Chemical and biological data collected for surface and bottom samples from all five stations along the transect from Charlotte Harbor to offshore in southwest Florida over the four sampling periods post-hurricane Ian during 2023-2024

Website: https://www.bco-dmo.org/dataset/1003828
Data Type: Cruise Results
Version: 1
Version Date: 2026-08-07

Project
» RAPID: Collaborative Research: Unprecedented Hurricane Ian Nutrient and Organic Matter Inputs to Southwest Florida Coastal Waters (RAPID: Ian Inputs)

Contributors	Affiliation	Role
Heil, Cynthia	Mote Marine Laboratory (Mote)	Principal Investigator
Glibert, Patricia A.	University of Maryland Center for Environmental Science (UMCES/HPL)	Co-Principal Investigator
Hall, Emily	Mote Marine Laboratory (Mote)	Co-Principal Investigator
Li, Ming	University of Maryland Center for Environmental Science (UMCES/HPL)	Co-Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This RAPID project, a collaboration between C. Heil and E. Hall (Mote Marine Laboratory) and P. Glibert and M. Li (University of Maryland Center for Environmental Science), examined the overarching hypothesis that the massive terrestrial inorganic and organic carbon and nutrient inputs to the southwest Florida coastal and shelf region from Hurricane Ian were priming this oligotrophic system for extensive phytoplankton blooms as well as significant changes in carbon chemistry and nutrient cycling that will lead to longer term regional hypoxia and anoxia. We measured a suite of water quality, carbon and nutrient parameters, as well as carbon and nutrient cycling at stations in Charlotte Harbor and the adjacent inner West Florida Shelf (WFS) system over four sampling efforts (May 2023, August 2023, September 2023, and October 2024) to examine how fast changes and recovery occurs in this system and the relationship of these hurricane inputs to hypoxia, anoxia, and ocean acidification. This dataset includes the chemical and biological data from surface and bottom samples from all five stations along the transect from Charlotte Harbor to offshore in southwest Florida over the four sampling periods post-hurricane Ian, during 2023 and 2024. Data include net community production and oxygen utilization rates, carbonate and nutrient suite and rate process measurements (including uptake and regeneration rates), as well as direct measurements of organic matter respiration to understand how Hurricane Ian impacted biogeochemistry, blooms, and dissolved oxygen of the region.

Table of Contents

Coverage

Location: Southwest Florida coastal waters
Spatial Extent: **N**:26.90435 **E**:-82.1404 **S**:26.5107 **W**:-82.4424
Temporal Extent: 2023-05-02 - 2024-10-02

Methods & Sampling

Sampling Plan: Four sampling efforts were conducted (May 2023, August 2023, September 2023, October 2024), focusing on five stations located from Charlotte Harbor to the adjacent inner West Florida Shelf (WFS) system directly impacted by Hurricane Ian and the resulting plumes using Mote's R/V Mote (42 ft). At each station, water column CTD profiles of temperature, salinity, dissolved oxygen, and pH were made, and discrete surface and bottom water samples were collected by rosette-mounted Niskin bottles and analyzed for the parameters and rates listed in Table 1. Sample processing occurred on board or immediately after return to the laboratory. Net community production and oxygen utilization rates were calculated using observed O2 differences at hour intervals after air-sea O2 corrections (e.g., Wang et al. 2017). The balance between ecosystem respiration and production, the net community production, yielded a measure of the net autotrophic or heterotrophic ecosystem state (Hopkinson and Smith 2005). The carbonate and nutrient suite and rate process measurements (including uptake and regeneration rates) and direct measurements of organic matter respiration allowed an assessment of how nutrient availability and forms influence hypoxia and how hurricane inputs influence carbonate chemistry in this system, specifically the connection between acidification and hypoxia (e.g. O2 vs. pH relationships).

Analytical Methods: See Table 1 (supplemental file).

BCO-DMO Processing Description

- Imported the original CSV file "Heil & Hall RAPID Chemical and BIological Data -FINAL as CSV.csv" into the BCO-DMO processing system.
- Renamed columns via a series of regex substitutions to remove/replace special characters: spaces to underscores, commas removed, closing parentheses removed, opening parentheses removed, "@" replaced with "at", periods removed, "/" replaced with underscore, hyphens replaced with underscore, ">" replaced with "gt", "+" replaced with "plus". These are requirements of BCO-DMO's naming conventions.
- Split column "Date_Collected_Time_Zone" into new columns "Date_Collected" and "Time_Zone", deleting the original input column.
- Converted column "Date_Collected" from string format "%m/%d/%Y" to date type with output format "%Y-%m-%d".
- Applied find/replace to column "Total_Karenia_species" to remove commas from numeric values.
- Set data types for all columns.
- Renamed column "Tital_Dinoflagellates" to "Total_Dinoflagellates".
- Saved the final file in CSV format as "1003828_v1_chem_bio_post-ian.csv".

Problem Description

No known problems with the dataset.

[table of contents | back to top]

Related Publications

Ammerman, J. W. (1993). Microbial cycling of inorganic and organic phosphorus in the water column. In P. Kemp, B. Sherr, E. Sherr, and J. Cole (Eds.) Handbook of Methods in Microbial Ecology. Lewis Publ., Florida. https://isbnsearch.org/isbn/9780873715645
Methods

Chen, Y., & Li, M. (2025). Impact of Hurricane Ian (2022) on *Karenia brevis* Bloom on the West Florida Shelf. Geophysical Research Letters, 52(6). Portico. https://doi.org/10.1029/2024GL113500

Results

Chen, Y., Li, M., Glibert, P. M., & Heil, C. (2023). Mu*rK*y waters: Modeling the succession from *r* to *K* strategists (diatoms to dinoflagellates) following a nutrient release from a mining facility in Florida. Limnology and Oceanography, 68(10), 2288–2304. Portico. https://doi.org/10.1002/lno.12420
Results

Devillier, V. M., Hall, E. R., Lovko, V., Pierce, R., Anderson, D. M., & Lewis, K. A. (2024). Mesocosm study of PAC-modified clay effects on Karenia brevis cells and toxins, chemical dynamics, and benthic invertebrate physiology. Harmful Algae, 134, 102609. https://doi.org/10.1016/j.hal.2024.102609
Methods

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to Best Practices for Ocean CO2 Measurements. PICES Special Publication 3, 191 pp https://isbnsearch.org/isbn/1-897176-07-4
Methods

Genty, B., Briantais, J.-M., & Baker, N. R. (1989). The relationship between the quantum yield of photosynthetic electron transport and quenching of chlorophyll fluorescence. Biochimica et Biophysica Acta (BBA) - General Subjects, 990(1), 87–92. https://doi.org/10.1016/s0304-4165(89)80016-9 https://doi.org/10.1016/S0304-4165(89)80016-9
Methods

Glibert, P. M., Heil, C. A., & Li, M. (2025). More sustained, more severe blooms and shifting monthly patterns of the toxigenic dinoflagellate Karenia brevis on the West Florida Shelf. Harmful Algae, 150, 102967. https://doi.org/10.1016/j.hal.2025.102967
Results

Glibert, P. M., Heil, C. A., & Li, M. (2026). Climate shifts and anthropogenic footprints driving increased severity and duration of toxic Karenia brevis blooms in the Gulf of Mexico over the past ~50 years. Frontiers in Marine Science, 13. https://doi.org/10.3389/fmars.2026.1769349
Results

Glibert, P.M. and D.G. Capone. 1993. Mineralization and assimilation in aquatic, sediment, and wetland systems, p. 243–271. In R. Knowles and T.H. Blackburn, editors, Nitrogen isotope techniques. Academic. https://isbnsearch.org/isbn/978-0124169654
Methods

Hall, E. R., Muller, E. M., Goulet, T., Bellworthy, J., Ritchie, K. B., & Fine, M. (2018). Eutrophication may compromise the resilience of the Red Sea coral Stylophora pistillata to global change. Marine Pollution Bulletin, 131, 701–711. https://doi.org/10.1016/j.marpolbul.2018.04.067
Methods

Holm-Hansen, O., Lorenzen, C. J., Holmes, R. W., & Strickland, J. D. H. (1965). Fluorometric Determination of Chlorophyll. ICES Journal of Marine Science, 30(1), 3–15. doi:10.1093/icesjms/30.1.3
Methods

Hopkinson, C., & Smith, E. M. (2005). Estuarine respiration: An overview of benthic, pelagic, and whole system respiration. In P. A. del Giorgio & P. J. le B. Williams (Eds.), Respiration in Aquatic Ecosystems (pp. 122–146). Oxford University Press. https://isbnsearch.org/isbn/978-0198527084
Methods

Hudson, J. J., & Taylor, W. D. (1996). Measuring regeneration of dissolved phosphorus in planktonic communities. Limnology and Oceanography, 41(7), 1560–1565. Portico. https://doi.org/10.4319/lo.1996.41.7.1560
Methods

Paasche, E. (1980). Silicon content of five marine plankton diatom species measured with a rapid filter method1. Limnology and Oceanography, 25(3), 474–480. Portico. https://doi.org/10.4319/lo.1980.25.3.0474
Methods

Revilla, M., Alexander, J., & Glibert, P. M. (2005). Urea analysis in coastal waters: comparison of enzymatic and direct methods. Limnology and Oceanography: Methods, 3(7), 290–299. Portico. https://doi.org/10.4319/lom.2005.3.290
Methods

Slawyk, G., Collos, Y., & Auclair, J.-C. (1977). The use of the ^{13}C and ^{15}N isotopes for the simultaneous measurement of carbon and nitrogen turnover rates in marine phytoplankton1. Limnology and Oceanography, 22(5), 925–932. Portico. https://doi.org/10.4319/lo.1977.22.5.0925
Methods

Wang, K., Chen, J., Ni, X., Zeng, D., Li, D., Jin, H., Glibert, P. M., Qiu, W., & Huang, D. (2017). Real-time monitoring of nutrients in the Changjiang Estuary reveals short-term nutrient-algal bloom dynamics. Journal of Geophysical Research: Oceans, 122(7), 5390–5403. Portico. https://doi.org/10.1002/2016jc012450 https://doi.org/10.1002/2016JC012450
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Heil, C., Hall, E., Glibert, P. A., Li, M. (2026) **CTD data collected for surface and bottom samples from all five stations along the transect from Charlotte Harbor to offshore in southwest Florida from May to September 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-08-06 http://lod.bco-dmo.org/id/dataset/1004016 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Sample_depth_surface_bottom	S=surface (Niskin bottle at surface), B=bottom (Niskin bottle 0.5 m above bottom), specific S and B depth for each station are in CTD DEPTH column	unitless
Client_ID	Funding agency	unitless
SampID	Station Identification	unitless
Latitude_1	Latitude	decimal degrees
Longitude_1	Longitude	decimal degrees
Date_Collected	Date (EDT)	unitless
Time_Zone	Time Zone	unitless
Tag_Number	Mote internal ID number	unitless
Nitrogen_Ammonia_as_N_Diss_mg_L	Ammonium	mg L-1
Nitrogen_Ammonia_as_N_Diss_uM	Ammonium	uM

Nitrogen_Nitrate_Nitrite_as_N_Diss_mg_L	Nitrate + Nitrite	mg L-1
Nitrogen_Nitrate_Nitrite_as_N_Diss_uM	Nitrate + Nitrite	uM
Nitrogen_Particulate_ug_L	Particulate Nitrogen	ug L-1
Nitrogen_Particulate_uM	Particulate Nitrogen	uM
Nitrogen_Total_Diss_mg_L	Total Dissolved Nitrogen	mg L-1
Nitrogen_Total_Diss_uM	Total Dissolved Nitrogen	uM
Phosphorus_Orthophosphate_as_P_Diss_mg_L	Orthophosphate	mg L-1
Phosphorus_Orthophosphate_as_P_Diss_uM	Orthophosphate	uM
Phosphorus_Particulate_ug_L	Particulate Phosphorus	ug L-1
Phosphorus_Particulate_uM	Particulate Phosphorus	uM
Phosphorus_Total_Diss_mg_L	Total Dissolved Phosphorus	mg L-1
Phosphorus_Total_Diss_uM	Total Dissolved Phosphorus	uM
Silica_as_SiO2_Diss_mg_L	Silica (as SiO2, dissolved)	mg L-1
Silica_as_SiO2_Diss_uM	Silica (as SiO2, dissolved)	uM
Silica_particulate_as_SiO2_ug_L	Particulate Silica	ug L-1
Silica_particulate_as_SiO2_uM	Particulate Silica	uM
Organic_Carbon_Dissolved_mg_L	dissolved organic carbon	mg L-1
Organic_Carbon_Dissolved_uM	dissolved organic carbon	uM
Carbon_Particulate_ug_L	Particulate Carbon	ug L-1

Carbon_Particulate_uM	Particulate Carbon	uM
CDOM_Abs_at_280_nm	Colored Dissolved Organic Material Absorption at 280 nm	unitless
CDOM_Abs_at_312_nm	Colored Dissolved Organic Material Absorption at 312 nm	unitless
CDOM_Abs_at_350_nm	Colored Dissolved Organic Material Absorption at 350 nm	unitless
CDOM_Abs_at_374_nm	Colored Dissolved Organic Material Absorption at 374 nm	unitless
CDOM_Abs_at_376_nm	Colored Dissolved Organic Material Absorption at 376 nm	unitless
CDOM_Abs_at_400_nm	Colored Dissolved Organic Material Absorption at 400 nm	unitless
CDOM_Abs_at_412_nm	Colored Dissolved Organic Material Absorption at 412 nm	unitless
CDOM_Abs_at_430_nm	Colored Dissolved Organic Material Absorption at 430 nm	unitless
CDOM_Abs_at_440_nm	Colored Dissolved Organic Material Absorption at 440 nm	unitless
Chlorophyll_a_free_of_pheophytin	Chlorophyll a (without phaeopigments)	ug/L
CTD_DEPTH	sample depth measured by CTD	meters (m)
CTD_DO	dissolved oxygen concentration from CTD	mg L-1
CTD_FLUOR	Fluorescence from CTD	unitless
CTD_PAR	Photosynthetically active radiation	µmol photons m-2 s-1
CTD_SAL	Salinity from CTD	PSU
CTD_TEMP	Temperature from CTD	degrees Celsius

CTD_TURB	Turbidity from CTD	NTU
Total_Karenia_species	Concentration of all Karenia species	cells L-1
Total_Phytoplankton	Concentration of all phytoplankton	cells L-1
Total_Dinoflagellates	Concentration of all dinoflagellates	cells L-1
Total_Diatoms	Concentration of all diatoms	cells L-1
Total_Other_Plankton	Concentration of all flagellates (excluding dinoflagellates)	cells L-1
Total_Cyanobacteria	Concentration of all cyanobacteria	cells L-1
Latitude_2	geographic coordinate specifying the north-south position of a point on Earth's surface	degrees
Longitude_2	angular distance of a point east or west of the Prime Meridian (0°),	degrees
Sigma_t	seawater density	kg/m3
Aragonite_saturation_state	Aragonite saturation state	unitless
Bicarbonate	Bicarbonate	µM Kg SW-1
Borate_Alkalinity	Borate Alkalinity	µM Kg SW-1
Calcite_saturation_state	Calcite saturation state	unitless
Carbon_dioxide_fugacity	effective partial pressure of CO2	µAtm
Carbonate	Carbonate	µM Kg SW-1
Dissolved_carbon_dioxide	Dissolved carbon dioxide	µM Kg SW-1

Hplus_in	Hydrogen ion concentration	unitless
Hydroxide_alkalinity	Hydroxide alkalinity	µM Kg-1
Organic_Alkalinity_calculated	Organic Alkalinity, calculated	µM Kg SW-1
Partial_pressure_of_carbon_dioxide	Partial pressure of carbon dioxide	µAtm
Revelle	ratio of instantaneous change in carbon dioxide (CO 2) to the change in total dissolved inorganic carbon	unitless
Total_Alkalinity	Total Alkalinity	µM Kg-1
Total_Alkalinity_calculated	Total Alkalinity, calculated	µM Kg-1
Total_Dissolved_Inorganic_Carbon	Total Dissolved Inorganic Carbon	µM Kg-1
Total_pH_calculated	Total pH, calculated	Calculated (Units)
Total_pH_measured	Total pH, measured	Calculated (Units)
BLANK_CORR_Photosynthetic_rate	blank corrected, O2 based photosynthetic rate	µmol O2 L-1 hr-1
BLANK_CORR_Respiration_rate	blank corrected, O2 based respiration rate	µmol O2 L-1 hr-1
Phosphorus_Uptake	33PO4 uptake rate of >0.7 um fraction	uM L-1 hr-1
Phosphorus_Regeneration_Bulk_whole_water	33Phosphorus Regeneration rate of whole water	uM L-1 hr-1
Phosphorus_Regeneration_gt07_um	33Phosphorus Regeneration rate of >0.7 um fraction	uM L-1 hr-1
TChl_a	HPLC Pigment -Total Chlorphyll a	ug L-1
TChl_b	HPLC Pigment -Total Chlorphyll b	ug L-1
TChl_c	HPLC Pigment -Total Chlorphyll c	ug L-1

Caro	HPLC Pigment -alphas + beta carotene	ug L-1
But_fuco	HPLC Pigment - 19′-butanoyloxyfucoxanthin	ug L-1
Hex_fuco	HPLC Pigment - 19′-hexanoyloxyfucoxanthin	ug L-1
Allo	HPLC Pigment -Alloxanthin	ug L-1
Diad	HPLC Pigment -diadinoxanthin	ug L-1
Diato	HPLC Pigment - diatoxanthin	ug L-1
Fuco	HPLC Pigment - fucoxanthin	ug L-1
Perid	HPLC Pigment -peridinin	ug L-1
Zea	HPLC Pigment - zeaxanthin	ug L-1
Chl_a	HPLC Pigment - Chlorophyll a	ug L-1
DVVChl_a	HPLC Pigment - Divinyl Chlorophyll a	ug L-1
Chlide_a	HPLC Pigment - chlorophyllide a	ug L-1
Chl_b	HPLC Pigment - Chlorophyll b	ug L-1
DVChl_b	HPLC Pigment - divinyl chlorophyll b	ug L-1
Chl_c12	HPLC Pigment - Chlorophyll c1, 2	ug L-1
Chl_c3	HPLC Pigment - Chlorophyll c3	ug L-1
Lut	HPLC Pigment - lutein	ug L-1
Neo	HPLC Pigment - neoxanthin	ug L-1
Viola	HPLC Pigment - violaxanthin	ug L-1

Phytin_a	HPLC Pigment - Phaeophytin a	ug L-1
Phide_a	HPLC Pigment - Chlorophyllide a	ug L-1
Pras	HPLC Pigment - prasinoxanthin	ug L-1
Gyr_diester	HPLC Pigment - Gyroxanthin diester	ug L-1

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Bran+Luebbe/Seal AA3
Generic Instrument Name	Bran+Luebbe / SEAL Analytical AutoAnalyzer 3 (AA3) continuous-flow analyzer
Generic Instrument Description	The AutoAnalyzer 3 (AA3) is a segmented continuous-flow analyzer (continuous flow analyzer, CFA) used for automated colorimetric analysis of dissolved nutrients and other analytes in environmental, seawater, freshwater, wastewater, soil, and agricultural samples. The AA3 was originally manufactured by Bran+Luebbe and, following acquisition of the product line in 2006, has continued to be manufactured and supported by SEAL Analytical. The AA3 is the third-generation instrument in the Technicon AutoAnalyzer family and is widely used for determination of nitrate, nitrite, ammonium, phosphate, silicate, and other dissolved nutrients. See the description from the manufacturer.

Dataset-specific Instrument Name	Apollo SciTech DIC Analyzer
Generic Instrument Name	Inorganic Carbon Analyzer
Generic Instrument Description	Instruments measuring carbonate in sediments and inorganic carbon (including DIC) in the water column.

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	At each station, water column CTD profiles of temperature, salinity, dissolved oxygen, and pH were made, and discrete surface and bottom water samples were collected by rosette-mounted Niskin bottles.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

[table of contents | back to top]

Project Information

RAPID: Collaborative Research: Unprecedented Hurricane Ian Nutrient and Organic Matter Inputs to Southwest Florida Coastal Waters (RAPID: Ian Inputs)

NSF Award Abstract:
Many coastal systems are facing the threats of continuing development and climate change, including an increased intensity of extreme weather events such as hurricanes. Such storms are now wetter than in prior years because warmer atmospheres hold more moisture. Thus, they release more rainfall and deliver more nutrients and organic matter to coastal areas. This, in turn, leads to phytoplankton blooms with potential for regional “dead zones” or areas with little or no dissolved oxygen. Hurricane Ian, a category 4 hurricane which hit southwest Florida in late September 2022, resulted in immense nutrient and organic carbon inputs to the coastal estuaries and southwest Florida shelf waters and presents an opportunity to examine the effects of a major storm disturbance on a coastal system that is under increasing coastal nutrient stress. The objective of this RAPID project is to examine carbon and nutrient cycling along a gradient of stations from the estuary to low-nutrient shelf waters to determine the rate of change and recovery in this system and the relationship of large hurricane inputs to hypoxia, anoxia, and ocean acidification. These data are being used to develop a regional model to predict the impact of future hurricanes on ocean acidification, phytoplankton blooms, and local hypoxia and anoxia. This study leverages ongoing monitoring programs funded by state and federal management agencies, as well as NSF-supported programs for undergraduate students. It provides partial support for training of postdoctoral investigators and a graduate student. Outreach will include presentations to elementary and high school students.

In September 2022, southwest Florida experienced a direct hit from category-4 Hurricane Ian, resulting in extensive watershed flooding and nutrient- and dissolved-organic-matter-laden estuarine plumes extending more than 50 miles onto the shallow oligotrophic west Florida shelf (WFS). The massive terrestrial organic carbon and nutrient inputs to the southwest Florida coastal and shelf region may be priming this oligotrophic system for extensive phytoplankton blooms, as well as significant changes in carbon chemistry and nutrient cycling that could lead to longer-term regional hypoxia and anoxia. In this RAPID project, the investigators are measuring a suite of carbon and nutrient parameters, as well as carbon and nutrient cycling, at stations in Charlotte Harbor and the adjacent inner WFS system in December 2022, February 2023, and September 2023. The objectives are to assess: 1) a timescale of system responses from shorter (weeks to months) to 1-year impacts post-hurricane; 2) how nutrient availability and forms influence hypoxia; and 3) how hurricane-driven inputs influence carbonate chemistry in this system, specifically the connection between acidification and hypoxia. The investigators are using new data collected in this study and monitoring data from regional state and federal programs in a coupled hydrodynamic-biogeochemical model to understand conditions on the WFS. Hindcast simulations and modeling experiments are assessing how large inputs of nutrients and organic matter affect phytoplankton, oxygen conditions, and carbon chemistry. Modeling experiments are exploring how storms of varying wind and precipitation intensity affect the WFS and estuaries, identifying the tipping point at which the WFS switches from episodic to persistent hypoxia.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2309081

[table of contents | back to top]