SCIENCE FOR SUSTAINABLE OCEANS

Teacher Resources - Lesson Plan

Image credit: David Clode

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Australian Curriculum Objectives

Years 9 & 10 (Stage 5) - Science

- AC9S9H02 / AC9S10H02
  Investigate how advances in technologies enable advances in science, and how science has contributed to developments in technologies and engineering
- AC9S9I01 / AC9S10I01
  Develop investigable questions, reasoned predictions and hypotheses to test relationships and develop explanatory models
- AC9S9I07 / AC9S10I07
  Construct arguments based on analysis of a variety of evidence to support conclusions or evaluate claims, and consider any ethical issues and cultural protocols associated with accessing, using or citing secondary data or information
- AC9S9H04 / AC9S10H04
  Examine how the values and needs of society influence the focus of scientific research

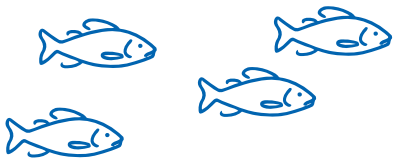
Extension Activities

- AC9S9I05 / AC9S10I05
  Analyse and connect a variety of data and information to identify and explain patterns, trends, relationships and anomalies

In this lesson for ages 14+ learners discover how the world's oceans are at risk from overfishing. Students understand how scientific knowledge and be used to prevent overfishing, and consider ways that science can be used to support sustainable fishing in the future.

Key terms

- Overfishing
- Sustainable fishing
- Ecosystem
- Scientific model
- Scientific data
- Species
- Migration
- Maximum Sustainable Yield (MSY)
- Marine Stewardship Council



Key questions

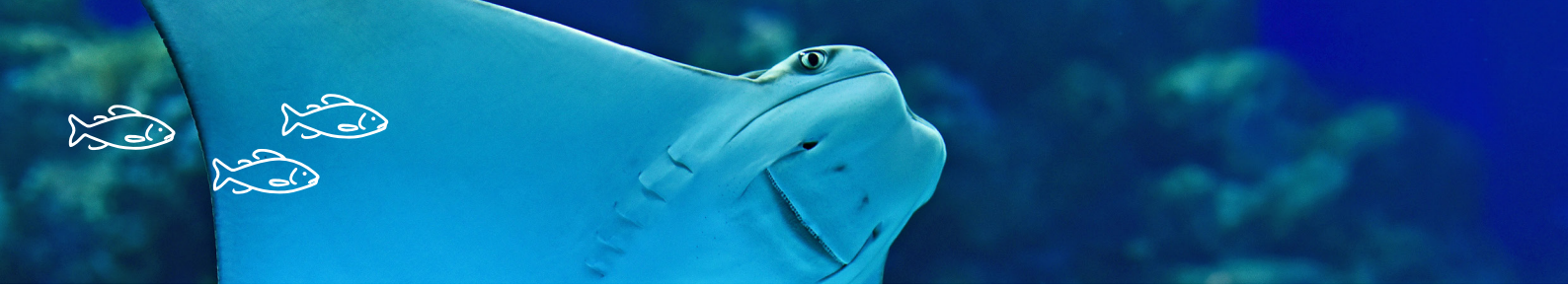
- How are we connected to the Ocean?
- What does 'Overfishing' mean?
- How is science used to prevent overfishing?
- How can scientific models develop over time?
- Why is it important for lobster fisheries in Australia to collect scientific data?
- What can we all do to prevent overfishing and protect our oceans?

You will need

- Printed or projected copies of the Ocean Connection cards (pages 5 to 8)
- Access to the film clip Overfishing
- Access to the film clip Fishing Sustainably
- Printed or shared digital copies of the MSY Worksheet (page 9)
- Printed or shared digital copies of the Lobster Fishery Factsheet (pages 10 and 11)
- Access to the Kahoot Quiz Science for Sustainable Oceans

Class Activities

- Learners explain their connections to the ocean
- Watch a video that explains overfishing and discuss
- Complete a worksheet and questions on the topic of Maximum Sustainable Yield
- Watch a video from an MSC-certified sustainable prawn fishery in South Australia
- Play a game to understand the concepts of Overfishing and Maximum Sustainable Yield in practice



Starter (5-10 mins)

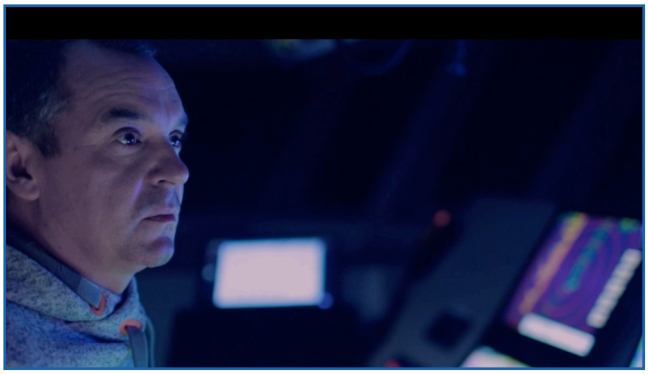
Begin by asking students to consider their personal connections to the ocean using the Ocean Connection cards (pages 5-8) to kick start ideas:

- *What is the ocean? What are its unique characteristics and qualities?*
- *In what ways are we (humans) connected to the ocean?*
- *Why is the ocean essential for life on earth?*

If time allows, you could also show students this video clip from the BBC Earth '*The Ocean and Us*' (4:17).

Main activity (30-40 mins)

Explain to learners that they are going to explore the Science of Ocean Sustainabilty by looking at the problem of **Overfishing**.



To start, show learners the clip Overfishing (2:55) from the short film '*My Dad the Fisherman*' (14:45).
Discuss as a class:

- *What does 'overfishing' mean?*
- *How does overfishing affect the entire ocean ecoystem?*

Then introduce learners to a scientific model used to prevent overfishing called **Maximum Sustainable Yield** (MSY). Show students the video Fishing Sustainably (2:54) to understand the concept of MSY.

Next, ask students to read the MSY Worksheet on pages 9-11. This worksheet includes:

- The WA Rock Lobster Fishery Factsheet
- Lobster management profile
- A short video from the University of Tasmania and IMAS, Data Collection by Lobster Fishers (3:23)

Ask students to read and complete the 5 questions at the bottom of the worksheet.

Discussion (5-10 mins)

Show students the video '*In the Blood*' (5:33) about the Spencer Gulf Prawn Fishery. This video explains another strategy that fishers have used combat the overfishing of juvenile prawns in South Australia.

Video Credit: Australian Council of Prawn Fisheries, FRDC and Millstream Productions

Ask students to consider

- *Why is it important to prevent overfishing?*
- *How can we use science to help fishers practice **sustainable fishing**?*
- *What can we all do to prevent overfishing and help to protect our oceans?*

Review

Host a 5-minute Kahoot challenge on this topic at Science for Sustainable Oceans

Extension Activities

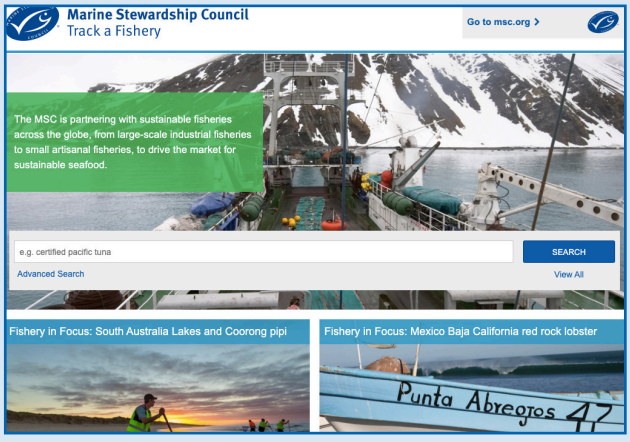
1. Learners work in groups to play Go Fish, a game that explores how MSY works. Follow the instructions on the sheets to run the game. The game includes a sheet with an explanation of MSY.

2. Students watch the video What does the MSC label mean? 1. Fish Stocks. Write one paragraph explaining what scientific knowledge a fishery needs to have about its fish stock in order to receive the Marine Stewardship Council (MSC) certification?

3. Students use the MSC Track a Fishery tool to choose one active sustainable fishery in the Asia-Pacific region. Students imagine that they are a scientist trying to calculate the MSY of their chosen fishery.

Consider:

i) What types of scientific data might be useful? Why? Examples might include fish biology and lifespans, migrations, predators and prey, reproduction rates etc.



ii) Which types of actors could you work with to collect this scientific data?

iii) What external influences might affect the quality of your data?

iv) How can you ensure that the fishery remains sustainable in the future?

OCEAN CONNECTIONS - SPACES (GEOGRAPHIES)

Ocean wave

Estuary

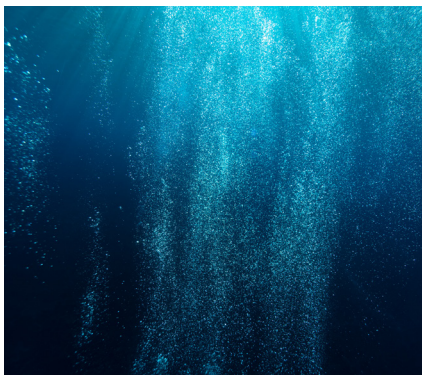
Coral Reef

Maritime Harbour

Sea floor

Beach

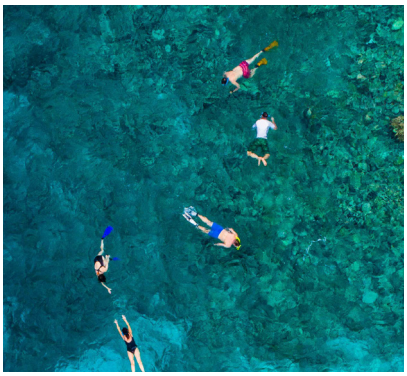
Aerial ocean



Under the sea

Sea Ice

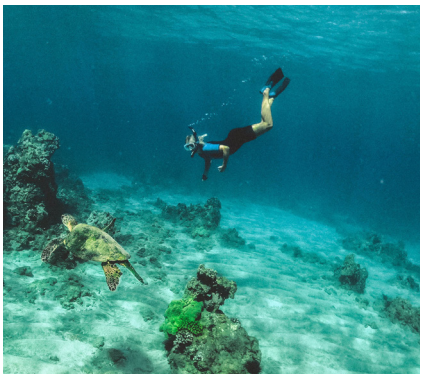
OCEAN CONNECTIONS - ACTIVITIES



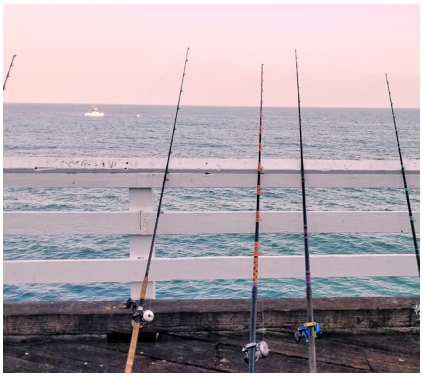
Snorkelling

Surfing

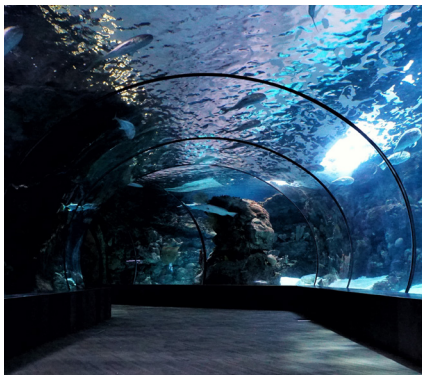
Boating



Diving

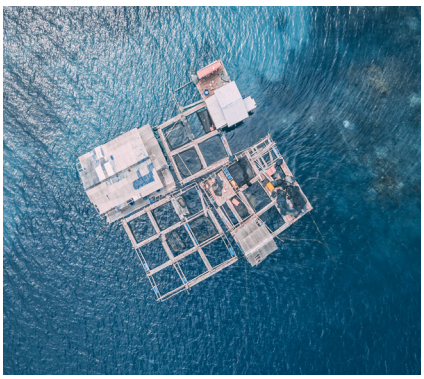


Fishing



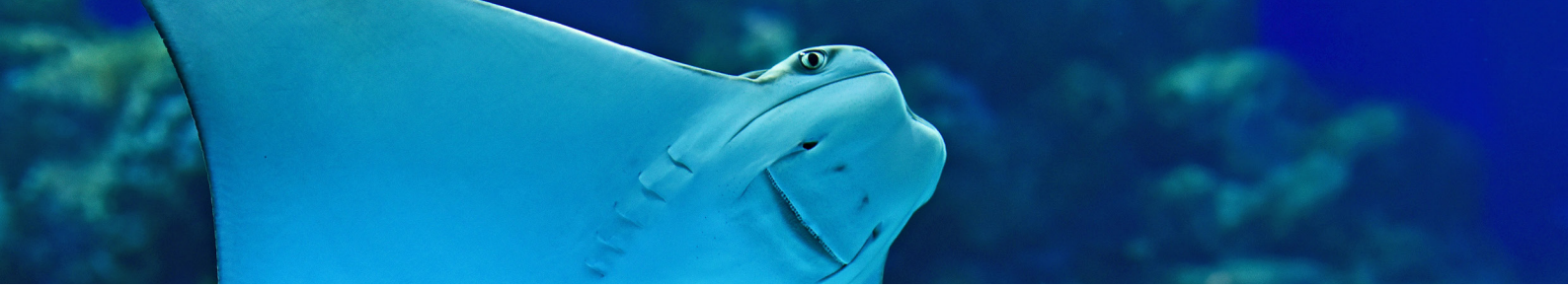
Aquariums

Relaxation



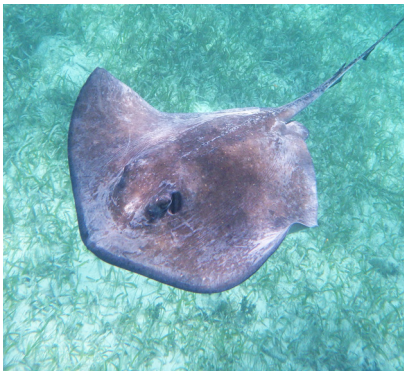
Fish Farming

Trade



OCEAN CONNECTIONS - OCEAN CREATURES

Shark



Stingray

Sea lion

Seahorse

Whale

Sea turtle

Clown fish

Octopus

Jellyfish

OCEAN CONNECTIONS - SEAFOOD

Tuna Sandwich

Fish Curry

Fish, Calamari and Chips

Fish Taco

Sushi

Prawn Dumpling

Seafood Pasta

Panfried Salmon

Oysters

MAXIMUM SUSTAINABLE YIELD (MSY) WORKSHEET

Key terms

- A fishery is an area of the sea where fish are caught for commercial purposes
- Overfishing occurs when the number of fish being taken out is much greater than the number of fish being added in
- The Maximum Sustainable Yield is a scientific calculation that shows fishers how much they can catch without overfishing

MSY - A Scientific Model

The first scientific model of a Maximum Sustainable Yield (MSY) was developed in the 1930s as a bioeconomic calculation in fisheries science. The Gordon-Schaefer model tried to calculate the MSY of a fishery by looking at:
i. The biological growth rates of the target fish species
ii. The carrying capacity of the habitat - the maximum fish population that a marine habitat could support, and
iii. Total and marginal costs and revenues of the fishery, in order for the fishery business to make a profit

Over time, it became apparent to some researchers that this model lacked the capability to deal with the real-world complexities and influence of fishing on the wider marine ecosystem, food web and other marine interactions.
Criticisms included:

- The model did not account for species other than the focus of the fishery
- The model did not account for spatial variability in productivity (the variance in fish populations across different ocean habitats and locations
- The model only considered the benefits, not the costs, of fishing

To fish sustainably, fishers need to know as much as they can about the fish species they catch and the ecosystem it lives in. Fisheries work with scientists to understand how sea life populations change over time looking at births, deaths and migrations in and out of a given fishery. This information is used to calculate the “maximum sustainable yield” – the amount of fish that they can take from the ocean without overfishing.
For example, the size of the fish stocks or number of fish available to catch in a fishery depends on
Fish added by:
+ New (young) fish
+ Fish migrating into the fishery
Fish taken away by:
- Fish die
- Fish are caught for food
- Fish migrate out of the fishery

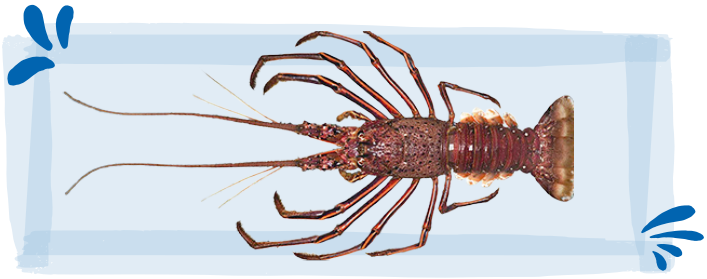
The data used to calculate the MSY of a species can change over time, so it is important to collect new data regularly to ensure that an accurate calculation of the MSY is made for each new fishing season.
To understand the way science data is used by sustainable fisheries in practice we will look at two Rock Lobster fisheries in Australia
1. Read the WA Rock Lobster Fishery Factsheet (pages 10 and 11), including the Lobster Management profile.
2. Watch the video ‘Data Collection by Lobster Fishers’ (3:23) about a Southern Rock Lobster fishery in Tasmania.

Questions

1. Why is it important for lobster fisheries to collect scientific data?
2. Where does the scientific data used by lobster fisheries come from?
3. What types of scientific data do the lobster fishers use to determine MSY?
4. How has the model of MSY used by the lobster fisheries today developed over time from the original Gordon-Schaefer model?
5. Is the data used by these fisheries reliable? How might the quality of this data be improved?

Credits - Lobster Management profile by Department of Primary Industries and Resources; Data collection by Lobster Fishers by University of Tasmania and IMAS, Millstream Productions

WA ROCK LOBSTER FISHERY FACTSHEET



The Western Rock Lobster industry is an iconic fishery that is based along Western Australia's coast between Shark Bay and Cape Leeuwin. It was the world's first fishery to be certified as sustainable by the Marine Stewardship Council (MSC) in 2000. Western Australia rock lobster is the most valuable single-species fishery in Australia. Exported to China and sold domestically in Australia.

Western Rock Lobster *(Panulirus Cygnus)*

Classification: Decapod family

Size: 70-90mm at maturity (up to 150mm at maximum), weighing up to 5kg

Diet: Coralline algae, detritus (dead and dying marine matter), molluscs and crustaceans

Eaten by: Large fish species and octopus. Lobsters can regrow legs and antennae lost as a result of skirmishes with predators.

Habitat: Juveniles live in shallow inshore reefs (up to 40m depth) and adults live in deep water habitats including coral reefs (up to 80m depth).

Markings: The Western Rock Lobster is identifiable by a single white dot on the outside edge of each tail segment.

Where do Rock Lobsters live?

Western Rock Lobsters are a temperate species, found on the continental shelf off the Southern coast of Western Australia.

J F M A M J J A S O N D

The Fishery

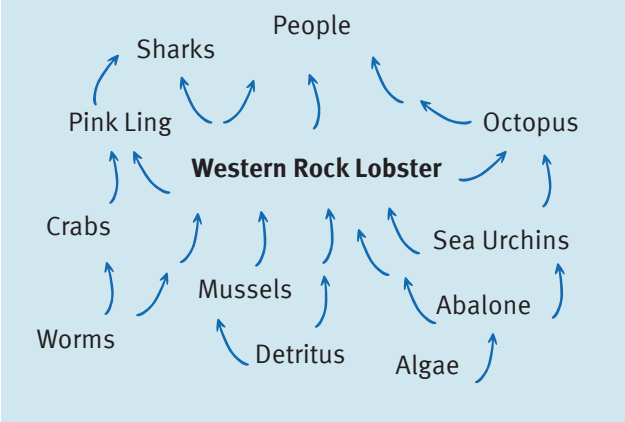
The Western Australia Rock Lobster Fishery is made up of around 250 commercial fishing boats, which operate under a quota management system. This means that commercial fishers have an allocated number of lobsters that they are allowed to catch during the lobster fishing season, which runs from November to August.

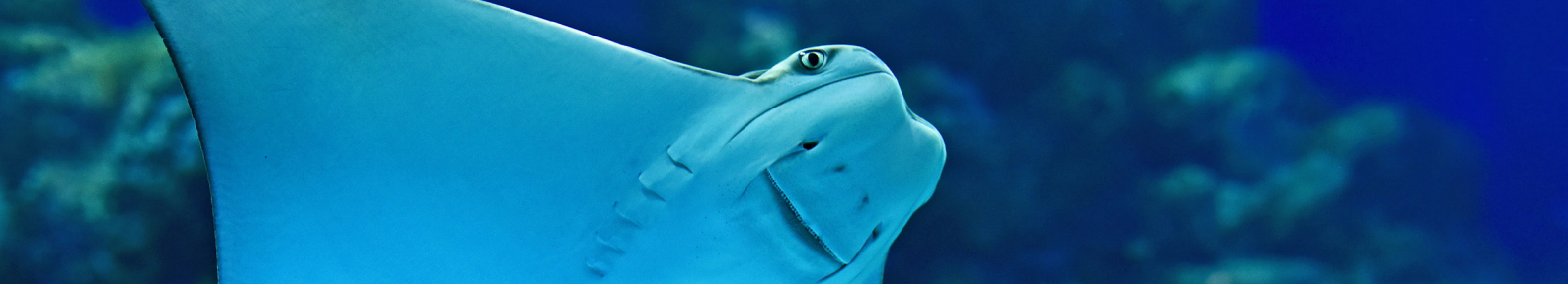
Family & lifecycle

The Western Rock Lobster typically live for 10 to 15 years. They mate in Winter and Spring, after which females carry eggs on the fine hairs beneath the tail. The eggs hatch in 4 to 8 weeks, releasing tiny larvae which drift offshore and grow in a series of moults. A lucky few will be carried close enough to the onshore reefs to settle. Many however will not make it, or will be eaten by predators along the way. The juvenile lives for 3 to 4 years on inshore reefs, after which they will moult their shells and turn a creamy white or pink colour, a colour which they will keep for a few months as they migrate into deeper waters. Lobsters trek in large groups in the night, until they resettle and return to their normal red colour.

See this WA Rock Lobster Lifecycle *poster from Marine Waters for more detail.*

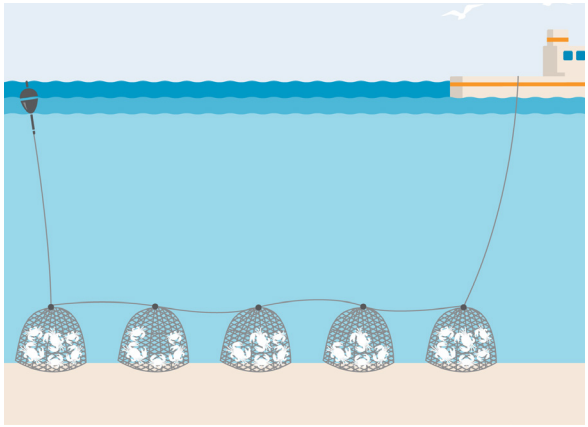
Western Rock Lobster Food Chain





Environmental impact

The Western Australia Rock Lobster is caught using **baited pots and traps**. These are fitted with special Sea Lion Excluder Devices (SLEDs) which block access to juvenile sea lions while still allowing lobsters to be caught.



Pots and Traps

There are strict controls in place such as a minimum size requirement for lobsters caught and a **ban on catching breeding females**.

Scientific data on the Western Australian lobsters has been recorded since the 1960s, and migrating lobsters are tracked through tagging programs. This enables scientists to predict catches accurately and measure the growth, migration and mortality of lobsters. This **scientific data** helps fishers to ensure that they maintain a sustainable population of lobsters, for today and for the future.

The Western Australia Rock Lobster Fishery was the **first in the world** to achieve MSC certification, demonstrating its exceptional sustainability.

Lobster Management profile: Read how science data is used monitor, assess and manage the WA Rock Lobster fishery.

Markets

The Western Australia Rock Lobster Fishery is a highly valuable fishery, with more than 95 percent of the commercially caught lobster sold directly to China. This crustacean is highly prized, and can sell for over $100 per kilogram. It is popularly eaten grilled with garlic butter, barbecued with lemon or steamed.

Rock lobster fishing is also a popular recreational activity in Western Australia. Fishers require a license and must follow strict size requirements and catch limits of 8 rock lobsters per licensed fisher per day.

The MSC Fisheries Standard

The MSC Fisheries Standard is designed to assess if a fishery is well-managed and sustainable. To meet this standard, fisheries must demonstrate that they meet three principles:

1. Sustainable fish stocks
The fishing activity must be at a level which ensures that it can continue indefinitely.

2. Minimising environmental impact
Fishing operations should allow for the maintenance and diversity of the ecosystem.

3. Effective management
The fishery must comply with relevant national and international laws and have a management system that is responsive to changing circumstances.

Today, over 15% of the global fishing catch worldwide is MSC certified.

Watch a video of the WA Rock Lobster Fishery celebrating their 15th year of MSC certification.

MSY FACTSHEET - ANSWERS

1. Why is it important for lobster fisheries to collect scientific data?

It is important for fisheries to ensure that lobster populations are sustainable over time. If the fishery catches too many lobsters today, there will be no lobsters in the future and the fishery will collapse. It is also important that the fishery is not causing damage to the ecosystem it is working in.

2. Where does the scientific data used by lobster fisheries come from?

Data is collected by
- Commercial fishers and processors
- Observers aboard fishing vessels
- Volunteer fishers
- Charter operators (Scientific researchers)

3. What types of scientific data do the lobster fishers use to determine MSY?

Examples include:
- Biomass (total weight of the catch)
- Egg production
- Lobster stock (populations)
- Size of lobsters caught
- Puerulus settlement

4. How has the model of MSY used by the lobster fisheries today developed over time from the original Gordon-Schaefer model?

- The model of MSY used by sustainable fisheries today takes into consideration the impact of a fishery on the whole marine ecosystem, not just one target fish species

- The lobster fisheries use data from a number of different sources and locations to get a big picture perspective of all fishing impacts on the lobster population. This includes accounting for the impacts of the indigenous and recreational fishing sectors.

- Management decisions are influenced by scientific data on the long-term health of the lobster population. This then effects the profitability of the fishery, which can vary from year to year.

5. Is the data used by these fisheries reliable? How might the quality of this data be improved?

The dataset is robust because it comes from multiple different sources and is analysed by academic researchers. The data has been collected frequently and over a long period of time - The Western Rock Lobster fishery has been collecting data for over 20 years!

The more data we collect in the future, the more reliable it will be. The quality of the data could also be improved if the cause of a drop in 'puerulus settlement' rates was identified.