A New Platform to Study Processes in the Gulf of Mexico and Western Caribbean across Time and Space Scales

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MV BULK XAYMACA

MV Bulk Xaymaca is a commercial vessel that regularly crosses the western Caribbean and Gulf of Mexico and is outfitted with scientific sensors (**Figure 1**). Ongoing cooperation between Pangaea Logistics Solutions, Seamar Management, and scientists from institutions comprising the Woods Hole Oceanographic Institution, University of Hawaii, University of Rhode Island, Stony Brook University, and Florida State University has culminated in a year of tremendous data acquisition during the vessel's regular transits.

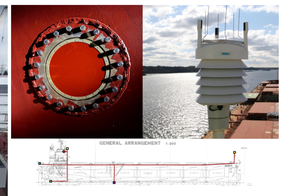

***Figure 1**. MV Bulk Xaymaca is a Panamax bulk carrier (14-m draft and 225-m LOA). Scientific sensors installed in drydock in January 2022 include a hull-mounted Teledyne RD Instruments 75 kHz ADCP and a Vaisala WXT-536 weather station. Related components were completed in October 2022 (electrical system) and July 2023 (navigation system).*

The FAIR (Findable, Accessible, Interoperable, and Reusable) data from *MV Bulk Xaymaca* can be used to investigate:

- How fast is the Loop Current? How does its strength and position vary over time?
- When and how does the Loop Current spawn Loop Current Eddies? These "ocean storms" are associated with intense currents that can damage offshore oil and gas platforms. Can the timing and path of these ocean storms be predicted for better preparedness?
- How do the region's currents disperse material carried in the ocean, like nutrients and Sargassum? Can this information be used to mitigate the damage from accidental release of pollutants?
- Where and how does the ocean fuel hurricane intensification and how might that change in a warming climate?

SCIENCE RoCS

This effort is a partnership between the shipping industry and the scientific research community under the umbrella of Science Research on Commercial Ships (Science RoCS), an ad hoc multi-institution group whose goal is to transform ocean science by outfitting commercial ships with scientific sensors. Science RoCS aims to complement capabilities of research vessels by making *in situ* measurements in remote locations or along repeated tracks. In 2023 alone, *MV Bulk Xaymaca* passed through the Yucatán Channel 30 times (**Figure 2**). Vessels from the US Academic Research Fleet reported velocity sections here just 5 times in 12 years (2008-2020, **Figure 3**).

***Figure 2**. MV Bulk Xaymaca's route from Discovery Bay, Jamaica to Gramercy , LA, USA crosses the Loop Current. Clearances to collect scientific data within exclusive economic zones (EEZs) have been obtained from Jamaica, Cayman Islands and Cuba. Initial year-long blanket clearances for 2023 have been renewed for 2024.*

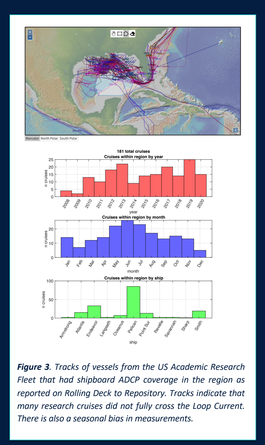

***Figure 3**. Tracks of vessels from the US Academic Research Fleet that had shipboard ADCP coverage in the region as reported on Rolling Deck to Repository. Tracks indicate that many research cruises did not fully cross the Loop Current. There is also a seasonal bias in measurements.*

VELOCITY PROFILES

In late 2022 and early 2023 *MV Bulk Xaymaca* captured the formation of a Loop Current Eddy and Loop Current Frontal Eddy (**Figure 4**). Velocity sections show general agreement between modeled and observed positions of the Loop Current and its eddies, but *in situ* observations reveal (1) stronger currents and (2) vertical velocity profiles with sharper gradients (e.g., **Figure 5**). The observed vertical shear is important for baroclinic instability and mixing. Assimilation of ADCP data into models is expected to improve both the representation of the Loop Current and forecasts of eddy shedding events.

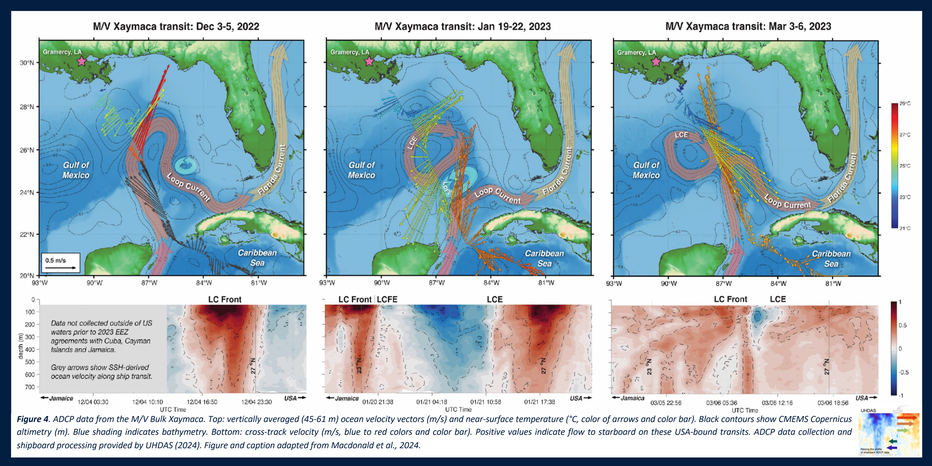

***Figure 4**. ADCP data from the M/V Bulk Xaymaca. Top: vertically averaged (45-61 m) ocean velocity vectors (m/s) and near-surface temperature (°C, color of arrows and color bar). Black contours show CMEMS Copernicus altimetry (m). Blue shading indicates bathymetry. Bottom: cross-track velocity (m/s, blue to red colors and color bar). Positive values indicate flow to starboard on these USA-bound transits. ADCP data collection and shipboard processing provided by UHDAS (2024). Figure and caption adopted from Macdonald et al., 2024.*

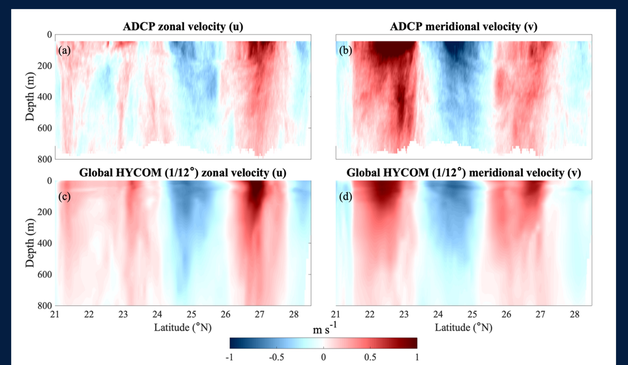

***Figure 5.** Gulf of Mexico velocity sections from January 2023 as measured by the ADCP and as reproduced by a 1/12° global HYCOM data assimilative system. The global HYCOM field was interpolated into the ADCP spatial and temporal grids to obtain equivalent spatial and temporal sampling. Figure and caption adapted from Macdonald et al., 2024.*

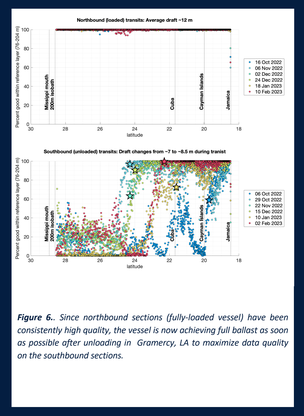

***Figure 6.**. Since northbound sections (fully-loaded vessel) have been consistently high quality, the vessel is now achieving full ballast as soon as possible after unloading in Gramercy, LA to maximize data quality on the southbound sections.*

The ADCP measures ocean velocities in 16-m bins beneath the hull from 30 m to depths exceeding 750 m, providing 5-minute averaged velocity profiles. On a typical 3-day transit, the ship travels at 11.5-13.5 knots (6-7 m/s) and collects velocity profiles at about 2 km along-track resolution returning up to 850 individual profiles in a section. Data quality is excellent particularly when the ship is fully ballasted (**Figure 6**).

ARGO & MET DATA

In July 2023 the crew of the *MV Bulk Xaymaca* launched a set of Argo floats in the western Caribbean. The floats have already collected 155 profiles of temperature and salinity in the under-sampled western Carribean (**Figure 7**). The WXT-536 weather station has been measuring wind speed and direction, air temperature, humidity, and sea-level pressure underway (**Figure 8**) and in port.

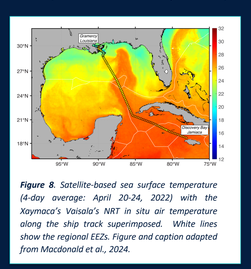

***Figure 8**. Satellite-based sea surface temperature (4-day average: April 20-24, 2022) with the Xaymaca's Vaisala's NRT in situ air temperature along the ship track superimposed. White lines show the regional EEZs. Figure and caption adapted from Macdonald et al., 2024.*

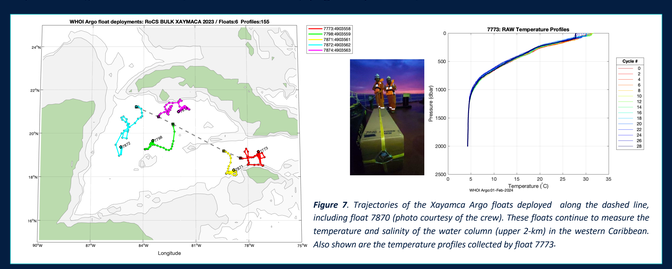

***Figure 7**. Trajectories of the Xayamca Argo floats deployed along the dashed line, including float 7870 (photo courtesy of the crew). These floats continue to measure the temperature and salinity of the water column (upper 2-km) in the western Caribbean. Also shown are the temperature profiles collected by float 7773.*

DATA ACCESS

A founding principle of Science RoCS is that our scientific data collection should serve the broader good and that the data should be "FAIR" for both scientists and stakeholder communities (**Figure 9**). To that end, installation of a "RoCS Box" on *MV Bulk Xaymaca* allows for time stamping and geolocating the data streams and includes a real-time dashboard to view underway data from shore for data quality assurance.

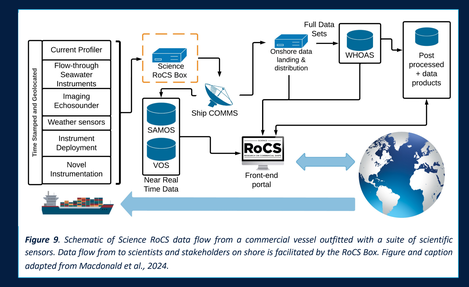

***Figure 9**. Schematic of Science RoCS data flow from a commercial vessel outfitted with a suite of scientific sensors. Data flow from to scientists and stakeholders on shore is facilitated by the RoCS Box. Figure and caption adapted from Macdonald et al., 2024.*

At the end of each *MV Bulk Xaymaca* voyage, the data are bundled into a "voyage distribution" and uploaded to the Science RoCS Collection at the Woods Hole Open Access Server (WHOAS), which is publically available:

https://darchive.mblwhoilibrary.org/collections/3cb9837e-60c4-4ea0-a1f4-be96b4fadc30

Other links where *MV Bulk Xaymaca* data can be accessed include:

MV Bulk Xaymaca Met Dashboard

These data are near-real time (NRT) and include weather data collected by the Vaisala WXT-536, data from the ship comprising speed, heading, and GPS positions, and data from a Hydrins high-performance Inertial Navigation System (INS) comprising pitch, roll, and heave (e.g. **Figure 10**). Note that this INS is on loan from another project; funding is being sought for a permanent Xaymaca-dedicated INS.

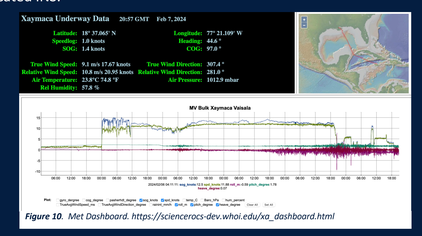

***Figure 10**. Met Dashboard. https://sciencerocs-dev.whoi.edu/xa_dashboard.html*

MV Bulk Xaymaca OpenGTS Data (e.g., **Figure 11**)
https://data.pmel.noaa.gov/generic/erddap/tabledap/xaymaca_gts.html

MV Bulk Xaymaca ADCP Dashboard

This link contains NRT data. Various plots are automatically generated by the UHDAS processing code (e.g. **Figure 12**).

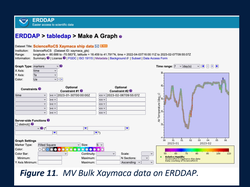

***Figure 11**. MV Bulk Xaymaca data on ERDDAP.*

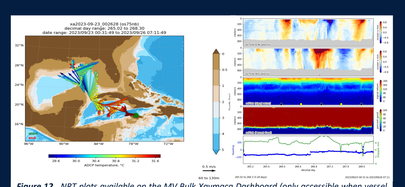

***Figure 12**. NRT plots available on the MV Bulk Xaymaca Dashboard (only accessible when vessel is underway).*

Argo Data

Float Map - https://argo.whoi.edu/solo2/maps/2023cruises.html (select "RoCS BULK XAYMACA 2023")
Argo Float 7773 - https://argo.whoi.edu/solo2/7773/index.html
Argo Float 7798 - https://argo.whoi.edu/solo2/7798/index.html
Argo Float 7871 - https://argo.whoi.edu/solo2/7871/index.html
Argo Float 7872 - https://argo.whoi.edu/solo2/7872/index.html

FUNDING

To date, outfitting the *MV Bulk Xaymaca* with scientific sensors has been supported with seed funding from the US Office of Naval Research and Woods Hole Oceanographic Institution, and generous in-kind support and invaluable technical assistance provided by the vessel owners and operators, Pangaea Logistics Solutions and Seamar Management, Ltd. We now seek funding to continue Xaymaca data collection and desemination, to expand the sensor suite, and to broaden the reach of Science RoCS to commercial ships in other scientifically valuable locations. We hope you will join us in this endeavor!

NEXT STEPS

To continue the collection and sharing of data from *MV Bulk Xaymaca*, Science RoCS seeks funding to:

- Secure a dedicated high performance Inertial Navigation System (INS) that will be installed on *MV Bulk Xaymaca,*
- Support the occasional maintainance required to keep the existing sensor suite aboard the vessel operational,
- Continue archiving raw data and continue basic quality control of the data streams by UHDAS (ADCP) and SAMOS (MET sensor) to supply near real time data,
- Expand the sensor suite hosted on the vessel.

To support research in the Gulf of Mexico and western Caribbean and to engage stakeholder communities, Science RoCS strives to:

- Work with scientists who aim to use Science RoCS data in their research proposals,
- Build relationships with the Centre for Marine Sciences at the University of the West Indies at Mona, Jamaica
- Collaborate with the OceanScope Project to increase access to historical and present-day datasets collected aboard Royal Caribbean cruise ships in the Gulf of Mexico and Caribbean.

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