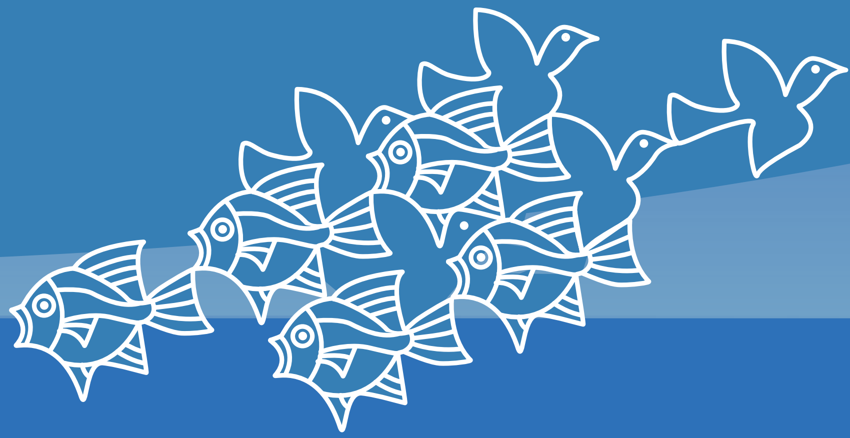

Guide to Teachers' Resource Sheets on Fisheries for Kiribati

Pacific Community
Communauté du Pacifique

TE MAURI TE RAOI AO TE TABOMOA

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).

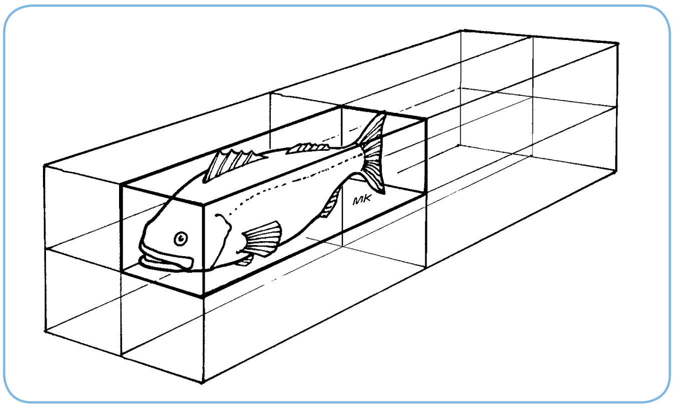
Large female fish produce many more eggs than small fish and are therefore important in maintaining healthy populations. That is why we must leave some large fish in the sea.

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).

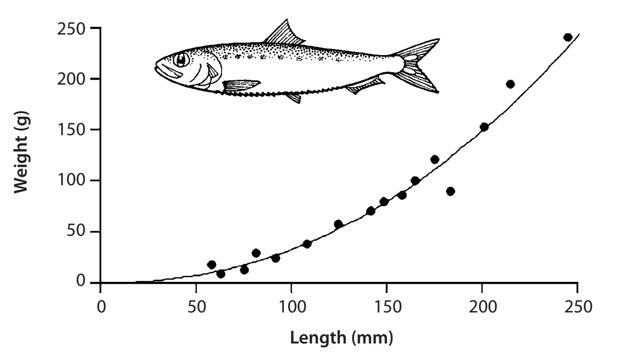
ii. Enter the data on an Excel spreadsheet and prepare a graph relating weight to length as in the example shown in the accompanying figure. Students studying statistics can extend the exercise to include the power curve equation and measures of goodness-of-fit.

The power curve equation is Weight = a (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.

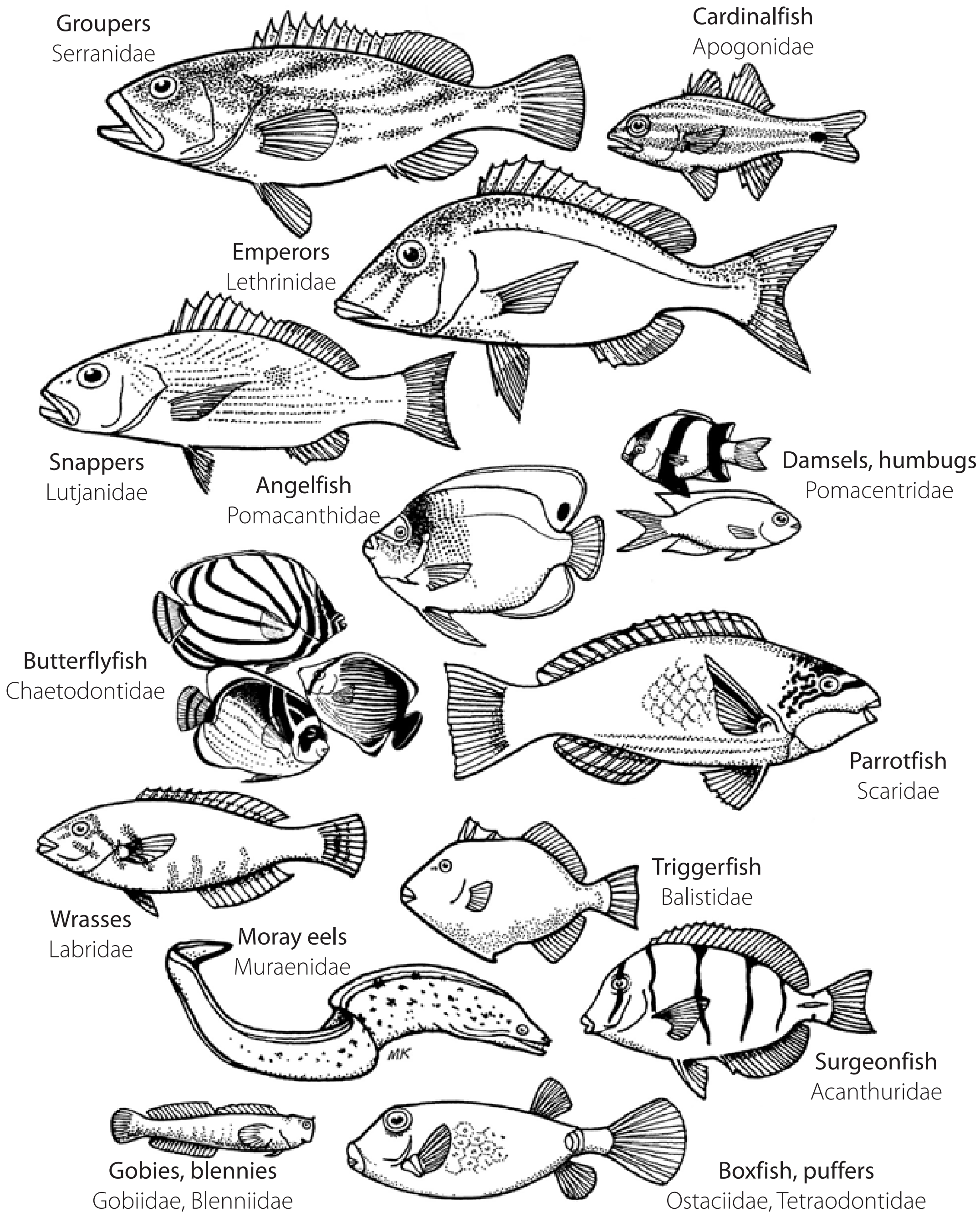
i. Build an Excel spreadsheet using rates of 2%, 3%, 4% and 5%, to calculate when the population will be twice what it is today.

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:

$$N = TC/R$$

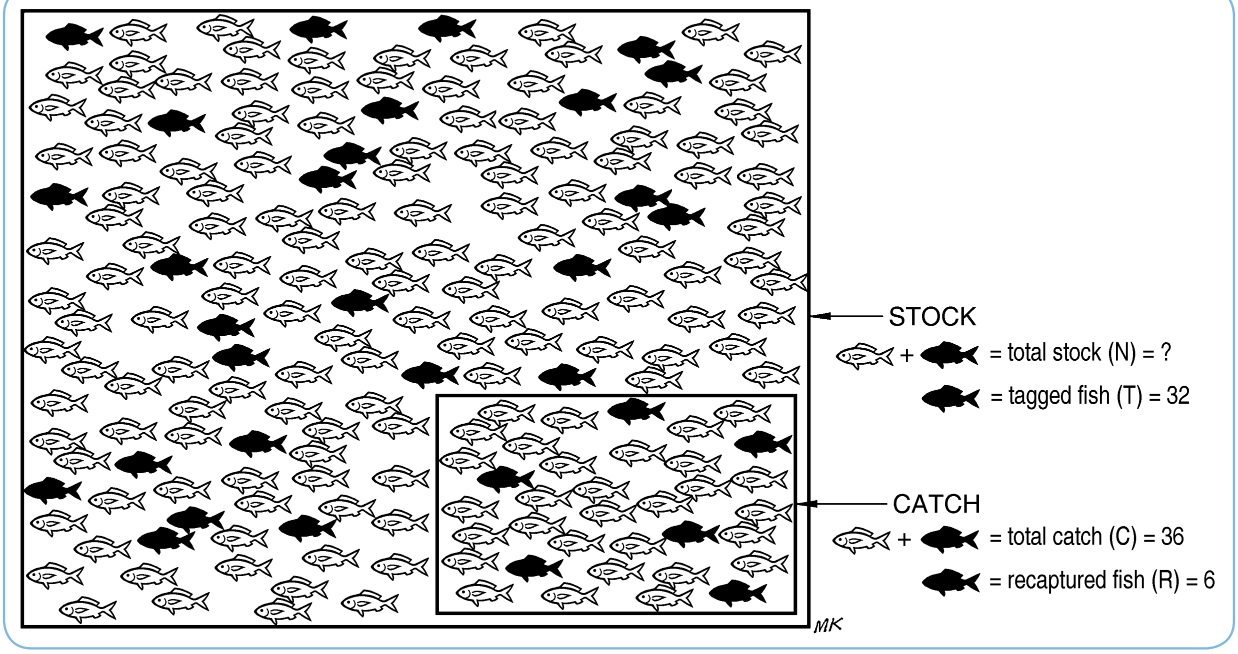
In this instance:

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

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.

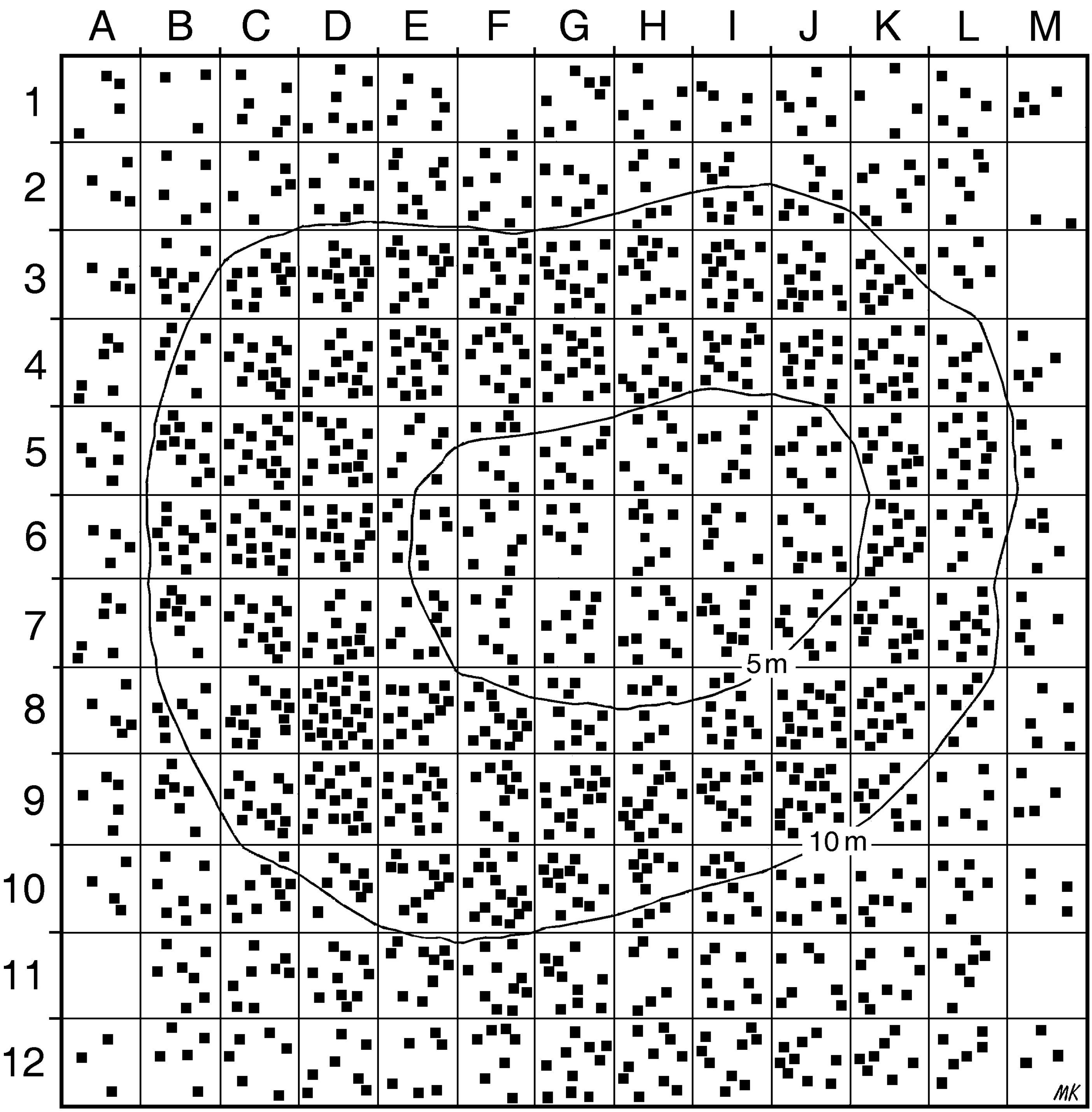
Have each student or student group randomly select six quadrats (the small squares). Statistics students could use random number tables to do this. Otherwise, one student in each group should use a pencil to touch the sheet six times without looking.

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.

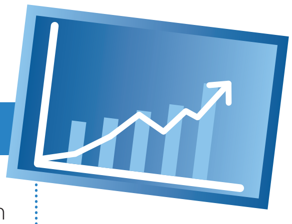
Senior students studying statistics could estimate the population size with 95% confidence limits.



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?

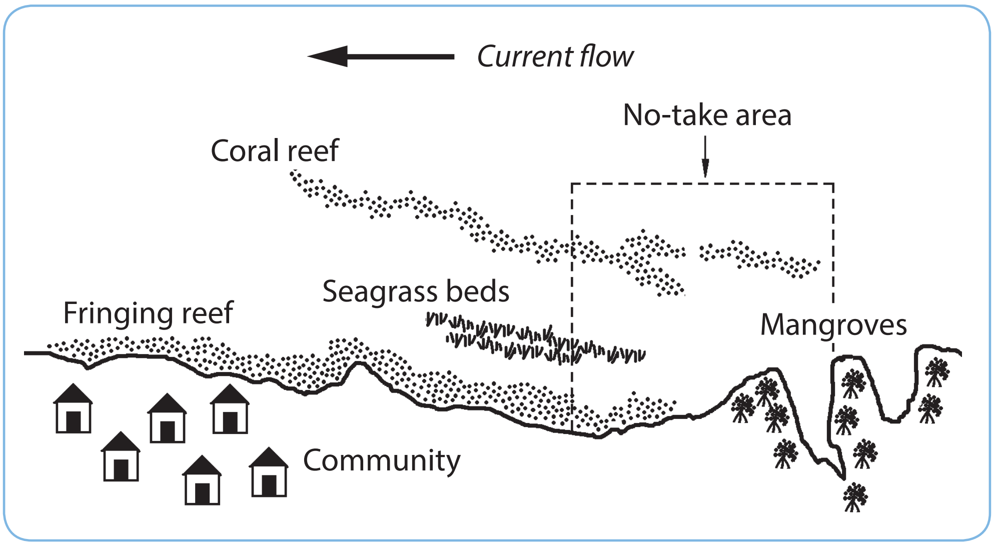
C. The following figure shows a hypothetical, community-managed, no-take area in a Pacific Island country. Show the figure on a screen (from the flash drive supplied as part of the Teachers' Resource Kit). Ask students to discuss the negative and positive aspects of the positioning of the no-take area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

Michael Sharp © SPC

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

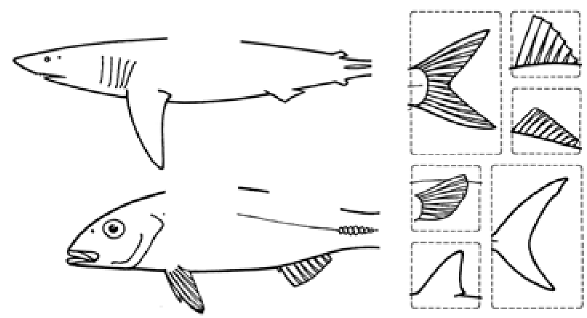
i. identify the fish;

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?



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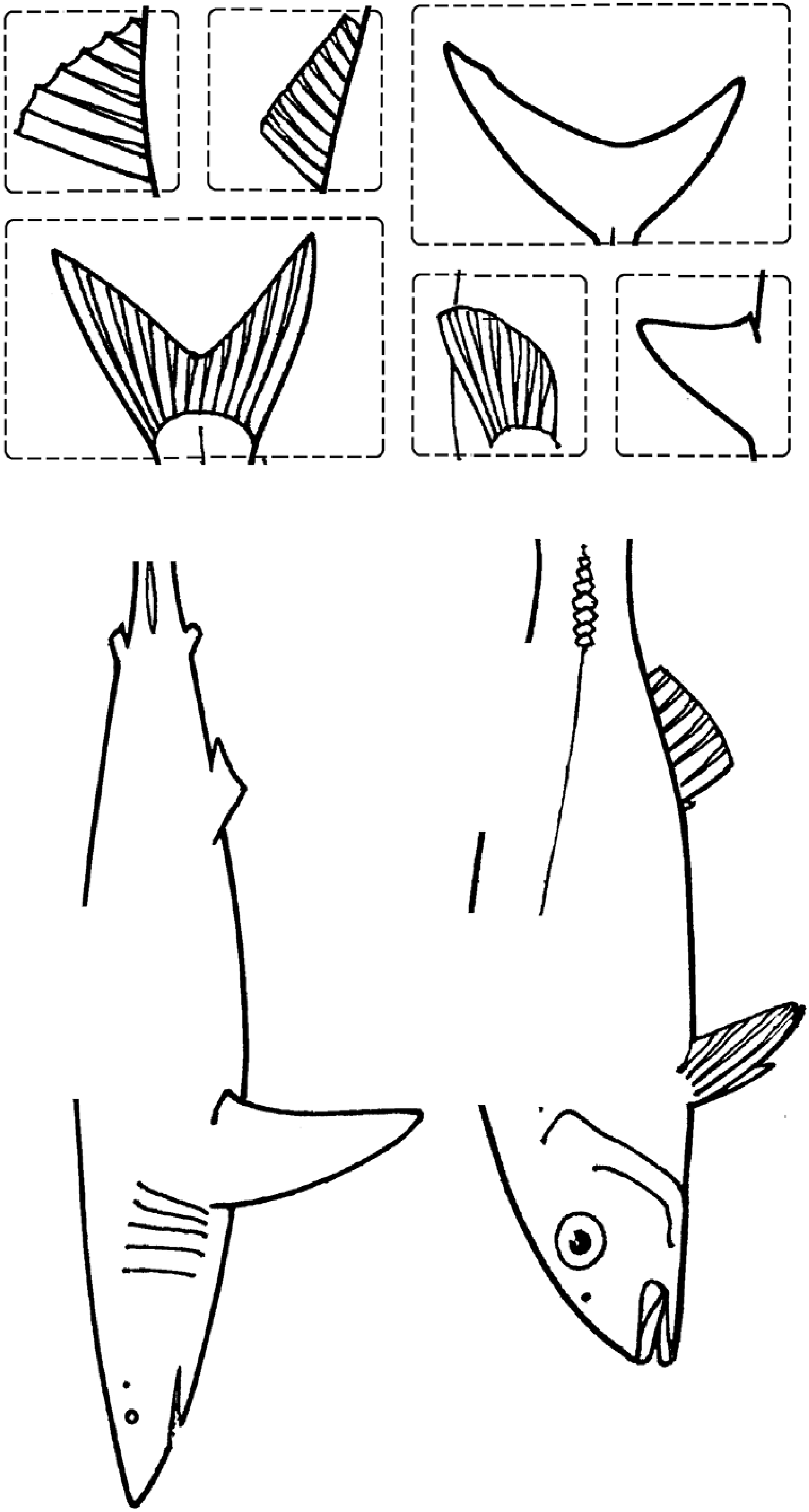


6. Marine food webs

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?

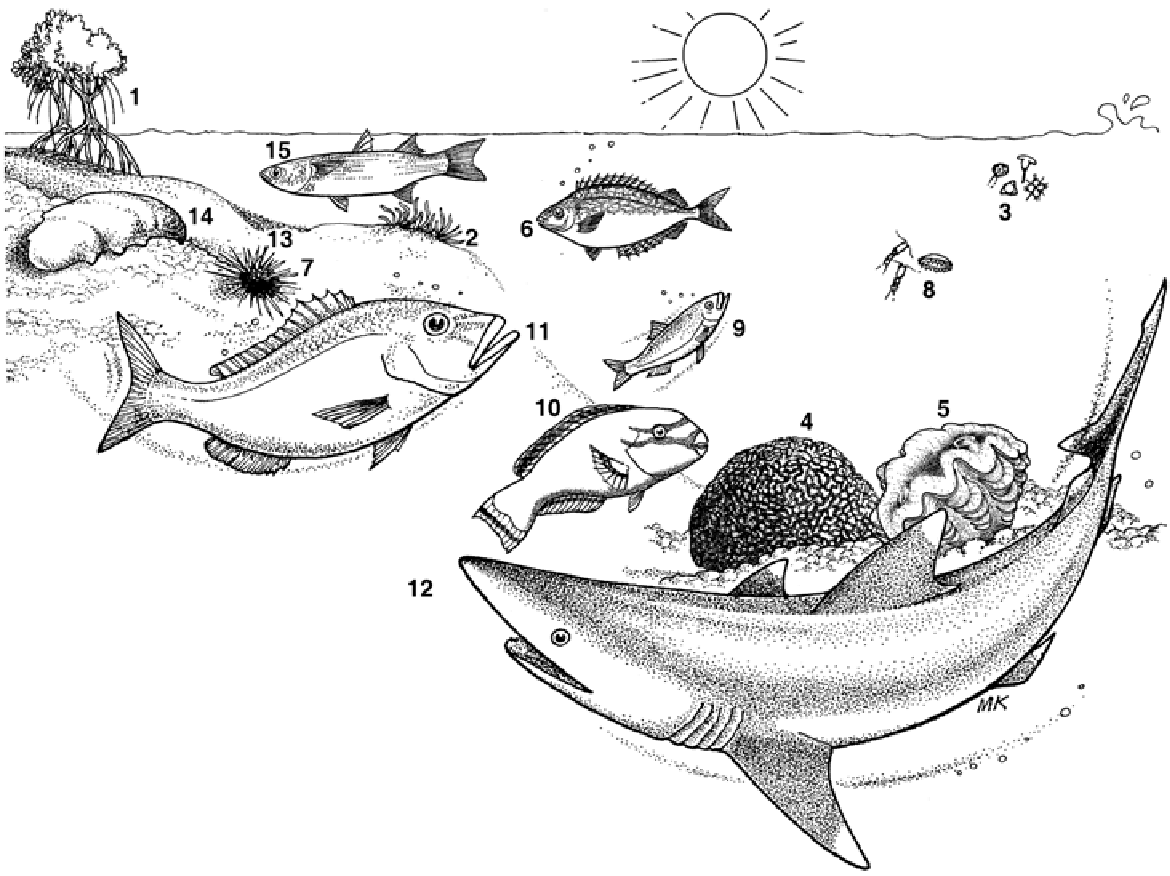
Activities for younger students

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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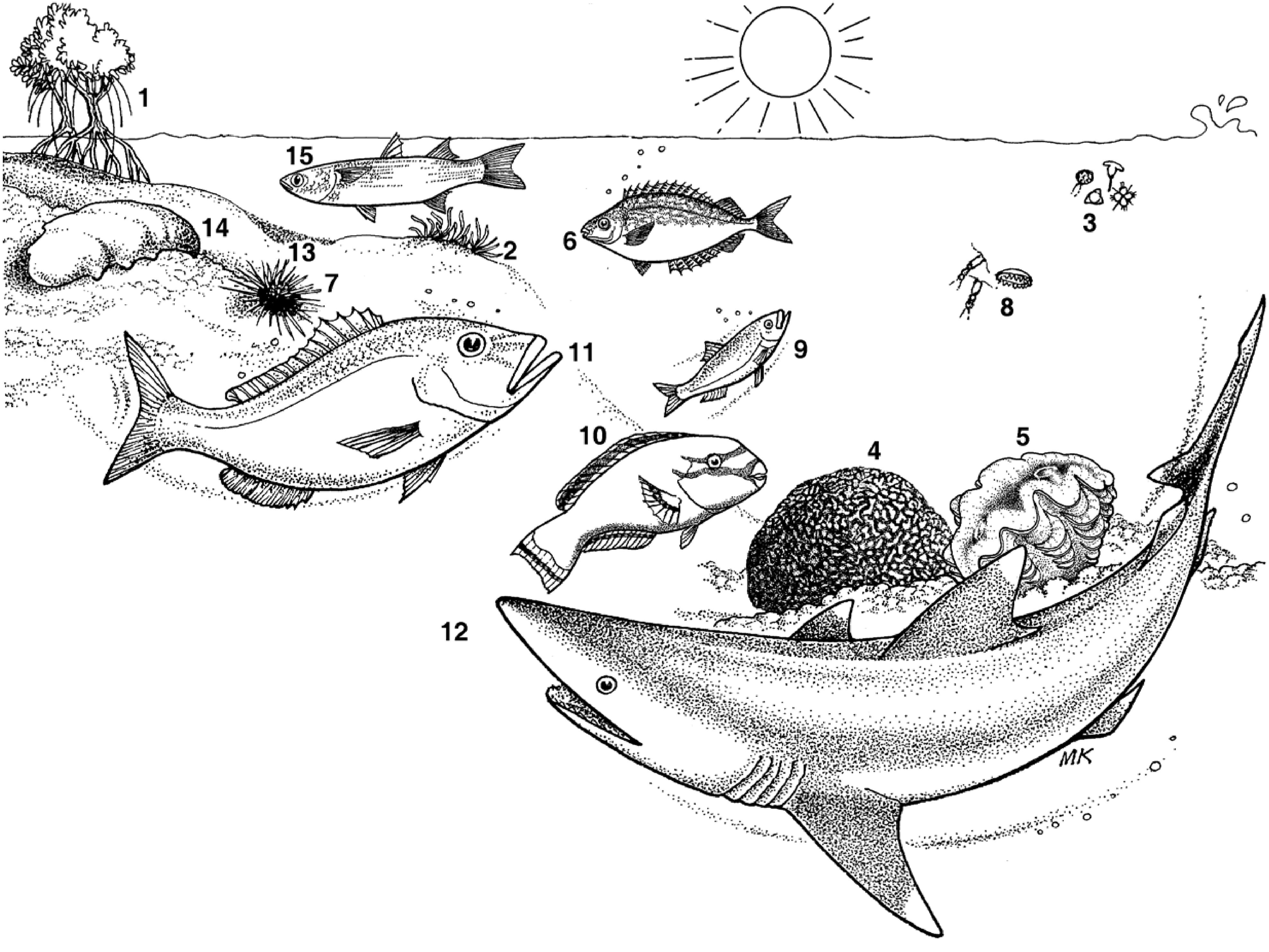
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7. Oceanic species

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.

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

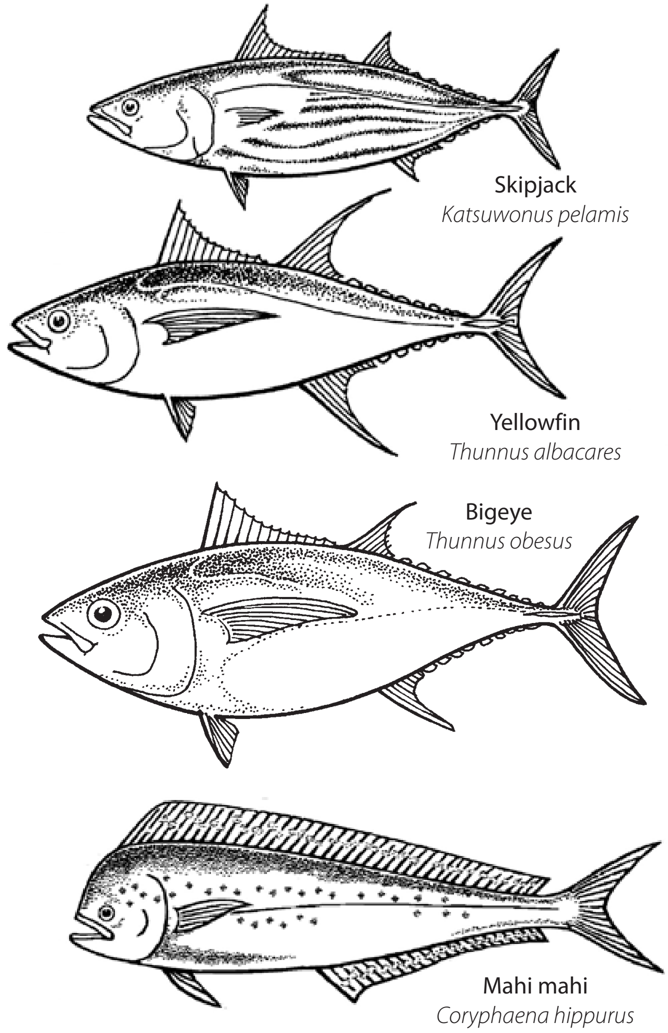
C. Show the figure of the fusiform shape and the fish with counter-shading on a screen (these figures are on the flash drive supplied as part of the Teachers Resource Kit.) Have students discuss the advantages of a fusiform shape. Extend the discussion to other applications of the shape – e.g. the hulls 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.



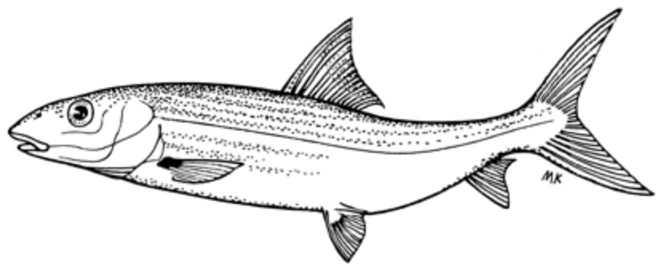
8. Bonefish

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?

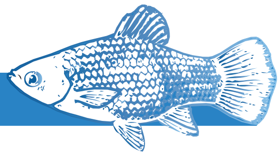
B. Ask students to find out how seaweeds get nutrients and how giant clams and sandfish get their food.

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.

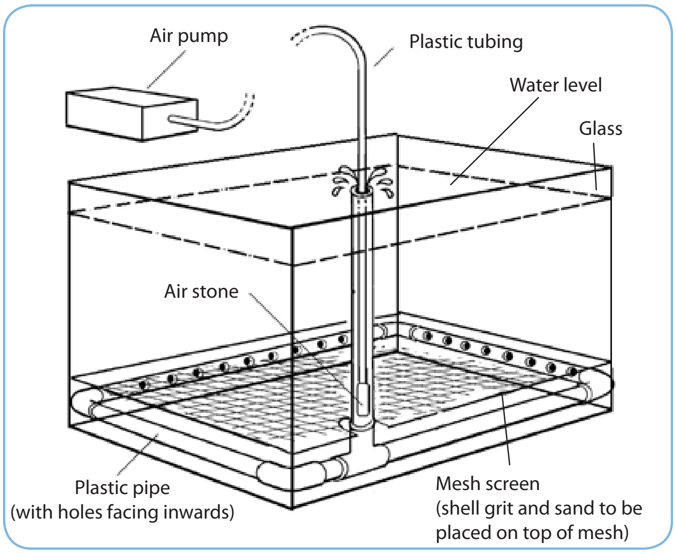
The air-stone must just fit inside the upright pipe. When operating, the air-stone "lifts" and oxygenates the water after it is drawn through the shell-grit and sand, which acts as a filter.

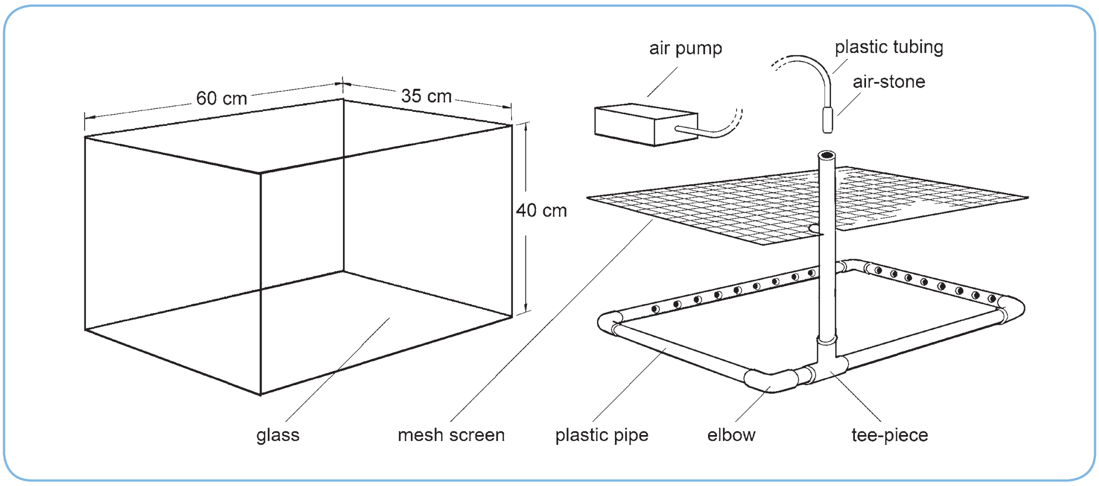
Stock the aquarium with very small sea cucumbers, small crustaceans and small coral fish such as humbugs and damselfish (see illustration earlier in this guide). The water in the aquarium must be changed every two to three weeks.

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.

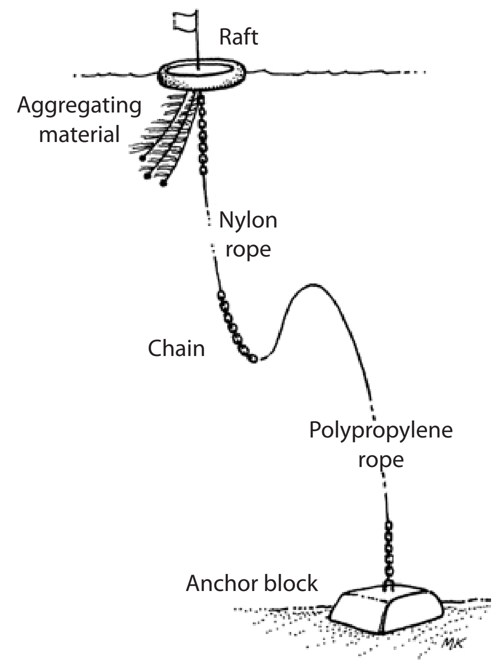
Older students will be able to compare traditional fishing methods with those used currently.

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

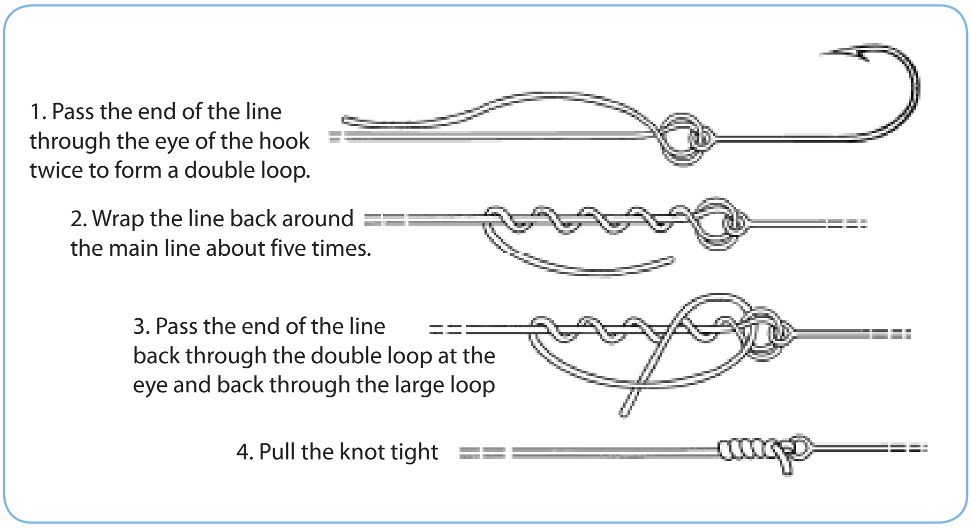
A. Ask students to talk to fishers about modern fishing methods that they use. This exercise should be followed up with a discussion in the classroom and a listing of the number and types of modern fishing methods used by the local community.

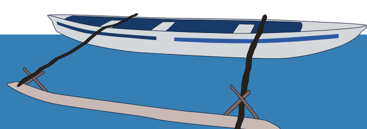
Activities for older students

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);

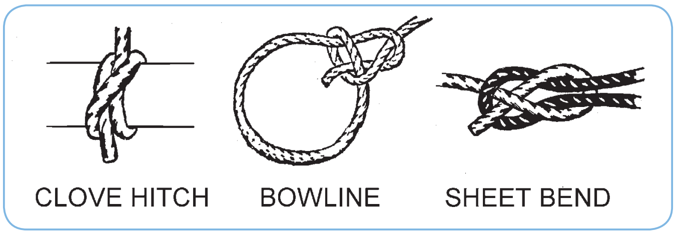
F. How does a sea anchor work and why is it useful to have onboard? (It reduces drift speed in case of engine breakdown and keeps the vessel's bow facing the wind and hence improves vessel stability.)

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).

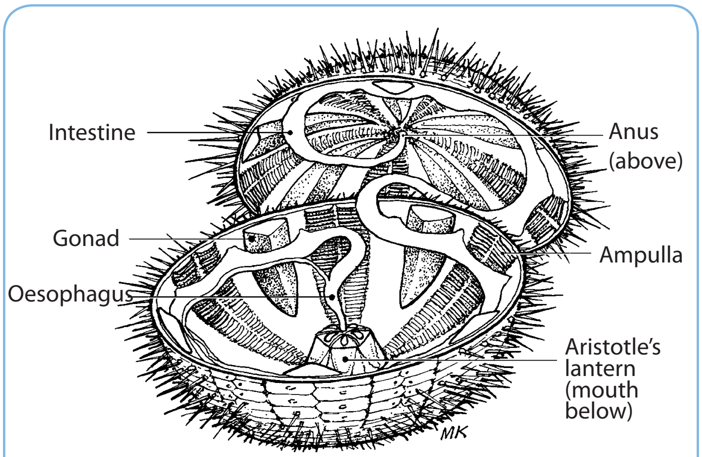
B. Sharks are fished in large numbers for their fins which are used in shark fin soup. Tens of millions of sharks are caught each year and in many cases their fins are removed and the rest discarded. Selling shark is prohibited in Kiribati, so shark fin exports are banned at the national level. Ask students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

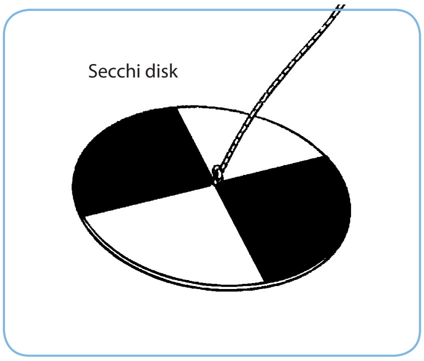
A. A watershed refers to an area of land over which water, dissolved material and sediments flow to rivers and the sea. This run-off often contains nutrients that cause the excessive growth of seaweeds and the appearance of harmful algal blooms (these are described in SPC Information Sheet 28). Ask students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