Quality requirement and calibration in the OMZ

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Thanks to: *Mélanie GIRAUD, Jesus LEDESMA, Jacques GRELET, François BAURAND, Dominique LEFEVRE*

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glazeO océanographie & environnement
UCA Universidad de Cádiz
AARHUS UNIVERSITY
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IRD Institut de recherche pour le développement

Workshop ODATIS-CES-OXYGENE (2-3 July 2019, Paris)

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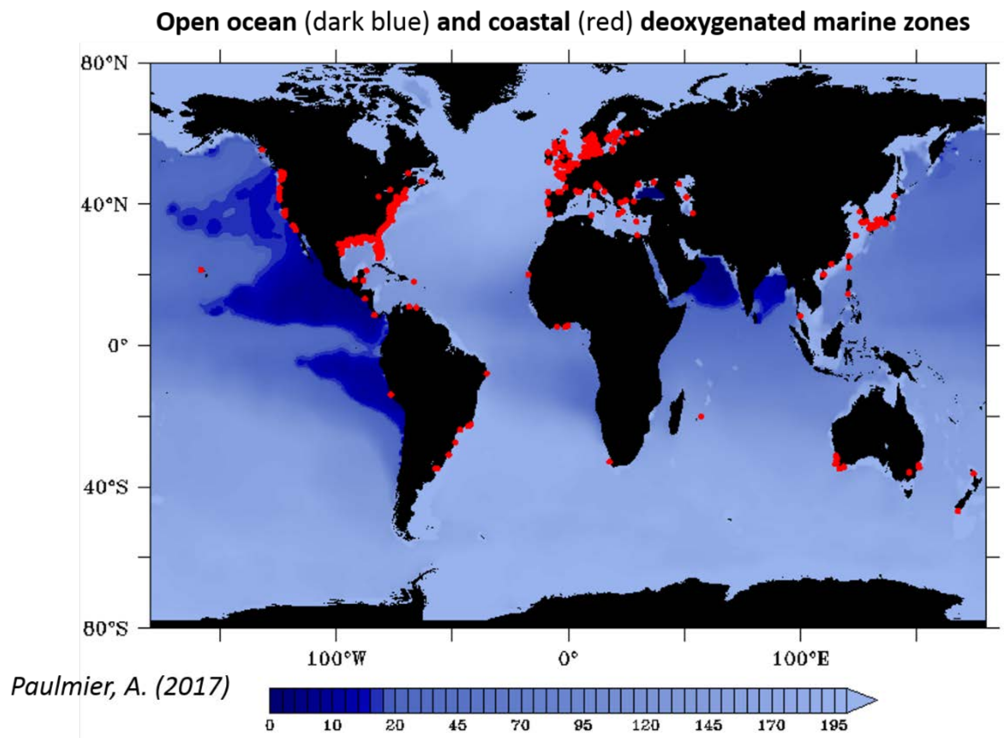
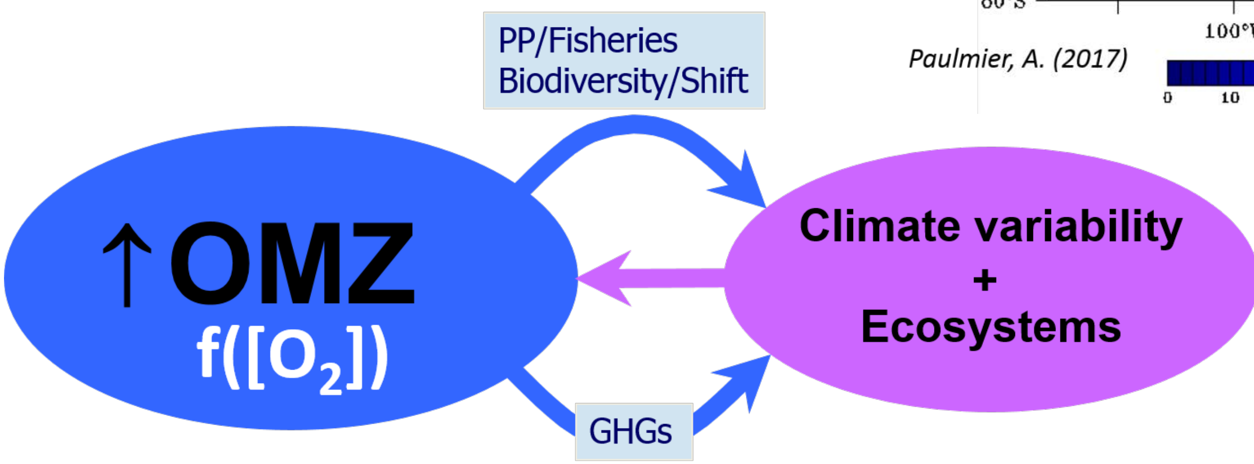
The very low $[O_2]$ areas



Why?



→ **Key-role** on: - **climate** (CO_2, N_2O, CH_4, DMS, …);

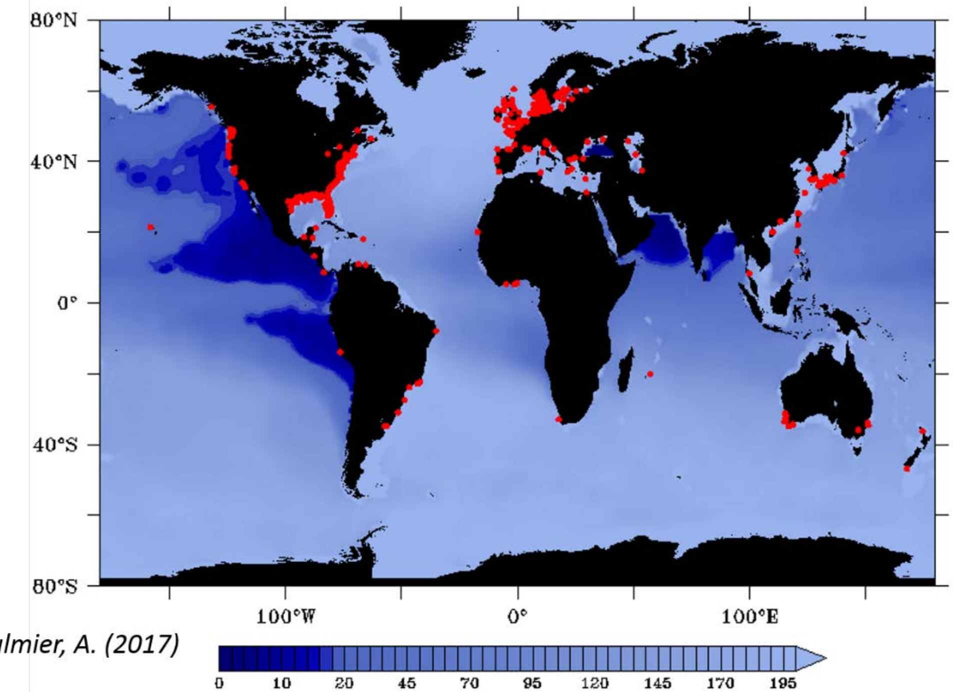
- **ecosystems** («Respiratory barrier», nitrogen loss)

→ **Sensitive** to **changes** of the:

- **climate** (warming; ENSO); **environment** (fertilizations)

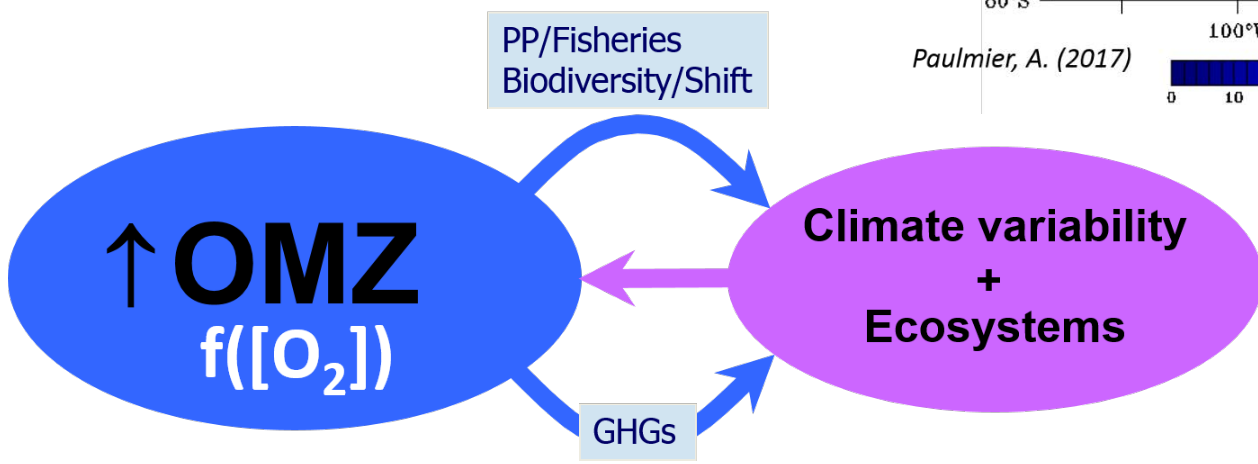
The very low $[O_2]$ areas

Open ocean (dark blue) **and coastal** (red) **deoxygenated marine zones**



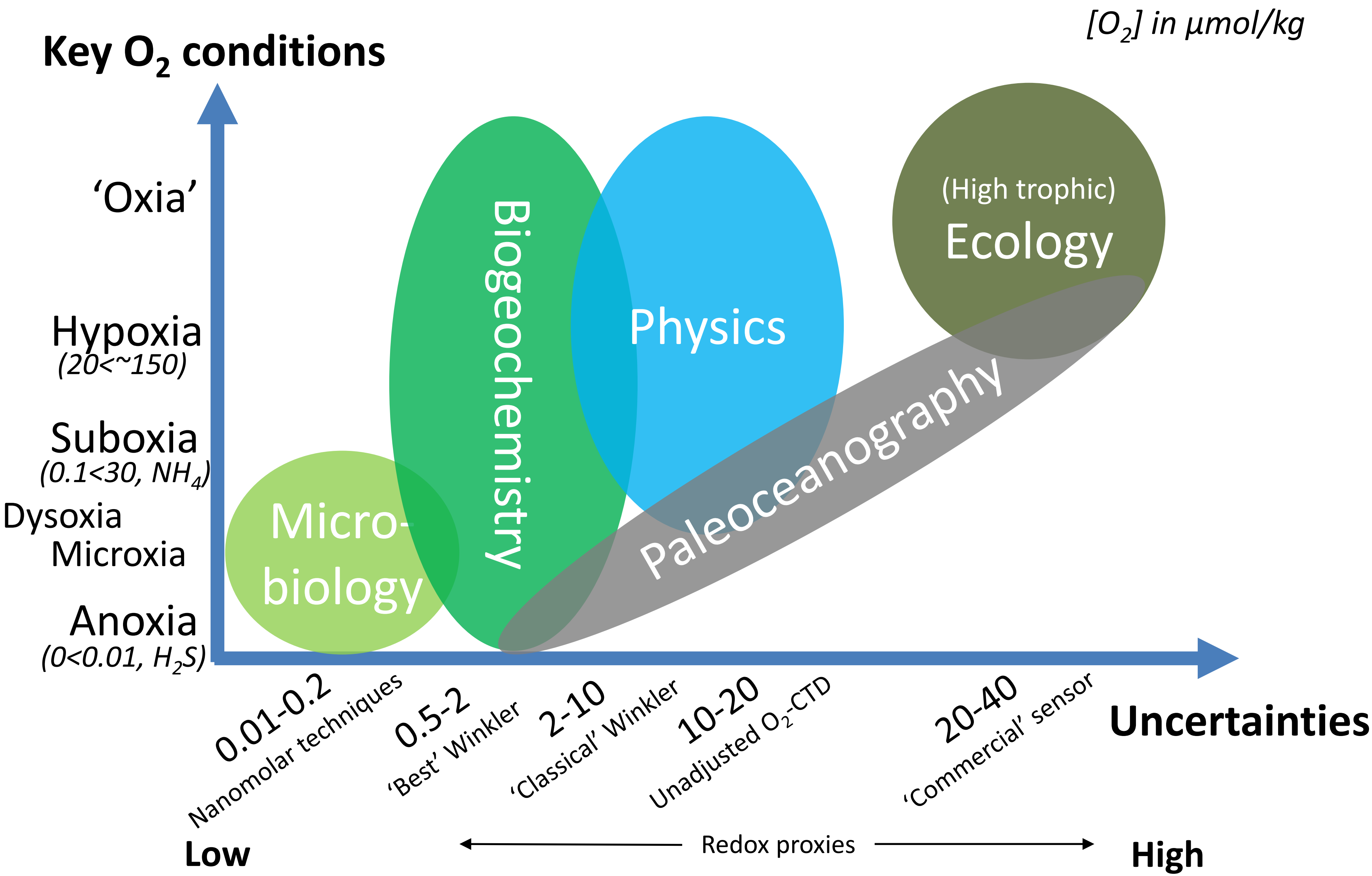
Paulmier, A. (2017)

Why?



Impliying different $[O_2]$ quality requirements

Different quality requirement in O_2-perturbated areas:



Different quality requirement in O_2-perturbated areas:

[O_2] in µmol/kg

Approaches	Accuracy (current)	Reproducibility (current)	Low Detection Limit (current)
Micro-biology (Nanomolar techniques)	**0.01** (0.01-0.2)	**0.01** (0.01-0.2)	**0.01** (0.01-0.2)
Biogeochemistry (Winkler + Niskin: 'Best' 'Classical')	**0.01-0.1** (~1.5) (5-10)	**0.01-0.1** (~0.1) (~2.5)	**0.01-0.1** (~1-2) (~1-4)
Physics (O_2-CTD without Winkler adjustment)	**0.5-2** (10-20)	**1-5** (~0.5; ±2% for 20 µmol/kg)	**4.5** (10-20)
Paleoceanography for: - Anoxia - Suboxia - Hypoxia	 **0.5-5** (0.5-5) **10-20** (10-20) **20-40** (20-40)	 **0.5-5** (0.5-5) **10-20** (10-20) **20-40** (20-40)	 **0.5-5** (0.5-5) **10-20** (10-20) **20-40** (20-40)
(High trophic) Ecology	**20** (20-40)	**20** (20-40)	**20-40** (20-40)

Outline:

I. ***WINKLER****: analyses of the O_2 measurement quality in a Oxygen Minimum Zone (OMZ): detection limit, reproducibility*

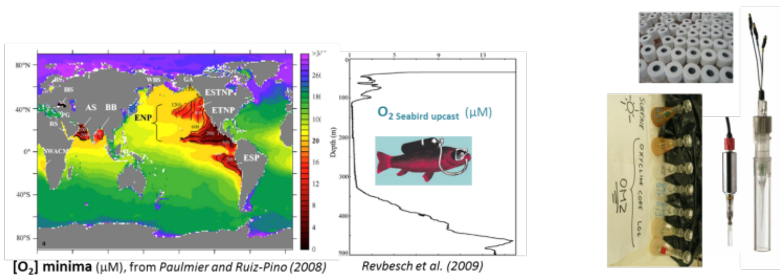
II. ***O_2-CTD ADJUSTMENT*** *WITH WINKLER: the OMZs issues*

III. ***ULTRA-LOW [O_2] ADJUSTMENT****: O_2-CTD using 0-STOX reference*

PACOP

Plateforme d'Analyse en Conditions Oxiques Perturbées

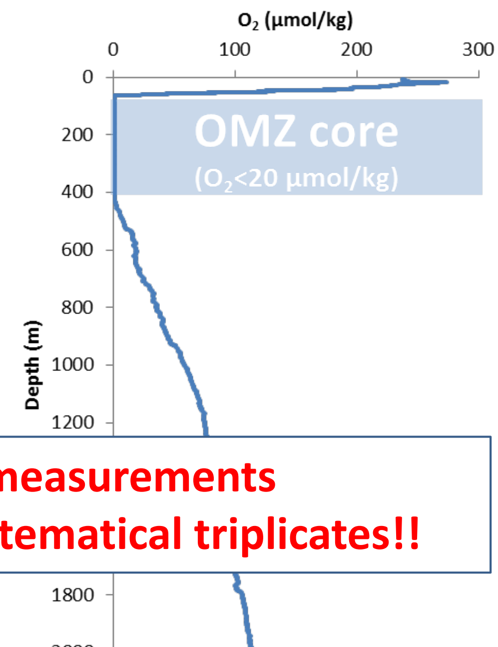
- Platform for Analysis in Conditions with O_2 Perturbations
- Plataforma de Análisis en Condiciones Oxicas Perturbadas



[O_2] minima (μM), from Paulmier and Ruiz-Pino (2008) Revbesch et al. (2009)

OXGEN MINIMUM ZONES (OMZs) MEASUREMENT & EXPERIMENTATION

AMOP
Eastern Pacific & oxygen minimum



> 1800 measurements with systematical triplicates!!

Illustration based on the AMOP project

(Activities of research dedicated to the Minimum of Oxygen in the eastern Pacific):

www.legos.obs-mip.fr/recherches/projets-en-cours/amop

TAKE HOME MESSAGE:

1) WINKLER MEASUREMENT

a) In the OMZ core, not relevant as a reference

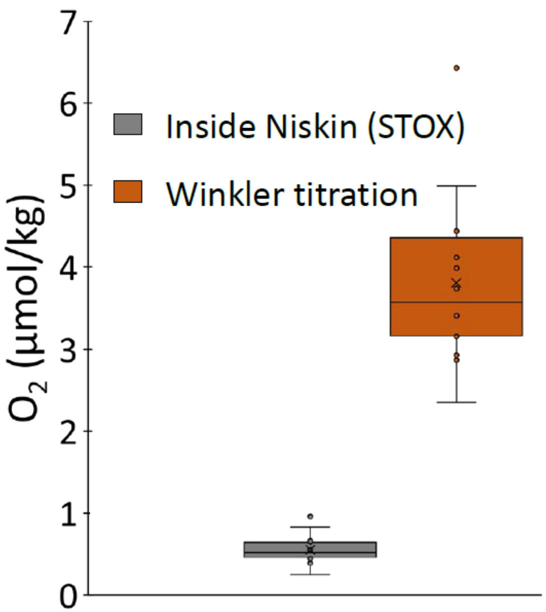
Limit of detection > 4 µM due to:

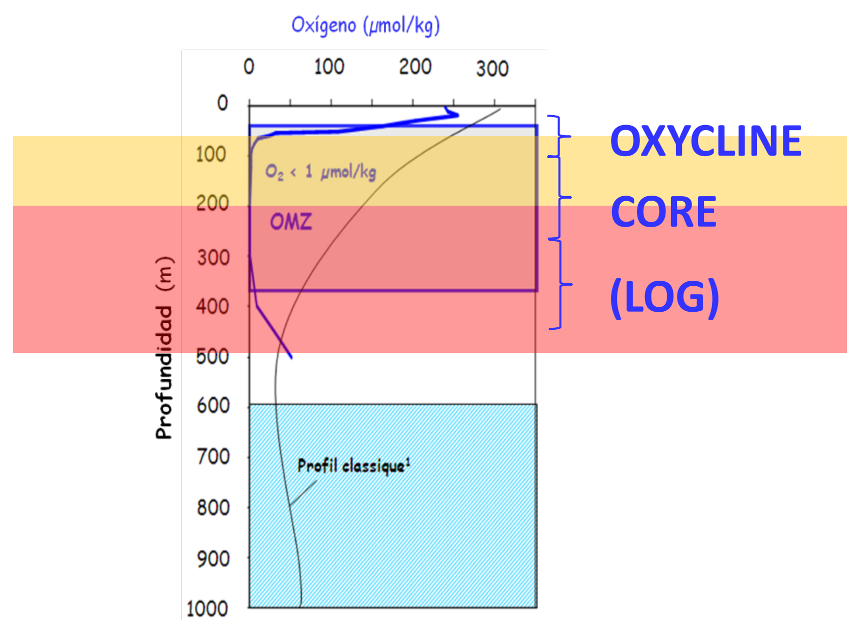
- O_2 release by the polymers in the Niskin bottle: 0.3<1 µM;
- Winkler sampling and fixation process: 2<7 µM

b) Reproducibility affected in the upper highest OMZ O_2 gradient (oxycline-core interface):

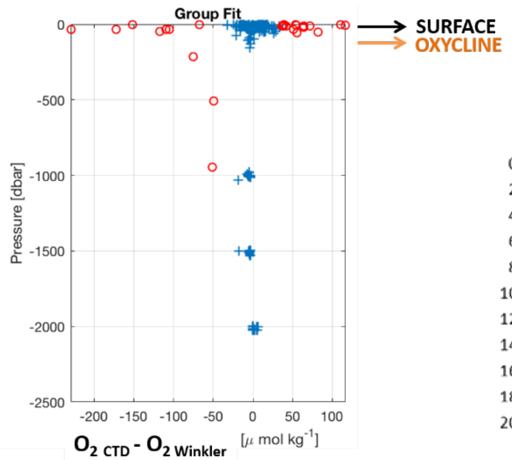
Lower core & LOG: ~80% better reproducibility compared to

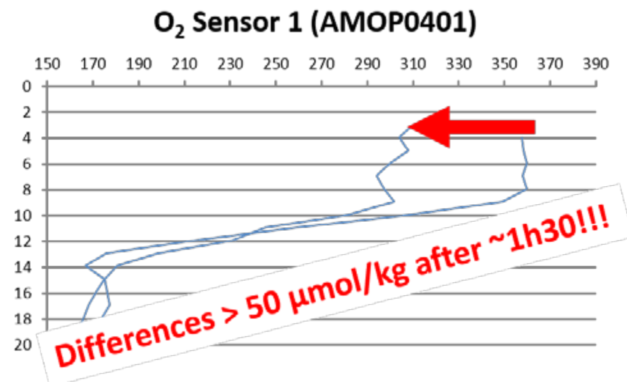
the lower oxycline & upper core

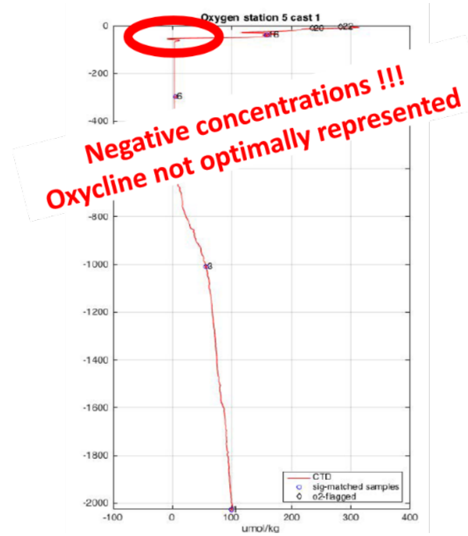




TAKE HOME MESSAGE:







2) ADJUSTEMENT OF O_2-CTD WITH WINKLER

a) Presence of very localized outliers, at the:

- surface → strong natural temporal variability
- oxycline → negative concentrations

b) Focus on the upcasts, & on the calibration parameters for downcasts

(without Tau20 → smoothed profiles)

$$O2\ [ml/l] = Soc*[V+Voff+Tau_{20}*exp[D_1*P+D_2*T]*dVdt]*os*exp[T_{cor}*T]*exp[P_{cor}*P/[273.15+T]]$$

TAKE HOME MESSAGE:

1) WINKLER MEASUREMENT

a) In the OMZ core, not relevant as a reference

Limit of detection > 4 µmol/kg

b) Reproductibility affected in the upper highest OMZ O_2 gradient (oxycline-core interface):

Lower oxycline & upper core: ~80% higher reproducibility compared to the lower core and LOG

2) ADJUSTEMENT OF O_2-CTD WITH WINKLER

a) Presence of very localized outliers, at the:

- surface → strong natural temporal variability
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b) Focus on the upcasts, & on the adjusments parameters for downcasts

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3) ADJUSTMENT OF O_2-CTD FOR LOW [O_2]

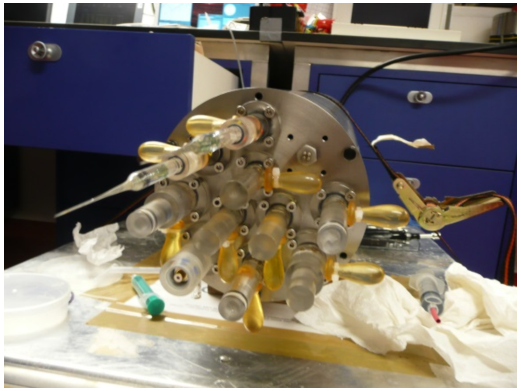
a) Requirement of a «anoxic» reference: STOX/LUMOS, historical

b) Limit of detection x~50 better than with Winkler: ~60 nmol/kg

NEXT:

1) **Proposition to write a Paper of Recommendations according to the protocols of O_2 sampling, measurements and adjustment in O_2-perturbated regions (e.g. OMZs) in order to:**

- share the results of those **methodological studies**;
- allow **inter-comparisons** between data, **assessing** and **increasing** the **quality** of the global datasets
- improve **key-observations** in terms of **low O_2 concentrations** and **variability**;

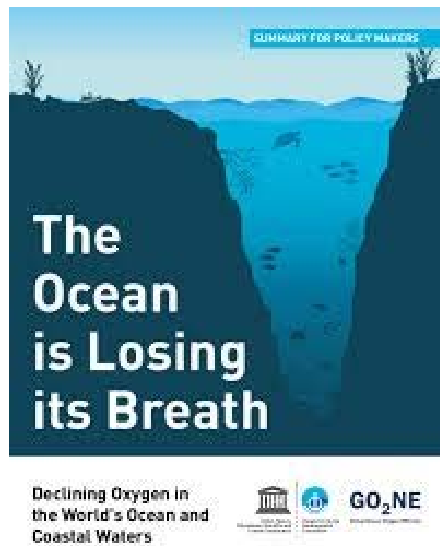


NEXT:

2) Importance to have connections between our communities and the international initiatives:

- **GO_2NE** (***Global Ocean Oxygen Network***), IOC-Unesco WG;
- **IOCCP** (***International Ocean Carbon Coordination Project***), SCOR/IOC-Unesco;
- **VOICE project** (***Variability in the Oxycline and its Impact on the Ecosystems***), outcome of IMSOO (*Implementation of Multi-disciplinary Sustained Ocean Observations*)/GOOS (*Global Ocean Observing System*), IOC-Unesco, WMO (*World Meteorological Organization*), UN Environment, ISC (*International Science Council*)

http://www.ioccp.org/oxygen



IOC

environment

OXYGEN EOV

International Science Council

Variability in the Oxycline and Its Impacts on the Ecosystem (VOICE) Science Plan Workshop, 13-15 September 2017, Monterey, CA, USA

http://mel.xmu.edu.cn/summerschool/go2ne/

Application closes: November 15, 2018

Ocean Deoxygenation: Drivers and Consequences
· Past · Present · Future ·

INTERNATIONAL CONFERENCE KIEL GERMANY
3 – 7 September 2018

SFB 754

Kiel Declaration on Ocean Deoxygenation

Participants of the international conference
"Ocean Deoxygenation: Drivers and Consequences – Past – Present – Future",
3 – 7 September 2018 in Kiel, Germany organized by:
Kiel Collaborative Research Center SFB 754 and Global Ocean Oxygen Network (GO_2NE – IOC-UNESCO)

The ocean is losing its breath

Oxygen in the ocean supports the largest ecosystems on the planet. It is alarming that the ocean is losing oxygen, termed ocean deoxygenation, primarily due to global warming by greenhouse gas emissions, and pollution by nutrients and organic wastes particularly in coastal waters. We call on all nations, societal actors, scientists and the United Nations to:

(a) Raise global awareness about ocean deoxygenation through local, regional and global efforts, including interdisciplinary research, innovative outreach, and ocean education.

(b) Take immediate and decisive action to limit pollution and in particular excessive nutrient input to the ocean.

(c) Limit global warming by decisive climate change mitigation actions.

Both the Paris Agreement addressing Climate Change and the United Nations' 2030 Agenda for Sustainable Development demand conservation and sustainable use of the ocean, seas and marine resources in order to safeguard ocean ecosystems and their current and future societal benefits. These are severely threatened by ocean deoxygenation.

Scientists assembled at the conference and from around the world agree that:

1. During the past 50 years oxygen-depleted waters have expanded four-fold. Some areas of the ocean have lost up to 40% of their oxygen.
2. The ongoing loss of oxygen from the ocean is a rapidly increasing threat to marine life, the ocean's ecosystems and coastal communities.
3. Global warming impacts ocean oxygen in two ways: the capacity to hold oxygen decreases in warming waters, whilst warming reduces ocean mixing and circulation limiting the supply of oxygen from the atmosphere. Pollution by nutrients and organic waste enhances oxygen demand by increasing biological production and oxygen consumption during decomposition.
4. Deoxygenation disrupts marine ecosystems, affects fish stocks and aquaculture and leads to loss of habitat and biodiversity. It can, in extreme cases, lead to the production of toxic gases when all oxygen in the water has been lost.
5. Deoxygenation can accelerate global warming via enhanced marine production of greenhouse gases under low oxygen conditions.
6. The problem of deoxygenation is predicted to worsen in the coming years under continued global warming and increasing nutrient input to coastal regions as human populations and economies grow.
7. Expanded observation is immediately required for accurate documentation and prediction of ocean oxygen changes, and for improved understanding of its causes and consequences.
8. Strategies to slow and eventually reverse deoxygenation and its ecological impacts need to be co-developed between science and societal actors. This will contribute to the UN Decade of Ocean Science for Sustainable Development.

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QUESTIONS

AMOP cruise on RV L'Atalante in the OMZ off Peru, January-February 2014

http://www.legos.obs-mip.fr/recherches/projets-en-cours/amop