GO-SHIP: 2012-2023 Decadal Survey
Background

In the late 1970s the Geochemical Ocean Sections Study (GEOSECS) conducted the first global survey, and in 1990s the World Ocean Circulation Experiment (WOCE) and Joint Global Ocean Flux Study (JGOFS) completed a comprehensive decadal ocean survey.

After WOCE is was recognised that a sustained decadal survey was required as part of the ocean observations system. The global decadal survey started under CLIVAR has now become the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) . GO-SHIP nows provides the international program oversight and determines the future direction of the sustained decadal survey of the global ocean.
Introduction

The Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) brings together scientists with interests in physical oceanography, the carbon cycle, marine biogeochemistry and ecosystems, and other users and collectors of ocean interior data to develop a sustained global network of hydrographic sections as part of the Global Ocean / Climate Observing System.

GO-SHIP is part of the Global Climate Observing System (GCOS)/Global Ocean Observing System (GOOS).
GO-SHIP Reference Sections.

GO-SHIP 2012-2023 Survey (53 Lines)  Design Map - 10 September 2015
GO-SHIP Oversight Committees

Project Coordinator: Martin Kramp (JCOMMOPS, IOC-UNESCO)

Executive Group

Bernadette Sloyan (CSIRO, Australia; co-chair)
Rik Wanninkhof (NOAA, USA; co-chair)
Masao Ishii (MRI-JMA, Japan)
Elaine McDonagh (NOCS, UK)
Takeshi Kawano (JAMSTEC, Japan)
Lynne Talley (SIO, USA)
Toste Tanhua (GEOMAR, Germany)

Country Representatives

Leif Anderson (U. Gothenburg, Sweden)
Isabelle Ansorge (UCT, South Africa)
Kumiko Azetsu-Scott (BIO, Canada)
Richard Feely (NOAA, USA)
Masao Fukasawa (JAMSTEC, Japan)
Gregory Johnson (NOAA, USA)
Mauricio Mata (FURG, Brazil)
Herle Mercier (IFREMER, France)
Aida F. Rios (CSIC, Spain)
Mike Williams (NIWA, New Zealand)
Emil Jeansson (BCCR, Norway)
Jae Hak Lee (KIOST, South Korea)
GO-SHIP: Program Aims

- Document the large-scale ocean water property distributions, their changes, and drivers of those changes
- Determine the distributions and controls of natural and anthropogenic carbon (both organic and inorganic),
- Determine ocean ventilation and circulation pathways and variability using chemical tracers,
- Provide high-quality full-depth reference observations to other components of the observing systems.
Deep Ocean contribution to Sea Level Rise

Basin means of sea level rise from the 1990s to the 2000s due to abyssal thermal expansion below 4000 m and deep thermal expansion in the Southern Ocean from 1000 to 4000 m south of the Subantarctic Front (from Purkey and Johnson, 2010)
Anthropogenic Carbon Storage

GO-SHIP/ GLODAP

anthropogenic CO$_2$ storage

IOCCP/ SOCAT

Air-sea CO$_2$ Flux

THE GLOBAL OCEAN SHIP-BASED HYDROGRAPHIC INVESTIGATIONS PROGRAM
Inventory of Ocean anthropogenic CO$_2$

Compilation of the 2010 column inventories (mol m$^{-2}$) of anthropogenic CO$_2$:
the global Ocean excluding the marginal seas $150 \pm 26$ PgC (Rhein et al. 2013; updated from Khatiwala et al. 2009). From Khatiwala et al. (2013).
Decadal storage rates of anthropogenic carbon (mol m\(^{-2}\) yr\(^{-1}\)), as observed from repeat hydrography cruises. (Upper panels): The horizontal lines depict the measurement intervals bracketed by repeat hydrography cruises. Lower panels): Maps of decadal storage rates from a Green’s function inversion averaged over 1980-2005 using data shown in top panels. (From Khatiwala et al. 2013.)
CO$_2$ storage in the North Atlantic

- The concentration of anthropogenic carbon increases in the whole subpolar gyre
- Its storage is modulated by the intensity of the MOC that brings the Cant-rich subtropical water to the areas of deep-water formation (Perez et al., 2013)
- An index was built to evaluate the impact of the MOC on the CO$_2$ physical pump in models (Zunino et al., 2014)
Global distributions of Dissolved Organic Carbon (DOC)

Distributions of DOC (µmol kg$^{-1}$). DOC is one of the largest bioreactive pools of carbon in the ocean. Arrows depict water mass renewal and circulation; white lines indicate isopycnal surfaces. Modified from Hansell et al. (2009).
Combined Oxygen, CFC and Carbon analysis

2005-1990 changes in oxygen and CFC-11 in the Pacific Indian and Atlantic (Right column) Difference between transit time distribution (TTD)-predicted and observed pCFC-12. Blues indicate that there is more pCFC-12 than expected in the 2005 occupation, hence younger water/greater ventilation, and yellows indicate that there is older water/less ventilation than expected. (After Waugh et al. 2013).
Diapycnal diffusivity $\kappa$ along 32°S in the Indian Ocean, estimated from CTD and LADCP profiles (Kunze et al. 2006) using a finescale parameterization, representative of numerous recent studies (e.g., Polzin et al. 2014).
Measurements: Level 1

Level 1 data
• CTD pressure, temperature, salinity (calculated from conductivity, temperature and pressure)
• CTD oxygen (sensor)
• Bottle salinity
• Nutrients by standard auto analyzer (NO$_3$/NO$_2$, PO$_4$, SiO$_3$)
• Dissolved oxygen

• Dissolved inorganic carbon (DIC)*
• Total Alkalinity (TAlk)*
• pH*
*(note any two of the above carbon related observations)
• Chlorofluorocarbons (CFC-11, -12) and SF$_6$
• Surface underway system (T, S, pCO$_2$)
• ADCP shipboard
• ADCP lowered
• Underway navigation and bathymetry
• Meteorological data.
Measurements: Level 2

Level 2 data
- Discrete pCO$_2$
- $^{14}$C (by AMS)
- CCl$_4$
- $\delta^{13}$C of DIC
- Dissolved organic carbon
- Dissolved organic nitrogen
- Fe/trace metals
- CTD Transmissometer
- Surface underway system (nutrients, O$_2$, Chl, skin temperature).
GO-SHIP: Measurements

• **Level 1 data** are of highest priority. GO-SHIP recommends that level 1 data should be collect at least once per decade on all sections. Sections occupied at higher frequencies (yearly, biennial) do not need to undertake all level 1 measurement on all re-occupations.

• **Level 2 data** are highly desirable. GO-SHIP recommends that level 2 should be collected when possible.

• **Level 3 data** are ancillary measurements are done according to opportunity and space available. They should not significantly interfere with Level 1 or 2 data collection, and may be regional or specific to an individual cruise.
The GO-SHIP data policy is stringent and geared toward rapid, open dissemination, with a clear structure for all data to undergo quality control and to be sent to and available from recognized data centers. The policy includes:

1) All Level 1 and 2 observations, cruise reports, and metadata are made public in preliminary form through a specified data center soon after collection ("early release"), with final calibrated data provided six months after the cruise, with the exception of those data requiring on-shore processing.

2) All data collected as part of the program are submitted to a designated data management structure for quality control and dissemination for synthesis.
Typical Sample Strategy for discrete Bottle measurements
GO-SHIP Measurement Reference Manual


IOCCP Report No. 14
ICPO Publication Series No. 134

Version 1, 2010

http://www.go-ship.org/HydroMan.html
GO-SHIP: Current status

Three voyages at sea: ARC01, DAVIS, ARC02.
GO-SHIP: Program review

GO-SHIP 2012-2023 Survey (53 Lines) Status Map - 10 September 2015

completed  at sea  funded  planned  not planned yet

The Global Ocean Ship-Based Hydrographic Investigations Program
GO-SHIP: Contacts

Bernadette Sloyan (GO-SHIP Co-Chair): Bernadette.Sloyan@csiro.au

Rik Wanninkhof (GO-SHIP Co-Chair): rik.wanninkhof@noaa.gov

Martin Kramp (GO-SHIP Project Coordinator): mkramp@jcommops.org
GO-SHIP: Current status

The GO-SHIP web site has information on planned occupation dates