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Ocean Acidification: Weaves to be tied on European and Global scale

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Image by Kristen Krumhardt

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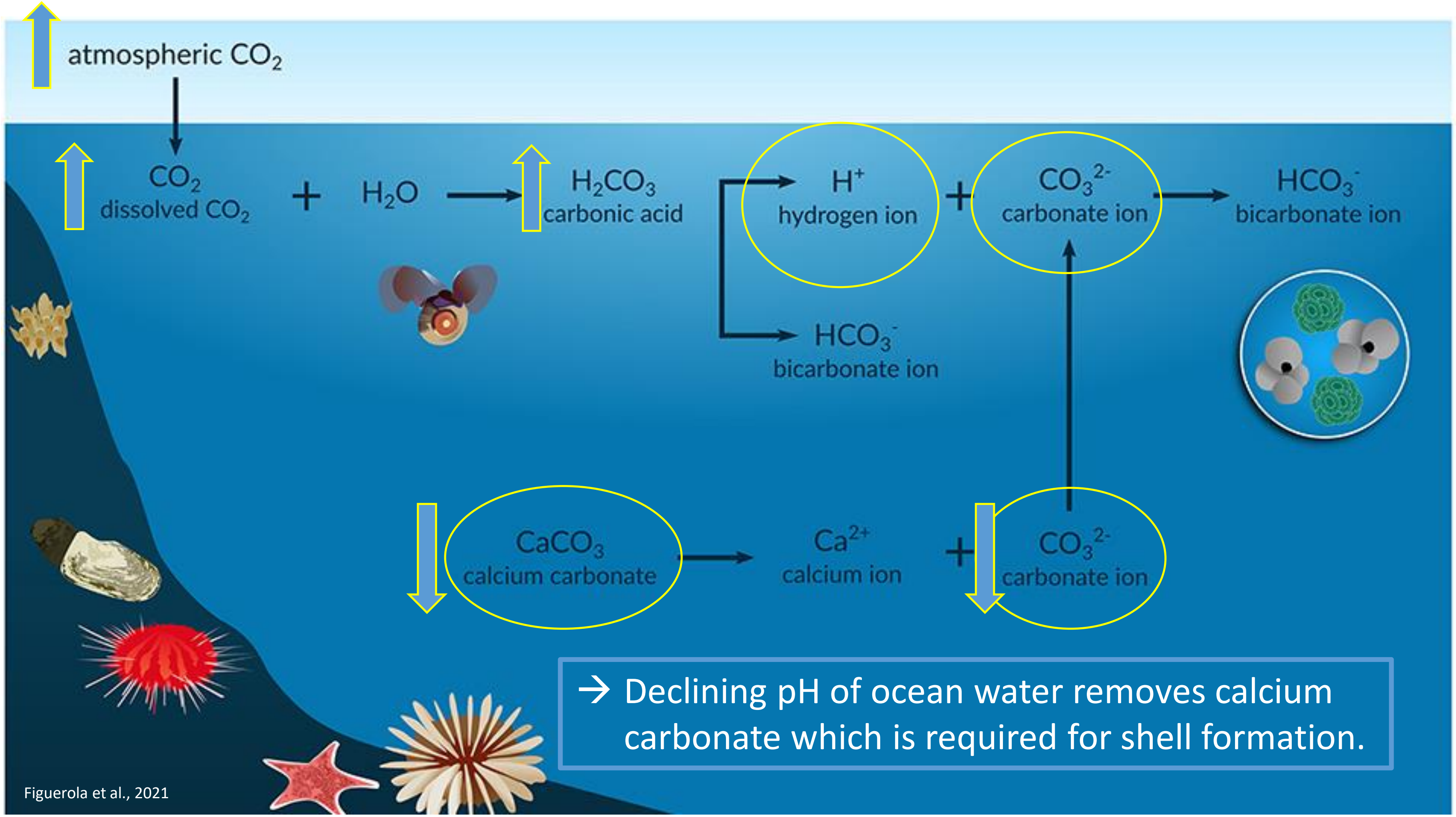
Blue whale, Mt. Maunganui, New Zealand
Photo: Kim Westerskov

Ocean Acidification

‘The ocean has absorbed about 30% of the emitted anthropogenic carbon causing ocean acidification since pre-industrial times.’
[IPCC, 2019]

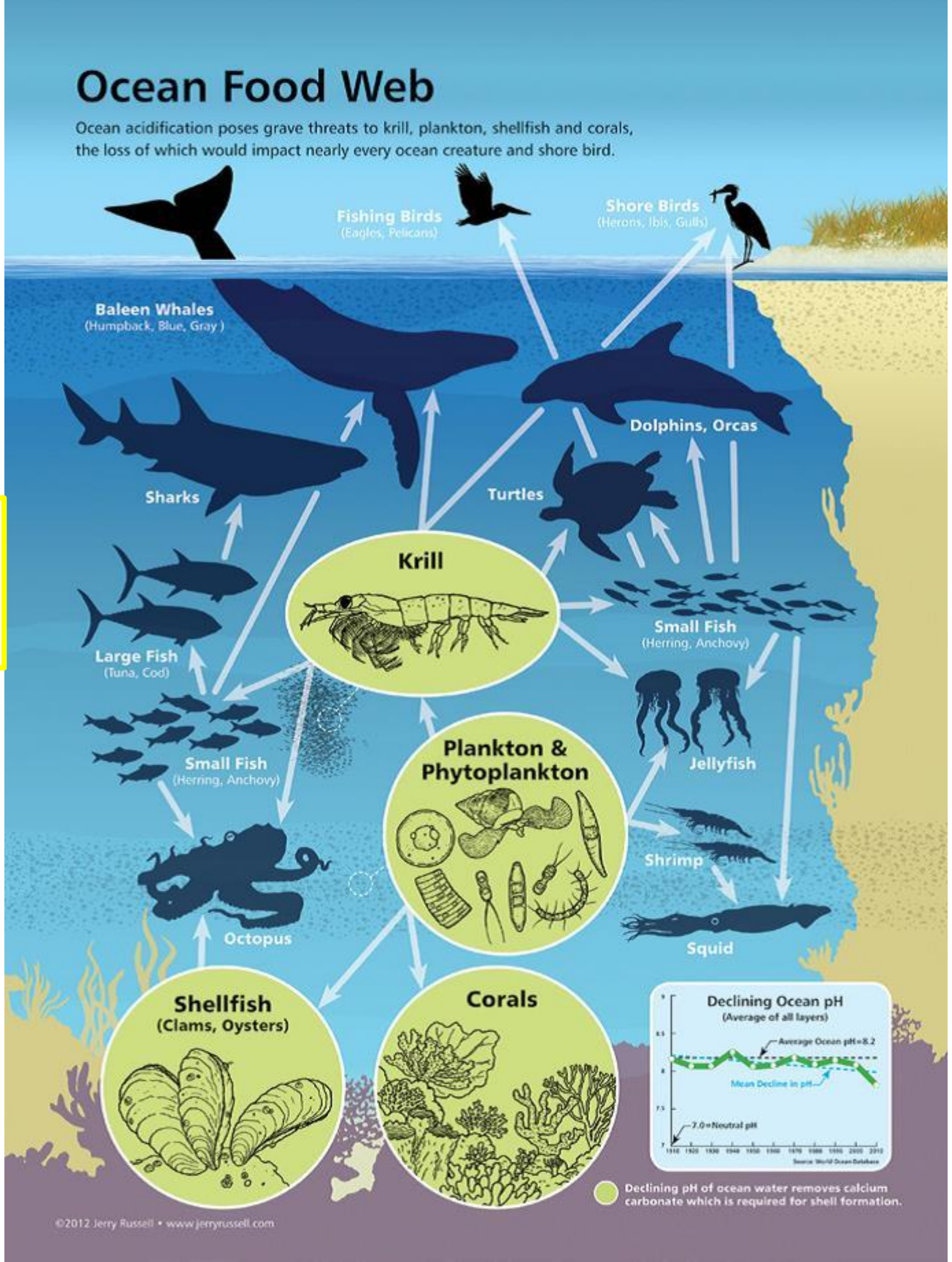
"Ocean acidification is a slow but accelerating impact with consequences that will greatly overshadow all the oil spills put together." - Sylvia Earle

Chemical reactions to the increased partial pressure of CO_2



→ states of $CaCO_3$: Aragonite, Calcite, Mg-calcite

Different types of marine calcifying organisms will respond in very different ways.



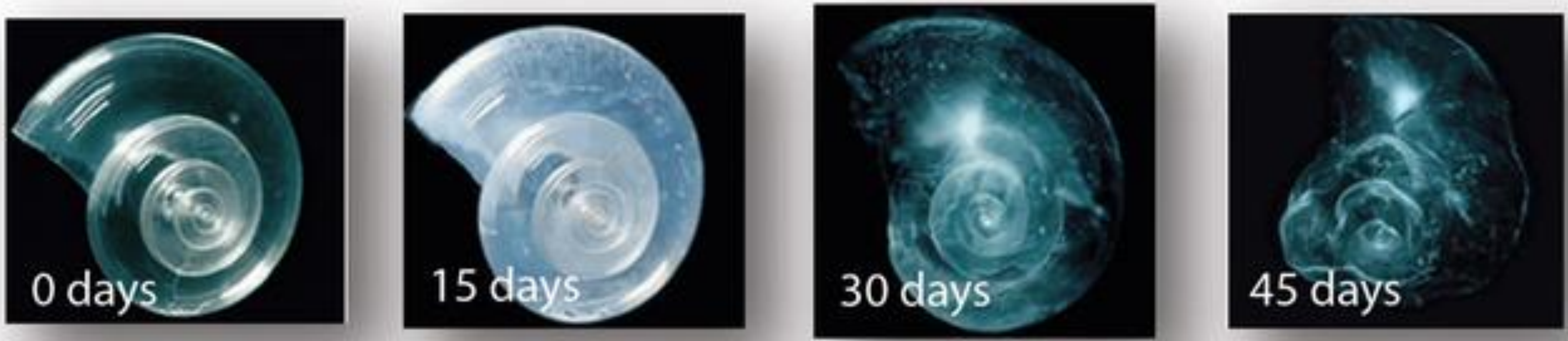
- The smallest plants and animals determine the state of the food web.
- **Food chains are shifted by a decreasing pH value.**
- Also shellfish have problems to build their shells.
- Many edible fish such as haddock, halibut, flounder and cod feed mainly on molluscs.

Pteropods: Sea butterflies (Limacina helicina)

→ important source of food for **juvenile Pacific salmon**

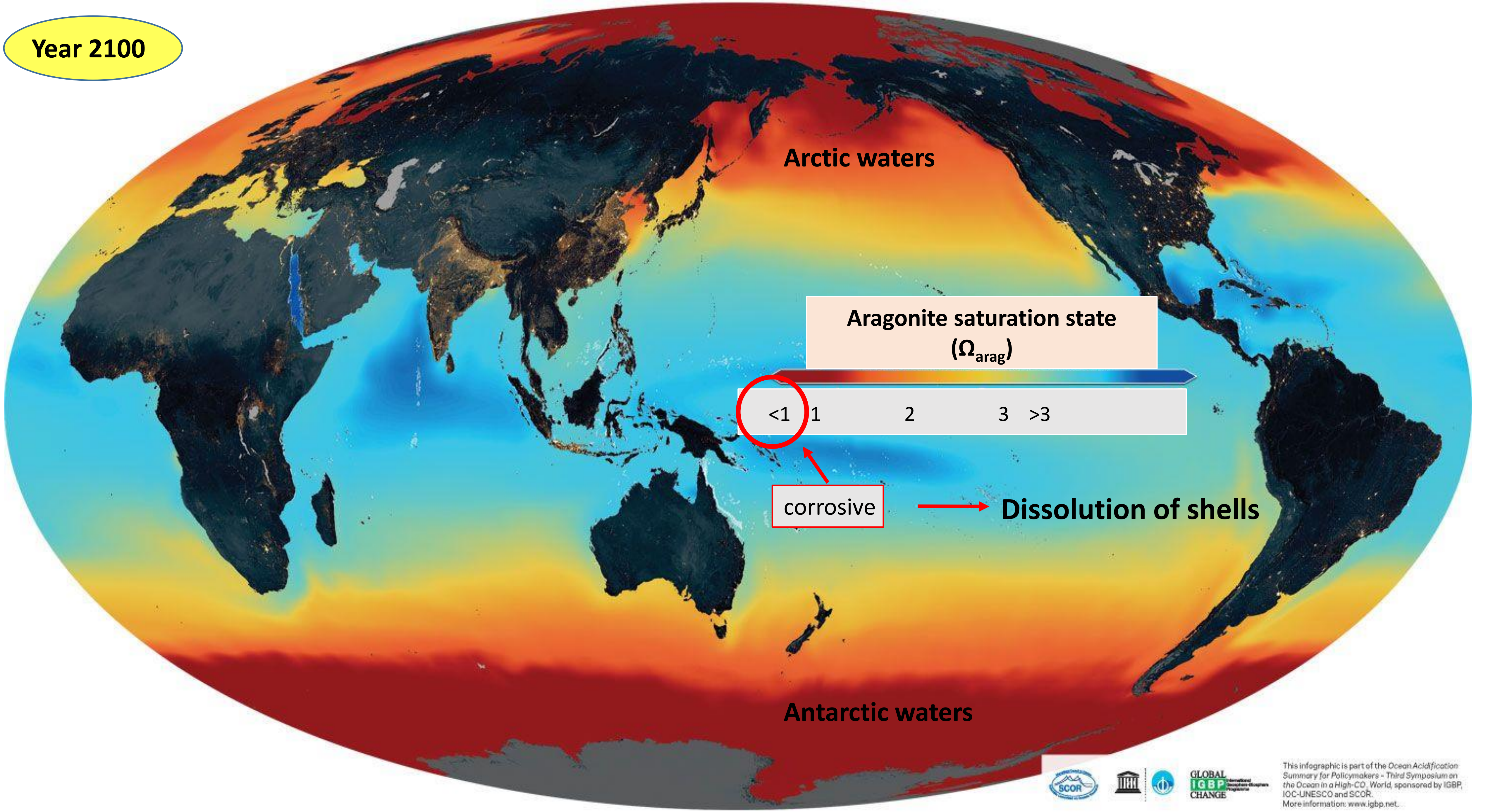
→ **Pteropods build their shells from aragonite**

→ In a lab experiment, a sea butterfly (pteropod) shell placed in seawater with increased acidity slowly dissolves over 45 days.



(Source: David Littschwager/National Geographic Society)

Year 2100



Arctic waters
Aragonite saturation state
(Ω_{arag})
<1
1
2
3
>3
corrosive
Dissolution of shells
Antarctic waters
SCOR
GLOBAL
IGBP
CHANGE
This infographic is part of the Ocean Acidification Summary for Policymakers - Third Symposium on the Ocean in a High-CO_2 World, sponsored by IGBP, IOC-UNESCO and SCOR.
More information: www.igbp.net.

Ocean Acidification is one of the Ocean Monitoring Indicators (OMI)

SDG Target 14.3 addresses **Ocean Acidification**.

The **SDG 14.3.1 Indicator Methodology** describes **how to measure and report the key carbonate chemistry variables for ocean acidification** to enable the **global comparison**.

→ Measurements of pH have existed from as early as **1910,** but show a **great lack of metadata until 1980/1990**.

→ Data from 1980/1990 until present are more complete, but sometimes also lack essential information about:

- important additional parameters such as ***salinity***, ***temperature*** and ***pressure***;
  &
- essential metadata: such as ***pH scales***, ***methods***, ***electrode***, ***buffer solutions***, ***formulae*** used;

→ In general pH measurements over decades involved **different in situ sampling, different pH buffers, different calibrations, intercalibrations, etc., i.e., as a consequence, the changes in pH over time might not reflect real pH changes.**

→ **Finer definitions of vocabularies and metadata are of great importance.**

*An **international working group on Ocean Acidification Vocabularies and Metadata** has been established to ensure the **long-term usability** of ocean acidification data for the* **SDG 14.3.1 Indicator Methodology .**

Overall Aim

→ **FAIR** (**F**indable, **A**ccessible, **I**nteroperable and **R**eusable) Ocean Acidification dataset

→ Including the parameters related to Ocean Acidification: **pH, Total Alkalinity (TA), Total Dissolved Inorganic Carbon (DIC) and partial pressure of CO_2 (pCO_2)**

→ Define standard **metadata** and **common vocabularies** (based on BODC Parameter Usage Vocabulary) → **Vocabulary and Metadata Working Group**

→ **Harmonization of world-wide ocean acidification databases**

Vocabulary and Metadata Working Group

- To ensure the ***long-term usability*** of pH data and to allow a ***complete description of the carbonate system*** by scientists, reliable data is important.

- ***The data can only be as good as the according metadata***

- **Example from the preliminary metadata template (for the parameter pH):**

→ **e.g.** sampling instrument, sampling method, calculation method, analyzing instrument, analyzing method, calibration information, temperature of pH & much much more …

150			**Variable abbreviation in data**		25 01	Column header name of the variable in the data files, e.g., pH
151			**pH scale**		25 02	The pH scale for the reported pH results, e.g., total scale, seawater scale, NBS scale, etc.
152			**Observation type**		25 03	How the variable is observed, e.g., surface underway, profile, time series, model output, etc. For experimental data, this could be: laboratory experiment, pelagic mesocosm, benthic mesocosm, benthic FOCE type studies, natural pertubration site studies, natural gradient studies, etc
153			**Discrete or continuous**		25 04	Whether the reported results are based on discrete-bottled measurements or continuous sensor measurements
154			**In-situ or manipulated**		25 05	Whether the variable reported is from an in-situ observation, or from a manipulated experiment.
155			**Manipulation method (special**		25 06	How the seawater chemsitry is manipulated (e.g., bubbling CO2, solid alkalinization, etc.)
156			**Measured or calculated**		25 07	Whether the variable is measured in-situ, or calculated from other variables
157			**Calculation method and parameters (special use only)**		25 08	Information about how the variable was calculated, e.g., using a Matlab version of the CO2SYS with the dissociation constants of Lueker et al., 2000 for carbonic acid, etc.
158			**Sampling instrument**		25 09	Instrument that is used to collect water samples, or deploy sensors, etc. For example, a Niskin bottle, pump, CTD, etc is a sampling instrument.
159			**Sampling method**		25 10	Additional information describing how the sample was collected.
160			**Analyzing instrument**		25 11	Instrument that is used to analyze the water samples collected with the 'sampling instrument', or the sensors that are mounted on the 'sampling instrument' to measure the water body continuously. For example, a coulometer, winkler titrator, spectrophotometer, pH meter, thermosalinograph, oxygen sensor, YSI Multiparameter Meter, etc is an analyzing instrument. We encourage you to document as much details (such as the make, model, resolution, precisions, etc) of the instrument as you can here.
161			**Analyzing method**		25 12	Additional information describing how the sample was analyzed.
162			**Calibration information**	**Calibration technique description**	25 13	Description of the pH calibration procedures.
163	**25**	**pH**		**Frequency of Calibration**	25 14	How frequent was the calibration carried out, e.g., every 6 hours, etc.
164				**Type of dye and manufacturer**	25 15	
165				**pH values of the**	25 16	pH values of the standards, e.g., 4.0, 7.0, 10.0.
166				**Temperature of calibration**	25 17	Temperature at which the calibration was done.
167			**Temperature of pH**		25 18	Temperature at which the samples were measured.
168			**At what temperature was pH reported**		25 19	The input could be a constant temperature value, or something like, in-situ temperature, temperature of analysis, etc.
169			**Temperature correction method (delete)**		25 20	How the temperature effect was corrected.
170			**Field replicate information**		25 21	Repetition of sample collection and measurement, e.g., triplicate samples.
171			**QC steps taken**		25 22	Describe what QC steps have been taken to improve the quality of the data
172			**Uncertainty**		25 23	Uncertainty of the results (e.g., 1%, 0.02 pH, etc), or a description of the uncertainties involved in this method.
173			**Weather or climate quality**		25 24	
174			**QC flag scheme**		25 25	Describe what the quality control flags stand for, e.g., 2 = good value, 3 = questionable value, 4 = bad value.

→ **Next step: International Ocean Acidification Data and Metadata Workshop in Venice in May 2024 organized by OGS, UNESCO and NOAA.**

→ This important global collaboration will provide more accurate and detailed OA data and **will help policy and decision makers to communicate more clearly and precisely** about the impacts of climate change on marine ecosystems and resources, enabling **holistic approaches**.

‘Philosophical part’

Solutions ?

Technical Solutions ?

→ fertilization

→ CO_2 removal

→ ……

→ Dangers: side effects, may increase ocean acidification [IPCC, 2019]

→ Does not try to solve the cause of the problem, tries to solve only the symptom.

Change in life philosophy ?

→ **Respect** for the earth and the oceans

→ **Interconnectedness** of all living and non-living beings

→ **Collaboration** instead of competition

→ **Connection** with nature; learning from indigenous people

The IPCC Special Report (2019) also states that reducing the general risks by limiting warming to 1.5 °C above pre-industrial levels would require ***transformative systemic change, integrated with sustainable development***.

‘Science accumulates knowledge faster than society accumulates wisdom.’
[science fiction author Isaac Asimov]

- The 2021-2030 UN Decade of Ocean Science for Sustainable Development aims to create a more **holistic and integrated approach**, with an emphasis also on indigenous people and the traditional knowledge of local people to achieve a truly sustainable approach and not just green- or bluewashing projects.
- Blue economy and blue growth is often doing more harm than good, because it is still based on exploitation and on the concept of economic growth on a finite planet (Ehlers, 2016), while indigenous people and their traditional conservation and management are based on the **respect of nature and taking care of the land** (Minerbi, 1999; Kealiikanakaoleohaililani et al., 2016; Berkes, 517 2017; Witte et al., 2018; UNESCO Man and Biosphere Programme, Reed, 2019).
- Such **holistic ways of understanding the environment** offer alternatives to the prevailing consumption-oriented values of Western societies (Berkes et al., 2006; Kimmerer, 2012; Brondízio et al., 2021).

Therefore, possible solutions cannot only be of technological nature, but require an urgent and strong shift of our way of thinking and of our entire worldview to make sure that future generations can experience healthy, living oceans and ecosystems.

→ Establish a **living stewardship of the earth**

.... Together

.... Interconnectedness

Thank you for your attention !

... Shift of consciousness

... 7 generation contract

For questions/ideas/discussions please write to:

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