GO-SHIP 6: Meeting Report

The 6th GO-SHIP Science Committee (SC) face-to-face meeting took place on 15 September 2019 from 8:30 am to 5:30 pm at the Hilton Conference Center in Honolulu, USA, kindly sponsored by NOAA's Ocean Observing and Monitoring Division (OOMD). In addition to the SC members, a number of experts had been invited and in total 40 participants (3 remotely) represented 14 countries (USA, Ireland, Canada, South Africa, Spain, Japan, UK, Korea, France, Brazil, Norway, Germany, Australia, New Zealand) and following international bodies: WMO, IOC, JCOMMOPS, IOCCP.

Event website with background information: www.jcomm.info/go-ship6
Emerging action items and associated leaders are marked in red.

Section1: Overview, setting the scene

1.1 Welcome and introduction

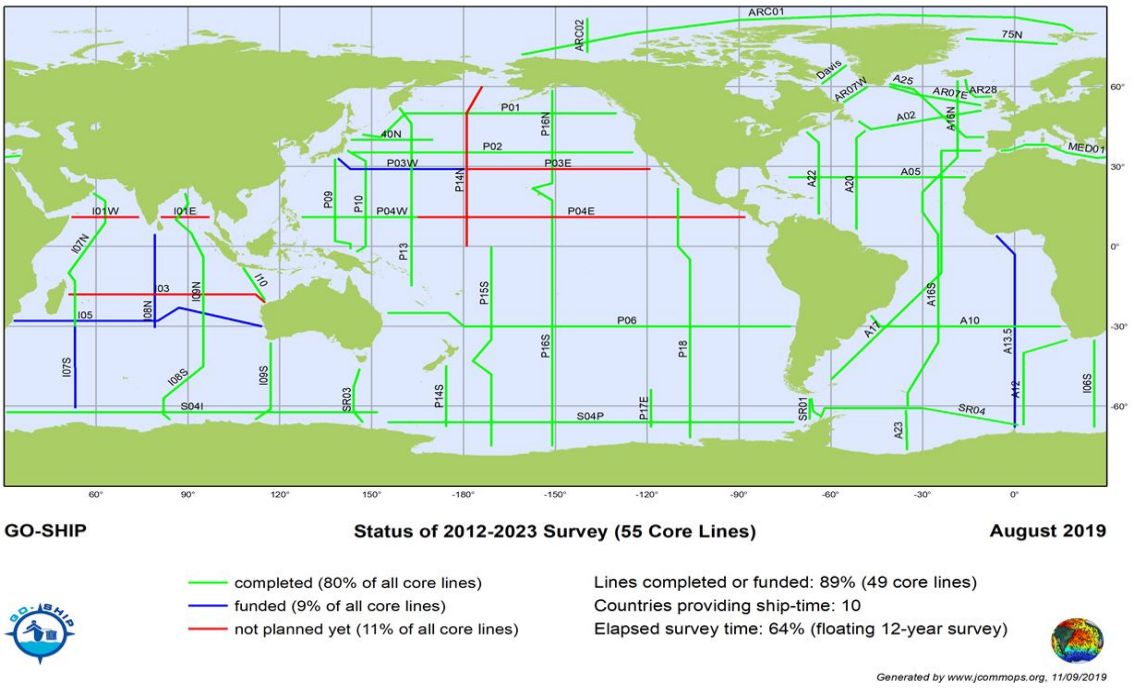
Rik Wanninkhof opened the meeting with round-the-table and online introductions (see participant list) with a special welcome to guests who were adding specific expertise, and program managers/directors supporting GO-SHIP in their nations. There was a strong representation of data managers to provide input on this critical aspect of GO-SHIP. The introduction was followed by a brief outline of the core objectives of GO-SHIP and of some of the key issues that would be addressed in the meeting. This included incorporation of biological measurements in GO-SHIP, the place of GO-SHIP within the GOOS 2030 strategy and related intergovernmental visions, and the GO-SHIP role and contribution in OceanObs19. Mr Wanninkhof reminded all that GO-SHIP is largely a voluntary effort, and relied on its members to be a successful program. He also mentioned that while this meeting had a focus on future efforts and rectifying deficiencies, the great success of the effort to date should not be forgotten.

1.2 Present status of GO-SHIP (including summary from national reports): TC Report

The JCOMMOPS Technical Coordinator for ships, Mr Martin Kramp, who works part time (1/3 FTE) as GO-SHIP Technical Coordinator, introduced the JCOMMOPS team of presently 7 staff members for the Argo, DBCP, OceanSITES, SOT (VOS, SOOP, ASAP), OceanGlider and GO-SHIP networks, including 2 IT engineers and a science/communication coordinator. Mr Kramp presented harmonized static maps and features of the integrated, interactive JCOMMOPS monitoring system, allowing for a view on ship contributions across all observing networks, or highlighting the support of the Argo network through GO-SHIP cruises. He also presented the last edition of the JCOMMOPS Report Card. Mr Kramp reported on latest developments of the JCOMMOPS metadata management system, with a particular focus on performance measurement efforts of other networks; the GO-SHIP SC decided that performance measurement is currently not a priority for the network and the need for a dedicated GO-SHIP performance working group or task team should be addressed at a future date.

Based on a summary of national reports collected ahead of the meeting, Mr Kramp presented the present status of GO-SHIP, with 55 core and 7 associated lines. He introduced a new status map for a moving survey interval (years n-6 to n+6). He also presented a tool which supports the appropriate accounting of GO-SHIP line occupations that comprised multiple legs.

14 decadal GO-SHIP cruises have been completed since 2016, 18 decadal cruises are planned or funded with a horizon going to 2027. 12 lines are sampled at high temporal frequency (yearly or biannually). Activity on or close to A10 (A9.5, A10, and A10.5) is high with 4 cruises in a 5 year period, and Mr Kramp reminded the SC of the corresponding south Atlantic recommendation letter.



Mr Kramp stressed that many of the GO-SHIP labelled cruises presently do not fully comply with the GO-SHIP data and sampling requirements.

The SC noted that the JCOMMOPS systems allows the continuous collection of cruise metadata, from early planning phase (line, year, nation) to more and more enriched metadata (precise dates, ship information, and sampled parameters). With appropriate m2m connection to data archives such as CCHDO, the flow of data into the archives based on the GO-SHIP data requirements could be monitored and lead to a system similar to the US hydrotable. This was considered a priority for GO-SHIP.

Mr Kramp presented the status of the GO-SHIP bibliography, with now more than 500 items, manually synchronized in Zotero and Google archives (the latter allowing for citation tracking, while Zotero has better citation functions).

The TC presented the GO-SHIP action item list, maintained as Trello board, and made the following recommendations:

- Review of GO-SHIP data requirements (parameters, line/depth/resolution-conformity, delays in data submission): Action for SC
- Update metadata in JCOMMOPS system as soon as they are available: Action for National Representatives (Nat Reps)
- Monitoring of data submissions: Set up m2m interface with GDACs: Action for “Data Team”
- SC Restructuring: Get SC members more involved, and track actions: Action for Chairs
- Submit bibliography updates as soon as possible: Action for GO-SHIP community

- Piggy-back projects: Collect (and exploit) corresponding metadata! (including float/drifter deployments): Action for cruise PIs with Nat Reps
- Establishment of standardized, metadata-based cruise reports: Evaluate and design (incl. Int Hydrotable): Action for SC
- Create Performance indicators: For GO-SHIP, but also in comparison with other observing networks: Action for SC
- Discuss associated lines: Action for SC
    - Consider: France (Pirata), Ireland (S Rockall Trough), Korea (Indian around 60°/67°E), India (Mauritius-Bharati)
    - Review: Brazil, South Africa, Sweden, Australia, Canada, Spain
    - Investigate: Mooring/OceanSITES transit cruises

1.3 Science Committee: Structure, Terms of Reference, Expectations, Gaps

Elaine McDonagh gave an overview of the updated terms of reference for the GO-SHIP science committee including expectations. Science committee members were encouraged to add their expertise, national representation and GO-SHIP relevant groups that they represent and interact with, e.g. Argo, GLODAP, GOOS to a list of SC member capabilities and expertise. This information will allow the co-chairs to ensure that there are no gaps in the areas that the science committee represents.

Chris Sabine suggested that the international GO-SHIP remit include advocacy for the global class ships it requires, which is not actively being considered or included in the terms of reference at the moment; the SC will consider it as a new action item going forwards.

1.4 GO-SHIP as part of the Global Ocean Observing System and decade of ocean science

Toste Tanhua gave an overview of the new GOOS 2030 strategy that is ambitious and requires increased partnership to deliver. Mr Tanhua also showed the organization of GOOS, and where GO-SHIP sits in that organization, in particular the connection to the Observations Coordination Group (OCG). David Legler added information on the role of OCG and the oversight for the observing networks that that group provides.

Questions were asked about the way to acknowledge the contribution from individual nations and groups in data products. A short discussion followed where the importance of this issue was acknowledged, but no direct solutions were presented.

1.5 US review and application for international GO-SHIP

Lynne Talley presented results from the national US GO-SHIP review. The purpose of the review, performed by an external committee of six scientists knowledgeable in the science, methods, and challenges of monitoring the ocean's response to climate change was to assess the program planning, progress, and opportunities in collecting, providing, and

synthesizing quality controlled ocean carbon,hydrographic, and velocity data to advance the scientific research of the US Climate Variability and Predictability (CLIVAR) and Ocean Carbon Biogeochemistry (OCB) programs.

The committee conducted a review of the progress and plans of the US GO-SHIP program in advancing the goals of the US CLIVAR and OCB programs, and noting that the US GO-SHIP projects are conducted in the context of GO-SHIP internationally as a sustained observing system program of GOOS.

Key findings of the review were:

- Program is critical, even essential, to ocean and Earth system climate research
- Provides highest quality data through well-planned and executed observational program
- Publications are numerous, wide-ranging, and of high quality and impact
- Program is essential to the development and calibration of autonomous sensors and platforms.The review committee wanted to emphasize that autonomous instruments will not replace the calibrated data collected by GO-SHIP, as many parameters essential to understanding of the climate system are not attainable with autonomous platforms
- Career opportunities for many students, postdocs, technical staff, and early-career faculty and researchers
- Leadership for international community in terms of effort, quality, development of new measurements, and commitment to the observational program

The review committee recommended that US GO-SHIP be continued and enhanced, with sufficient resources to allow sustained continuation of the observational program and data management system.

Section 2: Operational issues and best practices

In section 2 of the meeting, operational issues and best practices were discussed. It focussed on working groups which are being formalized in GO-SHIP as a means to clarify procedures and Best Practices. This will improve protocols that should be unified across all GO-SHIP participants, and aid in training new participants in GO-SHIP.

Background to this meeting report: Characteristics of a GO-SHIP working group (WG) as described by Elaine McDonagh for the working group on Niskin sampling:

What is a WG? – This is a group that delivers a specific task over a fixed lifetime (here probably 6-12 months) – the WG will report progress and ultimately its written recommendation at the International GO-SHIP science committee meetings.

What is the task for the Niskin sampling WG? – Review and revise best practice documentation on sampling the rosette with Niskins.

Who is in the WG? - This is up to the coordinating members – they can work alone, or invite more people whose expertise is needed.

2.1 Plankton observations (P-OBS) as part of GO-SHIP

Emmanuel Boss reported on SCOR Working Group-154, which has as objective the identification of best practices (technologies and sampling protocols) and technical feasibility to incorporate plankton measurements into global ocean observing platforms (GO-SHIP and OceanSITES, in particular) as a critical component of the global ocean observing system. He noted that technology is now mature, and infrastructure for data curation and community protocols exist for all. Six broad categories were suggested (genetics, quantitative imaging, flow cytometry, pigments and elemental analysis, bio-acoustics, bio-optics) with three collection methods (hull mounted, CTD-rosette, flow-through system) and two water sources (analysis of water samples on shore, automated sensors), all measured concurrently and on similar spatial scales as the physical & chemical characteristics of the environment.

The GO-SHIP SC will discuss the matter in a teleconference early 2020 and then take a decision or make a recommendation.

2.2 Report from working group: CTD/O2 operations and standardization

Joseph Gum reported that CTD working groups were proposed to review and update current sections of the GO-SHIP manual. Current thought is to form a single working group under "CTD/Rosette Operations" with the topics reviewed today. There was interest to apply for funding from IAPSO. Preliminary discussions for members of the working group have started with Brian King and Kats Katsumata.

CTD field operations manual:
Joseph Gum at Scripps is currently working on a field manual for ODF, that can be used for GO-SHIP. There is interest from UNOLS for such a field manual as well.

Action items:
Reach out to UNOLS training committee for input and volunteers to help with the manual
Reach out to NOAA technicians and marine technicians from other countries for similar help

CTD and oxygen processing:
Review current sections of the GO-SHIP manual for CTD data processing update if needed. Updates to the current manual may not be necessary.

There will be/should be overlap between this working group and the CTD sampling working group

2.3 Report from working group: deck/bottle operations

Susan Becker reported that she will and review and update sampling protocols, sampling depths, sampling order etc with Caroline Cusack.

2.4 Establishing and prioritizing other new working groups

Elaine McDonagh led a discussion on further working groups and will follow up with the SC in the next teleconference.

Salinity Intercomparison: Some inconclusive experiments were carried out on the US occupation of I06S, trying to compare procedures between the Japanese, AWI, and ODF. No members of the working group have been identified as of yet.

Juliet Hermes suggested a cruise leader forum. How to guide for chief scientists - could use the US working groups on this for international GO-SHIP.

Written documentation on cruise organisation: E.g. what does it take to make a GO-SHIP cruise happen. Significant elements of this would be nation-specific so it might be better to make this a delegated national responsibility.

2.5 L/SADCP tracking of data and data depository including biological applications of the ADCP (J. Hummon)

One-stop shopping for data should be possible through the JCOMMOPS page; it should point to the holders of all the data. It is up to GO-SHIP Nat Reps to identify which data have not yet been submitted. (1) Processed shipboard ADCP data are archived by USA, France (Ifremer) and Japan. These countries have large holdings of multiple datasets organized by ship and year, discoverable by cruise and instrument, but there is no "GO-SHIP" tag to identify those data. Raw data are archived by the USA. (2) Processed lowered ADCP is archived by Japan and the USA. Raw LADCP data (WOCE and CLIVAR) are at NCEI; GO-SHIP LADCP data will follow soon after.

Recommendations/TO-DO: (1) France and Japan should each make a GO-SHIP page with links to the processed data for GO-SHIP cruises/lines. That page of links could be hosted by JCOMMOPS. (2) UK should submit their processed SADCP data to the Joint Archive for Shipboard ADCP at U. Hawaii (JASADCP). (3) USA (Univ. Hawaii) will host the UK and Ifremer processed LADCP data if it was processed using the "inverse" method (Visbeck/Thurnherr), once the web site is up and functioning.

Section 3: GO-SHIP data and parameter levels

3.1 Report from CCHDO on data status and synchronization mechanism with JCOMMOPS

Karen Stocks reported on CCHDO activities. CCHDO provides a central point of access to international, reference quality repeat hydrography data. The current holdings span the globe, and include data from the 1980s and earlier. CCHDO posts publicly released data

immediately, allowing it to be discovered through the custom CCHDO user search portal. These data are curated, replicated, and preserved. In addition, for the majority of cruises it creates standard “if you can read one, you can read them all” aggregated files in several community-adopted formats, and works closely with the originating scientists to resolve quality issues. These files are supported by comprehensive documentation. In the near future, CCHDO will begin releasing its data in the widely adopted CF-compliant NetCDF standard format, enabling use by a broader audience, further improving standardization by core users, and positioning CCHDO for improved metadata management and to begin serving data by profiles in addition to by cruise. CCHDO also supports the US GO-SHIP Hydrotable, and provides the Argo reference database via a custom Application Programming Interface (API).

3.2 Interactions between data centers and data product producers (Ocean Atlas, GLODAP)

Tim Boyer reported on archival, use, and dissemination of GO-SHIP data and products at the U. S. National Centers for Environmental Information (NCEI). The GO-SHIP program oversees the collection of some of the most valuable oceanographic data extant. The utility of the data is enhanced by systematic long-term preservation of the data in NCEI. Dissemination of the original data and products generated from the original data, compilation of the data in NCEI databases, and utilization in downline products are also important functions of NCEI which extend the reach and use of GO-SHIP data. Data from different instrumentation packages have different paths to archival and use at NCEI. Marine meteorological data are sent over the Global Telecommunications System (GTS) from where it is used in models and forecast products and archived, eventually available in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). Surface underway data (carbon variables, etc.) are provided post cruise by investigators to the Surface CO2 Atlas - SOCAT - automated ingest and quality control system with the option of parallel submission to the NCEI Ocean Acidification Data System (OCADS). Furthermore data flows from those acquired by Dr. Takahashi (LDEO database), to the NCEI archive. From the archive, the data are aggregated in the NCEI Surface Underway Marine Database (SUMD) at full resolution, and eventually as hourly means, in ICOADS. Ship based Acoustic Doppler Current Profilers (S-ADCP) flow through specific data champions and/or the University of Hawaii ADCP center for processing, to the Joint Archive for S-ADCP at the University of Hawaii and NCEI. Lowered ADCP (L-ADCP) flow through the University of Hawaii ADCP center to the NCEI archive. From the archive, ADCP data are aggregated in the NCEI Global Ocean Currents Database (GOCD). Conductivity-Temperature-Depth (CTD) profiles of temperature, salinity, oxygen, and sometimes fluorescence, backscatter, and samples run onboard (salinity, oxygen nutrients, tracers, inorganic carbon are sent from ship to the CLIVAR and Carbon Hydrographic Data Office (CCHDO) immediately post-cruise where data, which is not fully quality controlled or calibrated are made available within hours. Samples from the Niskin Bottle (from the rosette on which the CTD is lowered) that are analyzed on shore take more time to process, and are made available to CCHDO within two years of measurement. The NCEI archive updates data from CCHDO on a quarterly basis. Carbon variables. Bottle Data are made available to Dr. Bob Key and/or the OCADS program where additional quality control may be performed before the data are resubmitted

to CCHDO and also directly to the NCEI archive. Products based on the carbon data, such as the Global Ocean Data Analysis for Carbon (GLODAP) climatological mean fields, are also archived and disseminated through NCEI. Ocean subsurface profile data from both bottle and CTD are aggregated with other ocean profile data in the World Ocean Database (WOD) at NCEI and incorporated into products such as the World Ocean Atlas (WOA), ocean heat and salt content updates, and others. Dissemination of GO-SHIP data and products directly from the NCEI archive, and through databases, as well as use of the data in aggregated products, enhances the value and utility of the GO-SHIP program. Some routes from GO-SHIP to archive are well-established, some are more ad hoc and can benefit from renewed attention.

Action item:
There is a specific action to understand why GO-SHIP cruises are sometimes issued a DOI by NCEI even when there is already a DOI for the particular cruise minted by the cruise primary investigators – and to look into implementing a mechanism to avoid this occurrence.

3.3 Issues with consistency of GO-SHIP reference lines (level 1 measurements, # of samples taken)

Masao Ishii led the discussion, and all national delegates reported their situation. Some expressed the absence of level 1 transient tracer measurements because of the lack of expertise and paucity of resources, or difficulty in the high-quality nutrients measurements. Others stated the problems in keeping the high-density station spacing due to the limited ship-time. To fulfill the gaps in the expertise, it is necessary for the GO-SHIP SC to continue efforts to coordinate the measurements within the international framework as has already been done successfully in some cruises. For better quality control of nutrients analyses, IOCCP SSG members recommended to use a hydro-manual and reference materials. The station-spacing issue needs further discussion and consultation with SC members.

3.4 Process for prioritizing measurements

Alison Macdonald led the discussion. There are two aspects to this subject. The first being how a measurement is labeled as level 1 (top priority, operational, funded in core program in U.S.), 2 (highly desirable, globally significant, a case can be made for funding based on GO-SHIP status) or 3 (ancillary, feasible), and how it might move up or down the levels. The present process is based on similar criteria as for EOVs (impact and feasibility), but it is clear that what is feasible for each country and even each cruise may be different. The more required variables - the more expensive & difficult it becomes to mount a cruise. The second aspect is how we deal with the potential issue of more funded level 3 requests than a cruise/ship can handle. This issue may arise because support is provided very late in the cruise planning process, at the time that proposal is funded. With new bio & biogeochemical measurements coming online the potential for conflict increases. Aspect 1: There must be a “gateway” document submitted to the steering committee making the case for a level 3 or 2

variable to become a level 2 or 1 variable. In the US this often happens at the proposal stage, but internationally, this needs to be a specific document assessed by the international committee. The second aspect was not discussed directly, however, it was stated that a) a variable would never become level 1, without first going through levels 2 and b) that a level 3 measurement has a lower priority than a level 2 or level 1 measurement.

3.5 Elevating pH and DOM to level 1

Mike Williams led the discussion on scientific rationale and national readiness of this item. For a listing of level 1, 2,and 3 parameters, see GO-SHIP data requirements.
The US GO-SHIP and GO-SHIP criteria for level 1 parameters are slightly different in that DOM is a level 2 parameter in GO-SHIP and level 1 in US GO-SHIP. pH is a level 1 parameter in US GO-SHIP while in GO-SHIP the criterium is that at least two of the three parameters: dissolved inorganic carbon (DIC),total alkalinity (TAlk) and pH should be measured. It was noted that few countries have the capabilities for accurate DOM measurements but that the availability of reference materials as supplied by the Laboratory and Hansel (U. Miami) will aid in improved quality. Not all nations have the capability to measure all inorganic carbon parameters to Best Practice specification. Moreover, it was unclear if groups that have the capability have the resources to increase the size of their operations to accommodate taking on more cruises. For DOM it was noted that sampling needed special care to avoid contamination (by grease and greasy fingers). Samples for DOM have successfully been frozen and analyzed on shore. All US cruises are performed this way. A best practices manual is in preparation by C. Carlson of UCSB.
The group noted that elevating DOM and pH to level 1 might be an opportunity to enhance multi-national cruise operations. However, before a recommendation could be made there has to be a clearer idea of capacity, and the ability to secure resources for these measurements.

3.6 List and criteria for GO-SHIP associated lines

Pascale Lherminier reminded the SC that associated GO-SHIP lines are defined as :

Repeat hydrographic sections that do not follow regular GO-SHIP lines and not necessarily coast-to-coast or coast-to-ice, but which i) deliver high quality data, ii) establish full depth stations below 2000m at least every 240nm, iii) are repeated on decadal frequency or more, at least once per decade with sufficient level 1 parameters to quantify decadal change in inorganic carbon and heat inventories, iv) at a minimum resolution of 60nm, and v) comply with the data policy.

A number of potential new lines were presented. Criteria and list of all lines will be reviewed with guidance from P. Lherminier by early 2020.

3.7 Discussion: Should GO-SHIP have a Data Management Team like e.g. Argo has?

G. Johnson led the discussion on “Should GO-SHIP have a Data Management Team like e.g. Argo has?”. During the discussion it was noted that Argo started from scratch with a real-time data requirement, and (even with the advent of BGC Argo) has a simpler set of data management issues than GO-SHIP, with more resources. GO-SHIP, with roots in WOCE/JGOFS and earlier programs, has been going for a long time, with multiple groups on each cruise collecting a very heterogeneous data set, with many different parameters from different platforms. Putting together a website with links to all the different measurements was mentioned as a worthy first goal for GO-SHIP. It was also noted that GO-SHIP does have an assemblage of groups that work on data management for the core measurements (including carbon, traditional hydrographic measurements, ADCP, etc.), making sure they are archived with relevant metadata. Streamlining reports and making metadata more searchable were also activities mentioned for GO-SHIP data management, as were DOIs for recognition of data collectors. The discussion concluded with a recommendation/action to form a working group to scope out the likely terms of reference for a GO-SHIP data management team.

Section 4: The future of GO-SHIP / all other business

4.1 Auxiliary operations: prioritization and requests

The meeting was reminded by Katsuma Katsumata that a form for float deployment request has been developed which is available from the document section of the GO-SHIP website.

4.2 Cost, value, priorities, and leveraging of paid support functions including JCOMMOPS Coordinator

Rik Wanninkhof reminded the SC that the JCOMMOPS Technical Coordinator (TC), Martin Kramp, is covered for 3-mo to work on GO-SHIP issues. His responsibilities go beyond the core JCOMMOPS responsibility of metadata tracking and harmonization of the different observing elements in JCOMM. His GO-SHIP duties include acting as the secretariat of GO-SHIP. The efforts are essential to maintain, expose, and advance GO-SHIP.
There is no permanent funding structure in JCOMMOPS for these duties and funds come from different nations on a somewhat ad hoc basis sometimes as “year-end leftovers” with issues of late or non-receipt of funds. In the next three years the GO-SHIP resources for the TC are i.a. secured through the EU Euroseas project but include associated responsibilities to the project. A national contribution scheme must be sought but participants pointed out the challenges of securing resources for their own operations, and sending funds to intergovernmental agencies. Several agencies/nations, notably NOAA cover a large part of core JCOMMPS operations. No clear solution to this ongoing uncertainty is apparent but it must maintain on the forefront to continue effective operation and management of GO-SHIP.

4.3 Opportunities/Challenges for the next survey, including (new) national commitments and 5-year strategy

Throughout the meeting there was mention of opportunities and challenges for the next survey. As this agenda item was at the end of the meeting only little further discussion was devoted to this. Rik Wanninkhof summarized the items mentioned in the meeting including:

- US GO-SHIP is preparing a six-year proposal for the time period 2021-2026. As with previous proposals all level 1 measurements are submitted as omnibus package. For the first time, the work statement will be done jointly for NSF and NOAA program management. A companion proposal covering biological measurements (as level 3) is anticipated.
- Progress is made in coordination of data management and data submission to single depository or linking of depositories such that easy data access is facilitated. In particular, the US CCHDO which is the depository for US GO-SHIP bottle and CTD data is willing to act as the international depository for these measurements as well. Good interactions between JCOMMOPS and CCHDO is improving with tracking of metadata, in particular the listing of upcoming and completed cruises.
- There is a lot of interest in GO-SHIP associated lines, and countries would like to receive GO-SHIP endorsement of the lines. Germany and France have lines that they would like to be listed as GO-SHIP associated. Korea and China have several occupations that could meet the criteria. Ireland is investigating if their cruises across the Rockall Plateau can meet associated line criteria.

4.4 Membership and Responsibilities of the Science Committee

This item will be rediscussed by the GO-SHIP SC in a teleconference early 2020 after completion of the expertise table referenced in item 1.3.

List of Participants:

Molly BARINGER
United States of America

Andrew BARNA
United States of America

Susan BECKER
United States of America

Carolina BERYS-GONZALEZ
United States of America

Emmanuel BOSS
United States of America

Tim BOYER
United States of America

Brendan CARTER
United States of America

Caroline CUSACK (remote)
Ireland

Stephen DIGGS (remote)
United States of America

Eric FIRING
United States of America

Blair GREENAN
Canada

Joseph GUM
United States of America

Juliet HERMES
South Africa

Alonso HERNANDEZ-GUERRA
Spain

Julia HUMMON
United States of America

Masao ISHII
Japan

Gregory JOHNSON
United States of America

Katsuro KATSUMATA
Japan

Brian KING
United Kingdom of Great Britain and Northern Ireland

Hiroshi KOIDE
Japan

Martin KRAMP
WMO/IOC-UNESCO/JCOMMOPS

Jae Hak LEE
Republic of Korea

David LEGLER
United States of America

Pascale LHERMINIER
France

Alison MACDONALD
United States of America

Elaine MCDONAGH (remote)
United Kingdom of Great Britain and Northern Ireland

Jose MUELBERT
Brazil

Benjamin PFEIL
Norway

Isa ROSSO
United States of America

Christopher SABINE
United States of America

Daisuke SASANO
Japan

Karen STOCKS
United States of America

Lynne TALLEY
United States of America

Toste TANHUA
Germany

Kathy TEDESCO
United States of America

Maciej TELSZEWSKI
IOCCP

Bronte TILBROOK
Australia

Rik WANNINKHOF
United States of America

Mike WILLIAMS
New Zealand

E. Malcolm WOODWARD
United Kingdom of Great Britain and Northern Ireland