Best practices in measuring and reporting some basic Biogeochemical Essential Ocean Variables

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Best practices (BP) in measuring and reporting some +

basic BioGeoChemical (**BGC**) +

Essential Ocean Variables (**EOVs**) +

Data Buoy Cooperation Panel + Mediterranean Training Workshop on Ocean Observations and Data Applications

?

Introduction

Introduction

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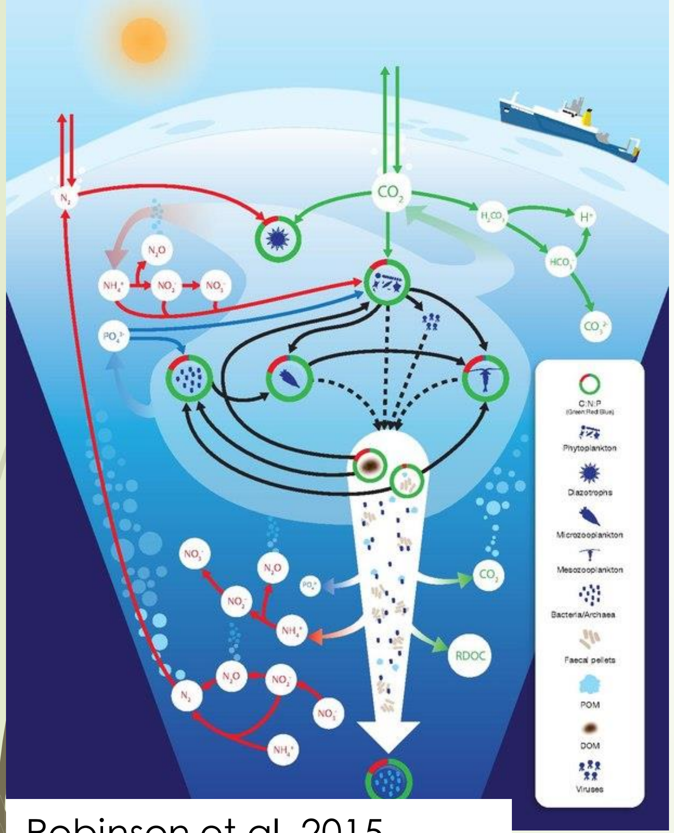
Best practices: commercial or professional procedures that are accepted or prescribed as being correct or most effective

basic BGC



Robinson et al. 2015

EOVs

- Perennial

- Impact: the variable addresses climate, operational ocean services and ocean health and also contributes to understanding from a scientific perspective or application from a service perspective.

- Feasibility: it is technically, politically and economically feasible to observe or derive the variable on a global scale using proven, scientifically understood methods.

- Some also are **Essential CLIMATE variables:** characterize Earth Climate

Biochemistry

- Oxygen
- Nutrients
- Inorganic carbon
- Transient tracers
- Particulate matter
- Nitrous oxide
- Stable carbon isotopes
- Dissolved organic carbon

GOOS web page

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Introduction

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Biochemistry

- Oxygen
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- Nitrous oxide
- Stable carbon isotopes
- Dissolved organic carbon

Basic BGC EOVs

- Historically measured
- Sound BP
- Involved in all ocean processes
- Useful at any temporal / spatial scale
- Sensor development, to be installed in different platforms
- Discrete measurements always needed

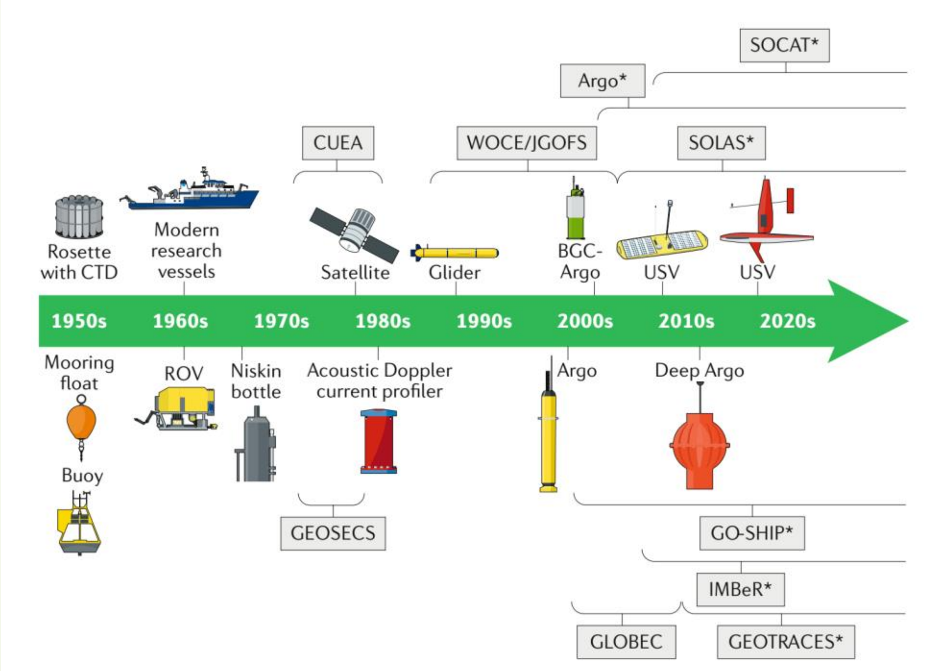


Fig. 1 | **Timeline of oceanographic observation platforms and international projects measuring marine biogeochemistry.** International project durations are indicated with brackets. Ongoing pro-

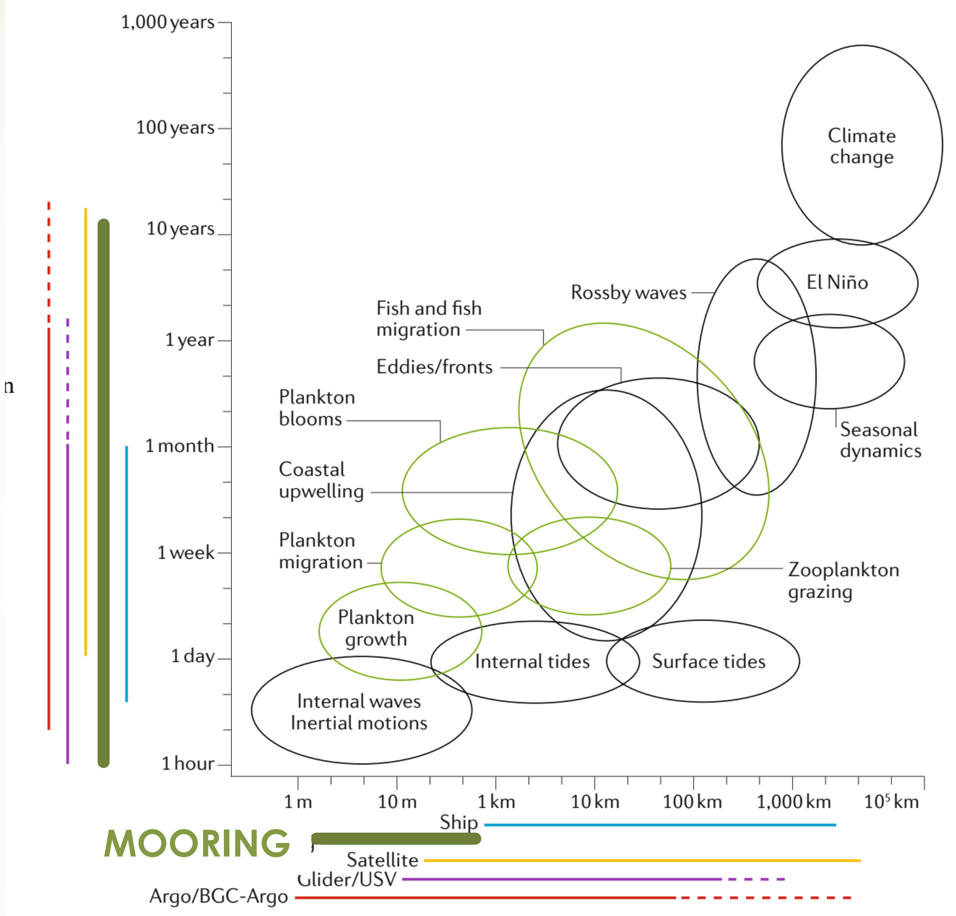


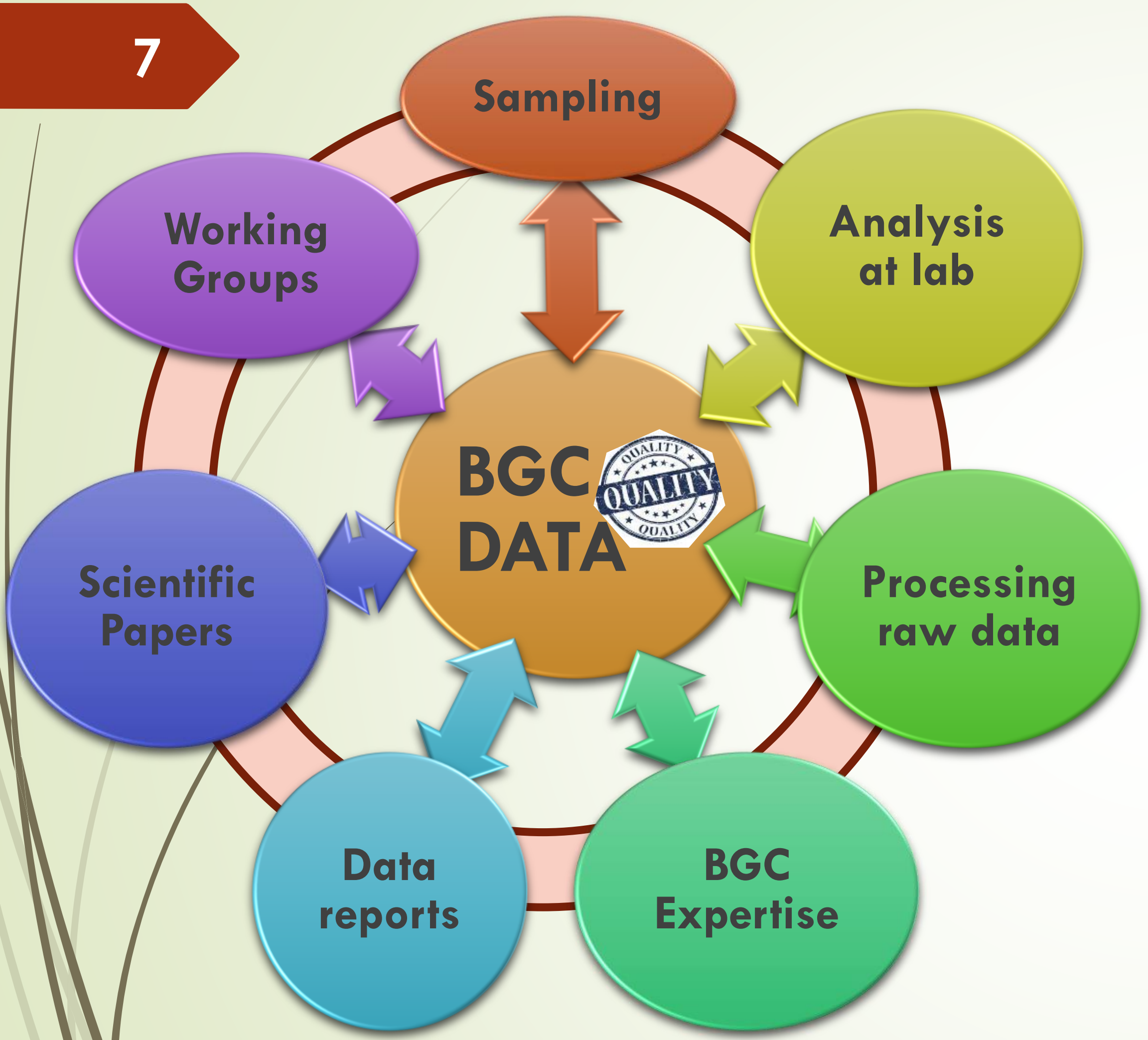
Fig. 2 | **Measuring across spatiotemporal scales in marine systems.** Spatial and temporal scales of marine dynamic and ecosystem processes, and the measurement capabilities of different observational platforms. Dynamic and/or physical processes are represented by black circles and biological and/or ecological processes by green circles. The presence of new autonomous platforms, such as

Chai et al 2020

OUTLINE

1. Common best practices for bBGC EOVs
2. Specific BP for dissolved oxygen
3. Specific BP for inorganic nutrients
4. Specific BP for CO2 variables
5. *Easy* reporting, formatting: metadata & data
6. *Easy* primary Quality Control (QC)
7. Examples of BAD practices / results

1. Common best practices for bBGC EOVs



SAMPLING & STORAGE & TRANSPORT

- As important as having reference materials!!
- Read the Standard Operational Procedure (SOP)
- Adapt the SOP to your circumstances
- Check all reagents prepared first
- Sampling = Training, training and training
- Make a video and never trust a newcomer
- Prepare your SOP, your WIKI with all the details (hard work but useful!!)
- Prepare reproducibility exercises (competition) for the samplers
- At the beggining qualified technitians need to KEEP an EYE on the sampling procedures around the rosette for example
- Water is terrible it escapes! Flows through the tiniest holes…
- Transport companies can be mad; FOAM!, PARAFILM, bubble wrap

2. Specific BP for dissolved oxygen

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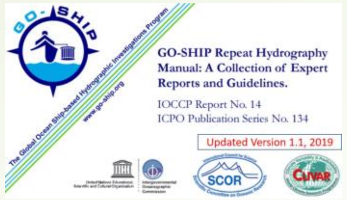
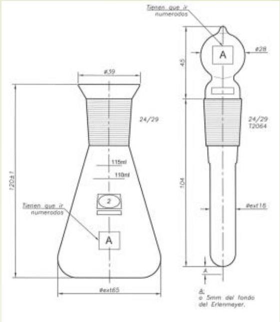
REF: Langdon (2010)

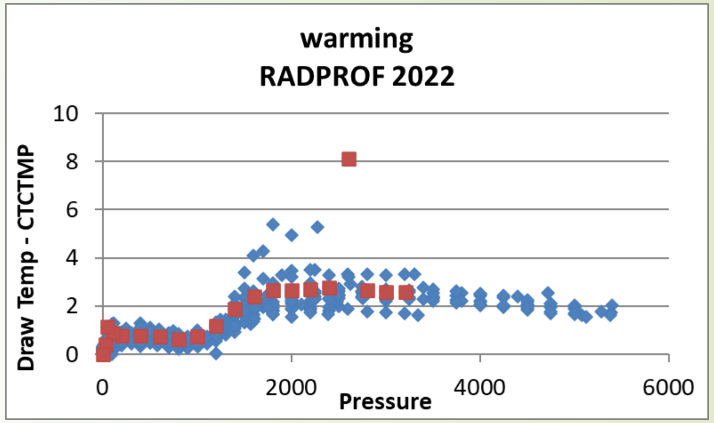




SAMPLING

- Flared neck flasks with long stopper – should be volume calibrated referred to 20°C
- Note the draw temperature – important for deep stations

  TMP differences > 2.5°C ≈ 0.1% in O2



STORAGE & TRANSPORT

- Cool and dark place, water in the flared neck
- Cumbersome transport!, no turn around the BOX
- Maximum storage 1-2 months, but not recommended

2. Specific BP for dissolved oxygen

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REF: Langdon (2010)

ANALYSING

- Air conditioning if possible, record temperature in the lab
- Be aware of CHEMICAL RISKS
- Bring the sampling sheets
- Use a notebook to mark and take NOTES
- Check the **bubbles** in the line of the titration solution (run junk samples at beginning)
- Prepare your standard with KiO3 or buy it from OSIL
- Blanks are a pain but needed
- All volumetric material needs to be calibrated at least every two years.
- Make long long batch (same day many samples) of analysis to profit the standarization

- No internal laboratory standard or substandard can really be used!
- NOTES on every change of reagents

2. Specific BP for dissolved oxygen

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PROCESSING

- Excel or whatever but the same checked template
- Check the notes
- Report on international units for dissolved oxygen CONTENT … umol /kg .. MASS units

REPORTING (for your shelf!)

- The report can also be a template with detailed information .. But always the same information

REPORTING (for others!!)

- Minimum and concise information

(1) OXYGEN
Potentiometric titration with Metrohm Titrando system with 5 ml burete coupled with a Metrohm Dosino, blanks determined, following Langdon (2010), standarization with OSIL KIO3 0.01 N, precision better than ±1 μmol/kg from replicate analysis

Table 1. Temporal evolution of the thiosulfate concentration and reagent blank along the cruise. CV stands for Coefficient of Variation and STD for standard deviation.

Batch	Date	Thiosulfate batch	Thiosulfate standardizations		Reagent Blank		N analises
			Molarity20ºC	CV*100	ml	STD*100	
1	13-7-20	1	0.027354	0.12	0.010	0.48	81
2	14-7-20	1	0.027282	0.09	0.006	0.05	50
3	15-7-20	2	0.027119	0.01	0.009	0.28	87
4	17-7-20	3	0.027107	0.15	0.011	0.26	97
5	19-7-20	3	0.027454	0.18	0.016	0.28	78
6	22-7-20	4	0.027776	0.15	0.007	0.06	84

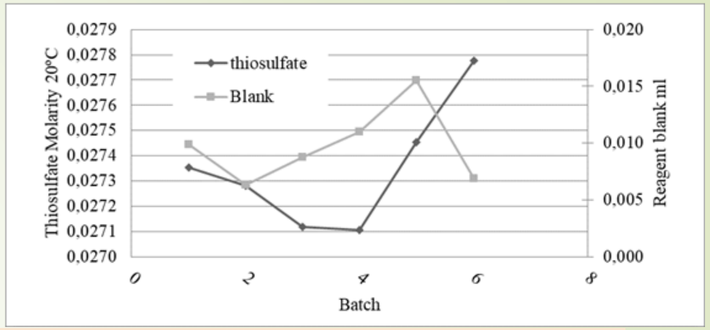

Table 2. Dissolved oxygen determinations (umol.kg^{-1}) for replicated samples at stations 18, 76, 108 and 109.

Station_cast_btl	Press	Salinity	O2 umol/kg	Diff O2	Diff Sal
18_16_5	1399.96	35.4957	219.11		
18_16_6	1400.50	35.4948	219.64	0.53	0.0009
18_16_7	1400.23	35.4946	219.24	0.13	0.0011
18_16_8	1400.60	35.4946	219.18	0.06	0.0000
18_16_9	1400.32	35.4952	219.12	0.07	0.0006
109_11_2	4749.52	34.8955	243.26		
109_11_3	4749.95	34.8955	242.78	0.48	0.0000
76_24_6	300.575	35.5720	213.02		
76_24_6	300.575	35.5720	212.96	0.06	0.0000
76_24_6	300.575	35.5720	210.68	2.28	0.0000
76_24_6	300.575	35.5720	214.05	3.37	0.0000
76_24_6	300.575	35.5720	209.71	4.34	0.0000
108_12_2	4399.62	34.8972	242.41		
108_12_3	4399.76	34.8972	242.36	0.05	0.0000

2. Specific BP for dissolved oxygen

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EOV specification sheets

The Global Ocean Observing System

Discrete meas. always needed!

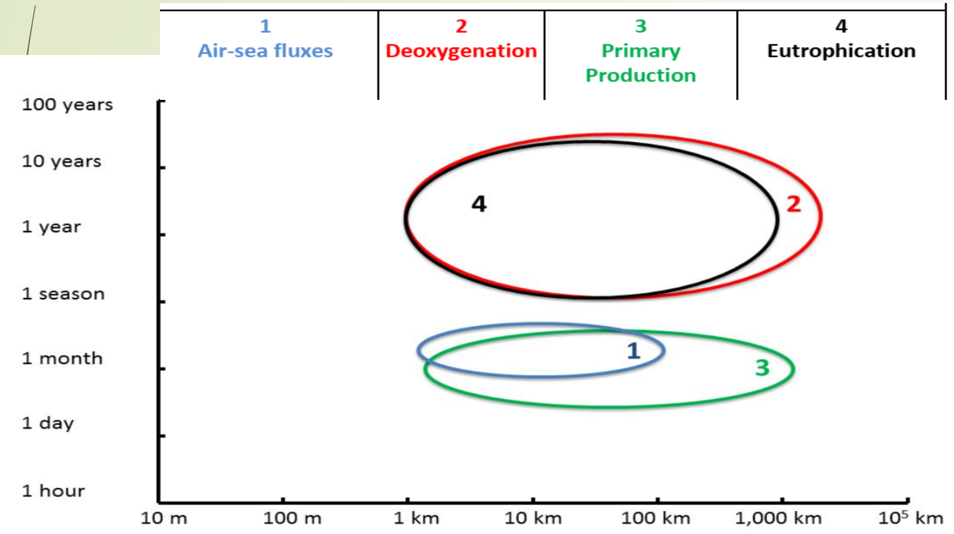


Figure 1: Spatial and temporal scales of phenomena (as color-coded and listed in Table 2 above) to be addressed.

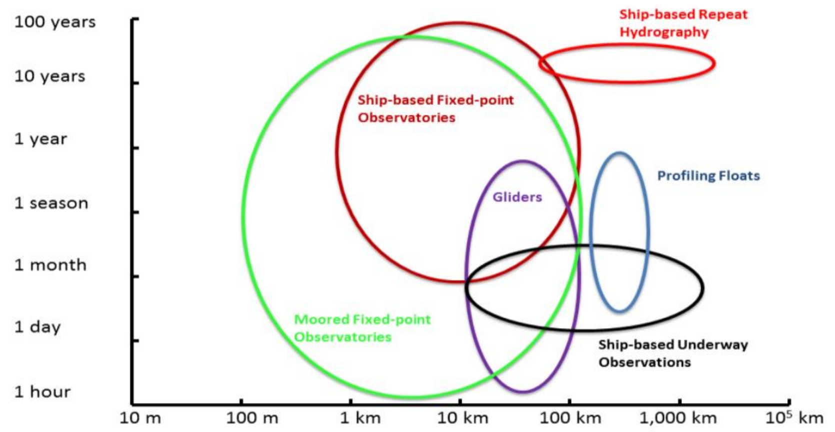
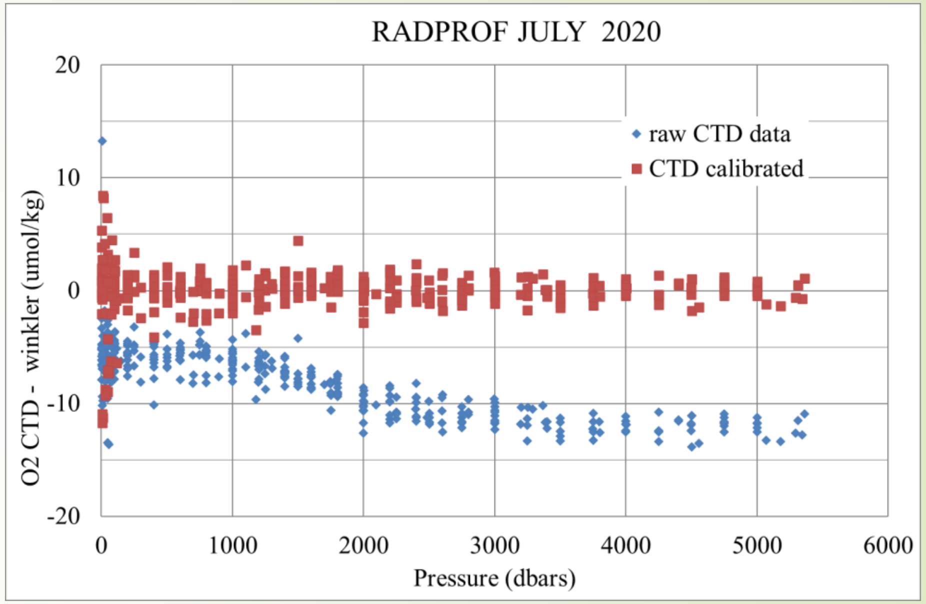


Figure 2. Spatial and temporal observation scales of component networks listed in Table 3 (thick coloured circles) and in Table 4 (thin black circles).

Observing Approach	**Moored Fixed-point Observatories**
Readiness Level of the Observing Approach for this EOV	Mature
Leading Observing Network	OceanSITES
Readiness Level of the Observing Network	Pilot
Phenomena Addressed	1,3,4
Spatial Scales Currently Captured by the Observing Network	Horizontal coverage: global Vertical coverage: Footprint: sub-basin scale (regional/biome scale)
Typical Observing Frequency	Hourly
Supporting Variables Measured	Surface and subsurface temperature, Surface and subsurface

Sensor(s)/ Technique	Optical oxygen sensor
Accuracy/Uncertainty Estimate (units)	±2.0 µmol O_2 kg^{-1}



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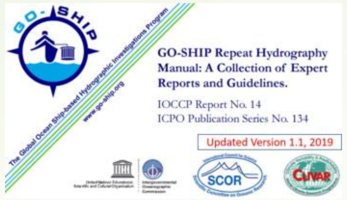
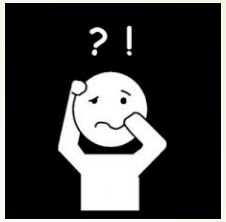
3. Specific BP for inorganic nutrients (uM, NO_{3+2}, PO_4, SiO_2)

REF: Becker et al. (2020)



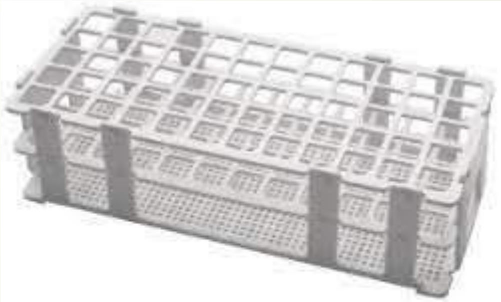


SAMPLING

- New sterile plastic High Density Polyethylene (HDPE) or Polypropylene (PP) (12-20 mL)
- Recycling tubes / containers is possible .. Cleaning investment
- NO smokers allowed
- Better NO gloves, that any gloves, …. Best .. Powder free vinyl gloves
- Avoid spigot from niskin bottles, or use clean silicon tube
- Buy a labeler is worthy!!

STORAGE & TRANSPORT

- Particles interferences: centrifugation or filtering (0.45 um filter)
- Analysis of FRESH samples is highly recommended .. But sometimes impossible
- Best option up to now: freezing …
    - Leave a headspace for expansion of seawater
    - Tight caps
    - Always upright till really frozen
- Buy many tube racks (sampling, organizing, freezing)
- Ziploc bags to store sets of tubes in horizontal
- Other options of storage to be tested in EuroGO-SHIP



EuroGO-SHIP Enhancing ocean observations

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3. Specific BP for inorganic nutrients

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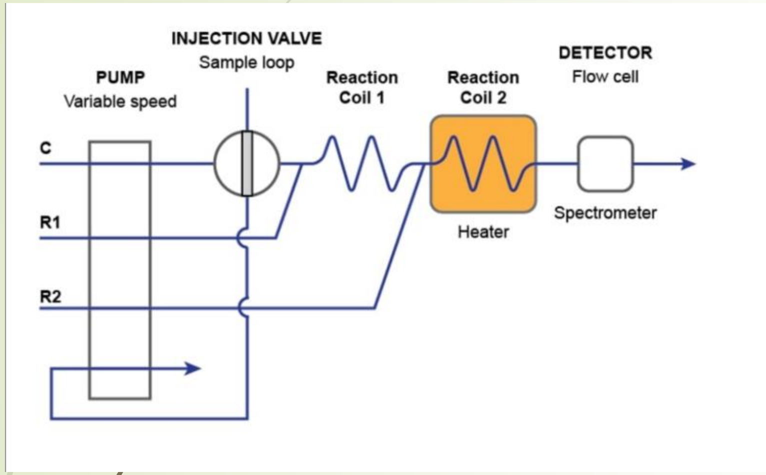
REF: Becker et al. (2020)   and also

Highly reccomended to understand PRINCIPLES of the Continous Flow Analysis for inorganic nutrients in seawater => Aminot and Kerouel (2007)



ANALYSIS

- N2 carrier / pumps / glassware / detector
- Many reagents
- Primary / secondary / working (mixed) standards
- Waste management

3. Specific BP for inorganic nutrients

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Quality control—The overall system of activities whose purpose is to control the quality of a measurement so that it meets the needs of users. The aim is to ensure that data generated are of known accuracy to some stated, quantitative degree of probability, and thus provides quality that is satisfactory, dependable, and economic.

Quality assessment—The overall system of activities whose purpose is to provide assurance that quality control is being done effectively. It provides a continuing evaluation of the quality of the analyses and of the performance of the analytical system.

Internal control using

- Tracking sample / substandard lab prepared
- External , bought as CRMs or RMs (KANSO, KIOST, MOOS) optimal to our content range !!
- MedSea .. Very low uM so difficult!!

Final control using

- Primary QC – visual inspection, prop-prop plots
- Secondary QC – comparison to other data in área / time

M. Belgacem et al.: Dissolved inorganic nutrients in the western Mediterranean Sea 1997

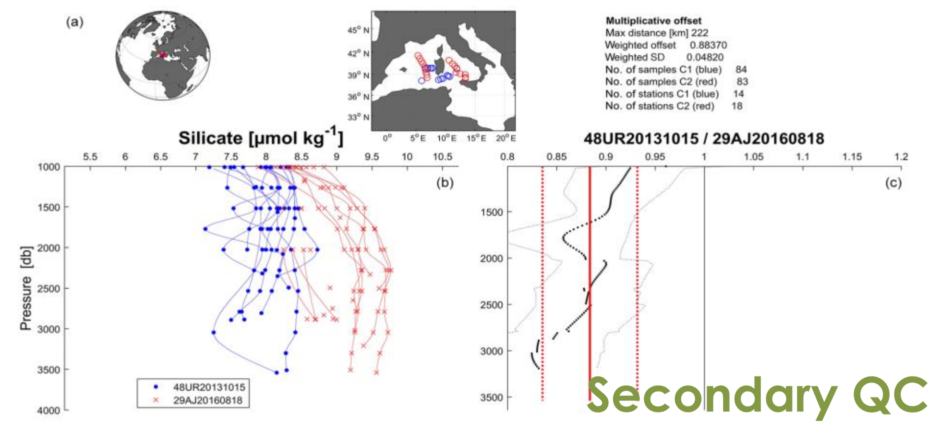

Figure 4. An example of the calculated offset for silicate between cruise 48UR20131015 and cruise 29AJ2016818 (reference cruise). **(a)** Location of the stations that are part of the crossover and statistics. **(b)** Vertical profiles of silicate data ($\mu mol\,kg^{-1}$) of the two cruises that fall within the minimum distance criteria (the crossing region), below 1000 dbar. **(c)** Vertical plot of the difference between both cruises (thick dotted black line) with standard deviations (thin dotted black lines) and the weighted average of the offset (solid red line) with the weighted standard deviations (dotted red lines).

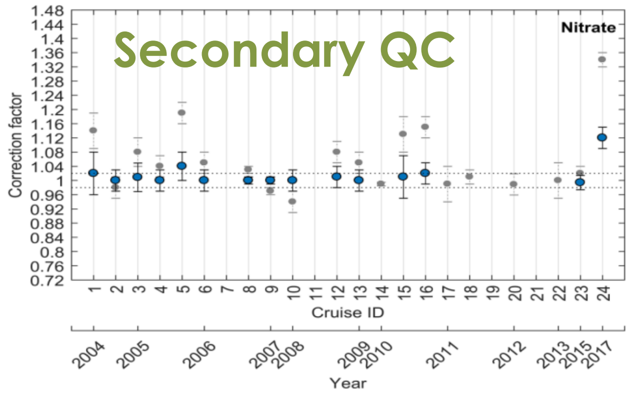

Figure 5. Results of the crossover analysis for nitrate, before (grey) and after (blue) adjustment. Error bars indicate the standard deviation of the absolute weighted offset. The dashed lines indicate the 2 % accuracy limit for an adjustment to be recommended.

3. Specific BP for inorganic nutrients

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REPORTING

Cruise Reports

The following should be included in the nutrient section of the cruise reports:

(i) Cruise designation (ID) and principle investigator(s).
(ii) If not listed in the cruise report elsewhere, CTD station information including station position, time, sampling depths, bottle numbers etc.
(iii) Names and affiliations of the analysts.
(iv) Numbers of samples analyzed, batches of standards used, pump tube and column changes.
(v) Equipment, methodology, and reagents used.
(vi) Sampling and any storage procedures.
(vii) Calibration standard information, methods, and values.
(viii) Data collection and processing procedures.
(ix) Details of any problems and trouble-shooting that occurred.
(x) QC/QA:

- stated accuracy and analytical precision;
- detection limits;
- values of check samples and/or tracking standards;
- measured values of the reference materials (including which batch was used, and assigned or certified values);
- if and how normalizations were made to the data, based on the internal check/tracking samples or the CRM.

(xi) Scientific References.

Becker et al. (2020)

REFERENCE MATERIALS : LOW AND HIGH CONCENTRATION

Table 1. Mean and standard deviation (STD) values for the #CE and #CG RMN analysis performed for the 5 RADPROF batch of analysis.

RADPROF RMN # CE	Mean±STD µmol/kg	certified value µmol/kg
Nitrate	0.02±0.03	0.01±0.03*
Nitrite	0.022±0.01	0.016±0.009
Silicate	0.00±0.32	0.06±0.09*
Phosphate	0.030±0.036	0.012±0.006*

RADPROF RMN # CG	Mean±STD µmol/kg	certified va µmol/kg
Nitrate	24.4±0.34	23.7±0.2
Nitrite	0.06±0.01	0.06±0.03
Silicate	57.431±0.7	56.4±0.5
Phosphate	1.67±0.07	1.70±0.02

INTERNAL LAB SUBSTANDARD: coastal water filtered

Mean and standard deviation (STD) values for the surface seawater analysed for the 5 RADPROF run of analysis.

RADPROF SW	Mean±STD µmol/kg
Nitrate	10.84±0.11
Nitrite	0.03±0.03
Silicate	7.55±0.20
Phosphate	0.33±0.02

5 runs => 4 weeks

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3. Specific BP for inorganic nutrients

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EOV specification sheets

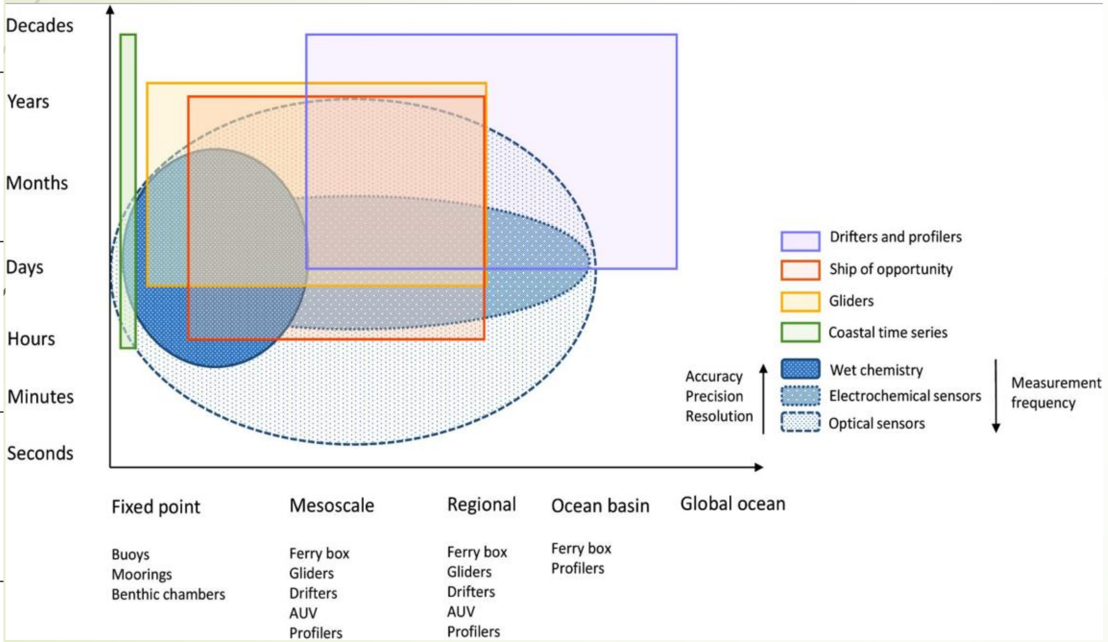
The Global Ocean Observing System

Moored Fixed-Point Observatories
Resolving water column measurements of nutrients.
NO3 Pilot <u>Other</u> Concept
1-100 km
Daily to annual
UV spectro-photometry
<u>NO3</u> ~0.5-3 µM

2017

Toward a Harmonization for Using *in situ* Nutrient Sensors in the Marine Environment

Daniel et al. (2020)



Advantages	Disadvantages	Optimal conditions of deployment	Tested deploy platforms
Wet chemical analyzers (spectrophotometry and fluorimetry)			
Limit of detection Low trueness Low precision: 1 – 4% Large concentration range for each nutrient *In situ* calibration Moderate response time (few min.) Not significantly affected by biofouling	High power requirements: 1, 5 –28 W Relatively bulky: 500 × 200 mm, 5 – 8 kg High maintenance costs Longevity limited by reagent use and stability (1 – 5 months) Hazardous waste chemical storage	Coastal and open ocean, relatively short time periods (days to months) Temperate	FerryBox Buoy Benthic chamb Gliders Fixed platform Moorings
UV optical sensors			
Good trueness Large nitrate concentration range Reagent free Fast response: few seconds – 2 min Low power requirement: 4.2 – 8 W Moderate weight: 1.8 – 3.4 kg	Nitrate only Biofouling Subject to optical interferences Nitrate only Moderate limit of detection Moderate trueness	Coastal waters and open ocean, long time period (months to year), polar temperate and tropical	Buoy Profiling floats Gliders Moorings
Electrochemichal sensors			
Moderate silicate concentration range Reagent free Moderate weight: 2.2 kg Not significantly affected by biofouling	Silicate only Moderate limit of detection Moderate trueness Moderate precision: 2% Subject to large variation of salinity Long measurement cycle (30 – 60 min)	Coastal waters and open ocean, relatively short time period (days to months), polar temperate and tropical	Buoys Profiling floats
Benchmark techniques in laboratories			
All nutrients High trueness and precision Not affected by biofouling Moderate response time	Only discrete samples Potential contamination during the sampling Substantial and consistent maintenance Not optimized for long-term unattended operation	/	/

*The authors of the references cited did not necessarily use the same way to calculate the Limit Of Detection. P, prototype; C

Wish List

- APNA, ChemFIN (Subchem systems, Egli et al., 2009) C
- WIZ (SYSTEA, Moscetta et al., 2009) C
- Micromac C (SYSTEA) C
- Hydrocycle PO4 (Seabird scientific) C
- NAS3X (Mills et al., 2005) S
- Digiscan (Plant et al., 2009) P
- ANAIS (Thouron et al., 2003) P
- Alchemist (Le Bris et al., 2000) P
- CHEMINI (Vuillemin et al., 2009a) P
- LoC (Beaton, 2012; Nightingale et al., 2015; Beaton et al., 2017; Clinton-Bailey et al., 2017; Grand et al., 2017; Vincent et al., 2018) P
- NuLAB (GreenEyes) C

- ISUS/SUNA (Seabird scientific; Johnson and Coletti, 2002; Johnson et al., 2006; D'Ortenzio et al., 2012, 2014; Frank et al., 2014) C
- ProPS/OPUS (TriOS; Zielinski et al., 2011; Meyer et al., 2018) C
- Spectro::lyser (S::can Measuring Systems, Etheridge et al., 2014) C
- SUV-6 (Finch et al., 1998) P

- ANESIS (Lacombe et al., 2008; Jońca et al., 2013; Barus et al., 2016, 2018) P

- AA3 and QuAAtro SEAL analytical C
- SkalarVR, C
- Lachat QuikChem C

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3. Specific BP for inorganic nutrients

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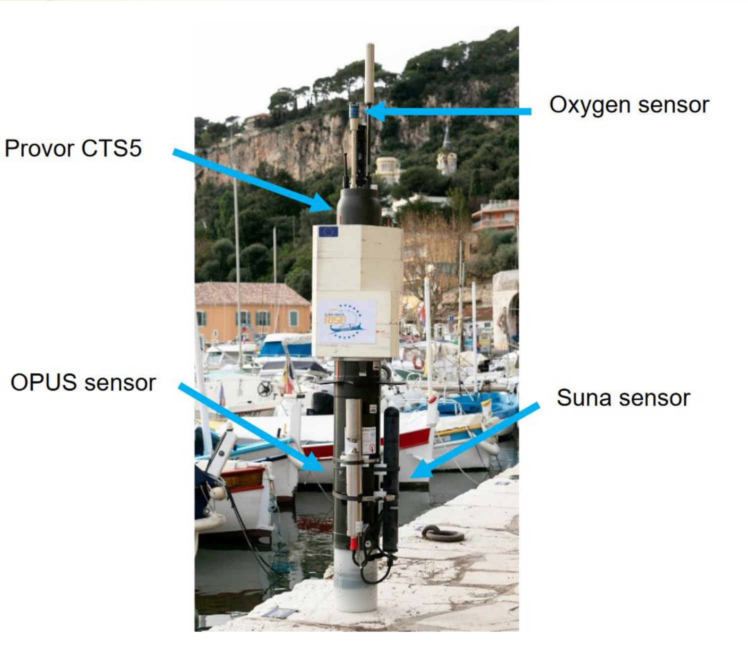
Discrete meas. always needed? .. Probably yes!

Date: 11/01/2021

Euro-Argo Research Infrastructure Sustainability and Enhancement Project (EA RISE Project) - 824131



Western MedSea Example

2.1.3 Data processing

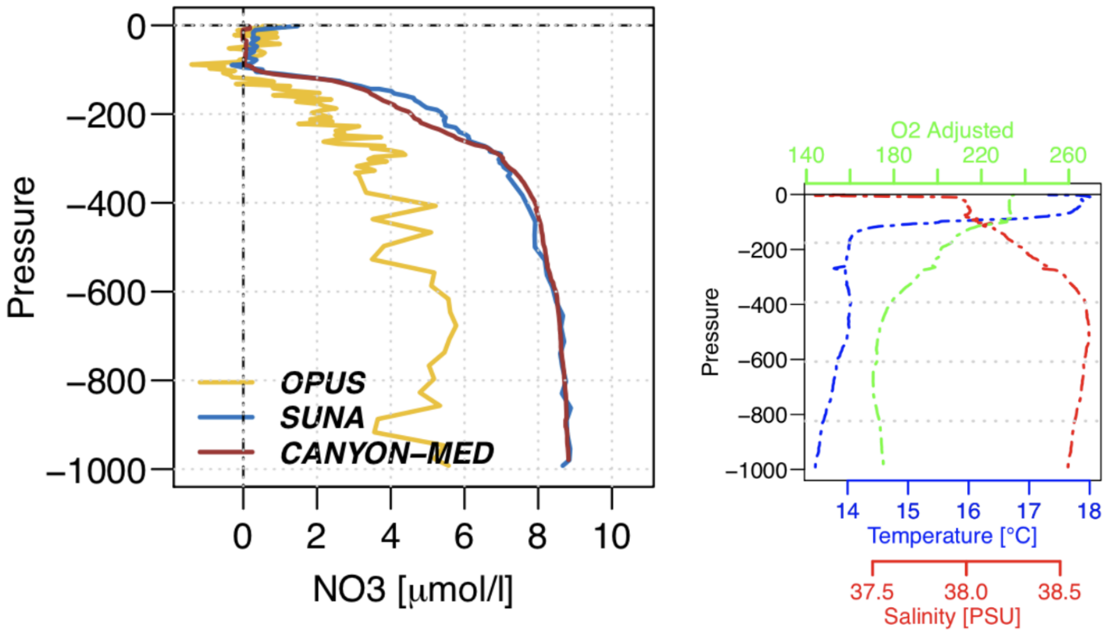
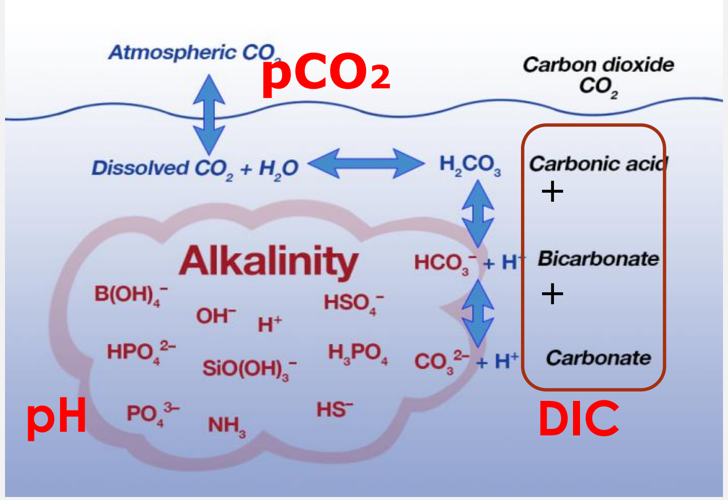


Figure 6: The comparison of the NO3 retrieval by the two sensors and through the neural network Canyon-Med method (left panel) for November 25, 2019. At this period, the surface waters are still stratified (right panel)

3. Specific BP for CO_2 variables

18 **Basic concepts!**

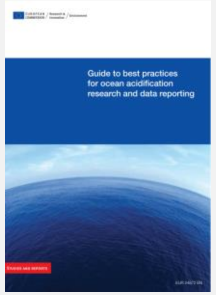
Seawater CO_2 system =>
acid base system of minor constituent in seawater (<0.7%, <200 mg)



REF: Dickson et al (2007)

Table 8. Estimates of the Analytical Precision and Accuracy of Measurements of pH, TA, TCO_2, and pCO_2

analysis	precision	accuracy	ref
pH (spectrophotometric)	±0.0004	±0.002	42
TA (potentiometric)	±1 μmol kg^{-1}	±3 μmol kg^{-1}	29
TCO_2 (coulometric)	±1 μmol kg^{-1}	±2 μmol kg^{-1}	96
f_{CO_2} (infrared)	±0.5 μatm	±2 μatm	97



Riebesell et al. (2011)

Certified Reference Material CRM

CO_2 software for calculated variables:

Table 1. Carbonate system software packages.

Package	Language	Version	Reference
CO2SYS[a]	QBasic	1.05	Lewis and Wallace (1998)
CO2SYS[b]	Excel	24	Pelletier et al. (2007)
CO2SYS[a]	Excel	2.1	Pierrot et al. (2006)
CO2SYS[a]	MATLAB	1.1	van Heuven et al. (2011)
CO2calc[c]	Visual Basic	1.3.0	Robbins et al. (2010)
csys[d]	MATLAB	04–2014	Zeebe and Wolf-Gladrow (2001)
ODV[e]	C++	4.5.0	Schlitzer (2002)
mocsy[f]	Fortran 95	2.0	Orr and Epitalon (2015)
seacarb[g]	R	3.0.6	Gattuso et al. (2015)
swco2[h]	Excel	2	Hunter (2007); Mosley et al. (2010)
swco2[h]	Visual Basic	2	Hunter (2007)

Orr et al. 2015

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3. Specific BP for CO_2 variables

19 **Basic concepts!**

Seawater CO_2 system =>
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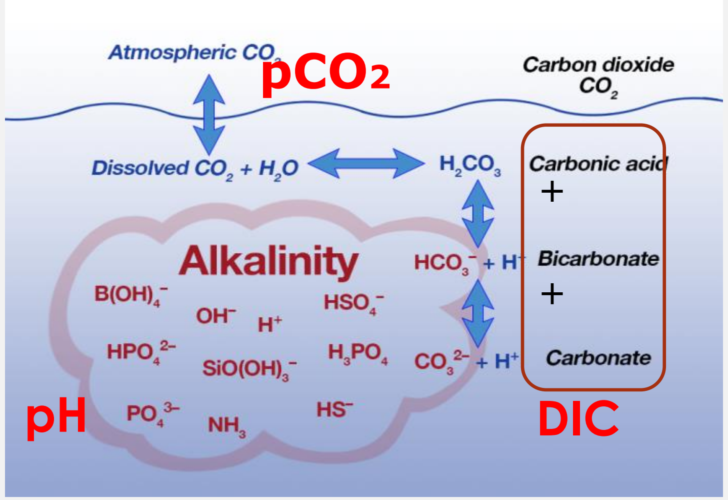


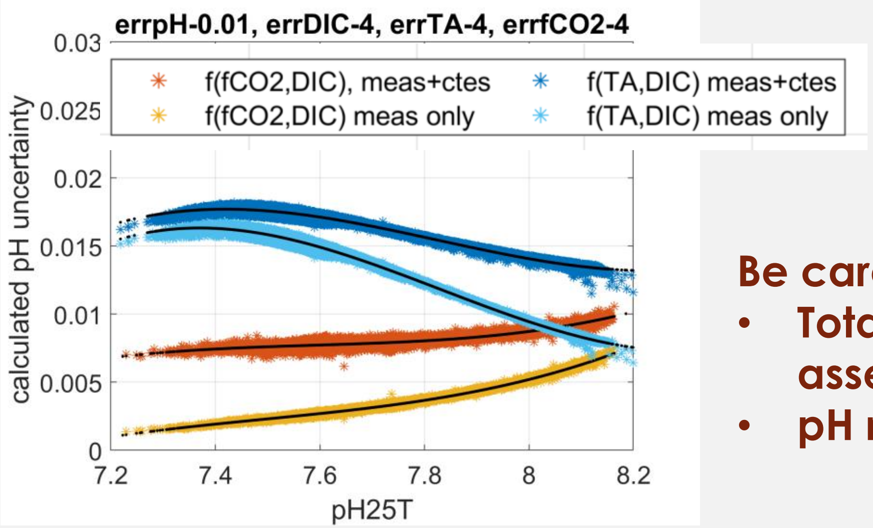
CO_2 software for calculated variables:

Table 9. Estimated Probable Errors in the Calculated Parameters of the Carbonate System Using Various Input Measurements

input	pH	TA (μmol kg^{-1})	TCO_2 (μmol kg^{-1})	f_{CO_2} (μatm)
pH−TA			±3.8	±2.1
pH−TCO_2		±2.7		±1.8
pH−f_{CO_2}		±21	±18	
f_{CO_2}−TCO_2	±0.0025	±3.4		
f_{CO_2}−TA	±0.0026		±3.2	
TA−TCO_2	±0.0062			±5.7

Orr et al. 2018

Calculated pH



Be careful

- **Total uncertainty assessment**
- **pH range?**

3. Specific BP for CO_2 variables

20

All ocean processes affect CO2 variables
QSR OSPAR, McGovern et al (2023)

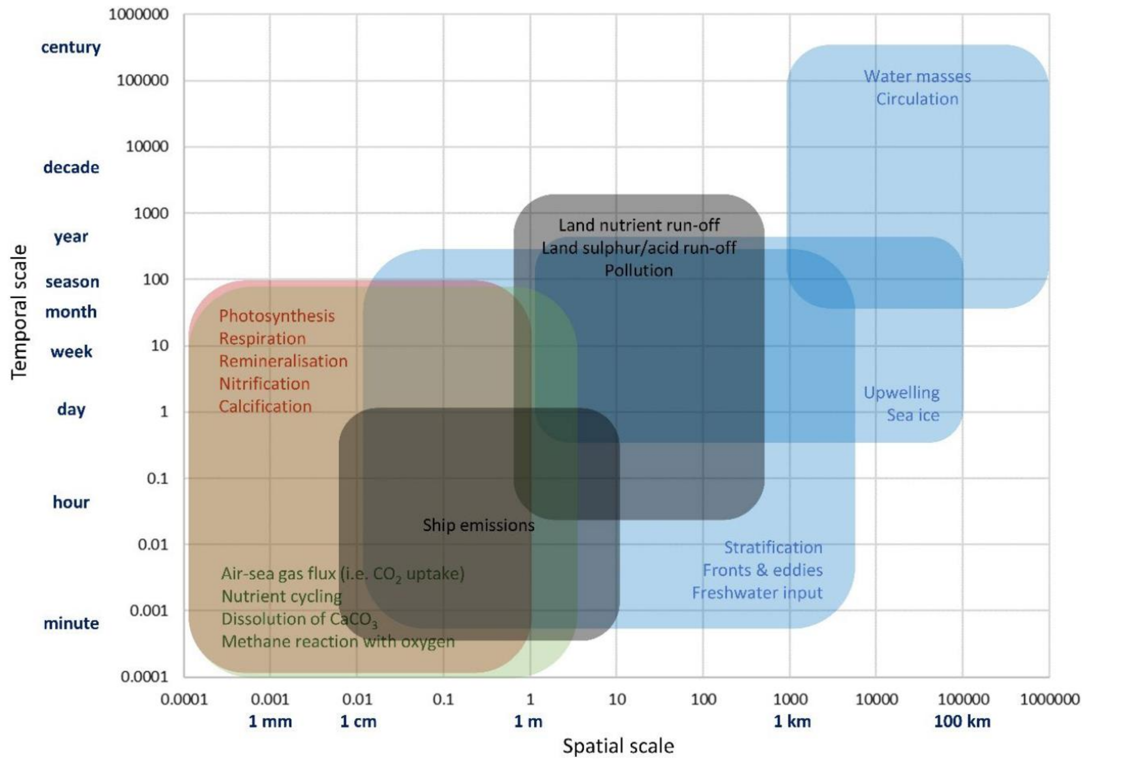


Figure 3.3: Simplified schematic overview on physical (blue boxes), chemical (green boxes), biological (red boxes) and anthropogenic (black boxes) processes that contribute to changes in ocean carbonate chemistry on different temporal and spatial scales.

Observing requirements, Ciais et al. (2014)

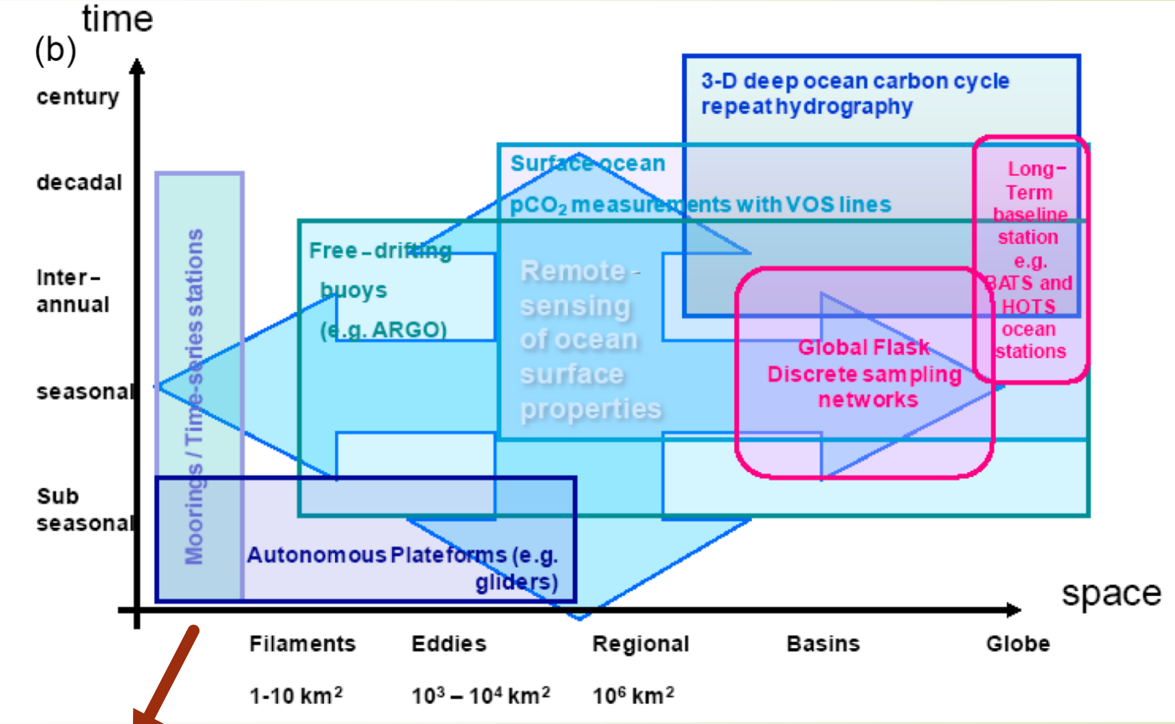


Table 1 | **Major observed biogeochemical properties on mobile platforms**

Observed property	Sensor	Platforms applied
pCO_2	NDIR spectrometer	USVs
	Equilibration-based infrared gas analyser	USVs
pH	Ion-sensitive field-effect transistor	All autonomous platforms

Chai et al 2020

3. Specific BP for CO_2 variables

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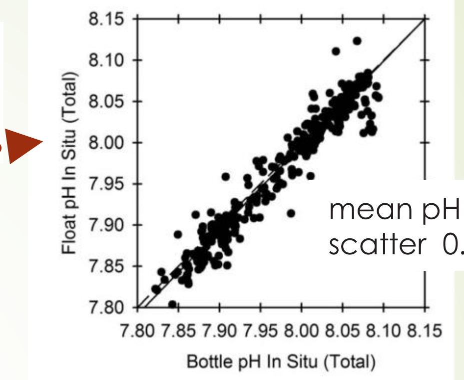
Observing requirements, Ciais et al. (2014)

Table 1 | **Major observed biogeochemical properties on mobile platforms**

Observed property	Sensor	Platforms applied
pH	Ion-sensitive field-effect transistor	All autonomous platforms
pCO_2	NDIR spectrometer	USVs
Chai et al 2020	Equilibration-based infrared gas analyser	USVs

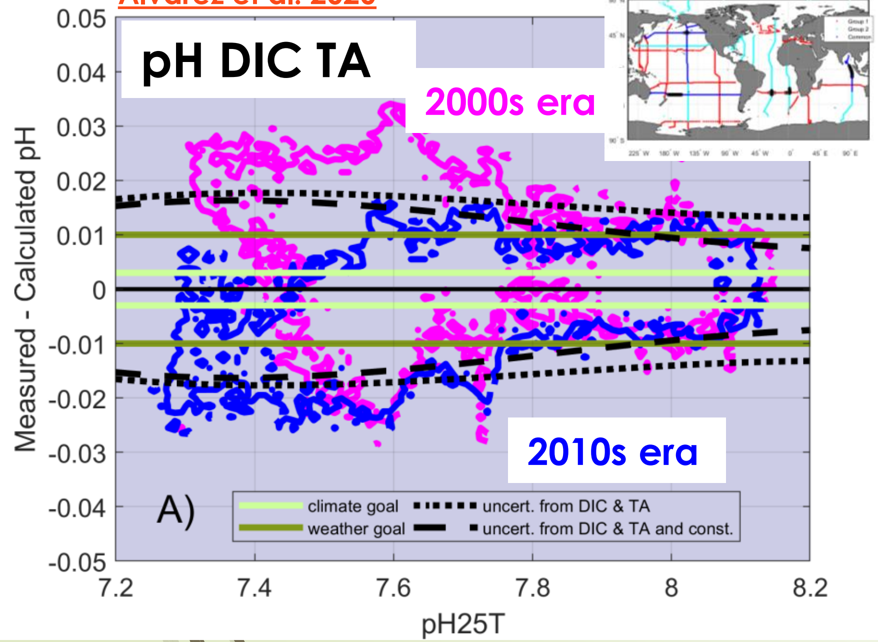
Check IOCCP web page

Very promising tech (Johnson et al. 2017) BUT

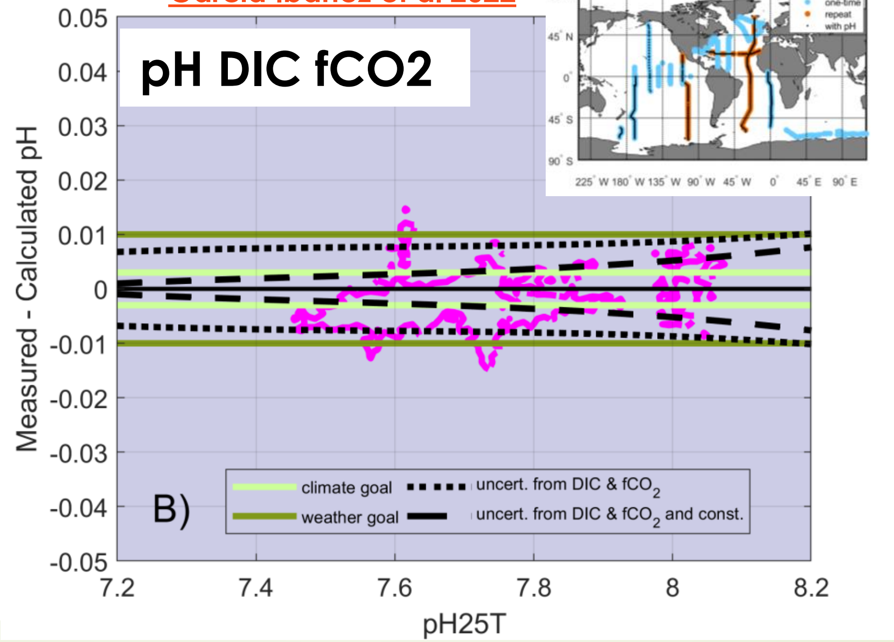


NEED to go back to DISCRETE MEASUREMENTS and CHECK

Álvarez et al. 2020



Garcia Ibañez et al 2022



- Method for TA
- Method for DIC
- Method for pCO2
- pH method
- Constants
- What???

3. Specific BP for CO_2 variables

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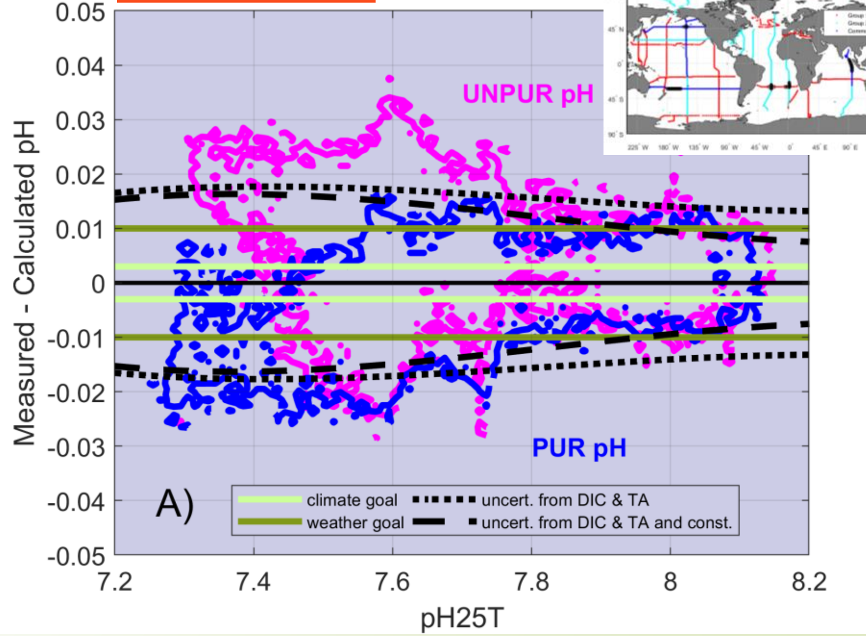
pH or not pH … ?¿?¿?

1990s	2000s	2010s	2020s
• Introduction of sulfonephtalein indicator dyes to measure pH • First characterization of m-cresol purple (Kodak mCP) and description of manual method • WOCE era, pH rarely measured in transoceanic sections • WOCE A25 (1997) – first spect pH measurements in IIM-CSIC group	• 2007 SOP description • CLIVAR era, more pH measurements • First GLODAP (2004) release, with no pH data included • Development of automated systems for benchtop and submersible autonomous systems • **Detection of impurities in mCP dyes**	• **Introduction and first characterization of purified mCP (1)** • Other characterizations and evaluation of uncertainties in pH method • Use of ISFET electrodes in seawater • GO-SHIP era, pH is EOV • 2009 – I09 first cruise with PUR mCP	• GLODAP.v2 2016 release with pH data –mostly UNPUR mCP data, in 2021 both • **Measured and calculated pH disagreement => GLODAP applies corrections to reach consistency (2)** • Wider salinity and temperatura range PUR mCP characterization • **A434_imp Method to correct UNPUR to PUR mCP (no paper published using it) (3)** • Lab tests to check agreement between ISFET and PUR pH • Lab test to check stability and consistency between PUR mCP pH

Álvarez et al. 2020



Douglas & Byrne (2017)

$$_{434}A_{imp} = \left(1 - \frac{e_3}{e_2} * R_{obs}\right) * {}_{434}A_{obs}$$

$$^{434}_{imp}A = {}^{434}_{obs}A - \frac{e3}{e2} * {}^{578}_{obs}A$$

unesco Intergovernmental Oceanographic Commission

WMO

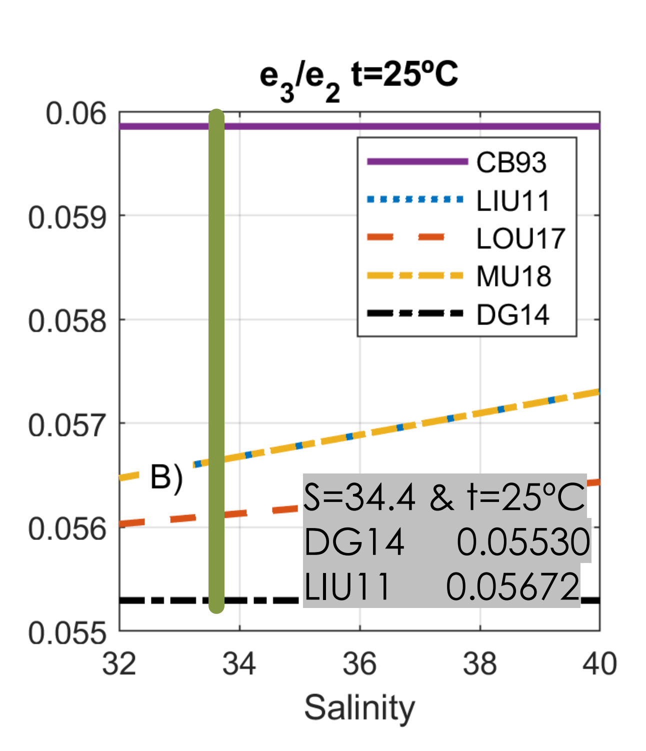
DBCP WMO - IOC

3. Specific BP for pH – correcting impurities

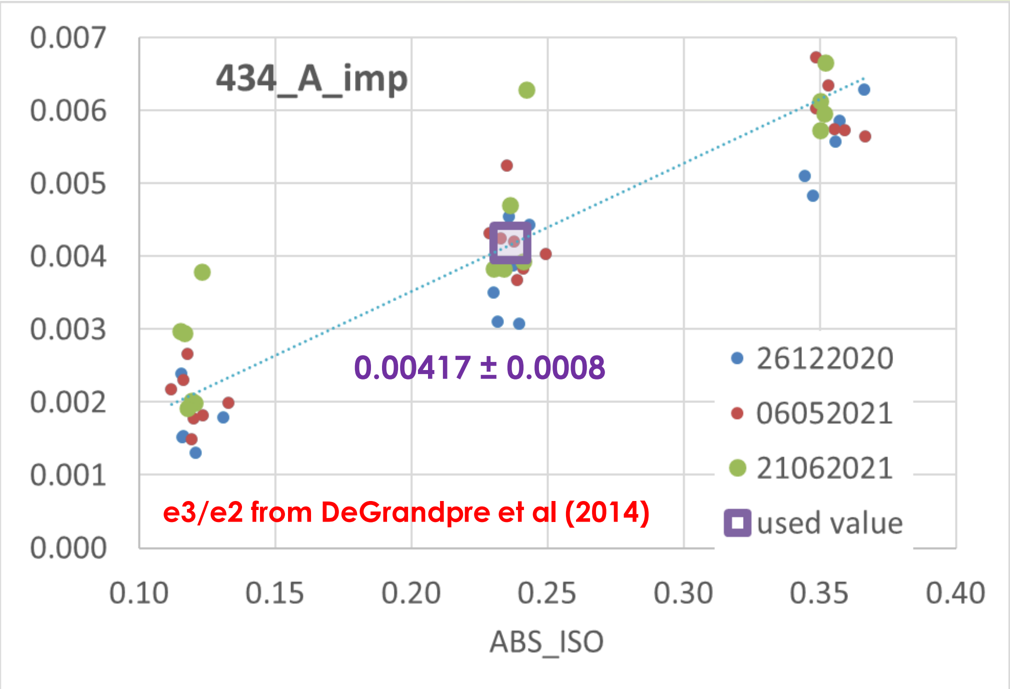
$$ {}^{434}_{imp}A = {}^{434}_{obs}A - \frac{e3}{e2} * {}^{578}_{obs}A $$

≃ (0.06 Abs) - 0.05xx · (≃ 1 ABS)

$_{434}$ A $_{imp}$ => Nearly zero or negative !!!



UNPUR Sigma Aldrich #11517KC



3. Specific BP for pH – correcting impurities

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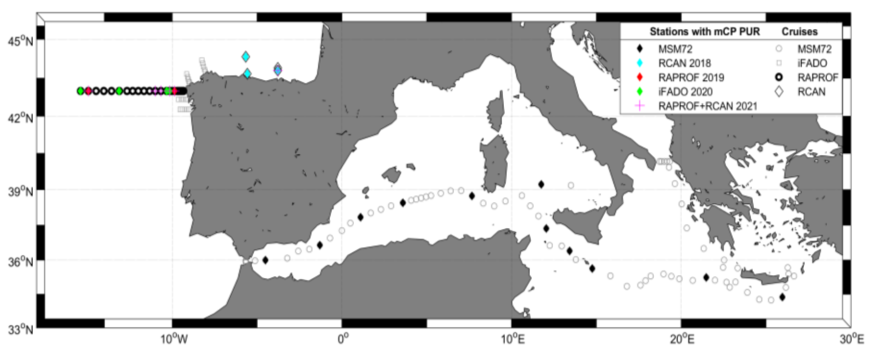
UNPUR Sigma Aldrich #11517KC $\ {}^{434}_{imp}A = $ **0.00417 ± 0.0008**

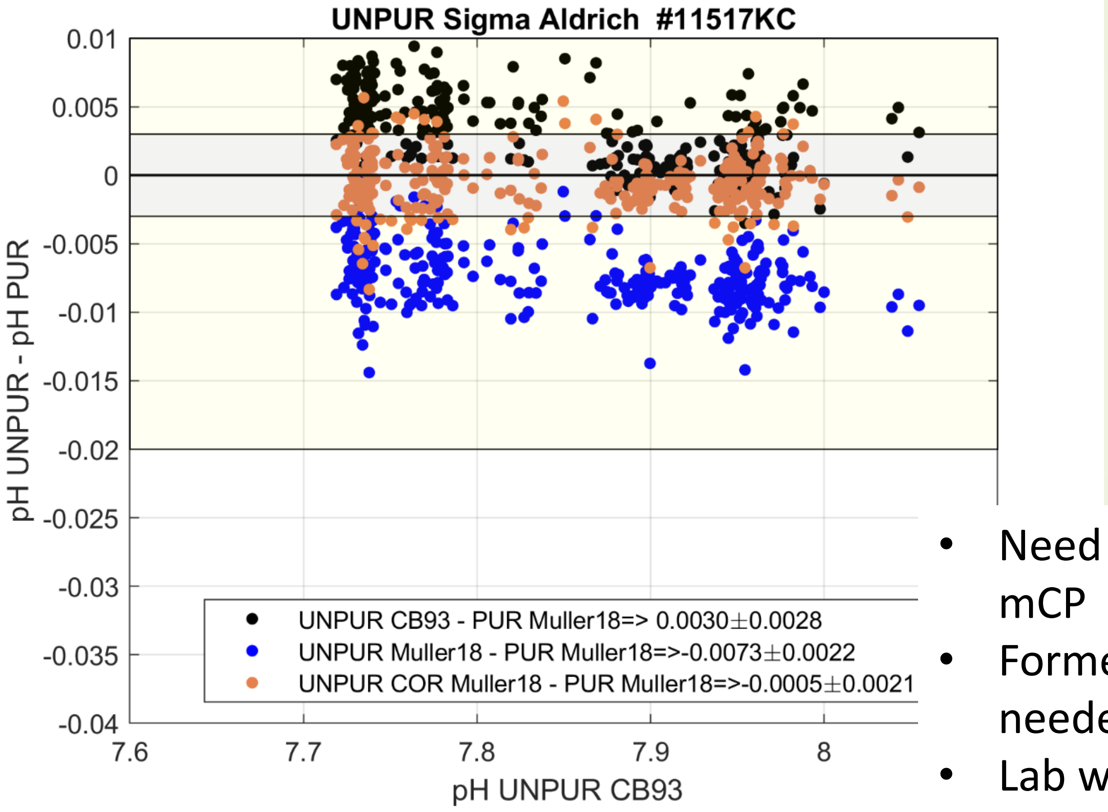


Muller et al (2018) equation

Clayton & Byrne (1993) equation

$$R_{pure} = R_{obs}\left(1 + \frac{{}_{434}A_{imp}}{{}_{434}A_{obs} - {}_{434}A_{imp}}\right)$$

AGREMENT with PUR measurements



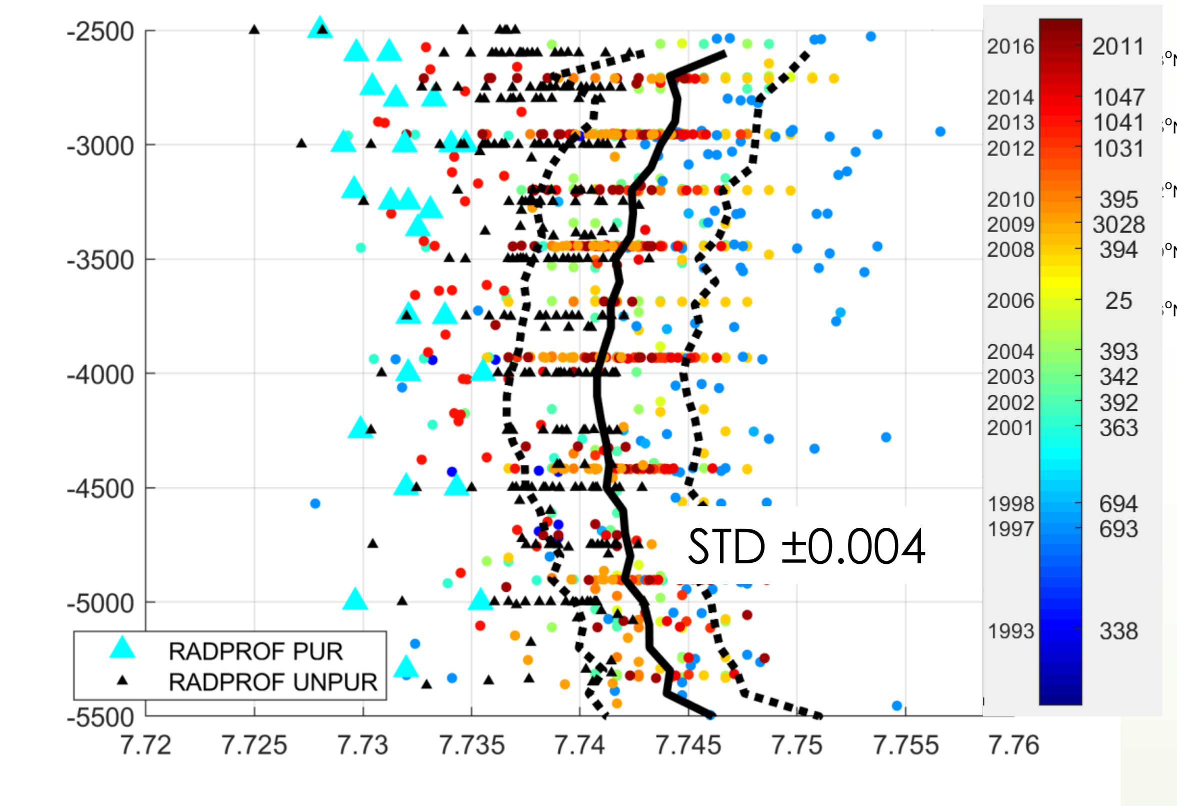
- Need to (even) check purified mCP
- Formerly used UNPUR mCP is needed to obtain ${}_{434}A_{imp}$
- Lab work
- Computer work to recover UNPUR mCP ABS and DeltaR

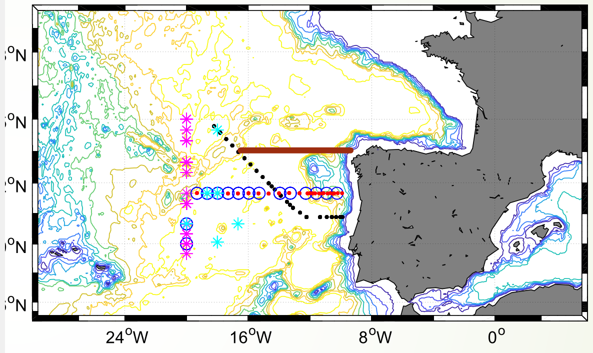
3. Specific BP for pH – correcting impurities

What happens if no mCP is available??

glodap

NE Atlantic pH time series – Depth > 2500 meters





3. Specific BP for pH – correcting impurities

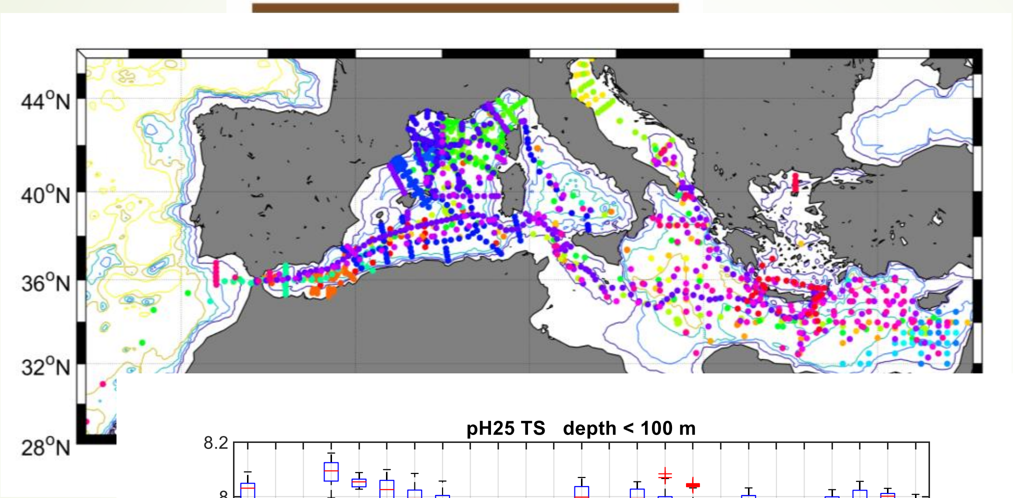
What happens IN THE MEDITERRANEAN

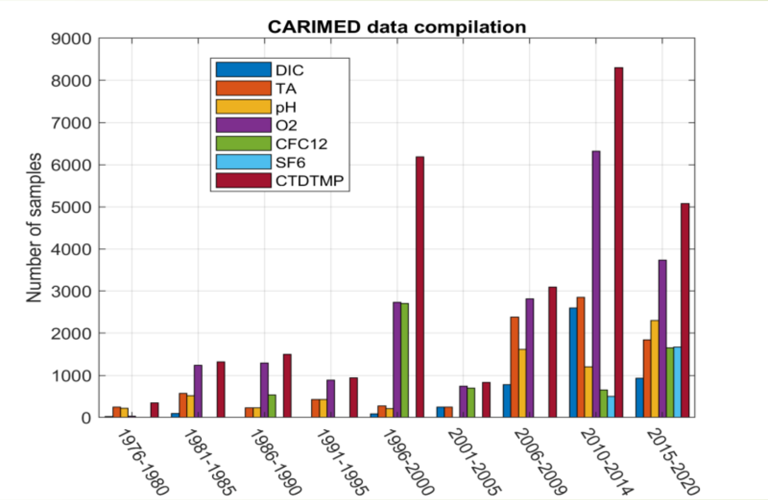
glodap

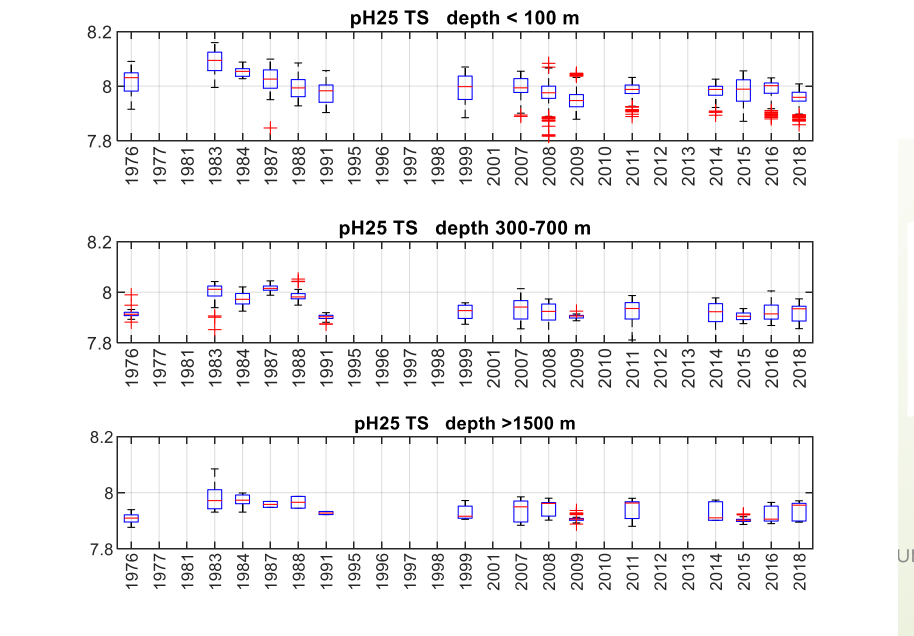
FEW DATA

carimed

HOPEFULLY TO BE RELEASED IN 2024







AIMS to be a consistent, calibrated data product to serve oceanographers and stakeholders

4. *Easy* reporting, formatting: metadata & data

Some reccomendations

- Create your template in excel for data & metadata
- Data
  - Vocabulary, variables names
  - International units
  - Always the same format for basic time / space variables
  - Always the same significant units for physical and BGC variables
- Metadata
  - Basic info about cruise
  - Basic info about each variable, methods, RMs?, precision and accuracy checks

- On line tool excel to CSV convertor by A. Velo (IIM-CSIC)

- Read Jiang et al. (2022)

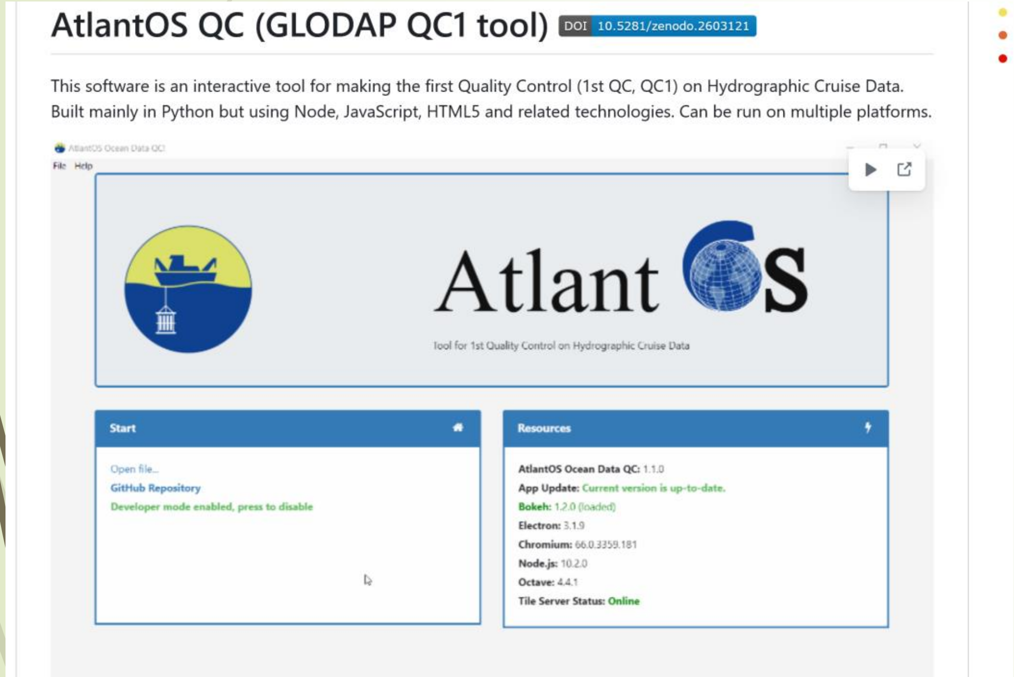
5. *Easy* primary Quality Control (QC)

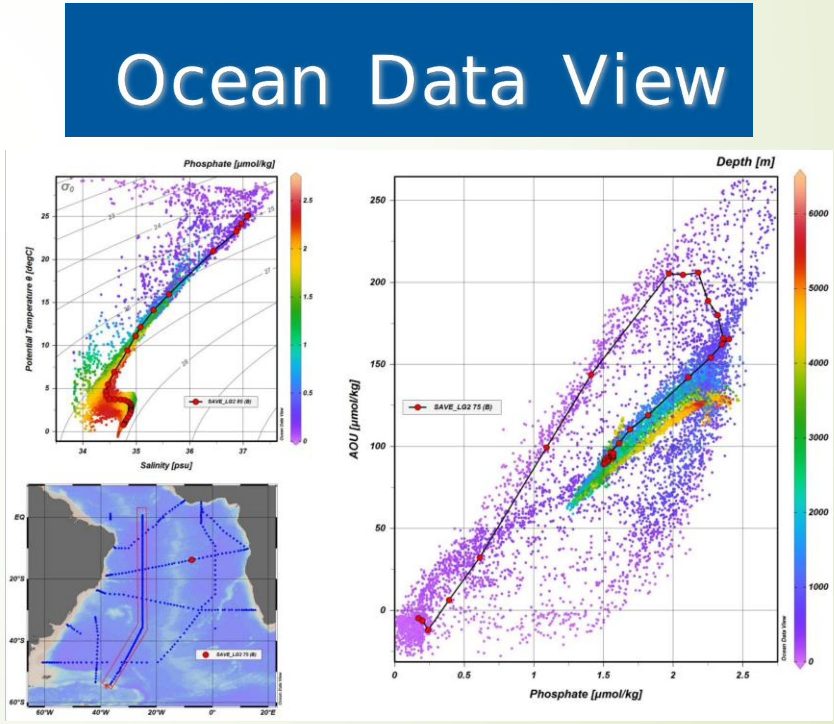
28

Some reccomendations

- Create your template in excel for checking data but it is tiresome
- Each data sample should be referenced Station / Cast / Niskin bottle

- Tool by Velo et al reads created CSV file   &   ODV as well





6. Examples of BAD practices / results

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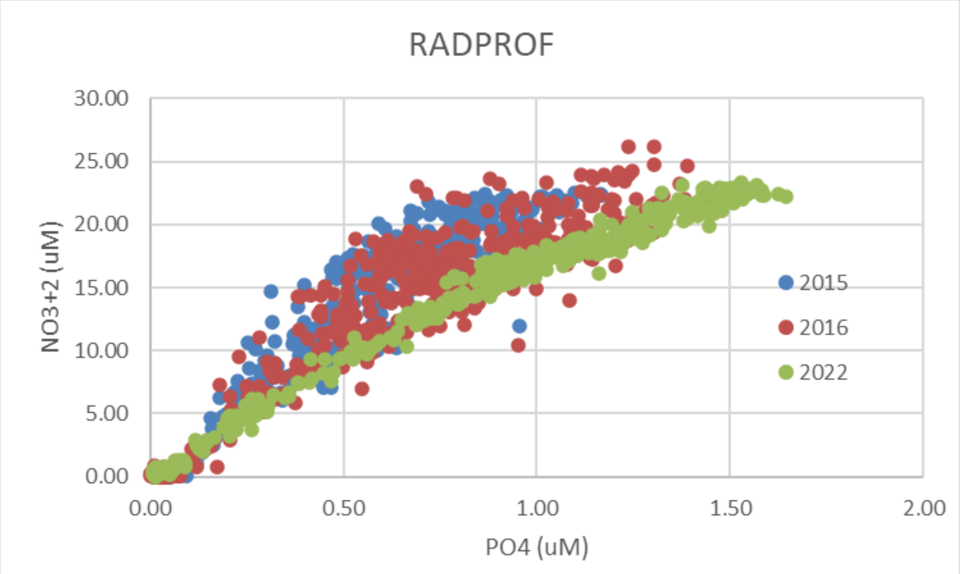
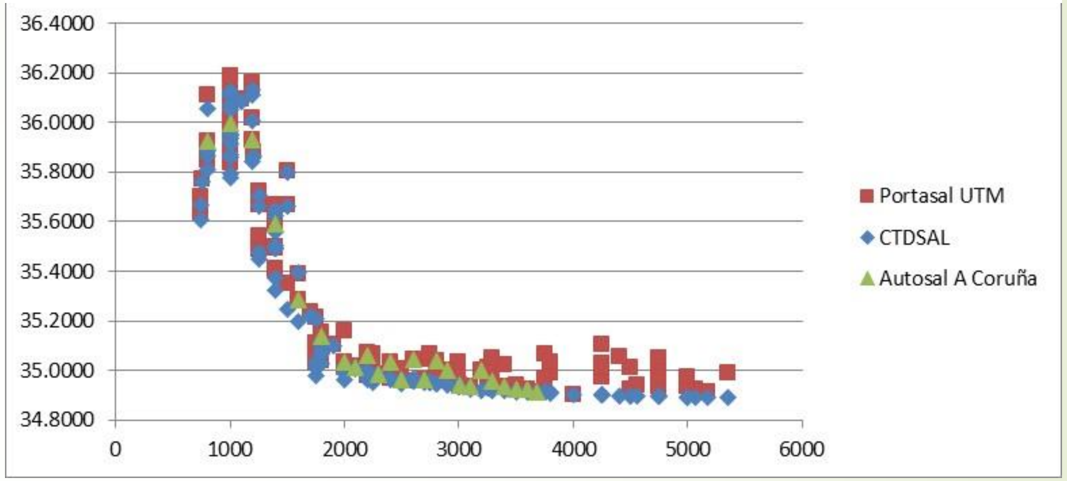
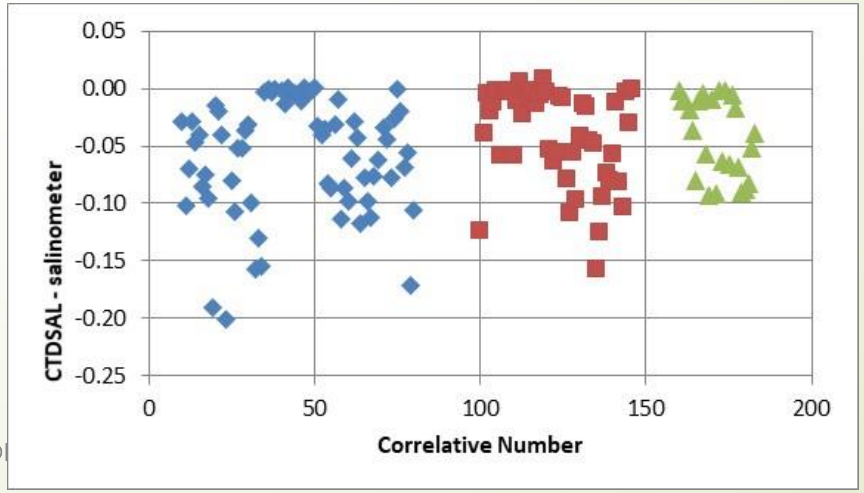
INOCEN's fault!!

NUT: bad conservation .. Too long freezing



Salinity: bad sampling/ conservation / analysis.. Who knows?





6. Examples of BAD practices / results

30

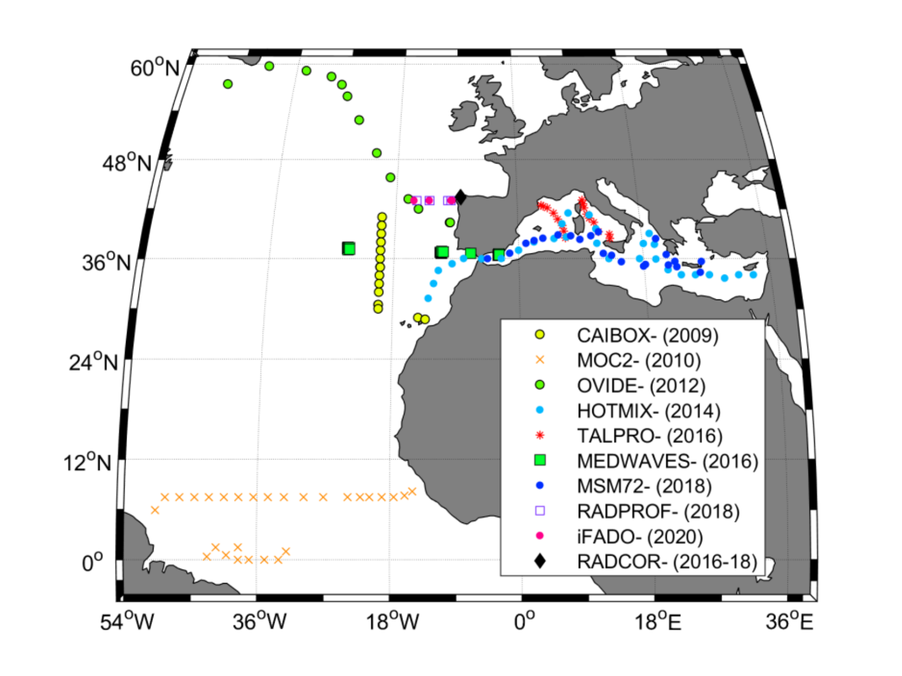
Somebody else's fault!!

pubs.acs.org/est

Critical Review

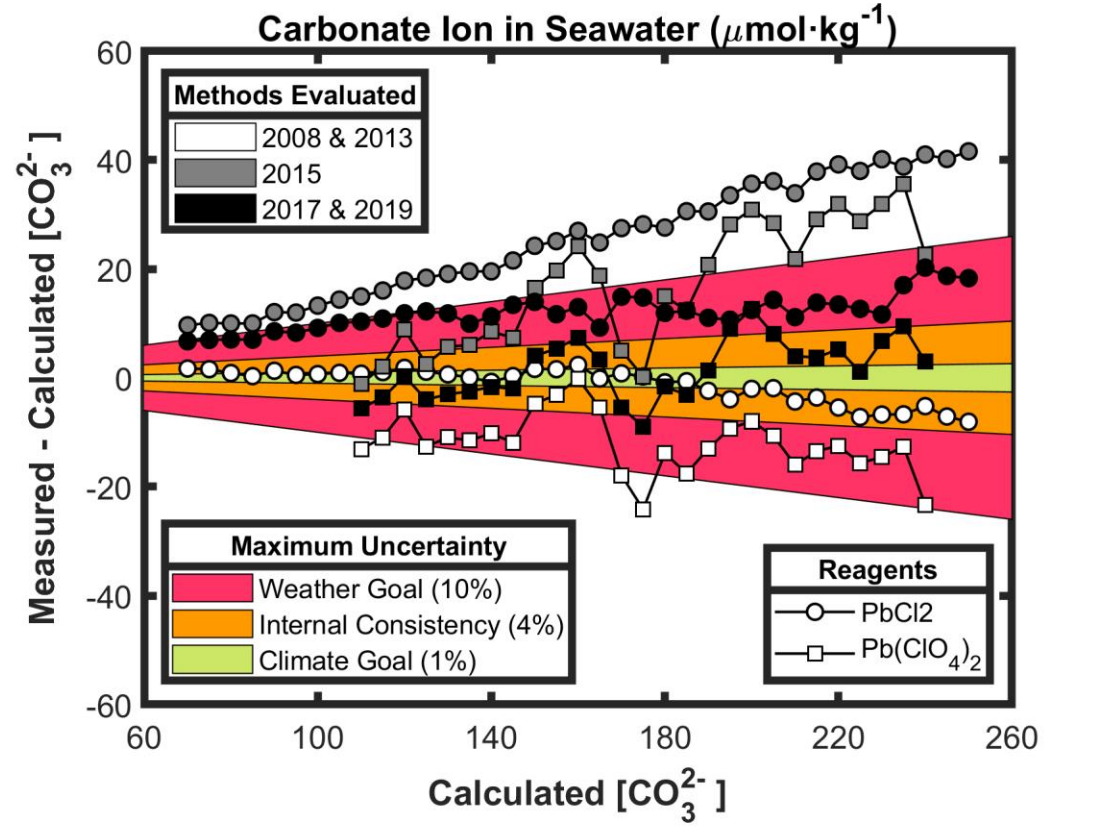
Spectrophotometric Measurement of Carbonate Ion in Seawater over a Decade: Dealing with Inconsistencies

Elisa F. Guallart,* Noelia M. Fajar, Maribel I. García-Ibáñez, Mónica Castaño-Carrera,



Guallart et al (2022)

Proposed BP not coherent with other CO2 variables



7. CONCLUSIONS

Best practices: could be misleading

basic BGC but not easy

Plea for cheaper / easier to maintain / sustained BGC sensors

Hope for an easier access to CRMs

Hope for pH metrology