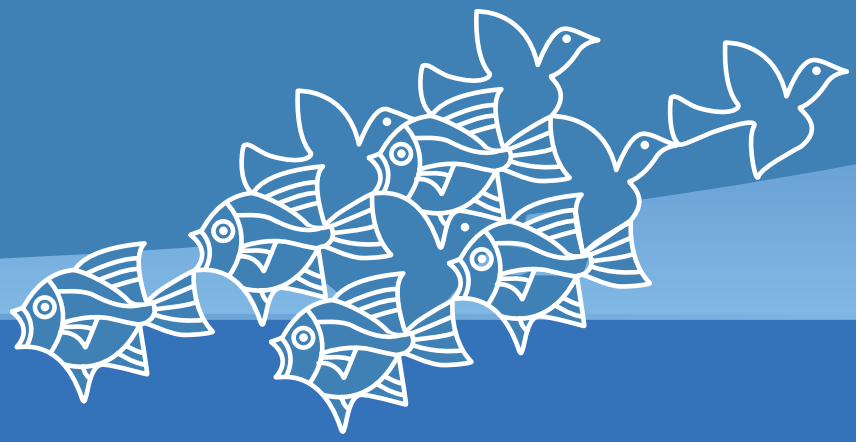

Guide to Teachers' Resource Sheets on Fisheries for the Cook Islands

Ministry of Marine Resources
GOVERNMENT OF THE COOK ISLANDS

COOK ISLANDS
Ministry of Education
Maraurau o te Pae Api'i

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GUIDE to Teachers' Resource Sheets on Fisheries for the

Cook Islands

This guide has been prepared for teachers in Cook Islands after discussions with local education and fisheries authorities. The guide is part of and should be used in conjunction with, the SPC Teachers' Resource Kit on Fisheries, the contents of which includes:

- *20 Teachers' Resource Sheets on Fisheries;*
- *29 SPC Information Sheets for Fishing Communities;*
- *four fish posters;*
- *one invertebrate poster;*
- *one sea safety poster;*
- *one marine debris poster;*
- *a DVD and/or flash drive (with graphics and photographs).*

This guide includes suggestions for exercises and activities for younger and older students, learning outcomes and curriculum links. It is expected that teachers will use their local knowledge and expertise to adapt, extend and add to these. The number and headings on the following pages refer to those on the Teachers' Resource Sheets on Fisheries (1 to 20) and on the Information Sheets for Fishing Communities (1 to 29). The latter 29 sheets were designed for fishing communities but contain much information useful to teachers and students.

All words followed by an asterisk (*) in the Teachers' Resource Kit on Fisheries are defined in the glossary on page 27 of this guide.

1. Fisheries management

At the completion of studies:

Younger students will realise the need for fisheries management and the need for regulations to control fishing and catches.

Older students will be aware of the need for fisheries regulations and understand the types of regulations imposed. They will be able to determine the relationship between fish length and egg production and appreciate the need to leave some large fish in the sea.

In Cook Islands, fisheries are managed by the Ministry of Marine Resources (MMR) often working with local community leaders. A particular fisheries management tool for which Cook Islands is well known is its *Ra'ui* (see Teachers' Resource Sheet 4: No-take areas).

For younger and older students

Social Science. Strand: Resources and Economic Organisation; Level 1–3

A. Request MMR to have a fisheries officer talk to students about fisheries management. What fisheries regulations have been imposed on local fisheries and why are they needed?

B. Why is it important to leave some large female fish in the sea?

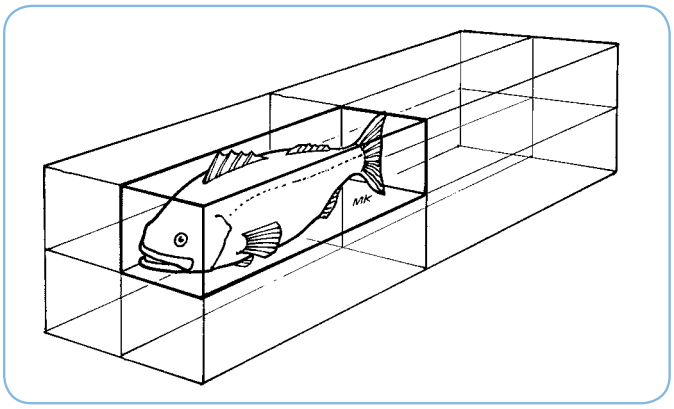
Mathematics. Strand: Measurement; Level 3

Most fish grow in length, width and height at the same rate (growth is said to be isometric). Egg production is related to the volume of female fish — that is, there is a cubic relationship between length and volume (and therefore egg production). If a mature fish doubles in length, how much does volume and therefore egg production, increase? (For younger students — count the "blocks" in the above diagram or use eight wooden blocks to suggest what happens when a fish doubles in length, width and height).

For older students

Mathematics. Strand: Statistics and Probability; Level 4–5

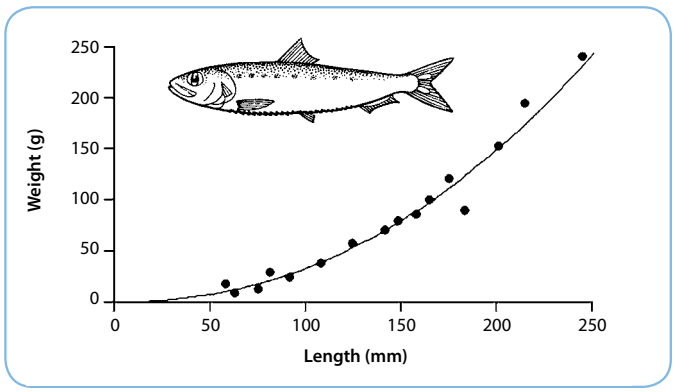
C. In the figure below, volume (V) = length (L) cubed, or $V = L^3$.
For example, a fish 30 cm long would have a volume related to $V = L^3$ or 30^3 or 27,000 cubic centimetres.
If the fish doubles in size to 60 cm, $V = 60^3$, that is 216,000 cubic centimetres.
That is, the egg carrying capacity has increased by eight times.



Have students collect a large number of one species of fish with a wide range of small to large sizes (alternatively the fish can be obtained by the teacher). Each fish should be measured to the nearest 5 millimetres and weighed to the nearest 10 grams.

Enter the data on an EXCEL spreadsheet and prepare a graph relating weight to length as in the example shown below.

Students studying statistics can extend the exercise to include the power curve equation and measures of goodness-of-fit. The power curve equation is of the form Weight = a $(\text{Length})^b$ where a is a constant and b should be close to 3 if the volumetric relationship holds true.



D. Although the rate of population increase in Cook Islands is low, the rate in many other Pacific Islands is as high as 4% each year. Build an EXCEL spreadsheet using rates of 2%, 3%, 4% and 5%, to calculate when the population will be twice what it is today. Discuss the problems for local people in catching seafood when the population is doubled.

E. Ask students to investigate the ways in which the local marine environment is being harmed — should excessive development be controlled, are trees left on the banks of rivers and coastlines, is garbage disposal satisfactory, is sewage treatment adequate?

2. Fisheries assessment

At the completion of studies:

Younger students will realise the need for fisheries assessments including the use of a 7-day fishing log to record catches in an extended family or community.

Older students will be aware of the need for fisheries assessments including the use of a 7-day fishing catch log and the use of fish tagging and quadrat sampling to estimate fish population size.

Scientists from MMR have completed assessments of many exploited marine species and these have been used in fisheries management. One example is the assessments of local trochus stock sizes and using these to set a quota* or catch limits for community fishers.

For younger students

Science. Strand: Living World; Aim 3, Level 1–2

A. Ask students to identify the common Cook Islands reef fish and oceanic fish from the posters supplied in the Teachers' Resource Kit on Fisheries.

For younger and older students

Social Science. Strand: Resources and Economic Organisation; Level 2–3

Science. Strand: Scientific Skills, Information Gathering; Level 2–3

B. Ask each student to keep a 7-day log of fish catches in their extended family. How much fish did they catch? How much fish did they buy? An example of a student 7-day basic fishing log is shown in the table below. The log can be extended to discover how much other meat is bought, etc.

If the exercise is done well, the information in these logs may be useful to MMR.

Student name .....

Time period from Saturday ..... to Friday .....

Area / Fishing location .....

	Sat	Sun	Mon	Tues	Weds	Thurs	Fri
No. of people fishing	|	|	|	|	|	|	|
Main method of fishing	|	|	|	|	|	|	|
Total hours fishing	|	|	|	|	|	|	|
Number of (species)	|	|	|	|	|	|	|
Number of (species)	|	|	|	|	|	|	|
Number of (species)	|	|	|	|	|	|	|
Number of (species)	|	|	|	|	|	|	|
Number of (species)	|	|	|	|	|	|	|
ETC	|	|	|	|	|	|	|

Students should use the fish posters to confirm identity of species used in the above log.

For older students

Social Science. Cultural Development and Change; Level 2–3

C. Ask students to interview older fishers in their community or extended family. How long does it take to catch a basket or string or number of a particular fish at present? How long did it take 5 years ago? How long did it take 10 years ago?

Each student should record the information from the interviews. Has there been a decrease in catch rates? If so, ask the fishers why has this happened? What could go wrong by relying on the memories of people?

Science. Strand: Living World; Aim 4, Level 6

Science. Strand: Scientific Skills, Information gathering; Level 3–4

Mathematics. Strand: Statistics and Probability, Level 3–4

D. Fisheries scientists tag or mark fish to examine fish migration, death rates and population size. Use the figure in Teachers' Resource Sheet 2: Fisheries assessment to discuss methods of tagging of marine species. The following activity uses beads to demonstrate how fish tagging can be used to estimate the population size of fish.

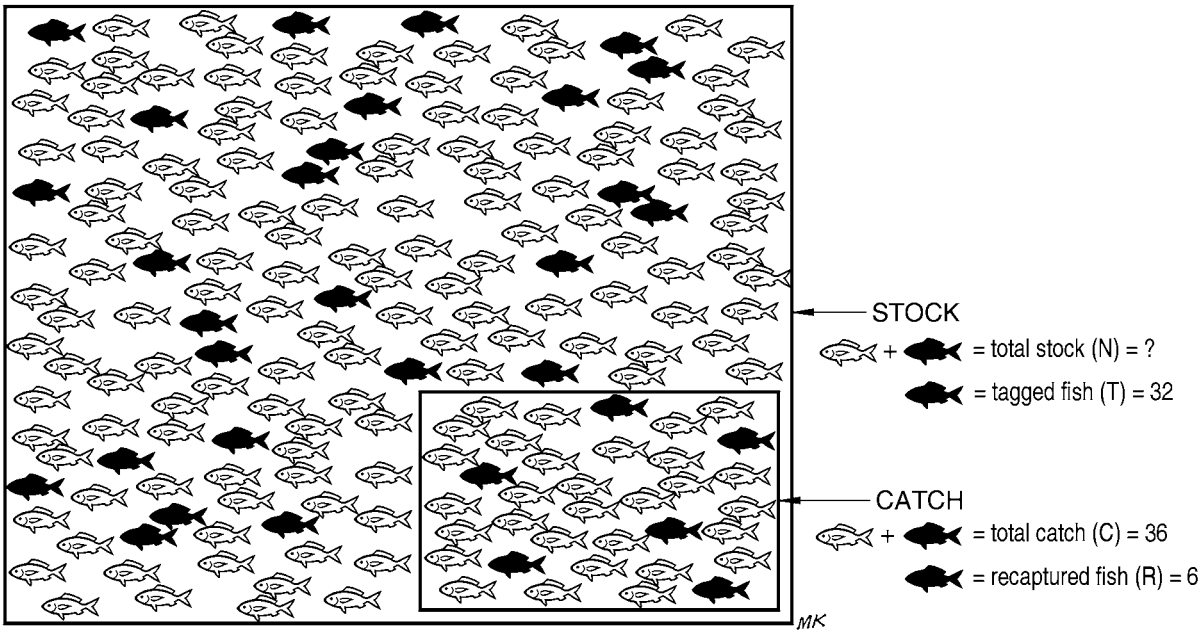
E. Spread a few thousand small white beads on a large tray (the actual number of white beads should be known to the teacher although this is not necessary). Add a smaller number, about 300, black beads to the tray — provide the actual number of black beads to the students. All the beads should be mixed up so that the black beads are randomly distributed with the white beads in the tray.

To add some interest, ask students to guess the total number of black and white beads on the tray. The white and black beads added together represent a population of fish (N). The black beads represent the tagged fish (T).

Divide the students into groups of two or three and give each group an empty tray. One student from each group should use a rectangular plastic container (about the size of a match-box, depending on the size of the beads) to represent the fishing gear. Without looking, the student should drag the container across the tray to "catch" a sample of the beads.

After emptying the caught beads in the group's tray, the students must count the number of black beads caught — these represent the recaptured tagged fish (R).

Count the number of white beads caught. This number added to the number of black beads represents the total catch (C).



Use the information to estimate the population or stock size (N) as demonstrated in the figure and example above.

The large rectangle in the figure shows a fish stock of unknown size, into which 32 tagged fish (solid shapes) were released. At a later time, a catch of 36 fish (in the small rectangle in the lower right-hand corner) was found to include 6 tagged individuals. The stock size may be estimated by assuming that the ratio of tagged fish (T) in the stock (N) is equal to the ratio of recaptured tagged fish (R) in the catch (C). That is:

$$T/N = R/C$$

From this, an estimate of the stock size (N) may be obtained as:

$$N = TC/R = (32 \times 36)/6 = 192 \text{ fish.}$$

Science. Strand: Living World; Aim 4, Level 5–6

Older students studying statistics can make a number of replicate catches and estimate the standard error and confidence limits.

The accuracy of the above method depends on several assumptions being met:

1. the tagged individuals must be distributed randomly over the population;
2. there must be no loss or gain of individuals during the experiment;
3. the tag must not alter the chance of a fish either surviving or being caught.

Have students discuss what happens if assumption number 3 is not true. For example,

1. if an external plastic spaghetti tag resulted in tagged fish being more likely to be caught by becoming entangled in a gill net; or,
2. if a tagged fish became stressed and would not take the bait on a fishing line as readily as untagged fish.

For the answers, think in terms of the equation N = TC/R. In the first case, R would be larger than it should be and N would be smaller (the population would be underestimated). In the second case, R would be smaller than it should be and N would be larger (the population would be overestimated).

Science. Strand: Scientific Skills, Information gathering; Level 3–4

Mathematics. Strand: Statistics and Probability, Level 3–4

F. The following question relates to the figure on next page in which the small black squares represent sea cucumbers distributed around a sand bank. The teacher should copy the figure full size on A4 sheets, one for each student or student group.

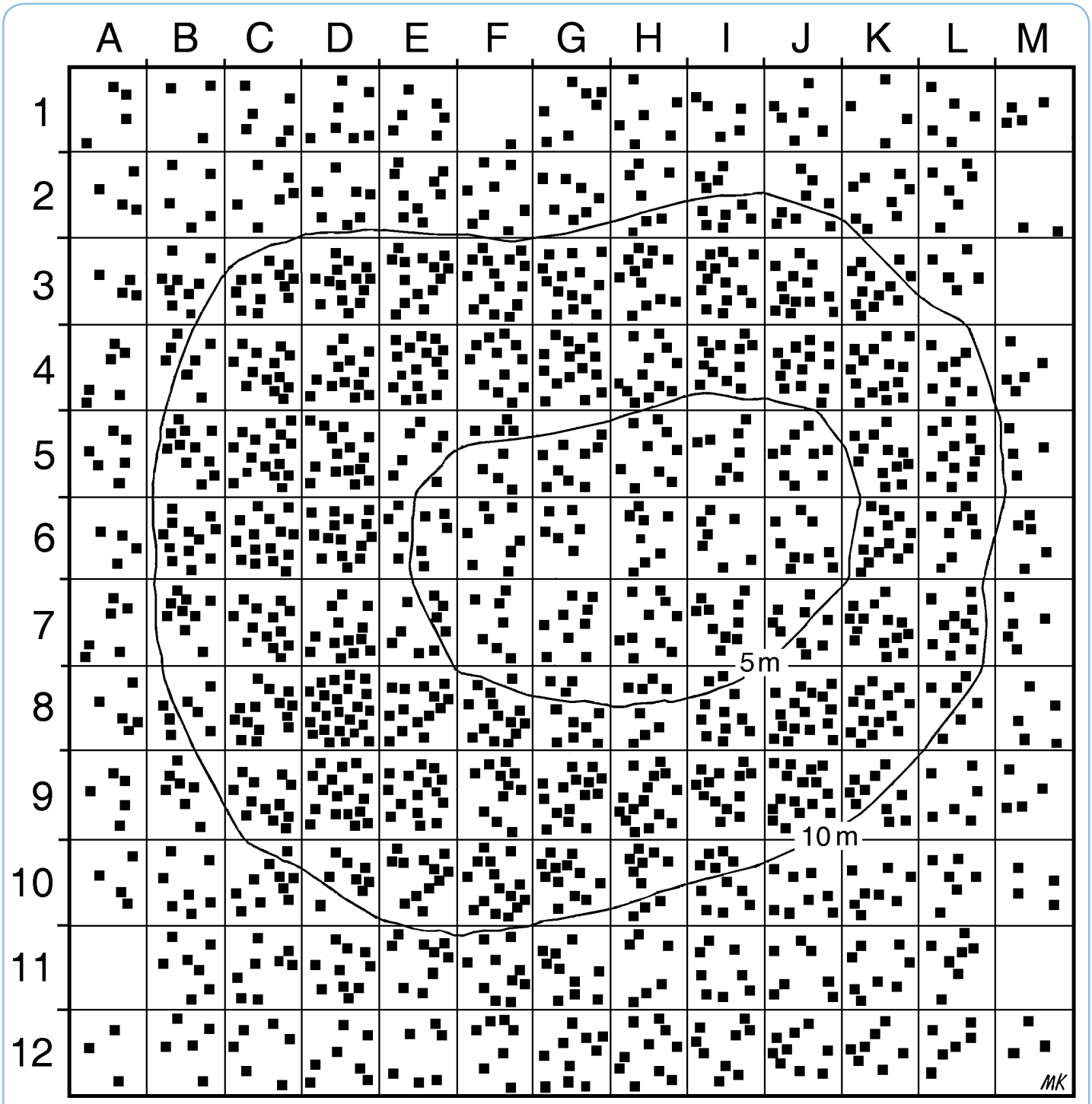
Have each student or student group randomly select 6 quadrats (the small squares). Statistics students could use random number tables to do this. Otherwise, one student in each group should use a pencil to touch the sheet 6 times without looking.

Count the number of sea cucumbers (black dots) in each of the 6 quadrats selected. Total the sea cucumbers from all 6 quadrats and divide the total number by 6 to estimate the mean number per quadrat.

Multiply the mean number per quadrat by the total number of quadrats (156). This is an estimate of the total population size. Why could this be inaccurate? If by chance, students had randomly picked quadrats from deeper than the 10 m depth contour, the population would be underestimated. Alternatively, if all 6 quadrats were from between 5 and 10 m depth, the population would be overestimated.

As a preferred method, sample along a transect, say by selecting every second small square along column G. Have students discuss why this method is likely to be more accurate.

Senior students studying statistics could estimate the population size with 95% confidence limits.



The distribution of sea cucumbers (square black points) in a total area of 15,600 m^2 around a sand bank. Each square grid (quadrat) is 100 m^2. Contours are shown at depths of 5 m and 10 m.
From King M. 2007. Fisheries biology, assessment and management. UK, Oxford: Wiley-Blackwell. 400 p.

3. Fisheries economics

At the completion of studies:

Younger students will appreciate the importance of fisheries to the economy.

Older students will be aware of the importance of fisheries to the economy and the value of fisheries taking into account costs and returns.

For younger students

Social Science. Strand: Resources and Economic Organisation; Level 1–3

A. Ask students to talk to older people in their community or extended family to discover the importance of local fisheries in supplying food and selling seafood for income.

For older students

Social Science. Strand: Resources and Economic Organisation; Level 4–5

B. Ask students to examine the value of different fisheries in Cook Islands. Which fisheries are the most valuable? Identify fisheries that are subsistence or commercial on your island? Discuss how your country and the people living in your country benefit from fisheries?

Jeff Muir © ISSF 2012

4. No-take areas

At the completion of studies:

Younger students will be aware of the cultural significance of *Ra'ui* in coastal areas of Cook Islands.

Older students will be aware of the role of *Ra'ui* and, through field work, appreciate their importance in conserving fish stocks.

Cook Islands is well known for its *Ra'ui* — a ban on fishing in an area for a given amount of time imposed by traditional leaders to ensure that seafood resources are sustainable.

For younger students

Social Science. Strand: People, Place and Environment; Level 1–3

A. Ask a community elder involved in *Ra'ui* to explain to students the history and benefits of *Ra'ui*. What are the likely benefits of having an area closed to fishing?

For older students

Social Science. Strand: People, Place and Environment; Level 4–5

B. Ask students to either talk to older people in their community or locate a *Ra'ui* in which fishing is banned. Find out the rules for the *Ra'ui*. Ask how long the *Ra'ui* has been in operation? Has it been successful? Do all people obey the community rules? What happens if the *Ra'ui* opens? Do they have control measures when the *Ra'ui* is opened? Ask students to suggest measures that would be beneficial to implement when opening up the *Ra'ui* for harvest?

C. Arrange for students to swim with masks and snorkels along a transect in a safe area of a lagoon (if possible and if permitted, do this within a *Ra'ui* area). Record the numbers and types of fish seen in a band width of 4 m (two metres each side of the swimmer). If possible, compare results from transects inside and outside a *Ra'ui* area.

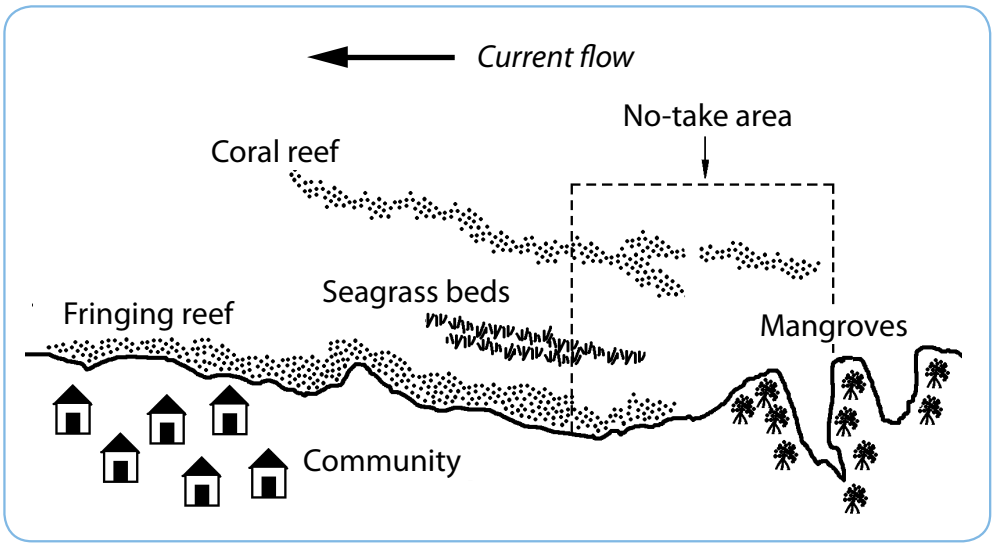
D. The following figure shows a hypothetical, community-managed, no-take area in another Pacific Island country (Cook Islands does not have the mangroves shown). Show the figure on a screen (from the DVD or flash drive supplied as part of the Teachers Resource Kit). Ask students to discuss the negative and positive aspects of the positioning of the no-take area shown.

Negative points that could be raised include:

- the community loses access to a part of its fishing area.

Positive points include:

- the area includes different habitats for marine life — seagrass beds, coral reef, estuary — which are important for the survival of many species.
- larvae from the no-take area are likely to drift out into the fished areas where they can settle and grow into adults that can be caught.



5. Fish anatomy

At the completion of studies:

Younger students will be aware of the external features of fish and sharks.

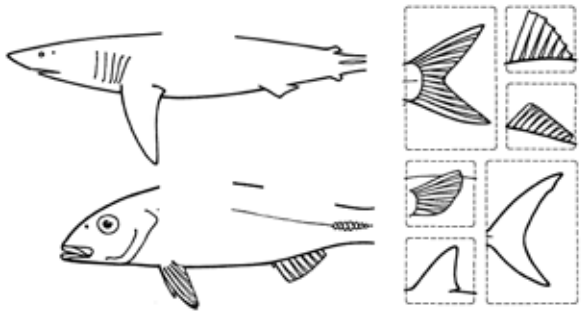
Older students will understand the structure and function of the external and internal parts of a fish.

Many young people, even those who have cleaned and gutted fish for their family, do not appreciate the structure and function of the different parts of a fish. These exercises are meant to increase awareness of fish, animals whose ancestors appeared on earth over 500 million years ago.

For younger students

Science. Strand: Living World; Aim 2, Level 1

A. Make full-size, A4 black and white copies of the accompanying drawing of the external features of a bony fish and a shark with separated parts. Ask students to cut out the parts (along the dotted lines) and paste them onto the drawings.



A4 size of this figure on next page.

For older students

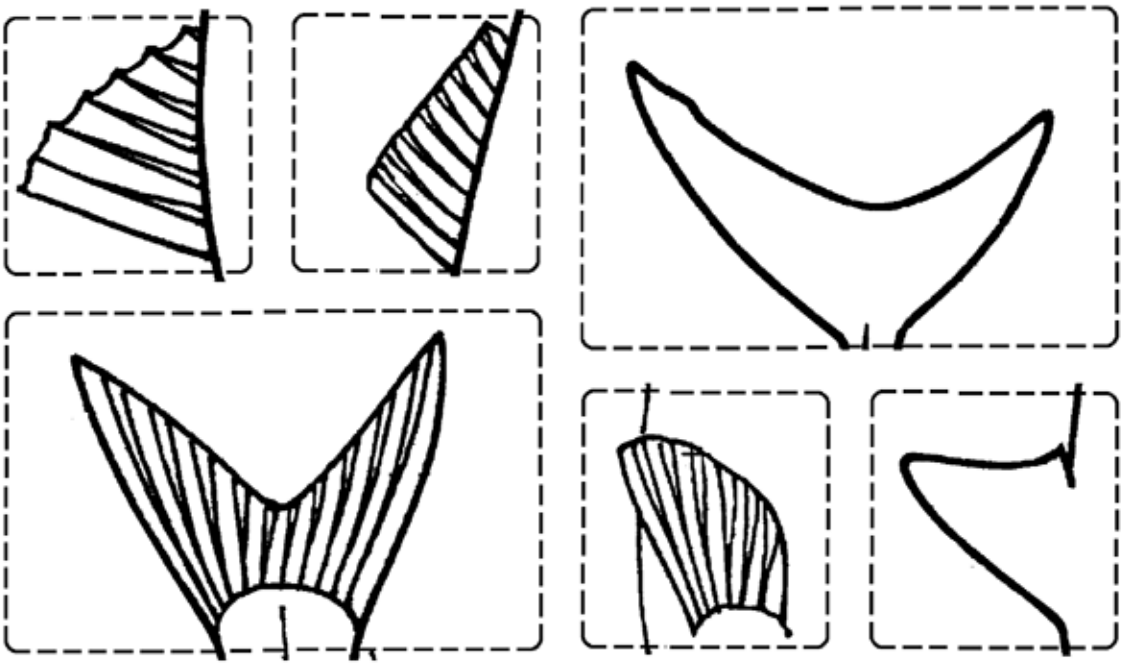
Science. Strand: Living World; Aim 2, Level 2–5

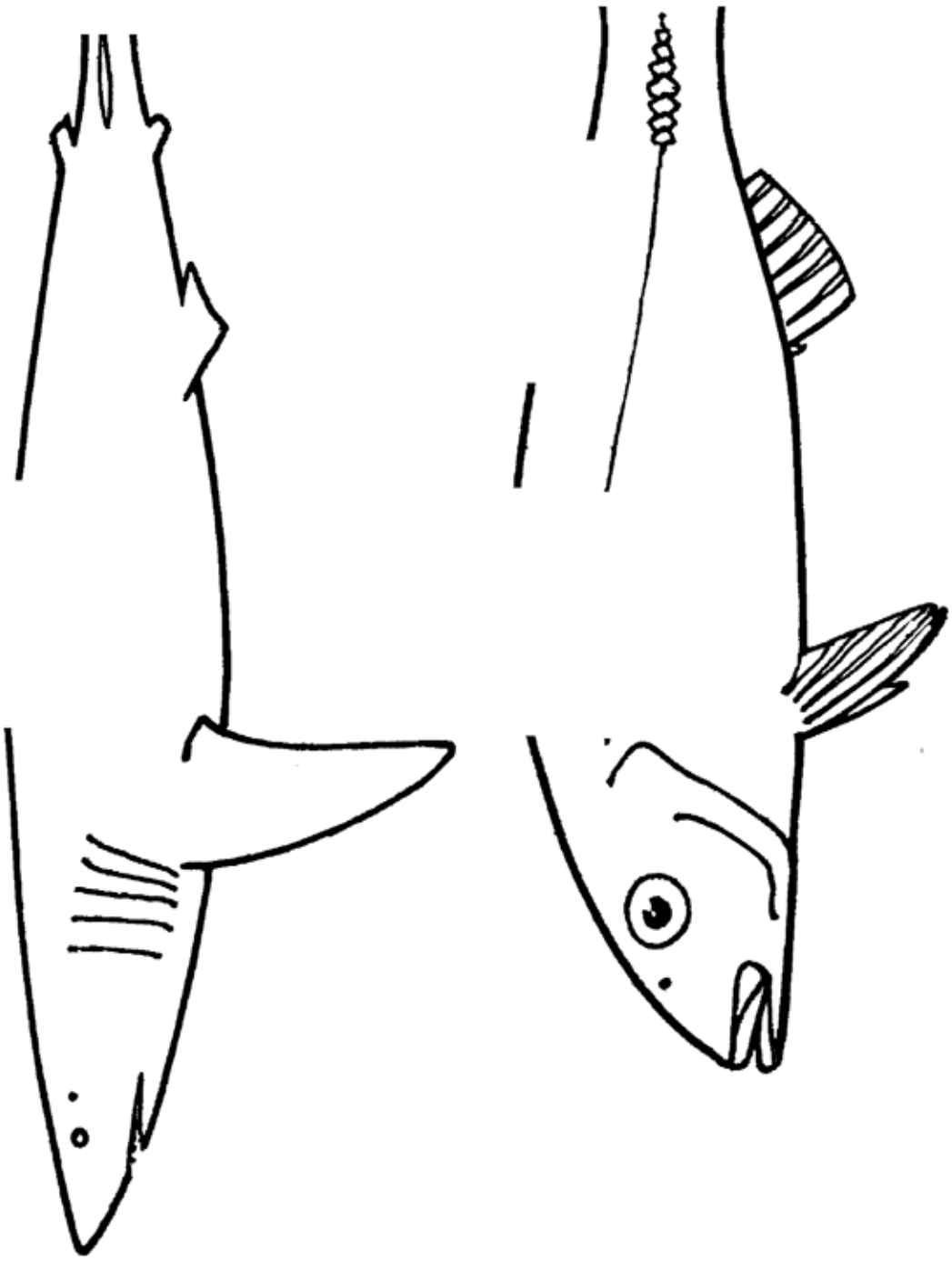
B. Supply fresh fish of different kinds, one to each group of two or three students working together (each group will require a dissecting kit with scissors, scalpel (or knife) and probe — the scalpel could be omitted if safety is a concern.

Have each group of students a) identify the fish from the posters supplied, b) dissect each fish by carefully exposing the internal organs as shown in the figure on Sheet 5 and c) make a labelled drawing (use the figures on Sheet 5 as a guide: show the figures on a screen using the DVD or flash drive supplied as part of the Teachers Resource Kit).

Students should answer the following questions — is the dissected fish a herbivore or a carnivore? (examine the length of its intestine and the type of teeth it has); label the important parts of the fish and give their function — how does a fish "breathe"; how does a fish move through the water?

Michael Sharp © SPC





6. Marine food chains

At the completion of studies:

Younger students will be aware of the position of fish in the food webs of marine species.

Older students will be aware of marine food webs and understand the reduction in energy and food from plants to top-level carnivorous fish.

Most students would have some idea of the range of species in coastal areas of Cook Islands. These exercises are meant to make students aware of the connections between the species — that is, what eats what?

For younger students

Science. Strand: Living World; Aim 4, Level 1–3

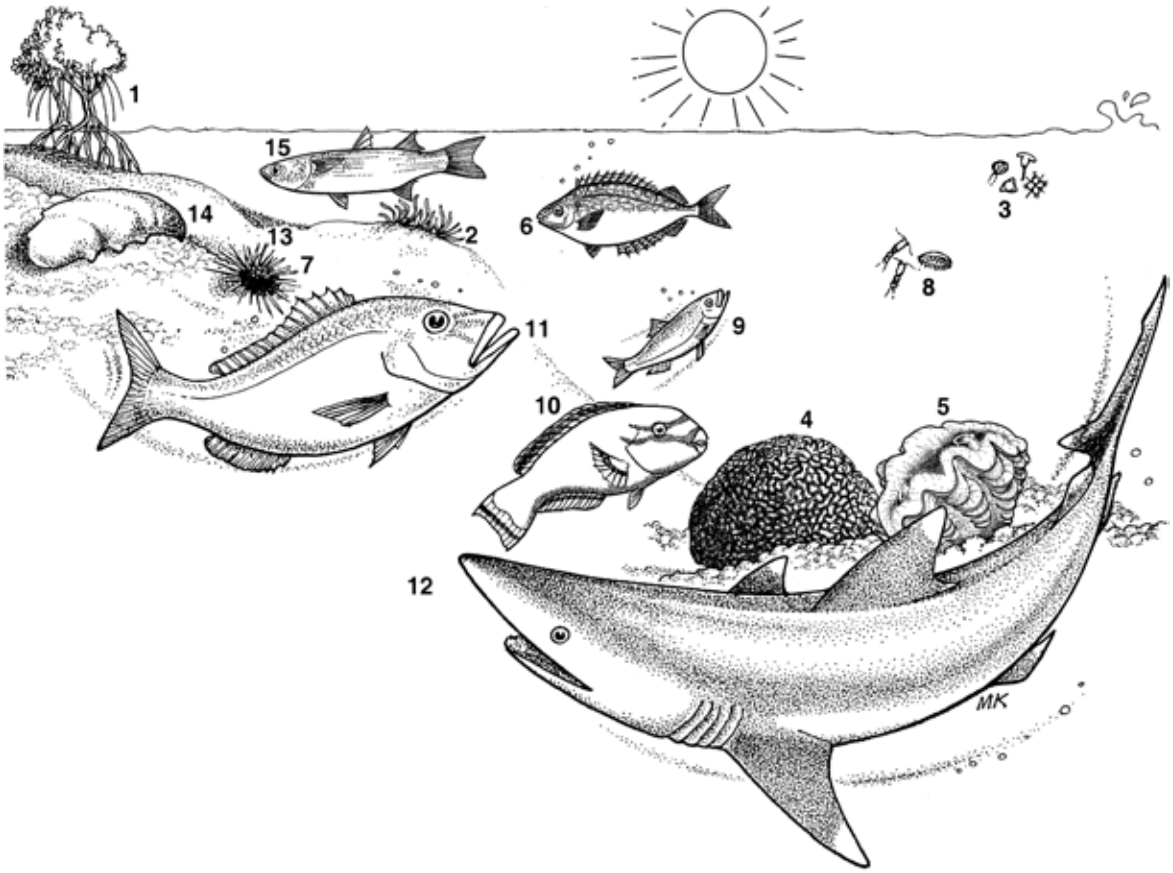
A. Ask students to draw common local fish and place them in a food web like the one shown in the accompanying illustration on Sheet 6. What does a rabbitfish eat? What does a parrotfish eat? What does an emperor eat?

For older students

Science. Strand: Living World; Aim 4, Level 3–5

B. Discuss the energy pyramid shown in the Teachers' Resource Sheet on Fisheries 6. Assuming an energy loss of 90% in each stage of the food web, estimate how much plant material it takes to ultimately produce 1 kg of snapper meat.

C. The food web shown below is the same as the one on Teachers Resource Sheet 6 but the connecting lines have been removed. Have students discuss primary production* (the use of sunlight, carbon dioxide and nutrients by plants) and the predator-prey relationships (what eats what?) and join the living things as well as detritus. Although the mangroves shown do not exist in Cook Islands, they are found in many other Pacific Islands.



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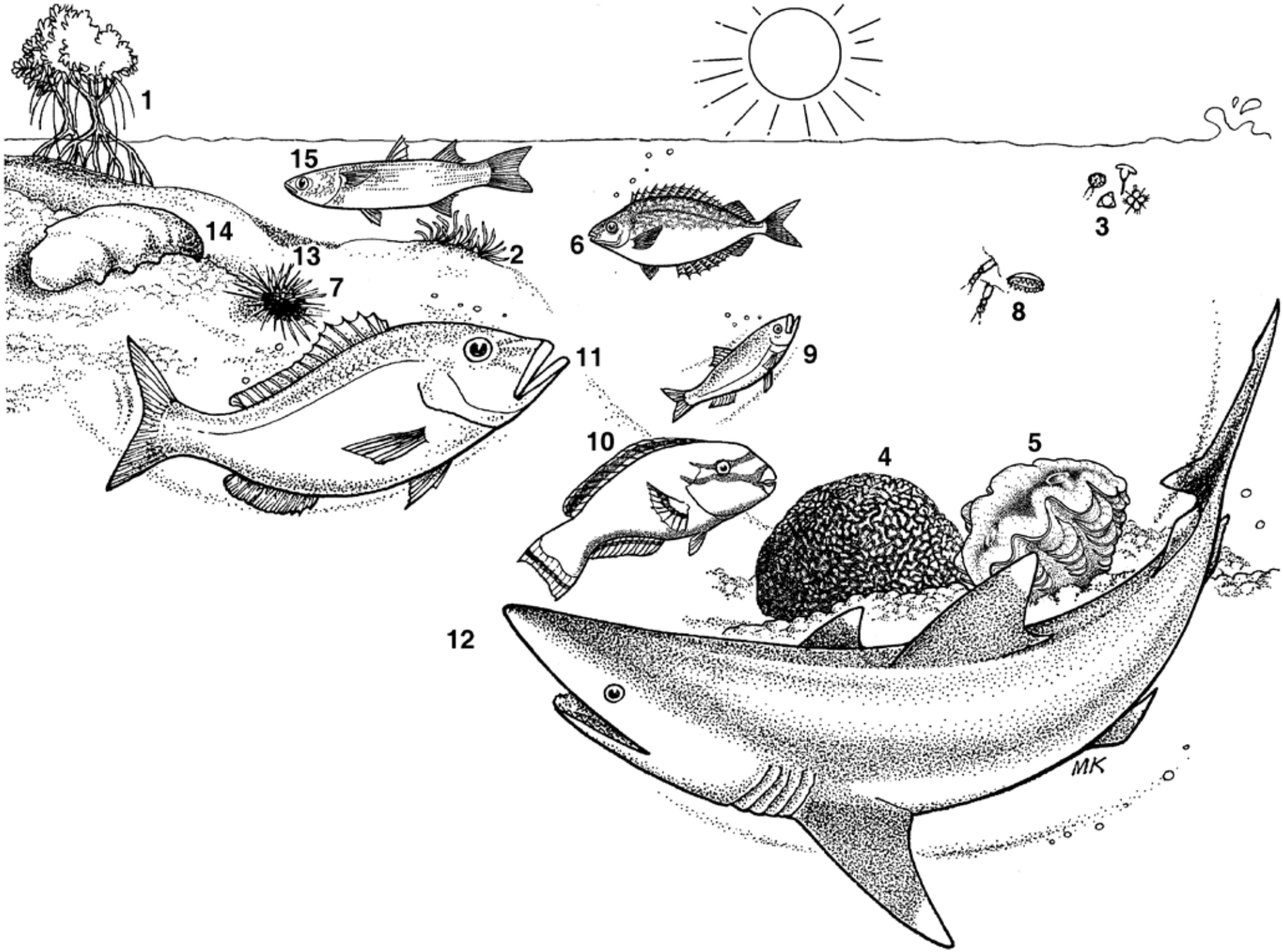
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7. Oceanic species

At the completion of studies:

Younger students will be aware of differences between reef and oceanic fish.

Older students will be aware of the importance of oceanic fish and the evolution of fusiform shapes and counter-shading.

The Exclusive Economic Zone (EEZ) of Cook Islands covers an area of 1.8 million km^2 and shares common borders with five other Pacific Island countries or territories. Fish caught in this huge area for both local food and export include yellowfin tuna (*a'ai*), skipjack tuna (*au'opu*), albacore tuna (*toe veri*), marlin (*akura*), wahoo (*paara*) and mahi mahi (*mai mai*).

For younger students

Science. Strand: Living World; Aim 3, Level 1–2

A. Ask students to examine the four fish posters of Cook Islands fish with the names hidden by masking tape. Ask them to write local and English names of the fish on the masking tape (local names may be different in each area).

B. Compare the lives of open sea fish with reef fish. Why do they look different?

For younger and older students

Science. Strand: Living World; Aim 2, Level 2–3

C. Show the figure of the fusiform shape and the fish with counter-shading on a screen. (These figures are on the DVD or flash drive supplied as part of the Teachers Resource Kit.) Have students discuss:
   - the advantages of a fusiform shape? Extend the discussion to other applications of the shape — e.g. the hulls of outrigger canoes and the bulbous bows on large sea-going vessels;
   - the purpose of counter-shading in fish.

For older students

Science. Strand: Living World; Aim 2, Level 4–5

D. Ask students to examine the four fish posters of Cook Islands fish. What is the most noticeable difference between fish that swim fast and those that live on the reef? What shape is common in oceanic fish? Why is this shape common? Why do tuna need so much food? Why does a dolphin have the same shape as a fish?

Science. Strand: Living World; Aim 2, Level 5

E. Ask students in student groups to prepare a status report on a local, exploited, marine species. The report should address the biology of the species, the history of the fishery, the state of the resource, current management measures and recommendations.

Social Science. Strand: Resources and Economic Organisation; Level 5

F. As a class exercise, conduct a brief survey of a local fish market. Make a list of all species offered for sale with estimated weights and price per kg. Interview sellers to find out where each species comes from and how the availability of the marketed species varies seasonally.

8. Bonefish

At the completion of studies:

Younger students will know about the bonefish fishery in Cook Islands.

Older students will be aware of the fishery and how it is regulated.

Fly-fishing* for bonefish brings foreign exchange to Cook Islands. Fishers are required to have a permit and to fish only in designated areas. Fishing in spawning areas and nurseries is prohibited from three days before until three days after the new moon — a spawning area is an area where fish gather to reproduce; a nursery is an area where very young fish settle to grow and hide from predators. Most sports fishers release their catch immediately after capture.

For younger students

Social Science. Strand: Resources and Economic Organisation; Level 1–4

A. Request a Fisheries Officer from MMR to talk about the bonefish fishery and the ways in which bonefish are caught.

For younger and older students

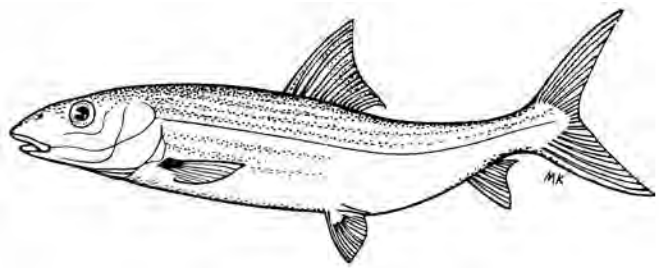
Social Science. Strand: Resources and Economic Organisation; Level 1–4

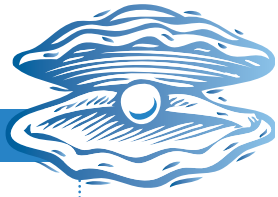
B. Ask a local guide or keen fly-fisher to explain his technique and show how his fishing gear works. If practical, have students make a fly under instruction from the guide.
(The video *"Itu's Bone"* includes local fly-fishing but is about one hour long.)

For older students

Social Science. Strand: Resources and Economic Organisation; Level 5

C. Ask students to find out all they can about bonefish from the internet and news articles on the new bonefish fishery. Why is the bonefish fishery valuable to Cook Islands? How is it managed? Are there other fish that can get oxygen from the air like bonefish.





9. Pearl oysters

At the completion of studies:

Younger students will appreciate why pearl shells are regarded as attractive and are used in craft work.

Older students will be familiar with pearl production in Cook Islands and the internal anatomy of a pearl oyster or other bivalve mollusc.

Cook Islands is famous for its dark-coloured pearls from the black-lipped pearl oyster or *parau* (*Pinctada margaritifera*), which is farmed on Manihiki and Penrhyn.

For younger students

Science. Strand: Material World; Aim 1, Level 1–2

A. If a sufficient quantity of pearl oyster shells can be obtained, ask each young student to make a small necklace pendant from a broken piece of shell. Each student will require some coarse sand-paper and a hole could be drilled into the shell by the teacher to complete the pendant.


Ben Ponia © SPC

For older students

Social Science. Strand: Resources and Economic Organisation; Level 1–5

B. Arrange a talk from a fisheries officer, pearl trader or pearl-farm owner.

C. Have students investigate why oysters produce pearls. How are pearls formed by the pearl oyster? Why is pearl shell so glossy and reflective? Has the production of pearls in Cook Islands changed over the years? — if so, why?

Science. Strand: Living World; Aim 2, Level 1–5

D. If a number of whole, live, pearl oysters can be obtained, provide one for each small group of two to three students. Ask each group to carefully remove one of the oyster's shells and one lobe of the mantle to expose the internal structure. Students should identify the muscle, gills and intestine and make a labelled drawing. The drawing of the internal structure of the pearl oyster given in Sheet 9 can be used as a guide.

E. If whole, live, pearl oysters are not obtainable, another two-shelled (bivalve) mollusc such as a *pipi* could be dissected instead. Alternatively, have students complete the labels on copies of the following drawing and discuss the functions of each. This figure is the same as the one on Teachers' Resource Sheet 9 but with the labels hidden.

WK

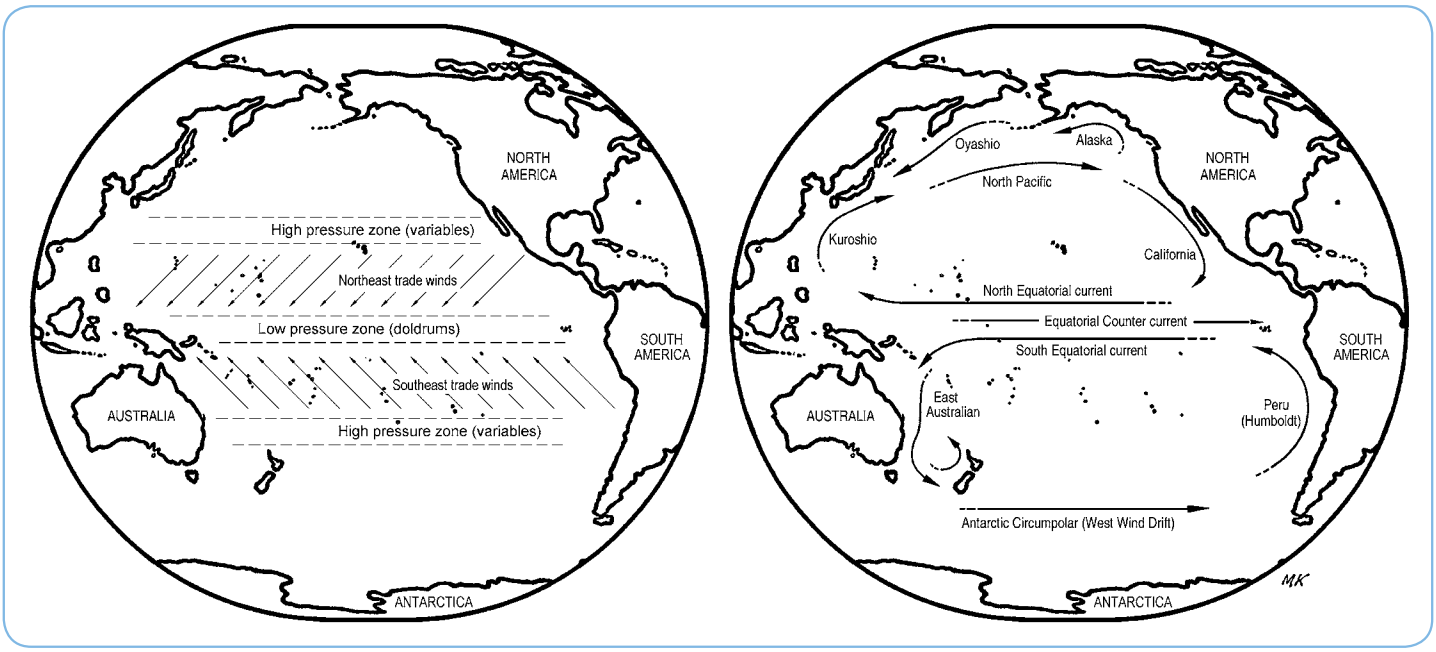
10. Freshwater fisheries

At the completion of studies:

Younger students will be aware of eels and shrimps in the freshwaters of Cook Islands.

Older students will be able to discuss the possible origins of freshwater species in Cook Islands.

A small number of fish and invertebrates that live in fresh water are found in Cook Islands. Eels live in both sea and fresh water and the freshwater fish, tilapia, has been introduced.



For younger and older students

Social Science. Strand: Cultural Development and Change; Level 2–3

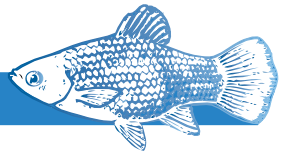
A. Ask students to talk to older people in their community or extended family about fishing for eels and shrimps. How much is caught? Have catches changed over the years?

For older students

B. The aquarium built as a student project described in Sheet 11 could be set up as a freshwater aquarium and stocked with shrimps and small tilapia caught by students.

C. The figure above shows (left) the prevailing winds and (right) the ocean surface currents in the Pacific Ocean. Ask students to discuss where freshwater species could have possibly come from (the origin of freshwater species in Pacific islands is not known but possibilities can be discussed).

11. Aquarium fish



At the completion of studies:

Younger students will be aware that aquarium fish are collected and exported from Cook Islands.

Older students will be aware of the details of the aquarium fish export industry and be able to build and maintain an aquarium.

The commercial exploitation of aquarium fish in Rarotonga began in the late 1980s and their export makes up a small but important component of the country's exports.

Giant clam aquaculture has been conducted since 1990 on Aitutaki at the Araura Marine Research Station operated by the Ministry of Marine Resources. Baby giant clams are exported to be sold on the marine ornamental (aquarium fish) market.

For younger students

Science. Strand: Living World; Aim 3, Level 1–4

A. Ask students to recognise aquarium fish from Cook Islands fish posters.

For younger and older students

Social Science. Strand: Resources and Economic Organisation; Level 2–5

B. For students in Rarotonga, arrange a talk from an aquarium fish exporter — how are fish collected on a sustainable basis? How are aquarium fish transported to overseas countries?

C. For students in Aitutaki, arrange a visit to the MMR giant clam farm — how are giant clams selected, bred and grown? How are they transported to overseas countries?

For older students

Science. Strand: Living World; Aim 4, Level 1–5

D. Ask students to cooperate in the building of an aquarium. Precut glass, silicone glue and masking tape will be required to build the aquarium. For the filter system, plastic pipe, plastic mesh and an air pump will be required. Details of construction are shown in the accompanying diagram.

A thin line of silicone glue must be carefully squeezed onto the edges of the glass that have to be joined. The glass can be temporarily held together with masking tapes until the glue sets.

The plastic pipe and connecting pieces are fitted together without glue as shown so that the rectangular structure just fits inside the aquarium.
3 to 4 mm holes are drilled along the inner sides of the pipes.

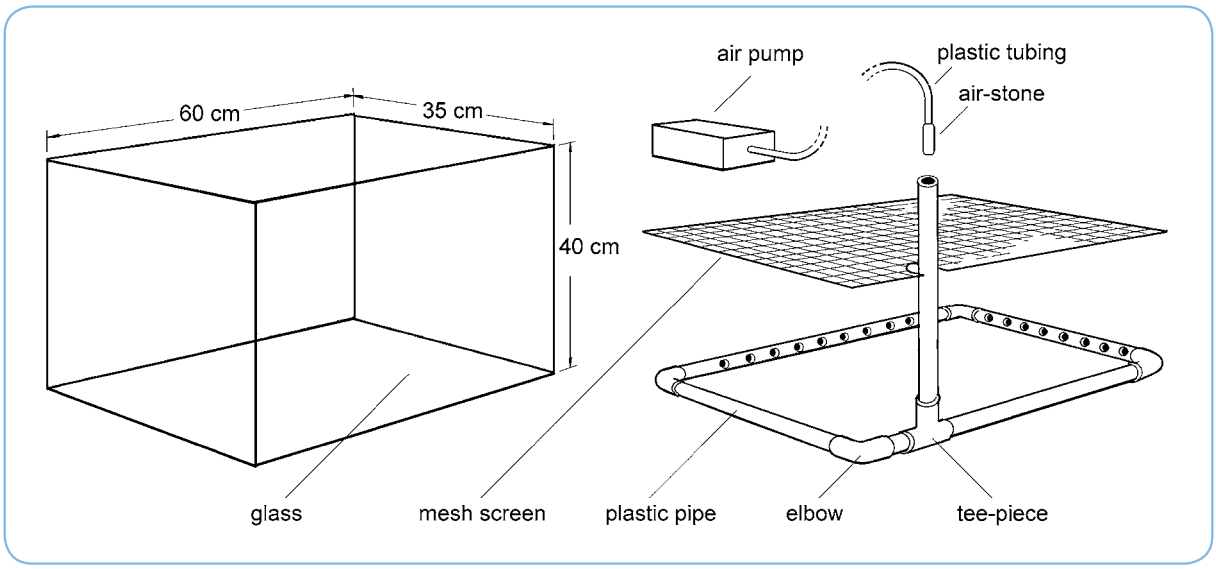
The plastic mesh is placed on top of the pipes and well-washed shell grit or coarse sand is placed on the mesh screen. In the centre of the aquarium, the screen may have to be supported from below with short cut-off lengths of pipe to stop it sagging.

The air-stone must just fit inside the upright pipe. When operating, the air-stone "lifts" and oxygenates the water after it is drawn through the shell-grit and sand, which acts as a filter.

A freshwater aquarium is easier to maintain but less interesting — it can be stocked with freshwater plants, small tilapia and freshwater shrimps.

A saltwater aquarium is more interesting but harder to maintain (the water must be changed every two to three weeks) — stock the aquarium with very small sea cucumbers, small crustaceans and small coral fish such as humbugs and damselfish.

E. An alternative to building an aquarium would be for students to build a virtual aquarium with virtual fish (several internet site are available).



12. Fish spoilage

At the completion of studies:

Younger students will be familiar with bacteria and the need for personal hygiene when handling food.

Older students will be aware of food spoilage caused by the action of bacteria and enzymes.

Most natural foods eventually spoil or become "bad". Spoilage refers to food items becoming unfit to eat. Seafood, in particular, has to be handled carefully so that it doesn't make people sick.

For younger students

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 1–3

A. Why is it necessary to wash your hands before handling food? Introduce the idea of removing contaminants and bacteria from hands before handling food.

B. Why do we keep food on ice or in a refrigerator? Introduce the idea of low temperatures slowing (but not stopping) the growth of bacteria on food.

For older students

Science. Strand: Living World; Aim 3, Level 5–6

C. Have students discuss the fact that honey is the only natural food that doesn't go bad. Introduce the concept of osmosis* which causes bacteria entering honey to shrivel up and die.

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 3–4

D. Obtain two fresh fish of a similar type and size. Place one fresh fish in a container with ice and one in a container without ice. Ask students to observe the fish each day for several days and note changes in the smell and appearance, particularly in the eyes and gills. What makes the fish without ice begin to smell after a few days? Why would this fish be unsafe to eat?

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 5

Science. Strand: Living World; Aim 3, Level 5–6

E. Have students discuss the difference between spoilage caused by bacteria and that caused by enzymes. What are the causes and symptoms of each type of poisoning?

F. Arrange to visit a Fish Processing Plant or ask a Fisheries Officer to give a talk on Seafood Handling.

13. Ciguatera and fish poisoning

At the completion of studies:

Younger students will be aware of ciguatera and the fish that cause it.

Older students will be aware of ciguatera and the sequence of events that result in some fish becoming toxic. They will also be aware of other effects of harmful algal blooms.

Not all fish poisoning is caused by poor handling and bacteria. Some forms of poisoning are caused by harmful algal blooms — a dramatic increase in the numbers of very small plants (phytoplankton*) that float in the sea. These microscopic plants produce toxins that can affect humans.

Interestingly, the toxins can become airborne (as toxic aerosols) because of wave action and cause people swimming and walking on the shore-line to suffer respiratory asthma-like symptoms from inhaling the airborne droplets. This has been noted in Rarotonga where sewage-derived nutrients were believed to be responsible for the blooms.

For younger and older students

Science. Strand: Living World; Aim 3, Level 1–3

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 1–3

A. Show students Cook Island fish posters and ask them to identify those fish that are known to cause ciguatera poisoning.

For older students

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 3–5

B. Ask students to interview members of their local community or extended family to identify species in a local area that are known to result in ciguatera poisoning. Find out how many people have suffered from ciguatera poisoning. Speak to someone who has suffered from ciguatera poisoning — which fish caused it? What were the symptoms? Was local medicine used to treat the symptoms?

C. For students in Rarotonga, interview people who believe they have suffered from exposure to airborne toxins while swimming or walking on the shoreline. What were the symptoms? When and how often did these occur?

Science. Strand: Living World; Aim 4, Level 4–5

D. Students could hypothesise on conditions that cause harmful algal blooms in their local area.

14. Job opportunities in fisheries

At the completion of studies:

Younger students will be aware of the range of opportunities in the fishing industry.

Older students will be aware of the range of job opportunities in the fishing industry and will be aware of working locations and conditions.

In Cook Islands, job opportunities may occur in pearl farming, fishing, processing, marketing, research and managing or conserving marine resources.

For younger and older students

Social Science. Strand: Social Organisation and Identity; Level 1–3

A. Arrange for talks by people who work in the fishing industry — from a fisher, a fish trader, a fish exporter and a member of an environmental NGO as well as a fisheries manager from MMR.

Social Science. Strand: Resources and Economic Organisation; Level 1–5

B. Arrange for visits to potential employment areas — to a tuna fishing vessel, an export factory and MMR.

15. Fish Aggregating Devices (FADs)

At the completion of studies:

Younger students will appreciate the role of fish aggregating devices in Cook Islands.

Older students will be aware of the purpose of fish aggregating devices and be able to discuss possible reasons why they attract oceanic fish.

Many species of fish that inhabit the open sea are attracted to floating objects. FADs are rafts set offshore to attract oceanic fish such as tuna (*a'ai*), wahoo (*paara*) and mahi mahi (*mai mai*) so that they can be more easily caught by fishers. The first FAD in Cook Islands was deployed in the early 1980s. Since that time, they have been constructed and placed around Rarotonga, Aitutaki, Mangaia, Atiu, Mauke, Mitiaro, Palmerston, Manihiki and Penrhyn.

For younger and older students

Science. Strand: Living World; Aim 4, Level 2–5

A. Build a model FAD using a raft (about 40 cm by 40 cm) made from bamboo or sticks and attached by rope to a brick or other weight; attach short lengths of frayed rope to the underneath of the raft. Set the model FAD (with a small flag) in the shallow water of a lagoon. Have students observe the raft using a diving mask and snorkel at weekly intervals. Note any plant material and other organisms growing on the rope. Are there more small fish near the model FAD than in surrounding bare areas?

For older students

Science. Strand: Living World; Aim 4, Level 4–5

B. Ask students to suggest why fish of the open sea such as tuna are attracted to FADs. Discussion possibilities include:
   - The FAD acts as a visual reference point in an otherwise empty ocean.
   - The FAD works by attracting smaller baitfish on which larger fish feed.
   - Baitfish use the FAD as a hiding place from predators.
   - Baitfish feed on the algae and small organisms that settle on the hanging material.

Social Science. Strand: Resources and Economic Organisation; Level 3–5

C. Ask MMR to provide a fisheries officer to explain how FADs are used in Cook Islands to enhance food security and livelihoods (increased catches of pelagic fish by subsistence and commercial fishers) and to mitigate impacts of climate change (shifting of fishing pressure from reefs to offshore areas hence increasing the resilience of coral reefs to the negative impacts of climate change).

D. Ask students to discuss the challenges faced by MMR or local communities in deploying FADs in outer islands (consider the transport, cost, availability of FAD materials from Rarotonga and the use of a vessel large enough to set FADs). How could the fishers using FADs contribute to the high cost of building, setting and maintaining them?

16. Cook Islands traditional fishing methods

At the completion of studies:

Younger students will be familiar with the range of traditional fishing methods used in Cook Islands.

Older students will be aware of the range of traditional fishing methods used in Cook Islands and be able to discuss the advantages and disadvantages of the methods used. They will know about damaging fishing methods used in the past.

For younger and older students

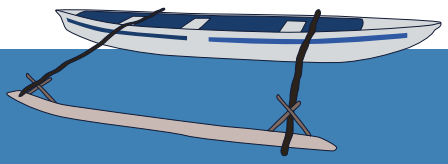
Social Science. Strand: Cultural Development and Change; Level 2–5

A. Ask students to talk to older people in their community or extended family to discuss traditional fishing. How have fishing methods changed over the years? What were the advantages and disadvantages of traditional fishing methods?
This should be followed up with a discussion in the classroom and a listing of the number and types of traditional fishing methods used by local communities (this could be done in conjunction with exercise A in Sheet 16. Modern fishing methods).

B. There is a tendency to think that only modern fishing methods are responsible for overfishing and environmental damage. Some are, but some traditional fishing methods can also be damaging. Have students discuss which traditional fishing methods are damaging — what about communal fish drives (leaf sweeps or rau) across a reef?

C. The fruit of the *utu* or *Barringtonia* tree, *Barringtonia asiatica* and the roots of the *ora papua* or *Derris* vine, *Derris* sp. and dynamite were once used to poison and stun fish. These practices have been banned because they not only kill the target fish, but also other fish, shellfish and coral in the area. Ask students to talk to older people in their community or extended family to ask about these methods of fishing in the past.

D. Have students discuss why many traditional fishing methods described in Information sheet 17 — hook-and-line methods, *maroro* fishing, *inaki* and *pata* fishing if it is only done during daytime — are sustainable because they are selective and allow, for most of them, to release baby fish alive.



17. Modern fishing methods

At the completion of studies:

Younger students will be familiar with the range of commercial fishing methods used in Cook Islands.

Older students will be aware of the range of commercial fishing methods used in Cook Islands and have practical knowledge of some of the methods used.

For younger students

Social Science. Strand: Cultural Development and Change; Level 2–5

A. Ask students to talk to people in their extended families or community about modern fishing methods that they use. This exercise should be followed up with a discussion in the classroom and a listing of the number and types of modern fishing methods used by the local community (which could be done in conjunction with exercise A in Teachers' Resource Sheet 17: Cook Islands traditional fishing methods).

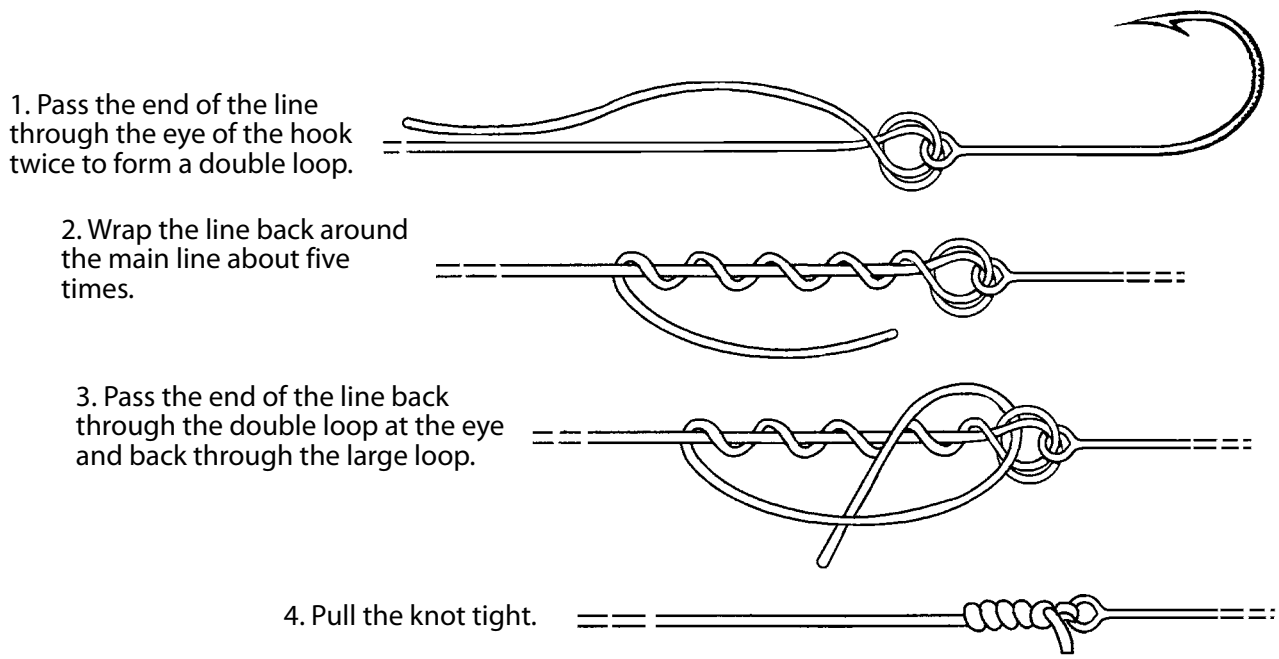
For older students

B. Have students demonstrate that they can tie the commonly used fishing knot (a blood knot) shown in the diagram below.

Social Science. Strand: Resources and Economic Organisation; Level 3–5

C. If possible, arrange a visit to a local fishing operation; visit a longliner or a game fishing charter boat. Ask students to examine and discuss the value of the operation to the country and the sustainability of the fish stocks targeted.

D. Ask students to discuss any impacts of a modern fishing method on the resources of their island.



18. Sea safety

At the completion of studies:

Younger students will be aware of the safety equipment that should be carried on all fishing boats.

Older students will be aware of the safety equipment that should be carried on fishing boats including sea anchors and signalling equipment; they will also know how to tie important knots relating to safety and seamanship.

For younger students

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 1–3

A. Show students a copy of the checklist on safety equipment with one item blanked out — ask students to identify the missing item.

B. Make black and white copies of the "Small boat safety checklist" for students to colour in. Why are life-jackets coloured bright yellow or orange? What is more important to carry on board the boat always — food or fresh water and why? In what circumstances can a knife be useful onboard a boat?

For younger and older students

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 3–5

C. Arrange for a talk from harbour authorities or from someone who has had an accident or been rescued at sea.

For older students

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 3–5

D. Ask students to interview members of their local community or extended family. How many accidents at sea have occurred? What is the cost of these accidents to families and society? What safety equipment was carried? Did they carry all items shown on the checklist on safety equipment?

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 2–3

E. How would fishers get information on the local weather before going to sea?

F. How does a sea anchor work and why is it useful to have onboard? (It reduces drift speed in case of engine breakdown and keeps the vessel's bow facing the wind and hence improves vessel stability.)

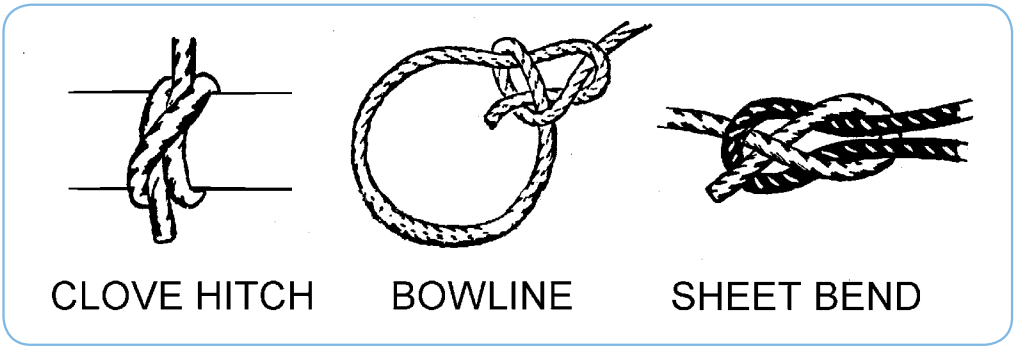
G. What are the cheapest options available for signalling devices (torch and mirror), propulsion means (sail or paddles), floating devices (plastic container or fishing buoy)?

Health and Physical Well-being. Strand: Me, Safety and Risk Management; Level 3–4

H. Ask students to discuss each of the following signalling devices:

- flares (good at night but not during daytime, works for passing air planes or boats, short lifespan so need to buy at regular intervals, not accepted on aircraft so difficult to acquire, particularly in the outer islands);
- VHF (good to alert people on shore or onboard other boats, hand-held models exist, relatively inexpensive, but requires power or A4 batteries to operate, limited range up to 20 nm and some areas are not equipped with VHF receiver/transmitters);
- mirror, also called heliograph (cheap, good during daytime but requires sun to work, does not work at night);
- torch or laser (good at night, cheap, but requires batteries to operate — although manually chargeable models exist — best to have waterproof lamp, not useful during daytime);
- personal locator beacon — PLB (unlimited range as works with satellites, best device to signal distress to international and local authorities, has a built-in GPS so that position is known, but expensive — around NZ$ 400, lifespan of built-in battery varies).

I. Supply each student with two pieces of rope each about one metre long. Have students demonstrate that they can tie a clove hitch, bowline and sheet bend.
The clove hitch is commonly used to tie a rope to an object (but it can jam tight under load). The bowline forms a loop that does not slip or tighten (it is used in many rescue operations and is traditionally pronounced BO-LIN). The sheet bend is used to join two ropes together. Show the following figure as a guide.



19. Financial management

At the completion of studies:

Younger students will be aware of the range of fish species that are caught.

Older students will be aware of the costs of equipment, gear and supplies required for fishing as well as profits from sales.

For younger students

A. Ask students to prepare a list of fish that are regularly caught and what the fishers do with the fish (what is the quantity eaten and sold).

For older students

Social Science. Strand: Resources and Economic Organisation; Level 4–5

B. Ask students to interview someone who makes a living from fishing.
Find out the fisher's average catch from a fishing trip (by species, in kg), how much they sell the fish for (income, in $) and how many fishing trips they usually complete in one year.
If possible, find out the costs of fishing — ice, bait, food, fuel, replacement of gear etc. Complete a spreadsheet on the costs of fishing and income from selling fish (a basic example is shown in the table below).

Fixed costs per year	
Fishing licence	$_____
Bank loan repayments	$_____
Boat regular maintenance	$_____
Insurance	$_____
Depreciation of boat and gear value	$_____
Total fixed costs per year	$_____
Running costs per fishing trip	
Crew payments	$_____
Fishing gear replacement	$_____
Fuel and food	$_____
Bait	$_____
Ice	$_____
Total running costs per fishing trip	$_____
Total annual running costs (fishing trip costs multiplied by the number of fishing trips per year)	$_____
Total annual costs (annual fixed costs plus annual running costs)	$_____
Annual income or loss (total income from fish sales minus total annual costs)	$_____

20. Climate change and fisheries

At the completion of studies:

Younger students will be aware of climate change.

Older students will be aware of the consequences of climate change in Cook Islands.

For younger and older students

Social Science. Strand: People, Place and Environment; Level 4–5

Science. Strand: Living World; Aim 4, Level 4

A. Ask students to find out all they can about climate change on the internet and from newspaper articles and books. How could climate change affect Cook Islands? Will stocks of fish be affected? Will there be more or fewer or stronger cyclones? Will the amount of rain change? Will sea-levels change? How will coral reefs be affected?

The following section includes suggested student activities and questions relating to the 29 SPC Information Sheets for Fishing Communities; these are included in the SPC Teachers' Resource Kit on Fisheries.

Information Sheet 01: Groupers

A. Groupers are not shaped like fish that swim fast like tunas. So, how do groupers catch their food?

B. Most species of groupers start out life as females and change sex to males at 3 to 7 years of age. What are the advantages of changing sex in this way?

C. What actions could local fishers take to ensure that groupers are not over-fished? Overfishing or overexploitation is the situation in which so many fish are caught, that there are not enough adults left in the sea to reproduce and replace the numbers lost.

D. Ask students to talk to fishers in their local community or extended family to find out about catches of the fish. Where are they caught? Are they as common as they were 5 years ago? At what time of the year do they contain ripe gonads* (see Teachers' Resource Sheet 5: Fish anatomy)? Do the fishers know if they migrate to gather in a particular place to spawn? (See Information Sheets for Fishing Communities 24: Spawning aggregations.)

(NOTE — C and D can be repeated for many of the species described in the following sheets.)

Information Sheet 02: Rabbitfish

A. Rabbitfish are herbivores and feed on seaweeds and seagrasses. Ask students to describe how this makes them an important link in tropical marine ecosystems? Refer to Teachers' Resource Sheet 6: Marine food webs.

B. Ask students to discuss the reasons that rabbitfish are important in maintaining the health of corals.

Information Sheet 03: Emperors

A. Many emperors are caught by fishers as they gather in large groups to breed (in spawning aggregations). Have students discuss the dangers involved in this type of fishing (refer to Information Sheet 24: Spawning aggregations).

B. An emperor is one of the fish shown in the food web shown in Teachers' Resource Sheet 6: Marine food webs. Have students discuss its position and role in marine food webs.

Information Sheet 04: Parrotfish

A. Have students discuss the habits of parrotfish that make them particularly vulnerable to overfishing.

B. In many places parrotfish have been overfished by people using spears and underwater torches at night to catch the fish as they sleep. Have students discuss the effects their removal has on coral reef ecosystems. What actions could local fishers take to ensure that parrotfish are not over-fished?

C. Large numbers of parrotfish are caught and exported in one particular island in Cook Islands. Ask student to identify this island and to find out about this fishery? How has it affected the stock on the island? Has it become more difficult to catch them?

Information Sheet 05: Reef snappers

A. In several Pacific Island countries, some species of snapper are responsible for ciguatera fish poisoning. Ask students to talk to people in their local community or extended family to find out which fish have been responsible for ciguatera.

B. There are many different species or types of snapper. Ask students to visit markets and talk to fishers to find out how many species are caught locally. Have some species become scarce over time?

Information Sheet 06: Trevallies

A. Trevallies are fast hunters in the sea. Ask students to compare the shape of a trevally with that of a grouper and discuss the reasons for any difference.

B. *Ru'i* (black trevally) fishing is a traditional type of fishing carried out in the northern Cook Islands, particularly on Penrhyn and Rakahanga. One fisher stays in the canoe while another dives down and spits ground-up bait (*paru*) from his mouth to entice the *ru'i* to the surface. The *ru'i* is then fed a baited hook and hauled in by another fisher in the boat.
According to local fishermen, it is becoming harder to catch a good-sized *ru'i*. Have students in the northern Cook Islands interview *ru'i* fishers and attempt to find out the reasons. Find out if the method of fishing for *ru'i* has changed.

Information Sheet 07: Mullets

A. Mullets often move long distances along the coast before moving to offshore waters where they spawn. Ask students to consider how this behaviour has resulted in their overexploitation in several Pacific island countries.

B. Mullets are omnivores, that is, they feed on plants and small animals (invertebrates) as well as by sucking up sediments on the sea floor. Have students discuss the advantages of this type of feeding behaviour.

Information Sheet 08: Surgeonfish

A. In many Pacific island coastal fisheries, surgeonfish are the most important group of fish taken for food. Ask students to survey their local community to discover the most important local food fish. How are they caught?

B. Surgeonfish can be dangerous to handle. Have students discuss why this is so.

C. Ask students to find out which species are regarded as a delicacy or popular on their island and in which month of the year that such species are normally in good condition or fat.

Information Sheet 09: Sea cucumbers

A. The most common species of sea cucumbers in Cook Islands are the *rori toto* (lollyfish), the *rori matie* (green sea cucumber) and the *rori puakatoro* (red surf fish). Have students talk to people in their local community to discover if these or other species are, or have been, collected.

B. Fishing for sea cucumbers has occurred at a low level in Cook Islands, where people mostly harvest them for their gonads. Ask students in the northern Cook Islands where sea cucumber fishing does occur or has occurred and ask them to prepare a history of the local fishery.

C. Ask students to interview people in their communities to find out about traditional methods of preparing sea cucumbers for food? What methods are used for each species?

D. Ask students to discuss the role of sea cucumbers in coral reef ecosystems. What would happen if their numbers were greatly reduced by fishing (consider their role in "clearing" debris and organic material from the sea floor).

Information Sheet 10: Giant clams

A. Ask students to discuss how giant clams can "feed" on sunlight. Discuss symbiosis.*

B. Ask students to discuss the actions that could be taken to ensure that giant clams are not over-fished?

C. Ask students to select an island and discuss the impacts of airports and regular shipping on local populations of giant clams. Discuss any measures that indicate that the island applies to protect giant clams.

Information Sheet 11: Trochus

A. Trochus (*Tectus niloticus*) were introduced into Cook Islands in the 1950s from Fiji. They were first released on Aitutaki; then, during the 1970s and 1980s they were taken to most of the other islands in the Cook group. Ask students to prepare a history of the introduction in their local area. Are the stocks managed well? Is the fishery valuable to local people?

B. MMR has imposed minimum and a maximum size limits on trochus — that is, trochus less than 80 millimetres and greater than 110 millimetres cannot be legally caught. What are the purposes of these regulations? (See Teachers' Resource Sheet 1: Fisheries management.)

C. Ask the students to discover if there was an impact of trochus introductions on other species that live in the same habitat?

Information Sheet 12: Mangrove crab

In Cook Islands, mangrove crabs are only caught in Aitutaki, but they are found in many other Pacific islands.

A. What actions could local fishers in Aitutaki take to ensure that mangrove crabs are not over-fished?

Information Sheet 13: Spiny lobsters

A. Spiny lobsters are caught in Cook Islands but the development of a large commercial fishery may not be possible. Ask students to discover why this is so.

B. Spiny lobsters usually live in crevices on reefs and move out at night to feed. Ask students to interview local people who catch lobster. How do they catch them? Where are they caught? Are they as common as they were 5 years ago? At what time of the year do the females carry eggs beneath their bodies?

Information Sheet 14: Coconut crab

A. Coconut crabs (*unga*, *kaveu*, *kavou*) were once found throughout the Pacific. In Cook Islands, coconut crabs have become rare in some islands but can be found in Aitutaki, Atiu, Mangaia, Manihiki, Mauke, Palmerston, Penrhyn, Pukapuka, Suwarrow and Takutea. Ask students to investigate the reasons why they have disappeared from many islands in the Pacific.

B. Coconut crabs have an unusual and complex life-cycle. Use the illustration in Information Sheet 14 to discuss this with students.

Information Sheet 15: Octopuses

Octopuses are fished locally throughout the Pacific Islands using a variety of fishing methods including the use of lures, baited lines and spears as well as by hand. Some fishing methods result in considerable destruction of corals as the octopuses are removed from their nests. In some countries, traditional lures made of cowry shells are used to attract and catch octopuses.

A. Ask students to interview local people who catch octopuses. How do they catch them? Where are they caught? Does the method damage corals? Are octopuses as common as they were 5 years ago?

Information Sheet 16: Green snail

Green snails are harvested in other Pacific Islands for their meat and their pearly shells, which are sold to processing factories for making buttons, jewellery and pearl inlays.

A. Ask student to investigate and discuss the benefits and possible dangers of introducing green snails to Cook Islands.

Information Sheet 17: Reef Sharks

A. Most fish reproduce by males releasing sperm and females releasing eggs into the water. The sperm fertilises the eggs in the sea. But sharks and rays reproduce differently — by internal fertilisation. Have students list the advantages and disadvantages of internal fertilisation (use the life-cycle illustration on Sheet 17).

B. Sharks are fished in large numbers for their fins which are used in shark fin soup. Tens of millions of sharks are caught each year and in many cases their fins are removed and the rest discarded. Ask students to discuss why sharks, in particular, are easily overexploited? Hint — think about a shark's method of reproduction and its position on the energy pyramid (see Teachers' Resource Sheet 6: Marine food webs).

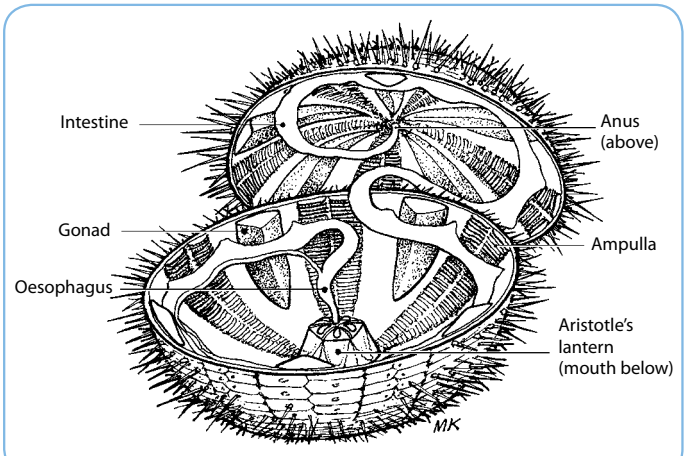
Information Sheet 18: Rays and Skates

A. Rays and skates are related to sharks but feed very differently. Ask students to discuss the feeding of rays including the related manta ray. Why is the manta ray quite different from other rays?

B. Since December 2012, Cook Islands waters have been declared shark sanctuary. Have students discuss the need to protect sharks. What is the shark position in the marine food chain (see Teachers' Resource Sheet #6)?

Information Sheet 19: Sea urchins

A. Sea urchins in Cook Islands include *atuke*, *kina* and *vana*. Obtain several sea urchins and have groups of students dissect them, using the illustration as a guide.
Observe the external parts of the sea urchin including the tube feet and spines.



Use scissors to carefully cut around the test (shell) as shown in the figure, without disturbing internal organs. The body is arranged in five parts like its seastar relatives. There are five gonads suspended on the inside of the test.
Sea urchins feed on algae and small animals using a specialised apparatus called Aristotle's lantern which includes five calcareous plates (pyramids) that support five band-like teeth. The mouth leads into an oesophagus and intestine which exits at the anus at the top of the sea urchin.

Information Sheet 20: Crown-of-thorns

A. Examine past outbreaks of crown-of-thorns in local areas. Were these outbreaks related to factors such as the time of the year? Investigate how local communities dealt with such outbreaks — were the methods used advisable?

Information Sheet 21: Slipper lobsters

A. Ask students to interview local fishers who catch slipper lobsters. How do they catch them? Where are they caught? Are slipper lobsters as common as they were 5 years ago?

B. What actions could local fishers take to ensure that slipper lobsters are not over-fished?

Information Sheet 22: Ark clams

In many Pacific Islands and atolls, ark clams and other small clams are important food items, particularly when the weather is too rough for fishing at sea. In densely populated atolls, they may be the most important source of food.

A. Ask students to investigate and list the types of two-shelled molluscs (such as *pipis*) that are used as food in their island or local community. How important is each species? How do people catch them? Where are they caught? Are they as common as they were 5 years ago?

Information Sheet 23: Edible seaweeds

A. Have students investigate the types of seaweeds that are collected for food in the Cook Islands.

B. Sea grapes (*Caulerpa racemosa*) are widespread and are harvested and sold, particularly in Aitutaki. Ask students to interview people who collect this seaweed. Is it as common as it was 5 years ago? What actions could be taken to ensure that seaweeds are not over-collected? (In Fiji, women collecting sea grapes traditionally leave clumps of the plant in crevices to regenerate.)

Information Sheet 24: Spawning aggregations

A. Many species gather together to form spawning aggregations or migrate in large groups to spawning sites. Have students interview fishers in their community or extended family to find out which fish species are known to form spawning aggregations. List the names of fish. What time of the year does this happen for each species? Where do they normally aggregate? Do fishers go fishing on these spawning aggregations?

B. Catching fish as they gather in spawning aggregations is destructive as these breeding fish are responsible for producing small fish, many of which will grow and be available to be caught in future years. Ask students to discuss the ways in which aggregations of spawning fish can be managed and protected.

Information Sheet 25: Mangroves

A. Have students discuss why none of the major species of mangroves (true mangroves) occur in Cook Islands? There are 33 different species of mangroves in Papua New Guinea, 25 in Solomon Islands, seven in Fiji and three in Samoa (consider the fact that true mangroves produce seeds or propagules that drift in the sea).

B. Have students discuss the possible advantages, disadvantages and dangers of introducing mangroves into Cook Islands.

C. In Cook Islands, *ngangie raupunupunu* (*Pemphis acidula*) and *ngangie mate* (*Suriana maritima*), which grow at the limit of the high tide line, provide good shore protection, as mangroves do in other countries. Have students discuss how *ngangie* and true mangroves compare and how they differ, and why it is important to protect *ngangie* areas.

Information Sheet 26: Seagrasses

A. Not many marine species eat seagrasses but they are important in marine ecosystems. Have students discuss the role of seagrasses (discussion could include roles in providing nursery areas and the formation of detritus — particles of material that provide food for a much wider range of marine species).

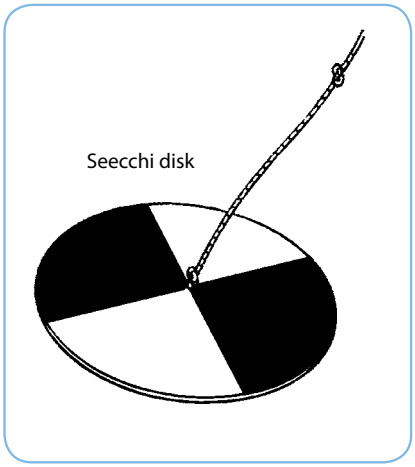
B. Organise a field trip in which older students use diving masks and snorkels to survey a shallow area of seagrass. Record the number and types of marine species living on seagrass and in seagrass beds. Students could swim along transects as described in exercise 4C in Teachers' Resource Sheet 4. No-take areas.

Information Sheet 27: Nutrients and sediments

A. A watershed refers to an area of land over which water, dissolved material and sediments flow to rivers and the sea. This run-off often contains nutrients that cause the excessive growth of seaweeds and the appearance of harmful algal blooms (these are described in SPC Information Sheet 28). Ask students to investigate the sources of nutrients in Cook Islands.

B. Ask students to examine how nutrients and sediments threaten coral reefs and fisheries?

C. Sediments can affect corals and therefore coral reef fisheries. The presence of sediments can be easily and cheaply measured using a simple instrument called a Secchi disk.
A Secchi disk is a circular disk, made from marine plywood 40 cm in diameter, weighted to sink with pieces of lead (such as vehicle wheel balancing weights) and painted black and white in quarter segments as shown in the illustration.
The disk is lowered into the water by a cord marked by knots at 1 m intervals, until it is no longer visible and a first depth reading recorded; it is then hauled in until it becomes visible again and a second depth reading is recorded. The mean of these two readings measures the visibility in the water.
Have students complete a field exercise to measure the visibility in water at various coastal locations including those near the mouths of rivers. Complete the exercise before and after rain.



D. Discuss possible sources of the sediments. Ask students what can be done locally to reduce sediments runoff into the lagoon.

Information Sheet 28: Harmful algal blooms

Student activities and exercises are given in Teachers' Resource Sheet 13: Ciguatera and fish poisoning.

Information Sheet 29: Plant-eating fish

A. Marine plants create food directly from sunlight, carbon dioxide and nutrients in the water. Ask students to list and discuss the consumers of the main types of marine plants — phytoplankton, algae (seaweeds) and seagrasses.

B. In many places seaweeds are replacing corals. This is usually caused when the numbers of plant-eating fish have been severely reduced by heavy fishing. Have students discuss the ways in which plant-eating fish are vital to the health and survival of coral reefs.

C. Ask students to compare the teeth of plant-eating fish with those of coral- or meat-eating fish.

Glossary

Bacterium (plural = bacteria): one of a large group of microscopic, single celled organisms, most of which are crucial to life on earth and some of which can cause disease.

Billfish: a family of fish that includes marlin, sailfish and spearfish (family Istiophoridae).

Biodiversity: the variety of plant and animal life in a particular habitat.

Biomass: the total weight of living things in a population, community or trophic level.

Bioerosion: the breaking down of substrates, usually coral, by the actions of various living organisms referred to as bioeroders.

Bivalve mollusc: an aquatic mollusc which has a body enclosed within two shells hinged together; examples include clams, oysters, mussels and scallops.

Brackish water: a mixture of seawater and fresh water (as occurs near the mouths of rivers).

Camouflage: the colouring or shape of an animal which enables it to blend in with its background or surroundings.

Ciguatera: fish poisoning resulting from the consumption of fish that have accumulated toxins produced by particular very small (microscopic) plants or phytoplankton species, including the benthic dinoflagellate *Gambierdiscus toxicus*, which is found in association with coral reefs.

Commercial fishing: the production of fish primarily for sale.

Community-based fisheries management (CBFM): arrangements under which a community takes responsibility, usually with government or NGO assistance, for managing its adjacent aquatic environment and species.

Critical habitats (or key habitats): habitats that are crucial in the life-cycle of species; for fisheries these may include nursery and spawning areas such as estuaries, mangroves, seagrass meadows and reefs.

Customary marine tenure (CMT): legal, traditional or *de facto* control of land, sea and resources by indigenous people.

Detritus: particles of organic matter resulting from the breaking down of dead plants, animals and faeces.

Dinoflagellate: a small and very abundant member of the marine plankton; it consists of a single cell with two whip-like threads or flagella, which it uses to move through the water.

Ecosystem: a biological community of interacting plants and animals (including humans) and the non-living components of the environment.

Environment: the surroundings or conditions in which an animal, or plant lives.

Enzyme: a protein that is produced by a living organism and promotes a specific biochemical reaction.

Eutrophic (of a body of water): water so rich in nutrients that it encourages a dense growth of plants, the decomposition of which uses up available oxygen and therefore kills animal life.

Evolution: the process by which different kinds of living things have developed from earlier forms, especially by natural selection.

Exotic: originating in a distant foreign country.

Exports: the sale of fish and seafood products to overseas markets.

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

Fishing effort: the amount of fishing activity on the fishing grounds over a given period of time. Effort is often expressed for a specific gear type, e.g. number of hooks set per day or number of hauls of a beach seine per day.

Fly fishing: a method of fishing or angling using a rod, reel, specialised weighted line and an almost weightless fly or "lure" to encourage the fish to strike.

Food web: a diagram that depicts the feeding connections (what eats what?) in an ecological community.

Fungus (plural = fungi or funguses): spore-producing organisms, including moulds, yeast and mushrooms, that feed on organic matter.

Gross domestic product (GDP): an economic measure of the productivity of an economy.

Genus: a category of living things with many similarities. For example, most giant clams belong to the genus *Tridacna* and, within this genus, the fluted giant clam is a particular species with the name *Tridacna squamosa*.

Gonads: reproductive organs, ovaries in females and testes in males, which produce eggs and sperm respectively.

Histamine poisoning: poisoning due to histamine which is converted from histidine in fish that have naturally high levels of this amino acid; high levels of histamine are indications of a failure to chill fish immediately after capture.

International Game Fish Association (IGFA): a not-for-profit organisation committed to the conservation of game fish and the promotion of responsible, ethical angling practices through science, education, rule making and record keeping.

Indigenous: originating or occurring naturally in a particular place; native.

Invertebrates: animals without backbones, such as worms, molluscs and crabs.

Laminar flow: the streamlines of flow that take place without turbulence around solid objects.

Larvae: the young stages of many marine animals including corals; most larvae are small and drift in the sea before becoming adults.

Maximum legal size: a regulation which specifies the largest captured individual that may be retained; usually justified on the grounds that larger individuals produce a greater number of eggs and are often less marketable than smaller individuals.

Minimum legal size: a regulation which specifies the smallest captured individual that may be retained; usually justified on the grounds that growth of smaller individuals eventually produces a greater harvestable biomass and that the size of the spawning stock is increased.

Natural selection: the process under which living things that are better adapted to their environment tend to survive and produce more offspring.

Niche: the role taken by a type of living thing within its community.

No-take area: an area in which fishing is not allowed.

Nutrients: in the context of the marine environment, dissolved food material (mainly nitrates and phosphates) required by plants to produce organic matter.

Osmosis: a process in which water passes through a membrane (such as the cell wall of a bacterium) from a less concentrated solution into a more concentrated one.

Over-exploitation or over-fishing: the situation in which so many fish are caught, that there are not enough adults left to reproduce and replace the numbers lost.

Pelagic: living things that live in the upper layers of the open sea.

Photosynthesis: the process by which green plants use sunlight, carbon dioxide and nutrients (including nitrates and phosphates) to synthesise proteins, fats and carbohydrates.

Phytoplankton: very small plants, which drift in the sunlit surface layers of the sea.

Plankton: small and microscopic organisms drifting or floating in water; some are permanently small and some are the eggs and larval stages of larger animals.

Pollutant: anything that degrades the environment.

Pollution (marine): the introduction by humans, either directly or indirectly, of any substance (or energy such as heat) into the sea which results in harm to the marine environment.

Predator: an animal that preys on others.

Primary production (in fisheries economics): activities that result in the catching or growing of fish and fish products.

Primary production (in biology): the use of sunlight, carbon dioxide and nutrients by plants to produce tissue through the process of photosynthesis.

Protein: a compound, made up of amino acids, which forms much of the structure in living things.

Quota: a limit on the weight or total number of fish that may be caught from a particular stock or in a particular area.

Recreational fisher: a person who catches fish for fun and sport rather than for food or for selling.

***Rigor* (*Rigor mortis*):** in medicine and food handling, the stiffening of the joints and muscles a few hours after death.

Rotational closures: a management system in which a fishery, or parts of a fishery, are closed to fishing on a rotational basis.

School (or shoal): a large number of fish swimming together.

Scientific name: a two-part (or binomial) name for a living thing. The first part is the genus to which the species belongs and the second part identifies the species within the genus. For example, most giant clams belong to the genus *Tridacna* and, within this genus, the fluted giant clam is a particular species with the name *Tridacna squamosa*. Note that only the first letter in the genus name is always a capital and the two-part name is written in italics.

Septic tank: an underground tank in which the organic matter in sewage is decomposed through bacterial activity.

Sewage: waste matter, particularly human faeces and urine, conveyed in sewers which are part of a sewerage system.

Shellfish: a general term for edible shelled molluscs (such as clams and sea snails) and crustaceans (such as crabs and shrimps).

Spawning aggregation: a grouping of a single species of reef fish that has gathered together in greater densities than normal for the specific purpose of reproducing.

Spawning: the act of releasing eggs, which in most fish, are fertilised by males releasing sperm into the sea.

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

Subsistence fishing: the production of fish primarily for personal or household consumption.

Swim bladder: a gas-filled sac in a fish's body, used to maintain buoyancy.

Symbiosis: a relationship between two different living things that is of advantage to both.

Target species: the resource species at which a fishing operation is directed.

Total allowable catch (TAC): the total catch permitted to be taken from a fishery, usually in one year.

Toxin: a poisonous substance produced by a living thing.

Traditional fishery: a fishery that has existed in a community for many generations, in which customary patterns of exploitation and management have developed.

Transect: a straight line or band along which observations or measurements are made.

Trophic level: a feeding level containing organisms that obtain their nourishment in a similar way and from a similar source.

Wetlands: low-lying terrestrial areas that are flooded by tides and either contain or are saturated with water; examples include salt marshes, coastal swamps and mangrove forests.

Zooplankton: very small animals that drift in the sea, including the larvae of many marine animals.

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