The Global Ocean Observing System

DRAFT

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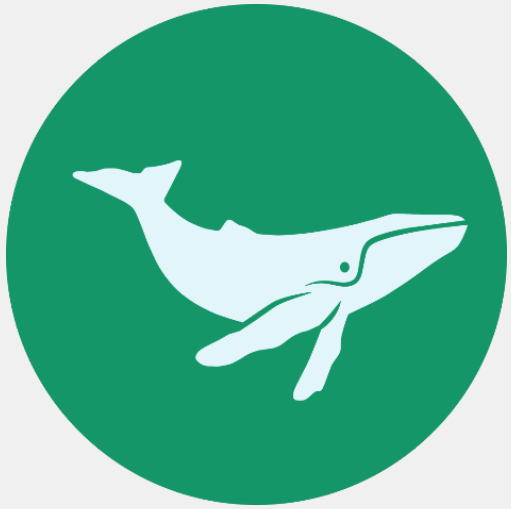
Essential Ocean Variable Specification Sheet

Marine mammal abundance and distribution



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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

As wide-ranging, relatively long-lived and large-bodied animals, marine mammals play a crucial role in maintaining the health of their ecosystems. These charismatic megafauna interact with and influence population dynamics and distribution of numerous prey species. To evaluate these interactions and their variability, an understanding of marine mammal abundance and distribution is essential. Stock assessment analyses require accurate, up-to-date information on abundance and distribution in order to inform appropriate management and/or conservation measures. This EOV will facilitate evaluation of the potential impacts of several pressures on upper trophic levels of marine food webs.

Abundance refers to the number of individuals within a population while distribution refers to the geographic or spatial extent of habitats used by individuals from the population. The majority of species of marine mammals are long-lived, slowly reproducing organisms; as such they are particularly vulnerable to human impacts such as fisheries – both through reduction of their prey species and incidental capture in fishing gear, i.e., bycatch – and climate change (e.g. reduction of habitat for Arctic species) and provide long term indicators of ecosystem health. Also, by virtue of their position high in the food web, they are susceptible to toxins and contaminants that bio-accumulate or accumulate up the food chain. As humans occupy a similar trophic position, marine mammals can act as sentinels for human health risks. Marine mammals have long held economic and cultural importance in human society. Before the discovery of fossil fuels, whale oil was used as a source of energy and a lubricant to run machinery. Its meat was a source of nutrition and whalebone was used to make a diverse range of utility products. Currently aboriginal subsistence hunting of marine mammals for cultural and nutritional requirements is being carried out by indigenous communities in Alaska, Greenland, Australia, Papua New Guinea, and many countries in south and southeast Asia. In modern human society, marine mammals have gained recognition as charismatic and sentient wildlife. The tourism industry to watch marine mammals has grown worldwide. Whale watching tourism around the world as of 2009 generated over 2.1 billion US dollars providing employment for over 13,000 people.Finally, marine mammals are often protected by national and international regulation, or recognized as needing such protection to prevent extinction (e.g., Red List of Threatened Species, CITES). As such, the high profile of these marine megafauna species can be used to engage and educate stakeholders, governments, and the public on ocean health and other issues.

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 (Miloslavich et al., 2018, 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. Thus, EOVs may be seen as the building blocks for GEO BON EBVs. The EOVs can be used to synthesise the EBVs as time series of BioEco 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):

EBVs: Species populations; Species traits; Ecosystem functioning; Ecosystem structure; Community composition

SDGs: 5 Gender Equality; 12 Responsible Consumption and Production; 14 Life Below Water

CBD: Target 1; Target 4; Target 5; Target 9; Target 11; Target 20; Target 21; Target 23

Other: CMS; Marine Mammal Protected Areas Task Force (IUCN SSC WCPA)

1. EOV information

ESSENTIAL OCEAN VARIABLE (EOV)	Marine mammal abundance and distribution
DEFINITION	Abundance refers to the number of individuals within a population, while distribution refers to the geographic or spatial extent of habitats used by individuals from the population. Both are evaluated on a species level for GOOS
EOV SUB-VARIABLES - key measurements that are used to estimate the EOV ***bare minimum**	Species-specific: • Presence/absence* (living or dead) • Count data • Repeated individual presence (tracking/resights)
SUPPORTING VARIABLES - other measurements that are useful to provide scale or context to the sub-variables of the EOV	Environmental Temperature and salinity (surface and subsurface), dissolved oxygen, suspended particulates, ocean colour, primary and secondary productivity, harmful algal blooms, prey availability/diet, bathymetry.
	EOV related Age*, sex, group size estimates, behaviour *Age information could be discrete age, age class, or a proxy from body size
DERIVED PRODUCTS - outputs calculated from the EOV and sub-variables, often in combination with the supporting variables	• Population status and trends (increasing, decreasing, stable) • Density (high density areas or aggregations) • Home range • Migration pathways • Habitat maps (distribution shifts and patterns of habitat use) • Documentation of mass mortality events* * Recently high pathogenicity avian influenza has resulted in several marine mammal mass mortality events around the globe. Estimating and counting mass mortality events to understand the causes and establish baselines are crucial to understand anthropogenic effects on marine mammals and their ecosystems

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 suggestions on how observation efforts can structure their planning and implementation. The GOOS applications areas that the phenomena are relevant for are depicted as follows Climate and ocean health

PHENOMENA TO OBSERVE		Population status and trends	Distribution shifts and migration	Mass mortalities
PHENOMENA EXTENT	HORIZONTAL	Local, regional (ocean basin)	Local, regional (ocean basin)	Local, regional (ocean basin)
	VERTICAL	surface to deep ocean (on shore)	surface to deep ocean (on shore)	surface to deep ocean (on shore)
	TEMPORAL	monthly to decadal	monthly to decadal	annual to decadal
RESOLUTION TO OBSERVE PHENOMENA	HORIZONTAL	<1km - 1,000s km	<1km - 1,000s km	10s km - 1,000 km
	VERTICAL	surface (on shore)	surface to deep ocean (on shore)	surface (on shore)
	TEMPORAL	seasonal to decadal	seasonal to decadal	seasonal to interannual
SIGNAL TO CAPTURE		25% change in abundance in 15 years	a change in latitudinal or longitudinal range that is persistent across a defined time period or a change in location and/or timing of migration	7 or more dead animals clustered in space and time of a noteworthy nature
SUB-VARIABLES NEEDED TO MEASURE		Species presence/absence, count data	Species presence/absence, count data, repeated individual presence (tracking/resights)	Species presence/absence, count data
SUPPORTING VARIABLES NEEDED		age, sex, group size estimates	age, sex, group size estimates, behaviour	age, sex

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	Marine mammal abundance and distribution							
PHENOMENA	Population status and trends, distribution shifts and migration, mass mortalities							
EOV SUB-VARIABLE	Species specific presence/absence (living or dead)			**DEFINITION**			Presence: observations of a species with an associated location and time. Absence: observation of a location and time when no species were observed (e.g. “on effort” during line transect surveys)	
	Resolution			**Timeliness***	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	Covering range of the population	N/A	Seasonal	Within a year		N/A	Visual, digital (inc. biologging), genetic or acoustic point observations, and/or line transect surveys from a variety of platforms: ships, small boats, aerial, drone, ROV, moorings	
DESIRABLE	Multiple repeatable survey areas	N/A	Annual			N/A		
MINIMUM	A repeatable survey area	N/A	Every three years			N/A		

* Although within a year is listed - data of any age is useful for these long-lived organisms

EOV SUB-VARIABLE	Count data				**DEFINITION**		Counts of individual animals (including age, sex and group size estimates where possible)	
	Resolution			**Timeliness***	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	Covering range of the population	N/A	Seasonal	Within a year		N/A	Visual, digital, or acoustic from a variety of platforms: ships, small boats, aerial, drone, ROV, moorings	
DESIRABLE	Multiple repeatable survey areas	N/A	Annual			N/A		
MINIMUM	A repeatable survey area	N/A	Every three years			N/A		

* Although within a year is listed - data of any age is useful for these long-lived organisms

PHENOMENA	Distribution shifts and migration							
EOV SUB-VARIABLE	Repeated individual presence (tracking/resights)				**DEFINITION**		Observations of the same individual at multiple locations through time (e.g. through photo ID matches, biologging/telemetry data)	
	Resolution			**Timeliness***	**Uncertainty Measurement**	**Stability**	**Sampling approach**	**References**
	Spatial Horizontal	**Spatial Vertical**	**Temporal**					
IDEAL	Covering range of the population	N/A	Seasonal	Within a year		N/A	Photo-ID, visual resights of marked animals, biotelemetry	
DESIRABLE	Multiple repeatable survey areas	N/A	Annual			N/A		
MINIMUM	A repeatable survey area	N/A	Every three years			N/A		

* Although within a year is listed - data of any age is useful for these long-lived organisms

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	Line - transect surveys	Photo-ID	Passive acoustic monitoring
EOV SUB-VARIABLE(S) MEASURED	Species presence/absence,	Species presence/absence, repeated individual presence (resights)	Species presence (living and vocalizing)
TECHNIQUE / SENSOR TYPE	Visual observers or digital imagery	Digital/film imagery	Static and towed hydrophones, single or array
SUGGESTED METHODS AND BEST PRACTICES	Thomas et al 2010 Buckland et al 2015	Melancon et al 2011 Rosel et al 2011	Van Parijs et al 2009 Robinson et al 2014 American National Standard 2020
SUPPORTING VARIABLES MEASURED	Age, sex, group size estimates, (behaviour) environmental: varies by survey	Age, sex, group size estimates, environmental: varies by survey	(Some behaviours for some species) Environmental: varies by survey

APPROACH / PLATFORM	Biotelemetry/tracking	Genetics (including eDNA)	Other visual observations (drones, ROVs, shore-based, citizen science)
EOV SUB-VARIABLE(S) MEASURED	Species presence, repeated individual presence (tracking/resights)	Species presence, repeated individual presence (resights)	Species presence/absence, count data, repeated individual presence (tracking/resights)
TECHNIQUE / SENSOR TYPE	Electronic instrument	Tissue or water sample	Platform dependent: visual or digital
SUGGESTED METHODS AND BEST PRACTICES	Andrews et al 2019 Horning et al 2019	Hoban et al 2022	Brown et al 2022 Raoult et al 2020
SUPPORTING VARIABLES MEASURED	Age, sex, behaviour	Age, sex	Age, sex, behaviour

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. .

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[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/

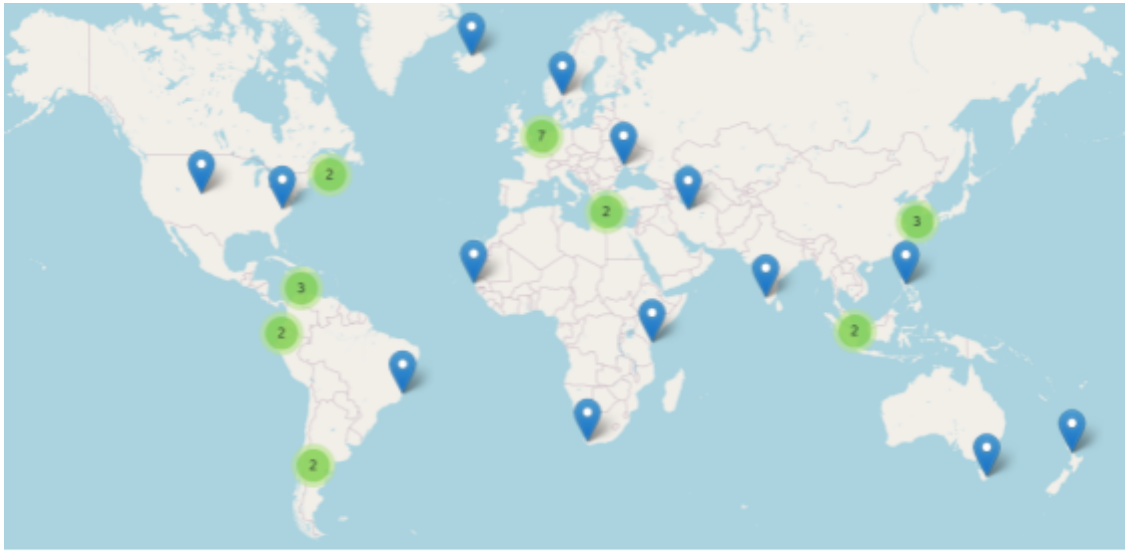

Figure 2. Map of OBIS Nodes. See https://obis.org/contact/ for a complete list.

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=PLIgUwSvpCFS4TS7ZN0fhByj_3EBZ5lXbF
- 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/

- Data products

[currently being sourced]

- Data schemas

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Guides, best practices and methods

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Acronyms and Abbreviations

CBD: Convention on Biological Diversity

CMS: Convention on the Conservation of Migratory Species of Wild Animals

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

IMMA: Important Marine Mammal Area

MBON: Marine Biodiversity Observation Network

OBIS: Ocean Biodiversity Information System

ODIS: Ocean Data Information System

OCG: Observation Coordination Group

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)

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

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).

Appendix - Additional information

A1. Applications

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

EOV		Marine mammal abundance and distribution
CORRESPONDING ESSENTIAL VARIABLES	**EBV**	Species populations: Species distributions, Species abundances Species traits: Phenology, Movement, Reproduction Community composition: Community abundance, Taxonomic/phylogenetic diversity Ecosystem functioning: Ecosystem phenology, Ecosystem disturbances Ecosystem structure: Ecosystem distribution, Ecosystem vertical profile
GLOBAL INDICATORS EOV CAN CONTRIBUTE	**SDG**	Sustainable development goal 14: Target 14.7: By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism Target 14.a: Increase scientific knowledge, research and technology for ocean health Sustainable development goal 12: Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources Target 12.a: Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production Sustainable development goal 5 Target 5.5: Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.
	CBD GBF	Goal A: Protect and Restore Goal B: Prosper with Nature Target 1: Plan and Manage all Areas To Reduce Biodiversity Loss - IUCN Red list Target 4: Halt species extinction, manage human-wildlife conflicts - IUCN red list, proportion of populations within species with an effective population size, CITES Target 5: Ensure Sustainable, Safe and Legal Harvesting and Trade of Wild Species - IUCN Red list, CITES Target 9: Manage Wild Species Sustainably To Benefit People - IUCN Red list Target 11: Restore, Maintain and Enhance Nature's Contributions to People - Contributions to ecosystem services Target 20: Strengthen Capacity-Building, Technology Transfer, and Scientific and Technical Cooperation for Biodiversity Target 21: Ensure That Knowledge Is Available and Accessible To Guide Biodiversity Action: Growth in marine species occurrence records accessible through OBIS Target 23: Ensure Gender Equality and a Gender-Responsive Approach for Biodiversity Action

	CCMS	Species included in Appendix I and Appendix II Specific agreements: ACCOBAMS and ASCOBANS
	IMMAs	Important Marine Mammal Areas (IMMAs)
GOOS APPLICATIONS		Ocean Health

A2. Additional supporting material and literature

Suggested literature

Other material

A3. Readiness level assessment

Essential Ocean Variable Specification Sheet

The Global Ocean Observing System

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