This *Teachers' Resource Kit on Fisheries for Kiribati* has been prepared by
the Pacific Community (SPC) in collaboration with
the Kiribati Ministry of Education (MoE), and
the Kiribati Ministry of Fisheries and Marine Resources Development (MFMRD).

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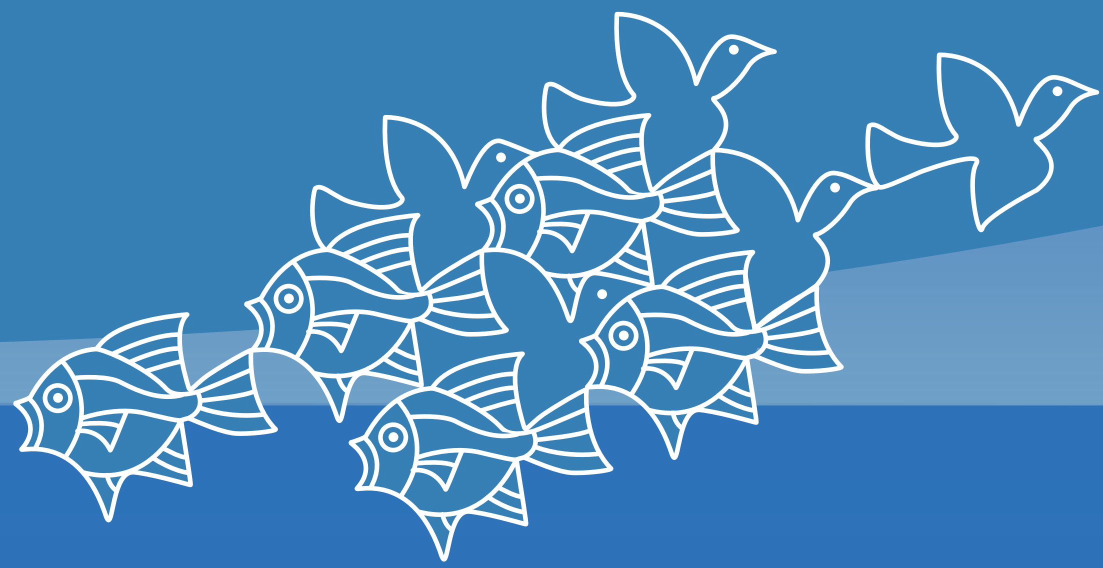

# Teachers' Resource Kit on Fisheries for Kiribati

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# Guide to Teachers' Resource Sheets on Fisheries for Kiribati

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NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme

*Guide to Teachers' Resource Sheets on Fisheries for*

# Kiribati

*This guide has been prepared by the Pacific Community (SPC) for teachers in Kiribati after discussions and input from local education and fisheries authorities. People interviewed, met with and/or involved in the production of these resource sheets include:*

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*This guide is part of, and should be used in conjunction with, the SPC Teachers' Resource Kit on Fisheries, the contents of which includes:*

- *18 teachers' resource sheets on fisheries;*
- *1 information kit for fishing communities, which includes:*
  - *1 'Guide to information sheets on fisheries management for communities';*
  - *30 information sheets for fishing communities;*
  - *3 leaflets: 'Community-resource management', 'Community-managed no-take areas in fisheries management', and 'Destructive fishing';*
  - *3 management posters: 'Are we finding it hard to catch fish?', 'What if we lost our mangroves?', 'What if we lost our seagrass?';*
- *2 sea safety posters: 'Ibukim maurim ao kabanea moa nimaua te miniti', and 'Karinanin bwaai aika riai ni mena';*
- *1 marine debris poster: 'The most dangerous species of our coasts and lagoons';*
- *1 fish poster: 'Deep bottom fish species of Kiribati' (to be supplied through Kiribati Coastal Fisheries)*
- *1 fish poster: 'Some common fish species of Kiribati'*
- *1 invertebrate poster: 'Marine invertebrates of the Pacific Islands';*
- *2 marine resource posters: 'Marin marawan Kiribati' and 'Marin aon oran Kiribati' (to be supplied through CRDC, Kiribati)*
- *1 poster: 'Marine ecosystem'*
- *1 poster: 'What is ciguatera'*
- *1 flash drive, with graphics and photographs (one each for 130 schools)*

*This guide includes suggestions for exercises and activities for younger and older students as well as learning outcomes. Work by the Ministry of Education in Kiribati may provide curriculum links to these exercises in the future.*

*It is expected that teachers will use their local knowledge and expertise to adapt, extend and add to these suggestions. The number and headings on the following pages refer to those on the Teachers' Resource Sheets on Fisheries (1 to 18) and on the Information Sheets for Fishing Communities (1 to 30). The latter 30 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 at the end of this guide.*

# Suggestions for exercises and activities related to the 18 Teachers' Resource Sheets on Fisheries for Kiribati

## 1. Fisheries management

By the end of this unit:

Younger students will be able to identify a range of fish species caught in Kiribati and be able to explain the importance of fishing sustainably to ensure the availability of resources in the future.

Older students will be able to:

1. understand the need for fisheries regulations and the range of regulations applied;
2. understand the need for enforcement and compliance to ensure seafood resource availability, and
3. discuss how poor coastal zone management can affect marine ecosystems and fisheries.

In Kiribati, fisheries are managed and regulated by the Ministry of Fisheries and Marine Resources Development (MFMRD). As in some other Pacific Island countries, there is interest in community-based fisheries management in which fisheries officers and community members work together to manage fisheries.

### Activities for younger and older students

A. The accompanying figure shows some of the most common fish found on coral reefs. Provide a local name for each type of fish and indicate which ones are commonly caught for food in your family or community.

B. Request MFMRD to provide a Fisheries Officer to talk to students about fisheries management and describe the regulations that are applied to ensure the sustainability of fish stocks. Regulations can include leaving small individuals in the sea (having size limits) to allow them to grow and reproduce.

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

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, by how much does volume and egg production increase? (For younger students — count the "blocks" in the accompanying figure or use eight wooden blocks to suggest what happens when a fish doubles in length, width and height).

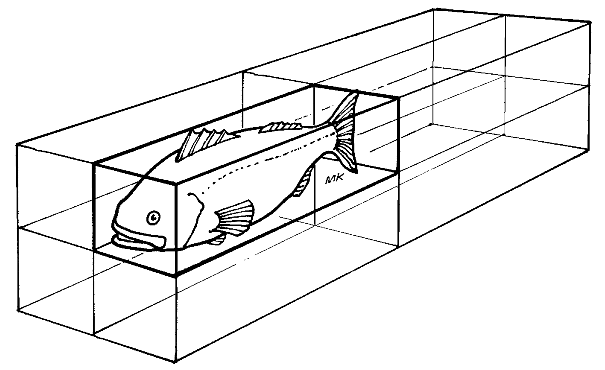
Large female fish produce many more eggs than small fish and are therefore important in maintaining healthy populations. That is why we must leave some large fish in the sea.

### Activities for older students

D. In the accompanying figure, volume (V) = length (L) cubed, or $V = L^3$.

For example, a fish 30 cm long would have a volume ($V = L^3$) of $30^3$ or 27,000 cubic centimetres.

If the fish doubles in size to 60 cm, $V = 60^3$, or 216,000 cubic centimetres.




That is, the egg-carrying capacity has increased by eight times.

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

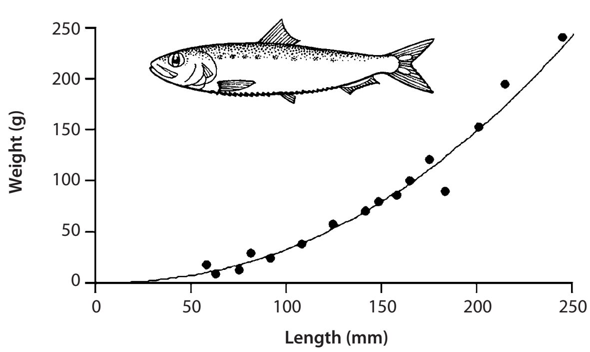
ii. Enter the data on an Excel spreadsheet and prepare a graph relating weight to length as in the example shown in the accompanying figure. Students studying statistics can extend the exercise to include the power curve equation and measures of goodness-of-fit.

The power curve equation is $\text{Weight} = a\,(\text{Length})^b$ where a is a constant and b should be close to 3 if the volumetric relationship holds true.

E. Sometimes there are too many people hunting too few fish. Although the rate of population increase in Kiribati is low (less than 2%) the rate in many other Pacific Islands is as high as 4% each year.

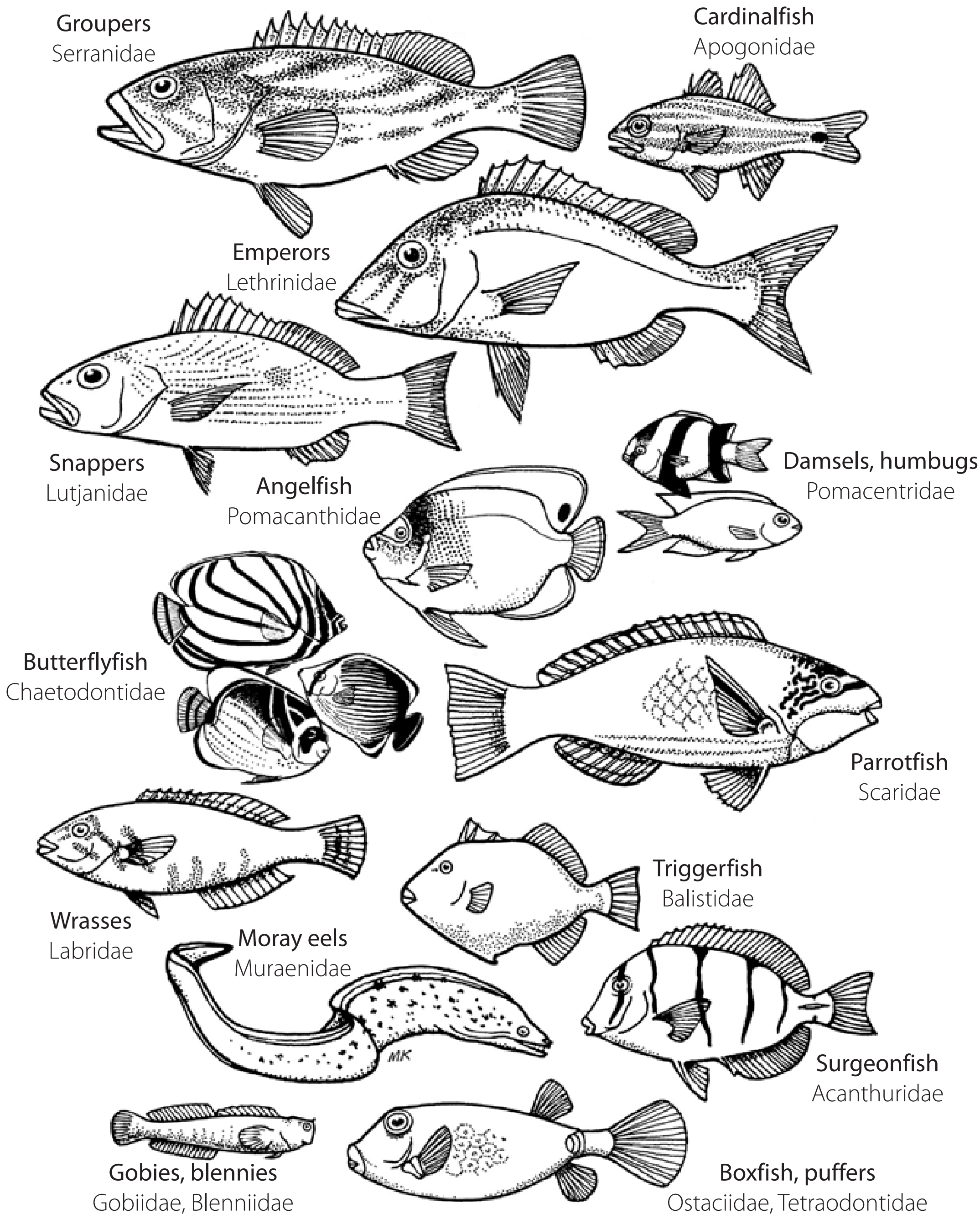
i. Build an Excel spreadsheet using rates of 2%, 3%, 4% and 5%, to calculate when the population will be twice what it is today.

ii. Discuss the problems for local people in catching seafood when the population is doubled.



F. Besides over-fishing or catching too many fish there are many other threats to fisheries. Particularly in lagoons, these include pollution, the release of sewage, coastal development, and reclamation (refer to Information Sheet for Fishing Communities number 27: Nutrients and sediments, and Information Sheet for Fishing Communities number 28: Harmful algal blooms).

Ask students to investigate the ways in which the local marine environment is being harmed — should excessive development be controlled? Is garbage disposal satisfactory? Is sewage treatment adequate?




Common fish families on a coral reef.

From: King M. 2015. Beneath the surface: Tales of a sailing marine biologist. Zeus Publications. 262 p.

## 2. Fisheries assessment

At the end of this unit:

Younger students will be able to estimate catches by keeping a seven-day log of their extended family or community fishing activities.

Older students will be able to explain the importance of stock assessment and monitoring and use a seven-day fishing log and use fish tagging and quadrat sampling to estimate fish population size.

### Activities for younger students

A. Ask students to identify the common reef fish from the figure shown earlier in this guide and commercial fish from the Kiribati fish posters.

### Activities for younger and older students

B. Ask each student to keep a seven-day log of fish catches in their extended family. How many fish did they catch? How long did it take? An example of a student seven-day basic fishing log is shown in the table below. The log can be extended to discover what other marine species are caught.

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

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 spent fishing | | | | | | | |
| Number of (*species) | | | | | | | |
| Number of (*species) | | | | | | | |
| Number of (*species) | | | | | | | |
| Number of (*species) | | | | | | | |
| Number of (*species) | | | | | | | |
| ETC | | | | | | | |

* Enter the name of the species of fish in the brackets above – eg parrotfish, snapper etc.

### Teaching and learning activities for older students

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 five years ago? How long did it take ten years ago?

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

D. Fisheries scientists tag or mark marine animals to examine 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 accompanying figure and example.

The large rectangle in the accompanying 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 six tagged individual fish. 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:

$$N = TC/R$$

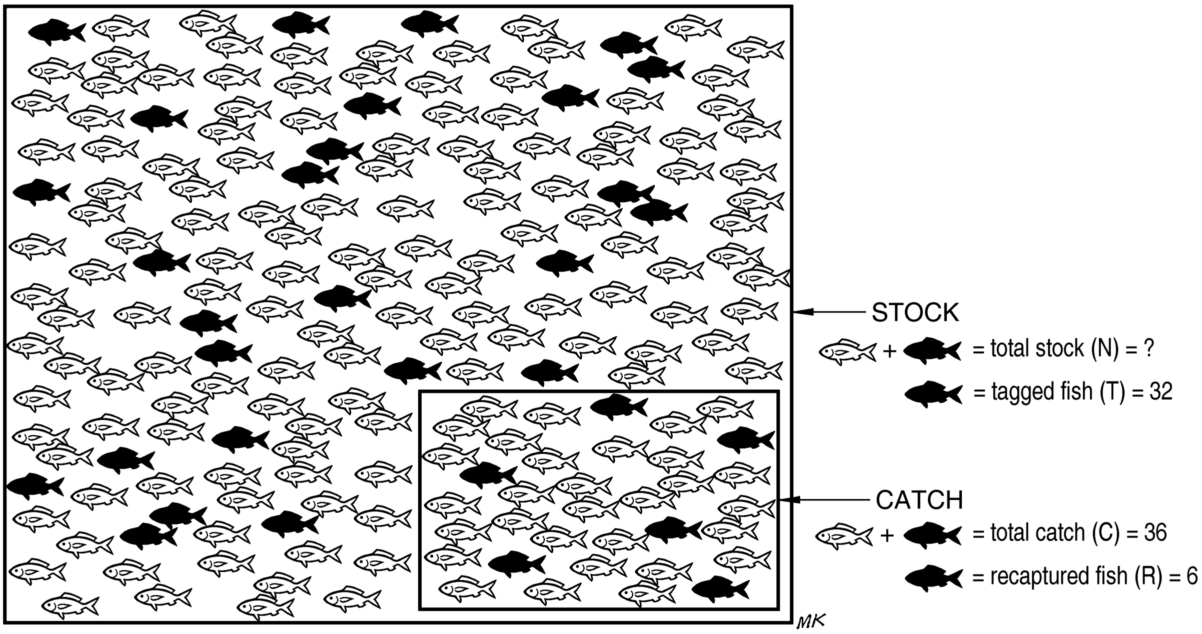
In this instance:

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

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:

1. the tagged individuals must be distributed randomly over the population;
2. there must be no loss or gain of individuals during the experiment; and
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:




i. if an external plastic spaghetti tag resulted in tagged fish being more likely to be caught by becoming entangled in a gill net; or,

ii. 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).*

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

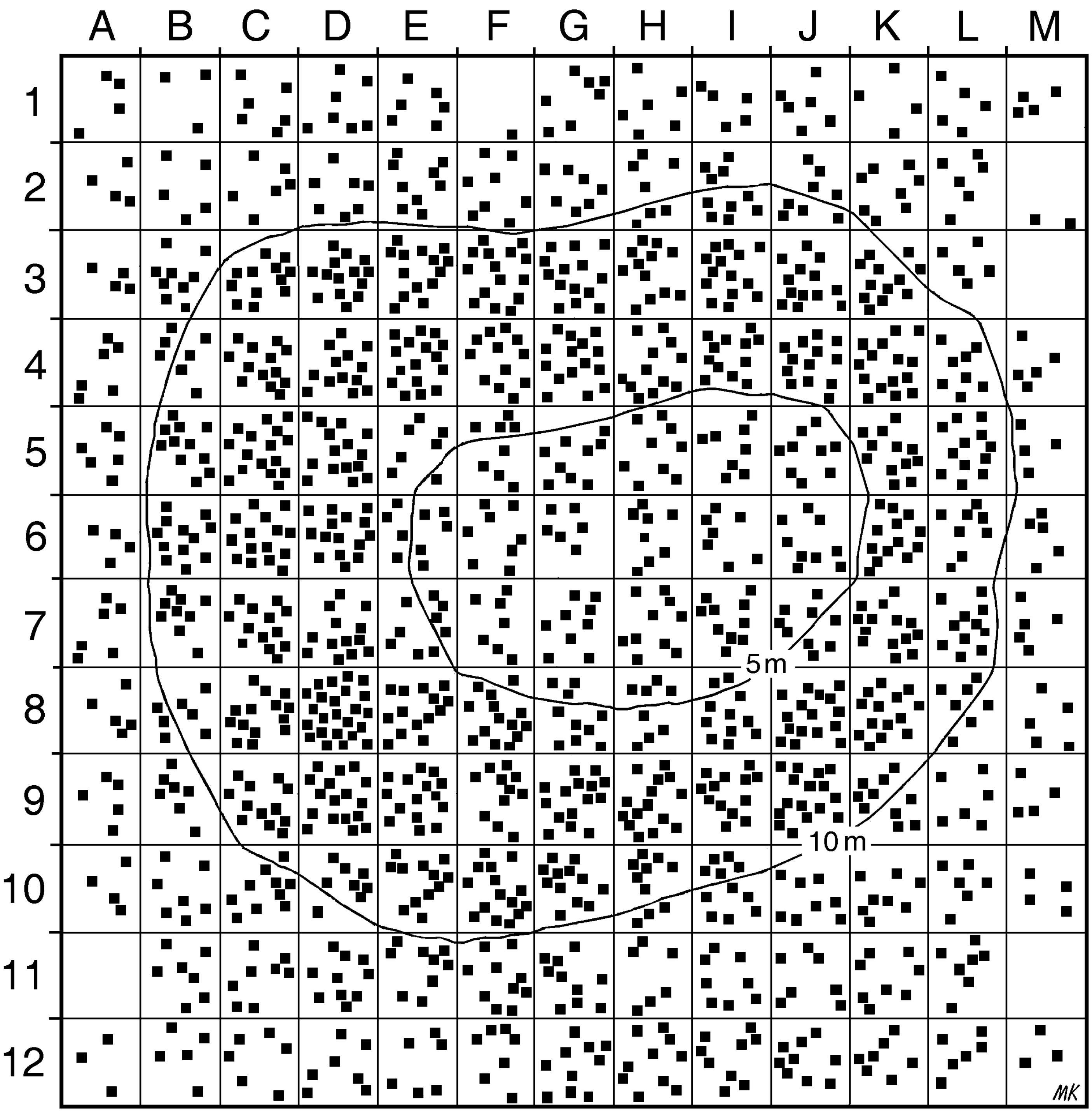
Have each student or student group randomly select six quadrats (the small squares). Statistics students could use random number tables to do this. Otherwise, one student in each group should use a pencil to touch the sheet six times without looking.

Count the number of sea cucumbers (black dots) in each of the six quadrats selected. Total the sea cucumbers from all six quadrats and divide the total number by six 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 six 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 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 end of this unit:

Younger students will be able to explain the importance of fisheries in the household income and in the community economy.

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

### Activities for younger students

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.

### Activities for older students

B. Ask students to examine the value of different fisheries in Kiribati. Which fisheries are the most valuable? Which fisheries are subsistence or commercial on your island? How does your country and the people living in your country benefit from fisheries?

Jeff Muir © ISSF 2012

## 4. No-take areas (Marine Protected Areas)

At the end of this unit:

Younger students will be able to appreciate the benefits of no-take areas in Kiribati.

Older students will be able to explain the role of no-take areas and discuss the importance of conservation areas in sustaining fish stocks.

Kiribati is made up of 33 islands with a total land area of some 811 km$^2$. The islands are divided into three widely spread groups, the Gilbert Group, the Phoenix Group and the Line Group. Although the land area is small, the Exclusive Economic Zone (EEZ) that surrounds them is large at around 3.55 million km$^2$.

Kiribati is well known for its protection of marine areas in which fishing is banned or restricted.

The Kiribati Government has declared the entire Phoenix Island Group a protected area. The Phoenix Island Protected Area (PIPA) is also a UNESCO World Heritage site and one of the largest protected areas in the world. All commercial fishing is banned and only the small number of local people living on Kanton can fish for food.

Commercial fishing is also banned in a 45 nautical mile band of water around all other islands in Kiribati.

The MFMRD is presently working on a Community-based Fisheries Management (CBFM) project under which communities will take greater responsibility for managing the fisheries on which they depend. Community actions may include designating local Marine Protected Areas in which fishing is banned. Such areas will result in fish having a refuge in which to breed.

### Activities for younger students

A. What are the likely benefits of having an area closed to fishing?

### Activities for older students

B. Ask students to either talk to older people in their community or locate an area in which fishing is banned. Find out the rules for the no-take area. How long it has been in operation? Has it been successful? What would happen if the no-take area was opened?

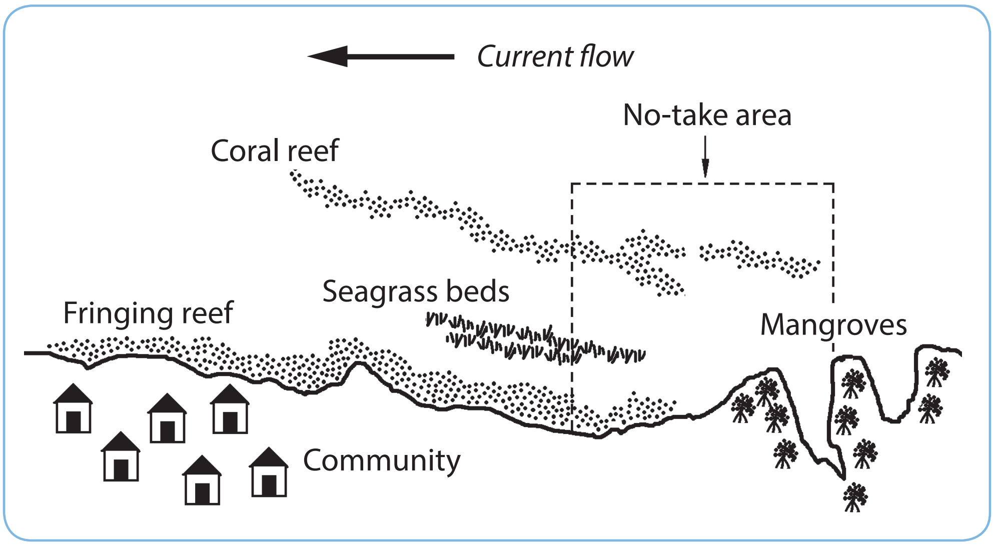
C. The following figure shows a hypothetical, community-managed, no-take area in a Pacific Island country. Show the figure on a screen (from the flash drive supplied as part of the Teachers' Resource Kit). Ask students to discuss the negative and positive aspects of the positioning of the no-take area shown.

Negative points that could be raised includes:

- the community loses access to a part of its usual 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; and
- larvae from the no-take area are likely to drift with the current out into the fished areas where they can settle and grow into adults that can be caught.




## 5. Fish anatomy

At the end of this unit:

Younger students will be able to identify the external features of fish and sharks.

Older students will be able to identify the structures and explain the functions of the external and internal parts of 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.

### Activities for younger students

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 and colour them in.

### Activities for older students

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.

Ask each group of students to

i. identify the fish;

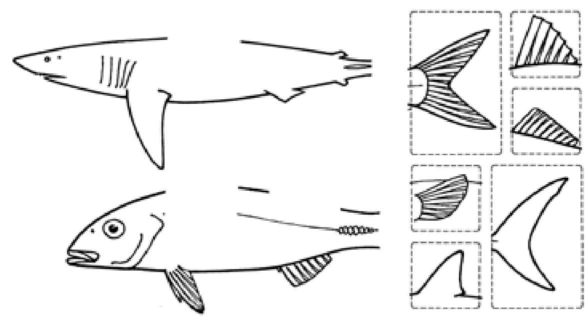
ii. dissect each fish by carefully exposing the internal organs as shown in the figure on Teachers' Resource Sheet 5: Fish Anatomy; and

iii. make a labelled drawing (use the figures on Sheet 5 as a guide: show the figures on a screen using the 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



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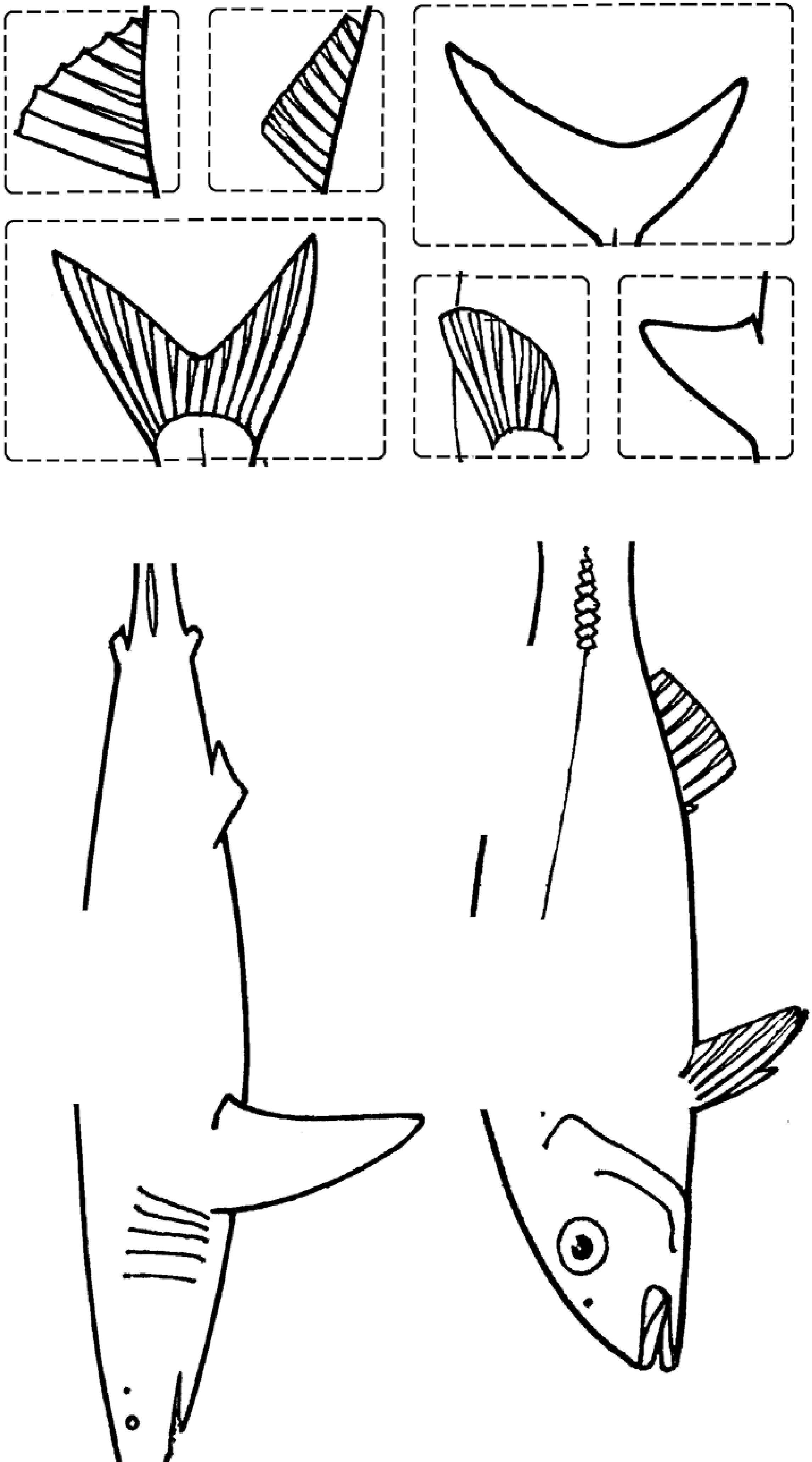


## 6. Marine food webs

At the end of this unit:

Younger students will be able to understand the simple food webs of marine species.

Older students will be able to explain marine food webs and the loss of energy in a food chain from plants to top-level carnivores.

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

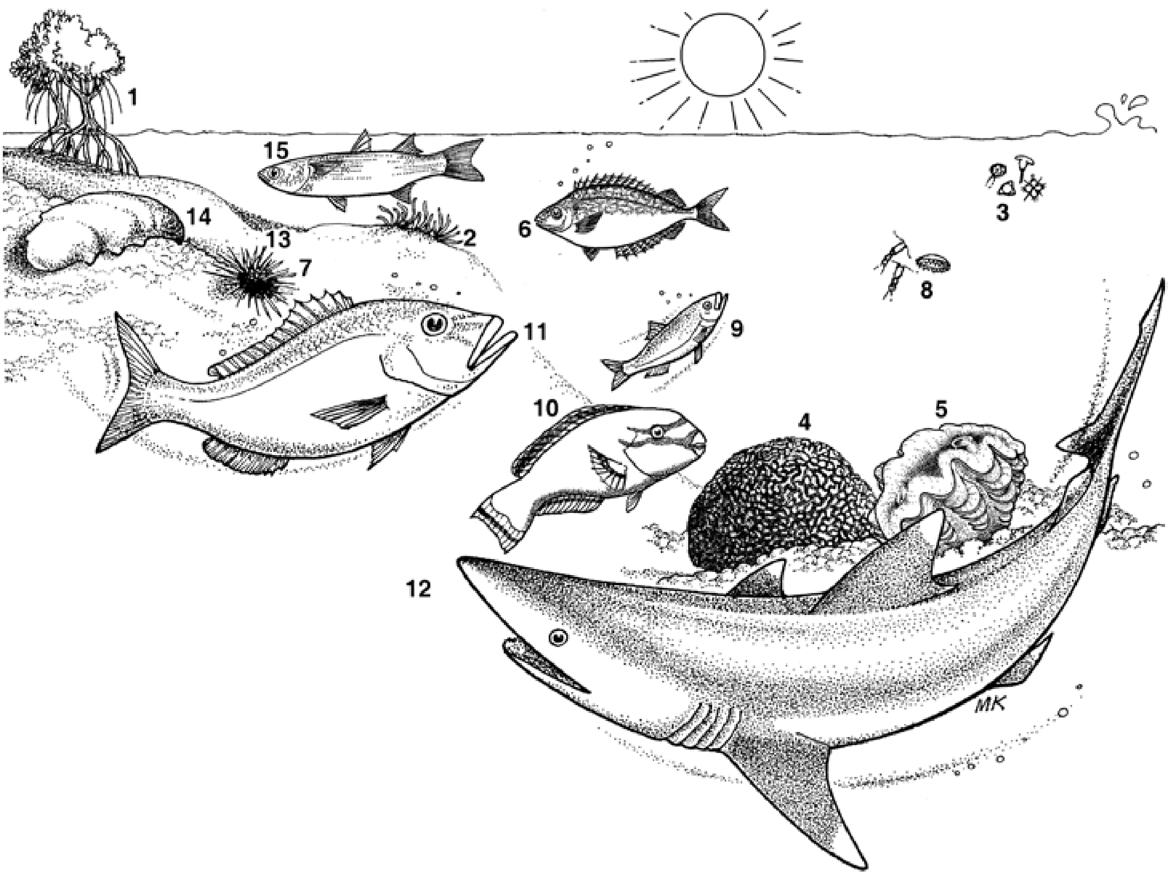
### Activities for younger students

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

### Activities for older students

B. Discuss the energy pyramid shown in the Teachers' Resource Sheet 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 in the accompanying figure 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.

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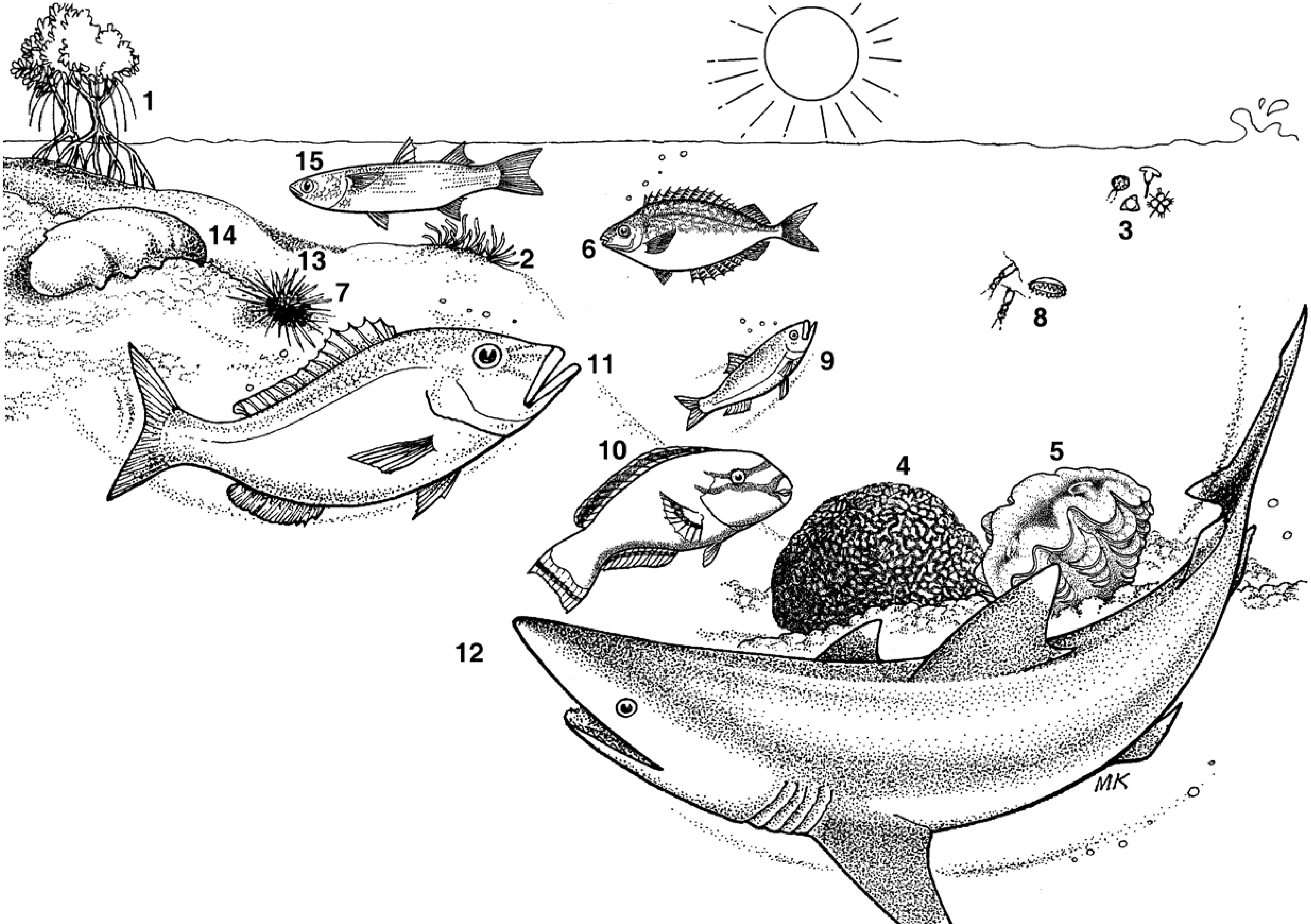
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## 7. Oceanic species

At the end of this unit:

Younger students will be able to identify oceanic fish species and distinguish them from reef species.

Older students will be able to discuss morphological and behavioural adaptations of oceanic species including fusiform shapes, counter-shading and schooling.

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Kiribati has a very large area of sea. Its Exclusive Economic Zone (EEZ) is around 3.55 million $km^2$.

Pelagic* fish caught in this area for both local food and export include yellowfin tuna, skipjack tuna, bigeye tuna and mahi mahi.

### Activities for younger students

A. Show the accompanying figure of oceanic fish on a screen (from the flash drive supplied as part of the Teachers' Resource Kit). Ask students to provide Kiribati names of the fish.
Kiribati fish posters of oceanic pelagic fish would broaden this exercise – the names on the poster could be hidden by masking tape and students could write local and English names of the fish on the masking tape

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

### Activities for younger and older students

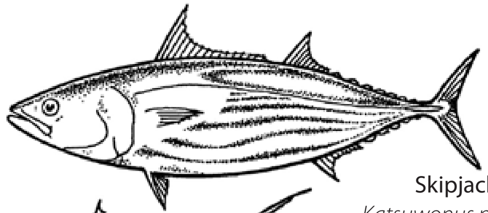
C. Show the figure of the fusiform shape and the fish with counter-shading on a screen (these figures are on the flash drive supplied as part of the Teachers Resource Kit.) Have students discuss the advantages of a fusiform shape. Extend the discussion to other applications of the shape – e.g. the hulls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

### Activities for older students

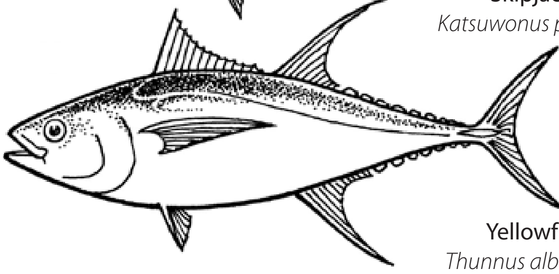
D. What is the most noticeable difference in shape between fish that swim fast and those that live on the reef? What shape is common in oceanic fish? Why is this shape common? Why do tuna need so much food? Why does a dolphin (a mammal) have a similar shape to that of a fish?

E. Ask students in 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.

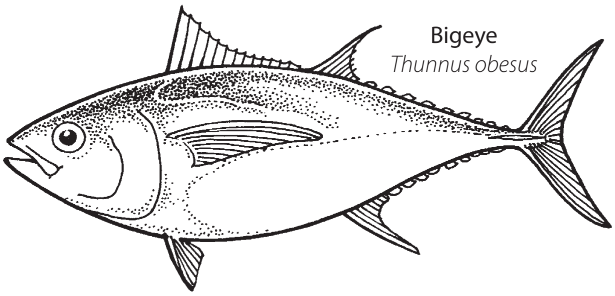
F. As a class exercise, conduct a brief survey of a local fish market. Make a list of all species offered for sale with estimated weights and price per kg. Interview sellers to find out where each species comes from and how the availability of the marketed species varies seasonally.



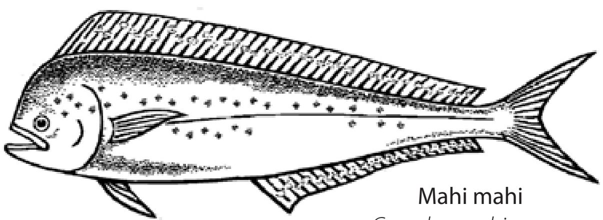
Skipjack
*Katsuwonus pelamis*



Yellowfin
*Thunnus albacares*



Bigeye
*Thunnus obesus*



Mahi mahi
*Coryphaena hippurus*

## 8. Bonefish

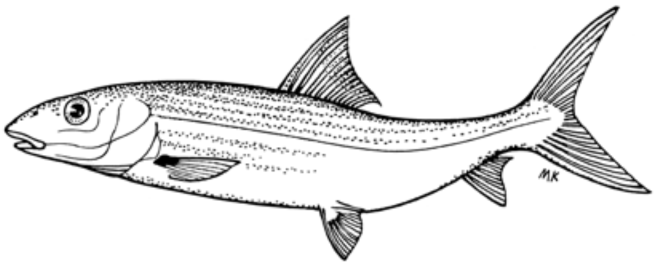
At the end of this unit:

Younger students will know about the bonefish fishery in the Line Islands and importance in recreational activities.

Older students will be aware of the fishery and the biology of bonefish.

Kiritimati (Christmas Island) in the Line Group of eastern Kiribati is famous for attracting visitors who travel there just to fish for bonefish.

Fly-fishing* for bonefish brings people and foreign exchange to Kiribati. And, as most sports fishers release their catch immediately after capture, there is little chance of overexploiting the stocks of bonefish.




### Activities for younger and older students

A) Request a visit by a Fisheries Officer or Assistant to talk about the bonefish fishery and the ways in which bonefish are caught.

B) If possible, 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.

### Activities for older students

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

D) Investigate why bonefish are mostly found in lagoonal islands.

## 9. Marine aquaculture

At the end of this unit:

Younger students will be able to list the species that are farmed in seawater in Kiribati.

Older students will be able to discuss the biology of farmed marine species and the methods used to farm them in Kiribati.

Marine aquaculture, or mariculture, is the farming of plants or animals in seawater. In Kiribati, aquaculture is based on seaweed, milkfish, giant clams and sea cucumbers.

### Activities for younger students

A. Giant clams have been produced in hatcheries in Kiribati. Small giant clams have been planted on reefs where stocks have been depleted due to overfishing. Ask students to consider the problems associated with this. How could they be protected from predators including humans while they grow?

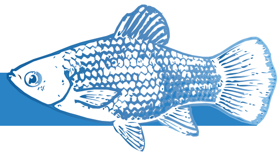
B. Ask students to find out how seaweeds get nutrients and how giant clams and sandfish get their food.

### Activities for older students

C. Ask the students to explain why cultured species are important for export. Give examples of products derived from aquaculture commodities – e.g. seaweed used for making cosmetics, food preservations, etc.

D. Giant clams are hermaphrodites – that is, an individual can act as a female to produce eggs and as a male to produce sperm. During reproduction, how does a clam avoid fertilising its own eggs?
Refer to Information Sheet for Fishing Communities number 10, Giant Clams.

E. The production of farmed milkfish is believed to be decreasing. Ask students to investigate why this is happening



# 10. Aquarium species

At the end of this unit:

Younger students will be able to list the species exported for the aquarium trade.

Older students will be able to discuss the aquarium export industry and demonstrate knowledge of maintaining an aquarium.

Aquarium species, often called marine ornamentals, are marine fish, corals, live rock and invertebrates that are kept alive in a glass tank or aquarium. Pet fish are exported and flown to Honolulu, Hawaii and hence to other destinations from Kiritimati Island.

## Activities for younger and older students

A. For students in Kiritimati arrange for a talk from an aquarium fish exporter — how are fish collected on a sustainable basis? How are aquarium fish transported to overseas countries? If possible, arrange a visit to an export facility.

## Activities for older students

B. Ask students to cooperate in the building of an aquarium. Pre-cut 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 figures.

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.

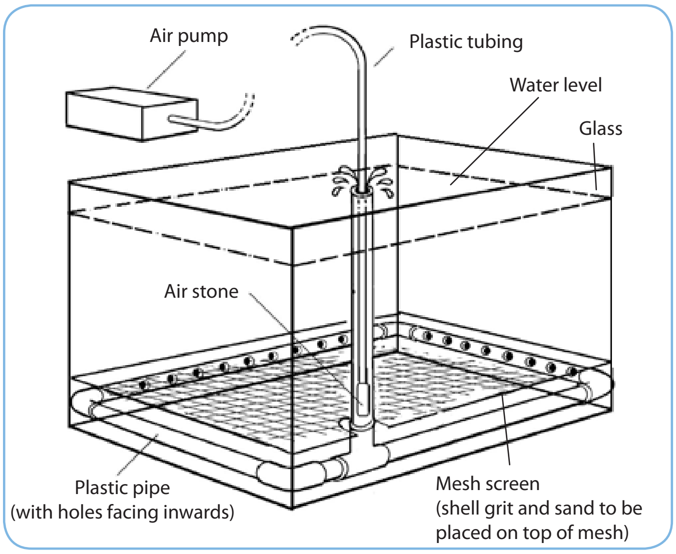
The air-stone must just fit inside the upright pipe. When operating, the air-stone "lifts" and oxygenates the water after it is drawn through the shell-grit and sand, which acts as a filter.

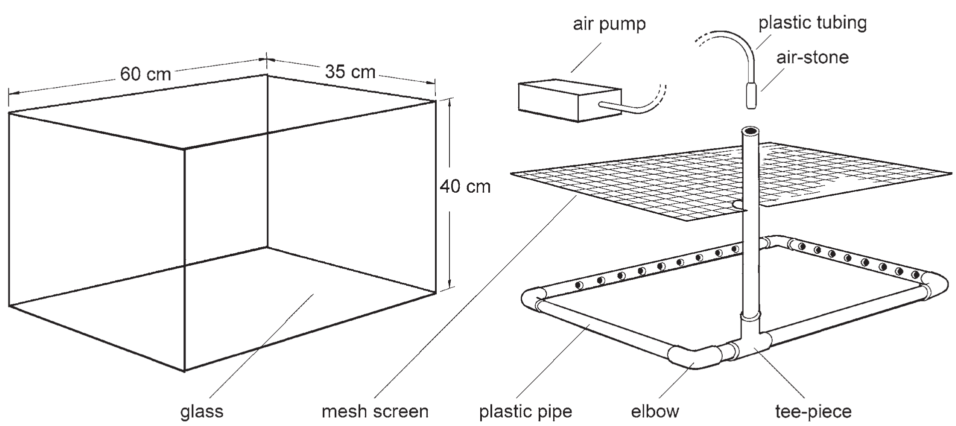
Stock the aquarium with very small sea cucumbers, small crustaceans and small coral fish such as humbugs and damselfish (see illustration earlier in this guide). The water in the aquarium must be changed every two to three weeks.

In the accompanying illustration the components are shown in the upper diagram and the finished aquarium is shown below.

C. Ask students to describe how the aquarium works. How is the water filtered? How is the water oxygenated? If marine fish and invertebrates are kept in the aquarium, why would you need to change the seawater every few weeks?

Students should understand that the water is filtered as it is drawn down through the grit/sand and the air-stone produces very small bubbles which become dissolved in the water. In addition, they will understand that soluble wastes (such a nitrogen compounds) build up in the water and unless they are used by marine plants, can reach toxic levels.



## 11. Fish spoilage

At the end of this unit:

Younger students will recognise fish freshness and understand the need for personal hygiene when handling seafood.

Older students will be able to explain the action of enzymes and bacteria in relation to food spoilage.

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.

### Activities for younger students

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.

### Activities for older students

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.

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?

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 market or processing plant and observe how seafood is handled. Is it as good as it could be?

## 12. Fish poisoning and ciguatera

At the end of this unit:

Younger students will be aware of ciguatera and marine species involved in poisoning.

Older students will be able to explain the sequence of events leading to fish and molluscs becoming toxic and their effects on humans.

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. Some of these microscopic plants produce toxins that can affect humans.

Interestingly, some of 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.

### Activities for younger students

A. Ask students to identify local fish that are known to cause ciguatera poisoning.

### Activities for older students

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. Students should consider the sort of conditions that cause harmful algal blooms in their local area. Could it be rain washing nutrients from the land? Could it be sewage or fertilizers entering the sea?

## 13. Fish aggregating devices (FADs)

At the end of this unit:

Younger students will be able to describe FADs.

Older students will be able to discuss the use and functions of FADs in terms of improving access to offshore fish and increasing the incomes of fishers.

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, wahoo and mahi mahi so that they can be more easily caught by fishers. In Kiribati, FADs have been deployed off several islands.

### Activities for younger and older students

A. Build a model FAD using a raft (about 60 cm by 60 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. The frayed rope acts as aggregating material (material which may act as a shelter for fish) as shown in the accompanying figure. 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?

### Activities for older students

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 may use the FAD as a hiding place from predators or they may be feeding on the algae and small organisms that settle on the hanging material.

C. Ask students to explain how FADs can be used 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 in deploying FADs in outer islands (consider the transport, cost, availability of FAD materials 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?

## 14. Kiribati traditional fishing methods

At the end of this unit:

Younger students will be able to identify the range of traditional fishing methods used in Kiribati.

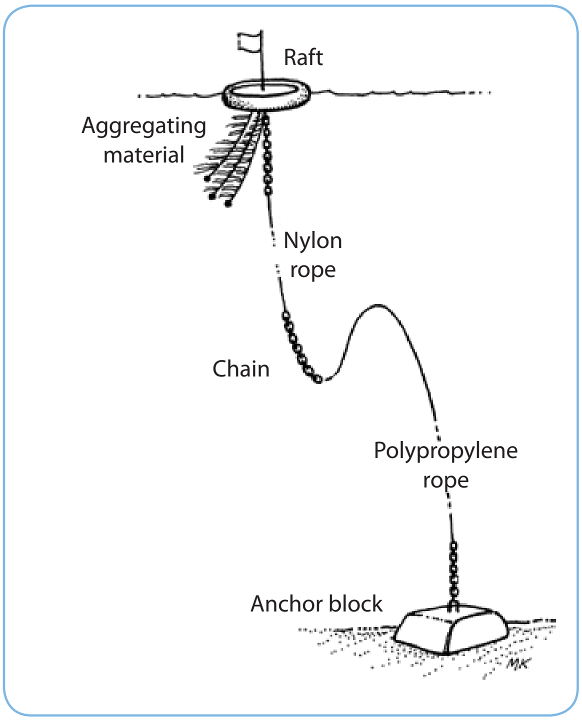
Older students will be able to compare traditional fishing methods with those used currently.

The culture of Kiribati is Micronesian in origin and traditions exist and thrive, particularly on the outer islands. Traditionally living on a subsistence basis on what can be sourced from the sea, I-Kiribati are expert sailors and fishers.

### Activities for younger and older students

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?

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



## 15. Modern large-scale fishing techniques

At the end of this unit:

Younger students will be able to identify the range of commercial fishing techniques used in Kiribati.

Older students will be able to describe a range of commercial fishing methods used in Kiribati and worldwide.

Approximately 60% of the world's catch of tuna, worth about USD 7 billion, comes from Pacific Islands. Of the fishing nations in the Pacific, Kiribati produces the highest volume of catch.

In Kiribati, over 90% of the catch is made by purse seine vessels which target skipjack and small yellowfin tuna. Longline vessels catch bigeye, yellowfin and some albacore. Of these species there is some concern that stocks of bigeye are being overfished.

### Activities for younger students

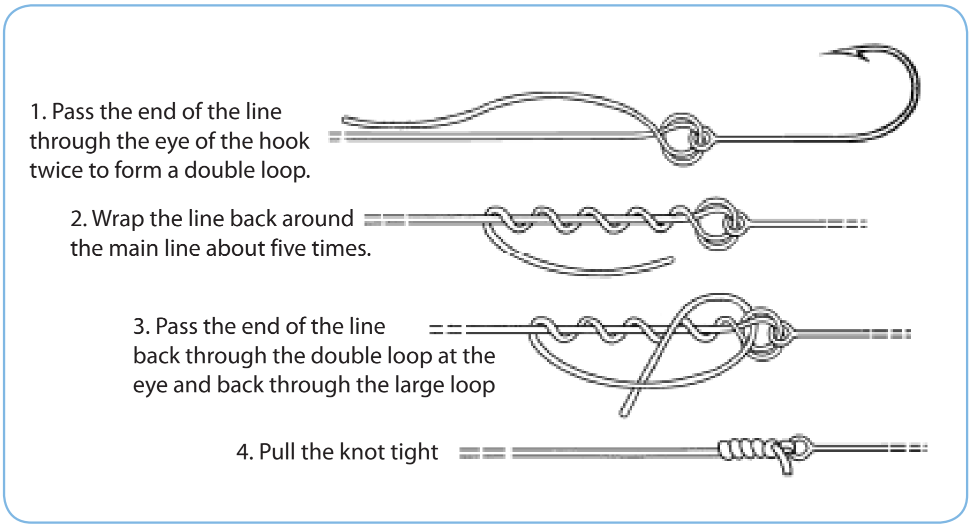
A. Ask students to talk to fishers about modern fishing methods that they use. This exercise should be followed up with a discussion in the classroom and a listing of the number and types of modern fishing methods used by the local community.

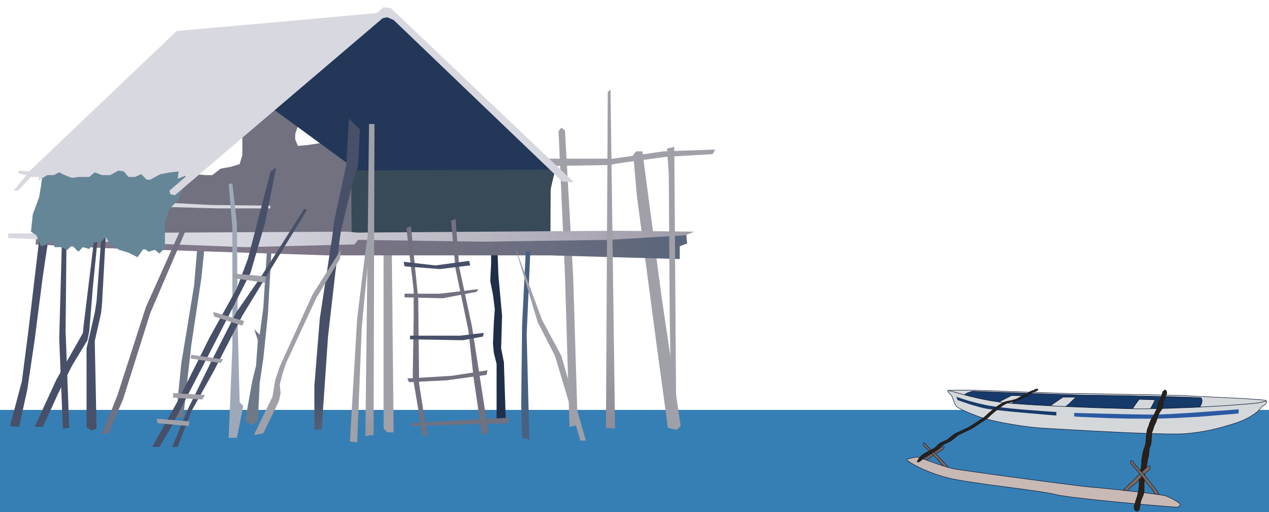
### Activities for older students

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

C. If possible, arrange a visit to a local fishing boat or tuna processing plant. 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 modern fishing methods on the resources of their island.



## 16. Sea safety

At the end of this unit:

Younger students will be able to identify the safety equipment that should be carried on fishing boats and other vessels.

Older students will able to explain marine safety procedures and the use of safety equipment including sea anchors, signalling equipment and tying important knots relating to safety and seamanship.

### Activities for younger students

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?

### Activities for older students

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

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 of safety equipment?

E. 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 radios (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);

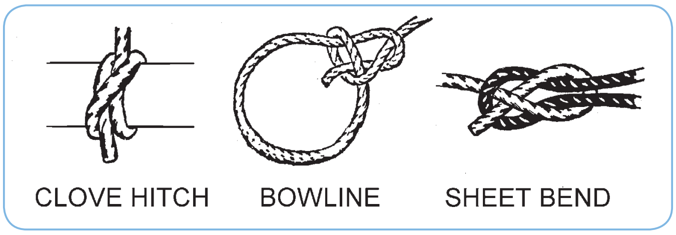
F. How does a sea anchor work and why is it useful to have onboard? (It reduces drift speed in case of engine breakdown and keeps the vessel's bow facing the wind and hence improves vessel stability.)

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)?

H. Ask students why fishers need to turn on to VHF channel 16 in case of emergency? (VHF channel 16 is internationally recognised as the emergency channel and it is constantly monitored by commercial ships and sea safety authorities) .

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 accompanying figure as a guide.



## 17. Financial management of a small fishing business

At the end of this unit:

Younger students will understand the price of a range of seafood species that are sold in their community

Older students will understand the fixed and running costs in a fishing business

### Activities 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).

### Activities for older students

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.

C. 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) | $_______ |

## 18.Climate change and fisheries

At the end of this unit:

Younger students will recognise the impacts of climate change on coastal fisheries.

Older students will be able to explain the impacts of climate change on fishery resources in Kiribati and other Pacific Islands and be aware of appropriate adaptive measures to mitigate the effects.

Continuous increase of sea surface temperature greatly affects the productivity of coral reefs.

As the ocean is getting warmer, corals are stressed and bleach.

Refer to Information Sheet for Fishing Communities number 30, Coral bleaching.

### Activities for younger and older students

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 Kiribati? 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?

B. Ask students to find out what measures can be taken by individuals, communities or nations to reduce the impact of climate change on fisheries.

C. Ask students to investigate the human activities that increase vulnerability to climate change impacts. What are the solutions?

# Suggestions for exercises and activities related to the 30 Information Sheets for Fishing Communities

## Information sheets for fishing communities

*The following section includes suggested student activities and questions relating to the 30 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 three to seven 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 five years ago? At what time of the year do they have 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. Ask students to 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?

### 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.

### 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. Ask students to discuss why this is so.

C. Ask students to find out which species are regarded as a delicacy or popular in their community or 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. Ask students to talk to people in their local community who have been involved in collecting sea cucumbers. What species were collected? Do fishers still collect them? If not, why not?
What are the traditional methods of preparing sea cucumbers for food?

B. 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?

### Information sheet 11: Trochus

A. Trochus were introduced to Kiribati from Fiji in the late 1990s, and juvenile trochus were bred in the Tarawa hatchery and introduced to Abaiang, Marakei, Banaba and other islands. But trochus remain very rare in Kiribati.
In countries where trochus are common, there is often a minimum size regulation — that is, trochus with a base measuring less than 90 mm cannot be legally caught. What is the purpose of this regulation?

B. Some countries also place a maximum size limits on trochus — say, trochus with a base measuring greater than 120 millimetres cannot be legally caught. What is the purpose of this regulation? (See Teachers' Resource Sheet 1: Fisheries management.)

## Information sheet 12: Mangrove crab

A. What sort of regulations could be imposed to protect stocks of mangrove crabs?

## Information sheet 13: Spiny lobsters

A. In Kiribati, it is forbidden to catch lobsters of less than 8.5 cm carapace length and egg-bearing females. Ask students why these regulations have been put in place, and what is their purpose.

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

## Information sheet 14: Coconut crab

A. Coconut crabs were once found throughout the Pacific but have disappeared from many islands. Ask students to investigate the reasons why this has happened.

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

A. Ask students to interview local people who catch octopuses. How do they catch them? Where are they caught? Does the method used result in damage to corals? Are octopuses as common as they were five years ago? Is there any season or time of the year for fishing octopuses?

## Information sheet 16: Green snail

A. Green snails are present in countries like Tonga and Vanuatu, but not in Kiribati waters. It is important for students to understand that despite Kiribati's great marine biodiversity, some tropical marine species don't grow in our waters. Ask students to explain marine biodiversity, and why some species are present in certain areas and not in others.

## 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).

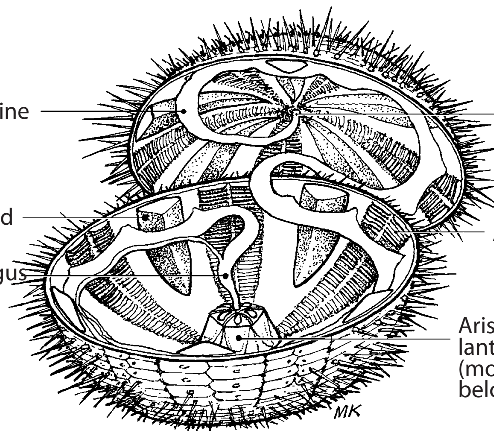
B. Sharks are fished in large numbers for their fins which are used in shark fin soup. Tens of millions of sharks are caught each year and in many cases their fins are removed and the rest discarded. Selling shark is prohibited in Kiribati, so shark fin exports are banned at the national level. Ask students 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?

## Information sheet 19: Sea urchins

A. Obtain several sea urchins and have groups of students dissect them, using the accompanying 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, or rainfall? 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 five years ago?

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

## Information sheet 22: Ark clams

A. Ask students to investigate and list the types of two-shelled molluscs (such as ark clams) 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 five years ago?

## Information sheet 23: Edible seaweeds

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

B. Sea grapes (*Caulerpa racemosa*) are widespread and are harvested from reefs. Ask students to interview people who collect this seaweed. Is it as common as it was five 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.

C. Discuss local fishing methods that might be destructive and impacting spawning runs.

## Information sheet 25: Mangroves

A. There are only five species of mangroves in Kiribati. :

- Te tongo- red mangrove (*Rhizophora stylosa*)
- Te nikabubuti- white mangrove (*Sonneratia alba*)
- Te tongo buangi- oriental mangrove (*Bruguiera gymnorhiza*)
- Te aitoa (*Lumnitzera littorea*)
- Tonga mangrove (*Lumnitzera racemosa*)

Ask students to identify these species and map their distribution in their local area.

B. Why does the number of mangrove species decrease in countries across the Pacific Ocean from west to east? (consider the fact that true mangroves produce seeds or propagules that drift in the sea; however, the prevailing South Equatorial Current flows from east to west). Investigate why some species are found in some islands and not in others.

C. What are the reasons why the mangrove ecosystem is important to the marine environment?

## 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

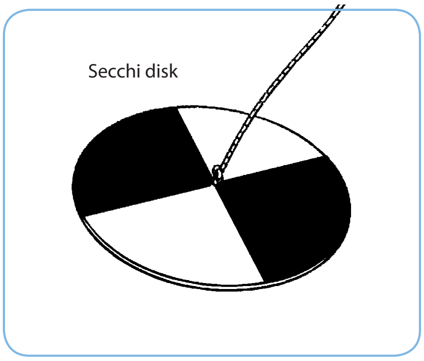
A. A watershed refers to an area of land over which water, dissolved material and sediments flow to rivers and the sea. This run-off often contains nutrients that cause the excessive growth of seaweeds and the appearance of harmful algal blooms (these are described in SPC Information Sheet 28). Ask students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

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

C. Scan affected 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 30 cm circular disk with alternating black and white quadrants. It can be made from marine plywood 30 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. 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.

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

## Information Sheet 30: Coral bleaching

A. Ask students to discuss the ways in which coral reefs are being destroyed in their local area – these ways could include the use of some fishing methods (such as gleaning), the overfishing of plant-eating fish (see Information Sheet 29) and coral bleaching.

B. The loss of zooxanthellae is associated with the bleaching (whitening) of corals. What are zooxanthellae and why are they important to corals?

C. What causes coral bleaching? Which of these causes are the most important in the areas where students live? – Increases in water temperature? The presence of fresh water from rain? Pollution from human waste and sewage? Pollution from oil or fuel from fishing boats? Turbid or cloudy water due to sediments (say from sand mining or land reclamation) - how could cloudy water result in corals dying?

D. The loss of corals in an area will result in the loss of food and shelter for fishes that live on coral reefs. Ask students to name five common fish that usually live on coral reefs and are used as food by local people. Are the catches of any of these fish being reduced by the bleaching of corals?

# 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.

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

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

**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).

**Brood-stock:** adult animals kept to produce young.

**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:** 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:** 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.

**Flyfishing:** 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.

**Gametes:** A male or female cell which is able to unite with another of the opposite sex to form a new individual.

**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*.

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

**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 or over-harvesting:** 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:** The act of releasing eggs, which in most fish, are fertilised by males releasing sperm into the sea.

**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.

**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.

**Zooxanthellae:** single-celled plants (dinoflagellates) that are able to live in symbiosis with diverse marine invertebrates including giant clams and corals.

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*Teachers' Resource Sheet on*

# Fisheries management

1

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

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

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

## Why manage fisheries?

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

## Who manages fisheries?

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

## Why do fisheries need to be managed?

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

## Who assesses fish stocks and fisheries?

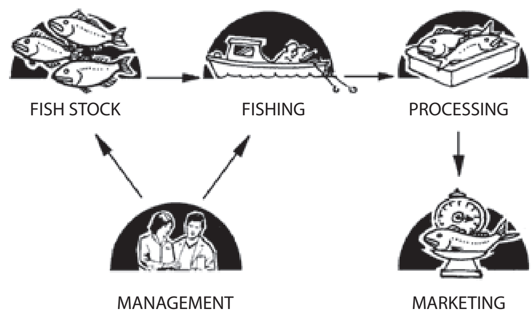
Managers rely on receiving assessments of the health of fish stocks. Sometimes this information comes from fishing communities. More technical assessments are made by scientific staff of government and regional fisheries agencies (see Teachers' Resource Sheet 3: Fisheries assessment).

## What or who are we managing?

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

## How can we ensure we have seafood for the future?

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




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

Manuel Ducrocq © Adecal

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

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Some general rules are:

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

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

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

Eric Clua © SPC

*Teachers' Resource Sheet on*

# Fisheries assessment

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


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

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

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

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

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

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

*Related facts to consider*

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

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

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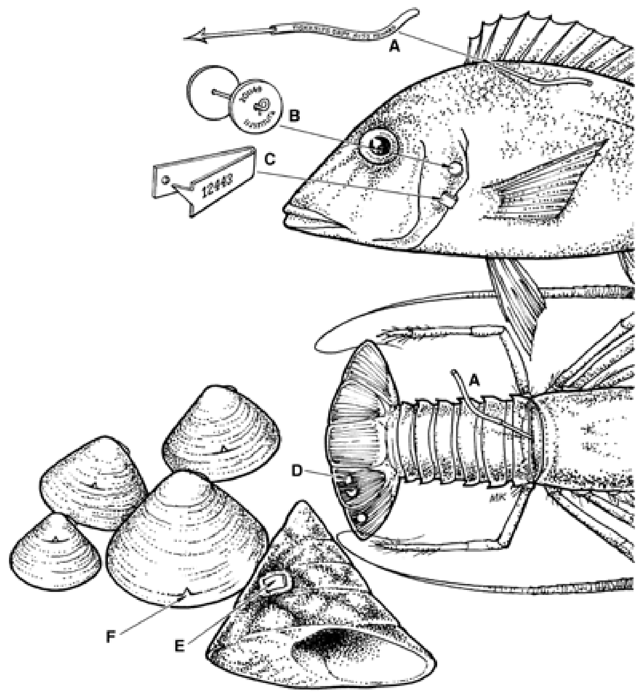
When seeking this information from fishers or in fishing communities it is often easier to ask about catch rates in terms of time taken to obtain a standard catch rather than catch per standard time. That is, for example, the time taken to catch a standard string of fish, a basket of clams, or a number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

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

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




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

Malo Hosken © SPC

*Teachers' Resource Sheet on*

# Fisheries economics

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

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

## How do fisheries contribute to Pacific Island economies?

Fisheries contribute to the economies of the Pacific Islands:

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

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

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

## Three major fisheries that contribute to Pacific economies

In the Pacific, the three main fisheries include:

i. the industrial tuna fishery;*

ii. small-scale fisheries;

iii. aquaculture.

### The industrial tuna fishery

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


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

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

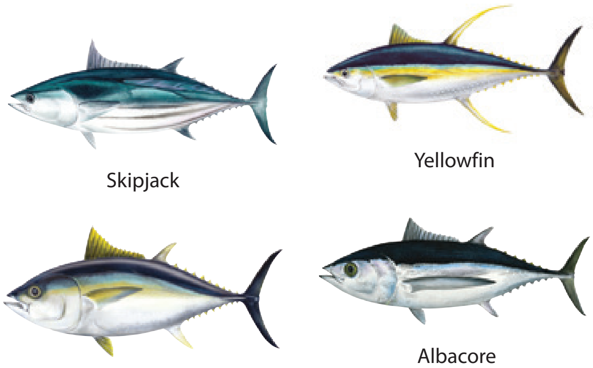



**Figure 2.** Four main target species* of industrial fishing vessels operating in the Pacific.

### Small-scale fisheries

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

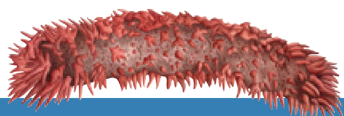
In the Pacific, the main small-scale fisheries that provide food and income to Pacific Islanders include:

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

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

iii. demersal fisheries capturing snapper and other deepwater fish;

iv. sport fishing tourism generating income from charter operations.



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### Aquaculture

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

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

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

Colette Wabnitz © SPC

## Businesses in the fisheries sector

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

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

Mecki Kronen © SPC

Teachers' Resource Sheet on

# 4 No-take areas (*Marine protected Areas*)

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

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

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

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

## What are no-take areas?

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

© Quentin Hanich

## Are there other types of restricted fishing areas?

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

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

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

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

## What are the purposes of no-take areas?

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

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

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

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

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

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

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

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

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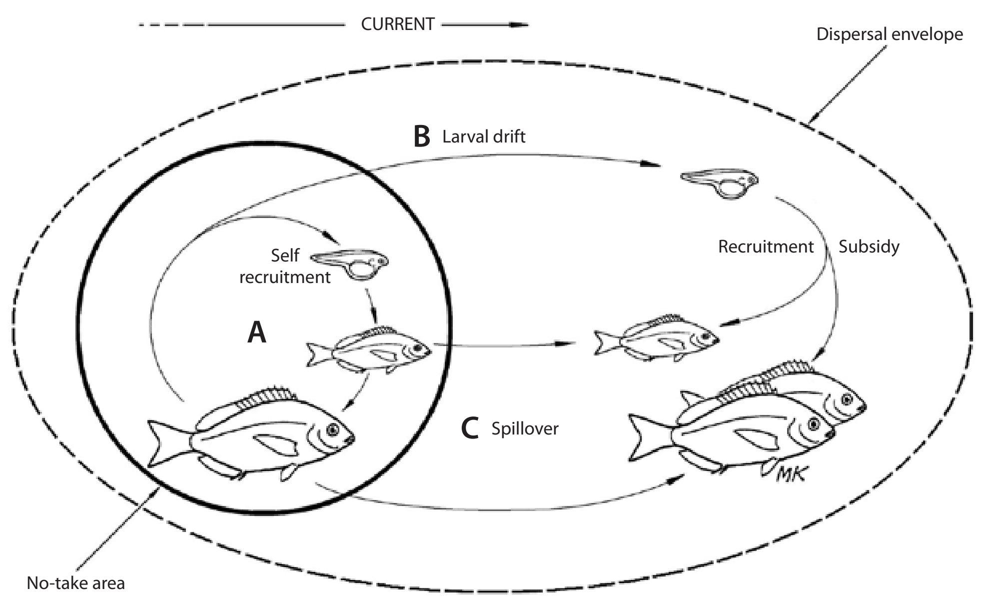
## How can no-take areas increase catches?

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

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

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




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

Teachers' Resource Sheet on

# Fish anatomy

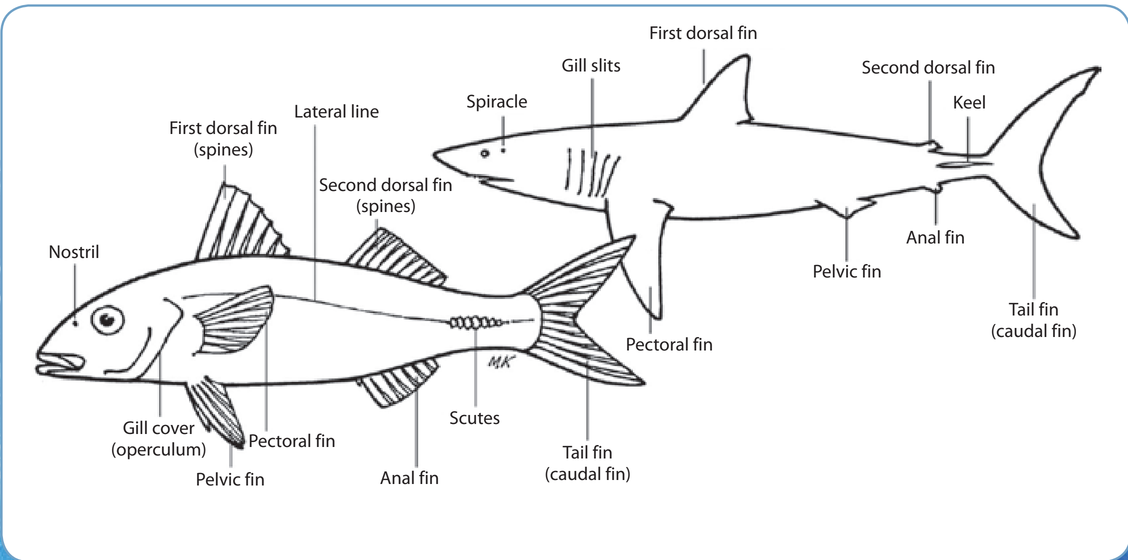
***Over half of all animals with backbones (vertebrates*) are fish. There are over 25,000 different species* of fish. Some fish are adapted to eat plants and others to eat meat and they have evolved to fill all available niches* in the marine environment.* Some evolved to hunt on coral reefs and others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

## External features

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

*An amazing fact*

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




Jeff Muir © ISSF 2012

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## Internal features

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

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

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

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

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

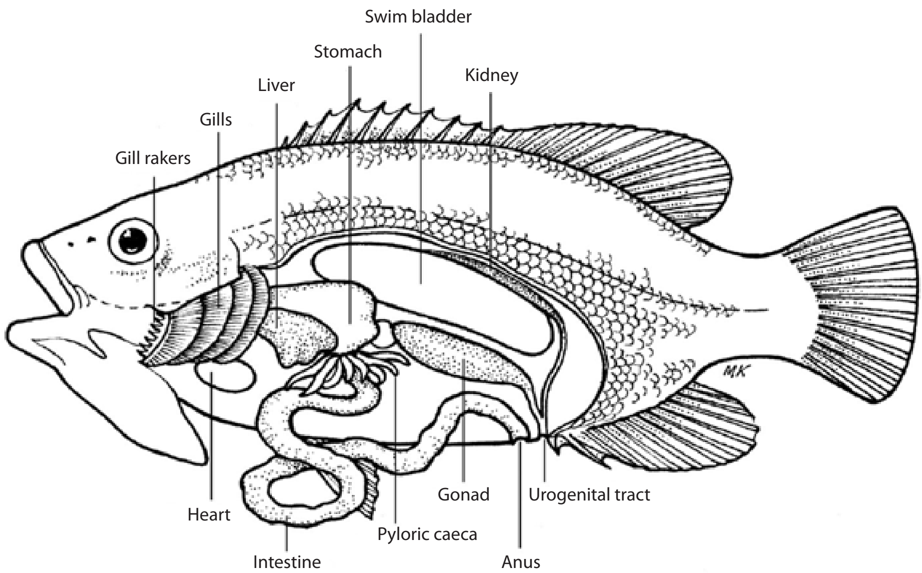
Fish have internal ears with no connection to the outside. Sound waves, travelling through the water and the head, strike dense calcium carbonate 'earstones' or otoliths which float in the fluid contained in the inner ear. The otoliths vibrate against sensory hairs in the ear. As the fish grows more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

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

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

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

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




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

*Did you know?*

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

*Teachers' Resource Sheet on*

# Marine food webs

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

## What eats what?

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

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

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

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

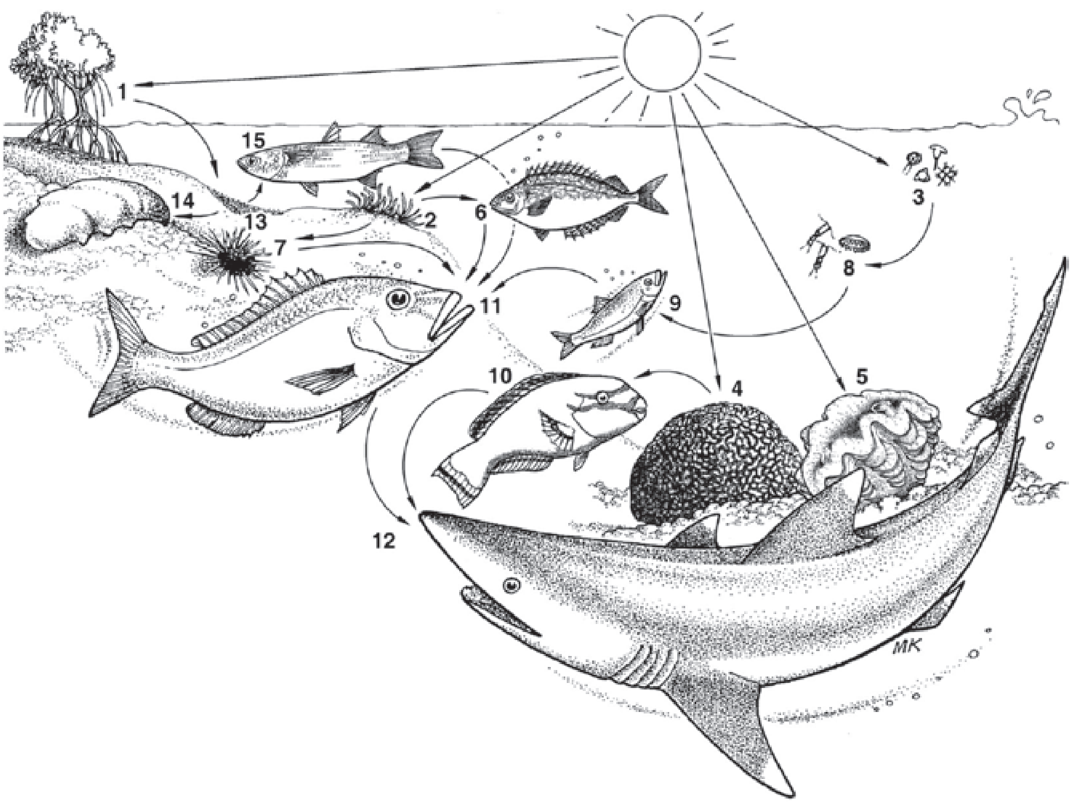
Several larger animals have evolved to take advantage of drifting phytoplankton. Bivalve molluscs,* the cockles and clams, filter out the phytoplankton. But the most important consumers of phytoplankton are the small animals, collectively called zooplankton* (magnified at point 8) that drift in the sea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

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

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

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

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




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

## Why are there not many sharks on a coral reef?

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

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

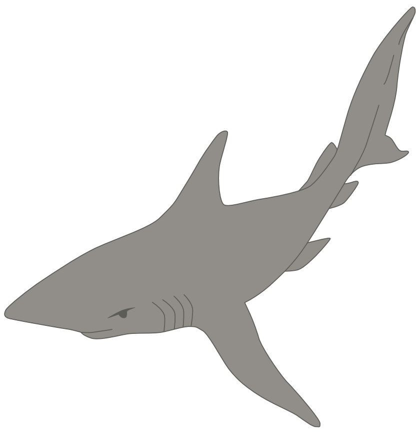
At each level most of the total weight of material or energy (the biomass*) is lost due to the use of energy for respiration, movement and reproduction. As a result, only a small proportion of the food consumed is devoted to flesh growth that may be passed on to the next trophic level. There is, therefore,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

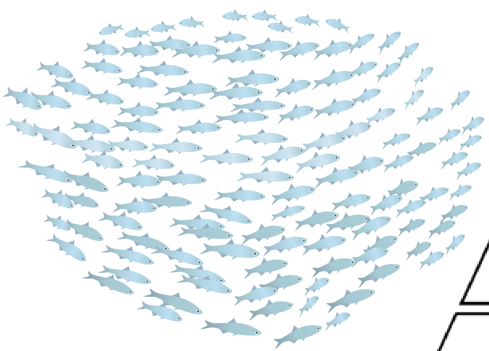
The biomass values shown to the right of the energy pyramid in the figure below arbitrarily assume a 10 per cent level of ecological efficiency – that is, the energy passed from one trophic level to the next. It therefore takes 1,000 kg of plant material to produce 1 kg of a higher level carnivore such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

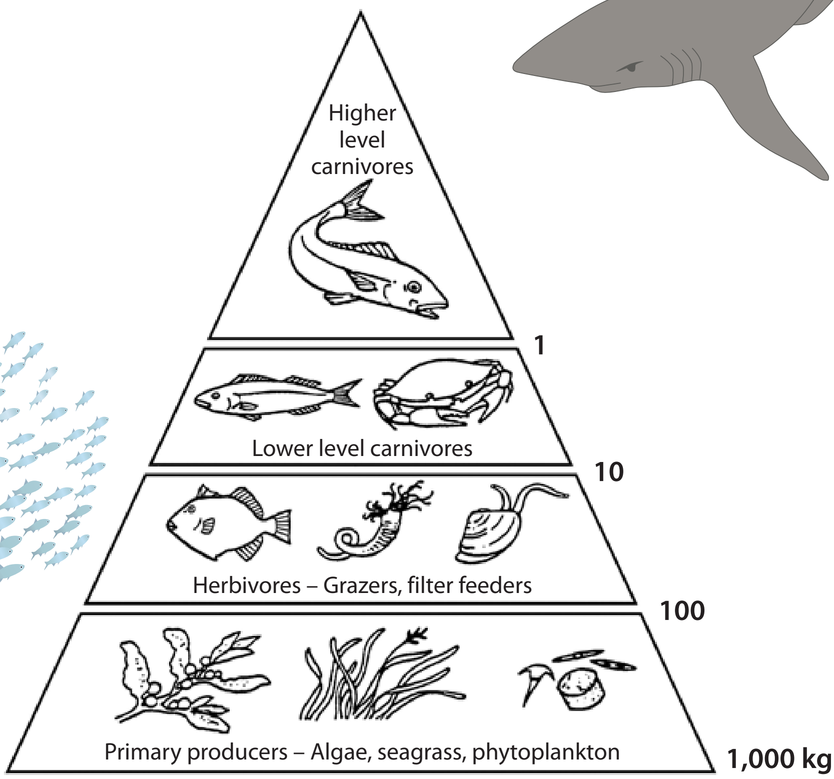
Because of this loss at each succeeding trophic level, animals at high trophic levels are unable to maintain very large populations. A top carnivore such as a large tiger shark is, perhaps thankfully, not common at all and most sharks need to swim over a huge territory to find all the food that they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

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

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








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

# Oceanic species



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

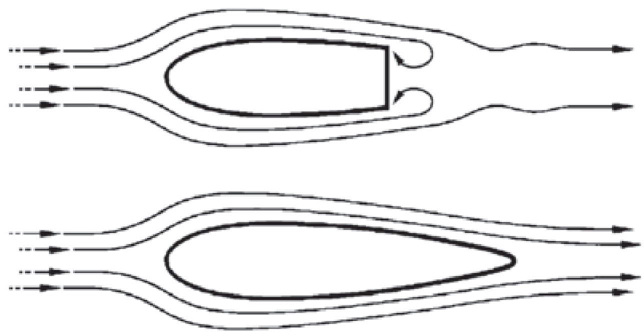
***But a few species* have managed to adapt to this difficult pelagic* environment.* The best known of these are the species of tuna, which are distributed over large areas of the Pacific Ocean where they hunt smaller fish. Other oceanic species include billfish*, mahi mahi and wahoo.***

Tuna are caught by local fishers often by towing (or trolling) lures behind small boats. Commercial fishing* vessels use longlines and purse seines – these fishing methods are described in Teachers' Resource Sheet 15: Modern large-scale fishing techniques. Here, we are more concerned with the amazing adaptations of fish that live in the open sea.

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

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

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



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

## Life in the fast lane

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

## Which is the fastest animal on the planet?

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

*Did you know?*

*The fusiform shape of fish has helped architects design more fuel efficient boats. The bulbous bow – the rounded bulb or bulge sticking out at the bow, or front, of a ship – makes the ship's underwater shape more fusiform, and allows water to flow around the hull more easily. Large ships with bulbous bows are 12–15% more fuel efficient that similar boats without them.*



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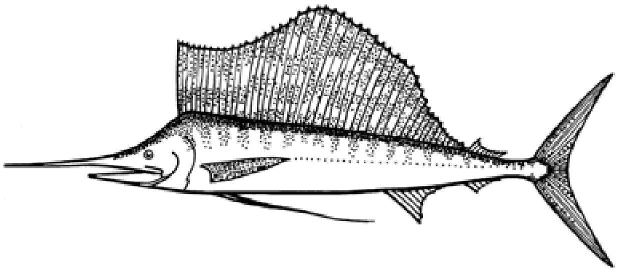
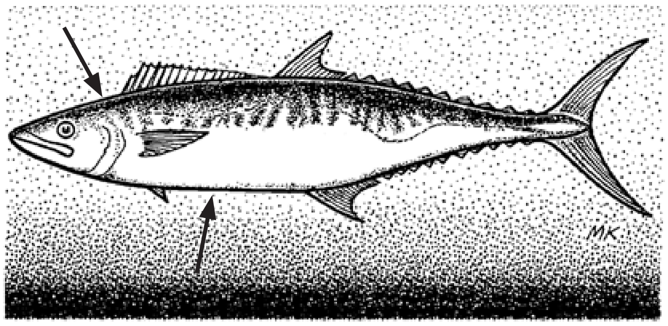





**Counter-shading in a pelagic fish.**
From: King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

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

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

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

Marc Taquet © FADIO/IRD-Ifremer

Teachers' Resource Sheet on

# Bonefish

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

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

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

***Kiritimati (Christmas Island) in the Line Group of eastern Kiribati is famous for attracting visitors who travel there just to fish for bonefish. Islands such as Abemama, Maiana and Nonouti have the potential to become bonefish fishing destinations.***

## The fish

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

Bonefish are named for the many fine bones they contain or for their elusive habits, with names such as grey ghost. It is known and called in Kiribati as ' te ikari' a fish of many bones. In French Polynesia they are called *o'io*, *albule* or 'sorte de mulet'.

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

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

Bonefish are generally not preferred as food although they are eaten in some countries such as Hawaii, where they are known as o'io. However, they are highly valued by sports fishers and have the potential to be of great economic benefit to countries in which they are found.

## Lifecycle

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

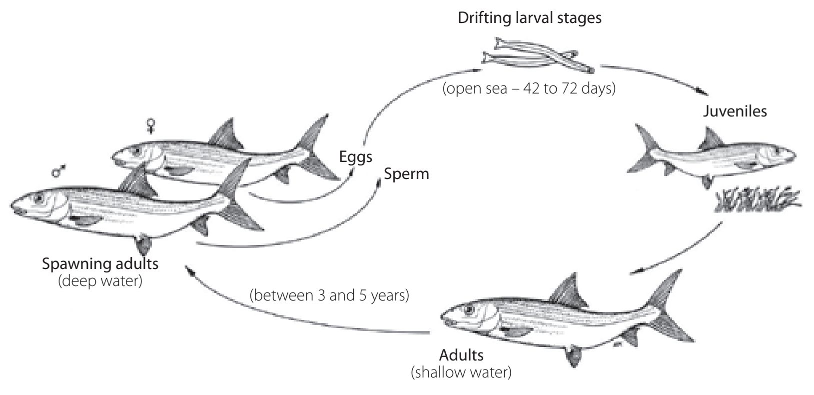
Fertilised eggs hatch into larvae* which drift in the ocean for long periods, perhaps for over two months. Many larvae do not reach areas in which to settle and many others become food for other fish. Only a small number of drifting larvae survive to settle in shallow sandy areas where they grow into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

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

## Habitat

In Kiribati, bonefish are commonly found in intertidal flats, mangrove areas and deeper adjacent waters.

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




**The life-cycle of the bonefish.**

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## Distribution

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

## Management

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

Some managers have imposed direct measures to protect bonefish stocks. For example, fishing may be confined to designated areas. And fishing in spawning areas may be prohibited at certain times.

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

However, management actions could include protecting important bonefish habitats* including seagrass beds in lagoons.

Michel Blanc © SPC

*Teachers' Resource Sheet on*

# Marine aquaculture in Kiribati

***What is marine aquaculture?*** *Marine aquaculture, or mariculture, refers to the farming of plants or animals in seawater. In Kiribati, marine aquaculture is based on seaweed, milkfish, giant clams and sea cucumbers.*

*With the limited availability of land for agriculture on atoll islands, aquaculture offers a potential for growing fish and sea plants to provide food.*

## Seaweed farming

There are a number of different species of the seaweed *Eucheuma* and the closely related *Kappaphycus* that have been introduced to the Pacific region for aquaculture. The plants are farmed in the sea, and dried before being sold to large companies. The companies extract carrageenan* jelly from this sea plant for use as a thickener in food processing, cosmetics and drugs.

In Kiribati, seaweed farming started in the late 1970s when the first seaweed was introduced from the Philippines. The seaweeds are tied at 20 cm intervals on lengths of rope suspended between two stakes in growing positions in shallow water. By the late 1990s Kiribati became the main seaweed producer in the region.

## Milkfish farming

Milkfish (*Chanos chanos*) can be farmed in either ponds or cages. In Kiribati, milkfish have been farmed since the early 1970s with the aim of producing baitfish for pole and line tuna fishing vessels as well as for human consumption. In Kiribati, milkfish are farmed using a method described as 'extensive'. In this method, fish are kept in ponds where they rely on the availability of natural food, and not on the supply of food by the fish farmers.

Baby milkfish, or fry*, are collected from nearby mangrove areas and kept in the ponds for about six to eight months before being harvested using gill nets and sold in local markets.

In early 2000 the Government of Kiribati in collaboration with the Taiwan Technical Mission started a milkfish hatchery in Ambo. The hatchery has two tanks for keeping parent fish (the brood-stock* ) in captivity. In 2013 the hatchery had its first successful spawning and continues to produce an average of 50,000 milkfish fry per month.

The ability to produce milkfish from the hatchery will greatly reduce the dependence on collecting fry from mangrove areas where their abundance is highly variable and transportation of fries to outer islands is possible through this program. .

## Giant clams farming

Giant clams are marine bivalves (molluscs with two shells) that are found in tropical areas. There are four species of giant clams found in Kiribati namely the *Tridacna squamosa*, *Tridacna maxima, Tridacna gigas* and *Hippopus hippopus*. The farming of giant clam in Kiribati is based on the *Tridacna maxima* (te were), and was started in late 1990.

The adult clams are collected from the wild and induced to spawn* (release their gametes*) in indoor tanks. The gametes (sperm and eggs) are collected and mixed together to allow the sperm to fertilise the eggs. After this, the fertilised eggs are kept inside a tank of sea water with minimum aeration until the eggs hatch and become free swimming larvae*.


Colette Wabnitz © SPC

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The free swimming clams are transferred to an outdoor tank on the fourth day of culture and kept there until the clams are visible (after six to eight weeks). Depending on the water quality, clams can be grown in outdoor tanks until they reach around 10–20 mm when they can be moved to a grow-out farm in the ocean and kept for another four to five months. At this stage the clams have reached market size of around 30–40 mm.

In Kiribati, clams are farmed for the aquarium market and for restocking coastal areas where they been depleted.

## Sea cucumber (sandfish) farming

In their natural habitat, sea cucumbers play an important role in the marine environment as they act as vacuum cleaners, feeding on decaying organic material on the seafloor. The farming of sandfish, *Holothuria scabra* (Tanoika), which does not occur naturally in Kiribati, started in 2013 with the introduction of brood-stock from Fiji.

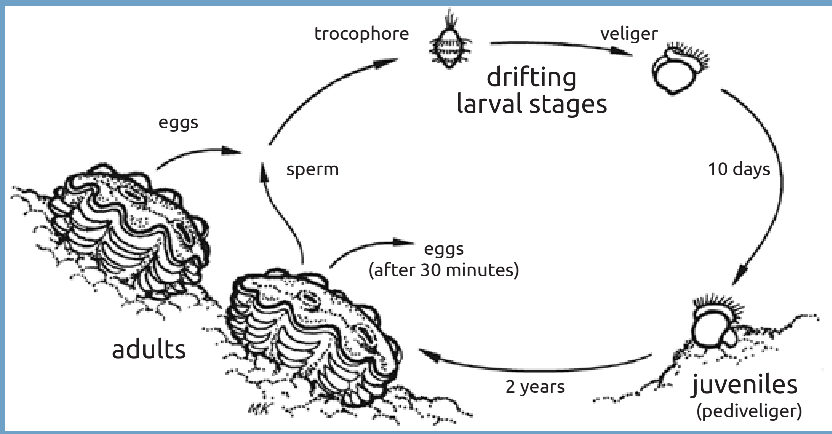
Sea cucumbers have separate sexes – each animal is either male or female. Adult female sandfish are kept in a small tank and induced to spawn by excess feeding around the time of the new or full moon. Eggs are collected from two or three females and sperm is collected from males kept in a separate tank.

Fertilization occurs when the sperm and eggs are left in a tank with minimum aeration for a day. The free-swimming larvae start to filter feed after the seventh day before changing to crawling juveniles which get their food by grazing. The life-cycle of a sea cucumber in the wild is shown in the accompanying diagram.

Sandfish are highly valued and farming them has the potential to generate income in local communities.

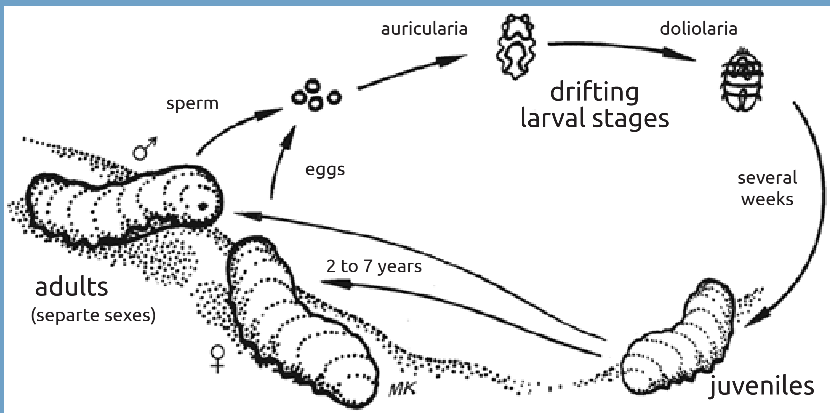
### *Giant clams life cycle*

*Giant clams are unique among bivalves in that they are able to obtain nutrients from a relationship with microscopic plant cells called zooxanthellae*, which become established in the mantle of the clam after settlement. After this, the now symbiotic* zooxanthellae photosynthesise* and produce nutrients which are used as food by the clam. This symbiotic relationship is found in a few other tropical invertebrates, including most shallow-water corals.*




The life-cycle of giant clams (from King, M. 2007. Fisheries Biology, Assessment and Management. 2nd Edition. Wiley Blackwell).

### *Sea cucumbers life cycle*




The life-cycle of sea cucumbers (from King, M. 2007. Fisheries Biology, Assessment and Management. 2nd Edition. Wiley Blackwell).

Michel Bermudes © SPC

*Teachers' Resource Sheet on*

# Aquarium species

***Many people around the world love to watch colourful fish swimming in a glass tank. The fish that are most popular are those from tropical coral reefs and many come from Pacific islands. Kiribati has an aquarium fish industry based in Kiritimati Island where pet fish are caught and exported to Honolulu, the US mainland and Asian markets.***

*Centropyge loricus* @Brian Gratwicke

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

*Are rocks alive?*

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

## Where and what species?

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

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

Colette Wabnitz © SPC

In Kiritimati Island, the flame angelfish (*Centropyge loricus*) is one of the most popular species caught and exported. According to data collected by SPC, the six most commonly exported species Pacific-wide include the following:

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

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

In Kiritimati Island, aquarium fish are caught by divers using hand nets before being stored in 500 ml plastic bottles drilled with holes to allow the flow of water. These are then placed in nets hanging from buoy lines in the open ocean. In preparation for export, the fish are transferred to packing houses where the bottles are placed in aerated seawater tanks. On the night before an international flight, the fish are placed, individually, in a small volume of water in a double-layered plastic bag. The air in the plastic bag is replaced with oxygen and the bag is closed with a rubber band and placed in cardboard box (around 30 bags per box, depending on the size of the fish). On Tuesday nights the fish are taken to the airport, where they are counted by compliance officers. The fish are then loaded onto the early-morning, once-weekly flight to Honolulu, where the fish are collected by the buyers.

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

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

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*Chrysiptera taupou @Jeff Dubosc*


*Dascyllus aruanus @Scott Mills*


*Amphiprion percula @Silvain de Munck*


*Centropyge bicolor @Aquarista Marinho*


*Centropyge bispinosus @LemonTYK*


*Chrysiptera cyanea @Brian Gratwicke*

## Management

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

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

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

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

- the promotion of sustainable fishery practices,
- the fostering of good fishing and handling practices prior to export.

In Kiribati, the fishery is managed primarily by issuing licences to exporters. There are about nine active licences and each licence holder is limited to catching 1,500 flame angel fish per month. There is also a limit of 800 fish per month for all other species and licence holders are required to provide records of all fish exported. Restrictions on the amount of cargo that can be carried effectively limit the total amount of marine aquarium fish that can be exported.

*Teachers' Resource Sheet on*

# Fish spoilage

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

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

## Spoilage by bacteria

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

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

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

## Spoilage by enzymes

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

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

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

*What does a properly handled fish look and smell like?*

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

## Stages of spoilage

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

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

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

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

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

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## Twice as nice on a bed of ice

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

## Keep it clean

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

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

Fabrice Bouyé © SPC

# 12 Fish poisoning and ciguatera

***Eating fish that hasn't been kept on ice can make you very sick! This is because of the build-up of enzymes* and bacteria* – see Teachers' Resource Sheet 11: Fish spoilage.***

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

## Harmful Algal Blooms (HABs)

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

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

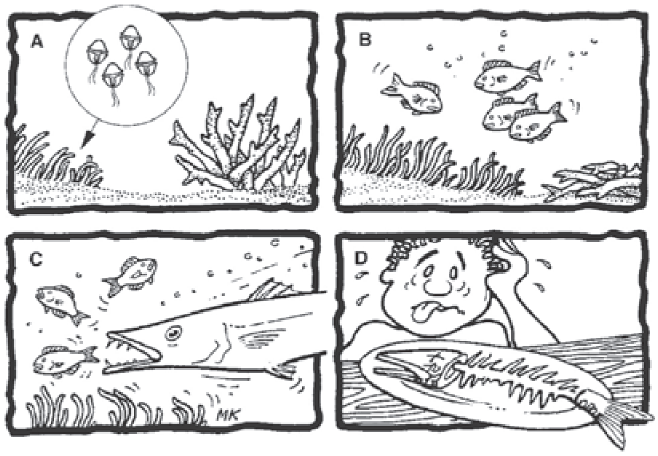
These blooms of toxic species (called Harmful Algal Blooms or HABs) are responsible for fish and shellfish poisoning in humans in many parts of the world.

*Myths about ciguatera*

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

## Ciguatera fish poisoning

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




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

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

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

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

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

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

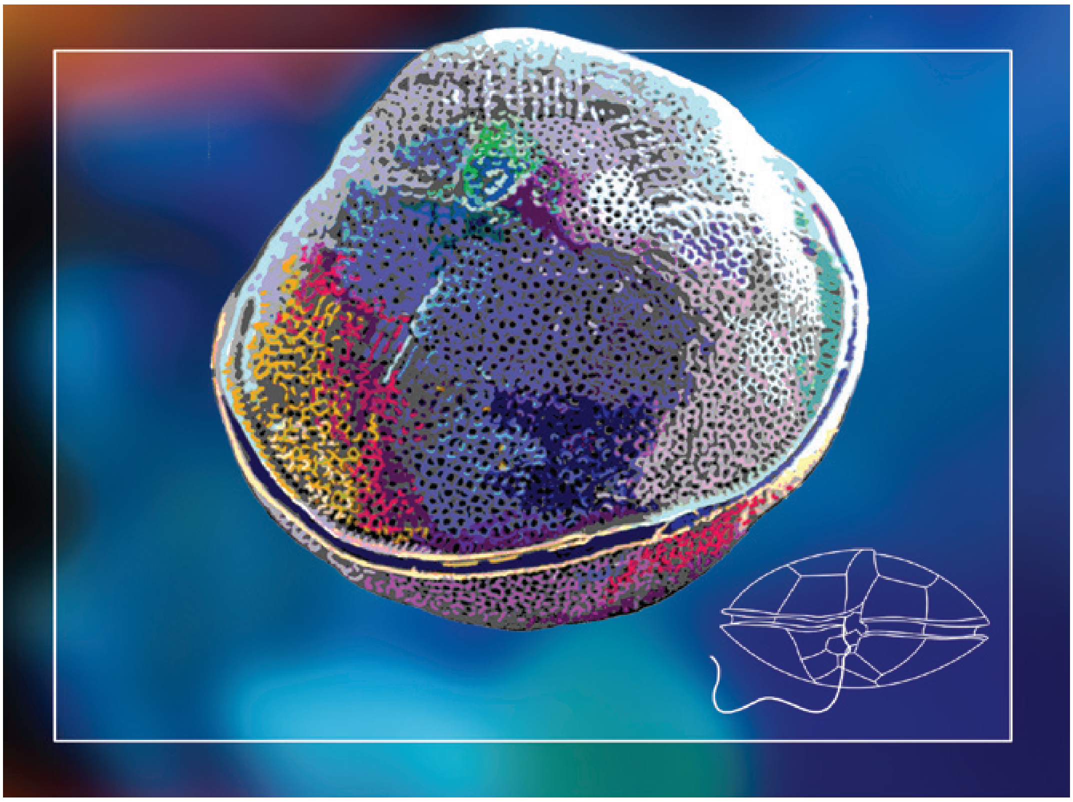
## Shellfish poisoning

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

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

*Did you know?*

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

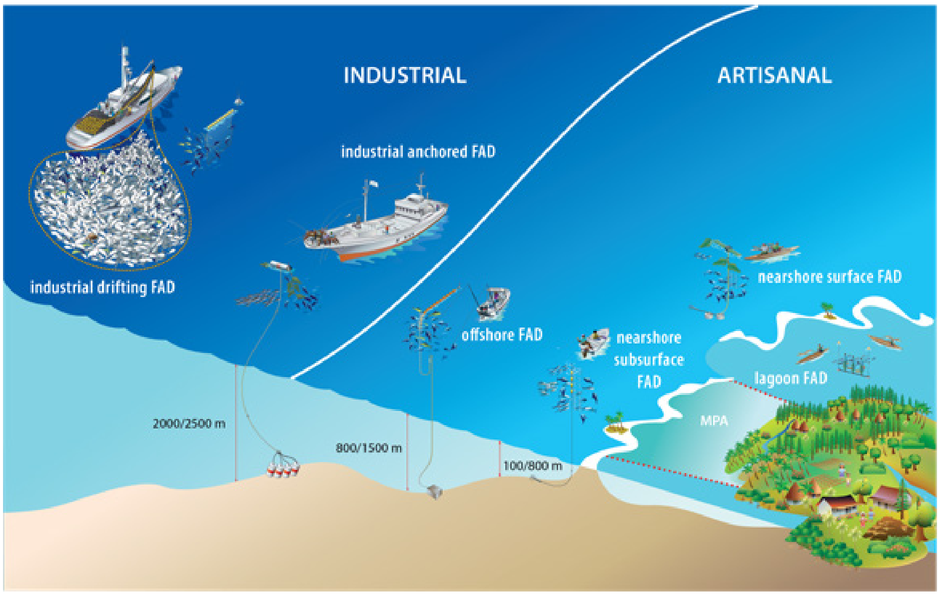


***Gambierdiscus toxicus.***
From: SPC/IRD Ciguatera field reference guide:
http://www.spc.int/coastfish/en/component/content/article/340-ciguatera-field-reference-guide.html

*Teachers' Resource Sheet on*

# Fish aggregating devices (FADs)

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




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

## Types of FADs and their use

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

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

*i*

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

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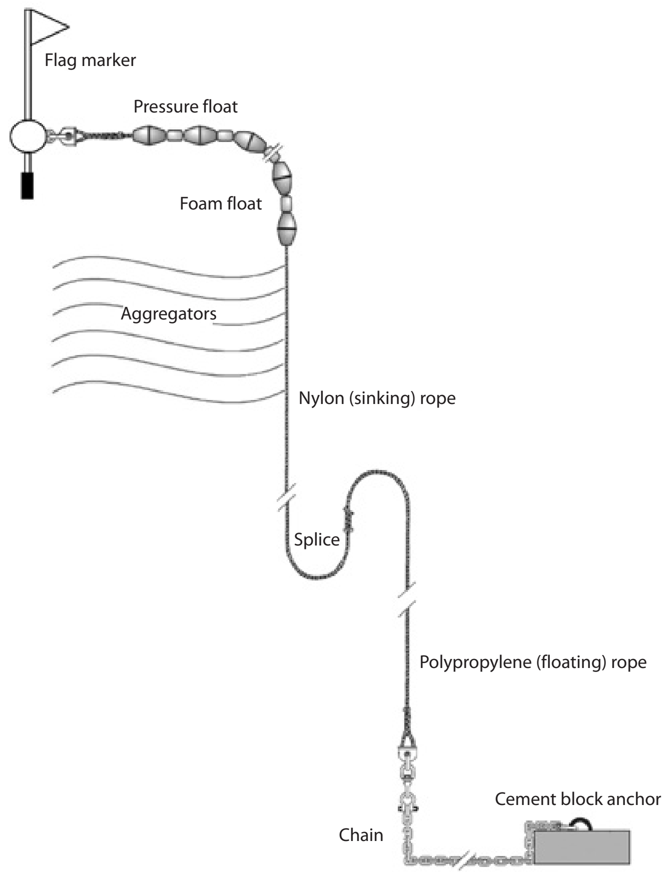
*Artisanal fishers in the Pacific currently catch less than 5% of the tuna caught in the western and central Pacific Ocean and will need to harvest more in future for food security. Anchored FADs are important tools for domestic fisheries development as they can contribute to increasing the share of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

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

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




**The Indian Ocean FAD design (main components).**


**Purse-seine catch.**


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

*A cause for concern: sabotage*

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

*Teachers' Resource Sheet on*

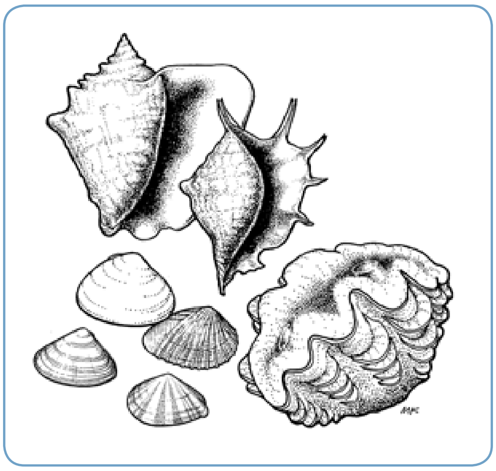
# Kiribati traditional fishing methods

***The culture of Kiribati is Micronesian in origin and traditions exist and thrive, particularly on the outer islands. Traditionally living on what can be sourced from the sea, I-Kiribati have had to become expert sailors and fishers.***

***Traditional fishing methods used by our ancestors ranged from gleaning (or collecting by hand) on reefs for seafood to fishing offshore from sailing canoes for tuna and deeper water fish.***

## 1. Gleaning and collecting

A range of invertebrates are collected along shorelines. Peanut worms (*Sipunculus*) and bivalve molluscs (*Asaphis*) are dug up from silty sand. A number of filter feeding bivalve molluscs can be collected just below high tide. In deeper water, clams (*Hippopus* and *Tridacna*) and spider conches (*Lambis*) are found. At the times of the month when tides are at their lowest (spring tides) it is possible to catch octopus from the fringing reefs.



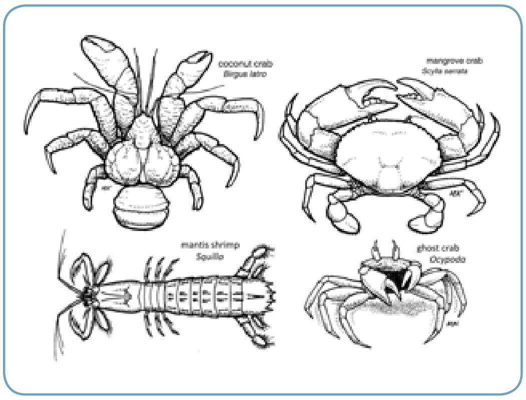
Crustaceans collected include the ghost crabs (*Ocypoda*) which scurry along the beaches at night. Large coconut crabs (*Birgus latro*), which were common before the introduction of dogs and pigs, were found in coastline shrubs usually in a hole covered by a partly-husked coconut. Each crab is taken by surprise and its two large claws are twisted off. Lands crabs were a particularly valuable food item when storms lasted for weeks and disrupted fishing.

## 2. Spears

Men use spears to catch fish from canoes or off the reef edge. Sometimes coconut fronds would be used to drive fish into the shallower water of a lagoon where they could be more easily speared.

## 3. Encircling nets

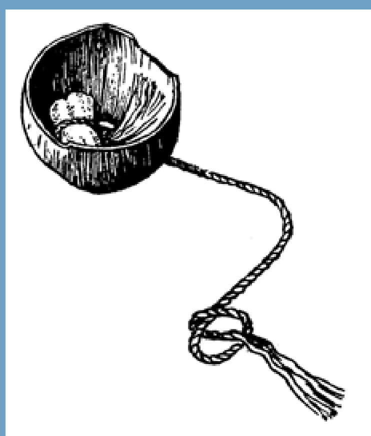
A large drag-net (karaun) about 20 to 50 m long and about 2-3 m deep is knotted from coconut fibre string and fitted with floats of Scaevola wood and sinkers made from cowrie shells. At a high flood tide, several people (men and women) carry the net into the water of the lagoon. When they are about 100 m from the shore they separate, unfold the




*Catching the mantis shrimp*

*The mantis shrimp (Squilla) is also dug out from the lagoon mud, not far from the shore. Capturing the mantis shrimp with its razor-sharp claws requires considerable skill. A rig is made up of the upper half of a coconut shell with a coconut fibre string passed through the eye. One end of the string is tied round a small piece of coral which acts as a toggle and the other end is tied around a small bait fish.*

*Several of these rigs are made and the coconuts with baits beneath them are placed on the mud near the burrows of the mantis shrimps. A watch is then kept until one of the coconut shells tilts and moves towards the burrow, indicating that a mantis shrimp has taken the fish. Next the lure is slowly raised and the fisher carefully feels with his right hand down into the hole and very gradually pulls to the surface the struggling crustacean, which is about 30 cm long. Great care is needed to avoid the sharp claws.*



**Lure (*bai ni kaun waro*)**

From: Koch G. 1986. The material culture of Kiribati. 270 p.

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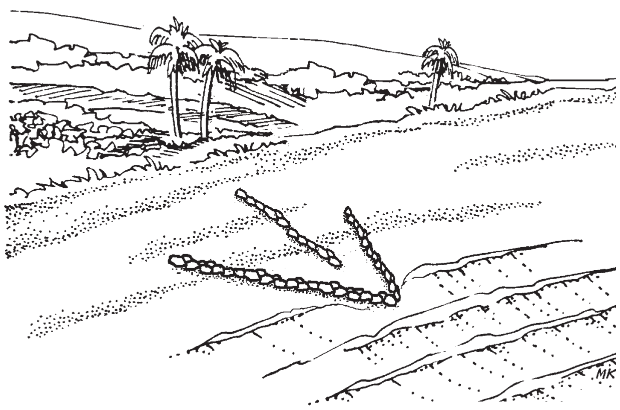
net and form a large circle with it. They then move closer together, encircling a number of fish. With the help of children who have come along, the fish are removed from the mesh of the net. The process is then repeated further down the shore.

Fish drives usually involve dragging a net to either surround fish or drive them into a small area. Traditionally, the dragnet is made from coconut fronds weaved on vines and may be over 100 m long. Many men, often over 30, are needed to drag the net either in a semi-circle facing the shoreline or a full circle about 20 m in diameter. Fish that are trapped inside the coconut frond enclosure are removed by hand or speared.

Fish drives usually involve many people moving across the reef and this is likely to damage corals and the habitats of marine organisms.

## 4. Weirs, fish fences and traps

The simplest traditional traps are based on v-shaped or semi-circular walls of stone or coral inside which fish are stranded by the falling tide. Fence traps are built at right-angles from shore-lines and reefs to guide migrating coastal fish into a large retaining area.



**A v-shaped stone weir used to catch fish with the falling tide.**

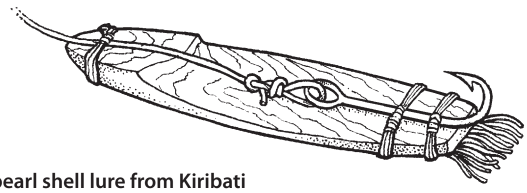
## 5. Traps and nets

Using traps to catch fish and moray eels (te 'uu') are also traditional fishing methods. The traps made for catching moray eels are beautifully made by master builders. Construction involves the use of wood tightly bound by coconut fibre string. After the walls and roof have been completed an entrance is worked into one end.

Nets with long handles are used by men for night-time fishing expeditions using burning torches made by women from dried coconut fronds

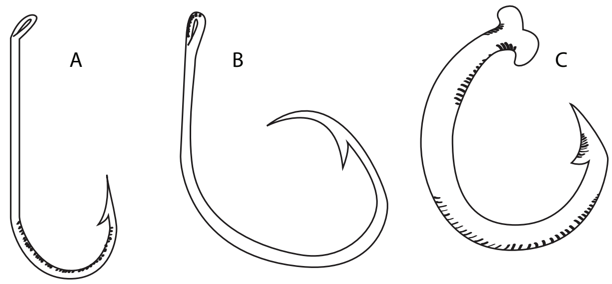
## 6. Hooks and lures

Tuna, including skipjack and yellowfin, were caught by towing lures attached to wooden poles. Lures were made from mother-of-pearl shell or feathers with hooks originally made from hard wood or coconut shell and attached to lines made from plant fibres. Besides being used for fishing, carved fish hooks were worn as personal ornaments.



**A pearl shell lure from Kiribati**
From: King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

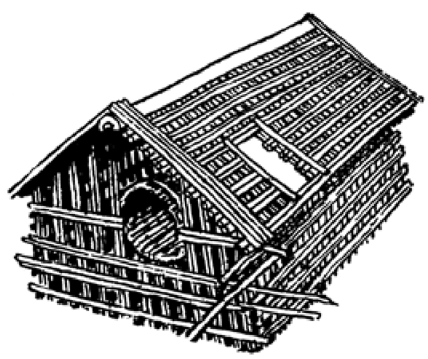
Modern fishing hooks are often J-shaped. However, in many commercial fisheries, circular steel hooks are used and these are similar in design to the bone or shell hooks which have been used since prehistoric times by Pacific Islanders. When a fish strikes a circle hook, the point rotates around the jawbone, ensuring that the fish remains caught without the fisher having to maintain pressure on the line.




**Fish hooks.** A) a common J-shaped hook, B) a modern circle hook, and C) a traditional bone hook.
From: King M. 2007. Fisheries biology, assessment and management. UK: Wiley Blackwell. 400 p.

Over time, traditional fishing methods have mostly given way to more modern ones in order to make fishing more effective and increase fish catches. Monofilament fishing line with plastic lures and steel hooks have replaced fibre lines with bone hooks. And monofilament gill nets have replaced the traditional ones. Modern vessels with outboard engines have replaced sailing canoes and decreased the time and effort required for fishing. However, beautifully built traditional canoes are still used in many parts of Kiribati.

Many modern fishing methods and gear are so efficient that many stocks of fish have been overfished* and their populations reduced to low levels.



**A trap for catching moray eels**
From: Koch G. 1986. The material culture of Kiribati. 270 p.

Major source – The material culture of Kiribati, Gerd Koch 1986. (English translation by Guy Slatter)

*Teachers' Resource Sheet on*

# Modern large-scale fishing techniques

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

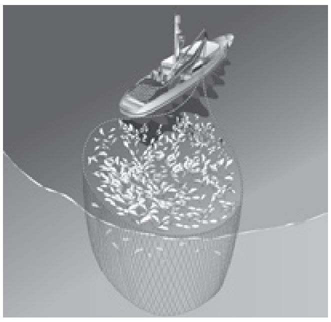

© Francisco Blaha

## Purse seine

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

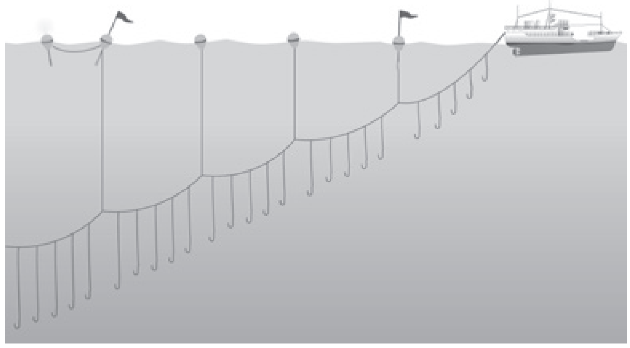
**Target:** Mainly skipjack and small yellowfin tuna. Most of the catch is for canning and thus ends up in tuna cans one can find in stores all over the world.

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



## Longline

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



*Note:*

*Over 50% of the world tuna catch, worth about USD 6 billion, comes from the Western and Central Pacific Ocean region. Of the fishing nations in the Pacific, Kiribati has had the highest volume of catch. In Kiribati, over 90% of the catch is made by purse seine vessels, which target skipjack and small yellowfin tuna. Longline vessels catch bigeye, yellowfin and some albacore. Of these species, there is some concern that stocks of bigeye tuna are being overfished.*

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There are two major types of longliners:

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

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

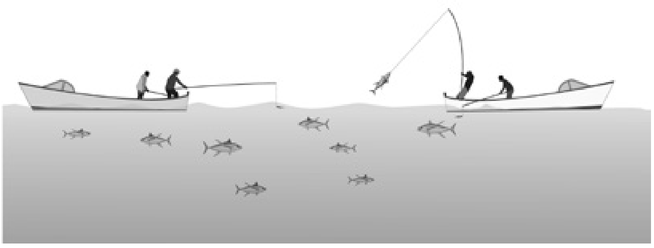
About 11% of the tuna catch in the WCPO region caught with longline gear – about 265,000 tonnes in 2011. Most of the longline catch is taken within 20 degrees of the equator.

## Pole-and-line

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

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

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



*Note:*

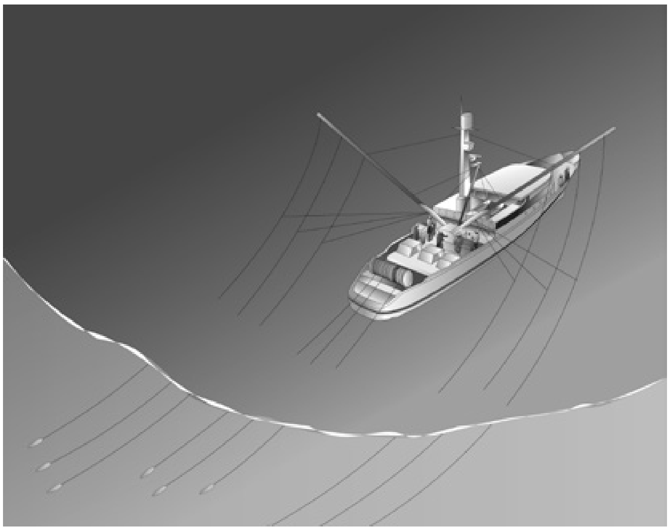
*Several small-scale fishing methods and gear types are described in the 'Guide to information sheets on fisheries management for communities', including reef gleaning; spears; portable traps; barrier and fence traps; baited hooks and lines; lures for trolling; as well as cast nets, scoop nets, gill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

## Troll

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

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

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



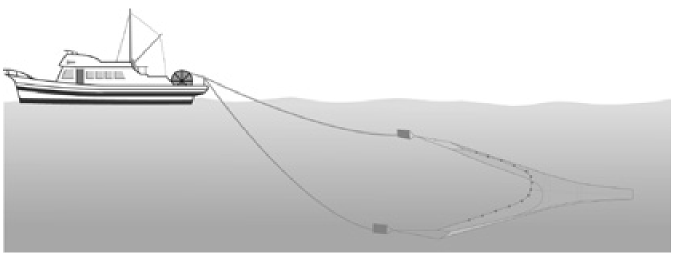
## Bottom trawl

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

1. it would destroy the corals, and
2. the trawl net would be damaged by the coral heads.

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

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



*Teachers' Resource Sheet on*

# Sea safety

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


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

## What is sea safety?

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

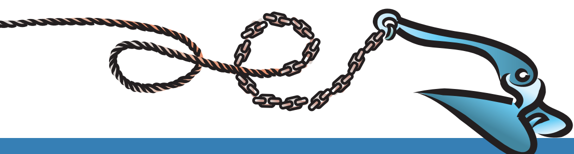
## The cost of small boat accidents at sea

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

## The causes of sea accidents

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


**Overloading of a small transport vessel in Papua New Guinea.**



### A world record of survival at sea?

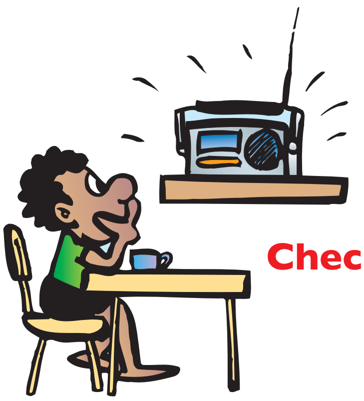
*On 18 November 1991, three I-Kiribati fishers left their village on Nikunau for an ordinary fishing trip. Two of them made land again on 11 May 1992… almost six months later, in Samoa! They had survived on rain water and the sharks they could lasso while drifting. This is the longest known drift in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

### A worrisome fact

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

### The importance of being prepared

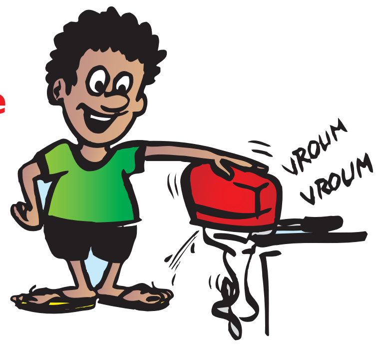
*Small boat users, particularly fishers, lack a culture of sea safety. To help change that situation, SPC has released a number of small boat safety awareness materials including two checklists (included in this information package): 'Five minutes which can save your life' and a recommended list of safety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



**Check the weather forecast**

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

**Make sure your engine is working well**





**Make sure all safety equipment is on board**

*Teachers' Resource Sheet on*

# Financial management of a small fishing business

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

## Types of fishing businesses

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

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

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

## Products sold by a fishing business

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

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

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

## Management of a fishing business

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

## Financial management of a fishing business

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

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

## What is income?

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

*Income per trip = Price x Quantity*

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

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

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

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

## What are the costs of fishing?

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

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

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

*Total cost = Total operating costs + Total fixed costs*

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

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## What is profit?

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

*Profit = Total income - Total costs*

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

Profit and loss analysis

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

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

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

Detailed profit and loss statement

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

## Other fields to consider in financial management

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

Quentin Hanich © SPC

*Teachers' Resource Sheet on*

# Climate change and fisheries

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

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

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

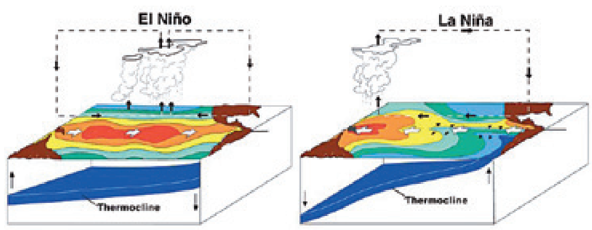


**Figure 1.** Effects of El Niño and La Niña conditions on the Pacific Ocean (source: SPC).

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

## Coastal fish

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

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

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

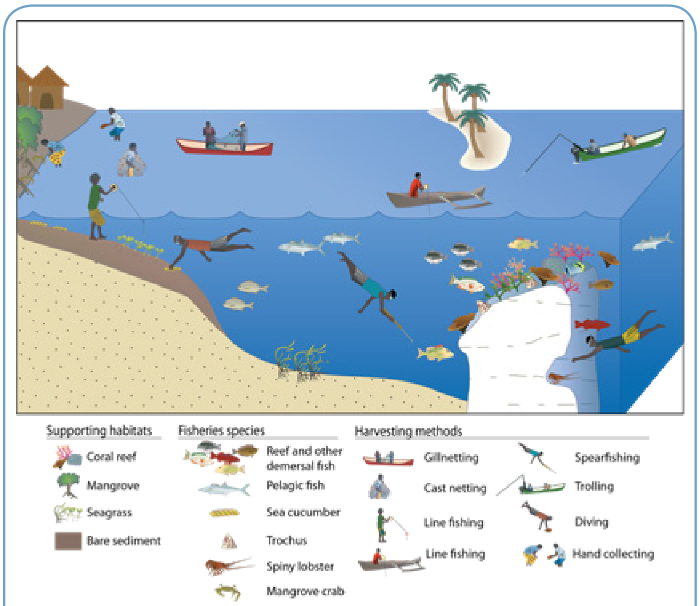


**Figure 2.** Range of coastal fishing activities in Pacific Islands (source: SPC).

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## Oceanic fisheries

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

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

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

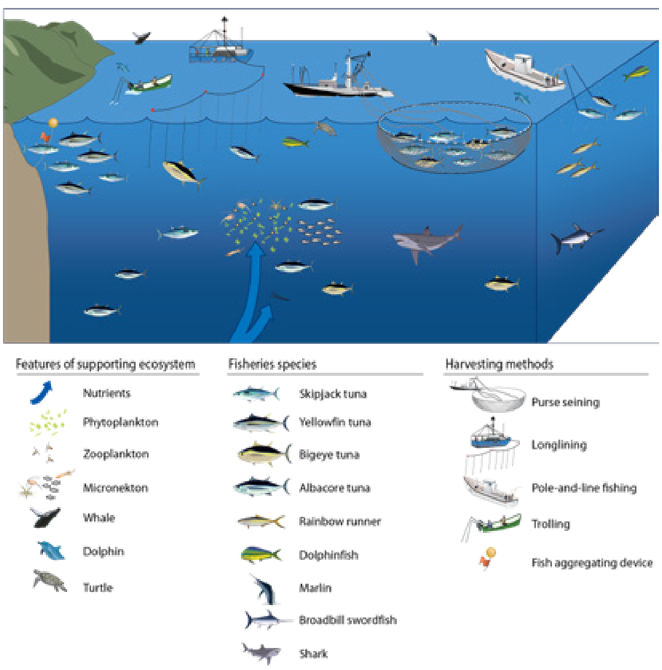


**Figure 3.** Range of oceanic fishing activities in Pacific Islands (source: SPC).

*Interesting fact*

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