NOAA Support for the CLIVAR and Carbon Hydrographic Data Office at UCSD/SIO, 2013-2015

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Table of Contents

1. Project Summary 1
2. Scientific and Observing System Accomplishments 1
3. Outreach and Education 5
4. Publications and Reports 5
   4.1. Publications by Principal Investigators 5
   4.2. Other Relevant Publications 6

1. Project Summary

The CLIVAR and Carbon Hydrographic Data Office (CCHDO) brings together, verifies, and corrects content and format errors in hydrographic and tracer data used in large-scale ocean carbon, global change, water mass, and circulation studies [CLIVAR = Climate Variability and Predictability, a component of the World Climate Research Program]. It assembles the data with relevant documentation, and carefully prepares them for dissemination and archive. In addition it works to promote appropriate methodology, applicable community standards, communications, and data compatibility. The CCHDO brings data together to a common content and readability standard, thereby greatly reducing the difficulties research and education data users encounter. Documentation associated with the data are collected, reorganized to a common standard (where possible), and preserved with the data. The CCHDO makes it possible for all data users to cope with the temporal-, content-, and format-related file diversity the different originators engender without requiring each user to hire data specialists to rework the data. The CCHDO supports CLIVAR and ocean carbon science programs, and is a critical component of a global observing system for the physical climate/CO_2 system. The CCHDO also manages public and non-public CTD data used for verification of data from the international Argo and OceanSITES programs.

CCHDO data are free and available (without passwords) in the community "WHP-Exchange" format, legacy WOCE format, and CF-compliant netCDF format.

The largest share of CCHDO support is provided by NSF, with about 20% of funding presently from NOAA. CCHDO activities of special interest to NOAA, and for which NOAA support is applied, include:

1. Provide data from specific cruises that are of special interest to NOAA.
2. Continue working to improve the relationship with NOAA's National Oceanographic Data Center (NODC) via:

a. Continued data assembly of cruise hydrographic data and metadata, particularly those from the GO-SHIP program. [GO-SHIP = the Global Ocean Ship-Based Hydrographic Investigations Program.]
b. Working with NODC to improve efficiency of transfer of data and to make CCHDO data more "archive ready".
c. Improved CCHDO participation in discussions towards enhancing integration of specific related Data Assembly Centers to reduce ambiguity and redundancy in data archiving.

3. Broaden and simplify the accessibility of CCHDO data sets.
4. Support CCHDO Data Manager travel to data meetings of special interest to NOAA.

2. Scientific and Observing System Accomplishments

During the reporting period the CCHDO continued to increase its US and non-US CTD profiles, including both public and non-public data available for Argo reference; reconciled EXPOCODE expedition identifiers among US data centers; improved data search capabilities and added bulk data download feature on CCHDO web site; and are developing an Applications Programming Interface to enable large data users (e.g., modelers) to directly download any/all data of interest. The CCHDO now supports the international GO-SHIP web site and related functions.

There is a substantial amount of CTD data of value to the Argo and ocean research/modeling communities. The CCHDO continues to work with NOAA to assemble and incorporate into NOAA-related holdings select cruise data sets. [For example, over 6500 HOT and BATS profiles were submitted to OceanSITES. Also, more than 3700 new CTD profiles from US and non-US cruises were added to the Argo reference CTD data set in the 2012-2013 year between Argo Data Management Committee meetings.]

The NOAA/NODC works with several data assembly centers, including the CCHDO, to bring data into NODC. The CCHDO continues to improve their relationship with NODC in the following areas:

i. Continued data assembly of cruise hydrographic data and metadata, particularly those from the GO-SHIP program. [Also, acquired the GO-SHIP web site, assisted the new GO-SHIP technical manager with start-up; held 2-day meeting with GO-SHIP and US HYDRO leadership.]

ii. Working with NODC to improve efficiency of transfer of data and to make CCHDO data more "archive ready". [Developing an Application Programming Interface for CCHDO and Argo. Working with Tim Boyer (NODC) to better synchronize data holdings.]

iii. Improved CCHDO participation in discussions towards enhancing integration of the related Data Assembly Centers (specifically CDIAC and BCO-DMO), to reduce ambiguity and redundancy in data archiving. [For example, an EXPOCODE reconciliation has taken place between the CCHDO, BCO-DMO, and CDIAC (this also reconciles GO-SHIP EXPOCODES since the CCHDO is the data assembly center for GO-SHIP.]

CCHDO holdings are of value to a wide audience of climate researchers (including modelers) and other users. The CCHDO is implementing changes to make their holdings more query-able and accessible through modern data management standards and practices (including those that NOAA and the international oceanographic community recommend). For example, data searches based on available parameters are now available and can be combined with other search features, the "OR" function is available in data searches, and a data cart now enables bulk download of selected files.

A broad international community makes use of CCHDO data, with use most intense from US researchers and students. For example, during the period July 1, 2012 - July 1, 2013 these are the visit statistics for the CCHDO web site http://cchdo.ucsd.edu (counting is done by IP address):

11,877 visits,
96 countries with visitors who stayed on the site longer than one minute,
4573 visitors,
1292 returning visitors, and
4289 new visitors.

[To eliminate in-house use, the above does not count visits originating from within UCSD. This does, however, also eliminate counting of use of the CCHDO by SIO researchers and students, which is significant.]

Data submissions and subsequent CCHDO web site data updates continue to be frequent. For example, during the period July 1, 2012 - July 1, 2013 these are data submission statistics:

	Files	**Cruises**
SUBMITTED Files (new and updated)	160	91
WEBSITE UPDATES		
Bottle	129	41
CTD	30	12
SUM	12	11
additional "AS RECEIVED" data files on line but not yet checked	124	

Over that same period the CCHDO added 3909 new pages of documentation to the website. These pages represent 43 unique cruises. And during this time period the data histories were updated 538 times as part of 180 data file submission and 358 website updates.

In terms of data submissions, participation from most US data originators (the PIs who are in charge of one or more parameters) has been excellent, with only one US PI (not NOAA funded) presently significantly overdue with data deliveries.

Regarding international participation, there are seven nations engaged in full-depth repeats of WHP basin-scale transects which include ocean carbon parameters: Australia, Canada, France, Germany, Japan, the UK, and the US. (The CCHDO also hosts data with less broad parameter content from other nations.) Of these, Australian, Japanese, and US investigators continue to

routinely provide their CTD and bottle data to the CCHDO on their nation's schedule, and data receipts from Canada from the Bedford Institute of Oceanography have become routine on the schedule they set. Some UK investigators by-pass their national data center to provide CTD/hydrographic data to the CCHDO on the schedule they set (sometimes preliminary shipboard data are sent immediately after a cruise). Through the CDIAC and Dr. Robert Key (Princeton) the CCHDO receives some data from other countries.

International coordination is improving steadily, partly due to CCHDO efforts and partly due to the growing success of the international scientific oversight and planning body GO-SHIP, which brings together scientists with interests in physical oceanography, the carbon cycle, marine biogeochemistry and ecosystems, and other users and collectors of hydrographic data to develop a globally coordinated network of sustained hydrographic sections as part of the global ocean/climate observing system. GO-SHIP has become a widely known and appreciated effort within the community. The CCHDO hosts the GO-SHIP web site (http://www.go-ship.org/) at the request of the IOC. The relationship with GO-SHIP assists the CCHDO in keeping up to date with international cruises of interest to the CCHDO's data users.

The CCHDO continues to enjoy a mutually beneficial relationship with both the Argo and OceanSITES programs. In exchange for the CCHDO providing both programs with specifically formatted CTD data, these NOAA programs in turn assist the CCHDO in the discovery and acquisition of hydrographic data from the PIs involved in those communities. CCHDO data management support of the NSF-funded DIMES project has developed well during the past year, including establishing the format of the HRP [High Resolution Profiler] data, CF format compliance and overall data access and distribution. The point here is that the tools, formats and methods that NSF and NOAA have invested in for the CCHDO have proven to be directly applicable to effective management of data for these types of process studies and field programs.

Since the time of WOCE and the WHPO (the CCHDO's predecessor), the CCHDO has provided direct benefits to NOAA and NOAA researchers, including, for example, supplying a full range of data and documentation services for NOAA cruises for the program, providing data to many NOAA scientists who routinely use CCHDO data and documentation, supporting CTD data services for the NOAA-supported Ocean-SITES program, and providing significant "front-end" data services which aid NOAA/NODC. The CCHDO's present, partial fiscal support from NOAA helps to support the above activities and to provide data from specific cruises that are of special interest to NOAA, to work more closely with NOAA on data assembly as related to NOAA data centers, to broaden and simplify the accessibility of CCHDO data sets to NOAA investigators, and to make holdings more query-able and accessible through modern data management standards and practices (including those that NOAA and the international oceanographic community recommend).

The CCHDO maintains files for more than 1300 cruises. The underpinnings of the CCHDO's in-house (staff only) and on-line (public) operations require continual modifications and updating to maintain compliance with security and operational guidelines, always with a focus on ease and power of use combined with underlying simplicity of operations and maintenance. The CCHDO continued to expand automation of routine work to speed the work of the data specialists and reduce time, errors, inconsistencies, and omissions. This streamlining contributed to a more than

doubling, compared to last year, of placing newly-received files on line. Also, the time to produce routine on-line maps for each cruise was greatly shortened via implementation of a new online map tool.

The CCHDO now has (internal) software modules that read and write data in WOCE, WHP-Exchange, netCDF, OceanSITES, MATLAB, and some "in-house" formats used by major data submitters. This software includes some unit conversions, conversion of depths to pressures, reorder of rows based on pressure, and so forth. In the past year a module has been developed to read some SeaBird CTD files directly. The new and updated modules resulted in large performance increases for reading and writing data formats.

The goal and result of CCHDO activities is an ever-growing library of World Ocean CTD, hydrographic, ocean carbon, and tracer data which are correct, up-to-date, properly attributed, well-documented, and with a clear data history (available to users). The CCHDO is a stable, mature operation with consistent goals - in terms of supplying a broad community with a dependable data set meeting community needs. The CCHDO's multi-year strategy for utilizing its NSF and NOAA support includes continuing to broaden its reach to more of the data originators who generate the data the community wishes to obtain from the CCHDO in consistent form, and continuing to work with all data providers to assist their transfer of data and documentation to the CCHDO in forms that mutually reduce the workload on them and the CCHDO. At the same time, internal CCHDO operations are continually being examined and improved for greater reliability, accuracy, and efficiency. Thus, an increasing volume of data can be handled from an increasing number of data originators, and supplied to an increasing number of data users, with minimal change in CCHDO staff or inflation/merit-adjusted agency support.

3. Outreach and Education

The CCHDO maintains a website (http://cchdo.ucsd.edu) where the data and accomplishments of the project are maintained for public/scientific view and use. CCHDO data form the core data used in the exercises developed for the new textbook "Descriptive Physical Oceanography - An Introduction" by Talley, Emery, Pickard, and Swift (see http://joa.ucsd.edu/dpo). The CCHDO contributed to and maintains the outreach pages on the USHYDRO web site, including a virtual cruise (ship plans, photos, videos, etc.) and an example of a complete cruise from proposal through preliminary data interpretation (see http://ushydro.ucsd.edu/outreach). Also, the USHYDRO site now includes blogs from students participating at sea. Additional community outreach is accomplished by attendance and poster presentations at conferences and meetings.

4. Publications and Reports

4.1. Publications by Principal Investigators

The CCHDO is a data assembly and distribution center. The work plan for the NOAA funding for the CCHDO does not involve traditional research activities that lead to peer-reviewed publications from the CCHDO Principal Investigators. Also, the NOAA funding does not

support preparation of peer-reviewed publications by the CCHDO PIs using NOAA OCO funds.

4.2. Other Relevant Publications

Many peer-reviewed publications are generated by the users of CCHDO data, by PIs from a wide range of institutions and nations who use data provided by the CCHDO, including data whose assembly and distribution are funded by NOAA support of the CCHDO. There is, however, no viable mechanism to track the publications generated by the thousands of data requests during the past year. The international GO-SHIP office has begun a bibliography of research publications resulting from thus Global Ocean Carbon and Repeat Hydrography program, for which the data are obtained from the CCHDO. The present contents of the bibliography may be viewed at the GO-SHIP web site (http://www.go-ship.org/20131001-bibliography.pdf). An improved on-line version of this bibliography will soon be available on the USHYDRO web site (http://ushydro.ucsd.edu).