Things you should know about ocean acidification
Ocean absorbs one-fourth of man-made CO₂ emissions

Half of emitted CO₂ remains in atmosphere (causing global warming)

Half absorbed by ocean & land (trees, plants, and soils)

Ocean absorbs 24 million tons of CO₂ every day (4 kg per person, daily)

Le Quéré et al 2013; CDIAC data; Global Carbon Project 2013
#2- More atmospheric CO₂ means increased ocean acidity

CO₂ is an acid gas (it produces acid when combined with water)

Each of us adds 4 kg CO₂ per day to the ocean (increasing acidity, reducing pH)

Ocean acidity up by 30% since start of industrial age

Most of that only in last 40 years
#3- Change in pH from ocean acidification already measurable

Data:
Bates (2007)
Dore et al. (2009)
Santana-Casiano et al. (2007)
Gonzàles-Dàvila et al. (2010)

IPCC AR5 WG1 Report, Chap. 3 (2013)
#4 Today’s rate of ocean acidification may be unprecedented

- overwhelms natural variations (last 800,000 years)
- may be 10 times faster than natural event (55 million years ago)
- rate may be unprecedented (over last 300 million years)
- 30% increase in acidity (H\(^+\)) during industrial era
- 100% increase (or more) projected by 2100

*Current change:*

Barker and Ridgwell (2012)
#5- Polar oceans become corrosive to shell material within decades

Models project that cold waters soon become corrosive to aragonite, a (CaCO$_3$) mineral in some marine shells & skeletons.

Corrosivity of waters to aragonite (when < 1, aragonite dissolves)

Latest model projections (IPCC AR5 WG1, 2013)

Confirms original warnings: Orr et al. (2005), Caldeira & Wickett (2005), Steinacher et al. (2009)

see also Bopp et al. (2013)
#6 These corrosive conditions dissolve shells of sea butterflies

Sea butterfly shells (CaCO$_3$) exposed to corrosive conditions expected by 2100

Orr et al. (2005)
Fabry et al. (2008)
Comeau et al. (2009; 2011; 2012)
Lischka et al. (2011); Lischka & Riebesell (2012)
Bednarsek et al. (2012)

Movie: Brad Seibel, University of Rhode Island

Image: Victoria Fabry, California State University San Marcos
**#7- Acidification will change marine ecosystems**

Organisms react differently

Corals and shell builders decline

Seagrasses may increase

Fish become disoriented

Prey loss affects predators

Potential fish catch decline

*Synthesis of existing experimental studies*

Wittmann & Pörtner (2013)

see also Kroeker et al. (2013)
#8 Ocean areas naturally rich in CO\textsubscript{2} confirm expected future trends

- Less biodiversity
- Fewer calcifiers
- More fragile shells
- More invasive species
- More seagrasses, degraded corals

CO\textsubscript{2} bubbles rise from seafloor at Ischia, Bay of Naples, a natural lab to study acidification

*Hall-Spencer et al. (2008)*
*Rodolfo-Metalpa et al. (2008)*

Photo: Steve Ringman, Seattle Times

Another natural CO\textsubscript{2} vent site in Papua, New Guinea, used to study effects of acidification on corals

Photo: Jason Hall-Spencer, University of Plymouth
#9- Ocean acidification will also affect humans

- Fish is primary source of animal protein for 1 billion people, mostly in developing countries (FAO)

- Coral reefs provide
  - home for millions of species
  - storm protection for coastlines
  - income from tourism
  - biodiversity legacy for future

- Ocean acidification already affecting oyster industry (U.S. west coast)

- Ocean acidification may generally affect aquaculture, fisheries, and human livelihoods
The intensity of ocean acidification depends on us

Future atmospheric CO₂ (latest IPCC scenarios)

Intesity of ocean acidification (change in pH) varies by a factor of 3

IPCC AR5 WG1, Technical Summary (2013)

see also Bopp et al. (2013)
For more information and resources on ocean acidification:

iaea.org/ocean-acidification