The Global Ocean Observing System

GCOS

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Essential Ocean Variable Specification Sheet

Phytoplankton Biomass and Diversity

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EOV Specification Sheet curated by:

Biology and Ecosystems Panel

The Global Ocean Observing System

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

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Background and justification

Biomass and diversity are basic characteristics of the phytoplankton, the photosynthetic microorganisms found in all aquatic habitats that receive sunlight. The phytoplankton can be planktonic, benthic, or grow as symbionts on or within other organisms. Phytoplankton are at the base of most marine food webs (except those fuelled by chemosynthesis). Phytoplankton support important ecosystem services in coastal, estuarine, and offshore pelagic areas and, thus, are part of “Nature Contributions to People”. They are also often sensitive indicators of water quality and ecosystem health. They are fundamental in the function of most food webs and ecosystems, not just as sources of food and energy, but for their role in the cycling of nitrogen and many micronutrients and metals, carbon fixation and emission, as well as in production and consumption of oxygen and other gases. Human pressures and natural environmental changes, including climate change, can significantly impact the phytoplankton biomass and the natural cycles of abundance, distribution, and biodiversity of phytoplankton. While some changes in phytoplankton biomass and diversity can be positive, other changes can be negative for the economy, jobs, and the well-being of coastal communities. Most phytoplankton blooms are beneficial, yet changes in the biomass, composition, and timing of blooms can affect fishery yields positively or negatively. Perturbations in biogeochemical cycles can also result in harmful algal blooms (HABs) and alter the overall health of marine habitats. Phytoplankton, in many ways, are the foundation for the 'blue economy' (Briscoe et al., 2016). Characterizing and monitoring phytoplankton biomass and diversity is useful to inform management decisions. Developing a standardised effort to monitor and forecast phytoplankton biomass and biodiversity is an important common goal for the private, academic, and government sectors, nationally and internationally.

Monitoring the “Phytoplankton Biomass and Diversity” essential Ocean Variable (EOV) requires a combination of observing tools. Of primary interest are the biomass, biological diversity, their horizontal and vertical distribution and phenology, and ideally also primary productivity and nutrient cycling and sequestration rates. These observations should be paired (if possible, co-located) with sets of physical and biogeochemistry EOVs to conduct assessments, develop understanding, and advance prediction skills. Routine data collection by operational and research programs, aligned with data and metadata management guidelines such as from OBIS and bio-optical databases such as SeaBASS, are fundamental to enable regional to global assessments.

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, communities, or ecosystems. The BioEco EOVs, by themselves or linked with other discipline EOVs, are building blocks for GEO BON EBVs. The EOVs can be used to synthesise the EBVs as time series at one location or time series of gridded, mapped, or modelled EOVs (Jetz et al., 2019).

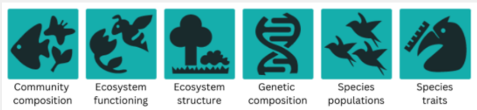
The Phytoplankton Biomass and Diversity EOV contributes to both ECVs and EBVs. It provides critical data for understanding and managing human activities that affect marine ecosystems over short periods to climate time scales. The GOOS Biology and Ecosystems Panel collaborates with the GOOS Physics and Climate and Biogeochemistry Expert Panels to advance EOVs, advocating the use and guidelines of biological observations, information management, and applications. GOOS, MBON, GEO BON (and its Marine Biodiversity Observation Network or MBON), and OBIS work together to standardise guidelines and data management for EOVs, EBVs, and ECVs, and to network the community of observers and users.

Current observing networks and coordination:

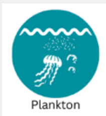
Diverse networks and communities are collecting observations of biology and ecosystems EOVs at different scales and in different regions. An initial baseline survey conducted in 2019/20 identified 203 active, long-term (>5 years) observing programs that systematically sample marine life. These programs 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):

Essential Biodiversity Variables (EBV)



Essential Climate Variables (ECV)



Sustainable Development Goals (SDG)

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1. EOV information

ESSENTIAL OCEAN VARIABLE (EOV)	Phytoplankton biomass and diversity
DEFINITION	Phytoplankton biomass typically refers to either: weight (mass as the concentration per unit area/volume) and/or abundance or quantity of organisms (number of individuals per volume). Phytoplankton diversity or composition refers to the variability among phytoplankton from all sources including, inter alia, marine and other aquatic ecosystems; this includes diversity within species and between species (e.g., genetic diversity, taxonomic diversity, size, etc.) (https://www.cbd.int/convention/articles?a=cbd-02) Cyanobacteria are primarily addressed here as key members of the phytoplankton, but also addressed in the microbes EOV as members of the Bacteria.
EOV SUB-VARIABLES key measurements that are used to estimate the EOV ***bare minimum**	*Phytoplankton biomass (concentration) *Composition (species, functional types) Number of HAB Events
SUPPORTING VARIABLES - other measurements that are useful to provide scale or context to the sub-variables of the EOV	Nutrients, sea surface temperature, subsurface temperature, sea surface salinity, subsurface salinity, oxygen, inorganic carbon, particulate organic matter concentration, total suspended organic matter concentration, ocean colour and bio-optical variables (remote sensing reflectance, absorption, scattering coefficients, photic or euphotic zone depth), mixed layer depth, surface currents and subsurface currents (vertical, horizontal), primary productivity
	Complementary: cell size, “biovolume”, nutritional content, density, DNA composition, ocean colour (bio-optics)
DERIVED PRODUCTS outputs calculated from the EOV and sub-variables, often in combination with the supporting variables	Phytoplankton Functional Types Diversity indices: species richness, species evenness, Simpson, etc.

	Harmful or beneficial algal bloom indices, including occurrence of Harmful Algal Events Global biogeography, spatial distribution and temporal changes in biomass and functional types Primary production Carbon and nutrient cycling, uptake, storage, export, sinking rate

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.

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

PHENOMENA TO OBSERVE		Status and trends	Role in transport/cycling of elements	HAB occurrence
PHENOMENA EXTENT	HORIZONTAL	Local, regional, global	Amount of carbon, nutrient, metals, or gases taken up or released over scales of metres to kilometers, at regional and basin-scale; biomass imported or exported from a location by advection or biological processes	Metres to kilometers, regional
	VERTICAL	Vertical profile structure in the photic zone, biomass exported from a location	Productivity in terms of carbon or nutrient uptake, sinking rate within and below the photic zone	Photic zone
	TEMPORAL	Changes in abundance, diversity, or productivity over short (hours to day), seasonal, to decadal scales	Changes in biogeochemical characteristics over short (hours to day), seasonal, to decadal scales	Hours-Decades (~week-scale changes are common)
RESOLUTION TO OBSERVE PHENOMENA	HORIZONTAL	~10m for each observation at one location or transects to over 1000 km	~10m to > 1000km	~10m to >1000km
	VERTICAL	Surface, subsurface maxima (deep chlorophyll maximum), and/or continuous profiles	Surface (at minimum), bottom of photic zone and mixed layer	Surface (at minimum), subsurface maxima
	TEMPORAL	Daily, weekly, monthly to seasonal, interannual, climatological	Daily, weekly. monthly to seasonal, interannual, climatological	Weekly to seasonal, interannual

SIGNAL TO CAPTURE	At least 1/10 of the signal (short-term events, seasonal cycle, phenology, interannual variation)	At least 1/10 of the signal (short-term events, seasonal cycle, phenology, interannual variation)	Incidence of HAB event, continuous monitoring of cell counts and other indicators of toxic species
SUB-VARIABLES NEEDED TO MEASURE	Phytoplankton biomass, composition: biomass (abundance, concentration), and as possible, phytoplankton functional types (e.g., size distribution, pigment types, taxonomy by microscopy or cytometry). If there is a bloom, extent (geographic area size) may be estimated with remote sensing (Ocean Colour EOV) in metres to kilometers at regional and basin-scale.	Phytoplankton biomass (concentration), composition	Phytoplankton biomass (concentration), composition, number of HAB events

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.

EOV	Phytoplankton biomass and diversity							
PHENOMENA	Status and trends / Role in transport and cycling of elements							
EOV SUB-VARIABLE	Composition				**DEFINITION**		Diversity or composition is the number of identified species, genetic composition, or other functional metric per liter or cubic meter, or other normalizing factor	
	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 /	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	Depending on question or problem: - near-real time for water quality, harmful algal bloom monitoring - monthly for long time series	Depends on method		Bottle samples, nets, filters for biomass, pigment concentration, chemical composition of particulates, bio-optics, genetic (eDNA and other). Samples preserved for subsequent taxonomic analyses, or frozen (liquid nitrogen/-80C) Platforms: ship, small boats, autonomous	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). Handbook of Methods for the Analysis of Oceanographic Parameters at the CARIACO Time-series

	same 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)				buoys, gliders, other samplers, Satellite or airborne remote sensing (ocean colour)	[Station: Cariaco Time Series Study.] [Quality-control procedures for ship-board biogeochemical time series data. EuroSea Deliverable D4.4. [Version 2]]
DESIRABLE	Regional	Surface, Deep Chlorophyll Maximum (DCM), bottom or bottom of euphotic zone	monthly	6 months or less	Depends on method			[Global observing for phytoplankton? A perspective | Journal of Plankton Research | Oxford Academic] [The Marine Biodiversity Observation Network Plankton Workshops: Plankton Ecosystem Function, Biodiversity, and Forecasting—Research Requirements and Applications - Grigoratou - 2022 - Limnology and Oceanography Bulletin - Wiley Online Library]
MINIMUM	local (single fixed location)	surface	seasonal	6 months				

EOV SUB-VARIABLE	Phytoplankton biomass				DEFINITION		Weight (mass as the concentration in grams per liter or cubic meter or [µg l^{-1}, g m^{-3}], or area-integrated [g m^{-2}]) of bulk organic matter, dry organic matter, or often chlorophyll-a and other pigments, or organic carbon or nitrogen). **NOTE: Primary productivity is the rate of change in biomass per unit time and unit area or volume.**	
	Resolution				Uncertainty		Sampling approach	References
	Spatial Horizontal	Spatial Vertical	Temporal	Timeliness	Measurement	Stability		
IDEAL	Co-located plankton and environmental observations (if known, within the decorrelation scale of the data) Sample similar / same locations across time if comparing for trends Regional for monitoring and over affected area 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	Depending on question or problem: near-real time for water quality, harmful algal bloom monitoring monthly for long time series	Depending on method		Bottle samples, nets, filters for biomass, pigment concentration, chemical composition of particulates, bio-optics, genetic (eDNA and other). Samples preserved for subsequent taxonomic analyses, or frozen (liquid nitrogen/-80C) Platforms: ship, small boats, autonomous buoys, gliders, other samplers,	(See above)

			scale of the data)					
DESIRABLE	regional	surface, DCM	monthly	monthly	Depends on method			Global observing for phytoplankton? A perspective | Journal of Plankton Research | Oxford Academic The Marine Biodiversity Observation Network Plankton Workshops: Plankton Ecosystem Function, Biodiversity, and Forecasting—Research Requirements and Applications - Grigoratou - 2022 - Limnology and Oceanography Bulletin - Wiley Online Library
MINIMUM	local (single fixed location)	surface	seasonal	monthly	Depends on method			

PHENOMENA	Harmful Algal Bloom (HAB) occurrence							
EOV SUB-VARIABLE	Number of HAB Events				**DEFINITION**		Phytoplankton bloom that has a detrimental effect on humans or ecosystems (e.g. high biomass, toxins, low oxygen event, fish kills)	
	Resolution				**Uncertainty**		**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**	**Timeliness**	**Measurement**	**Stability**		
IDEAL	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 spatial resolution to meters depth integrated - surface to bottom of euphotic zone		Continuous (near daily) for detection Daily to weekly over duration of event	weekly	Depends on method		Manual (whole water or net tow) from shore or ship; Automated systems (e.g. Imaging Flow Cytobot or IFCB, other microscopy and flow cytometer); Ocean Color (for some organisms); observational data (e.g. mortality event) Platforms: boats, autonomous platforms, satellite or airborne	Global harmful algal bloom status reporting - ScienceDirect Guidelines for the study of climate change effects on HABs.
DESIRABLE	spatial extent of the event to kilometers		surface and bottom or deep chlorophyll maximum	monthly				
MINIMUM	single point		surface	annual				

EOV SUB-VARIABLE	Harmful Algae Bloom (HAB) Species composition				DEFINITION		Phytoplankton composition of HAB organisms in blooms (cells/L to functional group or species)	
	Resolution				Uncertainty		Sampling approach	References
	Spatial Horizontal	Spatial Vertical	Temporal	Timeliness	Measurement	Stability		
IDEAL	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 Within the decorrelation scale of the data		depth integrated - surface to bottom of euphotic zone	sub-hourly to weekly	Depends on method		Manual (whole water or net tow) from shore or ship; Automated systems (e.g. Imaging Flow Cytobot or IFCB, other microscopy and flow cytometer); Ocean Color (for some organisms); observational data (e.g. mortality event) Platforms: boats, autonomous platforms, satellite or airborne	Recommendations for plankton measurements on the GO-SHIP program with relevance to other sea-going expeditions. SCOR Working Group 154 GO-SHIP Report. [GOOS ENDORSED PRACTICE] Guidelines for monitoring of phytoplankton species composition, abundance and biomass. SoundToxins manual: Puget Sound Harmful Algal Bloom Monitoring Program. [Revised December 2015]. Manual for Real-Time Quality Control of Phytoplankton Data: A Guide to Quality Control and Quality Assurance for Phytoplankton Observations. Version 1.0. ICES Guidelines for Biological Plankton data. (Compiled August 2001; reviewed April 2006) Novel methods for automated in situ observations of phytoplankton diversity and productivity: synthesis of exploration,
DESIRABLE	regional		surface, deep chlorophyll maximum (DCM), bottom of euphotic zone or bottom of water column	weekly to monthly				
MINIMUM	local (single point)		surface	event-based				

							intercomparisons and improvements. JERICO-NEXT WP3, Deliverable 3.2. Version 5. Novel methods for automated in situ observations of phytoplankton diversity and productivity: synthesis of exploration, intercomparisons and improvements. JERICO-NEXT WP3, Deliverable 3.2. Version 5. Novel methods for automated in situ observations of phytoplankton diversity. WP.3, D3.1,Version 9. Microscopic and molecular methods for quantitative phytoplankton analysis. Environmental DNA applications in biomonitoring and bioassessment of aquatic ecosystems: Guidelines.

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	Ship based: time-series or Fixed point - mooring	Remote sensing: satellite	Autonomous platforms: Imaging / underway
EOV SUB-VARIABLE(S) MEASURED	1) Phytoplankton biomass 2) Composition (Microscopy, cytometry)	Pigment concentration (chlorophyll a)	1) Phytoplankton biomass 2) species composition
TECHNIQUE / SENSOR TYPE	Phytoplankton biomass 1) HPLC - pigments 2) Flow cytometry - (usually for picoplankton) Composition 1) 20 / 37 micron mesh net (e.g. concentrated sample nets) (Integrated water column, non quantitative) 2) 0.2 micron filter to collect cells for genetics 3) bottle (depth stratified) 4) Pipe/hose/tube lowered vertically (Integrated water column) 5) Imaging systems (e.g. flowcam, etc.) 6) Microscopy Typical results/information: Genetic information Size distribution information Taxonomy / groups	Ocean Colour, reflectance	Phytoplankton biomass 1. Fluorometer-Fluorescence 2. IFCB - Pico-Phytoplankton 3. ESP-species composition Species comp 1. IFCB - Pico-Phytoplankton
SUGGESTED METHODS AND BEST PRACTICES	https://repository.oceanbestpractices.org/handle/11329/303 IOC Manuals & Guides no 55 (Karlsen et al) National Reference Stations Biogeochemical Operations Manual. Version 3.3.1.	Consult Ocean Colour EOV specification sheet ⇒ IOCCG: International Ocean-Colour Coordinating Group	⇒ IOCCG: International Ocean-Colour Coordinating Group

	Australia's Long-Term Plankton Observations: The Integrated Marine Observing System National Reference Station Network.		
SUPPORTING VARIABLES MEASURED	Nutrients, sea surface temperature, subsurface temperature, sea surface salinity, subsurface salinity, oxygen, inorganic carbon, particulate organic matter concentration, total suspended organic matter concentration, ocean colour and bio-optical variables (remote sensing reflectance, absorption, scattering coefficients, photic or euphotic zone depth), mixed layer depth, surface currents and subsurface currents (vertical, horizontal)	sea surface temperature, particulate organic matter concentration, total suspended organic matter concentration, ocean colour and bio-optical variables (remote sensing reflectance, absorption, scattering coefficients, photic or euphotic zone depth), mixed layer depth, surface currents	Nutrients, sea surface temperature, subsurface temperature, sea surface salinity, subsurface salinity, oxygen, inorganic carbon, particulate organic matter concentration, total suspended organic matter concentration, ocean colour and bio-optical variables (remote sensing reflectance, absorption, scattering coefficients, photic or euphotic zone depth), mixed layer depth, surface currents and subsurface currents (vertical, horizontal)

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

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

[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.

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/

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/

- Phytoplankton Data products

  https://haedat.iode.org/
  https://oceancolor.gsfc.nasa.gov/data/find-data/
  https://www.oceancolour.org/
  https://data.marine.copernicus.eu/product/OCEANCOLOUR_GLO_BGC_L4_MY_009_104/description
  https://giovanni.gsfc.nasa.gov/giovanni/

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Guides, best practices and methods

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Standards and reference materials

Integrated EOV products and visualisations

Contributors

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Acronyms and Abbreviations

CBD: Convention on Biological Diversity

DCM: Deep Chlorophyll Maximum

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

HAB: Harmful Algal Bloom

IFCB: Imaging Flow Cytobot

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 characterizes 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.

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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		Phytoplankton biomass and diversity
CORRESPONDING ESSENTIAL VARIABLES	ECV	Plankton
	EBV	● Genetic composition: Genetic diversity (richness and heterozygosity) ● Species populations: Species distributions, Species abundances ● Species traits: Morphology, Physiology, Phenology, Movement, Reproduction ● Community composition: Community abundance, Taxonomic/phylogenetic diversity, Trait diversity, Interaction diversity ● Ecosystem functioning: Primary productivity, Ecosystem phenology, Ecosystem disturbances, Ecosystem structure: Live cover fraction, Ecosystem distribution, Ecosystem Vertical Profile
GLOBAL INDICATORS EOV CAN CONTRIBUTE	**SDG (Sustainable Development Goal)**	SDG 2: Zero hunger 2.3: Increase productivity and incomes of small-scale food producers including fishers SDG 8: Decent work and economic growth SDG 13: Climate Action SDG14: Target 14.1: Reduce marine pollution (chlorophyll as water quality indicator, zooplankton as possible indicators of cholera or other pathogen; harmful algae bloom occurrence); Target 14.2: Protect and restore ecosystems (ensure clean water to promote healthy blooms) Target 14.3: Reduce ocean acidification (TBD); Target 14.4: Sustainable fishing (phytoplankton and zooplankton biomass timing, abundance, define fish habitat/timing of feeding); Target 14.5: Conserve coastal and marine areas (promote good water quality); Target 14.a: Increase scientific knowledge, research and technology for ocean health; Target 14.b: Support small-scale fishers (biofuels; pharmaceuticals such as oils, omega3, proteins; krill for protein, etc.) Target 14.7: Increase the economic benefits from sustainable use of marine resources.

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		Other SDG are also relevant
	CBD	Kunming-Montreal Global Biodiversity Framework Goal A: Protect and Restore Goal B: Prosper with Nature Target 1: Plan and Manage all Areas To Reduce Biodiversity Loss Target 2: Restore 30% of all Degraded Ecosystems Target 6: Reduce the Introduction of Invasive Alien Species by 50% and Minimize Their Impact Target 9: Manage Wild Species Sustainably To Benefit People Target 21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action
	CLIMATE	Phytoplankton biomass indicators, species composition indicators Zooplankton biomass distribution
	UN OCEAN DECADE	Challenge 2: Protect and restore ecosystems and biodiversity Challenge 3: Sustainably nourish the global population Challenge 4: Develop a sustainable, resilient and equitable ocean economy Challenge 7: Sustainably expand the Global Ocean Observing System Challenge 10: Restore society's relationship with the ocean Outcome 2: A healthy and resilient ocean where marine ecosystems are understood, protected, restored and managed. Outcome 3: A productive ocean supporting sustainable food supply and a sustainable ocean economy. Outcome 5: A safe ocean where life and livelihoods are protected from ocean-related hazards. Outcome 7: An inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development.
	OTHER	
GOOS APPLICATIONS		Ocean Health, Operational Services, Climate change

A2. Additional supporting material and literature

Suggested literature

T.K. Westberry, G.M. Silsbe, M.J. Behrenfeld. 2023. Gross and net primary production in the global ocean: an ocean color remote sensing perspective
Earth Sci. Rev., 104322 https://doi.org/10.1016/j.earscirev.2023.104322

Regaudie-de-Gioux, A.; Lasternas, S.; AgustÃ, S.; Duarte, C.M. 2014. Comparing marine primary production estimates through different methods and development of conversion equations. Front. Mar. Sci., 1. https://doi.org/10.3389/fmars.2014.00019

Other material

A3. Readiness level assessment

Essential Ocean Variable Specification Sheet

Sponsored by:

WMO

unesco Intergovernmental Oceanographic Commission

UN environment programme

International Science Council