

Pollution and Other Marine Issues

Teachers

This unit of work has been designed to support your class visit for the 'Pollution and Other Marine Issues' programme at the National Aquarium of New Zealand. Students will participate in a range of interactive activities.

The primary focus of this programme is the Planet Earth and Beyond Strand of the Science Curriculum, however when planning your unit of work links can be made to other strand and essential learning areas. Similarly, different essential skills can be emphasised depending on the needs of your students.

It is recommended that these materials be reproduced in their entirety for each of your students. It is hoped that students will be able to use this resource for preparatory work prior to their visit to the National Aquarium, as a workbook during their visit and as reference material after their visit.

Programme Overview

Why should you learn about pollution and other marine environmental issues at the aquarium?

Much of the pollution created by humans eventually ends up in the marine environment. Learning how pollution affects marine ecosystems increases the students' awareness of environmental issues which are, in most cases, 'out of sight, out of mind'.

Essential Learning Area: Science

Strand: Planet Earth and Beyond

Sub-Strand: Living World

Achievement Aim 4: investigate how people's decisions and activities change planet Earth's physical environment, and develop a responsibility for the guardianship of planet Earth and its resources.

| Level | Essential Learning Area | Strand | Achievement Aim | Achievement Objective |
|-------|-------------------------|-------------------------|--|--|
| 5 | Science | Planet Earth and Beyond | Human Influences on Earth's Physical Environment | Research a national environmental issue and explain the need for responsible and co-operative guardianship of New Zealand's environment. |
| 7 | Science | Planet Earth and Beyond | Human Influences on Earth's Physical Environment | Survey and evaluate the literature relating to an Earth sciences' issue. |
| 7 | Science | Living World | Interdependence of Living Things | Research and develop a defensible position, about a selected issue affecting the New Zealand environment. |

Scientific Skills and Attitudes

- Focusing and Planning
- Information Gathering
- Processing and Interpreting
- Reporting

The 'Pollution and Other Marine Issues' programme at the National Aquarium of New Zealand lays the foundations for developing the above investigative skills and attitudes.

Specific Learning Outcomes

- To become aware of environmental issues (e.g. oil spills, ballast water and exotic organisms) which affect the New Zealand coastal marine ecosystems and to become aware of other international environmental issues such as CITES.
- To realise the responsibility we have to ensure that pollution and exotic invasions do not occur and to understand ways in which effects of pollution can be rectified.

Introduction

Pollution and exotic invasion can be a real threat to the aquatic environment in New Zealand. Oil spills from wrecked boats can cause major environmental disasters along our coastlines and introduction of exotic organisms via ballast water or illegal introductions can threaten the existence of our native flora and fauna in waterways and coastlines.

Oil Spills

Oil spills from large ships or oil rigs occur globally and occasionally occur around the coastlines of New Zealand.



The CIBRO SAVANNAH exploded and caught fire while departing the pier at the CITGO facility in Linden, New Jersey, on March 6, 1990. About 127,000 gallons of oil remained unaccounted for after the incident; no one knows how much oil burned and how much spilled into the environment.



On November 1, 1979, the BURMAH AGATE collided with the freighter MIMOSA southeast of Galveston Entrance in the Gulf of Mexico. An estimated 2.6 million gallons of oil was released into the environment.



The EXXON VALDEZ ran aground on Bligh Reef in Prince William Sound, Alaska on March 24, 1989, spilling 10.8 million gallons of oil into the marine environment



The IXTOC I exploratory well blew out on June 3, 1979 in the Bay of Campeche off Ciudad del Carmen, Mexico. By the time the well was brought under control in 1980, an estimated 140 million gallons of oil had spilled into the bay.



The AMOCO CADIZ ran aground off the coast of Brittany, France on March 16, 1978, spilling 68.7 million gallons of oil.

Photos used with permission: NOAA Office of Response and Restoration
NOAA OR&R

How do oil spills affect aquatic environments?

Oil spills can affect aquatic organisms in a number of ways....

Oil is TOXIC: Some animals are very susceptible to toxins in the water (e.g. fish, frogs) and will die if they come in contact with the toxins. Toxins in oil (i.e. light substances) usually evaporate away reasonably quickly.

Oil changes the surface tension of the water: Water is a *sticky* (viscous) substance. For example, if you look closely at the water surface when you put the tip of a needle in the water and gently pull the needle away from the water surface, the water sticks. This sticky property of water is called the surface tension of water. The properties of oil are different to that of water (that's why oil floats!). Oil changes the water surface tension making it less sticky. Therefore, microscopic organisms that come to the surface for oxygen are unable to float and will drown.

Oil smothers animals and plants: The thicker substances of oil stick and mat together the fur of marine mammals, such as seals and feathers of birds. This leads to loss of insulation properties and can result in many animals dying of hypothermia. Oil also

destroys the complex structure of feathers which allows birds to float. This causes many birds to drown. Animals also ingest the oil when trying to clean themselves which leads to numerous problems such as, bioaccumulation of heavy metals and gut irritation. If oil slicks are not cleaned up or quickly broken up by wave action, oil slicks may cover intertidal seaweeds on the rocky shore and may decrease the level of light reaching sub-tidal seaweeds, therefore decreasing the ability of seaweed to photosynthesize.

Oil disrupts food webs: Oil can kill many marine organisms such as, fish and sub-tidal seaweeds and indirectly affects all other organisms that rely on them for food or habitat refuges. Food webs become contaminated with the heavy metals found in the oil and eventually affects humans too – since we are part of the marine food web!

Conducting a scientific investigation

The scenario:

You are a group of scientists whom have recently discovered that there has been an oil leakage from the town rubbish dump which has contaminated a nearby freshwater pond and a small estuary (a mix of salt and fresh water). You want to know how badly the oil leakage has affected the different environments.

The hypothesis:

WHAT IS YOUR HYPOTHESIS??

Your hypothesis clearly states what your predicted outcomes of the investigation are. For example do you think the oil will have a greater effect on organisms within the fresh or estuarine water?? Give your reasoning!

Methods:

In the lab there are four labelled containers, freshwater without contamination, estuarine water without contamination, freshwater with oil, estuarine water with oil. Each pair of scientists will take three separate water samples (with a plastic pipette) from ONE of the containers. You will have to decide amongst yourselves which pair of scientists is going to investigate which water type! Look for macro- and micro-organisms (using the microscopes) and count how many LIVE organisms you find in each of the three samples. Write the results in the table below.

Why do we take three samples of the same water?

The uncontaminated samples (without oil), in scientific terms, are called Controls. Why do we need to look at controls as well?

Results:

Table indicating the number of live macro and micro organisms found in four water types:

| | Contaminated water –oil | | | | | | Not contaminated water | | | | | |
|---|-------------------------|---|---|-----------------|---|---|------------------------|---|---|-----------|---|---|
| | freshwater | | | estuarine water | | | freshwater | | | estuarine | | |
| Samples | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| no. of macro-organisms | | | | | | | | | | | | |
| no. of micro-organisms | | | | | | | | | | | | |
| Total sum of all organisms | | | | | | | | | | | | |
| Mean number of organisms over all samples for each water type | | | | | | | | | | | | |

Explain from the results (i.e. the mean number of organisms found in each water type) what the outcome of the investigation was. Did the outcome match your hypothesis???

Explain the reasons why you think you got the observed results. Hint: Think about the variety of organisms that are found in these water types. How did the pollution affect them (e.g. water boatmen)?

How are oil slicks cleaned up?

There are many ways to clean up oil slicks... here are a few:

Allow environmental processes to break down the oil: The environment will naturally break down the oil slick. Light and heat evaporates the toxic fraction of the oil. Winds, waves and currents disperse the oil and break it into smaller lumps. The micro-organisms (e.g. bacteria and fungi) in the sea and on the shoreline decompose the smaller patches of oil. However, this process may take some time, particularly if the oil slick is large and in the process many animals such as seals, seabirds and fish may die.

Use of skimmers: Skimmers are machinery which literally 'skims' the oil off the surface of the water. Skimmers are only good in calm conditions and where the oil hasn't been mixed into the water to form an emulsion.

Use of dispersing agents: Emulsifiers and detergents are used to break up the oil within the sea and along the shorelines, into smaller droplets of oil. Imagine scrubbing oil off each rock on a rocky shore! Makes doing the dishes seem OK after all!!! However many of the dispersing agents used are highly poisonous to marine life.

Use of woollen booms: Woollen booms work in two ways; they contain areas of oil spill and absorb the oil (a bit like a huge mop!).

There are many other natural materials (i.e. 'absorbers') used to clean up oil spills. Can you think of any materials which may be useful?

Conducting a scientific clean up!

The scenario:

A group of scientists who, very recently, conducted an experiment to see how the oil leakage affected the organisms within fresh and estuarine water have decided to clean up the oil leakage but they need to know what is the best method of cleaning up oil slicks.

The hypothesis:

WHAT IS YOUR HYPOTHESIS??

Your hypothesis clearly states what your predicted outcomes of the investigation are.... For example, do you think the environment, detergents or woollen booms will be effective at cleaning up oil? Which method would be the best?? Give your reasoning!

Methods:

In the lab there are wooden paddles, dishwashing liquid and tufts of wool. In four groups, work out how you would simulate the natural environment, the skimmers, dispersing agents and woollen booms to clean up oil spills. Test each method in separate containers with oil contaminated water and estimate how much of the oil was removed from the water surface. Write the results in the table.

Results:

| Simulated methods of oil clean-up | Natural environment | Skimmer | Dispersal agent | Woollen boom |
|--|---------------------|---------|-----------------|--------------|
| Estimated percentage of oil removed from water surface | | | | |

Which method was the most effective? Would you use one, or more than one method to clean up the oil leakage at the rubbish dump, the nearby freshwater pond and the small estuary? State your reasons.

At the aquarium we often have a thin film of oil forming on the surface of the water in some of the tanks, such as the Oceanarium Tank. This oil comes from the food fed to the fish (pellet food or the fish we break up). Which method or methods of cleaning up oil slicks do you think would be most effective in this situation? Explain your reasoning. Hint: Observe where the water flows out of the goldfish tank and Oceanarium.

Ballast water

What is Ballast water?

Ballast water is a term given to water that is held in the hull of large ships and provides stability. Ballast water is only needed when ships are out in the open ocean so water is pumped out when the ship comes to port, normally within a harbour or sheltered bay and is pumped back in when the ship leaves the port. Ballast water is pumped through an intake pipe with coarse filters, these stop large fish and other organisms being sucked into the hull however, small organisms (<1 cm) are taken in with the ballast water.

So what is so bad about ballast water?

Water from one port is transported and released in another port and this occurs all over the world. Imagine the number of large ships that come to Napier's Port every year and each of these release water from another part of the world into the sea around Napier!! The small organisms taken in with the ballast water **often survive** the trip and are discharged with the ballast water. Usually the organisms that come with the ballast are from warmer tropical climates and once discharged from the ship don't survive in the cooler New Zealand water. However, if water temperatures are similar between ports of call or the tolerance range of an organism is wide, organisms will survive in New Zealand water and have the **potential to invade**. Many of the small organisms (<1 cm) found in the ballast water represent the **larval stage** of their life history and eventually grow into large organisms which have invasive characteristics such as fast growth rates, high reproductive rates and are efficient predators. So the large shipping vessels around the coast and ports of New Zealand not only have the potential to create huge oil spills, they also can bring unwanted marine organisms into our coastal waters.

A case study

Undaria, invasive seaweed!

Undaria is large brown seaweed which is farmed in Japan and South Korea for food products - Wakame (not too dissimilar to having a vegetable garden, but underwater!). The seaweed is usually dried or salted and is used in salads and soups after soaking.

See what Undaria looks like dried... and if you are brave enough try some soaked!

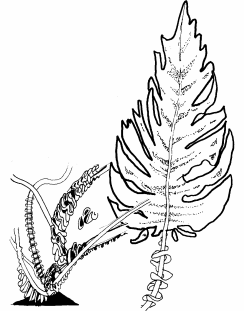
Undaria was introduced into New Zealand waters via ballast water and vessels which had seaweeds, including Undaria, attached to the bottom of the hull. Small spores called zoospores and other small life history stages of Undaria once discharged with the ballast water settle on other smaller boats, wharf piles and harbour walls and eventually grow into large seaweed kelps. The larger plants attached to the bottom of the ship produce zoospores and they are also released into the harbour water. Undaria is now well established within the Wellington, Timaru and Dunedin harbours. Undaria can be spread

to other ports and bays around New Zealand by small boats which have not been cleaned underneath regularly and have adult plants of Undaria attached.

Is Undaria a problem???

Undaria is large kelp, a little bit like our own native bull kelps that you see on rocky shores. However, Undaria has a high growth rate (1 cm per day) and is able to colonise areas of bare rock quickly (1 adult Undaria can produce up to 200 million zoospores!).

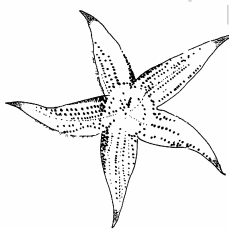
In fact, it can completely cover harbour walls and rocky shores, leaving very little space or light for other native seaweeds! Only paua frequently grazes Undaria and many of the other marine organisms must settle or graze in areas where the seaweed has not yet invaded. Undaria could be a major problem for New Zealand marine ecosystems; however, the long term effects of Undaria are still to be investigated.



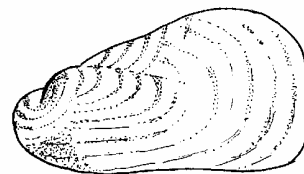
How do you think the spread of Undaria could be minimised? Give your ideas...

Potential Invaders

Other exotics have arrived in New Zealand via ballast water and many others have the potential to. These organisms are unwanted because they compete with New Zealand native flora and fauna. Invasive exotic seaweeds can compete with native seaweeds for natural resources such as sunlight and nutrients. Invasive animals can compete with native animals for habitat space, food and may have voracious appetites, which may lead to declines in shellfish or seaweeds.



The northern Pacific starfish feeds voraciously on bivalves such as mussels. This star fish breeds quickly and is having a large impact on the Japanese, Russian and Australian aquaculture industries. It arrived in Australia from Japan as a larval hitchhiker in ballast water. If it arrives in New Zealand, the potential for damage is enormous.



A small Asian mussel called *Musculista senhousia* was first seen in New Zealand in 1980 and has spread rapidly. This mussel is having a big effect on the seafloor and marine life in some North Island harbours.

How do we stop exotic invasions via ballast water?

There have been a few suggestions put forward to prevent the invasions via ballast water. **A high dosage of U.V. light kills** many of the organisms within the ballast water but it is costly to install lights within ballast tanks. **Fine mesh filters** placed on intake pumps would stop most organisms being included in ballast water, although this is likely to be impractical because this would slow down the intake water immensely and the filters would get blocked regularly! **Chemical treatment** of ballast water would be an effective way of killing all organisms within the ballast but these chemicals are not likely to be environmentally friendly and problems would arise when discharging the ballast water. **Disallowing ships to discharge ballast** in New Zealand waters seems the most feasible option. Ships instead have to exchange water in the ocean beyond the Continental Shelf. This is a voluntary option made available to all ships entering New Zealand waters, however the largest bulk carrier ships are not able to exchange ballast in mid ocean or in waves over a moderate height because they become unstable and could sink.

How does the aquarium stop invasions?

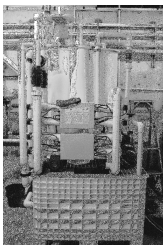
The invaders which can threaten aquarium tanks, and ultimately the health of our residents, are parasites and bacteria.

Parasites

The aquarium regularly obtains new stock from the waters around Napier. Before new fish are released into the aquarium tanks they are held in quarantine. During this period in quarantine the health of the fish is examined and the fish may be treated to remove any parasites present, such as leeches, ticks and lice. Many parasites however, have a free swimming larval stage which is difficult to detect.

Bacteria

Uneaten food can cause bacteria problems in aquarium tanks. A high bacteria level is detrimental to the health of fish, as it depletes the oxygen available in the water.



After listening to the explanation of the workings of the Tropical Life Support Systems and the Oceanarium Water Exchange System, identify what methods the aquarium uses to eliminate larval parasites and bacteria.

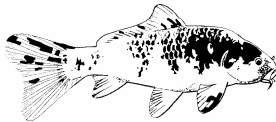
Exotics vs Natives

Other exotics have been introduced into New Zealand for pets, farming or just by mistake! When the first Europeans arrive in New Zealand, they deliberately introduced animals to make New Zealand seem more like their homeland - England!

Name five examples of animals that have been introduced into New Zealand

These days there are more rigorous controls in place about what is allowed into the country. However, some animals have been allowed to enter the country for farming purposes or to have as pets, for example Ostriches from Africa, llamas from South America and Carp fish from Asia. What if these animals escaped???

Some animals that are pets could potentially be pests if released into the wild. **Think carefully when you decide it is time for your wee pet frog, fish or aquatic plants to be set free into the wild!** Fortunately most of the animals kept as pets would not survive in the wild but some do, for example Carp.



Check out the displays of Carp and Blue-tongue lizards in the Aquarium. What characteristics do these animals have that would make them potential competitors to our native fishes like Galaxids and lizards such as the Tuatara.

CITES

What is CITES?

CITES stands for **C**onvention on **I**nternational **T**rade in **E**ndangered **S**pecies of wild fauna and flora. This is an international agreement between 150 state governments, including New Zealand, to ensure that the international trade of wild specimens of animals and plants does not threaten their survival. The international trade in wildlife is

estimated to be worth BILLIONS of dollars and is diverse, ranging in the trade of live animals and plants through to wildlife products such as exotic leather goods and tourist curios. Many animals and plants used for trade are heavily exploited and have depleted populations and some risk the chance of extinction!!

CITES works by making sure those countries involved with the agreement have strict importing and exporting licensing systems so that the use of animals and plants is controlled. Where a species is threatened with extinction or if a species is protected within a country, all CITES countries will not allow those species or products made with those species to enter the country. That's one reason why customs at the airport, when you come back from your overseas holidays, ask you to declare any animal or plant products that you may have with you!!!

There are 5000 species of animals and 25000 species of plants that are protected under the CITES convention! There are a huge variety of animals and plants that are protected, for example, dolphins, sea turtles, tortoises, parrots, frogs, boa constrictors, Chinese giant salamanders, basking sharks, cacti and orchids.

*Turtles and corals are two examples of organisms which are protected under CITES which are found in the aquarium. Why is it bad to collect turtle shells for tourist curios?? Hint: How long do turtles live for? Corals are a **very** important part of tropical reefs, how might coral collecting affect the other organisms that live on the reef?*

There is another animal in the aquarium which is protected under CITES in two ways. Can you guess which animal this is and in what ways it is protected?

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