MicroRESPIRE : The abiotic and biotic factors determining microbial respiration

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22 project partners & SCOR WG 161 ReMO Respiration in the Mesopelagic Ocean

University of East Anglia
COAS Centre for Ocean and Atmospheric Sciences
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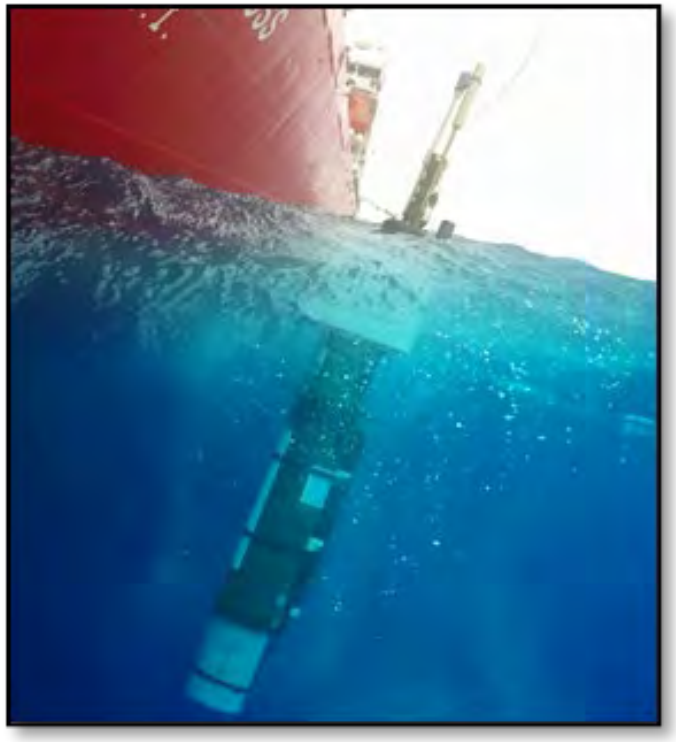
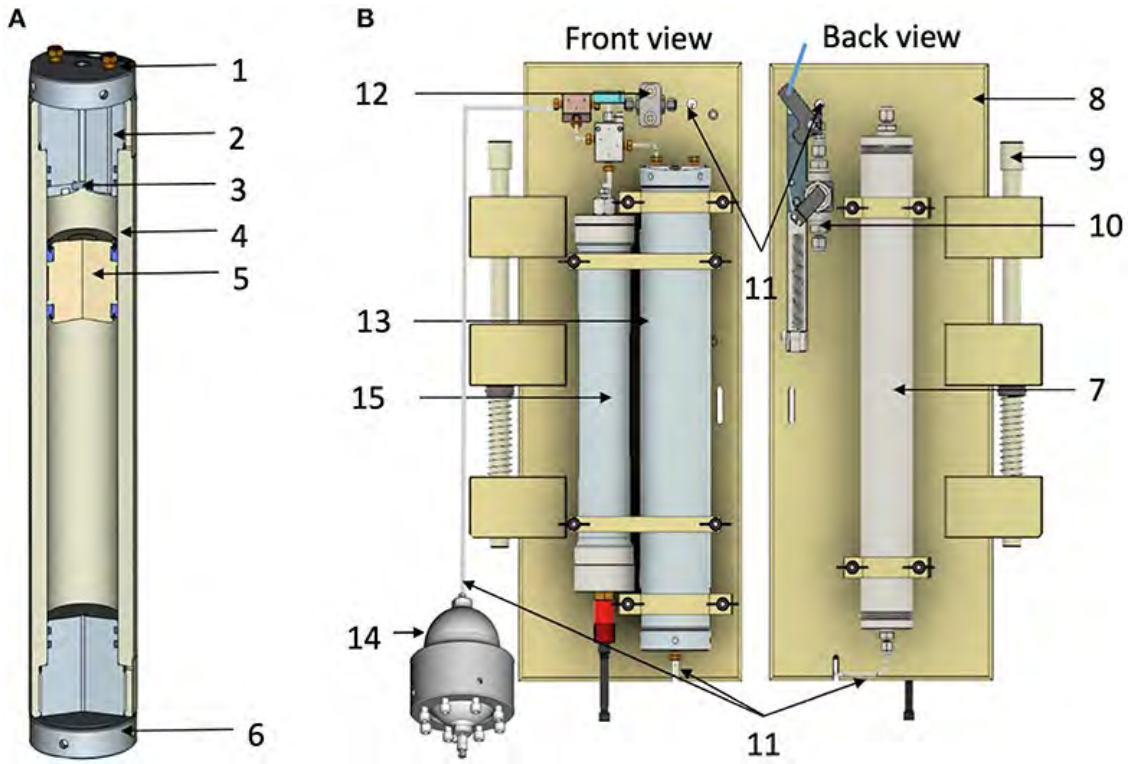
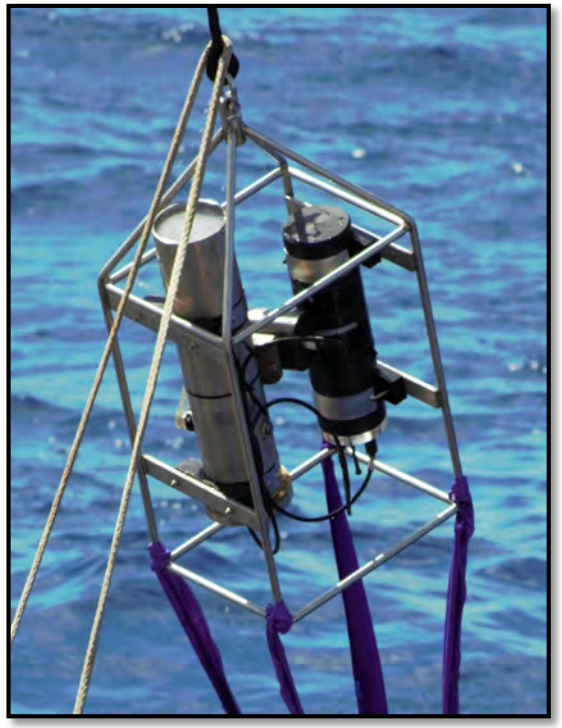
BACKGROUND / RATIONALE



Biogeochemical-Argo float
Photo G.Dall'Olmo



High Pressure Sampling Unit
Garel et al., 2019



RESPIRE sediment traps
Boyd et al., 2015

AIM & OBJECTIVES

OBJECTIVES

Determine how respiration varies in time and space.

Determine how respiration is apportioned between microbes and zooplankton.

Quantify how climate-sensitive biotic and abiotic factors (temperature, oxygen, organic matter) influence respiration.

AIM

To produce globally robust parameterisations that describe how mesopelagic respiration responds to climate change-induced shifts in environmental parameters.

WORK PACKAGE 1

Variability and proportion of microbial and zooplankton respiration

We will collate a global database of oceanic respiration, and make it accessible to and easily useable by ocean modellers.

We will exploit the proliferation of BGC-Argo floats to produce new seasonal estimates of respiration at the sub-basin scale.

Using this combined database, we will quantify the variability in oceanic respiration, determine the relative magnitudes of microbial and zooplankton respiration to test **Hypothesis 1**, and update global budgets of marine respiration to constrain current estimates of ocean carbon storage.

Hypothesis 1 : Deep-sea zooplankton respiration is significant, requiring a supply of organic carbon of comparable magnitude to that of sinking particulate matter.

WORK PACKAGE 2

The influence of climate-sensitive factors

Using the new database, we will derive parameterisations of respiration as a function of temperature, of oxygen and of a combination of temperature and oxygen.

We will test **Hypothesis 2** by quantifying which of these parameterisations best represents the data.

We will test **Hypothesis 3** by comparing the activation energies derived from short-term experiments with those derived from longer term measurements. If **H3** is verified, we will investigate the extent to which a parameterisation including the quality of organic matter can be obtained.

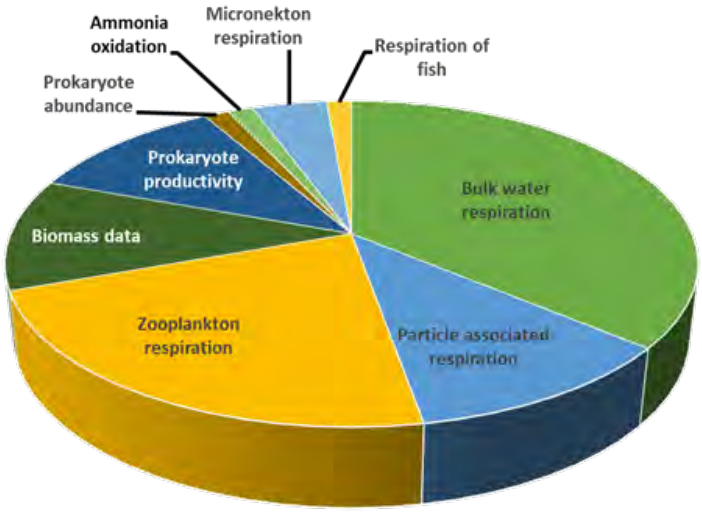
Hypothesis 2: Respiration can be parameterised solely as a function of in-situ oxygen concentration, because oxygen concentration incorporates both the effects of temperature change and oxygen availability on metabolism.

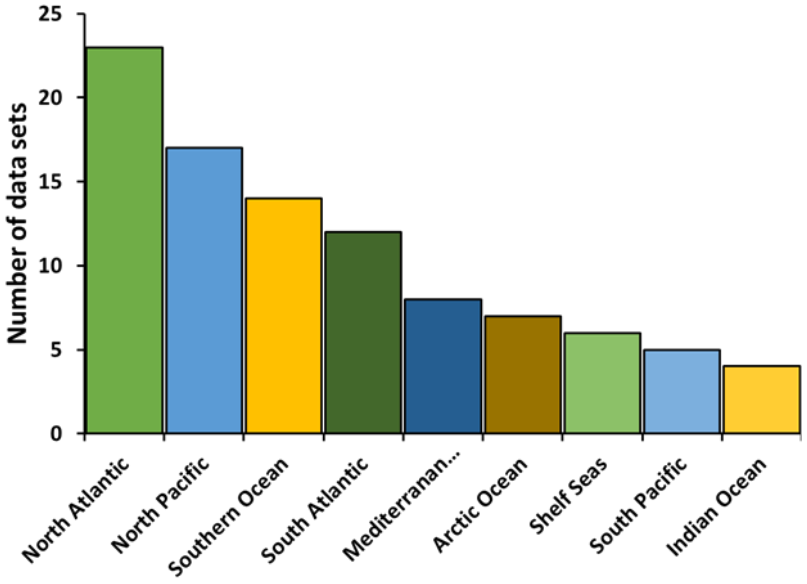
Hypothesis 3: Due to different lability of the organic substrate, respiration rates measured over short time scales are faster than those measured over longer time scales. This is important because faster respiration rates can bias model estimates of ocean carbon storage.

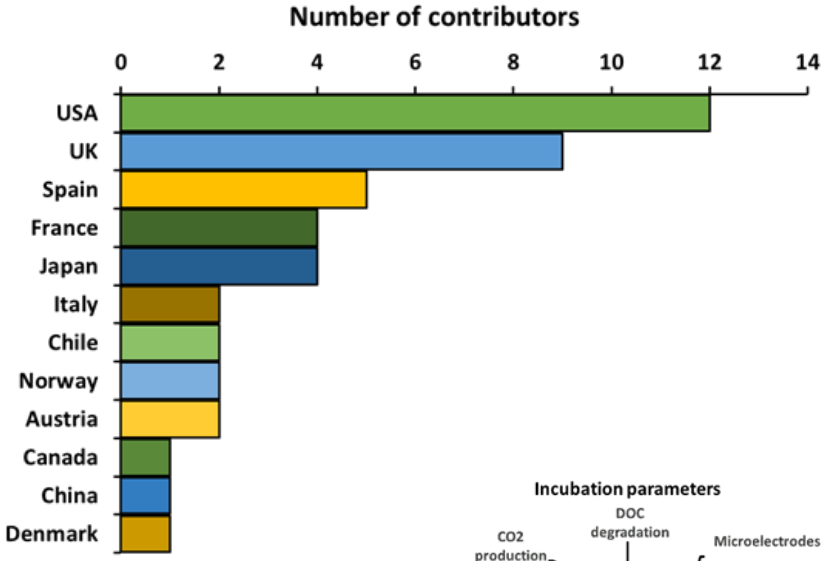
PROGRESS 0 to 6 months

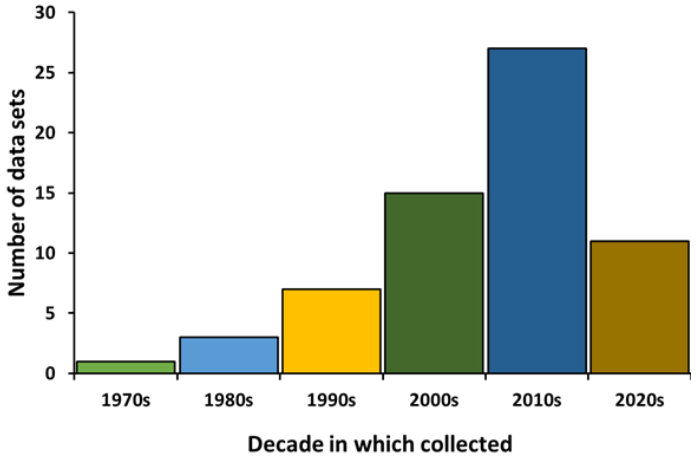
1. Data collation; 2. Controlled vocabularies; 3. BGC Argo float selection, coding and data analysis; 4. Capacity development

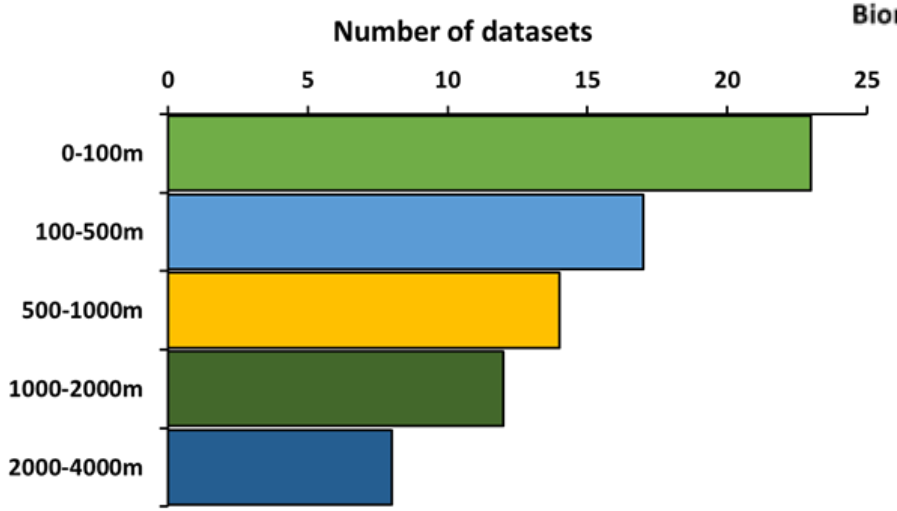
1. DATA COLLATION : Meta-data survey

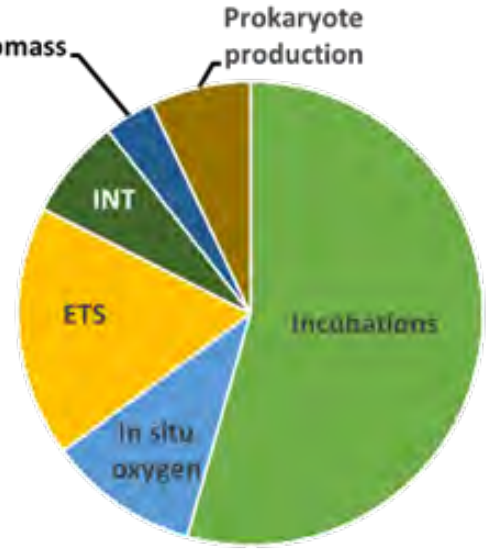


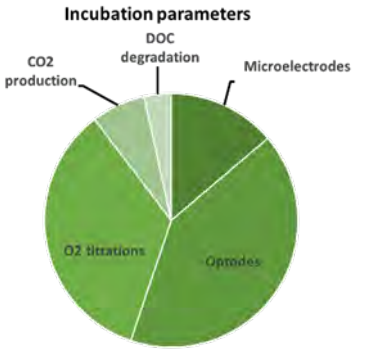


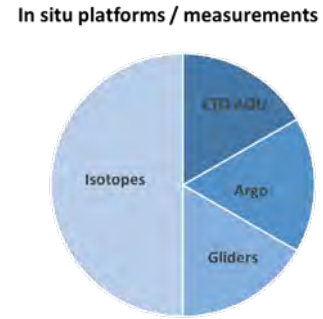






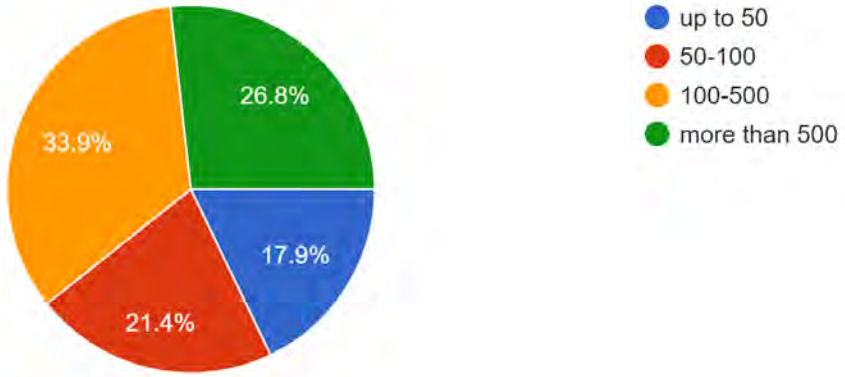




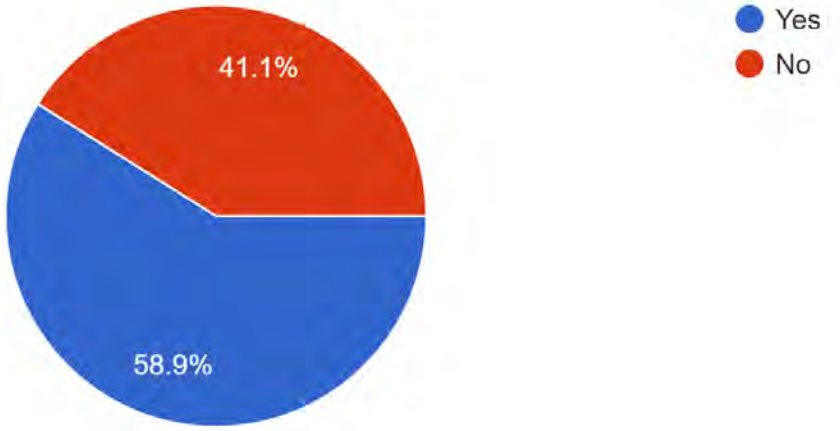


1. DATA COLLATION : Meta-data survey

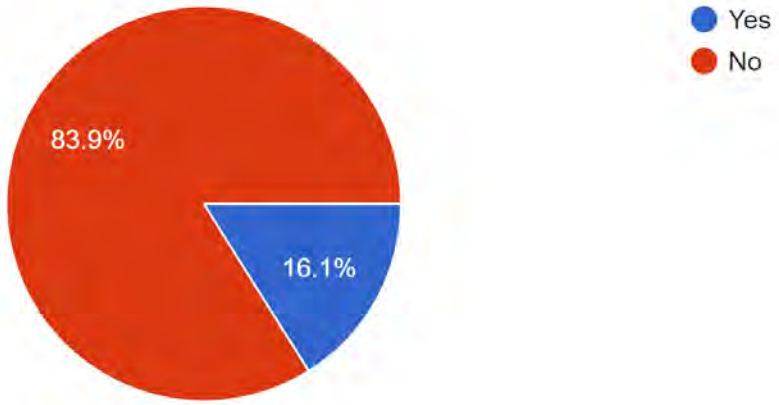
Approximate number of measurements to contribute to the database



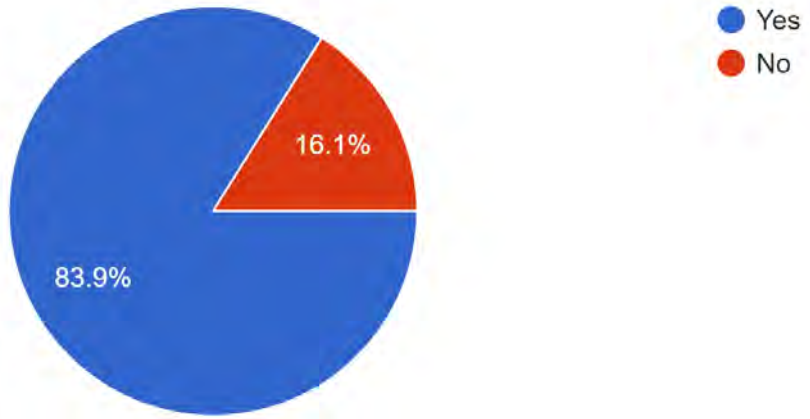
Are the respiration data published ?



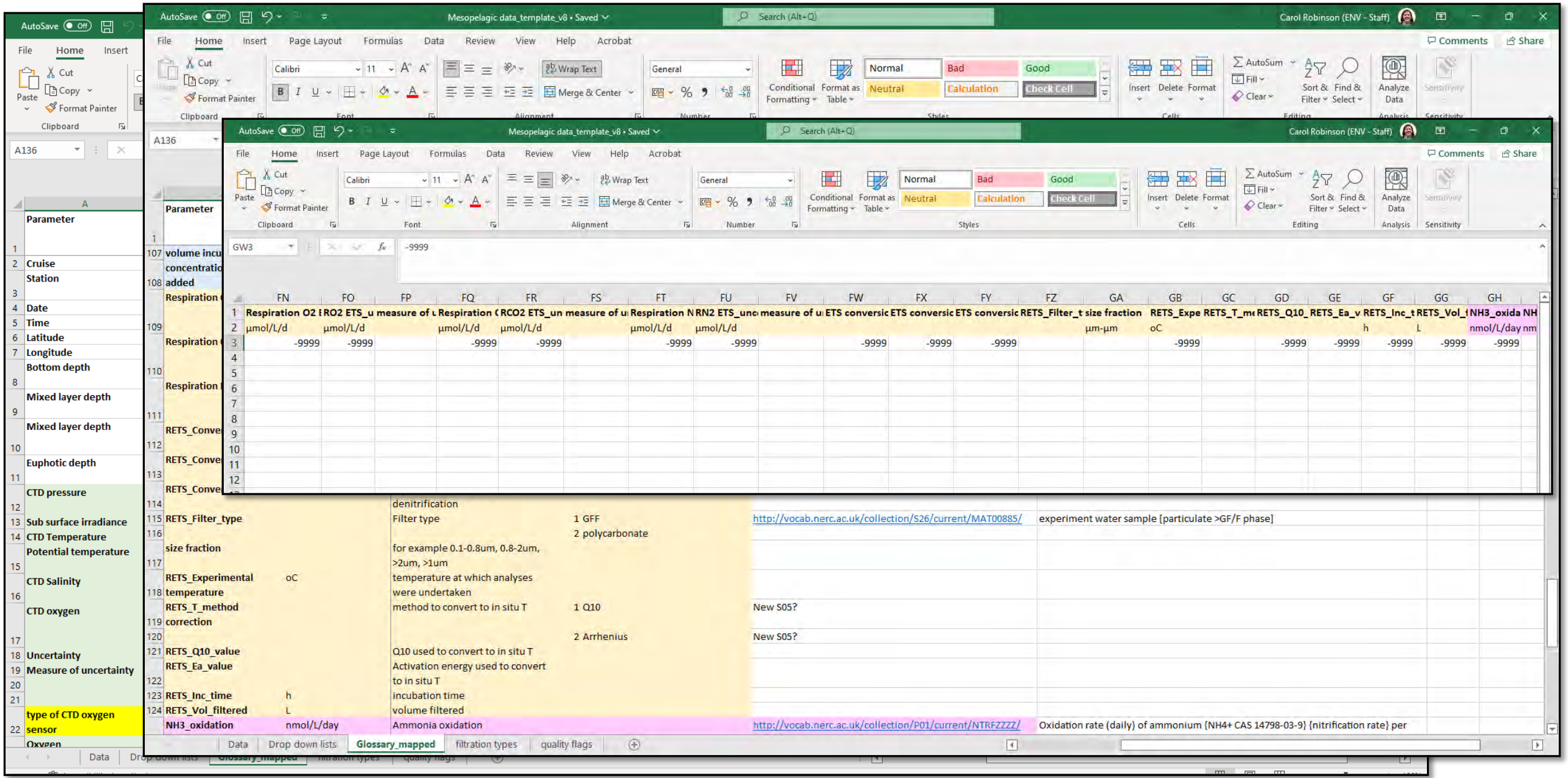
Are the respiration data deposited at a data centre ?



Are concurrent environmental data such as nutrients, dissolved oxygen, particulate organic carbon and temperature available ?



1. DATA COLLATION : Glossary



	Parameter					
1						
2	Cruise					
3	Station					
4	Date					
5	Time					
6	Latitude					
7	Longitude					
8	Bottom depth					
9	Mixed layer depth					
10	Mixed layer depth					
11	Euphotic depth					
12	CTD pressure					
13	Sub surface irradiance					
14	CTD Temperature					
15	Potential temperature					
16	CTD Salinity					
17	CTD oxygen					
18	Uncertainty					
19	Measure of uncertainty					
20						
21						
22	type of CTD oxygen sensor					
	Oxygen					
107	volume incu					
	concentratio					
108	added					
109	Respiration					
110	Respiration					
111	Respiration					
112	RETS_Conve					
113	RETS_Conve					
114	RETS_Conve					
			denitrification			
115	RETS_Filter_type		Filter type	1 GFF	http://vocab.nerc.ac.uk/collection/S26/current/MAT00885/	experiment water sample [particulate >GF/F phase]
116				2 polycarbonate		
117	size fraction		for example 0.1-0.8um, 0.8-2um, >2um, >1um			
118	RETS_Experimental temperature	oC	temperature at which analyses were undertaken			
119	RETS_T_method correction		method to convert to in situ T	1 Q10	New S05?	
120				2 Arrhenius	New S05?	
121	RETS_Q10_value		Q10 used to convert to in situ T			
122	RETS_Ea_value		Activation energy used to convert to in situ T			
123	RETS_Inc_time	h	incubation time			
124	RETS_Vol_filtered	L	volume filtered			
	NH3_oxidation	nmol/L/day	Ammonia oxidation		http://vocab.nerc.ac.uk/collection/P01/current/NTRFZZZZ/	Oxidation rate (daily) of ammonium {NH4+ CAS 14798-03-9} {nitrification rate} per

	FN	FO	FP	FQ	FR	FS	FT	FU	FV	FW	FX	FY	FZ	GA	GB	GC	GD	GE	GF	GG	GH
1	Respiration O2 I	RO2 ETS_u	measure of u	Respiration (	RCO2 ETS_un	measure of u	Respiration N	RN2 ETS_unc	measure of u	ETS conversic	ETS conversic	ETS conversic	RETS_Filter_t	size fraction	RETS_Expe	RETS_T_me	RETS_Q10_	RETS_Ea_v	RETS_Inc_t	RETS_Vol_f	NH3_oxida NH
2	µmol/L/d	µmol/L/d		µmol/L/d	µmol/L/d		µmol/L/d	µmol/L/d						µm-µm	oC				h	L	nmol/L/day nm
3	-9999	-9999		-9999	-9999		-9999	-9999		-9999	-9999	-9999			-9999		-9999	-9999	-9999	-9999	-9999
4																					
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9																					
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11																					
12																					

1. DATA COLLATION : data template

Environmental parameters

~ 16 including temperature, dissolved oxygen, nutrients, carbonate species

Microbial respiration

~ 19 methods

~ 40 methodological details, conversion factors, incubation time, fraction etc.

Zooplankton respiration

~ 5 methods

~ 12 methodological details, conversion factors, net size, taxonomy etc.

Previous database - predominantly euphotic zone (microbial n=4500, prokaryote n=700)

1. DATA COLLATION : time line

Template co-designed & ‘tested #1’ by partners	August 2022
Community primed via ‘open call’ metadata survey	October 2022
Template ‘tested #2’ by BODC	October 2022
Literature review / survey targeted invitations	January 2023
Results of metadata survey to community	February 2023
Input data by partners, template ‘tested #3’	January 2023
Input data by community	February 2023
First draft of database	April 2023
Second draft of database	September 2023
Publication + open access database	March 2024

How respiration varies in time and space, how apportioned between microbes and zooplankton

2. CONTROLLED VOCABULARIES

What are they?(*)

- **Units of knowledge** managed in dedicated repositories and accessible via a **persistent URL**
- They can be lists of terms (lexicon) or organised collections of related terms:
  - controlled (“drop-down”) lists
  - thesauri
- Terms can be connected with relations
  - Broader, Narrower, Same as, Related
  - But also more expressive relationships using ontologies
- Foundation on which to build more complex reasoning

What are they for?

Semantic annotation of datasets

- Machine-readable or actionable
- Standardise / Harmonise information about the data (“metadata”)
- Catalogue, Validate, Search, Automate processes

Semantic alignment and mapping

- Interoperability
- Data integration
- Linked data / Big data applications

(*) in the digital world

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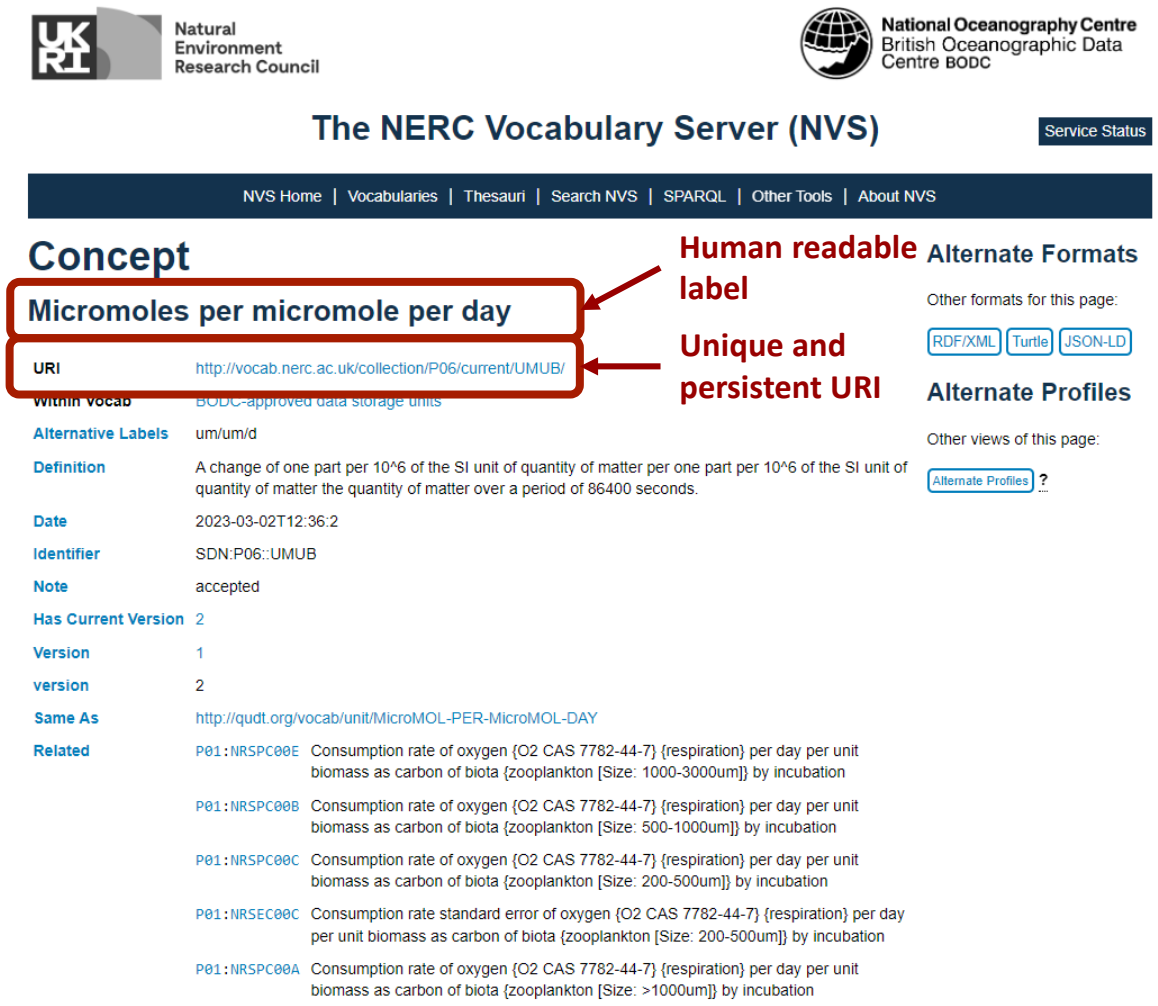
2. CONTROLLED VOCABULARIES



- The NVS, managed by BODC, provides **standardised lists of terms** for many concepts used to describe oceanographic data including **instrumentation**, **variable names**, **units and quality control flags**.

- Initial mapping of **MicroRespire** dataset concepts to existing vocabularies has been completed for
  - all 23 units of measurements
  - 51 of 72 identified variable types

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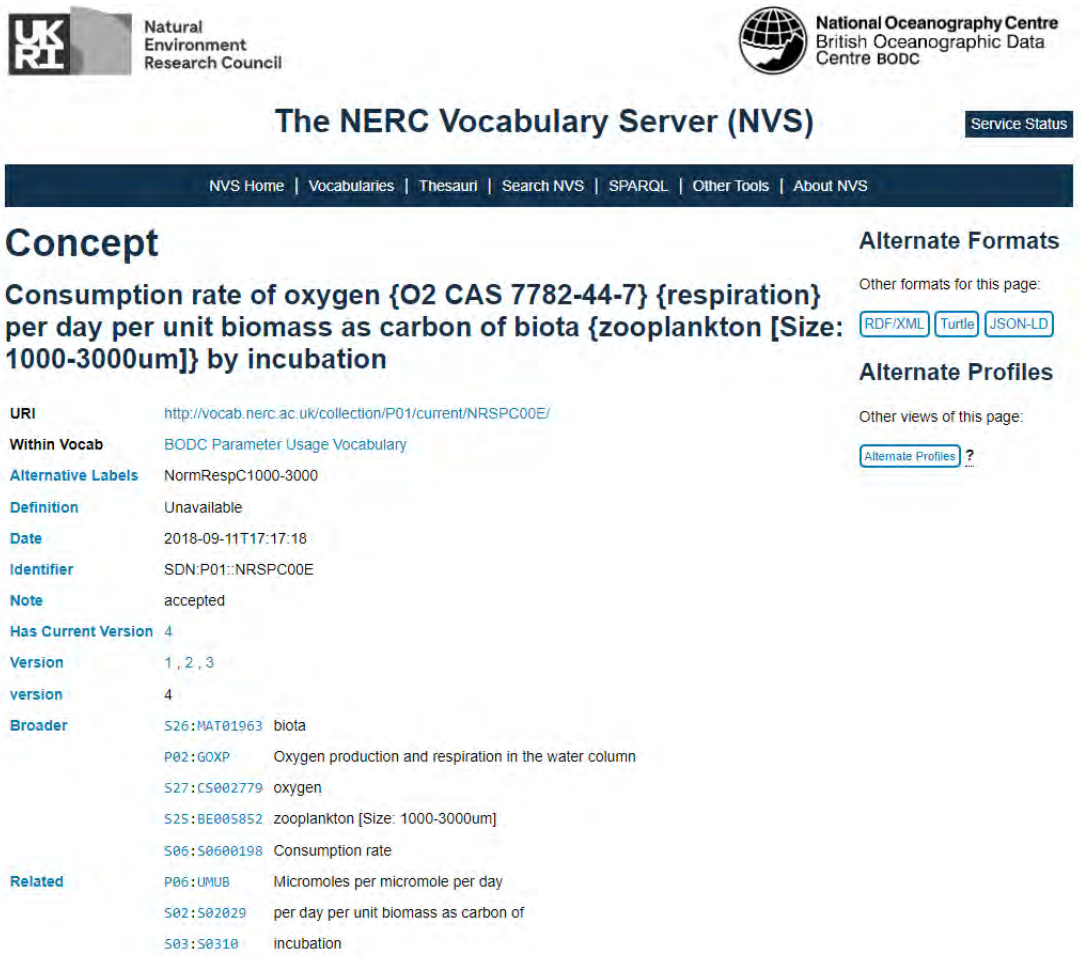
2. CONTROLLED VOCABULARIES



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The NERC Vocabulary Server (NVS)

Service Status

NVS Home | Vocabularies | Thesauri | Search NVS | SPARQL | Other Tools | About NVS

Concept

Consumption rate of oxygen {O2 CAS 7782-44-7} {respiration} per day per unit biomass as carbon of biota {zooplankton [Size: 1000-3000um]} by incubation

URI	http://vocab.nerc.ac.uk/collection/P01/current/NRSPC00E/
Within Vocab	BODC Parameter Usage Vocabulary
Alternative Labels	NormRespC1000-3000
Definition	Unavailable
Date	2018-09-11T17:17:18
Identifier	SDN:P01::NRSPC00E
Note	accepted
Has Current Version	4
Version	1 , 2 , 3
version	4
Broader	S26:MAT01963 biota
	P02:GOXP Oxygen production and respiration in the water column
	S27:CS002779 oxygen
	S25:BE005852 zooplankton [Size: 1000-3000um]
	S06:S0600198 Consumption rate
Related	P06:UMUB Micromoles per micromole per day
	S02:S02029 per day per unit biomass as carbon of
	S03:S0310 incubation

Alternate Formats

Other formats for this page:

RDF/XML | Turtle | JSON-LD

Alternate Profiles

Other views of this page:

Alternate Profiles ?

- **Still to be done:**
  - Full review of codes related to respiration measurements and methodology
  - Ensure essential details of all microbial and zooplankton methods can be captured accurately, consistently and persistently using standardised controlled vocabularies
  - Part of the legacy of this project
  - What is “essential” will be decided based on consultation with experts in these methods

Example of an existing parameter code for zooplankton respiration measurement in the BODC Parameter Usage Vocabulary
http://vocab.nerc.ac.uk/collection/P01/current/NRSPC00E/

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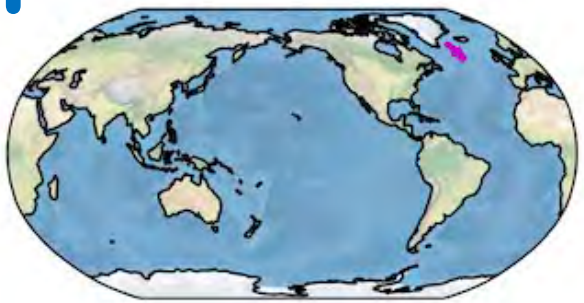
3. BGC Argo CODE DEVELOPMENT



Developed python script to estimate respiration rate from BGC-Argo float data

Steps to process oxygen data

For each float:

1. Read Sprof file ✅
2. Divide timeseries in seasons to analyse ✅
3. Extract seasons ✅
4. For each season:
   - A. Compute z_m ✅
   - B. Compute z_p ✅
   - C. Divide the water column below z_p into density layers ✅
   - D. For each layer:
     - a. Compute AOU ✅
     - b. Regress mean AOU within each density layer vs. time to estimate respiration rate ✅
     - c. Extract mean ± std of temperature, oxygen and b_{bp} within the layer during the time over which the regression is computed ✅
     - d. Extract mean ± std of DOC values from Roshan and DeVries (2017).

jupyter cmp_respiration_DOXY Last Checkpoint: 36 minutes ago (autosaved) Logout

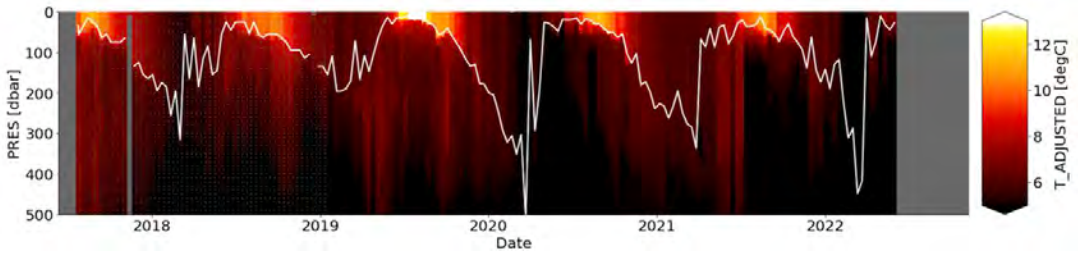
File Edit View Insert Cell Kernel Help Trusted Python 3 (ipykernel)

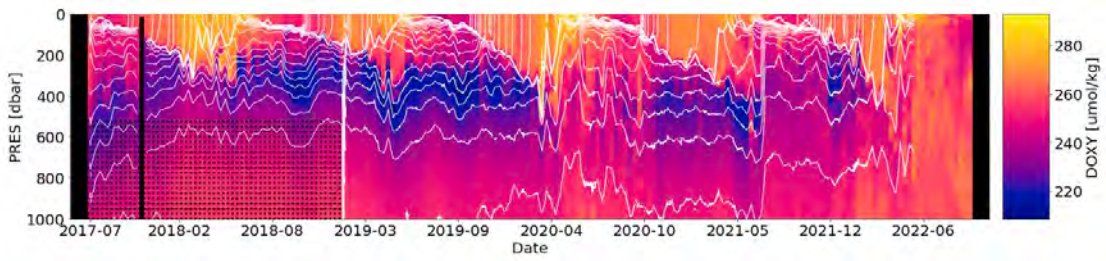
Run Markdown

```
In [3]:
import xarray as xr
import numpy as np
import scipy as sp
import pandas as pd
import subprocess
import glob
from matplotlib import pyplot as plt
import matplotlib as mpl
import hvplot.xarray

import bgc_tools
import cmocean

hvplot.extension('matplotlib')
%matplotlib inline
```

```
In [4]:
# DIN = "/mnt/Argo/"
# DIN = "/home/grg/Projects/Respiration/Data/"
DIN = "/Users/gdal/Dropbox/Project/Respiration/Data/Sprof/202210-BgcArgoSprof/dac/"
FN_ETOPO = '/Users/gdal/Data/Etopo/ETOPO1_Bed_g_gmt4.grd.gz.decomp'
```

```
In [5]:
cmdo2 = "grep DOXY " + DIN + "argo_synthetic-profile_detailled_index.txt | cut -d '/' -f1,2 | uniq  "
wmo_dac = subprocess.run(cmdo2, shell=True, stdout=subprocess.PIPE).stdout.decode('utf-8').split('\n')
WMO_dac = np.asarray(wmo_dac[::])
print(len(WMO_dac))
```

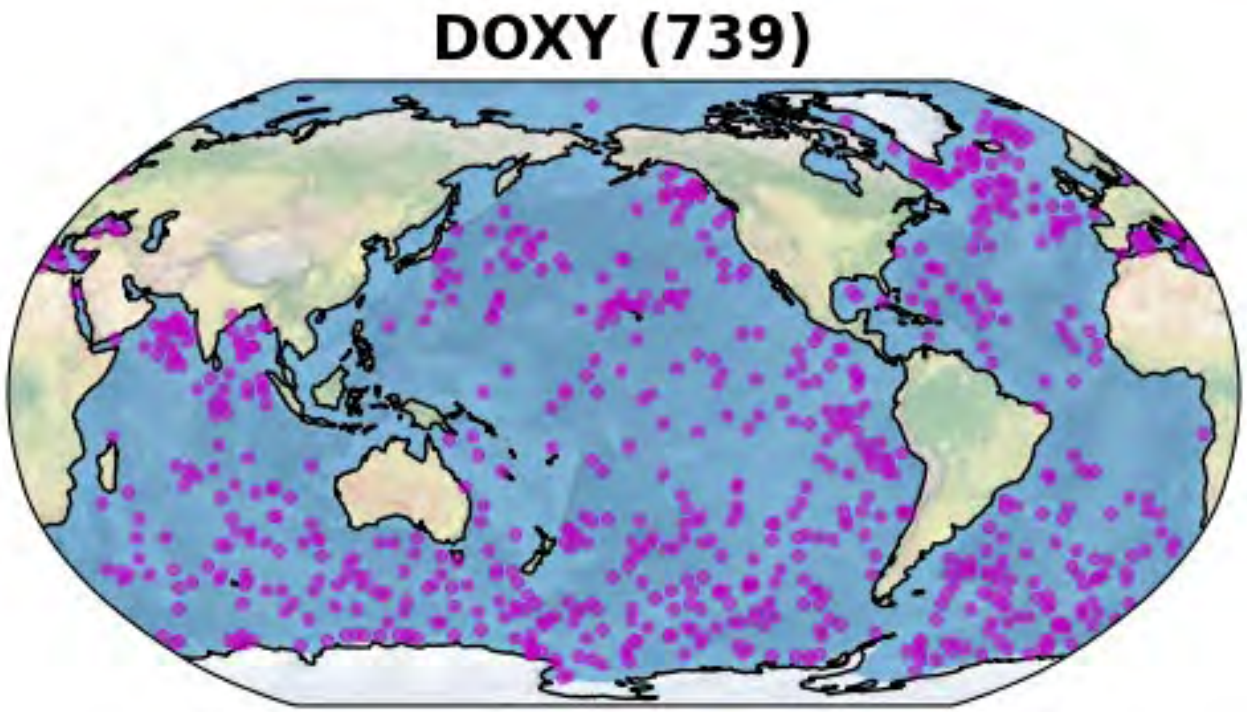


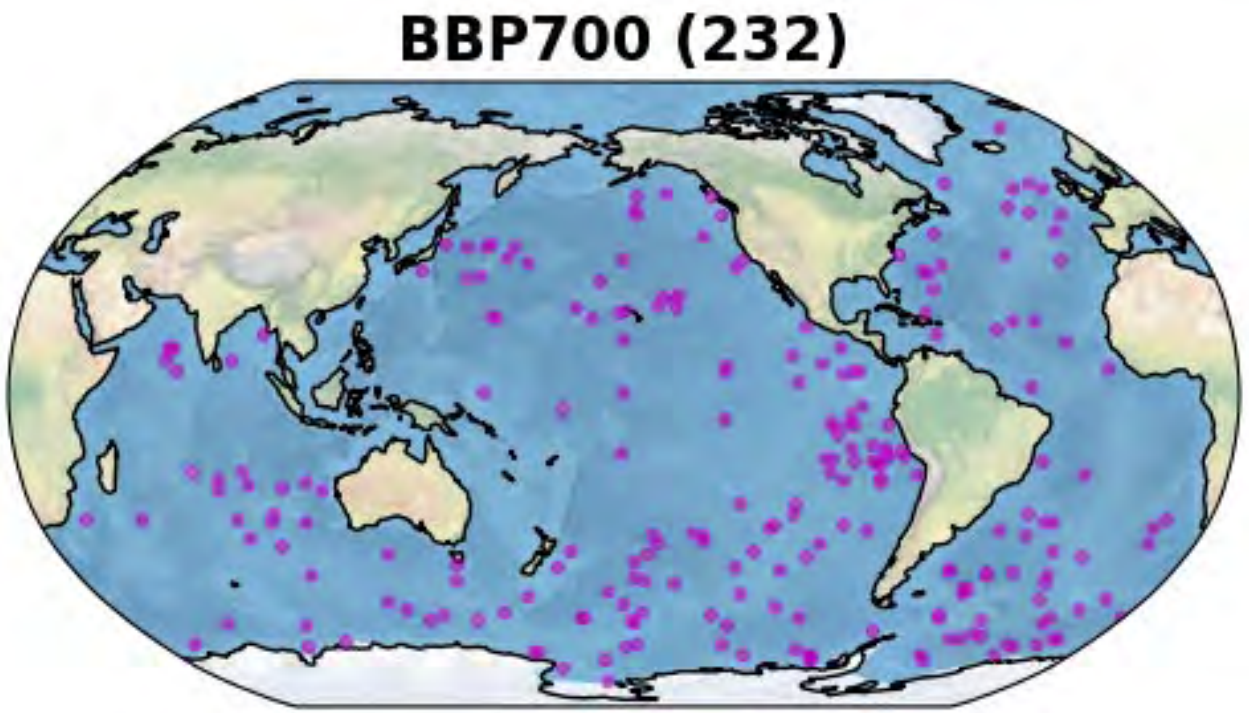


OGS

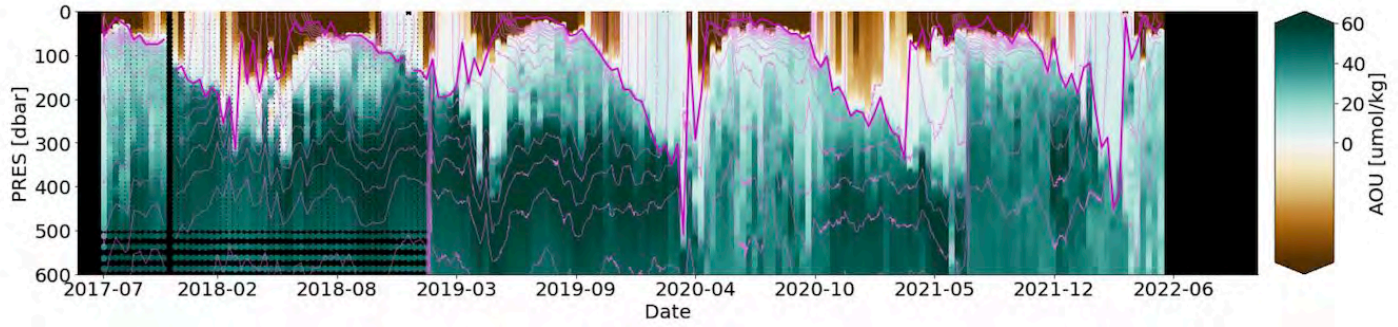
3. BGC Argo FLOAT SELECTION

From BGC-Argo Sprof index file : with DOXY or BBP700 and at least 365 days of data

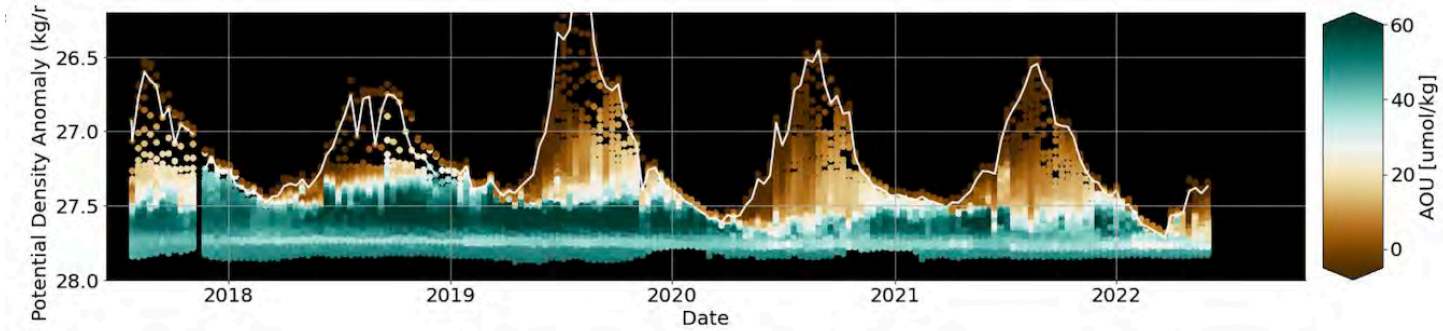




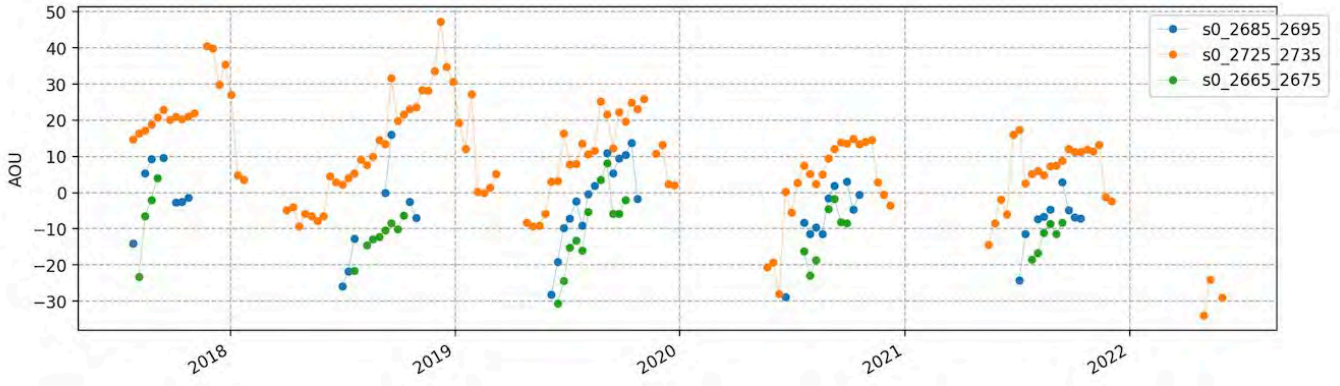
3. BGC Argo ESTIMATION OF RESPIRATION



AOU vs. depth



AOU vs. sigma



Median AOU in different sigma layers vs. time (slope = R)

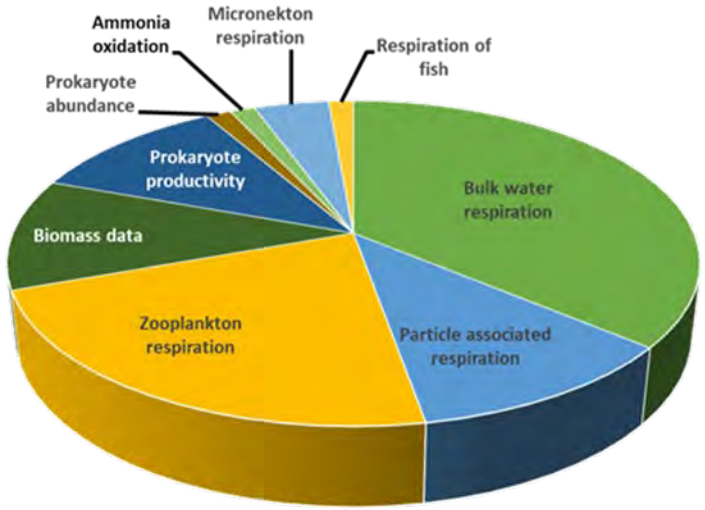
3. BGC Argo NEXT STEPS

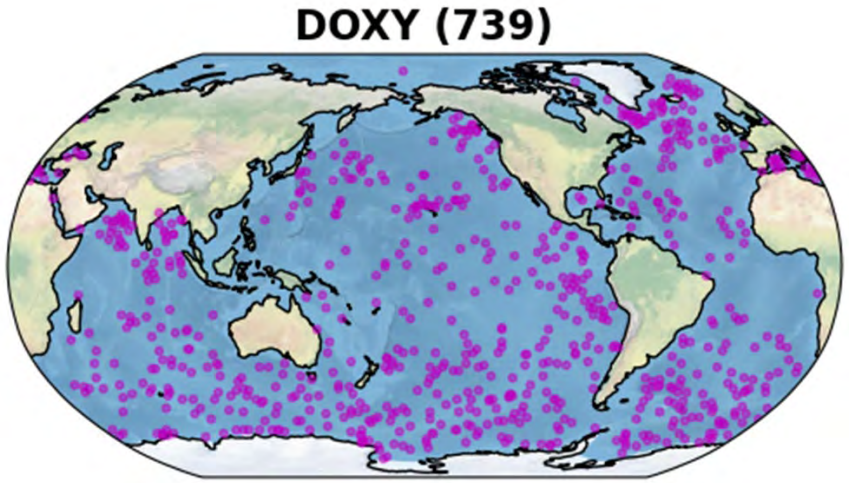
- Estimate R using all floats
- Extract related environmental variables
- Explore relationships between R and environmental variables
- Derive parameterisation(s) with temperature and dissolved oxygen

4. CAPACITY DEVELOPMENT

International training course 21-27 May 2023
In person at Universidad de Las Palmas de Gran Canaria, Spain
Online via Xiamen and Shanghai, China
Theory and hands-on practical exercises with OUR, BGC-Argo, modelling, oxygen consumption, particle attached and single cell respiration, enzymatic techniques
14 instructors including MicroRESPIRE investigators and partners
Online training materials

SUMMARY





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