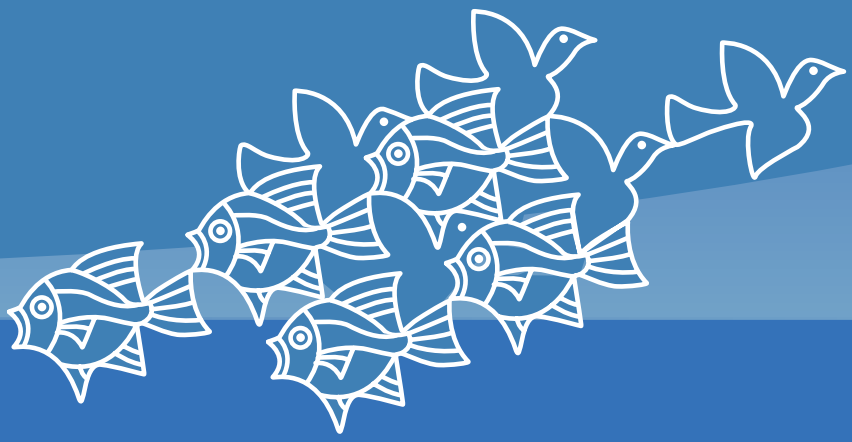

Guide to Teachers' Resource Sheets on Fisheries for Vanuatu

Pacific Community
Communauté du Pacifique

Project co-funded by the European Union

GUIDE to Teachers' Resource Sheets on Fisheries for
Vanuatu

This Teacher's Resource Kit on Fisheries for Vanuatu has been prepared by Mike King, consultant, in collaboration with staff from the Pacific Community (SPC) – Céline Barré, Aymeric Desurmont, Michel Blanc and Timothy Pickering – and with input from local education and fisheries authorities.

Members of the Curriculum Development Unit within the Ministry of Education and Training included Charley Robert, Leisel Masingiow, James Melteres, Felicity Rogers-Nilwo, Fedrick Tamata, Susie Homu and Simon David-Georges working with Jenny Kallie (Australia) and Jane Taurarii (Cook Islands).

Members of the Department of Fisheries within the Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity included Kalna Arthur, Graham Nimoho and Jeremie Kaltavara.

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

- *23 teachers' resource sheets on fisheries;*
- *29 information sheets for fishing communities;*
- *1 'Guide to information sheets on fisheries management for 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: 'Five minutes which can save your life before going out to sea', 'Safety checklist for small boats';*
- *1 marine debris poster: 'The most dangerous species of our coasts and lagoons';*
- *1 deepwater bottom fish poster: 'Dip botom fis blong Vanuatu';*
- *1 invertebrate poster: 'Marine invertebrates of the Pacific Islands';*
- *2 marine resource posters: 'Solwota laef blong Vanuatu' and 'Kostel wota laef blong Vanuatu'; and*
- *1 flash drive (with graphics and photographs).*

This guide includes suggestions for exercises and activities for younger and older students as well as learning outcomes and curriculum links.

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 (1–23) and on the information sheets for fishing communities (1–29). The latter 29 sheets were designed for fishing communities but contain 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.

Sheet #	Topics	Learning outcomes	Current curriculum (Year level/Subject/Topic/Subtopic/Resource)	Reviewed curriculum (Year level/Subject/Strand/Sub-strand)	Information sheet for fishing communities
1.	**Fisheries management**	Younger students identify a range of fish species caught in Vanuatu and explain the importance of fishing sustainably to ensure the availability of resources in the future.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54/71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	2, 3, 4, 5, 6, 7, 8, 9, 14, 16, 21, 24, 25
		Older students: 1. identify the need for fisheries regulations and the range of regulations applied; 2. identify 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.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The Ministry of Agriculture, pages 21–25	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
2.	**No-take areas (*tabu*)**	Younger students identify the cultural significance of *tabu* and its benefits in coastal areas in Vanuatu.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, page 81	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students explain the role of *tabu* and, through field work, discuss the importance of conservation areas in sustaining fish stocks and enhancing ecotourism.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The Ministry of Agriculture, pages 21–25	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
3.	**Fisheries assessment**	Younger students record catches by keeping a 7-day fishing log to assess the fish stock used by their extended family and community.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students explain the importance of stock assessment and monitoring to estimate fish population size by using a 7-day fishing log, fish tagging and quadrat sampling.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
4.	**Fisheries economics**	Younger students explain the importance of fisheries to the household income and the community economy.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students discuss the importance of fisheries to the national economy and the value of fisheries, taking into account costs and returns.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
5.	**Fisheries and climate change**	Younger students identify the impacts of climate change on coastal fisheries.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 13–25	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	20, 25, 26, 27, 28
		Older students explain the impacts of climate change on fishery resources in Vanuatu and other Pacific Island countries and describe appropriate adaptive measures to mitigate the effects.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
6.	**Fish anatomy**	Younger students identify the external features of fish and sharks.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	

		Older students identify the structures and explain the functions of the external and internal parts of fish.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
7.	Marine food webs	Younger students identify the simple food webs of marine species.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	27, 29
		Older students explain marine food webs and the loss of energy in a food chain from plants to top-level carnivores.	**Year level:** Year 8 **Subject:** Science **Topic:** Ecosystem **Subtopic:** Interdependence **Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
8.	Oceanic species	Younger students identify oceanic fish species and distinguish them from reef species.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	2, 3, 4, 5, 6, 7, 8, 9, 15, 17, 18, 19, 20, 21, 23, 29
		Older students discuss morphological and behavioural adaptations of oceanic species such as fusiform shapes, counter-shading and schooling.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
9.	Deepwater snappers	Younger students identify species of poulet in Vanuatu.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	1
		Older students describe the fishery and its importance in Vanuatu's economy and explain regulatory measures.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
10.	Bonefish	None	-	-	
11.	Pearl oysters	Younger students recognise common molluscs as sources of protein, and seashells as material for craftwork.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 38–53	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	10, 11, 16, 22
		Older students investigate common seashell production and harvesting in Vanuatu, and examine the internal anatomy of a bivalve mollusc.	**Year level:** Year 7 **Subject:** Science **Topic:** Living things **Subtopic:** Classification	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
12.	Freshwater species	Younger students identify eels, prawns and tilapia in freshwater sources of Vanuatu.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	

Sheet #	Topics	Learning outcomes	Current curriculum (Year level/Subject/Topic/Subtopic/Resource)	Reviewed curriculum (Year level/Subject/Strand/Sub-strand)	Information sheet for fishing communities
12.	**Freshwater species**	Older students discuss the possible origins of freshwater species in Vanuatu.	**Year level:** Year 7 **Subject:** Science **Topic:** Living things **Subtopic:** Classification	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
13.	**Aquarium fish**	Younger students list the species exported for the aquarium trade.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 38–53	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	10
		Older students discuss the aquarium fish export industry and demonstrate knowledge of building and maintaining an aquarium.		**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
14.	**Vanuatu traditional fishing methods**	Younger students identify the range of traditional fishing methods used in Vanuatu.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	13
		Older students compare traditional fishing methods with those used currently.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
15.	**Modern large-scale fishing techniques**	Younger students identify the range of commercial fishing techniques used in Vanuatu.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students describe a range of commercial fishing techniques used in Vanuatu and worldwide.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
16.	**Fish aggregating devices (FADs)**	Younger students describe fish aggregating devices.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students discuss the use and functions of fish aggregating devices in terms of improving access to offshore fish and increasing the incomes of fishers.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
17.	**Marine aquaculture**	Younger students identify species that are currently farmed in sea water in Vanuatu, and other species that present a potential.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 38–53	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	10, 11, 12, 16
		Older students discuss the biology of farmed marine species and the methods used to farm them in Vanuatu.	**Year level:** Year 7 **Subject:** Science **Topic:** Living things **Subtopic:** Classification	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
18.	**Freshwater aquaculture**	Younger students identify species that are currently farmed in fresh water in Vanuatu, and other species that present a potential.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 54–76	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	

		Older students discuss the biology of farmed freshwater species and the methods used to farm them.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
19.	Fish spoilage	Younger students recognise fish freshness and develop an understanding of the need for personal hygiene when handling seafood.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 67–69	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students explain the action of enzymes and bacteria in relation to food spoilage.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
20.	Fish poisoning and ciguatera	Younger students demonstrate knowledge of ciguatera and identify other marine species involved in poisoning.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 67–69	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	28
		Older students explain the sequence of events leading to fish and molluscs becoming toxic and their effects on humans.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
21.	Sea safety	Younger students demonstrate knowledge on the importance of being prepared before going out to sea in terms of safety measures and equipment.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students explain marine safety measures and the use of safety equipment, including sea anchors, signalling equipment and tying important knots relating to safety and seamanship.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
22.	Job opportunities in fisheries	Younger students identify employment opportunities in the fishing industry.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students explore a wide range of fisheries-related job opportunities in Vanuatu and overseas, including working requirements and conditions.	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	
23.	Financial management of a small fishing business	Younger students investigate the price of a range of seafood species that are sold in their community.	**Year level:** Year 4–6 **Subject:** Science **Topic:** Our environment **Resource:** The sea, pages 71–88	**Year level:** Year 4–6 **Subject:** Science **Strand:** Living things and the environment **Sub-strand:** Biodiversity, relationships and sustainability	
		Older students investigate the fixed and running costs in a fishing business	**Year level:** Year 10 **Subject:** Agriculture **Topic:** The development of agriculture in Vanuatu **Subtopic:** The village projects (fisheries projects)	**Year level:** Year 7–10 **Subject:** Agriculture **Strand:** Fisheries	

Suggestions for exercises and activities related to the 23 Teachers' Resource Sheets on Fisheries for Vanuatu

1. Fisheries management

At the completion of studies:

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

Older students:

1. identify the need for fisheries regulations and the range of regulations applied;
2. identify 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 Vanuatu, fisheries are managed by the Department of Fisheries, which is within the Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB). The Department of Fisheries often works with local communities. Vanuatu is particularly well known for its community-based management programme under which fisheries officers, environmental officers and community members work together to manage fisheries.

Teaching and learning activities for younger and older students

A. The accompanying figure shows some of the most common fish found on coral reefs in Vanuatu.

Investigate the vernacular name for each type of fish and indicate which ones are commonly caught for food in your community.

B. Request the Department of Fisheries to have an officer talk to students about fisheries management and describe the regulations that are applied to ensure the sustainability of fish stocks.

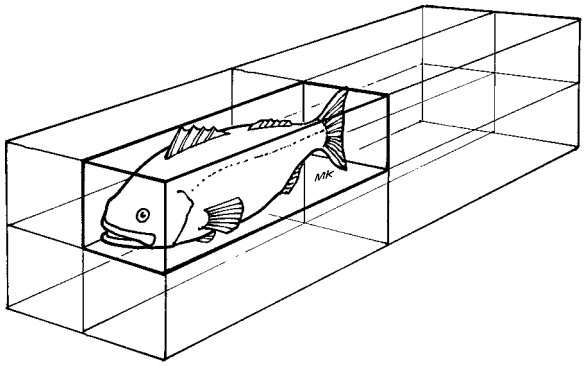
Alternatively, ask a village elder or a *Vanuatai* Resource Monitor to talk about the same subject.

For example, why is it important to have regulations on catching coconut crabs? Regulations can include leaving small individuals in the sea (size limits), setting up no fishing or tabu areas and closing some seasons to fishing.

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, how much does volume and, therefore, 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.



Teaching and learning 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.

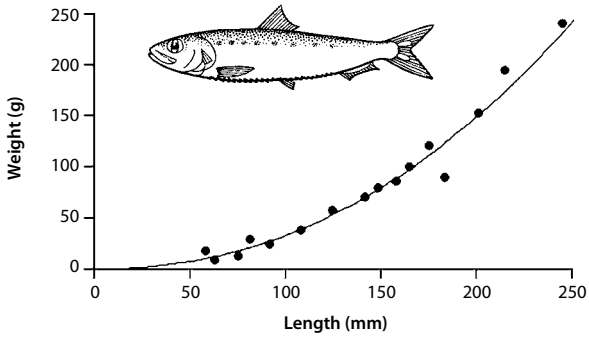
If the fish doubles in size to 60 cm, $V = 60^3$, or 216,000 cubic centimetres.

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 Vanuatu is low (2.01% estimated in 2014) the rate in many other Pacific Island countries is as high as 4% each year.

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

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

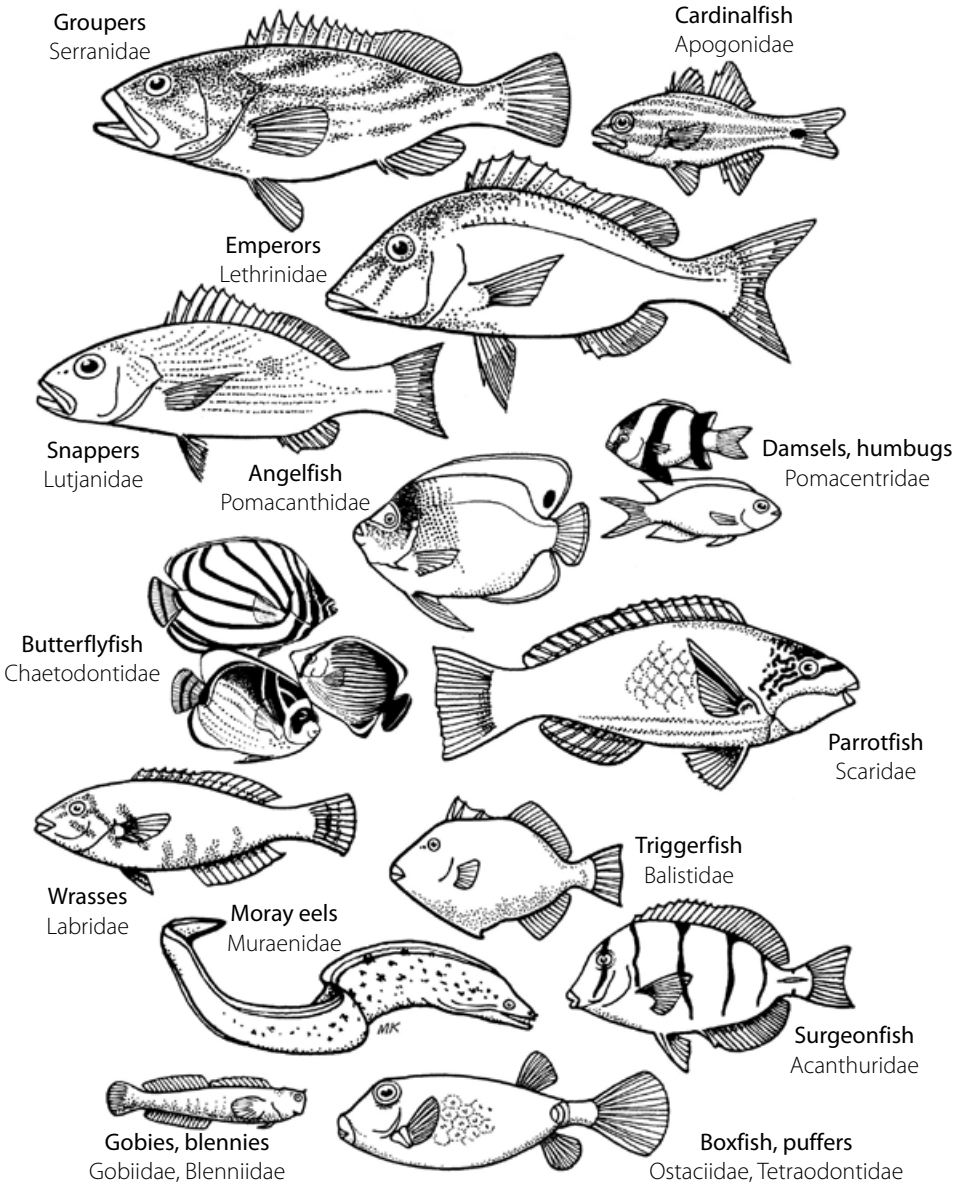
F. Besides overfishing, or catching too many fish, there are many other threats to fisheries. These include pollution*, the release of sewage, coastal development, and reclamation (refer to Information sheet for fishing communities 27: Nutrients and sediments, and 28: Harmful algal blooms).

Sea water in Port Vila harbour and the lagoons is believed to be highly polluted. The probable cause of the high pollution is the lack of sewerage systems and the poor management of many individual septic tanks*. Coastal development, including the construction of houses and hotels, may result in the siltation of coastal waters and sewage entering the sea.

Ask students to investigate the ways in which the local marine environment is being harmed.

i. Should excessive development be controlled? Are trees left on the banks of rivers and coastlines? Is garbage disposal satisfactory? Is sewage treatment adequate?

ii. Are large shoreline hotels required to build treatment plants for sewage?



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. No-take areas (*tabu*)

At the completion of studies:

Younger students identify the cultural significance of *tabu* and its benefits in coastal areas in Vanuatu.

Older students explain the role of *tabu* and, through field work, discuss the importance of conservation areas in sustaining fish stocks and enhancing ecotourism.

Vanuatu is well known for its protection of marine areas by declaring *tabu* areas in which fishing is banned or restricted. The Department of Fisheries estimates that over 200 communities have declared some type of *tabu* areas – some that are permanently closed and others that are closed at particular times of the year. These restrictions on fishing are imposed by traditional leaders to ensure that seafood resources are sustainable.

Teaching and learning activities for younger students

A. Ask a community elder to explain to students the history and benefits of *tabu* areas. How are decisions to set up a *tabu* area made? How is a *tabu* area marked? What are the punishments handed out to those who break the rules? What are the likely benefits of having an area closed to fishing?

Note: The photograph on the front of the Teachers' resource sheet 2: No-take areas (*tabu*) shows a pole and leaf that signifies a *tabu* area.

Teaching and learning activities for older students

B. Ask students to either talk to older people in their community or locate a *tabu* area in which fishing is banned. Find out the rules for the *tabu*. Ask how long the *tabu* has been in operation. Has it been successful? Do all people obey the *tabu* rules? What happens when the *tabu* area is opened?

C. Arrange for students to swim with masks and snorkels along a transect in a safe area of a lagoon (if possible and if permitted, do this within a *tabu* area). Record the numbers and types of fish seen in a band width of 5 m (two and a half metres each side of the swimmer, as in the figure on the front of the Teachers' resource sheet 3: Fisheries assessment). If possible, compare results from transects inside and outside a *tabu* area.

D. The following figure shows a hypothetical, community-managed, no-take area in a Pacific Island country. Show the figure on a screen (from flash drive supplied as part of the Teachers' Resource Kit).

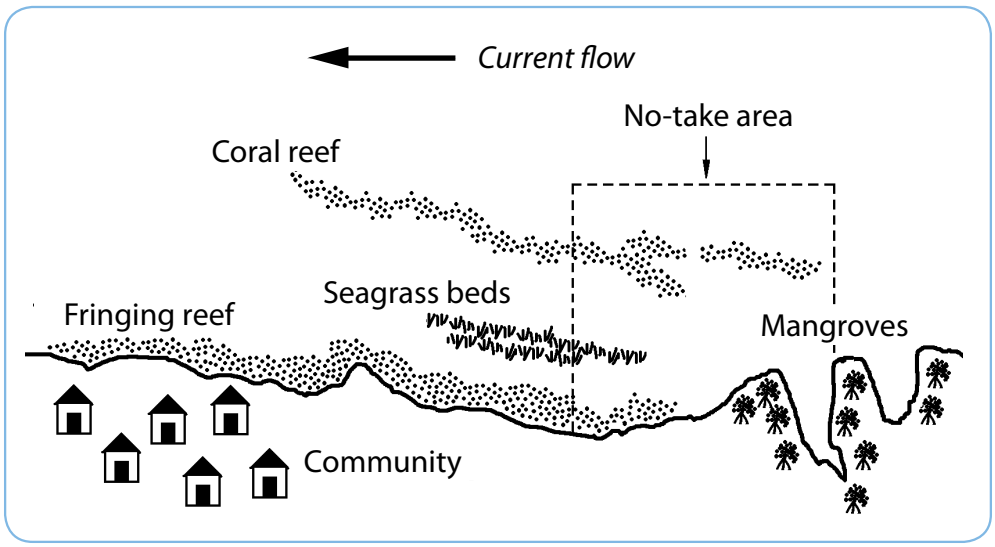
Ask students to discuss the negative and positive aspects of the positioning of the no-take area shown.

A negative point 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 out into the fished areas where they can settle and grow into adults that can be caught.



3. Fisheries assessment

At the completion of studies:

Younger students record catches by keeping a seven-day fishing log to assess the fish stock in their extended family or community.

Older students explain the importance of a stock assessment and monitoring to estimate fish population size by using a seven-day fishing log, fish tagging and quadrat* sampling.

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

Teaching and learning activities for younger students

A. Ask students to identify the common Vanuatu reef fish from the figure shown earlier in this guide, and identify oceanic fish from the poster 'Dip botom fis blong Vanuatu' supplied by the Department of Fisheries.

Teaching and learning 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 the other marine species harvested from the sea.

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

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.

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 10 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. Discuss methods of tagging of marine species by using the figure in the Teachers' resource sheet 3: Fisheries assessment. 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 individuals. The stock size may be estimated by assuming that the ratio of tagged fish (T) in the stock (N) is equal to the ratio of recaptured tagged fish (R) in the catch (C). That is:

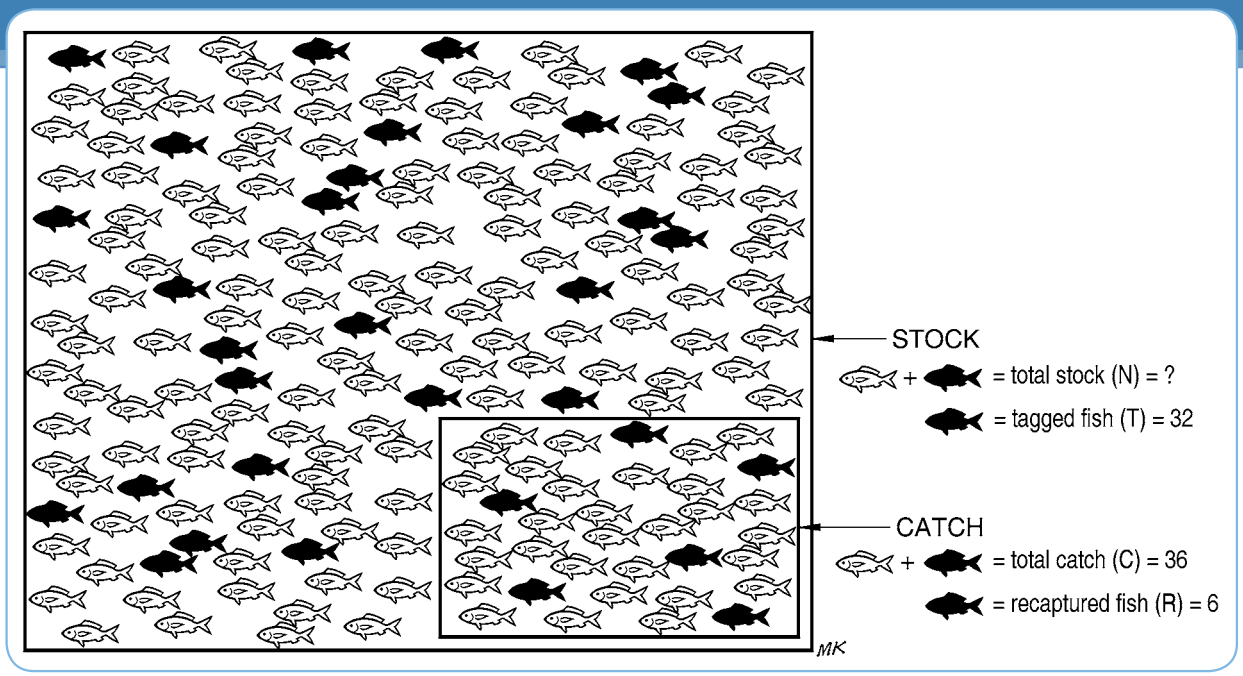
$$T/N = R/C$$

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

$$N = TC/R$$

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 being met:

1. the tagged individuals must be distributed randomly over the population;
2. there must be no loss or gain of individuals during the experiment; 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 (see Teachers' resource sheet 3: Fisheries assessment) 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. The following 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 onto A4 sheets, one for each student or student group.

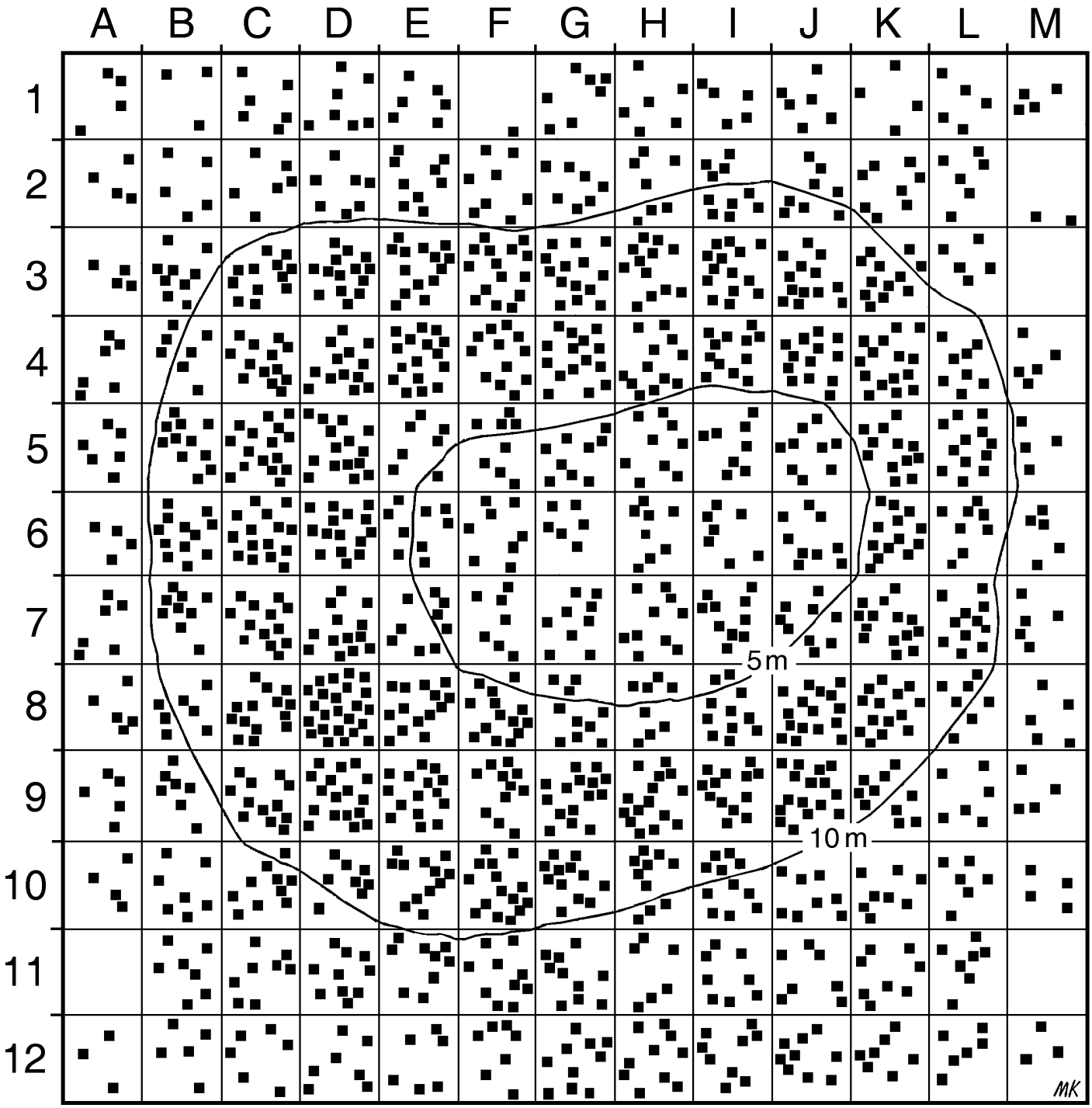
Have each student or student group randomly select six quadrats (the small squares; e.g. B2, G5, H10, K8, L1 and M9). Statistics students could use random number tables to do this. Otherwise, one student in each group should use a pencil to touch the sheet six times without looking.

Count the number of sea cucumbers (small black squares) 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 of sea cucumbers per quadrat.

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

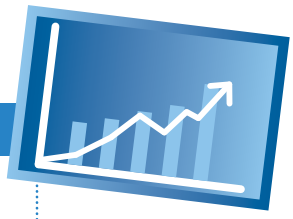
As a preferred method, sample along a transect; for example, by selecting every second small square along column G. Have students discuss why this method is likely to be more accurate.

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



The distribution of sea cucumbers (square black squares) 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.



4. Fisheries economics

At the completion of studies:

Younger students explain the importance of fisheries to the household income and the community economy.

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

Teaching and learning activities for younger students

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

Teaching and learning activities for older students

B. Ask students to examine the value of different fisheries in Vanuatu. Which fisheries are the most valuable? Ask students to identify subsistence fisheries and commercial fisheries on their island. Discuss how Vanuatu and its people benefit from these fisheries.

5. Fisheries and climate change

At the completion of studies:

Younger students will be able to identify the impacts of climate change on coastal fisheries.

Older students will be able to explain the impacts of climate change on fishery resources in Vanuatu and other Pacific Island countries, and describe appropriate adaptive measures to mitigate the effects.

Teaching and learning activities for younger and older students

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

B. Ask students to explain how the mangrove ecosystem can mitigate and adapt to the adverse effects of climate change (Information sheet for fishing communities 25: Mangroves).

Michael Sharp © SPC

6. Fish anatomy

At the completion of studies:

Younger students identify the external features of fish and sharks.

Older students 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.

Teaching and learning 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.

Teaching and learning 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

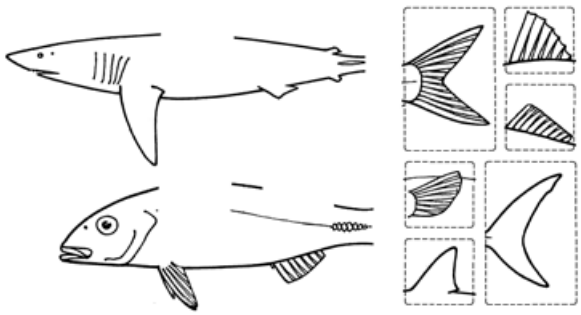
i. identify the fish;

ii. dissect each fish by carefully exposing the internal organs as shown in the figure on the Teachers' resource sheet 6: Fish anatomy; and

iii. make a labelled drawing (use the figures on the Teachers' resource sheet 6: Fish anatomy as a guide; show the figures on a screen using the flash drive supplied as part of the Teachers Resource Kit).

Ask students to label the important parts of the fish and give their function. Then, have students answer the following questions:

- Is the dissected fish an herbivore or a carnivore? (Have students examine the length of its intestine and the type of teeth it has.)
- How does a fish 'breathe'?
- How does a fish move through the water?



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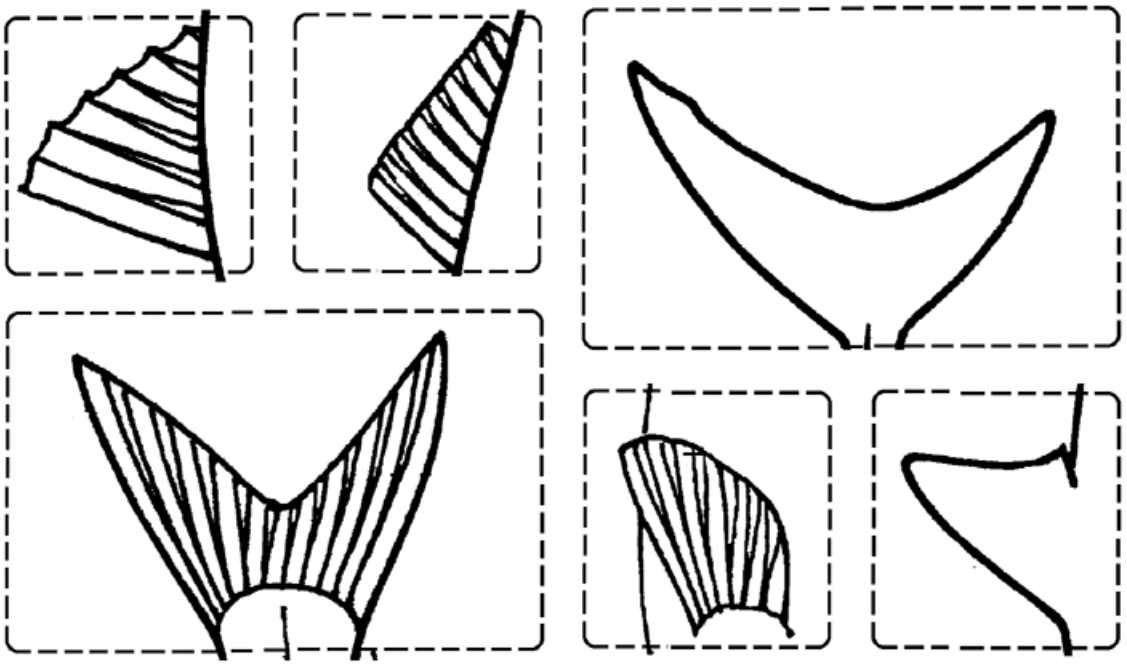
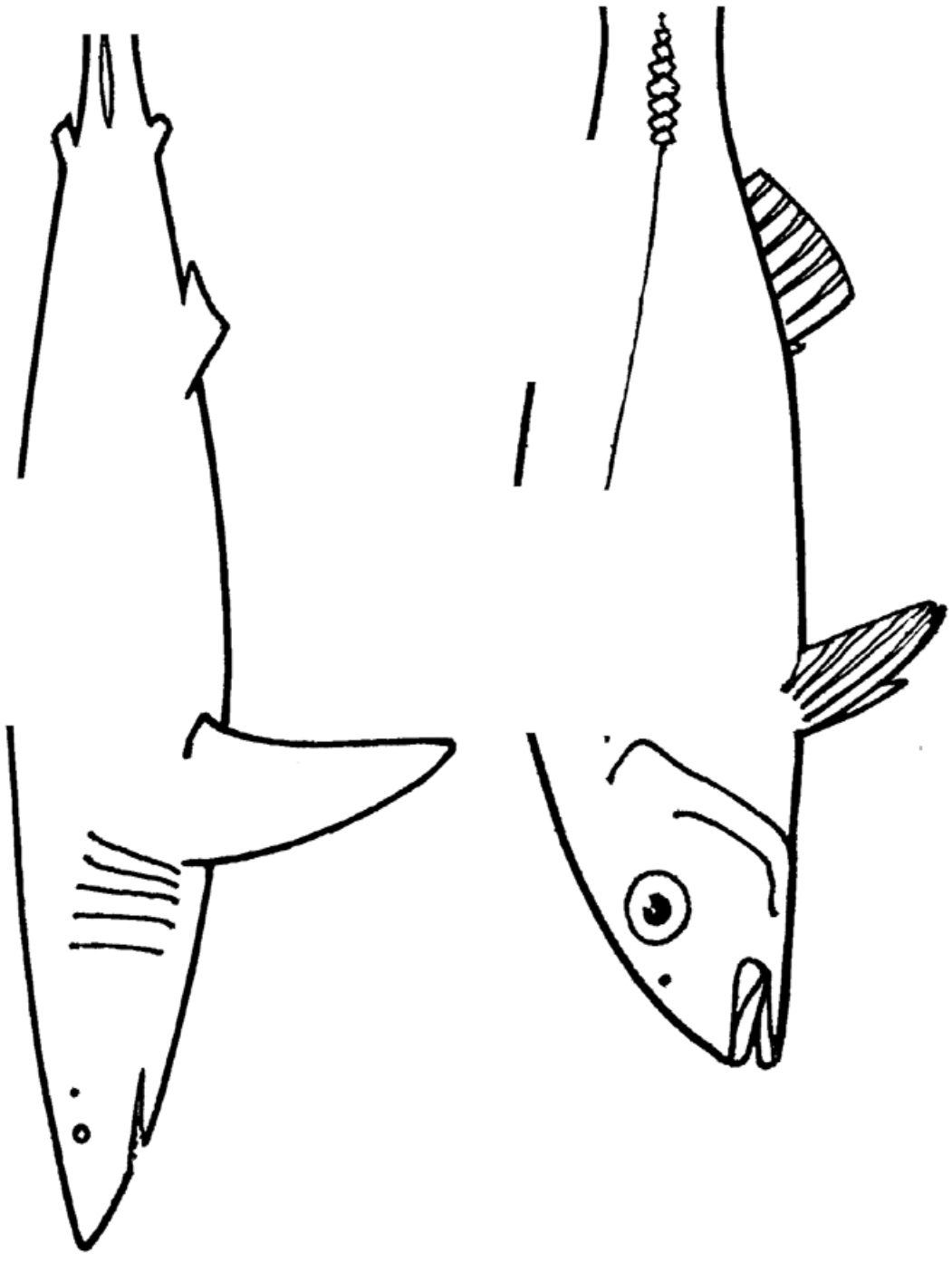




7. Marine food webs

At the completion of studies:

Younger students identify the simple food webs of marine species.

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

Most students will have some idea of the range of species in coastal areas of Vanuatu. These exercises are meant to make students aware of the connections between species; in other words, what eats what?

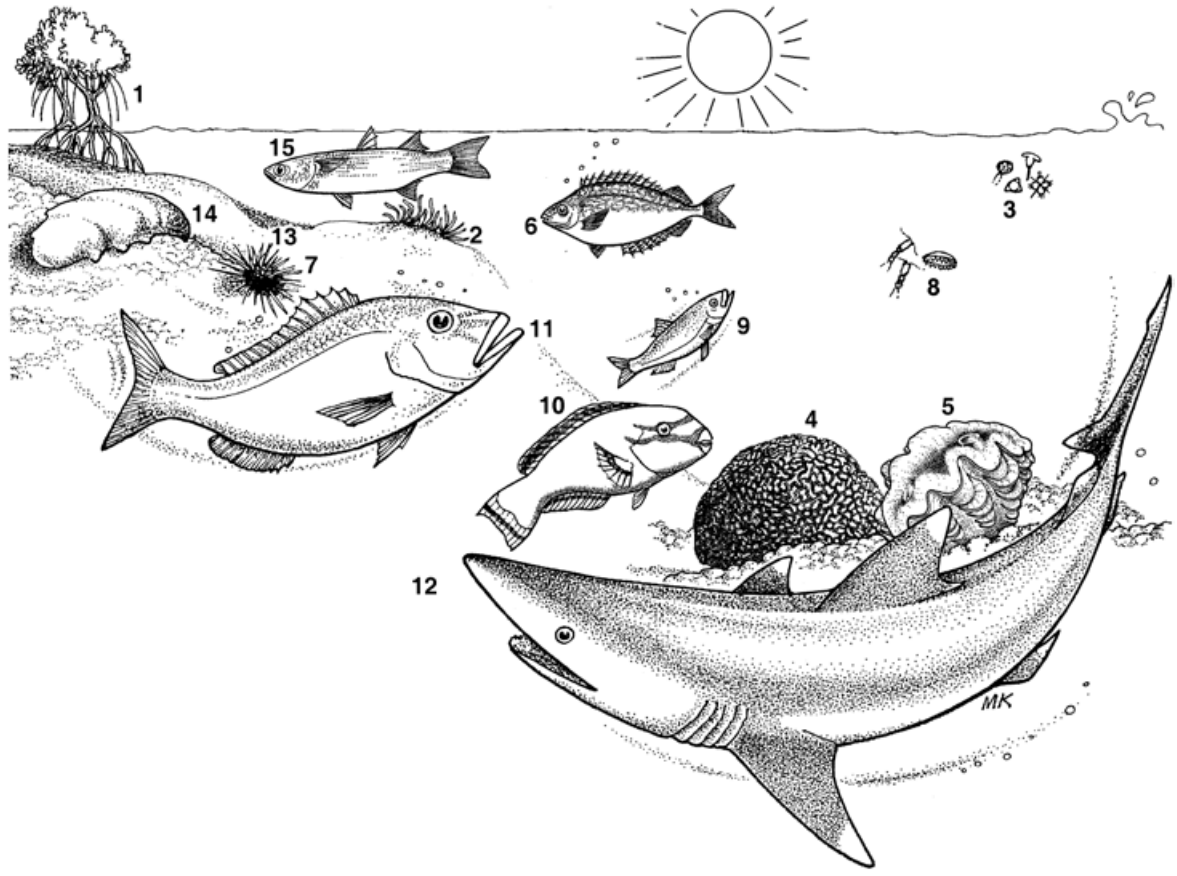
Teaching and learning activities for younger students

A. Ask students to draw common local fish and place them in a food web like the one shown in the accompanying illustration on the Teachers' resource sheet 7: Marine food webs. What does a rabbitfish eat? What does a parrotfish eat? What does an emperor eat?

Teaching and learning activities for older students

B. Discuss the energy pyramid shown in the Teachers' resource sheet 7: Marine food webs. 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 the Teachers' resource sheet 7: Marine food webs, but the connecting lines have been removed. Have students discuss primary production* (the use of sunlight, carbon dioxide and nutrients by plants) and predator-prey relationships (what eats what?). Also ask students to connect the living things (as well as detritus) to one another by drawing a line.



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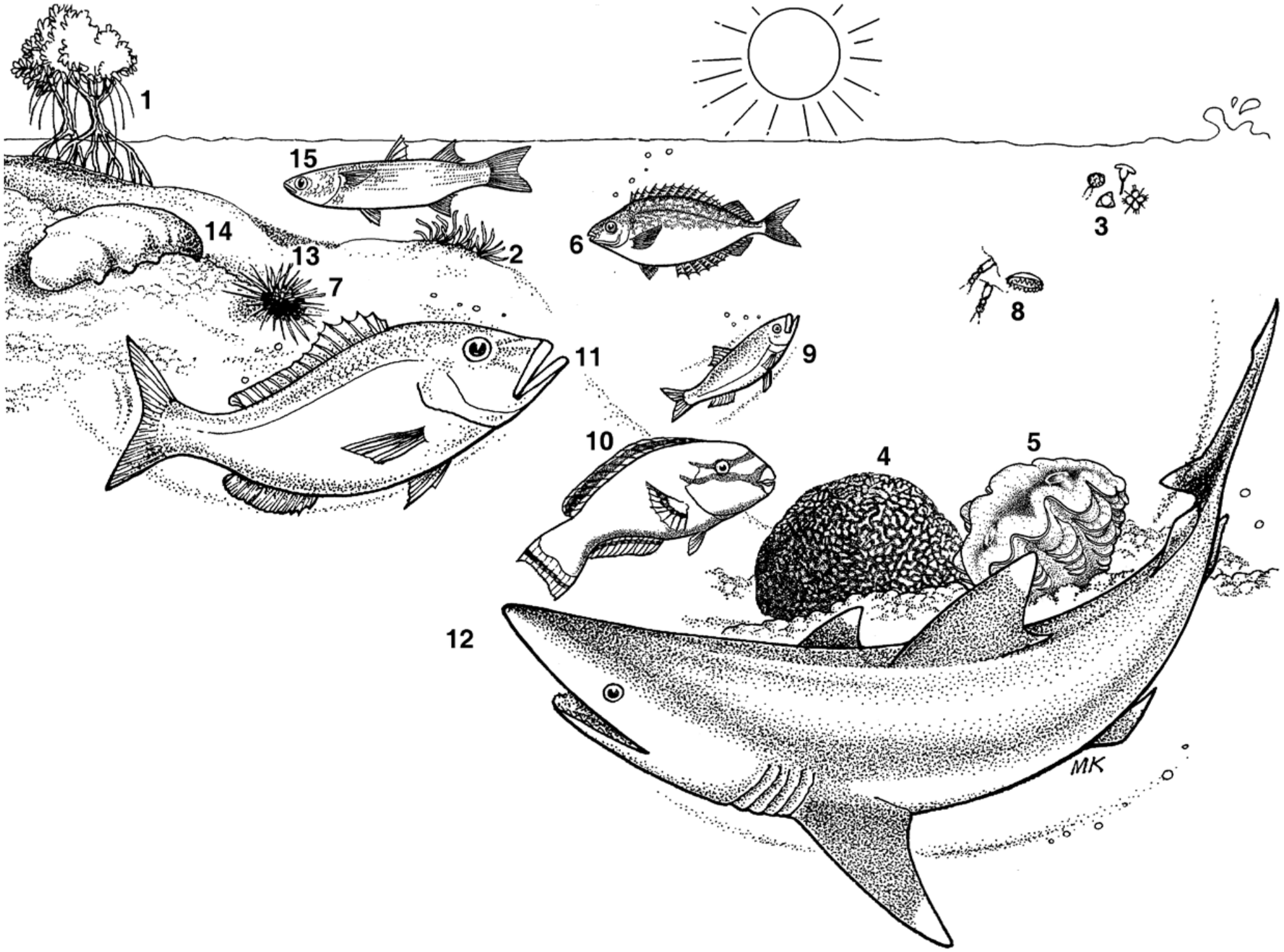
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8. Oceanic species

At the completion of studies:

Younger students identify oceanic fish species and distinguish them from reef species.

Older students discuss morphological and behavioural adaptations of oceanic species such as fusiform shapes, counter-shading and schooling.

Vanuatu shares its maritime borders with New Caledonia, Solomon Islands, and Fiji. The undisputed portion of Vanuatu's exclusive economic zone (often referred to as 'EEZ') covers 680,000 km^2 of sea. Pelagic* fish caught in Vanuatu's EEZ are for both local food and export, and include yellowfin tuna, skipjack tuna, albacore tuna, marlin, wahoo and mahi mahi.

The Department of Fisheries determines a total allowable catch* for each of the major species of tuna and issues a number of fishing licenses.

Teaching and learning 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 identify each of the fish in Bislama (e.g. mai mai for mahi mahi, and local names if appropriate).

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

Teaching and learning 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).

   Ask students to:

   i. discuss the advantages of a fusiform shape. Ask what human made objects use this same shape (e.g. the hulls of outrigger canoes and the bulbous bows on large sea-going vessels).

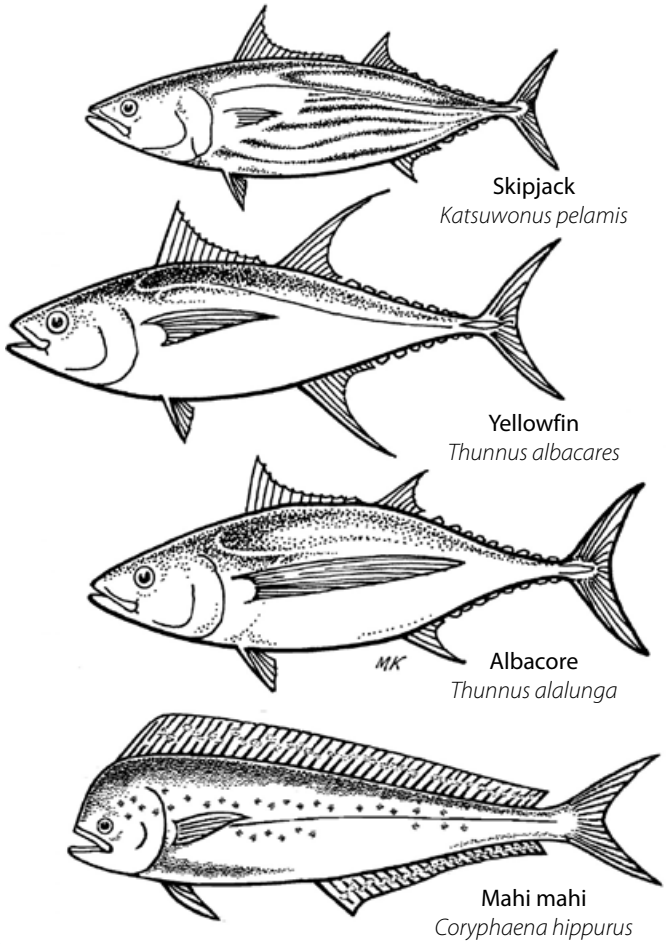
   ii. explain the purpose of counter shading in fish.

Teaching and learning 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 the same shape as a fish?

E. In groups, ask students 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 of the species offered for sale, and include their estimated weights and price per kg. Interview fish sellers to find out where each species comes from and how the availability of the marketed species varies seasonally.



9. Deepwater snappers

At the completion of studies:

Younger students identify species of *poulet* in Vanuatu.

Older students describe the fishery and its importance in Vanuatu's economy, and explain regulatory measures for *poulet*.

Teaching and learning activities for younger students

A. There is a range of deepwater species of fish or *poulet* caught in Vanuatu and these are illustrated in the 'Dip botom fis blong Vanuatu' poster.

   Ask students to indicate species of *poulet* on the poster.

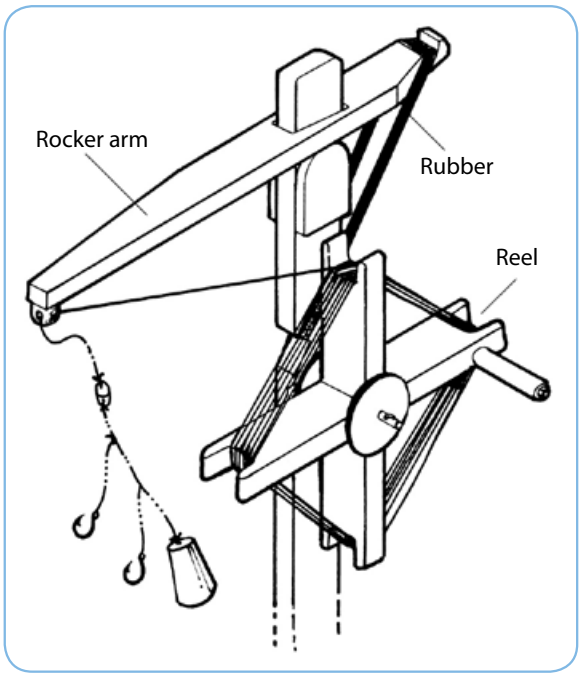
Teaching and learning activities for older students

B. Most small boats that go fishing for *poulet* are fitted with the wooden hand reel to haul in fishing lines from deep water (see accompanying figure). Ask students to visit a fishing boat and study the cleverly designed hand reel. Why is the rocker arm free to move up and down? What is the purpose of the rubber strap? (Powerful fish such as *poulet* can break a taut line unless it has some elasticity.)

C. Pressure on a fish at the surface of the sea is due to the weight of the column of air above the fish. Because water is about 800 times heavier than air, pressure increases rapidly with increasing depth. In fact, pressure increases by one atmosphere* with each 10 m of depth. Thus, at about 10 m below the surface, the water exerts twice the pressure on the fish as air does at the surface. Some deepwater *poulet* may be caught at about 200 m where the pressure is 20 times that at the surface.

   Consider what would happen to the swim bladder of a fish caught at 200 m as it is hauled to the surface (see Teachers' resource sheet 6: Fish anatomy).

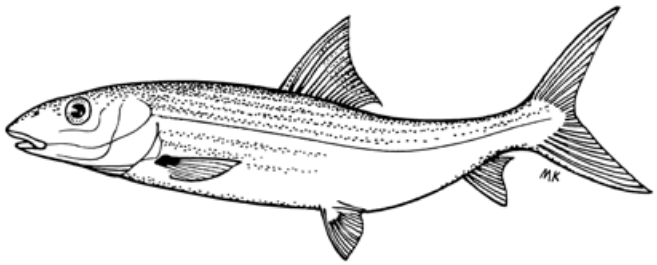
The Department of Fisheries sets rules to conserve stocks of *poulet* and ensure that they are not overfished. One regulation is that fishers cannot use a dropline with more than 10 hooks attached to it. Why would a minimum size limit and returning smaller fish to the sea be an unreasonable conservation measure?



10. Bonefish

Bonefish are found in Vanuatu but are not exploited the way they are in some other parts of the Pacific Islands region. This sheet could be used to show how sport fishing for bonefish is benefiting some island countries such as the Cook Islands.

Flyfishing* for bonefish brings foreign exchange to the Cook Islands. Sport fishers, mostly tourists, are required to have a permit and to fish only in designated areas. Fishing in spawning areas and nurseries is prohibited from three days before until three days after the new moon. A spawning area is an area where fish gather to reproduce; a nursery is an area where very young fish settle to grow and hide from predators. Most sport fishers take a photograph of their catch and release it quickly to give it the best chance of survival. Sport fishing is, therefore, an eco-friendly tourism activity.



11. Pearl oysters

At the completion of studies:

Younger students recognise that common molluscs are sources of protein*, and explain that their attractive shells are used in handicrafts.

Older students investigate common seashell production and harvesting in Vanuatu and examine the internal anatomy of a bivalve mollusc.

Pearl oysters are collected from Vanuatu's reefs for food but they are not farmed for the production of pearls as they are in some other Pacific Island countries. Many other molluscs are collected for food and the shells of some are used in handicrafts (see accompanying figure).

The green snail is sought after both for food and its valuable shell, but the green snail has has been fished to near extinction in Vanuatu. In 2005, a ban was placed on collecting green snails. The Department of Fisheries has moved adult green snails to depleted areas, and green snails are now showing signs of recovery.

Teaching and learning activities for younger students

A. Collect a quantity of molluscs, recognise the edible ones and keep the ones with a pearly layer inside the shell, such as a pen shell, trochus or pearl oyster.

   The shells should be broken up by the teacher and a small piece of broken shell (about the size of a 50 vatu piece) given to each student. Ask each student to make a small necklace pendant from their broken piece of shell. Each student will need some coarse sandpaper to shape their piece of shell. A hole could be drilled (using a nail) into the shell by the teacher so that the student can put the shell on a string to wear as a pendant.

Teaching and learning activities for older students

B. Ask students to find out how molluscs eat. Most two-shelled (bivalve) molluscs, such as the ark shell, eat by filtering out microscopic plants (phytoplankton*) from the surrounding water. Many gastropods (single-shelled sea snails) are carnivores. The helmet shell, for example, hunts and eats sea urchins.

C. Ask students to investigate how some seashells produce pearls. How are pearls formed? Why is pearl shell so glossy on the inside?

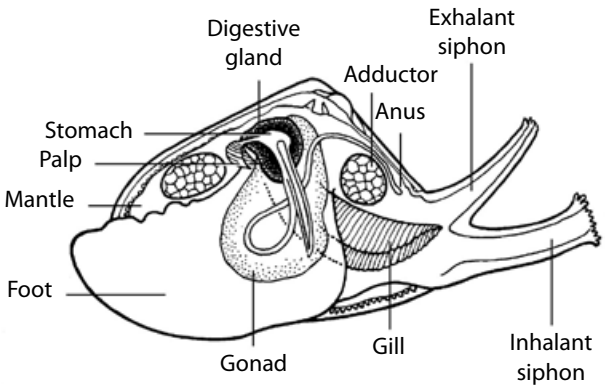
D. Obtain a number of live bivalve (two-shelled) molluscs such as ark shells or cockles (shown in the accompanying illustration). Provide one shell for each small group of two to three students. Ask each group to carefully remove one of the shells and one lobe of the mantle to expose the internal structure.

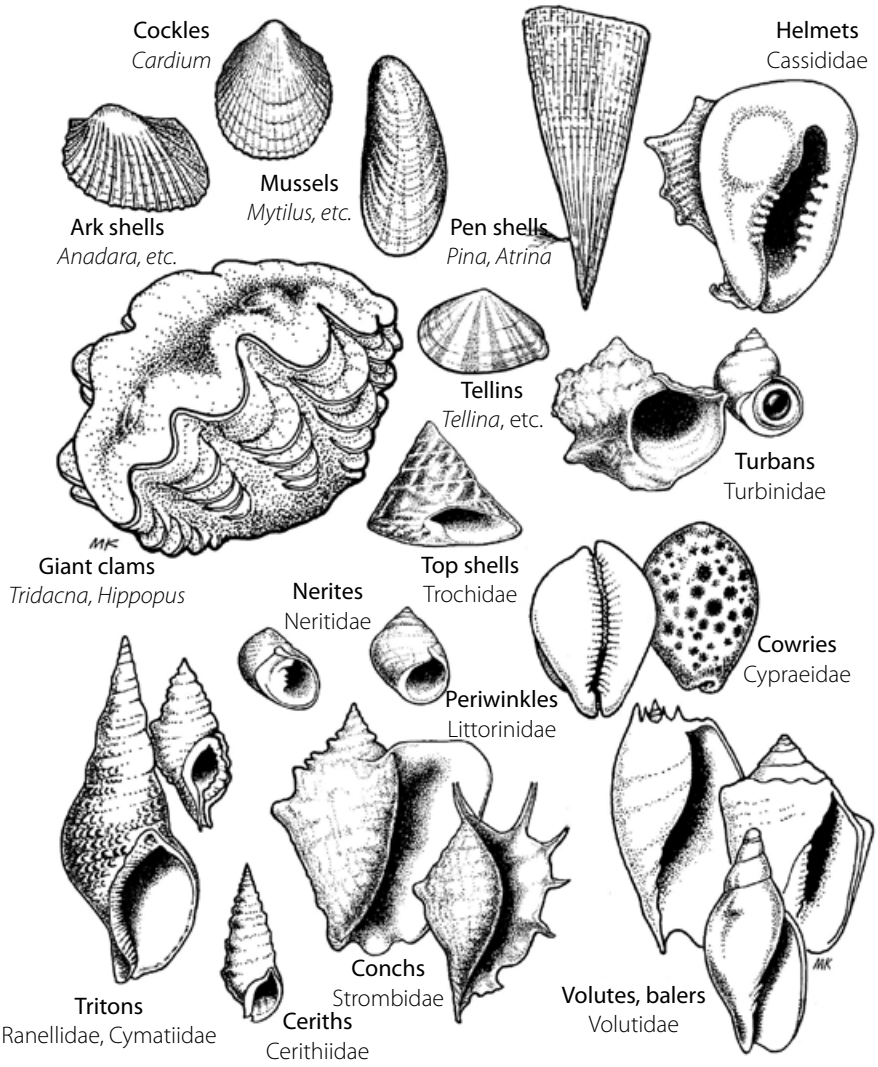
Show the figure of the internal structure of the bivalve mollusc in the accompanying figure on a screen (this figure is on the flash drive supplied as part of the Teachers' Resource Kit.)

This drawing can be used as a guide for students to identify the muscles, gills and intestine, and to make a labelled drawing.

The internal structures of the pearl oyster could also be shown. The oyster and the cockle are similar except that the cockle has two adductor muscles* (the pearl oyster has only one) and it has two siphons – one to draw in water and one to expel it.

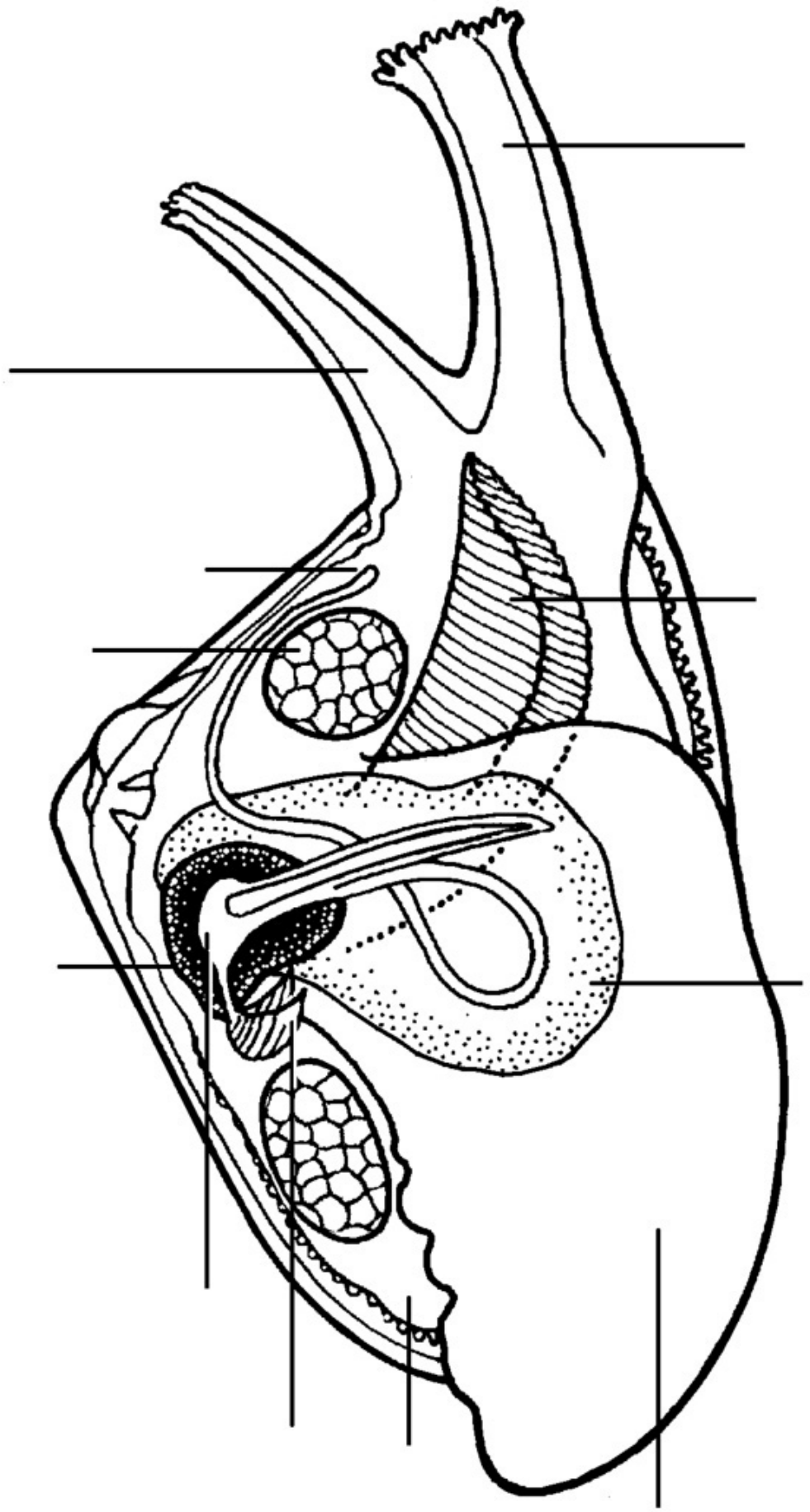
E. If dissections cannot be done, have students complete the labels on copies of the accompanying drawing of a bivalve mollusc, and discuss the functions of each structure.





Common mollusc families used for food and handicrafts in Vanuatu. *Turbo marmoratus* is the scientific name for the green snail, which is totally protected in Vanuatu.

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



12. Freshwater species

At the completion of studies:

Younger students identify freshwater eels, prawns and tilapia in Vanuatu.

Older students discuss possible origins of freshwater species in Vanuatu.

A small number of fish and invertebrates in Vanuatu live in fresh water. Species include some fish, eels and prawns. Eels live in both sea water and fresh water, and the freshwater fish, tilapia, has been introduced for farming.

Teaching and learning activities for younger and older students

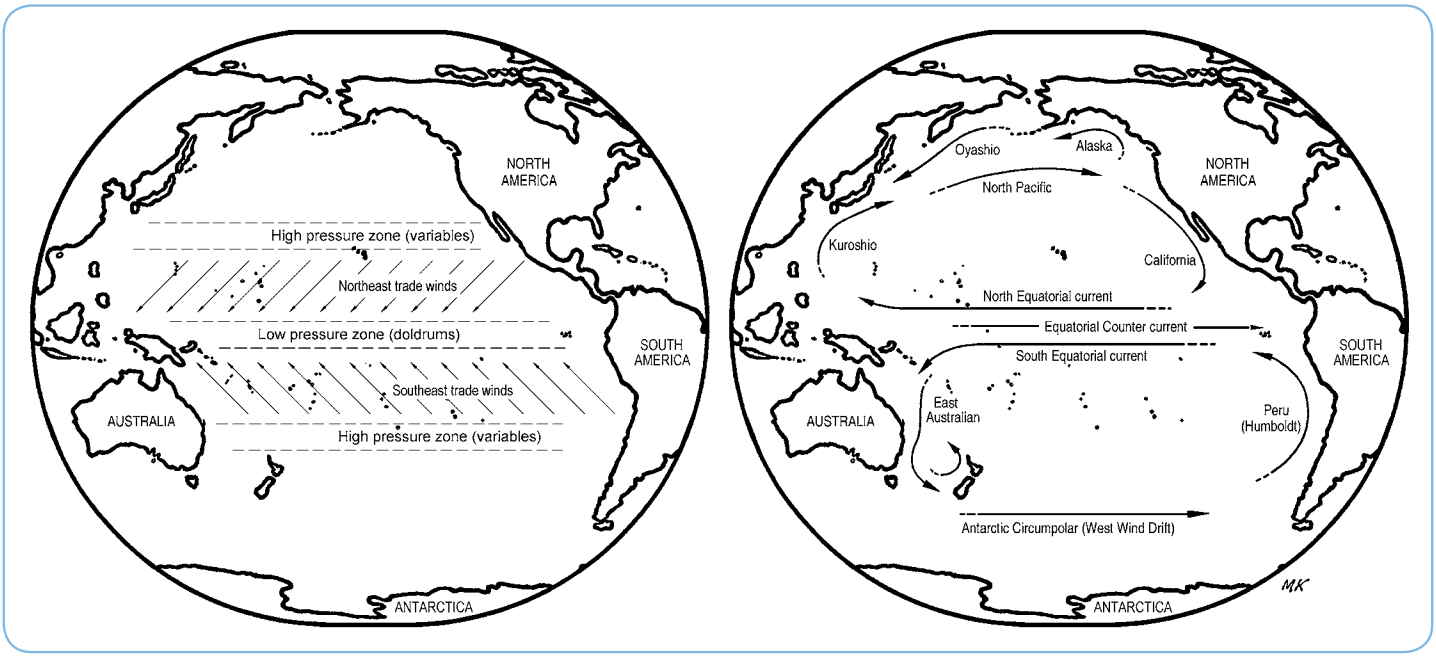
A. Ask students to talk to older people in their community or extended family about fishing for eels and shrimps. How many are caught? Have catches changed over the years?

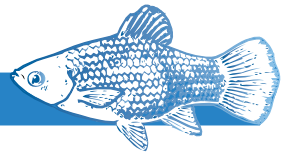
Teaching and learning activities for older students

B. The aquarium built as a student project described in page 24 could be set up as a freshwater aquarium and stocked with shrimps and small tilapia caught by students.

C. The figure below shows (left) the prevailing winds and (right) the ocean surface currents in the Pacific Ocean.

Ask students to discuss where freshwater species could have possibly come from (the origin of freshwater species in Pacific islands is not known but possibilities can be discussed).





13. Aquarium species

At the completion of studies:

Younger students list the species of fish that are exported for the aquarium trade.

Older students discuss the aquarium fish export industry and demonstrate knowledge of building and 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. Two companies based on Efate are licensed to export small clams and small reef fish for the marine ornamental trade.

Colourful species of fish are collected from reef areas around Efate, and clams are farmed in various locations by the Department of Fisheries (see Teachers' resource sheet 17: Marine aquaculture).

Teaching and learning activities for younger and older students

A. For students in Efate, arrange for a talk from an aquarium fish exporter. Ask him or her to explain how are fish (and other species) are collected on a sustainable basis, and how aquarium fish are transported overseas. If possible, arrange a visit to an export facility or a giant clam farm.

Teaching and learning 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, a plastic pipe, plastic mesh and an air pump will be required. Details of construction are shown in the accompanying diagram.

   A thin line of silicone glue must be carefully squeezed onto the edges of the glass that have to be joined. The glass can be temporarily held together with masking tape 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; 3–4 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 lengths of pipe to stop it from sagging.

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

   A freshwater aquarium is easier to maintain than a saltwater aquarium. It can be stocked with freshwater plants, small tilapia and freshwater prawns.

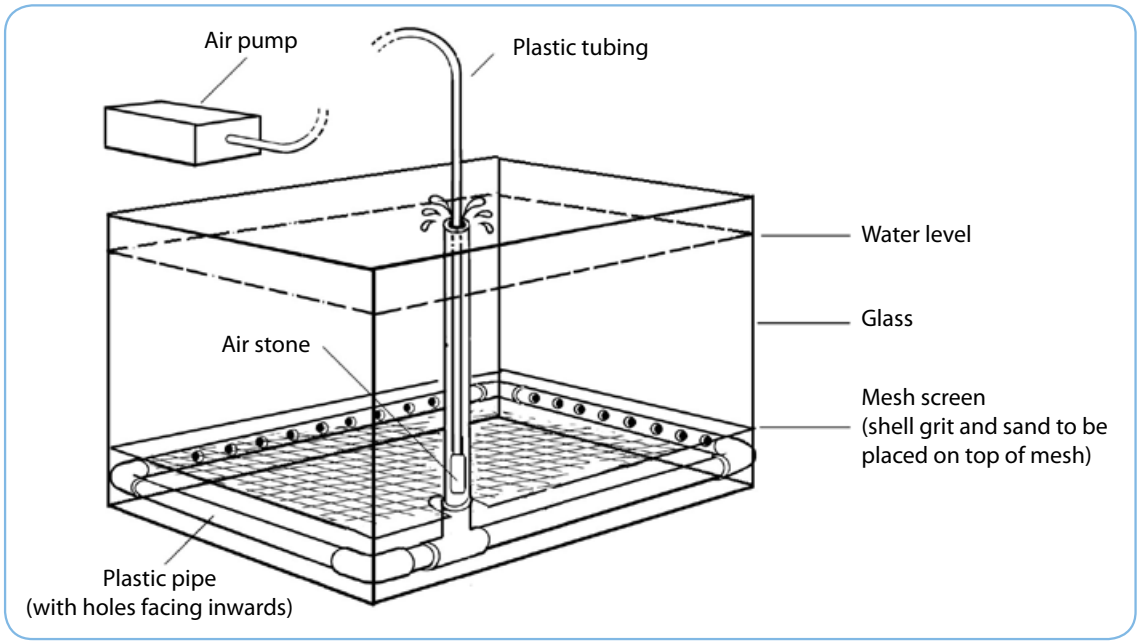
   A saltwater aquarium is more difficult to maintain (the water must be changed every two to three weeks). The aquarium can be stocked with very small sea cucumbers, small crustaceans and small coral fish such as humbugs and damselfish (see illustration earlier in this guide, page 8).

C. If funds are not available for building an aquarium, show the accompanying figure of a completed aquarium (this figure is on the flash drive supplied as part of the Teachers' Resource Kit).

   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 and sand, and the airstone produces very small bubbles that become dissolved in the water. In addition, students should understand that soluble wastes (such a nitrogen compounds) build up in the water and unless they are used by marine plants, will reach toxic levels.

D. An alternative to building an aquarium is for students to watch a virtual aquarium with virtual fish (several internet site are available such as www.youtube.com/watch?v=cYU_dhrmvyU)



14. Vanuatu traditional fishing methods

At the completion of studies:

Younger students identify the range of traditional fishing methods used in Vanuatu.

Older students compare traditional fishing methods with those in use today.

Teaching and learning 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? This should be followed up with a classroom discussion.

   A list should be made of the traditional fishing methods used by local communities (this could be done in conjunction with exercise A in Teachers' resource sheet 15: Modern large-scale fishing techniques.

B. There is a tendency 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?

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

Futuna, the easternmost island of Vanuatu, takes its name from futu, *the local name for the fish poison tree.*

15. Modern large-scale fishing techniques

At the completion of studies:

Younger students identify the range of commercial fishing techniques used in Vanuatu.

Older students describe a range of commercial fishing techniques used in Vanuatu and worldwide.

Teaching and learning activities for younger students

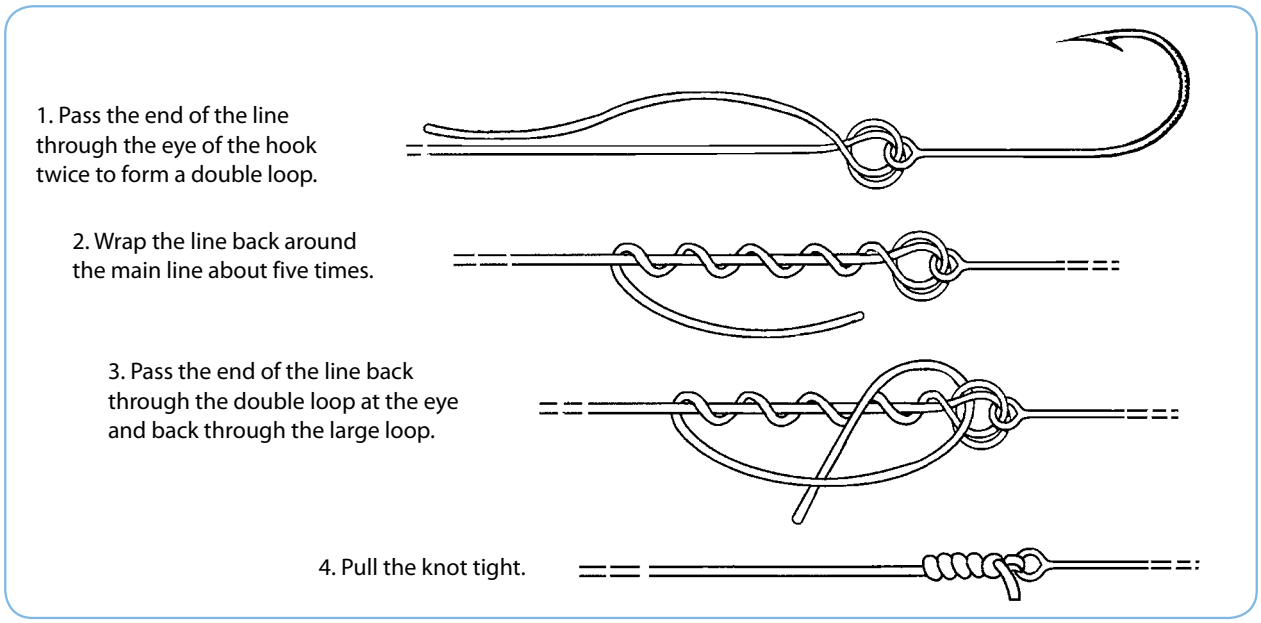
A. Ask students to talk to fishers about modern fishing techniques that they use. This exercise should be followed up with a classroom discussion. Ask students to make a list of the types of modern fishing techniques used by the local community.

Teaching and learning 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 a gamefishing charter boat. Ask students to examine and discuss the value of the operation to the country, and the sustainability of the fish stocks targeted.

D. Ask students to discuss any impacts of modern fishing techniques on marine resources in their community.



16. Fish aggregating devices (FADs)

At the completion of studies:

Younger students describe FADs.

Older students 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 Vanuatu, at the end of 2014, there were 26 FADs deployed off the main islands in the provinces of Tafea, Shefa, Malampa, Penama and Sanma.

Teaching and learning activities for younger and older students

A. Build a model FAD using a raft (about 40 cm by 40 cm) made from bamboo or sticks, and attached by rope to a brick or other weight; attach short lengths of frayed rope to the underneath of the raft.

   The frayed rope acts as 'aggregating' material (material that acts as a shelter for fish) as shown in the accompanying figure.

   Set the model FAD (with a small flag, which makes it easier for fishermen to find) 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 frayed rope. Are there more small fish near the model FAD than in surrounding bare areas?

Teaching and learning activities for older students

B. Ask students to suggest why pelagic fish such as tunas are attracted to FADs. Discussion possibilities include FAD:

   - acting as a visual reference point in an otherwise empty ocean;
   - working by attracting smaller baitfish on which larger fish feed.

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

C. Ask a fisheries officer or a *Vanuatai* Resource Monitor to explain how FADs are used in Vanuatu to enhance food security and livelihoods (increased catches of pelagic fish by subsistence and commercial fishers), and to mitigate impacts of climate change (by shifting fishing pressure from reefs to offshore areas, which enables coral reefs to better cope with the negative impacts of climate change).

D. Ask students to discuss the challenges faced by the Department of Fisheries 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 fishers using FADs contribute to the high cost of building, setting and maintaining them?

17. Marine aquaculture

At the completion of studies:

Younger students identify species that are currently farmed in sea water in Vanuatu and other species that could potentially be farmed.

Older students discuss the biology of farmed marine species and the methods used to farm them in Vanuatu.

Teaching and learning activities for younger and older students

A. Trochus and green snail have been produced in hatcheries in Vanuatu. Seed (very young, small molluscs) have been released on reefs where stocks had been depleted due to overfishing. Ask students to consider the problems associated with this effort. How can juvenile molluscs be protected from predators, including humans while they grow? Request a talk from a fisheries officer, *Vanuatai* Resource Monitor or farm operator.

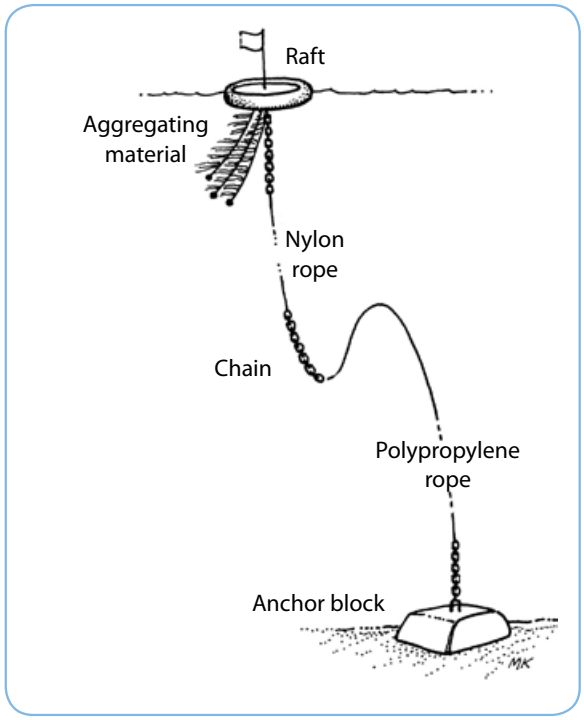
B. There are four giant clam farms in Vanuatu: one on the mainland of Efate, one at Lelepa Island, and two at Mosso Island. Both Lelepa and Mosso are offshore islands of Efate.

   For students on Efate or nearby islands, arrange for a visit and a conducted tour of a giant clam farm. Ask students to draw a diagram showing the process of rearing molluscs – from adult reproduction to juvenile production to commercial size.

Teaching and learning activities for older students

C. Giant clams are hermaphrodites, which means that a single individual clam can act as both a female, which produces 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 10: Giant clams.



18. Freshwater aquaculture

At the completion of studies:

Younger students identify species that are currently farmed in fresh water in Vanuatu and other species that could potentially be farmed.

Older students discuss the biology of farmed freshwater species and the methods used to farm them.

Teaching and learning activities for younger students

A. A new type of tilapia called GIFT (genetically improved farmed tilapia) has been produced by selectively breeding the fish so that they grow larger and live longer.

   GIFT tilapia is a freshwater fish that is often farmed to provide food for communities that do not live near the coast. For students from communities that are growing tilapia, ask them to interview people involved. Are the tilapia grown in a pond or in a river? What do people feed the tilapia? Do people in the community like eating tilapia? Refer also to Teachers' resource sheet 12: Freshwater species.

Teaching and learning activities for older students

B. There is interest in farming freshwater prawns, including the native *Macrobrachium lar* and the introduced *Macrobrachium rosenbergii*. Ask students to discover the life cycle of these prawns and how this information could be used in aquaculture (unlike marine prawns, female freshwater prawns carry their eggs beneath their abdomens).

19. Fish spoilage

At the completion of studies:

Younger students recognise fish freshness and develop an understanding of the need for personal hygiene when handling seafood.

Older students 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, must be handled carefully so that it does not make people sick.

Teaching and learning 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? Explain how low temperatures slow (but do not stop) the growth of bacteria on food.

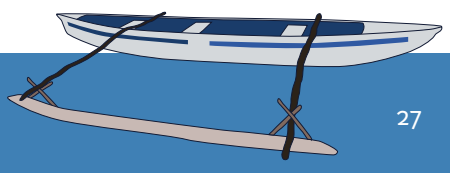
Teaching and learning activities for older students

C. Have students discuss the fact that honey is the only natural food that does not 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 spoilage 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? Alternatively, ask a Fisheries Officer or *Vanuatai* Resource Monitor to give a talk on seafood handling.



20. Fish poisoning and ciguatera

At the completion of studies:

Younger students demonstrate their knowledge of ciguatera and identify other marine species that can cause poisoning.

Older students 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 bloom is a dramatic increase in the numbers of very small plants (called phytoplankton*) that float in the sea. Some of these microscopic plants produce toxins that can cause people to become sick.

Interestingly, some of the toxins can become airborne because of wave action, and can cause people walking on shorelines to suffer respiratory asthma-like symptoms from inhaling the airborne droplets.

Teaching and learning activities for younger and older students

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

Teaching and learning 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, and ask which fish caused it. What were the symptoms? Was any kind of medicine used to treat the symptoms?

C. Students should consider the type 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 fertilisers entering the sea?

21. Sea safety

At the completion of studies:

Younger students demonstrate their knowledge on the importance of being prepared before going out to sea in terms of safety measures and equipment.

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

The Vanuatu Maritime College based in Santo runs training programmes on fishing vessel skills and safety.

Teaching and learning activities for younger students

A.

i. Show students a copy of the checklist 'Five minutes which can save your life' on safety equipment with one item blanked out. Ask students to identify the missing item.

ii. Ask students to state the four important things to do before going out to sea.

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 on board a boat?

Teaching and learning 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 on safety equipment?

E. How can fishers get information on local weather and sea conditions before going to sea?

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

G. At present, in Vanuatu 80% of local fishers use small boats less than 8 m in length, which have no VHF radios. What sort of safety issues does this result in? What sort of system could be installed? How much would it cost to install this system?

H. What are the least expensive signalling devices (torch and mirror), propulsion means (sail or paddles), and floating devices (plastic container or fishing buoy)?

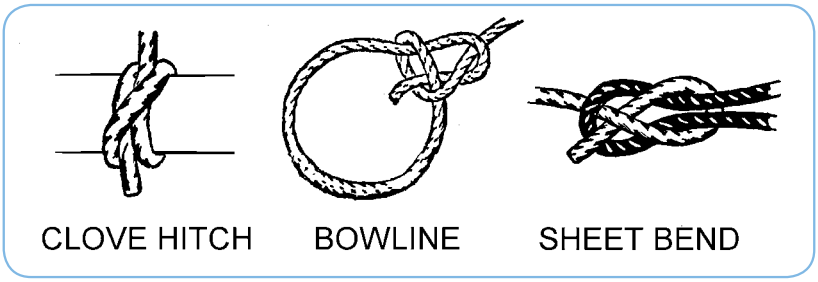
I. Ask students to discuss each of the following signalling devices:

- flares (effective at night but not during daytime; alert passing airplanes or boats; have a short lifespan so need to buy at regular intervals; are not accepted on aircraft so difficult to acquire, particularly in the outer islands);

- VHF radio (good for alerting people onshore or on board other boats; hand-held models exist; is relatively inexpensive, but requires power or AA batteries to operate; has a limited range of up to 20 nautical miles; and some areas are not equipped with VHF receiver/transmitters);
- mirror, also called heliograph (is inexpensive; is effective during daytime but requires sun to work, and does not work at night);
- torch or laser (effective at night; is inexpensive but requires batteries to operate – although manually chargeable models exist; best to have a waterproof lamp; is not useful during daytime); and
- personal locator beacon (PLB) (has unlimited range and works with satellites; is the best device to signal distress to international and local authorities; has a built-in GPS so that the user's position is known; is expensive – around 40,000 vatu; the lifespan of built-in battery varies).

J. Supply each student with two pieces of rope, each one 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.



22. Job opportunities in fisheries

At the completion of studies:

Younger students identify employment opportunities in the fishing industry.

Older students explore a wide range of fisheries-related job opportunities in Vanuatu and overseas, including working requirements and conditions.

In Vanuatu, employment opportunities may include fisheries personnel such as advisers, biologists, scientists and economists in the government service (the Department of Fisheries) as well as in non-governmental organisations involved in environmental and conservation work. There may also be opportunities for working on commercial fishing boats, both in Vanuatu and overseas.

Some careers involve university study while others require practical training at institutions such as the Vanuatu Maritime College.

Teaching and learning activities for younger and older students

A. Arrange for talks by people who work in the fishing industry, such as a fisher, a fish trader, a fish seller, a fish exporter, a member of an environmental organisation, and a Fisheries Officer from the Department of Fisheries.

B. Arrange for visits to potential employment and training areas such as a tuna fishing vessel, an export factory, the Department of Fisheries, the Provincial Fisheries Office, the Vanuatu Maritime College and the University of the South Pacific.

23. Financial management of a small fishing business

At the completion of studies:

Younger students determine the price of a range of seafood species that are sold in their community.

Older students determine the fixed and running costs in a fishing business.

Teaching and learning 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 quantity of the catch is eaten by the fisher (and his or her family), and what quantity of the catch is sold).

Teaching and learning 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 vatu) and how many fishing trips the fisher usually completes in one year.

If possible, find out the costs of fishing: ice, bait, food, fuel, replacement of gear. 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	Vatu_____
Bank loan repayments	Vatu_____
Boat regular maintenance	Vatu_____
Insurance	Vatu_____
Depreciation of boat and gear value	Vatu_____
Total fixed costs per year	Vatu_____

Running costs per fishing trip

Crew payments	Vatu_____
Fishing gear replacement	Vatu_____
Fuel and food	Vatu_____
Bait	Vatu_____
Ice	Vatu_____
Total running costs per fishing trip	Vatu_____
Total annual running costs (fishing trip costs multiplied by the number of fishing trips per year)	Vatu_____
Total annual costs (annual fixed costs plus annual running costs)	Vatu_____
Annual income or loss (total income from fish sales minus total annual costs)	Vatu_____

Suggestions for exercises and activities related to the 29 Information Sheets for Fishing Communities

Information sheets for fishing communities

The following section includes suggested student activities and questions relating to the 29 information sheets for fishing communities; these are included in the Teachers' Resource Kit on fisheries.

Information sheet 01: Groupers

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

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

C. What actions could local fishers take to ensure that groupers are not overfished? Overfishing or overexploitation occurs when so many fish are caught, that there are not enough adults left in the sea to reproduce and replace the fish that have been lost or caught.

D. Ask students to talk to fishers in their local community or extended family to find out about fish catches. Where are the fish caught? Are the fish they catch as common as they were five years ago? At what time of the year do the fish have ripe gonads* (see Teachers' resource sheet 6: Fish anatomy)? Do the fishers know if fish migrate to gather in a particular place to spawn? (See Information sheet 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 7: 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. Emperors are easily caught because 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 for fishing communities 24: Spawning aggregations).

B. An emperor is one of the fish shown in the food web shown in Teachers' resource sheet 7: Marine food webs. Have students discuss its position and role in the marine food web.

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 effect of overfishing of parrotfish on coral reef ecosystems. What actions could local fishers take to ensure that parrotfish are not overfished?

Information sheet 05: Reef snappers

A. In several Pacific Island countries, some snapper species 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 of snappers are caught locally. Have some species become scarce over time?

Information sheet 06: Trevallies

A. Trevallies are fast swimming fish. 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 swim 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 of surgeonfish are regarded as a delicacy or are popular in their community or on their island, and in which month of the year that such species are normally in good condition or are 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).

Bislama – The name of the language is derived from the French word for sea cucumber – bêche-de-mer.

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 overfished.

Information sheet 11: Trochus

A. Trochus have been overexploited in Vanuatu. Ask students to prepare a history of trochus exploitation, including the use of the meat for food, the use of shells, and the amount of trochus caught each year.

B. The Vanuatu Department of Fisheries has imposed minimum size limit on trochus; in other words, trochus that measure less than 90 millimetres across the base of the shell cannot be legally caught. What is the purpose of this regulation?

C. Some countries also place a maximum size limits on trochus. For example, trochus that measure more than 120 millimetres across the base 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. Spiny lobsters are caught in Vanuatu but the development of a large commercial fishery may not be possible. Ask students to give reasons why.

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 (what tools do they use)? 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 for fishing communities 14: Coconut crab, 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 to catch octopuses result in damage to corals? Are octopuses as common as they were five years ago?

Information sheet 16: Green snail

A. Green snails have been harvested in Vanuatu for their meat and their pearly shells, which are sold to processing factories for making buttons, jewellery and pearl inlays. Because of severe overfishing, green snails are now protected in Vanuatu. How is the Vanuatu Department of Fisheries addressing this problem? Request a talk from a Fisheries Officer or a *Vanuatai* Resource Monitor.

Information sheet 17: Reef sharks

A. Most fish reproduce when males release sperm and females release 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 using the life cycle illustration.

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 of the shark thrown out. 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 7: Marine food webs).

Information sheet 18: Rays and skates

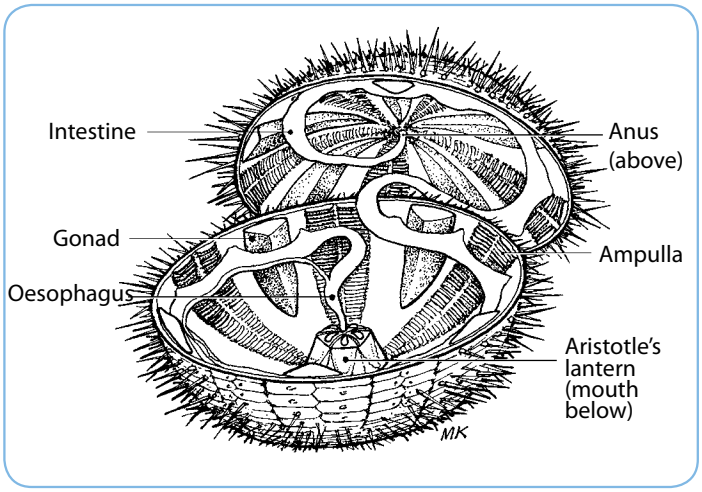
A. Rays and skates are related to sharks but feed very differently. Ask students to discuss how rays, including the related manta ray, feed. Why is the manta ray quite different from other rays?

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 sea star 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?

Note: Crown-of-thorns can be used as an organic fertiliser in agriculture.

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 overfished?

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 on their island or in their 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 Vanuatu.

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 overcollected? (In Fiji, women collecting sea grapes traditionally leave clumps of the plant in crevices to regenerate.)

Information sheet 24: Spawning aggregations

A. Many species of fish 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 the fish normally aggregate? Do fishers go fishing on these spawning aggregations?

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

Information sheet 25: Mangroves

A. There are 21 species of mangroves in Vanuatu. Three common types with the different types of root systems shown on the sheet are:

- Drrong jok (*Bruguiera gymnorhiza*)
- Drrong nevis (*Rhizophora stylosa*)
- Naviv (*Avicennia marina*)

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.)

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. (A discussion could include the 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 2: 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 Information sheet for fishing communities 28: Harmful algal bloom). Ask students to investigate the sources of nutrients in their local area.

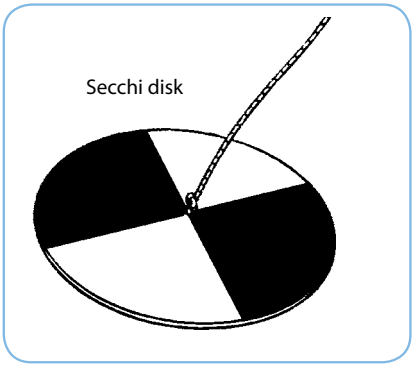
B. Ask students to examine how nutrients and sediments threaten coral reefs and fisheries.

C. Sediments can affect corals and, therefore, coral reef fisheries. The presence of sediments can be easily and inexpensively 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 using pieces of lead (such as vehicle wheel balancing weights) so that it sinks, 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 of the water.

Have students complete a field exercise to measure the visibility of water at various coastal locations including those near the mouths of rivers. Complete the exercise before and after it rains.



D. Discuss possible sources of sediments. Ask students what can be done locally to reduce sediment run-off into the lagoon.

Information sheet 28: Harmful algal blooms

Student activities and exercises are given in Teachers' resource sheet 20: Fish poisoning and ciguatera.

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.

Glossary

Adductor muscle: Muscle allowing the bivalve to close the shell tightly.

Atmosphere: A unit of measurement that refers to the force per unit area that is exerted against a surface by the weight of the air above that surface.

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

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

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

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

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

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

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

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

Ciguatera: A kind of fish poisoning caused by eating fish that have accumulated toxins produced by certain types of very small (microscopic) plants or phytoplankton, that are found in association with coral reefs.

Commercial fishing: The production of fish primarily for sale.

Community-based fisheries management: Arrangements under which a community takes responsibility, usually with the assistance of the government or a non-governmental organisation, 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 beds 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 type of 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; for example. 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.

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

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

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

Herbivore: Animal that feeds on plants (algae and seagrass).

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 that specifies the largest captured individual that may be kept after it is caught; 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 that specifies the smallest captured individual that may be kept after it is caught; 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 by 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.

Overexploitation, or overfishing, or over-collecting: A situation where so many fish are caught, that there are not enough adults left to reproduce and replace the numbers that have been lost or caught.

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 that drift in the sunlit surface layers of the sea.

Plankton: Small and microscopic organisms that drift or float in sea 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 other species.

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.

Quadrat: A sampling unit to assess the density of organisms.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Toxin: A poisonous substance produced by a living thing.

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

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

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

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

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

Pacific Community
BP D5 - 98848 Noumea Cedex
New Caledonia
Telephone: +687 26 20 00
Facsimile: +687 26 38 18
E-mail: cfpinfo@spc.int
Web: www.spc.int

Pacific Community
Communauté du Pacifique