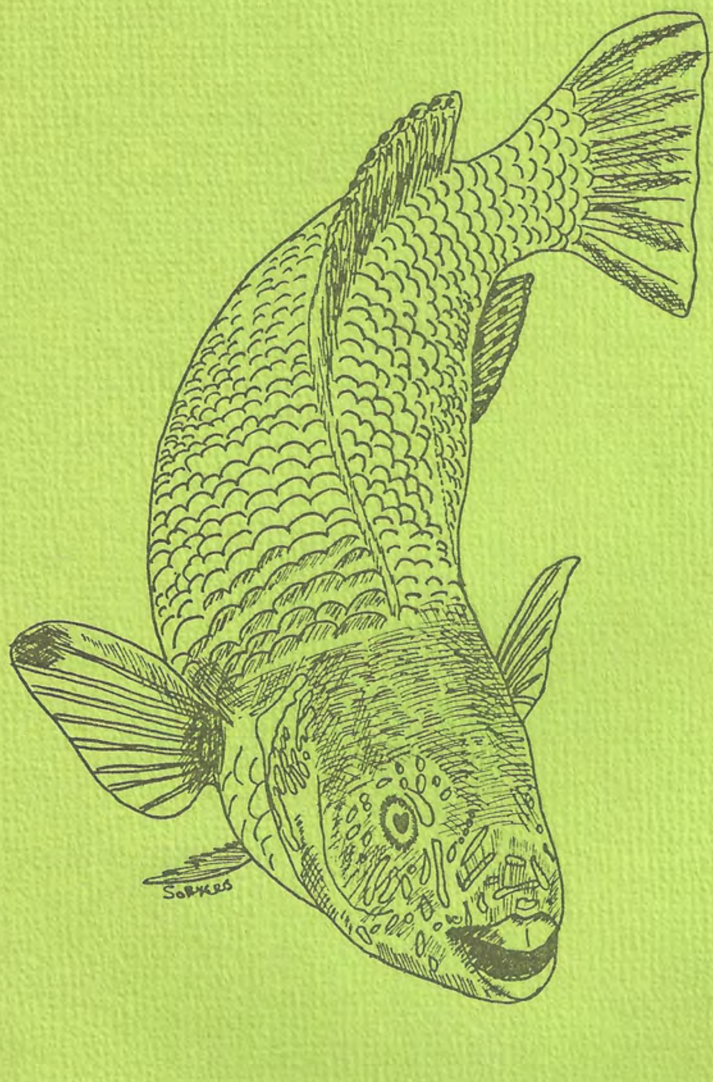
BRISBANE SOUTH MARINE STUDIES PROJECT



MARINE STUDIES SERIES

UNIT 6

FISHERIES BIOLOGY

written by

R.D. MOFFATT
B.Sc., Dip. Ed.,
Grad. Dip. Ed. Admin., M.A.C.E

"TO GREAT DAYS AT THE ALEX"

Australia's coastline forms a special place in our environment because over 90% of us live there. Due to different Ecological, Economic, Social and Recreational interests many conflicts arise over the use of our Estuaries, Beaches and Barrier Reefs. Sand Mining, High Rise development, Longline Fishing, Low water Land sales, Resort Development and Oil Pollution are but a few of the real issues that face us now. There is an urgent need for all Australians to develop an attitude towards sensible resolution of these conflicts. This set of notes is one in a series that hopefully will give students the skills necessary to become involved in these issues and make sensible contributions to coastal environmental decision making. In doing so I hope that the coastline may be managed in such a way that future Australians will derive as much pleasure out of it as I have.

My thanks must go to STAQ for providing the financial backing and support to start this project. Thanks also to my Mother and Father who deciphered and typed my bad writing; and to Len Zell of the Great Barrier Reef Marine Park Authority who read and critised the draft and for making many useful contributions. As this is a first draft any comments would be gratefully acknowledged.

NATIONAL LIBRARY OF AUSTRALIA
CATALOGUING-IN-PUBLICATION

FISHERIES BIOLOGY

R.D.Moffatt

ISBN 0 9598303 9 1

For further information contact:

R.D. MOFFATT
Benowa State High School
Mediterranean Drive
BENOWA
GOLD COAST MAIL CENTRE,Q,4217

First Printed: 1984 Draft copies by S.T.A.Q. publications
Second Printing: 1985 Benowa Marine publications
Third Printing: February 1986

Published by
BENOWA MARINE
Mediterranean Drive
Benowa, Qld. 4217
P.O. Box 5733
Gold Coast Mail Centre. 4217
Telephone : (075) 39 4222

FISHERIES

BIOLOGY

written by

R.D. Moffatt

This module has 3 sections:

1. Plankton....................9-23

2. Nekton.....................24-49

3. Benthos.... 50-60

Some Commercial Fishing Methods

This module is compatable with the Syllabus Topics:

* Science Technology and Society *
* Ecology *

Students, Teachers and Parents are referred to the Multistrand Science Syllabus (Qld) Board of Secondary School Studies, Spring Hill, Brisbane.

Acknowledgements:

The author wishes to thank Allistair Martin (M.S.C. Tas.); David Kopelke (B.I.F.S.C. Qld); Jim Redfield (C.S.I.R.O.); Roy Jenkins (F.U.S.E.); Dennis Bridger; Ann Kenny; Graham Mitchell; Greg Martin; Steve Hall (G.S.H.S.); Sue Oates; Meran Kilgour (B.S.H.S.); Ken Kretchmer; and the Departments of Harbours and Marine, Fisheries, Oceanography, Great Barrier Reef Marine Park Authority, The Beach Protection Authority and The Brisbane Education Centre for all their help.

WHY STUDY THIS UNIT

The study of Fisheries Biology affords an opportunity to study two syllabus topics of the Multistrand Science Syllabus e.g. Science Technology and Society and Ecology.

ECOLOGY

Life on earth depends on a delicate balance of events. Each living thing depends for its survival on other living things, on the physical characteristics of its immediate environment, and on energy from the sun. Any disruption to this delicate balance may threaten the life of living things, including man.

This topic should introduce students to the many interrelated factors which govern this delicate balance of nature. Students should become conversant with techniques to study the environment and man's effect upon it. They should attain a working knowledge of the principles of ecology, through a detailed study of a suitable ecosystem in their own environment. Field work would necessarily form an important part of this topic.

In addition to basic ecological principles, various aspects of man's effect on this delicate balance e.g. pollution, use of technological controls, conservation, should be stressed where applicable.

BOSSS Draft Syllabus 1982

SCIENCE, TECHNOLOGY AND SOCIETY

The aims of this topic are to assist the student in developing:

a) a recognition of the influence of science on contemporary society;
b) the ability to identify the impact of technological innovation and to study the factors which govern it; and
c) those attitudes and values related to effective exercise of the citizen's role in controlling the products of science.

These aims may be viewed as arming the citizen with three levels of preparedness. They are the required knowledge, the necessary abilities, and the willingness to participate in the debate and decision making concerning science and its products. In order to ensure that people are not only informed but involved, it is important to give significant weighting to the Affective Objectives. Such aims encompass much of the broad perspective of the whole subject and thus may be attained by a variety of means. While it is possible to construct a single unit of work to promote the objectives of this topic, an alternative which may be preferred, is to incorporate such learning experiences into a number of work units whose principle focus is another of the topics (core or optional). In this way the interactions of science, technology and society could form an underlying theme for much of the program.

BOSSS Draft Syllabus 1982

PRACTICAL ACTIVITIES

1. Mariniculture
2. Model Boats and Rigs
3. Making Nets

STUDY ASSIGNMENTS

1. The Australian Maratime College
2. Computer Fishing
3. Oil Drilling Research, Mineral Sand Research

SCIENCE TECHNOLOGY AND SOCIETY

SECTION 1: NEKTON

The Fishing Industry
Fishing Boats
Fisheries
Fisheries Management

SECTION 2: BENTHOS

Prawn Trawlers
Prawn Fisheries
Scallapoling, crabing, oysters and related industries

DIRECTED TOPICS

1. Distinction and Interdependence of Science and Technology.
2. Dependence of Economic Fisheries on Technology.
3. Potential for abuse by Multinationals Fishing Australian waters.
4. Sand Mining Technology, Oil Drilling Technology

AUDIO VISUAL

Prawn Fishing

Fisheries Training Films

OBJECTIVE STATEMENT (SYLLABUS)

CONTENT OBJECTIVES: The student should have a knowledge of:

a) The distinction between and interdependence of science and technology.

b) The dependence of society upon technology (e.g. communications, electrical appliances).

c) The potential for abuse of technological products (e.g. computer fraud, arms development).

d) Some moral and ethical dilemmas posed by science (e.g. genetic engineering, use of pesticides).

PROCESS OBJECTIVES: The student should be able to:

a) Analyse a product of technology to determine its scientific basis.

b) Identify arguments for and against the adoption of a technological innovation.

c) Identify an example of basic scientific research that depends on technological development.

d) Assemble balanced arguments on ethical implications of research.

AFFECTIVE OBJECTIVES: Students will have the opportunity to become:

a) Receptive to the limitations of science and man.

b) Tolerant of conflicting opinion.

c) Prepared to consider new information or points of view.

d) Willing to be involved in decision making.

OBJECTIVE STATEMENT (TEACHER/STUDENT)

CONTENT: The student should have knowledge of:

a) The distinction between and interdependence of marine science on fisheries, Biology and management.

b) The dependence of commerical fishing on modern technology, (nets, navigators, fish tracking, lightweight rigs, etc).

c) The potential for abuse of marine band radios, computer fraud in overseas marketing of prawns and fish.

d) Moral obligations and ethical dilemas posed by technology (e.g. pesticides on cane fields, marine pollution).

PROCESS: The student should be able to:

a) Analyse a prawn or beam trawl net to determine its scientific basis (eg. construction, water tunnel experiments).

b) Identify arguments for and against the adoption of a deep sea fishery (eg. as planned by the Australian Maratime College, Tasmania).

c) Identify equipment required for marine scientists to work underwater.

d) Assemble balanced arguments on ethical implications for either oil drilling on the Barrier Reef or Sand Mining of a local environment.

AFFECTIVE: The student should have the opportunity to become:

a) Receptive to the limitations of the Sea as a Resource.

b) Tolerant of conflicting opinions on oil drilling, sand mining, tourist development, fisheries development in the marine environment.

c) Prepared to consider new points of view on (b) above.

d) Willing to become involved in Marine Resource development management.

STUDENT MATERIALS

Specific learning tasks are found in the Notes but class discussion and debate should further attainment of objectives. The booklets on Management of Reef Resources by the Townsville CAE would prove very useful.

PRE-EXPOSURE

Students with debating points of view or researching arguments would be an advantage.

RESOURCES

Encounters with the Reef: Townsville CAE

Mining Wardens Court Cases - write to the Australian Maratime College,
PO Box 986
LAUNCESTON. TAS. 7250

TIME REQUIRES

Minimum 10 hours

EXCURSIONS

Visit a local fish board and see how fish are processed.

Visit a Marina and look at the different hulls and construction of ships, vessels.

Visit a prawn trawler and examine the different rigs for catching prawns.

FISHERIES BIOLOGY

PRACTICAL ACTIVITIES

1. Phyto plankton and zoo-plankton
2. Jellyfish arms
3. Pressing seaweeds
4. Dog fish disection
5. Boney fish disection
6. Fish activities
7. Crab paintings
8. Prawn life cycle
9. Keying out prawns and algae
10. A snorkel with the Dolphins

STUDY ASSIGNMENTS

1. Poster of marine stingers
2. Seaweed uses
3. Plankton farming
4. Barramundi
5. DDT and birds eggs
6. Mercury pollution of oysters
7. Project Jonah
8. Greenpeace
9. Dolphin intelligence
10. Shark meshing

ECOLOGY

SECTION 1 : THE PLANKTON

Plankton groups
Phyto plankton and zooplankton
Jellyfish and seaweeds
Food webs, chains and pyramids of the sea
The Web of life
Plankton nets

SECTION 2 : THE NEKTON

Nekton types
Squids, Sharks and Rays
Fish and Turtles
Birds and Marine Mammals

SECTION 3 : THE BENTHOS

Benthos types
Prawn Biology
Oysters, Crabs and Scallops
Pearls, Abolone and Mussels

DIRECTED ACTIVITIES

1. Delicate balance concept
2. Interrelationships concept
3. Diversity of marine life
4. Ecosystem concept
5. Marine pollution, coil, heavy metal, DDT etc.

AUDIO VISUAL

1. Hastings Point excursion Set of slides Merrimac State High School
2. Reproductive Biology of Prawn. Set of slides Benowa State High School
3. Plankton and the open sea

CONTENT OBJECTIVES: The student should have a knowledge of:

a) The basic terminology used to describe the various components, factors and relationships of an environment.
b) The energy and nutrient flow in an ecosystem.
c) The forms of interaction between organisms: food chains, food webs, parasitism, predator-prey relationships.
d) The techniques and methods used to conduct a field study of an area (physical, chemical and biological characteristics, use of keys).
e) Some ways our environment can become polluted and how man reacts.

PROCESS OBJECTIVES: Students should be able to:

a) Use simple keys to identify the major flora and fauna of the ecosystem studied.
b) Compile lists of producers, consumers and decomposers in a local community.
c) Deduce energy flow and feeding relationships within a community.
d) Interpret data compiled during field study and discuss relationships between physical, chemical and biological components of the ecosystem.
e) Write a report on his/her field work.
f) Identify any factors polluting the area of study and discuss their effect and possible ways they could be controlled.
g) Discuss rationally conservation measures as applied to man's use or abuse of the natural environment.
h) Report on local environmental activities and their effects and controls needed, e.g. sewerage, garbage, factories, noise.

SKILL OBJECTIVES: The student should be able to:

a) Use the necessary apparatus or measuring devices to determine physical and chemical environmental factors.
b) Use the correct equipment and techniques to collect and maintain living specimens for the purpose of identification.
c) Conduct a systematic investigation of the factors and components in a field study area of their own choice.
d) Carry out simple tests for pollution of the local environment

AFFECTIVE OBJECTIVES: Students should have an opportunity to:

a) Develop an interest in the diversity of life and a respect for it.
b) Value the balance and interactions in nature.
c) Value the need for scientific data for statements on pollution and conservation.

STUDENTS OBJECTIVES

CONTENT OBJECTIVES: The student should have knowledge of:

a) The following terms as applied to the marine environment - plankton, nekton, benthos, photosynthetic zone, food web, food chain, food pyramid, producer, consumer, decomposer.
b) Energy pyramids in the sea and how nutrients cycle in the sea.
c) Interactions between phytoplankton, zooplankton, small fish, larger fish, parasitic fish, and a variety of marine invertebrates.
d) Plankton, nekton and benthic sampling methods as well as abiotic (temperature, salinity, dissolved oxygen) methods.
e) Marine pollutants.

PROCESS OBJECTIVES: The student should be able to:

a) Use a prawn key to identify local prawns and construct a simple key to local algae.
b) Compile list of producers, consumers and decomposers in a Barrier Reef pool or slope. (or rocky shore)
c) Construct a food webs for a rocky shore pool or Barrier Reef pool indicating energy flow.
d) Interpret sample data from the Australian Institute of Marine Science and discuss relationships between sample data collected at a rocky shore (or Barrier Reef pool) in terms of physical, chemical and biological components.
e) Write a report on the Ecology of a rocky shore pool (or Barrier Reef pool).
f) Identify factors that could pollute the study pools and discuss practical management procedures.
g) Discuss rationally the conservation of the Great Barrier Reef
h) Report on pollution at a local beach, rocky shore, sand dune or reef.

SKILL OBJECTIVES: The student should be able to:

a) Use a reversing thermometer, hygrometer, echo sounder, nansen bottle, (or Van dorn water sampler), burette and associated equipment.
b) Use a plankton net, benthos dredge, beam trawl, core sampler and aquarium.
c) Write and record data of a reef or rocky shore pool underwater. Also snorkel to a level capable of recording data and experience Manta Tow techniques.
d) Carry out B.O.D. titrations and analysis.

AFFECTIVE OBJECTIVES: The student should have an opportunity to:

a) Develop an interest in the diversity of life on a Barrier Reef (or rocky shore) and a respect for it.
b) Sort out his or her relationship with the environment and discuss it with others.
c) Appreciate the need for sensible, wise discussion about the conservation and management of our Great Barrier Reef and coastline in general.

STUDENT MATERIALS:

Specific learning tasks are found in the Notes however many general references are suitable (see below).

PRE EXPOSURE:

Many students will already have some basic ideas of Ecology that should now be enhanced here with practical experience in the field.

RESOURCES:

Web of Life: Australian Academy of Science

Exploring Science Book 2: Stannard and Williamson, McMillan

Fundamentals of Ecology: Odum, Saunders

Oceanography and Our Future: Oxenhorn and Goldfield, Globe Books

Exploring the Oceans: Weinhaupt, McMillan

Invertebrate Zoology: Barnes, Saunders

Marine Plants: Cribb, University of Queensland Press

For a more detailed Bibliography write to the Education Officer, Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville. Q. 4810.

EXCURSIONS:

Visiting the Great Barrier Reef is an ecological experience that serious students of the subject should consider. For an excellent guide write for Project Reef Educational Materials available from the Great Barrier Reef Marine Park Authority. However a rocky shore can also provide an excellent environment to study. Students should be encouraged to gain a Snorkeling Certificate and get underwater to work as modern marine scientists.

FISHERIES BIOLOGY

SECTION 1

THE PLANKTON

Page

1.1 Plankton Groups 9
1.2 Phytoplankton 10
1.3 Zooplankton 12
1.4 Larger than Microscopic: Jelly Fish 15
1.5 The Sea Weeds 16
1.6 Uses of Sea Weeds 17
1.7 The Food Web 19
1.8 The Food Chain 20
1.9 The Food Pyramid 20
1.10 The Web of Life 21
1.11 Plankton Nets 22

INVESTIGATIONS:

1-1 Phytoplankton and Zooplankton 9
1-2 Jelly Fish Arms 16
1-3 Pressing Sea Weeds 18

SECTION 2

THE NEKTON

2.1 Types of Nekton 24
2.2 The Squids 24
2.3 Sharks and Rays 25
2.4 Bony Fish, Their: Anatomy 29
Scales 29
Internal Organs 30
Adaptions 31
2.5 Swimming Reptiles ....
2.6 The Birds that prey on the Nekton ....
2.7 The Mammals of the Sea ....
2.8 Fishing Methods ....
2.9 Fisheries ....
2.10 Management of Fish Resources ....

INVESTIGATIONS:

2-1 A dogfish Dissection 27
2-2 A Bony Fish Dissection 32
2-3 Fish Activities: Poke Poling 33
Fishes Age 33
Fish Prints 34
Fish Mobiles 35

SECTION 3

THE BENTHOS

3.1 Types of Benthos 50
3.2 Prawn Biology 51
3.3 Prawn Trawling 54
3.4 The Prawn Fishery 55
3.5 Scalloping 56
3.6 Crabs 56
3.7 Oysters 57
3.8 Pearling 57
3.9 Abalone 58
3.10 Mussels 58
3.11 The decomposer role of the Benthos 59

INVESTIGATIONS:

3-1 Crab paintings 50
3-2 Prawn Life Cycle and Biology 53
3-3 Using a Crustacean Key to Prawns 53

SECTION 1.

THE PLANKTON

To study the Biology of an estuary you have to divide it up into three main parts:

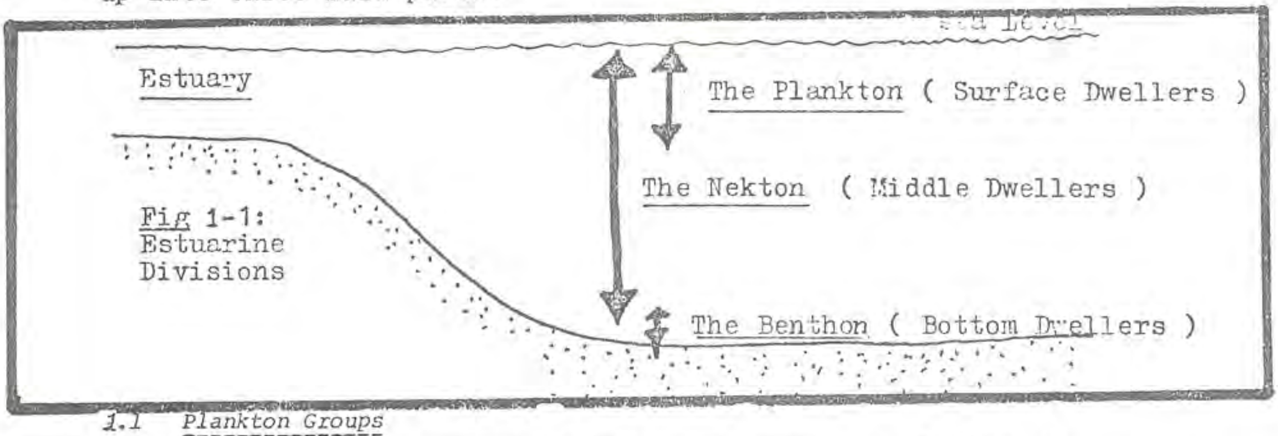


Fig 1-1: Estuarine Divisions

1.1 Plankton Groups

In the estuary there exists an enormous population of organisms, too large to count, called plankton. This term refers mostly to microscopic plants and animals that wander or drift with the ocean tides and currents. While many are capable of movement, their effort to control their direction is useless against the winds and currents. The animal portion is called *ZOOPLANKTON*, and the plant portion is called *PHYTOPLANKTON*.

Phytoplankton consists of two main groups called *DIATOMS* (di-a-toms) and *FLAGELLATES* (fla-gel-ates).

Zooplankton is the drifting animal life of the ocean. It is composed of temporary and permanent members. The permanent members are those which spend their entire lives as plankton, eg. copepods and lucifers. The temporary plankton is composed of members who spend the first stage of their life as drifting plankton either as eggs or larvae, and then grow into non-planktonic adults (eg. the prawn, barnacle, or crab).

Investigation 1-1: Phytoplankton and Zooplankton

You will need

* A stereomicroscope (you may share this with your class).
* A monocular microscope (you may share this with two others).
* Good drawing paper, pencil, and rubber.
* Reference books.
* Petri dish, 2 microscope slides and coverslips.
* Preserved plankton sample.

What to do

PART A: The Stereomicroscope

1. Take about 1 ml of sample and place it in a petri dish and examine it under a stereomicroscope.

☐ Record as many different shapes as possible.

2. Select 6-10 plankters and mount them on 2 microscope slides.

PART B: The Monocular Microscope and Permanent Plankters

1. Focus on low, medium, and high power, to attempt to locate permanent phytoplankton and zooplankton. (Your teacher will help you with this).
2. Draw as carefully as you can each of these.
3. Use reference books to identify each, and assign labels to parts. Try to find prawn crab, barnacle or fish larval stages.

1.2 *Phytoplankton*

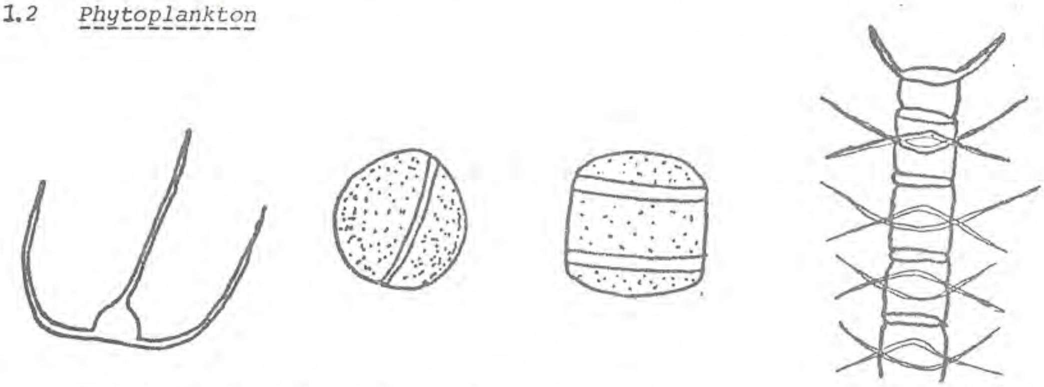


Fig: 1-2. Some Phytoplankters:

Diatoms are single-celled plants which consist of 2 plates.

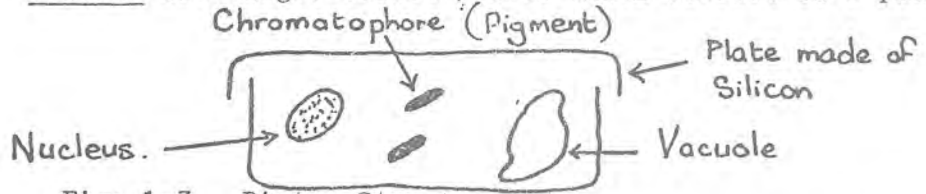


Fig: 1-3. Diatom Structure.

They reproduce by dividing in half many times.

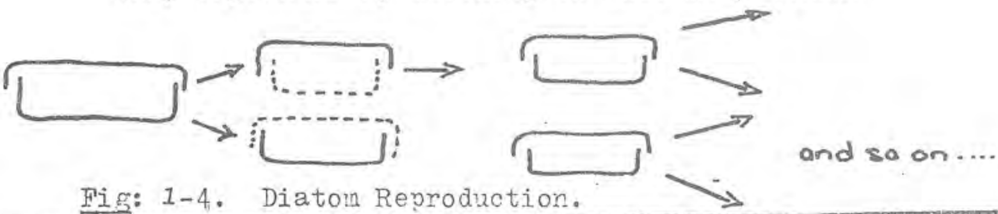


Fig: 1-4. Diatom Reproduction.

When a diatom dies it decomposes, but the silicon dioxide in the cell will remain to form the fragile shell. These shells sink to the bottom of the ocean where they form great deposits of diatomaceous earth. Some of these deposits are being "mixed" on dry land in areas once covered by sea millions of years ago. Diatomaceous earth is used commercially as a base for toothpaste, paint, polish, and kitchen cleaners. It is also used as a lubricant, a rust preventive, and in filters for swimming pools.

The *CHROMATOPHORE* is a special part of the phytoplanktons internal cell structure. It has the ability to trap the suns rays and convert the carbon dioxide in the sea into oxygen. This can only happen in the photic zone.

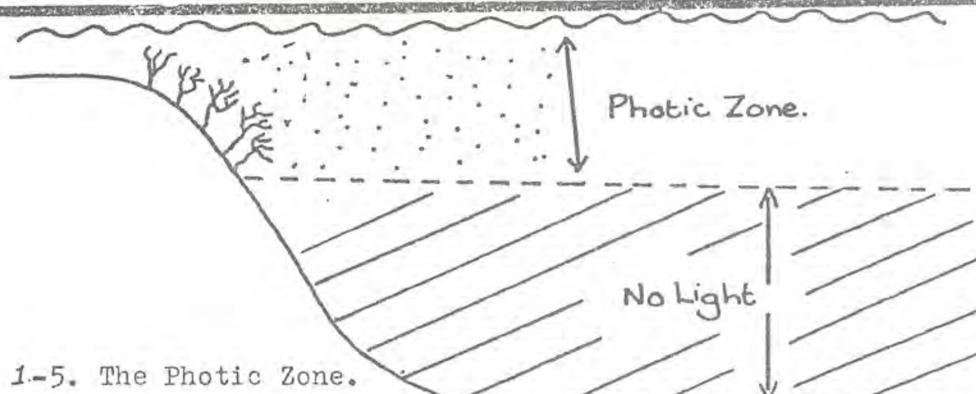


Fig: 1-5. The Photic Zone.

This is the maximum distance that light can penetrate in the estuary. It varies in depth according to the amount of dissolved matter in the water. It is also called the *PHOTOSYNTHETIC ZONE* which refers to the special ability that these phytoplankters have of converting the sun energy. *If we represent the reacting MOLECULES as follows:*

O_2:	*Oxygen Molecule*	- that dissolve in water and fish breathe
CO_2:	*Carbon Dioxide Molecules*	- that fish breathe out and dissolve in water also
$C_6H_{12}O_6$:	*Sugar Molecules*	- that make up the phytoplankters body
H_2O:	*Water Molecules*	- the solution in which the fish lives

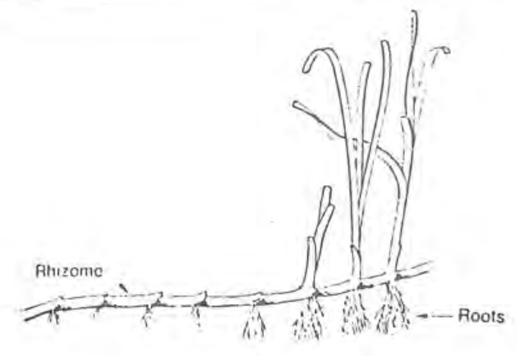
We can now represent *PHOTOSYNTHESIS* as follows:

Raw Materials	Light Energy	Useful food	Waste Gas
Sea Water + Carbondioxide ——	*Chemical change caused by the sun* →	*Sugar*	*Oxygen + Water*

$$12H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

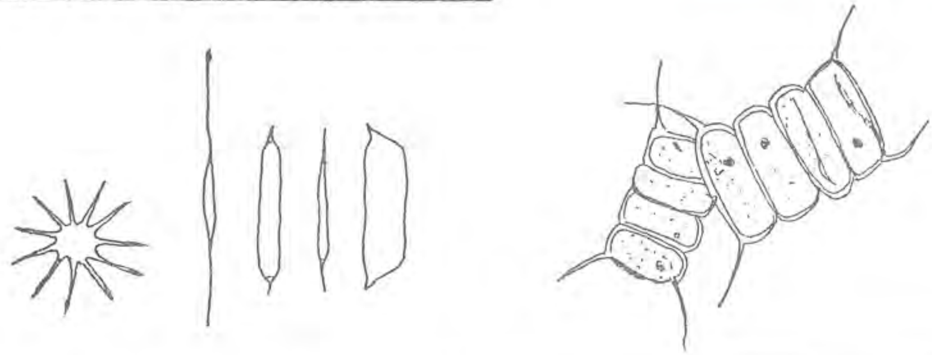
12 Molecules of water + *6 of Carbon Dioxide* gives *Sugar* + *6 Molecules of Oxygen and Water*

As the sugar is produced from within the phytoplankter it is stored in the cell wall. The oxygen is released into the sea and air. It has been estimated that 80 to 90% of all the worlds oxygen comes from these *PHYTOPLANKTERS* in the sea. The energy trapped by these phytoplankters will be passed on to all animals that eat them. Without the Diatoms it would be doubtful whether we would be able to survive.



Zostera, a nearshore Spermatophyta.

Phytoplankton you may have seen:



The important point to remember about phytoplankton is that they trap the sun's energy for the animals that live in the sea. Other animals can trap this energy by eating the phytoplankters. Let us have a look at these now.

Are dinoflagellates plants or animals? This has been the subject of much debate in recent years. Although classified as plants, they appear to have some animal characteristics. The tiny one-called diniflagellate gets its name from the long whip, or flagella, which it lashes back and forth to move through the water. Some forms prey on small animals or plants. *Locomotion and predation* are the characteristics of an animal. However, dinoflagellates contain chlorophyll, a pigment which allows them to use sunlight for photosynthesis, which is a characteristic of plants.

Usually the number of plankton remains constant. Occasionally, however, conditions change and there may be a sudden *"blooming"* period where the number of plankton increases rapidly. It is believed that "blooms" are caused by a change in ocean conditions which make it *more favourable for growth and reproduction of plankton*. Some of the conditions which may change and effect the plankton reproduction are: salinity, nutrients, currents, temperature, biological factors (such as absence of predators), etc.

Certain *dinoflagellate "blooms"* have caused what is known as the *"red tide"*, with large numbers of dinoflagellates making the ocean look red. Dinoflagellates produce a toxin which kills great numbers of fish. Shellfish (mussels, clams, oysters) appear to be immune to the toxin, but may pass it on to humans. Many dinoflagellates are bioluminescent. They produce light at night when the water is churned. This light is cold chemical light similar to that produced by fireflies on land. Other marine forms also bioluminesce, including jellyfish and some deep fish.

The colour of the ocean lets you know whether plankton is present or not. A blue colour usually indicates a sparse population, but a green (or blue-green) indicates a dense plankton population.

The most important factor that determines whether plankton will be present or not, is sunlight. Without sunlight, the phytoplankton could not photosynthesize, and would not be able to make food and nutrients it needs to live. Therefore, phytoplankton must stay in the lighted zones of the ocean, and are seldom found more than 200-300 feet below the surface.

1.3 *Zooplankton*

Zooplankton is the drifting animal life of the ocean. It is composed of permanent and temporary members. The permanent members are those which spend their entire lives as plankton;

included are Protozoans and certain crustaceans.

The most *abundant crustaceans* of the permanent zooplankton population are the copepods. *Copepods* and other crustaceans make up 70% of the total zooplankton population. There are more copepods than all other multicellular animals combined, including insects.

The temporary zooplankton is composed of members who spend the first stage of life as *drifting plankton*, either as eggs or larvae, and then grow into non-plankton adults. With the exception of marine mammals and reptiles, nearly every creature in the sea spends part or all of its life as plankton.

Zooplankton occur in all ocean waters, but are most abundant where there is a lot of *phytoplankton*. This is because many zooplankton are herbivores and feed on phytoplankton. In turn, many species of fish and crustaceans feed on *zooplankton*. The fish that eat *zooplankton* are called *"filter feeders"* because they strain out the zooplankton by passing water over their gill rakers. These fish include *bream, flathead, mullet, perch, or whiting.*

Plankton

- *Phytoplankton*
  - *Diatoms*
  - *Dinoflagellates*
- *Zooplankton*
  - *Permanent*
  - *Temporary*

Because of their *vast numbers*, wide distribution and helpful biological activities (such as making oxygen) plankton are considered the most important inhabitants of the marine world. All forms of life are directly or indirectly dependent on them. *Without plankton*, the sea would surely be a wet desert.

Some of the *zooplankters* you may have seen are:

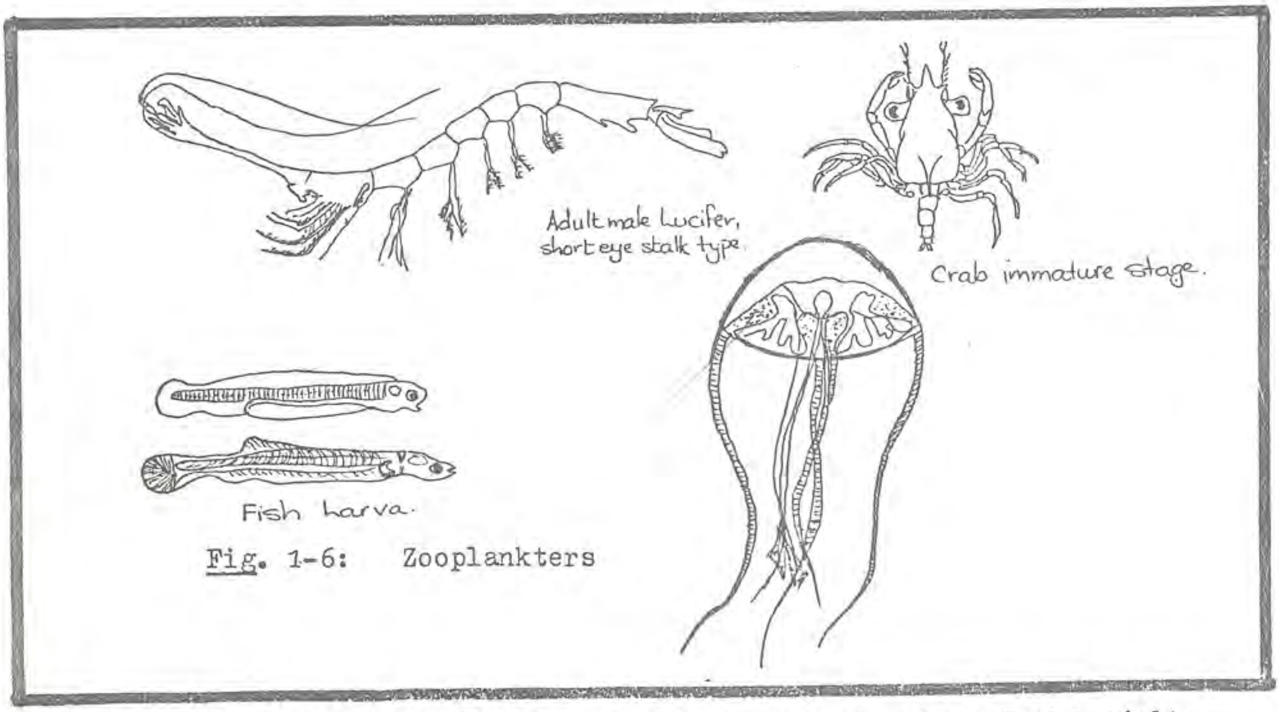
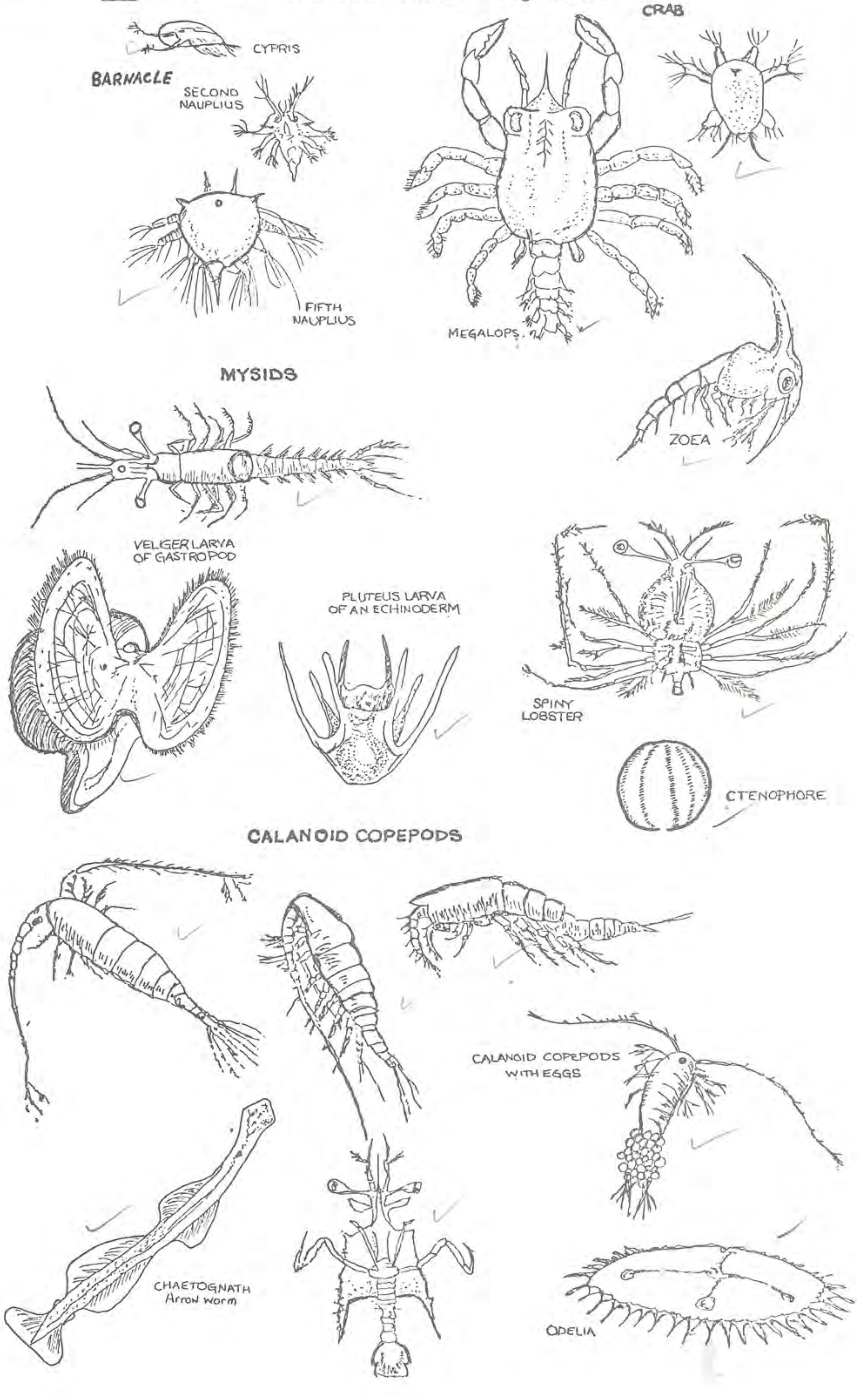


Fig. 1-6: Zooplankters

As we study the Nekton and the Benthon we will see the adult stages of many of the plankters drawn above.

Fig. 1-7. Some Planktonic Consumer Organisms.



1.4 Larger than Microscopic: *Jelly Fish*

Not all plankton is microscopic. The jelly fish can be seen clearly with the naked eye floating with the tide in our estuaries.

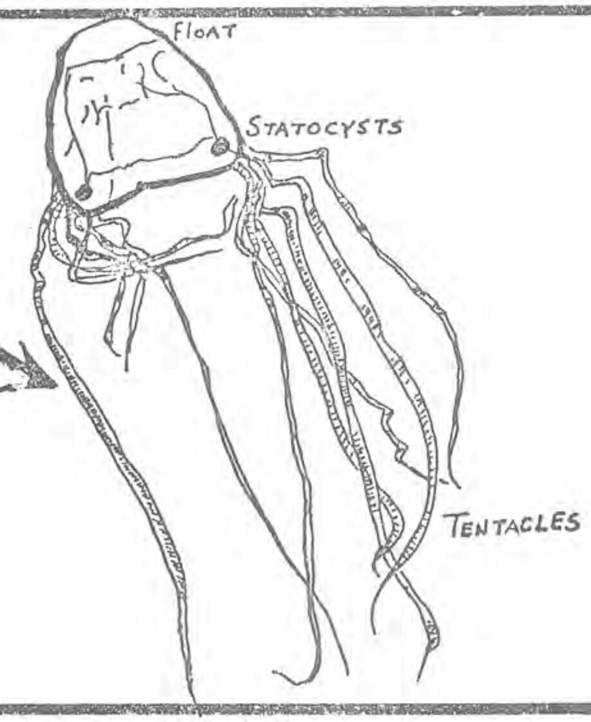


Fig. 1-8: Jellyfish

The jelly fish has a gas filled float and has specialised arms called *TENTACLES* which hang below the float. The jelly fish can actively swim using its float to pulsate backwards and forwards. The tentacles of the jelly fish are loaded with special *stinging cells*.

These stinging cells are called *NEMATOCYSTS*, and in the Queensland Box Jelly Fish produce a *POISON* which can kill humans. If we were to take a close look at a tentacle we would see that the Nematocyst cells were specialised.

When the trigger is activated, eg. when the tentacles *BRUSH UP* against your arm, the thread fires out, the *BARB* penetrates your skin and the poison is injected into your arm.

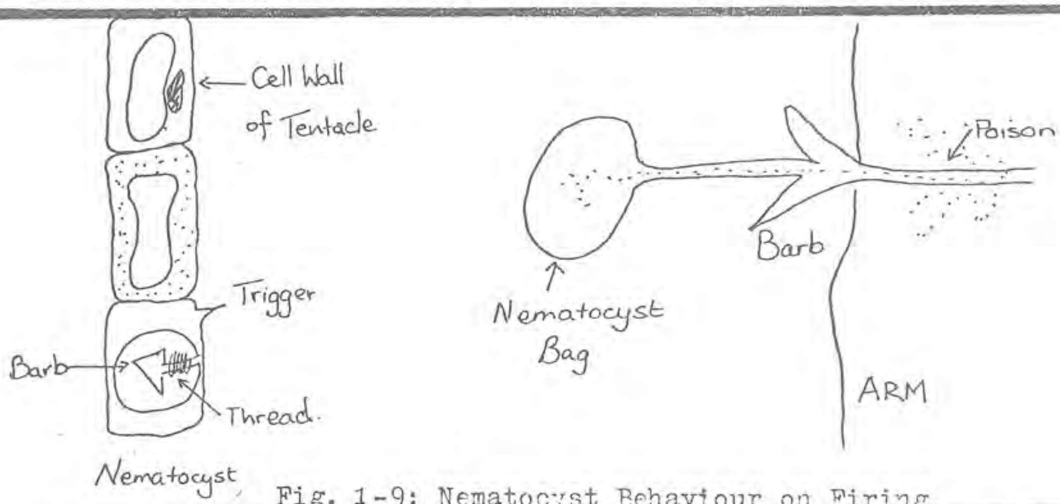


Fig. 1-9: Nematocyst Behaviour on Firing

Treatment these days is to rub or *pour vinegar over a sting*. This paralyses the *NEMATOCYST BAGS*, or stops further *NEMATOCYSTS* from firing. Medical help is then sought immediately. *If you rub the sting with sand* this will only cause more nematocysts to fire and inject more poison into your arm.

So, *NEVER RUB SAND* into a *JELLY FISH STING*, always take some vinegar to the beach in Summer.

Investigation -2: Jelly Fish Arms

Try to obtain a tentacle from a jelly fish and press it on a microscope slide and look for the *NEMATOCYSTS*.

.5 The Sea Weeds

The proper name for seaweeds is algae. Not all algae, however, are seaweeds, as some live on dry land or in fresh water. Not all marine algae are seaweeds. Microscopic algae are called *phytoplankton*. Only the marine algae are large enough to be seen without the use of a microscope (macroscopic) are called seaweeds.

Seaweeds do not have roots, stems and leaves as land plants do. The entire plant body is called a thallus. Seaweeds that are attached have a thickened rootlike or foot-like portion called *a holdfast*. While many seaweeds will die if cut off or broken above the holdfast, many will continue to grow. Instead of leaves or stems, some seaweeds have a stem-like area called the stipe, and a leaf-like area called the blade. Most seaweeds have a holdfast, stipe and blade, although they may be hard to distinguish on many plants.

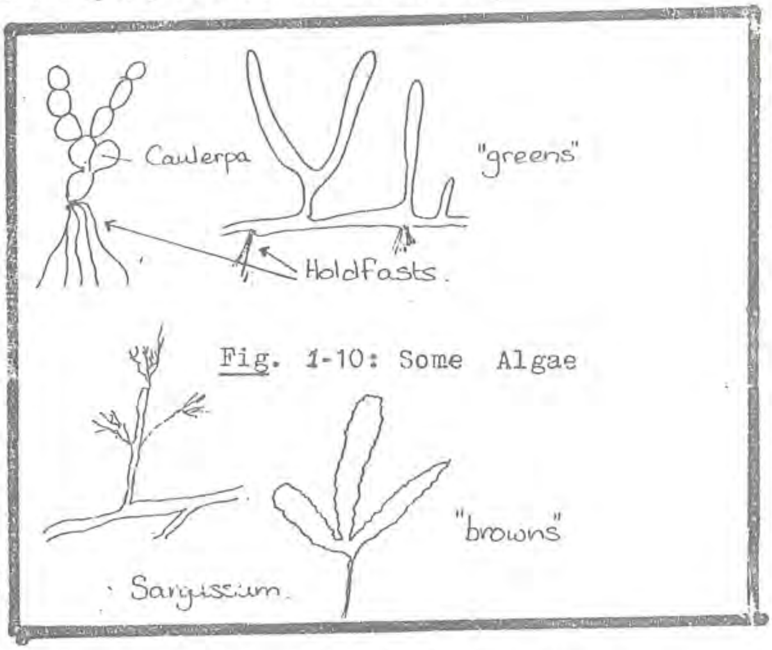


Fig. 1-10: Some Algae

Green plants reproduce by forming flowers, which in turn produce seeds, but seaweeds do not produce either one. Instead they produce spores on the tips of their branches. The spores are very tiny, and when released, float away to become part of the great mass of floating *phytoplankton*.

Seaweeds, like land plants, must carry on *photosynthesis* (formation of carbohydrates in the chlorophyll-containing tissues of plants exposed to light) to produce energy and nutrients needed for growth. This complicated process is carried on by structures in the plant called chloroplasts, which contain pigment (colouring) that give plants their green colour. This green pigment is called *chlorophyll*. All seaweeds contain chlorophyll, even though they are not all green in colour. Many seaweeds contain other pigments too, and these pigments are what give seaweeds their *brown*, *golden* or *red* colours.

Seaweeds are an important part of the ocean community. Animals such as nudibranchs, snails, and crabs live on the blades. Starfish, clams, crabs and worms seek shelter among the holdfasts. Some small fish and crabs, that are the same colour as the seaweeds, hide there from predators. In addition to providing shelter, seaweeds also provide oxygen for these marine animals.

1.6 Uses of Seaweed

If someone asked you if you have ever eaten seaweed, you would probably say "no". Who would want to eat that green, slimy, smelly stuff so often seen washed up on the beach? However, if someone asked you if you have ever eaten ice-cream, and you answered "yes", then you have indirectly, eaten seaweed. One of the products extracted from seaweed in "agar-agar" which is used in ice cream to make it smooth and creamy.

People in China and Japan have been using seaweed for centuries as a source of food. The ancient inhabitants of Japan ate a certain species of seaweed, Porphyra, as a supplement to their rice diet. Even today seaweed is known as a delicacy to the Japanese. Known as "nori", the demand has grown steadily and seaweed is now being farmed like a vegetable.

In Europe, species of seaweeds have been used for food for over twelve centuries. The best known and most widely used food algae in Western Europe in recent centuries was Irish Moss, Chondrus, which was cooked in milk, seasoned with vanilla or fruit, and made into a highly edible dish.

Many countries today are facing serious food shortages. Increases in population have forced the agricultural farmers to give up land for housing. Many scientists are now exploring the possibilities of culturing or farming the ocean. Researchers are looking for substitutes for regular food. "New" crops must be able to grow a number of times a year, in little space, and at a low cost. In addition, they must be nutritious and produce needed vitamins and minerals. Researchers have found that not only are algae a suitable substitute, providing the necessary protein, carbohydrates and vitamins, but that they produce a higher yield of food per acre than regular food crops.

What other uses do seaweeds have? In addition to providing food for humans, they provide fodder for sheep and cattle industries. When they are allowed to rot in the field, they can also be used as fertilizers.

Seaweeds also produce a number of very important resources. One of these is called alginic acid. It is used to prepare soups, sauces and creams; it is used as a thickener in cosmetics and drugs; it is used in preparing polishes and paints and can be used during surgery to stop bleeding.

A jelly-like substance called agar-agar (or simply agar) comes from certain type of red algae. The most important use of agar is as a substrate for growing fungi and bacteria. It is also used as a stabilizer or emulsifier in food such as ice cream, jams, jellies, candy and cheese. In addition, it is used in cosmetics, leather and pharmaceutical industries. Agar is also used in canning fish, sizing fabrics and in the paper industry.

Carrageenin is very much like agar and is taken from Irish Moss, another of the red algae. Carrageenin is often used as a cough remedy, as a pharmaceutical emulsifier and is utilized in textile, cosmetic and brewing industries, (it prevents wines from becoming cloudy).

Seaweeds then provide more than oxygen, food and habitat for marine animals. Without realizing it, most of us use some form of seaweed every day. In addition, with a growing population and decreasing amounts of farmland, mariculture could become a real necessity.

Investigation 1-3: Pressing Seaweeds

The objective of this activity is to prepare herbarium mounts of marine algae. NOTE: Always check with the National Parks and Wild Life Services before making any kind of a collection.

You will need:

* plastic bags and ties
* labels
* shallow pans or trays
* probes
* dissecting needle
* scissors
* putty knife
* 5 x 8 file cards or herbarium sheets
* plant press (plywood with belts or rope to tie)
* wax paper
* cellophane wrap
* identification keys
* field notebook

What to do:

PART A: In the Field

1. Collect seaweeds at low tide. All specimens from each particular habitat should be placed in the same bag. Remember the specimens should fit the 5 x 8 card (with 3 inches free for information) so limit the size of the specimens. Number the bag and record the information in your field notebook as to where the specimens were found.

2. Try to collect living specimens. Dried, decaying or insect-eaten plants are worthless. The plant's holdfast should be *CAREFULLY* removed from the substrate with the putty knife.

PART B: In the Classroom

1. Wash the specimen thoroughly to remove all mud and debris. Trim the specimen if necessary to fit the 5 x 8 card.
2. Try to identify the specimen with use of a key, pictures or comparison. It is much easier to identify seaweeds when they are *WET*.
3. If the specimen is coarse, it can be spread out on the card by hand or teased out with the dissecting needle.
4. If the specimen is delicate, it may have to be "floated out". Place the algae in a shallow pan filled with water. Float the specimen to a natural position. Slip the card under the algae and lift the card slowly and carefully so the water will drain.
5. Leave the lower three inches of the card under the algae free for the label. The label should be written in pencil and contain all the information on the sample label (see illustration), so you can identify it after pressing.
6. Place the specimen on blotter paper (or newspaper). A number of specimens can be placed on one blotter. Place a piece of wax paper over each of the specimens.

7. Place the specimens in the plant press in the following manner and make a "sandwich" in this order

   Cardboard
   newspaper
   blotter
   wax paper
   (specimen on card)
   blotter
   newspaper
   cardboard.

   After stacking all of your specimens, place one one piece of plywood and place plywood on the other side of the stack. Secure the press with belts or ropes.

8. Place the plant press near a heater (or a fan) so that air blows through the cardboard spaces.

9. Change thelayers of blotter paper and newspaper once each day so that drying is thorough.

10. Most plants "glue" themselves. If not, glue them to a piece of mounting paper and label.

    SAMPLE LABEL:

Scientific Name:	
Common Name:	
Location Found:	
Habitat:	
Collector's Name:	
Date:	*Specimen No.*

Questions:

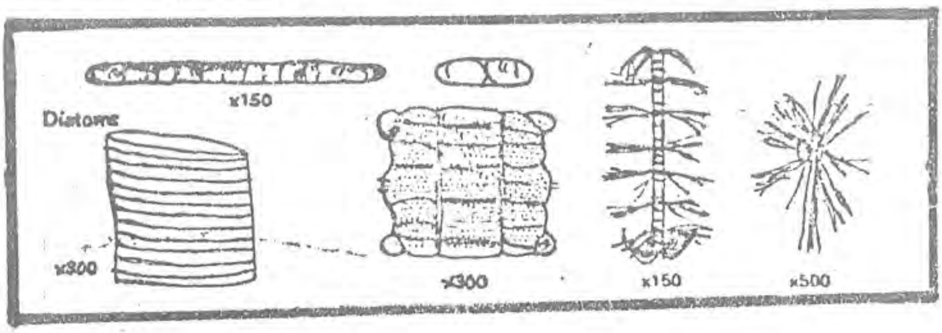
1. What was the most abundant species of marine alga you found? The least abundant?
2. What educational value does a herbarium collection have?
3. Of what value is the information that is recorded on the label of the seaweed specimen.

NOTE: It is suggested that the instructor choose the best specimens each year and use to build up a school phycology collection. Be sure to cover with plastic to preserve.

1.7 The Food Web

All forms of life are tied together by food chains (eating-eaten relationships). The food web is the total of all of the food chains in the plant and animal communities.

The food chain starts at the "top" of the ocean, where sunlight provides for photosynthesis. The plants, marine algae and phytoplankton, use this sunlight to grow, giving off oxygen. The plants in this area are the basic for all animal life in the marine



environment. Without these organisms, none of the animals of the ocean could exist. Zooplankton feed directly on the phytoplankton, which, in turn, are fed on by small fish, which are eaten by larger fish and so on.

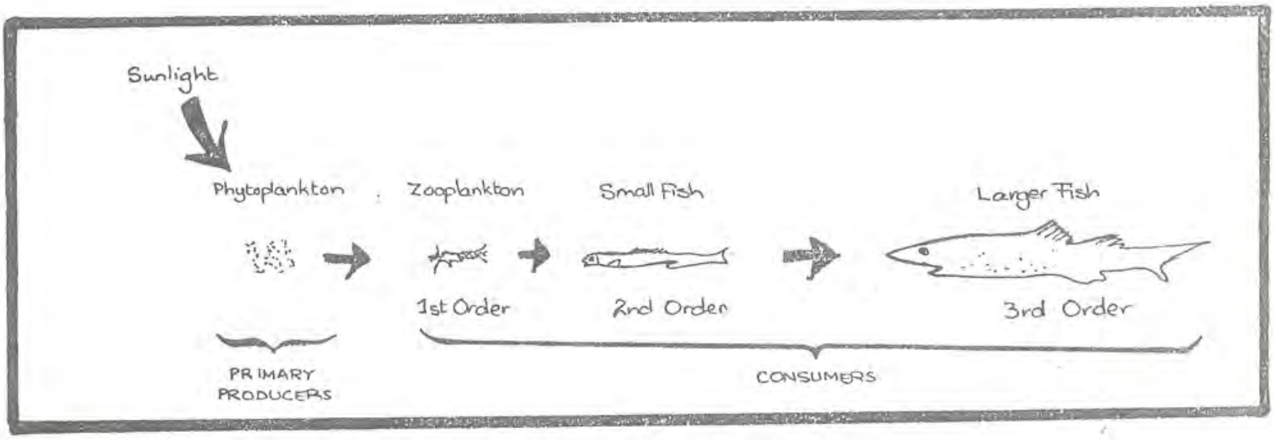


Fig 1-11: A Typical Food Chain.

1.8 A Food Chain

Plants are known as primary producers because they are the primary food source of food in the food chain. They are the only organisms which make their own food from raw materials, carbon dioxide, water, sunlight and minerals. Part of their food is converted into energy for performing the plant's activities as a living organism. The remainder of this plant food is stored and probably eaten by a herbivorous animal.

Animals are consumers and are placed in groups, called orders. The more an animal depends on plants for its food supply, the lower the order to which that animal belongs.

Since zooplankton feed directly on phytoplankton, they are called 1st order consumers. They are the first of the animal kingdom to consume the plant food directly for energy. Other 1st order consumers might include fish, molluscs, crustaceans and even whales, that sometimes feed directly on phytoplankton.

1.9 Food Pyramid

The 2nd order consumers, such as small fish, feed on the 1st order consumers. This order includes many fish and birds.

Large sharks are representative of the 3rd order consumers. These animals feed on the lower orders and are in little danger of being eaten themselves.

Several animals fit into two or more categories depending on what they are eating. Birds, for example, can be 1st, 2nd or 3rd order consumers.

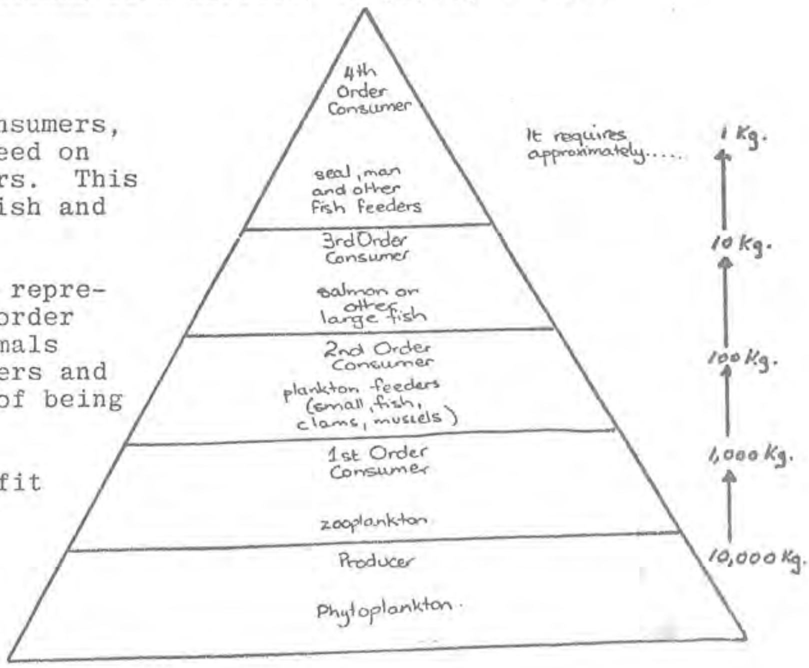


Fig. 1-12: A Food Pyramid

Scavengers and decomposers (microscopic bacteria and fungi) play a special role in the food chain. All living organisms eventually die and are decayed and decomposed by microscopic fungi and/or bacteria called decomposers. Decomposers perform the important function of releasing the nutrients (phosphates, nitrates and other minerals) from the dead animals back into the ocean water. These nutrients are then used by plants for growth.

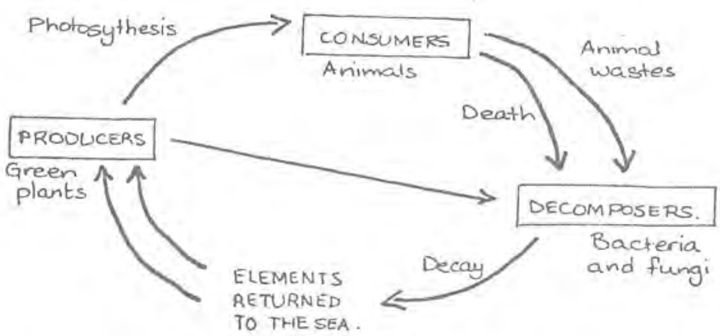
All organisms of a food chain are linked. The survival of an organism at each step depends on the survival of the organism below it in the food chain. For example, zooplankton depend on the phytoplankton to survive. If phytoplankton are scarce, the small fish starve, and so throughout the food chain.

The food pyramid shows the amount of plants and animals, or the total weights of living materials, at each step of the food chain.

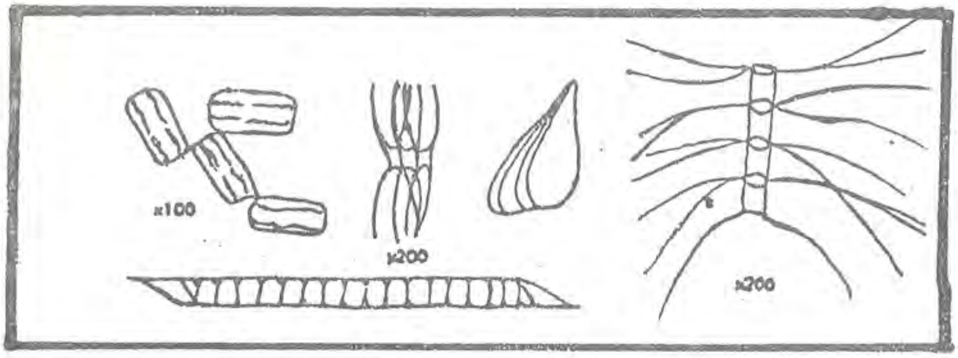
The primary producers, the phytoplankton, are at the base and are the most numerous. With each step of the pyramid, the order of consumers increases and the number of organisms decrease. The decrease occurs because energy is lost when one organism eats another. The energy of the organism eaten is converted to "growth minerals" for the eater, while some of the energy is lost as heat during the conversion. *As we move up the pyramid, less and less energy is available to support living matter.*

1.10 The Web of Life

Fig. 1-13: The Cycle Of Matter



In this cycle all matter is returned to the sea. It is then used by the producers to start the cycle again. Can you see why matter cannot be created or destroyed? Can you see the important role decomposers play? Can you visualize these phytoplankters absorbing the elements from sea water to photosynthesise?



1.11 The Plankton Net

This device is used to collect plankton. Several basic designs are illustrated. A nylon stocking can be used to make the mesh part of the net. The mesh size of the stocking should be measured so that you can anticipate the size of the plankton you will be collecting. A good average mesh size is between 50 and 100 microns (to measure the size, use a micrometer with a microscope, or use a microscope and a metric ruler and estimate the size). You will probably be collecting microplankton and mesoplankton. Microplankton and larger organisms are usually referred to as *net plankton* because they can be caught with commercially produced nets, whereas nannoplankton

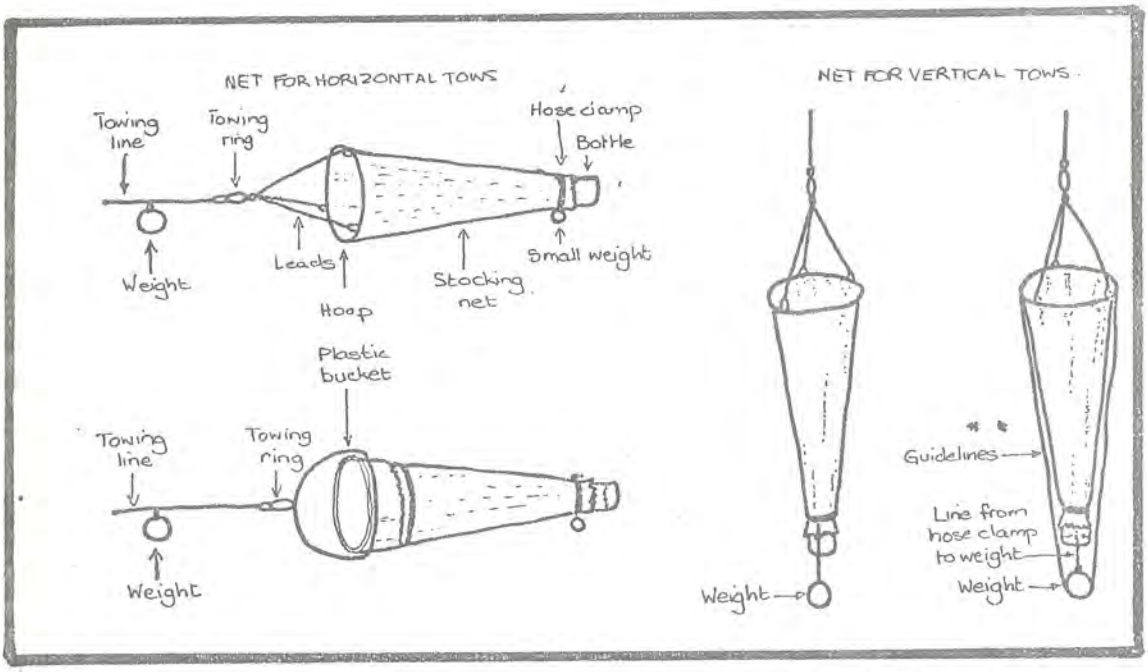


Fig. 1-14: Plankton Nets

and ultra nannoplankton are usually collected by bottles or some device other than a net. The wide end of the stocking (Fig. should be tied to a handle consisting of a loop with leaders going to a towing ring. The towing ring can then be tied to a rope or a cable (if a cable is used in towing and the net, a swivel should be placed between the towing ring and the cable to prevent the cable from unraveling). A very good bridle (handle) can be made from a small plastic bucket with the bottom cut out. The bucket handle can serve as the lead to the tow line (Fig. 7-1(a))

The *cod end* of the plankton net is the collecting chamber at the tail of the net. It can be either a bottle or a heavy plastic jar, but the plastic is better since glass can break as it hits the side of the boat. The bottle or jar can be attached to the net by a hose clamp, after the end of the stocking is cut off and the bottle is then clamped in place. For horizontal tows (sampling runs) a weight (of a kg or so) should be placed as shown in Figure so the net will sink beneath the water surface, and another weight may be needed at the hose clamp to keep the cod end from floating. For vertical tows a weight (of a few pounds) should be placed on the cod end; if it puts too much strain on the stocking, guide lines can be constructed.

MAIN IDEAS

1. Plankton are surface dwelling organisms which move with ocean currents. There are two types - zooplankton (animal) and phytoplankton (plant).

2. Phytoplankton inhabit the photic zone and produce oxygen using light and carbon dioxide. This process is called *photosynthesis* and produces over 70% of the earths oxygen.

3. Photosynthesis also produces sugar ($C_6H_{12}O_6$) which is stored in the phytoplankters cell walls.

4. $12H_2O + 6CO_2 \xrightarrow{sun} C_6H_{12}O_6 + 6O_2 + 6H_2O$

5. Phytoplankters are called producers because they produce this food. Zooplankters receive this sugar and associated energy it releases by eating the phytoplankters. They are called *consumers*.

6. A chain of consumers and producers is called a *food chain*. A combination of chains is called a *food web*.

7. *Energy cycles* in this web but is reduced higher up the food chain. We can represent this in a *food pyramid*.

REVIEW QUESTIONS

1. What is the photic zone and why is it important to man?

2. Draw the structure of a phytoplankton and indicate how the raw materials for photosynthesis enter the plant.

3. Where are plankton found? Draw 8 different types.

4. Write the balanced photosynthetic equation.

5. What is a *Dino Flagellate Bloom?*

6. Detail how a Nematocyst fires and state the treatment for marine stings.

7. List 5 uses of seaweed.

8. What is a Food Chain and detail any 2.

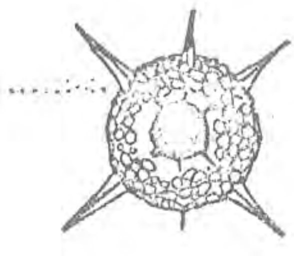
9. Why does energy decrease in the chain? Use a pyramid to illustrate your answer.

STUDY ASSIGNMENTS

1. Design a poster showing First Aid procedure for marine stingers.

2. Research uses of seaweed further in a book on Marine Botany.

3. Find out about Plankton Farming in Japan or other overseas countries.



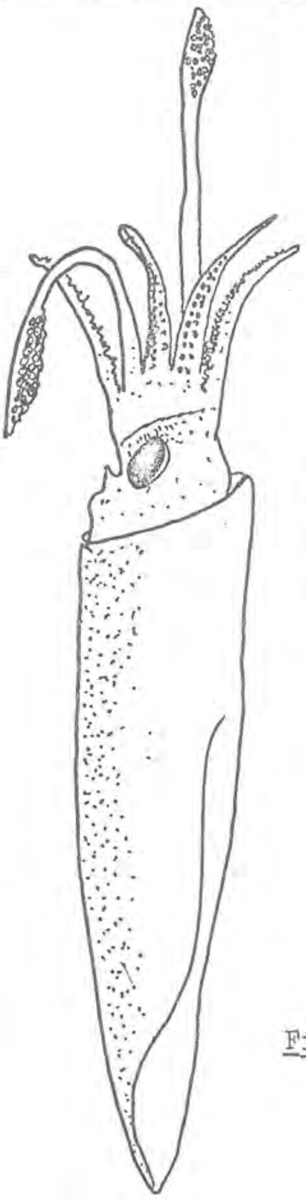
SECTION 2

THE NEKTON

2.1 Types of Nekton

Ever since "Jaws" and "Moby Dick", Nekton have been famous. This group includes the animals that swim freely in the sea from top to bottom. Some live very close to the bottom and are called *Demersal* while others move freely between the middle and upper layers of the estuary. These are called *Pelagic*. Types of Nekton include the Sharks, the Bony Fish, Turtles, Sea Snakes, Dolphins, Whales and Squid. In this chapter you will learn a little about each and discover how man seeks to manage their populations for commercial and conservation purposes. But let's start with the Squid.

2.2 The Squids



These amazing animals belong to the class of animals called Molluscs. They are closely related to the octopus and *cuttle fish*. Most of you would have seen a cuttlefish "bone" on a beach. This is the only remains of the shell that once covered these animals. Other animals in the class Mollusca have shells (e.g. Cowries, Limpets).

Squid make excellent bait for fishermen or exquisite restaurant delicacies. They have been the subject of science fiction writer and scientist alike. Many interesting experiments have been done on their cousin the Octopus and his eye. Scientists have found that the Octopus can discriminate between shapes and can learn in a maze.

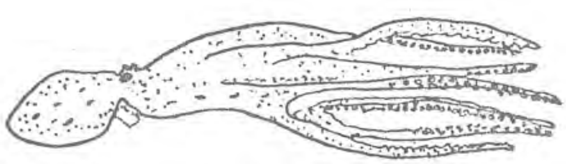


Fig. 2-1: Squid and Octopus

2.3 Sharks and Rays

There are two major groups of fishes, the cartilaginous fish, and the bony fish. The cartilaginous fish, of which there are 600 different kinds, include sharks, rays, skates, sawfishes and guitarfishes. Most of these live in marine waters, although a few are strictly fresh water fish.

There are 250 species of sharks found all over the world. While some of the species prefer shallow water, others are found in water as deep as 3,000 metres. Sharks vary in size from very small to enormous. The smallest known shark is called "tsuranagakobitozame" by the Japanese, which means "the dwarf shark with a long face". It is about six inches long when full grown. Only a few have ever been captured. The largest shark is a whale shark, which grows to over 15 metres in length and may weigh several tonnes.

While most sharks and rays may look like fish, they are not true fish because their skeletons are made of cartilage instead of bone. Sharks breathe by gills, as fish do, but their gills are behind their heads, slightly above the pectoral fins, instead of on the sides. Most sharks have five gill slits, although a few have six or seven.

In rays and skates, the gills lie on the underside of the head. Instead of taking water in their mouths as do the sharks, the rays take it in through two openings called spiracles, lying on top of their head in back of the eyes. Each spiracle is fitted with a special valve. When the fish breathes out, the valve is shut off and water is forced out through the gill opening on the underside of their flat bodies.

Sharks lack air bladders (sacs filled with air that help keep fish buoyant). Because sharks don't have air bladders, they must continually swim or they will sink, which many of them do when resting.

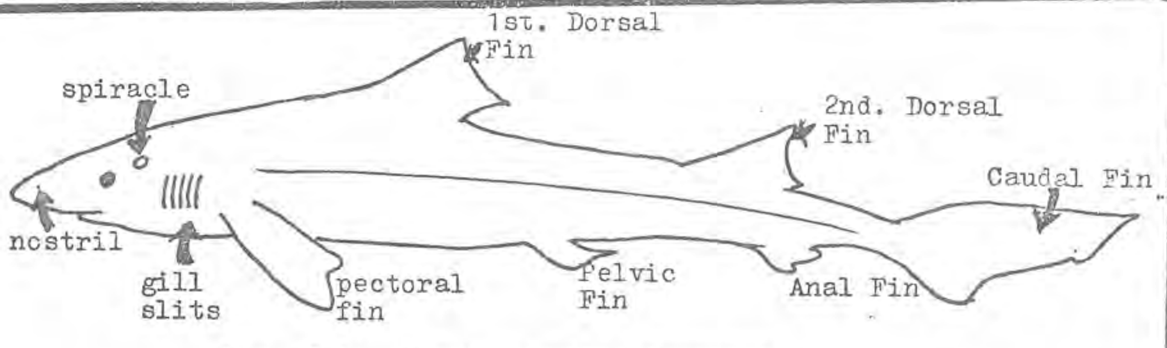


Fig. 2-2: Shark, general features

Sharks and rays have varied breeding habits. Unlike bony fish, they reproduce by internal fertilization. Some sharks lay eggs which are covered by hard cases that protect them while they develop. In others, the eggs hatch within the mother and the young are born live. A tiger shark may produce as many as 50 young in one litter.

Shark's skin is rough, made up of thousands of tiny "teeth" or scales called placoid scales which are modified teeth. These sharp scales extend into the animal's mouth, where they are modified into rows of sharp teeth. As soon as a tooth breaks off or wears out, another takes its place. It is estimated that in the course of ten years, a shark may produce and shed 24,000 teeth.

How do sharks find food? They have an incredible sense of smell that lets them detect the blood of an animal more than a half a kilometre away, or the juice of a dead tuna although it is diluted to one part in 1½ million. The inner surface of their organ of smell, called the olfactory pit, has many thin folds. These leaf-like folds, called lamellae, are constructed so that water from the outside constantly flows over this sensitive surface. It is said that the smelling surface of the olfactory organs of a shark has an area of ½ hectare because of this intricate folding!

As a shark gets closer to his prey, its sense of hearing takes over. Sharks possess a highly complex system of pressure sensors called the lateral line system. This system allows them to "feel" vibrations in the water such as those a struggling or injured fish might make. Finally, when a shark gets within 15 metres of its prey, it can see what it has been smelling and feeling.

What do sharks eat? With their incredible denture system and sense of smell, almost anything! Some sharks, such as whale or basking sharks, feed only on plankton and small shrimp or fish. Some eat only clams and snails. Other sharks feed on live or dead organisms, and the larger sharks may consume fish up to half their own length.

Many sharks are not very discriminating in their tastes. In exploring the contents of a shark's stomach, people have found a variety of amazing objects including bird bones, grass, turtle shells, a cow and horse skull, a kerosene can, bicycle parts, seat cushions, raincoats, and even a car number plate. While shining metal objects seem to attract sharks, they are generally inedible and smaller objects are usually eventually regurgitated.

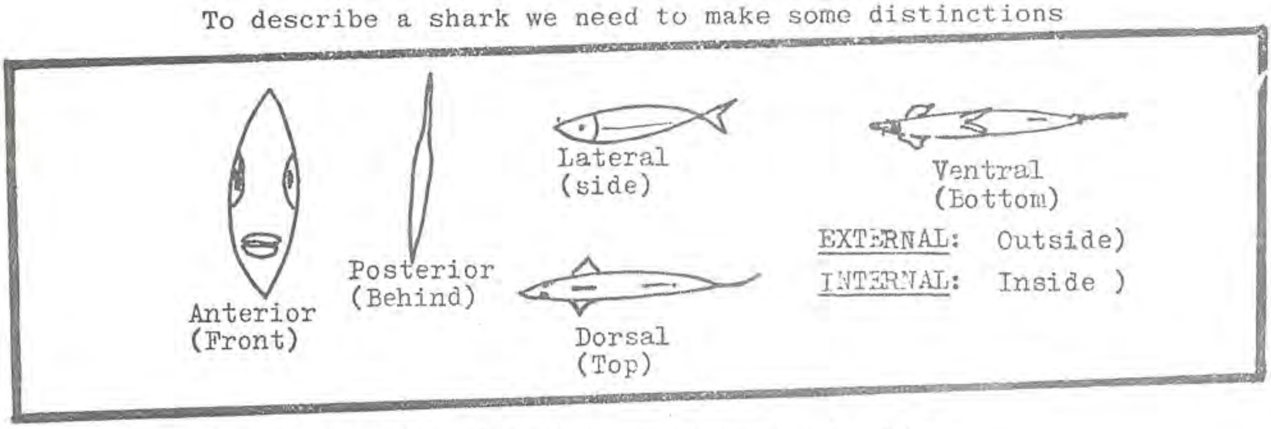
What commercial value do sharks have? In the 1940's oil from shark's liver was an important source of Vitamin A. Since then, synthetic vitamin A has been developed and sharks are no longer hunted for this reason. In other parts of the world, sharks contribute their skins as shoe leather, their teeth as jewellery and their remains as glue and fertilizer. Oriental gourmets relish soup made of shark fin, and shark meat has been sold under the name of scallops and barramundi.

Since the making of the movie "Jaws", the word *SHARK* conjures up images of bloody water and mangled bodies. One of the first recorded shark attacks took place around 700 BC, and sharks have been regarded with fear since that time.

Just how dangerous are most sharks? Of the 250 species of sharks, only about 24 are potentially dangerous to man. Recent reports point out that there are less than 30 unprovoked shark attacks on man a year, and fewer than 10 are fatal. The chances of being struck by lightning or dying from a bee-sting are much greater than being attacked by a shark.

The best way to avoid sharks while swimming is to avoid known shark infested waters. Do *NOT* swim where blood, fish scraps or bait is present, or where there is much fishing from piers or with nets. If spear-fishing, do not attach your catch close to your body - attach it on a long line or put it immediately in your boat or on shore. If you do see a shark while swimming, stay calm! Don't make a noise, splash, yell or try to hit the shark on the nose. None of these are effective. Instead, immediately wade or swim as quietly as possible to shore.

To describe a shark we need to make some distinctions



Investigation 2-1: A Dogfish (gummy shark) Dissection

You will need

* A preserved dogfish (available from the Fish Board)
* For injection of latex details see Appendix
* Dissection board and instruments
* Binocular microscope
* Gloves (bring your own) or soap and towel

What to do

PART A: The External Features

1. Locate the following - fins, heterocercal (upswept) tail, fins - anterior, posterior dorsal, posterior ventral, anterior pectoral, posterior pelvics.

2. Locate the eyes, gill slits, cloaca (identify the claspers in the male) lateral line and denticles in the skin. Draw all these features in a line drawing.

PART B: A Cross Sectional View

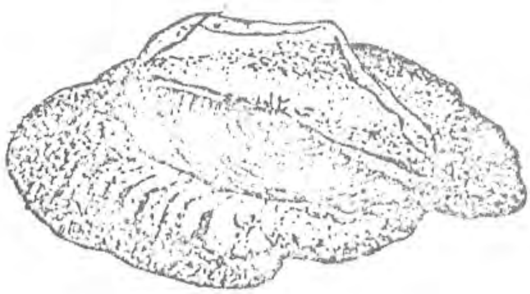
1. Carefully cut off the tail and examine its cross section under a stereomicroscope.

2. Draw the positions of the vertebral column, nervous cord, outside skin and surrounding muscle.

PART C: The Digestive System

1. Remove the dorsal fin and lay the shark on its back. Make a long cut from tail to pectoral fin region in the middle of the body. Open the body wall and pin back.

2. Identify the liver lobes and pin them back. Now locate the *OESOPHAGUS*, and follow it to *THE STOMACH*, *THE INTESTINES*, *RECTUM* and *ANUS*. *DRAW*.



3. Locate the *GALL BLADDER* (embedded in the liver), the *SPLEEN* (a dark reddish structure located near the stomach), the *PANCREAS* (a creamy white organ near the intestine with two lobes and a short tube that enter into the intestine near the *BILE DUCT*. *ADD THESE TO YOUR DRAWING.*

PART D: *Reproductive System*

(a) *In the Female:* Locate the oviducts and trace them towards the ovaries. Then trace them the other way towards the *Shell Gland* and *Cloaca*. *DRAW.*

(b) *In the Male:* Locate the claspers, the kidneys, the testis, vas deferens and sperm sac. *DRAW.*

PART E: *Nervous Systems*

* *Wherever possible nerves should be TRACED from their point of origin in the brain or spinal cord to their FAR ENDS.*

1. Dissect the brain by skinning the head carefully from snout to just behind the eye.

2. Carefully chip away the cartliage around the eye.

3. Locate the optic nerve and draw its relationship with the brain.

4. Explain the brain. Locate the Fore, Mid and Hind Brain, Optic Nerve Medulla and Olfactory Lobes

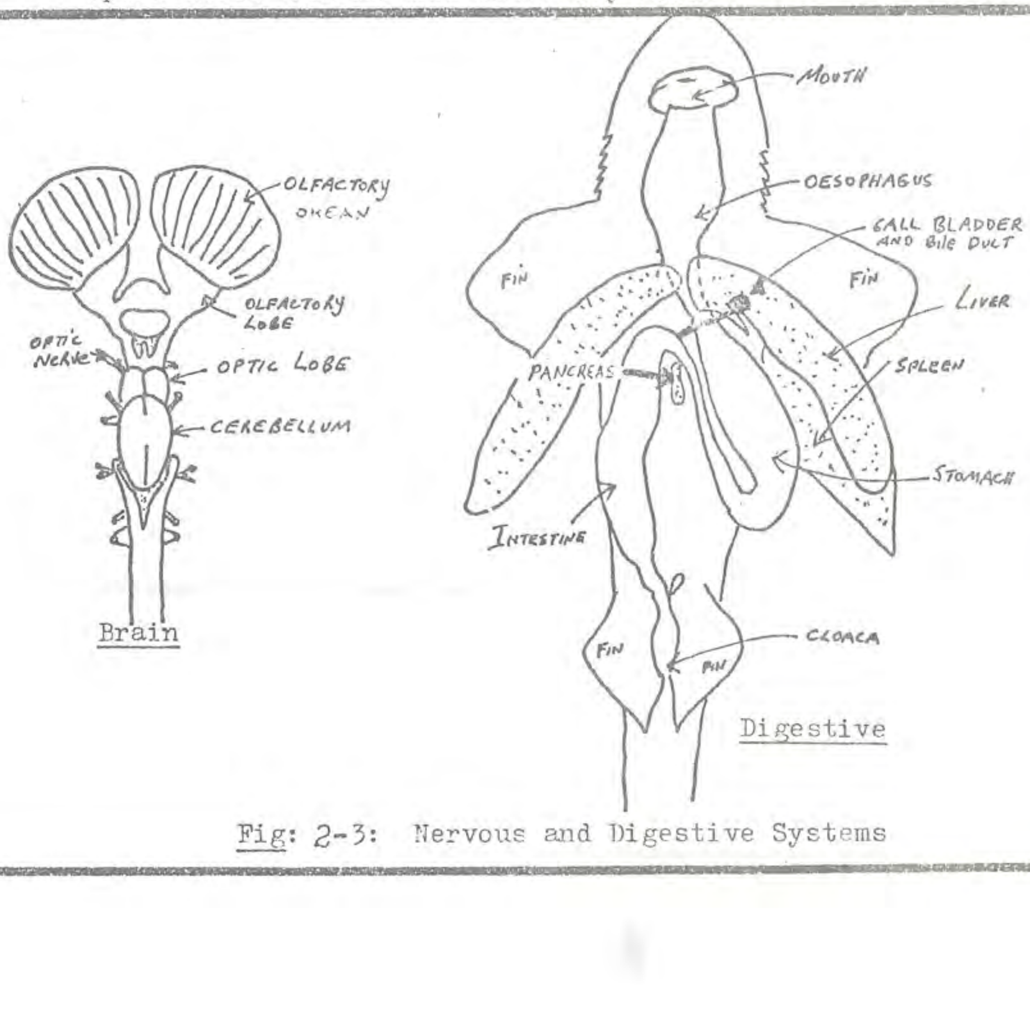


Fig: 2-3: Nervous and Digestive Systems

2.4 Bony Fish

The bony fishes make up 25-40 thousand species of fish. These include Cod, Whiting, Flathead, Perches, Bream and many, many more. The fish of this group have a bony internal skeleton and a single pair of external gill openings. Fertilization may be internal, but usually is external.

(a) *Anatomy:*

Fish have two sets of paired fins, the pectoral and the pelvic or ventral. The pectoral fins can be used individually to turn the fish in either direction or control the up and down movement. Together, these fins act as brakes, or when used in a reverse motion, they allow the fish to swim backward. The pelvic fins are used for braking and steering. Fish also have three unpaired fins; the dorsal, anal and caudal. The dorsal (back) fin may consist of two parts, the first spiny, the second soft, or the entire fin may be composed of soft rays. The number of rays in the fin are often used for identifying the fish. The dorsal and anal fins are used like a keel or rudder to stabilize the fish. The caudal fin or the tail is used to give the fish power to move through the water.

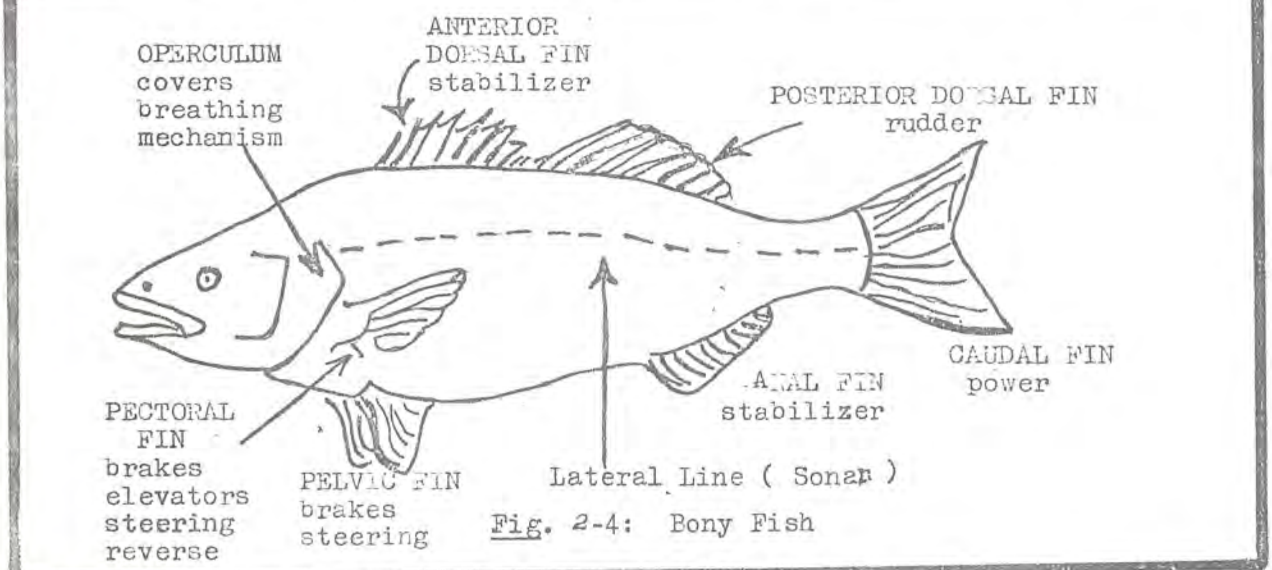


Fig. 2-4: Bony Fish

(b) *Scales:*

Most all fish have scales. Fish are scaleless when hatched but develop scales the first year. Scales serve as a protective covering and for further protection against bacterial infection, all fish secrete a slimy coating. There are five types of scales.

Fig. 2-5: Types of Fish Scales.

Placoid scales are the type found on sharks and rays, and are small tooth-like in shape.

Ganoid scales are found on gars and are shiny and plate-like.

Cycloid scales, found on sole, flounder, and are over-lapping scales.

Ctenoid scales are found on most bony fish and have comb-like edges. Scales grow from pockets in the skin, growth being marked in rings. In winter, growth is usually less and rings are closer together, forming annulus or annual rings. These rings can be counted like a tree, the number of rings tell the age of the fish.

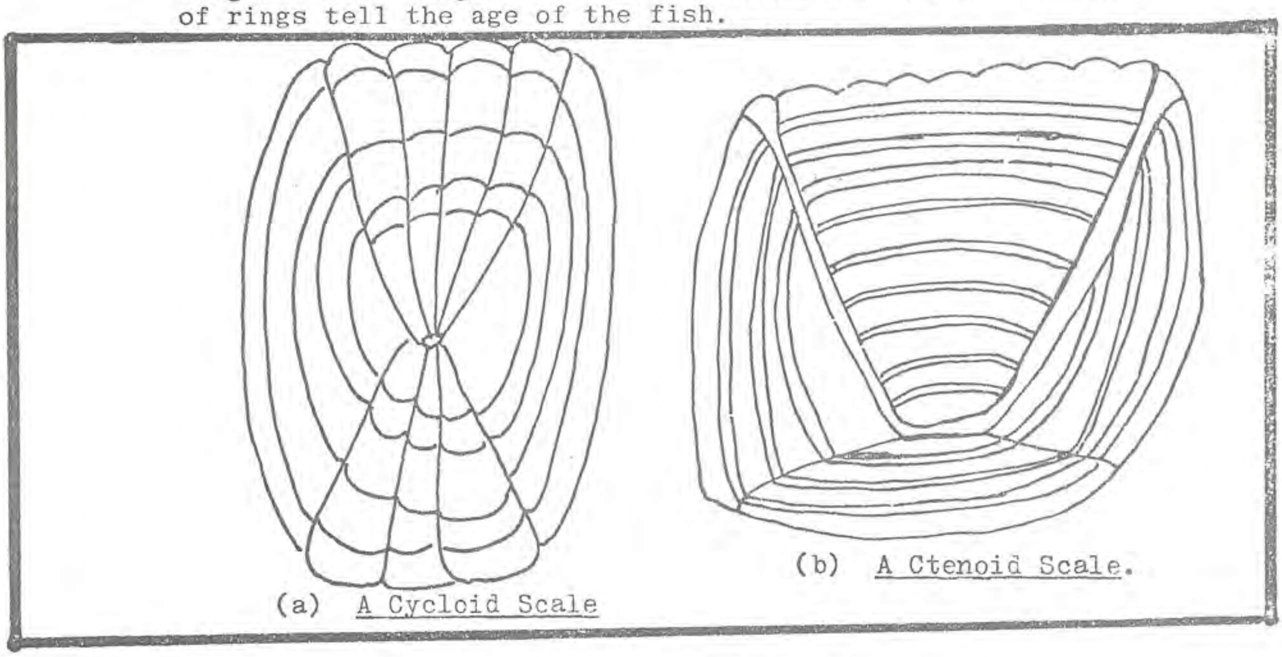


Fig. 2-6: Types of Fish Scale

(c) *Internal Organs:*

Fish have three main skeletal parts; the skull, vertebral column and the *fin skeleton. The skeleton* provides support to the body, protection to the brain and an attachment place for muscles.

Fish with large mouths and many long, sharp teeth are carnivorous. Some deep ocean carnivorous fish have a large enough mouth to swallow fish almost as large or larger than themselves. This is an adaptation for survival in a habitat where food is scarce. The stomach of a 4 metre marlin caught by a local fisherman, contained a 1 metre yellowfin tuna weighing 70 kg.

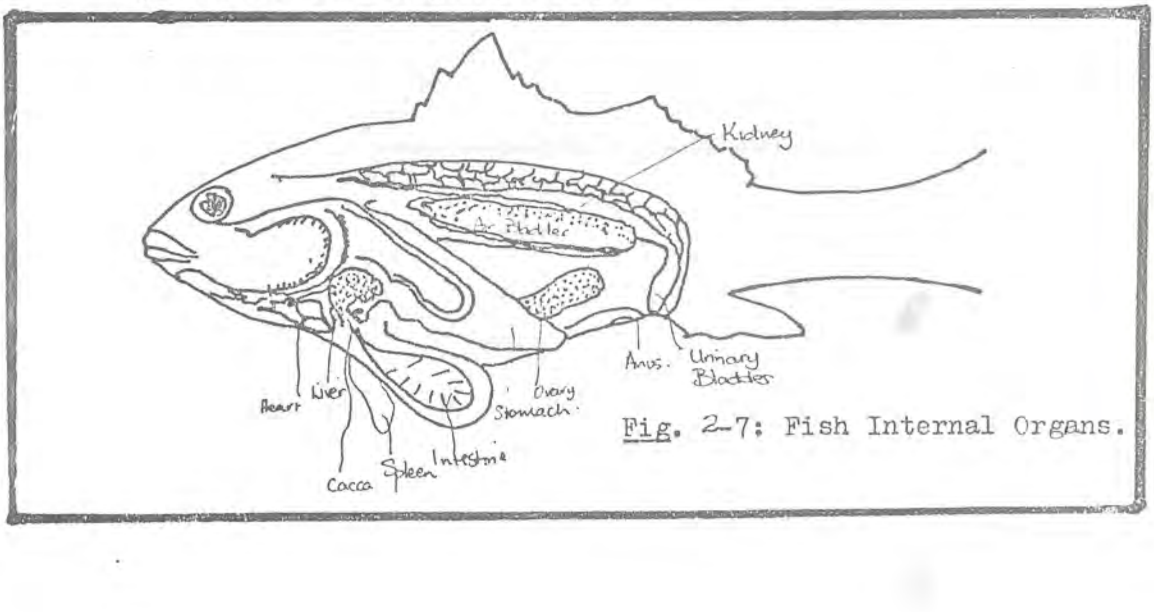


Fig. 2-7: Fish Internal Organs.

Those with smaller mouths and cutting teeth are generally plant eaters. Those with molar teeth eat primarily shellfish. Those with large lips and toothless mouths are suckers and suck up their food. Fish with toothless mouths and well developed gill rakers are plankton feeders, taking in water through their gills, straining plankton out. Sardines and anchovies are well known examples of plankton feeders.

The pharynx is located in the gill region. It connects the mouth to the stomach. This organ is very stretchable so that it can accommodate anything the fish can get into the mouth.

The stomach (or gullet) is the place where much of the digestive processes take place. In carnivorous fish, the stomach is quite long, and in omnivorous fish, it is sac-shaped as in humans.

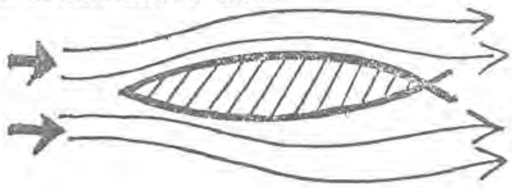
The pylorus is a constriction between the stomach and intestines. It opens to let the food pass into the intestine for further digestion. Those fish with short intestines are carnivorous. Those with long intestines are herbivorous. Digested wastes are eliminated from the intestine through the anus and the kidneys extract urine from the blood.

Bony fish breathe through gills, which are best observed by lifting the gill cover, the operculum, and peering under it, but can also be seen from the mouth. Water passes through the mouth and over the gills, where some of the oxygen dissolved in it is removed.

Blood is circulated by a two-chambered heart, passes through the gills where it receives a fresh supply of oxygen before coursing through the remainder of the body. The air bladder, a thin-walled sac, also aids in breathing in some fishes as well as keeping the fish buoyant.

(d) *Fish Adaptations:*

The word means to be "well suited to the environment" So how is a fish well adapted. Like the shark, it has a *STREAMLINED BODY*



which allows water currents to pass over easily.

It has *fins* for steerage and direction. A *lateral line* helps it hear. A well developed eye with an almost 360° vision, are but a few of the *ADAPTATIONS* that help the *FISH SURVIVE*. Can you think of others?

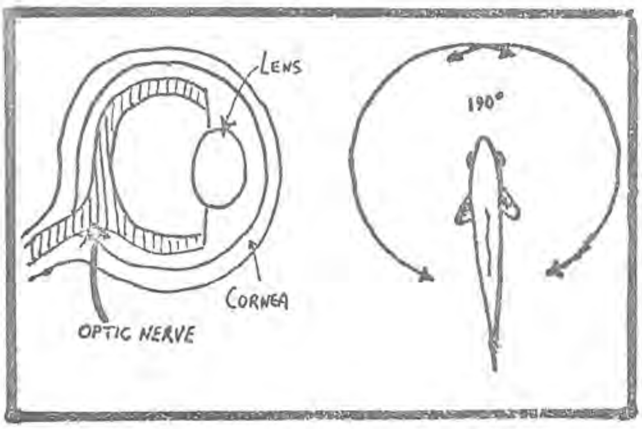


Fig. 2-9: Fish Vision.

circular cyloid scale, a very easy scale for beginners to work with.

Investigation 2-2: Fish Dissection

The purpose of this activity is to study the external and internal morphology of a typical bony fish.

What you need

* dissection board or tray
* dissecting pins (or straight pins or thumb tacks)
* dissecting kit (scalpel, scissors, probe)
* drawings of the external and internal anatomy of a fish.

What to do

(a) Identify your fish (scientific name, notable characteristics, colour, size, etc).

(b) *External Anatomy* - using the diagram of the external parts of a fish, locate the following:-

spiny dorsal fin (if present)	pectoral fin
	nostrils
soft dorsal fin	scales
caudal fin or tail	operculum or gill cover
ventral fin (pelvic)	gills (look under operculum)

Consider and answer the following questions:

1. Is there evidence from its external morphology that leads you to believe that the fish eats plants, animals or organic debris?
2. Does it capture live food?
3. Can you locate the gill rakers?
4. Is your specimen a pelagic fish? A bottom fish?
5. What kind of scales does your fish have? Can you tell?

(c) *Internal Anatomy*

To dissect your fish:

1. Pin your fish to your dissecting board with dissecting pins, straight pins or thumb tacks.
2. Make a horizontal cut from the operculum to the caudal fin (down the centre of the fish - 1st cut)
3. Make vertical cuts at the operculum, above, and below the 1st cut (2nd cut).
4. Make vertical cuts near the caudal fin, above and below the 1st cut (3rd cut).

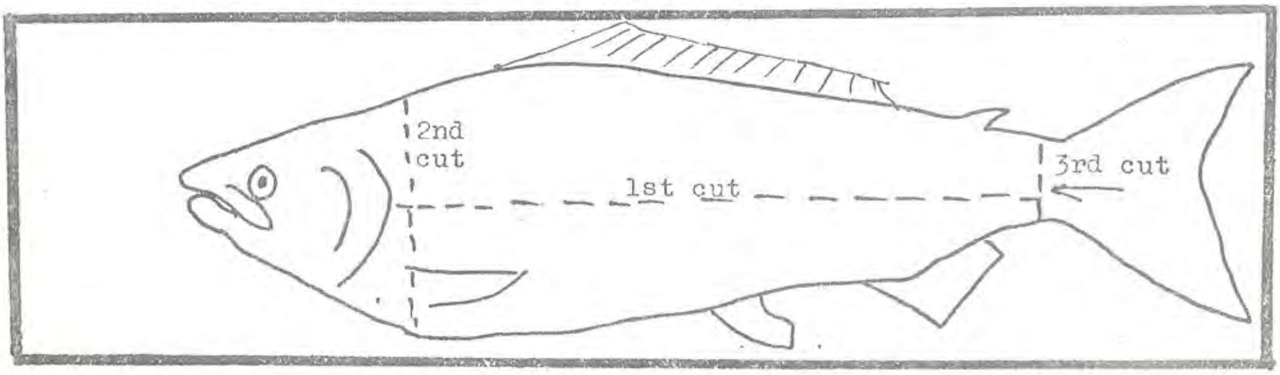


Fig. 2-10: Where to cut the Fish.

5. Peel back the flaps of skin, the internal organs should now be exposed.

6. Using the diagram, the Internal Organs of a Typical fish, identify the following structures:

heart	backbone
stomach	muscles
liver	larynx
kidney	phlorus
air bladder	anus
gills	urinary bladder
intestines	

FISH ACTIVITIES

Activity 1. Poke Pole Fishing:

(If you don't like this activity why not see your local trawler operator and get him to save some trash fish)

Poke poling is a simple, inexpensive type of fishing that allows you to learn more about fish. You can make your own fishing pole from a long bamboo pole, a piece of heavy wire, and a fish hook.

Poke poling is a very rewarding sport. You will be surprised at the number and size of the fish you can catch. Also, you are practically going into the fish's environment to catch it. This means you can learn more about its habits and its relationship to other plants and animals in the intertidal zone.

When you go poke poling, be sure to dress warmly, check the tides (low tide is the best time) and be safety conscious. If there is a large surf, stay away from the water's edge.

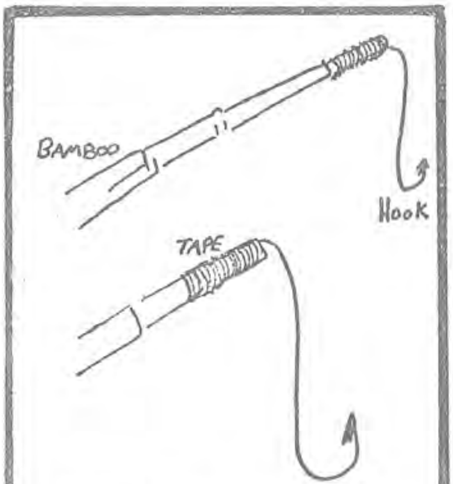


Fig. 2-11: Poke Pole

Here are some of the things you may want to do with your catch.

* Identify, measure, and release the fish.
* Try the technique of Japanese fish printing (Gyotaku)
* Study the contents of each fish's stomach to gain understanding of its food habits. Read about the life history of the fish
* Have a fish fry.

Activity 2. Age Determination of Fish

The purpose of this activity is to determine the age of a fish by counting scale rings.

To the fishery biologist, the fish scale represents a valuable tool in the investigative process. The biologist can choose to use the scale to determine the age of the fish. This information can be used in the interpretation of the life history for some fish. In addition, scientists use scales in the identification&classification of fish.

It should be mentioned, however, that not all fish have scales, and those having scales do not all have the same type. Scales are not exclusive to fish. The more primitive forms have placoid scales. This is a scale possessing a dense enamel and dentine layers. Other fish scales are non-placoid types, having no enamel or dentine.

There are three types of non-placoid scales. First, the cosmoid type scale found on all lung fish of the world. The second type is the tile-like arranged ganoid scale found in gars and reed fish. The third type is the bony-ridge scale. Typically, they are thin and translucent. There are two types of bony-ridge scales. The first is the ctenoid (teen-oid), having characteristically small sharp spines on the scale with no complete rings. The second type is the

Activity 3. *Gyotaku* *(Japanese Fish Printing)*

The technique of Japanese fish printing has been used in Japan for over 100 years to record the catches of sports fish and to gain ichthyological (fish biology) information. These prints have even been used at the University of Washington to study how the physiology of a fish is related to its surface area.

The art of *GYOTAKU* (pronounced ghio-ta-koo) is a good way to gain understanding and appreciation of the beauty and great variety of marine organisms. You can also use this technique for making prints of shells, rocks, flowers, etc.

Before you make a print, identify the fish. What are the distinguishing characteristics of the fish? Study the life history of the fish. Where and how was it caught?

You will need

* A very fresh fish - flounders, bluegills, or rockfish are good to start with. If you buy the fish at a market, select one that has bright red gills, clear eyes, and a fresh smell. If the fish has been gutted, make sure that it has not been cut anywhere else on the body.
* Newspaper and pins
* A stiff ½-inch brush and a very small brush
* Rice paper, newsprint or other moisture tolerant paper (since rice paper is so expensive you might prefer to start with newspaper)
* Plastic modelling clay
* Water-base ink (Linoleum block ink is best)

What to do

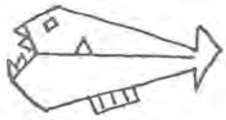
1. Use soap and water to clean the outside of the fish as completely as possible. The cleaner the fish, the better the print. Dry the fish well.
2. Place the fish on a table covered with newspapers. Spread the fins out over some clay and pin them in this position. Continue to dry the fish.
3. Brush on a thin, even coat of ink. Leave the eye blank, unless you prefer to fill it in.
4. Place a piece of newsprint or rice paper over the top of the fish.

5. Carefully lay the paper over the entire fish. Use your fingers to gently press the paper over the surface area of the fish. Be careful not to move the paper too much since this results in double prints. Remove the paper and you have a fish print.
6. Use a small brush to paint the eye.

Activity 4. Fish Mobiles

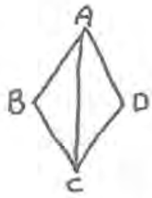
Construct a fish to be displayed alone or in groups as a mobile. Your own imagination, with the aid of a reference in an exotic fish book or a copy of National Geographic, will give you ideas about colour and shape.

Fish number one



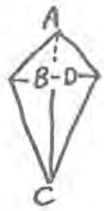
You will need

* 2 squares of coloured construction paper (the same size)
* Scraps of coloured paper
* White paper
* White glue
* Scissors
* Thread

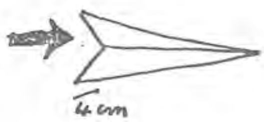


What to do

1. Crease one sheet along the line AC.
   Unfold
   Repeat for the second sheet.
2. Bring the Point B to the line AC and crease the fold.
   Repeat with point D.
   Do this with both sheets.



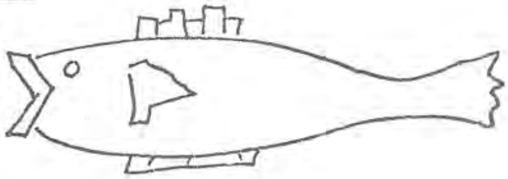
3. Overlap B and D. Join the two sides by glueing the edge all the way down to C. Be sure each paper overlaps the same distance. You now have two triangular-shaped cones the same size.
4. Glue the two flat base surfaces together to form the fish body, pressing the edges firmly together.
5. When dry, cut in about 4 cm on top point and the same on the lower point. Overlap and paste to form a rounded mouth.



6. Cut teeth out of a strip of white paper and line the upper and lower jaws.
7. Cut one dorsal fin, top and bottom tail fins, 2 pectoral fins and glue to the body. The paired pelvic fins can be cut from one piece of paper folded in half, the fold indented and then pasted on to the fish's bottom.

8. Add eyes and other decorations. A small fish or worm in the mouth adds interest. A foot sticking out might suggest another "Jaws". The shape of the fish can be changed during construction by varying the depth of the body sections. Hang completed fish by a thread from the dorsal fin. Use dowels or coat hanger wires for mobiles.

Fish number two

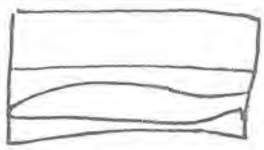


You will need

* Tissue paper (assorted colours)
* White glue
* Construction paper
* Scissors

What to do

1. Crease a full sheet of tissue paper in half along the long axis.
2. Open the sheet, and using the white glue as a marker, draw the outline of a fish on the bottom half of the sheet using as much of the area as possible. Add several rays of glue in the tail for strength. Fold the top over and press firmly. This will dry quickly.

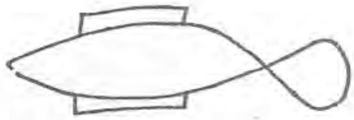


3. Cut around the outline, outside the glued line.
   Cut a V-shaped mouth opening.

4. Gently stuff the fish with scraps of crumpled tissue, the same or different colour, until it is inflated.
5. Cut two strips, each folded in half, and glue over mouth opening for "lips".
6. Add fins, eyes and other markings. Suspend by dorsal fin.

Fish number three

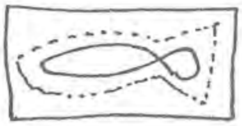
You will need



* Basket making reed or rattan (from hobby shop)
* Coloured tissue paper
* Construction paper scraps
* White glue
* Thread

What to do

1. Soak the reed in a bucket of water for several hours to soften. Remove and dry thoroughly before use.
2. Cut a piece of reed about 70-100cm long. Fold in half (that point is the tail end), and shape the body as desired. Tie with thread at the tail end, leave the ends free, tape, tie or glue together.
3. Put white glue all along one side of the reed shape and lay it down on a piece of tissue. Cut the paper to the fish shape, leaving a border to be folded and glued over the reed.



4. When dry, turn it over. Add fins, eyes, decorations. Several colours of tissue may be used on different parts of the body. These fish are light in weight and delicate looking. Hang by thread from dorsal fin.

3.5 Swimming Reptiles

Turtles

Small scale turtle farms, established on islands in the Torres Strait provide employment and a cash income for islanders and at the same time assist in the conservation of wild stocks.

FOLLOWING studies of green sea turtles (*Chelonia mydas*) in Torres Strait, Dr. H. R. Bustard of the Australian National University set up a pilot farm on Darnley Island in 1970. Subsequently five commercial farms were established at Darnley Island and another 25 on 13 other islands in Torres Strait.

Farming turtles has an immediate appeal to the islanders who see in it an opportunity to work near home and earn money to support their families. At present only Torres Strait islanders and aborigines have licences to farm turtles.

Turtle farming is an ideal cottage industry and the capital required to establish a farm is small — only about $20. Those wishing to become farmers undergo a period of training and are then supplied with 150 turtle eggs and a further 250 eggs after three months.

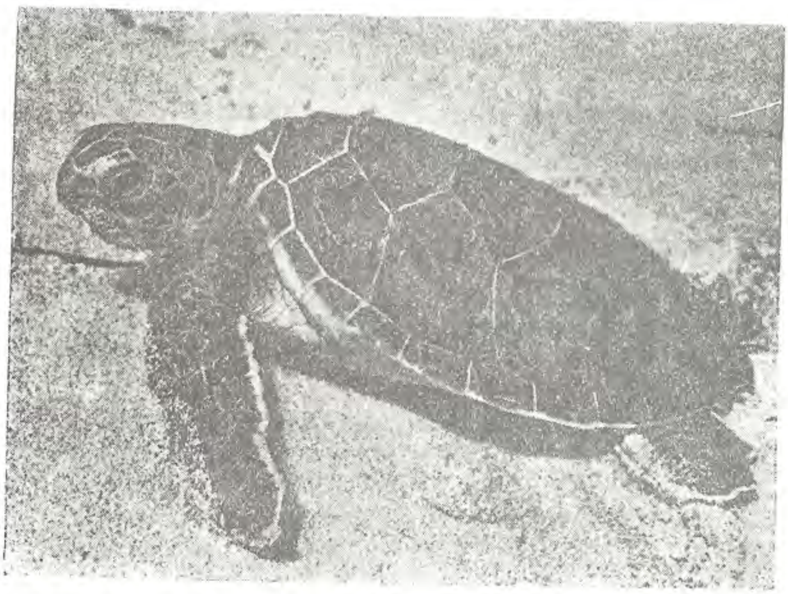
When they are one year old 10 per cent of green turtles are released to build up the wild stock and the remainder are kept on the farm for food and to be sold commercially.

Green turtles are sought for their oil which is used in the manufacture of cosmetics and for their calipee, the gristle-like material between the shell bones which is used to make turtle soup.

Turtle shells are also in keen demand. It takes about three years for a turtle to grow to commercial size but a new and profitable outlet for part grown one-year olds has been found — they are killed, cured, stuffed and sold as ornaments.

A female green sea turtle lays between 600 and 800 eggs in a summer, in clutches of about 150 at fortnightly intervals, but only breeds every fourth year. The eggs hatch in two months and the baby turtles make straight for the sea and do not stop swimming to rest or feed for several days. By the time this initial frenzy is over they may be up to 200 miles away from their birthplace.

They remain in the sea until about one year old. During this time many are taken by predators and it has been estimated that only one per cent survive to return to shallower waters at the beginning of the second year. By rearing baby turtles in captivity the huge losses from predators are avoided.

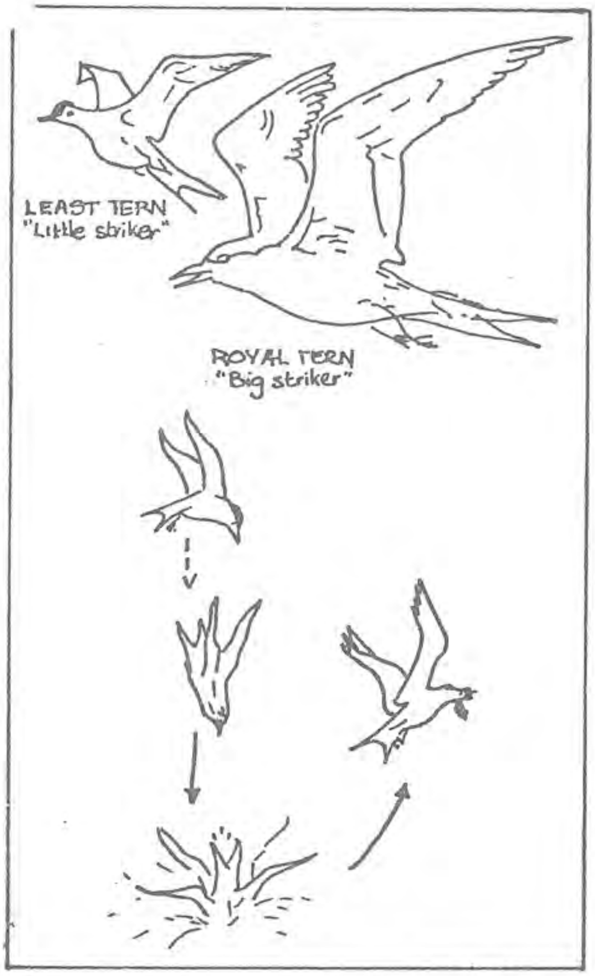


Fisheries of Australia 1973 (Reproduced with permission)

All other turtles are protected under the National Parks and WildLife and Marine Park Authorities. Aborigines and Torres Strait Islanders are the only Australians now able to turtle farm. In the past turtle factories were established at many places in Queensland's Great Barrier Reef Islands. Heron Island for example was a turtle farming base.

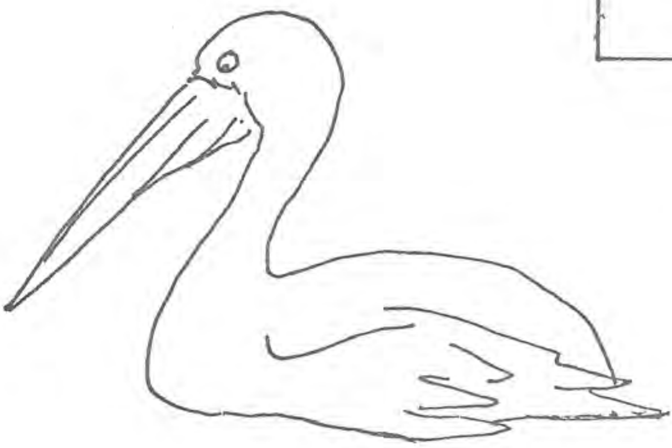
2.6 *The Birds That Prey on Nekton*

Birds form an integral part of the coastal Ecosystem. They are usually the highest order consumer in the Food Chain. Any change lower in the Food Chain usually shows up in birds.



They are well adapted with light skeletons and feathers. They have keen eyesight and excellent fishermen.

They breed during spring and identify themselves prior to mating by a courtship display. After the pair bond forms nesting behaviour begins and the pair mate. After a short period of time the eggs are laid and *incubated*. After hatching the pair fish for the young.



The pelican dives for fish and fills its beak. It then returns to the nest and allows the young chick to feed from its mouth.

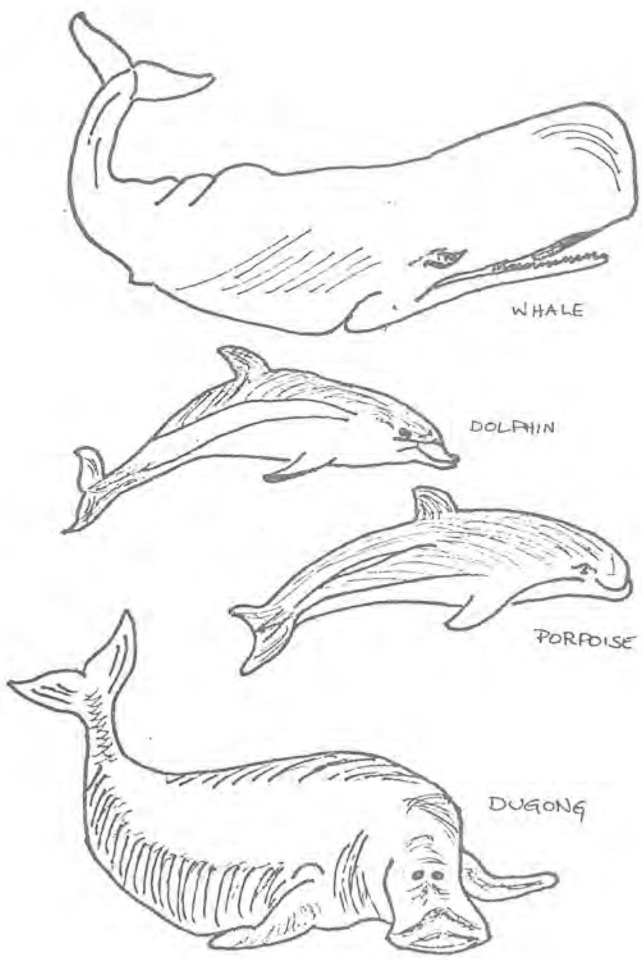
Birds are badly affected by oil pollution. Many die because the oil stops them from getting food. Oil pollution in coastal areas can have a devistating effect on bird populations.

2.7 The Mammals of the Sea

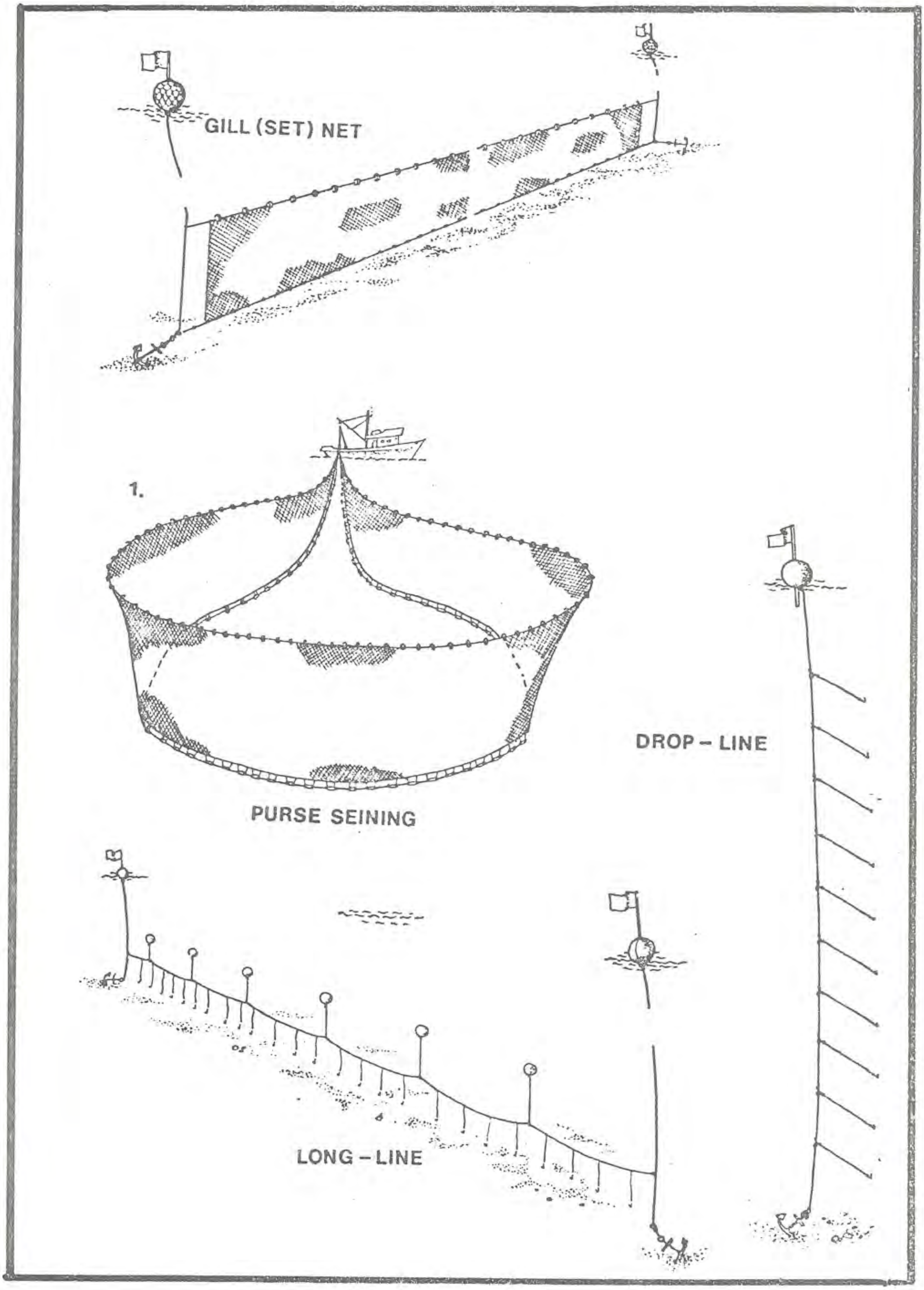
Whales, Dolphins, Porpoise and Dugongs (Sea Cows) are the decendants of sea creatures that once lived on the land, but for some unknown reason, returned to the sea millions of years ago. From time to time they appear along our coastline on their annual migration from Antarctica. They move northward to mate and give birth to their pups in the warmer waters of the Coral Sea. After the pups are born they grow rapidly and migrate back to the Antarctic for winter. Whales feed on the *ANTARCTIC KRILL* and have thick layers of fat to protect them from the Antarctic cold.

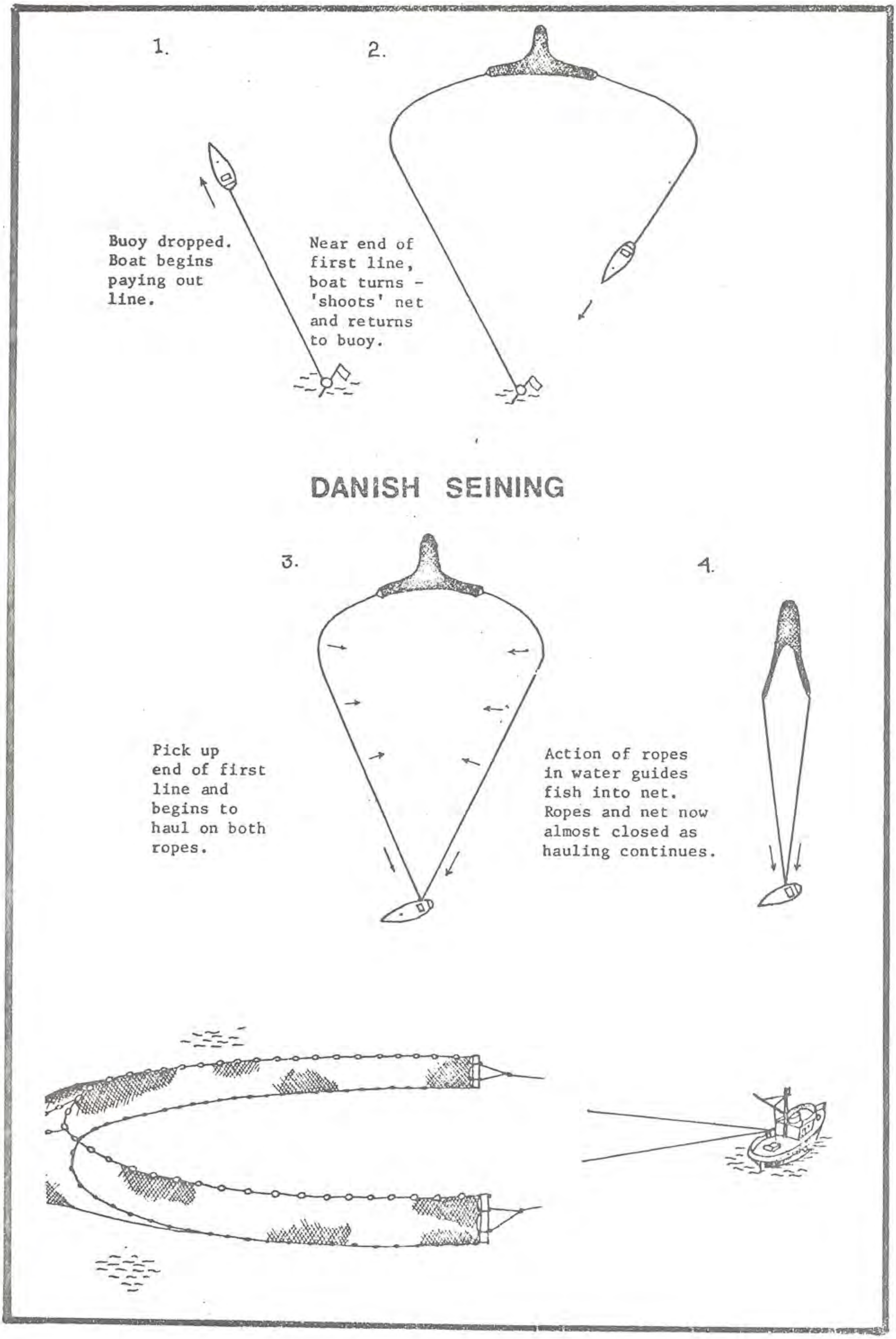
Like all marine animals, they are streamlined. What was once their forelegs, has been modified into flippers with which they steer themselves, their hindlegs have disappeared entirely.

Although they look like fish, they are breathing mammals that bear their young live and suckle them on the mothers. These animals are also warm blooded mammals that have a special protective layer of fat to prevent them from losing too much heat in the colder waters.



2.8 *Fishing methods*




1.
Buoy dropped. Boat begins paying out line.
2.
Near end of first line, boat turns - 'shoots' net and returns to buoy.
DANISH SEINING
3.
Pick up end of first line and begins to haul on both ropes.
4.
Action of ropes in water guides fish into net. Ropes and net now almost closed as hauling continues.

2.9 *Fisheries*

Australia is surrounded by some of the world's largest oceans but its fisheries resources are confined mostly to the relatively shallow waters of the Continental Shelf. The term Fishery is used to define an area used by fishermen to catch their fish. The article below is reproduced, with permission, from *Australian Fisheries* and is given as an example.

Beach, estuarine and inlet fisheries

The inshore fisheries provide the greater portion of the wet fish supplied to the fresh fish trade, major species being mullet, whiting and bream.

THE fish resources of the shallow bays, estuaries and coastal waters have always been heavily exploited by hand-line and net fishermen because they are so accessible.

Operating handlines from small dinghies or netting from the beach, 'part-time' commercial fishermen often obtain excellent catches. Most full-time commercial fishermen, however, work from larger powered boats, occasionally travelling up to 50 miles to the grounds.

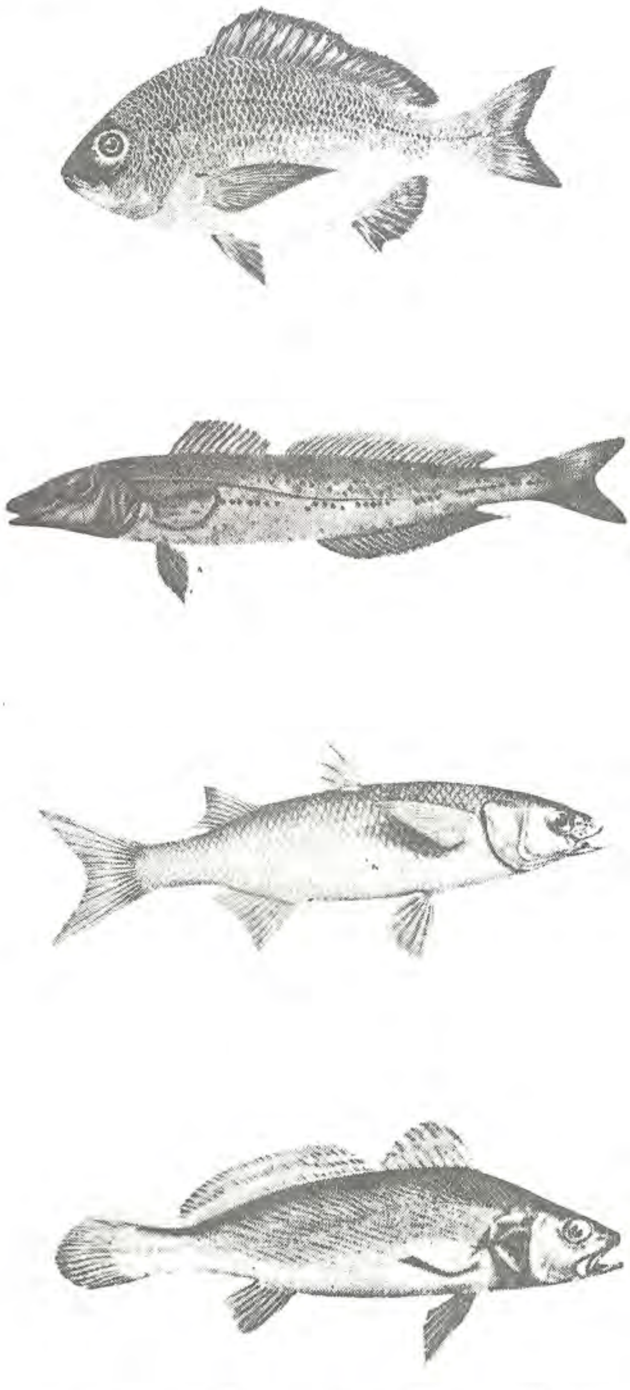
These fisheries were established by the early settlers and their expansion has been closely linked with the development of coastal regions. They have always attracted large numbers of fishermen and the resultant competition has led to arguments about priority over grounds and antagonism between groups using different types of gear. Because of this clash of interests, management of the fisheries is a complex task.

The varieties of fish represented in the catch vary from State to State, illustrating the difference in the fisheries.

In Queensland and New South Wales there are many estuary systems and mullet, prawns, bream and tailor are commonly taken. Eastern Victoria has a number of important estuaries producing bream and mullet but in South Australia the only estuary is the Murray mouth — Coorong area where mullet, bream and mulloway are taken. In this State the hand line and net fisheries operate in the two Gulfs and the shallow coastal bays. The mainstay of the fishery is King George whiting (one of Australia's finest eating fish) but garfish are also important.

In Western Australia many varieties are represented in the catch because of the different coastal configurations that occur there.

Tasmania's inshore fishery is relatively small and flounder, mullet and garfish which are taken, contribute little to that State's total catch.



From top: Black bream, King George whiting, yelloweye mullet and mulloway are among species caught in different estuarine and inlet fisheries.

(Reproduced with Permission)

Fisheries of Australia 1973

2.10 Management of Fish Resources

If there are going to be fish for people of the future to eat, then Australians have to manage carefully our fish stocks. Licences are issued to Commercial fishermen, fishing seasons are implimented and the type of net and gear are controlled. However much damage is done by the amateur fisherman. For example in some fishing trips to the reef, Amateurs return with ice boxes full of fish that they sell off to pay for their trip. If unrestricted fishing practices were to continue then fish stocks would be depleted rapidly. The notes below have been compiled by officers of the Department of Harbours and Marine and have been reproduced for discussion. They are found in all tide tables.

RECREATIONAL FISHING

SUMMARY OF THE PROVISIONS OF THE QUEENSLAND FISHERIES ACT AND REGULATIONS

INTRODUCTION

These notes are a summary of some of the provisions relating to the orderly management of Recreational Fishing.

While they are not intended to be a precise statement of the law, this guide will enable the recreational fisherman to become aware of the requirements of the Act and Regulations likely to have some influence over these activities.

The regulations are subject to change from time to time and at such times amendments will be announced in the news media.

Any person wishing to obtain clarification of any points should contact the Liaison Officer, Queensland Fisheries Service, Brisbane (Telephone: 224 4303) or any of the offices of the Queensland Boating and Fisheries Patrol listed hereunder:—

Brisbane	260 1633 ext. 35
Caloundra	91 2571
Roma	427
Southport	32 5933
Tewantin	49 7555
Rockhampton	2 1089
Bundaberg	72 4633
Gladstone	72 1533
Mackay	57 7238
Maryborough	21 4001
Townsville	71 5135
Bowen	86 1933
Cairns	51 6289
Karumba	45 9142

Copies of the Act and Regulations themselves may be purchased from the Government Printer, George Street, Brisbane.

LICENCES

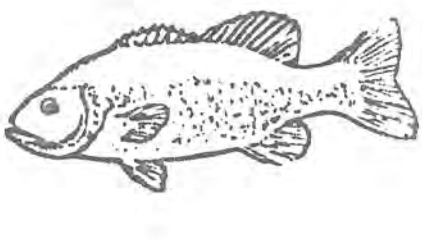
No licence is required for amateur fishing in Queensland, irrespective of whether the fishing is conducted in freshwater or saltwater.

BAG LIMITS

No bag limits are currently in force anywhere in Queensland.

CLOSED SEASONS

No closed seasons affecting angling species are currently in force anywhere in Queensland.



PROTECTED SPECIES

The following species are protected throughout Queensland:—

(a) Ceratodus or Lungfish
(b) Helmet, Trumpet and Clam Shells
(c) Female mud and sand crabs
(d) Whales, porpoises, dugong and other marine mammals
(e) Turtles

MALE AND FEMALE CRAB IDENTIFICATION

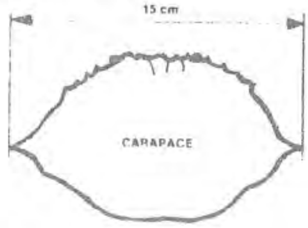
MALE

FEMALE

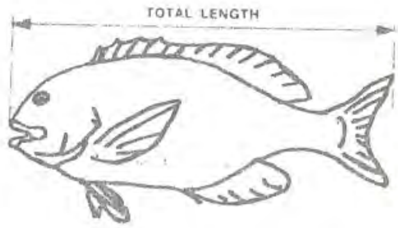
The following minimum sizes of relevance to recreational fishing apply to fish and shell fish throughout Queensland:—

	cm		cm
Barramundi	50	**Luderick**	23
Bass		**Mackerel**	
Australian	25	Broad-barred	45
Bream		Narrow-barred	45
Pikey	23	Queensland school	45
Yellow-finned	23	Spotted	45
Cod		**Mullet**	
Estuary rock	35	Sea	30
Murray	50	**Mulloway**	30
Crab		**Perch**	
Mud (carapace)	15	Golden	30
Sand (carapace)	15	**Saratoga**	35
Emperor		**Snapper**	25
Red	35	**Tarwhine**	23
Red-finned	30	**Teraglin**	
Sweetlip	30	Jew	30
Flathead		Silver	30
Bar-tailed	30	**Trout**	
Mud	30	Coral	35
Sand	30	**Salmon**	
Groper		Burnett	40
Queensland	35	Cooktown	40
Javelin-fish		Dawson River	35
Small-spotted	30	**Whiting**	
Spotted	30	Gold-lined	23
Jew-fish		Sand	23
Silver	30		
Spotted	30		

CRAB MEASUREMENT



FISH MEASUREMENT



Any person who unintentionally takes protected or undersized fish should return them to the water immediately, taking as much care as possible to avoid causing injury thereto. However, bona fide amateur anglers (i.e. persons taking fish solely for recreational or sporting reasons and not for sale) may keep or have in their possession at any one time one undersized male mud crab, or six undersized specimens of any of the other species protected by a minimum legal size.

BAIT NET MEASUREMENT

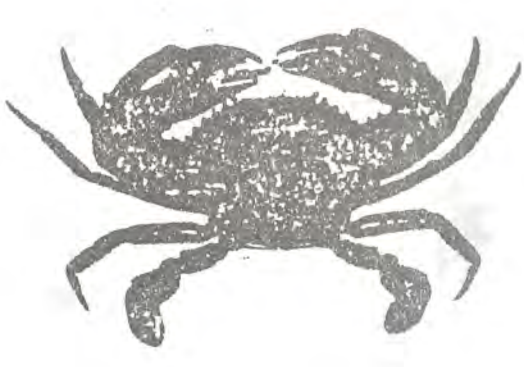
Length (16 m) distance along the head rope (float rope) between the outermost points of attachment of the meshes when the headrope is extended and taut and after the net is wet.

Mesh (Max. 28 mm) distance between the innermost edges of two diagonally opposite knots in the same mesh, when extended until the twine is taut and after the net is wet.

APPARATUS PERMITTED FOR USE BY AMATEUR FISHERMEN

Lines—Hand-lines or rod-lines with up to six hooks on each line are permitted in tidal waters, and with a single hook in freshwaters. (An artificial fly or lure is deemed to be equivalent to a hook). Cross-lines, or more than six set lines are not permitted in freshwaters. Any person may use a gaff or landing net to secure line-caught fish.

Crab pots or dillies—Up to four crab pots or dillies may be used in tidal waters by any person aged 15 years or over. Such pots or dillies, if not attached to a boat, jetty or other fixed object, must carry a light-coloured surface float at least 15 cm in its greatest dimension. The apparatus must be marked or tagged with the owner's name and address, boat number, or other identificatory means approved by the Director. It is recommended that the float be similarly marked.



Crab hook—Persons aged 15 years or over may use a crab hook, but not in such a manner as to damage a crab hole. Hooks may not be used in a Habitat Reserve.

Spears and spear-guns—See "Spear Fishing"

Cast nets—In tidal areas open to fishing, any person may use a cast net up to 6 m in diameter, with a mesh not exceeding 63 mm.

Scoop or dip nets—In tidal areas open to fishing, any person may use a scoop or dip net not exceeding 2 m in any dimension, with a handle or shaft not more than 2·5 m long, with a mesh not less than 25 mm.

Bait net—In tidal waters open to fishing any person aged 15 years or over may use a small beach seine or hauling net not exceeding 16 m in length, with a mesh not greater than 28 mm. The use of such net is subject to the following conditions:—

(a) it shall not be anchored, staked or fixed;

(b) any portion of the net containing fish shall not be drawn or dragged on to the land above the level of the tide, or allowed to lie out of water;

(c) any protected or unwanted fish in the net shall be cleared in water of sufficient depth to allow their free escape and the net shall be cleared in time to prevent the death of fish in the net.

Shell dredges—Persons wishing to use dredges for amateur shell-collecting should consult the Regulations directly.

Yabby pumps—Hand pumps may be used for taking yabbies in any tidal waters not closed to fishing generally.

REPORTING FISH KILLS

A fish kill may be identified by a larger number of dead fish in a relatively small area. A variety of agents may be responsible for fish kills. Some of these are natural phenomena, others are man made. The public are advised that investigations into the cause of fish kills are often hindered by the delay in reporting such kills to the appropriate authority. Fish kills should be reported immediately to the Queensland Boating and Fisheries Patrol, Department of Harbours and Marine. In more remote areas samples of the dead fish should be collected and frozen and then forwarded to the above body.

TAGGED FISH

The research staff of the Queensland Fisheries Service is engaged in a number of research programmes involving the tagging of fish and crabs. Should you catch a fish or crab with tag attached, a small reward will be paid for the return of the tag to the Director, Queensland Fisheries Service, 138 Albert Street, Brisbane, together with the following information:—

(a) date and place of capture;

(b) length of fish (or shell width of crab);

(c) method of capture;

(d) your name and address.

As the research staff would like to examine the specimen wherever this is convenient, an early phone call to your nearest laboratory (Brisbane: 203 1444 or 224 4338, Cairns: 51 5045, or Bundaberg: 72 2938) would be appreciated if you happen to live near these centres.

ADDITIONAL INFORMATION

For additional information or clarification of Fisheries matters contact:—Queensland Fisheries Service, P.O. Box 36, North Quay, or Queensland Boating and Fisheries Patrol, Department of Harbours and Marine.

AREAS CLOSED TO ALL FORMS OF FISHING

Total fishing prohibitions exist in the following areas:—

(a) Swan Bay;

(b) Coombabah Lake;

(c) Coomera River for distances of 200 m downstream and 1 200 m upstream of Saltwater Weir;

(d) Within 100 m of the Coral Reef Observatory on Hook Island;

(e) Certain areas within the Marine Parks at Green Island (off Cairns) and Heron Island;

(f) Queen Mine Waterhole, on the Severn River near Ballandean;

(g) Nelgai Fish Refuge on the Condamine River;

(h) Within 400 m upstream and downstream of the following rivers:—

- Mungindi Weir on the Barwon River
- Goondiwindi Weir on the Macintyre River
- Bonshaw Weir on the Dumaresq River
- Jack Taylor Weir on the Balonne River
- Miles Weir on Dogwood Creek
- Ben Dor Weir on Macintyre Brook
- Whetstone Weir on Macintyre Brook
- Dalby Weir on the Condamine River
- Kolan Barrage Weir on the Kolan River
- Chinchilla Weir on the Condamine River
- Burnett Barrage Weir on the Burnett River;

(i) That portion of the Barron River known as the Barron Waters;

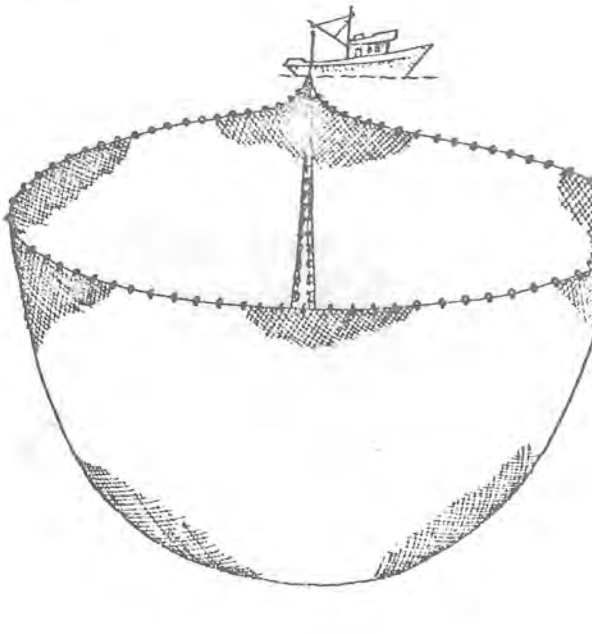
(j) Mission Bay, near Cairns;

(k) Certain waters of the Torres Strait near Hammond Island.

SPEAR FISHING

Spear-guns may only be used by persons aged 15 years and over.

Although at the time of issue of this guide there is no prohibition on the use of underwater breathing apparatus while spear-fishing, some restrictions on the use of such gear are expected to be introduced.



Spear-fishing is prohibited in the following areas (for precise boundaries consult the Regulations):—

(a) All freshwaters and Marine Parks;
(b) Vicinity of the Artificial Reef off Moreton Island near Cowan Cowan;
(c) Vicinity of the Artificial Reef near Woody Island, North Sandy Straits;
(d) Noosa River downstream of Parkyn's Jetty at Tewantin;
(e) Maroochy River downstream of and including the Cod Hole;
(f) Mooloolah River downstream of the David Low Bridge;
(g) Pumicestone Passage, north of Bell's Creek;
(h) Pumicestone Passage south of Elimbah Creek;
(i) Jumpinpin and the Southport Broadwater;
(j) Within 10 m of all public jetties in and south of the Noosa River;
(k) Within 10 m of the public jetties at Dungeness and Lucinda Point;
(l) The north-western, western and southern sides of Great Keppel Island;
(m) The western and southern sides of North Keppel Island;
(n) The waters between Brampton and Carlisle Islands;
(o) The southern and western sides of Lindeman Island;
(p) Seaforth Island;
(q) The western side of Long Island;
(r) The northern side of South Molle Island;
(s) Daydream Island;
(t) The eastern, south-eastern and southern sides of Hook Island;
(u) The southern and western sides of Hayman Island;
(v) The north-western and western sides of Dunk Island;
(w) The northern, north-western and western sides of Bedarra Island.

SPECIAL CLOSURES

Waters adjacent to Fitzroy and High Islands (near Cairns) and Michaelmas and Upolu Cays are closed to all forms of fishing other than a hand-line or rod-line with not more than two hooks attached.

FISHING CLOSURES BY LOCAL AUTHORITIES

In addition to the foregoing certain Lakes and Dams come directly under the control of Statutory Authorities, and fishing therein may be restricted or prohibited by these authorities. In such cases the authority should be consulted to ascertain where fishing is permitted.

For example: Fishing is restricted in the following Lakes—

Lake Somerset, Lake Kurwongbah, Lake Manchester, Adjacent to Fitzroy River Barrage.

MISCELLANEOUS PROHIBITIONS

The following activities are illegal throughout Queensland—

(a) Jagging or foul-hooking of fish;
(b) Using explosives, poisons or electrical devices to take fish. (Divers may use a power head on a hand-spear for protection against sharks).
(c) Trespassing on licensed oyster areas;
(d) Digging worms within 5 m of the boundary of a licensed oyster area or within a Habitat Reserve;
(e) Removing oysters from any oyster ground. However, a person may consume oysters "on the spot" in any public oyster reserve or on unlicensed oyster grounds;
(f) Obstructing lawful netting operations, damaging or interfering with fishing apparatus, or removing fish therefrom without lawful authority;
(g) Possession or carriage of prohibited apparatus in closed waters unless the apparatus is dismantled, secured or stowed;
(h) Collection of coral without lawful authority;
(i) Selling fish without a licence or permit,
(j) Interfering with marine life and the habitat generally in any marine park or habitat reserve. (Note, however, that line-fishing is allowed in certain areas of marine parks, and there is no specific prohibition on fishing in a habitat reserve. Digging of yabbies with a hand-pump or worms taken by hand capture is also allowed in habitat reserves);
(k) Removing, damaging or interfering with markers or signs erected under the authority of the Fisheries Act 1976.

FISH HABITAT RESERVES

The purpose of Fish Habitat Reserves is to preserve in a relatively undisturbed state the shallow water sandbanks, marine weed beds and mangrove areas which are essential for the maintenance of fish and prawn stocks. The destruction or disturbance of plant life, sedentary animals or shallow banks within these areas is prohibited.

Fish and crabs may be taken within Fish Habitat Reserves by lawful methods provided that no physical damage is done to the area. However, crab hooks may not be used to take crabs. Maps of Fish Habitat Reserves throughout Queensland are shown on pages 97-110.

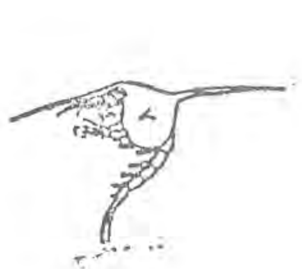
OFFICIAL BOUNDARY MARKERS

Official markers are erected to indicate the boundaries of areas where forms of fishing are restricted in some way.

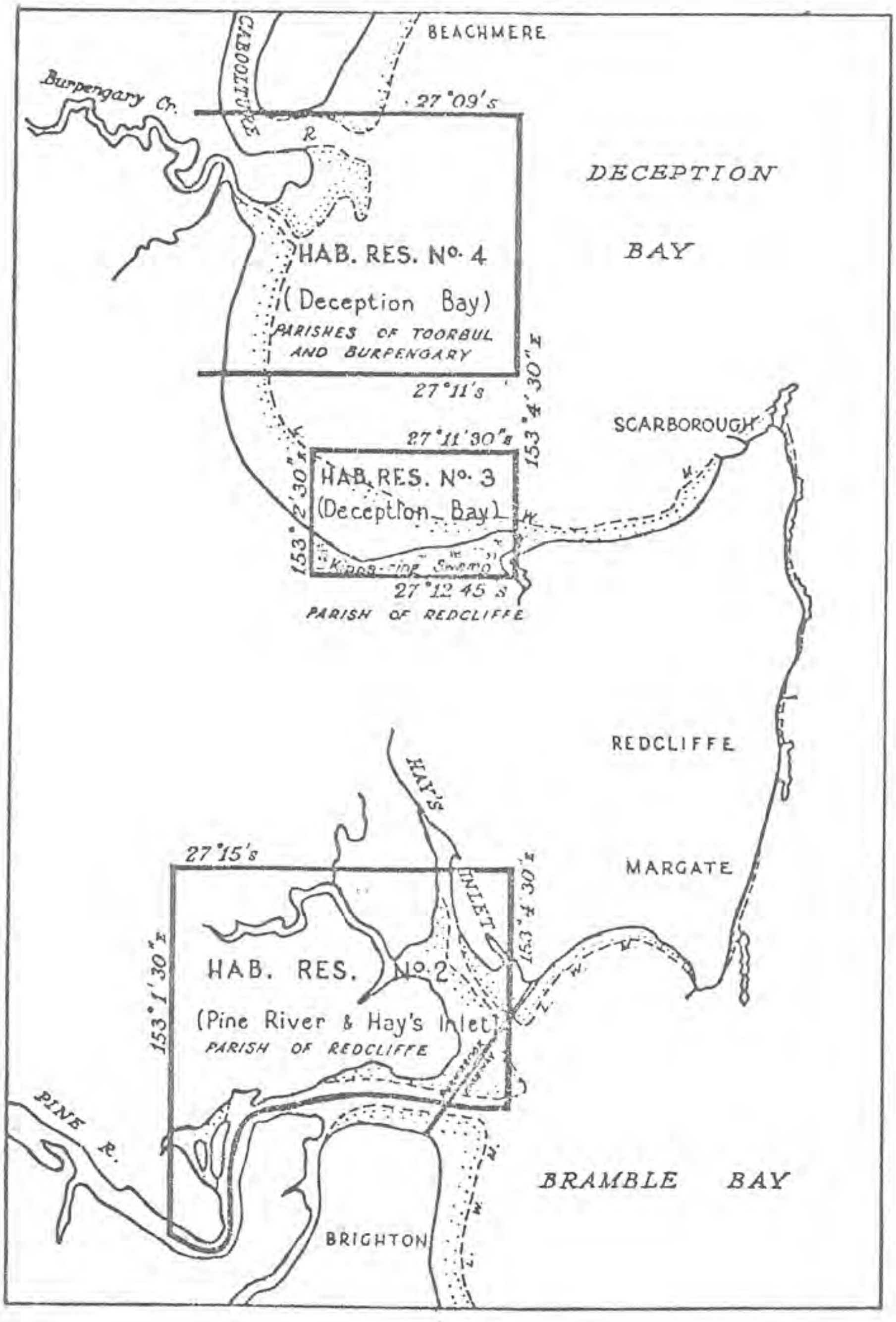
These markers more frequently refer to net fishing; however, where applicable, they may refer to recreational activities such as angling or spear fishing.

Signs with the markings F↑B or SF↑B indicate "Fishing Boundary" or "Spear Fishing Boundary".

(See Inside Back Cover.)

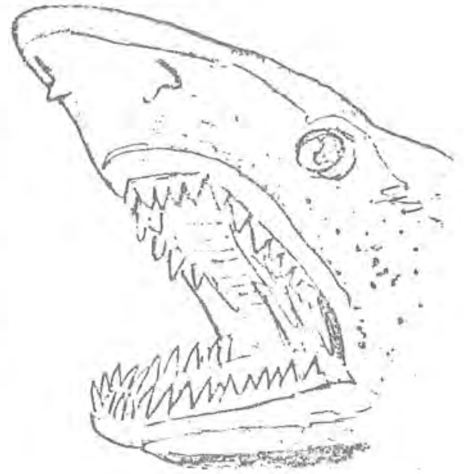


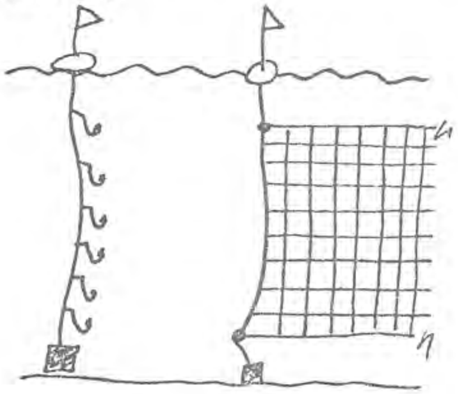
(b) A Typical Habitat Reserve



(c) *Management of Sharks and Whales*

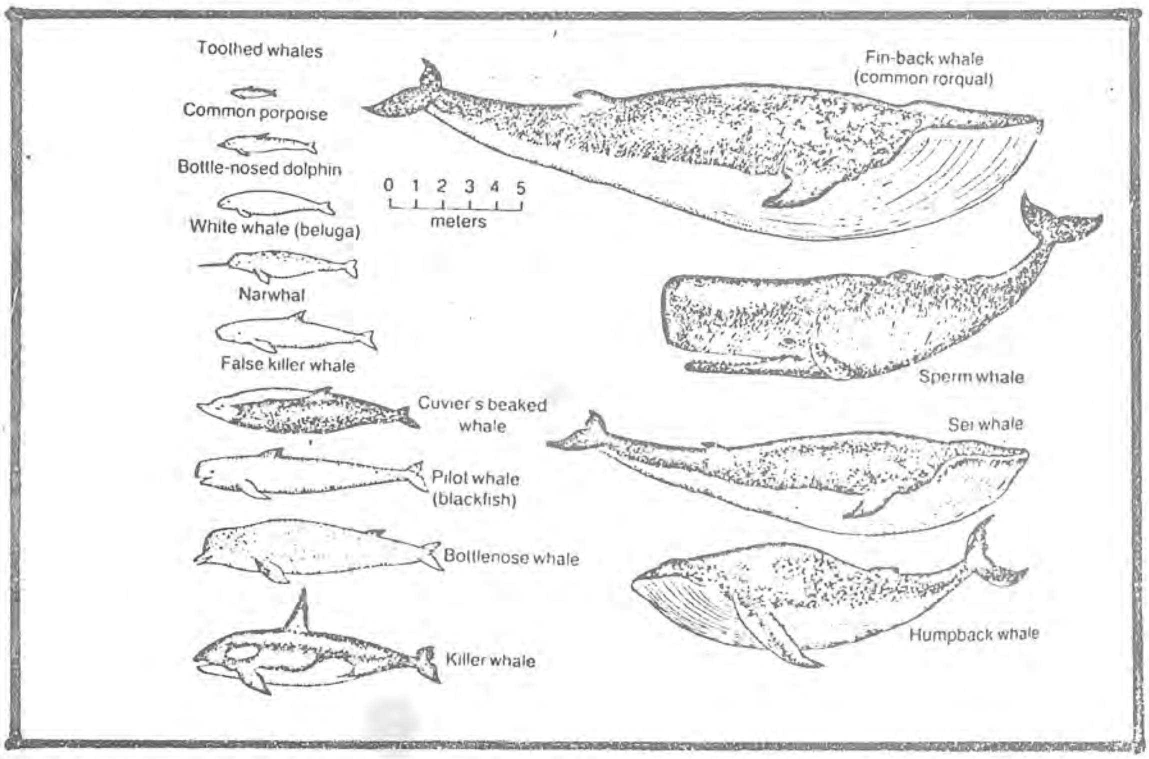
Of the 250 species of shark less than 24 of these are dangerous to man. However pictures like the one on the right instill fear into many who enter the water. Along the coast of Queensland shark meshing programmes operate to protect swimmers in the surf. The only places the meshing programme operates in Queensland are the Gold and Sunshine Coasts, Yepoon, Mackay and Cairns.





Contractors by either nets or lines to catch sharks of up to 3-4 metres. The programme has been in operation since 1969 and since then there have been no fatalities off meshed beaches. The catch numbers since 1969 declined for some years but have increased again. The shark nets also catch dolphins, turtles and other protected animals. Sharks seem to be attracted to blood and at Byron Bay where a meat works discharges into the sea, at least 6 fatalities over the past 10 years have occurred.

Whaling stopped in Queensland in the late 60's at Tangalooma and at Byron Bay in New South Wales. In 1972, 965 sperm whales were taken in Western Australia but now there is a total ban on all whaling in Australia. The International Whaling Commission (I.W.C.) came into being in 1946 and meets annually, among many protests, to decide on Restrictions among the Whaling Nations. Japan and the U.S.S.R. are the biggest of these.



MAIN IDEAS

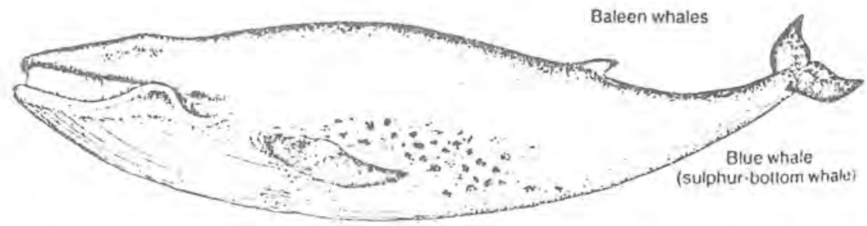
1. Nekton are the free swimmers of the sea and either live near the bottom (Demersal) or swim between the middle and upper layers (Pelagic).
2. Commercial Nekton include Squid, Shark, Bony Fish, Whales and Turtles.
3. To save these species from extinction, management of their numbers is necessary.
4. Fishing methods vary with the type of area fished.
5. The Tide Book sets out the rules for mateur fishermen.
6. Birds of the Coast are important indicators of Food Chain pollution.
7. Shark meshing is used to dispel fear of shark attack on our commercial beaches.
8. Whaling is now banned in Australia to protect the species from becoming extinct.

REVIEW QUESTIONS

1. Why did "Jaws" strike fear into peoples minds.
2. What is/are: *Anterior, Posterior, Ventral, Lateral, Dorsal.*
3. Draw a fully labelled diagram of a Bony Fish and Shark.
4. How can Scales be used to age fish.
5. Detail 4 fishing methods and say what fish are caught.
6. What is a Fishery?
7. What is a Sea Cow? What does it eat? Where does it live?

STUDY ASSIGNMENTS

1. Why is there a Burramundi season?
2. Find out about D.D.T. and birds eggs.
3. How dangerous is Mercury in the environment?
4. How do whales breathe?
5. Find out about Project Jonah - contact 100 Bowen Street, Spring Hill. Q. 4000. What is Whale Watch?
6. Visit a Fish Board. Find out about your Local Fishery. The gear, species caught, Regulations.
7. Find out about a local Habitat Reserve. What Local Council Regulations control it and why?
8. What is Green Peace? What is the I.W.C.
9. How intelligent are Dolphins?
10. Find out about Octopus behaviour.



SECTION 3

THE BENTHOS

3.1 *Types of Benthos*

The word "Benthos" means *bottom dwelling*. Therefore anything that lives on the estuarine floor is *BENTHOS*. This could range from scallops, peacons, crabs, worms, old tin cans, broken bottles and even telephone cables. To live on the bottom special requirements must be met.

Animals
* need to move from side to side or through the mud
* need some form of protection from above
* need some burrowing mechanism
* need mouths on the bottom

The crab is an excellent example

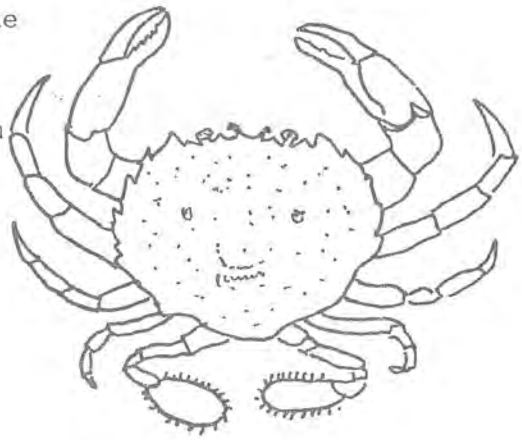


Fig. 3-1:

Investigation 3-1: Crab Paintings

What you need

* Preserved crabs
* Dissection dish or board
* Water colour paints or coloured pencils

What to do

1. Lay the crab out on the dish in front of you.
2. Count the number of appendages.
3. Locate the eyes, mouth parts, swimmerets, carapace, pincers, antennae, abdomen.
4. Sex the crab. Look at the flap.
5. Now do a pencil sketch.
6. Then paint the colours.

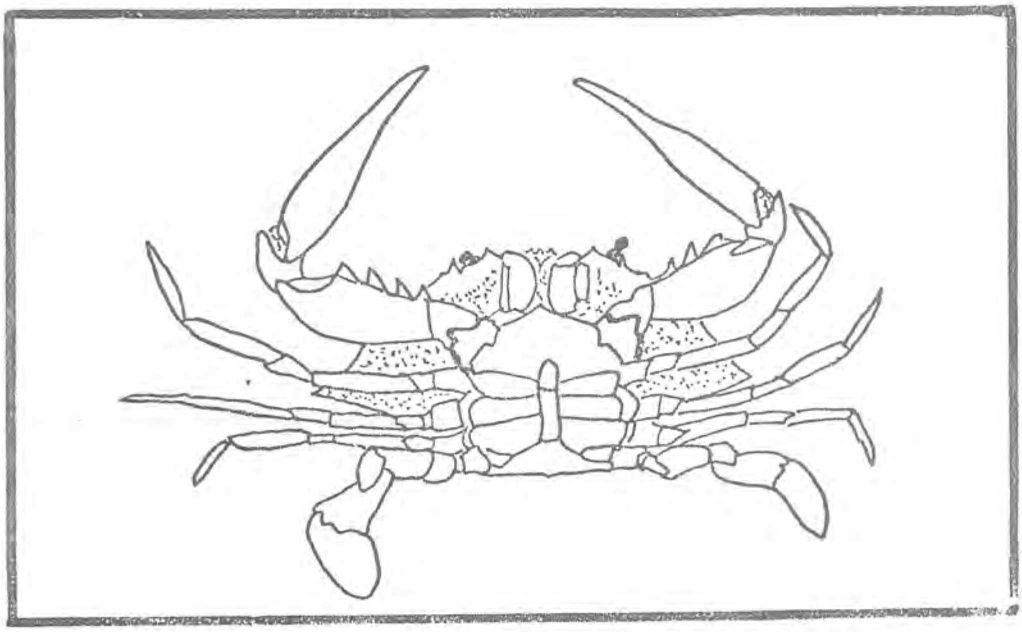
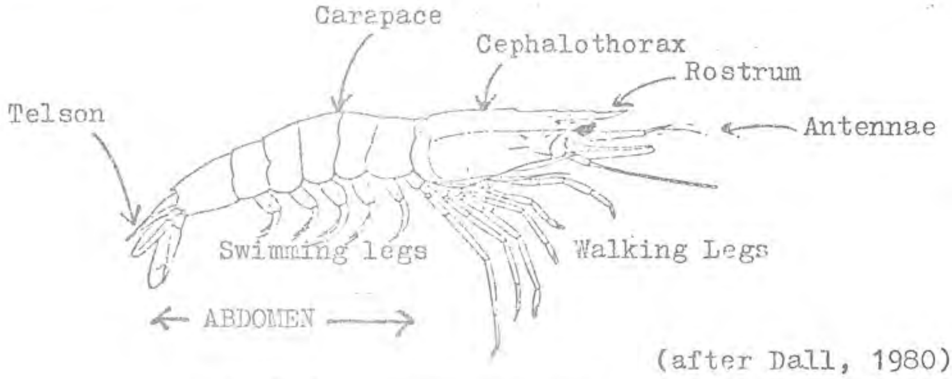


Fig. 3-2: Male Crab, Ventral View.

3.2 Prawn Biology

Let us consider the Tiger Prawn as another example of a commercial Benthic animal.

The body of a typical prawn is divided into two main parts. The head - *CEPHALOTHORAX*, and the tail - *ABDOMEN*. The head is covered by a hard shield or *CARAPACE* which extends at the front into a head spike or *ROSTRUM*. The abdomen is divided into six segments, each of which is covered by its own shell plate. The last segment has a rear triangular projection called a *TELSON*.



(after Dall, 1980)

Fig. 3-3: Prawn General Features

A pair of stalked eyes rise from beneath the carapace on either side of the rostrum. Behind the eyes the animal has a number of jointed appendages. These are the *ANTENNAE* or *FEELERS*, *MOUTHPARTS* and *FEEDING LEGS* which transfer food to the mouth, *WALKING LEGS*, *SWIMMING LEGS*, and a fan tail at the end of the *ABDOMEN* used for swimming.

Males have modifications on the first and second pairs of walking legs which help in the reproductive process. Males produce *SPERM* which are put into bags called *SPERMATOPHORES*.

Females have a specialized organ called a *THELECUM* which is the female copulatory organ. The *THELECUM* is usually hard and inpenetrable, but just after moulting it is soft and that is when the male courts and copulates with the female.

Fig. 3-4: Thelecum of Female Prawn.

Sperm are produced in the male *TESTIS* and are put into special bags called *SPERMATOPHORES* which are situated at the base of one of the walking legs. The male then mates with the female by placing these *SPERMATORPHORES* in the *THELECUM* of the recently moulted female. They are then stored for several weeks until the eggs are mature. *SPAWNING* is when the female releases these mature eggs which are fertilized at the time of spawning.

So, where do tiger prawns live? Adult prawns are caught off the Coast of Queensland, on the Continental Shelf, in depths of up to 50m. This area, called *FISHERY* can best be understood if we take a slice of the ocean and look at it from the side.

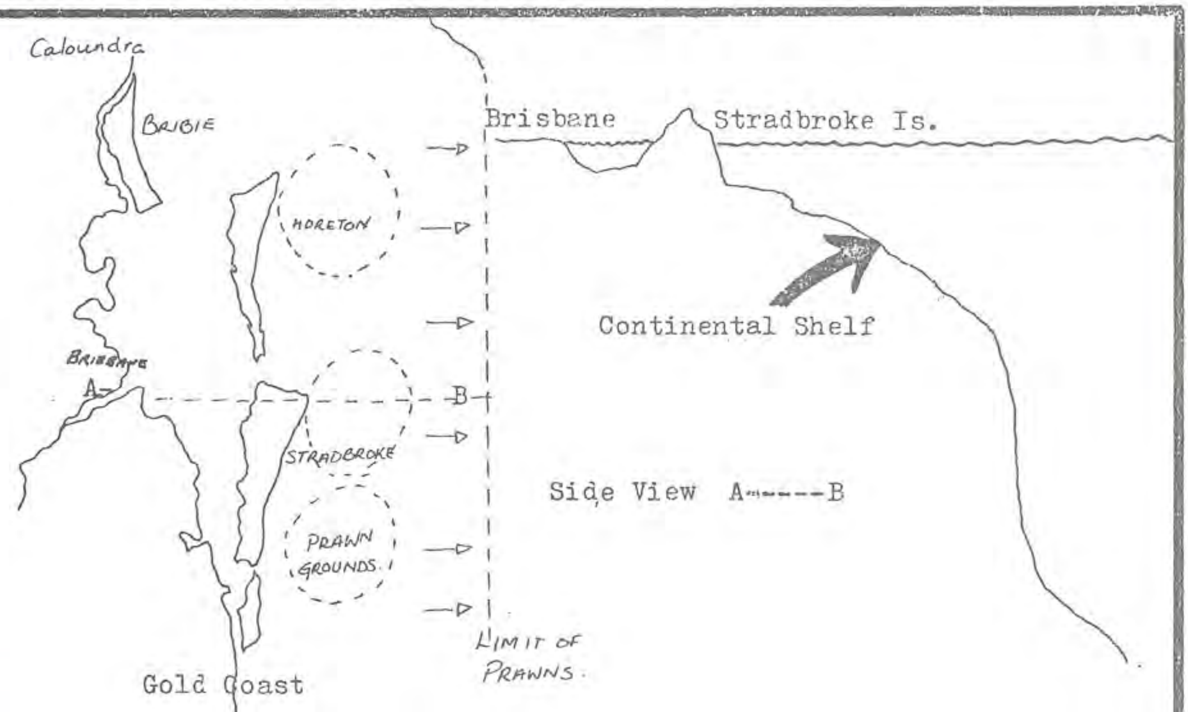


Fig. 3-5: Prawning Grounds S.E. Qld.

The Life Cycle of the Tiger Prawn

This prawn lives on the Continental Shelf, a short distance off the coast in depths averaging 50m. Spawning takes place out here, and once the eggs are fertilized they sink to the bottom. After about 24 hours on the bottom, the eggs hatch into the first larval stage called the *NAUPLIUS*.

Fig. 3-6 Nauplius Stage

Notice the pear-shaped body and the three pairs of appendages. Already you can see the jointed legs that give its name of *ARTHROPODA*.

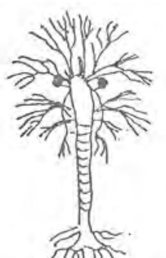


Fig. 3-7 Protozoe Stage

From here the larva sheds its skin 8 times in a process called moulting. Each time the old skin is shed, a new larger one grows. This stage is called a *PROTOZOE*. Notice the small *ROSTRUM* developing eyes and the fork in the *TELSON*. The *PROTOZOE* has now moved up to become part of the *PLANKTON*. So looking at our figure of Moreton Bay above we can see that the larva are now actively migrating up from the sea bed to the top of the ocean. Now water currents begin to move them towards the coast. On the way the *PROTOZOE* moult a further 5 times into a *MYSIS* stage. This stage still forms part of the *PLANKTON* but begins to look like the adult prawn.

The entire *CEPHALOTHORAX* is covered by a hard *CARAPACE* and embryonic walking and swimming legs are starting to form.

Fig. 3·8: Mysis Stage

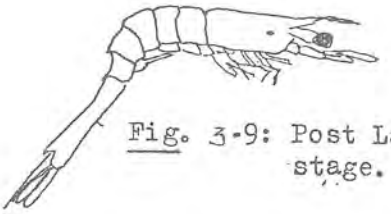


Fig. 3·9: Post Larval stage.

After 3 more moults the *MYSIS* changes into a *POST LARVAL* stage which looks like a baby prawn. Within a month of hatching this stage reaches the nursery areas near the coast. They are now able to leave the *PLANKTON* and start to live on the bottom once again. In the nursery areas the settled *POST LARVAL* stages gradually change into juvenile prawns. For about 3 or 4 months they feed and grow. As adult prawns they then migrate to the sea.

At sea the prawns become sexually mature, mate, and spawn and the cycle begins again.

Investigation 3·2: Prawn Life Cycle and Biology

You will need:

* Monocular Microscope
* Plankton sample
* and Prawn (green or cooked)
* Petri dish
* Microscope slides and coverslips
* Dissection Dish

PART A: External Features

1. Lay the prawn out in a dissecting tray.
2. Remove all the external appendages and stick them in a folder
3. Use reference books to identify the parts mentioned in the last few pages

PART B:

1. Collect a sample of plankton.
2. Use reference books to identify the following stages: *NAUPLIUS, PROTOZOE, MYSIS.*
3. Make original drawings from microscope analysis.

Write a report of your investigation called the Biology of the Prawn.

Investigation 3·3: Using a Key

You will need * A selection of prawns

3.3 Prawn Trawling

Prawning is big business and requires special equipment and personel. Technology has advanced to the point where satellites and on-board computers chase prawns. However, if 99% of all prawns are caught, the 1% of the population has enough energy to regenerate the 99% catch. To trawl for prawns, the estuary bottom must be free of rocks and reefs. Apart from those restrictions and depth, prawn fisheries operate all around Australia. The most famous grounds are the Gulf of Carpentaria, where a good catch can yield $4,000.

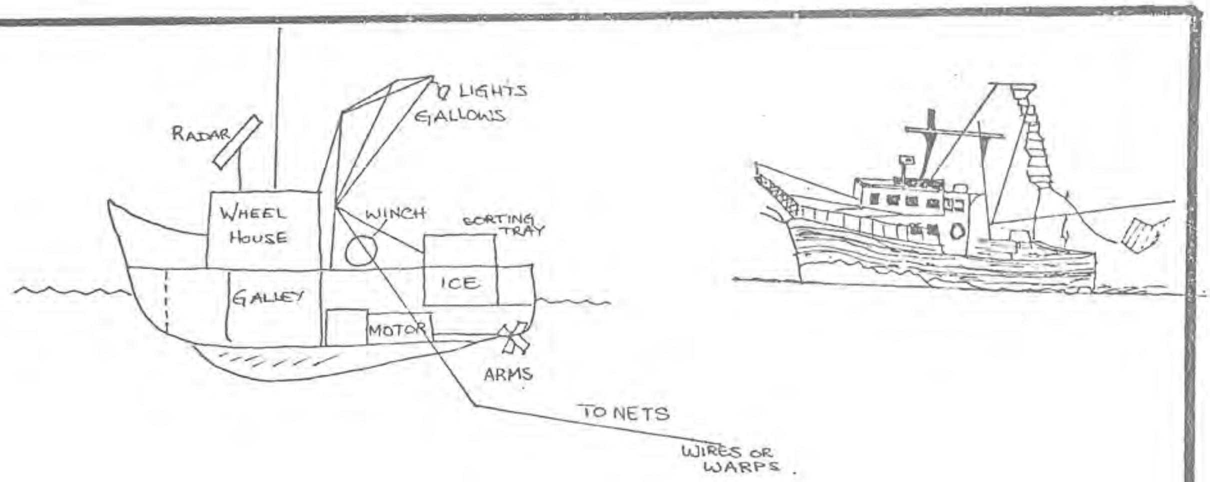


Fig: 3-10: Prawn Trawler, General View.

A typical trawler uses otter boards which shear outwards when pulled forwards thus billowing out the net.

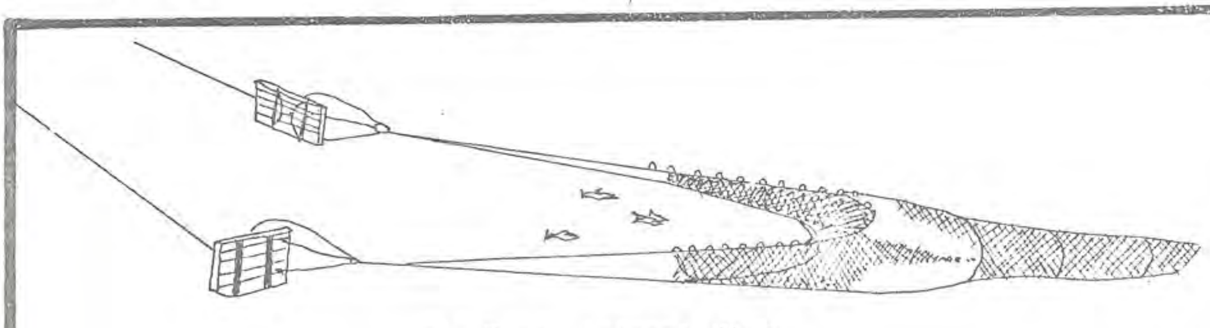


Fig 3-11: Lateral View

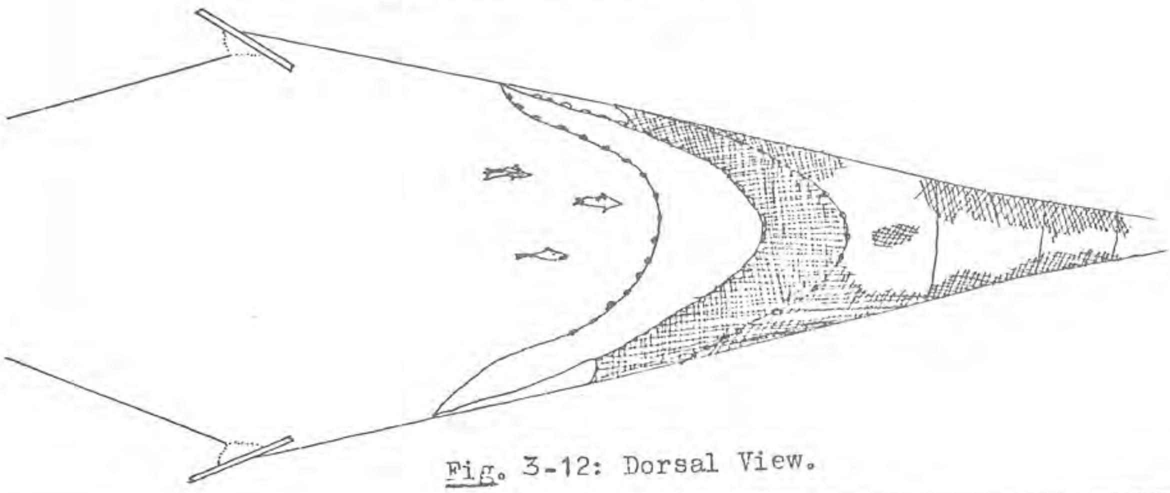


Fig. 3-12: Dorsal View.

A chain, called a "tickler chain" rattles along just in front of the net and is said to frighten the prawns. They jump up and into the net and are caught in the cod end. The net is winched on board, with the mouth of the net held high on the gallows. A "lazy" line, which ties together a hole in the cod end is used to manouver the cod end over the sorting tray. When in position, the lazy line is undone and the catch spills into the tray. Prawns are then hand sorted and the "trash" (crabs, algae, small fish etc) is thrown to a hungry bunch of dolphins which always follows. The prawns are then snap frozen in the storage area below the sorting tray or cooked and then frozen.

East coast prawns

The East coast prawn fishery takes in grounds in New South Wales and Queensland. Before the development of the northern prawn fishery, this region produced more than three-quarters of the total Australian prawn catch.

THE east coast fishery was based on small scale inshore prawning until 1950 when large stocks of prawns were found north of Newcastle and near Evans Head in New South Wales. This led to the development of deep water techniques and trawling spread into Queensland waters.

The east coast inshore and New South Wales set pocket prawn fisheries are continuations of the early fisheries. Based mainly on the school prawn and the eastern king prawn the fisheries are located in the estuaries and inland waters of the New South Wales coast from the Bega river in the south to the Tweed river in the north, in particular the Clarence, Hawkesbury and Hunter Rivers and Tuggerah and Wallis Lakes, Lake Illawarra and Sussex Inlet. Total production of prawns taken in estuarine waters in New South Wales is about 1,000 tonne annually.

A survey by the chartered trawler *Challenge* in 1957 located king and eastern tiger prawns in commercial quantities off Fraser Island in Queensland and this was followed by the discovery of the rich Moreton Bay ground near Brisbane.

Recent surveys by the New South Wales research vessel *Kapala* have located commercial quantities of royal red prawns in 150-300 fathoms of water between Sydney and Port Stephens.

Prawn tagging is carried out in New South Wales in order to establish migration patterns with a view to better management of the prawn fisheries. Evidence from tag returns so far indicates a northerly breeding migration for king prawns along the east coast. A fish culture research station was established at Port Stephens in 1972 with the primary aim of investigating the feasibility of farming prawns for local and overseas markets.

The fishery

Resource

Species	Eastern king prawn (*Penaeus plebejus*) Greentail prawn (*Metapenaeus bennettae*) Brown tiger prawn (*Penaeus esculentus*) Banana prawn (*Penaeus merguiensis*) School prawn (*Metapenaeus macleayi*)
Distribution	Eastern king prawn: From Lakes Entrance, Victoria to approximately Cairns, Queensland. Greentail or bay prawn: From southern New South Wales to at least Bowen and occasionally to Cooktown, Queensland. Tiger prawn: From Shark Bay in Western Australia, Northern Territory, Queensland to central New South Wales. Banana prawn: Apparently widely distributed in Indo-Pacific tropical waters. Penetrates the Australian region southward to Exmouth Gulf, Western Australia, and Evans Head, New South Wales. School prawn: From Eden, New South Wales, to approximately Bundaberg, Queensland.

Scallops

VICTORIA is the major scallop producing State with a catch in 1971–72 of 7,565 tonne, followed by Queensland with 2,158 tonne. Minor catches come from New South Wales, Tasmania and Western Australia. Experimental dredging in South Australia has located scallop beds in Coffin Bay but catches are not expected to be large.

The fishery started in Tasmania in 1905 with dredging in the Derwent River estuary and extending to the D'Encastreaux Channel in the 1920s as markets improved. In the mid 1950s prawn fishermen operating out of Bundaberg in Queensland located saucer scallops in beds extending from Fraser Island to Round Hill, further beds being located off Tin Can Bay in the early 1960s.

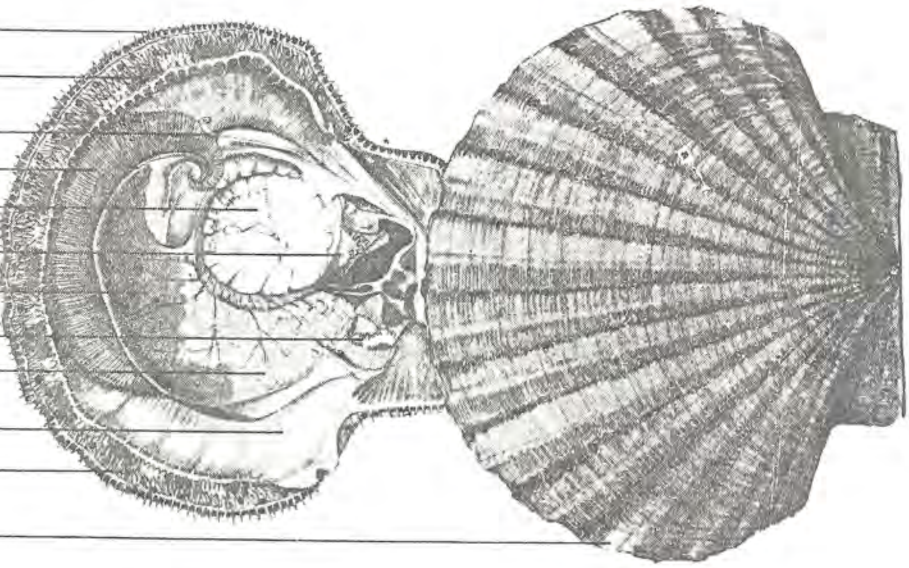
As the fishery declined in Tasmania scallop boats moved to Port Phillip Bay in Victoria where big catches were taken between 1963 and 1968. By 1969 production again declined and the discovery of good beds off Lakes Entrance saw the movement of the scallop fleet to that area.

About this time small beds were located off the southern coast of New South Wales and small dredge fisheries were developed at Eden, Bermagui, Bateman's Bay and Jervis Bay. Later with the assistance of the New South Wales fisheries research vessel *Kapala* beds were located as far north as Tuncurry and Forster.

In Western Australia beds of saucer scallops were located in Shark Bay and a small fishery was started in that State. After four seasons of fishing the catch declined and interest shifted to Cockburn Sound, south of Fremantle, where new beds were located. Here, too, catches have since declined.

Contrary to popular belief, the extreme fluctuations in catches and localities of scallops are not a result of irresponsibile fishing but seem to be a natural characteristic of the resource. Grounds may be barren for many years until a good spatfall produces large numbers of scallops. The natural death rate of scallops is also high.

Strict limitation of the rate of exploitation of scallop beds, imposed in the hope that stocks will be maintained has met with little success. It now seems certain that assured and continuous production requires a mobile fleet that can move from ground to ground as the beds become productive.



Crabs

Two crabs are of commercial significance in Australia. They are the mud, or mangrove crab and the sand crab.

(Reproduced with permission)

MUD crabs are found around northern, eastern and western Australia and are exploited commercially in Queensland, New South Wales and to a small extent in the Northern Territory. They inhabit the inter-tidal zone of estuaries and coastal creeks, particularly the muddy areas around mangroves, where they dig burrows for shelter at low tide. Fishermen capture them in crab pots or hoop nets or drag them from their holes with a hook.

The big claws contain the choicest meat and because mud crabs are marketed alive, claws are carefully tied and pegged to prevent damage.

Sand crabs are common in shallow muddy or sandy inshore waters around the entire Australian coastline. They are of commercial importance in New South Wales, Queensland and Western Australia. Small quantities are sold in other States.

Most sand crabs are taken incidentally in prawn trawls or beach seine nets but fishermen also set crab pots baited with fish to catch them. Unlike mud crabs, sand crabs are always cooked before being sent to market and are considered to be of better flavour.

Fisheries of Australia 1973

Oysters

The cultivation of rock oysters is one of the most valuable sectors in the New South Wales fishing industry, production in 1971-72 being worth $6 million.

Trial shipment of Sydney rock oysters airfreighted to London.

THE Sydney rock oyster is found all along the eastern coast of Australia from mid-northern Queensland southwards to eastern Victoria. It is cultivated extensively in New South Wales in estuarine systems, notably in Georges River, Port Stephens, Wallis Lake and Hawkesbury River.

Most of the oysters are consumed in Australia where they have a high reputation for quality and taste. There is a small export trade, mainly to the Far East.

The oyster lives on microscopic organisms (plankton) which it filters from the water. It spawns when food is abundant and the water temperature has reached a certain level — usually in late summer and autumn. After fertilisation and a freeswimming period the microscopic larvae (spat) settle on culch material — rocks, clean shell, sticks or tarred timber racks — provided by the oyster farmer.

Several methods of cultivation are employed — rock, dredge bed, shell-bed, stick, and tray. Of these stick and tray are the most important and productive.

Winter mortality, a main subject of research now being undertaken by the New South Wales State Fisheries Department, has for many years caused serious losses in oyster leases. It has been particularly bad during drought periods. Summer heat has also been a problem but this can be overcome by the installation of spray systems.

Oysters are sold by the bag and usually reach the public either opened on the half shell or in bottles.

Pearling

Mother-of-pearl shell from the silver or gold-lipped pearl oyster was formerly the mainstay of the fishery. It was used for making buttons and knife handles. Natural pearls were an added bonus but were not the prime motive for pearling operations.

INCREASED use of plastics in the button manufacturing industry in the 1950s, however, reduced the world demand for mother-of-pearl shell, of which Australia supplied about 85 per cent, and production gradually dropped. The introduction of pearl culture 12 years ago arrested this decline in the industry.

The first pearl culture farm was started at Brecknock Harbour, in Western Australia in 1956 and by 1961 six other companies had entered the industry. Effort was increasingly diverted from the fishing of mother-of-pearl shell to gathering live shells for culture farms.

The live shell tonnage rose from about five tonne in 1956 to a high of 420 tonne in 1967 but has declined since then. From $3,352,000 in 1968-69 the value of pearl exports fell to $931,000 in 1971-72.

There are now seven companies operating 11 pearl culture farms, four in Western Australia, six in Queensland and one in the Northern Territory. The majority are joint Australian-Japanese ventures and in most the Japanese partner supplies the technical staff and is responsibile for marketing cultured pearls and by-products while the Australian partner establishes and maintains the farm and supplies the live pearl oysters.

Live shells are collected by luggers and specially designed ships are used to transport them to the farms. In the culture of round pearls a nucleus about 8 mm in diameter is inserted into a healthy oyster and the oyster then suspended in the water from rafts. If the graft is successful, layers of pearl are secreted over the nucleus which is removed after 18 to 20 months when another nucleus is implanted.

Approximately 35 per cent of oysters operated upon produce good pearls. Of the remainder about 20 to 30 per cent die and 20 per cent reject the nucleus. About 10 per cent of all pearls are rejected because of poor quality.

Half pearls are also prepared by inserting a half round nucleus but these are not in strong demand at present.

Abalone AND Mussels

THE abalone fishery was established by amateur divers in 1963, many of whom soon became fulltime professionals when the value of abalone as an export became known.

The catch grew from about 75 tonne to 9,400 tonne (estimated in-shell weight) by 1968, the peak producing year. Due to over-exploitation of stocks, landings declined in the following years but careful management, introduced in part by divers themselves, halted the drop in production and in 1970–71 it had climbed to 8,450 tonne worth a record $4.3 million.

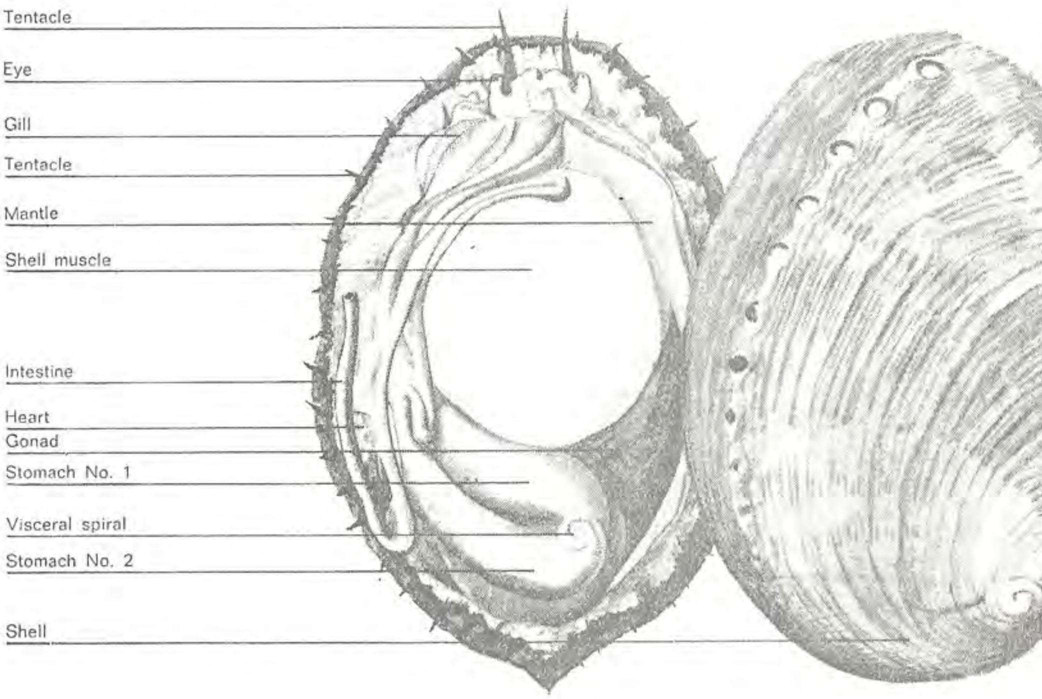
Fifteen species of abalone are found in Australian waters but only three are fished commercially. The black lip or red ear shell (*Notohaliotis ruber*) is the most important commercial species and is found in all States except Queensland.

The species grows to a maximum length of 8 in. (20 cm.) and can produce up to 1¼ lb. (575 g.) of cleaned flesh.

The green lip abalone or mutton fish (*Schismotis laevigata*) is preferred by processors because of its white flesh. It is an important species in South Australia and is also caught in Victoria and Tasmania. This species is easier to collect than the black lip abalone because it occurs on more exposed sites, choosing smooth rock substrates. Because of this the green lip abalone is more susceptible to over fishing.

Abalone generally occur from low tide level to depths of about 100 ft. (30 metres) in four main areas. These are:

- The eastern area which extends from Lakes Entrance in Victoria to the central coast of New South Wales, main ports being Mallacoota and Eden.
- The Tasmanian area which includes the whole coast and the surrounding islands of that State except the northern area between Stanley and Bridport.
- The southern area between Wilson's Promontary in Victoria to Cape Jaffa in South Australia.
- The western area which extends westward from Kangaroo Island in South Australia as far as Albany in Western Australia. There is a small fishery centred within 30 miles of Perth based on Roe's abalone.



EDIBLE mussels occur around the southern coast of Australia with a northern limit of distribution, apart from isolated populations, of 32°S. This corresponds to Perth in the west and Cape Hawke in the east.

A small fishery exists in Victoria, based on dredging natural stocks. Small amounts are also taken in New South Wales, but development of the fishery has been hampered by a limited market and low prices.

Current production is about 600 tonne annually.

Raft culture, the most efficient method of culturing mussels, is being tested in N.S.W., Victoria, Tasmania, S.A. and W.A. by Dr. R. J. MacIntyre of the University of New South Wales.

Leader of the N.S.W. mussel culture project, Dr R. J. MacIntyre, and research assistant, Miss J. Hum, inspect a rope on an experimental raft in Sydney Harbour for the presence of mussel spat. The raft has been made in sections for ease of transport

3.11 The Decomposer Role of Benthon

Living in the mud are many more animals than those mentioned above. We must be careful not to over exploit the Benthos resources because they play a vital role in the estuary. Just like your vacuum cleaner vacuums the dirt and dust out of your carpet, the Benthic animals vacuum clean the estuary bottom. They constantly turn over the mud allowing the decomposer bacteria to break down the "dirt and dust" into elements. These elements then dissolve in the sea water and are carried to the producer phytoplankters and algae.

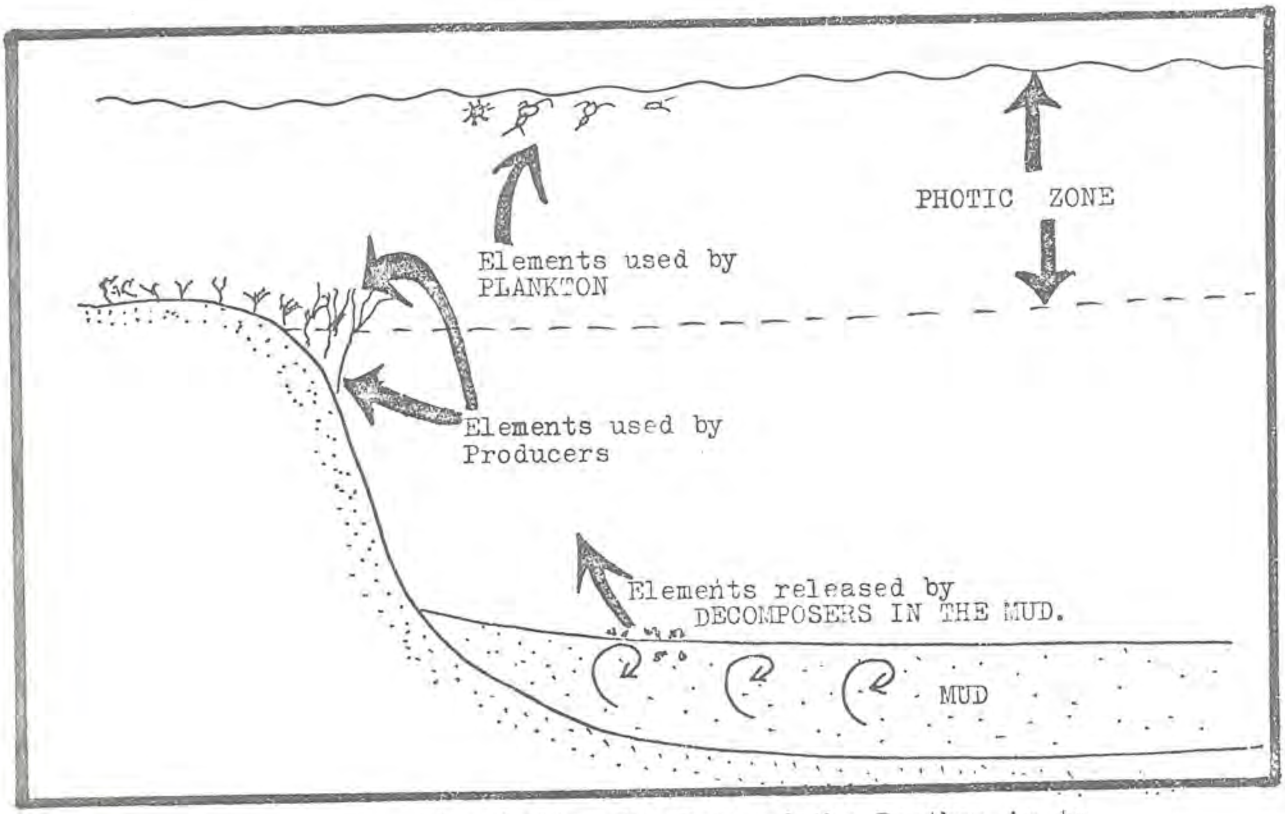


Fig. 3-21: The Role of the Benthon is to release elements back into the sea.

MAIN IDEAS

1. Benthos are bottom dwellers with special adaptations to live in or on mud.
2. Prawns live a Benthic existance only as an adult. The eggs and larval stages live in the Plankton.
3. Prawn trawling involves dragging the ocean bottom for prawns using nets.
4. Scallops, crabs, oysters, abalone and pearls are other important commercial Benthos.
5. Commercial Benthos must be carefully managed to prevent depletion of stocks.
6. The Benthos provide a crucial link in the Ecology of the estuary by returning matter to producers.

REVIEW QUESTIONS

1. List 4 adaptations of Benthic animals.
2. Where does a female crab keep her eggs.
3. Outline the life cycle of the prawn.
4. Why can't prawns be trawled off the Continental Slope?
5. Draw a crossectional view of a prawn trawler.
6. Describe how the prawn catch is brought aboard.
7. How are scallops caught? What part of the scallop is trash? is processed?
8. What is the legal crab length? How is it determined?
9. How are oysters farmed?
10. Outline the decomposer role of Benthon.

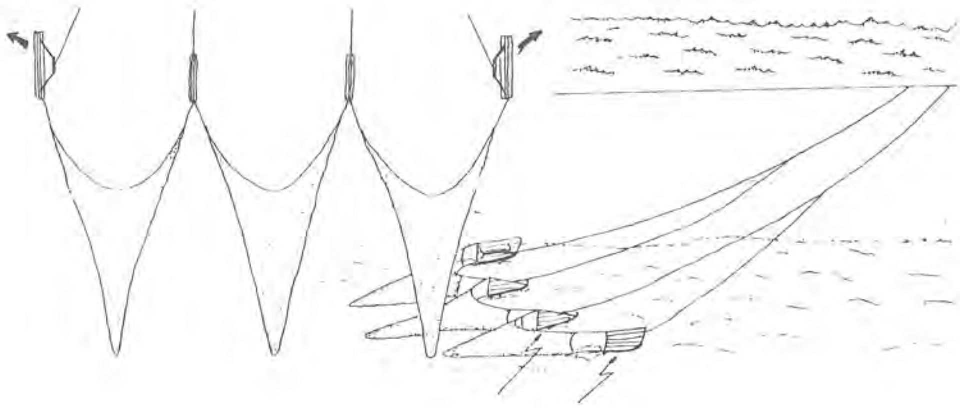
STUDY ASSIGNMENTS

1. Find out how pearls are cultured.
2. How much does a Abalone Licence cost? How many are issued? Write to the Tasmanian Fishing Industry to find out.
3. What is Mariculture? How does it work? Is it profitable? How do you set up your own.
4. Visit a local trawler boat operator. Ask him how he sets his nets; where he processes his food.
5. How are prawns cooked. List 4 prawn recipes.

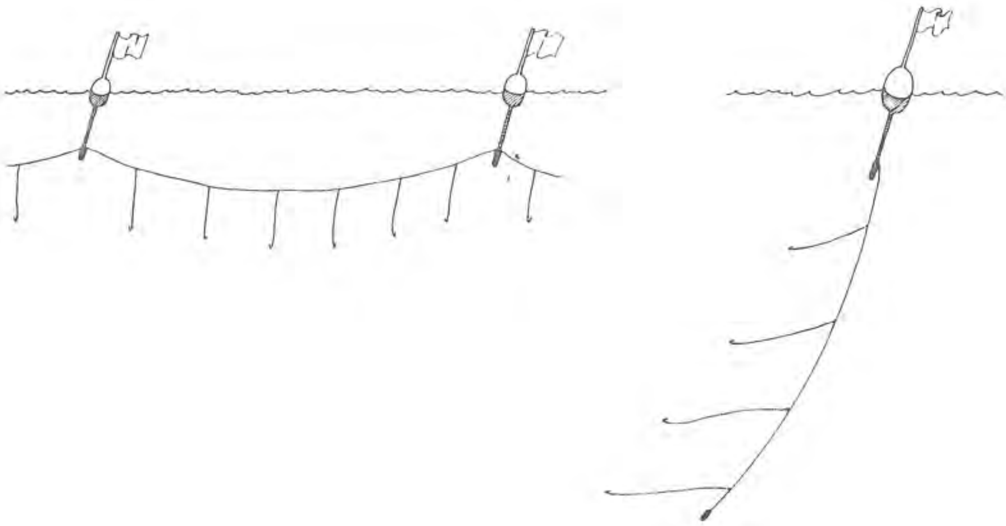
COMMERCIAL FISHING METHODS - Some Notes.

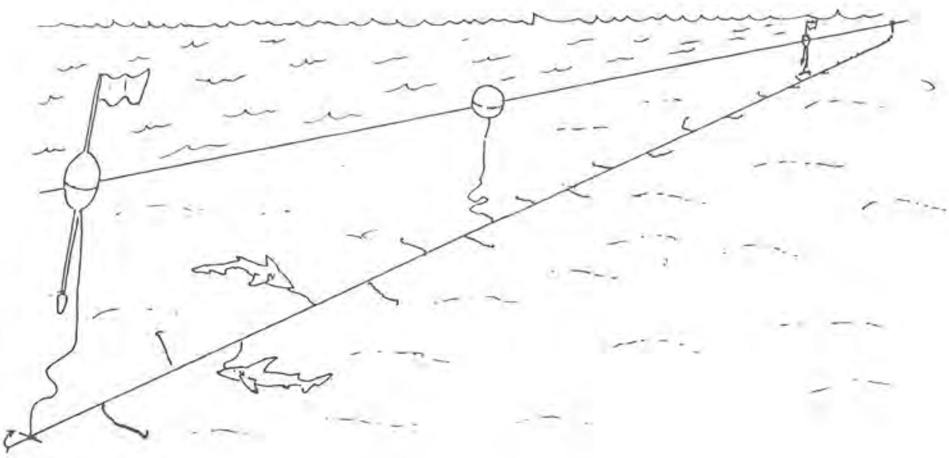
The following notes are taken from the New South Wales Booklet on Commercial Fisheries

Offshore triple-rig prawn trawling gear with nets and boards



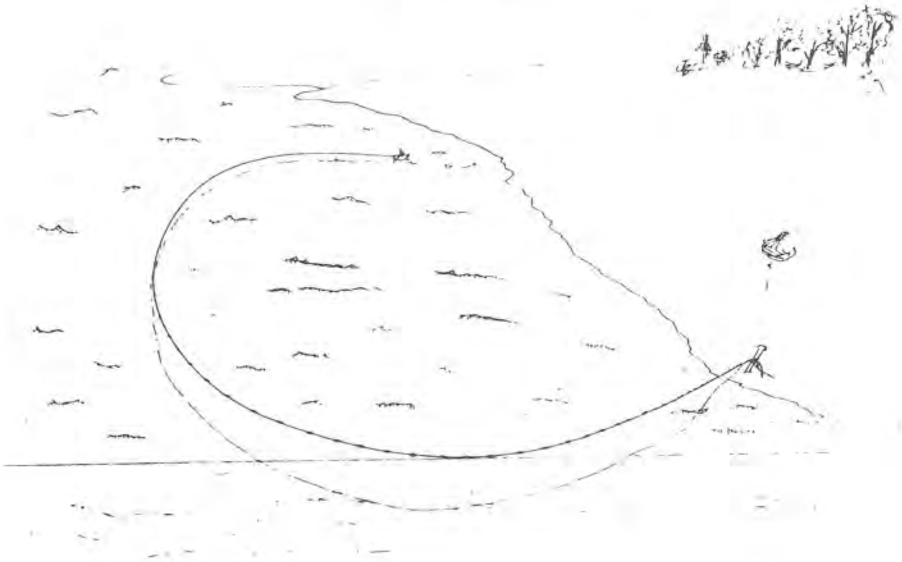
Surface set long line, drop line

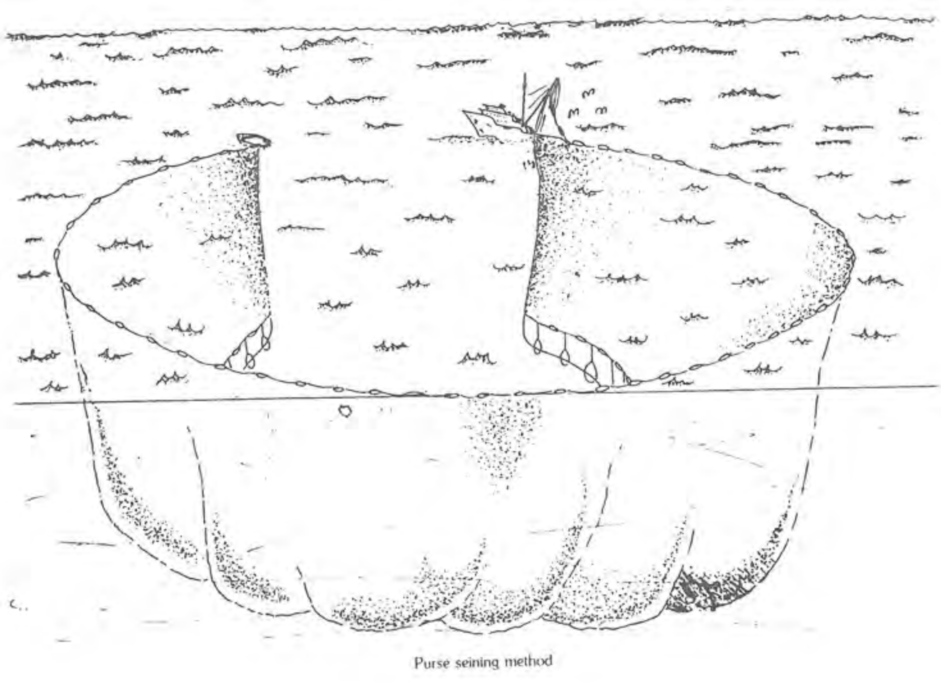




Bottom set long line

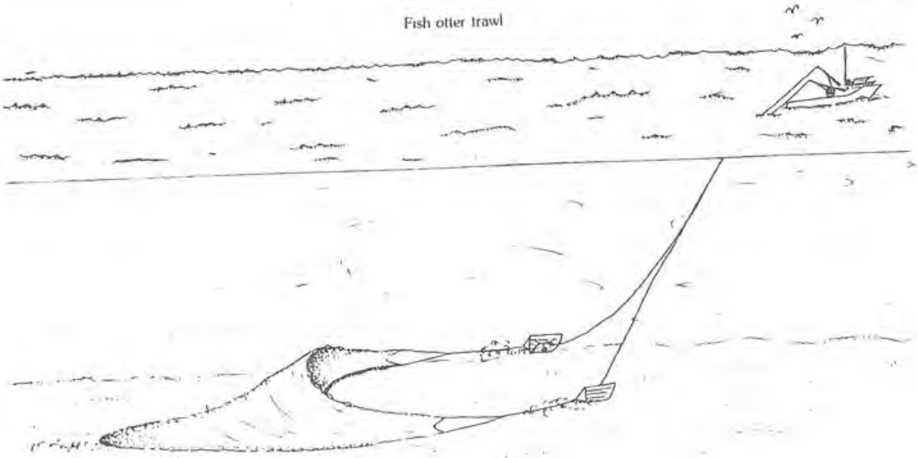
Beach seining method



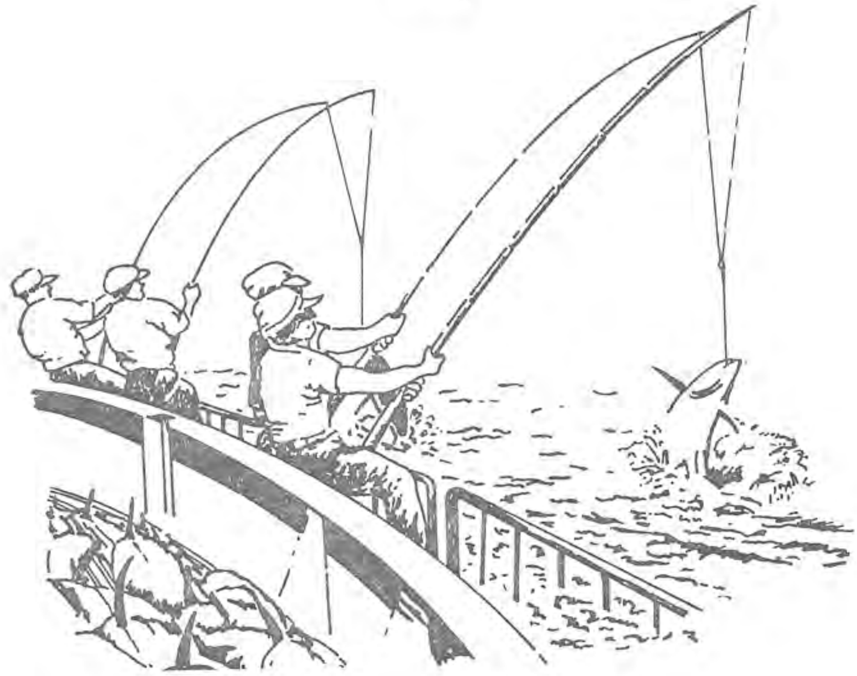


Purse seining method

Fish otter trawl



Tuna poling



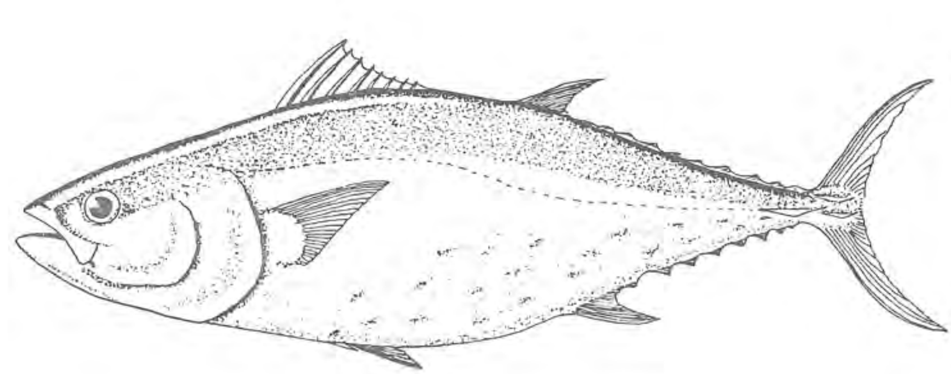
SOUTHERN BLUEFIN TUNA
Thunnus maccoyii

Distribution
These fish are restricted to the southern hemisphere from about 10°S to 50°S and are seldom found in water exceeding 20°C in temperature. While the longitudinal range is circumglobal, fish appear to be concentrated between 20°E and 180°E. The fishery in New South Wales ranges from the Victorian border to the mid north coast (34°S) and up to 350 miles from the coast. Juveniles are found around the western, southern and eastern parts of Australia — off New South Wales the fishery covers their northward migration during June, July and August and their southward movement from September to December.

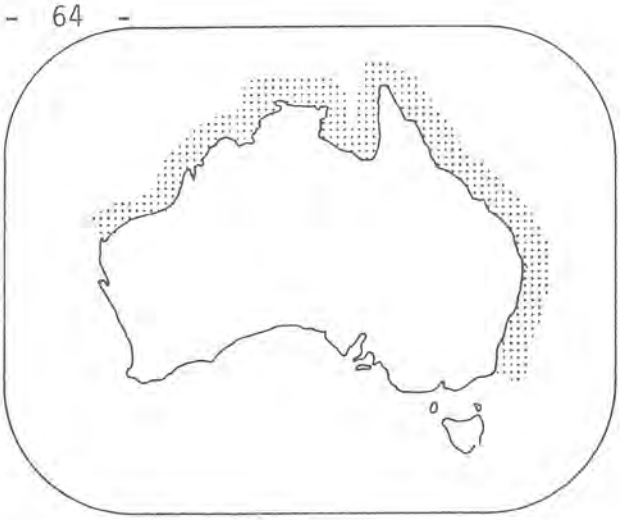
Migrations
The general trend is for some young fish in the Australian Fishing Zone to migrate from west to east — from the Indian Ocean round the southern coast of the Australian continent. They move north along the coast of New South Wales from June to September to about the latitude of Sydney where they form schools and return south ahead of warmer water. At about 5 or 6 years of age many leave coastal waters and move seawards. Eventually adult fish are scattered widely across the southern oceans. Other young fish appear to enter the oceanic fishery without passing along the Australian coast.

Growth and Reproduction
The southern bluefin tuna is relatively slow growing compared to other tunas. The largest on record was 225 cm long. This tuna matures at between 7 and 8 years of age, at approximately 115-150 cm. Spawning takes place in a restricted area in the Indian Ocean, between Java and the north-west of Australia, from September to March.

Feeding
It is a pelagic and midwater feeder taking a large variety of fish, squid, crustaceans and salps.



MUD CRAB *Scylla serrata*



Other common names
Mangrove crab, muddy, black crab.

Distribution
The mud crab is widely distributed throughout the Indo-Pacific region. Within Australia the geographical range of the species extends from Broome in Western Australia, north along the coast of the Northern Territory and Queensland, continuing down the east coast as far as Bermagui in New South Wales.

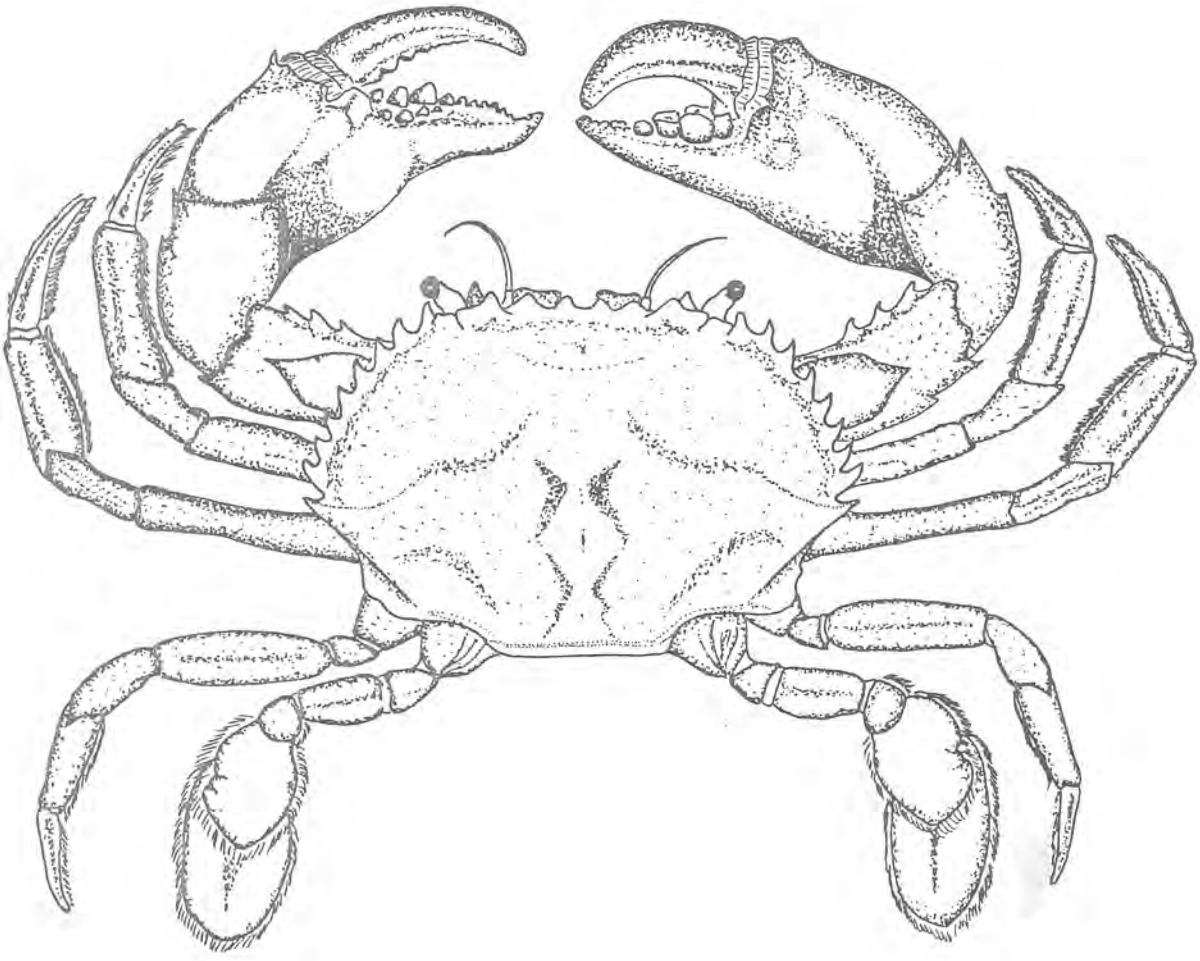
Throughout New South Wales mud crabs inhabit both the intertidal and subtidal regions of estuaries, particularly those lined with mangroves. Planktonic larvae may be found at sea. The juvenile crabs prefer the intertidal regions of mangroves and seagrassed areas, whereas the adults prefer the deeper subtidal regions. Adult crabs live in burrows amongst the roots of mangroves and in the banks of the waterways.

Migrations
Mud crabs are most active at night and usually undergo only small scale movements within the estuary. After mating, adult female crabs migrate seaward to spawn. The planktonic larvae are dispersed along the coast and carried back inshore by currents and tides.

Growth and Reproduction
Growth is accomplished through a series of moults. The growth rate and the time taken to reach maturity varies considerably, depending mainly upon water temperature. The maximum size attained is about 20 cm carapace width. Male crabs grow larger than females.

Mating occurs within the estuary, and may be conducted within the burrow, predominantly during the summer months. Each female may shed up to 8 million eggs at a single spawning. The resultant larvae live as plankton for up to 2 weeks before adopting the bottom dwelling existence. Maturity is usually reached by the time the animal has attained a carapace width of 10 cm, but this is greatly dependent upon water temperature.

Feeding
The diet of the mud crab consists of bottom dwelling invertebrates, mainly bivalves, gastropods and crustaceans. The crab also scavenges on dead animal and plant remains.

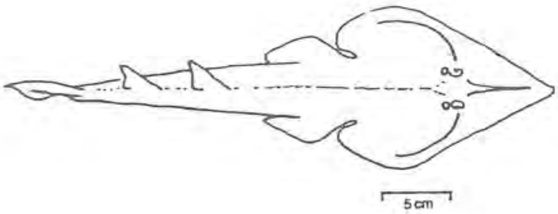


Fish of the Australian North West Shelf

A guide to fishermen

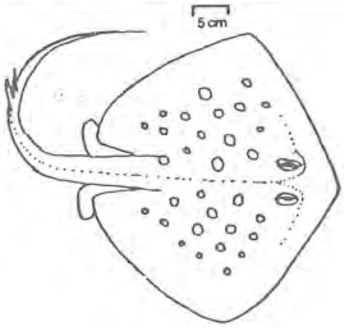
This fish identification guide is designed to be issued with the North West Shelf Midwater and Bottom Trawling Log Book. The codes for each illustration and their order, are the same as those in the species catch entries on the lower part of the log book.

Illustrations are adapted from "FAO Species, Identification Sheets for Fishery Purposes, 1974".



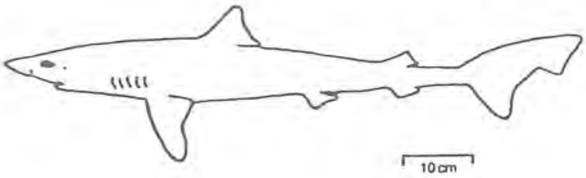
Shovelnose ray
Rhynchobatidae

Code = 027
e.g. *Rhynchobatus* spp.



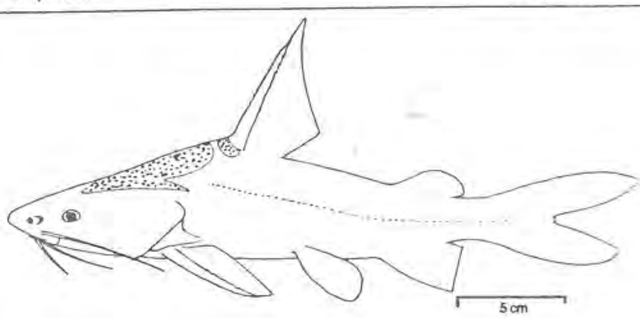
Ray
Dasyatidae

Code = 035
e.g. *Dasyatis* spp.



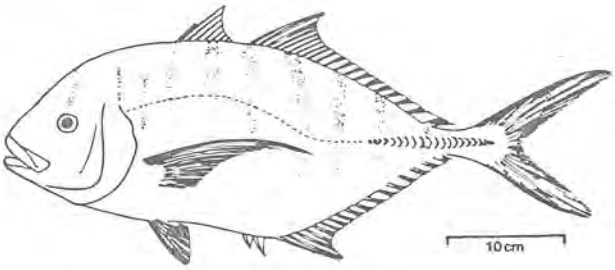
Shark
Carcharanidae, Triakidae

Code = 018



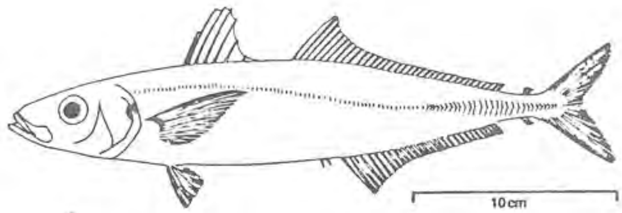
Catfish
Ariidae

Code = 188
e.g. *Arius thalassinus*



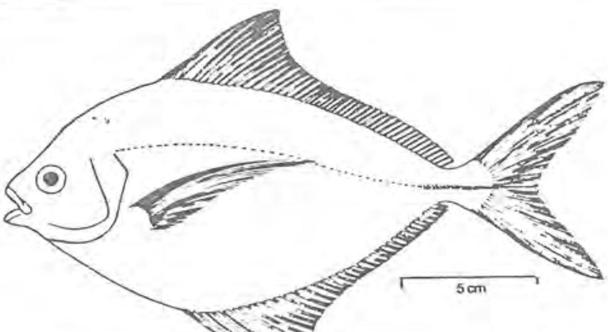
Trevally
Carangidae

Code = 337.1
e.g. *Carangoides* spp.



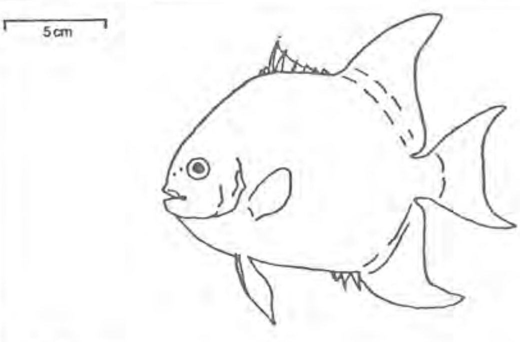
Scad
Carangidae

Code = 337.2
e.g. *Decapterus* spp.



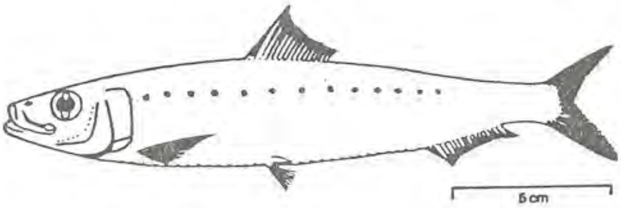
Pomfret
Formionidae

Code = 446.1
e.g. *Formio niger*



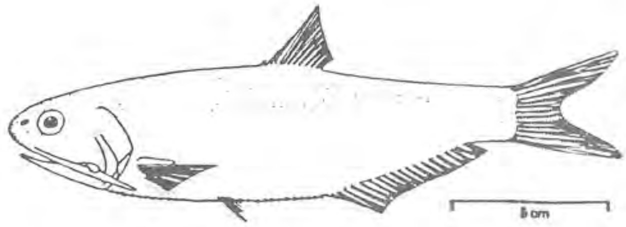
Batfish
Ephippidae

Code = 352
e.g. *Platax* spp.



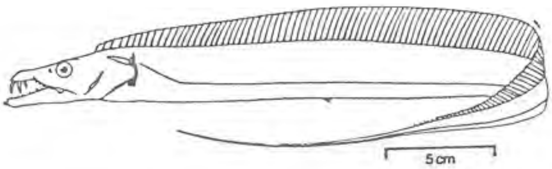
Sardines/Pilchards
Clupeidae

Code = 085
e.g. *Sardinella sirm*



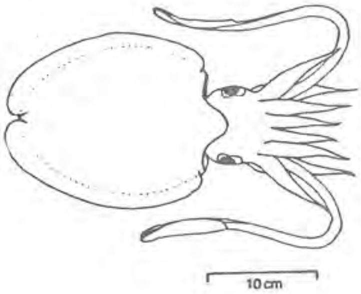
Anchovies
Engraulidae

Code = 086
Stolephorus heterolobus



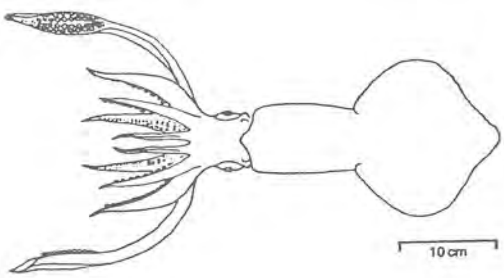
Hairtails
Trichiuridae

Code = 440
e.g. *Trichiurus savala*



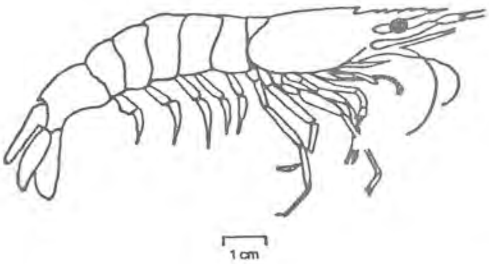
Cuttlefish
Cephalopoda

Code = 000.1
e.g. *Sepia* spp.



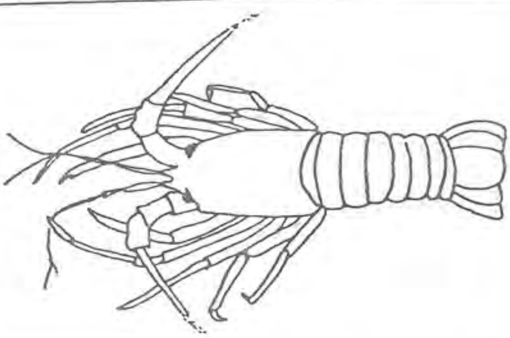
Squid
Cephalopoda

Code = 000.2
e.g. *Loligo* spp.



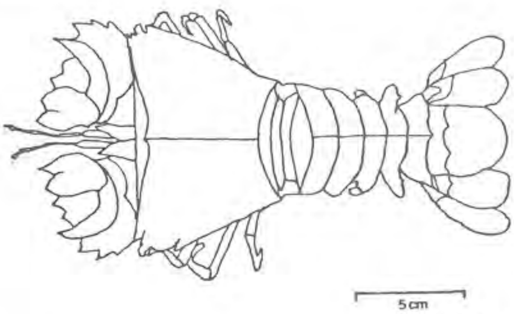
Prawn
Crustacea

Code = 000.3
e.g. *Penaeus* spp.



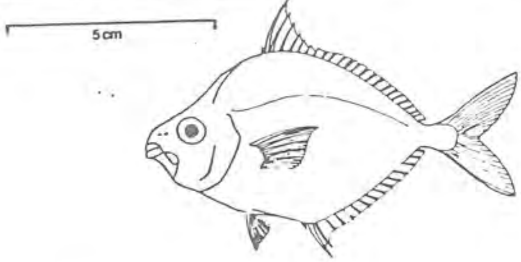
Tropical rock lobster
Crustacea

Code = 000.4
e.g. *Panulirus* spp.



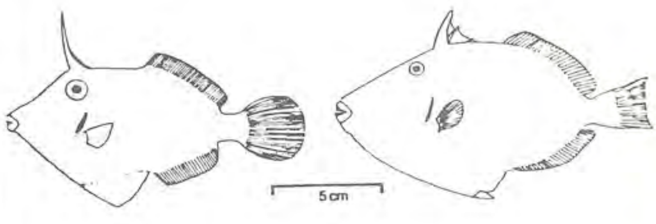
Shovel-nosed lobster
Crustacea

Code = 000.5
e.g. *Thenus* spp.



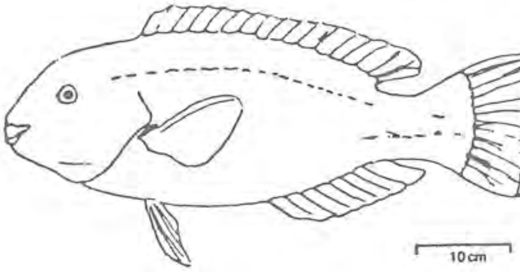
Ponyfish
Leiognathidae

Code = 341
e.g. *Leiognathus splendens*

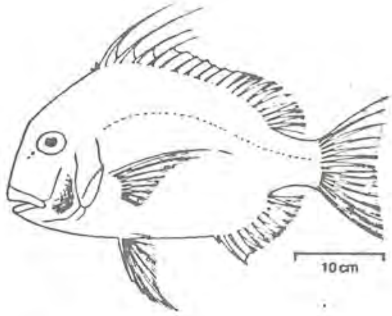


Triggerfish/Leatherjackets
Balistidae

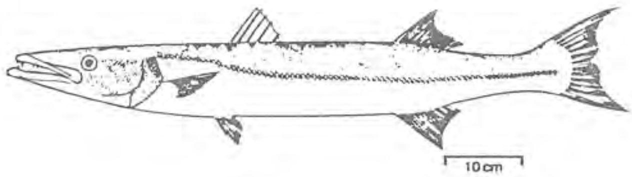
Code = 485
Abalistes stellatus



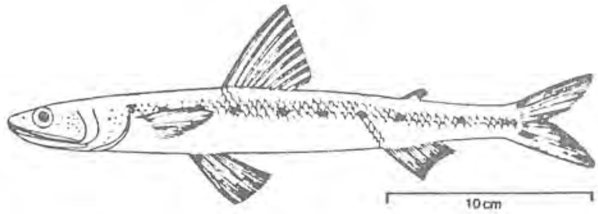
Parrotfish
Scaridae
Code = 386



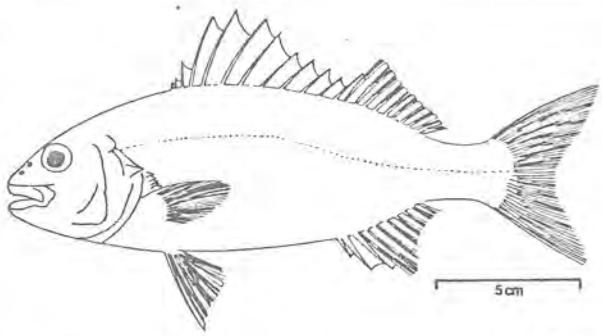
Sea bream/Porgies
Sparidae
Code = 353
e.g. *Argyrops spinifer*



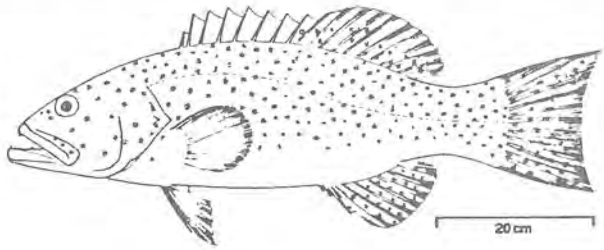
Sea pike/Barracuda
Sphyraenidae
Code = 382
e.g. *Sphyraena barracuda*



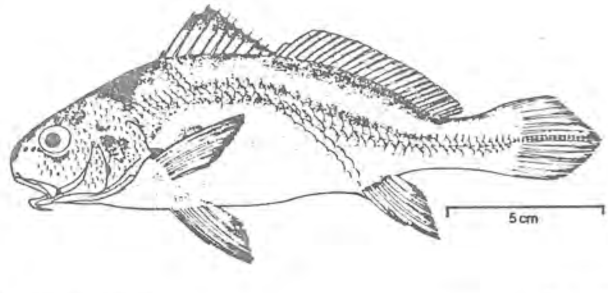
Lizardfish
Synodontidae
Code = 118
e.g. *Saurida undosquamis*



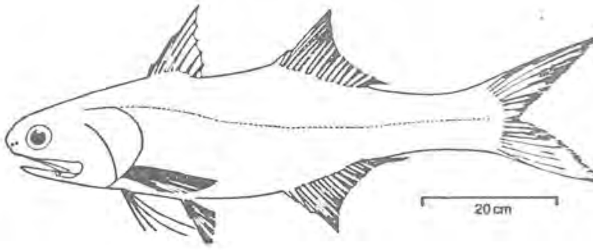
Grunters/Therapon perches
Theraponidae
Code = 321
e.g. *Therapon jarbua*



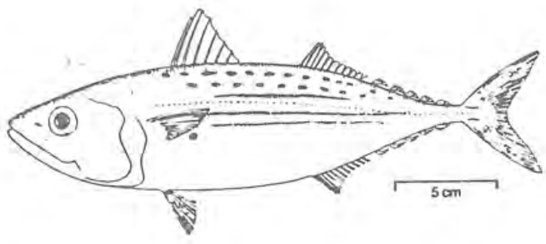
Rock cod/Groupers
Serranidae
Code = 311
Plectropomus leopardus



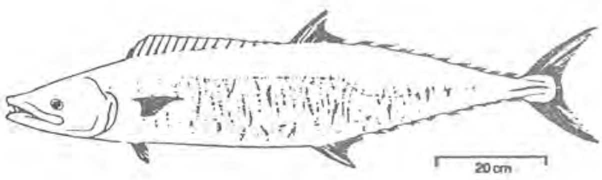
Croackers/Drummers
Sciaenidae
Code = 354
e.g. *Dendrophysa russelli*



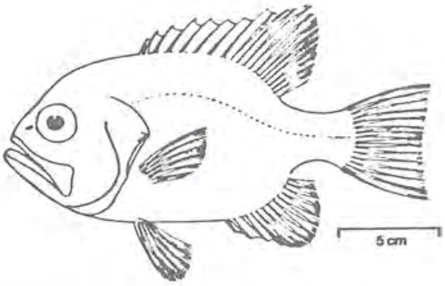
Tasselfish/Threadfins
Polynemidae
Code = 383
Eleutheronema tetradactylum



Indian mackerel
Scombridae
Code = 441.1
e.g. *Rastrelliger kanagurta*

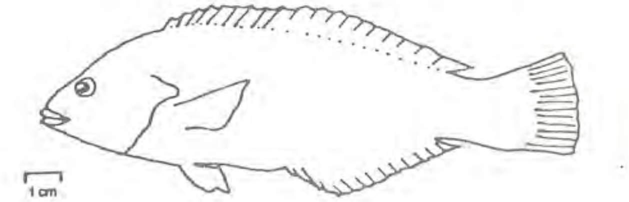


Spanish mackerel
Scombridae
Code = 441.2
e.g. *Scomberomorus commerson*



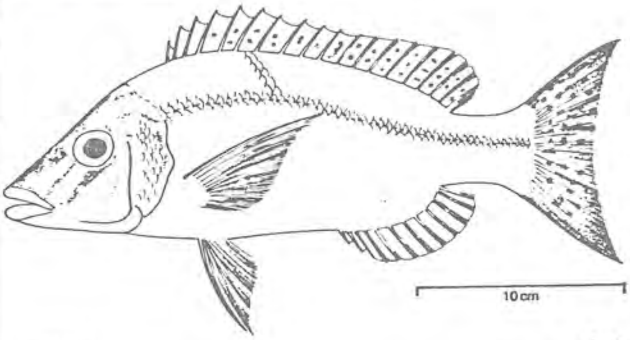
Jewfish/Pearl perch
Glaucosomidae

Code= 320
e.g. *Glaucosoma burgeri*



Tuskfish
Labridae

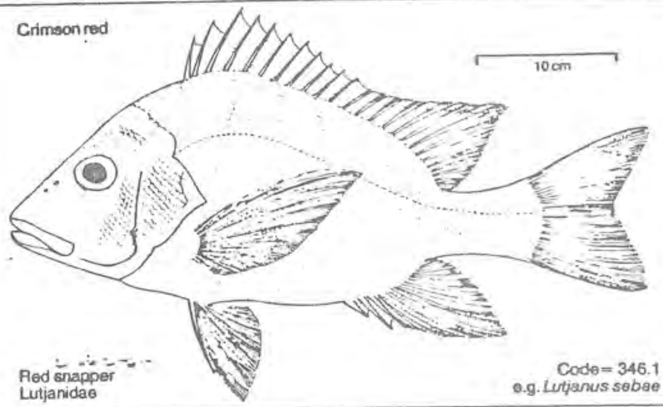
Code= 384
e.g. *Choerodon cephalotes*



Emperor
Lethrinidae

Code= 351
e.g. *Lethrinus choerorynchus*

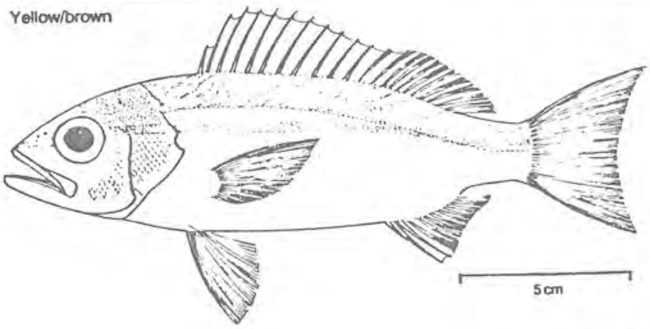
Crimson red



Red snapper
Lutjanidae

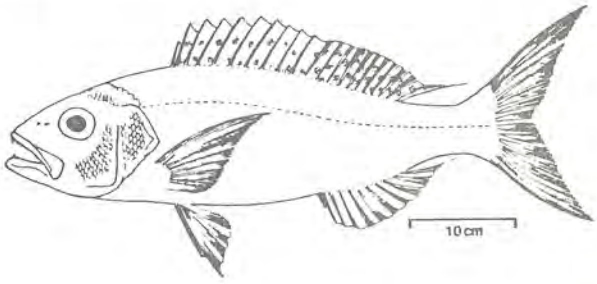
Code= 346.1
e.g. *Lutjanus sebae*

Yellow/brown



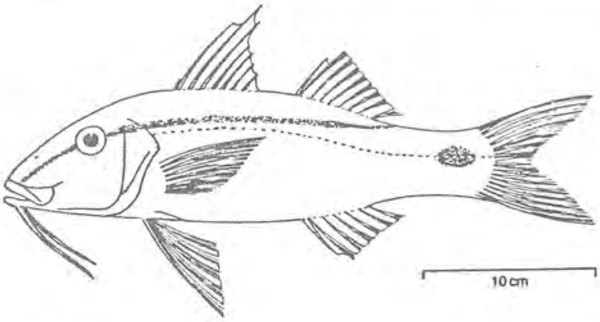
Spotted/Striped snapper
Lutjanidae

Code= 346.2
e.g. *Lutjanus lineolatus*



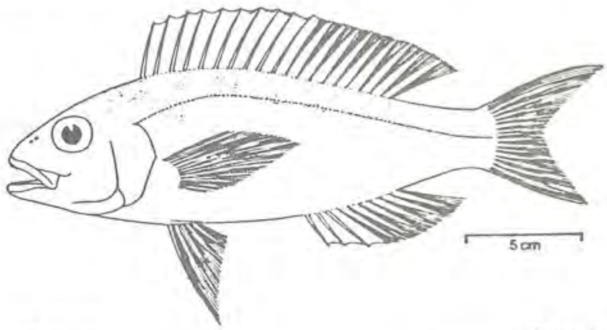
Sharp toothed snapper
Lutjanidae

Code= 346.3
Pristipomoides argyrogrammicus



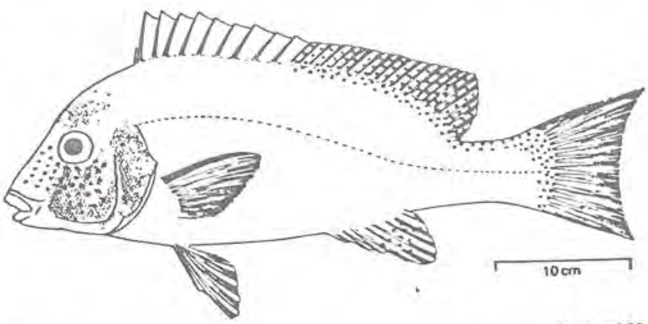
Goatfish
Mullidae

Code= 355
e.g. *Parupeneus barberinus*



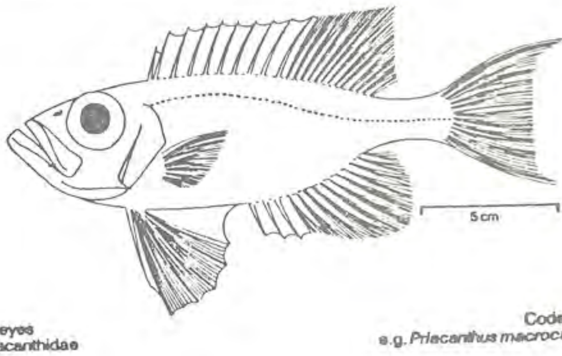
Threadfin bream
Nemipteridae

Code= 347
e.g. *Nemipterus perroni*



Sweetlips
Pomadasyidae

Code= 350
e.g. *Plectorhynchus pictus*



Bigeyes
Priacanthidae

Code= 326
e.g. *Priacanthus macrocanthus*

BENOWA HIGH SCHOOL PARENTS & CITIZENS ASSOCIATION

PRESIDENT: Roger Brewster
Ph. 381 755 Bus.
501 660 A.H.

SECRETARY: Leslie Ponti
Ph. 323 782

17th July, 1986

Mr. R. Moffatt,
Benowa State High School,
Mediterranean Drive,
BENOWA. QLD. 4217

Dear Bob,

On behalf of the P & C Association and the students of the school, I would like to express our deep appreciation for your personal commitment and untiring efforts in relation to the Marine Studies program.

The P & C Association has benefitted financially from your generous loan of the copyright over the Marine Studies classroom notes. The sale of notes to other schools has defrayed the costs of establishing the Marine Studies program here at Benowa as well as assisting many other schools in Queensland to begin their school programs.

This letter acknowledges the return of the copyright over the following classroom notes to yourself as owner:

Navigation, snorkelling, coastal physics, fisheries biology, estuarine chemistry, oceanography, science of diving, field methods, boating and marine radio.

The P & C Association will continue to be able to sell copies of the sea notes which will continue to operate under the Marine Studies Sub Committee. The Association acknowledges that these notes were produced in school time and therefore remain the property of the Education Department.

Finally, we are very pleased that the inaugural Castrol Sea Safety Award was made to you. It is a fitting tribute and worthy honour to your entrepeneurial achievement.

Yours faithfully,

Roger J Brewster

ROGER J. BREWSTER
PRESIDENT

MARINE STUDIES SERIES

OTHER UNITS :

There are two types of Classroom Note : Practical & Applied

(a) Practical Notes

Unit 1	: Navigation	: Features of the Coastline, Navigation Methods, Practical, Weather, Pilotage, Tides, Exam.
Unit 2	: Snorkelling	: Physiology, Techniques, First Aid, Dangerous Marine Animals, Safety, Certificate.
Unit 3	: Radio	: Components, Features, Discipline, Types, Practice Excercises, Certificate.
Unit 4	: Boating	: Buying a Boat, Safety, Seamanship skills, Handling, Maintenance, Licence.
Unit 5	: Camping	: Types of, Equipment for Camping with a boat, Campsites, Practical Conservation, Safety, Leadership Skills.

(b) Applied Notes

Unit 6	: Fisheries Biology	: Plankton, Nekton, Benthos, Fishing Methods, Protected Species, Fisheries Management
Unit 7	: Estuarine Chemistry	: Laboratory Methods, Pollution, Salinity, Temperature, Ph, and other parameters.
Unit 8	: Coastal Physics	: Waves, Tides, Beach Erosion, Beach Protection, Coastal Management, Local Coast Management
Unit 9	: Diving Science	: Boyles Law, Charles Law, Effects of Pressure on Diver, Marine Medicine.
Unit 10	: Sampling Methods	: Marine Technology in Scientific sampling apparatus, student project, collection methods.

SAFE BOATING = KNOWLEDGE + COMMON SENSE + COURTESY