The Global Ocean Observing System

DRAFT

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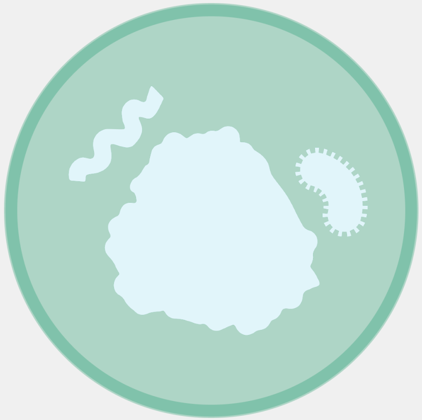
Essential Ocean Variable Specification Sheet

Microbe Biomass and Diversity



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EOV Specification Sheet curated by:

Biology and Ecosystems Panel

DETAILED INFORMATION ON HOW TO READ THE SPECIFICATION SHEET CAN BE FOUND IN THIS GUIDE

Background and justification

Microbes, or microorganisms, are unseen but essential for life on Earth, inhabiting every environment on the planet. They constitute the majority of the world's biodiversity, representing nearly 80% of all life. Marine microbes play pivotal roles in ocean health, underpinning food webs, producing essential vitamins, mediating global biogeochemical cycles and carbon sequestration, sustaining symbioses, coastal and oceanic health including coral reefs, fisheries, and nurseries. Their metabolisms and thereby their roles in ocean biogeochemistry are diverse. They fix nitrogen, thus supplying limiting nutrients to fuel primary production, cycle greenhouse gases, and they respire organic carbon, contributing to the creation of oxygen minimum zones. They are key to the improvement of water quality after eutrophication events or oil spills (Dombrowski et al., 2016), the defense of disease in coral reefs (Rosenberg, et al., 2007), and many other ecosystem services. Richness and dynamism of microbial communities spans from marine planktonic and sediment systems to host-associated habitats. Assessing the states and activities of microbiomes in changing oceans is essential due to their connection to the rest of life (Eren and Banfield, 2024).
The role of microbes in planetary, organismal and societal health is unquestioned, as evidenced by industrial applications from natural products, including pharmaceuticals and probiotics, to waste water treatment. Emphasising their importance in global climate, 24 concurrent publications across scientific journals form a call to action to urgently support innovation and the upscaling of known microbial solutions to the climate catastrophe (e.g. Peixoto et al., 2024). It's important that microbial observations are standardised and harnessed to understand natural change as a background to interpret and quantify human-induced impacts, such as employment of these 'microbe-mediated solutions' and escalating effects of climate change.
For the sake of this specification sheet, "microbes" include microscopic Eukaryotes, Bacteria and Archaea but only touch on phytoplankton and viruses. Cyanobacteria and Eukaryotic phytoplankton are well-covered in the Phytoplankton EOV.

Integration with Global Observation Frameworks
The Global Climate Observing System (GCOS) developed the Essential Climate Variable (ECV) framework to define necessary observations for monitoring Earth's climate (Bojinski et al., 2014). Some EOVs, including ocean physics, biogeochemistry, and biology/ecosystems variables (GCOS, 2022a; GCOS, 2022b), are also ECVs.

The Essential Biodiversity Variables (EBVs) defined and curated by the Group on Earth Observations Biodiversity Observation Network (GEO BON) complement the GOOS biological and ecosystem (BioEco) EOVs (Muller-Karger et al., 2018; Bax et al., 2019). The EOVs represent the basic observations of a particular parameter or process. EBVs are time series of biodiversity observations across genes, species populations, EOV sub-variables at one location, or as time series of gridded, mapped, or modelled EOVs (Jetz et al., 2019).

The GOOS Biology and Ecosystems Panel collaborates with the Physics and Climate and Biogeochemistry Panels to advance EOVs, advocating for the need for biological observations, information management, and applications. GOOS, MBON, GEO BON, and OBIS work together to standardise guidelines and data management for EOVs, EBVs, and ECVs.

Current observing networks and coordination

Diverse networks and communities are collecting observations of biology and ecosystems EOVs at different scales and in different regions. An initial baseline survey conducted in 2019/20 identified 203 active, long-term (>5 years) observing programs systematically sampling marine life. These programs spanned about 7% of the ocean surface area, mostly concentrated in coastal regions of the United States, Canada, Europe, and Australia (Satterthwaite et al 2021). This information can be found in the GOOS BioEco Metadata Portal, which is continually updated. To consult the latest information, please visit: https://bioeco.goosocean.org

Contributes to (please click on the symbol for more information):

EBV: Community composition, Ecosystem functioning, Ecosystem structure, Genetic composition, Species populations, Species traits

ECV: Plankton

SDG: 2, 3, 6, 9, 11, 13, 14, 17

CBD: Target 1, Target 8, Target 9, Target 10, Target 11, Target 13, Target 17, Target 20, Target 22

communities, or ecosystems. Thus, EOVs may be seen as the building blocks for GEO BON EBVa. The EOVs can be used to synthesise the EBVs as time series of BioEco		

1. EOV information

ESSENTIAL OCEAN VARIABLE (EOV)	Microbial Biomass and Diversity
DEFINITION	The operational definition of microbes for the purpose of this specification sheet includes Bacteria, Archaea and Eukaryotic microbes, but exclude viruses. As phytoplankton, cyanobacteria are more thoroughly addressed in the Phytoplankton specification sheet, though genetic methodologies can be applied. Microbial biomass refers to: - weight (mass as the concentration per unit area/volume), - abundance or quantity of organisms (number of individuals per unit area or volume, or per mass of sediment). Microbial diversity refers to: - variability of microbes from all sources; including diversity within and between species (genetic diversity, functional diversity, etc.)
EOV SUB-VARIABLES key measurements that are used to estimate the EOV ***bare minimum**	* Microbial concentration (biomass / abundance) * Diversity - Genomic and genetic diversity - Phenotypic diversity - Functional diversity Presence of fecal indicator bacteria
SUPPORTING VARIABLES	**Environmental** Temperature Depth

	Salinity Oxygen pH Currents Redox elements (N, Mn, Fe, S, etc) Dissolved and particulate organic carbon Dissolved and particulate organic nitrogen Suspended solids Visual inspections for waste
	EOV related Functional diversity Size spectra Cell volume Substrate(s) Oxidant(s) Growth rate Growth phase Colony-forming units Number or grams per volume seawater Number or grams per gram sediment
DERIVED PRODUCTS Describe EOV using sub-variables and relating to supporting variables	Microbial community composition (concentrations of all types of microbes in a sample), microbial community function, richness, phylogeny, participation (role) of microbes in global biogeochemical cycles. Biogeography of important microbial groups. Changes in microbial community related or due to anthropogenic actions

2. Phenomena to observe - what we want to observe with this EOV

This section presents examples of priority phenomena for GOOS that can be (partly) characterised by this EOV's sub-variables. This list is not exhaustive but serves to provide general guidance on how observation efforts can structure their planning and implementation to observe certain phenomena.

The GOOS application area(s) the phenomena are relevant for are depicted as follows: Climate, ocean health, operational services

PHENOMENA TO OBSERVE		Geographic variation in diversity / composition	Role in transport/cycling of elements	Detection and enumeration of fecal indicator bacteria (*Escherichia coli*) in bathing waters	Oil spill degradation by microbial community
PHENOMENA EXTENT	HORIZONTAL	Sequences of taxonomic / functional gene markers or full metagenomic sequencing tracked locally, regionally, or globally (meters to 1000's of kilometers) depending on the application	Amount of carbon, nitrogen, redox intermediates or gases taken up or released over scales of meters to kilometers, at regional and basin-scale; biomass imported or exported from a location by advection or biological processes	metres to kilometres, regional	Local to regional can be tracked by HTS of targeted taxonomic/functional genes or full shotgun sequencing
	VERTICAL	Vertical stratification of the same sequence identifications over meters to kilometers, depending on the applications	Fluxes in terms of nitrogen fixation rates, greenhouse gas production or uptake, redox cycling, exopolysaccharide production, respiration of dissolved and particulate organics, ballast characteristics, within and below the photic zone	Photic zone; can settle to benthos	m

	TEMPORAL	monthly or seasonally, over decadal scales	Changes in biogeochemical characteristics over short (hours to day), seasonal, or decadal scales	Observed annually and over decades; with sustained elevated occurrence possible over days to weeks	daily to monthly
RESOLUTION TO OBSERVE PHENOMENA	**HORIZONTAL**	10s km	~10m to > 1000km	In each bathing water region: One single location where most bathers are expected or where the greatest risk of pollution is expected	10s km
	VERTICAL	m	m	Photic zone	m
	TEMPORAL	seasonal	weekly	1 pre-bathing-season; with 4-20 bathing season samples taken at intervals	weekly
SIGNAL TO CAPTURE		changes in microbial community composition and abundance over depth (oxygen minimum zones, nitrite maxima, association with exported particulates); phenology (seasonality, episodic events, annual variation)	changes over depth (oxygen minimum zones, nitrite maxima, association with exported particulates); phenology (seasonality, episodic events, annual variation)	Presence of fecal indicator bacteria; to be monitored daily once statutory limits are exceeded	increase in oil degrading bacterial groups/ increase in genes involved in oil degradation
SUB-VARIABLES NEEDED TO MEASURE		Microbial diversity Microbial concentration	Microbial diversity Microbial concentration	Presence of fecal indicator bacteria	Microbial diversity Microbial concentration
SUPPORTING VARIABLES NEEDED		Temperature Depth Salinity Oxygen pH Currents	Temperature Depth Salinity Oxygen pH Currents	Suspended solids Visual inspections for waste	Temperature Depth Salinity Oxygen pH

	Redox elements (N, Mn, Fe, S, etc) Dissolved and particulate organic carbon Dissolved and particulate organic nitrogen	Redox elements (N, Mn, Fe, S, etc) Dissolved and particulate organic carbon Dissolved and particulate organic nitrogen		

3. GOOS Observing Specifications or Requirements

This section outlines ideal measurements for an optimal observing system for this Essential Ocean Variable (EOV). It offers guidance on creating a long-term system to observe key phenomena related to the EOV. These values are not mandatory, and no single system is expected to meet all requirements. Instead, the combined efforts of various observing systems should aim to meet these goals. Observations at different scales are also valuable contributions to global ocean observation if shared openly.

EOV	Microbe Biomass and Diversity		
PHENOMENA	geographic variation in diversity/composition; role in transport / cycling of elements		
EOV SUB-VARIABLE	Microbial diversity	**DEFINITION**	identifying microbial taxa /functional groups by sequencing, qPCR, microscopy (e.g. FISH)

	Resolution			**Timeliness**	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	Co-located plankton and environmental observations (if known, within the decorrelation scale of the data) Sample similar / same	Depth-resolved at standard oceanographic sampling depths for deep water or higher resolution for euphotic zone.	Depending on question or problem: day-night variations, weekly, monthly or every few months (e.g., seasonal). Similar timing if building climatologie	depends on the purpose: near-real-time for harmful organisms; monthly for long time-series	Depends on method		Bottle samples, nets, filters for biomass, chemical composition of particulates, genetic (eDNA and other), microscopy. Samples preserved for subsequent taxonomic analyses, or frozen (liquid nitrogen/-80C) Platforms: ships, small boats, autosamplers, marine snowcatchers, sediment traps	Hawaii Ocean Time-series Program: Time-series sampling strategy Oxygen minimum zone time-series design Continental-scale marine microbiome time-series: Australian Marine Microbiome Initiative

	locations across time if comparing for trends	Identify vertical plankton biomass and nutrient variations, gradients, location of mixed layer depth and nutricline	s and comparing trends over time Concurrent plankton and environmental observations (if known, within the decorrelation scale of the data) Twice-monthly					[Global Inter comparability in a Changing Ocean: an international time-series methods workshop, November 28-30, 2012 (Bermuda Institute of Ocean Sciences, St. Georges, Bermuda).]()
DESIRABLE	Regional	Surface, Deep Chlorophyll Maximum (DCM), bottom or bottom of euphotic zone	monthly	< 6 months				
MINIMUM	Local (single fixed location)	surface	seasonal (3 months)	6 months				

EOV SUB-VARIABLE	Microbial concentration				DEFINITION		relative abundance of sequenced taxa or specific abundance of targeted microbe (% of taxa or gene copy number, respectively)	
	Resolution			Timeliness	Uncertainty Measurement	Stability	Sampling approach	References
	Spatial Horizontal	Spatial Vertical	Temporal					
IDEAL	Co-located plankton and environmental observations (if known, within the decorrelation scale of the data) Observation resolution higher where discrete stratified layers, fronts or features exist - dependent on the feature Sample similar / same locations across time if comparing for trends		Depth-resolved at standard oceanographic sampling depths for deep water or higher resolution for euphotic zone. Identify vertical plankton biomass and nutrient variations, gradients, location of mixed layer depth and nutricline	Depending on question or problem: day-night variations, weekly, monthly or every few months (e.g., seasonal). Similar timing if building climatologies and comparing trends over time Concurrent plankton and environmental observations (if known, within the decorrelation scale of the data) Twice-monthly	depends on the purpose: near-real-time for harmful organisms; monthly for long time-series	Depends on method	Bottle samples, nets, filters for biomass, chemical composition of particulates, genetic (eDNA and other), microscopy. Samples preserved for subsequent taxonomic analyses, or frozen (liquid nitrogen/-80C) Platforms: ships, small boats, autosamplers, marine snowcatchers, sediment traps	Marine snow catcher Sediment traps SCOR Working Group 134: The Microbial Carbon Pump in the Ocean SCOR Working Group 144: Microbial responses to ocean deoxygenation SCOR Working Group 126: The role of viruses in marine ecosystems

DESIRABLE	Regional	Surface, Deep Chlorophyll Maximum (DCM), bottom or bottom of euphotic zone	monthly	< 6 months			
MINIMUM	Local (single fixed location)	surface	seasonal (3 months)	6 months			

PHENOMENA	Detection and enumeration of fecal indicator bacteria (Escherichia coli)							
EOV SUB-VARIABLE	Presence of fecal indicator bacteria				**DEFINITION**		culture-based enumeration of Escherichia coli for water quality assessment in bathing waters	
	Resolution			**Timeliness**	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	0.5m from bathers; within and 0.5m from area at greatest risk of pollution	photic zone; 5-10m from shore	4 times monthly (if high risk)	daily if hazardous (polluted) conditions are present (36-72h for analysis), in case of hazardous conditions	Can be >30% based on difficulty collecting a representative sample; and analytical variation associated with culturing and counting E. coli ddPCR has 9.6% uncertainty relative to EPA approved reference methods		100ml water is collected at each site, early morning to ensure time to finalise the protocol that day; samples are refrigerated during	Review of bathing water recommendations in England Uncertainties in stormwater E. coli levels

DESIRABLE	0.5m from bathers; 0.5m from area at greatest risk of pollution	photic zone; 5-10m from shore	2 times monthly	2 weeks			transport to the lab	Droplet digital PCR (ddPCR) assay for Enterococcus and human associated fecal indicators
MINIMUM	0.5m from bathers	photic zone	1 sample pre-bathing-season; 1 sample per month during the bathing season	1 month				Application of droplet digital PCR in coastal water quality monitoring

PHENOMENA	Oil spill degradation by microbial community		
EOV SUB-VARIABLE	1. Microbial concentrations (abundance /biomass) 2. Microbial diversity	**DEFINITION**	1. cells/ml or cells/g sediment; g/ml or g/g sediment 2. identifying microbial taxa capable of degrading oil as well as functional genes involved in degradation

	Resolution							
	Spatial Horizontal	**Spatial Vertical**	**Temporal**	**Timeliness**	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
IDEAL	1 km	0.5 m	bi monthly	daily if hazardous (polluted) conditions are present	To ASV level (species level) and real time for abundance/bio mass		100 L water	Liu and Liu, 2013. Mason et al 2012.
DESIRABLE	5 km	1m	monthly	2 weeks	Genus level and each month for abundance/bio mass		20 L water	Nikolopoulou & Kalogerakis 2010
MINIMUM	10s km	5 m	6 months	1 month	Class level and every 3 months for abundance/bio mass		10 L water	Warr et al., 2013 Liu et al., 2022

4. Observing approach, platforms and technologies

This table provides examples of approaches and technologies used to collect this EOV to help observe priority phenomena

APPROACH / PLATFORM	eDNA and Sequencing	Cultivation dependent	Bacterial counts
EOV SUB-VARIABLE(S) MEASURED	Taxonomic diversity	Taxonomic diversity	Microbial abundance
TECHNIQUE / SENSOR TYPE	High throughput sequencing	cultivation on seawater agar + nutrients media	microscopy, cytometry
SUGGESTED METHODS AND BEST PRACTICES	Marine Microbiome Initiative microbial sampling, section 5.5.9; Sample processing and storage, section 6.7; metadata collection, section 8.2, 8.3 Sediment sampling for marine microbes; Extraction of DNA from seawater; Library preparation for sequencing; High throughput sequencing (Illumina); DNA and RNA analytical workflows (for amplicon, metagenomic, metatranscriptomic sequences); Intercomparison of marine microbiome sampling protocols	Zobell Marine Agar; Culturing marine bacteria; Microscopy; Morphological feature identification	Bacterioplankton abundance, Chapter 18 Direct counts by microscopy; Marine microscopy image analysis; Fluorescent in situ hybridisation (FISH) for microbes in marine sediments; Colony-Forming Units*; Bacteria counts by flow cytometry * restricted to enumeration of culturable microbes
SUPPORTING VARIABLES MEASURED	Temperature Depth Salinity Oxygen pH	Temperature Depth Salinity Oxygen pH	Temperature Depth Salinity Oxygen pH

APPROACH / PLATFORM	Bacterial biomass	Viral ecology	Detection and enumeration of Escherichia coli	Microbial activity
EOV SUB-VARIABLE(S) MEASURED	Biomass	Concentration, diversity	Presence of fecal indicator bacteria	Diversity (function)
TECHNIQUE / SENSOR TYPE	weight or cell volume	Concentration of viruses; metagenomics; microscopy	4-methylumbelliferyl-b-D-glur onide (MUG) hydrolysis by cultured E. coli after 36-72h, detected under UV light by the release of a fluorescent compound	Field methodologies to measure rates of processes
SUGGESTED METHODS AND BEST PRACTICES	Fluorescent in situ hybridisation (FISH) for microbes in marine sediments; Particulate carbon, nitrogen, phosphorus, silica; Imaging Flow Cytobot (IFCB); Water column: g/ml Sediment: g/g	Iron chloride precipitation of viruses from seawater; Viral identification from sequence data; Wet-mounted method for enumeration of aquatic viruses	Bathing water sampling frequency Membrane filtration for microbes for water quality assessments Detection and enumeration of Escherichia coli qPCR with Internal Amplification Control for Enterococci in water Recommendations for E. coli measurement by qPCR Water quality indicator intercomparison	New production by 15N, Chapter 17 Bacterial production: methyltritiated Thymidine, Chapter 20 15N2 fixation rates; Free-floating arrays for export flux; Microbial ATP
SUPPORTING VARIABLES MEASURED	Temperature Depth Salinity Oxygen pH	Host identification (by viral tagging); Growth rate; Growth phase	Visual inspections for waste Suspended solids	Temperature Depth Salinity Oxygen pH

5. Data and information management

Access to data and information is at the core of an ocean observing system. This section provides essential information on how to contribute data to the GOOS

GOOS approach to data management is aligned with open data and FAIR (Findable, Accessible, Interoperable, Reusable)[1] practices. All EOV data and information is valuable, thus effective data management practices are essential to ensure it remains accessible and (re)usable for future generations.

In this section you will be directed to resources that explain how you can contribute data to global ocean observing and ensure your data and information is accessible, interoperable and sustained. This resource has instructions for different scenarios: an individual submitting data, or existing data centres connecting to the system.

Please follow these practices carefully, as BioEco EOV data FAIRness relies on compliance with these guidelines.

Before proceeding, please note these important points:

1. As a **minimum**, you must ensure information describing your EOV data (i.e. metadata) are visible in the Ocean Data and Information System (ODIS)[2]. Regardless of where the actual data is stored, evidence of its existence must be findable within ODIS.
2. BioEco EOV data is successfully managed if it is discoverable in the **GOOS BioEco Portal.** The BioEco Portal is the central point of access and coordination of BioEco EOV observing programmes. Data visible in ODIS will automatically be visible in the BioEco Portal and vice versa.
3. If data is published to OBIS[3], it will also be visible in ODIS and the BioEco Portal. You do not need to also add it elsewhere, unless there is extra information you would like to include.

The main data management steps are as follow:

1. Become discoverable: ensure the data producers (e.g., organisation, programme, project, etc.) and datasets are visible in ODIS
2. Prepare the required metadata about the data producer and the datasets
3. Publish EOV data (e.g. OBIS)
4. Verify discoverability in ODIS

[1] Wilkinson et al. 2016 https://doi.org/10.1038/sdata.2016.18
[2] ODIS, part of IOC-UNESCO's International Oceanographic Data and Information Exchange (IODE), is a global federation of data systems sharing interoperable (meta)data about holdings, services, and other resources to enhance cross-domain data accessibility.
[3] OBIS is a global biodiversity database and IOC-UNESCO IODE component, connecting +30 nodes, +1000 institutions, and 99 countries, interoperating with other major biodiversity hubs like GBIF and makes data visible in ODIS as an ODIS node.

Not all steps may be relevant for you, but **Step 1 is the minimum required** to ensure your data contributes to EOVs. .

TO CONTRIBUTE DATA AND METADATA TO THE GLOBAL OBSERVING SYSTEM, PLEASE GO TO: https://iobis.github.io/eov-data-management/

Figure 2. Map of OBIS Nodes. See https://obis.org/contact/ for a complete list.

Contact the OBIS Secretariat (helpdesk@obis.org) for help setting up your data workflows. To publish BioEco EOV data from systems like NCEI or ERDDAP to OBIS, consider becoming an OBIS node or collaborating with one. The OBIS Secretariat can help guide you through the process of becoming a Node, or connect you with an appropriate OBIS node (Figure 2).

Help Resources

- EOV Metadata Submission tool: https://eovmetadata.obis.org/

Best Practices for data submission

- Better Biomolecular Ocean Practices: https://github.com/BeBOP-OBON
- Minimum Information about an Omics Protocol: https://doi.org/10.3389/fmars.2021.758694
- Making eDNA data FAIR: https://onlinelibrary.wiley.com/doi/10.1002/edn3.173

ODIS

- General help https://book.odis.org/index.html
- Connecting to ODIS https://book.odis.org/gettingStarted.html
- ODIS Catalogue of Sources: https://catalogue.odis.org/
- Ocean Info Hub: https://oceaninfohub.org/
- Schema.org framework https://schema.org/

OBIS

- OBIS Manual: https://manual.obis.org/
- OBIS YouTube data formatting and publishing videos: https://www.youtube.com/playlist?list=PLlgUwSvpCFS4TS7ZN0fhByj_3EBZ5IXbF
- Darwin Core term reference list: https://dwc.tdwg.org/terms/
- WoRMS taxonomy: https://www.marinespecies.org/
- Spreadsheet template generator https://www.nordatanet.no/aen/template-generator/config%3DDarwin%20Core
- BioData Guide with example code for transforming datasets to DwC: https://ioos.github.io/bio_data_guide/

GOOS BioEco Portal

- Documentation https://iobis.github.io/bioeco-docs/
- Access https://bioeco.goosocean.org/

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Background information

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Guides, best practices and methods

Ocean Biomolecular Observing Network: https://obon-ocean.org/

github repository for OBIS training for DNA data sharing: https://github.com/iobis/obon-2024-dna-training/tree/master oceanbestpractices.org

Protocol for ARISA fingerprinting of microbial communities (Fuhrman Lab):

https://docs.google.com/document/d/1Si8x3bax_7sfEx749LQSwEt0spaYNgCd/edit

Marine Omics Technology and Instrumentation:

https://sites.google.com/mbari.org/moti-workshop/home

NOAA omics data management guide (includes data management guides and templates):

https://noaa-omics-dmg.readthedocs.io/en/latest/index.html

Metadata templates:

https://noaa-omics-dmg.readthedocs.io/en/latest/study-data-templates.html

Protocols for the collection, processing and analysis of microbial DNA from the water column and sediments are here:

https://research.csiro.au/ambsm/

https://www.embrc.eu/sites/default/files/publications/2024.04_EMOBON%20Handbook_FINAL.pdf

e.g. Figure 1 from the EMO-BON Handbook:

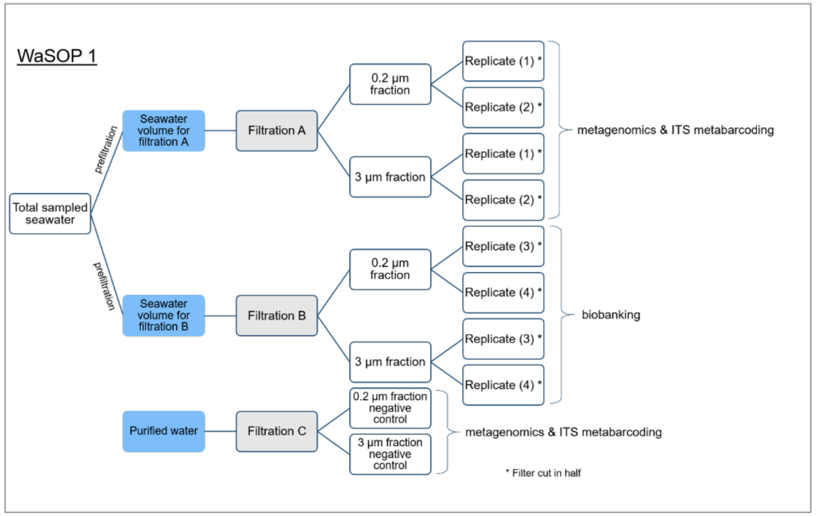

Figure 1: Diagram summarizing the WaSOP1 procedures, the samples collected, and the destination of the samples after collection.

10.17504/protocols.io.3byl49842go5/v1

Standards and reference materials

DNA and RNA standards:

https://zymoresearch.eu/collections/zymobiomics-microbial-community-standards

https://www.nist.gov/publications/reference-material-8376-microbial-pathogen-dna-standards-detection-and-identification

https://www.sigmaaldrich.com/GB/en/campaigns/vitroids-and-lenticule-discs

Microorganisms (Yeast, mold, bacteria):

https://www.atcc.org/microbe-products/collections-and-projects/certified-reference-materials

Integrated EOV products and visualisations

Contributors

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Acronyms and Abbreviations

CBD: Convention on Biological Diversity

EBV: Essential Biodiversity Variables

ECV: Essential Climate Variables

EOV: Essential Ocean Variables

GCOS: Global Climate Observing System

GEO BON: Group on Earth Observations Biodiversity Observation Network

GOOS: Global Ocean Observing System

IOCCP: International Ocean Carbon Coordination Project

MBON: Marine Biodiversity Observation Network

OBIS: Ocean Biodiversity Information System

ODIS: Ocean Data Information System

OCG: Observation Coordination Group

OOPC:Ocean Observations Physics and Climate Panel

SDG: Sustainable Development Goals

Glossary of terms

Derived products: outputs calculated from the EOV and sub-variables, often in combination with the supporting variables, that contribute to evaluating change in phenomena. For example, evaporation can be determined from sea surface temperature measurements; air-sea fluxes of CO2 can be derived from inorganic carbon EOV; fish stock productivity can be determined from fish abundance.

Indicators: An indicator can be defined as a ‘measure based on verifiable data that conveys information about more than just itself’. This means that indicators are purpose dependent - the interpretation or meaning given to the data depends on the purpose or issue of concern. (BIP definition)

Measurement Uncertainty: the parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand (GUM)1. It includes all contributions to the uncertainty, expressed in units of 2 standard deviations, unless stated otherwise

Phenomena: properties (e.g., of a species such as distribution), processes (e.g., of the ocean such as surface ocean heat flux), or events (e.g., such as algal blooms) that have distinct spatial and temporal scales, and when observed, inform evaluations of ocean state and ocean change

Stability: The change in bias over time. Stability is quoted per decade.

Supporting variables: other measurements that are useful to provide scale or context to the sub-variables of the EOV (e.g., pressure measurements to provide information on the depth at which subsurface currents are estimated, sea temperature to understand dissolved inorganic carbon, water turbidity to support estimations of hard coral cover).

Sub-variables: key measurements that are used to estimate the EOV (e.g., counts of individuals to provide an estimate of species abundance (such as fish, mammals, seabirds or turtles), partial pressure of carbon dioxide (pCO_2)to estimate ocean inorganic carbon, or wave height to estimate sea state).

Timeliness: The time expectation for availability of data measured from the data acquisition time.

Appendix - Additional information

A1. Applications

This table provides examples of applications of this EOV, including, contribution to other essential variable frameworks, multilateral environmental agreements, contribution to indicators and GOOS applications

EOV		Microbes: Diversity and Biomass
CORRESPONDING ESSENTIAL VARIABLES	ECV	plankton
	EBV	community composition; ecosystem functioning; ecosystem structure; genetic composition; species populations; species traits
GLOBAL INDICATORS EOV CAN CONTRIBUTE	SDG	zero hunger; good health and well-being; clean water and sanitation; industry, innovation and infrastructure; sustainable cities and communities; climate action; life below water; partnerships for the goals
	CBD	Plan and manage all areas to reduce biodiversity loss; Minimise the impacts of climate change on biodiversity and build resilience; Manage wild species sustainably to benefit people; Enhance biodiversity and sustainability in agriculture, aquaculture, fisheries and forestry; Restore, maintain and enhance nature’s contributions to people; Increase the sharing of benefits from genetic resources, digital sequence information and traditional knowledge; Strengthen biosafety and distribute the benefits of biotechnology; Strengthen capacity-building, technology transfer and scientific and technical cooperation for biodiversity; Ensure participation in decision-making and access to justice and information related to biodiversity for all
	CLIMATE	Climate; Ocean health
	OTHER	
GOOS APPLICATIONS		

A2. Additional supporting material and literature

Suggested literature

Brown, M.V., Ostrowski, M., Messer, L.F. *et al.* 2024. A marine heatwave drives significant shifts in pelagic microbiology. *Commun Biol* 7, 125 (2024). https://doi.org/10.1038/s42003-023-05702-4

E.J. Raes, L. Bodrossy, J. van de Kamp, A. Bissett, M. Ostrowski, M.V. Brown, S.L.S. Sow, B. Sloyan, & A.M. Waite, 2018. Oceanographic boundaries constrain microbial diversity gradients in the South Pacific Ocean, Proc. Natl. Acad. Sci. U.S.A. 115 (35) E8266-E8275, https://doi.org/10.1073/pnas.1719335115

Other material

A3. Readiness level assessment

Essential Ocean Variable Specification Sheet

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