



Module 3: Estuaries



Estuaries in Marine Parks

An estuary is a unique environment where flowing fresh water from a river or creek meets the salty seawater, creating a brackish region of mixed water. Being so close to the sea, the estuary is subjected to the daily fluctuations of the tide. The combination of the sheltered area, lack of wave energy and fine soft sediment creates a very special habitat where highly specialised plants have become adept at living. Three highly productive estuarine vegetation communities are particularly important: mangroves, saltmarsh and seagrass.

Mangroves

Mangroves are found mostly in sheltered estuarine environments, growing primarily on areas of soft sediment, which form a distinct habitat known as a “mangrove forest”. Mangrove trees are well adapted to changes in salt levels, and have developed exceptional ways of dealing with the estuarine environment.

There are seven species of mangrove in NSW, of which the grey mangrove is the most common. Possibly the easiest to recognise, it has long thin roots (known as pneumatophores) that rise vertically up through the mud. Since the mud is so thick that oxygen cannot get much deeper than the first couple of centimetres, these roots act like snorkels. To get to oxygen, the mangrove sends the roots up above the mud and respire oxygen through little holes on the pneumatophores, which then store oxygen in the plant during high tide.

Mangroves play a very important role for many of the animals that live in estuaries. The pneumatophores, root systems and fallen branches create a nursery habitat for juvenile prawns and fishes, such as bream, mullet, whiting and luderick. The trunks and roots also provide a home to oysters, barnacles and limpets, as well as an array of seaweeds and lichens for animals to graze on. In the branches of the mangroves it is often possible to find some beautiful birds such as the mangrove gerygone (a mangrove specialist), the sacred kingfisher and various honeyeaters which come to enjoy the sweet mangrove blossoms.

L-R: Grey mangrove (*Avicennia marina*) and river mangrove (*Aegiceras corniculatum*)



Saltmarsh

Saltmarsh consists of a diverse range of grasses, saltbushes, rushes and sedges, and is found in the upper intertidal area of the shoreline in estuaries. The plants making up saltmarsh differ from one area to another. In NSW, 25 different plant compositions have been identified along the central NSW coast alone. Saltmarsh in southern NSW is generally more species-rich than in northern NSW.

Saltmarsh improves breeding in fisheries by providing shelter, a feeding ground and a general nursery area for juvenile fishes, similar to the way that mangroves also provide a nursery habitat. Many animals use saltmarsh as feeding grounds. Fishes and crabs feed in saltmarsh during king and spring tides, and shorebirds often feed at low tide.

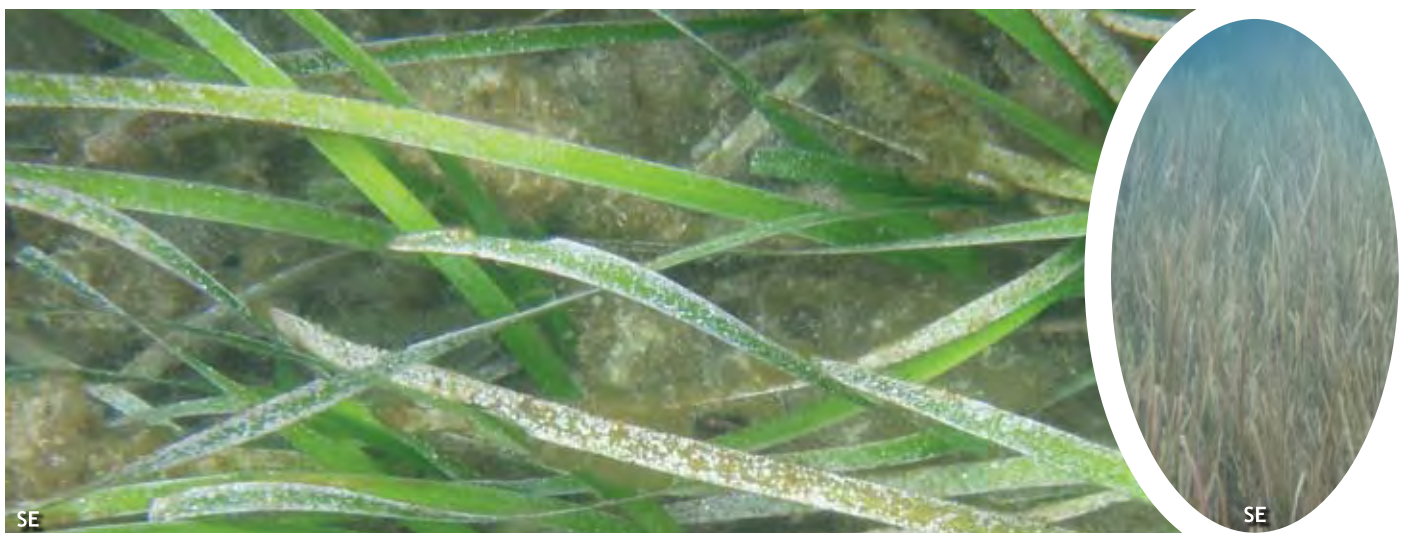
Saltmarsh supplies a large amount of decaying organic material into food chains in estuaries. Bacteria and scavengers, such as crabs, break down the organic material (known as “detritus”) into nutrients, which in turn becomes food for fish, crabs and other crustaceans, shellfish, and then larger animals. Saltmarsh is also very important for controlling floods and erosion, and for filtering pollution. In NSW, saltmarsh is a threatened community, with only a fraction of its original area still remaining.



Seagrass

Seagrasses are unique marine plants that grow in nearshore environments, estuaries and sheltered bays. Seagrasses, like their terrestrial grass cousins, are anchored to the sea floor by roots or “rhizomes”, and have leaves with veins. They also reproduce using flowers and seeds, and require sunlight to grow.

Seagrass beds are found in many marine park estuaries and are another very important habitat for a range of marine life. Fish, prawns and swimmer crabs are often spotted hiding and feeding amongst the seagrass. Seagrass also assists in sediment stabilisation, where it helps to reduce erosion. There are six species of seagrass found in NSW waters, but the most common are *Zostera capricorni* (bottom right), *Halophila ovalis* and *Posidonia australis* (bottom left).



Estuarine seagrass supports many coastal fisheries by providing an important area for juvenile and adult fish to hide, eat and breed in. Approximately 70% of commercially and recreationally important fish species in NSW rely on estuaries and their seagrass habitats at some stage in their life cycle.

Management of estuaries

There are several different types of estuaries, such as drowned river valleys, barrier estuaries, which are mostly open to the tide, and coastal lagoons, which are intermittently closed and open to the tide (known as Intermittently Closed and Open Lakes and Lagoons or ICOLLs).

The importance of such estuarine systems means that they have been included in NSW marine parks. Of the 133 major estuaries in NSW, approximately 50 estuaries are included in NSW marine parks.



Industry & Investment

Industry and Investment NSW has management responsibilities for mangroves and seagrasses, which are protected through the *Fisheries Management Act 1994*. The Department of Environment, Climate Change and Water manages saltmarsh, which is an endangered ecological community.



Environment, Climate Change & Water

Popular activities in NSW marine park estuaries

Estuaries provide a perfect place for recreational activities with their sheltered waters, productive habitats and extensive waterways. Boating, swimming, recreational fishing and collecting are very popular activities. Some estuaries are also very important for aquaculture, with oyster aquaculture present in most tidal estuaries. Commercial tour operators provide opportunities for dolphin watching and fishing, and hire businesses supply boats, kayaks and other equipment for recreational enjoyment.



Estuaries of the Jervis Bay Marine Park

There are six estuaries in the marine park. Four are small coastal creeks (Callala Creek, Carama Inlet, Currarong Creek and Wowly Gully), and two are larger wave-dominated estuaries (Currumbene Creek and Moona Moona Creek). At present, 22% of estuarine habitats in the marine park are protected in sanctuary zones, with three estuaries (Carama Inlet, Moona Moona Creek and Wowly Gully) totally or predominantly included in these zones.

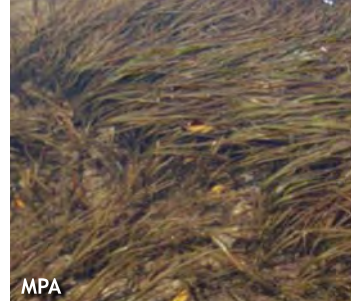
Estuarine vegetation, such as mangroves, saltmarsh and seagrass meadows, are well-represented in the marine park, with a high percentage occurring in sanctuary zones. Two types of mangrove – the grey mangrove (*Avicennia marina*) and, in the upper reaches, the river mangrove (*Aegiceras corniculatum*) – are found in the marine park. Some of the most extensive seagrass beds in NSW are also found in Jervis Bay, and these are dominated by *Posidonia australis* (strap weed), *Zostera capricorni*, or eelgrass (right top), and *Halophila ovalis* (paddle weed). Seagrasses possess extensive root systems which help to stabilise surrounding soft sediments and, in Jervis Bay, contribute to the crystal-clear water for which the area is known.

Carama Inlet is one of the most diverse and pristine saltmarsh environments in NSW. The inlet is fed by clean marine waters with no significant freshwater inflow or development on the adjacent land. The saltmarsh plain contains extensive stands of the endangered species *Wilsonia backhouseii*, as well as the northernmost stand of the shrub *Sclerostegia arbuscula*. Carama Inlet is wholly included within the Hare Bay Sanctuary Zone, which also protects one of the largest intact seagrass beds in NSW. This meadow is dominated by *Posidonia* (strap weed), which has been found to contain 75 different species, including the more unusual spotted pipefish, bridled leatherjacket and weed whiting.

Tidal flats are an important part of estuarine ecosystems as the organisms living there are responsible for transforming nutrients and food from the surrounding catchment into new food for marine ecosystems and fish. Over 80 species of invertebrates have been recorded in the Currumbene Creek Mudflat Sanctuary Zone, including polychaete worms, ghost shrimps (right), soldier crabs, amphipods and molluscs. Dominant species that rely on intertidal flats for food, shelter or as nursery areas include bream, flathead, leatherjacket, mulloway and stingrays (right bottom).

A range of shorebirds can be seen foraging around estuarine habitats, including various waders (e.g. white-faced herons, royal spoonbills and egrets), summer migrants (such as the eastern curlew), and threatened species (such as the pied oystercatcher). Terns, white-bellied sea eagles, black swans and pelicans are also a commonly sighted.

The area of estuary outside sanctuary zones is predominantly zoned habitat protection. The primary intent of the habitat protection zoning is to protect estuarine habitats from direct human-related disturbance, such as coastal development, pollution, siltation and erosion. Fishing, boating, swimming and kayaking are popular pastimes in the estuaries of the Jervis Bay Marine Park. The zoning plan regulates these activities to ensure that impact on these sensitive areas is minimised.



MPA



MP



SB



DH

Estuarine Organisms of the Jervis Bay Marine Park



MPA

White-faced heron

(*Egretta novaehollandiae*)

A diverse wetland bird that uses its long beak to stab at prey in the water.



MPA

Pelican

(*Pelecanus conspicillatus*)

This bird collects fish in a large pouch in its lower bill.



MPA

Pied oystercatcher

(*Haematopus longirostris*)

Listed as vulnerable, this bird is found on beaches feeding on pipis and nesting in the dunes.



□

Black swan

(*Cygnus atratus*)

Often seen in sheltered estuaries, this large bird forages for algae growing on the seagrass.



SB

Semaphore crab

(*Heloeucis cordiformis*)

This crab is commonly found burrowing around the terrestrial fringe of mud and sand flats.



SB

Mudwhelk

(*Pyrazus ebeninus*)

Large snails that filter food from the mud, these animals are eaten by birds, octopuses and stingrays.



DM

Rock oyster

(*Saccostrea glomerata*)

The rock oyster attaches to mangrove roots and filters plankton from the water at high tide.



SB

Ghost shrimp

(*Thalassinidea* spp.)

This shrimp burrows in intertidal sand/mud flats and feeds on tiny organisms in the sediment.



MPA

Grey mangrove

(*Avicennia marina*)

The grey mangrove breathes through peg roots (pneumatophores).



SB

Eelgrass

(*Zostera capricorni*)

Eelgrass provides an important habitat for many fish and invertebrates.



MPA

Soldier crab

(*Mictyris platycheles*)

The soldier crab burrows into sandflats and mudflats, and sifts through sediment for its food.



SB

Polychaete worm

(various species)

These worms live beneath the surface, coming out at high tide to feed.



DH

Smooth stingray

(*Dasyatis brevicaudata*)

The smooth stingray burrows into the sandy bottom at high tide to feed on crabs and shellfish.



DH

Yellowfin bream

(*Acanthopagrus australis*)

Bream feed on oysters, crabs and shellfish.



□

Mullet

(*Mugil* spp.)

Mullet feed by vacuum-cleaning the mud with soft lips that filter out food.



□

Luderick

(*Girella tricuspidata*)

This fish feeds on marine algae such as sea lettuce.

Stage 1 - Local Places

Teacher Activity Plan

Level

Stage 1 - Local Places
COG Group A - Exploring Our Place

Key Learning Areas

ENS1.5, ENS1.6 and DMS1.2

Objectives

The objectives of this activity are: to gather information about the natural estuarine environment; and to increase the understanding of relationships between animals, their environment and humans.

Excursion Timing

The excursion must be undertaken at low tide. Check the tide times at:

<http://www.bom.gov.au/oceanography/tides>

Equipment Used

- coloured pencils
- scissors
- A3 paper

Teacher Resources

Please contact the marine park office on 4428 3000 for a copy of all educational material on CD or to request staff attendance for excursion support. Additional resources are available on:

<http://www.mesa.edu.au>

Link to habitat mapping fact sheet on saltmarsh and estuaries:

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/236234/mangroves.pdf

About this program

This module is designed to cover ENS1.5, ENS1.6 and DMS1.2, and when combined with the other three modules in this kit, addresses the key learning areas for COG Group A, Stage 1 - Local Places. Follow up this module with the Marine Parks, Rocky Shores and Sea Country modules for further insight into the local environment. The modules are designed to address the NSW DET primary school curriculum, and can be used to complement current teaching programs.

Education material in this module consists of this **Activity Plan** to guide teachers through an excursion, a **Fact Sheet** to provide background information on estuaries, and an **ID Guide** for both teachers and students to identify the most common animals and plants found in estuaries.

Program outline

This program introduces some estuarine plants and animals, and provides information on where they live, and how they interact with each other, their environment and humans.

Activity 1

Using the fact sheets, explain the significance of mangroves in estuaries. Copy the activity sheets at A3 size and use the mangrove tree as a base for developing the estuary food chain. Students then, either individually or in small groups, colour the animals, cut them out and construct the food chain below the mangrove tree using arrows to link the chain together (see the example on p.59). The animals should be represented on the diagram in their preferred habitat. Illustrate the page further with other animals that live in the estuary, such as crabs in the mud, insects in the trees, yabbies under the mud, etc.

Reiterate how important mangroves are to all of these animals, and why these habitats need to be cared for.

Optional excursion

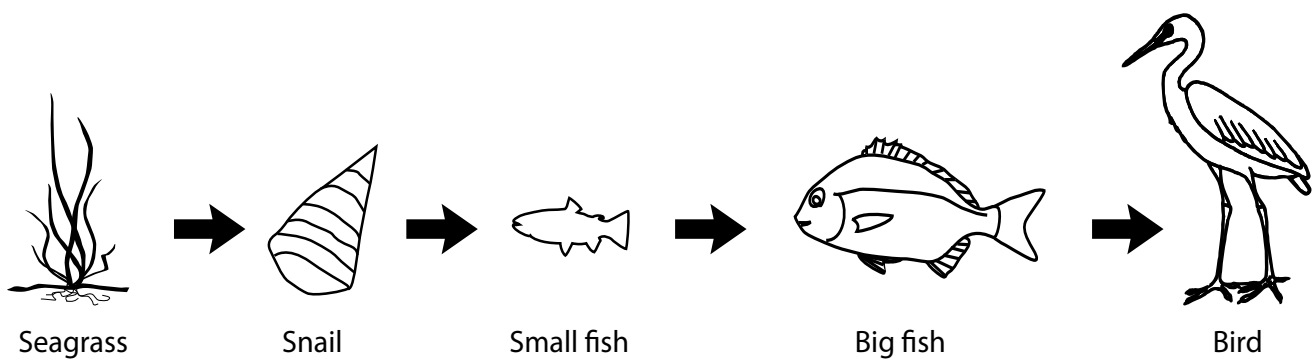
Follow up with an excursion to your nearest estuary to meet the inhabitants in person. Use the ID guide to identify some of the plants and animals found in the estuary, and tick them off "bingo"-style when you have found them.

During the excursion, discuss which zone the estuary is in (refer to the Jervis Bay Marine Park zoning guide provided in Module 1). Mud crab trapping and recreational line fishing are permitted in the habitat protection zone but not in the sanctuary zone. Which would you guess has a healthier population (larger numbers and larger sized animals) of fishes and crabs? Use the Estuaries Risk Analysis (pp.74-75) to ensure student safety.

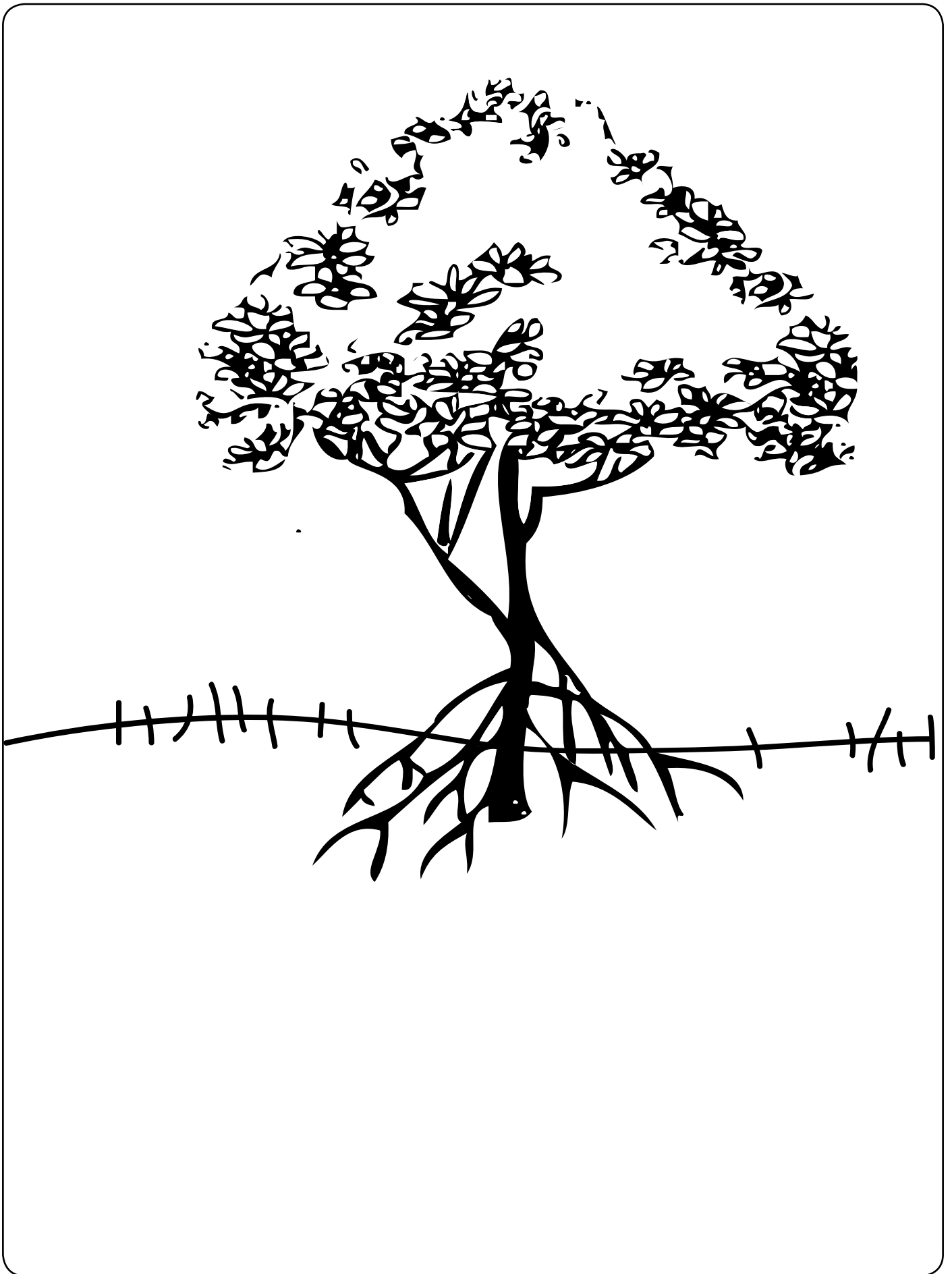
Possible locations within the Jervis Bay Marine Park

- Currumbene Creek
- Moona Moona Creek
- Callala Creek

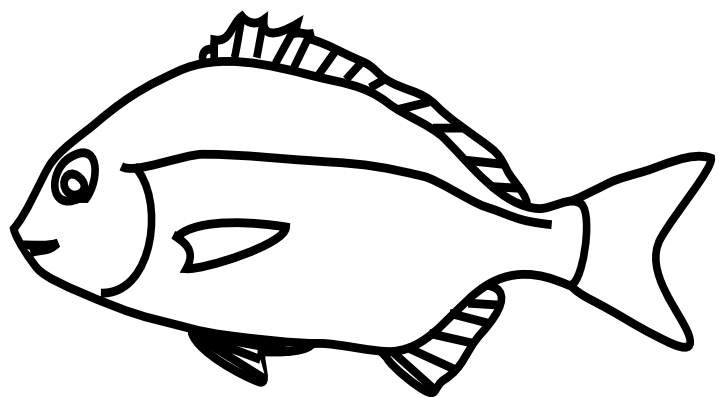
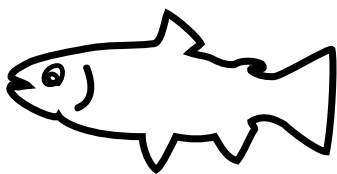
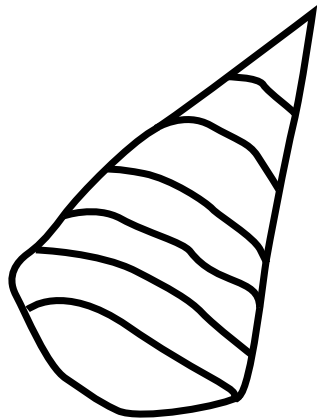
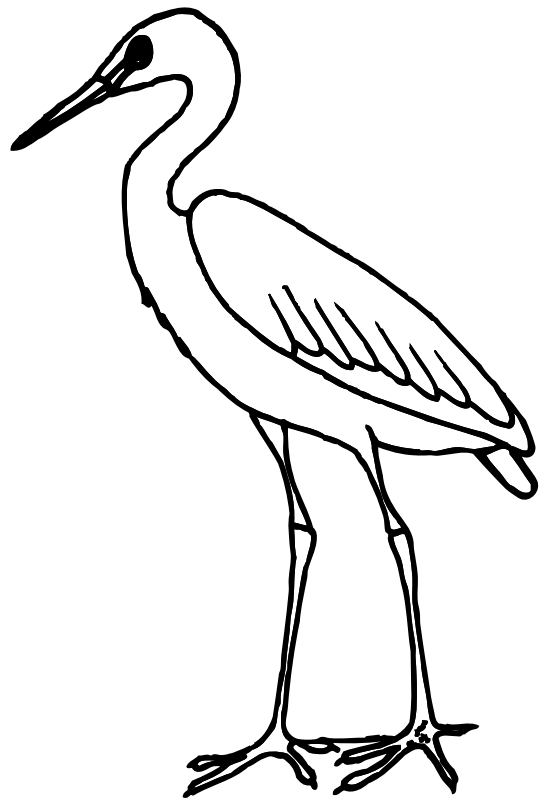
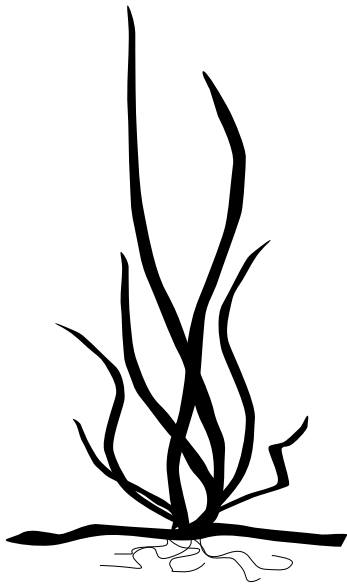
Develop an Estuary Food Chain - EXAMPLE



Activity Sheet - Develop an Estuary Food Chain



Activity Sheet - Develop an Estuary Food Chain



Stage 2 - Local Environments

Teacher Activity Plan

Level

Stage 2 - Local Environments
COG Group A - Exploring Our Place

Key Learning Areas

ENS2.5, ENS2.6, SLS2.13, PSS2.5

Objectives

The objectives of this activity are: to identify local estuarine species; to use a range of problem-solving strategies when faced with issues in the natural environment; to identify who to contact in order to solve a localised problem; and to understand the difference between zones within marine park estuaries.

Excursion Timing

The excursion must be undertaken at low tide. Check the tide times at:

<http://www.bom.gov.au/oceanography/tides>

Equipment Used

- pencils
- sustainable bags
- rubber gloves
- clipboards

Teacher Resources

Please contact the marine park office on 4428 3000 for a copy of all educational material on CD or to request staff attendance for excursion support. Additional resources are available on:

<http://www.mpa.nsw.gov.au>

<http://www.cleanup.org.au/au>

<http://www.waterwatch.nsw.gov.au>

<http://www.dpi.nsw.gov.au/fisheries/recreational/saltwater/sw-species/tiger-flathead2>

http://www.ozcoasts.org.au/geom_geol/toolkit/mapfish.jsp

About this program

This module is designed to cover ENS2.5, ENS2.6, SLS2.13 and PSS2.5, and when combined with the other three modules in this kit, addresses the key learning areas for COG Group A, Stage 2 - Local Environments. Follow up this module with the Marine Parks, Rocky Shores and Sea Country modules for further insight into the local environment. The modules are designed to address the NSW DET primary school curriculum, and can be used to complement current teaching programs.

Education material in this module consists of this **Activity Plan** to guide teachers through an activity, **Fact Sheets** to provide background information on estuaries, a student **Work Sheet** to record information, and an **ID Guide** for both teachers and students to identify the most common animals and plants found in estuaries.

Activity 1 - Excursion

Choose a local estuary to visit and use as a case study. Use the ID guide to find some of the local inhabitants, and also look for signs of animals, such as whelk tracks through the mud, spider webs, and yabby and crab holes. Outline how important the plants are as both a food source and home for the resident animals. Discuss the place where the animals are found, and how important it is for them to have a safe home. How are these animals affected by human activities?

While in the field, discuss the issue of litter and pollution, and how it washes into the ocean to become marine debris. Reiterate that what happens on land influences the ocean: litter in rivers ends up as litter in oceans. Introduce the concept of storm water drains and rubbish catchers. Ask the students whether they would go swimming where it is heavily littered or polluted.

What can we do about this problem? We can help by:

- not littering
- picking up the rubbish we see
- participating in local "Clean Up Australia" days
- organising school clean up events, especially after heavy rains
- reporting pollution spills to the local council.

Using the litter survey sheet, conduct a clean up along the shores of your local estuary. Remember to estimate the length of the foreshore you have cleared. At the end, tally the results and congratulate the students on preventing the rubbish they have collected from entering the ocean. Use the Estuaries Risk Analysis (pp.74-75) to ensure student safety.

Possible locations within the Jervis Bay Marine Park

- Currumbene Creek
- Moona Moona Creek

Activity 2

Use the flathead activity to illustrate the benefits of sanctuary (or no fishing) zones compared to areas that can be fished. (Refer to the fact sheets and the Jervis Bay Marine Park zoning guide provided in Module 1 for background information). This activity reflects research that has been conducted throughout various marine parks in Australia.

- Print out the flathead image in different sizes.
- Explain the activity to the students using the teacher activity sheet.
- Help the students to graph their results.
- Discuss the benefits of protected areas as outlined in the fact sheets for Modules 1 and 3.
- Write up the key findings on the fish and display them in the classroom.

Activity Sheet: Litter Survey

Area of estuary bank surveyed (length in metres):

Confectionery	Quantity
Lolly sticks	
Wrappers	

Total =

Beverages	Quantity
Glass bottles and pieces	
Plastic bottles and cups	
Plastic caps, straws and utensils	
Paper cups	
Tetra boxes (such as Popper Juice cartons)	
Aluminium cans	
Styrofoam cups/pieces	
Metal caps, ring pulls and pieces	

Total =

Organic	Quantity
Food	

Total =

Plastic Film	Quantity
Plastic film/cling wrap	
Plastic bags	
Plastic wrappers	
Plastic pieces	

Total =

Paper	Quantity
Paper bags	
Serviettes and tissues	
Paper pieces	
Newspaper	
Advertising materials	
Takeaway boxes	
Cardboard boxes and pieces	

Total =

Cigarettes	Quantity
Cigarette butts	
Cigarette packets, wrappers, foil and matches	

Total =

Unidentified	Quantity

Total =

Total number of litter items collected:

Activity Sheet - Flathead Teacher Reference

Background

The aim of this activity is to highlight the benefit of protective zoning for species in marine parks. The activity is based on research conducted in NSW marine parks comparing the number and size of invertebrates (specifically mud crabs) found in areas that are fished and those that are not fished. This hypothetical exercise uses flathead as an example of a species that would benefit from protective zoning. The results of this simple exercise should show that, in general, there are more fish and larger fish in sanctuary zones (areas that are not fished) when compared to areas that are open to fishing.

The flathead is a fish commonly found in estuaries and coastal areas in Australian waters. There are several different species of flathead, with some occurring in southern waters and others in northern tropical waters. Flathead are a popular target species with fishers. The legal minimum length for the dusky or common flathead is 36cm. They can be caught using baitfish such as poddy mullet. The bag limit is 10, with only one over 70cm.

One method for collecting information on the number and size of fish in different areas is with the use of underwater stereo video cameras, which are left underwater for a specific period of time (for example, 30 minutes). A bait bag is attached to a pole in front of the camera to attract fish. The fish are filmed, and footage is reviewed back in the office. This allows a researcher to study the fish assemblages and sizes in a variety of locations both within and outside of sanctuary zones without capturing or harming the fish.

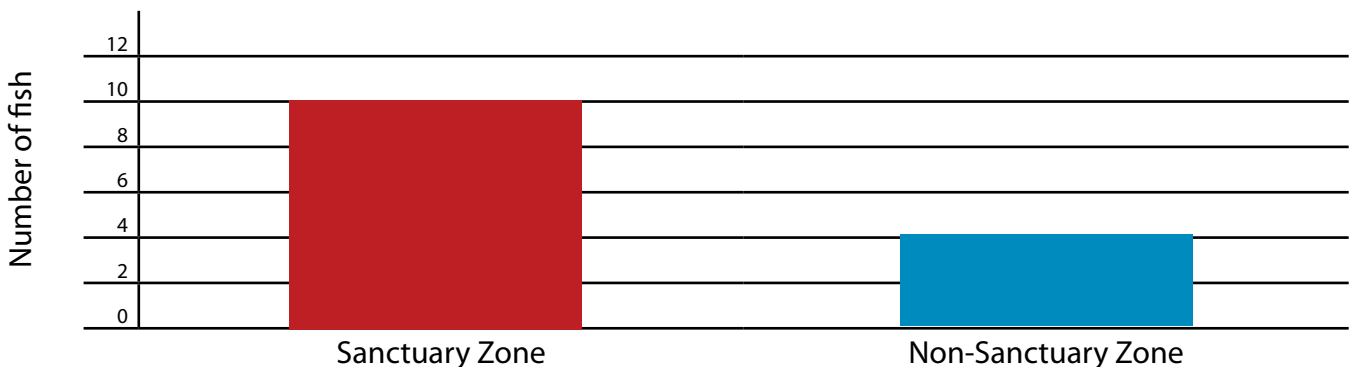
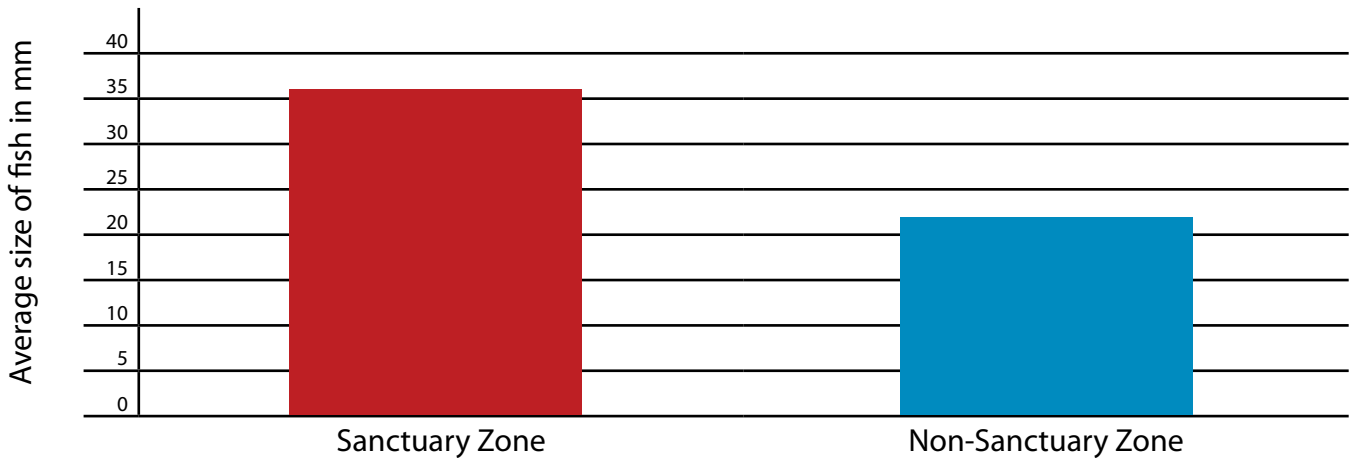
Activity

- Print out the fish at a range of different sizes, cut them out, and laminate them if time permits. 15 to 20 should be sufficient.
- Allocate eight areas on the floor: four sanctuary zones and an additional four areas that are non-sanctuary zones. Label these areas as such.
- Place the fish into their "study sites" around the room, with more fish and larger fish in sanctuary zones than non-sanctuary zones, thus representing what was captured on camera.
- Break the class into small groups/pairs to make measuring easier.
- Each group/pair should have a data sheet (student activity sheet), a pen and a ruler.
- Students then rotate around the eight sites, entering data on the sheet by: (1) recording the number of fish at each site, and (2) measuring the length of each fish at each site with a ruler.
- Next calculate the mean sizes of fish for sanctuary zones and non-sanctuary zones, and graph the results. The final step is to calculate the total number of fish in each zone and compare the difference between zones.
- At the end of the activity, discuss the results with the students and come up with some key points. These can be written on the back of the fish and then pinned up around the room or on a board. Some example discussion points may include:
 - Flathead like to live in estuaries.
 - Estuaries are important habitats for many animals.
 - Fishers like to catch flathead.
 - Sanctuary zones are important refuge sites for fish where they are unlikely to be caught.
 - We can go fishing in habitat protection zones but not sanctuary zones.

- Flathead can grow larger in protected areas as they are less likely to be caught by fishers.
- Fish may be smaller in unprotected zones as they are more likely to be caught by fishers when they are young.
- Fish can also be impacted by pollution (litter, chemicals, etc.) and a range of other impacts adjacent to estuaries.
- Areas outside sanctuary zones that have little to no fish are either popular fishing sites OR the site may not be the preferred habitat for flathead.
- Areas inside sanctuary zones that have large numbers of fish are protected from capture and/or are the perfect habitat for the fish (e.g. an area with a sandy bottom and places to hide).

Below is an example of some results for the fish measuring exercise. The students' results may look similar to this.

	Sanctuary Zone				Non-Sanctuary Zone			
	Area 1	Area 2	Area 3	Area 4	Area 1	Area 2	Area 3	Area 4
Average length of each fish caught (cm)	45	32	42	35	34	0	27	25
	30	26		40			33	
	40	38						
	22							
Number of fish caught	4	3	1	2	1	0	2	1
Total number of fish	10				4			
Average sizes of fish	34.5	32	42	37.5	34	0	30	25
	Average size of all sanctuary fish = 36.5cm				Average size of all non-sanctuary fish = 22cm			





Activity Sheet - Flathead Data Sheet

Introduction

Estuaries are areas where rivers meet the sea. They are very special habitats that are important to many plants and animals. Flathead love to live in the soft, muddy sediment of estuaries.



Activity

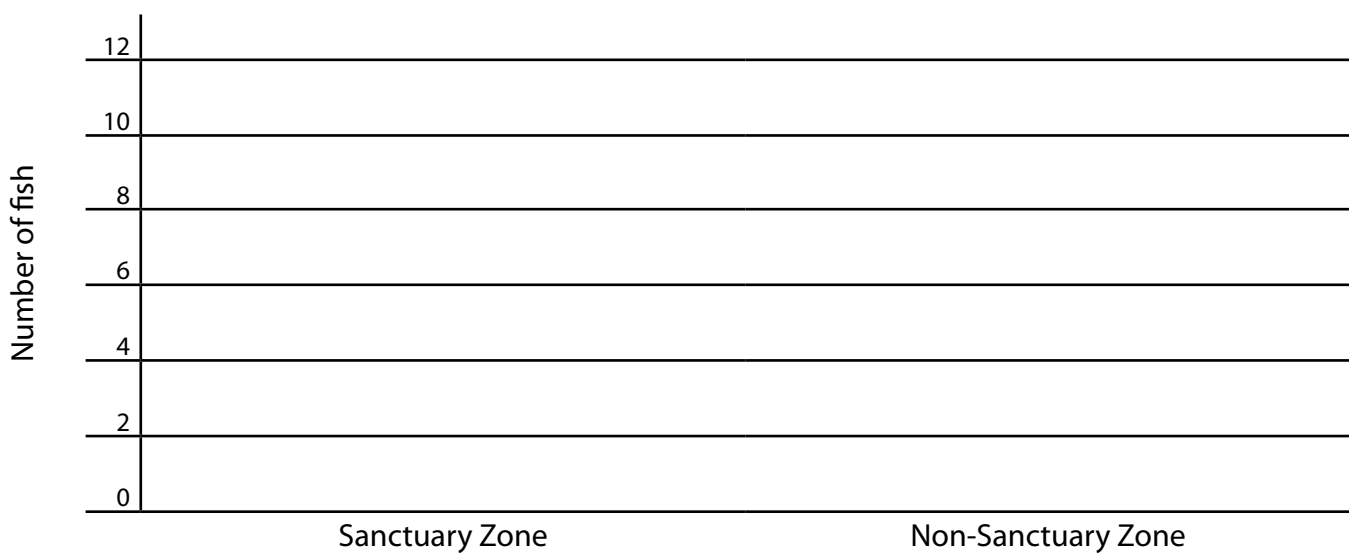
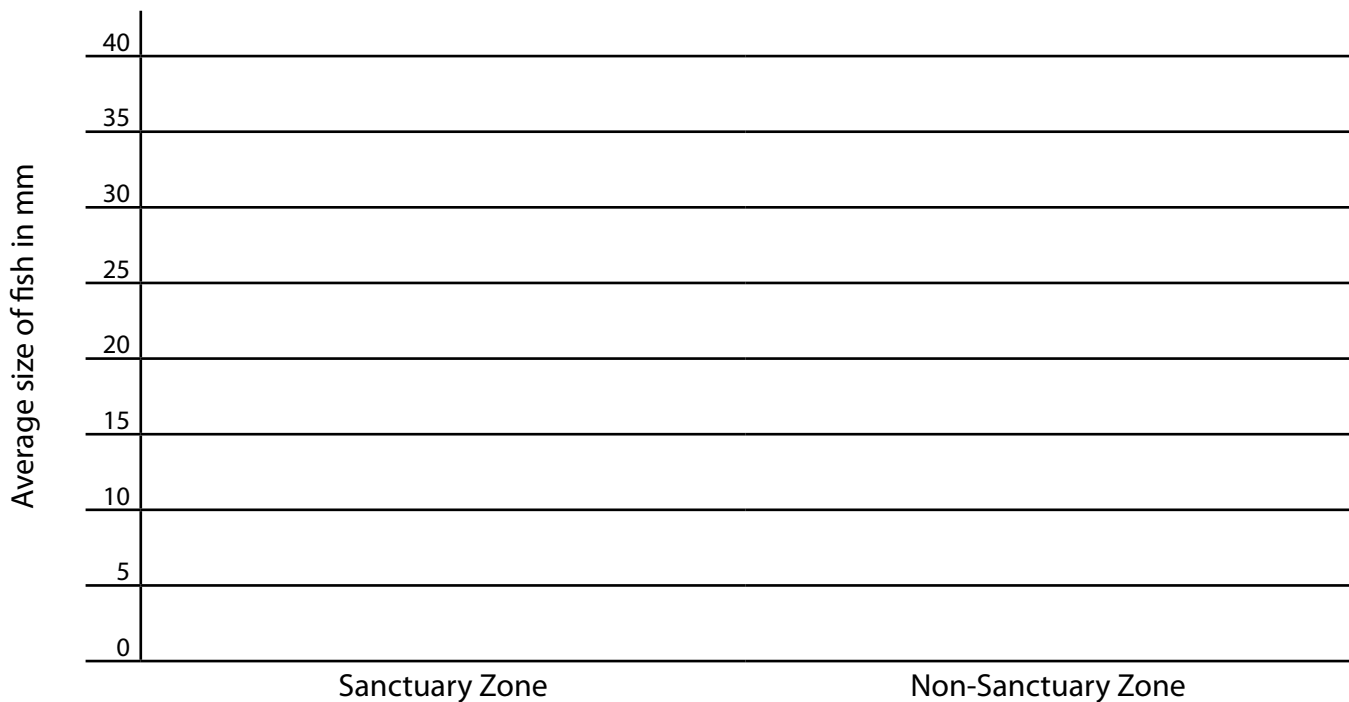
You are a researcher studying the sizes of flathead in sanctuary (no fishing) zones and non-sanctuary (fishing) zones. In small groups:

1. Measure the size and count the number of fish at each site.
2. Record the details in the table below.
3. Get your teacher to help you calculate the mean sizes of the fish.
4. To show the difference between the numbers and sizes of fish between the sanctuary and non-sanctuary zones, fill in the graphs over the page. (Your teacher will show you how to enter these results in.)

	Sanctuary Zone				Non-Sanctuary Zone			
	Area 1	Area 2	Area 3	Area 4	Area 1	Area 2	Area 3	Area 4
Average length of each fish caught								
Number of fish caught								
Total number of fish								
Average sizes of fish								
	Average size of all sanctuary fish =				Average size of all non-sanctuary fish =			



Results



Discussion

Which column shows the highest number of fish?

Which column shows the largest fish measured?

What does this tell you about sanctuary zones?

.....

.....

.....

Stage 3 - Living Land

Teacher Activity Plan

Level

Stage 3 - Living Land
COG Group A - Exploring Our Place

Key Learning Areas

ENS3.5, ENS3.6, DRAS3.1, DRAS3.2, DRAS3.3, DRAS3.4, MUS3.3

Objectives

The objectives of this activity are: to develop an understanding through role-play of the different interests held by stakeholders and users of marine parks; and to determine how such groups can act in an ecologically responsible manner.

Excursion Timing

The excursion must be undertaken at low tide. Check the tide times at:

<http://www.bom.gov.au/oceanography/tides>

Equipment Used

- paper
- pencils

Teacher Resources

Please contact the marine park office on 4428 3000 for a copy of all educational material on CD or to request staff attendance for excursion support. Additional resources are available on:

<http://www.mesa.edu.au>

Link to habitat mapping fact sheets on saltmarsh and estuaries:

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/236234/mangroves.pdf

<http://www.waterwatch.nsw.gov.au>

About this program

This module is designed to cover ENS3.5, ENS3.6, DRAS3.1, DRAS3.2, DRAS3.3, DRAS3.4 and MUS3.3, and when combined with the other three modules in this kit, addresses the key learning areas for COG Group A, Stage 3 - Living Land. Follow up this module with the Marine Parks, Rocky Shores and Sea Country modules for further insight into the local environment. The modules are designed to address the NSW DET primary school curriculum, and can be used to complement current teaching programs.

Education material in this module consists of this **Activity Plan** to guide teachers through this group activity, a **Fact Sheet** to provide background information on estuaries, a student **Work Sheet** for gathering information in the field, an **ID Guide** for both teachers and students to identify the most common animals and plants found in estuaries, and **Information Cards** to help students understand the group they are representing in their debate.

Activity 1 - Excursion

Choose an estuary in the local area. Using the fact sheets provided and any additional resources, students then undertake research on that estuary. (Activity Sheet 1 will help to guide their research.)

Visit this estuary on an excursion. Introduce the program, and brief the class on the safety issues involved with the excursion using the Estuaries Risk Analysis (pp.74-75). Break the class into small groups and explain that the information they gather will eventually lead to a role-play back in the classroom (see Activity 2).

On a large piece of paper, get the students to draw an outline of the estuary, illustrating where the major habitat types are (mangrove, seagrass, etc.). Include other features of interest, such as jetties, ramps, boardwalks and shops.

Note: If an excursion is not possible, display a photo of a local estuary in the classroom. You could also use Google Earth or Google Maps to help identify some of the features in the surrounding area.

Activity 2

This activity outline is a guide only that can be modified by staff into an interactive class activity. Break the class into groups and hand out the cards to the students, informing them of their group's issues (use as few or as many as necessary). In their groups, the students are to formulate a discussion/debate supporting their stakeholder group.

Each group will have positive and negative points that the debaters must emphasise to illustrate their point. The group then chooses a representative to debate their cause.

The outcome is for the class to come to a decision on how the estuary is to be managed sustainably while trying to satisfy the desires of the different stakeholders. Use the estuary drawing to help plan the outcome. Discuss this as a class, asking "What can the estuary cope with?" and "What will the impacts be?", and keep in mind that:

- The estuary can be divided into different zones to accommodate all activities.
- Conditions can be made. For example: line fishing can occur in some areas but not in others, or not at certain times of the year; or perhaps building can go ahead as long as the structure is a certain distance from the water's edge, complies with environmental standards so that as little impact occurs on the natural environment as possible, barriers are put up to stop waste entering the water, and, to compensate for habitat that is destroyed, areas that need revegetation are replanted.

Activity Sheet 1 - Research a Local Estuary

Answer the following questions, and then write a paragraph describing the estuary. The marine park fact sheet may help you answer some of these questions.



1. Is the estuary open to the ocean?

2. Does the estuary include the following vegetation? Use the ID guide to help you identify these plants. Tick "yes" or "no", and then estimate the amount of vegetation present by placing a tick in the appropriate box.

Vegetation	Yes/No	Sparse	Patchy	Dense
Seagrass				
Mangroves				
Saltmarsh				
Weeds				
Paperbarks				
She-oaks				

3. Does the estuary have a large or small catchment area?

4. Is the land around the estuary flat or hilly?

5. Does the land around the estuary have many buildings (houses, schools, shops, etc.)?

6. Is there rubbish in the water and/or along the banks?

7. Are you allowed to fish here? If so, is it a good fishing spot? (Can you see people fishing from the banks or in boats?)

8. Is there a walking track or boardwalk for people to access the estuary?

9. Are there any local Aboriginal sites (such as middens) along this estuary?

10. Use this information to describe this estuary and its importance for natural, community and cultural values.

Card 1

Developer

The land on the bank of this estuary is perfect for development. We want to build a new housing complex here because:

- The units will have estuarine and sea views, which will attract people to buy the units, which increases our profits.
- We can attract people to live here who love to fish.
- No one needs or uses this part of the estuary, and it's full of sandflies. We will fill in the mud with concrete and make it look great by planting beautiful gardens.
- It will be a great place for tourists to come and stay, and they will spend money in our local shops.

Card 2

Conservationist

This estuary has a range of habitat types, such as (*describe what was found on the excursion*), which are homes to a large variety of animals. Fishes and crabs use these areas as nursery grounds, so we need to protect a large amount of this habitat. If the estuary is damaged, all the young fishes might die.

Seagrass and mangroves are protected through the Fisheries Management Act, and it is illegal to destroy them.

Mangroves are important in reducing erosion of the nearby land from water movement, and to filter pollutants from runoff.

If hundreds of people come here, they will have a huge impact on this area by increasing the levels of rubbish and pollution.

Card 3

Local Aboriginal Elders Group

Our people have been using this estuary for thousands of years. We still use the bay today to harvest fish, and we don't want them to be poisoned or moved away because of pollution or damage caused by new buildings.

There is a midden site here where our ancestors left shell and bone remains many years ago, and this area is sacred to us.

Some of the mangrove trees are scar trees where we cut out our shields, so we also want these trees preserved.

We don't want large numbers of people trampling our sacred sites.

Tourist Operator

Such a beautiful environment will attract many tourists! We can attract hundreds of people to explore this estuary, and hire out motor boats to them, and organise fishing events.

We will need more tourist accommodation: maybe a caravan park near by, some toilet blocks and some barbeque areas.

This natural environment is perfect for eco-tourism. We can provide canoeing tours, guided walking tours and bird watching events.

We can increase visitors' spending money in our local community by advertising, and even attract people here from all over the world.

Recreational Fisher

Our families have been fishing in these waters for generations. We have always caught good numbers of fish here.

This estuary is important to the locals and needs to be kept local. This is where we catch our dinner! Lots of new people will reduce fish stocks and damage the habitat.

A new boat ramp would be good, though, for better access to the estuary.

We don't want too many "outsiders" coming in here, competing for – and scaring off – our fish.

Researcher

This estuary is an ICOLL, so it is not always open to the sea. Studies show it is very sensitive to pollution because of this feature as not much new water gets in.

Any changes to the land surrounding the estuary may increase pollution.

Research shows this estuary is an important area for juvenile fishes and shellfish, and contains valuable seagrass beds.

According to climate change research, the sea is predicted to rise, so any new developments must be carefully considered.

Estuaries Risk Analysis

Location:		Project/Job Name/No:			Date:
Work Activity/Task: School excursion to estuary.		Staff consulted:			Signature:
Item	Job step Break the job down into steps.	Potential dangers and incidents	Risk rating	Controls to prevent incidents What you are going to do to make the job as safe as reasonably practicable.	Person who will ensure this happens
1	Communications with staff	Participant gets lost/Accident/ Other unforeseen event	M	<ul style="list-style-type: none"> • Make role calls at regular intervals, including commencement and finish, and implement a buddy system setup. • Give a safety brief to participants at the beginning of the activity. • Advise administration staff of departure and arrival times. • Ensure at least one staff member has relevant first aid certification. • Carry a mobile phone, map and first aid kit. • Ensure mobile phones are charged before departure. 	Teaching staff
2	Weather conditions	Storm conditions/ Exposure	M	<ul style="list-style-type: none"> • Check the weather and tides prior to leaving for the activity. (The activity must be undertaken at low tide.) • Ensure participants are correctly attired (i.e. with a hat, long-sleeved shirt, or a jacket if it is cold or rainy), and include such needs on the excursion consent form. • Have sunscreen and water available for participants, and include such needs on the excursion consent form. 	Teaching staff
3	Wet, slippery boardwalk/ Muddy areas	Falling over and subsequent injury, such as cuts or sprains	M	<ul style="list-style-type: none"> • Brief participants on the care needed when walking on slippery surfaces. • Review the study area and identify slippery patches and trip hazards. • Ensure that all participants have appropriate footwear, and include such needs on the excursion consent form. 	Teaching staff

Item	Job step Break the job down into steps.	Potential dangers and incidents	Risk rating	Controls to prevent incidents What you are going to do to make the job as safe as reasonably practicable.	Person who will ensure this happens
4	Falling into estuary	Drowning	H	<ul style="list-style-type: none"> Ensure sufficient staff are in attendance to provide the appropriate "high risk" level of supervision. Brief participants on the care needed near the water (e.g. stay away from the edge of boardwalks and the estuary edge, and make sure a "buddy" system is implemented). Ensure participants are sensible around the water's edge. Ensure participants are visible at all times. 	Teaching staff
5	Dangerous fauna	Snakes and stingrays	M	<ul style="list-style-type: none"> Warn children to watch where they walk. If a snake is sighted, they are to stop walking and inform a teacher. Students are not to walk in the water; however, if this is necessary, then they are to shuffle their feet so as to kick stingrays out of the way. 	Teaching staff
6	Cuts	Broken glass	M	<ul style="list-style-type: none"> Make children aware of any broken glass, tell them not to touch it, and let the staff pick it up. Wear appropriate footwear. 	Teaching staff

Reviewed by:

Principal/Executive

Signature

_____/_____/_____

Date

Risk Assessment Rating:

- E Extreme risk; immediate action required
- H High risk; senior management attention needed
- M Moderate risk; management responsibility must be specified
- L Low risk; manage by routine procedures.