



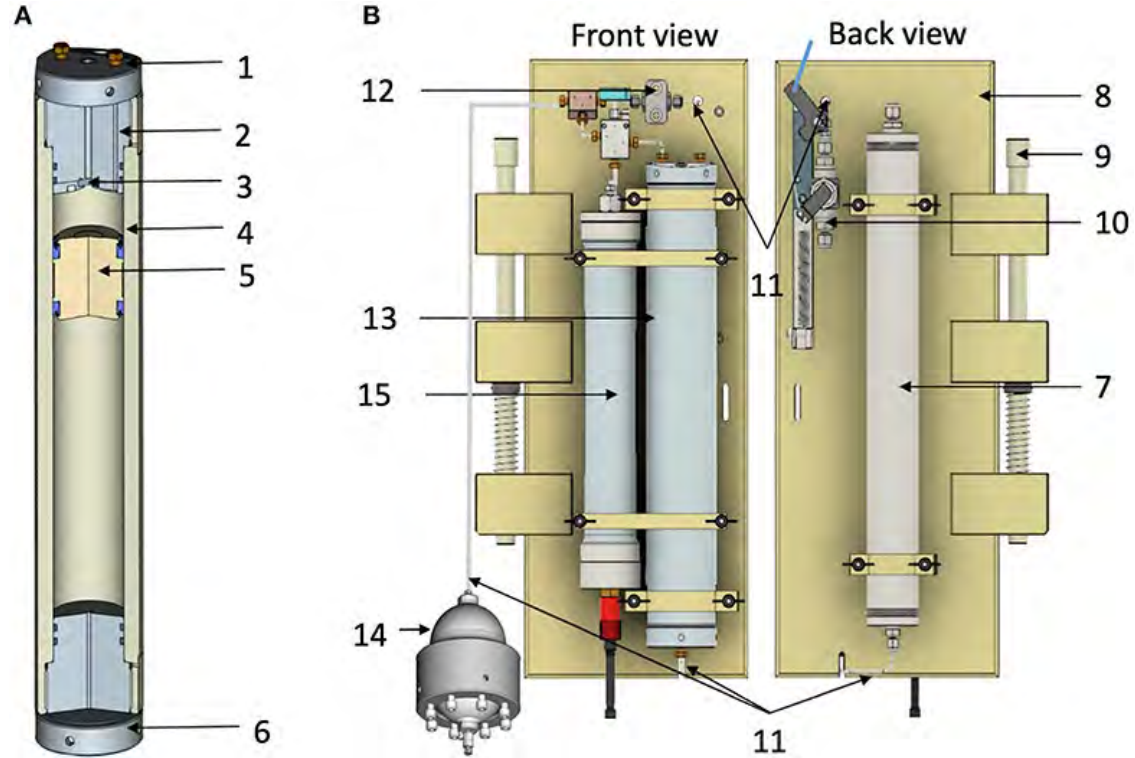
MicroRESPIRE : The abiotic and biotic factors determining microbial respiration

Carol Robinson, Isabel Seguro, Giorgio Dall'Olmo, Gwen Moncoiffé
22 project partners & SCOR WG 161

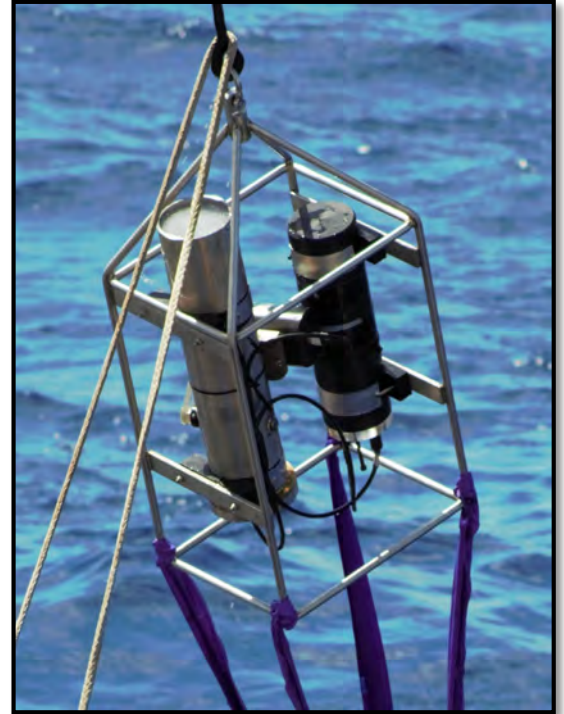




Biogeochemical-Argo float
Photo G.Dall'Olmo



High Pressure Sampling Unit
Garel et al., 2019



RESPIRE sediment traps
Boyd et al., 2015

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.

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.

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.

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




MicroRESPIRE

MicroRESPIRE

Summary

The balance between the production of organic carbon during phytoplankton photosynthesis and its consumption by bacterial, zooplankton and phytoplankton respiration determines how much carbon can be stored in the ocean and how much remains in the atmosphere as carbon dioxide. The amount of organic carbon stored in the ocean is as large as the amount of carbon dioxide in the atmosphere, and so is a key component in two global carbon cycle calculations needed to avoid a global temperature rise of more than 1.5 degrees C: the calculation of the technological and societal efforts required to achieve net zero carbon emissions and the calculation of the efficiency of ocean-based engineering approaches to directly remove carbon dioxide from the atmosphere.

Yet, despite its vital role, our ability to predict how ocean carbon storage will change in the future is severely limited by our lack of understanding of how plankton respiration varies in time and space, how it is apportioned between bacteria and zooplankton and how sensitive it is to climate change-induced shifts in environmental conditions such as increasing temperature and decreasing oxygen. This woeful situation is due to the significant challenge of measuring respiration in the deep-sea and the uncoordinated way in which these respiration data are archived. This project will directly address these two problems.



MicroRESPIRE

Aim, objectives and deliverables

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

We will achieve this aim by addressing three objectives:

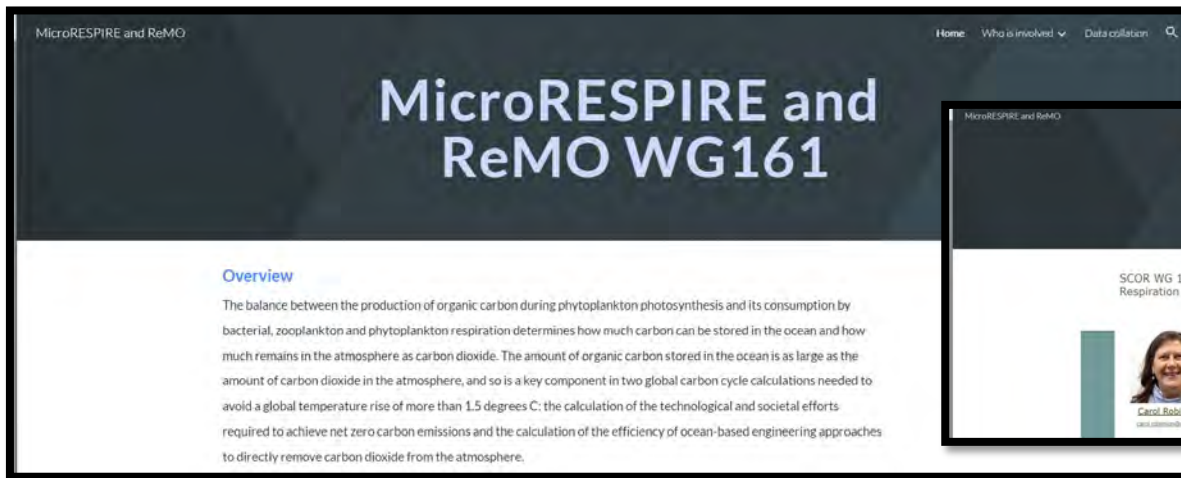
- O1: Determine how respiration varies in time and space
- O2: Determine how respiration is apportioned between microbes and zooplankton
- O3: Quantify how (climate-sensitive biotic and abiotic factors (temperature, oxygen, organic matter) influence respiration)



MicroRESPIRE

12 January 2023

[Notes of meeting, 12 January 09:00](#)



MicroRESPIRE and ReMO

MicroRESPIRE and ReMO WG161

Overview

The balance between the production of organic carbon during phytoplankton photosynthesis and its consumption by bacterial, zooplankton and phytoplankton respiration determines how much carbon can be stored in the ocean and how much remains in the atmosphere as carbon dioxide. The amount of organic carbon stored in the ocean is as large as the amount of carbon dioxide in the atmosphere, and so is a key component in two global carbon cycle calculations needed to avoid a global temperature rise of more than 1.5 degrees C: the calculation of the technological and societal efforts required to achieve net zero carbon emissions and the calculation of the efficiency of ocean-based engineering approaches to directly remove carbon dioxide from the atmosphere.



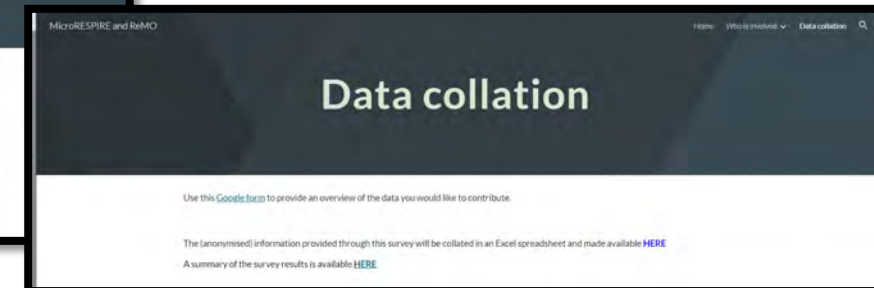
MicroRESPIRE and ReMO

ReMO WG 161 members

SCOR WG 161
Respiration in the Mesopelagic Ocean

ReMO

Carol Robinson
Isis Kriest
Javier Aristegui
Gerhard Merz



MicroRESPIRE and ReMO

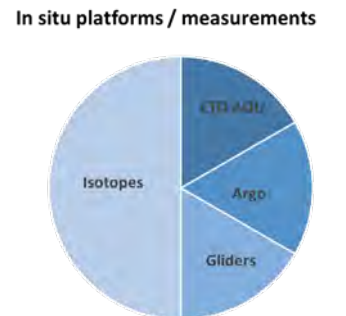
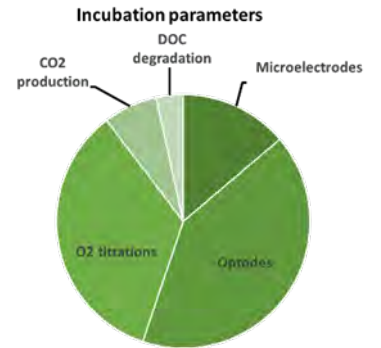
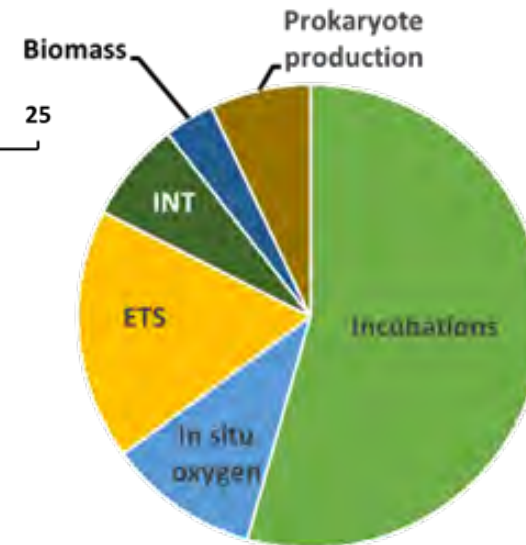
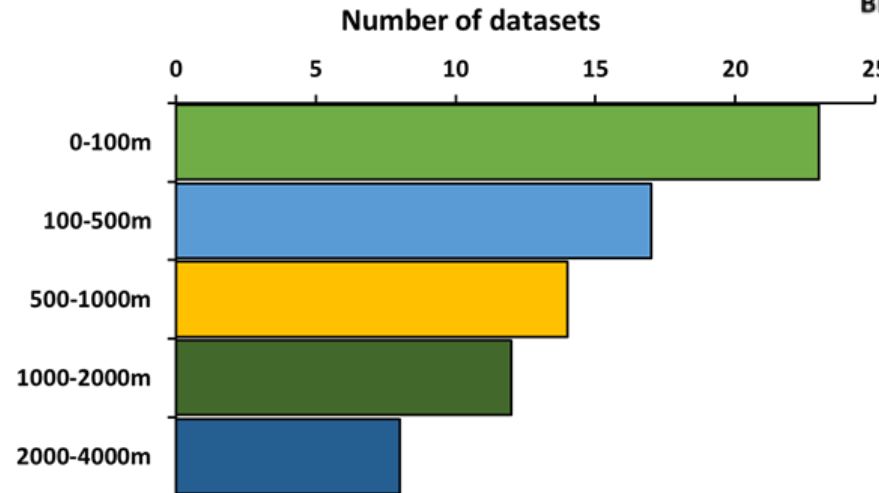
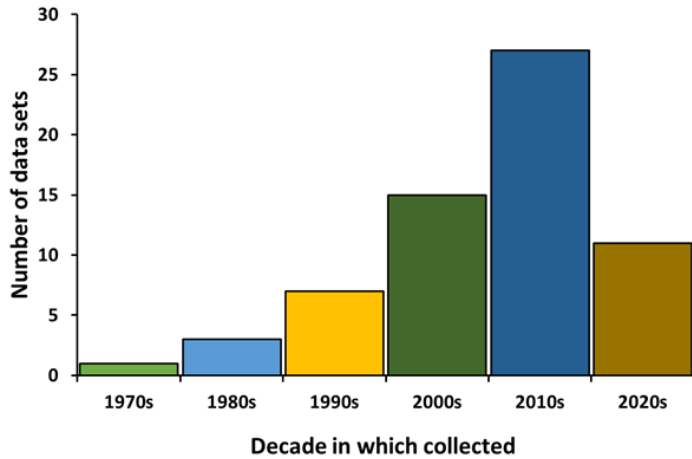
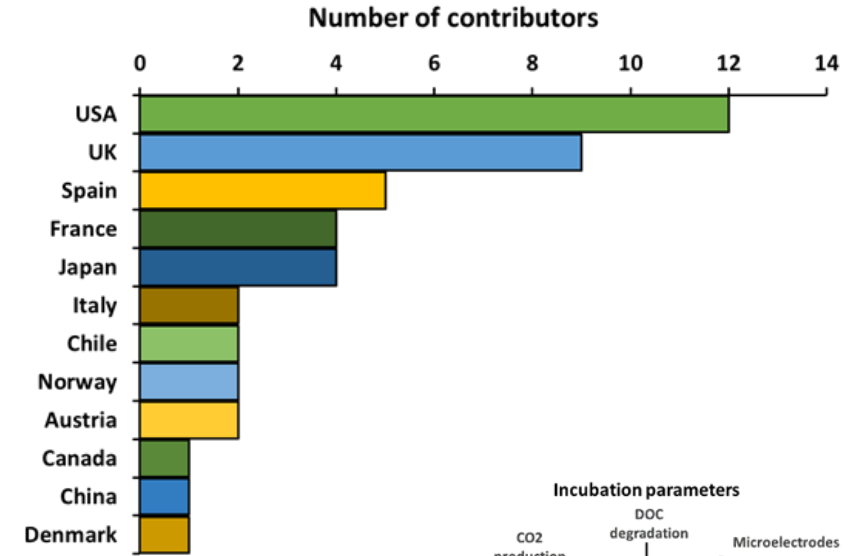
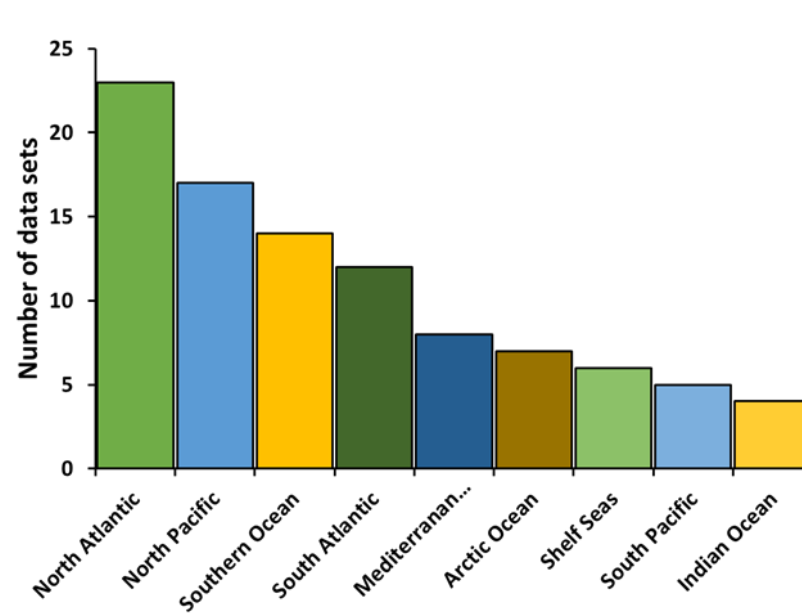
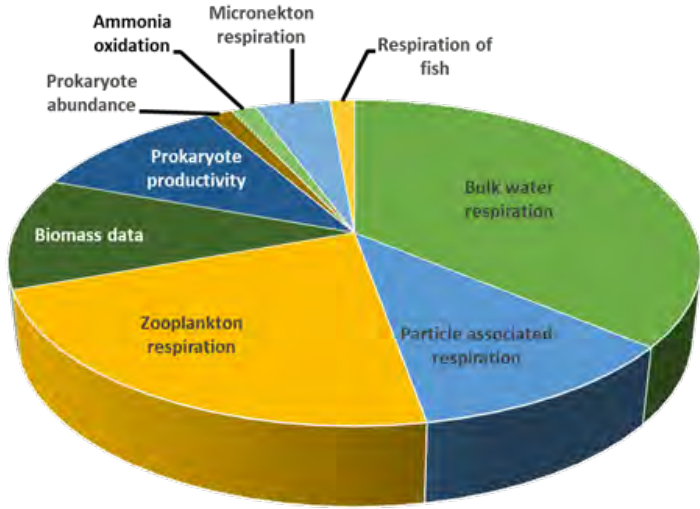
Data collation

Use this [Google form](#) to provide an overview of the data you would like to contribute.

The (anonymised) information provided through this survey will be collated in an Excel spreadsheet and made available [HERE](#)

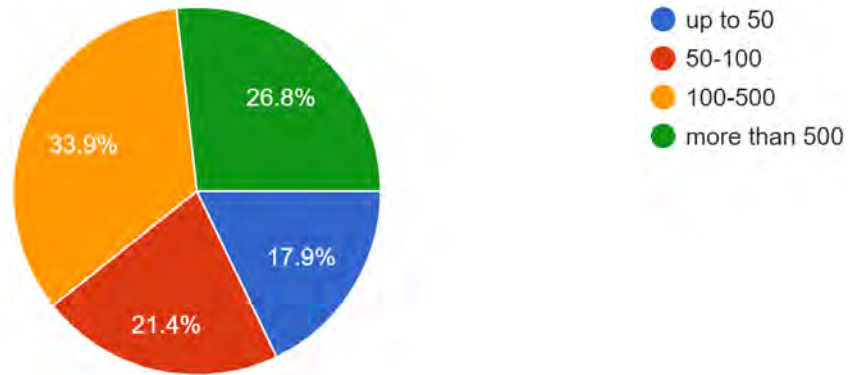
A summary of the survey results is available [HERE](#)

1. DATA COLLATION : Meta-data survey

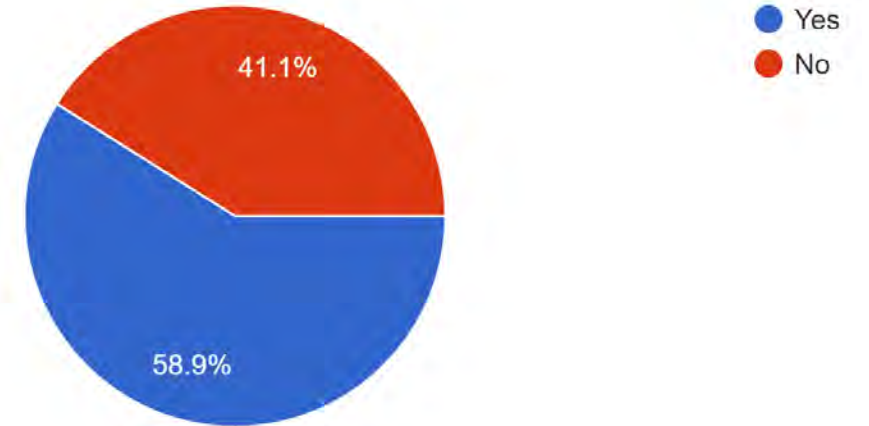


1. DATA COLLATION : Meta-data survey

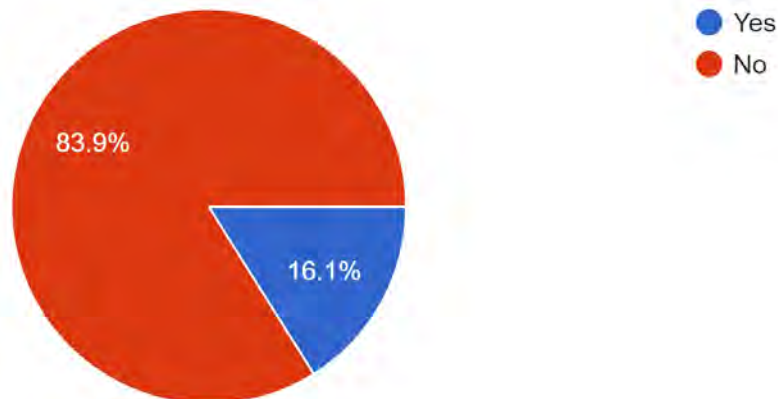
Approximate number of measurements to contribute to the database



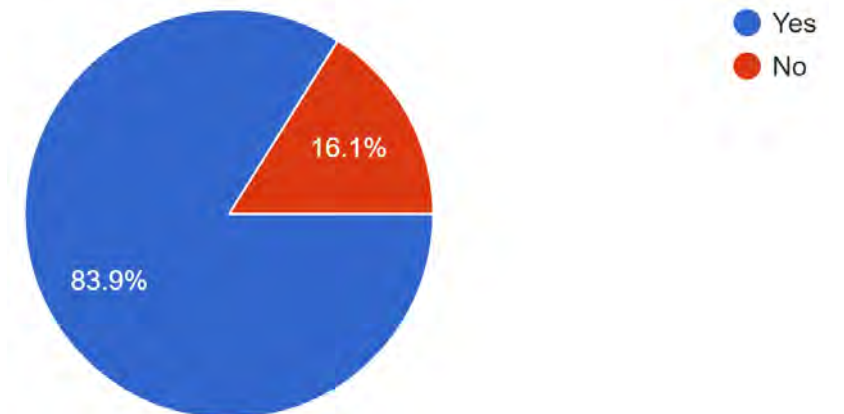
Are the respiration data published ?



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

The screenshot displays a Microsoft Excel spreadsheet titled 'Mesopelagic_data_template_v8'. The spreadsheet contains a table with columns labeled FN through GH. A yellow glossary overlay is positioned over the bottom portion of the spreadsheet, providing definitions for various parameters. The glossary entries include:

- denitrification**
- Filter type**: 1 GFF, 2 polycarbonate
- size fraction**: for example 0.1-0.8um, 0.8-2um, >2um, >1um
- temperature at which analyses were undertaken**
- method to convert to in situ T**: 1 Q10, 2 Arrhenius
- Q10 used to convert to in situ T**
- Activation energy used to convert to in situ T**
- incubation time**
- volume filtered**
- Ammonia oxidation**: <http://vocab.nerc.ac.uk/collection/P01/current/NTRFZZZZ/>, Oxidation rate (daily) of ammonium {NH4+ CAS 14798-03-9} {nitrification rate} per

The spreadsheet data shows values of -9999 for most cells in the FN-GH columns, with some cells containing text like 'Respiration O2', 'Respiration', and 'Respiration N'. The glossary also includes a link to a NERC vocabulary collection for 'experiment water sample [particulate >GF/F phase]'.

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

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



The NERC Vocabulary Server (NVS)

[Service Status](#)

[NVS Home](#) | [Vocabularies](#) | [Thesauri](#) | [Search NVS](#) | [SPARQL](#) | [Other Tools](#) | [About NVS](#)

Concept

Micromoles per micromole per day

URI <http://vocab.nerc.ac.uk/collection/P06/current/UMUB/>

Within vocab BODC-approved data storage units

Alternative Labels um/um/d

Definition A change of one part per 10⁶ of the SI unit of quantity of matter per one part per 10⁶ of the SI unit of quantity of matter the quantity of matter over a period of 86400 seconds.

Date 2023-03-02T12:36:2

Identifier SDN:P06::UMUB

Note accepted

Has Current Version 2

Version 1

version 2

Same As <http://qudt.org/vocab/unit/MicroMOL-PER-MicroMOL-DAY>

Related **P01:NRSPC00E** 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

P01:NRSPC00B Consumption rate of oxygen (O2 CAS 7782-44-7) {respiration} per day per unit biomass as carbon of biota {zooplankton [Size: 500-1000um]} by incubation

P01:NRSPC00C Consumption rate of oxygen (O2 CAS 7782-44-7) {respiration} per day per unit biomass as carbon of biota {zooplankton [Size: 200-500um]} by incubation

P01:NRSEC00C Consumption rate standard error of oxygen (O2 CAS 7782-44-7) {respiration} per day per unit biomass as carbon of biota {zooplankton [Size: 200-500um]} by incubation

P01:NRSPC00A Consumption rate of oxygen (O2 CAS 7782-44-7) {respiration} per day per unit biomass as carbon of biota {zooplankton [Size: >1000um]} by incubation

Human readable label

Unique and persistent URI

Alternate Formats

Other formats for this page:

[RDF/XML](#) [Turtle](#) [JSON-LD](#)

Alternate Profiles

Other views of this page:

[Alternate Profiles](#) ?

- 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



The NERC Vocabulary Server (NVS)

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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

Alternate Formats

Other formats for this page:

[RDF/XML](#) [Turtle](#) [JSON-LD](#)

Alternate Profiles

Other views of this page:

[Alternate Profiles](#) ?

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

- **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

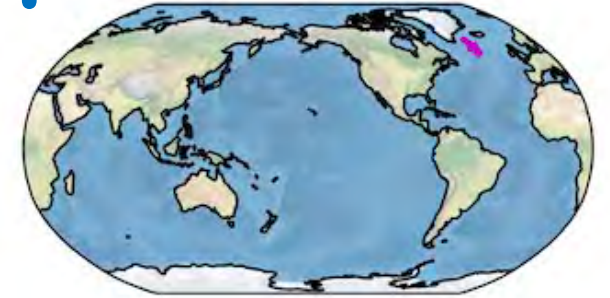
Example of an existing parameter code for zooplankton respiration measurement in the BODC Parameter Usage Vocabulary

<http://vocab.nerc.ac.uk/collection/P01/current/NRSPC00E/>



3. BGC Argo CODE DEVELOPMENT

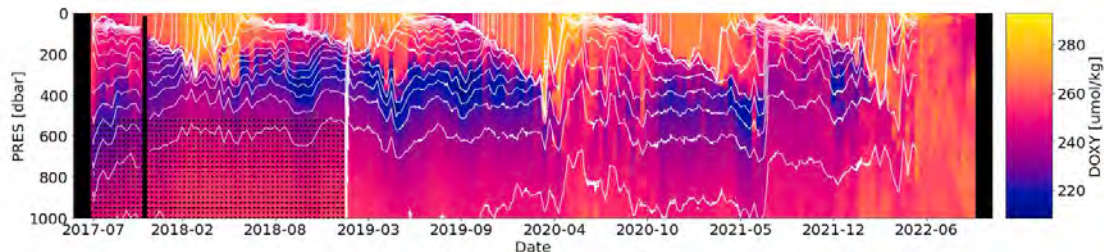
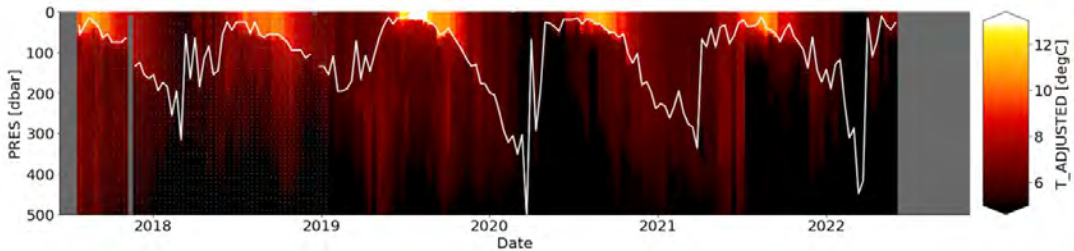
Developed python script to estimate respiration rate from BGC-Argo float data



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 \pm std of temperature, oxygen and b_{sp} within the layer during the time over which the regression is computed ✓
 - d. Extract mean \pm std of DOC values from Roshan and DeVries (2017).



```

jupyter cmp_respiration_DOXY Last Checkpoint: 36 minutes ago (autosaved)
File Edit View Insert Cell Kernel Help Trusted Python 3 (pykernel)

In [3]: 1 import xarray as xr
        2 import numpy as np
        3 import scipy as sp
        4 import pandas as pd
        5 import subprocess
        6 import glob
        7 from matplotlib import pyplot as plt
        8 import matplotlib as mpl
        9 import hvplot.xarray
        10
        11 import bgc_tools
        12 import cmoccean
        13
        14 hvplot.extension('matplotlib')
        15 %matplotlib inline
        16

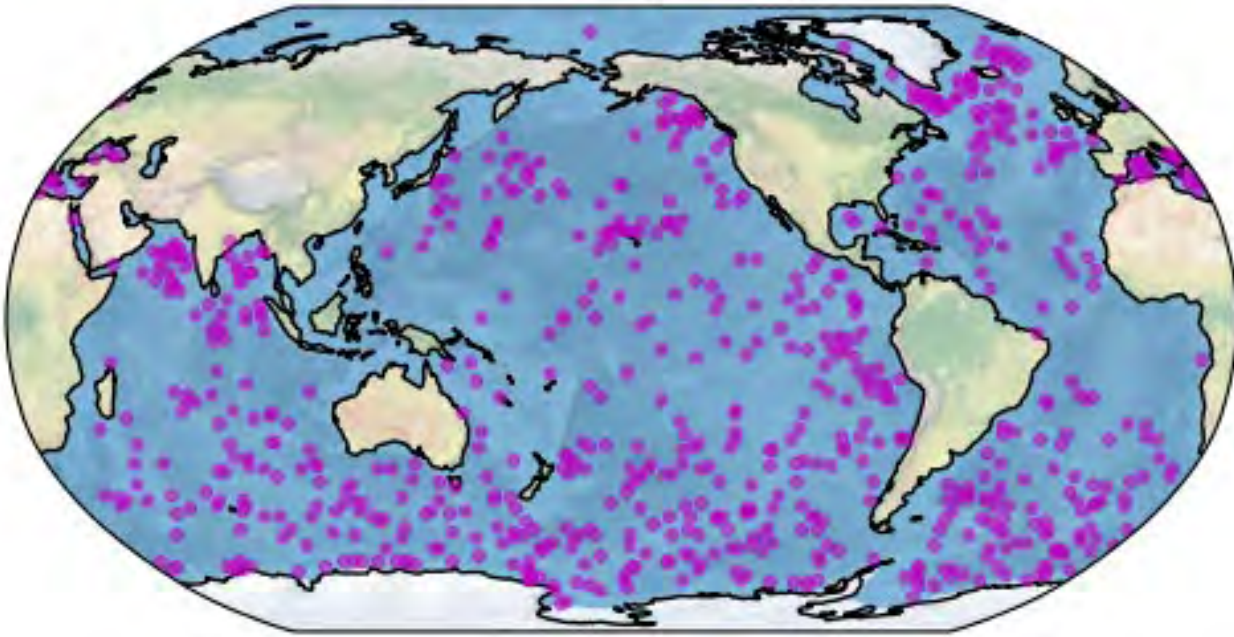
In [4]: 1 # DIN = "/mnt/Argo/"
        2 # DIN = "/home/grg/Projects/Respiration/Data/"
        3 DIN = "/Users/gdal/Dropbox/Project/Respiration/Data/Sprof/202210-BgcArgoSprof/dac/"
        4 FN_ETOPO = '/Users/gdal/Data/Etopo/ETOPO1_Bed_g_gmt4.grd.gz.decomp'
        5

In [5]: 1 cmdo2 = "grep DOXY " + DIN + "argo_synthetic-profile_detailed_index.txt | cut -d '/' -f1,2 | uniq "
        2 wmo_dac = subprocess.run(cmdo2, shell=True, stdout=subprocess.PIPE, stdout.decode('utf-8').split('\n')
        3 WMO_dac = np.asarray(wmo_dac[:])
        4 print(len(WMO_dac))
    
```

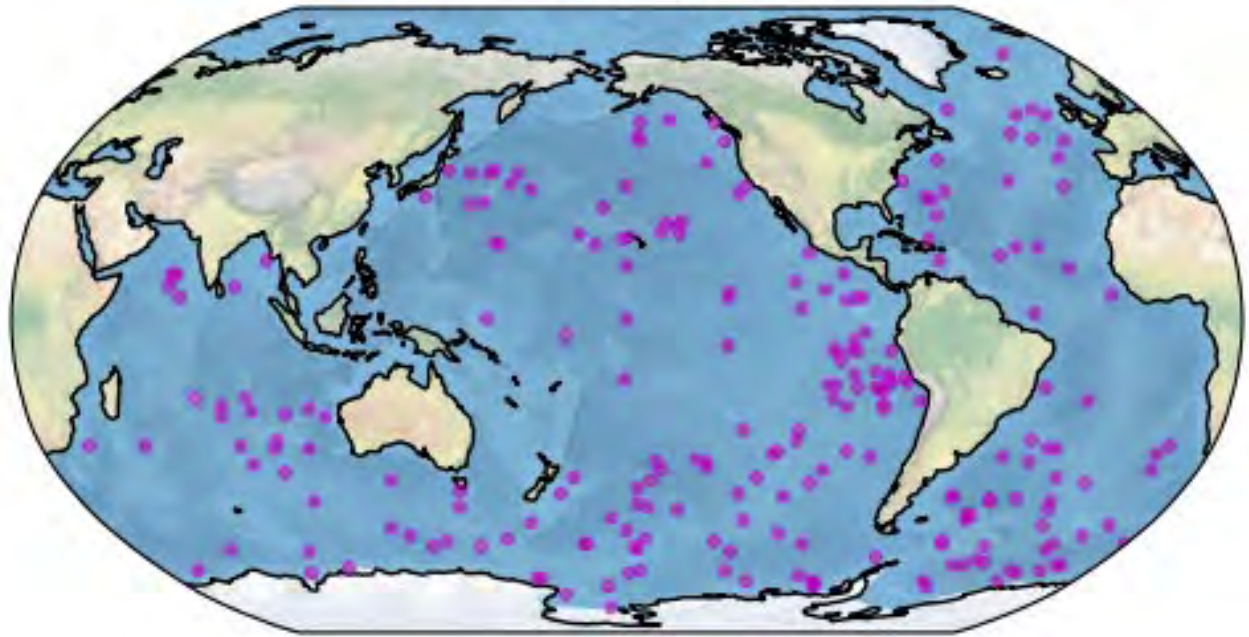
3. BGC Argo FLOAT SELECTION

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

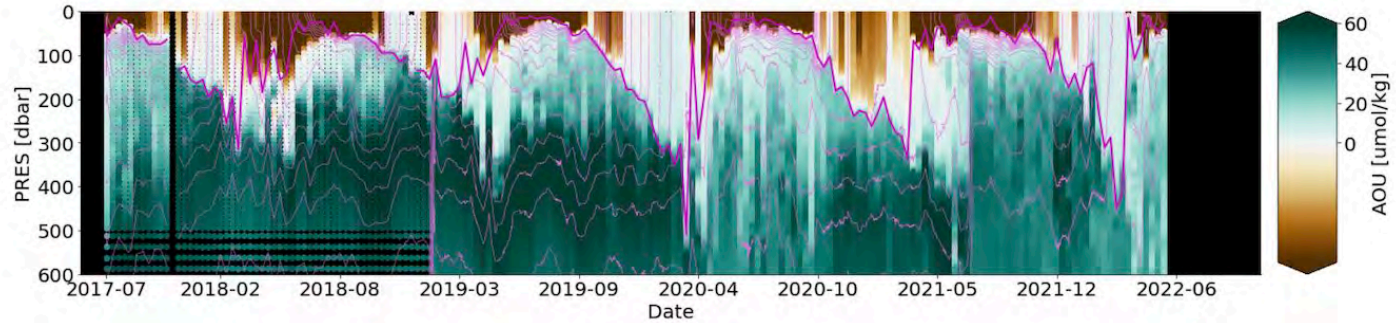
DOXY (739)



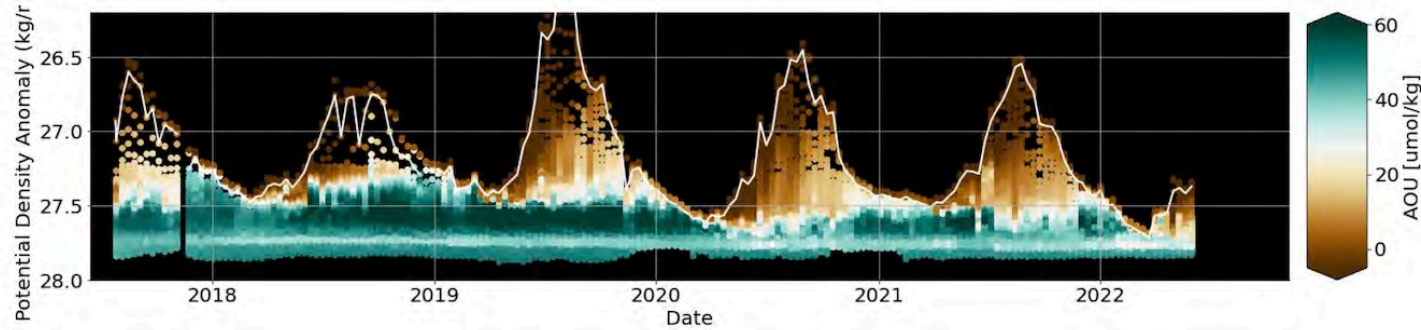
BBP700 (232)



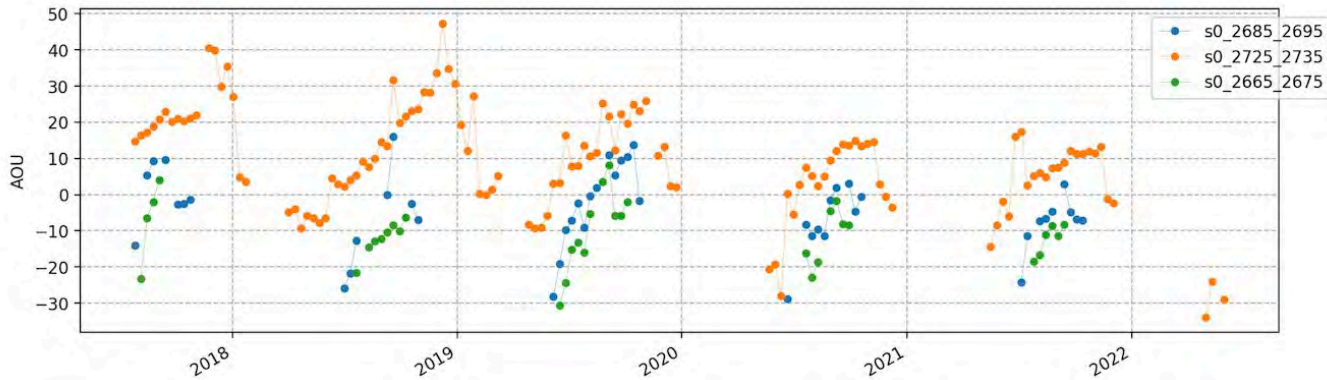
3. BGC Argo ESTIMATION OF RESPIRATION



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



SCOR WG 161
Respiration in the Mesopelagic Ocean

International Training Course on Mesopelagic Respiration
Canary Islands, Spain – 21-28 May 2023

Aims:

- To train early career researchers in the latest science and technologies
- To provide hands-on experience in using traditional and state-of-the-art methods
- To enable knowledge exchange
- To develop an international network of researchers focused on mesopelagic processes and ocean carbon storage

Program:

- Six days of lectures and practicals on mesopelagic respiration:
 - O₂ consumption and CO₂ production
 - Enzymatic techniques
 - Particle and single cell respiration
 - Biogeochemical ARGO data
 - Biogeochemical approaches
 - Modelling

How to apply? - Please submit

- [Application form](#)
- your CV
- a letter of motivation
- a letter of recommendation

to Carol.Robinson@uea.ac.uk

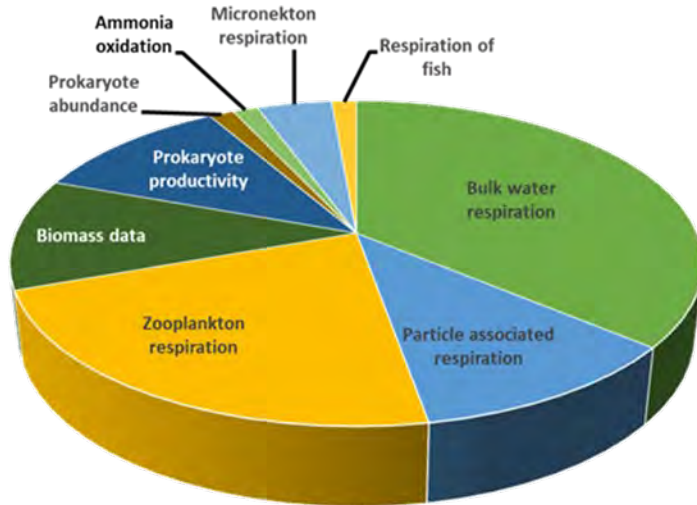
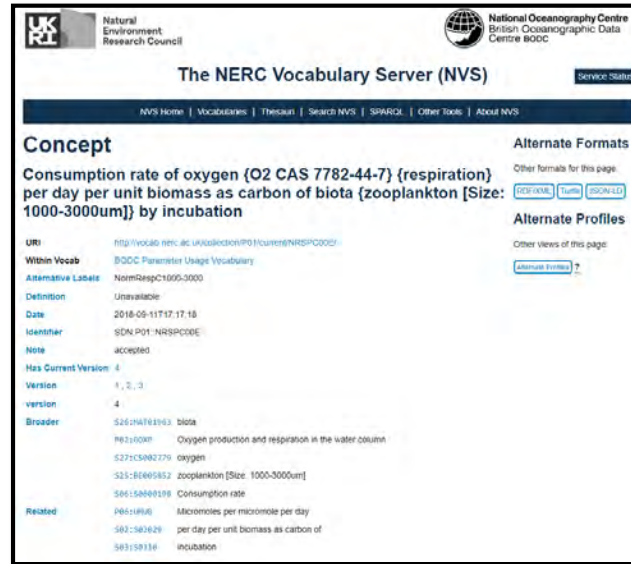
Deadline for applications:
23 January 2023

Venue:
Las Palmas de Gran Canaria, Spain
IOCAG-ULPGC Instituto de Oceanografía y Cambio Global – Universidad de Las Palmas de Gran Canaria & PLOCAN: Plataforma Oceánica de Canarias.

Costs:

- Travel costs
- Accommodation and food
- Registration fee of 500 €

Please find further information on program, application and support at:
<https://www.remo-scor-wg161.com/about-8>

The NERC Vocabulary Server (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.nerf.ac.uk/ontology/P01/current/NRSPCODE/>

Within Vocab: BODC Parameter Usage Vocabulary

Alternative Labels: NormRespC1005-3000

Definition: Unavailable

Date: 2018-09-11T17:17:18

Identifier: SDN.P01.NRSPCODE

Note: accepted

Has Current Version: 4

Version: 1, 2, 3

version: 4

Broader:

- S26:04161963 biota
- P82:0008 Oxygen production and respiration in the water column
- S27:CSA0270 oxygen
- S25:EE000852 zooplankton [Size: 1000-3000um]
- S66:5A000108 Consumption rate

Related:

- P46:14906 Micromoles per micromole per day
- S62:503629 per day per unit biomass as carbon of
- S63:59134 incubation

