These presentation files have been put together to complement the ocean acidification resource:

**The Ocean of Tomorrow**

prepared by the NZ Marine Studies Centre.

Please do not print or re-use this presentation for any other purpose.

Unless otherwise stated, graphs are taken from the Intergovernmental Panel on Climate Change (IPCC) reports, 2008 – 2014.

www.marine.ac.nz
Part 1

Introduction and background: CO$_2$, climate change and link to OA and pH.

To follow activity 1A. To lead into activity 1B and 3A.
A complicated subject

- Air
- Water
- Skeletons
- Ecosystems
- Planet
Greenhouse gases
Human Influence on the Greenhouse Effect

**Natural Greenhouse Effect**
- More heat escapes into space

**Greenhouse Effect Intensified by Humans**
- Less heat escapes into space
- More re-radiated heat

- **Greenhouse Gases**
  - $\text{CO}_2$
  - $\text{N}_2\text{O}$
  - $\text{CH}_4$
  - Solar Radiation
  - Re-radiated Heat

**Atmosphere**

- Earth's surface
- American continent
- Oceanic regions
Higher than it’s been for a long time

For the animated history of atmospheric carbon dioxide from 800,000 years ago until January 2016 see: https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html
Up in the air

- Pre-industrial levels of atmospheric CO$_2$ were about 280 ppm
- They have climbed to over 400 ppm today
- Could reach 1000 ppm by 2100
- We know a lot about this because CO$_2$ is an important greenhouse gas
Atmospheric CO$_2$ is increasing

At Mauna Loa, Hawaii

(www.planetforlife.com)
CO₂ in atmosphere now

Latest CO₂ reading
November 22, 2015

400.23 ppm

Carbon dioxide concentration at Mauna Loa Observatory

Week ending November 22, 2015

Hourly average
Daily average

CO₂ Concentration (ppm)

Mauna Loa Local Time
Jump into the water

- Oceans absorb CO$_2$ from atmosphere — about 1/3 of what we produce

- CO$_2$ (gas) + H$_2$O $\leftrightarrow$ HCO$_3^-$ + H$^+$
  (bicarbonate)

- HCO$_3^-$ $\leftrightarrow$ CO$_3^{2-}$ + H$^+$

- More atmospheric CO$_2$ means more H$^+$ ions in sea water.
Human emissions of CO₂ are causing our oceans to become more acidic! A pH unit is a measure of acidity ranging from 0-14. The lower the value, the more acidic the environment.

Some CO₂ reacts with the water to form carbonic acid. Some carbonic acid molecules react with a water molecule to give a bicarbonate ion and a hydrogen ion, increasing the ocean's "ACIDITY"
\[ \text{pH} = -\log [\text{H}_3\text{O}^+] \]

pH is a log scale
All about pH

• Name comes from “potential hydrogen”
• Negative logarithm of concentration of hydrogen ions (H+) in a solution
  – Higher pH means fewer H+ ions
  – A change of 1 pH unit is 10x the amount
• Water at 25° C is neutral: pH = 7.0 units
• Less than 7 is acid, greater is alkaline
• Arbitrary scale goes from 0 to 14
\[ \text{pH} = -\log [\text{H}_3\text{O}^+] \]

pH difference 1 means concentration of \( \text{H}_3\text{O}^+ \) ions differs by factor of 10.

A change of ocean pH from 8.1 to 7.6 is a 120% change in concentration of \( \text{H}_3\text{O}^+ \).

The current value of 8.14 is itself about 0.1 less than the preindustrial value (about 30% change) so by 2100 the \( \text{H}_3\text{O}^+ \) concentration will have changed by about 150% since the start of the industrial revolution.
Activity 1B and 3A: Exploring Ph

• What is pH?
• How do we measure pH?
• What is the pH of different solutions?
• How does carbon dioxide change the pH of seawater?