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Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1760006
Project Title:	RAPID: Capturing the Signature of Hurricane Harvey on Texas Coastal Lagoons
PD/PI Name:	Paul Montagna, Principal Investigator Xinping Hu, Co-Principal Investigator Michael Wetz, Co-Principal Investigator
Recipient Organization:	Texas A&M University Corpus Christi
Project/Grant Period:	10/01/2017 - 08/31/2019
Reporting Period:	10/01/2018 - 08/31/2019
Submitting Official (if other than PD\PI):	N/A
Submission Date:	N/A
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	N/A

Accomplishments

* What are the major goals of the project?

The research goal of this project is to examine how the resulting freshwater inflow pulses resulting from the unprecedented rain from Hurricane Harvey drive water quality, estuarine biogeochemistry, and biological responses along the mid-Texas coast.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Post-Harvey water quality samples were collected from the following bays: Lavaca-Colorado – monthly from October 2017 to December 2018. San Antonio - weekly to biweekly from September to December 2017, and then monthly through August 2018. Nueces-Corpus Christi - monthly from October 2017 to August 2018. Samples were collected for hydrographic variables (temperature, salinity, dissolved oxygen, pH), chlorophyll a, inorganic nutrients, dissolved and total organic carbon and nitrogen.

Post-Harvey study for carbonate chemistry quantification were conducted from Guadalupe Estuary weekly to biweekly from September to December 2017, then January, April, and July 2018 in three estuaries: Nueces Estuary (Nueces and Corpus Christi Bays), Guadalupe Estuary (San Antonio Bay), and Lavaca-Colorado Estuary (Lavaca and Matagorda Bays). Ongoing Mission-Aransas Estuary sampling also occurred on biweekly to monthly basis. All samples have been analyzed except those from July 2018. Hu's group has joined Dr. Hui Liu's (TAMUG) monthly cruises from October 2017 to September 2018 (except May, 2018) to examine carbonate chemistry and underway CO₂ partial pressure (*p*CO₂) in Galveston Bay, TX.

Post-Harvey benthic samples were collected in October 2017, and January, April, and July 2018 in three estuaries: Nueces Estuary (Nueces and Corpus Christi Bays), Guadalupe Estuary (San Antonio Bay), and Lavaca-Colorado Estuary (Lavaca and Matagorda Bays). These complement samples taken for one year prior to the hurricane. All of the Guadalupe samples are analyzed, and half of the Nueces samples have been analyzed. Our focus is on Guadalupe because that is where the major storm impact was.

Specific Objectives:

- To characterize the temporal change in key indicators of biogeochemical processes. and biodiversity shifts.
- To characterize habitat changes and recovery post-storm.
- To create a dataset that can be used to forecast future changes with other estuary or climate related disturbances.

Significant Results:

In San Antonio Bay, high-frequency (15 min) sonde data showed that salinity decreased rapidly as floodwaters reached the estuary, but returned to pre-storm levels within one month. Strong salinity stratification developed in the estuary which, when combined with an influx of organic matter from the watershed, resulted in bottom water hypoxia that lasted ~1 week. Concurrent with the decline in dissolved oxygen was a decline in pH. Average pH prior to the storm was 7.94, which dropped to a low of 6.91 during the hypoxic period and took approximately 15 days to return to baseline conditions. Aside from a brief increase in inorganic nutrients and chlorophyll in the system during Fall 2017 after the storm, no effects were seen on water quality beyond this timeframe. Likewise, there were no clear longer-term effects of Harvey in Lavaca Colorado or Nueces-Corpus Christi Estuaries.

In 2017, one month of extreme increase in *p*CO₂ led to a contribution of 35% to annual CO₂ emission in the Guadalupe Estuary. In contrast, even though the hurricane passed right through the adjacent Mission-Aransas Estuary, there was barely any increase in CO₂ flux post storm compared to our multiyear average.

In San Antonio Bay, there was a large decline in benthos abundance, biomass, and diversity as a result of the storm. Four months prior to the storm in April 2017, abundance was as high as 53,900 ind./m² and dropped to a high of 9,800 ind./m² in October 2017 and a high of 9,400 ind./m² in January 2018. Biomass decline was not as great but did decline from a maximum of 38.6 g/m² in July to a maximum of 6.1 g/m² in October and 1.7 g/m². Diversity declined from a maximum of 10.3 species/core prior to the storm to 3.3 species/core in October 2017 and 6.7 species/core in January 2018.

Key outcomes or Other achievements:	All Co-PIs have been working with Texas state agencies to help promote conservation and management of water and natural resources. The Texas Commission for Environmental Quality (TCEQ) manages water supply, quality, and permitting, Texas Parks and Wildlife Department (TPWD) manages fisheries and coastal resources, and the Texas Water Development Board (TWDB) manages water project construction and helps determine environmental flow needs. All the data and analyses produced here have been communicated directly with resource managers at these three agencies and the information is being used in planning resilience of coastal communities.
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*** What opportunities for training and professional development has the project provided?**

A total of 6 graduate students, 1 undergraduate, and 1 high school students have participated in the project. Ph.D. student Lily Walker has been engaged in the water quality sampling, data from which will be used in her dissertation. Ph.D. student Melissa McCutcheon has been engaged in both field sampling and lab analysis of this project. Two other Ph.D. students, Larissa Dias and Hongming Yao participated in sampling and analysis at various times of this project and took the opportunity to study for their respective research projects. Ph.D. student Patricia Cockett is working on the analyses of bivalve response to the hurricane in the context of life history traits. M.S. student Jaime Smith was engaged in the laboratory analyses of the benthos and received a MS degree in May 2018 based on her work. Liz Obst recently graduated with a B.S. was employed as an hourly technician on the project. Finally, a high school student, Amya Reynoso, has accompanied the sampling team on several trips.

*** How have the results been disseminated to communities of interest?**

Paul Montagna (and his students and staff) have made four presentations at conferences (one a Hurricane Harvey conference), and submitted two journal articles. Michael Wetz (and his students and staff) has made four presentations at scientific conferences and will submit a journal article in January 2020. Xinping Hu (and his students and staff) has made three presentations at scientific conferences and one manuscript is currently under revision for the journal *Frontiers in Marine Science*.

All of the project data has been archived with the Biological & Chemical Oceanography Data Management Office (BCO-DMO) as project number 783256, <https://www.bco-dmo.org/project/783256>. The data sets include water quality, carbonate chemistry, and benthic responses.

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers

View all journal publications currently available in the [NSF Public Access Repository](#) for this award.

The results in the NSF Public Access Repository will include a comprehensive listing of all journal publications recorded to date that are associated with this award.

Patrick, C.J., Yeager, L., Armitage, A.R., Carvallo, F., Congdon, V., Dunton, K.H., Fisher, M., Hardison, A.K., Hogan, J.D., Hosen, J., Hu, X., Kiel Reese, B., Kinard, S., Kominoski, J.S., Lin, X., Liu, Z., Montagna, P.A., Pennings, S. C., Walker, L., Weaver, C.A., Wetz, M. A Systems level analysis of ecosystem responses to hurricane impacts on a coastal region. *Estuaries and Coasts* In press.. Status = ACCEPTED.

Licenses

Other Conference Presentations / Papers

Montagna, P.A. X. Hu, and M. Wetz. (2018). *Biogeochemical Impact of Hurricane Harvey on Texas Coastal Lagoons*.. Ocean Sciences Meeting. Portland, OR, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

L.M. Dias and X. Hu. (2019). *Carbonate system dynamics in Galveston Bay*.. Coastal and Estuarine Research Federation Meeting. Mobile, AL, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A. (2019). *Development of Freshwater Inflow/Biological Indicator Relationship*. Colorado-Lavaca Bay and Basin Area Stakeholder Committee. LaGrange, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hu, X., C.J. Staryk, M.R. McCutcheon, H. Yao, M.S. Wetz, P.A. Montagna. (2018). *Extreme weather event induced changes in estuarine CO2 flux and carbon cycle*.. Ocean Sciences Meeting. Portland, OR, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, L.M. and Wetz, M.S. (2018). *Hypoxia dynamics in a semiarid South Texas estuary*.. Association for the Sciences of Limnology and Oceanography Summer meeting. Victoria, BC, Canada. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A., L. Hyde, R. Kalke, E. Morgan, L. Walker, M. Wetz. (2018). *Impact of Hurricane Harvey on benthos*.. Harvey Research Symposium. Port Aransas, TX USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, L., M. Wetz, K. Hayes, and P. Montagna. (2019). *Impact of Hurricane Harvey on the water quality of Texas estuaries*.. Aquatic Sciences Meeting. San Juan, Puerto Rico. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A. (2019). *Importance of Freshwater Inflow to Lavaca Bay*. Formosa Plastics, Environmental Seminar. Point Comfort, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A. (2019). *People, Climate, and the Importance of Freshwater Inflow to Estuaries*.. University of Texas, Research Experiences for Undergraduates. Corpus Christi, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, L.M., Wetz, M.S., and Hayes, K.C. (2018). *The effects of hurricane Harvey on South Texas water quality*.. Ninth Biennial NOAA EPP/MSI Education and Science Forum. Washington, DC, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Walker, L., P. Montagna, X. Hu, K. Hayes, and M. Wetz. (2019). *Timescales of water quality change in three Texas estuaries induced by passage of Hurricane Harvey (2017)*. Coastal and Estuarine Research Federation Meeting. Mobile, AL, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Hu, X. (2018). *Two tales of one storm*.. Harvey Research Symposium. Port Aransas, TX USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A. (2019). *Using Comparative Long-Term Benthic Data for Adaptive Management of Freshwater Inflow to Three Estuaries (Colorado-Lavaca, Guadalupe, and Nueces)*.. Colorado-Lavaca Bay and Basin Area Stakeholder Committee. LaGrange, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Montagna, P.A. (2018). *Why Mollusks are Great Indicators of Ecosystem Health*.. Texas Shell Club. Corpus Christi, TX, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Databases.

Wetz, M.S. RAPID: Capturing the Signature of Hurricane Harvey on Texas Coastal Lagoons – water quality data. <https://www.bco-dmo.org/project/783256> Submitted to Biological & Chemical Oceanography-Data Management Office (BCO-DMO) 11-DEC-2019.

Publically available on BCO-DMO.

Databases.

Hu, X. 2019. Effects of Hurricane Harvey in San Antonio Bay and Mission Aransas Estuary-Carbonate chemistry. <https://www.bco-dmo.org/project/783256> Submitted 4-DEC-2019.

Posted on the Biological & Chemical Oceanography-Data Management Office website.

Databases.

Montagna, P.A. Project: RAPID: Capturing the Signature of Hurricane Harvey on Texas Coastal Lagoons – Benthic biomass data. <https://www.bco-dmo.org/project/783256> Submitted 3-DEC-2019.

Posted on the Biological & Chemical Oceanography-Data Management Office website.

Databases.

Montagna, P.A. Project: RAPID: Capturing the Signature of Hurricane Harvey on Texas Coastal Lagoons – Benthic species data. <https://www.bco-dmo.org/project/783256> Submitted 3-DEC-2019.

Posted on the Biological & Chemical Oceanography-Data Management Office website.

Databases.

Montagna, P.A. Project: RAPID: Capturing the Signature of Hurricane Harvey on Texas Coastal Lagoons – Hydrography data. <https://www.bco-dmo.org/project/783256> Submitted 3-DEC-2019.

Posted on the Biological & Chemical Oceanography-Data Management Office website.

Other Publications

Montagna, P.A. and P.M. Cockett, and M. Rohal. (2019). *Using Comparative Long-term Benthic Data for Adaptive Management of Freshwater Inflow to Three Basins*.. Final Report to the Texas Water Development Board, Contract # 1800012223.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Smith, Jaime K.. *Multiple stressor effects on macrobenthic communities in Corpus Christi Bay, Texas, U.S.A.* (2018). Texas A&M University-Corpus Christi. Acknowledgement of Federal Support = Yes

Websites

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Montagna, Paul	PD/PI	3
Hu, Xinping	Co PD/PI	2
Wetz, Michael	Co PD/PI	1
Breaux, Natasha	Technician	1
Hayes, Kenneth	Technician	2
Hyde, Larry	Technician	6
Kalke, Richard	Technician	6
Morgan, Elani	Technician	6
Obst, Elizabeth	Technician	1
Saryk, Cory	Technician	6
Tominack, Sarah	Technician	1
Reuscher, Michael	Staff Scientist (doctoral level)	6
Cockett, Patricia	Graduate Student (research assistant)	9
Dias, Larissa	Graduate Student (research assistant)	3
McCutcheon, Melissa	Graduate Student (research assistant)	3
Smith, Jaime	Graduate Student (research assistant)	3
Walker, Lily	Graduate Student (research assistant)	6
Yao, Hongming	Graduate Student (research assistant)	3
Reynoso, Amya	High School Student	1

Full details of individuals who have worked on the project:

Paul A. Montagna

Email: paul.montagna@tamucc.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 3

Contribution to the Project: Project Director, Co-PI benthic ecology. Data archiving, analysis, and report writing.

Funding Support: TAMUCC, NOAA, TWDB

International Collaboration: No

International Travel: No

Xinping Hu

Email: xinping.hu@tamucc.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 2

Contribution to the Project: Co-PI, Carbon cycling. Data analysis, synthesis, and report writing.

Funding Support: TAMUCC, NOAA

International Collaboration: No

International Travel: No

Michael S. Wetz

Email: michael.wetz@tamucc.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Co-PI , Water quality. Data analysis, report writing.

Funding Support: TAMUCC, NOAA, TWDB, TGLO

International Collaboration: No

International Travel: No

Natasha Breaux

Email: nbreaux@islander.tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Water quality sample analysis, field collections

Funding Support: National Oceanic and Atmospheric Administration, Coastal Bend Bays & Estuaries Program

International Collaboration: No

International Travel: No

Kenneth C. Hayes

Email: Kenneth.Hayes@tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Nutrient analyses

Funding Support: Texas Water Development Board, Coastal Bend Bays & Estuaries Program

International Collaboration: No

International Travel: No

Larry J. Hyde

Email: Larry.Hyde@tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Benthic sample analyses, Field collections

Funding Support: Texas Water Development Board, National Fish and Wildlife Foundation

International Collaboration: No

International Travel: No

Richard D. Kalke

Email: Rick.Kalke@tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Benthic sample analyses, Field collections

Funding Support: Texas Water Development Board, National Fish and Wildlife Foundation

International Collaboration: No

International Travel: No

Elani K. Morgan

Email: Elani.Morgan@tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Benthic sample analyses, Field collections

Funding Support: Texas Water Development Board, National Fish and Wildlife Foundation

International Collaboration: No

International Travel: No

Elizabeth Obst

Email: eobst@islander.tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Water quality sample analysis, field collections

Funding Support: Coastal Bend Bays & Estuaries Program

International Collaboration: No

International Travel: No

Cory J. Staryk

Email: Cory.Staryk@tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Carbonates

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No

International Travel: No

Sarah Tominack

Email: stominack@islander.tamucc.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Water quality sample analysis, field collections

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No

International Travel: No

Michael G. Reuscher

Email: michael.reuscher@tamucc.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 6

Contribution to the Project: benthic sample analyses

Funding Support: Gulf of Mexico Research Initiative

International Collaboration: No

International Travel: No

Patricia M. Cockett

Email: pcockett@islander.tamucc.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 9

Contribution to the Project: Mollusk life cycle analyses

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No

International Travel: No

Larissa Dias

Email: Larissa.Dias@tamucc.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: Carbonates

Funding Support: Texas A&M University-Corpus Christi internal fund

International Collaboration: No

International Travel: No

Melissa McCutcheon

Email: mmccutcheon@islander.tamucc.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: Carbonates

Funding Support: National Science Foundation

International Collaboration: No

International Travel: No

Jaime K. Smith

Email: jamiekatesmith@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: benthic sample analyses

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No

International Travel: No

Lily Walker

Email: lwalker2@islander.tamucc.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 6

Contribution to the Project: Dissolved Oxygen, water quality analyses

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No
International Travel: No

Hongming Yao
Email: hyao1@islander.tamucc.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Carbonates

Funding Support: National Science Foundation

International Collaboration: No
International Travel: No

Amya Reynoso
Email: amyareynoso@gmail.com
Most Senior Project Role: High School Student
Nearest Person Month Worked: 1

Contribution to the Project: Water quality sample analysis, field collections

Funding Support: National Oceanic and Atmospheric Administration

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Texas Parks and Wildlife Department	State or Local Government	Rockport, TX
Texas Water Development Board	State or Local Government	Austin, TX
Universtiy of Texas at Austin	Academic Institution	Marine Science Institute

Full details of organizations that have been involved as partners:

Texas Parks and Wildlife Department

Organization Type: State or Local Government
Organization Location: Rockport, TX

Partner's Contribution to the Project:
Collaborative Research

More Detail on Partner and Contribution: supplying fisheries data, collaborating on manuscripts.

Texas Water Development Board

Organization Type: State or Local Government

Organization Location: Austin, TX

Partner's Contribution to the Project:

Financial support

More Detail on Partner and Contribution: Support additional sampling and analysis.

Universtiy of Texas at Austin

Organization Type: Academic Institution

Organization Location: Marine Science Institute

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution: Collaborating on sharing data and writing manuscripts.

What other collaborators or contacts have been involved?

Patrick, C.J.1, Yeager, L.2, Armitage, A.R.3, Carvallo, F.1, Congdon, V.2, Dunton, K.2, Fisher, M.4, Hardison, A.2, Hogan, J.1, Hosen, J.5, Kiel Reese, B.1, Kinard, S.1, Kominoski, J.6, Lin, X.7, Liu, Z.2, Pennings, S.8, Weaver, C.1

1Texas A&M University Corpus Christi, 2University of Texas Marine Science Institute, 3Texas A&M University at Galveston, 4Texas Parks and Wildlife Department, 5Yale University, 6Florida International University, 7East China Normal University, 8University of Houston

Hui Liu at Texas A&M University Galveston has been providing the Carbon Cycle Group ship of opportunity to study Galveston Bay carbon cycle on board *R/V Trident*.

Impacts

What is the impact on the development of the principal discipline(s) of the project?

This project has helped the investigators extend long-term ecological datasets that are needed to explain long-term variability of abiotic and biotic metrics of coastal ecosystem health and the causes for those changes.

What is the impact on other disciplines?

Demonstrating links between climate dynamics and dynamics of coastal ecosystems.

What is the impact on the development of human resources?

Training of graduate students and high school students.

What is the impact on physical resources that form infrastructure?

Nothing to report.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

Nothing to report.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

Increasing awareness of the resilience of coastal ecosystems, planning for recovery and restoration.

Changes/Problems

Changes in approach and reason for change

Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

We had two machines break down, the DIC analyzer and the DOC/TOC analyzer. The DIC machine was repaired, and we replaced the DOC/TOC analyzer. To resolve these issues, we requested and received a no-cost extension to August 31, 2019.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.