Ocean Acidification International Coordination Centre

IAEA OA-ICC

OA ALLIANCE — INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

Basic Training Course on Ocean Acidification

9 - 13 September 2024

EVT2205463

hosted by

United Methodist University (UMU)

Welcome

Agenda for today

Monday 9 September	*Day 1*	
09.00-10.00	**Welcome and Introduction** • Opening remarks • Overview of the training objectives and deliverables • Introduction of participants and trainers • Group photo	**Hon. Emmanual K. Urey Yarkpawolo** **Ms Yar Donlah Gonway-Gono** **Mr Anthony Dioh** & **Mr Samuel Dupont** **Ms Lina Hansson**
10.00-10.30	**Lecture 1: Why Ocean Acidification? Why now?** • Overview of ocean acidification and its global impact	**Mr Samuel Dupont**
10.30-10.45	*Coffee break*	
10.45-12.15	**Lecture 1: Why Ocean Acidification? Why now?** • What science do we need to address and minimize ocean acidification? • SDG 14.3.1 indicators (process, history) • Introduction to Group Exercise (national strategic planning)	**Mr Samuel Dupont**
12.15-13.15	*Lunch break*	
13.15-14.45	**Lecture 2: Carbonate chemistry, theoretical aspects** • Fundamentals of seawater carbonate chemistry • Understanding pH, pCO_2, alkalinity, and other parameters	**Mr Jose Martin Hernadez-Ayon**
14.45-15.00	*Coffee break*	
15.00-16.30	**Group exercise 1: Challenges and Solutions in Ocean Acidification Research in West Africa** • Identify a question • Regional challenges and opportunities • Potential solutions and collaborations	
16.30-17.00	**Wrap-up and Review of Day 1** • Summary of key points • Q&A	

Introduction, goals

<u>Lecture</u>: Why ocean acidification?

<u>Lecture</u>: Carbonate chemistry

<u>Exercise</u>: Expectations, opportunities

Objectives and deliverables

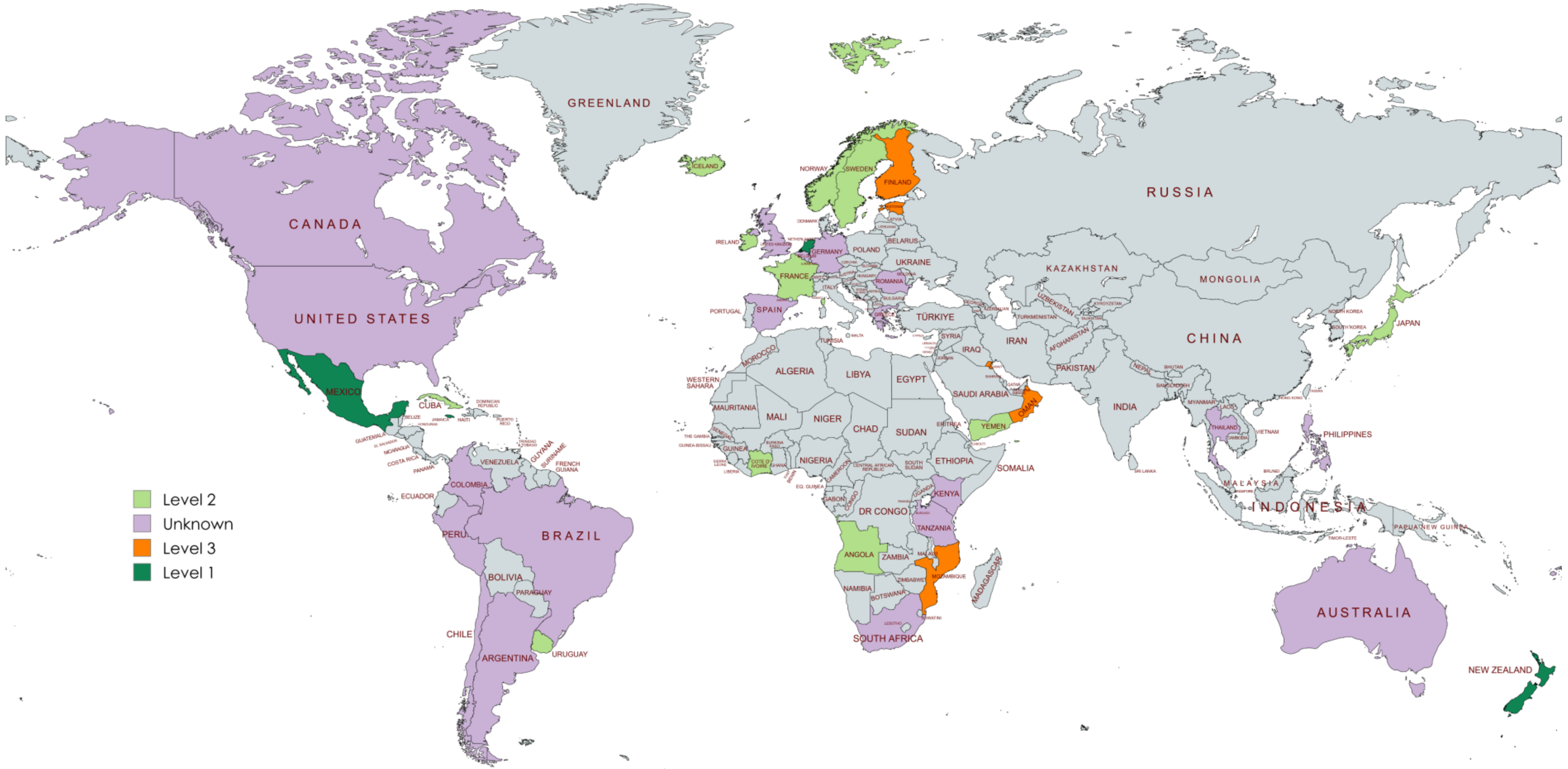
What do YOU want to achieve?

- ✓ Theoretical background on ocean acidification
- ✓ Focus on chemical monitoring
- ✓ **Ability to report to SDG 14.3.1**
- ✓ Strategic plan for each country
- ✓ Communication plan (policy document)
- ✓ Opportunities for collaboration and funds

SDG 14.3.1

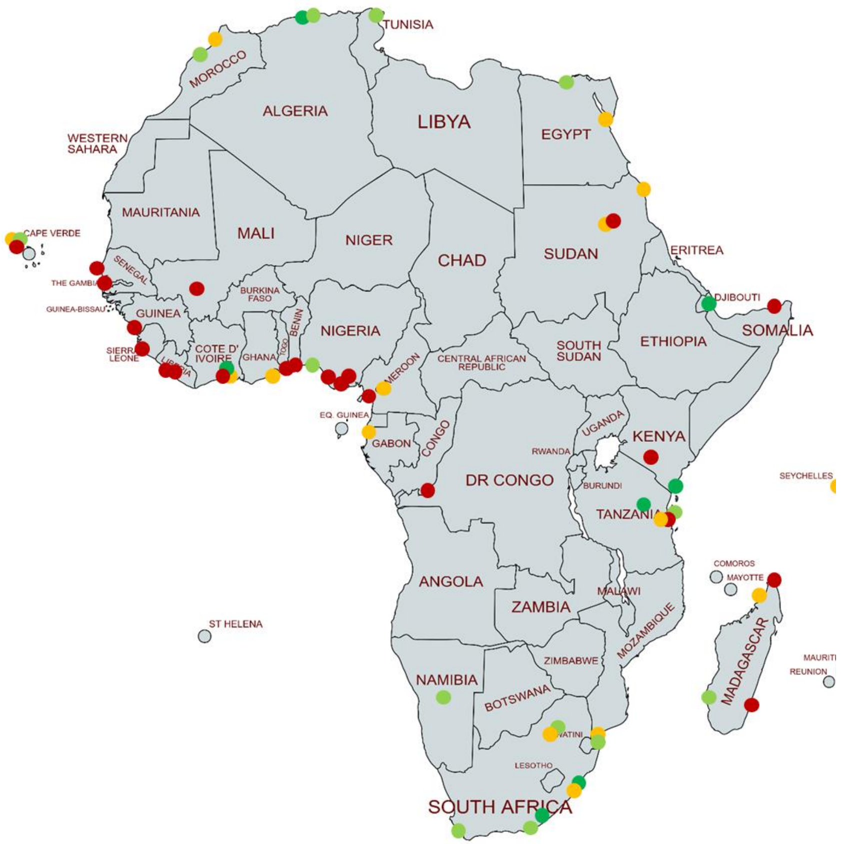
Minimize and address ocean acidification

Measure and report pH



Short introduction

Who are we? Participants



Angola	1
Ghana	7
Liberia	6
Nigeria	1
Gambia	1
Togo	1

Short introduction
Who are we?

Sam Dupont

Kristineberg Center
Vice Director
Science policy & Management

University of Gothenburg
Professor
Teaching & research (biological impacts of global changes), communication

United Nations IAEA - Monaco
Consultant
Capacity development

Pre-course evaluation

Dear Scientist,

We would like to employ you to develop a monitoring program on ocean acidification. We are particularly worried about potential impacts on our local population of blue mussels. Mussels are present all along our coast and a major economic resource for the country. In particular, we would like to set-up a monitoring program in an area located at the extreme southern distribution of the species (Cool Harbor, famous for his mussel soup). It is predicted that by the end of the century, the average annual pH in the water will decrease by 0.3 pH unit and we need to know how this could impact the survival of the adult mussels at Cool Harbor.

We have already employed two scientists, but they had very different conclusions (see their reports below).

I am little confused by their conclusions. Can you please have a look and help us to understand which of the two scientists is correct? Please, justify your answer.

Thanking you in advance

Pre-course evaluation

Report of Scientist #1

I recommend using the budget to develop the capacity to measure pH, alkalinity, temperature and salinity using the highest standards for accuracy and precision (climate standard). When these methods are established, the remaining budget can be used for monthly sampling. This will allow to evaluate the rate of ocean acidification at the sampling site and then the risk of negative impacts on local species, including the blue mussel.

Report of Scientist #2

The budget can be used to support an extensive sampling campaign at Cool Harbour. I suggest to measure pH using the glass pH electrodes already available locally (Marine Station next to Cool Harbour). pH measurements should be measured every 30 minutes over 24h, one day per week over a whole year. These data will allow us to resolve the pH experienced by mussels at the sampling site, and then their sensitivity to ocean acidification.

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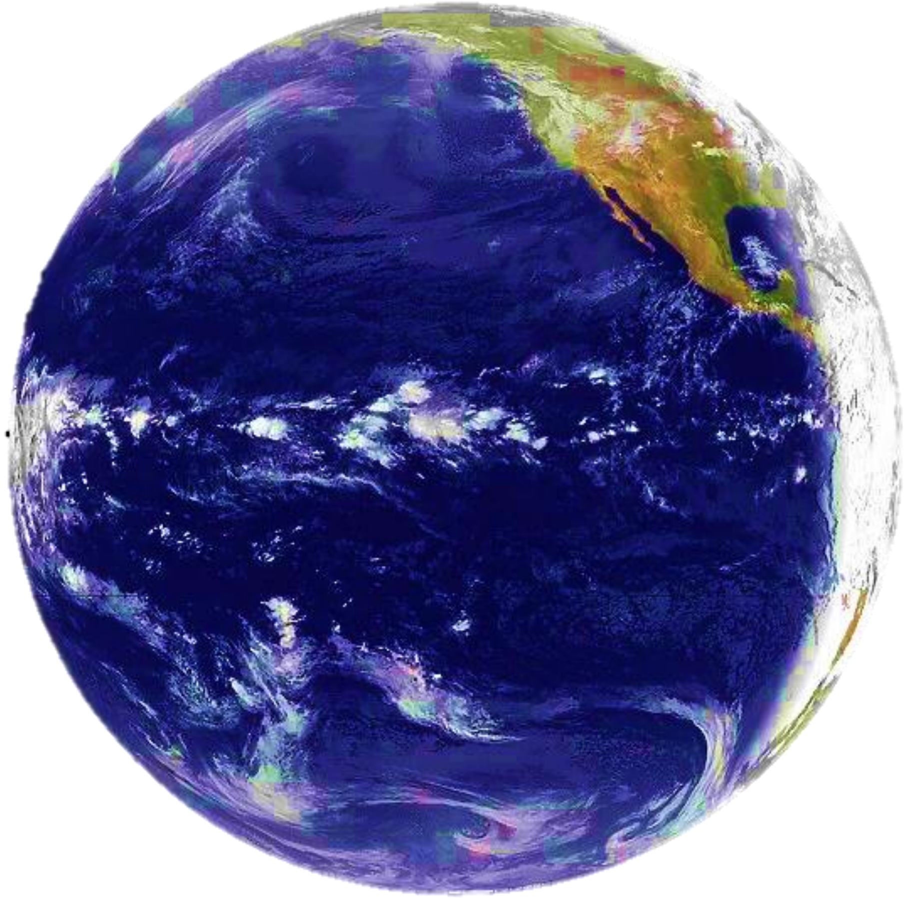
Why ocean acidification?
Why now?

Blue planet



Q1: What are the services provided by the ocean?

The blue planet

Ocean Health = Human health

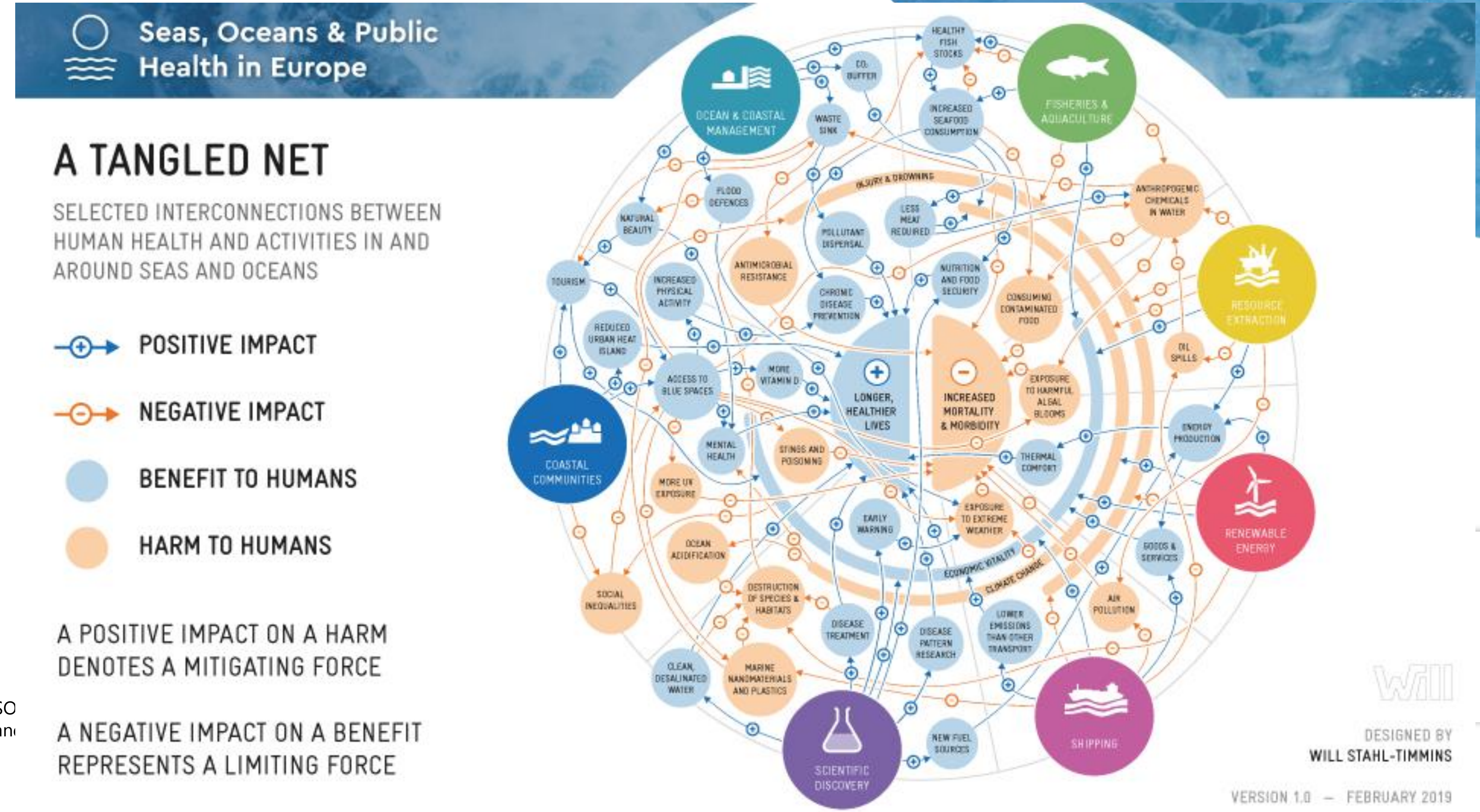
e.g. Chronic disease = main cause of mortality

Obesity caused by:

- Nutrition → Seafood based diet
- Exercise (lack of)
- Mental health / Stress → Recreation/biodiver.
- Genetics
- Medication → New medicine
- Culture

Seas, Oceans & Public Health in Europe

Linking oceans and health research



SO
an

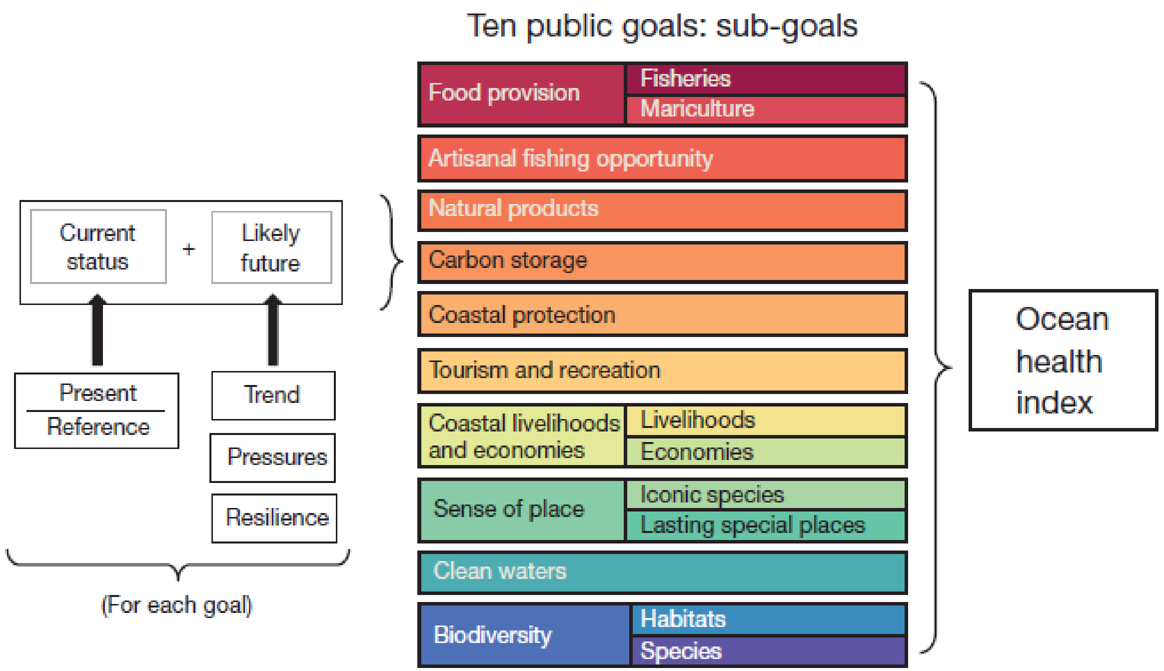
Ocean Health

ARTICLE

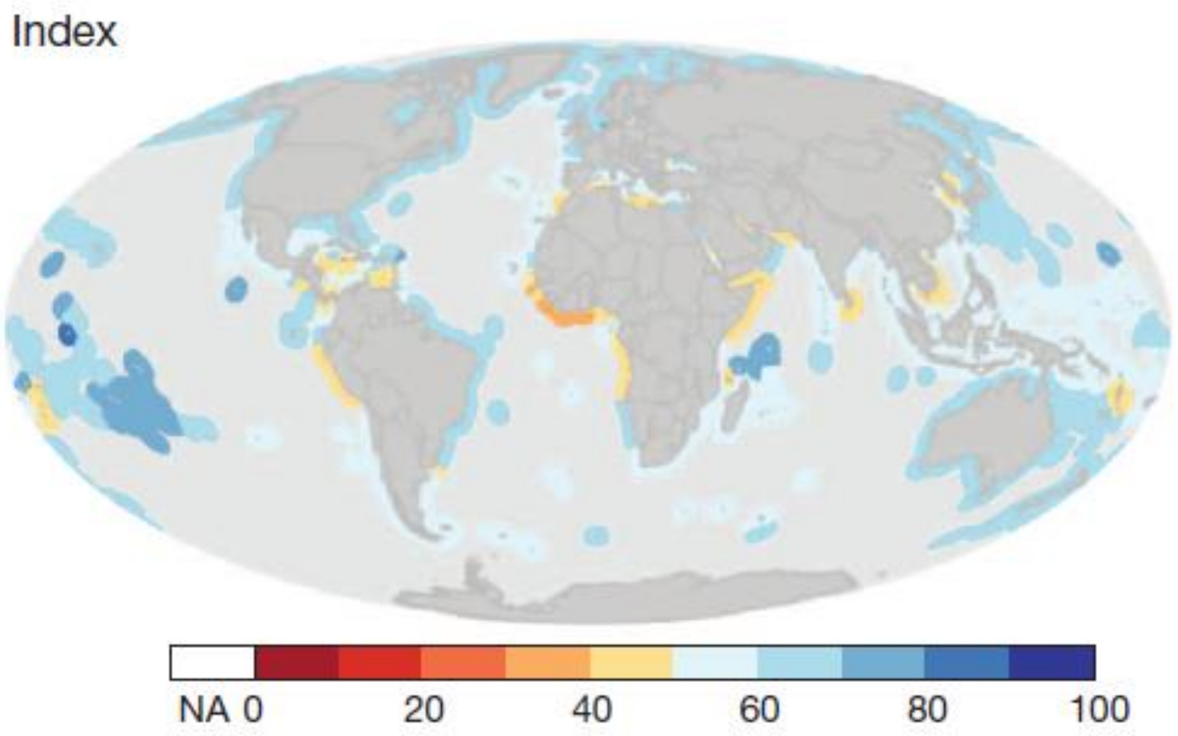
doi:10.1038/nature11397

An index to assess the health and benefits of the global ocean

Benjamin S. Halpern[1,2], Catherine Longo[1], Darren Hardy[1], Karen L. McLeod[3], Jameal F. Samhouri[4], Steven K. Katona[5], Kristin Kleisner[6], Sarah E. Lester[7,8], Jennifer O'Leary[1], Marla Ranelletti[1], Andrew A. Rosenberg[5], Courtney Scarborough[1], Elizabeth R. Selig[5], Benjamin D. Best[9], Daniel R. Brumbaugh[10], F. Stuart Chapin[11], Larry B. Crowder[12], Kendra L. Daly[13], Scott C. Doney[14], Cristiane Elfes[15,16], Michael J. Fogarty[17], Steven D. Gaines[8], Kelsey I. Jacobsen[8], Leah Bunce Karrer[5], Heather M. Leslie[18], Elizabeth Neeley[19], Daniel Pauly[6], Stephen Polasky[20], Bud Ris[21], Kevin St Martin[22], Gregory S. Stone[5], U. Rashid Sumaila[6] & Dirk Zeller[6]



Ocean Health

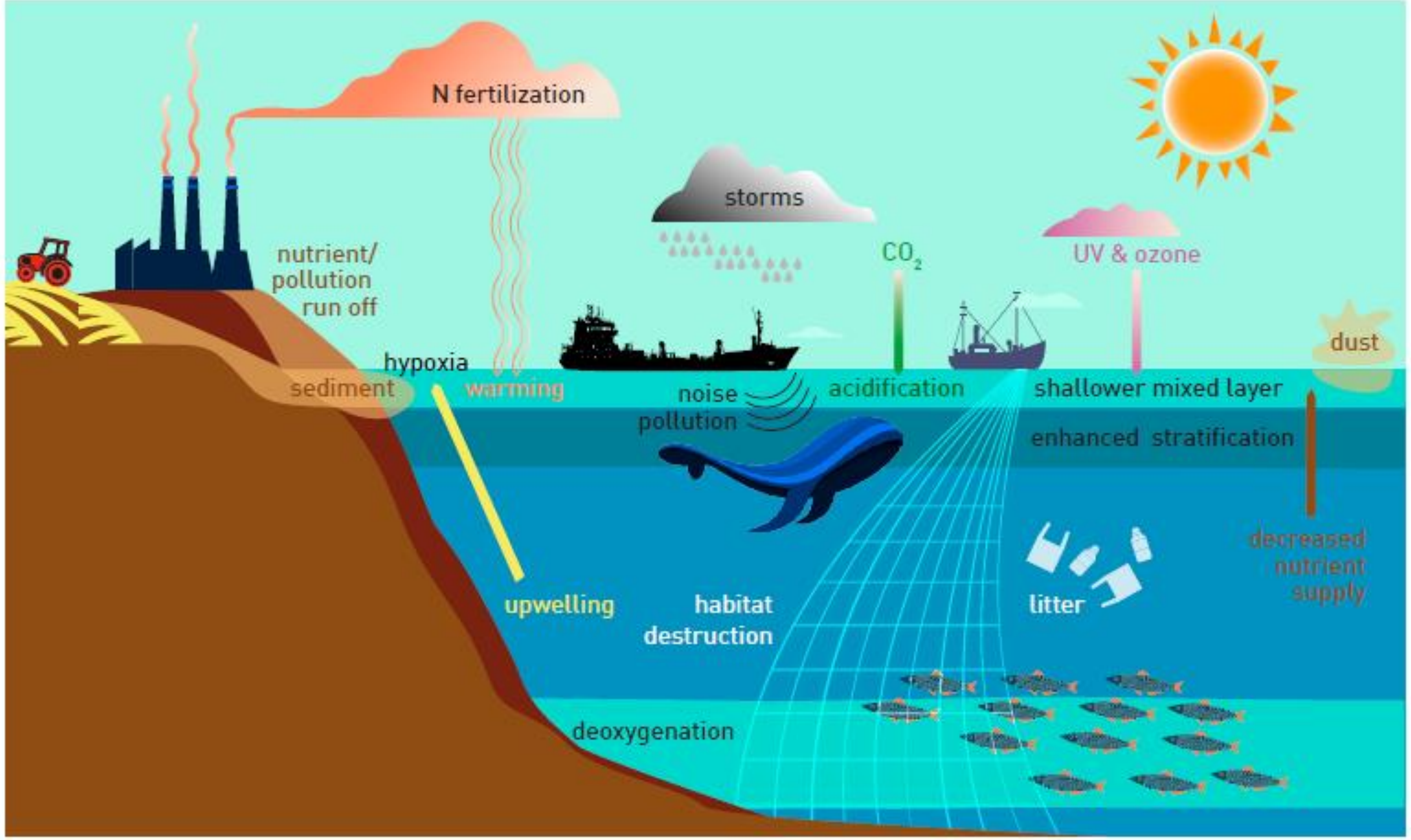


OHi = 60% [36-86]

Changes

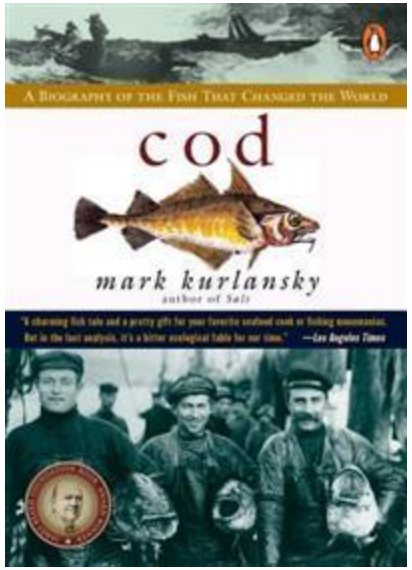
Q2: What are the main pressures on the ocean?

Human threats on the ocean

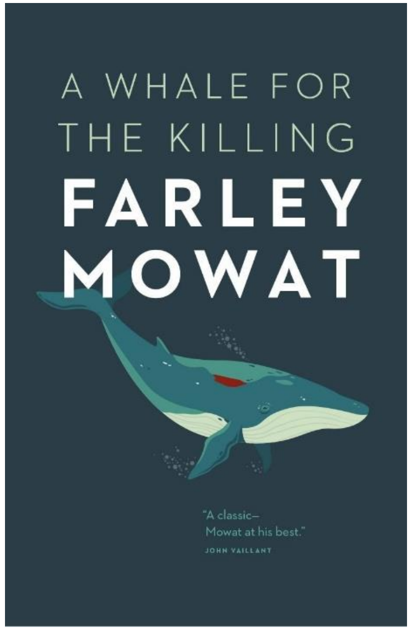


Multiple stressors

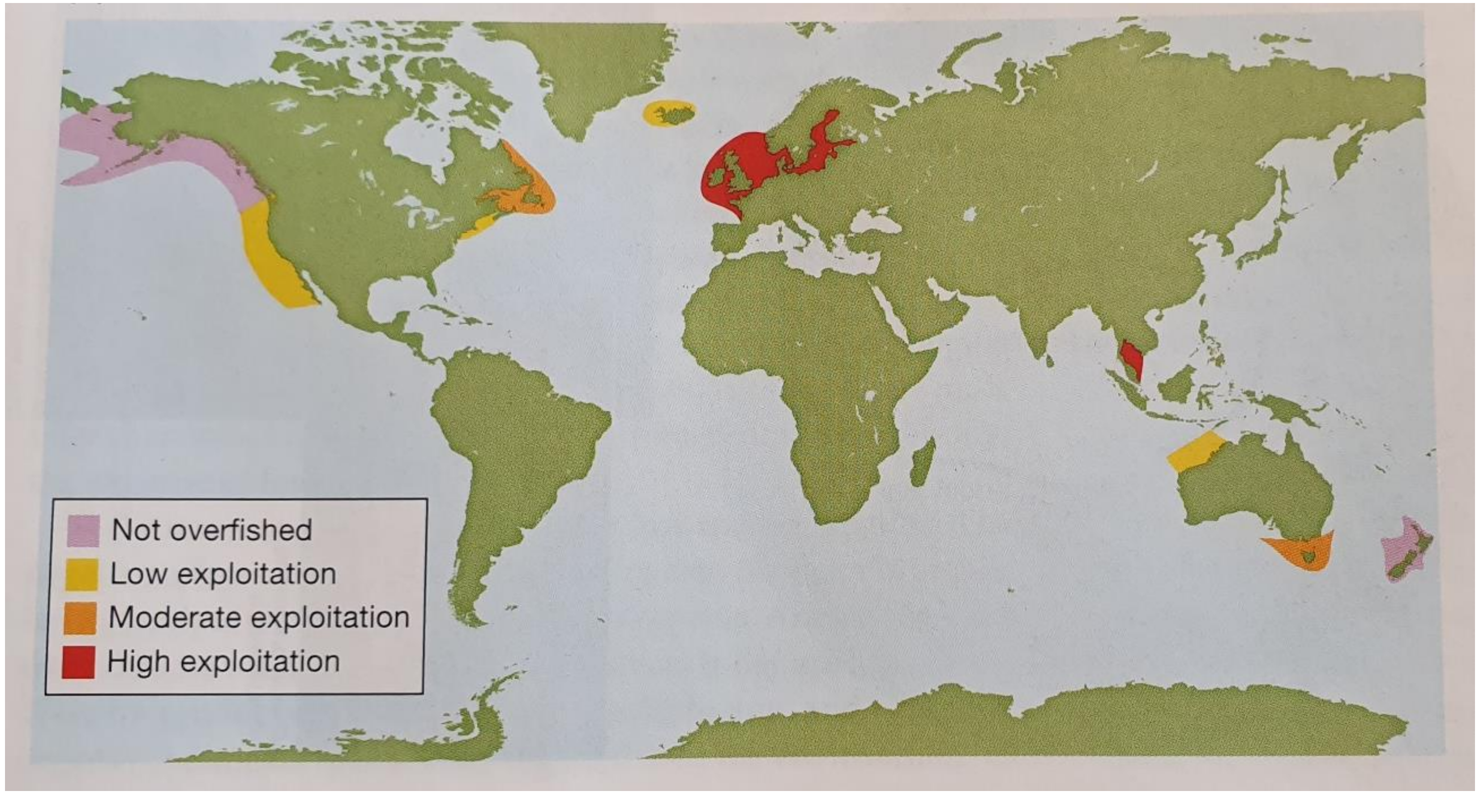
Main pressures: Over-fishing



Humans have fished for 40000 years
Increased efficiency with technology
Market pressure



Main pressures: Over-fishing

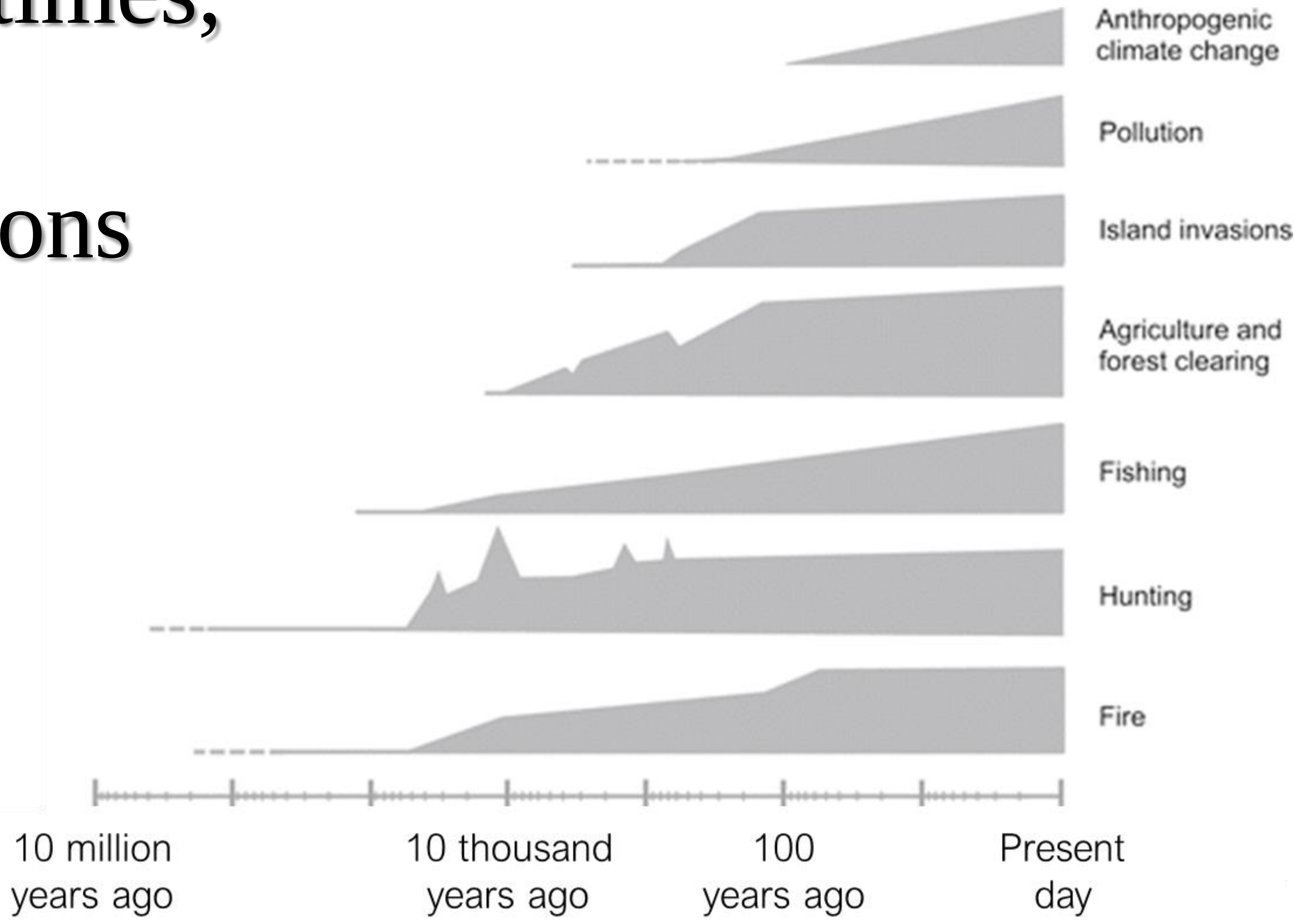


14% exploited fish populations collapsed

e.g. cod, tuna, sardines

Intensity depending on location

Different times, different combinations



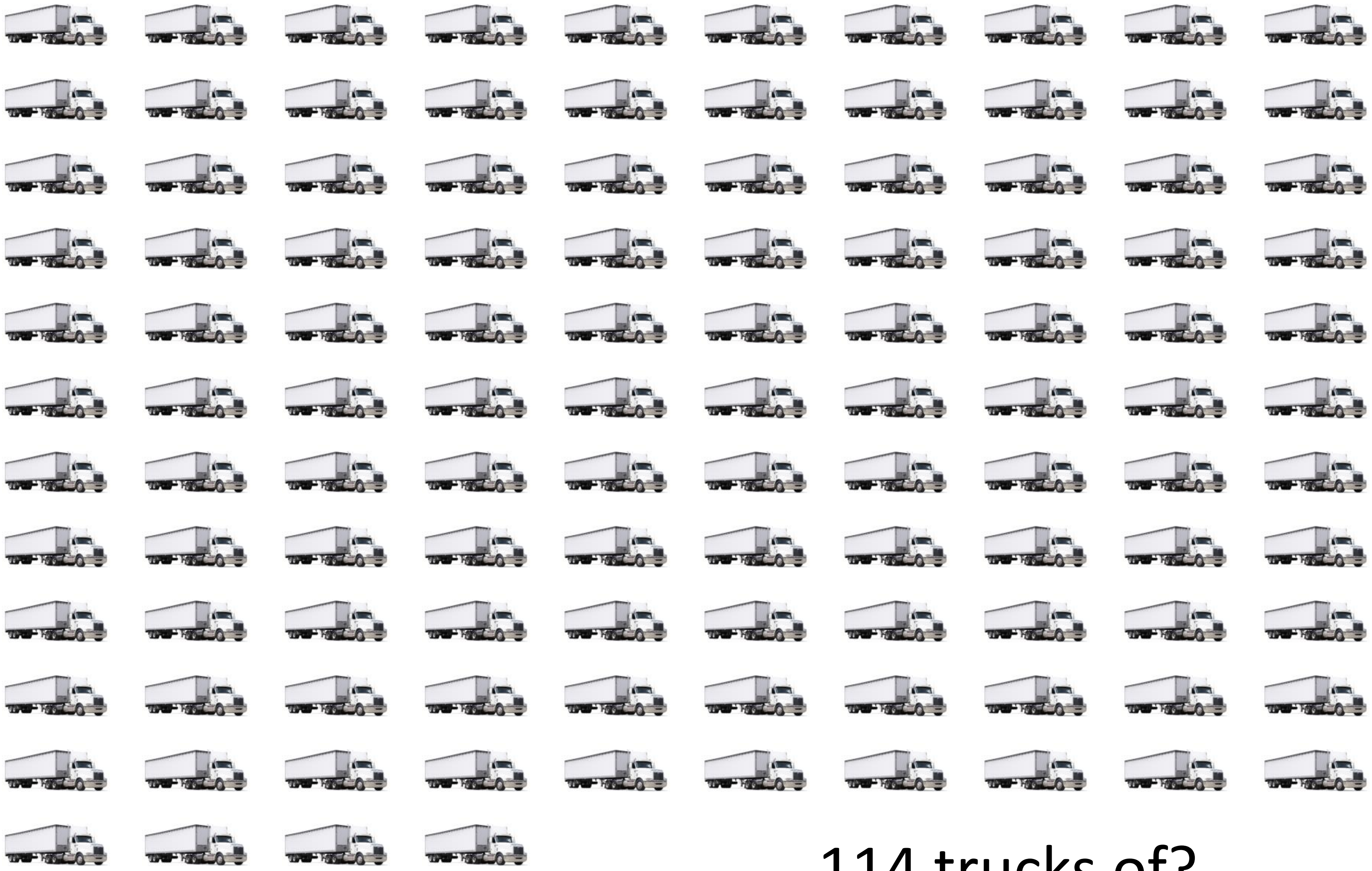
Many consequences

- ✓ Toxicants (>100.000)
- ✓ Over-fishing
- ✓ Warming
- ✓ Deoxygenation
- ✓ Ocean acidification
- ✓ Litters (macro, micro, nano)
- ✓ Etc.

Global impacts

25 million tonnes of plastic packaging

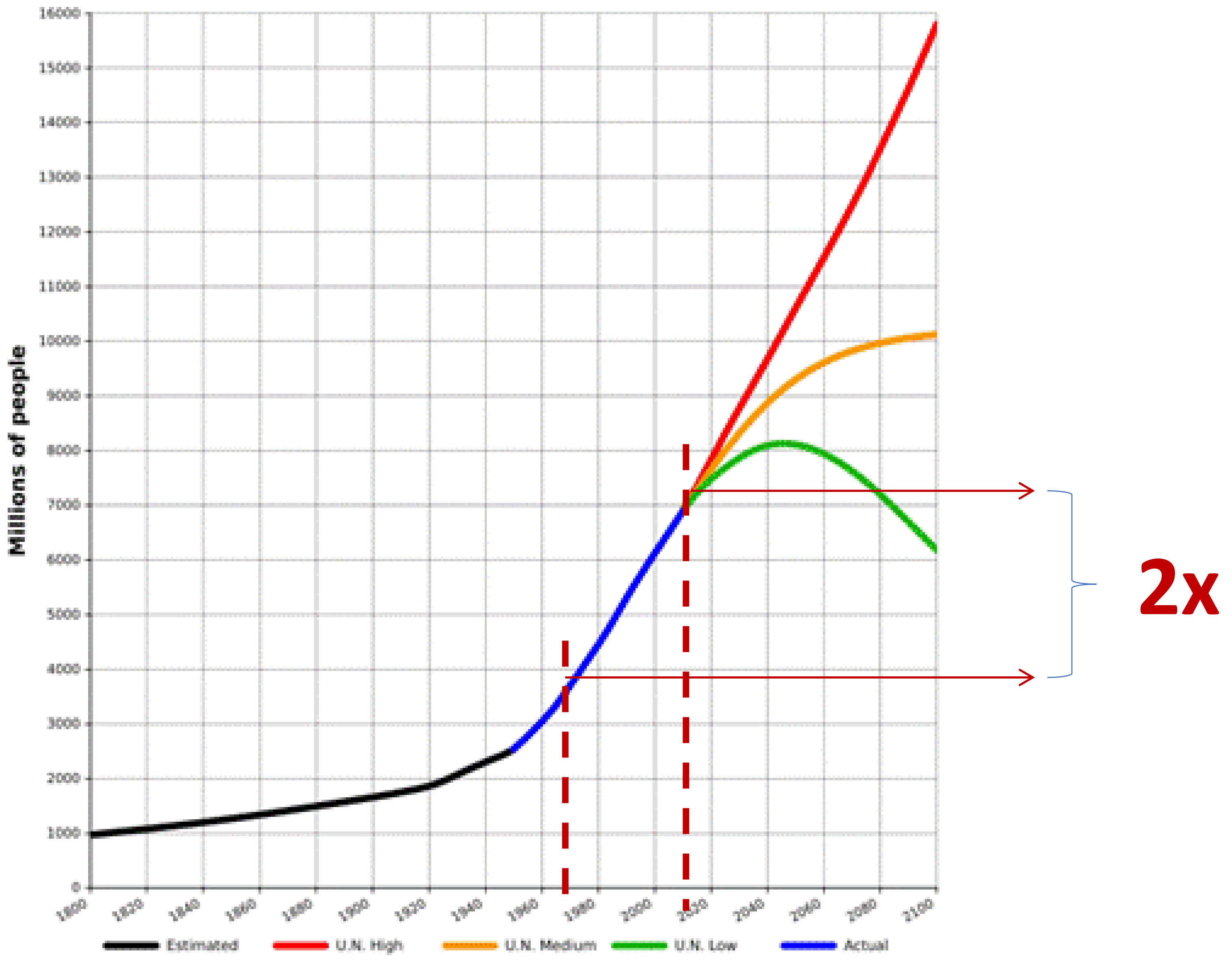
For every truck of plastic in the ocean…



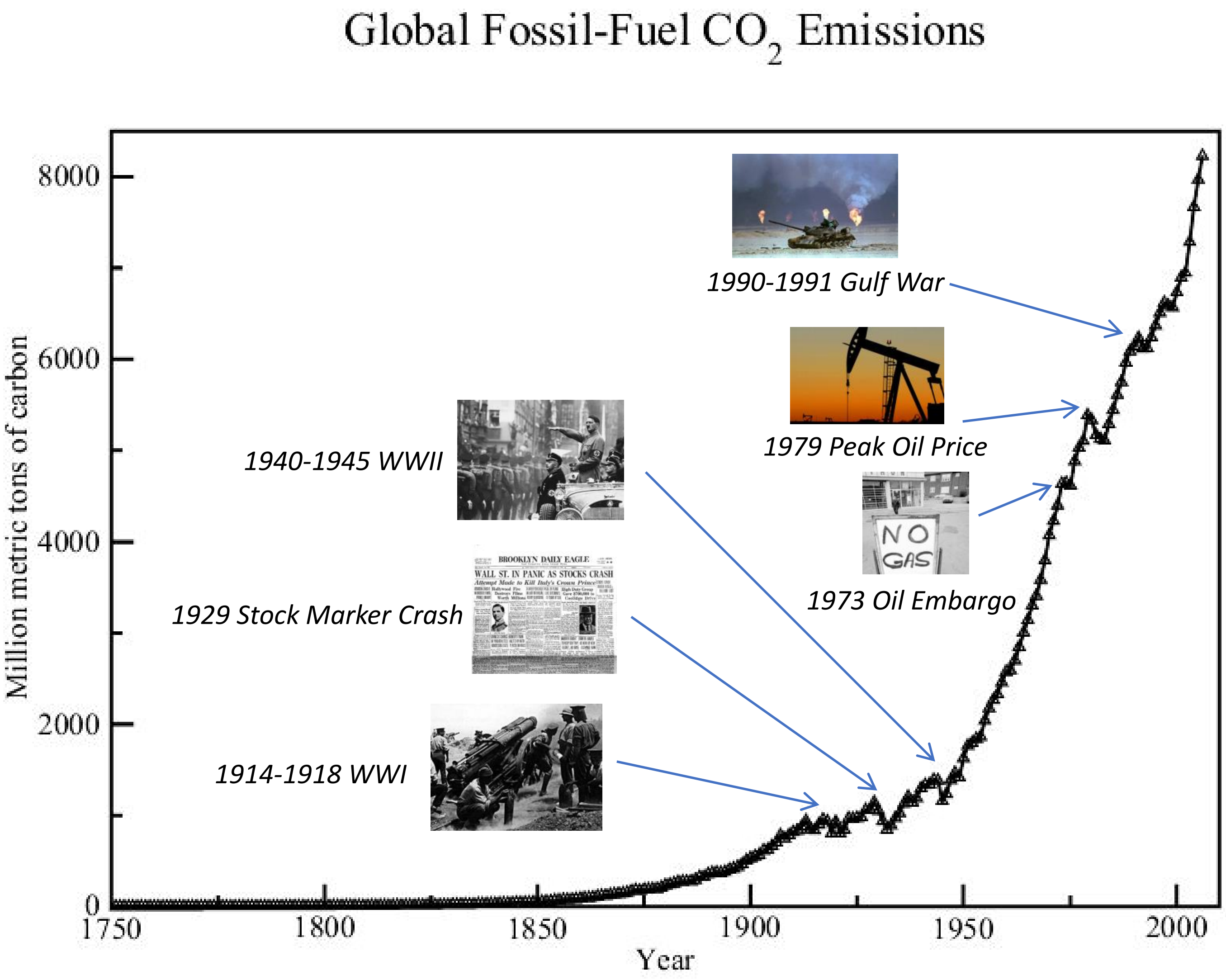
… 114 trucks of?

A clue?

Cause: human demography



Energy = carbon dioxide (CO_2)



Symptoms

Global warming

Catastrophic events

Ice melting

Sea level rise

Hypoxia

Salinity changes

Ocean acidification

Ocean acidification is chemistry…

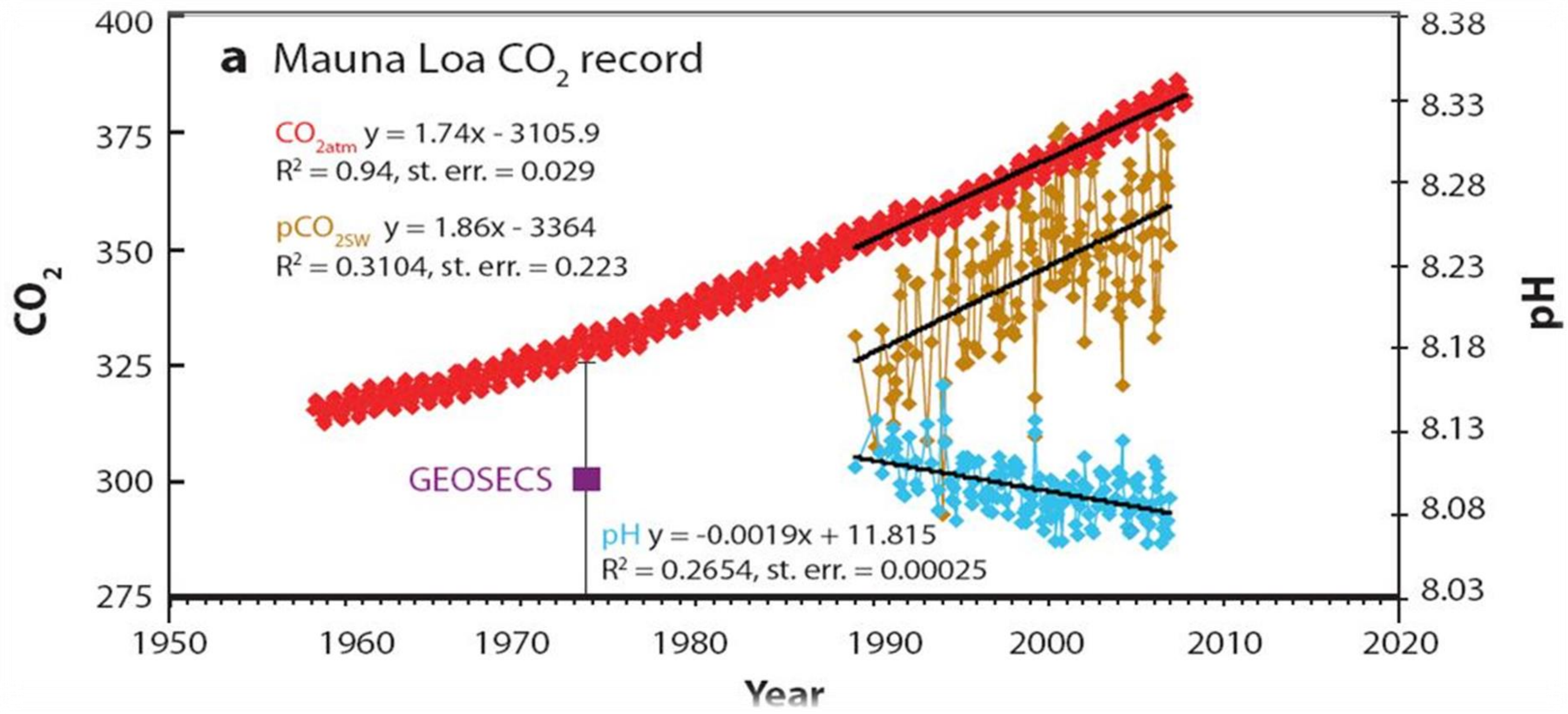
… not conjecture

$$CO_2$$

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

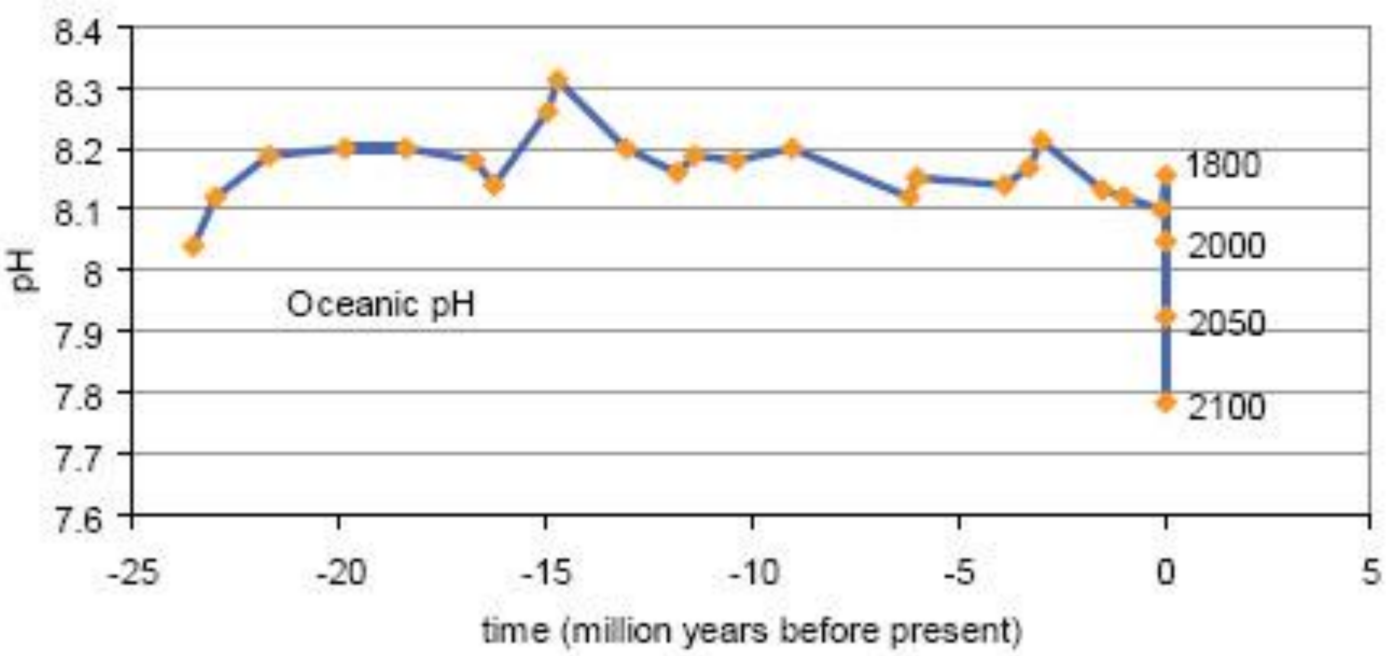
Carbon dioxide	Water	Carbonic acid

Ocean acidification is happening now



Doney et al. (2009)

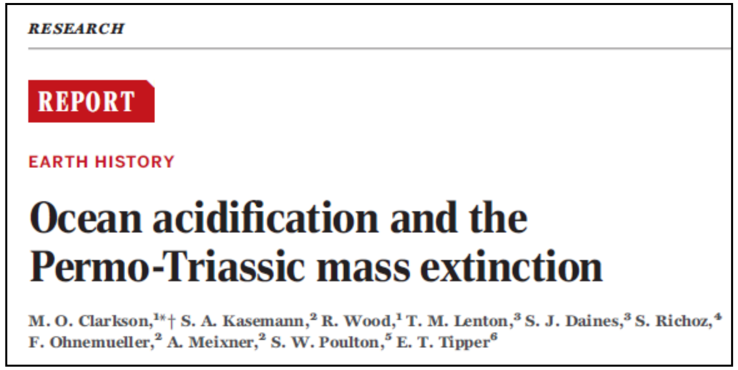
Fast and strong



Ocean 2x more acidic by 2100

Ocean acidification is a real, fast and directly related to our CO_2 emissions

Last ocean acidification event: the third extinction

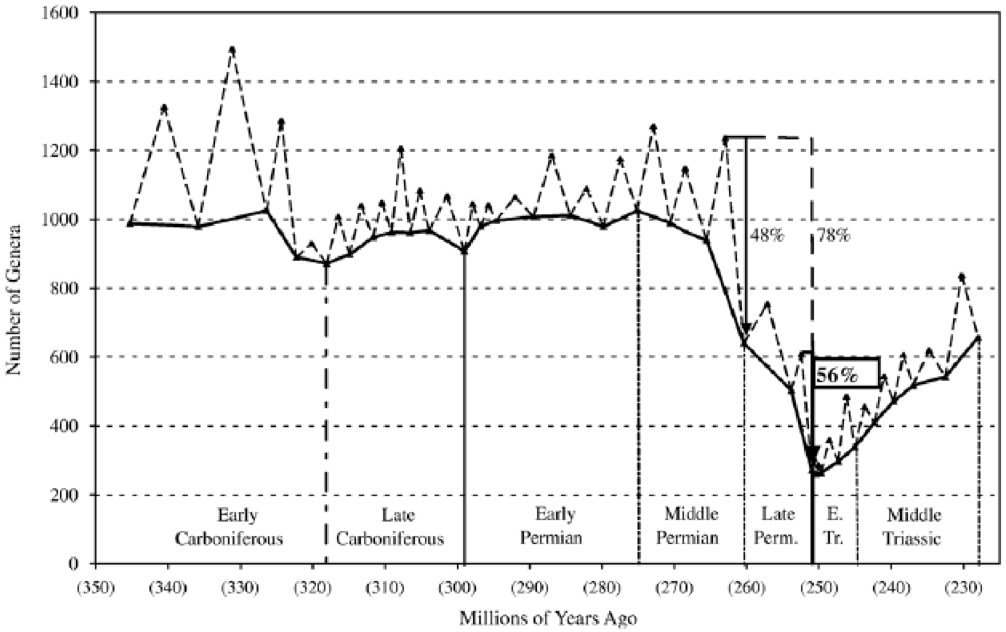

RESEARCH

REPORT

EARTH HISTORY

Ocean acidification and the Permo-Triassic mass extinction

M. O. Clarkson,[1*†] S. A. Kasemann,[2] R. Wood,[1] T. M. Lenton,[3] S. J. Daines,[3] S. Richoz,[4] F. Ohnemueller,[2] A. Meixner,[2] S. W. Poulton,[5] E. T. Tipper[6]

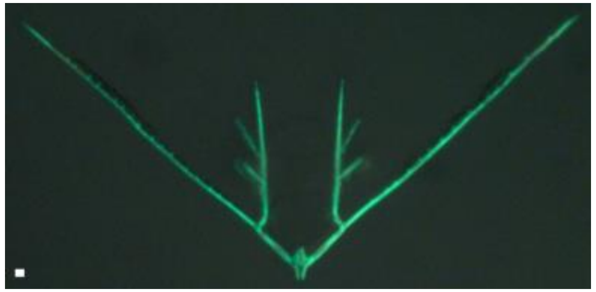


(Knoll et al. 2007)

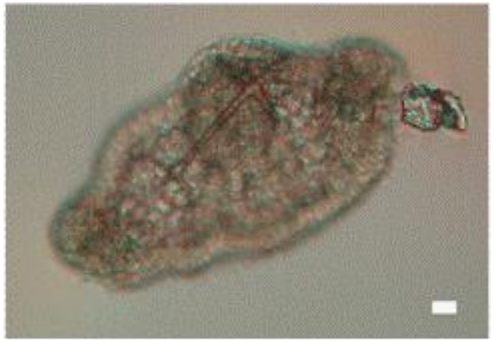
Extinction of 92% of all marine species

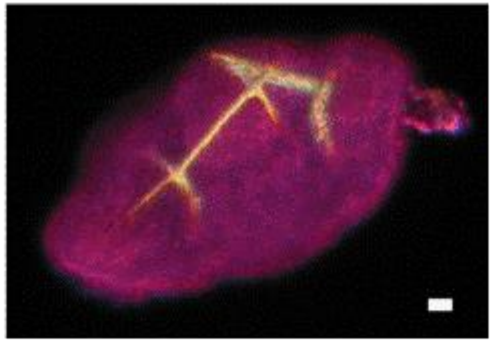
Can lead to species extinction

8.1



7.9





(Dupont et al. 2008)

Challenge marine ecosystems

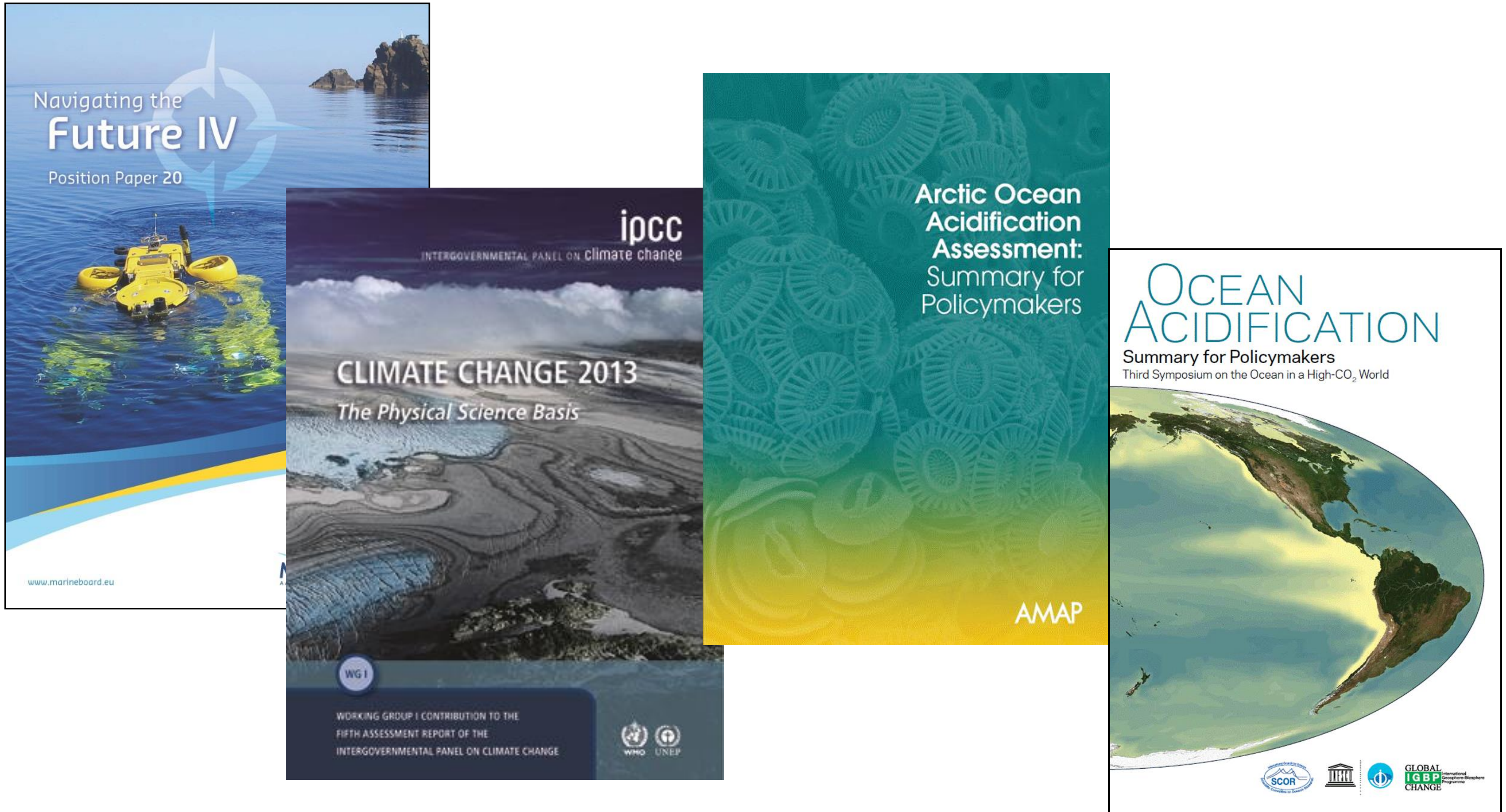
50% of marine animals threaten by ocean acidification

(Wittmann & Pörtner 2013)

It is already happening

Impact aquaculture and industry

Scientists are "virtually certain" that ocean acidification will lead to dramatic consequences



SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

1 NO POVERTY

2 ZERO HUNGER

3 GOOD HEALTH AND WELL-BEING

4 QUALITY EDUCATION

5 GENDER EQUALITY

6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

10 REDUCED INEQUALITIES

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

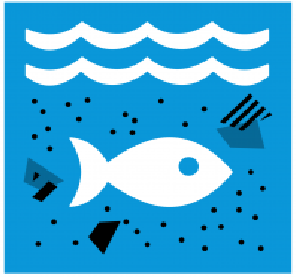
17 PARTNERSHIPS FOR THE GOALS

SUSTAINABLE DEVELOPMENT GOALS

SUSTAINABLE DEVELOPMENT GOAL 14

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

TARGET 14·1

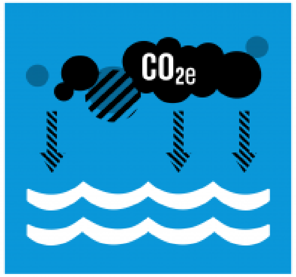


REDUCE MARINE POLLUTION

TARGET 14·2

PROTECT AND RESTORE ECOSYSTEMS

TARGET 14·3



REDUCE OCEAN ACIDIFICATION

TARGET 14·4

SUSTAINABLE FISHING

TARGET 14·5

CONSERVE COASTAL AND MARINE AREAS

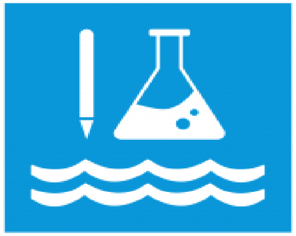
TARGET 14·6

END SUBSIDIES CONTRIBUTING TO OVERFISHING

TARGET 14·7

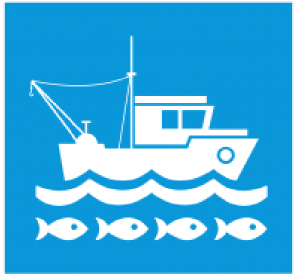
INCREASE THE ECONOMIC BENEFITS FROM SUSTAINABLE USE OF MARINE RESOURCES

TARGET 14·A



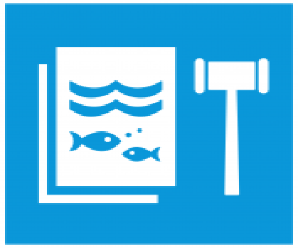
INCREASE SCIENTIFIC KNOWLEDGE, RESEARCH AND TECHNOLOGY FOR OCEAN HEALTH

TARGET 14·B

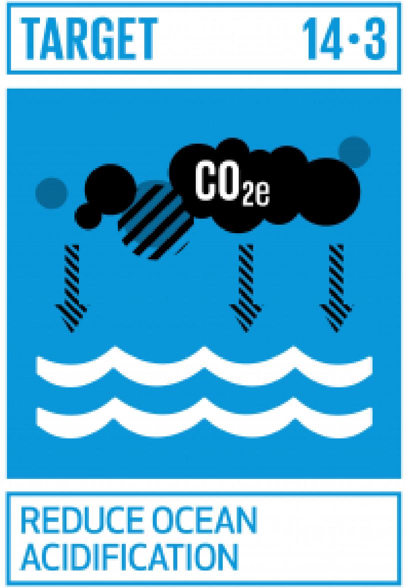


SUPPORT SMALL SCALE FISHERS

TARGET 14·C



IMPLEMENT AND ENFORCE INTERNATIONAL SEA LAW



Target 14.3
Minimize and address the impacts of **ocean acidification**, including through enhanced scientific cooperation at all levels

What can we do?

Fight?

Flight?

or nothing?

- NOTHING: Face to the consequences
- FIGHT: Mitigation - Work on the cause (decrease CO_2)
- FLIGHT: Adaptation - Work on the symptoms (buy some time)

A problem of scale

GLOBAL challenges

GLOBAL options: ↓ CO_2

GLOBAL/LOCAL data

Mitigation

Mitigation: We know what to do

Demography

CO_2 emissions

WHY NO MORE ACTIONS???

Told you so !

2008

Vol. 373: 285–294, 2008
doi: 10.3354/meps07800
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published December 23

Contribution to the Theme Section 'Effects of ocean acidification on marine ecosystems'

OPEN ACCESS

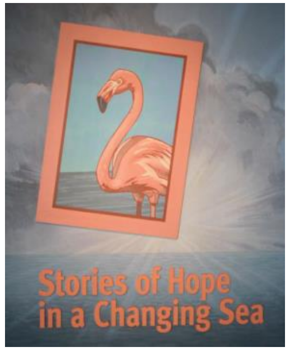
Near-future level of CO_2-driven ocean acidification radically affects larval survival and development in the brittlestar *Ophiothrix fragilis*

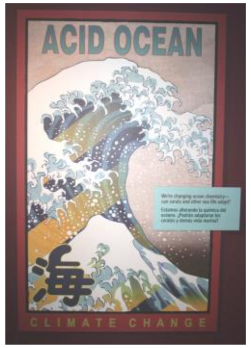
Sam Dupont[1,*], Jon Havenhand[2], William Thorndyke[1], Lloyd Peck[3], Michael Thorndyke[1,4]

Our data show that small changes in pH as low as the 0.2 unit decrease predicted for the coming few decades (Caldeira & Wickett 2003, 2005) can have dramatic consequences for larval development and survival of key species. Our results for the brittlestar *Ophiothrix fragilis* clearly show that such changes could threaten the long-term viability of the species. Whether other species of marine inverte-

2010

MONTEREY BAY AQUARIUM

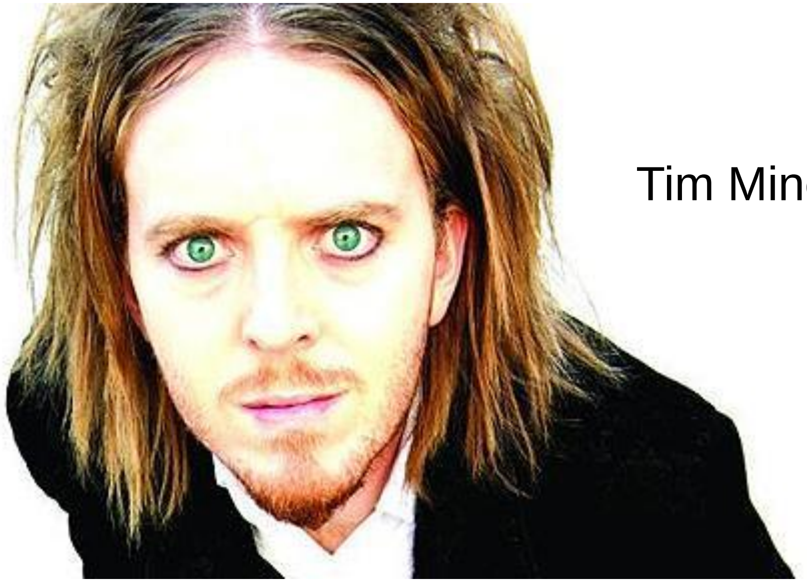




2022

Gone, baby, gone

A failure to communicate?



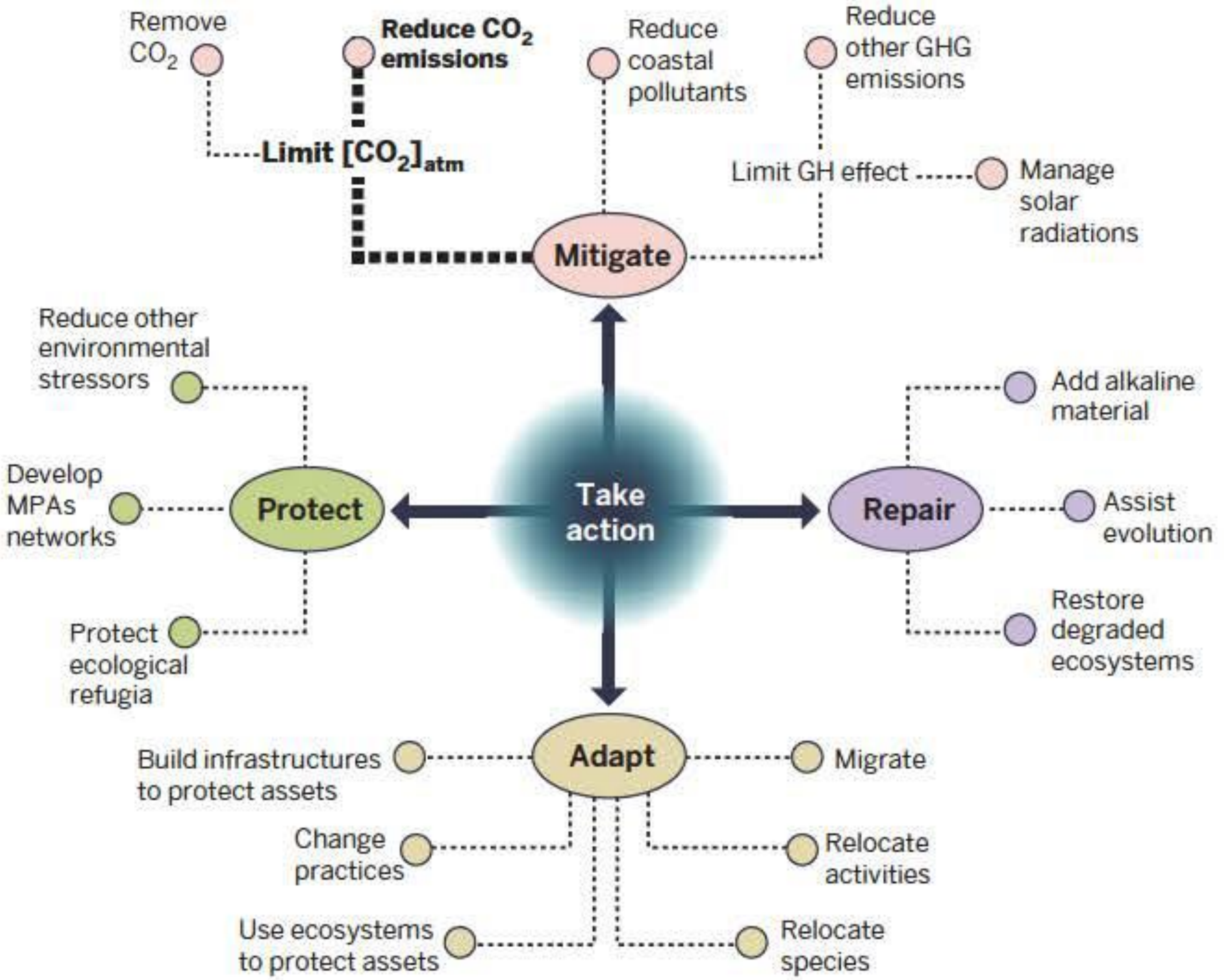
Tim Minchin

The idea that (...) the science of anthropogenic global warming is controversial is a powerful indicator of the extent of our failure to communicate.


KEN CALDEIRA
on Inquiring Minds
"People have to sacrifice a little bit of their short term self interest to help the world be a better place for the long term. And how you get people to do that, I think, is the most important research that can be done."
@inquiringshow

Adaptation

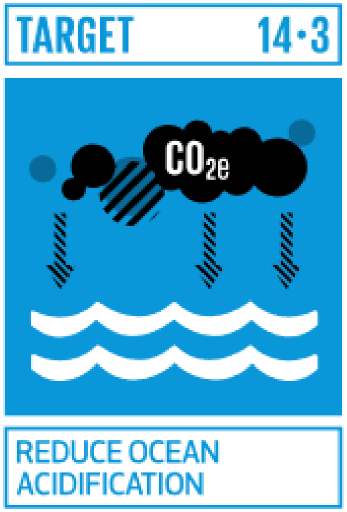
Actions


Remove CO_2
Reduce CO_2 emissions
Reduce coastal pollutants
Reduce other GHG emissions
Limit $[CO_2]_{atm}$
Limit GH effect
Manage solar radiations
Mitigate
Reduce other environmental stressors
Develop MPAs networks
Protect
Protect ecological refugia
Take action
Add alkaline material
Repair
Assist evolution
Restore degraded ecosystems
Adapt
Build infrastructures to protect assets
Migrate
Change practices
Relocate activities
Use ecosystems to protect assets
Relocate species

We need both to address (mitigation) and minimize (adaptation)

- ✓ Mitigation will take some time
- ✓ Adaptation buy some time

What data do we need to address and minimize?



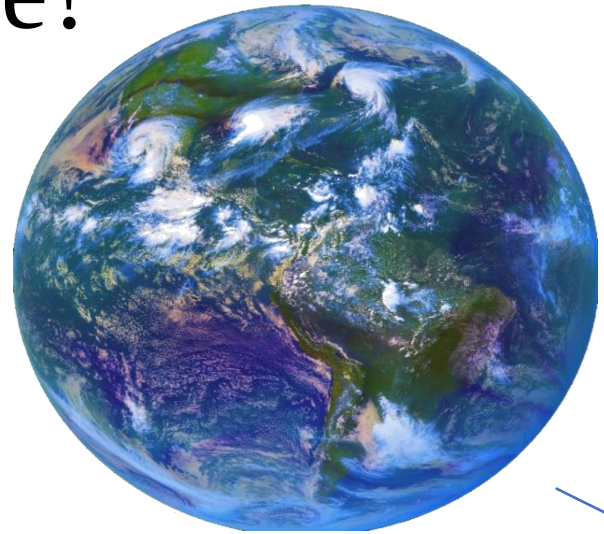
Target 14.3
Minimize and address the impacts of **ocean acidification**, including through enhanced scientific cooperation at all levels

Indicator 14.3.1
Average marine acidity (pH) measured at agreed suite of representative sampling stations

Irrelevant indicator !

- ✓ Does not allow to characterize ocean acidification
- ✓ Would lead to low quality data (no quality control)
- ✓ Biologically irrelevant

What data do we need to address and minimize?



GLOBAL challenges

GLOBAL options: ⬇ CO_2

MITIGATION

GLOBAL & LOCAL

LOCAL challenges

LOCAL options

LOCAL

ADAPTATION

How do we collect those data?

- ✓ Monitoring
- ✓ Modeling
- ✓ Paleo
- ✓ Field (e.g. natural analogs, gradients)
- ✓ Field experiments
- ✓ Laboratory experiments
- ✓ Etc.

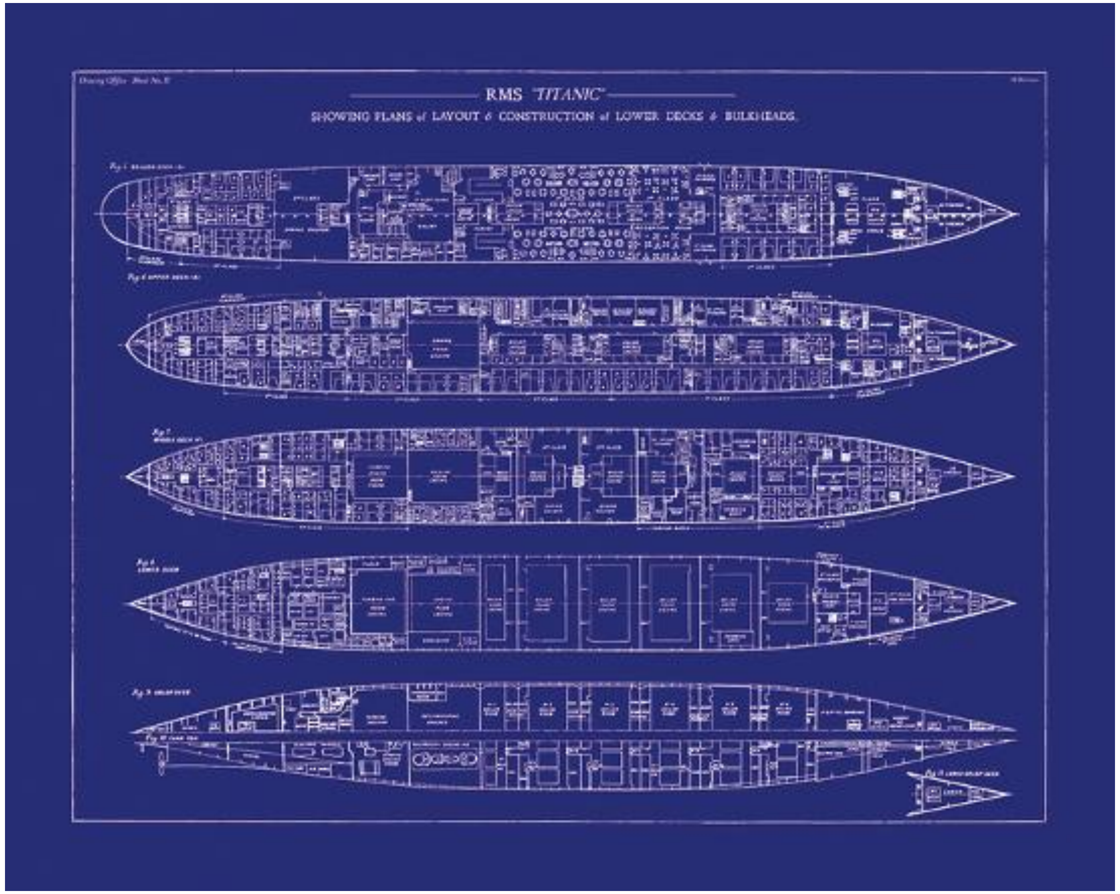
What is the best approach?

- ✓ A good question cannot be answered using only one approach…
  … or one experiment
  ➡ *Importance of a strategy*

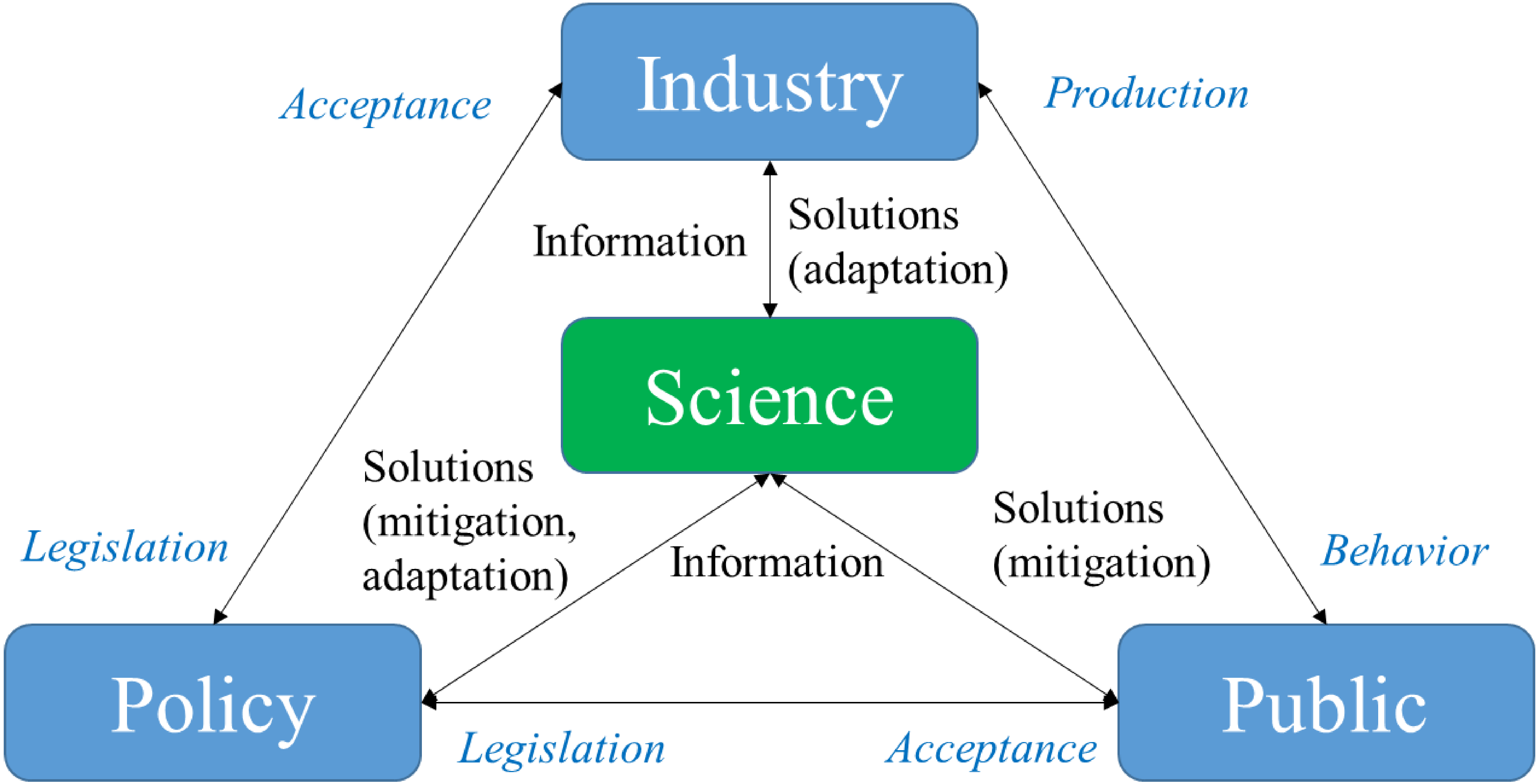
- ✓ All experiments are an abstraction of reality (and then ”wrong”)
  ➡ *Importance of diversity (and honnesty)*


House is on fire !
Priorities !

Need to prioritize



What (data) is important FOR YOU?



Read read read

Read the literature ! or ask experts

… not only specific literature…

[Theoretical background, methods, etc.]

Standing on the shoulders of giants

Doing the right thing: What shall I do?

- ✓ What are my local key services challenges by OA
- ✓ What are the solutions to minimize and address?

→ *Question*

Doing the right thing: What shall I do?

- ✓ What are my local key services challenges by OA
- ✓ What are the solutions to minimize and address?

→ *Question*

- ✓ What data do I need?
- ✓ How can I collect those?

→ *Strategy*

Doing the right thing: What shall I do?

- ✓ What are my local key services challenges by OA
- ✓ What are the solutions to minimize and address?

  ➡ *Question*

- ✓ What data do I need?
- ✓ How can I collect those?

  ➡ *Strategy*

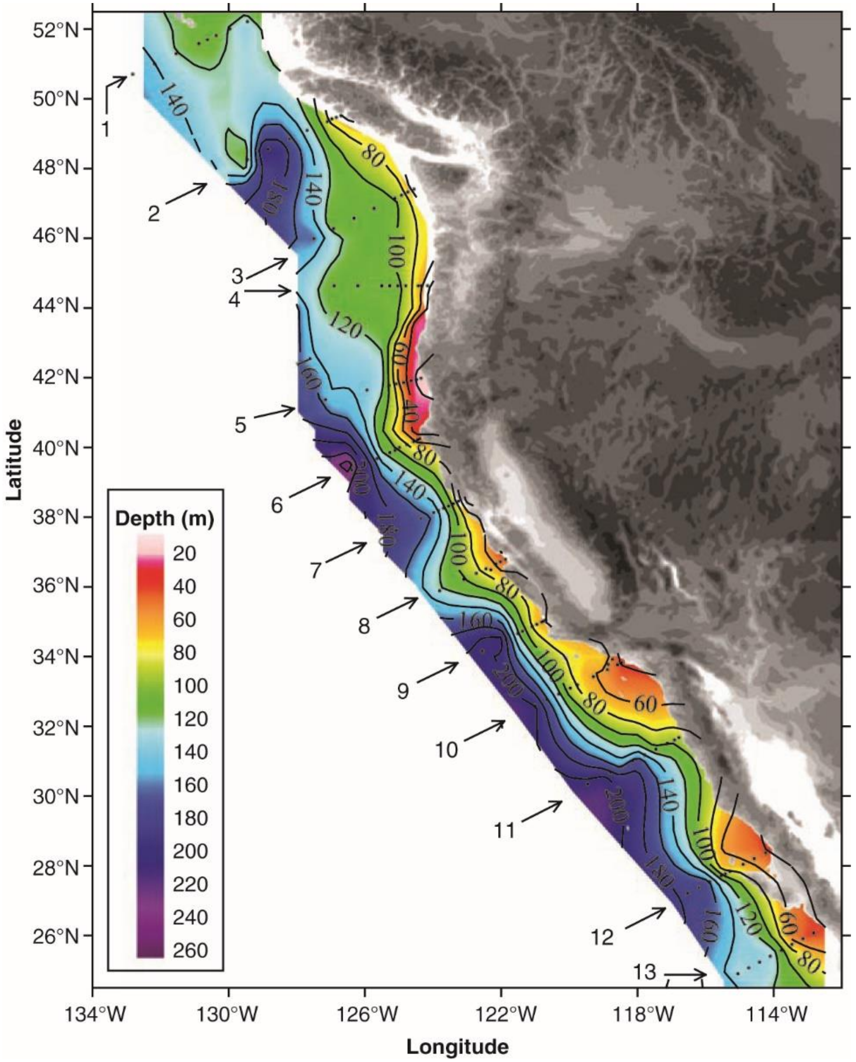
- ✓ What monitoring / experiment(s) need to be done?

  ➡ *Design*

Case study #1 – Oyster aquaculture in the USA

Problem: Not possible to produce spats in hatcheries
-> No production, no money, no jobs

Step 1 – Diagnosis: what is the problem?



Feely et al. 2008

Cause: Ocean acidification

Combined with upwelling

Step 2 – Diagnosis: what is the source?

Environ. Res. Lett. **14** (2019) 124060 https://doi.org/10.1088/1748-9326/ab5abc

Environmental Research Letters

LETTER

Attributing ocean acidification to major carbon producers

R Licker[1], B Ekwurzel[1], S C Doney[2,3], S R Cooley[4], I D Lima[3], R Heede[5] and P C Frumhoff[6]

<u>Cause</u>: CO_2 emissions

Step 3.1 – Diagnosis: What are the solutions?

Solution: *Mitigation*

- ✓ Policy
- ✓ Change
- ✓ Acceptance

Citizen

Problem: Inefficient (time scale)

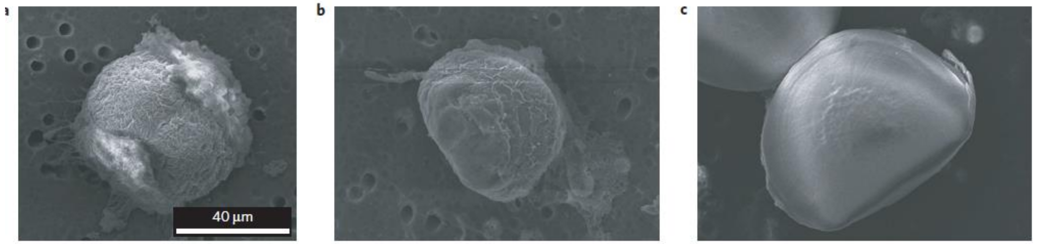
Step 3.2 – Diagnosis: What are the solutions?

Solution: *Adaptation*

= Change aquaculture practices to make it more resilient to ocean acidification

Step 4 – Data collection (experiment)

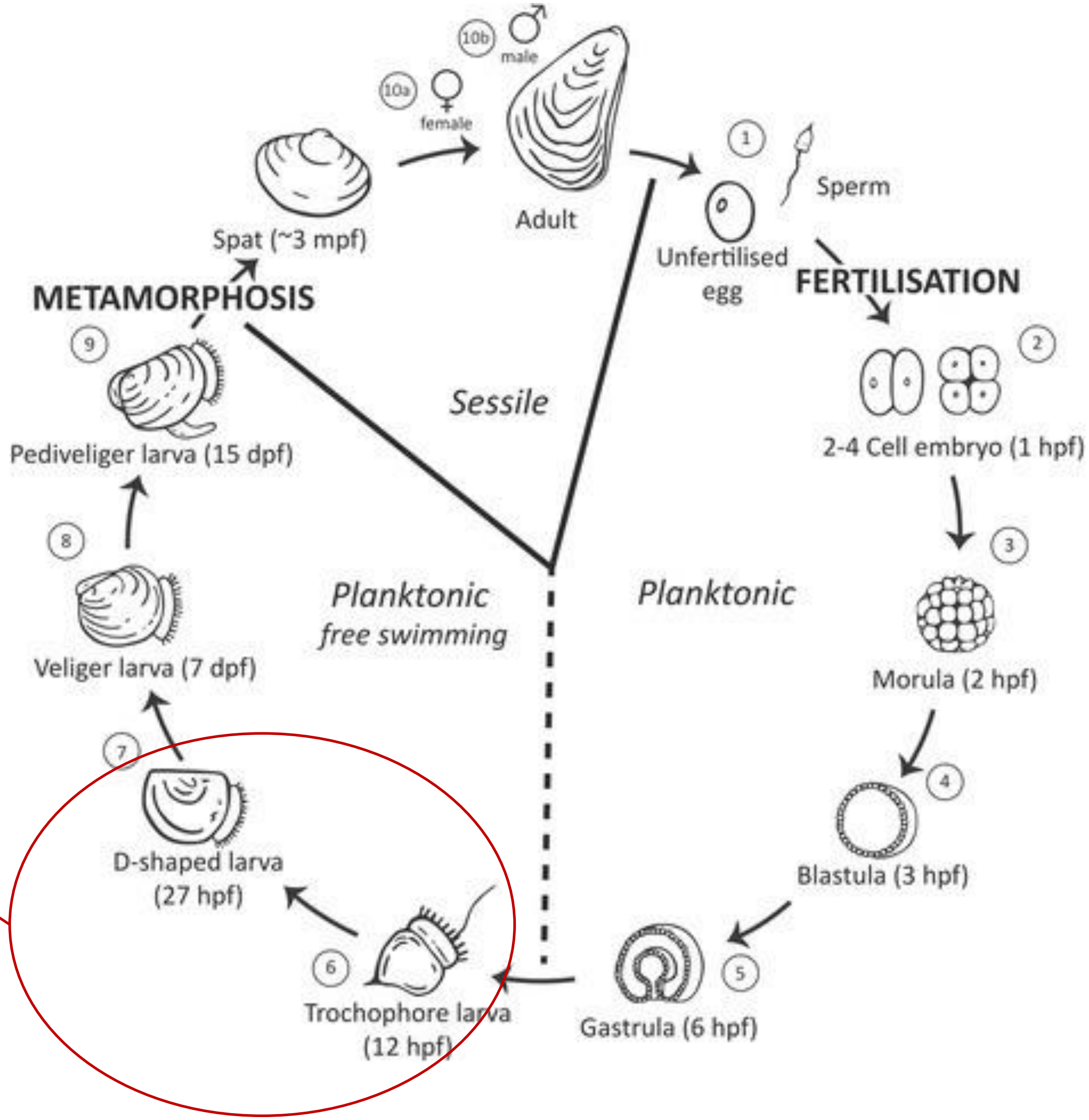
Window of opportunity
-> keep conditions good
over that period



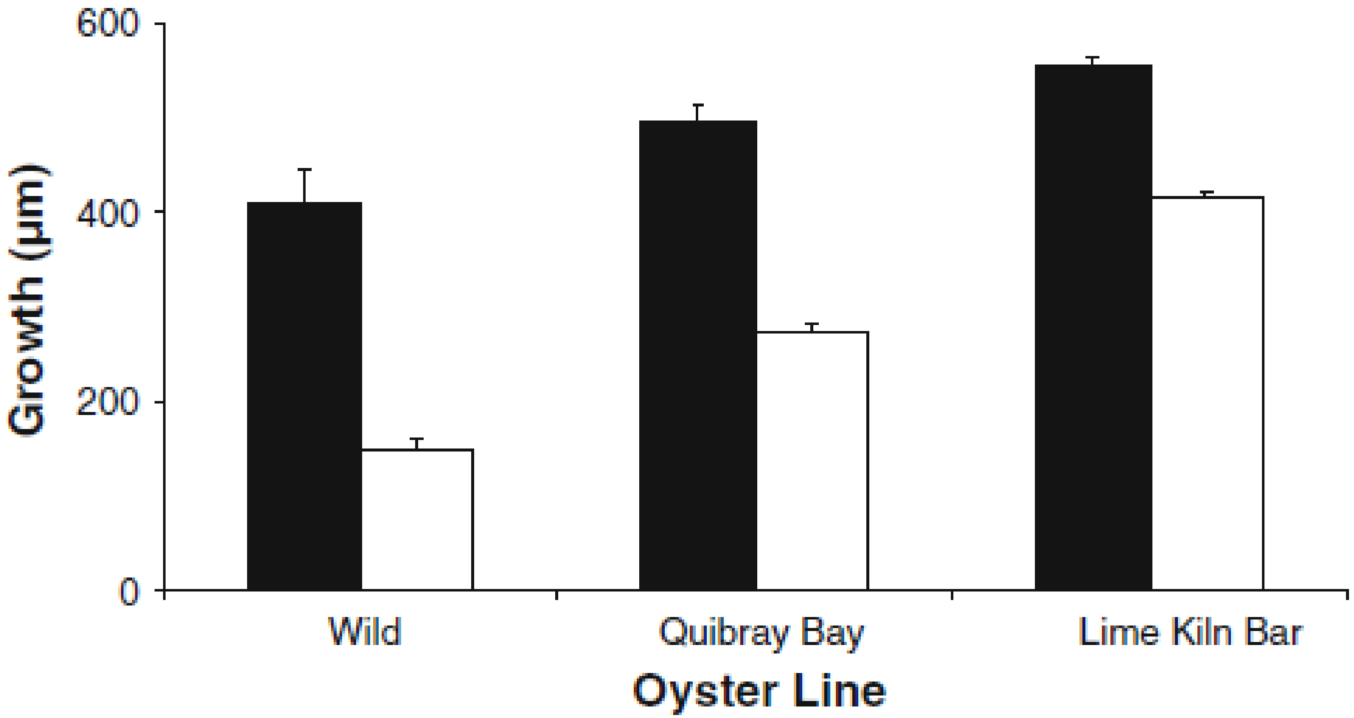
nature climate change
ARTICLES
PUBLISHED ONLINE: 15 DECEMBER 2014 | DOI: 10.1038/NCLIMATE2479

Saturation-state sensitivity of marine bivalve larvae to ocean acidification

George G. Waldbusser[1]*, Burke Hales[1], Chris J. Langdon[2], Brian A. Haley[1], Paul Schrader[2], Elizabeth L. Brunner[1], Matthew W. Gray[2], Cale A. Miller[3] and Iria Gimenez[1]



Step 4 – Data collection (experiment)



Positive genetic correlation: fast growing strains are more resilient:
-> Use resilient strains

Mar Biol
DOI 10.1007/s00227-010-1592-4

ORIGINAL PAPER

Populations of the Sydney rock oyster, *Saccostrea glomerata*, vary in response to ocean acidification

L. M. Parker · Pauline M. Ross · Wayne A. O'Connor

Case study #1 – Oyster aquaculture in the USA

- ✓Problem: ocean acidification
- ✓ Cause: CO_2 emissions
- ✓ Solution: Mitigation – but need to buy some time
- ✓ Solution: Adaptations – change of practices

Back to business (for now)

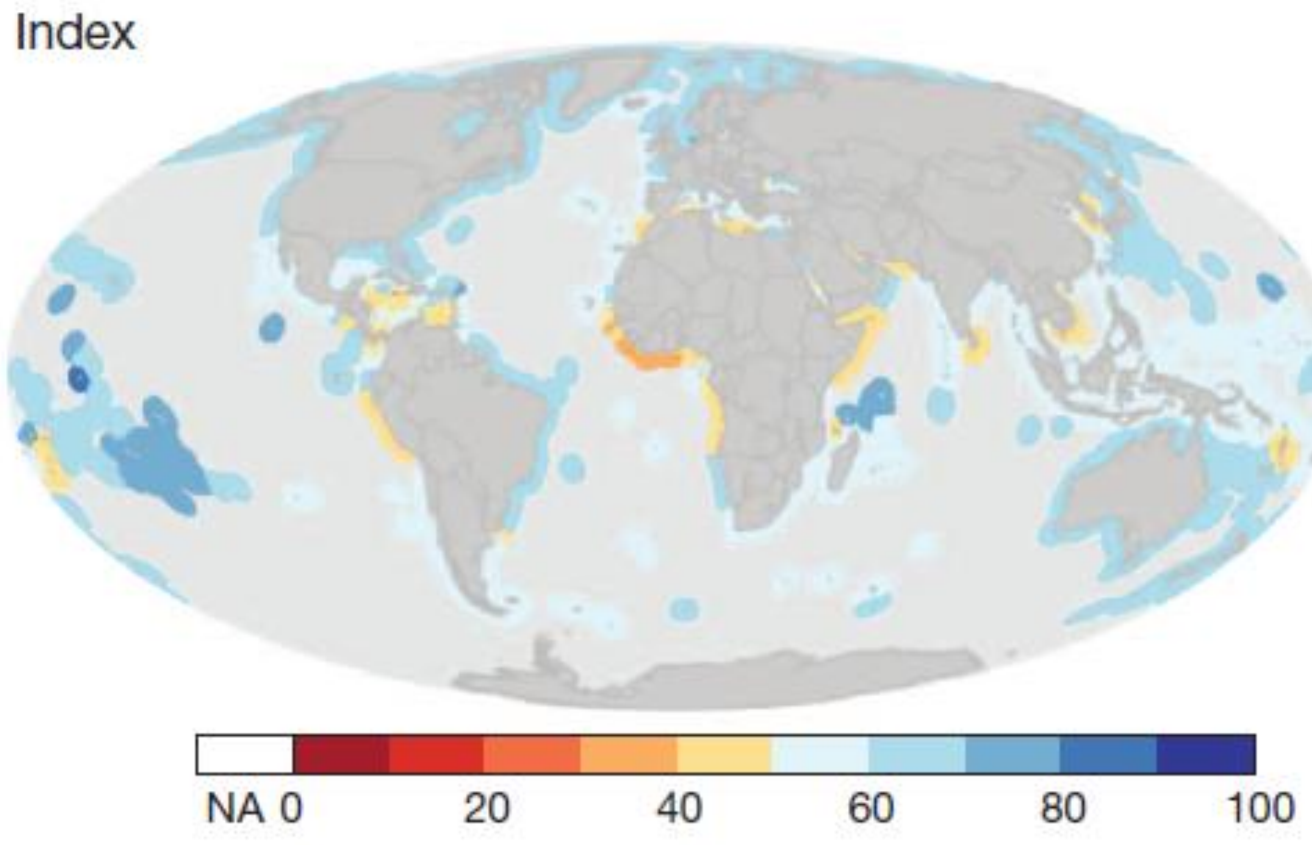
Case study #2 – Global ocean health

ARTICLE

doi:10.1038/nature11397

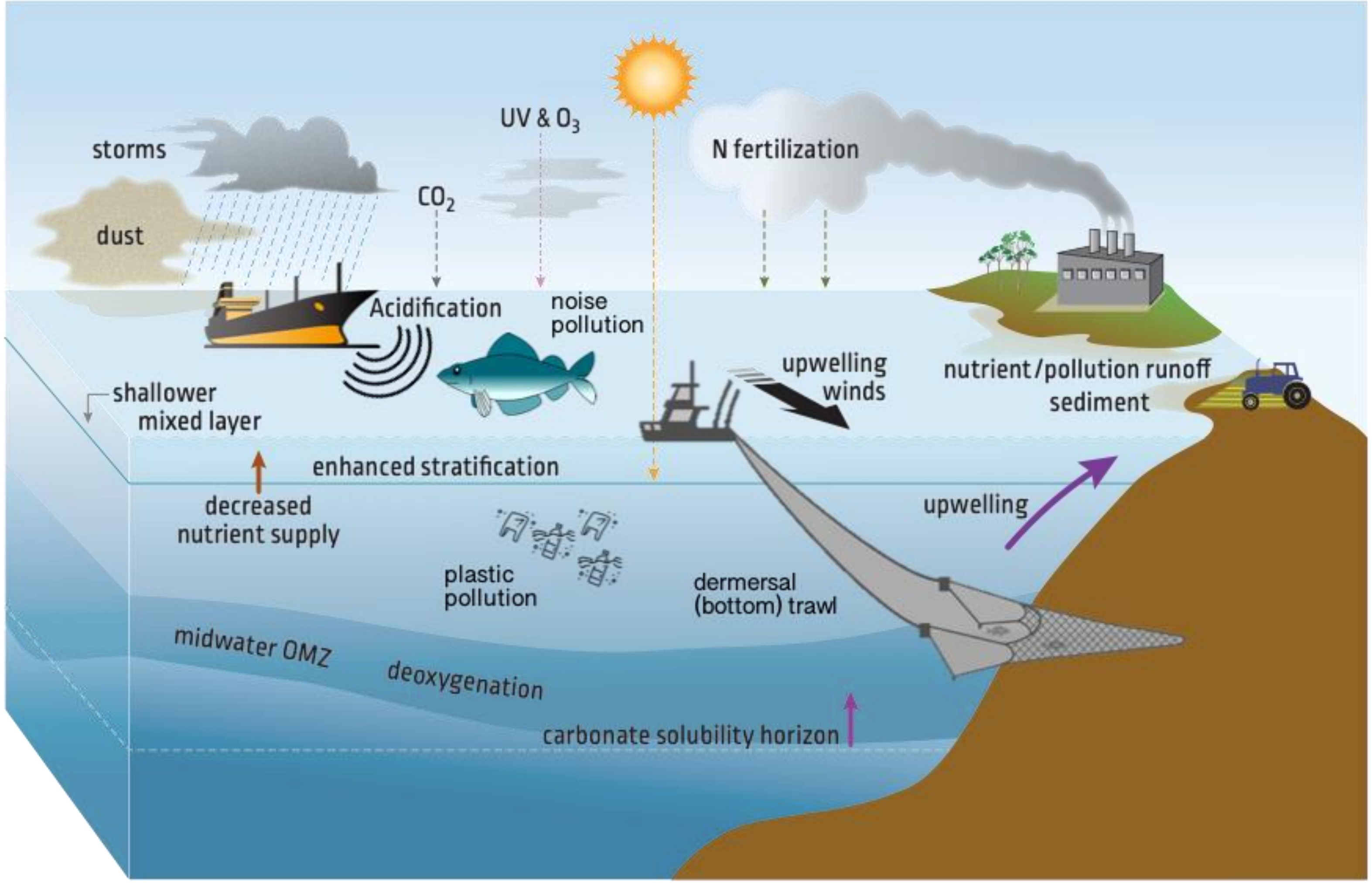
An index to assess the health and benefits of the global ocean

Benjamin S. Halpern[1,2], Catherine Longo[1], Darren Hardy[1], Karen L. McLeod[3], Jameal F. Samhouri[4], Steven K. Katona[5], Kristin Kleisner[6], Sarah E. Lester[7,8], Jennifer O'Leary[1], Marla Ranelletti[1], Andrew A. Rosenberg[5], Courtney Scarborough[1], Elizabeth R. Selig[5], Benjamin D. Best[9], Daniel R. Brumbaugh[10], F. Stuart Chapin[11], Larry B. Crowder[12], Kendra L. Daly[13], Scott C. Doney[14], Cristiane Elfes[15,16], Michael J. Fogarty[17], Steven D. Gaines[8], Kelsey I. Jacobsen[8], Leah Bunce Karrer[5], Heather M. Leslie[18], Elizabeth Neeley[19], Daniel Pauly[6], Stephen Polasky[20], Bud Ris[21], Kevin St Martin[22], Gregory S. Stone[5], U. Rashid Sumaila[6] & Dirk Zeller[6]



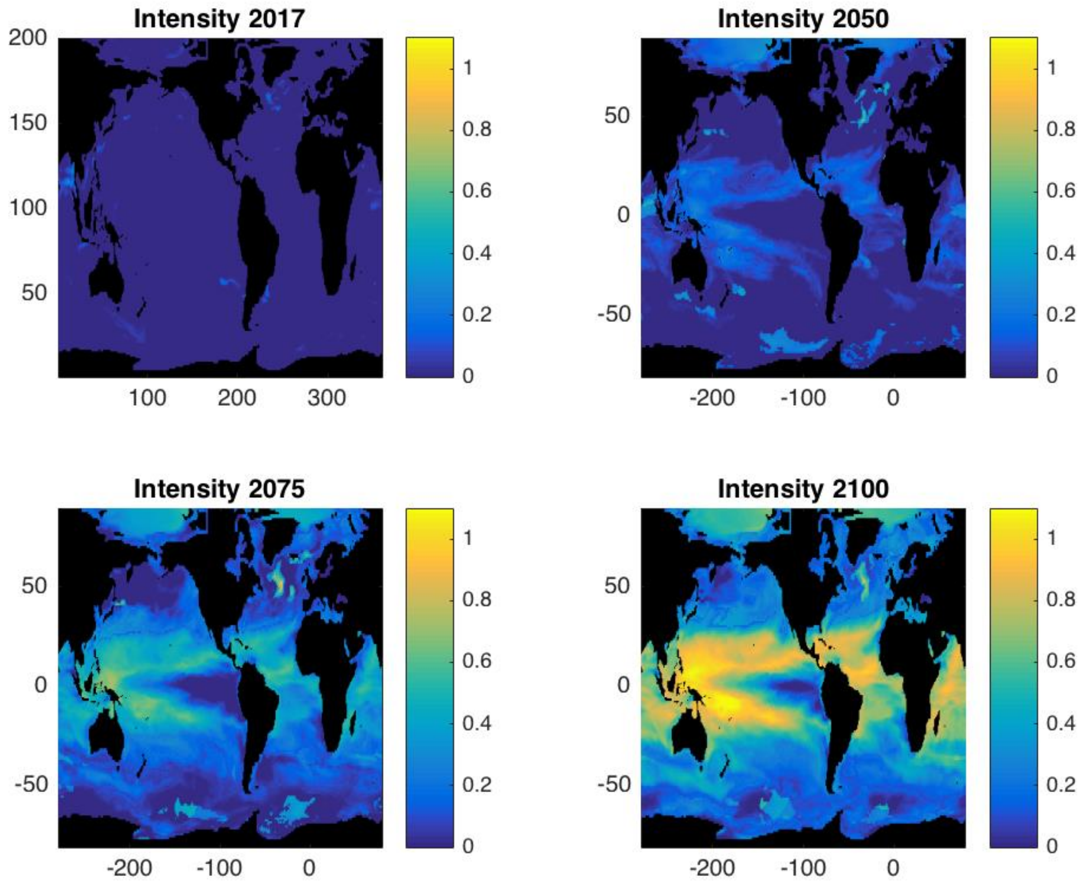
OHi = 60% [36-86]

Step 1 – Diagnosis: multiple stressors

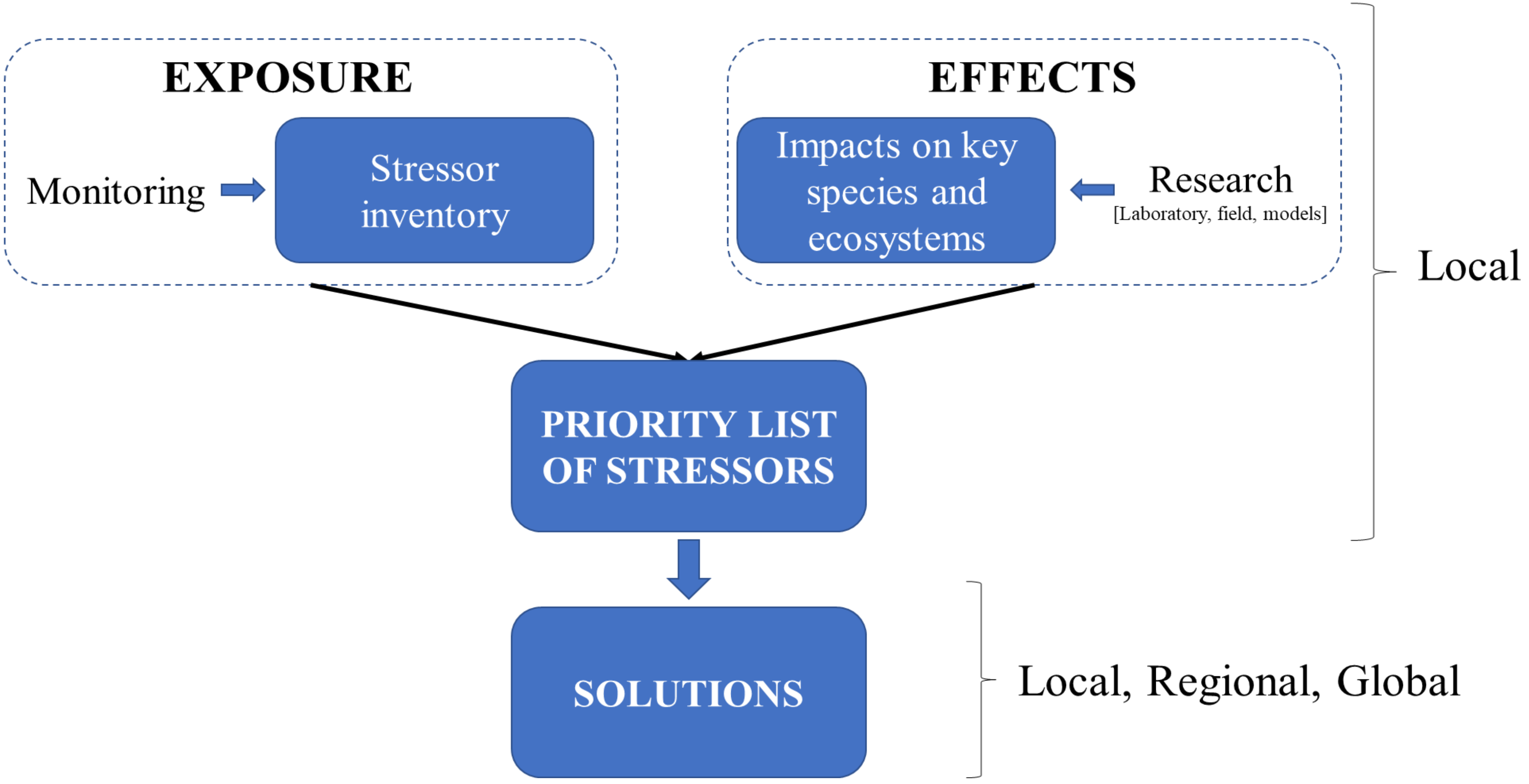


Step 2 – Solution: Science based management

Need to develop projection / forecasting for key regions / services



Step 3 – Data needs: Define (LOCAL) priorities and sources



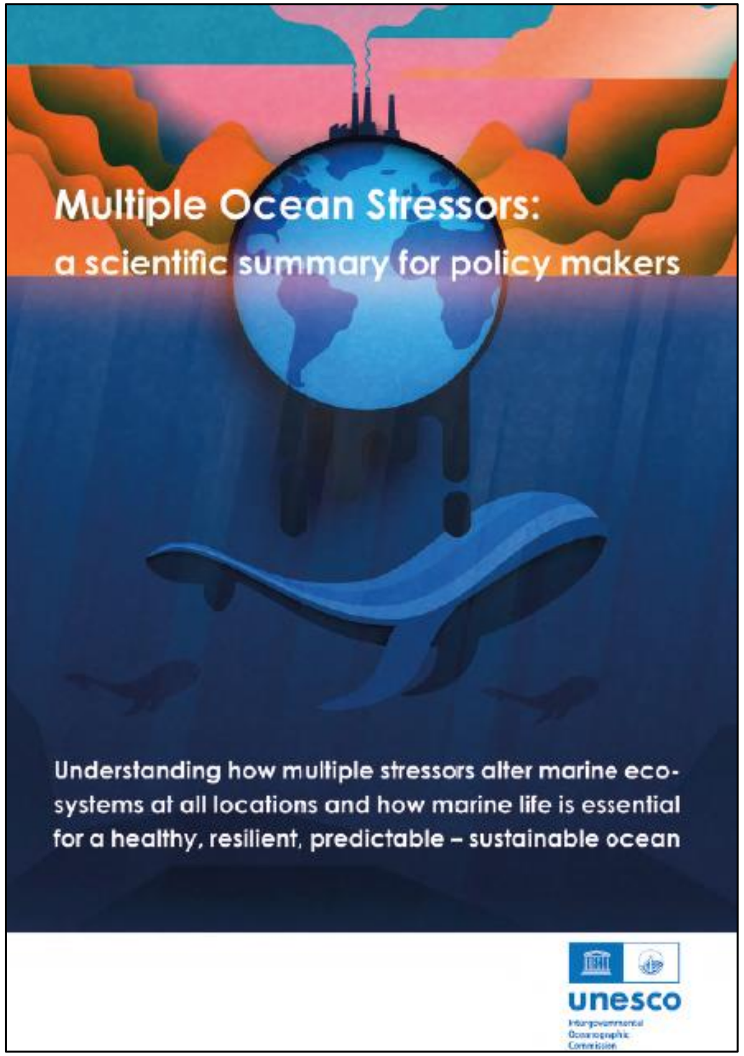
Identify priorities – now and then

Identify priorities – now and then

Step 4 – Diagnosis: poor scientific understanding of combined effects

$$A + B \neq C$$

Step 5 – Solution: multiple stressor understanding



Scientific strategy
(and complex designs)

Case study #2 – Global ocean health

- ✓Problem: Poor ecosystem health
- ✓ Cause: Multiple local and global pressures
- ✓ Solution: Forecasting – Science-based management
- ✓Gap: poor understanding on how drivers work in combination

Research priority & strategy

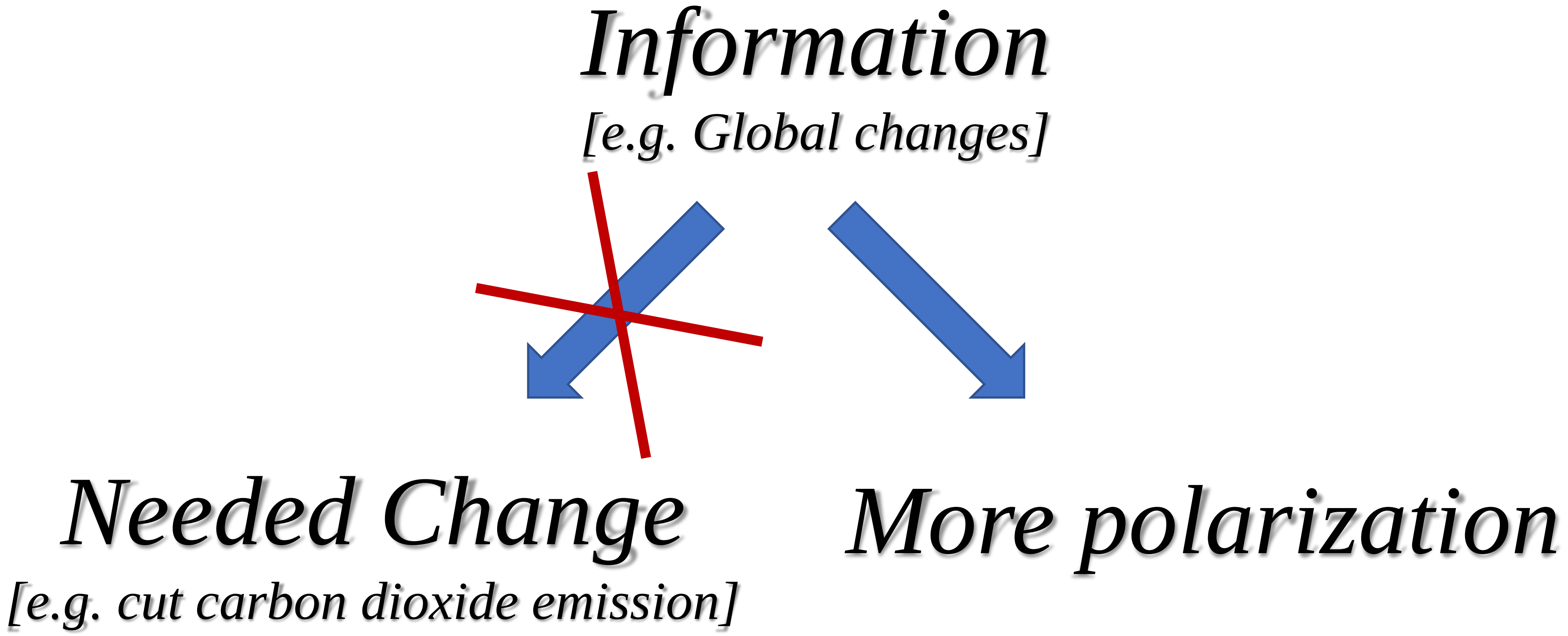
Case study #3 – Mitigation through societal changes

Demography

CO_2 emissions

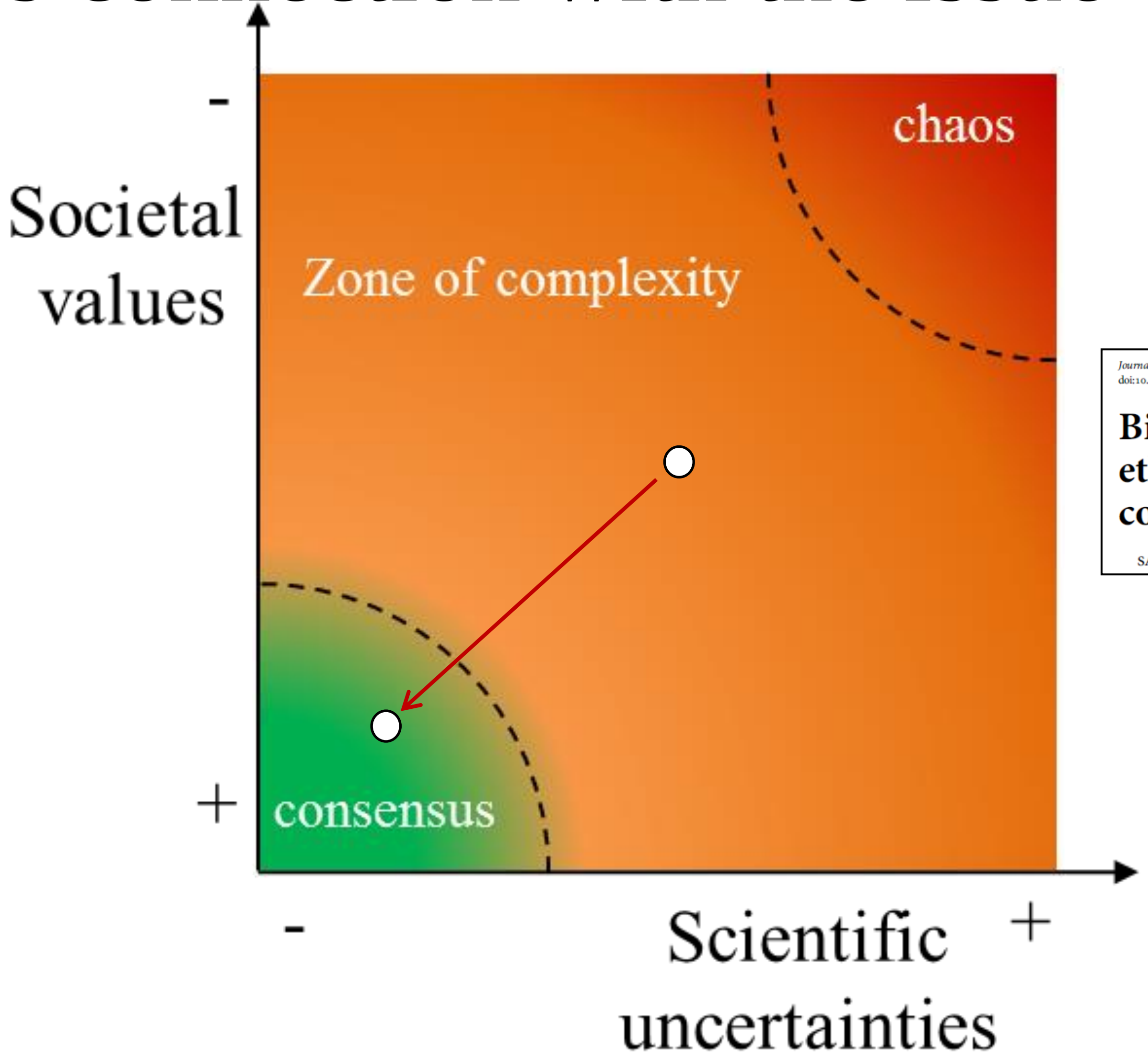
WHY NO MORE ACTIONS???

Step 1 – Diagnosis: science fails to drive change



(Dupont & Fauville 2017)

Step 2 – Solution: prioritize science that drives connection with the issue



Journal of the Marine Biological Association of the United Kingdom, page 1 of 2.
doi:10.1017/S0025315415000193

Bird is the word – on the importance of ethical and effective scientific communication

SAM DUPONT[1], GREGORY PUNCHER[2] AND PIERO CALOSI[3]

What do you care about? E.g. seafood

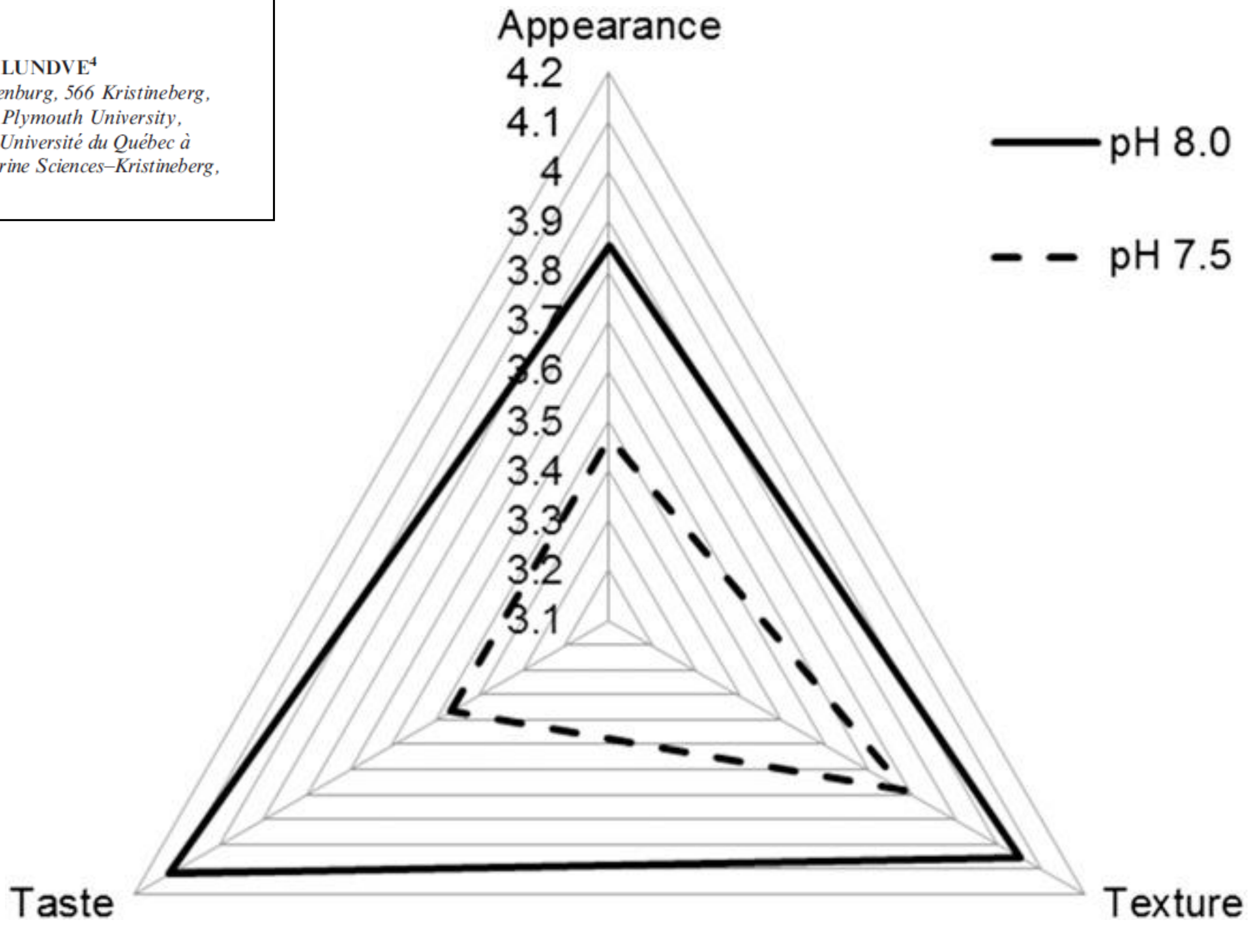
Simple experiment: You can taste ocean acidification

Journal of Shellfish Research, Vol. 33, No. 3, 857–861, 2014.

FIRST EVIDENCE OF ALTERED SENSORY QUALITY IN A SHELLFISH EXPOSED TO DECREASED pH RELEVANT TO OCEAN ACIDIFICATION

SAM DUPONT,[1]* EMILIE HALL,[2] PIERO CALOSI[2,3] AND BENGT LUNDVE[4]

[1]*Department of Biological and Environmental Sciences, University of Gothenburg, 566 Kristineberg, Fiskebäckskil 45178, Sweden;* [2]*School of Marine Science and Engineering, Plymouth University, Plymouth PL4 8AA, UK;* [3]*Département de Biologie, Chimie et Géographie, Université du Québec à Rimouski, Rimouski QC G5L 3A1, Canada;* [4]*The Sven Lovén Centre for Marine Sciences–Kristineberg, University of Gothenburg, 566 Kristineberg, Fiskebäckskil 45178, Sweden*

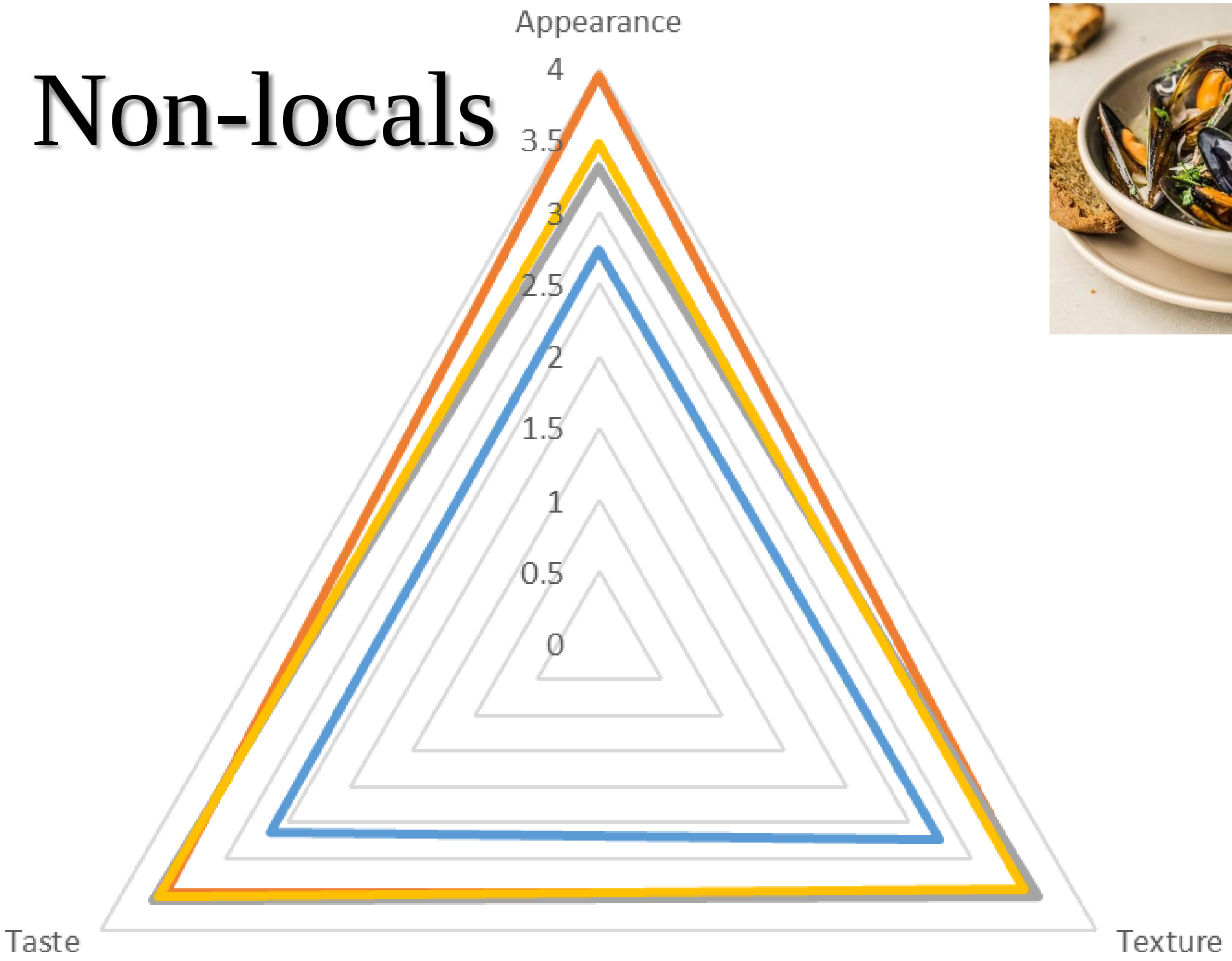


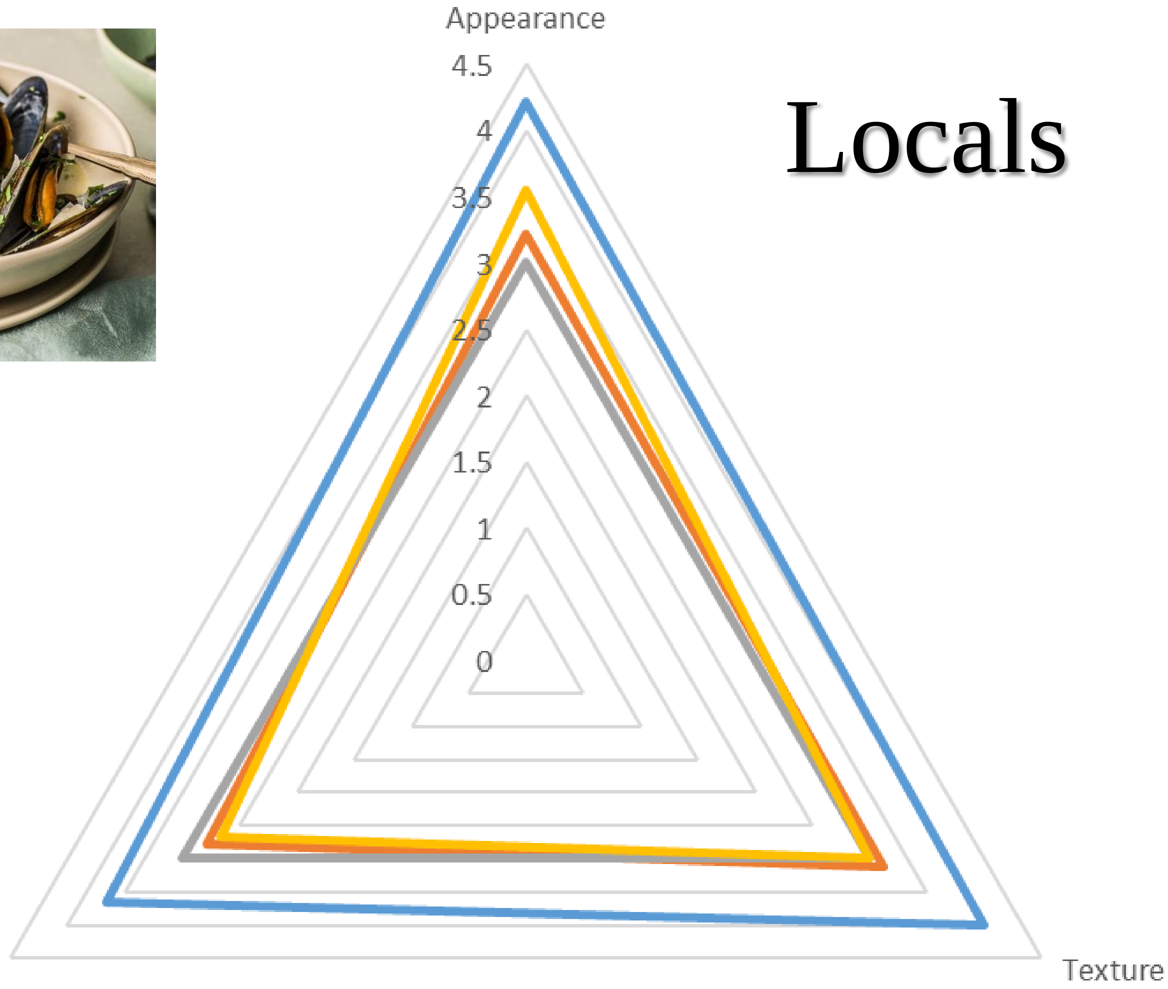
Citizen centered scientific information can drive change

On the importance to think local

Control OA OW OWA

Non-locals





Locals

Case study #3 – Mitigation through societal changes

- ✓Problem: ocean acidification and climate change
- ✓ Cause: CO_2 emissions
- ✓ Solution: Individual change
- ✓Gap: What type of information drivers change?

Priority: natural and social science

Conclusions

- ✓ Ocean acidification is (mostly) **applied science**
- ✓ As "the house is on fire", it is important to identify **key local questions** based on ocean services under threat from ocean acidification
- ✓ For each question, you should identify the **best solutions** (realistic, relevant time scale, etc.)
- ✓ For each solution, you need to identify the data needs and associated **scientific strategy** and best approach to collect them.
- ✓ **When science is needed, adopt the best practices**

Do the right thing

Do things right

Why do we need to study ocean acidification?

Need solutions (mitigation, adaptation)

Need better information

Think carefully of your question / scale

Why do we need to study ocean acidification?

This course will provide the tools to find relevant questions, design good monitoring strategy / experiments, work according to best practices and build a network

Ocean Acidification International Coordination Centre

IAEA OA-ICC

OA ALLIANCE

INTERNATIONAL ALLIANCE TO COMBAT OCEAN ACIDIFICATION

Basic Training Course on Ocean Acidification

9 - 13 September 2024

EVT2205463

hosted by

United Methodist University (UMU)

SDG 14.3.1

Thanks for Kirsten Isensee – IOC/UNESCO for many of the slides

United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
Oceanographic
Commission

United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
Oceanographic
Commission

17 objectives to transform our world: 2030 Agenda

SDG indicator framework

- SDG **Goals and Targets were set by Member States** with the adoption of the 2030 Agenda for Sustainable Development (2015).
- The General Assembly tasked the **UN Statistical Commission** with developing a monitoring framework.
- **Inter-Agency and Expert Group on the SDG Indicators (IAEG-SDG),** 30 member states and other members, established to develop the indicator framework.
- IAEG-SDG agreed on a **framework of 244 indicators** and designated **UN agencies as custodians** of the various indicators. (adopted by UN General Assembly in 2017).

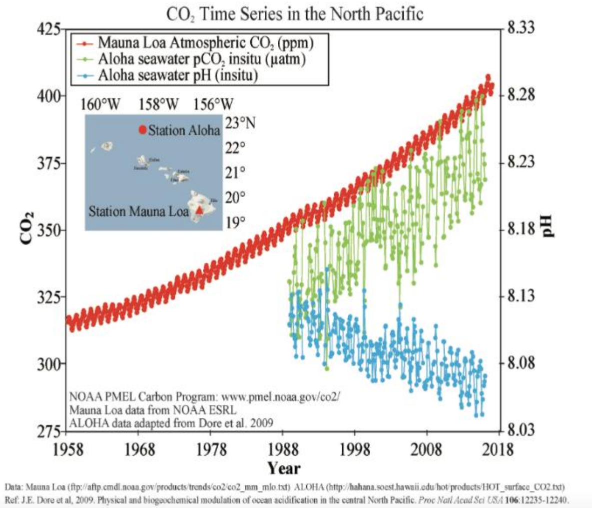
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission

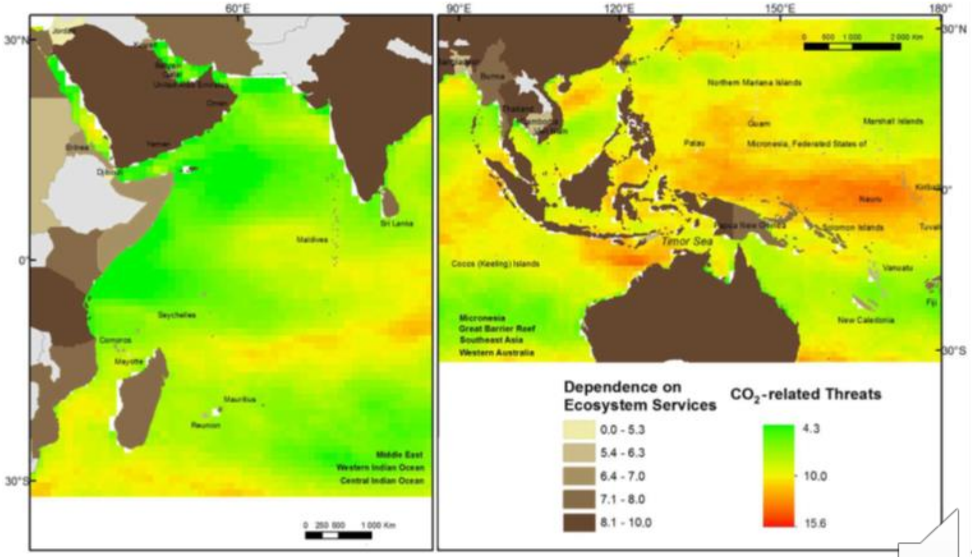
What does Custodianship mean?

1. Develop internationally agreed standards, coordinate the indicator development, and support increased adoption and compliance with the internationally agreed standards at the national level;

2. Collect data in relevant domain from countries (or regional organizations) as appropriate through existing mandates and reporting mechanism to provide internationally comparable data and calculate global and regional aggregates;

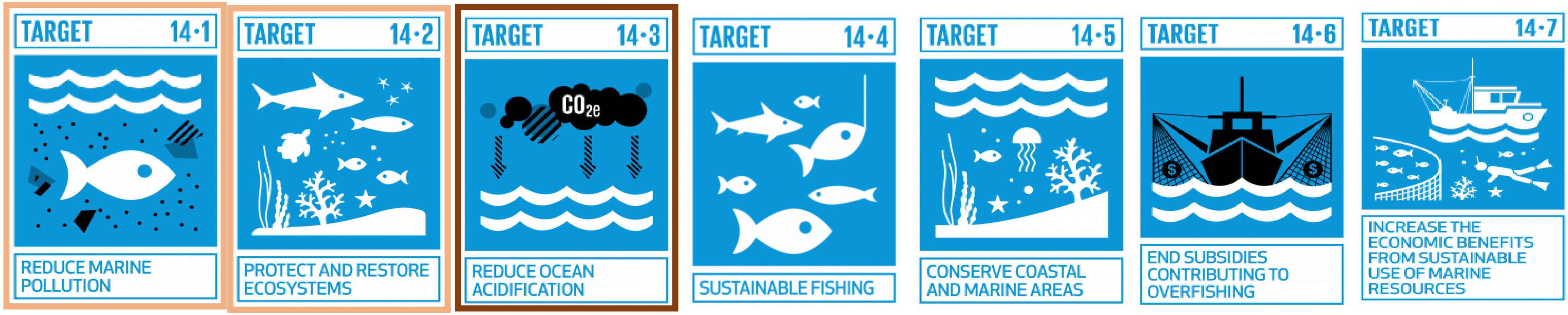
3. Strengthen national statistical capacity and improve reporting mechanisms

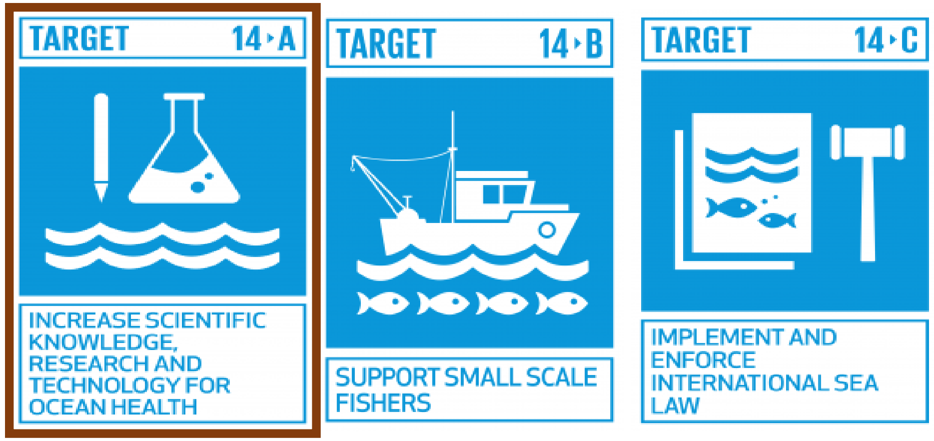




Pendelton et al. 2016

SDG 14 – 10 targets – 10 ways to collect data





14.1	**UNEP supported by IOC-UNESCO**	**Tier III**	**2025**
14.2	**UNEP supported by IOC-UNESCO**	**Tier III**	**2020**
14.3	**IOC-UNESCO**	**Tier II**	**-**
14.4	FAO	Tier I	2020
14.5	UNEP-WCMC supported by IUCN	Tier I	2020
14.6	FAO	Tier II	2020
14.7	FAO supported by UNEP-WCMC	Tier III	2030
14.A	**IOC-UNESCO**	**Tier II**	**-**
14.B	FAO	Tier II	-
14.C	DOALOS	Tier III	-

SDG indicator 14.3.1

Goal 14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Target 14.3	Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

Indicator: 14.3.1 ***Average marine acidity (pH) measured at agreed suite of representative sampling stations***

Sick

Solution???

SDG indicator 14.3.1

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Target 14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

Indicator: 14.3.1 ***Average marine acidity (pH) measured at agreed suite of representative sampling stations***

Need to re-evaluate

SDG indicator 14.3.1 development

Meeting of Expert Group 16-18 January 2018 at IOC HQ, Review of existing preliminary methodology

51st Session of IOC Executive Council July 2018 – Endorsed 14.3.1 methodology

July-August 2018: Data collection approaching NODCs and ADUs, which stated to have relevant data sets

October 2018: IOC expert meeting, to apply data quality control mechanisms, categorize the data quality of different data sets, review of data collection, strategy to develop related capacity building activities and additional documentation

November 2018: updated metadata and data files, IAEG meeting to apply for upgrade of 14.3.1 methodology from Tier III to Tier II

December 2018-September2019: 14.3.1 SDG data repository development

March 2019-October 2019: 14.3.1 IOC Manual on 14.3.1 reporting, including step by step guides for data providers and data repositories

Developing methodology

Restricted Distribution

IOC/EC-LI/2 Annex 6

Paris, 13 June 2018
Original: English

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

Fifty-first Session of the Executive Council
UNESCO, Paris, 3–6 July 2018

Item **4.4** of the Revised Provisional Agenda

UPDATE ON IOC CUSTODIANSHIP ROLE IN RELATION TO SDG 14 INDICATORS

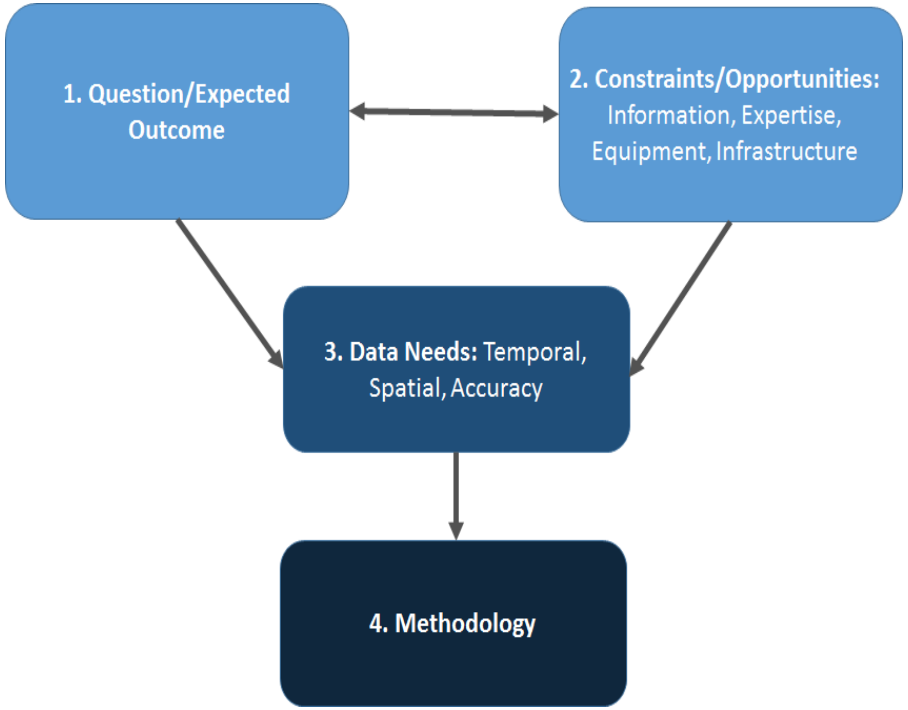
Summary

In Decision XXIX/9.1, the IOC Assembly took note of the assignment of IOC as a custodian agency for specific SDG 14 indicators, particularly under targets 14.3 and 14.a. This means that the IOC is responsible for the methodological development and measurement of these SDG indicators at global scale. The Assembly also welcomed the proposed methodology for indicator 14.a.1 and requested the Secretariat to finalize the methodology for indicator 14.3.1 and to submit it to the IOC Executive Council for its consideration at its 51st session.

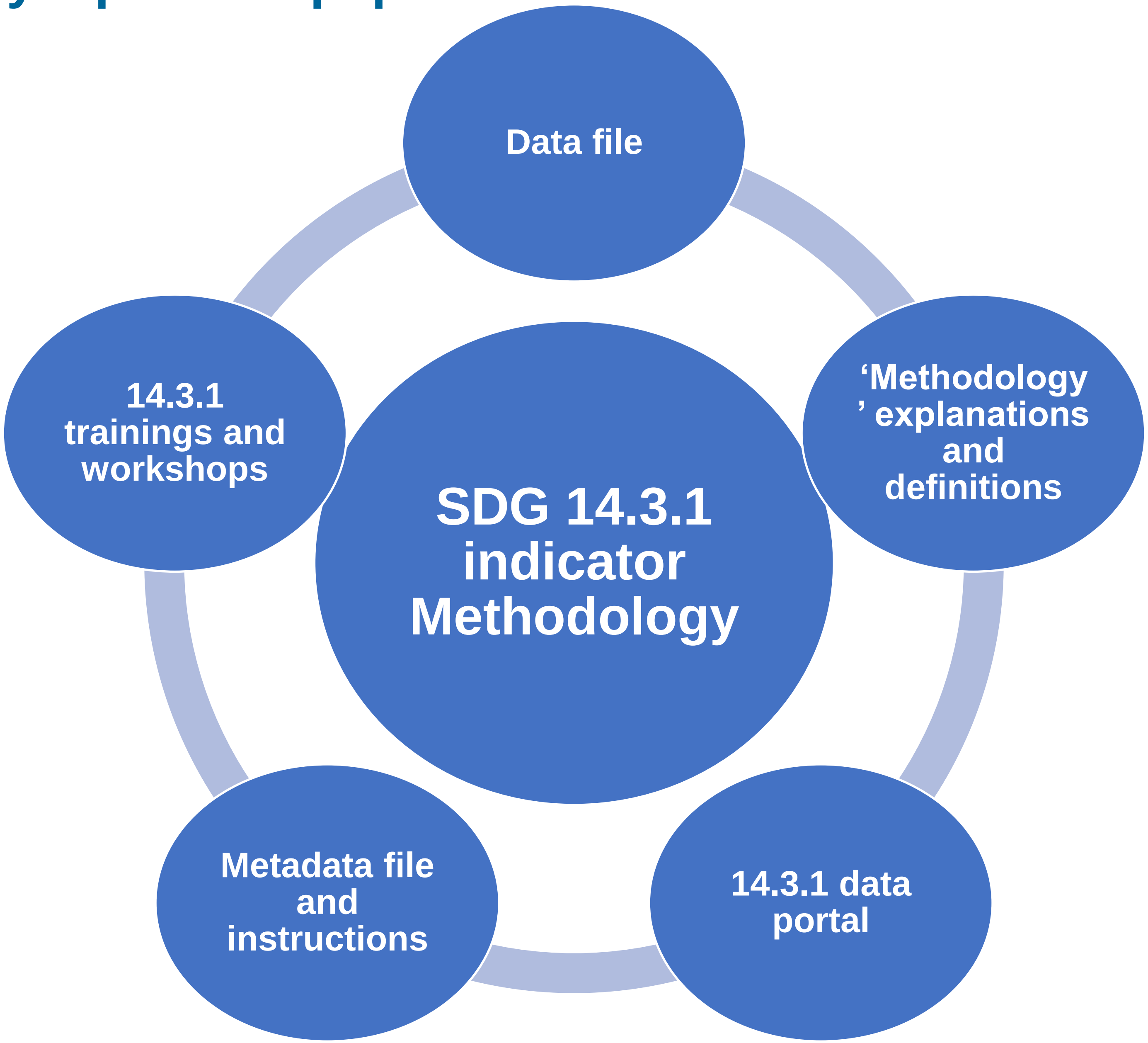
Purpose of the document: This document provides an overview of the work initiated by the IOC Secretariat to advance the methodology development and data collection for the indicators for which it is identified as a custodian agency, as well as for those where it is providing technical support to other UN bodies. Specifically, the methodology for indicator 14.3.1 is presented in appendix to this document in English only. The Executive Council is

14.3.1 provides guidance on:

- Definitions,
- Units
- Rationale for inclusion
- Computation method – aggregation and disaggregation
- Sampling strategy, including sampling frequency
- Methods and guidance available to countries for the compilation of data at the national level, including:
    - overview on best practices,
    - standard operating mechanisms,
    - measurement and data collection,
    - measurement and data quality
- Data sources, including:
    - the collection process,
    - data visualization and
    - quality control mechanisms



14.3.1 not only a piece of paper



Evaluation & Solutions

SDG indicator framework - categories

Tier 1: Indicator conceptually clear, established methodology and standards available and data regularly produced by countries.

Tier 2: Indicator conceptually clear, established methodology and standards available but data are not regularly produced by countries.

Tier 3: Indicator for which there are no established methodology and standards or methodology/standards are being developed/tested.

SDG indicator 14.3.1

Goal 14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Target 14.3	Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

Indicator: 14.3.1 ***Average marine acidity (pH) measured at agreed suite of representative sampling stations***

Tier II Indicator conceptually clear, established methodology and standards available but data are not regularly produced by countries (upgraded from III to II in November 2018)

Data quality

Category 1: Climate quality

- used to determine trends in the open ocean, shelf and coastal waters, providing data on seasonal through interannual variability on regional scales.
- requires that a change in the dissolved carbonate ion concentration to be estimated at a particular site with a relative standard uncertainty of 1%.
- The carbonate ion concentration is calculated from two of the four carbonate system parameters and implies an uncertainty of approximately 0.003 in pH; of 2 μmol kg^{-1} in measurements of TA and DIC, relative uncertainty of about 0.5% in the $p\mathrm{CO_2}$
- only currently achievable by a limited number of laboratories and is not typically achievable for all parameters by even the best autonomous sensors.

Category 2: Weather quality

- suitable for many coastal and nearshore environments, particularly those with restricted circulation or where CO_2 system parameters are forced by processes like upwelling, pollution or freshwater inputs that can cause large variability,
- requires the carbonate ion concentration to have a relative standard uncertainty of 10%. This implies an uncertainty of approximately 0.02 in pH; of 10 μmol kg^{-1} in measurements of TA and DIC; and a relative uncertainty of about 2.5% in $p\mathrm{CO_2}$,
- precision should be achievable in competent laboratories, and is also achievable with the best autonomous sensors.

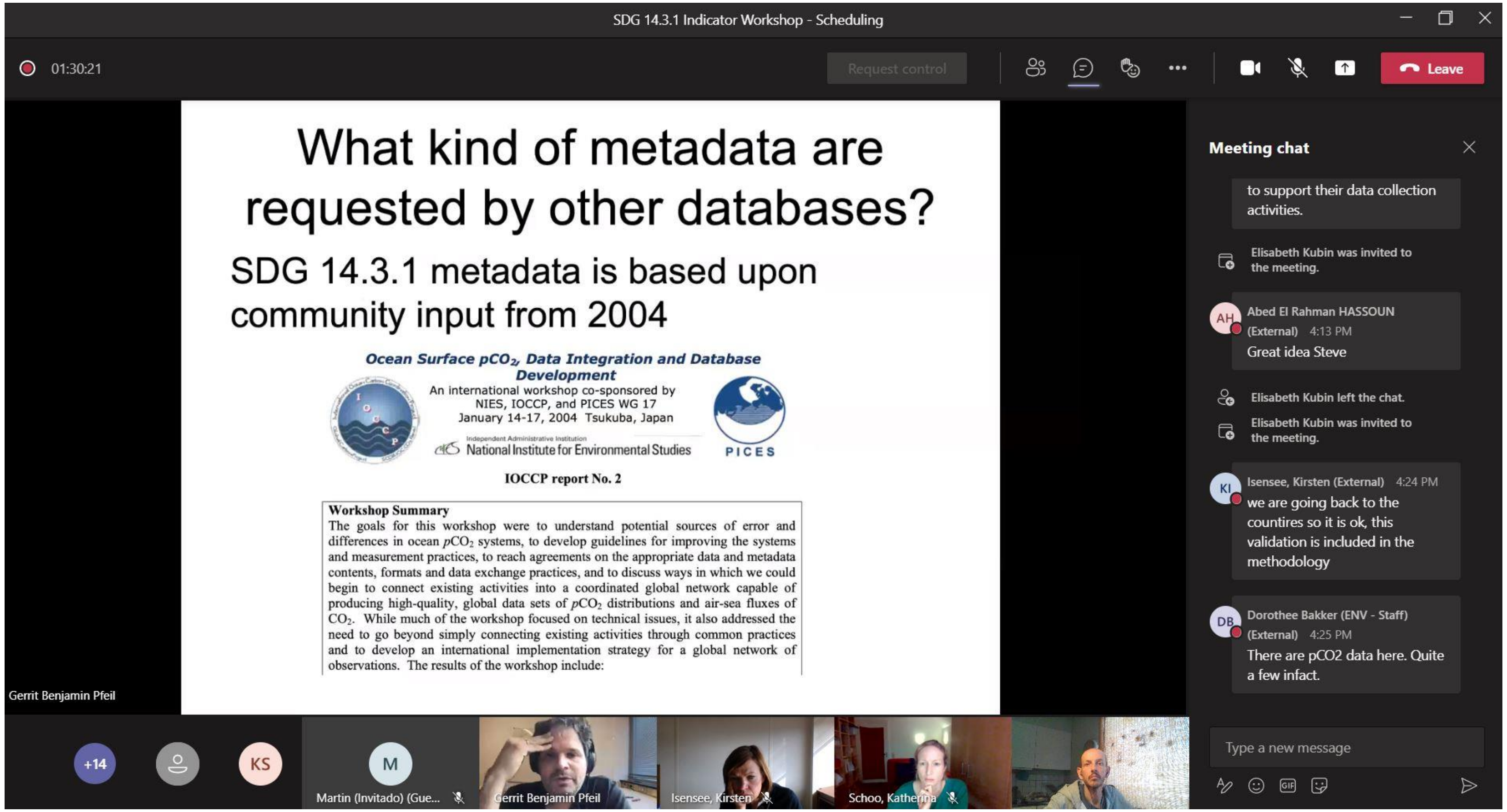
Category 3: Measurements of undefined quality

- Remaining measurements, e.g. pH measurements using glass electrodes will be considered Category 3 due to the challenges of using glass pH electrodes in seawater,
- useful information for countries building capacity towards Category 1 and 2 measurements,
- Category 3 measurement sites will be presented as data collection sites only, no data values will be visualized.

All those contributing data to SDG 14.3.1 are encouraged to adopt measurement quality Category 1 or 2.

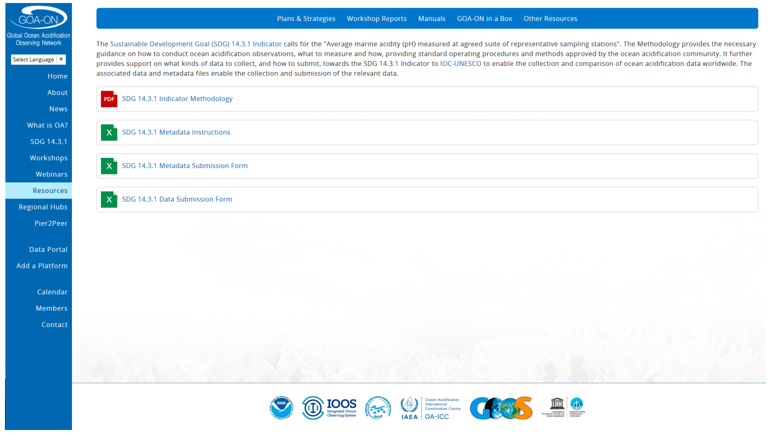
Continuous progress

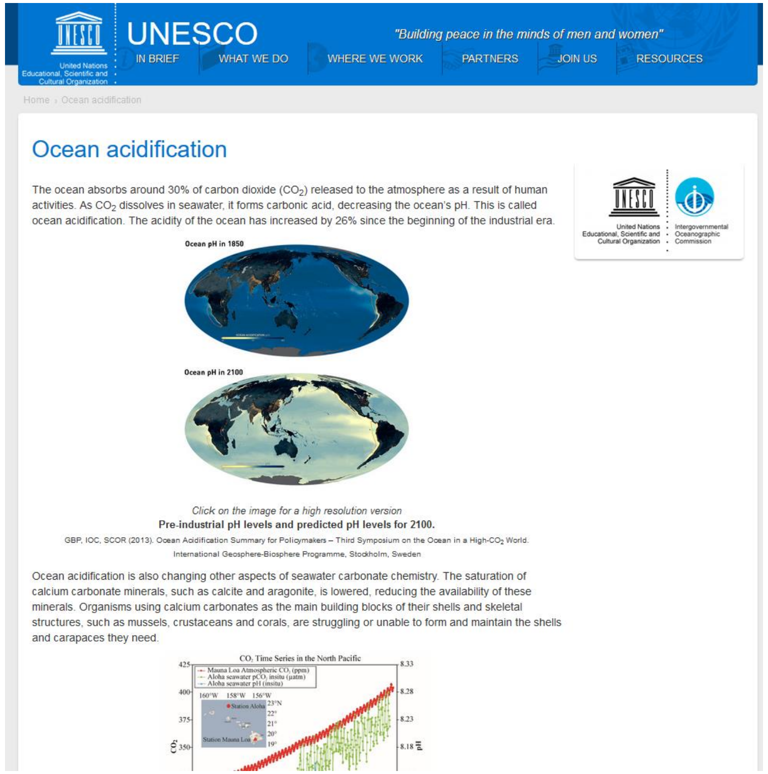
Second expert meeting – 12-13 April 2021



Documents available on:

Global Ocean Acidification Observing Network

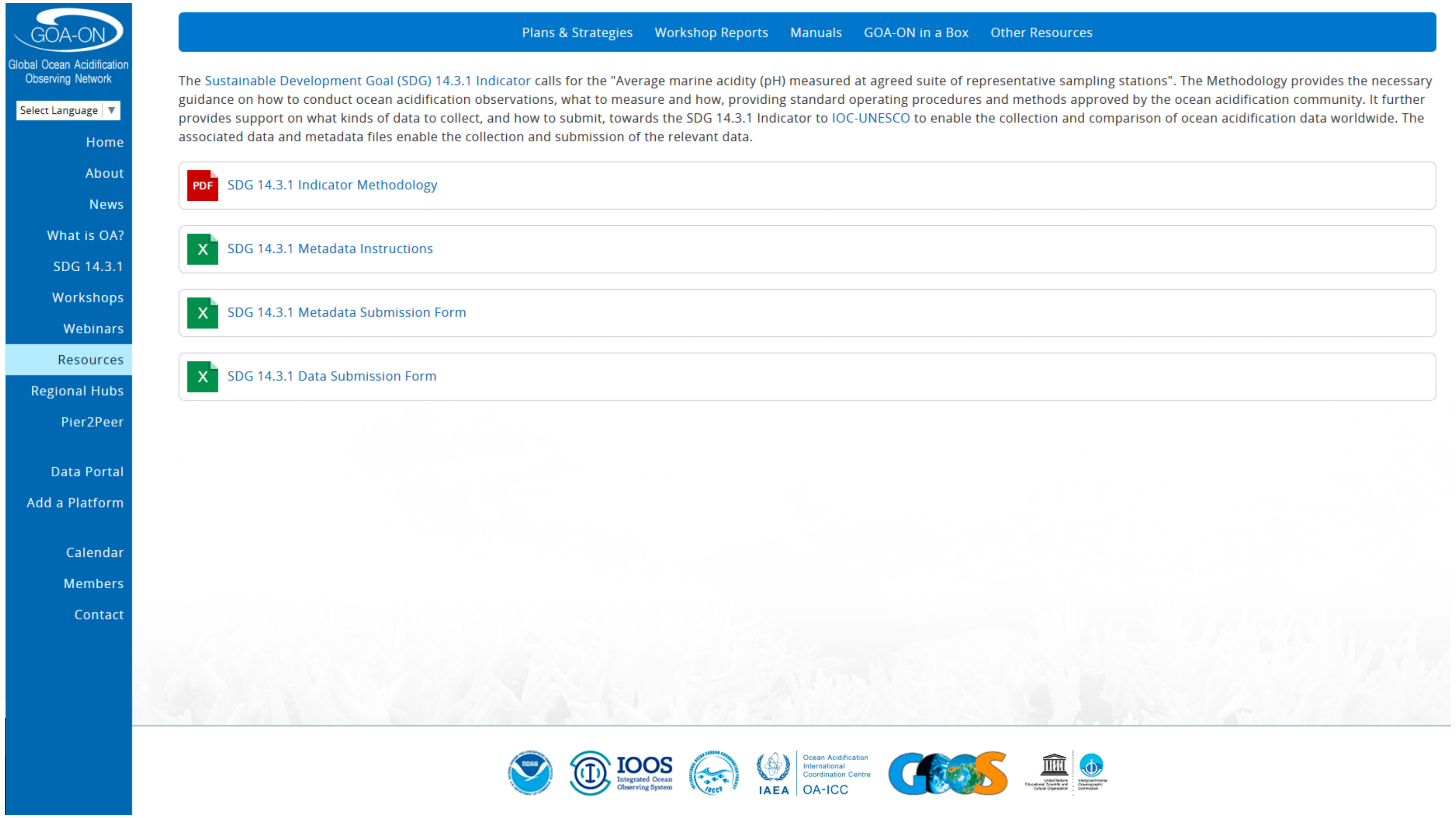




http://goa-on.org/resources/sdg_14.3.1_indicator.php

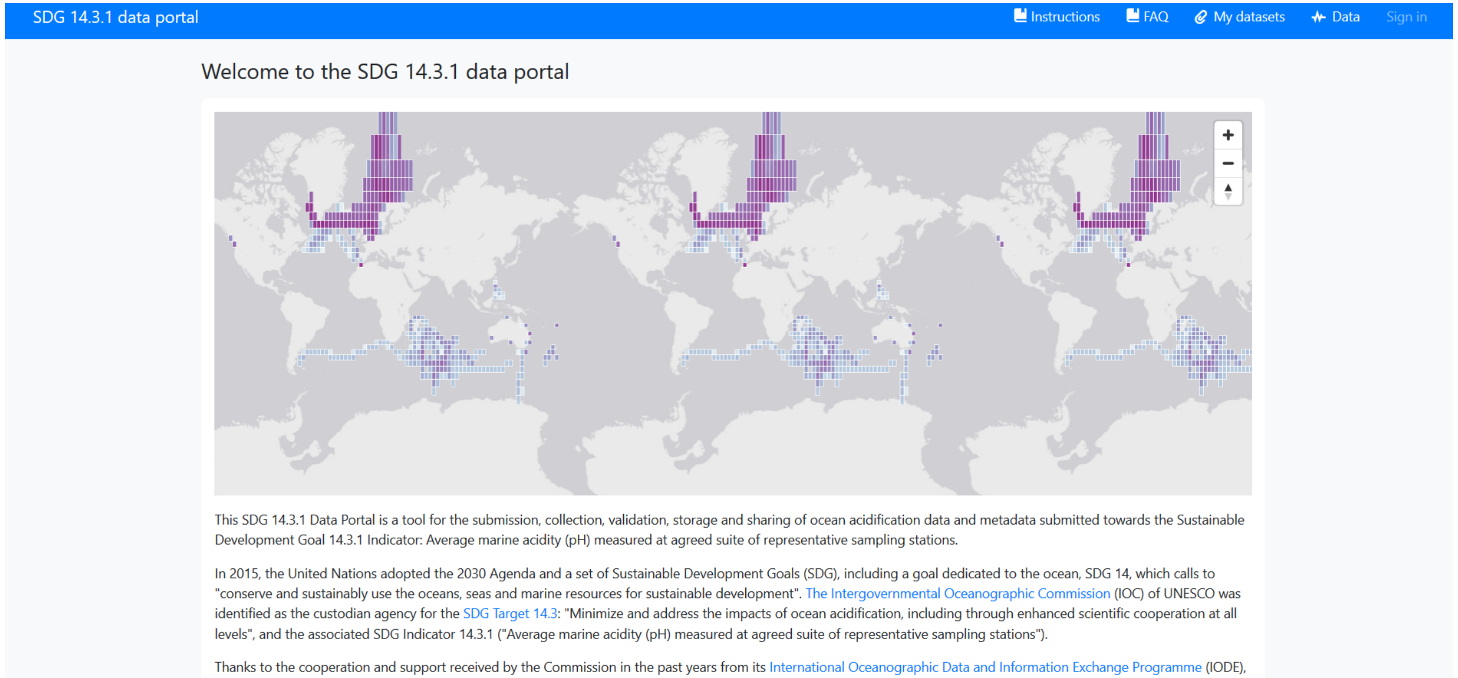
https://en.unesco.org/ocean-acidification

Reporting methodology: data / meta-data



http://goa-on.org/resources/sdg_14.3.1_indicator.php

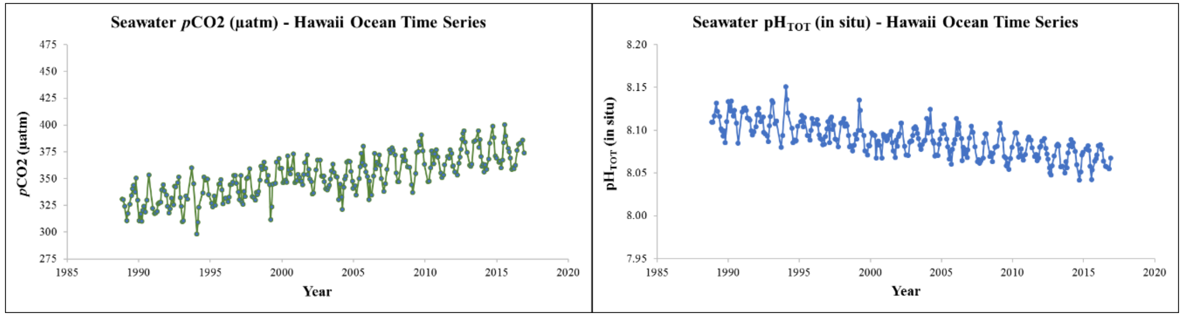
Data reporting: International Oceanographic Data and Information Exchange



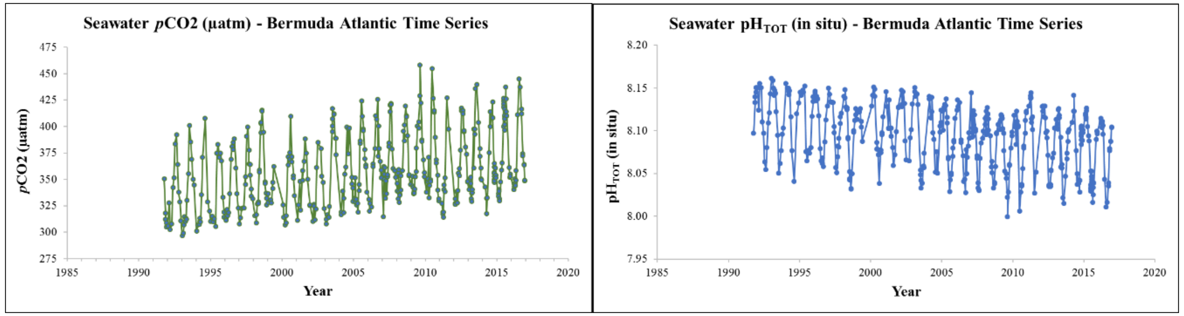
14.3.1 data portal – Facilitating Reporting

https://oa.iode.org/

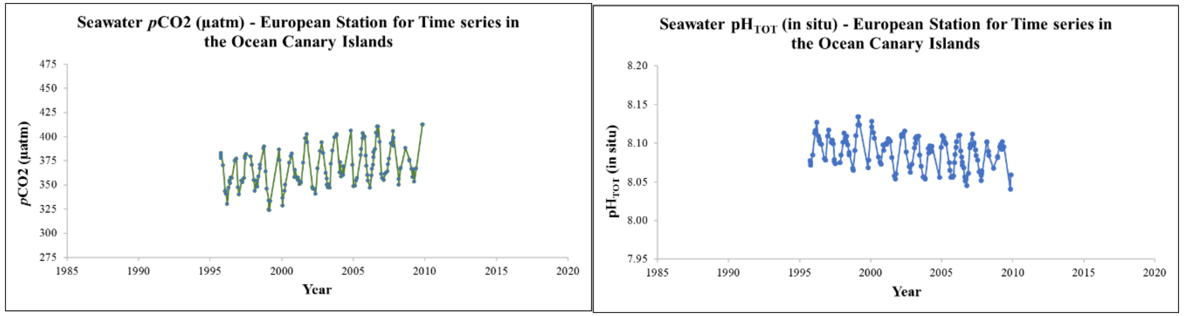
14.3.1 data examples



pCO$_2$ and pH records from the Hawaii Ocean Time Series (HOTS) in the Pacific Ocean.



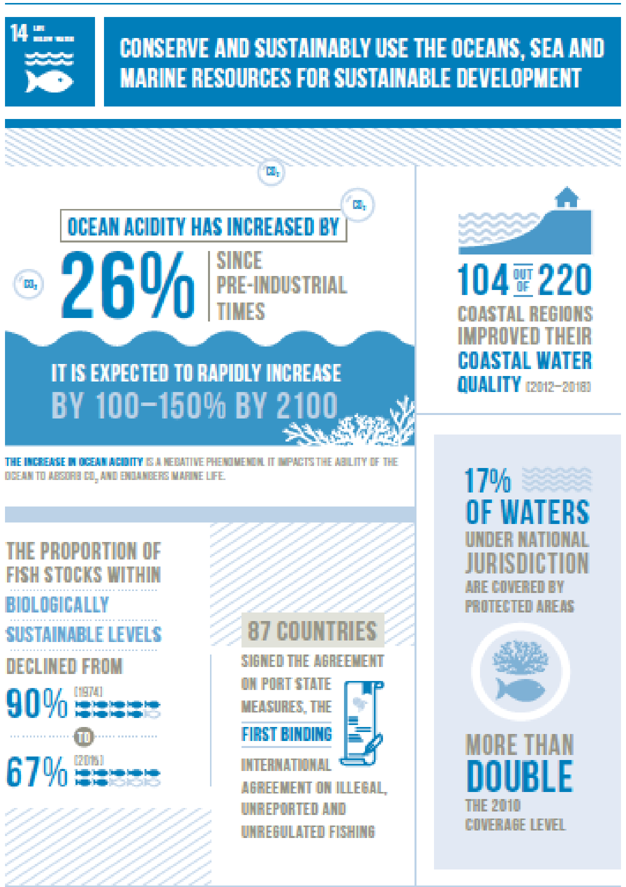
pCO$_2$ and pH records from the Bermuda Atlantic Time Series (BATS).

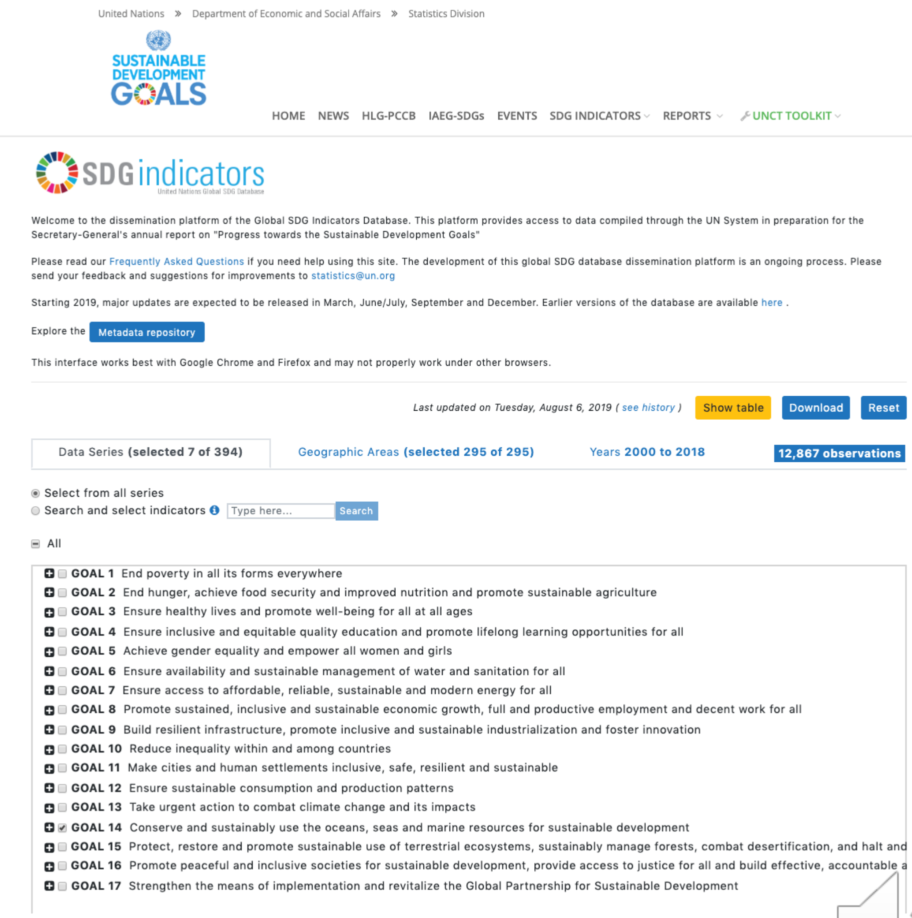


pCO$_2$ and pH records from the European Station for Time series in the Ocean Canary Islands (ESTOC).

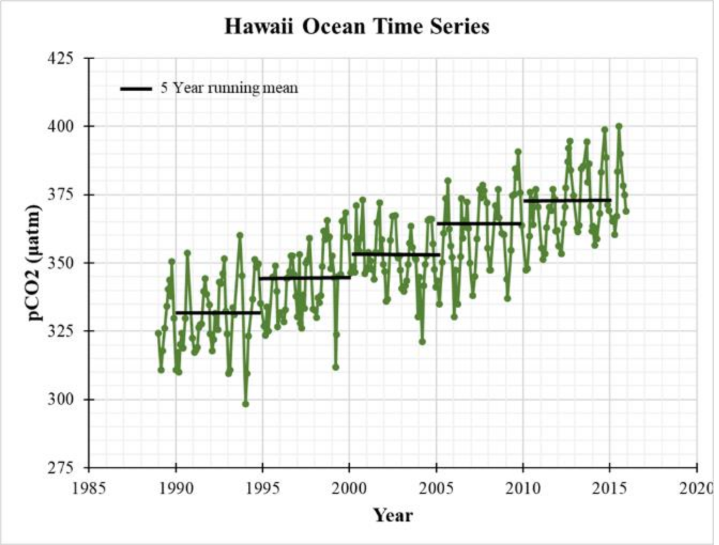
Year	Annual equally weighted mean pH		
	HOTS	BATS	ESTOC
1989	8.108		
1990	8.119		
1991	8.111	8.113	
1992	8.107	8.118	
1993	8.110	8.125	
1994	8.107	8.115	
1995	8.104	8.105	8.077
1996	8.096	8.105	8.104
1997	8.100	8.095	8.090
1998	8.094	8.114	8.094
1999	8.095	8.102	8.110
2000	8.087	8.106	8.099
2001	8.087	8.112	8.088
2002	8.089	8.090	8.093
2003	8.093	8.101	8.086
2004	8.091	8.094	8.088
2005	8.083	8.084	8.080
2006	8.087	8.087	8.077
2007	8.077	8.090	8.080
2008	8.079	8.082	8.087
2009	8.076	8.087	8.083
2010	8.078	8.110	
2011	8.078	8.085	
2012	8.068	8.086	
2013	8.069	8.085	
2014	8.071	8.070	
2015	8.067	8.081	
2016	8.070	8.133	
Annual average change pH	**0.0017**	**0.0017**	**0.001**

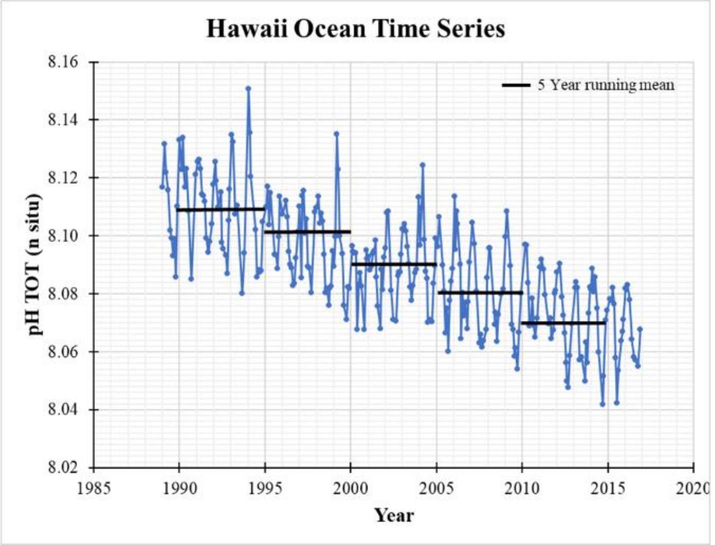
Outcome Documents/information

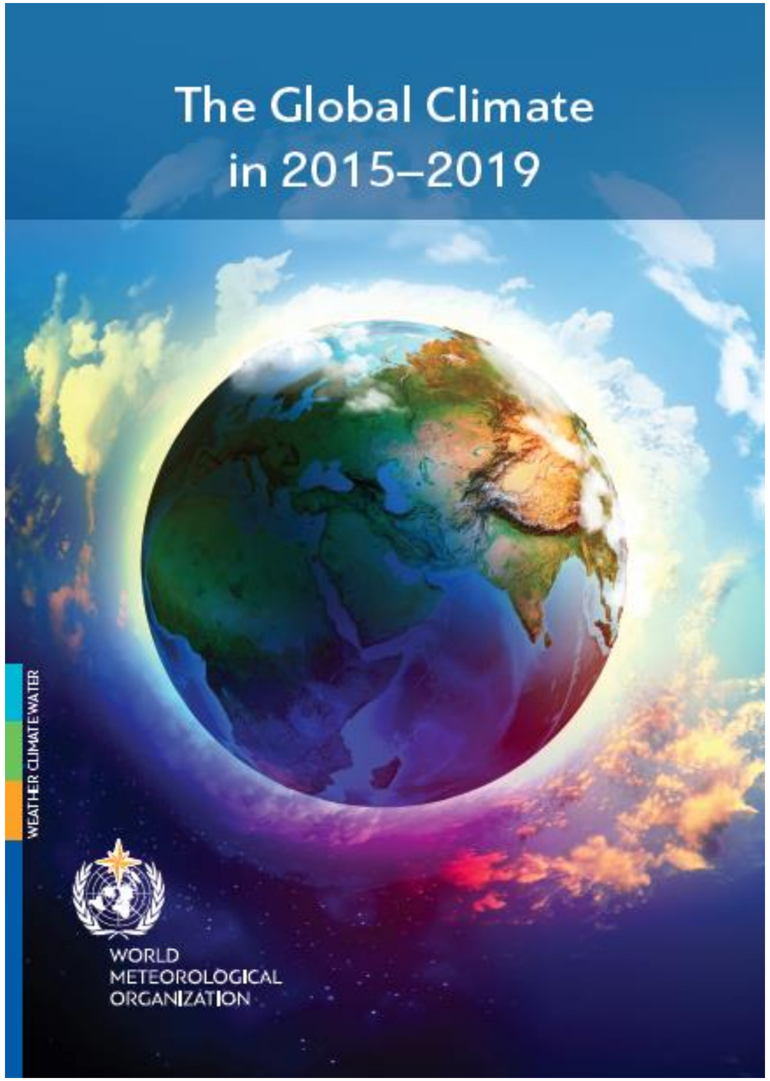




Outcome Documents - Global Climate Indicator





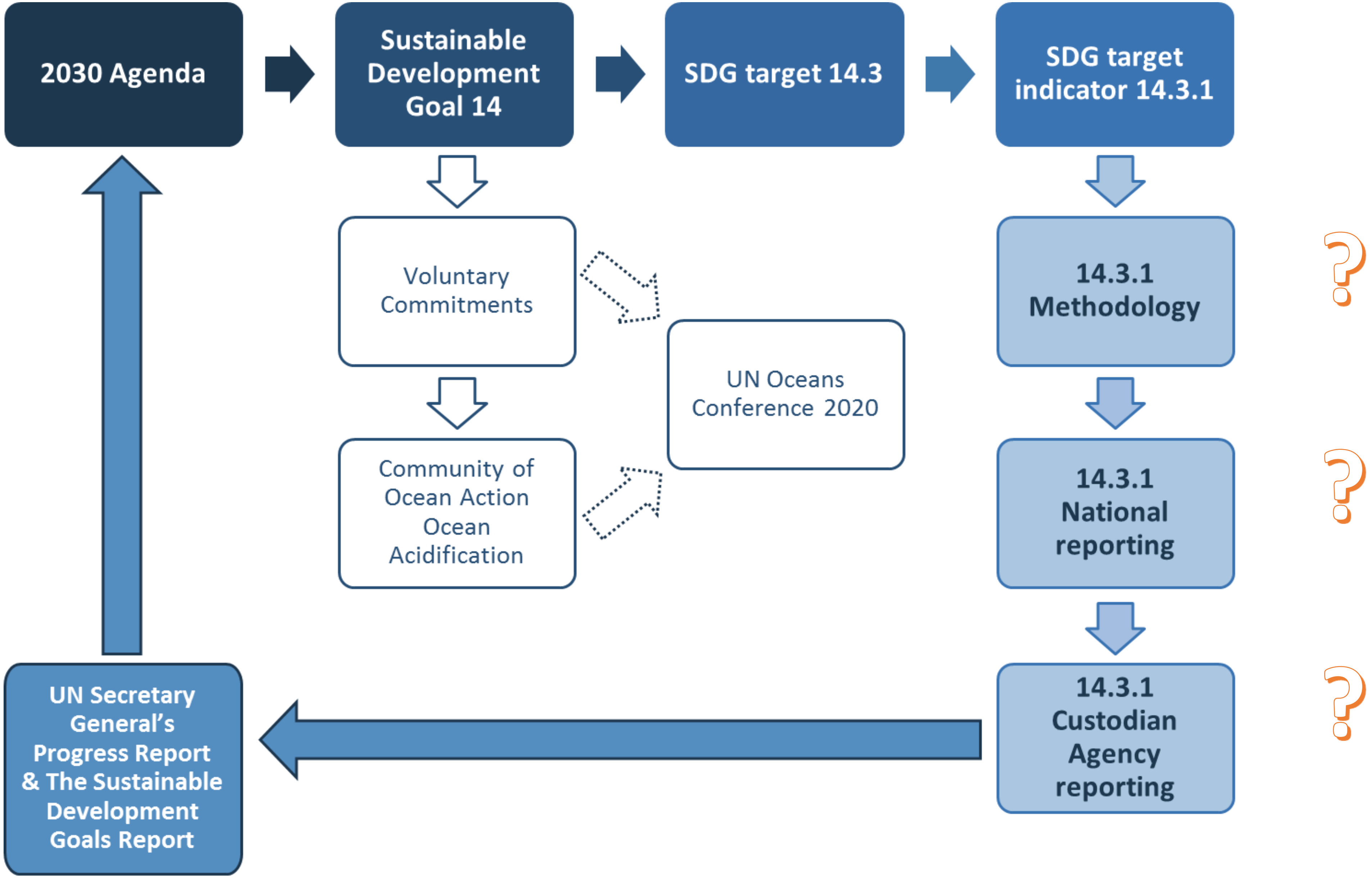


Information published

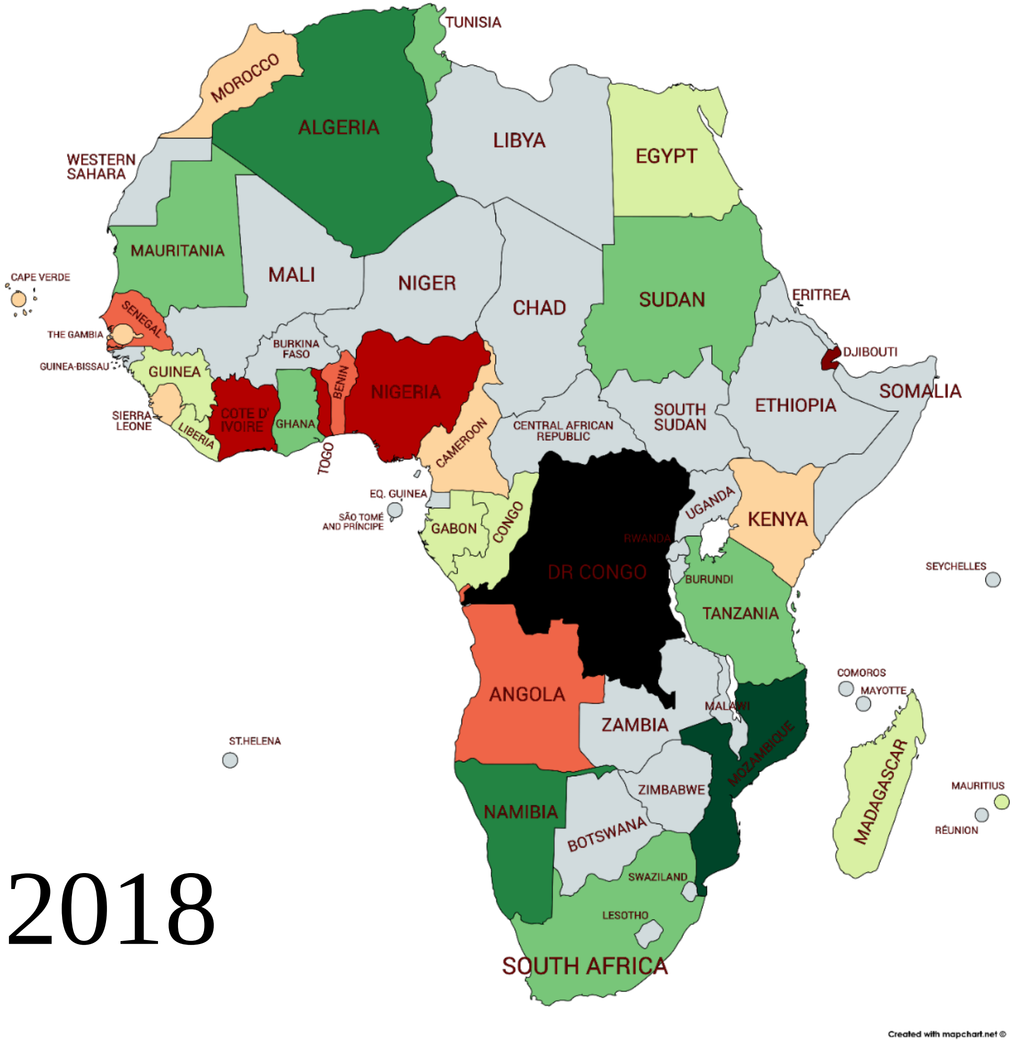
- in WMO Statement of the Global Climate annually
- In 5 year summary The Global Climate in 2015-2019

High visibility at the annual UNFCCC COPs, Climate Summit

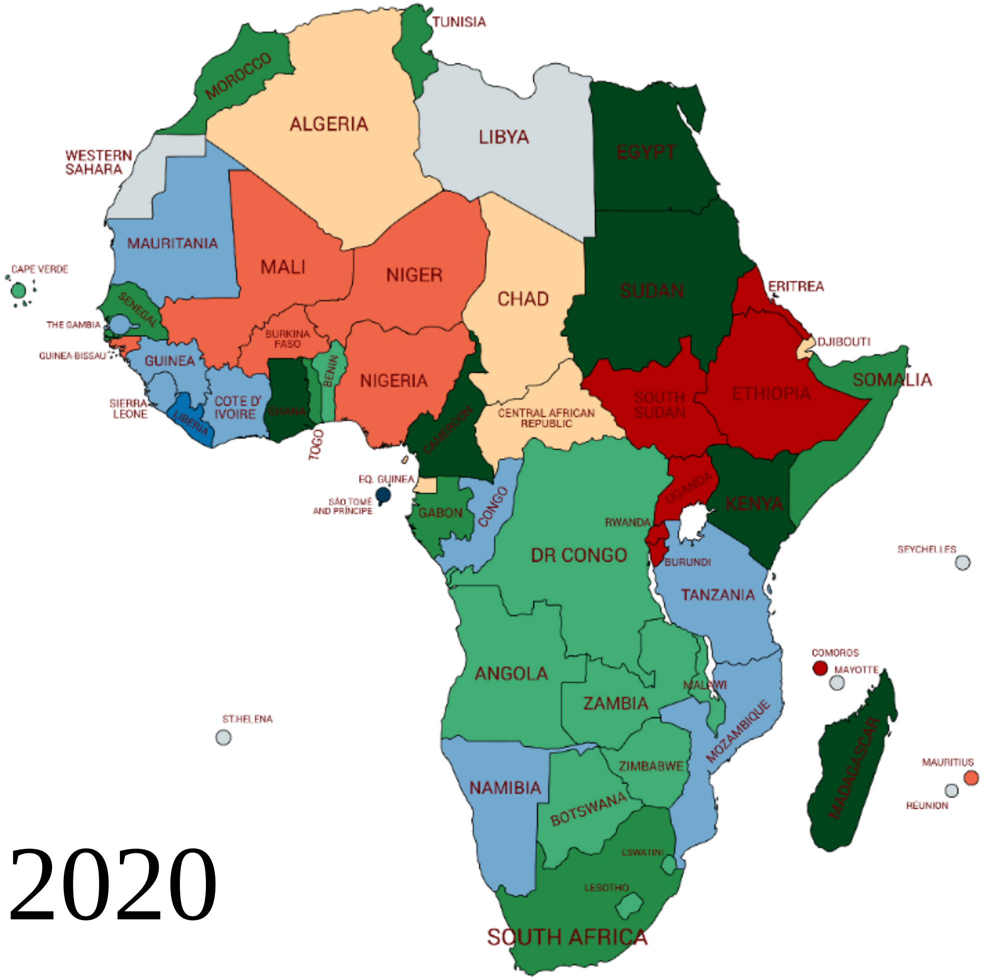
Processes involved in the achievement of the GOAL 14



Amazing progress in 2 years



2018



2020

Amazing progress in 2 years

- ✓ 91% of countries made progress since 2019
  [only 3 decreased their score: Algeria, Comoros and Mauritius]
- ✓ Best country in the world is from Africa
  [Sao Tome and Principe with 83%]
- ✓ 44% countries are above the world's average (61%)

How much closer are we to “minimize and address the issue?”

Are SDGs the right tool to reach sustainability?

- ✓ Even if all countries in the world would fulfil the requirement, would we address ocean acidification?
- ✓ Good communication tool and entry gate to develop the real science we need?

+ LECTURE on Tuesday