

An ocean productivity database using consistent, globally-acquired data from in situ primary productivity based on 14C assimilation, and including ancillary data, 1985-2008

Website: <https://www.bco-dmo.org/dataset/814803>

Data Type: Cruise Results

Version: 1

Version Date: 2020-06-11

Project

- » [U.S. JGOFS North Atlantic Bloom Experiment](#) (NABE)
- » [U.S. JGOFS Arabian Sea](#) (Arabian Sea)
- » [U.S. JGOFS Antarctic Environment and Southern Ocean Process Study](#) (AESOPS)
- » [Optical and Nutrient Dependence of Quantum Efficiency](#) (ON DEQUE)
- » [Development of new solar radiation and primary production products from MODIS ocean-color measurements](#) (ISPP14C)
- » [ARLINDO Circulation, A Study of the Indonesian Ocean Circulation and Mixing](#) (ARLINDO)
- » [Biowatt Experiment: Bioluminescence and Optical Variability of the Sea \(Biowatt II\)](#) (Biowatt II)
- » [Primary Production in the Arabian Sea](#) (Arabian Sea Primary Prod)
- » [U.S. JGOFS: Response of Arabian Sea Phytoplankton Biomass, Pigmentation, Growth Rates, and Community Structure To Seasonally Varying Physically Forcing](#) (Arabian Sea Phyto Seasonality)
- » [Photo-Ecological Investigations in the Arabian Sea](#) (Arabian Sea Photo-Ecology)
- » [Biowatt Experiment: Bioluminescence and Optical Variability of the Sea \(Biowatt I\)](#) (Biowatt I)
- » [Primary Production Measurements for the 20-West Program \(NABE\)](#) (JGOFS NABE Primary Prod 20W)
- » [A Tracer Kinetics Approach to the Production Ecology of Oligotrophic Oceans \(PRPOOS\)](#) (PRPOOS Tracer Kinetics)
- » [Primary Production in the Southern Ocean](#) (AESOPS Primary Production)
- » [Coordination and Logistics For the Prpoos Program. Planktonic Rate Processes in the Central Oligotrophic Oceans](#) (PRPOOS logistics)
- » [Marine Light-Mixed Layer Experiment](#) (ML-ML)
- » [Upgrade the KD\(490\) product to the normalized diffuse attenuation coefficient at 490 nm \(NKD\(490\)\) for SUOMI NPP](#) (KD490 Upgrade)

Programs

- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [Ocean Carbon and Biogeochemistry](#) (OCB)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)
- » [U.S. Joint Global Ocean Flux Study](#) (U.S. JGOFS)

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Abstract

In situ primary productivity based on 14C assimilation and nutrients from samples collected by many research projects and on numerous cruises globally, 1985-2008.

Table of Contents

- [Coverage](#)
- [Dataset Description](#)
 - [Methods & Sampling](#)
 - [Data Processing Description](#)
- [Data Files](#)
- [Related Publications](#)

- [Parameters](#)
 - [Instruments](#)
 - [Deployments](#)
 - [Project Information](#)
 - [Program Information](#)
 - [Funding](#)
-

Coverage

Spatial Extent: N:59.5 E:176.9818 S:-78.0406 W:-178.0325

Temporal Extent: 1985-04-05 - 2008-07-22

Dataset Description

From the project's Statement of Work:

The objective of this project is to synthesize over three decades of data collected on primary production in the ocean. The collected data uses a consistent methodology for primary production, using the uptake of inorganic ¹⁴C through photosynthesis, in incubations carried out in situ.

The primary support for this dataset was the National Aeronautic and Space Administration grant NNX14AM15G (P.I.: Z.-P. Lee).

Methods & Sampling

Carbon assimilation was measured from the uptake ¹⁴C into particulate matter as an estimate of primary production (see Barber et al., 2001). Two replicate samples (in polysulfone tissue culture flasks or polycarbonate bottles) retrieved from eight depths in the euphotic zone were suspended from a spar buoy, floating free of the ship, from dawn until dusk. See Barber et al. (2001).

Phytoplankton absorption procedure followed that described in Mueller and Austin (1995). Two liters of water were collected onto GF/F filters and scanned over 400-700 nm in a Perkin-Elmer Lambda-3 spectrophotometer. The detrital spectrum was similarly scanned after an extraction in hot methanol and the phytoplankton pigment spectrum (aph, aphw) found by difference. The pathlength amplification (beta-correction) factors were determined for the Lambda-3, prior to the cruises, based on a composite of 12 different cultures of phytoplankton. See Marra et al. (2000).

HPLC methods for pigments varied over time. References are Trees et al. (2000), Bidigare et al. (1990), Latasa and Bidigare (1998), and Goericke and Repeta (1993).

PAR sensors (model QSP-200, Biospherical Instruments San Diego, CA), were used in a self-contained PAR-sensing and data-logging unit. Spectral irradiance ("irradiance" in the dataset) was measured using a Marine Environmental Recorder (MER) model 2040 (Biospherical Instruments) from which PAR was calculated. See Marra et al. (2000).

Methods for nutrient concentrations followed JGOFS protocols (see Barber et al., 2001).

Sampling and analytical procedures: The samples were subsequently filtered through GF/F filters, and the filters assayed for their radioactivity by liquid scintillation counting aboard ship. In the database, the primary production values are presented as the mean of the two replicate samples.

Data Processing Description

BCO-DMO Processing Notes:

- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- re-formatted dates from m/d/yy to yyyy-mm-dd
- NaN and blank values were replaced with no data value 'nd'

Data Files

File
c14_primary_prod.csv (Comma Separated Values (.csv), 310.62 KB) MD5:8b03684ebc4470ae146952dcca1ed88e
Primary data file for dataset ID 814803

Related Publications

Barber, R. T., Marra, J., Bidigare, R. C., Codispoti, L. A., Halpern, D., Johnson, Z., ... Smith, S. L. (2001). Primary productivity and its regulation in the Arabian Sea during 1995. *Deep Sea Research Part II: Topical Studies in Oceanography*, 48(6-7), 1127-1172. doi:10.1016/s0967-0645(00)00134-x [https://doi.org/10.1016/S0967-0645\(00\)00134-X](https://doi.org/10.1016/S0967-0645(00)00134-X)

Methods

Bidigare, R. R., Ondrusek, M. E., Morrow, J. H., & Kiefer, D. A. (1990). In-vivo absorption properties of algal pigments. *Ocean Optics X*. doi:[10.1117/12.21451](https://doi.org/10.1117/12.21451)

Methods

Goericke, R. and Repeta, D. J. (1993). Chlorophylls a and b and divinyl chlorophylls a and b in the open subtropical North Atlantic Ocean. *Marine Ecology Progress Series*, 101, 307-313. <https://www.int-res.com/articles/meps/101/m101p307.pdf>

Methods

Latasa, M., & Bidigare, R. R. (1998). A comparison of phytoplankton populations of the Arabian Sea during the Spring Intermonsoon and Southwest Monsoon of 1995 as described by HPLC-analyzed pigments. *Deep Sea Research Part II: Topical Studies in Oceanography*, 45(10-11), 2133-2170. doi:10.1016/s0967-0645(98)00066-6 [https://doi.org/10.1016/S0967-0645\(98\)00066-6](https://doi.org/10.1016/S0967-0645(98)00066-6)

Methods

Marra, J., Trees, C. C., Bidigare, R. ., & Barber, R. . (2000). Pigment absorption and quantum yields in the Arabian Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, 47(7-8), 1279-1299. doi:10.1016/s0967-0645(99)00144-7 [https://doi.org/10.1016/S0967-0645\(99\)00144-7](https://doi.org/10.1016/S0967-0645(99)00144-7)

Methods

Mueller, J. L., & Austin, R. W. (1995). Ocean optics protocols for SeaWiFS validation, revision 1. *Oceanographic Literature Review*, 9(42), 805.

Methods

Trees, C. C., Clark, D. K., Bidigare, R. R., Ondrusek, M. E., & Mueller, J. L. (2000). Accessory pigments versus chlorophylla concentrations within the euphotic zone: A ubiquitous relationship. *Limnology and Oceanography*, 45(5), 1130-1143. doi:[10.4319/lo.2000.45.5.1130](https://doi.org/10.4319/lo.2000.45.5.1130)

Methods

Parameters

Parameter	Description	Units
Project	research project associated with sampling	unitless
Cruise_Designation	cruise identifier	unitless

Ocean	ocean sampled	unitless
Year	sampling year	unitless
Month	sampling month	unitless
Day.UTC	sampling day	unitless
Date.UTC	sampling date, UTC time	yyyy-mm-dd
Julian_Date.UTC	Julian day of the year, UTC time	integer day
Event_Number	number from event log	unitless
MLD_meters	mixed layer depth	meters
Pigment_Event_Number	pigment event identifier	unitless
Site	site name	unitless
Station	standard station identifier	unitless
Cast	cast number	unitless
Cruise	sequential cruise number for multi-cruise projects; from event log	unitless
Temperature	temperature	degrees Celsius
Latitude	Latitude; north is positive	decimal degrees
Longitude	Longitude; east is positive	decimal degrees
Depth_m	sampling depth	meters
Bottle_Type	Bottle type: TCF = Tissue Culture Flask; PC = PolyCarbonate	unitless

Z_Sample	sample depth; same as depth	meters
Z_incubation	sample depth; same as depth-rounded	unitless
Cup_mean_12h_mgC_m3_12h	Carbon assimilation over 12 h (dawn-dusk)	mg C m ⁻³ 12h ⁻¹
Cup_mean_24h_mgC_m3_12h	Carbon assimilation over 24 h (dawn-dawn)	mg C m ⁻³ 24h ⁻¹
chl_a_tot_ng_L	Chlorophyll-a fm HPLC	nanograms/liter (ng/L)
Chlorophyll_a_T_ug_L	Chlorophyll-a fm Turner fluorometer	micrograms/liter (ug/L)
aphi_440	absorption by phytoplankton at 440nm	/meter
aph_pig_m_1	absorption by phytoplankton averaged over 400-700 nm	/meter
aphiw_pig	absorption by phytoplankton weighted by in situ irradiance	/meter
aphi_fpt	absorption by phytoplankton averaged over 400-700 nm; using the filterpad technique	/meter
Irradiance_z	in situ PAR at depth	mol photons m ⁻² day ⁻¹
Irradiance_o	in situ PAR near surface	mol photons m ⁻² day ⁻¹
k	diffuse attenuation coefficient averaged over euphotic zone	/meter
PAR	Irradiance from PAR logger	mol photons m ⁻² day ⁻¹
chlde_a	chlorophyllide-a	nanogram/liter
chl_c12	chlorophyll c12	nanogram/liter
chl_c3	Chlorophyll c3	nanogram/liter
chl_c3_p	phytolated chlorophyll c3 (+)	nanogram/liter
chl_c1_c2	chlorophyll c1 and c2	nanogram/liter

chl_c	Chlorophyll c	nanogram/liter
peridinin	Peridiin	nanogram/liter
fucox_but	19'-Butanoyloxyfucoxanthin	nanogram/liter
fucox	Fucoxanthin	nanogram/liter
fucoxanthiol	fucoxanthiol	nanogram/liter
fucox_hex	19'-Hexanoyloxyfucoxanthin	nanogram/liter
fucox_iso1	fucoxanthin isomer 1	nanogram/liter
fucox_iso2	fucoxanthin isomer 2	nanogram/liter
cis_fucox	Cis-fucoxanthin	nanogram/liter
cis_hex	Cis-19'-hexanoyloxyfucoxanthin	nanogram/liter
prasinox	Prasinoxanthin	nanogram/liter
violax	Violax	Violaxanthin
diadinox	Diadinoxanthin	nanogram/liter
allox	Alloxanthin	nanogram/liter
diatox	Diatoxanthin	nanogram/liter
lutein	Lutein	nanogram/liter
zeax	Zeaxanthin	nanogram/liter
chl_b2	Divinyl chlorophyll b	nanogram/liter
chl_b1	Monovinyl chlorophyll b	nanogram/liter

chl_a2	Divinyl chlorophyll a	nanogram/liter
chl_a1	Monovinyl chlorophyll a	nanogram/liter
chl_a1_prime	monovinyl chlorophyll a prime	nanogram/liter
carotene	Carotene	nanogram/liter
carotene_a	Alpha-carotene	nanogram/liter
carotene_b	Beta-carotene	nanogram/liter
carotene_g	Gamma-carotene	nanogram/liter
chl_b_tot	Divinyl chlorophyll b plus Monovinyl chlorophyll b	nanogram/liter
chl_a_tot	Divinyl chlorophyll a plus Monovinyl chlorophyll a plus chlorophyllide a	nanogram/liter
neox	Neoxanthin	nanogram/liter
chl_c4_1	Chlorophyll-c4 isomer 1	nanogram/liter
chl_c4_2	Chlorophyll-c4 isomer 2	nanogram/liter
NO3	nitrate	micromoles per liter
NO2	nitrite	micromoles per liter
PO4	phosphate	micromoles per liter
SiO4	silicate	micromoles per liter
NH4	ammonium	micromoles per liter
Date_Local	sampling date; local time	yyyy-mm-dd
Julian_Date_Local	Julian day of the year; local time	day

Instruments

Dataset-specific Instrument Name	model QSP-200, Biospherical Instruments San Diego, CA
Generic Instrument Name	Biospherical QSP-200L underwater PAR Sensor
Dataset-specific Description	For light measurement
Generic Instrument Description	Underwater radiometer with a PAR spectral response (400-700nm). Standard configuration had a spherical collector measuring 4-pi scalar irradiance but a flat plate cosine collector was available as an identically-designated option.

Dataset-specific Instrument Name	
Generic Instrument Name	CTD Sea-Bird
Generic Instrument Description	Conductivity, Temperature, Depth (CTD) sensor package from SeaBird Electronics, no specific unit identified. This instrument designation is used when specific make and model are not known. See also other SeaBird instruments listed under CTD. More information from Sea-Bird Electronics.

Dataset-specific Instrument Name	
Generic Instrument Name	High-Performance Liquid Chromatograph
Dataset-specific Description	Used to measure pigments
Generic Instrument Description	A High-performance liquid chromatograph (HPLC) is a type of liquid chromatography used to separate compounds that are dissolved in solution. HPLC instruments consist of a reservoir of the mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by high pressure pumping of the sample mixture onto a column packed with microspheres coated with the stationary phase. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

Dataset-specific Instrument Name	Perkin-Elmer Lambda-3 spectrophotometer
Generic Instrument Name	Perkin Elmer Lambda 35 Spectrophotometer
Generic Instrument Description	The Lambda 35 is a double beam UV/Vis spectrophotometer from Perkin Elmer, packing pre-aligned Tungsten and Deuterium Lamps. It has a wavelength range of 190-1100nm and a variable bandwidth range of 0.5 to 4nm.

Dataset-specific Instrument Name	
Generic Instrument Name	Sea-Bird SBE 33 Carousel Deck Unit
Generic Instrument Description	The rack-mountable SBE 33 provides power and real-time data acquisition and control for an SBE 32 Carousel Water Sampler that has the SBE 33 interface option installed in its pylon. The SBE 33 is compatible with all Carousel sizes - full size, compact, and sub-compact. When powered and controlled by the SBE 33, the Carousel can be used: - with an SBE 19, 19plus, 19plus V2, 25, 25plus, or 49 CTD - without a CTD - with a Neil Brown Mk III CTD (requires optional interface for both SBE 32 and 33) The SBE 33 can also provide power and real-time data acquisition and control for the smaller SBE 55 ECO Water Sampler used with an SBE 19, 19plus, 19plus V2, 25, 25plus, or 49 CTD, or no CTD. See http://www.seabird.com/sbe33-deck-unit for further details.

[[table of contents](#) | [back to top](#)]

Deployments

All-119-4

Website	https://www.bco-dmo.org/deployment/57737
Platform	R/V Atlantis II
Start Date	1989-04-17
End Date	1989-05-11
Description	early bloom cruise; 17 locations; 60N 21W to 46N 18W

CH-05-08

Website	https://www.bco-dmo.org/deployment/58137
Platform	R/V Cape Hatteras
Start Date	2008-07-05
End Date	2008-07-22

NBP-96-04A

Website	https://www.bco-dmo.org/deployment/57718
Platform	RVIB Nathaniel B. Palmer
Report	http://usjgofs.who.edu/aesops/p1.html
Start Date	1996-10-02
End Date	1996-11-08
Description	Ross Sea Process Study 1

NBP-97-01

Website	https://www.bco-dmo.org/deployment/57720
Platform	RVIB Nathaniel B. Palmer
Report	http://usjgofs.who.edu/aesops/p2.html
Start Date	1997-01-13
End Date	1997-02-11
Description	Ross Sea Process Study 2

NBP-97-03

Website	https://www.bco-dmo.org/deployment/57721
Platform	RVIB Nathaniel B. Palmer
Report	http://usjgofs.who.edu/aesops/p3.html
Start Date	1997-04-04
End Date	1997-05-11
Description	Ross Sea Process Study 3

NBP-97-08

Website	https://www.bco-dmo.org/deployment/57722
Platform	RVIB Nathaniel B. Palmer
Report	http://usjgofs.who.edu/aesops/p4.html
Start Date	1997-11-05
End Date	1997-12-13
Description	Ross Sea Process Study 4 SeaWiFS transmits images to U.S. JGOFS scientists aboard the Palmer, for first time on November 23, 1997.

KIWI7

Website	https://www.bco-dmo.org/deployment/57725
Platform	R/V Roger Revelle
Report	http://usjgofs.who.edu/aesops/RRp1.html
Start Date	1997-12-02
End Date	1998-01-03
Description	Polar Front Process I. Additional information about this cruise can be found at https://usjgofs.who.edu/aesops/aboutrr7.html

KIWI9

Website	https://www.bco-dmo.org/deployment/57727
Platform	R/V Roger Revelle
Report	http://usjgofs.who.edu/aesops/RRp2.html
Start Date	1998-02-13
End Date	1998-03-19
Description	Polar Front Process II. Additional information about this cruise can be found at https://usjgofs.who.edu/aesops/aboutrr9.html

TT043

Website	https://www.bco-dmo.org/deployment/57704
Platform	R/V Thomas G. Thompson
Report	http://osprey.bcodmo.org/datasetDeployment.cfm?ddid=2580&did=353&flag=view
Start Date	1995-01-08
End Date	1995-02-05
Description	Purpose: Process Cruise #1 (Late NE Monsoon)

TT045

Website	https://www.bco-dmo.org/deployment/57706
Platform	R/V Thomas G. Thompson
Start Date	1995-03-14
End Date	1995-04-10

TT049

Website	https://www.bco-dmo.org/deployment/57710
Platform	R/V Thomas G. Thompson
Start Date	1995-07-17
End Date	1995-08-15

TT050

Website	https://www.bco-dmo.org/deployment/57711
Platform	R/V Thomas G. Thompson
Start Date	1995-08-18
End Date	1995-09-15

TT053

Website	https://www.bco-dmo.org/deployment/57714
Platform	R/V Thomas G. Thompson
Start Date	1995-10-29
End Date	1995-11-26

TT054

Website	https://www.bco-dmo.org/deployment/57715
Platform	R/V Thomas G. Thompson
Start Date	1995-11-30
End Date	1995-12-28

MV85xx

Website	https://www.bco-dmo.org/deployment/815428
Platform	R/V Melville
Start Date	1985-08-16
End Date	1985-09-08
Description	Phytoplankton studies in the North Pacific subtropical gyre. Cruise number is not known.

EN215

Website	https://www.bco-dmo.org/deployment/815460
Platform	R/V Endeavor
Description	No information available, estimated date is 1989.

EN224

Website	https://www.bco-dmo.org/deployment/815461
Platform	R/V Endeavor
Start Date	1991-04-27
End Date	1991-05-01
Description	Cruise to the sub-Arctic North Atlantic ocean, approximately 275 miles south of Reykjavik, Iceland for the Marne Light-Mixed Layer (MLML) experiment. A central surface mooring was deployed and recovered on cruise EN227.

EN227

Website	https://www.bco-dmo.org/deployment/815463
Platform	R/V Endeavor
Start Date	1991-09-05
End Date	1991-09-23
Description	Cruise to the sub-Arctic North Atlantic ocean, approximately 275 miles south of Reykjavik, Iceland for the Marne Light-Mixed Layer (MLML) experiment. A central surface mooring was deployed on cruise EN224 and recovered on this cruise.

OC182-01

Website	https://www.bco-dmo.org/deployment/815470
Platform	R/V Oceanus
Start Date	1987-02-26
Description	Biowatt-II cruise

OC186-02

Website	https://www.bco-dmo.org/deployment/815472
Platform	R/V Oceanus
Start Date	1987-05-16
Description	Biowatt-II cruise

OC192-01

Website	https://www.bco-dmo.org/deployment/815474
Platform	R/V Oceanus
Start Date	1987-08-21
Description	Biowatt-II cruise

OC196-02

Website	https://www.bco-dmo.org/deployment/815476
Platform	R/V Oceanus
Start Date	1987-11-28
Description	Biowatt-II cruise

Baruna Jaya 1993-xx

Website	https://www.bco-dmo.org/deployment/815497
Platform	Baruna Jaya
Start Date	1993-08-08
End Date	1993-09-09
Description	Part of Arlindo Mixing experiment.

Baruna Jaya 1994-xx

Website	https://www.bco-dmo.org/deployment/815502
Platform	Baruna Jaya
Start Date	1994-01-28
End Date	1994-02-25
Description	Part of Arlindo Mixing experiment.

KN112

Website	https://www.bco-dmo.org/deployment/815494
Platform	R/V Knorr
Start Date	1985-04-01
Description	Biowatt-I cruise

[[table of contents](#) | [back to top](#)]

Project Information

U.S. JGOFS North Atlantic Bloom Experiment (NABE)

Website: <http://usjgofs.whoi.edu/research/nabe.html>

Coverage: North Atlantic

One of the first major activities of JGOFS was a multinational pilot project, North Atlantic Bloom Experiment (NABE), carried out along longitude 20° West in 1989 through 1991. The United States participated in 1989 only, with the April deployment of two sediment trap arrays at 48° and 34° North. Three process-oriented cruises were conducted, April through July 1989, from R/V *Atlantis II* and R/V *Endeavor* focusing on sites at 46° and 59° North. Coordination of the NABE process-study cruises was supported by NSF-OCE award # 8814229. Ancillary sea surface mapping and AXBT profiling data were collected from NASA's P3 aircraft for a series of one day flights, April through June 1989.

A detailed description of NABE and the initial synthesis of the complete program data collection efforts appear in: Topical Studies in Oceanography, JGOFS: The North Atlantic Bloom Experiment (1993), Deep-Sea Research II, Volume 40 No. 1/2.

The U.S. JGOFS Data management office compiled a preliminary NABE data report of U.S. activities: Slagle, R. and G. Heimerdinger, 1991. U.S. Joint Global Ocean Flux Study, North Atlantic Bloom Experiment, Process Study Data Report P-1, April-July 1989. NODC/U.S. JGOFS Data Management Office, Woods Hole Oceanographic Institution, 315 pp. (out of print).

U.S. JGOFS Arabian Sea (Arabian Sea)

Website: <http://usjgofs.whoi.edu/research/arabian.html>

Coverage: Arabian Sea

The U.S. Arabian Sea Expedition which began in September 1994 and ended in January 1996, had three major components: a U.S. JGOFS Process Study, supported by the National Science Foundation (NSF); Forced Upper Ocean Dynamics, an Office of Naval Research (ONR) initiative; and shipboard and aircraft measurements supported by the National Aeronautics and Space Administration (NASA). The Expedition consisted of 17

cruises aboard the R/V Thomas Thompson, year-long moored deployments of five instrumented surface buoys and five sediment-trap arrays, aircraft overflights and satellite observations. Of the seventeen ship cruises, six were allocated to repeat process survey cruises, four to SeaSoar mapping cruises, six to mooring and benthic work, and a single calibration cruise which was essentially conducted in transit to the Arabian Sea.

U.S. JGOFS Antarctic Environment and Southern Ocean Process Study (AESOPS)

Website: <http://usjgofs.whoi.edu/research/aesops.html>

Coverage: Southern Ocean, Ross Sea

The U.S. Southern Ocean JGOFS program, called Antarctic Environment and Southern Ocean Process Study (AESOPS), began in August 1996 and continued through March 1998. The U.S. JGOFS AESOPS program focused on two regions in the Southern Ocean: an east/west section of the Ross-Sea continental shelf along 76.5°S, and a second north/south section of the Southern Ocean spanning the Antarctic Circumpolar Current (ACC) at ~170°W (identified as the Polar Front). The science program, coordinated by Antarctic Support Associates (ASA), comprised eleven cruises using the R.V.I.B Nathaniel B. Palmer and R/V Roger Revelle as observational platforms and for deployment and recovery of instrumented moorings and sediment-trap arrays. The Ross-Sea region was occupied on six occasions and the Polar Front five times. Mapping data were obtained from SeaSoar, ADCP, and bathymetric systems. Satellite coverage was provided by the NASA SeaWiFS and the NOAA/NASA Pathfinder programs.

Optical and Nutrient Dependence of Quantum Efficiency (ON DEQUE)

Coverage: Western North Atlantic Ocean. Sargasso Sea, Gulf stream, slope waters, shelfbreak front, continental shelf, mid-Atlantic bight

The control of photosynthetic quantum yield of phytoplankton by light intensity and diapycnal nutrient flux

Primary production in the ocean is probably the least known part of the ocean's carbon cycle. One reason that primary production is little known is the lack of understanding of the geographical and temporal variability in phytoplankton physiology. For example it is only recently that the importance has been revealed, of the so-called photoprotectant pigments, pigments that, in effect, shield the photosynthetic apparatus from too much sunlight. This project will investigate the geographic and temporal variability of a fundamental property of oceanic photosynthesis: the quantum yield, or the ratio of the available light to the amount of carbon fixed in photosynthesis. The PIs propose an hypothesis based on earlier measurements, that in the lower parts of the euphotic zone in the stratified ocean, the upward flux of nutrients regulates the value of the quantum yield, while in the upper parts, irradiance governs its value, through the pigment composition of the phytoplankton. This hypothesis will be tested by making estimates of the quantum yield's maximum value through very careful and comprehensive measurements of the bio-optical properties and species composition of the phytoplankton, as well as the submarine light environment, hydrography, and nutrients. These measurements will be along both temporal and spatial gradients in the ocean to create the basis for environmental regulation of quantum yield. These measurements will be used to establish precisely how the maximum value of the quantum yield is regulated by solar flux and plant nutrients. This research provides a mechanism to understand how the processes of nutrient supply and light affect the physiology of natural populations of phytoplankton, a long-standing problem in biological oceanography. It also provides a means for improving the modeling primary productivity, including estimating productivity in the global ocean from space.

Development of new solar radiation and primary production products from MODIS ocean-color measurements (ISPP14C)

Coverage: Global

The present MODIS standard products for the oceans include the above-surface photosynthetic available radiation (PAR(0+)) and the diffuse attenuation coefficient at 490 nm (Kd(490)). They are valuable for many studies, but are not adequate for the estimation of solar radiation in the upper water column. This is mainly because: 1) the transmittance of light from above surface to below surface is not a constant, but varies with location and time; 2) Kd(490), a single wavelength product, cannot be used to calculate the vertical attenuation of PAR (a broad band product); and 3) PAR(0+) represents daily total radiation, while Kd(490) (and the evaluation Kd(PAR) product) represents an instantaneous attenuation. Because the light attenuation coefficient also varies diurnally, a combination of daily PAR(0+) and instantaneous Kd(PAR) will result in significant (can be a factor of 2 or 3, as it is depth dependent) errors in the estimated PAR at depth.

Separately, the primary production (PP) values of the global oceans estimated from the traditional chlorophyll-based approaches contain significant uncertainties, which make the current satellite-derived water-column PP unreliable for the assessment of spatial and temporal variations. Mainly the uncertainty arises from the large spatial and temporal variation of chlorophyll-specific absorption coefficient (a^*_{ph}), which is required, explicitly or implicitly, for the retrieval of chlorophyll-a concentration from water color and for the estimation of biomass-normalized photosynthetic efficiency. It has long been argued that it is necessary to take an approach that estimates PP without the engagement of a^*_{ph} .

To overcome the limitations listed above, and more importantly to maximize the value offered by MODIS Terra/Aqua for ocean physical and biogeochemical studies, we will develop and refine new algorithms for the generation of these new products from MODIS ocean-color measurements: 1) sub-surface, daily, usable solar radiation (USR), 2) diffuse attenuation coefficient of USR (K(USR)), and 3) daily, water-column primary production (P_{Peu}). USR is defined as the solar radiation in the spectral window of 400-560 nm, a window that penetrates most in the global oceans and is most significant for phytoplankton photosynthesis. Because USR and K(USR) products are consistent both spectrally and temporally, it will then be straightforward, and accurate, to estimate solar radiation at depths when the values of K(USR) and subsurface USR are known. Further, the proposed P_{Peu} estimation will be based on the 'first principles of phytoplankton photophysiology and light penetration' [Behrenfeld 1998], i.e., it will use directly the absorption coefficient of phytoplankton for the estimation of absorbed photons, thus by-passing the engagement of a^*_{ph} when using chlorophyll concentration. The resulted PP products will then significantly improve the spatial and temporal characterizations of P_{Peu} in the global oceans.

Completion of this project will not only result in innovative products directly applicable to studies of the ocean's heat budget and photosynthesis in the upper water column, but will also be important for investigating photo-oxidation and phytoplankton phenology. The project will further enhance our capabilities in meeting NASA Strategic Sub-goal 3A 'to study Earth from space to advance scientific understanding and meet societal needs'.

ARLINDO Circulation, A Study of the Indonesian Ocean Circulation and Mixing (ARLINDO)

Website: <https://www.ldeo.columbia.edu/res/fac/physocean/Arlindo/>

Coverage: Indonesian Seas, Banda Sea

9529648 Gordon In this project, the PI will carry out phase 2 of ARLINDO (Indonesian acronym for Indonesian Throughflow), called ARLINDO Circulation (AC). The objective is to study the circulation and water mass stratification within the Indonesian Seas in order to formulate a thorough description of the source, spreading patterns, inter-ocean transport and dominant mixing processes. AC is specifically aimed at resolving the throughflow transport and velocity field across the central passages of the Indonesian Seas, and extending hydrography to the eastern Banda Sea. Moorings are designed to measure the mean and variable current and thermohaline stratification. The lead PI in this award will provide overall guidance for the entire project, and carry out water mass analysis from the CTD hydrography. The Co-PI will oversee the deployment, recovery, and analysis of data from temperature pods, particularly to determine the role and importance of internal

waves in both mixing and transport of the throughflow water.

Biowatt Experiment: Bioluminescence and Optical Variability of the Sea (Biowatt II) (Biowatt II)

Website: <http://uop.whoi.edu/projects/biowatt/biowatt.html>

Coverage: Sargasso Sea

Start and end dates not known at this time [2020-06-11]

Primary Production in the Arabian Sea (Arabian Sea Primary Prod)

Coverage: Arabian Sea

Barber 9312355: This project will investigate primary production and photosynthetic parameters during the course of a year in the monsoon dominated Arabian Sea. The project is a component of the U. S. Joint Global Ocean Flux Study (JGOFS) effort called the Arabian Sea Process Study. The Arabian Sea is a low latitude oceanic region with strong and reversing monsoon winds together with relatively modest seasonal variability in solar radiation and sea surface temperature. The strong episodic wind forcing is accompanied by large changes in nutrients and massive phytoplankton blooms with high primary productivity. The objectives of the project are to 1) determine the seasonal and spatial pattern of variability of primary production using in situ and deck incubations in order to understand the processes that control both total production and export production; 2) determine the seasonal and spatial pattern of the photosynthetic parameters incubations to understand the effect of environmental covariables such as nutrients on these parameters; and 3) use the newly determined photosynthetic parameters in bio-optical models to improve estimates of primary production and compare these model estimates with our direct observations of primary production.

MARRA 9311255 This proposal is a continuing effort of to collect and process data on optics and pigment distribution by combining the efforts of JGOFS and the World Ocean Circulation Experiment (WOCE) Hydrographic Program (WHP). The program will operate a bio-optical profiler to collect data on the biological and optical properties of the upper water column. Data to collected include spectral irradiance (7 channels each of upwelling and downwelling), broad-band visible irradiance (PAR), fluorescence, and beam transmission. This is perhaps the first undertaking of a systematic and consistent data collection on the oceans pigment and optical properties, and would be invaluable in improving algorithms for satellite imaging of ocean pigments and in estimating primary production.

U.S. JGOFS: Response of Arabian Sea Phytoplankton Biomass, Pigmentation, Growth Rates, and Community Structure To Seasonally Varying Physically Forcing (Arabian Sea Phyto Seasonality)

9311244 Goericke The U.S. Arabian Sea JGOFS program offers the unique opportunity to study the response of an oceanic ecosystem to strong and seasonally predictable physical forcing in an environment with strong spatial gradients. Biological conditions in the Arabian Sea vary from extreme oligotrophy to extreme eutrophy. Primary production and concentrations of chlorophyll a, for example, change by one to two orders of magnitude over space and time. We propose to study the effects of the seasonally varying physical forcing on the phytoplankton community as a whole and on individual populations of microalgae, using primarily pigment-based methods. We will test the hypothesis, suggested by data from other environments, that phytoplankton community structure and growth rates during most of the year. The exception is the area off Oman during the SW monsoon when oceanic upwelling occurs. At this time the community is expected to be dominated by diatoms growing at high rates. Phytoplankton community structure will be monitored by measuring the concentration of taxon-specific chlorophylls and carotenoids by high-pressure liquid chromatography. It is proposed to carry out these analyses as part of the JGOFS core measurements. Using the pigment 14c-

labeling method we propose to measure phytoplankton carbon-biomass, phytoplankton growth rates and taxon-specific growth rates to study the physiological response of the phytoplankton community to the seasonally varying physical forcing. Carbon to Chl a ratios will be calculated from phytoplankton biomass and chl a and used to calculate seasonal maps of phytoplankton carbon-biomass for the Arabian Sea from remotely sensed ocean and biomass will allow us to determine factors which control the growth and abundance of the individual phytoplankton population, such as coccolithophores or prochlorophytes, and their contribution to carbon cycling in this environment.

Photo-Ecological Investigations in the Arabian Sea (Arabian Sea Photo-Ecology)

Coverage: Arabian Sea

9311312 BIDIGARE The northern Arabian Sea exhibits regular, predictable oscillations in phytoplankton biomass and production driven by monsoonal atmospheric forcing. In this project, the principal investigator will characterize phytoplankton pigment distributions during the Arabian Sea Process Study (ASPS) using state-of-the-art high-performance liquid chromatography (HPLC) methods. There are four major research objectives. Seasonal and spatial pigment data will be used (1) to document phytoplankton biomass (as chlorophyll-a) and species composition of pigments and other variables and (4) use the model to estimate time-and-depth-dependent rates of primary production. This work will complement the efforts of other ASPS investigators studying phytoplankton dynamics both by water column sampling and via satellite imagery.

Biowatt Experiment: Bioluminescence and Optical Variability of the Sea (Biowatt I) (Biowatt I)

Website: <http://uop.who.edu/projects/biowatt/biowatt.html>

Coverage: Sargasso Sea

Primary Production Measurements for the 20-West Program (NABE) (JGOFS NABE Primary Prod 20W)

Coverage: N. Atlantic

The Joint Global Ocean Flux Study (JGOFS) of the spring bloom in the North Atlantic will begin in 1989. This study will be conducted along longitude 20oW from the beginning of April through August. The significance of this first U.S. JGOFS experiment revolves around the large biological signals in the plankton and the hypothesized importance of these large signals to the overall yield of the system. This is a Level-1 component of the U.S. contribution to JGOFS for the measurement of primary production during the processes-oriented cruises of the North Atlantic Experiment. Primary production measurements will be conducted in situ, using metal-clean techniques.

A Tracer Kinetics Approach to the Production Ecology of Oligotrophic Oceans (PRPOOS) (PRPOOS Tracer Kinetics)

Primary Production in the Southern Ocean (AESOPS Primary Production)

Coverage: Southern Ocean

95-30611 MARRA This research project is part of the US Joint Global Ocean Flux Study (JGOFS) Southern Ocean Program aimed at (1) a better understanding of the fluxes of carbon, both organic and inorganic, in the Southern Ocean, (2) identifying the physical, ecological and biogeochemical factors and processes which regulate the magnitude and variability of these fluxes, and (3) placing these fluxes into the context of the contemporary global carbon cycle. The Joint Global Ocean Flux Study (JGOFS) has had three successful field efforts (North Atlantic, Equatorial Pacific, Arabian Sea), and the next major field effort will be in the Southern Ocean. The overall objectives of JGOFS are to quantify and understand processes controlling the time-varying fluxes of carbon and associated biogenic elements, and to predict the response of marine biogeochemical processes to climate change. The Southern Ocean is critical to the global carbon cycle, as judged by its size and the physical process which occur there (e.g., deep and intermediate water formation), but its present quantitative role is uncertain. In order to address the objectives of USJGOFS successfully, the measurement of primary production is required for all process cruises planned for the Southern Ocean Study. Three methods will be employed: in situ incubations, deck incubations, and the photosynthesis-irradiance response. The areas of study will be the continental shelf of the Ross Sea, and the Polar Front region to the north of the Ross Sea. The controls on photosynthesis will also be investigated. It is hypothesized that on the continental shelf, irradiance limitation is the major factor controlling phytoplankton productivity, whereas in the Polar Front region, the availability of iron limits phytoplankton growth and influences the size distribution of the populations. The productivity data in conjunction with hydrographic data, will form a large part of the Southern Ocean JGOFS database which both at-sea investigators and modelers will use to clarify the role of the Southern Ocean in the global carbon cycle.

95-31981 BARBER This research project is part of the US Joint Global Ocean Flux Study (JGOFS) Southern Ocean Program aimed at (1) a better understanding of the fluxes of carbon, both organic and inorganic, in the Southern Ocean, (2) identifying the physical, ecological and biogeochemical factors and processes which regulate the magnitude and variability of these fluxes, and (3) placing these fluxes into the context of the contemporary global carbon cycle. The Joint Global Ocean Flux Study (JGOFS) has had three successful field efforts (North Atlantic, Equatorial Pacific, Arabian Sea), and the next major field effort will be in the Southern Ocean. The overall objectives of JGOFS are to quantify and understand processes controlling the time-varying fluxes of carbon and associated biogenic elements, and to predict the response of marine biogeochemical processes to climate change. The Southern Ocean is critical to the global carbon cycle, as judged by its size and the physical process which occur there (e.g., deep and intermediate water formation), but its present quantitative role is uncertain. In order to address the objectives of USJGOFS successfully, the measurement of primary production is required for all process cruises planned for the Southern Ocean Study. Three methods will be employed: in situ incubations, deck incubations, and the photosynthesis-irradiance response. The areas of study will be the continental shelf of the Ross Sea, and the Polar Front region to the north of the Ross Sea. The controls on photosynthesis will also be investigated. It is hypothesized that on the continental shelf, irradiance limitation is the major factor controlling phytoplankton productivity, whereas in the Polar Front region, the availability of iron limits phytoplankton growth and influences the size distribution of the populations. The productivity data in conjunction with hydrographic data, will form a large part of the Southern Ocean JGOFS database which both at-sea investigators and modelers will use to clarify the role of the Southern Ocean in the global carbon cycle.

Coordination and Logistics For the Prpoos Program. Planktonic Rate Processes in the Central Oligotrophic Oceans (PRPOOS logistics)

Marine Light-Mixed Layer Experiment (ML-ML)

Coverage: Boreal North Atlantic (60N 20W)

The Marine Light-Mixed Layers (MLML) experiments took place in the subarctic North Atlantic Ocean, approximately 275 miles south of Reykjavik, Iceland, during 1989 and 1991. The 1991 field program took place from April 30 to September 6 and included a central surface mooring to document the temporal evolution of physical, biological, and optical properties. In this paper we describe the physical variability observed at the

1991 mooring site, concentrating on the vertical structure of temperature and velocity in the upper 300 m of the water column and their changes in response to heat and momentum fluxes at the sea surface. The deployment period included the spring transition, when upper ocean re stratification was initiated after deep winter mixing, and the fall transition, when mixed layer deepening began again. The dominant signal in temperature was seasonal variation, with a 6°C increase observed at the sea surface from May to August. Prior to development of the seasonal stratification, a period dominated by near-surface temperature variability was observed in association with a 15-day mean flux of only 20 W m⁻² into the ocean. Pronounced day/night oscillations of heat flux during this period resulted in alternating development and destruction of stratification and intense diurnal cycling of the mixed layer depth. A qualitative comparison of the observed temperature structure to the prediction of a one-dimensional mixed layer model showed that local processes dominated during the initiation of restratification and during most of the summer warming period. Nonlocal processes were important after the fall transition

Upgrade the KD(490) product to the normalized diffuse attenuation coefficient at 490 nm (NKD(490)) for SUOMI NPP (KD490 Upgrade)

Coverage: global

The diffuse attenuation coefficient at 490 nm, $K_d(490)$, is one of the standard ocean data products of the Earth Observing System (EOS), which represents an important component of the Earth Data Records (EDR). Traditionally, and even today, its derivation from satellite ocean color measurements takes the same approach as that for producing chlorophyll-a concentration ([Chl]), i.e. using the blue-green ratios of remote-sensing reflectance (R_{rs}) as the sole input to empirically generate the desired product. Such an approach is generally appropriate for deriving [Chl] in oceanic (or Case-1) waters, but is subject to inherent ambiguity and errors for $K_d(490)$ for both oceanic and coastal waters. This is because that the diffuse attenuation coefficient is an apparent optical property, i.e. it varies with sun angle, while [Chl] does not. We propose to upgrade this attenuation product from two aspects: 1) remove the sun-angle related ambiguity, and 2) improve data quality through a retrieval system based on the radiative transfer theory. To achieve this upgrade, we propose to generate the normalized diffuse attenuation coefficient at 490 nm, $nK_d(490)$, from the R_{rs} products provided by Suomi NPP VIIRS. $nK_d(490)$ is defined as the diffuse attenuation coefficient for the Sun at zenith with a black sky, which matches the definition of the normalized water-leaving radiance (nL_w) for satellite ocean color missions. This $nK_d(490)$ product is thus not only clear in its representation, but also facilitates its evaluation with field measurements. In addition, because $nK_d(490)$ will be produced through a mechanistic system rooted in the radiative transfer theory, this product will have higher science quality for the global oceans, in particular for turbid coastal waters. Furthermore, because the semi-analytical system takes a step-wise approach for the calculation of $nK_d(490)$, an uncertainty map of the $nK_d(490)$ product will also be generated via the error-propagation theory. The results from this effort will provide data products important not only to support the decadal continuity of the EDR, but also to study Earth from space to advance scientific understanding and meet societal needs.

[[table of contents](#) | [back to top](#)]

Program Information

U.S. Joint Global Ocean Flux Study (U.S. JGOFS)

Website: <http://usjgofs.whoi.edu/>

Coverage: Global

The United States Joint Global Ocean Flux Study was a national component of international JGOFS and an integral part of global climate change research.

The U.S. launched the Joint Global Ocean Flux Study (JGOFS) in the late 1980s to study the ocean carbon cycle.

An ambitious goal was set to understand the controls on the concentrations and fluxes of carbon and associated nutrients in the ocean. A new field of ocean biogeochemistry emerged with an emphasis on quality measurements of carbon system parameters and interdisciplinary field studies of the biological, chemical and physical process which control the ocean carbon cycle. As we studied ocean biogeochemistry, we learned that our simple views of carbon uptake and transport were severely limited, and a new "wave" of ocean science was born. U.S. JGOFS has been supported primarily by the U.S. National Science Foundation in collaboration with the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Department of Energy and the Office of Naval Research. U.S. JGOFS, ended in 2005 with the conclusion of the Synthesis and Modeling Project (SMP).

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Ocean Carbon and Biogeochemistry (OCB)

Website: <http://us-ocb.org/>

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO₂ and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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[[table of contents](#) | [back to top](#)]