaki trochus harvest is a good example of this. During each harvest season, each resident is given a quota, a maximum number of trochus he or she is allowed to harvest. The combined total quota (all individual quotas added together) is called the community or island's total allowable catch. By issuing individual quotas, everyone in the community has an opportunity to benefit from the resources.

Closures

There are three common types of closures used for marine management:

1) closed seasons,
2) closed area, and
3) permanent closure.

Closed seasons are placed on one or many species at certain times of the year. Mangaia and Nga-pu-Toru practice closed seasons with bigeye scad (ature) and freshwater eels.

A closed area is protected from any kind of fishing. Rarotonga and Aitutaki have several areas along the coast that are closed to fishing. Both forms of closures can be combined. For example, fishing in a certain area can be closed during a period when fish are spawning.

Permanent closure is done to protect all organisms in the ecosystem of a particular area.

Ra'ui is a customary community-based management system imposed to protect or conserve particular resources or areas. Routine use of the ra'ui system meant that a long-term ra'ui was not necessary. Ra'ui can be placed on an area of land, lagoon, swamp, fruit trees, coconuts, birds, coconut crabs, turtles, and many other plants and animals for the purposes of conservation or management.

Marine-Based Careers

Some careers in the marine field involve on-the-job practical training, others require study. In either case, a career in the marine field, whether in fishing, farming, processing, marketing, research, developing, managing or conserving resources, is challenging and rewarding. Marine-based careers are extremely varied and it is impossible to list all the directions students can take, but some are listed below.

In the fishing field there are: fishermen and women, boat skippers, engineers, boat crews, master fishermen and boat builders, fish processors, sales-persons, accountants. In the pearl industry, there are farmers, seeding technicians, divers, processors, marketing and sales persons.

Tourism-related activities include charter fishing, advertising, recreational dive and snorkel tour operations.

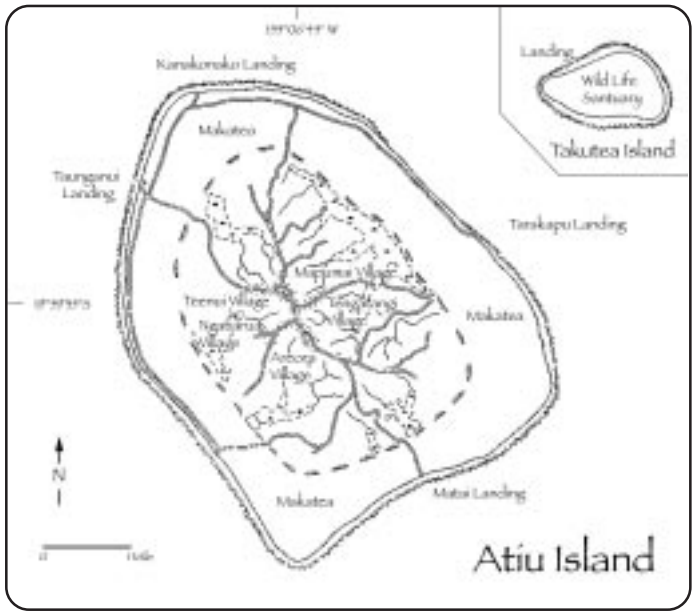
For those interested in government or other organisations, there are career positions for scientists, economists, sociologists, resource managers, fisheries surveillance officers, information and training officers, development officers, and teachers. There are also positions with non-governmental agencies as environmentalists.

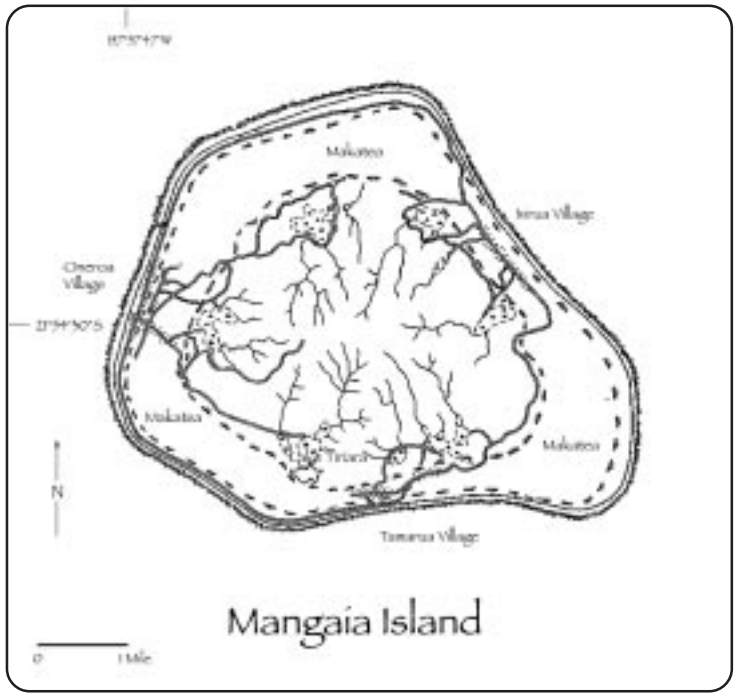
Anyone interested in a career in fisheries or any other marine-related area can visit the Ministry of Marine Resources.

A Brief Overview of the Marine Environment for Each Individual Island

Nga-pu-Toru and Mangaia

The Nga-pu-Toru islands (Atiu, Mauke and Mitiaro) and Mangaia have several similarities. All are upraised coral islands surrounded by a narrow bench reef with limited access through the reef. Due to a lack of lagoons and limited reef area, coupled with a steep outer reef slope, the diversity and abundance of fish are relatively low. During the 1970s, 80s and early 90s pineapples, coffee and citrus were propagated for export. Exports, however, came to a halt due to the moderate supply and strong competition from other countries. Handicrafts, the export of taro, and a limited tourist industry currently support the islands' economy. Subsistence agriculture and fishing provides much of the islands' nutritional needs.

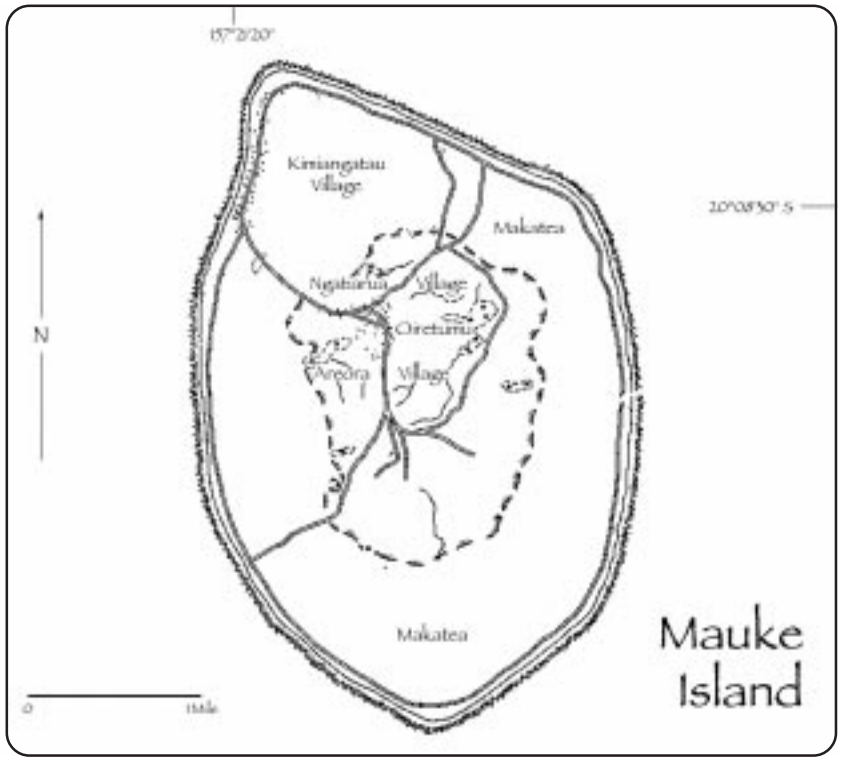




The majority of reef slope fishing activities is carried out in canoes (2 to 2.5 metres in length) which are either hand-paddled or powered by small outboard motors (1.5 to 4 horsepower). In 1998 there were a total of 37 active fishing crafts on Atiu, 42 on Mitiaro, 25 on Mauke, and 64 on Mangaia. Men generally fish the reef and outer reef slope and women carry out reef-gleaning activities. These communities use ra'ui (traditional community-based management systems) to conserve fish stocks for communal use. The four islands have significant freshwater systems that support an abundance of fresh water eels and tilapia.

Takutea

Takutea is located 22 kilometres south of Atiu. The land area covers 120 hectares, and rises approximately six meters above sea level. Although the island is unpopulated it has close social ties to neighbouring Atiu Island. Takutea, a gift to the people of Atiu by the traditional family landowners, is considered a "wildlife sanctuary". In 1950, the Aronga Mana (traditional leaders) of Atiu were appointed as "trustees for all the native land owners of Atiu and their descendants", and an elected committee administers the island. The island is considered to be the most important seabird-breeding site in the southern Cooks.



When the seas are calm, small groups from Atiu visit the island. Atiuans must notify the Takutea trust or the Aronga Mana. Each person must pay a NZD 10 fee before going onto the island. Each boat going to Takutea to trawl must pay NZD 10 per boat. Limitations are put on harvests and, from time to time, boats are checked in Atiu for evidence of overharvesting (fishing in Takutea is generally done from boats). There is not much collection of reef animals and not much spear fishing. Takutea is a rather unique island in the Cook group because of the relatively low level of harvest pressure. However, the animals and plants that live in the lagoons and on the surrounding reef have small populations that could easily be overharvested if visitors take too much. The harvest of turtles is totally banned on Takutea and traditional leaders limit the harvest of coconut crabs.

Aitutaki

Aitutaki, in the southern Cooks, has a population of approximately 2300. It has 15 small islets and a main volcanic island with a height of 119 metres. The lagoon at Aitutaki is shallow (11 metres maximum depth) and almost completely enclosed by a substantial barrier reef. There is only one major pass to the open ocean, on the western side, and this is too shallow to be navigated by large boats. Because of this, the lagoon is fairly cut off from oceanic waters and differs slightly in temperature and salinity from the surrounding sea, depending on the state of the tide and rainfall.

As with all enclosed lagoon systems, live coral grows much better outside of the reef than on the inside. Aitutaki lagoon is not only a visitor attraction but also a source of livelihood for local people. It is estimated that over 80% of households are engaged in fishing activities, and 85% of the total catch is for home consumption. The majority of fishing occurs in the lagoon.

There is not much commercial fishing at Aitutaki except for the occasional trochus shell harvest and fishing for local sale. Fish resources appear to be in good shape and sustainable. However, the traditional community practices that once regulated the fishery in times past, are being eroded by the modern way of life. The Aitutaki Island Council has introduced measures to help control what might become problem areas in the future.

Aitutaki lagoon is an ideal training ground for novice snorkellers and divers with many schools of small colourful fish; however, the real sights are outside the reef where the coral and fish are more abundant. The eastern outer reef slope is virtually undisturbed by human activity, and can be visited in calm weather.

The main way the Island Council ensures the protection of Aitutaki's marine environment is through the establishment and management of marine reserves. These provide areas where fish can live and breed undisturbed and have benefits both for visitors and locals.

Marine reserves are located at both of the southern corners of the triangular-shaped barrier reef, and enclose the outer reef-slope, the reef-top, and a portion of the lagoon. No fishing or taking of marine life is allowed in any of these areas. Another no-take reserve covers the shallow enclosed area at O'otu, in the northeast lagoon. This almost-estuarine environment appears to be unique in the Cook Islands, and is an important habitat for juvenile bonefish, milkfish, and mud crabs.

The existing bylaws at Aitutaki prevent the possession of nets more than 100 metres by 4 metres in size, or with a mesh size of less than 60 millimetres. A net must not be set less-than 100 metres from another net, and one person may not set more than one net. If setting a net between two motus (small islands on the barrier reef), the net may not extend over more than one third of the channel width between the motus. In addition, the person setting the net must remain "in the vicinity" for the whole time that the net is set.

Unfortunately, it is difficult to enforce these partial restrictions and the Island Council is now in the process of implementing a total ban on gillnetting at Aitutaki, and searching for funds to implement a buy-back scheme for every gill net on the island. Although gillnetting is one of the quickest and easiest ways to put food on the family table, the prospects for other fishing methods, particularly handlining, rapidly improve if no one uses gill nets.

Because of problems with wholesale exports in the past, the bylaws state that no one may take more than 20 pa'ua (giant clams), 20 kai (*Asaphis* sp.) or 20 ariri (turban shells) out of Aitutaki. Shells of these species taken out of Aitutaki must be larger than 75 mm for pa' ua, 50 mm for kai and 38 mm for ariri. These named species are banned from sale within Aitutaki except by special permit, and are normally taken only for home consumption or special occasions.

The use of SCUBA gear or other underwater breathing apparatus for catching fish or shellfish is banned on Aitutaki. Unlike many more developed countries, spearfishing is not banned entirely, and may still be carried out using a snorkel. Spearing fish is a traditional Pacific island fishing method and a complete ban on spearfishing as well as the imposition of gillnetting restrictions would cause undue hardship to local people who still depend heavily on fish. Many species of commonly found fish, particularly herbivorous fish, cannot be caught with hook-and-line gear. SCUBA gear is also banned for the purpose of hand-collecting any species, or for setting a gill net.

Although explosives are not used to catch fish at Aitutaki, there is a law that makes it an offence to do so, or to use poisons. It is also against the law to use any methods that damage coral, such as crowbars for extracting pa'ua embedded in the reef.

The Ministry of Marine Resources research station at Aitutaki breeds several species of marine life both for conservation purposes and to assist in the potential development of future marine farming enterprises. The hatchery was set up with assistance from the Government of Australia and has concentrated mainly on breeding pa'ua (giant clams). Pa'ua stocks are now regenerating, but overharvesting (mainly to provide gifts to visitors from other islands and to supply Rarotonga) was a serious concern in the past decades. The hatchery breeds several species of giant clam and also experiments with trochus, and is open to the public at certain times. The ocean nursery, where the clams are grown out to "escape size" in underwater cages (to protect them from triggerfish and other predators), is in the reserve boundary at Maina and can be visited by snorkellers.

Trochus were introduced to Aitutaki from Fiji in 1957, close to the site of the old seaplane alighting area in the southeastern lagoon, and has since spread throughout the entire barrier reef. Trochus shells are the main source of mother-of-pearl buttons found on high-quality shirts, and command a good export price in Asia and Europe. These conical shells graze on algae and can be found in and around the surf zone on the barrier reef.

The Island Council tightly controls the trochus shell harvest at Aitutaki, both in the conduct of the fishery and the distribution of financial benefits. The harvesting period is short – usually for one week every

two years. A "total allowable catch" (TAC) for the whole island is calculated after a resource survey by the Ministry of Marine Resources, and set at a level intended to maintain the stock at a sustainable level of long-term maximum production. The number of households on the island then divides this TAC by the Council and each family is given a quota (usually 10-20 kilograms of shell). This quota can either be caught by that family during the harvest period, or in the case of those who are unable to do their own fishing, transferred to another family. The Island Council supervises the collection, shipping and sale of shells and distributes the resulting cash according to the allocated quota. This "community transferable quota" system is currently unique in the world.

In addition to restrictions on harvesting time and volume, there are also size limits in place (the legal size of trochus is 80 to 110 mm shell diameter) and there is a trochus reserve close to the original introduction site where no trochus fishing is allowed at any time. Another way of promoting lagoon resource conservation while continuing to provide food and income is to encourage fishing activity on the more resilient resources of the open ocean. This takes a larger boat and is mainly for the more commercially minded, but produces fish that are usually more to the taste of visitors than reef fish.

Manuae

Manuae Island is an uninhabited atoll about 50 kilometres southeast of Aitutaki. Manuae comprises two main islets (Motu Manuae and Motu Te Au Otu) and a lagoon area extending approximately 7 km x 4 km. Manuae lagoon is shallow and subject to large shifting sand banks. The lagoon has few coral patch reefs. The island once supported a small copra industry with a settlement established adjacent to the small reef passage at Turakino. The island has an airfield, although this has not been used for several years.

Aitutakian fishermen occasionally organise trips to Manuae and all regulations applicable to Aitutaki, apply to Manuae as well. The offshore waters of Manuae are reputed to be good fishing grounds for demersal and pelagic fish species. The marine environments of Aitutaki and Manuae are very similar.

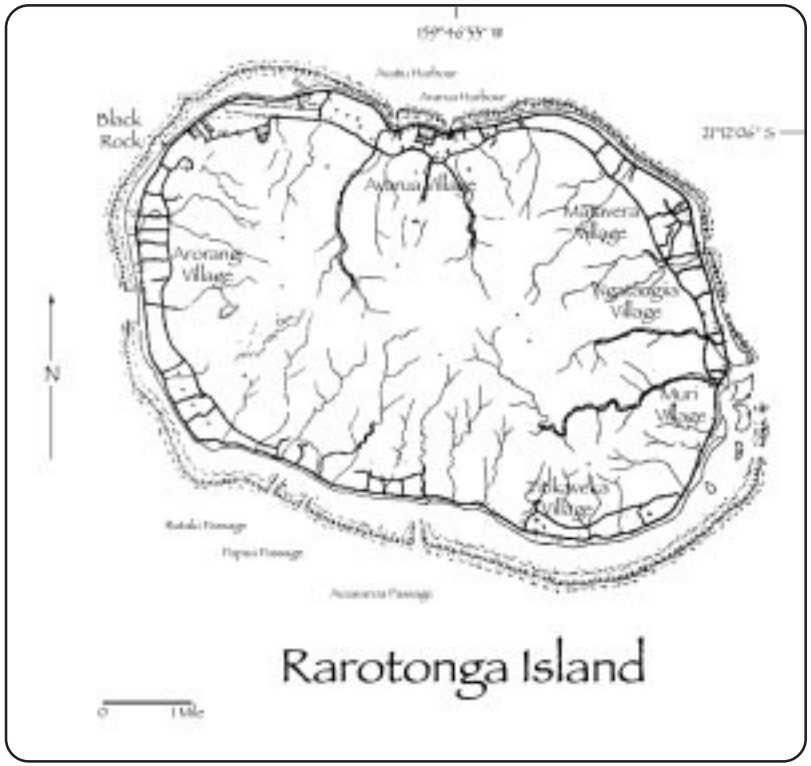
Rarotonga

Rarotonga has a land area of 67 square kilometres. The volcanic activity that thrust the island above sea level occurred about two million years ago. The island's major mountains are the remains of the outer rim of the volcano's cone. The highest point on Rarotonga is Te Manga, which rises 653 metres. Rarotonga receives large amounts of rainfall compared with most other islands in the group, averaging over 2000 mm per year. About 11,000 people live on the island. Income for the island is generated mainly through tourism. Many people are privately employed and the public sector accounts for over 750 jobs on the island. There are three main land divisions on Rarotonga called vaka. The largest one to the south and southeast is Takitumu, which includes the villages of Titikaveka, Muri and Ngatangiia. Te-Au-O- Tonga district lies to the northern side of the island and is centered on the villages of Avatiu and Avarua. The third district is that of Puaikura in the Arorangi area. These three areas are further divided into tapere. A chief (Mataiapo or Rangatira) manages each subdivision.

The fringing reef defines the lagoon, which is broad and sandy to the south, and narrow and rocky on the north and east. Compared to those of the atolls, the lagoon surrounding Rarotonga is quite small, covering eight square kilometres. In most areas the lagoon is relatively shallow.

The marine environment of Rarotonga has been affected by human activities in several areas. Coral is smothered by eroded soil and other material (e.g. pesticides, plastic containers) washed into the lagoon;

man-made structures alter the lagoon environment by affecting current flows; and heavy fishing of most of the edible resources may have caused the noticeable decline of many marine animals. However, most areas still have healthy coral and support large numbers of fish and shellfish.



The Cook Islands Natural Heritage Project has identified around 1,000 reef invertebrate species in Rarotonga. Some of the harvested invertebrates include pa'ua (giant clams), ariri (turban snail), rori (sea cucumbers), vana, avake and atuke (sea urchins). It has been estimated that 70% of residents over 15 years of age search the reef for food or go fishing at least once within the year.

A number of aquatic species have been introduced to Rarotonga including, trochus, tilapia and fresh water prawns (*Macrobrachium rosenbergii*). Populations of tilapia are abundant in freshwater streams and are occasionally consumed. Trochus are well established on the reef-flats and lagoon.

There has been a considerable amount of impact from the introduction of modern fishing gear and methods and also from increases in demand for seafood. Monofilament gill nets and SCUBA spear fishing are examples of very efficient modern techniques.

Stocks of invertebrates such as giant clams, kuku (mussels) are reported to have declined. Reasons for the decline are not certain, but are thought to be due to high fishing pressure coupled with land runoff.

Several Acts have been passed to protect the Cook Islands marine environment. These include the 'Ministry of Marine Resources Act 1984' the 'Marine Resources Act 1989' (and amendments 1990, 1991), the 'Rarotonga Environment Act 1994-95' and the 'Prevention of Marine Pollution Act 1998'.

In Rarotonga, ra'ui (traditional community based management systems) have recently being implemented to safeguard marine resources from further decline and for communal use.

Palmerston

More than half of Palmerston's lagoon is greater than 20 metres, with a maximum depth of 35 metres, and is largely closed off by the reef.

Palmerston islanders have well developed fishing skills that have changed since the settlement of Palmerston to suit their island and it's particular resources. The islanders catch a wide range of fish and shellfish. At least one member of each household fishes or gleans daily (except Sundays).

Hook-and-line fishing is conducted either from a boat beyond the reef or inside the lagoon, or by walking along the reef-flat and casting into surge channels. Ature (big eye scad), koperu (mackerel scad) and ungaunga (hermit crabs) are used for bait. Pelagic fishing is generally carried out on the leeward (NW) side of the island although some trolling occurs on the windward side. Spear guns are not widely used.

The Palmerston Island Council, and fishermen and women have expressed growing concern for the future of the parrotfish fishery, and occasionally put the parrotfish under partial ra'ui.

Pa'ua, mainly *Tridacna maxima*, have recently been harvested for sale because of an increase in demand and price offered for them. Lobsters are captured all around the reef at night by hand, usually on rising tides on dark nights. The crayfish resource is believed to be small and vulnerable to heavy exploitation. Adult green turtles and, to a lesser degree hawksbill turtles, are occasionally captured at night.

Commercial fisheries and in particular the parrotfish fishery are important to the local economy.

Penrhyn

Penrhyn, referred to by its local name as Tongareva, is the largest atoll in the Cook Islands and its numerous motus have a combined land area of 10 square kilometres. The highest point is about four meters above the average sea level. There are two main settlements on Tongareva, Omoka, which is on Moananui, and Tetautua which is on Pokerekere. The distance between Omoka and Tetautua, across the lagoon, is over 14 kilometres.

The soils on Penrhyn are derived from coral and reef materials with a thin layer of organic topsoil. They are relatively infertile and as a result, vegetables are hard to grow, but crops such as breadfruit, banana and coconuts are plentiful. Income is generated mainly through pearl farming and sales of mother-of-pearl, and natural pearls (pipi pearls) which are collected by free divers. The women make handicrafts such as baskets, purses, kikau brooms and hats from local materials. The men carve jewellery such as earrings, necklaces and hairpins out of pearl shells. Private enterprise on the island is in cultured pearl farming, handicraft making, retail stores, and visitor accommodations. In the early 1980s, fish were sent to Rarotonga on small ships with refrigeration; however, this no longer occurs and the majority of fish caught is for local consumption.

The lagoon is unpolluted and well flushed by incoming and outgoing tides through the three wide passages and areas of the barrier reef without landmass. The northern end is shallower and is where most of the pearl farms are concentrated. Penrhyn lagoon is suitable for pearl farming because there are large areas that are shallow enough for SCUBA divers to set farm lines. Already there are as many pearl farms on Penrhyn as on Manihiki, although they are much smaller than those of Manihiki are. The Island Council is responsible for issuing pearl farming licenses. Individual farmers must submit their proposal to the Council for approval. The island has one wharf at Omoka, a national port of entry with customs and immigration facilities. Fisheries in Penrhyn are generally on a subsistence scale with limited artisanal activity. Occasionally, fish are sent to Rarotonga either for relatives or for sale. About 95% of the population are engaged in some form of fishing activity whether domestic or commercial. This includes methods such as patia, verovero, tavere, sisi, poito, i'i and kupenga.

Other fishing methods that are still used on Penrhyn to catch a particular fish species but not practised on some of the other islands, include the following.

• Rui (black trevally) fishing: This type of fishing is carried out in the northern Cooks, particularly on Penrhyn. Essential equipment includes a boat, heavy fishing line, hooks, bait, snorkelling gear and at least two men. On arrival at the rui fishing ground, one of the fishermen remains on the boat and the other enters the water. The diver takes ground-up bait (paru) in his mouth to where he knows the rui will be and then spits it out. The diver's goal is to attract the fish to the surface. Once the fish are at the surface the diver reaches out to his buddy on the canoe for a baited hook. S/he then offers the baited hook to the feeding rui, once the fish takes the bait the person in the canoe hauls in the catch. According to local fishermen, it is becoming harder to catch a good-sized rui. Many people spear the rui at the passages and this may be having an effect on stock numbers.

• Hapuku (cod) fishing-spawning season: Fishermen know when the hapuku will begin aggregating by checking the size of the gonads (sexual organs) of their catch. When the gonads become large, spawning (aggregating time) is about to begin. This generally occurs during April, May or June. The aggregations occur at the reef passages, and include hapuku from both the ocean and the lagoon. The aggregations can be quite large. Fishermen anchor at the passage during the day and catch the hapuku using handlines or Samoan reels. Bait used includes skipjack, milkfish, tuna and ature. SPAWNING AGGREGATIONS MUST BE PROTECTED.

• Nato fishing: Nato (squirrel fish) is generally caught at night from boats or from the reef. Rod or bamboo fishing line is use with white lures including feathers and white cotton. When fishing from a boat the rods are shorter. Generally, fishermen will fish near the reef passages. Dark nights are good for catching nato. Nato is abundant in Penrhyn.

• Milkfish pond culture: Milkfish ponds in Penrhyn are generally privately owned and stocked. Milkfish are usually farmed for a particular purpose or function, such as the opening of a new community building, for ceremonies, or other celebrations. During high tide, the young milkfish are driven into the fishponds and then the exit is blocked. Sometimes, milkfish fry will be transported manually to ponds using a bucket or basin. The milkfish are then left to grow for six months to over a year before they are harvested. A net is used for the harvest.

• Trochus: Populations of trochus on Penrhyn are increasing to harvestable numbers. It is expected that over the next 5-10 years trochus harvests will be economically viable. No management exists for any resources in Penrhyn with the exception of parau (pearl oysters). The island council has imposed a restriction on the use of SCUBA and hookah for the collection of wild shells and individuals must have a permit to farm or dive for shells. The majority of pearl oysters for the farms are collected from the wild. Pearl farmers free dive to collect the young oysters, often to great depths and for long periods of time.

Pukapuka/Nassau

Pukapuka, traditionally named Te Ulu-o-te-Watu (meaning "head of the rock"), is one of six islands in the northern group. Its nearest neighbour is Nassau, which is populated by Pukapukans. The lagoon is about eight kilometres long and three to five kilometres wide and is surrounded by reef, sandbanks and three main islets. These are Motu Ko, Motu Kotawa and Motu Wale and cover about 700 hectares (7 km^2). The inhabitants often refer to Motu Wale as Pukapuka, and this is where the entire population resides. The other two islets are kept as reserves administered by the Island Council. There are three

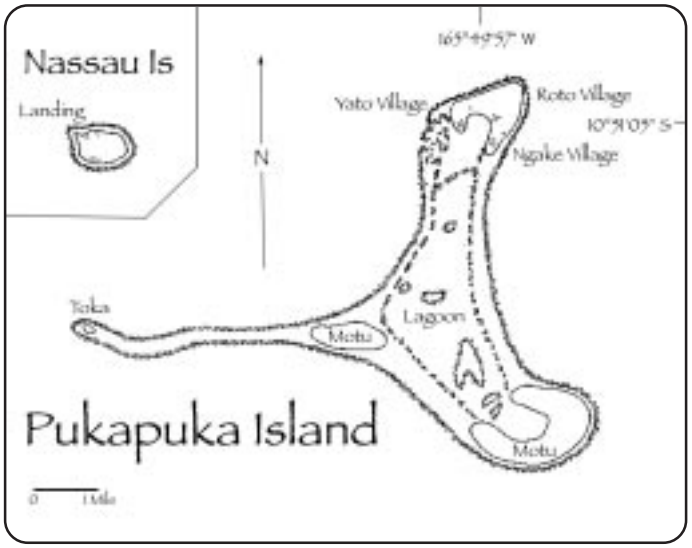
villages on Motu Wale; Roto, Yato and Ngake, all are situated along the coast. According to a 1996 census, Pukapuka has a population of 780.

The atoll has a maximum elevation of no more than five metres. Lagoon depth ranges from less than 1.5 metres to more than 60 metres in some areas. Pukapuka is just outside the regular hurricane belt but the occasional hurricane does occur and wreaks havoc on the island. In pre-contact times, famine caused by hurricanes drastically reduced the population of Pukapuka.

The land in Pukapuka consists mostly of sand and coral gravel. Staple foods like wawa (puraka) and bananas are grown in the swamps and in excavated pits, which are fertilised by filling with ferns, coconut husks and leaves. Lime trees and breadfruit trees are scattered around the island. Coconut palms are prominent. Pukapukan people subsist mainly on coconut, fish and puraka. Cargo ships provide flour, rice, canned food and fresh meat to vary their diet. Other protein such as locally-bred pigs and chickens also supplement their limited diet.

The taking of coconut crabs (kaveu/unga) and seabirds are restricted except during certain seasons. Each of the three villages has their own reserve lands and each reserve has a small settlement of houses, which are used during visits for food supplies and copra processing. Pukapukans believe in conserving specific areas for a period of time, which they can exploit later. The islanders have a principle that is commonly understood as "resources of the people, and not for the individual".

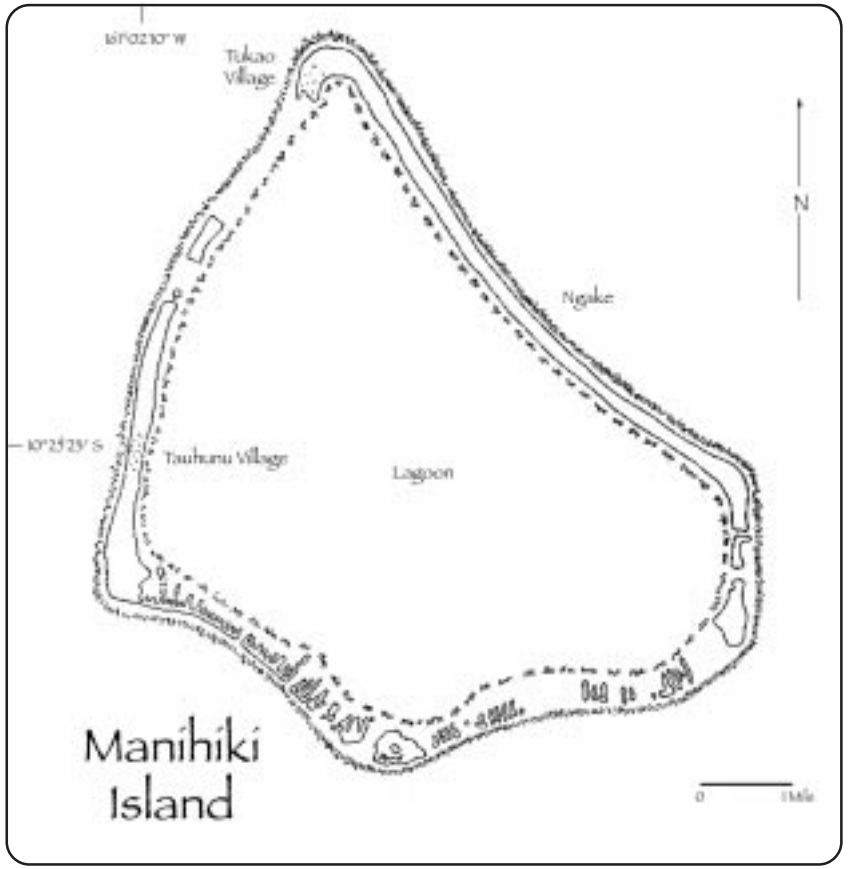
Men are customarily the fishermen, but women do beach angling, shell fishing and assist in torch fishing inside the lagoon. The main fishing areas in Pukapuka are the lagoon, reef, and beach and now with outboard motor boats, the outer reefs.



There is virtually no commercial fishing on Pukapuka. Although attempts have been made in the past, they have not been successful. This is due to a lack of infrastructure such as large freezers and the reliability of shipping to and from Pukapuka. The Pukapukans, by necessity, live close to nature and so have the ability to read the diurnal, seasonal cycles, phases of the moon, tides and flow of current. With this high degree of awareness of the environment, pressures on the resources are few. But the change in thinking of Pukapukans, population growth, and changing of life styles are gradually increasing pressure on many resources.

Manihiki and Rakahanga

Manihiki Atoll produces over 90% of the black pearls from the Cook Islands, which is the country's major export commodity. The island was heavily damaged during a severe storm in November 1997. The population resides on two low-lying islets, Tauhunu and Tukao.



Rakahanga lies 42 kilometres north of Manihiki. The island has a shallow lagoon, which appears to be poor in terms of fish and coral diversity. The main source of income is from wages from public servants and welfare payments. Both islands carry out similar fishing activities, including trolling, drop-line, spear and net fishing. On Rakahanga, midwater tuna fishing plays an important part on the men's fishing activity. The catch of pelagic fish on Manihiki is in high demand. The majority of offshore fishing activities are carried out on aluminium and fibreglass boats, which are predominately used for fishing on Rakahanga and pearl farming on Manihiki. The two communities commute between islands on small boats with outboards.

Suwarrow

A continuous reef surrounds the lagoon. There are more than 40 motus (small reef islands) on the atoll rim, ranging in area from 0.01 square kilometre to 0.1 square kilometre. Total land area of the islets is approximately 1.68 square kilometres. The water chemistry inside the lagoon is strongly influenced by oceanic waters.

The atoll is dominated by southeasterly tradewinds, and is subject to tropical cyclones coming from the north and northwest. The atoll vegetation was damaged in 1914, 1940, 1942 and 1967 by severe cyclones.

Suwarrow has a very well developed algal ridge and broad reef flat (100 to 800 metres wide). Numerous patch reefs (some greater than 100 m in diameter) nearly reach sea level in the central portion of the lagoon. Smaller patch reefs are scattered throughout the lagoon but are more abundant in the western area. Corals that exist on these patch reefs include only a few species. *Acropora* sp., which dominates the top of most patch reefs, is common to a depth of 20 metres. Below 20 metres corals are less abundant. The upper reef flat lacks significant amounts of live coral. Much of the upper reef flat is exposed at low tides creating either no water or warm water conditions in which corals find it difficult to survive.

The island possesses large populations of reef fish, including trevally (Carangidae), groupers (Serranidae), snappers (Lutjanidae) and parrotfish (Scaridae). The island also has abundant and diverse populations of shark (Carcharhinidae) and manta ray (Mobulidae); there have even been a few rare sightings of the whale shark (*Rhiniodon typus*).

Many marine invertebrates are found including sea cucumber (Holothuridae), lobster (*Panulirus* sp.), sea urchin (Echinodermata) and giant clam (*Tridacna* sp.). The island also has a small population (several hundred thousand) of the commercially valued black-lip pearl oyster (*Pinctada margaritifera*) that has been found to differ genetically from other populations in the Cook Islands.

The island is host to a variety of marine mammals and reptiles, the humpback whale (*Megaptera novaeangliae*) frequents the near vicinity of the island. Several of the motus are nesting sites for the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*).

It has recently been proposed that pearl farming be conducted on Suwarrow. Pearls naturally occur in the lagoon but to a lesser degree

than on islands such as Penrhyn and Manihiki where pearl farming is underway. This makes it difficult to naturally collect adult or even to collect young oysters on spat collectors. The Ministry of Marine Resources conducted a trial in 1988 to see if it was feasible to collect young oysters. A total of 5000 spat collectors were left in the lagoon for one year. Only one spat collector in every ten had a pearl oyster on it after one year. There is a lack of basic infrastructure to support a pearl farming industry on Suwarrow. There are no houses or power, water and shipping facilities or a pearl hatchery for raising young spat. The island is remote and is located in the cyclone belt and, therefore, prone to massive damage and mass evacuation of workers.

Yachts travelling through the Central Pacific Ocean frequently visit Suwarrow Atoll.

Summary information on the Cook Islands

Island	Type	Position		Dist. from Rarotonga		Main landing passages	Strata area (km²)				Human pop.	Govt. workers	Dwell.	Ave. dwel. size	Ave. rainfall	Ave. temperature	
		Lat. (S)	Long. (W)	Km	N.m		Reef	Lagoon	Kaoa	Land	(1996)	(1999)	(1996)	(1996)	(mm)	max.	min.
Rarotonga	High Volcanic	21.12'06"	159.46'33"			3	2.6	8.0		67.2	9933	774	2581	3.8	2040	27.0	20.8
Takutea	Coral Cay	19.49'02"	158.17'12"							1.2							
Mangaia	Raised Island	21.54'30"	157.57'47"	204	110	1				51.8	1104	90	237	4.7	2337		
Atiu	Raised Island	19.59'35"	155.06'45"	215	116	1				26.9	960	53	198	4.8	2044		
Manuae	Coral Atoll	19.15'40"	158.55'57"	230	124			13.0		6.2							
Aitutaki	Almost Atoll	18.51'45"	159.48'10"	259	140	2	4.4	74.0		18.1	2332	117	501	4.7	1894	28.3	22.9
Mitiaro	Raised Island	19.51'33"	157.43'13"	263	142	1				22.0	319	34	64	5.0	1842		
Mauke	Raised Island	20.08'30"	157.21'20"	278	150	1				18.4	646	49	133	4.9	1575	27.8	22.1
Palmerston	Coral Atoll	18.03'17"	163.11'31"	500	270	1	3.0	53.0	0.8	2.0	49	11	11	4.5	1988	28.8	23.4
Suwarrow	Coral Atoll	13.14'40"	163.06'15"	950	513	1		120.0		0.4	4		1	4.0			
Manihiki	Coral Atoll	10.25'23"	161.02'10"	1204	650	2	1.3	48.0	5.0	9.8	662	36	150	4.4	2337		
Nassau	Coral Cay	11.33'21"	165.25'13"	1246	673					1.2	99	9	23	4.3		31.2	24.2
Rakahanga	Coral Atoll	10.02'30"	161.06'15"	1248	674	1		5.0		4.1	249	31	42	5.9	2360		
Pukapuka	Coral Atoll	10.51'05"	165.49'57"	1324	715	1		12.0		5.1	780	51	121	6.4	2816	31.2	24.5
Penrhyn	Coral Atoll	8.59'45"	158.03'33"	1365	737	3	1.1	208.0	15.0	9.8	600	53	113	5.3	1866	29.7	25.6

The Future of Cook Islands Marine Resources

Ultimately, the aim of marine resource management is to:

- Increase self-sufficiency in food and protein production from the ocean;
- Maximise development in areas offering the greatest potential for import substitution and foreign exchange earnings; and
- Implement proper conservation measures to ensure sustainable development of the industry.

The following section describes the potential future of some of the more important marine resources in the Cook Islands. The Ministry of Marine Resources has more information on this subject.

Pearl production

Black pearls have been produced in export quantities from Manihiki since the mid 1980s. Further expansion of the industry on this island appears limited. However, the expansion of black pearl production is expected on Penrhyn, which is currently using less than 2% of the potential farming area and has a hatchery supplying young oysters. Pukapuka, Aitutaki, Suwarrow and Palmerston islands all have suitable lagoons to set up pearl culture. Unlike the other three, Suwarrow has no permanent inhabitants to establish and support the industry. In the foreseeable future it is expected that pearl farming will spread to the three islands.

Larger and more efficient farms are likely to develop into substantial and profitable businesses. There are other specialised niches areas such as spat production and oyster cleaning, which are profitable and open for private enterprise.

Mother-of-pearl (trochus and pearl shell)

Aitutaki is the only island currently exporting trochus shell, although populations on Palmerston, Manihiki, Rarotonga and Penrhyn are reaching harvestable numbers. It is expected that over the next five to ten years, trochus harvests on several islands will be economically viable.

On Aitutaki, trochus are harvested only when there are sufficient numbers to offset freight costs. Typically this occurs once every one to two years. In 1998, a harvest worth over 200,000 NZD was earned by the local community as a whole.

Most Cook Island trochus shell exports go to the United Kingdom in the raw unprocessed form, where they are manufactured into buttons or jewellery and ornaments.

Aquarium fish trade

Aquarium fish are an important export commodity, earning approximately 3% of total exports. The operation at this stage is limited to Rarotonga but in the future it is expected to spread to the outer islands. Several islands may need to pool their catch to provide a constant supply of good quality, valuable species. To date, the lack of interest, experience, knowledge and capital has prevented much collecting on the outer islands.

Divers using SCUBA and either a small-meshed barrier net or a hand-held scoop net collect a total of 35 species of reef fish. Only five of these species are in regular demand, these include the flame angel, red hawkfish, Scotts wrasse, ventralis, and lemonpeel angelfish.

Beche-de-mer production

Generally, sea cucumbers do not generate much income for fishermen. Little exploitation exists; only one known commercial exporter of beche-de-mer operated for a short period in the late 1990s. Potential for commercial development of sea cucumbers appears limited, due to the relatively low commercial value and the relatively high investment of time and effort in processing for export. Limited harvesting in the northern Cook Islands could, however, supplement household incomes on a part-time basis.

Crustaceans

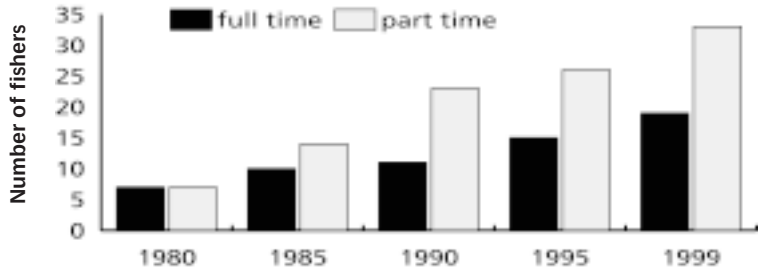
Lobster resources in the Cooks are few but valuable and catches have been poorly marketed, and existing markets in Rarotonga should be re-examined. The production of quality frozen tails and possibly packs of head and leg meat may be possible. The resource itself requires further assessment and a management plan may be needed prior to the further exploitation.

Coastal finfish resources

Coastal finfish resources include pelagic species (e.g. tuna, wahoo, and flyingfish), deep bottom fish (e.g. snapper and snake mackerel) and reef associated finfish (parrotfish, grouper, surgeonfish). Little scope exists for the overseas export of reef fishes, due to the multi-species nature of island fish resources, volume and lack of processing equipment. There is a high demand, however, for quality reef fish in Rarotonga from local markets. Current prices for reef fish range from NZD 5-7/kg unprocessed, to NZD 11-15/kg for processed fish (e.g. frozen fillets or smoked fish, flying fish, parrotfish, snapper, mullet, vena and milkfish). The lack of suitable smoking wood on atolls represents a constraint for smoked fish production on many of the northern atolls.

The establishment of fish aggregating devices (FADs) since 1980 has resulted in increased catch of pelagic fish species including tunas (skipjack, yellowfin, albacore, and bigeye), dolphinfish, wahoo and billfish. When in place, FADs are an effective way of increasing catch per unit effort. Fishermen can reduce their search time and save on fuel by going to just one location. They also increase the safety of fishing, as fishermen only have to visit one spot.

In the future, fishing organisations in conjunction with government will no doubt want to deploy more FADs to significantly increase the volume of catches of tuna, wahoo and flying fish. As can be seen by the graph below the number of Rarotongan fishermen using FADs, both part-time and full-time, is increasing. This is a sign that fishing is an effective means of gaining income, and that there is a market for pelagic fish in Rarotonga.



Number of full-time and part-time fishers* on Rarotonga

* The graph exludes recreational or fishers that occasionally go fishing.
Full time: those that earn about 90% of their income from fishing.
Part time: those that fish once a week.

Despite the high cost of transportation, it may be appropriate to investigate ways of adding value to export produce. Smoked fish, jerky products, filleted fish and dried fish are all potential exports. In the near future, it is hoped that a fish market will be established in Rarotonga, selling various kinds of seafood from the Cook Islands. This would be a point from which both exports and local sales could increase, and would be a good opportunity to provide outer islanders with a market for selling their produce.

The expanding tourism industry provides a captive and ongoing market for a range of fish and other marine products. Catch rates in the northern islands are generally higher than those in the southern group and the long-term marketing of frozen fish to supply the Rarotonga tourism trade may be feasible on islands such as Penrhyn, Manihiki, Rakahanga and Palmerston. Fresh-chilled fish are far better than frozen fish, although frozen fish may be the only option.

Offshore fishing

The Cook Islands currently has limited capacity to fish its oceanic waters. Because of this, the Ministry of Marine Resources has established licensing agreements with distant water fishing nations in order to exploit the country's tuna resources. The Cook Islands is, however, keen to establish a locally-based, small-scale longline fishery (using 20 to 30 metre vessels), possibly through a joint-venture basis with foreign investors.

Manganese nodules

The Cook Islands EEZ contains vast quantities of manganese nodules. Cobalt is the most valuable metal in the nodule, worth 10 to 30 times more than copper or nickel also found in the nodule. The Cook Islands nodules have among the highest cobalt content recorded in the world. It is estimated that the cobalt resource is about 32 million tonnes, enough to sustain the current world demand for 520 years. Cobalt is utilised in diverse industrial applications, although mostly it is used as a superalloy in the aircraft industry. Demand is also increasing for use in rechargeable batteries for laptop computers and other applications.

Cook Island nodules occur in very deep water, on the order of five thousand meters. This depth poses many challenges, not the least of which includes methods for making the extraction of nodules economically viable. Exploitation of this resource (depending on technology development) will not occur in the near future, although one day it will be a valuable resource for the Cook Islands.

Constraints to fisheries development

To date, a number of constraints have prevented the full development of potentially viable small-scale operations, especially in the outer islands. These constraints include:

- expensive transport links,
- unsatisfactory infrastructure (such as freezing arrangements)
- variable market requirements in a relatively small-demand situation,
- high operating costs (such as setting up capture or warehouse facilities and freight from the outer islands),
- limited access to modern fishing technology and equipment,
- relatively high cost associated with development on outer islands,
- expertise and management skills relating to marine economic ventures, and
- relatively low human populations.

Activities for Students

1. Reef life

What you need:

- Reef life poster (Natural Heritage Project)

Divide the class into small groups and ask them to write down all the things that they usually see on the reef.

They can divide their list into things that:

- they eat,
- they sell,
- they use to make other things.

Ask the groups to come back together and tell the class what they discovered.

The responses can be written on the blackboard.

Put up the reef life poster and see if there is anything on it that the students didn't mention.

Ask them to draw a picture to illustrate something new they have learned.

2. Changes on the reef

Ask the students to interview their mother, father, grandparents, or an older person in their village about the reef and what they find there.

Here are some questions they can ask:

- When you were young did you see things on the reef that you don't see now?
- Is the reef itself (the corals) the same as it was when you were young?
- What have people taken from the reef to sell during your lifetime?
- Can you catch big fish on or near the reef? Could you 10 or 20 years ago?
- Are there any reef creatures that you used to eat before, but you don't eat now or don't eat very often? Why?
- What are some of the reasons why you no longer see these creatures?
- How is the marine environment affected by activities on land?

Each person in the group can read the answers to their survey to the other students. You may want to take the students on a field trip to the reef with some of the older members of the community.

The Ministry of Marine Resources in Rarotonga is extremely interested in anecdotal information about changes to the reef. You can ask the students to write a letter to the information officer of the Ministry of Marine Resources, Avarua, Rarotonga and include their findings.

3. Know your island

What you need:

- Information about fishing techniques and marine management. You may be able to think of information more specific to your island to share with the students.
- Compare the old fishing methods on your island with new ones.
- Make a list (with illustrations) of traditional methods, describing how they were used.
- Make a list (with illustrations) of newer methods.

Ask the class to think about the different fishing methods and try to work out which methods catch more fish. Do some kinds of fishing gear catch too many fish? Why?

4. Marine management

What you need:

- Information from this handbook about marine management

Research

- Find out about marine reserves. Are there some on your island? In your country?
- Who set them up and why?
- What is the purpose of a reserve and what uses does it have?
- What about other forms of marine management (e.g. gill net restrictions)?
- Has there been marine management on your island in the past? What sort?
- Is there a need for marine ra'ui or some other sort of marine management on your island?
- The word 'ecosystem' is used a lot these days when talking about the environment. Can you explain what an ecosystem is?

Use books from the library to help make a diagram showing how an ecosystem works.

5. An in-depth look at animals

What you need:

- Information sheets on the animals and plants found in the sea around the Cook Islands: parrotfish, coconut crabs, sharks, and others. Information sheets can be obtained from the Ministry of Marine Resources or the Natural Heritage Project of the Cook Islands.

Ask the students to get together and write down what they know about a particular animal or plant. If you teach older students you may want to ask individual students to research a particular animal or plant and find out all they can about it from the library and from people they know.

What is it? How is it caught? What is it used for? What parts do you use? Is it dangerous? What does it eat?

6. Turtles of the Cook Islands

What you need:

- 'Turtles of the Cook Islands' poster
- 'Turtles of the Cook Islands' information sheet
- Colouring-in sheets and coloured pencils

Ask students to tell what they know about turtles. If they have see one, if their family eats turtle, how turtle is caught, where on the reef the turtle was found, if they have ever seen young turtles.

7. Reef walk

What you need:

- Information sheet on the Cook Islands marine animals and plants
- Mask and snorkel (if students have access to them)
- Bucket or other container
- Shoes (a must)
- Natural Heritage Project fish card

Before the walk:

- On the day before, remind students to bring shoes to wear on the reef. It can be quite painful walking on the reef over a long period of time without them.
- Talk about the 'reef life' information sheet. Determine with the students which animals shown on the sheet they might expect to see. Some of the invertebrates (animals without a backbone) may be absent on your island. Ask the students what the local names for these animals are, how they use them, how they catch them. If teaching older students, you may want to use some of the more complex information on the sheets, such as scientific names and groupings (phylum, class, etc.).
- In Rarotonga, the MMR have glass bottom buckets to see under the water. Ask if you can borrow these. In the other islands, the students will need to have goggles or a mask. There will no doubt be a shortage of these but they can be shared.
- Ask students to not eat, kill, torment or take any of the animals they find.

For the walk to be organised and informative there should be about four to six students to one adult. If you have a Marine Resources Office on your island, invite one of the staff to come along on the walk.

Ideally, each group should have a bucket or something in which to place the animals so they can be observed out of the water.

Don't forget that some animals such as the pa'ua and coral should not be removed from where they are. You should put things back once you have finished looking at them. Remind students of the dangerous animals that should not be touched at all (e.g. cone shells, sea urchins, flame coral).

Look at how the seastar (etu) hides its tube feet, how it bends in your hand, how tough it feels. Imagine a fish trying to eat this animal.

Pick up rocks and look for other marine organisms

Ask students what they know about any of the marine creatures they see. What are the local names and uses of each animal they find?

8. Overfishing

Small group discussion. Ask your class what they know about overfishing

- What does overfishing mean?
- What happens if a traditional leader thinks too much is being taken from the sea?
- If a traditional leader puts a ra'ui on a reef, is that good or bad?
- Do people take too much from the sea in your area?
- If you think too much is being taken from the sea, is there anything you can do about it?

9. Money and marine resources

The Cook Islands are using various marine resources to make money. How are people on your island making money from the marine environment? Are these resources being exported or are they for sale locally?

10. Surveys

Ask the class to help in a fish consumption survey: "Artisanal and Subsistence Fisheries Survey in the Cook Islands". Students can fill in a form about what time of the day and what days of the week their family goes fishing; what they catch; how much they catch; what methods they used. The Ministry of Marine Resources will help design a survey form.

The information collected will be extremely useful to the Ministry of Marine Resources. So when the survey is finished you may want to send the pamphlets to Rarotonga.

11. Adaptations

What you need:

- Information on adaptations of marine life to avoid being eaten by other marine animals.

Go through the sheet with the students and talk to them about adaptations of various fish and shellfish.

Ask them if they can think of other adaptations that fish, plants, invertebrates and other animals have to avoid being eaten.

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Glossary of Terms

Algae: Marine plants or seaweed. Some common algae found in the Cook Islands include coralline algae, zooxanthellae, sea grapes (rimu) and *Halimeda.*

Artisanal fishing: A type of fishing in which part of the catch is consumed by the fisher's family and the rest is sold locally.

Basal diameter: The width of the base of a trochus shell which is used to determine if an animal is large (or small) enough to be harvested. Trochus with an 8 to 11 centimetre basal diameter can be harvested.

Calcium carbonate: The white limestone material which makes up the skeletons of hard corals and the shells of molluscs. The chalk used on blackboards is mostly calcium carbonate.

Carnivorous: An animal that eats other animals

Demersal: Living or occurring in deep water or on the bottom of the sea. Paru marau (red snapper) and manga (snake mackerel) are demersal fish.

Ecosystem: The whole complex interaction of all animals and plants and their environment.

Exclusive Economic Zone (EEZ): An area of sea out to 200 nautical miles from the low water mark on the coastline or outer reef, in which an adjacent country has control and responsibilities.

Fish aggregating device (FAD): A man-made floating object anchored between one to three miles off an island coast to attract pelagic fish such as tuna, marlin, wahoo, and mahimahi.

Hard corals: Coral types that produce a hard skeleton of calcium carbonate. These include:
- *Acropora* such as tabulate and digitate corals.
- non acroporid species such as submassive and brain coral.

Herbivorous: An animal that eats plant materials.

Invertebrate: Animals with no backbones.

Larvae: The young, immature stages of many terrestrial and aquatic invertebrates including corals. Most larvae are small and drift in the sea before undergoing a radical transformation to become adults.

Overexploitation: The situation where so many fish are removed from a stock that reproduction cannot replace the fish numbers lost or caught.

Pelagic: Living, reproducing and feeding in the surface layers of the sea. A'ai (tuna), pa'ara (wahoo), some jellyfish, maroro (flying fish) and miromiro (garfish) are all examples of pelagic species.

Photosynthesis: The process by which plant material (and oxygen) is formed from water, nutrients and carbon dioxide using energy absorbed from sunlight.

Phytoplankton: Small miroscopic plants, which drift in the sunlit surface layers of the sea.

Ra'ui: A traditional community-based management system to conserve particular resources for communal use.

Recruitment: The addition of young or juvenile animals to an adult fishable stock.

Spat: A tiny young parau (pearl oyster) shell.

Soft coral: A broad group of coral types that carry tiny limestone crystal structures (spicules) embedded in their tissues. These include lobophytum and sinularia corals.

Species: A distinct group of animals or plants able to breed among themselves but unable to breed with other groups.

Subsistence fishing: A type of fishing in which most of what is caught is consumed by the fisherman and his family.

Superalloy: A superalloy is a metallic material, consisting of two or more metals or of metallic with non-metallic elements, which is a superior and strong material.

Symbiosis: A relationship between two different creatures, which live together for the benefit of both. Such a relationship exists between corals and the zooxanthellae that live within their tissues (a symbiotic relationship).

Zooplankton: Small animals, or the larvae of larger animals, which drift in the sea.

Zooxanthellae: Microscopic algae living within coral polyps and the mantle of giant clams (paua), for the benefit of both parties.

Ministry of Marine Resources
Government of the Cook Islands

Information Section
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