IMOS Integrated Marine Observing System

National Mooring Network

NRS Combined BGC product

Product Specification

Document Change Control

Version Number	Date of Issue	Brief Description of Change
Version 0.1	13-05-2021	Draft version for review and comment
Version 0.2	03-06-2021	Draft version for review and comment
Version 0.3	25-07-2022	Final

Introduction

Summary

This dataset includes the biogeochemical (BGC) parameters collected and analysed from the National Reference Stations (NRS) excluding the biological compositional data which can be accessed through other products. Nine Sites are included in the IMOS NRS field sampling stations. Maria Island (TAS), Kangaroo Island (SA), Esperance (WA), Rottnest Island (WA), Ningaloo (WA), Darwin (NT), Yongala (QLD), North Stradbroke Island (QLD) and Port Hacking (NSW). All data included in this product are obtained from water samples collected from small vessels. Parameters in this product include salinity, carbon, alkalinity, oxygen, pigments (from High Performance Liquid Chromatography - HPLC), carbon, picoplankton cells count (from flow cytometry), secchi depth, total suspended matter (inorganic and organic components) and nutrients, comprising of ammonium, nitrate, phosphate and silicate. Over the course of the long-term monitoring program some parameters have been discontinued, others introduced and depths at which samples have been taken may have changed. Therefore, there may not be a continuous time series for each parameter, it is advised to consult the IMOS NRS Biogeochemical Operations Manual (Davies & Sommerville 2020) for more details. Data is also available in this collection from other projects which collect and analyse samples in similar methods to the NRS. The biogeochemical data from SARDIs sampling at non IMOS stations is included along with the nutrient and picoplankton data from the Coastal Sampling Stations. Specifically, SARDI data are available in all the subproduct from which the NRS Combined Biogeochemical Parameters has been derived: Raw Picoplankton Data, Pigments Only, Raw TSS Data and Chemical Parameters Only. Coastal Sampling data for various locations are available in the Raw Picoplankton Data and Chemical Parameters Only. Content details of each product are specified below.

Product Specifications

General information

Product name	NRS Combined Biogeochemical Parameters Raw Picoplankton Raw Pigments Raw TSS Raw Chemical Parameters
Geographic coverage	Australian Coastal region, 9 National Reference Stations and coastal station in Botany Bay
Temporal coverage	2009 -- present
Temporal resolution	Monthly[1]
Update frequency	Weekly
Delivery mechanism	AODN Portal OGC WFS
Format	CSV

Details of products content

Name	Description	Units/format	Data type
- ALL PRODUCTS - **NRS Combined BGC Parameters, Chemical Parameters Only, Raw TSS Data, Raw Picoplankton Data and Pigments Only**			
Project	Name of the project		string
StationName	Name of the station where sample was collected		string
TripCode	Unique code for the sampling trip	<station_code> YYYYMMDD	string
TripDate_UTC	Trip date (UTC)	YYYY-MM-DD	date
SampleTime_Local	Sampling date (Local)	YYYY-MM-DD hh:mm:ss	string
Latitude	Nominal latitude (North) of the station where sample was collected	Degrees (deg)	double precisio n
Longitude	Nominal longitude (East) of the station	Degrees (deg)	double precisio

	where sample was collected		n
SecchiDepth_m	Secchi depth	Metres (m)	real
SampleDepth_m	Depth below surface of the water body where the sample was collected	Metres (m)	real
SampleID	Sample ID composed by trip code and sample depth		string
NRS Combined BGC Parameters and Chemical Parameters Only			
Salinity	Practical salinity of the water body	Practical Salinity Unit (PSU)	real
Salinity_flag	Salinity quality control	Values from 0 to 9	real
DIC_umolkg	Dissolved inorganic carbon (DIC) per unit mass of the water body	Micromoles per kilogram (µmol kg^{-1})	real
DIC_flag	DIC quality control	Values from 0 to 9	real
Alkalinity_umolkg	Total alkalinity per unit mass of the water body	Micromoles per kilogram (µmol kg^{-1})	real
Alkalinity_flag	Alkalinity quality control	Values from 0 to 9	real
Oxygen_umolL	Concentration of oxygen (O_2) per unit volume of the water body	Micromoles per kilogram (µmol L^{-1})	real
Oxygen_flag	Oxygen quality control	Values from 0 to 9	real
Ammonium_umolL	Concentration of ammonium (NH_4) per unit volume of the water body	Micromoles per litre (µmol L^{-1})	real
Ammonium_flag	Ammonium quality control	Values from 0 to 9	real
Nitrate _umolL	Concentration of nitrate ($N0_3$) per unit volume of the water	Micromoles per litre (µmol L^{-1})	real

	body		
Nitrate_flag	Nitrate quality control	Values from 0 to 9	real
Nitrite_umolL	Concentration of nitrate ($N0_2$) per unit volume of the water body	Micromoles per litre (µmol L^{-1})	real
Nitrite_flag	Nitrite quality control	Values from 0 to 9	real
Phosphate_umoL	Concentration of phosphate (PO_4) per unit volume of the water body	Micromoles per litre (µmol L^{-1})	real
Phosphate_flag	Phosphate quality control	Values from 0 to 9	real
Silicate_umolL	Concentration of silicate (SiO_4) per unit volume of the water body	Micromoles per litre (µmol L^{-1})	real
Silicate_flag	Silicate quality control	Values from 0 to 9	real
AustralianMicrobiomeId	Data handle to link to BPA data for NRS samples where a molecular samples was also taken	Web address	string
NRS Combined BGC Parameters and Raw TSS Data			
TSSorganic_mgL	Concentration of suspended particulate material (organic) per unit volume of the water body	Milligrams per litre (mgL^{-1})	real
TSSinorganic_mgL	Concentration of suspended particulate material (inorganic) per unit volume of the water body	Milligrams per litre (mgL^{-1})	real
TSS_mgL	Concentration of total suspended solids (TSS)	Milligrams per litre (mgL^{-1})	real
TSSall_flag	TSSorganic, TSSinorganic and TSS	Values from 0 to 9	real

	quality control		
Only in Raw TSS Data			
Replicate	TSS sample replicate number		real
TSScomments	Comments for each TSS sample replicate		string
NRS Combined BGC Parameters and Raw Picoplankton Data			
Prochlorcoccus_cellsmL	Prochlorococcus cells count per millilitre	Number of cells per millilitre (cellsml^{-1})	double precision
Prochlorcoccus_flag	Prochlorococcus cells count quality control	Values from 0 to 9	real
Synechococcus_cellsmL	Synechococcus cells count per millilitre	Number of cells per millilitre (cellsmL^{-1})	double precision
Synechococcus_flag	Synechococcus cells count quality control	Values from 0 to 9	real
Picoeukaryotes_cellsmL	Picoeukaryotes cells count per millilitre	Number of cells per millilitre (cellsmL^{-1})	double precision
Picoeukaryotes_flag	Picoeukaryotes cells count quality control	Values from 0 to 9	real
Only in Raw Picoplankton Data			
Replicate	Picoplankton sample replicate number		real
Bacteria_cellsmL	Bacteria cells count per millilitre	Number of cells per millilitre (cellsmL^{-1})	double precision
Bacteria_flag	Bacteria cells count quality control	Values from 0 to 9	real
Virus_cellsmL	Viruses count per millilitre	Number of viruses per millilitre (cellsmL^{-1})	double precision
Virus_flag	Viruses count quality control	Values from 0 to 9	real
PicoplankComments	Comments for each sample		string
AnalysisLocation	Location where the analysis was		string

	performed		
AnalysisDate	Date when the analysis was performed	YYYY-MM-DD	date
AnalystName	Name of the person that analysed the sample		string
TempThawed_DegC		Degrees Celsius (°C)	real
InternalStandard			string
InstrumentBrandModel	Instrument brand model		string
InstrumentSerialNumber	Instrument serial number		string
Laser_nm	Laser wavelength/s used for the analyses	Nanometre (nm)	
ModeType			string
AnalysisVolume_uL		Microlitres (µL)	real
Flowrate_uLmin		Microlitres per minutes ($\mu Lmin^{-1}$)	real
AnalysisTime_min	Total time of analysis	Minutes (min)	real
BatchComments	Comments		string
NRS Combined BGC Parameters and Pigments Only			
Allo_mgm3	Concentration of alloxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
AlphaBetaCar_mgm3	Concentration of alpha-carotene and beta-carotene per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Anth_mgm3	Concentration of antheraxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Asta_mgm3	Concentration of astaxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision

BetaBetaCar_mgm3	Concentration of beta-carotene per unit volume of the water body	Milligrams per meter cube (mgm^{-3}	double precision
BetaEpiCar_mgm3	Concentration of alpha-carotene per unit volume of the water body	Milligrams per meter cube (mgm^{-3}	double precision
Butfuco_mgm3	Concentration of 19-butanoyloxyfucoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Cantha_mgm3	Concentration of canthaxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlA_mgm3	Concentration of chlorophyll-*a* per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlB_mgm3	Concentration of chlorophyll-b per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlC1_mgm3	Concentration of chlorophyll-c1 per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlC2_mgm3	Concentration of chlorophyll-c2 per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlC3_mgm3	Concentration of chlorophyll-c3 per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
CphlC1C2_mgm3	Concentration of chlorophyll-c1c2 per unit volume of the	Milligrams per meter cube (mgm^{-}	double precisio

	water body	^{3})	n
CphlideA_mgm3	Concentration of chlorophyllide-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Diadchr_mgm3	Concentration of diadinochrome per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Diadino_mgm3	Concentration of diadinoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Diato_mgm3	Concentration of diatoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Dino_mgm3	Concentration of dinoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
DvCphlA+CphlA_mgm3	Concentration of chlorophyll-a plus divinyl chlorophyll-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
DvCphlA_mgm3	Concentration of divinyl chlorophyll-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
DvCphlB+CphlB_mgm3	Concentration of chlorophyll-b plus divinyl chlorophyll-b per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
DvCphlB_mgm3	Concentration of divinyl chlorophyll-b per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision

Echin_mgm3	Concentration of echinenone per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Fuco_mgm3	Concentration of fucoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Gyro_mgm3	Concentration of gyroxanthin diester per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Hexfuco_mgm3	Concentration of 19-hexanoyloxyfucoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Ketohexfuco_mgm3	Concentration of 4-keto-19-hexanoyloxyfucoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Lut_mgm3	Concentration of lutein per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Lyco_mgm3	Concentration of lycopene per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
MgDvp_mgm3	Concentration of Mg-2,4-divinyl pheoporphyrin a5 monomethyl ester per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Neo_mgm3	Concentration of neoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Perid_mgm3	Concentration of peridinin per unit	Milligrams per meter cube (mgm^{-}	double precisio

	volume of the water body	^{3})	n
PhideA_mgm3	Concentration of pheophorbide-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
PhytinA_mgm3	Concentration of pheophytin-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
PhytinB_mgm3	Concentration of pheophytin-b per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Pras_mgm3	Concentration of prasinoxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
PyrophideA_mgm3	Concentration of pyropheophorbide-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
PyrophytinA_mgm3	Concentration of pyropheophytin-a per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Viola_mgm3	Concentration of violaxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Zea_mgm3	Concentration of zeaxanthin per unit volume of the water body	Milligrams per meter cube (mgm^{-3})	double precision
Pigments_flag	All pigments quality control	Values from 0 to 9	real

Nutrients
Triplicate samples are collected at 10 m intervals to have a nutrient distribution across the water column. For consistency across NRS stations, all samples are unfiltered and frozen. The averaged value for each depth is supplied here.

Carbon, alkalinity and dissolved oxygen
Carbon, alkalinity and dissolved oxygen represent important data to monitor the 'marine biological pump'. Alkalinity and dissolved inorganic carbon (DIC) samples are returned to CSIRO Hobart for analyses. Measurements of carbon are provided in the form of dissolved inorganic carbon (DIC). Sample for DIC, alkalinity and dissolved oxygen are taken at 10 m intervals. While DIC and alkalinity samples are provided for all NRS, samples for dissolved oxygen are collected only at Maria Island (MAI) and Rottnest Island (ROT) stations.

Secchi disk and total suspended solid (TSS)
Secchi disk values provided by this collection represent the limit of visibility in the water column. These values are derived by the average of two depths, the depth the disk is just no longer visible, and the depth the disk becomes visible again. Total suspended solid (TSS) were collected in duplicate, now they are collected in triplicate with a blank. The averaged value of these measurements, accounting for the blank when present, is provided for total TSS, organic and inorganic TSS fraction.

Flow cytometry cells count
Flow cytometry analyses are performed to count specific phytoplankton cells, in this case Prochlorococcus, Synechococcus and Picoeukaryotes. The values provided by this product are derived by an average of two replicate for each sample.

High Performance Liquid Chromatography (HPLC)
HPLC analyses are performed to obtain phytoplankton pigment observation, from which it is possible to estimate the taxonomic composition of phytoplankton assemblages. These samples are currently collected at the surface and at the same depth as the shallowest water quality monitor (WQM) on the mooring, an average is provided here.

Product delivery

Format
This product is available in comma-separated values (CSV) format.

AODN Portal
Dataset collections:

- **IMOS National Reference Station (NRS) - Combined BGC product**

The specific product is selected under the *Download as...* drop-down menu on Step 3.

The collections can be subset by

- Geographic bounding box
- Temporal range

- Station name

AODN Geoserver

The product can be accessed via a Web Feature Service (WFS) query to the AODN Geoserver. The relevant layers are:

- `imos: combined_bgc_data`
- `imos: bgc_chemistry_data`
- `imos: bgc_picoplankton_data`
- `imos: bgc_tss_data`
- `imos: bgc_pigments_data`

The Web Map Service (WMS) layers used for preview in Step 2 on the AODN Portal is

- `imos:combined_bgc_map`

Step 3 in the AODN Portal allows user to select to download a specific sub-product of the combined bgc product (i.e., bgc_chemistry_data, bgc_picoplankton_data, bgc_tss_data or bgc_chemistry data)

Data Lineage

Provenance

Water samples are collected off small vessels at the IMOS National Reference Stations. The depth of the sample varies at each station. The sampling methods are fully described in the IMOS NRS Biogeochemical Operations Manual (Davies & Sommerville 2020). The analysis and quality control (QC) procedures performed at CSIRO are also described in this manual.

Harvest to AODN

The combined BGC product is based on raw data harvested from the following WFS layers in the CSIRO Geoserver:

- **bgc_trip** - metadata (project, station, sample date local, trip code, latitude, longitude, secchi depth)
- **bgc_chemistry** - trip code, depth, sample date local, salinity, nutrients, carbon, alkalinity and oxygen (including flags) and MicroBiomeSample_id data handle.
- **bgc_tss** - trip code, total TSS (average), organic and inorganic TSS fraction (average), (including TSS)
- **bgc_tss_meta** - trip code, total TSS (raw data), organic and inorganic TSS fraction (raw data), (including TSS), blankadjustavailable
- **bgc_picoplankton** - trip code, depth, Prochlorococcus, Synechococcus and Picoeukaryotes (average, including respective flags)
- **bgc_picoplankton_meta** - trip code, sample_code, depth, Prochlorococcus, Synechococcus and Picoeukaryotes (average, including respective flags), additional metadata from raw data.
- **bgc_pigments** - trip code, all pigments measurements from HPLC analyses (including pigments flag).

Each of these layers is downloaded into a CSV file, then processed by the AODN data ingestion pipeline.

Processing at AODN

- Create the combined product
- Convert sample time local to sample time UTC.
- AODN Harvest Database schema

Schema name: imos_bgc_db

Tables to hold data & metadata harvested:

- `bgc_trip`
- `bgc_chemistry`
- `bgc_picoplankton`
- `bgc_picoplankton_meta`
- `bgc_tss`
- `bgc_tss_meta`
- `bgc_pigments`

Materialised views for Geoserver layers:

- `combined_bgc_data`
- `bgc_chemistry_data`
- `bgc_picoplankton_data`
- `bgc_tss_data`
- `bgc_pigments_data`
- `combined_bgc_map`

Glossary and abbreviations

AODN	Australian Ocean Data Network
CSV	Comma-separated values
CTD	Conductivity Temperature Depth
IMOS	Integrated Marine Observing System
NRS	National Reference Station
QC	Quality Control
WFS	Web Feature Service

References

Davies, C. and Sommerville, E. (Eds.) (2020), National Reference Stations Biogeochemical Operations Manual. Integrated Marine Observing System. DOI: 10.26198/5c4a56f2a8ae3 (http://dx.doi.org/10.26198/5c4a56f2a8ae3)