CDIAC and Global Ocean CO_2 Data Management

Alex Kozyr

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Course Plan

Introduction

- **Science and Technology at ORNL**
- **Environmental Sciences at ORNL**
- **CDIAC Background Basics**
- **Impacts**
- **Present Data Holdings**
- **CDIAC Data and Information Products**
- **CDIAC Most Popular Holdings and Products**
- **Current Data Emphasis**
- **CDIAC Ocean Carbon Projects**

CDIAC Global Ocean CO_2 Database Components

CDIAC Search Engines

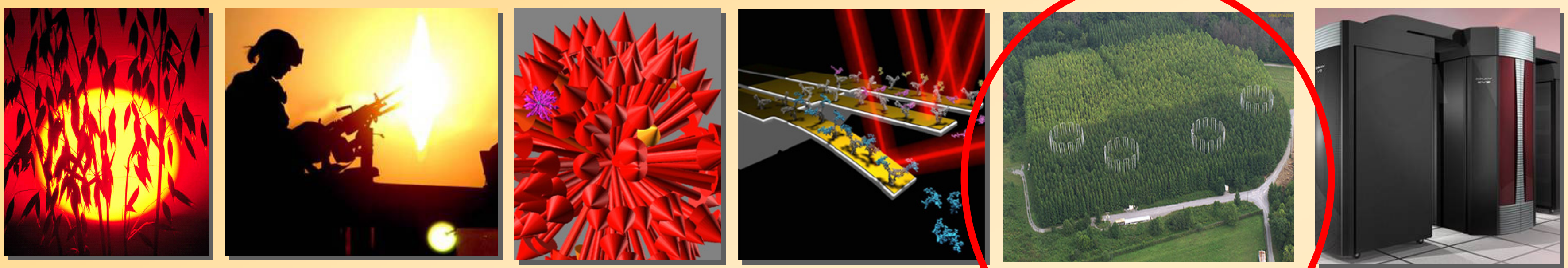
How to submit data to CDIAC

CDIAC Data formats

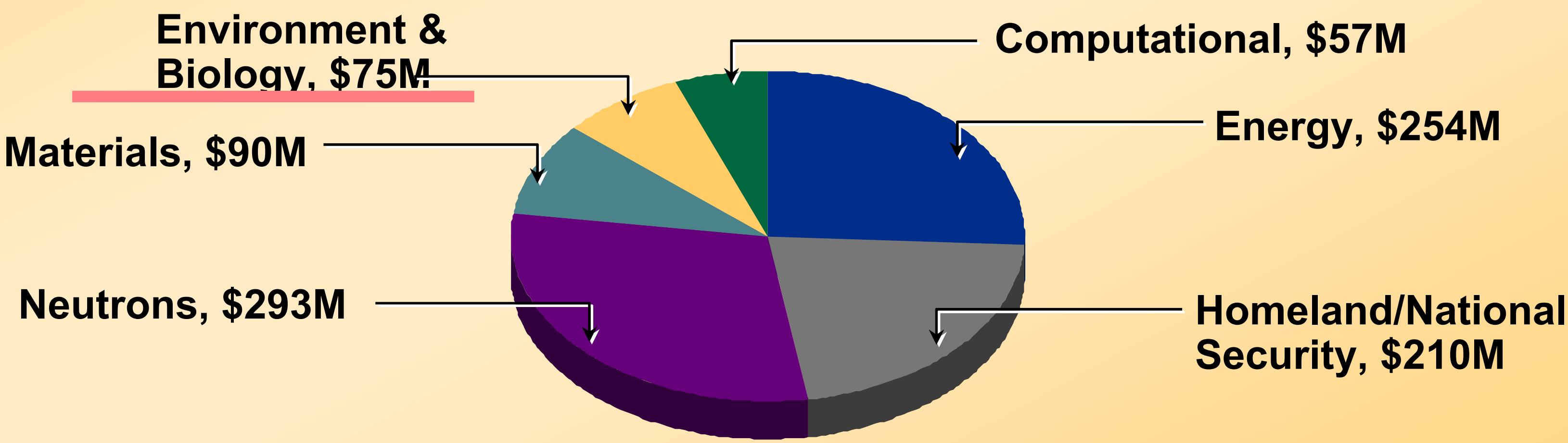
CDIAC routines for data QA-QC work

CDIAC Numeric Data Packages(NDPs) and other publications

Science and Technology at ORNL

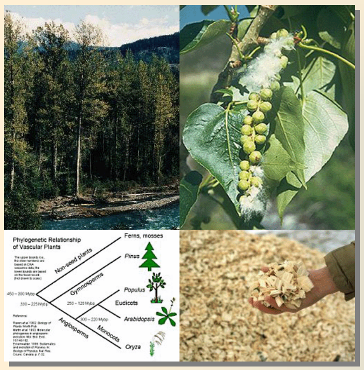


Energy | Homeland/ National Security | Neutron Science | Materials | Environment & Biology | Computing



Environmental Sciences at ORNL

Plant Sciences



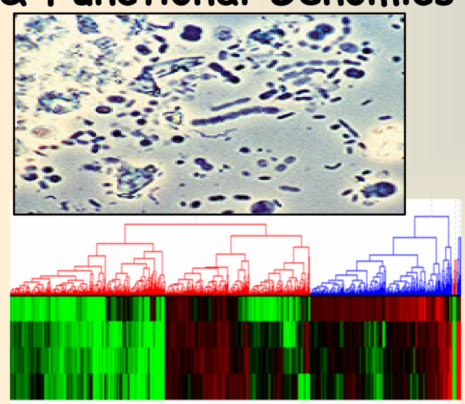
Carbon Cycle & Ecosystem Research

Subsurface Science

Ecological Management

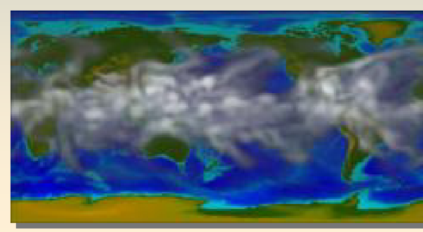
Detecting and Simulating Environmental Responses

Microbial Ecology & Functional Genomics



Society – Technology Interfaces

Global Climate Simulation



Environmental Data Systems

CDIAC Background Basics

- The Carbon Dioxide Information Analysis Center (CDIAC) was established in 1982
- Funded and managed by the U.S. Department of Energy, Office of Biological and Environmental Research, Climate Change Research Division
- Dr. Wanda Ferrell, DOE, is the Program Manager for CDIAC
- Housed within the Environmental Sciences Division at Oak Ridge National Laboratory and co-located with researchers investigating a broad range of climatic change/environmental topics
- Science-oriented data center resulting in diverse data holdings critical to climatic change
- Provide the full spectrum of data management services with data, analysis and information services provided to anyone worldwide

Impacts

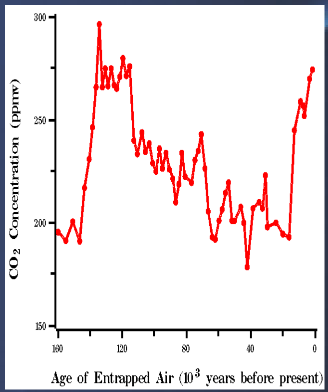
- Quantified the most critical anthropogenic piece (i.e., releases from fossil-fuel consumption) to the carbon cycle budget
- Amassed the most diverse, selective collection of data fundamental to climate change research in the world
- Assembled the world's richest collection of ocean carbon measurements
- Satisfy over 500,000 requests annually to a diverse audience of users worldwide
- Most models associated with climate change over historic time use CDIAC data
- Data distributed by CDIAC are better than the data arriving at CDIAC (i.e., value-added data and services).

Impacts

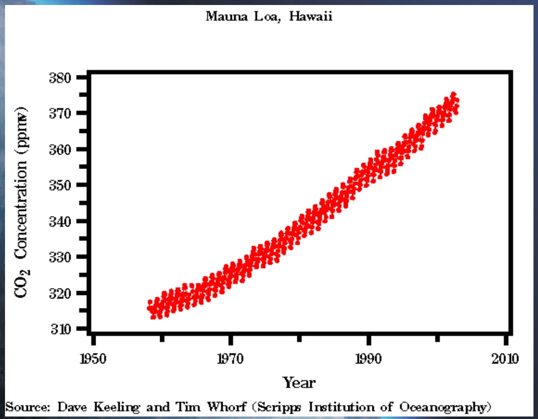
Examples of Scientific Issues/Questions Addressed by CDIAC or by Data Furnished From CDIAC:

- Quantifying CO_2 releases from fossil-fuel consumption over multiple temporal and spatial scales
- Elucidating global and regional trends in ocean carbon transports and inventories over decadal time scales
- Understanding the sources and sinks of CO_2, CH_4, and CO in North America and adjacent ocean regions
- Identifying regional scale trends in observed cloudiness
- Addressing the sensitivity of biogeochemical models to site-specific carbon and nitrogen stock estimates
- Science Citation Index shows >1500 scientific journal publications have cited CDIAC data products from 2003-2009

Present Data Holdings



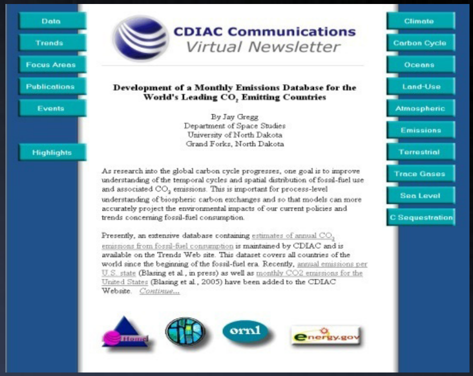
- 450 data sets totaling 500 GB
- Terrestrial, oceanic/hydrospheric, atmospheric, cryospheric, pedologic
- Classic/Unique/Not available elsewhere
- Temporal scales ranging from one second to millennium
- Spatial scales ranging from point sources to global scales
- Vertical profiles from 6000 m below surface to stratosphere
- Field campaigns
- Network-wide databases



CDIAC Data and Information Products

- Data Products
  - Numeric Data Packages (NDPs)
  - DBs (databases)
  - Trends Compendium
  - Synthesis products
    - Network-wide databases
    - Gridded products
    - GIS coverages
  - Web summaries
    - Current greenhouse gas concentrations
    - Kyoto time series

- Information Products
  - Newsletter (*CDIAC Communications*)
  - Brochures
  - Glossaries
  - DOE Research Summaries



Most Popular Holdings and Products

(http://cdiac.esd.ornl.gov/pns/top10.html)

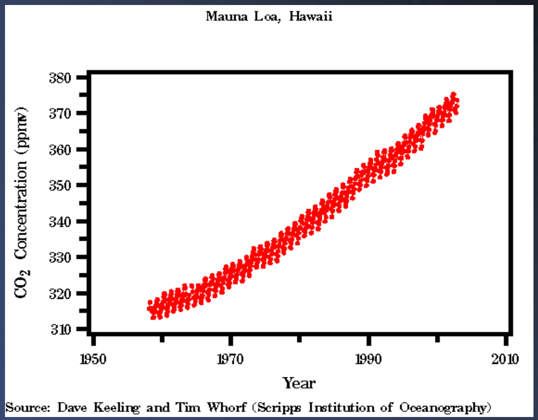
Trends compendium

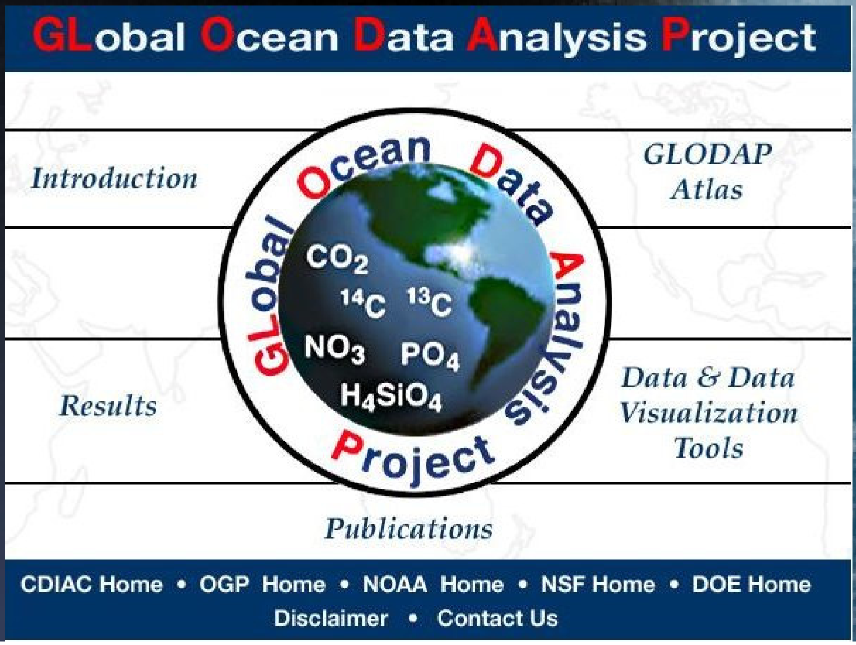
GLODAP Database

AmeriFlux holdings

Mauna Loa record

Fossil-fuel series





Current Data Emphasis

- Fossil-fuel CO_2 emissions
- Atmospheric measurements of climate relevant species
- Historical greenhouse gas and climate reconstructions from ice cores
- Long-term climate (precipitation, temperature, clouds) measurements
- Terrestrial micrometeorological measurements
- Processing fine particulate, aerosol, and ozone-precursor measurements from NARSTO field intensives
- Soil carbon measurements necessary to evaluate terrestrial carbon sequestration potential
- Compiling detailed carbon and nitrogen stock information for the NACP Mid-Continent Intensive
- Developing data streams for modeling activities
- Developing data processing tools and capabilities
- Keeping existing data holdings current & automated data processing
- Ocean carbon (pCO_2, TCO_2, TALK, pH) and other measurements

US Ocean Carbon Project
Origins

- 1989 – beginning of Joint Global Ocean Flux Study (JGOFS)
- 1990 – beginning of World Ocean Circulation Experiment (WOCE)
- DOE and NOAA funded 10 US institutions to develop instrumentation and perform carbon-related measurements on WOCE cruises
  - Princeton (Bob Key, Chris Sabine)
  - WHOI (Catherine Goyet)
  - SIO (Andrew Dickson, Charles Keeling, Ray Weiss)
  - RSMAS University of Miami (Frank Millero)
  - University of Hawaii (Chris Winn)
  - LDEO (Taro Takahashi)
  - BNL (Doug Wallace)
  - PNL (Linda Bingler)
  - AOML (Rik Wanninkhof)
  - PMEL (Dick Feely)

CDIAC's Role in the Global Ocean Carbon Projects

- 1993 – CDIAC became a member of the DOE/NOAA Ocean Carbon Science Team with Data Management and Data Archive responsibilities for WOCE CO_2 data
- 1996 – CDIAC was invited to participate in the UNESCO/IOC panel for Underway pCO_2 measurements
- 1998 – CDIAC became a member of the PICES WG-13/17
- 1998 – CDIAC became a member of CARINA Project
- 1999 – GLODAP Project started, CDIAC is a member of GLODAP Science team funded by DOE and NOAA
- 2003 – GLODAP database was published by CDIAC
- 2003 – CLIVAR Repeat Section Project started, CDIAC is a member of US CLIVAR Science Team funded by NOAA
- 2003 – The VOS and Time Series Projects started, CDIAC is a member of the project Science Team funded by NOAA
- 2004 – CDIAC involvement in the International SOLAS Program, member of IMG-3 and Data Management Group
- 2005 – Understanding the temporal evolution of the global carbon cycle using large-scale carbon observations project; CDIAC is a member of the project Science Team funded by NOAA
- 2005 – CDIAC involvement in the NACP
- 2005 – EU CARBOOCEAN Project, CDIAC member of Science Steering Committee
- 2006 – Member of PICES Carbon & Climate Section (CC-S).
- 2007 – CDIAC is a member of OceanSITES Data Management team
- 2007 – CDIAC is a member of EuroSITES Oversight Committee
- 2008 – CDIAC is a member of UNESCO IOCCP Science Steering Group
- 2009 –The CARINA Database was published by CDIAC

CDIAC Global Ocean CO_2 Database Components

- WOCE Database
- GLODAP Database
- CLIVAR Repeat Hydrography and Carbon Database
- VOS Underway pCO_2 Database
- Moorings and Time Series Database
- Global Coastal Program Data
- CARINA Database
- Global Surface Ocean Alkalinity Climatology Database (K. Lee)
- LDEO (Takahashi) Global Surface pCO_2 Database

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All CDIAC Ocean Carbon Data

General Information

WOCE Project Carbon Data

Ocean Carbon and Repeat Hydrography CLIVAR Program Data

VOS Project Carbon Data

Timeseries and Moorings Data

Global Coastal Program Data

CARINA Database

PICES Database

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- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- *Mercury* Ocean Data Search Engine
- *WAVES*: WEB-Accessible Visualization and Extraction System
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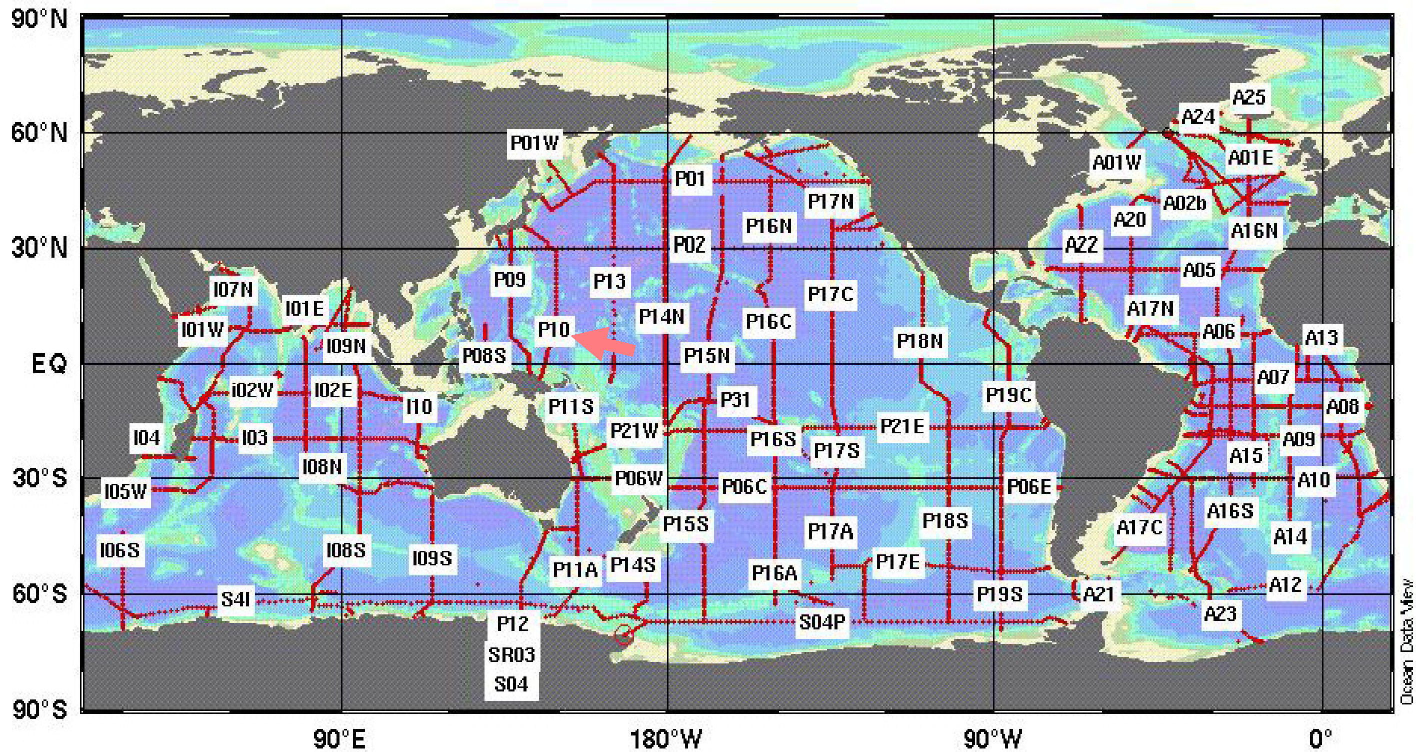
CDIAC/WOCE Database (All Data)

Click on section for data and information



Original data from 74 WOCE cruises

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http://cdiac.ornl.gov/oceans/woce_p10.html

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- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
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WOCE Section P10

Data Set Name	Graphics	Research Vessel	Place	Period	Chief Scientist	Carbon-related data Contributor	Variables in Data Set	Data	NDP No.	Date of Publication
WOCE Section P10	See map and section plots	R/V *Thomas Thompson*	Pacific ocean	5 Oct.-10 Nov. 1993	Melinda Hall /WHOI	Chris Sabine /NOAA-PMEL	Hydrogr., Nutr., CFC11, CFC12, ^{14}C, TCO_2, TALK, underway pCO_2	Data files Metadata	NDP-071 **read online**	August, 1999

CLIVAR Repeat Section P10_2005

Data Set Name	Country/Status	Research Vessel	Place	Period	Chief Scientist	Carbon-related data PI(s)	Variables in Data Set	Data/Availability NDP No.
P10_2005 (49MR0502_1) See map	Japan/ Completed	R/V Mirai	Pacific Ocean	25 May - 2 July, 2005	Takeshi Kawano/ JAMSTEC, Japan	Akihiko Murata / JAMSTEC, Japan	CTD, Hydrogr., Nutr. TCO_2, TALK, pH, pCO_2(und), CFCs, $\Delta^{14}C$, $\Delta^{13}C$	Data files Metadata

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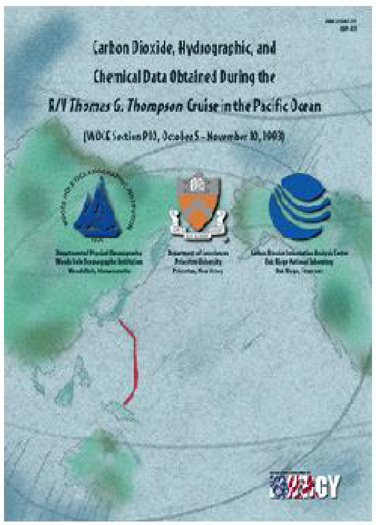
NDP-071 (1999)

Download the Data and ASCII Documentation files of NDP-071

Download PDF of NDP-071

Carbon Dioxide, Hydrographic, and Chemical Data Obtained During the R/V *Thomas G. Thompson* Cruise in the Pacific Ocean (WOCE Section P10, October 5 - November 10, 1993)



Contributed by
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and Melinda Hall[2]

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Woods Hole, Massachusetts

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General Information

WOCE Project Carbon Data

Ocean Carbon and Repeat Hydrography CLIVAR Program Data

VOS Project Carbon Data

Timeseries and Moorings Data

Global Coastal Program Data

CARINA Database

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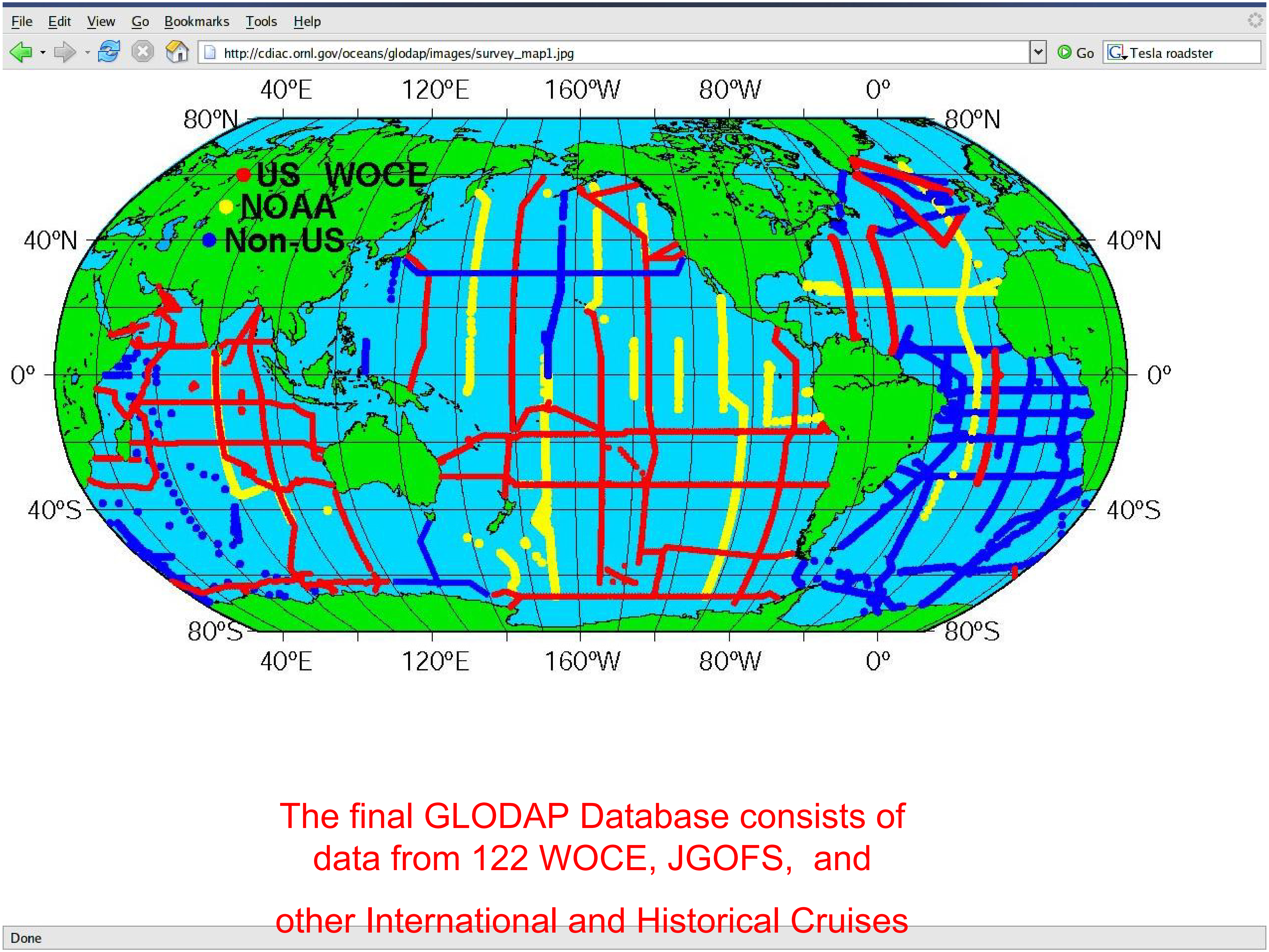
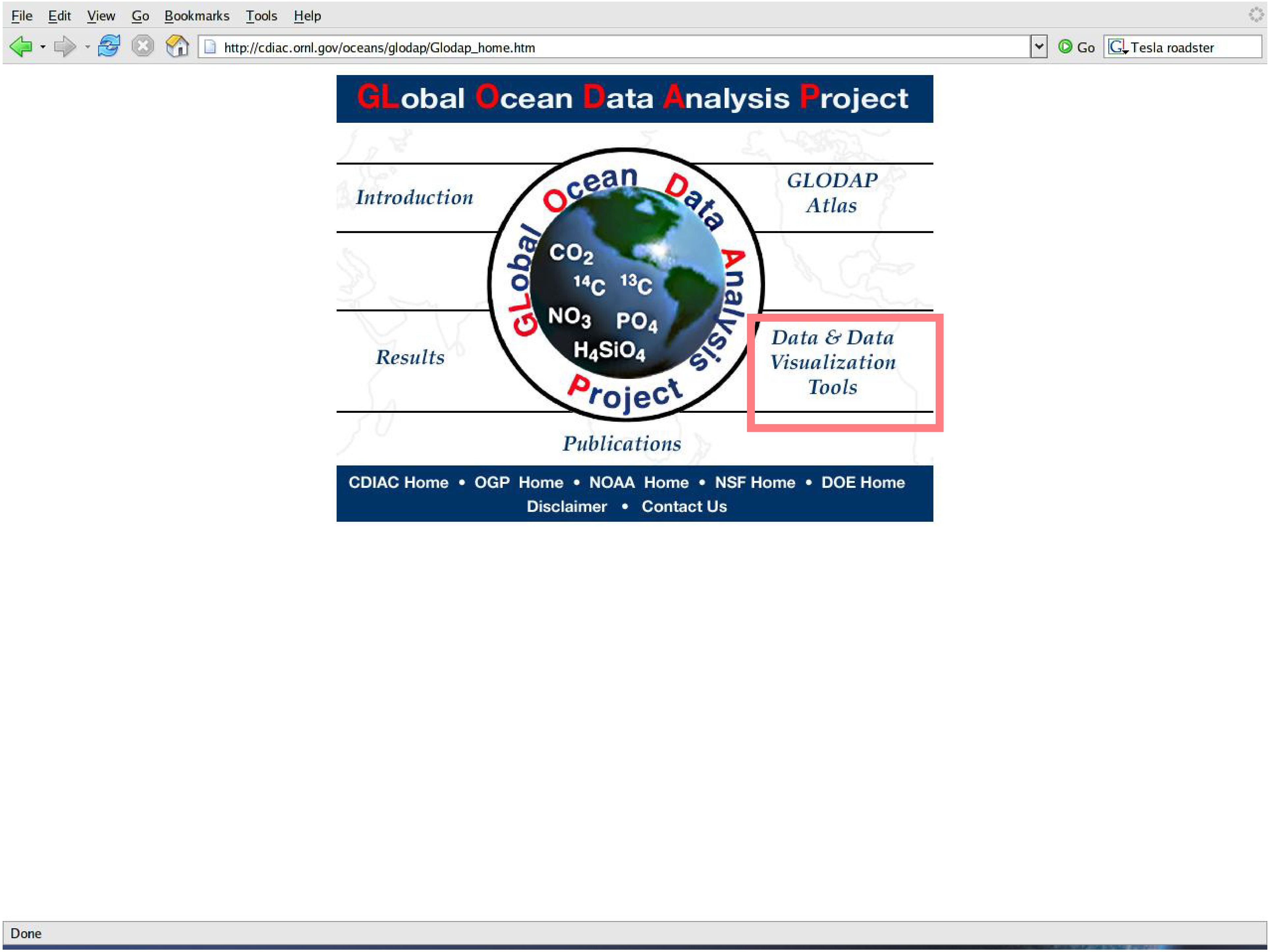


The final GLODAP Database consists of data from 122 WOCE, JGOFS, and

other International and Historical Cruises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Introduction
GLODAP Atlas
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CO2
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NO3 PO4
H4SiO4
Results
Data & Data Visualization Tools
Publications
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Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J. Bullister, R.A. Feely, F. Millero, C. Mordy, T.-H. Peng. 2004. A global ocean carbon climatology: Results from GLODAP. Global Biogeochemical Cycles, Vol. 18, GB4031 - has been cited 150 times so far

GLobal Ocean Data Analysis Project

Data & Data Visualization Tools ----

- Introduction
- Results
- GLODAP Atlas
- Data & Data Visualization Tools
- Publications
- Project Contacts
- GLODAP Home

NDP-083 Global Ocean Data Analysis Project: Results and Data (PDF format)

Live Access Server (LAS)* for GLODAP Gridded and Bottle Data

GLODAP Gridded and Bottle Data Files

GLODAP Ocean Data View (ODV) Collection for Bottle Data

GLODAP Ocean Data View (ODV) Collection for Gridded Data

Global Surface Ocean Alkalinity Climatology

Indian Ocean Correction Factors (Detailed information)

Pacific Ocean Correction Factors (Detailed information)

Atlantic Ocean Correction Factors (Detailed information)

Note 1: Please, cite the GLODAP Data Set in your publications as:
Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J. Bullister, R.A. Feely, F. Millero, C. Mordy, T.-H. Peng. 2004. A global ocean carbon climatology: Results from GLODAP. *Global Biogeochemical Cycles*, Vol. 18, GB4031

Note 2: Details of the assembly of these data sets and gridded products are published in:
Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J. Bullister, R.A. Feely, F. Millero, C. Mordy, T.-H. Peng. 2004. A global ocean carbon climatology: Results from GLODAP. *Global Biogeochemical Cycles*, Vol. 18, GB4031

Note 3: Anthropogenic CO_2 numbers are the raw values, including any negative values. Although in reality there can be no negative anthropogenic CO_2 concentrations, we left them in the data set to provide some idea of the uncertainty in the results on deeper surfaces. To get an inventory that is consistent with the values published in *Science* in 2004, set all negative numbers to zero. Also, the choice of ocean bottom masking will also slightly affect final total inventory.

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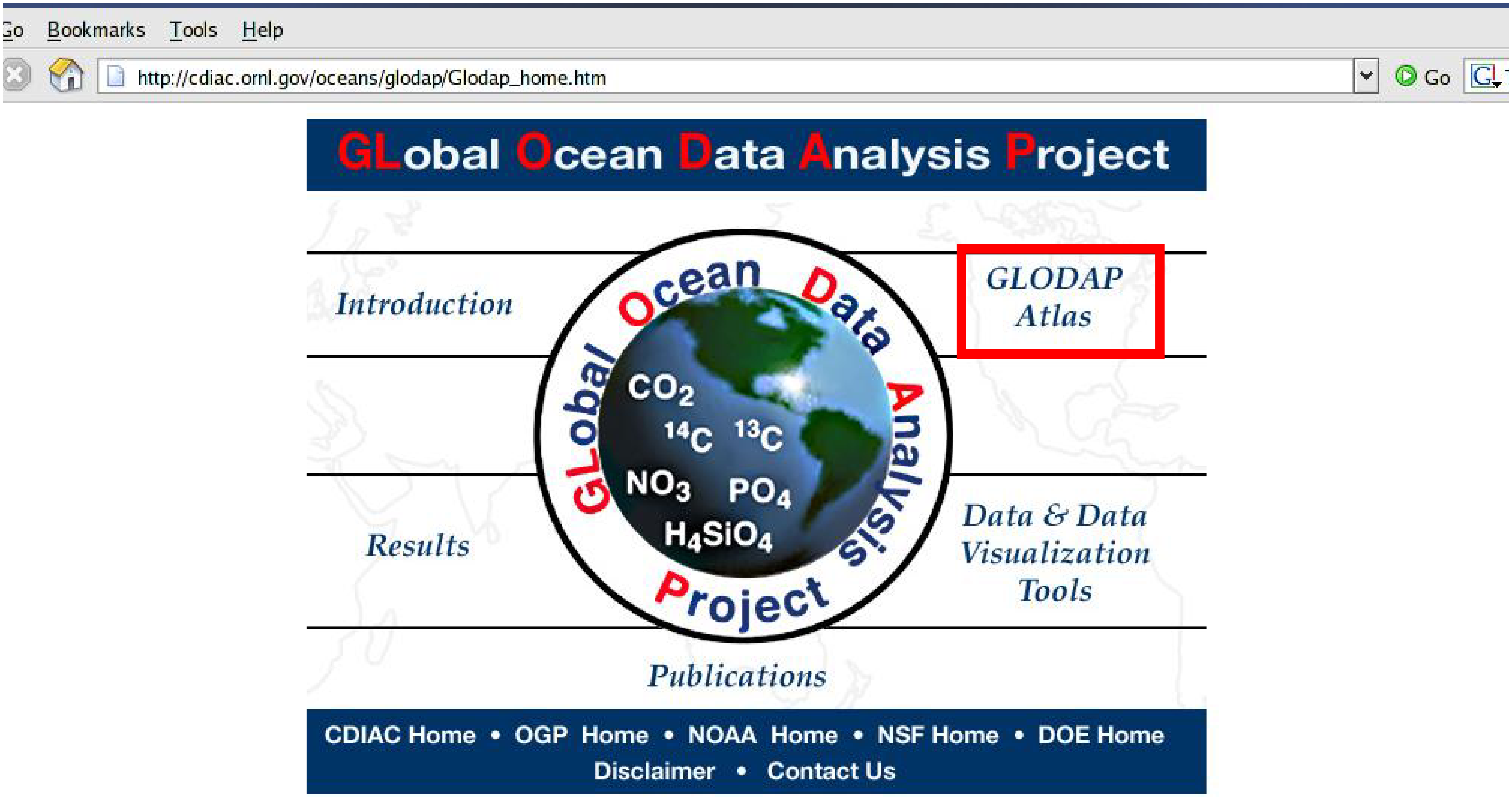
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Results
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GLODAP Atlas ----

- Introduction
- Results
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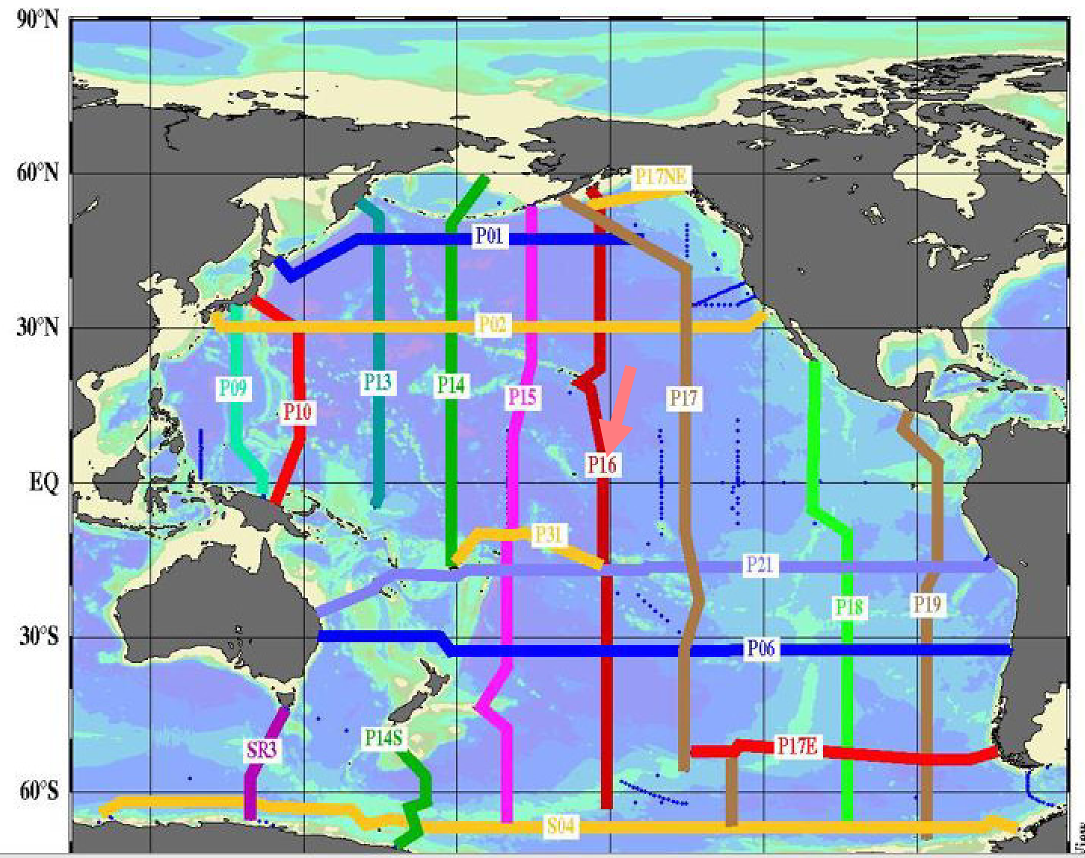
Pacific Ocean

Click on the Section to download plots



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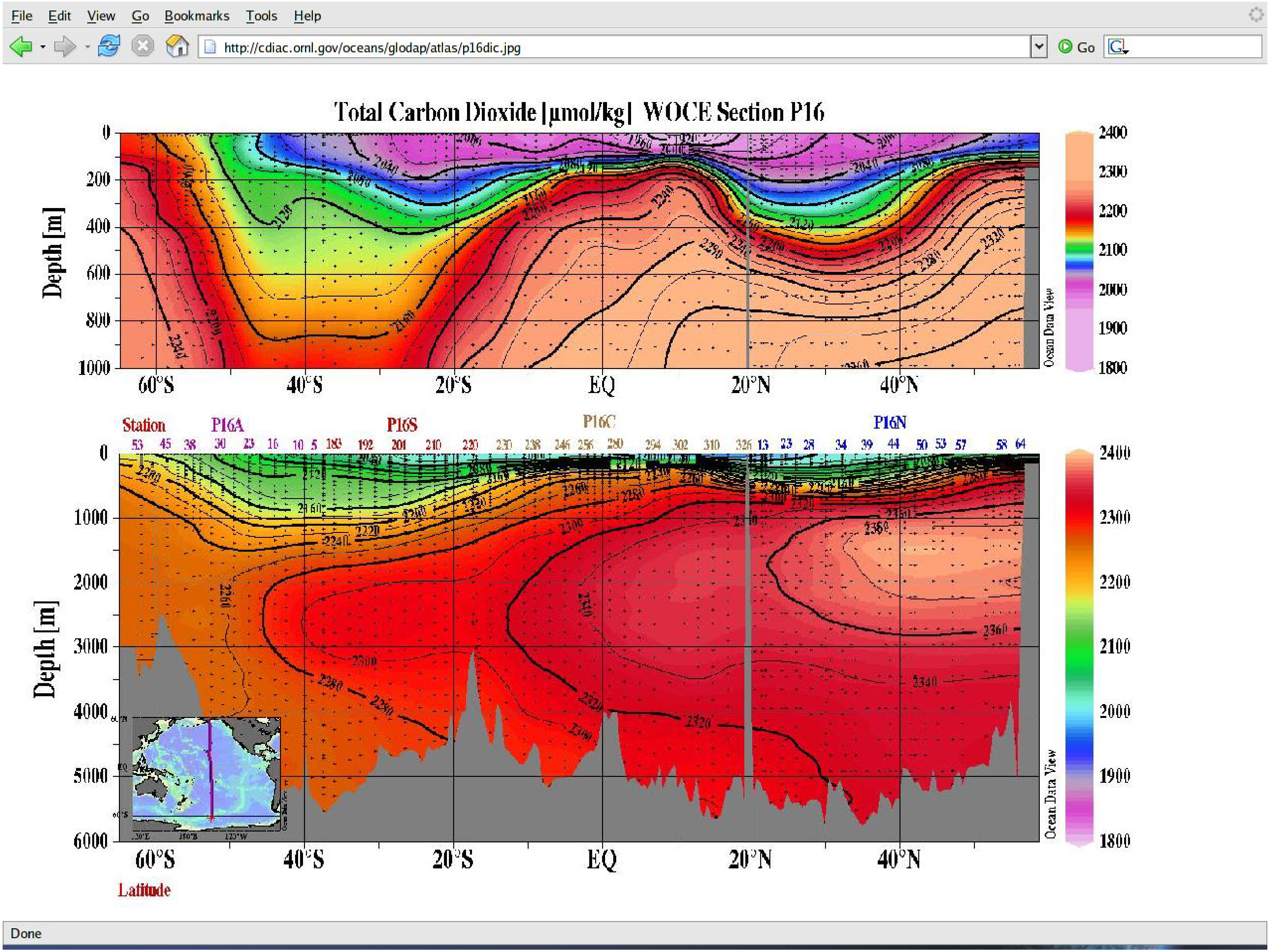
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Total Carbon Dioxide [µmol/kg] WOCE Section P16
Depth [m]
0
200
400
600
800
1000
60°S
40°S
20°S
EQ
20°N
40°N
2400
2300
2200
2100
2000
1900
1800
Ocean Data View
Station
P16A
P16S
P16C
P16N
53 45 38 30 23 16 10 5 183 192 201 210 220 230 238 246 256 280 294 302 310 326 13 23 28 34 39 44 50 53 57 58 64
Depth [m]
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4000
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6000
60°S
40°S
20°S
EQ
20°N
40°N
Latitude
2400
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2000
1900
1800
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All CDIAC Ocean Carbon Data	General Information	WOCE Project Carbon Data
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Timeseries and Moorings Data		Global Coastal Program Data
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CLIVAR Repeat Sections Data - Windows Internet Explorer provided by ORNL

http://cdiac.ornl.gov/oceans/RepeatSections/repeat_map.html

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CLIVAR Repeat Sections Data

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Repeat Hydrography

- Repeat Hydrography Global Map
- Introduction
- CDIAC/WHPO (CCHDO) Data Management Plan (PDF)
- Repeat Carbon Measurements Science Team
- U.S. Repeat Hydrography Program Office
- Program Links
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- *WAVES* Search

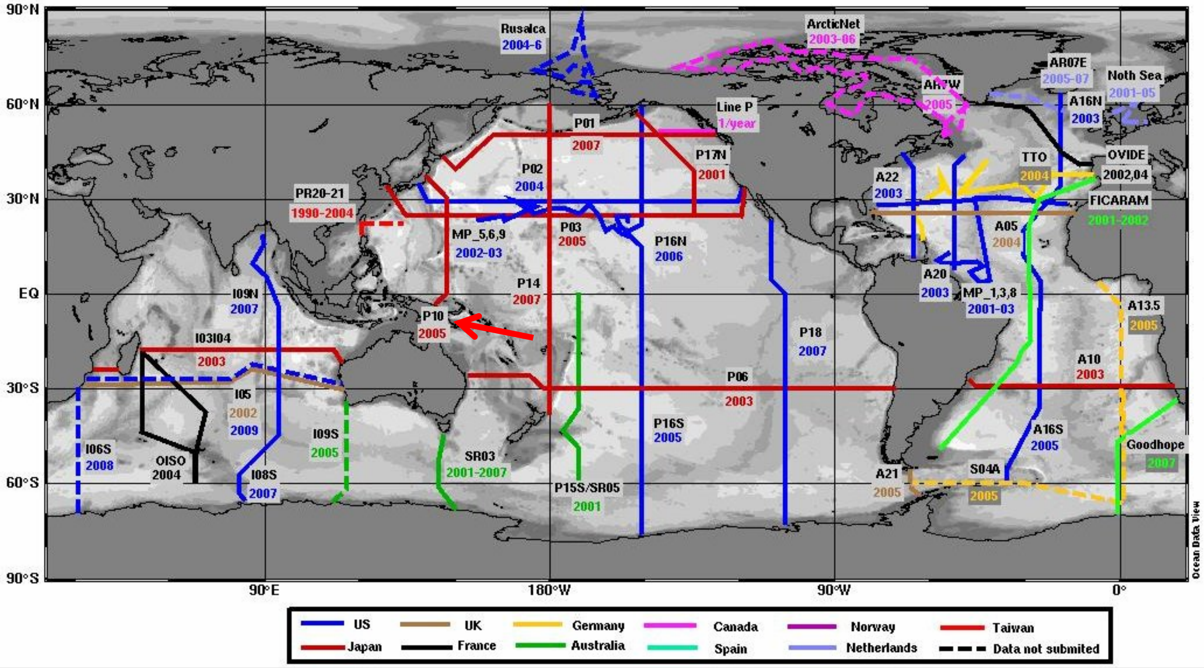
Data Management Support for the International Global Ocean Carbon and Repeat Hydrography Program

See a Table of the Repeat Hydrography Program Data Status

For on-going and planned cruise information see IOCCP Repeat Hydrography Carbon Map

Map of Completed International Repeat Hydrography Program Sections **(Note: dashed lines indicate that the data have not been submitted to CDIAC at this time)**

Click on section for cruise information and data!



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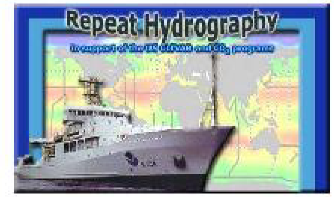

Data Management Support for the International Global Ocean Carbon and Repeat Hydrography Program

CLIVAR Repeat Section P10_2005

Data Set Name	Country/Status	Research Vessel	Place	Period	Chief Scientist	Carbon-related data PI(s)	Variables in Data Set	Data/Availability NDP No.
P10_2005 (49MR0502_1) See map	Japan/ Completed	R/V Mirai	Pacific Ocean	25 May - 2 July, 2005	Takeshi Kawano/ JAMSTEC, Japan	Akihiko Murata / JAMSTEC, Japan	CTD, Hydrogr., Nutr. TCO_2, TALK, pH, pCO_2(und), CFCs, $\Delta^{14}C$, $\Delta^{13}C$	Data files Metadata

Historical Data: WOCE Section P10

Data Set Name	Country/Status	Research Vessel	Place	Period	Chief Scientist	Carbon-related data PI(s)	Variables in Data Set	Data/Availability NDP No.
WOCE Section P10 See map	USA/Completed	R/V *Thomas Thompson*	Pacific Ocean	5 Oct.-10 Nov. 1993	Melinda Hall /WHOI, USA	Chris Sabine /NOAA-PMEL, USA	Hydrogr., Nutr., CFC11, CFC12, ^{14}C, TCO_2, TALK, underway pCO_2	Data files NDP-071, 1999

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General Information

WOCE Project Carbon Data

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Global Coastal Program Data

CARINA Database

PICES Database

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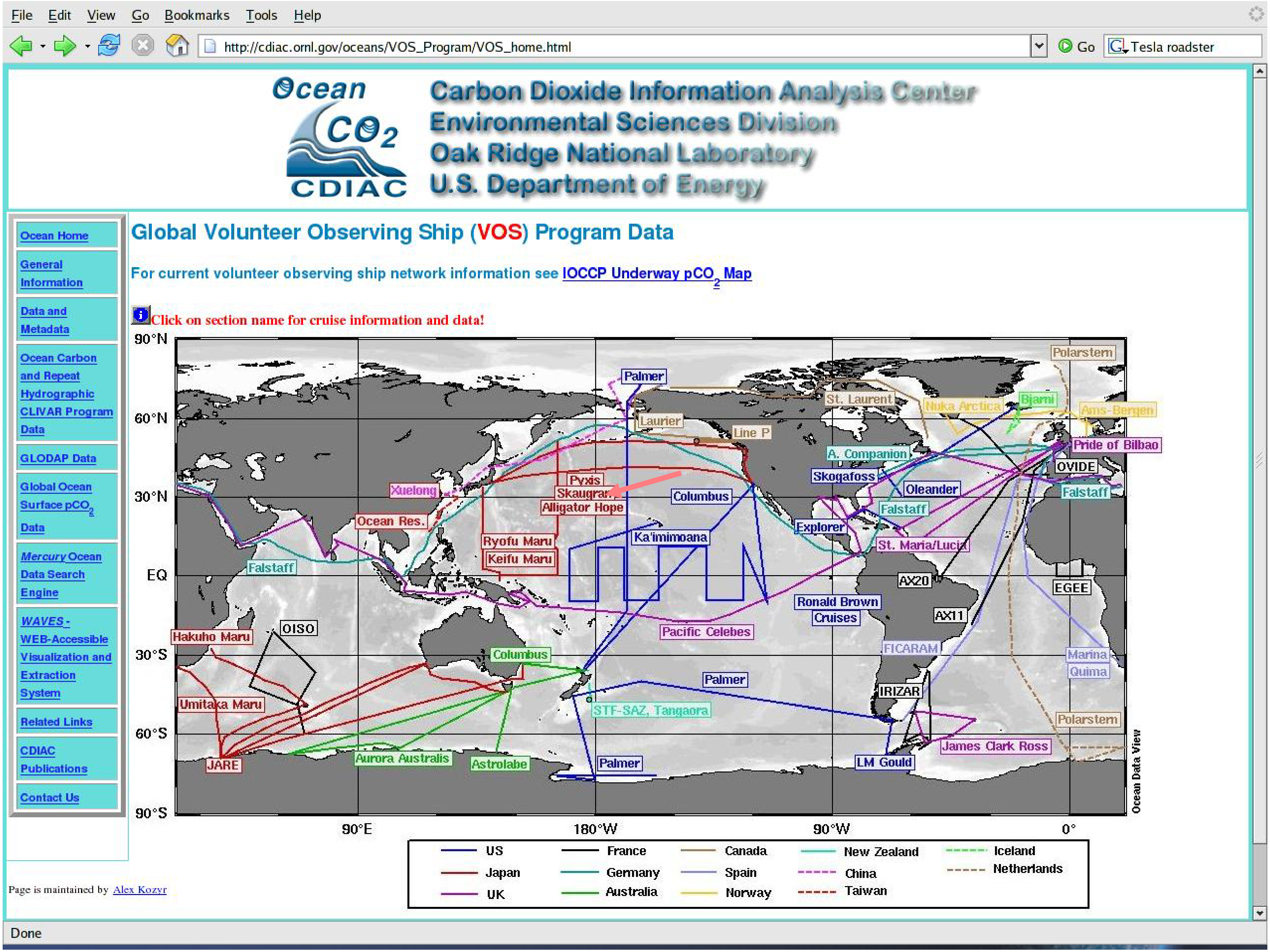
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General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO2 Data
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Global Volunteer Observing Ship (VOS) Program Data
For current volunteer observing ship network information see IOCCP Underway pCO2 Map
Click on section name for cruise information and data!
90°N
60°N
30°N
EQ
30°S
60°S
90°S
90°E
180°W
90°W
0°
Polarstern
Palmer
St. Laurent
Nuka Arctica
Bjarni
Ams-Bergen
Laurier
Line P
Pride of Bilbao
A. Companion
OVIDE
Skogafoss
Oleander
Falstaff
Pyxis
Skaugran
Alligator Hope
Columbus
Xuelong
Ocean Res.
Explorer
Ryofu Maru
Keifu Maru
Ka'imimoana
St. Maria/Lucia
Falstaff
AX20
EGEE
Ronald Brown Cruises
AX11
OISO
Hakuho Maru
Pacific Celebes
FICARAM
Columbus
Marina Quima
Palmer
IRIZAR
Umitaka Maru
STF-SAZ, Tangaora
Polarstern
James Clark Ross
JARE
Aurora Australis
Astrolabe
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Spain
China
Netherlands
UK
Australia
Norway
Taiwan
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- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- *Mercury* Ocean Data Search Engine
- *WAVES* - WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

Skaugran Line

Vessel	Country	Map	Ports	Dates of Operation	Frequency of Repeat	PI/Chief Scientist	Measurements	Data	Project Link
MS *Skaugran*	Japan (completed)	See map	Chiba, Japan - Vancouver, BC - San Diego, USA	03/29/1995 - 09/25/1999	1-2/Month	Y. Nojiri / Japan	Hum, Atmos Press, SST, SSS, xCO_2_Eq, pCO_2_SST, ΔpCO_2, XCO_2_atm, pCO_2_atm	Data files	NIES Monitoring Web site

Alligator Hope Line

Vessel	Country	Map	Ports	Dates of Operation	Frequency of Repeat	PI/Chief Scientist	Measurements	Data	Project Link
MS *MS Alligator Hope*	Japan (completed)	See map	Ohi, Tokyo, Japan - Vancouver, BC, CA.	11/12/1999 - 05/11/2001	1-2/Month	Y. Nojiri / Japan	Hum, Atmos Press, SST, SSS, xCO_2_Eq, pCO_2_SST, ΔpCO_2, XCO_2_atm, pCO_2_atm	Data files	NIES Monitoring Web site

Pyxis Line

Vessel	Country	Map	Ports	Dates of Operation	Frequency of Repeat	PI/Chief Scientist	Measurements	Data	Project Link
MS *Pyxis*	Japan (ongoing)	See map	Nagoya, Japan - Portland, Oregon - Los Angeles - Toyohashi, Japan - US East coast - Japan	11/06/2001 - 04/07/2006	Monthly	Y. Nojiri / Japan	Ambient Temp, Hum, Solar Radiation, Rel WV, Ship Speed, Abs WV, Atmos Press, Air xCO_2, Air fCO_2, Air pCO_2, Eq Temp, SST, xCO_2_Eq, fCO_2_Eq, fCO_2_SST, xCO_2_SST, pCO_2_SST, ΔfCO2, ΔxCO2, ΔpCO2, Sal.	Data files	NIES Monitoring Web site

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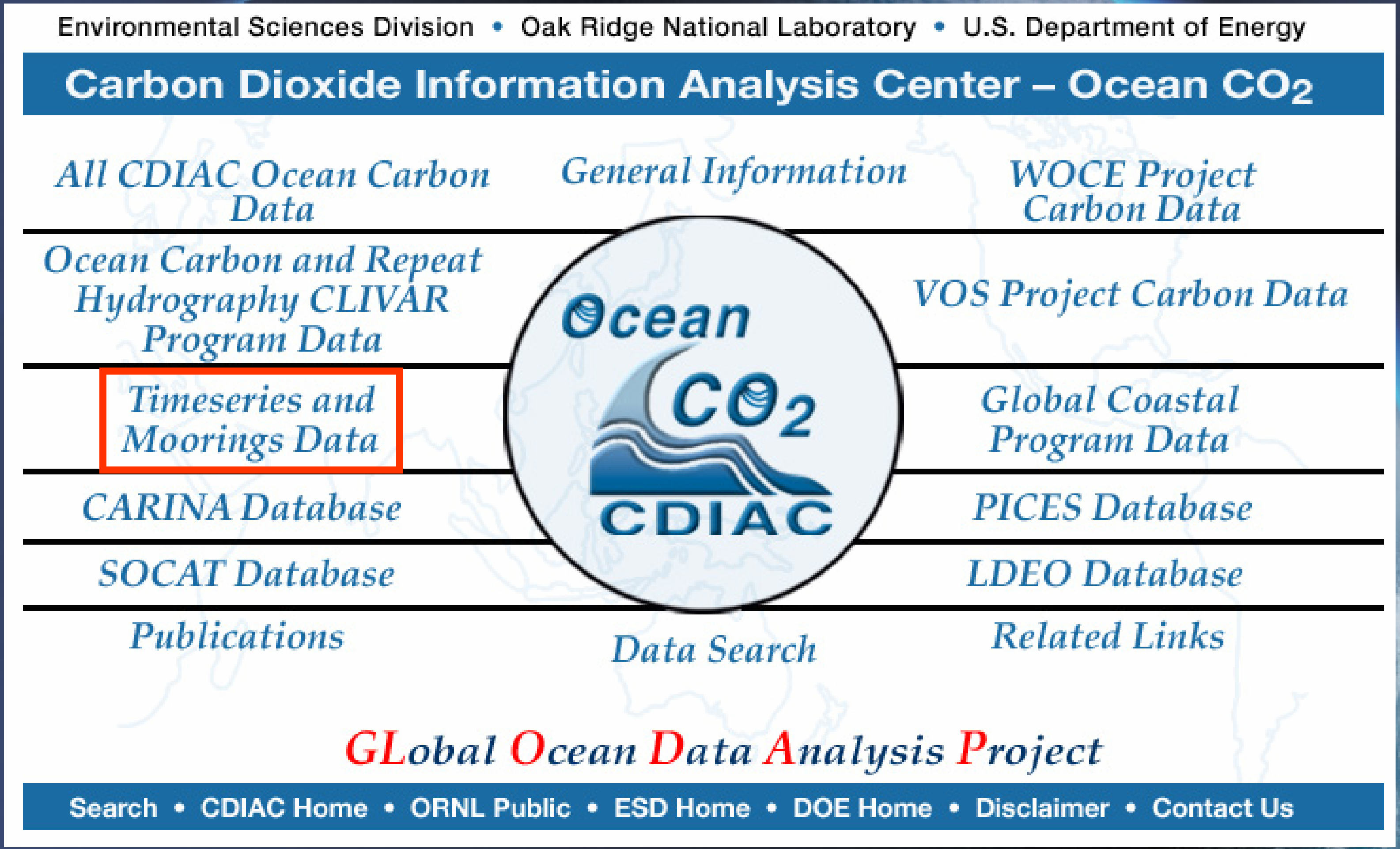
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Carbon Dioxide Information Analysis Center – Ocean CO_2
All CDIAC Ocean Carbon Data
General Information
WOCE Project Carbon Data
Ocean Carbon and Repeat Hydrography CLIVAR Program Data
VOS Project Carbon Data
Timeseries and Moorings Data
Ocean CO_2 CDIAC
Global Coastal Program Data
CARINA Database
PICES Database
SOCAT Database
LDEO Database
Publications
Data Search
Related Links
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Ocean CO_2 CDIAC

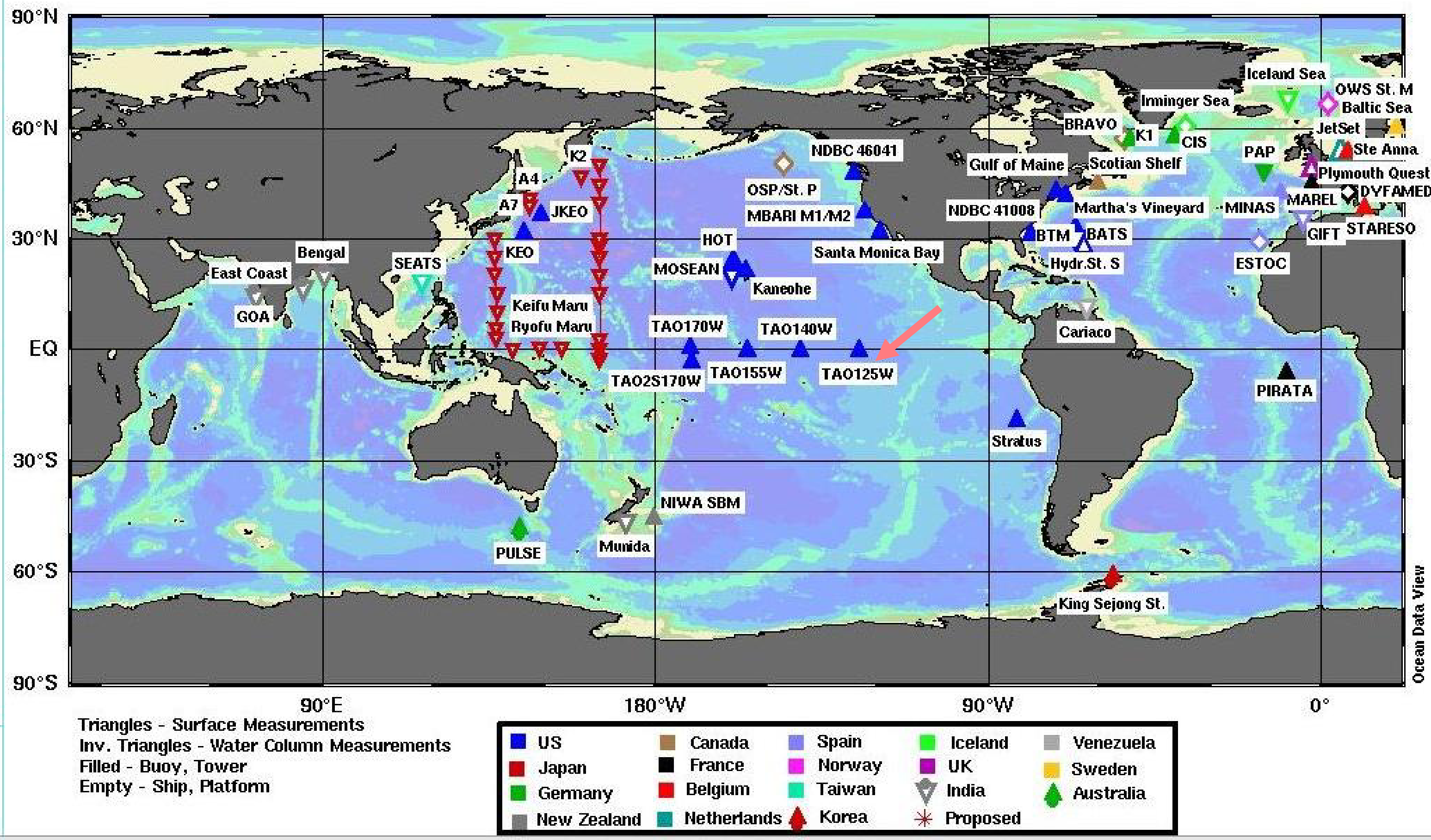
Carbon Dioxide Information Analysis Center
Environmental Sciences Division
Oak Ridge National Laboratory
U.S. Department of Energy

- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- *Mercury* Ocean Data Search Engine
- *WAVES*: WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

CO_2 Moorings and Time-series Project

For on-going and planned Moorings and Time-series information see IOCCP Mooring and Time-series stations Map or Table

Click on mooring name for data and information



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Ocean Home
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO_2 Data
Mercury Ocean Data Search Engine
WAVES: WEB-Accessible Visualization and Extraction System
Related Links
CDIAC Publications
Contact Us

CO_2 Moorings Project

Mooring TAO125W (Buoy Position: 0.2° S, 124.4° W)

Data Set Name	Graphics	Platform	Place	Period	Carbon-related data Contributor	Variables in Data Set	Data	NDP No.	Date of Publication
TAO125W 2004-2005	See graphics for this mooring	TAO125W	Equatorial Pacific Ocean	8 May 2004 - 15 Sep 2005	Chris Sabine / PMEL	SST, SSS, Atm. press, xCO_2 water, xCO_2 air, fCO_2 water, fCO_2 air	Data files		

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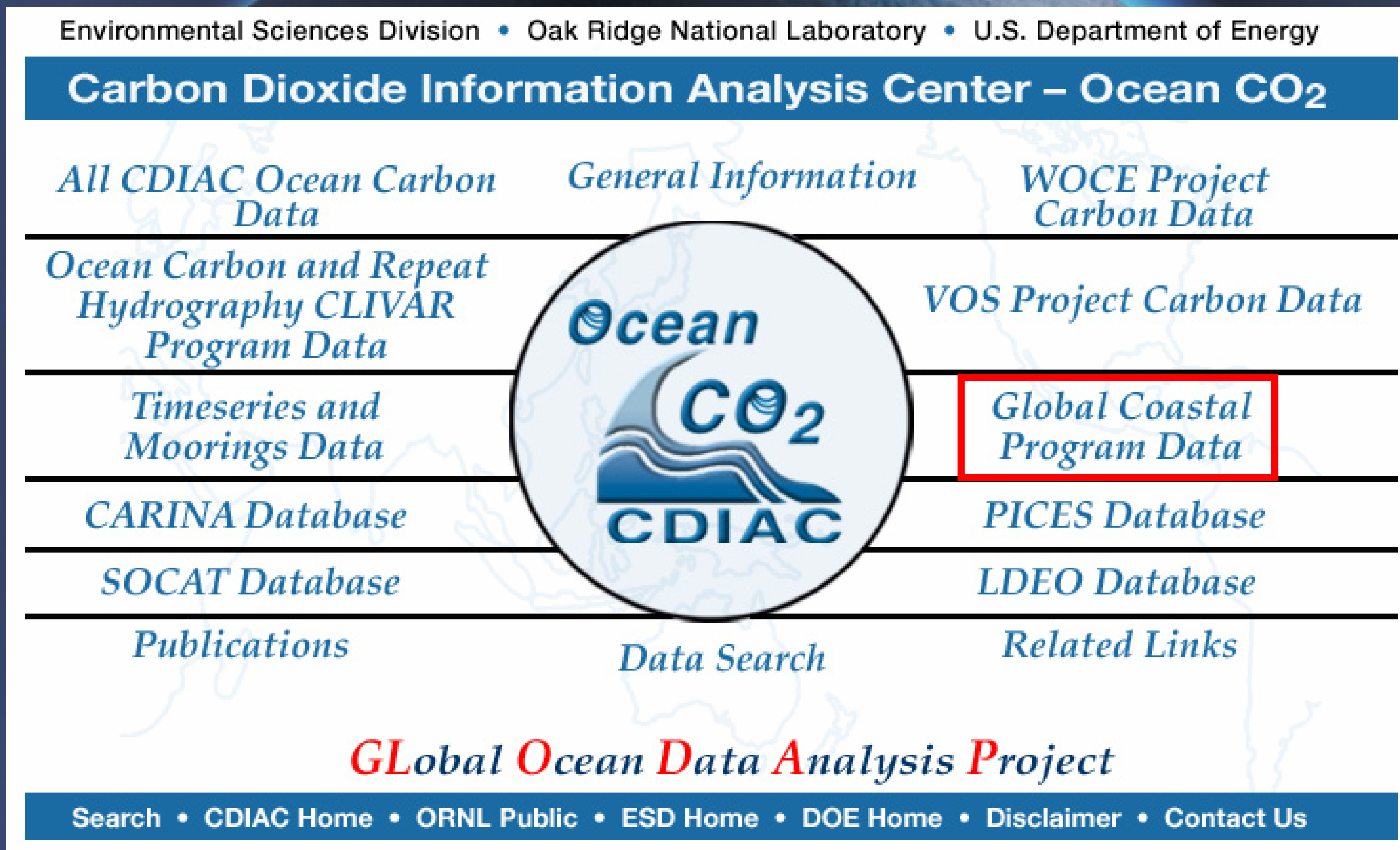
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Carbon Dioxide Information Analysis Center – Ocean CO_2
All CDIAC Ocean Carbon Data
General Information
WOCE Project Carbon Data
Ocean Carbon and Repeat Hydrography CLIVAR Program Data
VOS Project Carbon Data
Ocean CO_2 CDIAC
Timeseries and Moorings Data
Global Coastal Program Data
CARINA Database
PICES Database
SOCAT Database
LDEO Database
Publications
Data Search
Related Links
GLobal Ocean Data Analysis Project
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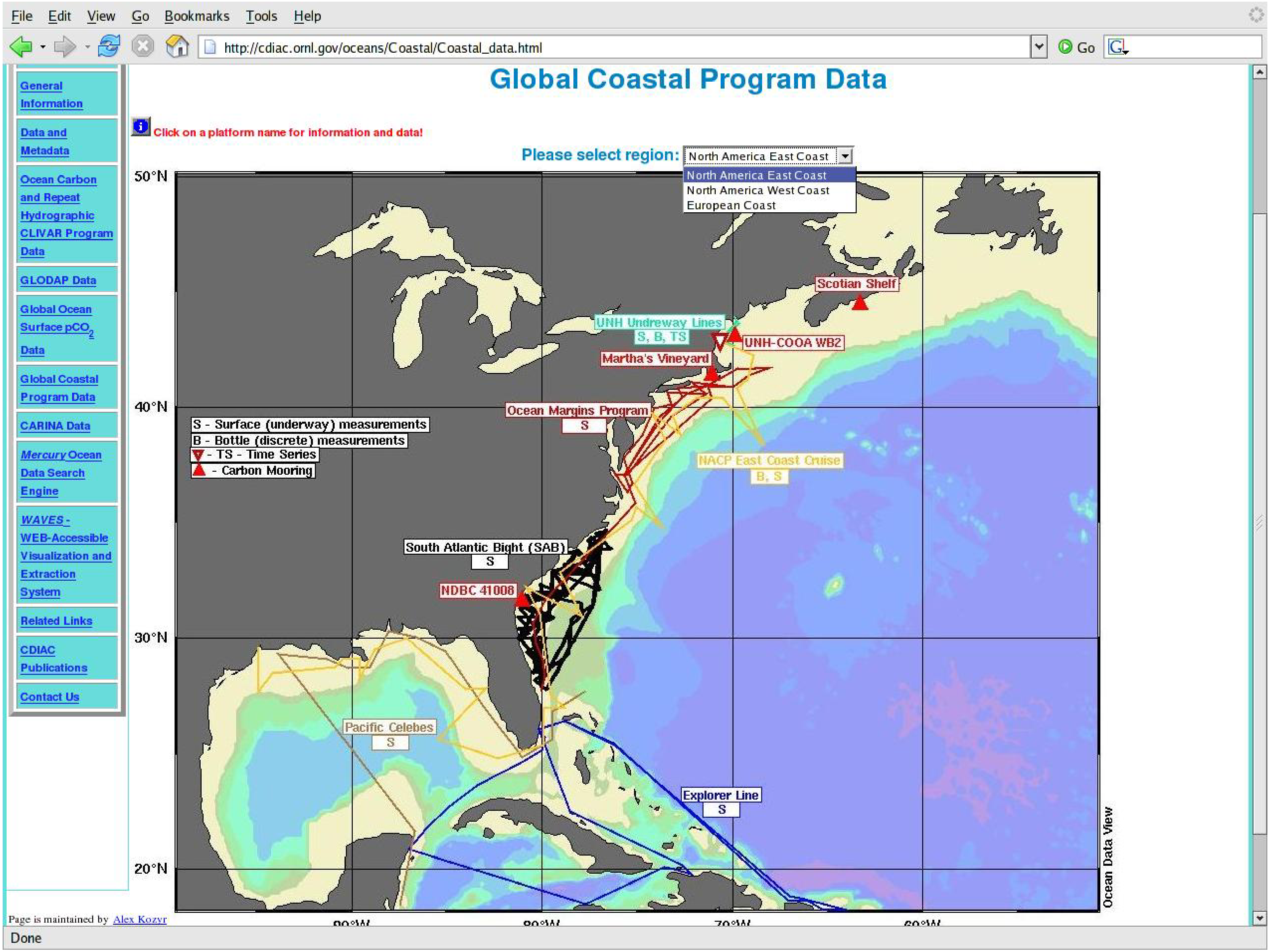
File Edit View Go Bookmarks Tools Help
http://cdiac.ornl.gov/oceans/Coastal/Coastal_data.html
Go
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO2 Data
Global Coastal Program Data
CARINA Data
Mercury Ocean Data Search Engine
WAVES - WEB-Accessible Visualization and Extraction System
Related Links
CDIAC Publications
Contact Us
Page is maintained by Alex Kozyr
Global Coastal Program Data
Click on a platform name for information and data!
Please select region:
North America East Coast
North America East Coast
North America West Coast
European Coast
50°N
40°N
30°N
20°N
Scotian Shelf
UNH Undreway Lines
S, B, TS
UNH-COOA WB2
Martha's Vineyard
Ocean Margins Program
S
S - Surface (underway) measurements
B - Bottle (discrete) measurements
- TS - Time Series
- Carbon Mooring
NACP East Coast Cruise
B, S
South Atlantic Bight (SAB)
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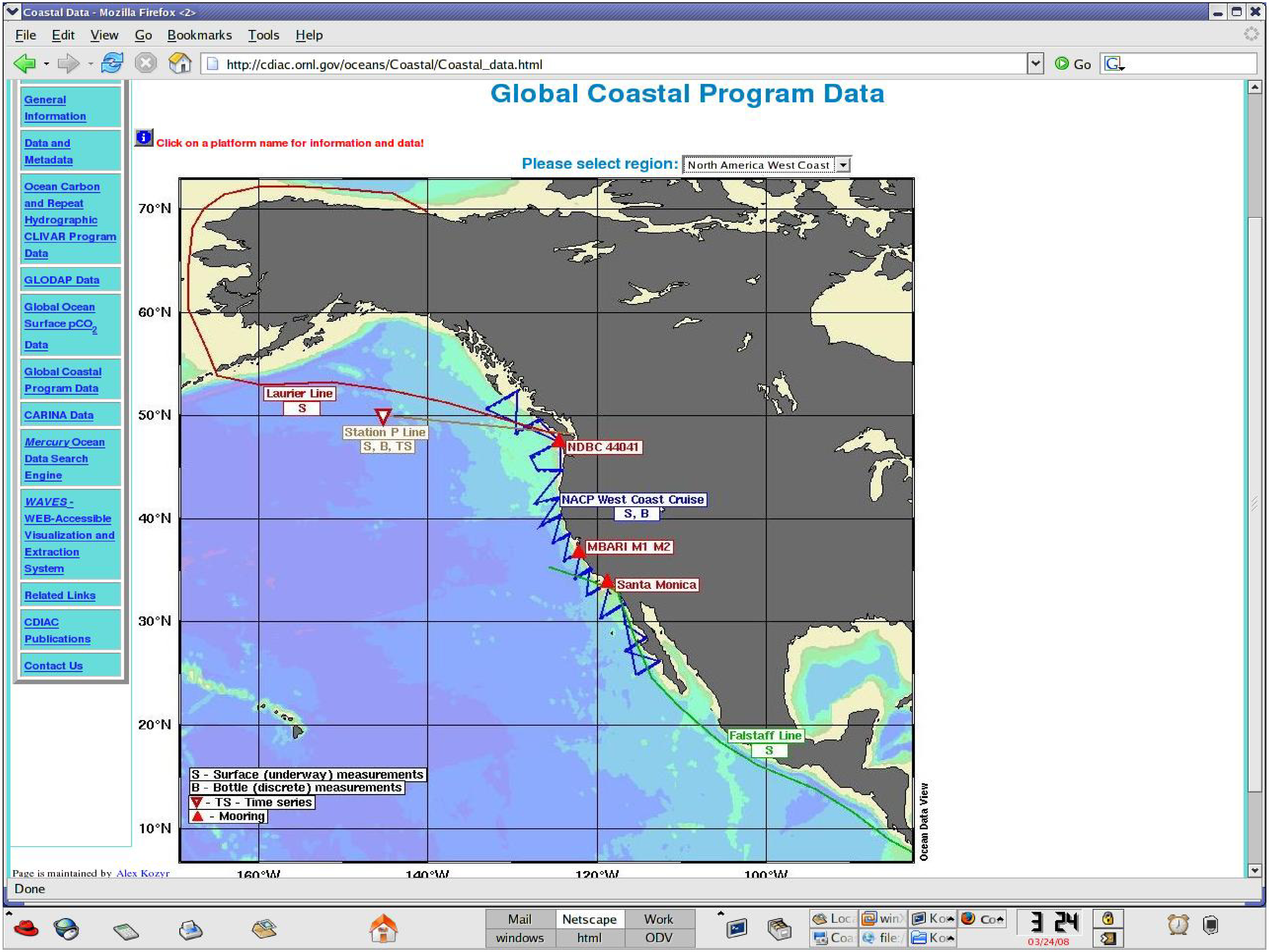
NDBC 41008
Pacific Celebes
S
Explorer Line
S
Ocean Data View
Done


Coastal Data - Mozilla Firefox <2>
File Edit View Go Bookmarks Tools Help
http://cdiac.ornl.gov/oceans/Coastal/Coastal_data.html
Go
Global Coastal Program Data
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO2 Data
Global Coastal Program Data
CARINA Data
Mercury Ocean Data Search Engine
WAVES - WEB-Accessible Visualization and Extraction System
Related Links
CDIAC Publications
Contact Us
Click on a platform name for information and data!
Please select region: North America West Coast
70°N
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NDBC 44041
NACP West Coast Cruise
S, B
MBARI M1 M2
Santa Monica
Falstaff Line
S
S - Surface (underway) measurements
B - Bottle (discrete) measurements
- TS - Time series
- Mooring
Ocean Data View
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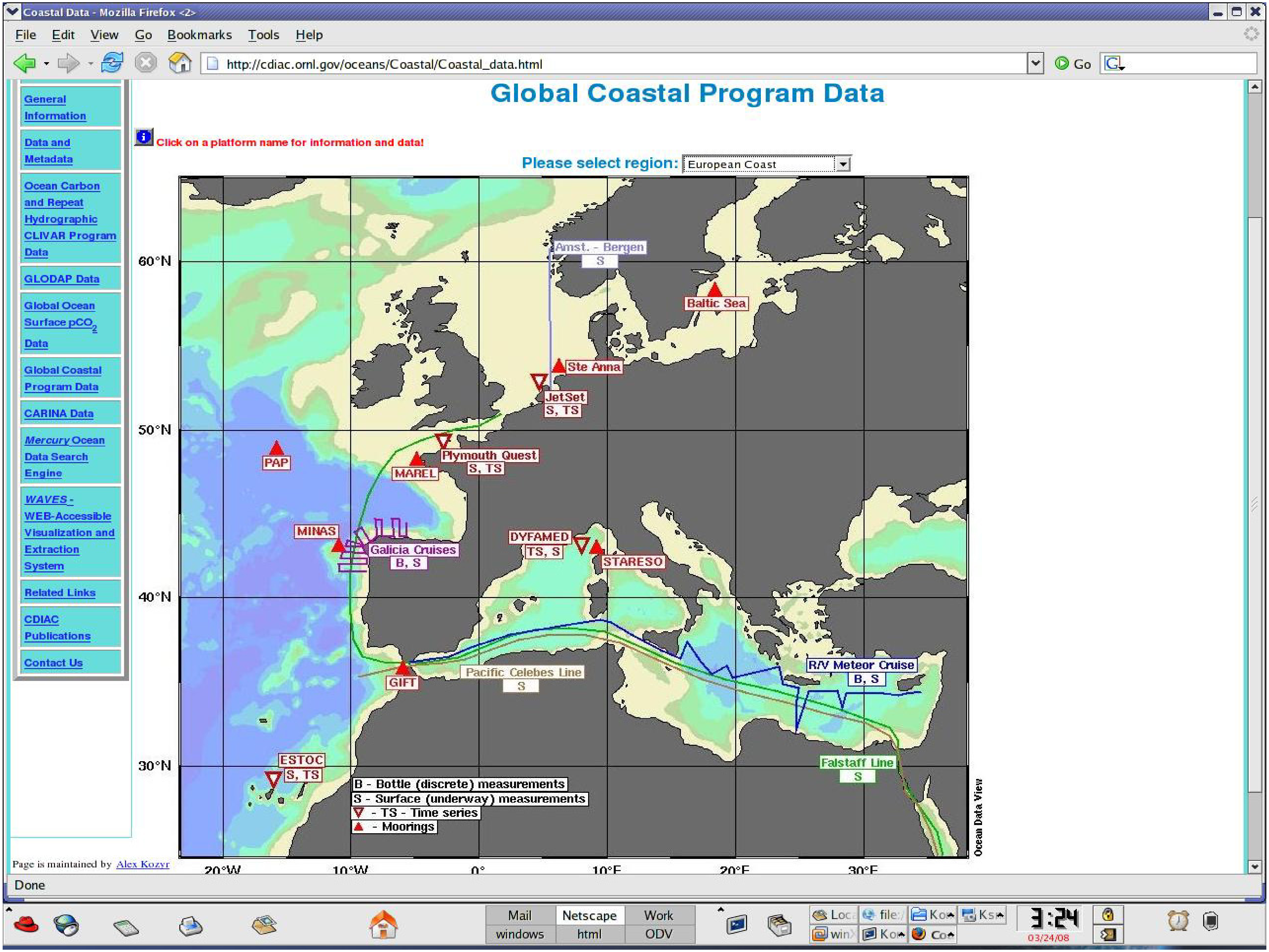
Mail
windows
Netscape
html
Work
ODV
03/24/08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File Edit View Go Bookmarks Tools Help
http://cdiac.ornl.gov/oceans/Coastal/Coastal_data.html
Go
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO2 Data
Global Coastal Program Data
CARINA Data
Mercury Ocean Data Search Engine
WAVES - WEB-Accessible Visualization and Extraction System
Related Links
CDIAC Publications
Contact Us
Page is maintained by Alex Kozyr
Global Coastal Program Data
Click on a platform name for information and data!
Please select region: European Coast
Amst. - Bergen
S
Baltic Sea
Ste Anna
JetSet
S, TS
Plymouth Quest
S, TS
MAREL
PAP
MINAS
Galicia Cruises
B, S
DYFAMED
TS, S
STARESO
GIFT
Pacific Celebes Line
S
R/V Meteor Cruise
B, S
Falstaff Line
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S, TS
B - Bottle (discrete) measurements
S - Surface (underway) measurements
- TS - Time series
- Moorings
Ocean Data View
60°N
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Done
Mail windows
Netscape html
Work ODV
03/24/08

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All CDIAC Ocean Carbon Data	*General Information*	*WOCE Project Carbon Data*
Ocean Carbon and Repeat Hydrography CLIVAR Program Data		*VOS Project Carbon Data*
Timeseries and Moorings Data		*Global Coastal Program Data*
CARINA Database		*PICES Database*
SOCAT Database		*LDEO Database*
Publications	*Data Search*	*Related Links*

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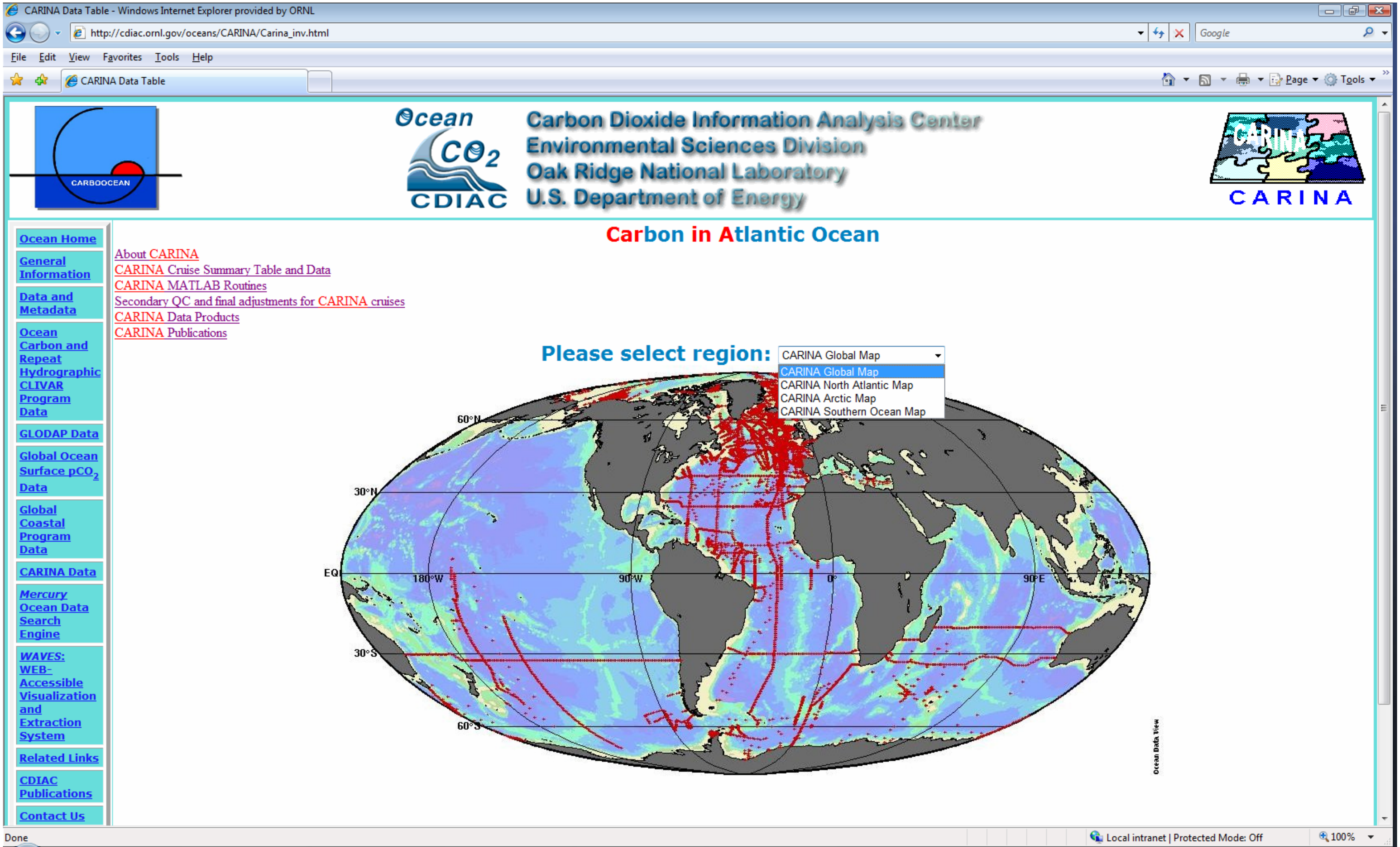
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File Edit View Favorites Tools Help
CARINA Data Table
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Carbon Dioxide Information Analysis Center
Environmental Sciences Division
Oak Ridge National Laboratory
U.S. Department of Energy
CARINA
Carbon in Atlantic Ocean
Ocean Home
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
Global Ocean Surface pCO2 Data
Global Coastal Program Data
CARINA Data
Mercury Ocean Data Search Engine
WAVES: WEB-Accessible Visualization and Extraction System
Related Links
CDIAC Publications
Contact Us
About CARINA
CARINA Cruise Summary Table and Data
CARINA MATLAB Routines
Secondary QC and final adjustments for CARINA cruises
CARINA Data Products
CARINA Publications
Please select region:
CARINA Global Map
CARINA Global Map
CARINA North Atlantic Map
CARINA Arctic Map
CARINA Southern Ocean Map
60°N
30°N
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60°S
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Ocean Data View
Done
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CARINA Data Table

- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES:* WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

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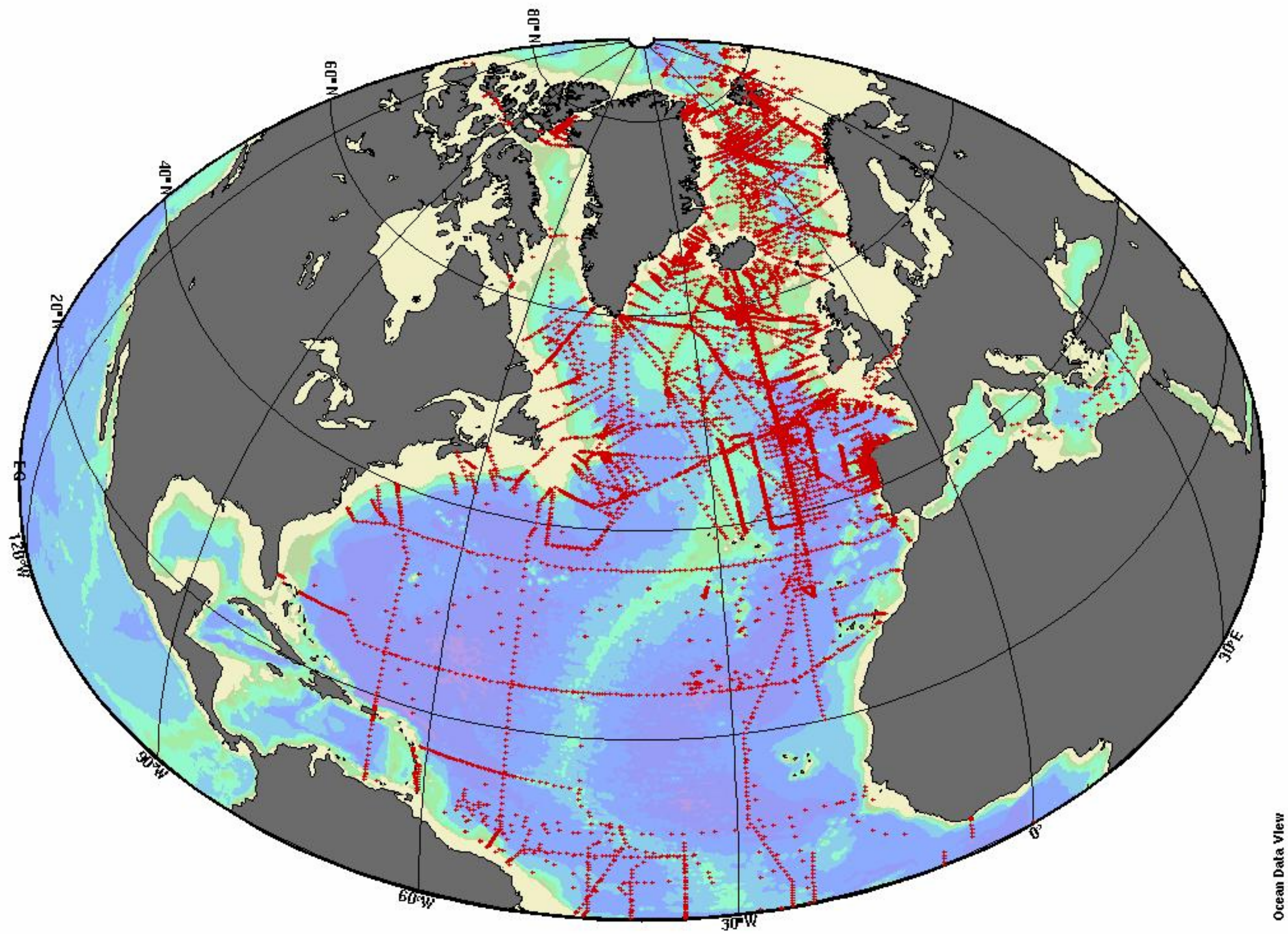

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CARINA Data Table

- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES:* WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

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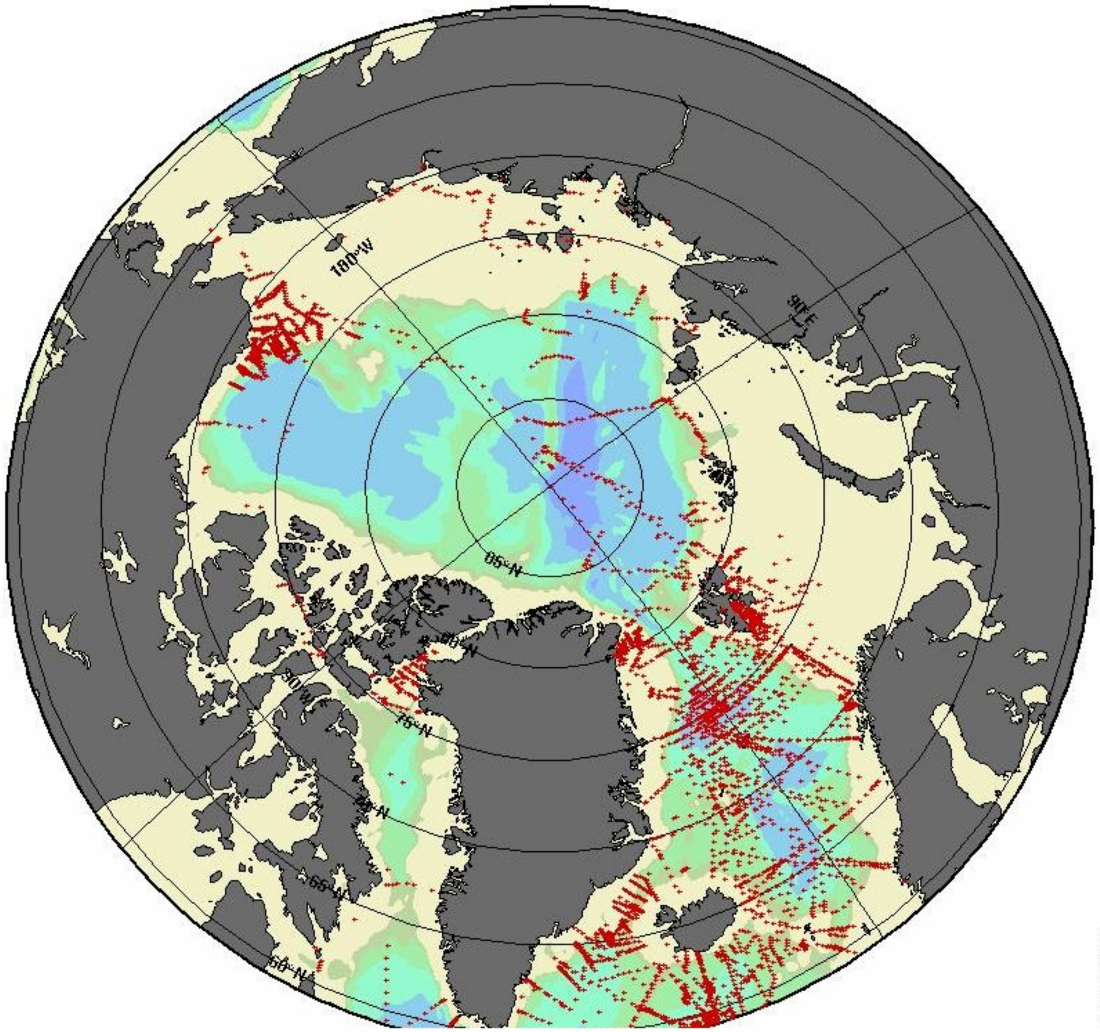

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CARINA Data Table

- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES:* WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

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CARINA Publications

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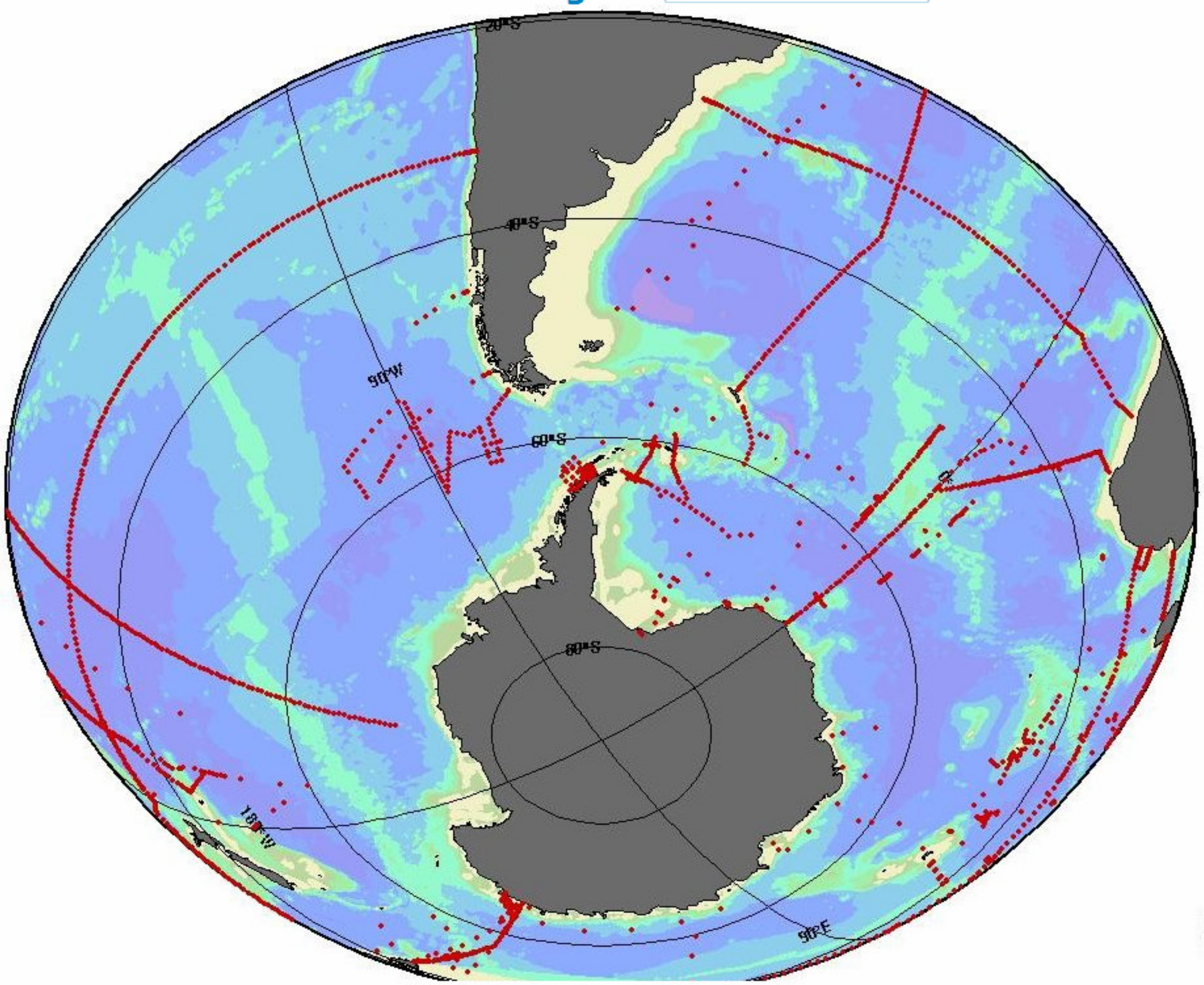

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Carbon dioxide in the Atlantic Ocean

CARINA

home
data inventory
overview
info board

welcome to CARINA

NEW! **CARbon dioxide IN the Atlantic Ocean** NEW!

2nd CARINA general meeting and open science conference

FEB. 26 - MAR 1, 03

Gran Canaria, Spain

more......

The project CARINA (carbon dioxide in the Atlantic Ocean) emerged from a workshop on "CO_2 in the northern North Atlantic", that was held in June 1999 in Delmenhorst, Germany (overview). Objectives are:

- to bring together research groups that measure CO_2 in the Atlantic Ocean (CARINA partners)
- to create an inventory of CO_2-measurements carried out in the Atlantic Ocean (data inventory)
- to make available also yet unpublished data to the data contributors (data access).
- to form working groups, that cooperate on various aspects of the CO_2 system in the Atlantic (working groups)
- to exchange actual information concerning CO_2 research in the Atlantic and assist in future cooperation (info board)

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U.S. Department of Energy

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- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES*: WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications

CARINA Cruise Summary Table and Data

Notes:
1. Users are requested to report any data or metadata errors in the CARINA cruise files to CDIAC.
2. Parameter units in all CARINA data files are in CCHDO exchange format.

Last updated: 08-April-2009

No	Cruise Name[a] (Alias)	Area[b]	Number of Stations	Date[c]	Ship	Chief Scientist	Carbon PI	Oxygen	Nutrients	TCO_2[d]	TALK	pCO_2[e]	pH[f]	CFC	Other Measurements	Data Files
1	06AQ19920929[g] (06ANTX_6) (See map)	3	118	9/29-11/30/1992	*Polarstern*	V. Smetacek	M. Stoll, J. Rommets, H. De Baar, D. Bakker	62	114[h]	53	54[i]	U	C	0	Choloroa,b Fluorescence, NH_4	Data Files
2	06AQ19930806 (06ARKIX_4) (See map)	1	64	8/6-10/5/1993	*Polarstern*	D.K. Fëtterer	L. Anderson	64	63	63[j, bb]	0	0	0	59[he]	^3H, ^3He, ^{18}O, ^{14}C, ^{85}Kr, Ba[k]	Data Files
3	06AQ19960712[l] (06ARKXII, AQN12) (See map)	1	102	7/12-9/6/1996	*Polarstern*	E. Augstein	L. Anderson	102	102	78	63	0	82	97[m], [he]	^3H, ^3He[aw], ^{18}O, DOM, DOC	Data Files
4	06AQ19980328 (06AQANTXV_4, WOCE SR04e) (See map)	3	132	3/28-5/23/1998	*Polarstern*	E. Fahrbach	M. Hoppema, R. Bellerby	130	128	116[n]	0	U	0	104[o]	^3H, ^3He, ^4He, Neon, CFC-113	Data Files
5	06BE20001128 (06BE152, WOCE AR04) (See map)	2	122	11/28-12/27/2000	*Sonne*	M. Rhein		0	0	0	0	0	0	104[p]		Data Files
6	06GA19960613 (06GA276) (See map)	2	125[fv]	6/13-6/27/1996	*Gauss*	A. Sy	Schneider, H.Thomas	0	0	122	0	0	0	0		Data Files
7	06GA20000506 (06GA3501, WOCE AR19f) (See map)	2	75	5/6-6/6/2000	*Gauss*	P. Kolterman	D. Wallace	74	74	59	60	0	C	0		Data Files
8	06MT19920316 (06MT021/1) (See map)	2	140	3/16-4/9/1992	*Meteor*	H.Thiel	K. Pegler	0	128	59	129	0	0	0	NH_4	Data Files

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CARINA MATLAB

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CARINA MATLAB Routines

Download MATLAB Crossover Toolbox

ABOUT CROSSOVER_TOOLBOX:

This set of m-files was created and developed during the secondary quality control of the CARINA data set.

This package allows users to perform consistency control (or secondary quality control) of hydrographic data using crossover analysis. The package also includes MATLAB routines to read the merged CARINA data files. Crossover location refers to cruise tracks that cross each other, or at least come close to each other. For each crossover, comparisons of the parameter concentrations were made in the deep part of the water column, normally > 1500 meters depth. The result of each crossover is an offset and a standard deviation of the offset. These offsets (and their uncertainty) were used to generate a set of corrections for each cruise with a set of least square models (inversions). Using the results from the inversion, the analyst can derive a set of adjustments that should (could) be applied to the data in order to make the dataset internally consistent. For more information, see Tanhua et al. (and references therein) in the CARINA special issue in Earth Systems Science Data, 2009 (in preparation).

For more information, please refer to the PDF file included in this package.

INSTALLING:

Download the zip directory and place the file(s) in a location that Matlab can see (or add the location of the file(s) to Matlab's search path). You will also need to have m-map installed on your system (available at http://www.eos.ubc.ca/~rich/map.html). See the attached pdf to get started.

CITATION:

Tanhua, T., 2009. *MATLAB program developed for secondary quality control of hydrographic data.*
http://cdiac.ornl.gov/ftp/oceans/CARINA/CARINA_MATLAB. Carbon Dioxide Information Analysis Center,
Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

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File Edit View Favorites Tools Help

Index of /ftp/oceans/CARINA/CARINA_Database

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Name	Last modified	Size	Description
Parent Directory		-	
CARINA.AMS.V1.0.csv.zip	01-Jul-2009 14:57	4.4M	
CARINA.ATL.V1.0.csv.zip	01-Jul-2009 11:10	8.6M	
CARINA.SO.V1.0.csv.zip	24-Jun-2009 10:53	3.7M	

Apache Server at cdiac.ornl.gov Port 80

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Carbon Dioxide Information Analysis Center
Environmental Sciences Division
Oak Ridge National Laboratory
U.S. Department of Energy

- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES*: WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

Publications Resulting from CARINA Project

- Falck, E., A. Olsen, et al. 2009. Nordic Seas oxygen data in CARINA. *ESSD.*
- Hoppema, A. Velo, S. van Heuven, T. Tanhua, R.M. Key, X. Lin, D.C.E. Bakker, F.F. Perez, A.F. Ríos, C. Lo Monaco, C.L. Sabine, M. Álvarez, and R.G.J. Bellerby. 2009. Consistency of cruise data of the CARINA database in the Atlantic sector of the Southern Ocean. *ESSD.*
- Jeansson, E., A. Olsson, T. Tanhua, et al. 2009. CARINA CFC data in the Nordic Seas. *ESSD.*
- Jutterström, S.A, L.G. Anderson, N.R. Bates, R. Bellerby, T. Johannessen, E.P. Jones, R.M. Key, X. Lin, A. Olsen, and A. Omar. 2009. Arctic Ocean data in CARINA. *ESSD.*
- Key, R.M., T. Tanhua, A. Olsen, M. Hoppema, S. Jutterström, C. Schirnick, S. van Heuven, A. Kozyr, X. Lin, A. Velo, D. Wallace and L. Mintrop. 2009. The CARINA data synthesis project: Introduction and overview. *ESSD*
- Lo Monaco, M. Álvarez, R. M. Key, X. Lin, T. Tanhua, B. Tilbrook, D. C. E. Bakker, S. van Heuven, M. Hoppema, N. Metzl, A. F. Ríos, C. L. Sabine and A. Velo. 2009. Assessing internal consistency of the CARINA database in the Indian sector of the Southern Ocean. *ESSD.*
- Olsen, A. R.M. Key, E. Jeansson, E. Falck, J. Olafsson, S. van Heuven, I. Skjelvan, A.M. Omar, K.A. Olsson, L.G. Anderson, S. Jutterström, F. Rey, T. Johannessen, R.G.J. Bellerby, J. Blindheim, J. Bullister, B. Pfeil, X. Lin, A. Kozyr, C. Schirnick, T. Tanhua and D.W.R. Wallace. 2009. Overview of the Nordic Seas CARINA data and salinity. *ESSD.*
- Olsen, A., et al. 2009. Nordic Seas total dissolved inorganic carbon data in CARINA. *ESSD.*
- Olsen, A., et al. 2009. Nordic Seas total alkalinity data in CARINA. *ESSD.*
- Olafson, J., A. Olsen, et al. 2009. Nordic Seas nutrient data in CARINA. *ESSD.*
- Sabine, C.L., M. Hoppema, R. M. Key, B. Tilbrook, S. van Heuven, C. Lo Monaco, N. Metzl, M. Ishii, A. Murata and S. Musielewicz. 2009. Assessing the internal consistency of the CARINA data base in the Pacific sector of the Southern Ocean. *ESSD.*
- Steinfeldt, R., T. Tanhua, M. Rhein, J.L. Bullister, D.W.R. Wallace, and J. Köhler. 2009. North Atlantic CFC data in CARINA. *ESSD.*
- Pierrot, D., P. Brown, S. van Heuvan, T. Tanhua, U. Schuster, R. Wanninkhof and R.M. Key. 2009. CARINA TCO2 Data in the Atlantic Ocean. *ESSD.*
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- Tanhua, T., S. van Heuven, R.M. Key, A. Velo, A. Olsen, C. Schirnick. 2009. Quality control procedures and methods of the CARINA database. *ESSD.*
- Velo, A., F.F. Perez, P. Brown, T. Tanhua, U. Schuster and R.M. Key. 2009. CARINA Alkalinity data in the Atlantic Ocean. *ESSD.*
- Velo, A., F.F. Perez, X. Lin, R.M. Key, T. Tanhua, M. de lo Paz, S. van Heuven, S. Jutterström, and A.F. Ríos. 2009. CARINA pH data. *ESSD.*

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PICES Cruise Summary Table and Data

Last updated: 04-June-2007

Cruise Name	No. Sta.	Date[a]	Ship	Chief Scientist	Carbon PI	TCO_2	TALK	pCO_2[b]	pH	CFC	Other Measurements	Data Files
09AR20011029 CLIVAR SR03_2001 (See map)	135	10/29 – 11/22/2001	*Aurora Australis*	S. Rintoul	B.Tilbrook	97	96	0	0	88	CFC113	Data files
09FA20010524 CLIVAR P15S_2001 (See map)	129	05/24 – 07/08/2001	*Franklin*	S. E. Wijffels	B.Tilbrook	126	125	0	0	107	CFC113, CCl_4	Data files
49NZ20010725 CLIVAR P17N_2001 (See map)	79	07/25 – 08/28/2001	*Mirai*	M. Fukasawa	A.Murata	37	37	0	37	0	^{14}C, ^{13}C	Data files
33KK20020701 MP-5 (See map)	17	07/01 – 07/15/2002	*Kaimikai-O-Kanaloa*	R. Siefert	P. Yager	17	17	0	0	0	No nutrients	Data files
33KB20020923 M-P6 (See map)	34	09/23 – 10/15/2002	*Kilo Moana*	D.Capone	P. Yager	34	34	0	0	0	No Nutrients	Data files
33RR20030714 MP-9 (See map)	32	07/14 – 08/21/2003	*Roger Revelle*	R. Siefert	P. Yager	32	32	0	0	0	No Nutrients	Data files

Done

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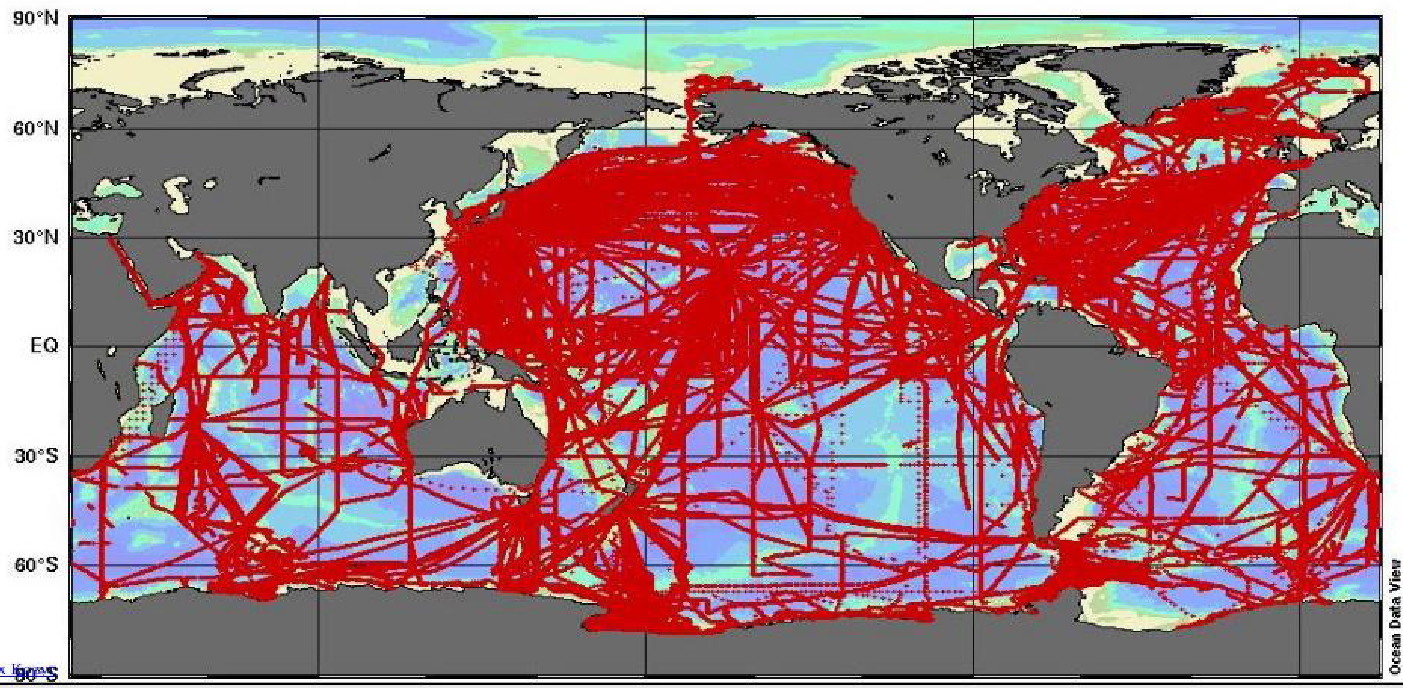
Global Surface pCO_2 (LDEO) Database

- LDEO Database (V1.0 and V2007) ASCII Files
- LDEO Database V2007 ODV Collection
- Takahashi Annual Flux Gridded Database with spatial resolution of 4° (latitude) X 5° (longitude).
- *WAVES*: LDEO Database V1.0 Search (will be updated soon)
- *LAS*: LDEO Database V1.0 Search (will be updated soon)

Metadata for the dataset can be found in: Takahashi, T., S.C. Sutherland, and A. Kozyr. 2007. Global Ocean Surface Water Partial Pressure of CO_2 Database: Measurements Performed During 1968 - 2007 (Version 2007). ORNL/CDIAC-152, NDP-088a. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, 20 pp.

Dataset should be cited as: Takahashi, T., S. C. Sutherland, R. Wanninkhof, C. Sweeney, R. A. Feely, D. W. Chipman, B. Hales, G. Friederich, F. Chavez, C. Sabine, A. Watson, D. C. E. Bakker, U. Schuster, N. Metzl, H. Y. Inoue, M. Ishii, T. Midorikawa, Y. Nojiri, A. Koertzinger, T. Steinhoff, M. Hoppema, J. Olafsson, T. S. Arnarson, B. Tilbrook, T. Johannessen, A. Olsen, R. Bellerby, C. S. Wong, B. Delille, N. R. Bates, H. J. W. de Baar. 2008. Climatological Mean and Decadal Change in Surface Ocean pCO_2, and Net Sea-air CO_2 Flux over the Global Oceans. Deep -Sea Research II, accepted April 2008.



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Global Ocean Surface Water Partial Pressure of CO_2 Database WAVES search

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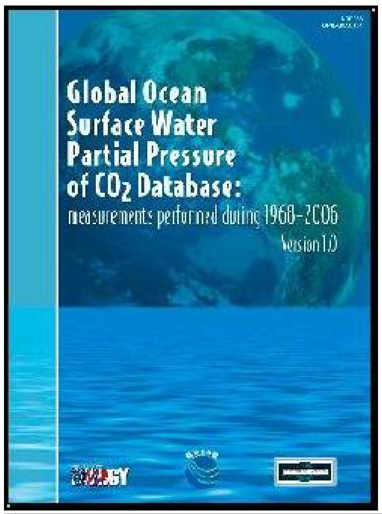

Contributed by

Taro Takahashi and **Stewart C. Sutherland**

Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY

Prepared by

Alex Kozyr

Carbon Dioxide Information Analysis Center

Oak Ridge National Laboratory

Oak Ridge, Tennessee, U.S.A.

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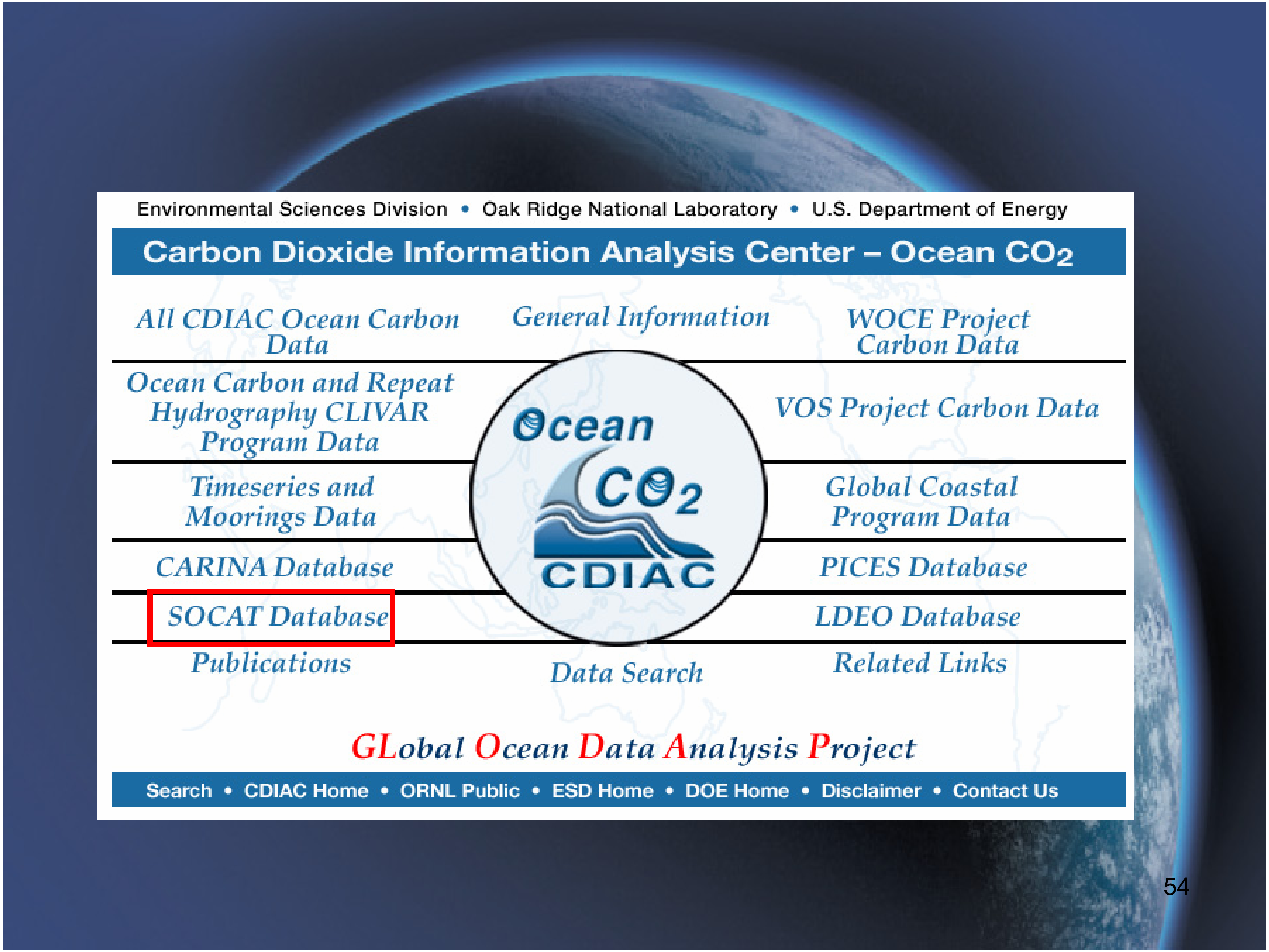
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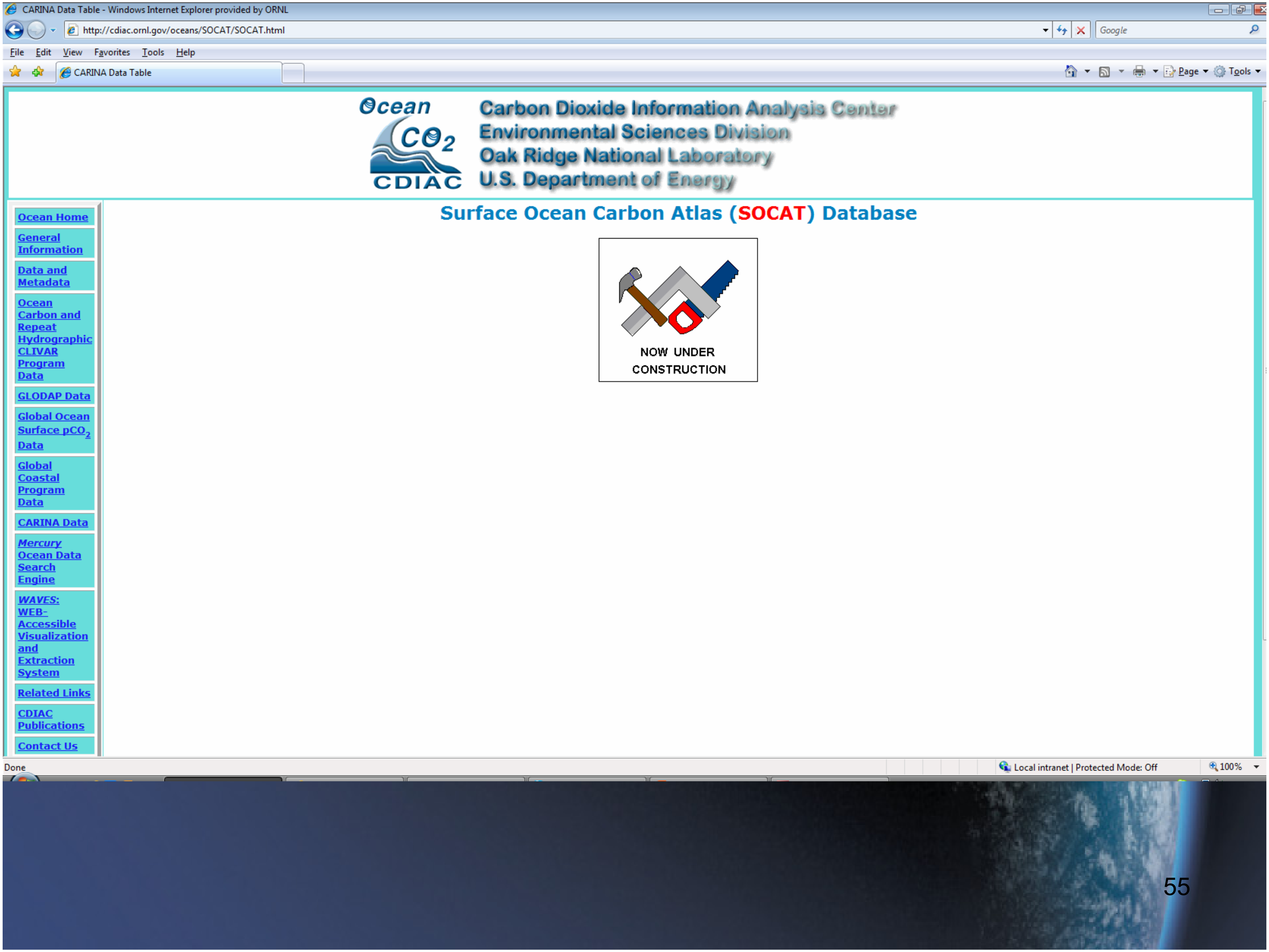
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Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
GLODAP Data
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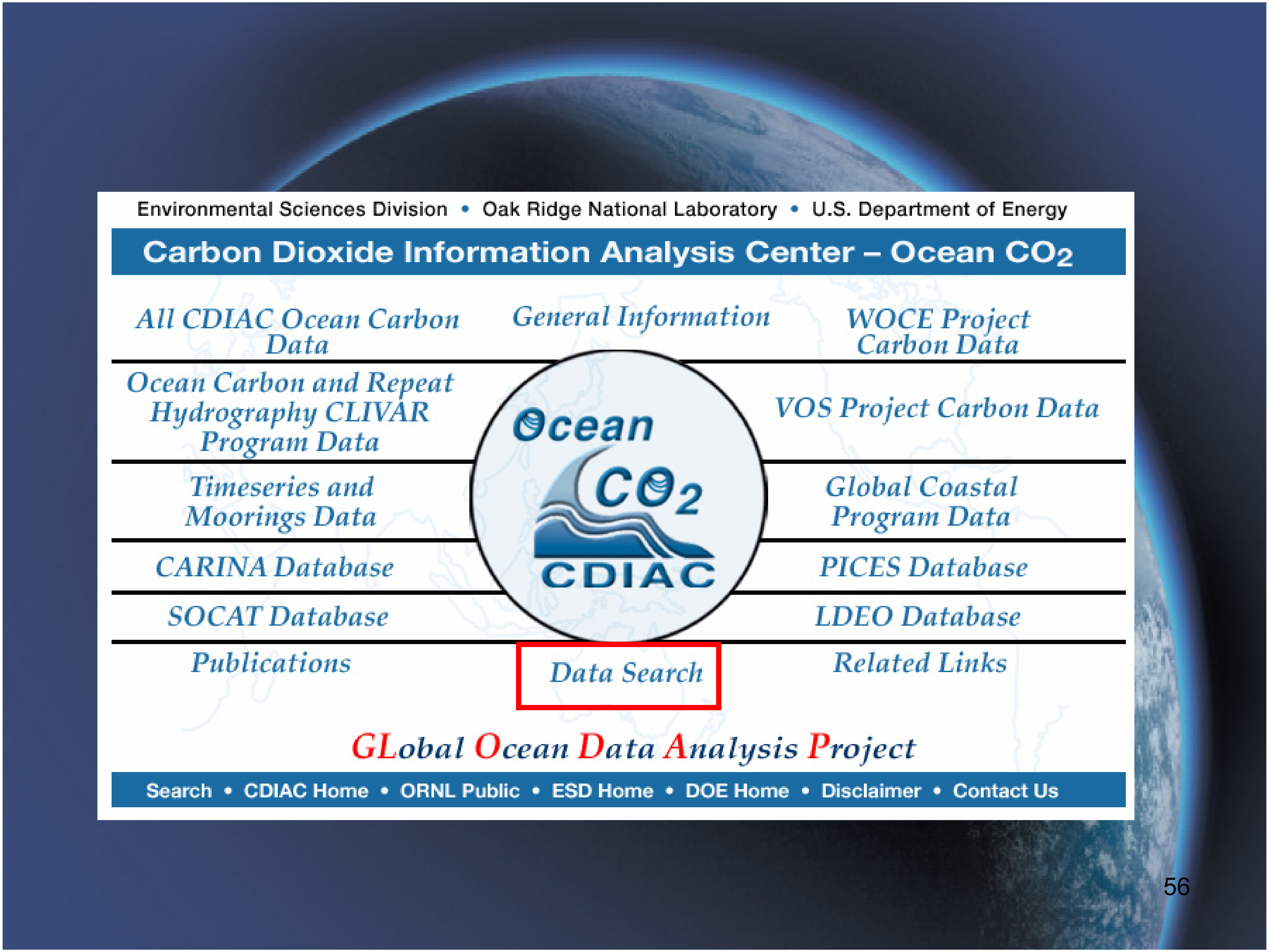
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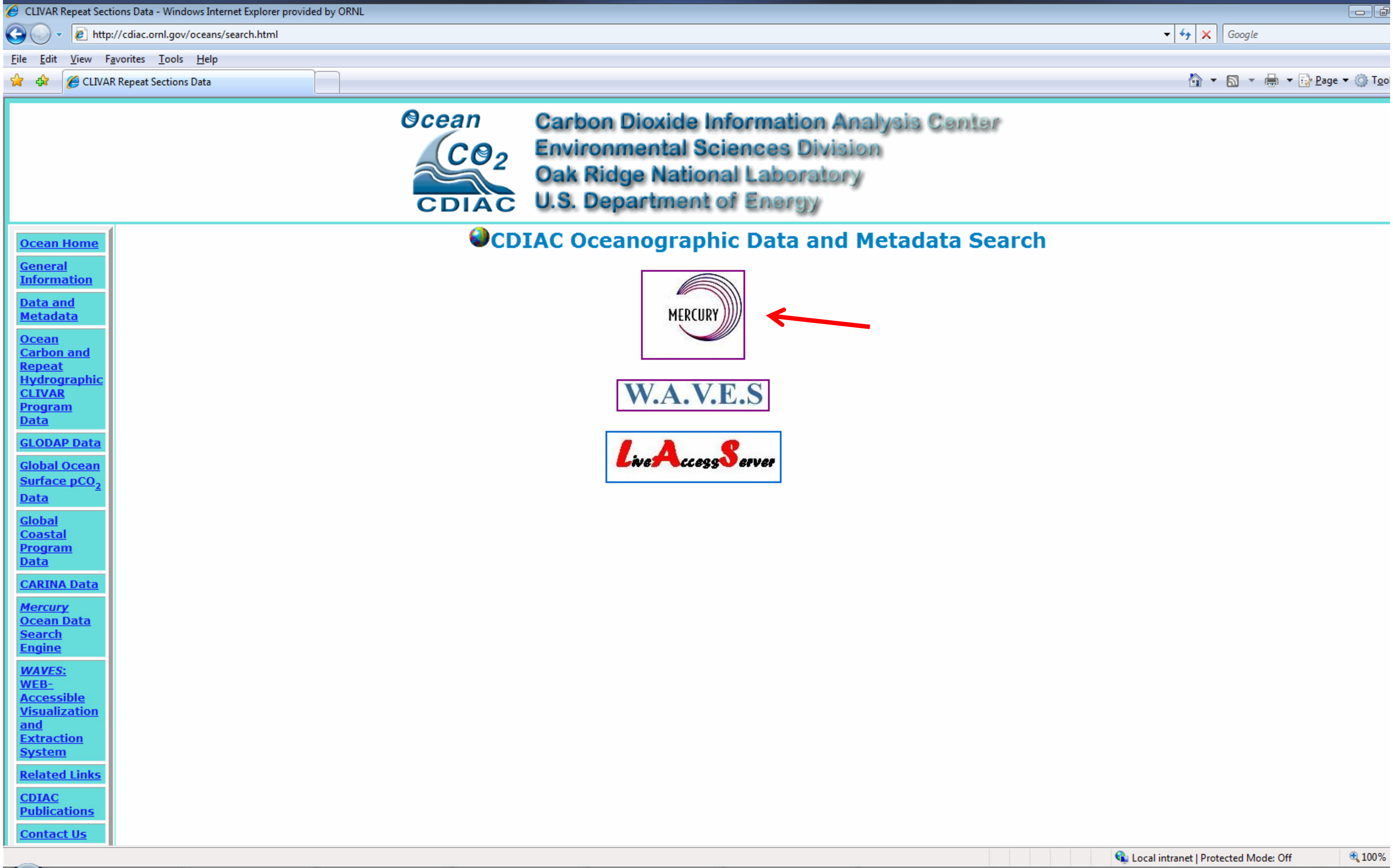
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Ocean Home
General Information
Data and Metadata
Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
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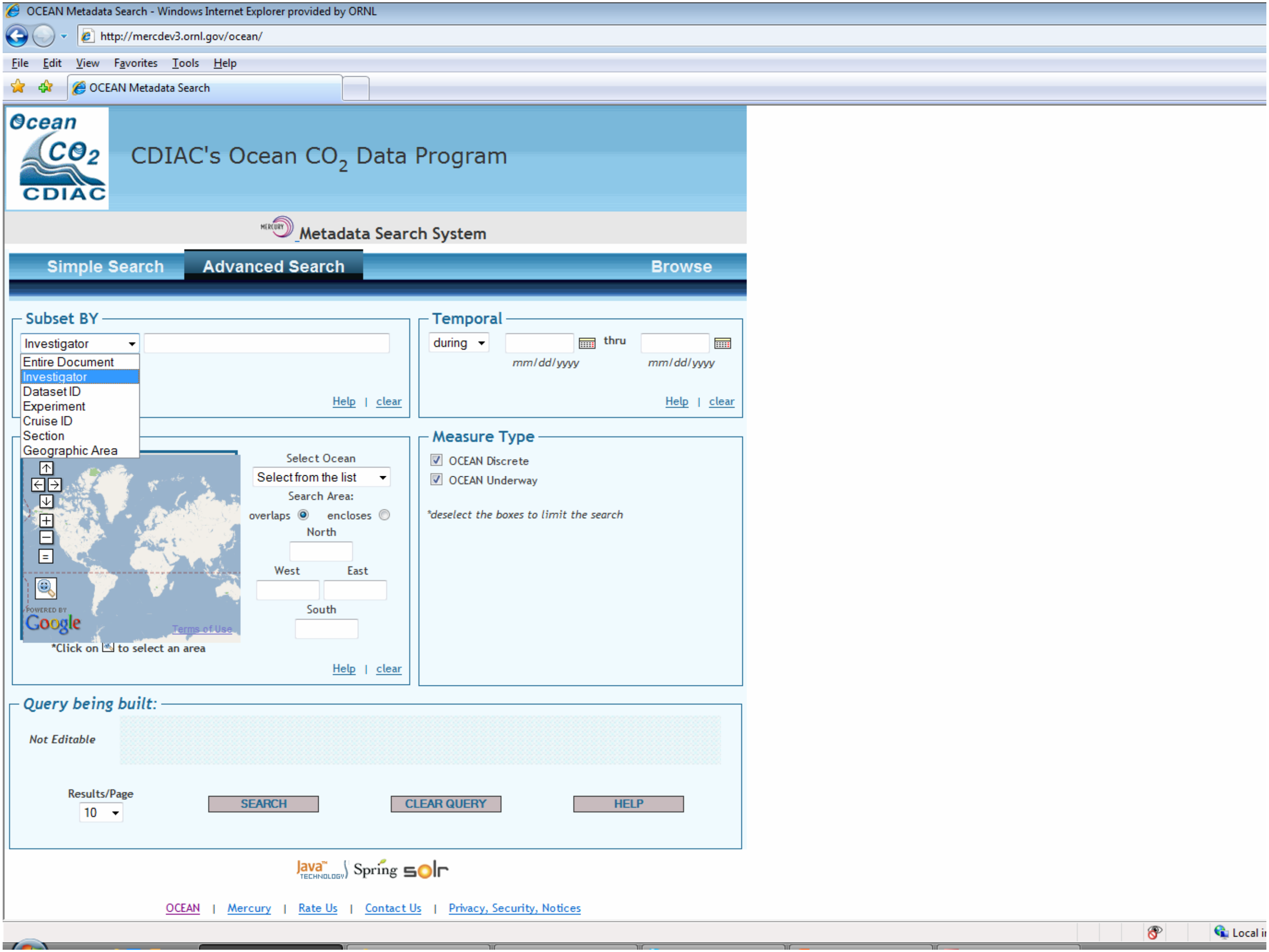
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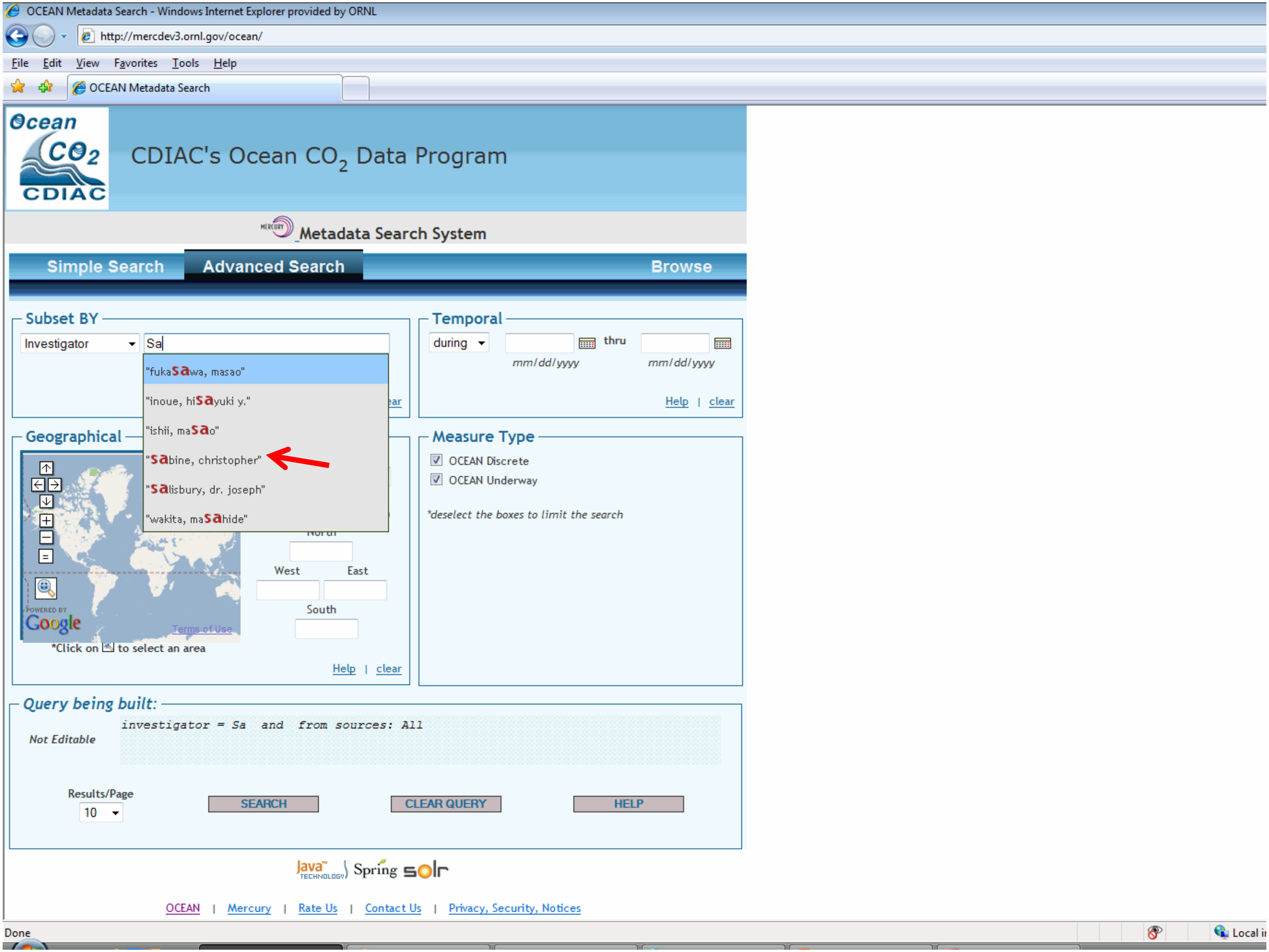
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Ocean CO_2 CDIAC

CDIAC's Ocean CO_2 Data Program

Metadata Summary

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Your search found: 11 documents.
Query: Investigator:sabine, christopher AND (datasource :(oceanbt))

Filter by data providers	Filter by Geographical Region	Filter by Cruise ID	Filter by Variables
OCEAN Discrete (11)	atlantic ocean (3)	09ar20011029 (1)	talk (9)
	indian ocean (3)	09fa20010524 (1)	tco2 (9)
	pacific ocean (3)	316n145 13 (1)	ctd oxygen (7)
	southern pacific (2)	316n145 6 (1)	ctd temperature (7)
		316n20030922, (kn173/1) (1)	nitrate (7)
		316n20031023, (kn173/2) (1)	nitrite (7)
		325020060213 (1)	phosphate (7)
		3250tn026 1 (1)	silicate (7)

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clivar_p15s_2001 — 05/24/2001 - 07/07/2001
Datasource: OCEAN Discrete
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woce_i10 — 11/05/1995 - 11/23/1995
Datasource: OCEAN Discrete
View full metadata

woce_p10 — 10/05/1993 - 11/10/1993
Datasource: OCEAN Discrete
View full metadata

clivar_a20_2003, carina 316n20030922 — 09/22/2003 - 10/23/2003
Datasource: OCEAN Discrete
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clivar_p16s_2005 — 01/06/2005 - 02/19/2005
Datasource: OCEAN Discrete
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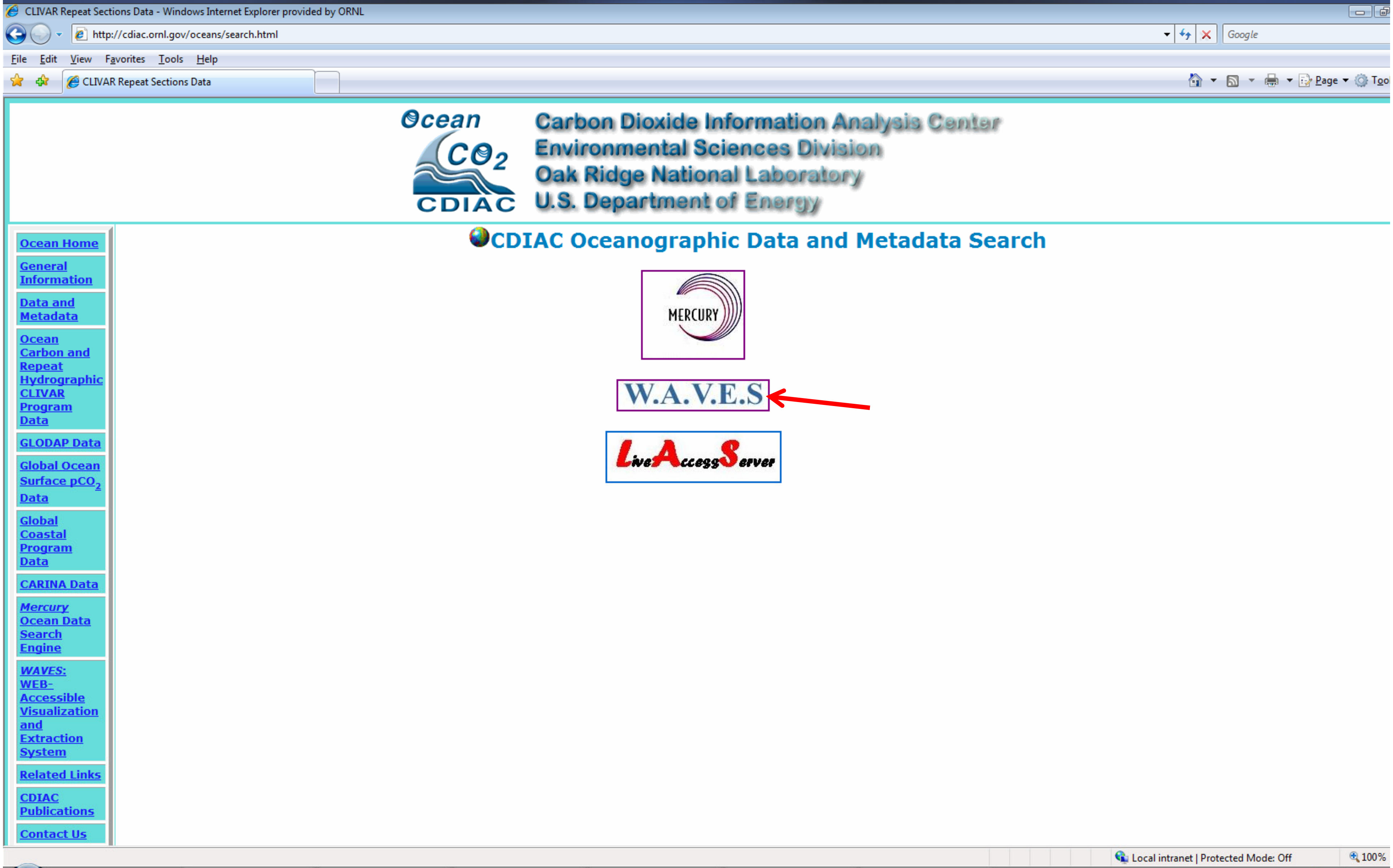
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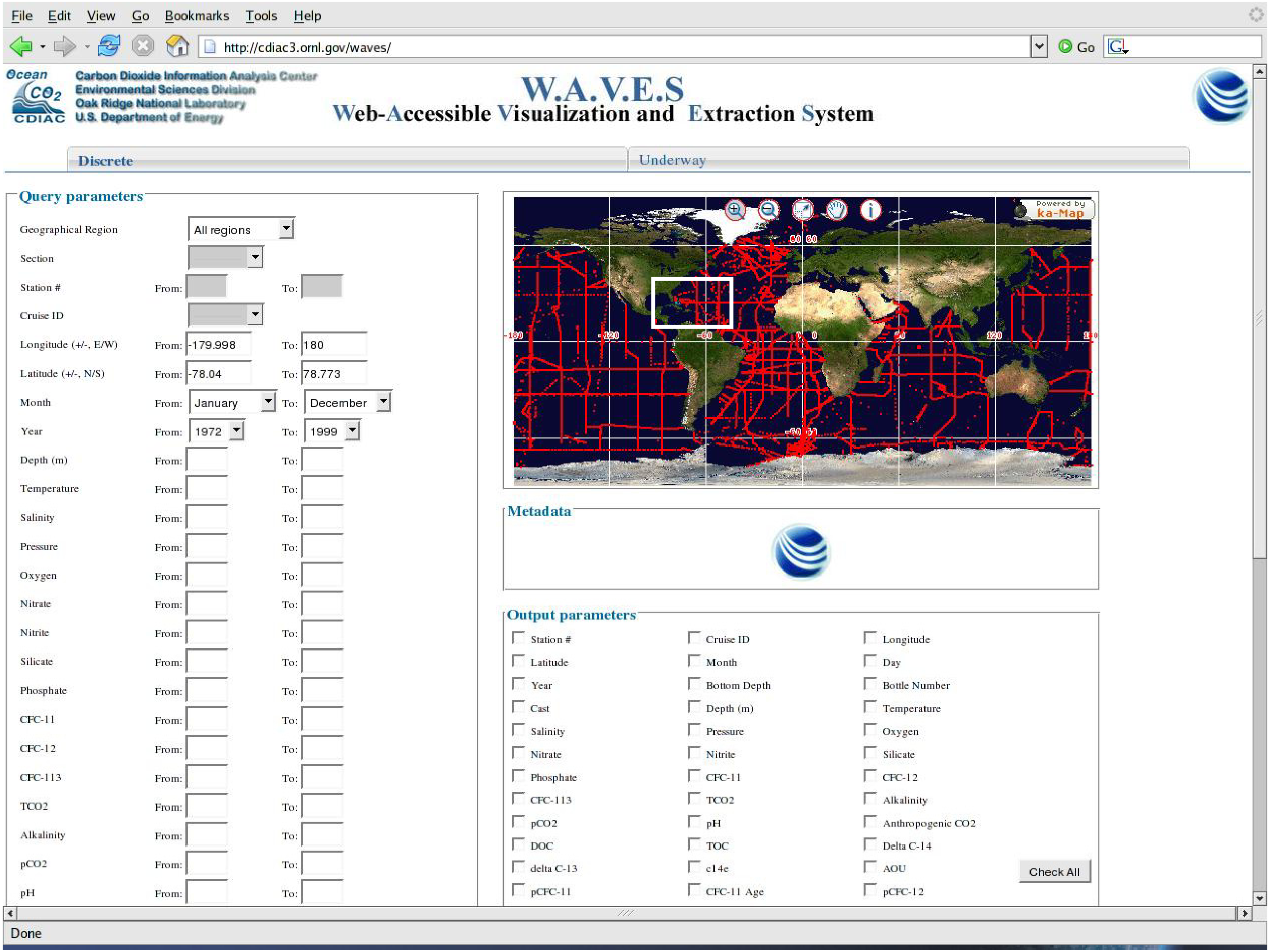
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Discrete
Underway
Query parameters
Geographical Region
All regions
Section
Station #
From:
To:
Cruise ID
Longitude (+/-, E/W)
From: -179.998
To: 180
Latitude (+/-, N/S)
From: -78.04
To: 78.773
Month
From: January
To: December
Year
From: 1972
To: 1999
Depth (m)
Temperature
Salinity
Pressure
Oxygen
Nitrate
Nitrite
Silicate
Phosphate
CFC-11
CFC-12
CFC-113
TCO2
Alkalinity
pCO2
pH
Powered by ka-Map
-180
-120
-60
0
60
120
180
60
-60
Metadata
Output parameters
Station #
Cruise ID
Longitude
Latitude
Month
Day
Year
Bottom Depth
Bottle Number
Cast
Depth (m)
Temperature
Salinity
Pressure
Oxygen
Nitrate
Nitrite
Silicate
Phosphate
CFC-11
CFC-12
CFC-113
TCO2
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Discrete | Underway

Query parameters

Geographical Region	Atlantic Ocean			
Section	All sections			
Station #	From:	558	To:	47379
Cruise ID	All cruises			
Longitude (+/-, E/W)	From:	-78.623468	To:	-48.288429
Latitude (+/-, N/S)	From:	6.19082429	To:	40.2403578
Month	From:	January	To:	December
Year	From:	1972	To:	1998
Depth (m)	From:		To:	
Temperature	From:		To:	
Salinity	From:		To:	
Pressure	From:		To:	
Oxygen	From:		To:	
Nitrate	From:		To:	
Nitrite	From:		To:	
Silicate	From:		To:	
Phosphate	From:		To:	
CFC-11	From:		To:	
CFC-12	From:		To:	
CFC-113	From:		To:	
TCO2	From:		To:	
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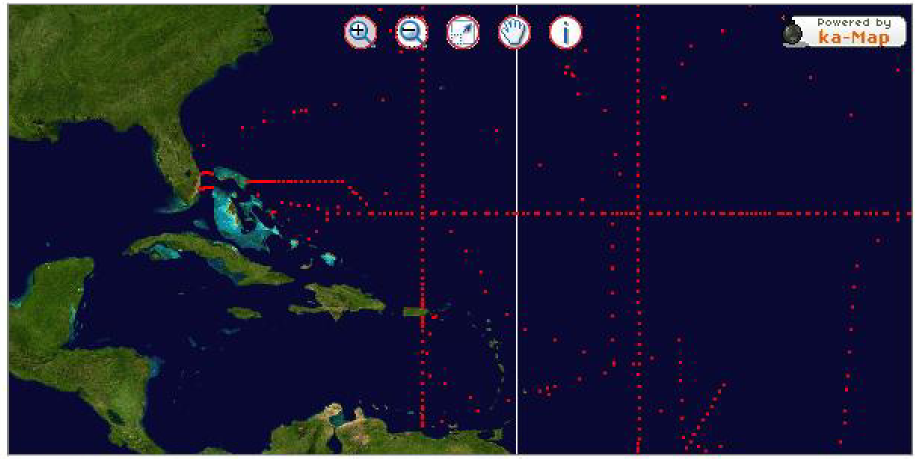
pCO2	From:		To:	
pH	From:		To:	



Metadata

Geographical Region: Atlantic Ocean

Section(s): WOCE_A05, WOCE_AR01(A05), WOCE_A06, WOCE_A17, WOCE_A20, GEOSECS Atlantic, TTO-NAS, TTO-TAS, WOCE_A22.

Output parameters

Station #	Cruise ID	Longitude
Latitude	Month	Day
Year	Bottom Depth	Bottle Number
Cast	Depth (m)	Temperature
Salinity	Pressure	Oxygen
Nitrate	Nitrite	Silicate
Phosphate	CFC-11	CFC-12
CFC-113	TCO2	Alkalinity
pCO2	pH	Anthropogenic CO2
DOC	TOC	Delta C-14
delta C-13	c14e	AOU
pCFC-11	CFC-11 Age	pCFC-12

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OCEAN Mercury Metadata Report

CDIAC's Ocean CO_2 Data Program

Metadata Summary

Search Criteria: dataset id:"woce_a05" and (datasource :(oceanbt))

Email

Dataset_ID: WOCE_A05

Investigator(s)
Name: Millero, Frank J.
Organization: RSMAS/MAC
Address: University of Miami,4600 Rickenbacker Causeway,Miami, FL 33149
Phone: (305) 361-4707
Email: fmillero@rsmas.miami.edu

Dataset Info: **Dataset ID:**WOCE_A05

Submission Dates:
Initial Submission: 20040611
Revised Submission: 20040611

Cruise Info: **Experiment:**
Experiment Name: WOCE

Cruise:
Cruise ID: 29HE06_1-3
Section: WOCE_A05
Geographical Coverage:
Geographical Region: Atlantic Ocean

Bounds:

North	West	South	East	
25	-79	25	-15	Locate

-79 -15 25 25

Temporal Coverage: **Start Date:** 19920615 **End Date:** 19920723

Done

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OCEAN Mercury Metadata Report

Temporal Coverage:	**Start Date:** 19920615 **End Date:** 19920723
Vessel:	**Vessel Name:**R/V Hespérides **Vessel ID:**29HE **Country:**Spain **Vessel Owner:**Armada Espanola
Data Center URL:	http://cdiac.esd.ornl.gov/
Download Data Sets:	Descrete measurments from WOCE A05 Section
Variable Info:	

Variable Name	Description of Variable
CTD Pressure	DBAR
CTD Temperature	
CTD Salinity	
Bottle Salinity	
CTD Oxygen	UMOL/KG
Bottle Oxygen	UMOL/KG
Silicate	UMOL/KG
Nitrate	UMOL/KG
Nitrite	UMOL/KG
Phosphate	UMOL/KG
CFC-11	PMOL/KG
CFC-12	PMOL/KG
DELC14	/MILLE
TCO2	UMOL/KG
TALK	UMOL/KG
pH	@25 degree C
C14 Error	/MILLE

Method Description:

Total C02 Data:

- **TCO2 Analysis Method:**
- **Standardization Technique:**
  - **Technique Description:**
  - **Sample Volume:**
  - **CRM Info:**
    - **Correction Magnitude:**
    - **Batch Number:**
    - **CRM Analysis Info:**
- **Field Replicate Info:**
- **Poisoning Info:**
  - **Poisoning Correction Description:**
  - **Poison Volume:**
- **Accuracy Info:** Based upon the CRM calibrations at sea, accuracy of the measured parameters is estimated to be ±7 µmol/kg for TALK and TCO2
- **Method References:**
- **Citations:**

Alkalinity:

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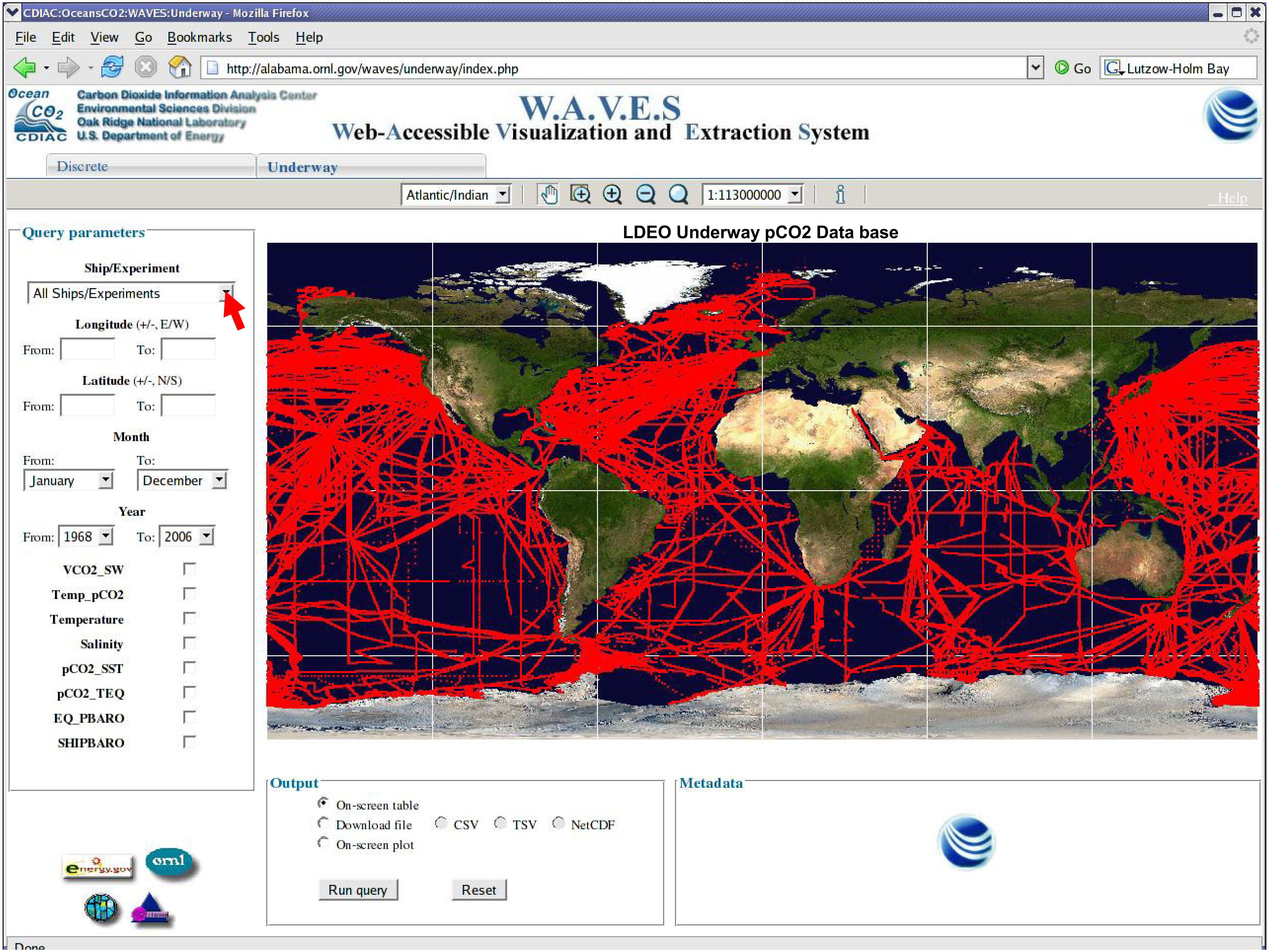
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http://alabama.ornl.gov/waves/underway/index.php
Go
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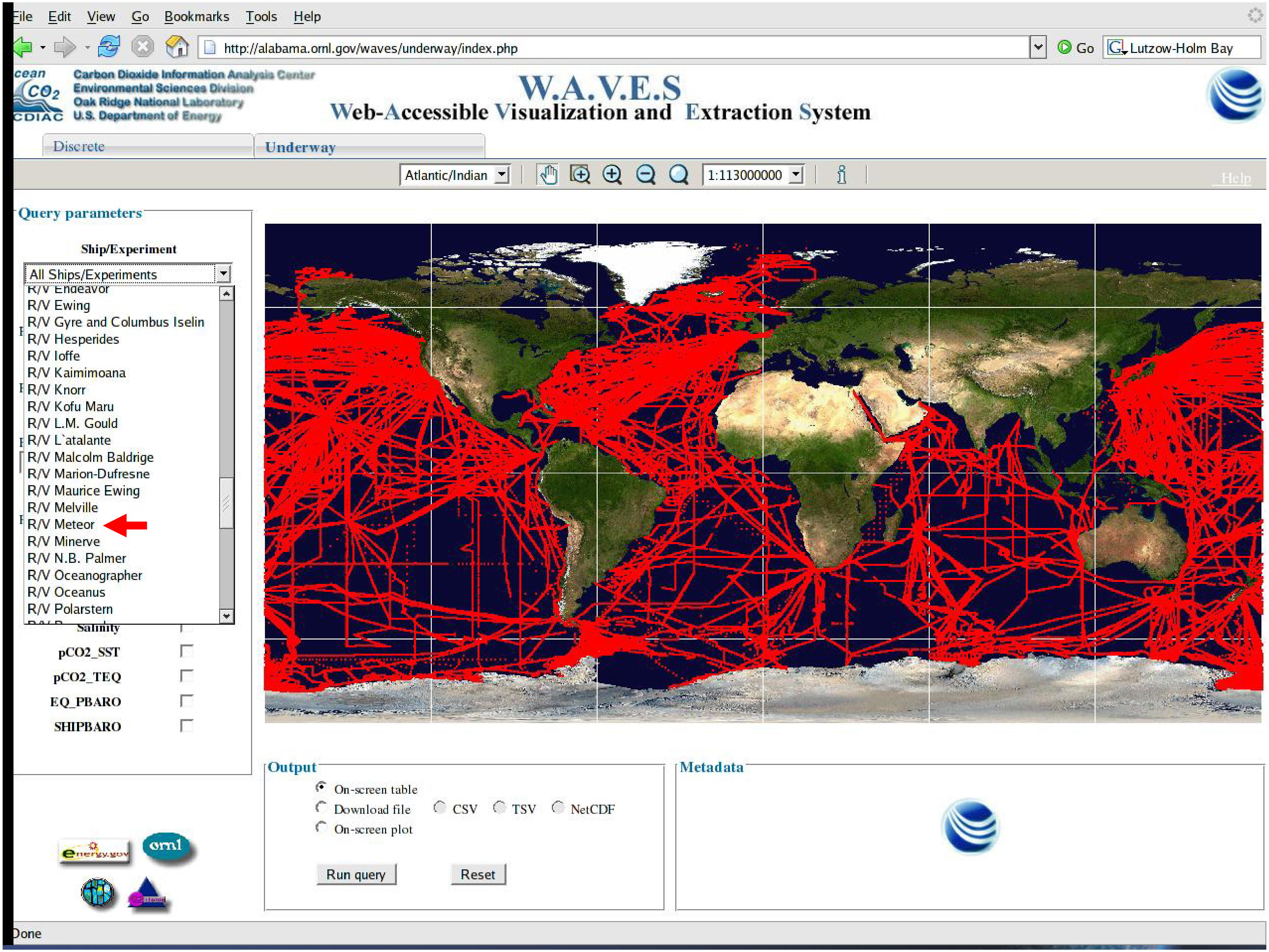
Environmental Sciences Division
Oak Ridge National Laboratory
U.S. Department of Energy
W.A.V.E.S
Web-Accessible Visualization and Extraction System
Discrete
Underway
Atlantic/Indian
1:113000000
Help
Query parameters
Ship/Experiment
All Ships/Experiments
Longitude (+/-, E/W)
From: To:
Latitude (+/-, N/S)
From: To:
Month
From: To:
January
December
Year
From: 1968 To: 2006
VCO2_SW
Temp_pCO2
Temperature
Salinity
pCO2_SST
pCO2_TEQ
EQ_PBARO
SHIPBARO
LDEO Underway pCO2 Data base
Output
On-screen table
Download file
CSV
TSV
NetCDF
On-screen plot
Run query
Reset
Metadata
ornl
Done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Discrete
Underway
Atlantic/Indian
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Help
Query parameters
Ship/Experiment
All Ships/Experiments
R/V Endeavor
R/V Ewing
R/V Gyre and Columbus Iselin
R/V Hesperides
R/V Ioffe
R/V Kaimimoana
R/V Knorr
R/V Kofu Maru
R/V L.M. Gould
R/V L`atalante
R/V Malcolm Baldrige
R/V Marion-Dufresne
R/V Maurice Ewing
R/V Melville
R/V Meteor
R/V Minerve
R/V N.B. Palmer
R/V Oceanographer
R/V Oceanus
R/V Polarstern
Salinity
pCO2_SST
pCO2_TEQ
EQ_PBARO
SHIPBARO
Output
On-screen table
Download file
CSV
TSV
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On-screen plot
Run query
Reset
Metadata
energy.gov
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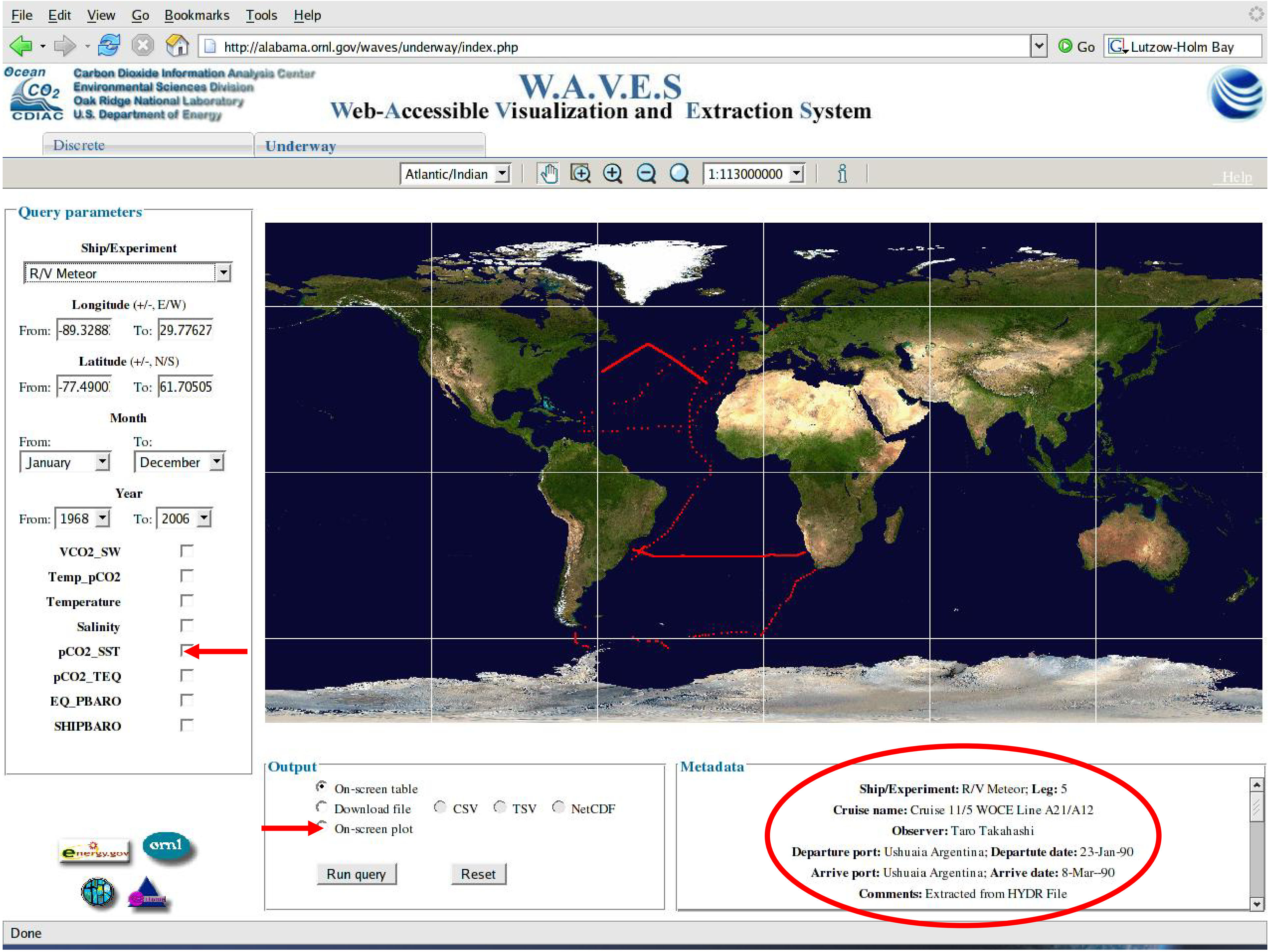
Done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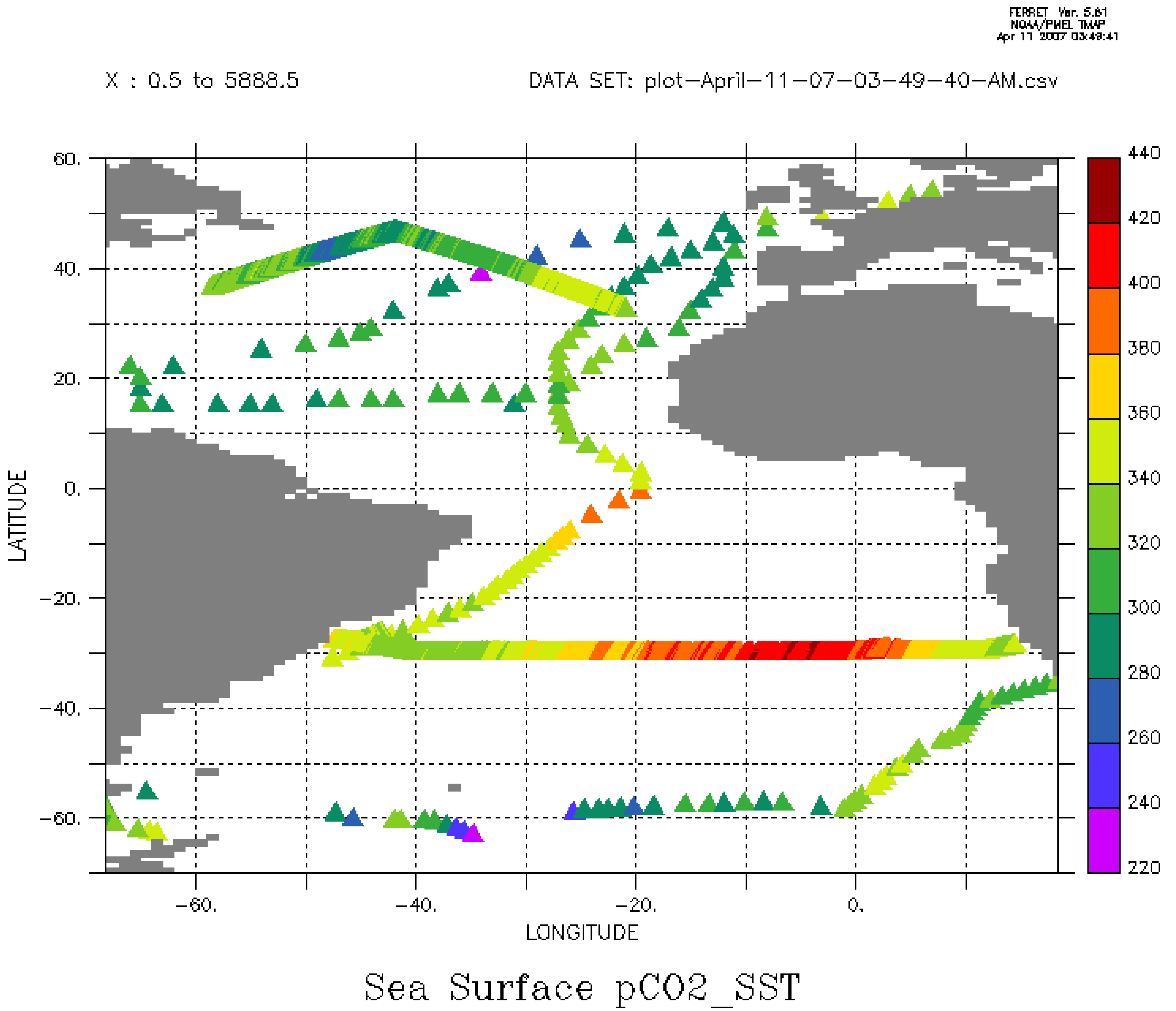
Discrete
Underway
Atlantic/Indian
1:113000000
Help
Query parameters
Ship/Experiment
R/V Meteor
Longitude (+/-, E/W)
From: -89.3288
To: 29.77627
Latitude (+/-, N/S)
From: -77.4900
To: 61.70505
Month
From:
January
To:
December
Year
From: 1968
To: 2006
VCO2_SW
Temp_pCO2
Temperature
Salinity
pCO2_SST
pCO2_TEQ
EQ_PBARO
SHIPBARO
Output
On-screen table
Download file
CSV
TSV
NetCDF
On-screen plot
Run query
Reset
Metadata
Ship/Experiment: R/V Meteor; Leg: 5
Cruise name: Cruise 11/5 WOCE Line A21/A12
Observer: Taro Takahashi
Departure port: Ushuaia Argentina; Departute date: 23-Jan-90
Arrive port: Ushuaia Argentina; Arrive date: 8-Mar--90
Comments: Extracted from HYDR File
Done



FERRET Ver. 5.81
NOAA/PMEL TMAP
Apr 11 2007 03:49:41
X : 0.5 to 5888.5
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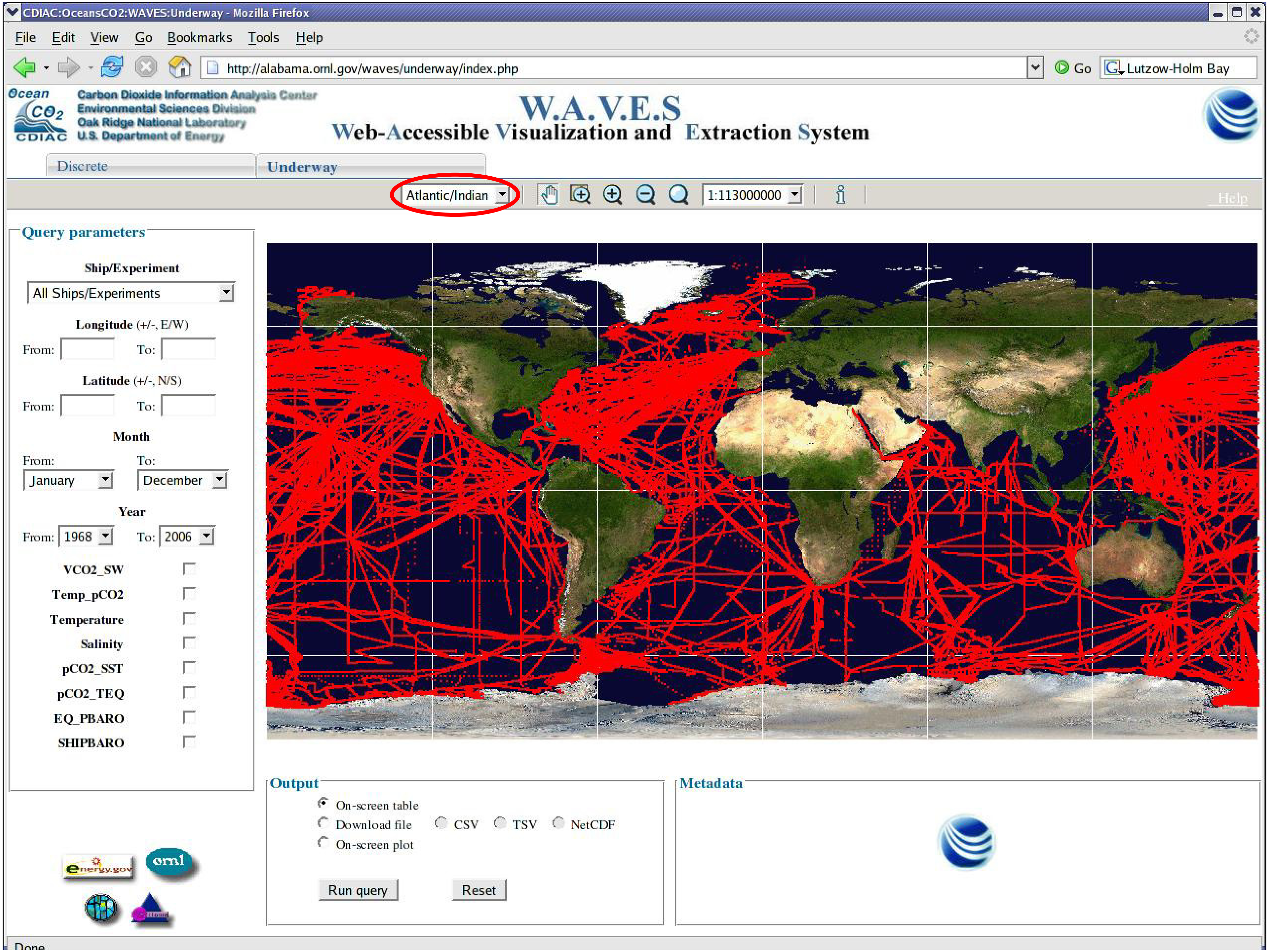
60.
40.
20.
0.
-20.
-40.
-60.
LATITUDE
-60.
-40.
-20.
0.
LONGITUDE
440
420
400
380
360
340
320
300
280
260
240
220
Sea Surface pCO2_SST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Web-Accessible Visualization and Extraction System
Discrete
Underway
Atlantic/Indian
1:113000000
Help
Query parameters
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All Ships/Experiments
Longitude (+/-, E/W)
From: To:
Latitude (+/-, N/S)
From: To:
Month
From: To:
January
December
Year
From: 1968 To: 2006
VCO2_SW
Temp_pCO2
Temperature
Salinity
pCO2_SST
pCO2_TEQ
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SHIPBARO
Output
On-screen table
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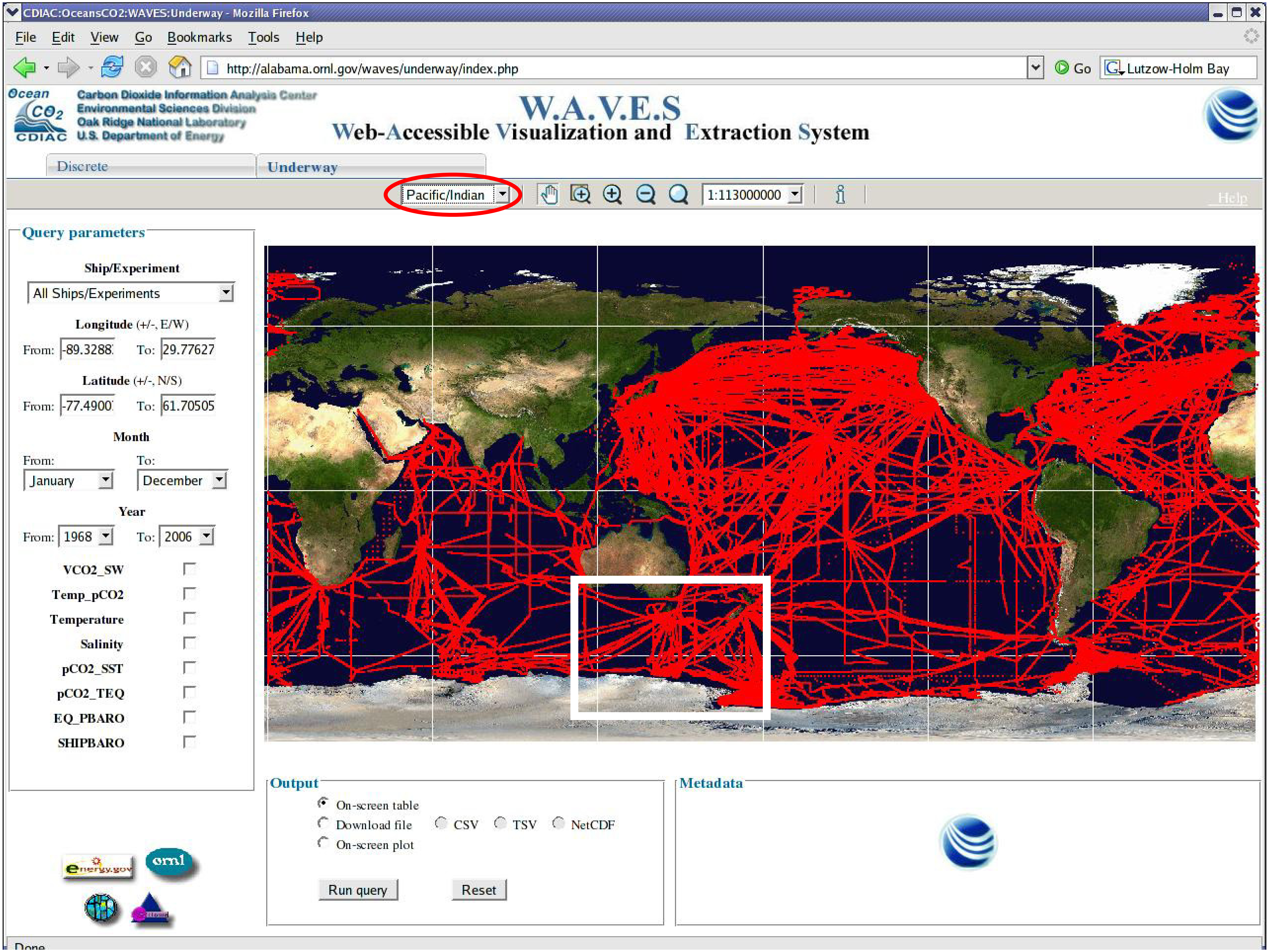
CSV
TSV
NetCDF
On-screen plot
Run query
Reset
Metadata
energy.gov
ornl
Done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Discrete
Underway
Pacific/Indian
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Help
Query parameters
Ship/Experiment
All Ships/Experiments
Longitude (+/-, E/W)
From: -89.3288 To: 29.77627
Latitude (+/-, N/S)
From: -77.4900 To: 61.70505
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From: January To: December
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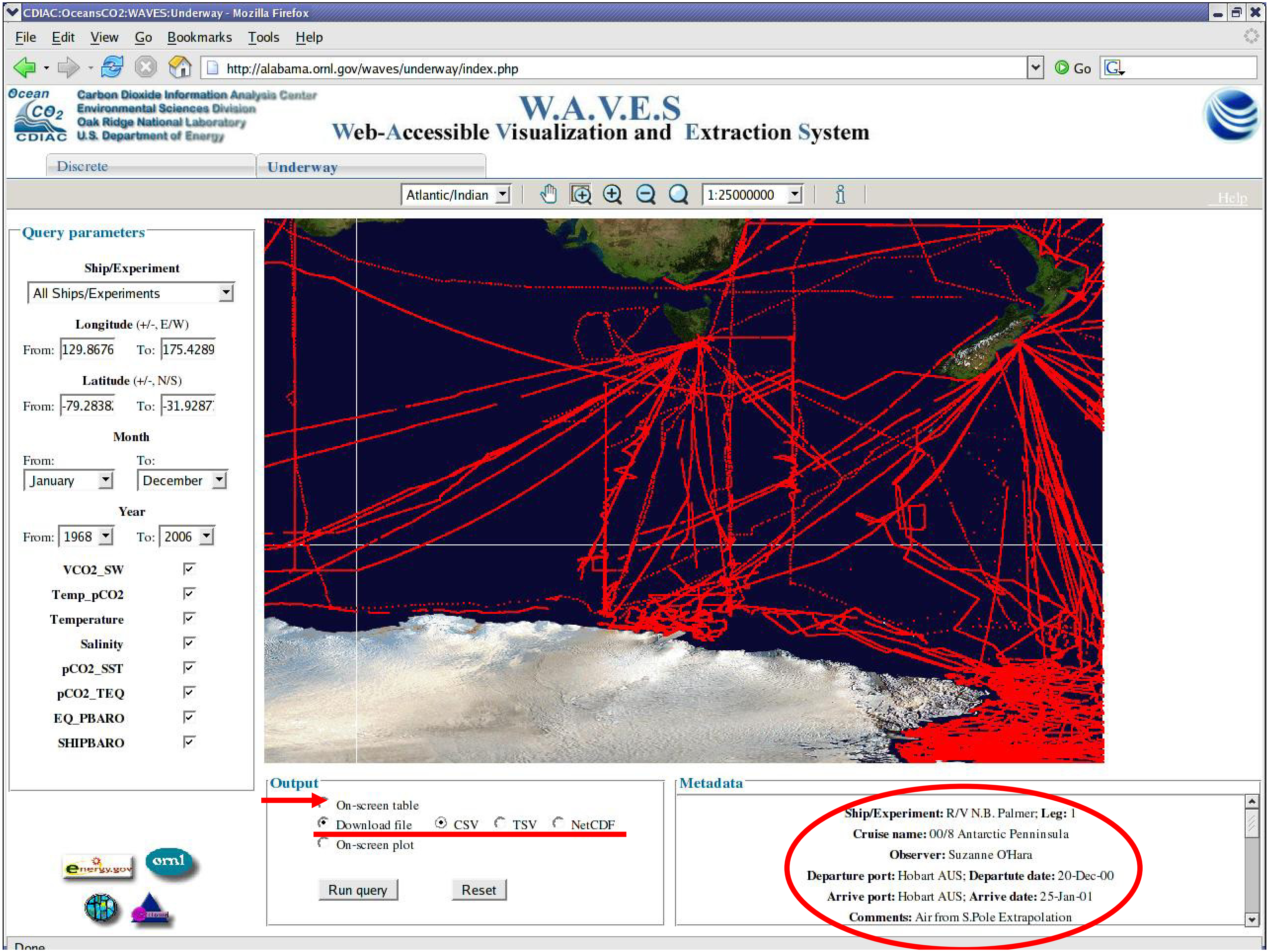
CSV
TSV
NetCDF
On-screen plot
Run query
Reset
Metadata
energy.gov
ornl
Done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Discrete
Underway
Atlantic/Indian
1:25000000
Help
Query parameters
Ship/Experiment
All Ships/Experiments
Longitude (+/-, E/W)
From: 129.8676 To: 175.4289
Latitude (+/-, N/S)
From: -79.2838 To: -31.9287
Month
From: January To: December
Year
From: 1968 To: 2006
VCO2_SW
Temp_pCO2
Temperature
Salinity
pCO2_SST
pCO2_TEQ
EQ_PBARO
SHIPBARO
Output
On-screen table
Download file CSV TSV NetCDF
On-screen plot
Run query
Reset
Metadata
Ship/Experiment: R/V N.B. Palmer; Leg: 1
Cruise name: 00/8 Antarctic Penninsula
Observer: Suzanne O'Hara
Departure port: Hobart AUS; Departute date: 20-Dec-00
Arrive port: Hobart AUS; Arrive date: 25-Jan-01
Comments: Air from S.Pole Extrapolation
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ornl
Done

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Ocean CO_2 CDIAC

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Environmental Sciences Division
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W.A.V.E.S
Web-Accessible Visualization and Extraction System

Underway measurments query results

Created on: 30th of March 2007 10:35:26 AM

The following parameters were used:

Longitude>=129.8676
Longitude<=175.4289 Latitude>=-79.2838
Latitude<=-31.9288

Total rows: 250847, not more than 5000 rows per page

<<FIRST <PREV Page 1 of 51 NEXT> LAST>>

Latitude	Longitude	Date	JDate	VCO2_SW	Temp_pCO2	Temperature	Salinity	pCO2_SST	pCO2_TEQ	EQ_PBARO	SHIPBARO
-49.935	146.241	2000-12-22	357.11844	366.68	9.99	9.92	34.17	346.72	351.0	9.99999	980.94
-49.942	146.240	2000-12-22	357.11969	366.35	9.99	9.93	34.16	346.33	350.6	9.99999	980.89
-49.948	146.238	2000-12-22	357.12097	365.99	9.99	9.94	34.17	345.93	350.2	9.99999	980.85
-49.955	146.237	2000-12-22	357.12222	366.26	9.99	9.94	34.17	345.98	350.4	9.99999	980.80
-49.958	146.236	2000-12-22	357.12350	366.26	9.99	9.94	34.17	346.23	350.5	9.99999	980.76
-49.965	146.235	2000-12-22	357.12476	366.10	9.99	9.94	34.17	345.64	350.2	9.99999	980.69
-49.971	146.233	2000-12-22	357.12601	365.94	9.99	9.95	34.18	346.12	350.1	9.99999	980.56
-49.978	146.232	2000-12-22	357.12729	365.99	9.99	9.96	34.18	346.27	350.1	9.99999	980.50
-49.984	146.230	2000-12-22	357.12854	365.70	9.99	9.97	34.18	345.73	349.7	9.99999	980.51
-49.988	146.229	2000-12-22	357.12982	366.31	9.99	9.97	34.18	346.13	350.4	9.99999	980.49
-49.994	146.228	2000-12-22	357.13107	366.10	9.99	9.98	34.18	345.83	350.1	9.99999	980.44
-50.000	146.226	2000-12-22	357.13232	365.79	9.99	9.97	34.18	345.49	349.9	9.99999	980.39
-50.007	146.225	2000-12-22	357.13361	365.07	9.99	9.98	34.19	345.14	349.1	9.99999	980.33
-50.013	146.223	2000-12-22	357.13486	365.09	9.99	9.98	34.19	344.84	349.1	9.99999	980.31
-50.020	146.222	2000-12-22	357.13614	365.22	9.99	9.97	34.20	344.75	349.3	9.99999	980.26
-50.023	146.221	2000-12-22	357.13739	365.08	9.99	9.97	34.20	344.89	349.0	9.99999	980.24
-50.029	146.219	2000-12-22	357.13864	364.90	9.99	9.96	34.20	344.74	349.0	9.99999	980.29
-50.036	146.218	2000-12-22	357.13992	364.95	9.99	9.95	34.21	345.18	349.0	9.99999	980.26
-50.042	146.216	2000-12-22	357.14117	365.27	9.99	9.95	34.21	345.23	349.2	9.99999	980.13
-50.049	146.215	2000-12-22	357.14243	365.62	9.99	9.95	34.22	346.17	349.7	9.99999	980.04
-50.052	146.214	2000-12-22	357.14371	366.00	9.99	9.95	34.22	345.88	350.0	9.99999	980.00
-50.058	146.213	2000-12-22	357.14496	365.71	9.99	9.95	34.22	345.88	349.7	9.99999	980.01
-50.065	146.211	2000-12-22	357.14624	365.94	9.99	9.95	34.21	345.39	349.8	9.99999	980.04
-50.100	146.204	2000-12-22	357.15402	366.98	9.99	9.93	34.22	346.77	350.9	9.99999	979.80
-50.107	146.203	2000-12-22	357.15530	364.49	9.99	9.93	34.22	344.40	348.5	9.99999	979.77
-50.113	146.202	2000-12-22	357.15656	363.56	9.99	9.93	34.21	343.41	347.5	9.99999	979.73
-50.120	146.201	2000-12-22	357.15781	363.74	9.99	9.94	34.21	343.61	347.7	9.99999	979.68
-50.126	146.200	2000-12-22	357.15909	363.66	9.99	9.94	34.20	343.51	347.6	9.99999	979.60
-50.129	146.199	2000-12-22	357.16034	363.72	9.99	9.93	34.20	343.22	347.6	9.99999	979.56
-50.136	146.198	2000-12-22	357.16162	363.77	9.99	9.93	34.20	343.46	347.7	9.99999	979.52
-50.142	146.197	2000-12-22	357.16287	363.90	9.99	9.93	34.20	343.56	347.8	9.99999	979.50

Done

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Carbon Dioxide Information Analysis Center – Ocean CO_2

All CDIAC Ocean Carbon Data

General Information

WOCE Project Carbon Data

Ocean Carbon and Repeat Hydrography CLIVAR Program Data

VOS Project Carbon Data

Timeseries and Moorings Data

Global Coastal Program Data

CARINA Database

PICES Database

SOCAT Database

LDEO Database

Publications

Data Search

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Carbon Dioxide Information ... | CLIVAR Repeat Sections Data

Ocean CO_2 CDIAC

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- Ocean Home
- General Information
- Data and Metadata
- Ocean Carbon and Repeat Hydrographic CLIVAR Program Data
- GLODAP Data
- Global Ocean Surface pCO_2 Data
- Global Coastal Program Data
- CARINA Data
- *Mercury* Ocean Data Search Engine
- *WAVES*: WEB-Accessible Visualization and Extraction System
- Related Links
- CDIAC Publications
- Contact Us

How to Submit Data and Documentation to CDIAC

The data should be submitted to CDIAC using the following metadata forms. Please, type in all information required in these forms, attach the files and click a "submit" button.

- **Underway pCO_2 metadata and data submission form**
- **Discrete measurements (TCO_2, TALK, pCO_2, and pH) metadata and data submission form**

Please use the following data file format for the underway pCO_2 data submission:

- **Underway pCO_2 data file format**

Also, you can use CDIAC special ftp area for submitting the data. You can put your data files in this area, simply following instruction:

- **FTP to cdiac.ornl.gov (160.91.18.18)**
- **Enter "anonymous" as the user ID**
- **Enter your electronic mail address as the password**
- **Change to directory "/incoming/ocean.co2"**
- **Submit the files using the FTP "put" or "mput" command**

If you submit the data using FTP, please send us a metadata information on the data set in a format listed in the metadata forms above.

If you have any problems or questions, please, sent a message to kozyra@ornl.gov.

Page is maintained by Alex Kozyr

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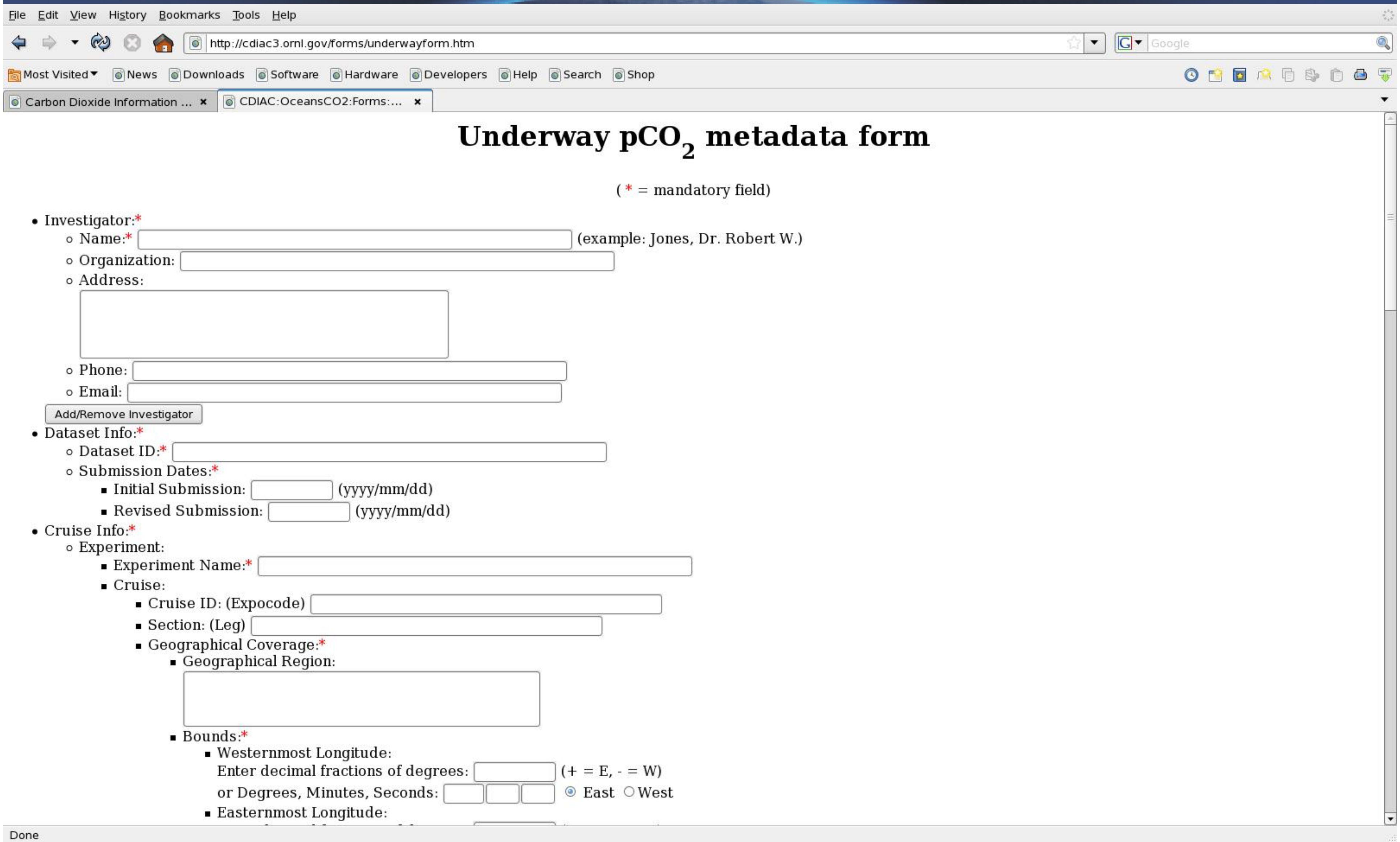

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Carbon Dioxide Information ... CDIAC:OceansCO2:Forms:...

Underway pCO_2 metadata form

(* = mandatory field)

- Investigator:*
  - Name:* (example: Jones, Dr. Robert W.)
  - Organization:
  - Address:
  - Phone:
  - Email:

Add/Remove Investigator

- Dataset Info:*
  - Dataset ID:*
  - Submission Dates:*
    - Initial Submission: (yyyy/mm/dd)
    - Revised Submission: (yyyy/mm/dd)
- Cruise Info:*
  - Experiment:
    - Experiment Name:*
    - Cruise:
      - Cruise ID: (Expocode)
      - Section: (Leg)
      - Geographical Coverage:*
        - Geographical Region:
        - Bounds:*
          - Westernmost Longitude:
            Enter decimal fractions of degrees: (+ = E, - = W)
            or Degrees, Minutes, Seconds: East West
          - Easternmost Longitude:

Done

or Degrees, Minutes, Seconds: East West

- Northernmost Latitude:
  Enter decimal fractions of degrees: (+ = N, - = S)
  or Degrees, Minutes, Seconds: North South
- Southernmost Latitude:
  Enter decimal fractions of degrees: (+ = N, - = S)
  or Degrees, Minutes, Seconds: North South

- Temporal Coverage:
  - Start Date: (yyyy/mm/dd)
  - End Date: (yyyy/mm/dd)
- Ports of Call: (One per line)

- Vessel:*
  - Vessel Name:
  - Vessel ID:
  - Country:
  - Vessel Owner:

- Variables Info:*
  - Variable:
    - Variable Name:*
    - Description of Variable: (units)

  Total Variables in the Data Set: 1
- Method Description:*
  - Equilibrator Design:
    - Equilibrator type:
    - Equilibrator volume (L):
    - Water_Flow_Rate (L/min):
    - Headspace_Gas_Flow_Rate (L/min):
    - Vented: Yes No
  - Measurement Method
  - Manufacturer of Calibration Gas:
  - $C0_2$ Sensors:
    - Manufacturer:
    - Model:

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Carbon Dioxide Information ... | CDIAC:OceansCO2:Forms:...

Discrete measurements (TCO2, TALK, pCO2, and pH) metadata form

(* = mandatory field)

- Investigator:*
  - Name:* (example: Jones, Dr. Robert W.)
  - Organization:
  - Address:
  - Phone:
  - Email:

Add/Remove Investigator

- Dataset Info:*
  - Dataset ID:*
  - Submission Dates:*
    - Initial Submission: (yyyy/mm/dd)
    - Revised Submission: (yyyy/mm/dd)
- Cruise Info:*
  - Experiment:
    - Experiment Name:*
    - Cruise:
      - Cruise ID: (Expocode)
      - Section: (Leg)
      - Geographical Coverage:*
        - Geographical Region:
        - Bounds:*
          - Westernmost Longitude:
            Enter decimal fractions of degrees: (+ = E, - = W)
            or Degrees, Minutes, Seconds: East West
          - Easternmost Longitude:
            Enter decimal fractions of degrees: (+ = E, - = W)

Done

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Carbon Dioxide Information ... | CDIAC:OceansCO2:Forms:...

Total Variables in the Data Set: 1

- Method Description:*
  - Total C02 Data:
    - TCO2 Analysis Method:
    - Standardization Technique:
      - Technique Description
      - Sample Volume: (mL)
      - CRM Info:*
        - Correction Magnitude:
        - Batch Number: (One Used Batch Number per Line)
        - CRM Analysis Info: (e.g., Refer to plots for CRMs)
    - Field Replicate Info:
    - Poisoning Info:
      - Poisoning Correction Description: (e.g., Refer to plots for CRMs)

Done

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Carbon Dioxide Information ... | CDIAC:OceansCO2:Forms:...

- Alkalinity:
  - Curve Fitting Method:
  - Type of Titration:
  - Description of Other Titration: (If other, please describe)
  - Cell Type:
  - CRM Scale:
  - Sample Volume: (mL)
  - Magnitude of Blank Correction:
  - Accuracy Info: (Estimate overall precision and accuracy, and why)
  - Method References: (Publication(s) describing method)
- pCO2 Data:
  - Analysis:
    - pCO2 Analysis Method:
    - Sample Volume: (mL)
    - Headspace Volume:

Done

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Carbon Dioxide Information ... × Ocean Surface pCO2, Data ... ×

UNDERWAY pCO_2 DATA FILE FORMAT

(Focuses on results from underway measurement systems.)

I. REQUIRED ELEMENTS

Measured atmospheric information

- Date / Time of Measurement (UTC)
- Position of measurement
  - Latitude in decimal degrees (North is positive, South is negative)
  - Longitude in decimal degrees (East is positive, West is negative)
- Mole fraction of CO_2 in ambient atmosphere (µmol/mol in dry air)
- Atmospheric pressure at sea-surface pressure (hPa)

Measured seawater information

- Date / Time of Measurement (UTC)
- Position of measurement
  - Latitude in decimal degrees (North is positive, South is negative)
  - Longitude in decimal degrees (East is positive, West is negative)
- Mole fraction of CO_2 in air from equilibrator (µmol/mol)
- Mole fraction of of H_2O in air from equilibrator (µmol/mol)
- Pressure of equilibration = the pressure in the equilibration vessel (hPa)
- Temperature of equilibration = the temperature of the seawater in equilibrator at the time of equilibration (°C)
- Sea surface temperature (in situ) (°C)
- Sea surface salinity (in situ)

II. DERIVED PARAMETERS

Atmosphere

- $x(CO_2)$ value for the ambient atmosphere (µmol/mol in dry air); interpolated to match the date/time/position of the seawater information in this section

Seawater

- $f(CO_2)$ for air in equilibrium with seawater at sea surface temperature (µatm). Note: the air will be at 100% humidity
- $p(CO_2)$ for air in equilibrium with seawater at sea surface temperature (µatm). Note: the air will be at 100% humidity
- $x(CO_2)$ for air in equilibrium with the seawater at sea surface temperature and 1013.25 hPa applied pressure (expressed as µmol/mol in dry air)

III. OPTIONAL ANCILLARY INFORMATION

- Quality flags
- Detailed Ships Heading Information
- Other measurements (chemical, physical, meteorological)

Done

The quality assurance/quality control (QA/QC) procedure (GLODAP example)

- ANALYTICAL AND CALIBRATION TECHNIQUES
- RESULTS OF SHIPBOARD ANALYSIS OF CERTIFIED REFERENCE MATERIALS
- REPLICATE SAMPLES
- CONSISTENCY OF DEEP CARBON DATA AT THE LOCATIONS WHERE CRUISES CROSS OR OVERLAP
- MULTIPLE LINEAR REGRESSION ANALYSIS
- ISOPYCNAL ANALYSES
- INTERNAL CONSISTENCY OF MULTIPLE CARBON MEASUREMENTS
- FINAL EVALUATION OF OFFSETS AND DETERMINATION OF CORRECTION TO BE APPLIED

ANALYTICAL AND CALIBRATION TECHNIQUES

- **Total carbon dioxide (TCO_2) analysis and calibration**

  All TCO2 samples that were retained in this synthesis work were analyzed by coulometric titration. The primary differences between the various groups were the sample volume use, the level of automation, and the primary calibration method. On many cruises the coulometer (UIC, Inc.) was coupled to a semi-automated sample analyzer (Johnson and Wallace 1992; Johnson et al. 1985, 1987,1993, 1998). The most common system, a single-operator multiparameter metabolic analyzer (SOMMA), was typically outfitted with a 20- to 30-mL pipette and was calibrated by filling a gas loop with a known volume with pure CO2 gas, then introducing the gas into the carrier gas stream and performing subsequent coulometric titration (Johnson and Wallace 1992; Johnson et al. 1987,1993, 1998). Some systems were calibrated by analyzing sodium carbonate standards. In TCO2 systems that were not coupled with a semi-automated sample analyzer, the sample was typically introduced manually by a pipette or a syringe.

ANALYTICAL AND CALIBRATION TECHNIQUES (continued)

- **Total alkalinity (TALK) analysis and calibration.**

  All shipboard TALK measurements were made by potentiometric titration using a titrator and a potentiometer. TALK was determined either by characterizing a full titration curve (Brewer et al. 1986; Millero et al. 1993; DOE 1994; Ono et al. 1998) or by a single point titration (Perez and Fraga 1987). Analytical differences were in the volume of sample analyzed, the use of either an open or closed titration cell, and the calibration methods. Results were obtained from different curve-fitting techniques such as Gran plots, nonlinear fitting, or single-point analysis.

ANALYTICAL AND CALIBRATION TECHNIQUES (continued)

- **Fugacity of CO_2 (fCO_2) analysis and calibration.**

  Two different types of instruments were used to measure discrete fCO_2 samples. With each, an aliquot of seawater was equilibrated at a constant temperature of either 4 or 20°C *with* a headspace of known initial CO_2 content. Subsequently, the headspace CO_2 concentration was determined by non-dispersive infrared analyzer (NDIR) or by quantitatively converting the CO_2 to CH_4 and then analyzing the concentration using a gas chromatograph (GC) with flame ionization detector. The initial fCO_2 in the water was determined after correcting for loss (or gain) of CO_2 during the equilibration process. This correction can be significant for large initial fCO_2 differences between the headspace and the water, and for systems with a large headspace-to-water volume ratio (Chen et al. 1995).

ANALYTICAL AND CALIBRATION TECHNIQUES (continued)

- **pH analysis and calibration**

  The pH measurements were determined by a spectrophotometric method (Clayton and Byrne 1993), with m-cresol purple as the indicator and either scanning or diode array spectrophotometers, or by using pH electrodes

RESULTS OF SHIPBOARD ANALYSIS OF CERTIFIED REFERENCE MATERIALS

Certified Reference Materials (CRMs) were used on many of the cruises as secondary standards for TCO2, with some exceptions during the Pacific Ocean and Atlantic survey. Routine analysis of shipboard CRMs helped verify the accuracy of sample measurements. Certification of the CRM for TCO2 is based on vacuum extraction/manometric analysis of samples in the laboratory of C. D. Keeling at Scripps Institution of Oceanography (SIO). A complete discussion of the technique developed for CRMs can be found at: http://www-mpl.ucsd.edu/people/adickson/CO2_QC/. Most groups which routinely ran CRM samples for TCO2 also analyzed the samples for TALK. The CRMs were certified for TALK in July 1996. However, archived CRMs produced prior to 1996 were calibrated as well so that post-cruise adjustments of TALK could be made (See Table 3 in Lamb et al, 2002) CRMs at the time of measurements were not available for the other carbon parameters

REPLICATE SAMPLES

Replicate samples were routinely collected and analyzed at sea, thus allowing the analyst to determine the overall precision of the measurement. The imprecision of replication includes the error associated with the collection and handling of the carbon sample, as well as the analytical precision. In addition, replicate samples for TCO2 were collected and stored for analysis ashore at SIO by laboratory of C.D. Keeling (see Guenther, P. R., C. D. Keeling, and G. Emanuele III. 1994b. Oceanic CO2 Measurements for the WOCE Hydrographic Survey in the Pacific Ocean, 1990-1991: Shore Based Analyses. SIO Reference Series, Ref. No. 94-28. University of California, San Diego)

CONSISTENCY OF DEEP CARBON DATA AT THE LOCATIONS WHERE CRUISES CROSS OR OVERLAP

One approach for evaluating the consistency of the cruises was to compare data where cruises crossed or overlapped. A location was considered a crossover if stations from two cruises were within 1° (~100 km) of each other. If more than one station from a particular cruise fell within that limit, the data were combined for the comparison. For this analysis, only deep-water measurements (>2000 m for the Pacific Ocean, >2500 m for the Indian Ocean, and >3000 m for the Atlantic Ocean) were considered, because CO2 concentration in shallow water can be variable, and the penetration of anthropogenic CO2 can change relationships between the carbon parameters measured at different times. Once the stations were chosen, the data were plotted against potential density referenced to 3000 dB (or 4000 dB in the Atlantic) since water moves primarily along isopycnal surfaces. In order to quantitatively estimate the mean difference between legs, each of the two fitted curves for a restricted deep water density range was evaluated at evenly spaced intervals covering the range of space common to the selected stations from both legs. A mean was taken of the differences, and standard deviation was calculated

MULTIPLE LINEAR REGRESSION ANALYSIS

Another approach used to evaluate the data at the crossover locations was a multi-parameter linear regression analyses (MLR). Brewer, et al. (1995) and subsequently others (Wallace 1995; Slansky et al. 1997; Goyet and Davis 1997; Sabine et al. 1999), have shown that both TCO2 and TALK concentrations in deep and bottom waters can be fit well with MLR functions using commonly measured hydrographic quantities for the independent parameters. The geographic extent over which any such function is applicable depends on the number of water masses present, and the uniformity of chemical and biological processes which have affected the carbon species concentration in each water mass

ISOPYCNAL ANALYSES

At a few locations in the North Pacific the estimated offsets at the crossovers were not consistent with the offsets from the basinwide MLR analysis. In an attempt to determine whether the limited number of stations analyzed biased on the crossovers, we expanded the crossover analysis to include additional stations along each cruise and/or stations from neighboring cruises. The deep (> 2200 m) station data were averaged at specific potential density (sigma-3) values and fitted with a 2nd-order polynomial function. The average differences and standard deviations were determined from evenly spaced differences along the curves. The range of values observed for a particular cruise at each isopycnal level indicated whether the stations initially used in the crossover analysis were offset from the surrounding stations. Although more assumptions about oceanographic consistency are necessary, the additional stations used in the isopycnal analysis can provide a better estimate of the difference between cruises because more data points are included in the analysis

INTERNAL CONSISTENCY OF MULTIPLE CARBON MEASUREMENTS

An additional independent approach for evaluating the accuracy of data is the examination of the internal consistency of the CO2 system parameters. The CO2 system parameters in seawater can be characterized by temperature, salinity, phosphate and silicate, and two of the four measured inorganic carbon parameters: TCO2, TALK, *f*CO2, or pH. Thus, the carbon system is overdetermined on cruises where three or more carbon parameters were measured. By comparing estimates using different pairs of carbon measurements, one can evaluate potential offsets. In addition, examination of internal consistency over several cruises lends confidence to the reliability of the equilibrium constants. The constants of Mehrbach et al. (1973) as a refit by Dickson and Millero (1987) were used for this analysis, along with equilibrium constants for other components (e.g., boric acid dissociation, solubility of CO2, water hydrolysis, and phosphoric and silicic acid dissociation) necessary to characterize the carbonate system in seawater as recommended in Millero (1995). This choice was made based on the analysis of a large data set (15,300 samples) obtained from all the ocean basins (Lee et al. 2000; Millero et al. 2002). For this analysis, TALK was calculated using a combination of either TCO2 and *f*CO2, or TCO2 and pH [adjusted upward by 0.0047 (DelValls and Dickson 1998) for the Pacific and Indian Ocean but not for the Atlantic analysis].