

Freshwater Inflow to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations

This report was funded in part through a grant from the Texas General Land Office (GLO) providing Gulf of Mexico Energy Security Act of 2006 funding made available to the State of Texas and awarded under the Texas Coastal Management Program. The views contained herein are those of the authors and should not be interpreted as representing the views of the GLO or the State of Texas.

Project # 21-155-007-C879

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March 31, 2025

Submitted to:

Texas General Land Office
Coastal Management Program
1700 Congress Ave.
Austin, TX 78701-1495



Cite as:

Montagna, P.A. 2025. Freshwater Inflow to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations. Final Report to the Texas General Land Office for Project # 21-155-007-C879, Texas A&M University-Corpus Christi, Corpus Christi, Texas, USA. 28 pp.

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Executive Summary

More than 31 years have passed since the 1994 publication of the seminal book “Freshwater Inflows to Texas Bays and Estuaries: Ecological Relationships and Methods for Determination of Needs”, which had an enormous impact on the management of environmental flows to estuaries in Texas and world-wide. Since then, the 2007 Texas Senate Bill 3 (SB3) changed management goals from a single inflow number to an inflow regime and from protecting seven sport and commercial fisheries to an ecosystem-based management approach, and the science supporting environmental flow standards has changed dramatically. The purpose of the current project was to synthesize three decades of new management goals, data, and scientific methods. This resulted in the publication of an open access book entitled, “Freshwater Inflow to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations,” which was published by Springer Nature on January 2, 2025.¹ Springer Nature is the first or second largest scientific publisher in the world.²

There were four major tasks in this project: 1) holding a workshop, 2) database assembly, 3) writing chapters for a book, and 4) project monitoring and reporting.

Task 1, the workshop on “Freshwater Inflows to Texas Bays and Estuaries”, was held in a hybrid virtual and in person mode on June 7-8, 2021. It brought together stakeholders from around the state interested in the adaptive management implementation of environmental flow standards for bays and estuaries created under Senate Bill 3 (SB 3). The purpose of the workshop was to introduce a new project to synthesize over three decades data and scientific methods on a State-wide basis to create a new version of the classic book “Freshwater Inflows to Texas Bays and Estuaries” (Longley 1994) that may be used as tools for coastal resource management decision-making. The goals of this workshop were three-fold: 1) to ensure stakeholder needs are met by project products, 2) to identify existing relevant data and potential partners, and 3) to identify potential reviewers for the final product. A total of 84 stakeholders participated.

Task 2, database assembly resulted in the creation of 40 datasets being archived in publicly available data archives, 46 documents archived in publicly available Texas Digital Library, and 11 oral histories archived in the Texas A&M University-Corpus Christi Digital Library.

Task 3 resulted in writing of 17 book chapters that focus on ecological processes and compared differences and responses across Texas estuaries. The chapters covered: 1) a summary of inflow management since the 1950s, 2) history of freshwater inflow policy and law, 3) climate, 4) hydrology, inflow, circulation, and salinity, 5) groundwater, 6) sediments, 7) nutrients and phytoplankton, 8) biogeochemical conditions and water quality, 9) coastal habitats, 10) seagrasses, 11) sediment quality and benthos, 12) oysters, 13) plankton dynamics, 14) nekton, 15) nutrient

¹ <https://link.springer.com/book/10.1007/978-3-031-70882-4>

² <http://dx.doi.org/10.1108/JD-04-2022-0083>

<https://www.inven.ai/company-lists/top-18-scientific-publishing-companies>

budgets, 16) social and economic values, and 17) recommendations for the future. The open access book was published January 2, 2025, and had 15,000 downloads after just one month.

Task 4 resulted in submitting 15 quarterly reports, 3 annual reports, and this final report. Meetings were held with four stakeholder groups, and a StoryMap³ was created that summarized the book and acts as an introduction to the science and management of environmental flow research. A total of 61 people participated in the project as co-principal investigators, students, or professional staff. These people participated as either creator of the data bases or coauthor of the book chapters.

³ <https://arcg.is/0OGqeS0>

Task 1 – Workshop

Task 1, the workshop on “Freshwater Inflows to Texas Bays and Estuaries”, was held in a hybrid virtual and in person mode on June 7-8, 2021 (Figure 1). It brought together stakeholders from around the state interested in the adaptive management implementation of environmental flow standards for bays and estuaries created under Senate Bill 3 (SB 3). The purpose of the workshop was to introduce a new project to synthesize over three decades data and scientific methods on a State-wide basis to create a new version of the classic book “Freshwater Inflows to Texas Bays and Estuaries” (Longley 1994) that may be used as tools for coastal resource management decision-making. The goals of this workshop were three-fold: 1) to ensure stakeholder needs are met by project products, 2) to identify existing relevant data and potential partners, and 3) to identify potential reviewers for the final product. A total of 84 stakeholders participated. A final report is available at <https://hdl.handle.net/1969.6/90119>.⁴



Figure 1. Paul Montagna and Audrey Douglas lead the workshop.

The format of the workshop was designed to group related fields and expertise to facilitate discussion and resource identification/sharing. Due to ongoing COVID-19 concerns and restrictions, the workshop was held in hybrid model with participants attending in-person and joining remotely (Figure 2). To prevent virtual meeting fatigue, the workshop was held in two half-day meetings. Prior to the event, the organizers distributed the proposed book outline/topics list and short introduction to the project to all participants to promote conceptualization of the issues.

⁴ Montagna, P.A. and A.R. Douglas. 2021. Workshop Report: Freshwater Inflow to Texas Bays and Estuaries. Report to the Texas General Land Office for Project # 21-155-007-C879. Harte Research Institute, Texas A&M University-Corpus Christi, Corpus Christi, Texas, USA, 41 pp.

By providing lead time for participants to consider the topics, they would be able to better identify and assess stakeholder needs, recognize potential gaps in the proposed work, discover existing data and tools that could be used.

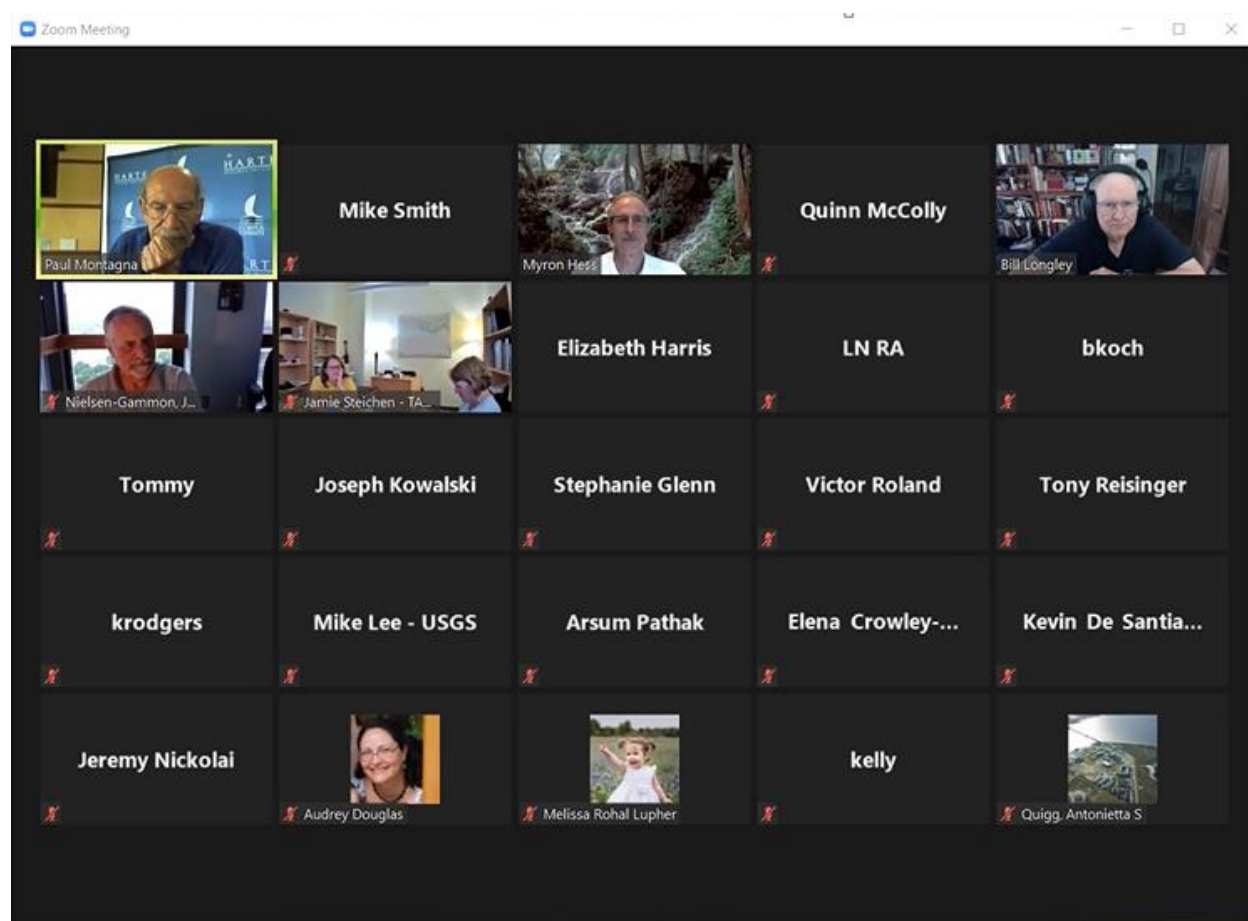


Figure 2. Screen shot of virtual workshop participants.

At the meeting, principal investigator Paul Montagna gave a short introduction to the synthesis project and then interviewed William Longley, author of the 1994 “Freshwater Inflows to Texas Bays and Estuaries”, to provide more history and context. This interview was followed by short 10-minute presentations on the importance of each proposed topic. Breakout sessions for related topics followed the presentations, which proved to be an effective strategy. The breakout sessions allowed for Co-PIs to meet with relevant stakeholders to ensure the three goals of the workshop were satisfied. There were three breakout sessions Day 1 and two breakout sessions Day 2.

Main Outcomes from the Workshop

The Freshwater Inflows to Texas Bays and Estuaries Workshop focused on introducing attendees/stakeholders to the project goals and providing an opportunity for attendees to suggest gaps in the approach, identify key topics for inclusion in the project products, identify potential data sources and relevant studies, and identify prospective reviewers for project products. A brief

introduction to each proposed topic was provided and helped prepare participants for the breakout sessions. The introductions included why the topic was relevant/important, a proposed approach to the topic, and a little about known data sources. These topic introductions were followed by 60-minute breakout sessions with participants. In the breakout sessions, participants were asked to identify areas of interest/need that should be included in the project products. In particular, stakeholders were asked if Co-PIs covered all issues related to their topic or if a key issue was missed. Breakout session participants were also asked to identify potential data sources, studies of relevance, and prospective reviewers. To summarize:

- In total, **77 stakeholders** representing 39 local, state and federal government agencies and non-governmental organizations and **8 students** representing 3 universities participated in the workshop.
- Five breakout groups were held over two days to discuss stakeholder needs/interests, knowledge and data gaps, potential data sources and sharing, and identification of potential reviewers for project products.
- A common discussion point in the breakout sessions was the appropriate approach and organization of the book and whether the proposed chapter outline may need to be revisited and restructured to better allow for topic cross-over and interdependence. It was determined that Co-PIs need to formulate chapter outlines as soon as possible to further assess these concerns.
- Stakeholders successfully identified key issues that were not included in the initial topic overviews presented by Co-PIs, such as sea level rise, mangrove habitats, extreme events.
- Multiple data sources, ranging from individual studies to government managed long-term datasets, were identified for each topic.
- Several participants volunteered their own datasets for inclusion in the synthesis.
- Fifteen participants volunteered to serve as reviewers for specific topics/chapters and 11 names were suggested as prospective reviewers.

Task 2 — Archived Data

Task 2, database assembly resulted in the creation of 40 datasets being archived in publicly available data archives, 46 documents archived in publicly available Texas Digital Library, and 11 oral histories archived in the Texas A&M University-Corpus Christi (TAMUCC) Digital Library.

The project did not collect new field data, but it did discover, ingest, and compile existing biophysical and ecological data describing the physical-chemical environmental characteristics of estuaries and multi-species assemblages along the Texas coast.

Data, metadata, and associated information products were mainly deposited in the Harte Research Institute operated Gulf Research Initiative Information and Data Cooperative (GRIIDC) <https://data.gulfresearchinitiative.org/>. The GRIIDC is a research database focusing on the data and information needs of the Gulf of Mexico (Gulf of America) and was created via the Gulf of Mexico Research Initiative. Some data was archived in the Global Biodiversity Information Facility (GBIF) <https://www.gbif.org/>. The Texas Digital Library (TDL) <https://tamucc-ir.tdl.org/home> was used to archive original documents, reports, and texts. The TAMUCC library for the Gulf Podcasts of the oral histories.

Below is a list of all archived data by chapter of the final product, which is the book entitled, “Freshwater Inflows to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations.”

Chapter 1: Introduction - History of Inflow Studies in Texas. Paul A. Montagna (PI, TAMUCC), William L. Longley, Elizabeth A. Goma (Department of Homeland Security), and Jen Corrinne Brown (TAMUCC). Personnel that worked on data assembly, analysis, and submission for this project included Paul Montagna, and Jen Corrinne Brown.

Brown, J.C. 2022. Freshwater inflow oral history: Ray Allen. Nueces Delta Preserve, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2259>

Brown, J.C. 2022. Freshwater inflow oral history: Jim Blackburn. Houston, Texas. <https://www.tamucc.edu/library/exhibits/s/thegulf/item/2271>

Brown, J.C. 2021. Freshwater inflow oral history: Myron Hess. Videoconference. <https://library.tamucc.edu/exhibits/s/thegulf/item/2003>

Brown, J.C. 2021. Freshwater inflow oral history: Ken Kramer. Chappell Hill, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2127>

Brown, J.C. 2022. Freshwater inflow oral history: Cindy Loeffler. San Marcos, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2237>

Brown, J.C. 2020. Freshwater inflow oral history: Larry McKinney. Videoconference. <https://www.tamucc.edu/library/exhibits/s/thegulf/item/1525>

Brown, J.C. 2017. Freshwater inflow oral history: Paul Montagna-1. Corpus Christi, Texas. <https://www.tamucc.edu/library/exhibits/s/thegulf/item/275>

Brown, J.C. 2022. Freshwater inflow oral history: Paul Montagna-3. Corpus Christi, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2120>

Brown, J.C. 2022. Freshwater inflow oral history: John Nielsen-Gammon. Videoconference. <https://library.tamucc.edu/exhibits/s/thegulf/item/2255>

Brown, J.C. 2022. Freshwater inflow oral history: Andrew Sansom. San Marcos, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2252>

Brown, J.C. 2021. Freshwater inflow oral history: Joe Trungale. Austin, Texas. <https://library.tamucc.edu/exhibits/s/thegulf/item/2010>

Chapter 2: Environmental Flow, Policy, and Regulation. Myron Hess (Co-PI, Law Office). Personnel that worked on data assembly, analysis, and submission for this project included Paul Montagna and Myron Hess.

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Science Advisory Committee. 2009. Fluvial Sediment Transport as an Overlay to Instream Flow Recommendations for the Environmental Flows Allocation Process. Report # SAC-2009-04, May 29, 2009. <https://hdl.handle.net/1969.6/94355>

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Texas Commission on Environmental Quality. 2010. Rio Grande, Rio Grande Estuary, and Lower Laguna Madre - [30 TAC, 298(H)] <https://hdl.handle.net/1969.6/94363>

Chapter 3: Climate Effects on Inflows. John Nielsen-Gammon (Texas A&M University). Personnel that worked on data assembly, analysis, and submission for this project included John Nielsen-Gammon and Alison A. Tarter.

Nielsen-Gammon, John; Alison A. Tarter. Texas climate, climate change, and impacts on inflows to bays and estuaries evaluated through the use of hydrologic model simulations driven by downscaled global climate model simulations and projections. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/qhkhp60n>. Published on 13 October 2023.

Chapter 4: Hydrology, Circulation and Salinity. Dan Opdyke (Anchor QEA, Co-PI), Joe Trungale (The Nature Conservancy), and Paul Montagna (TAMUCC, PI), Hydrology and Circulation. Personnel that worked on data assembly, analysis, and submission for this project included Dan Opdyke, Joseph Hoffmann, Joe Trungale, and Paul Montagna.

Trungale, Joe; Hoffmann, Josef; Montagna, Paul A.; Opdyke, Dan 2023. Freshwater Inflows to Texas Bays and Estuaries: Hydrology, Circulation, and Salinity. Data (1977-2018). Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/8KR3TNDT>. Published on 20 March 2024.

Chapter 5: Groundwater -Surface Water Interactions in the Coastal Zone. Audrey Douglas (Postdoc, TAMUCC) and Dorina Murgulet (TAMUCC). Personnel that worked on data assembly, analysis, and submission for this project included Audrey R. Douglas and Cody Lopez.

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Chapters 6 & 11: Sediments and Benthos. Paul Montagna (PI), and Richard D. Kalke, (TAMUCC). Personnel that worked on data assembly, analysis, and submission for this project included Paul A. Montagna, Gabrielle Davis, Audrey R. Douglas, Catana Faison, Elizabeth Harris, Larry Hyde, Rick Kalke, Danielle Marshall, Elani Morgan, Juan Palacios, and Dusty Teague.

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Montagna, P.A. 2023. Long-term monitoring of water and sediment quality to identify freshwater inflow effects from 1984-01-01 to 2019-10-01. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. Available from: <https://doi.org/10.7266/aa36pm7h>. Published 23 October 2023.

Montagna, P.A., H. Ehrmann, C.M. Olson, E.L. Turner. Effects of small freshwater inflow volumes on water and sediment quality obtained from bays in Texas from 2015-09-30 to 2016-09-15. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. Available from: <https://doi.org/10.7266/6ptst906>. Published 23 October 2023.

Montagna, P.A., and R. Kalke. Effect of freshwater inflow on macrobenthos in minor bay and river-dominated estuaries collected from 2000-10-04 to 2005-08-06, Texas. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/btehjm5n>. Published 29 September 2023.

Chapter 7: Nutrient-Phytoplankton Dynamics in Texas Estuaries. Michael S. Wetz (Co-PI, TAMUCC), Laura Beecraft (TAMUCC), Molly McBride (TAMUCC), Jamie L. Steichen (TAMUG), and Antonietta Quigg (TAMUG, Co-PI). Personnel that worked on data assembly, analysis, and submission for this project included Michael S. Wetz and Laura Beecraft.

Wetz M.S. 2021. Monthly discrete water quality measurements of Baffin Bay, Texas between 2013-05-15 and 2013-12-13. Distributed by: Gulf of Mexico Research Initiative Information and

Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi.
<https://doi.org/10.7266/JPT4ZJX0>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0002>). Published 7 September 2021.

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<https://doi.org/10.7266/H3H4EHCJ>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0004>). Published 3 October 2021.

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<https://doi.org/10.7266/VQHNN7HB>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0005>). Published 3 October 2021.

Wetz M.S. 2021. Monthly discrete hydrographic measurements of Baffin Bay, TX, USA from 2017-02-16 to 2017-12-13. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi.
<https://doi.org/10.7266/H65DRM8M>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0006>). Published 5 October 2021.

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<https://doi.org/10.7266/HCK0G337>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0007>). Published 19 October 2021.

Wetz M.S. 2021. Monthly discrete hydrographic measurements of Baffin Bay, TX, USA from 2019-01-16 to 2019-12-05. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi.
<https://doi.org/10.7266/H6XCBTQS>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0009>). Published 19 October 2021.

Wetz M.S. 2021. Monthly discrete hydrographic measurements of Baffin Bay, TX, USA from 2020-01-14 to 2020-12-01. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi.
<https://doi.org/10.7266/DWXXDKXJ8>
(<https://data.gulfresearchinitiative.org/data/HI.x847.000:0010>). Published 19 October 2021.

Chapter 8: Physical and Biogeochemical Conditions and Trends in Texas Estuaries. Xinping Hu (TAMUCC, Co-PI) and Hang Yin (TAMUCC). Personnel that worked on data assembly, analysis, and submission for this project included Xinping Hu and Hang Yin.

Hu, X. 2023. Water column physical and biogeochemical data in Texas estuaries (1969-2020). Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/6pdpe3ra> (<https://data.gulfresearchinitiative.org/data/HI.x962.000:0009>). Published 1 December 2022.

Chapter 9: Coastal Wetland Habitats in Texas. James C. Gibeaut (TAMUCC, Co-PI), Paul A. Montagna (TAMUCC, PI), Jessica Magolan (TAMUCC), and Pu Huang (TAMUCC). Personnel that worked on data assembly, analysis and submission for this project included Lihong Su, Mukesh Subedee, Marissa Dotson, James Gibeaut, Brach Lupher, Anthony Reisinger, and Rhiannon Bezore.

Su, L., M. Subedee, M. Dotson, J. Gibeaut, B. Lupher, A. Reisinger, and R. Bezore. 2021. 2-meter Topographic Lidar Digital Elevation Model (DEM) of the Lower Texas Coast. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/Z7WG9EGN> (<https://data.gulfresearchinitiative.org/data/HI.x833.000:0010>). Published 9 August 2021.

Chapter 10: Submerged Aquatic Vegetation, Marshes, and Mangroves. Kyle A. Capistrant-Fosa (UTMSI), Berit E. Batterton (UTMSI), and Kenneth H. Dunton (UTMSI, Co-PI). Personnel that worked on data assembly, analysis, and submission for this project included Ken Dunton, Kyle Capistrant-Fossa, and Berit Batterton.

Marsh/Seagrass/Mangrove Distribution Data: NOAA Coastal Change Analysis Program (C-CAP) Regional Land Cover Database. Data collected 1995-present. Charleston, SC: National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management. Data accessed at coast.noaa.gov/landcover.

Species-Level Seagrass Distribution and Environmental Salinities: Dunton, Ken, Kim Jackson, Sara Wilson, Victoria Congdon, Meaghan Cuddy, Wayne Hall, Madison Becker, Joe Meiman, Tim Whiteaker, Patrick Bohannon, Faye Grubbs, Cindy Hobson (2018). Seagrass canopy height, water depth, chlorophyll-a concentration and other plant and water quality indicators in Coastal Waters of Texas (NCEI Accession 0181898). NOAA National Centers for Environmental Information. Dataset. <https://www.ncei.noaa.gov/archive/accession/0181898>.

Freshwater SAV Distribution:

GBIF.org (05 September 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.v4369n>

GBIF.org (05 September 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.835ty3>

GBIF.org (12 August 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.7ymbxt>

GBIF.org (12 August 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.pm7zn6>

GBIF.org (12 August 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.nd3erg>

GBIF.org (12 August 2022) GBIF Occurrence Download <https://doi.org/10.15468/dl.qecnez>

Chapter 12: Effects of Climate-Driven Salinity Regimes on Oyster Disease Dynamics at Local and Regional Scales. Kelley B. Savage (TAMUCC), Terence A. Palmer (TAMUCC), Paul A. Montagna (TAMUCC, PI), and Jennifer Beseres Pollack (TAMUCC, Co-PI). Personnel that worked on data assembly, analysis, and submission included Beseres Pollack, Jennifer, Natasha Breaux, Terence A. Palmer, Kelley B. Savage, Kevin De Santiago, and Danielle Downey.

Beseres Pollack, Jennifer, Natasha Breaux, Terence A. Palmer, Kelley B. Savage, Kevin De Santiago, and Danielle Downey. 2022. Monitoring of *Perkinsus marinus* (Dermo disease) infection intensity in the *Crassostrea virginica*, and water quality in the Mission-Aransas Estuary, 2014-2021. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/JJZYJ9AT> (<https://data.gulfresearchinitiative.org/data/HI.x846.000:0008>). Published 16 February 2022.

Chapter 13: Plankton Dynamics in Texas Estuaries. Antonietta Quigg (TAMUG, Co-PI), Jamie L. Steichen (TAMUG), Laura Beecraft (TAMUCC), and Michael S. Wetz (TAMUCC, Co-PI). Personnel that worked on data assembly, analysis, and submission for this project included Antonietta Quigg, Jamie Steichen, Jessica Hillhouse, Michael S. Wetz, and Laura Beecraft.

Hillhouse, J., A. Quigg, and J. Steichen. 2022. Microbial, physical, and chemical data collected from Galveston Bay research cruises from 2010-01-18 to 2019-11-16. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/CTVAS53B> (<https://data.gulfresearchinitiative.org/data/HI.x962.000:0001>). Published on 1 June 2022.

Hillhouse, J., A. Quigg, and J. Steichen. 2022. Phytoplankton pigment and Secchi data collected from Galveston Bay research cruises from 2010-01-18 to 2019-11-16. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/Q0ASPQFS> (<https://data.gulfresearchinitiative.org/data/HI.x962.000:0002>). Published on 25 February 2022.

Steichen, J. Galveston Bay – IFCB harmful algal bloom species. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/emmc0zdt> (<https://data.gulfresearchinitiative.org/data/HI.x962.000:0008>). Published on 27 January 2023.

Tominack S.A., K.C. Hayes and M.S. Wetz. 2021. Physical, chemical, and biological data for the quantitative description of phytoplankton dynamics in Corpus Christi Bay, Texas from 2016-08-04 through 2018-10-31. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/NCPYG0DH> (<https://data.gulfresearchinitiative.org/data/HI.x847.000:0011>). Published on 9 December 2021.

Wetz, M.S. 2022. Environmental and phytoplankton data for comparison across a gradient of freshwater inflow within San Antonio Bay, Nueces-Corpus Christi Bay, and Baffin Bay, Texas from 2018-03-13 to 2019-07-11. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/Q3Y0RBNM> (<https://data.gulfresearchinitiative.org/data/HI.x847.000:0014>). Published on 30 April 2022.

Chapter 14: Nekton and Mobile Epibenthos. Daniel M. Coffey (TAMUCC), Greg W. Stunz (TAMUCC, Co-PI), and Paul A. Montagna (TAMUCC, PI). Personnel that worked on data assembly, analysis, and submission for this project included Greg Stunz, Daniel Coffey, and Paul Montagna.

Coffey, Daniel M.; Stunz, Greg W.; Montagna, P.A. 2023. Texas Parks and Wildlife Department fishery-independent monitoring program bay trawl and bag seine surveys, Texas, 1982-2020. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/m663qn60> (<https://data.gulfresearchinitiative.org/data/HI.x949.000:0002>). Published on 29 March 2023.

Chapter 15: Nitrogen and Phosphorous Budgets for Texas Estuaries. Danielle A. Marshall (TAMUCC), and Paul A. Montagna (TAMUCC, PI). Personnel that worked on data assembly, analysis, and submission for this project included Paul Montagna and Danielle Marshall.

Marshall, D.A. and P.A. Montagna. 2023. Nitrogen and phosphorous land-ocean interaction in the coastal zone (LOICZ) budgets for Texas estuaries. Distributed by: Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC), Harte Research Institute, Texas A&M University–Corpus Christi. <https://doi.org/10.7266/7gx3tv5c>. Published on 16 February 2023.

Task 3 – The Book

Task 3 resulted in writing of 17 book chapters that focus on ecological processes and compared differences and responses across Texas estuaries. The chapters covered: 1) a summary of inflow management since the 1950s, 2) history of freshwater inflow policy and law, 3) climate, 4) hydrology, inflow, circulation, and salinity, 5) groundwater, 6) sediments, 7) nutrients and phytoplankton, 8) biogeochemical conditions and water quality, 9) coastal habitats, 10) seagrasses, 11) sediment quality and benthos, 12) oysters, 13) plankton dynamics, 14) nekton, 15) nutrient budgets, 16) social and economic values, and 17) recommendations for the future (Table 1).

Table 1. Table of contents of the book, “Freshwater Inflow to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations.”

Chapter	Title / Author(s)	Pages
0	Preface Paul A. Montagna	i-x
1	Introduction: History of Inflow Studies in Texas Paul A. Montagna, William L. Longley, Elizabeth Gomaa, and Jen Corrinne Brown	1-30
2	Historical Perspective and Context of Freshwater Inflow Policy and Law in Texas Myron J. Hess	31-53
3	Climate Effects on Inflows John W. Nielsen-Gammon and Alison A. Tarter	55-83
4	Hydrology, Circulation, and Salinity Daniel Opdyke, Josef Hoffmann, Paul A. Montagna, and Joseph F. Trungale	85-141
5	Groundwater-Surface Water Interactions in the Coastal Zone Audrey R. Douglas and Dorina Murgulet	143-172
6	Influence of Inflows on Estuary Sediments Audrey R. Douglas, Paul A. Montagna, and Timothy Dellapenna	173-190
7	Nutrient-Phytoplankton Dynamics in Texas Estuaries Michael S. Wetz, Laura Beecraft, Molly McBride, Jamie L. Steichen, and Antonietta Quigg	191-204
8	Physical and Biogeochemical Conditions and Trends in Texas Estuaries Xinping Hu and Hang Yin	205-220
9	Coastal Wetland Habitats in Texas James C. Gibeaut, Jessica Magolan, Pu Huang, and Paul A. Montagna	221-230
10	Submerged Aquatic Vegetation, Marshes, and Mangroves Kyle A. Capistrant-Fossa, Berit E. Batterton, and Kenneth H. Dunton	231-257
11	Effect of Freshwater Inflow on Benthic Infauna Paul A. Montagna, Richard D. Kalke, and Larry J. Hyde	259-293
12	Effects of Climate-Driven Salinity Regimes on Disease Dynamics of the Eastern Oyster, a Key Estuarine Resource and Bioindicator Kelley B. Savage, Terence A. Palmer, Paul A. Montagna, and Jennifer Beseres Pollack	295-307
13	Plankton Dynamics in Texas Estuaries Antonietta Quigg, Jamie L. Steichen, Laura Beecraft, and Michael S. Wetz	309-334
14	Freshwater Inflow and Salinity Shape Nekton Diversity and Community Structure Within Texas Estuaries Daniel M. Coffey, Gregory W. Stunz, and Paul A. Montagna	335-361
15	Nitrogen and Phosphorus Budgets for Texas Estuaries	363-388

Chapter	Title / Author(s)	Pages
	Danielle A. Marshall and Paul A. Montagna	
16	Social and Economic Values of Environmental Flows to the Coast David W. Yoskowitz	389-393
17	Summary of Recommendations for the Future Paul A. Montagna and Audrey R. Douglas	395-401
18	Archived Datasets	403-406
	Archived Documents	407-410
	Archived Oral Histories	411

The open access book was published January 2, 2025, and the cover features the series in which it is published and notes that it is open access (Figure 3). The book is available on a Springer Nature Link website (Figure 4). It had 15,000 downloads within one month of publication and greater than 21,000 downloads by the end of March 2025.⁵

⁵ <https://link.springer.com/book/10.1007/978-3-031-70882-4>

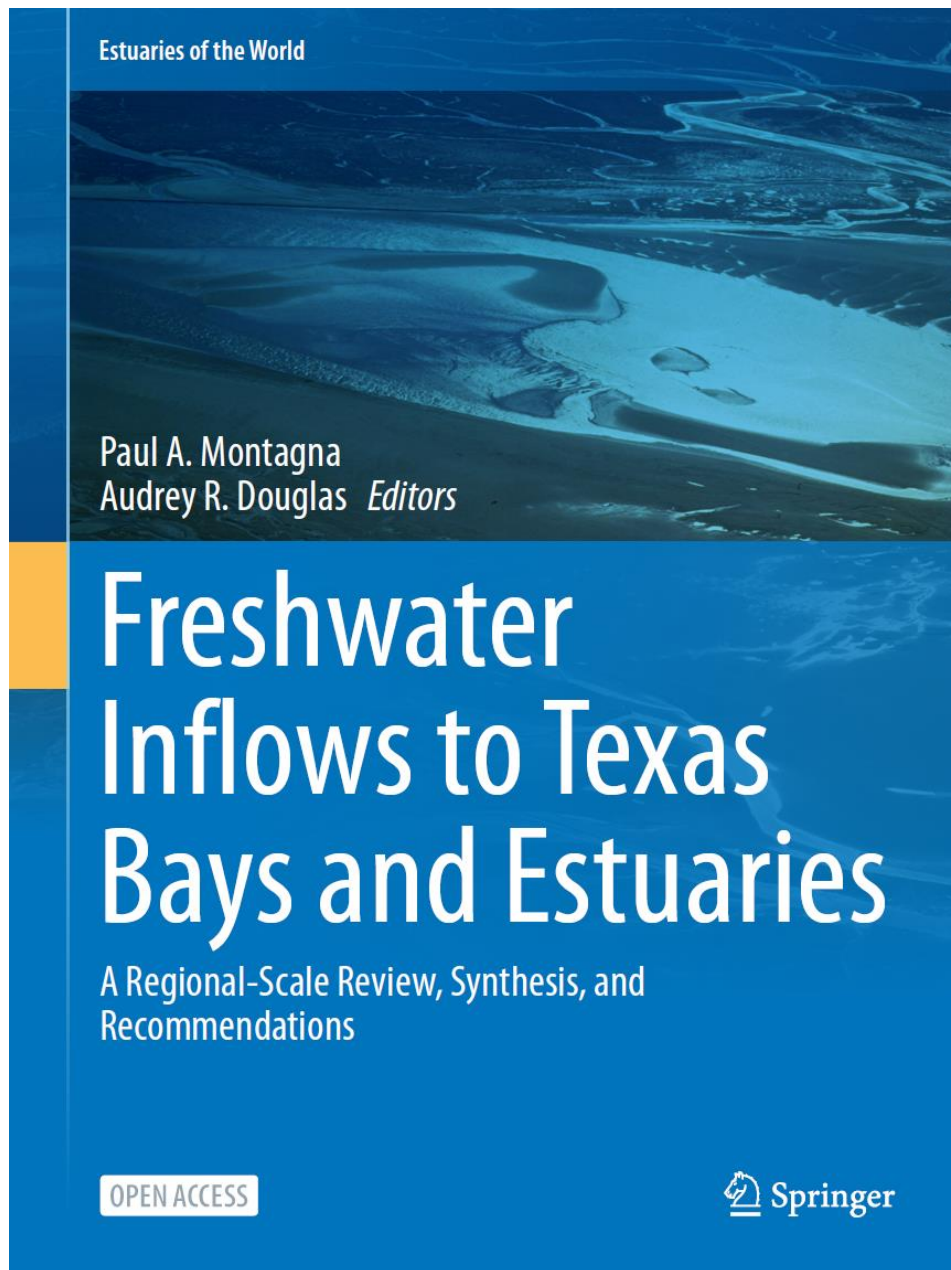


Figure 3. Book cover for “Freshwater Inflow to Texas Bays and Estuaries: A State-Wide Review, Synthesis, and Recommendations.”

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A Regional-Scale Review, Synthesis, and Recommendations

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Overview

Editors: [Paul A. Montagna](#), [Audrey R. Douglas](#)

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- Outlines methods for measuring inflow effects in coastal zones and determining inflow needs
- Outlines methods for determining inflow standards
- Includes regional scale estuary comparison along a climate gradient to discover processes

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Figure 4. Screenshot of the Springer Nature website advertising the book availability. The link is <https://link.springer.com/book/10.1007/978-3-031-70882-4>

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Task 4 – Project Management, Reporting, and Engagement

Reporting

Task 4 resulted in submitting 15 quarterly reports, 3 annual reports, and this final report.

Timeline

The project period was from 1 April 2021 to 31 March 2025. The four tasks were completed on the following timeline:

- Task 1: Workshop was held 7-8 June 2021 and the final report completed 30 August 2021.
- Task 2: All data sets were published by 19 March 2024.
- Task 3: The final draft of the book was submitted to the publisher on 7 January 2024, and the book was published on 2 January 2025.
- Task 4: The draft final report was submitted on 28 February 2025, and the project ends on 31 March 2025.

Staffing

This project employed a very large number of people, most funded in part by the project, but many as unfunded volunteers, co-funded, or funded by a separate entity. A total of 61 people participated in the project as co-principal investigators, students, or professional staff (Table 2). These people participated as either creator or curator of the data bases, coauthor of the book chapters, or content-creator for the StoryMap. There was a total of 14 topic leaders, 17 students, and 30 professional staff. Participants were from 8 institutions including 43 from Texas A&M University-Corpus Christi, 3 from Texas A&M University-Galveston, 2 from Texas A&M University-College Station, 5 from the University of Texas at Austin, 1 from Texas Parks and Wildlife Department, 1 from The Nature Conservancy, 4 from Anchor QEA, and 2 private contractors.

Table 2. Participatants in the project. Abbreviations: Ch = chapter (from Table 1), Co-PI = co-principal investigator, SAV = submerged aquatic vegetation.

Ch.	Topic	Co-PI	Institution	City, State Zip code	Students	Professional Staff
1	Introduction	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Elizabeth DelRosario	Jen Brown
1	Introduction	Paul Montagna		Austin, TX 78744		William Longley
2	Policy/Law	Myron Hess	Law Office of Myron Hess PLLC	Austin, TX 78704		
3	Climate	John Nielsen-Gammon	Texas A&M University	College Station, TX 77843		Alison Tarter
4	Hydrology/Salinity	Dan Opdyke	Anchor QEA, LLC	Austin, TX 78746		Josef Hoffmann
4	Hydrology/Salinity	Dan Opdyke	Anchor QEA, LLC	Austin, TX 78746		Jill Oliver
4	Hydrology/Salinity	Dan Opdyke	Anchor QEA, LLC	Austin, TX 78746		Michelle Culver
4	Hydrology/Salinity	Joe Trungale	The Nature Conservancy	Boulder, CO 80302		
5	Groundwater	Audrey Douglas	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Cody Lopez	Dorina Murgulet
6	Sediments	Audrey Douglas	Texas A&M University-Galveston	Galveston, TX 77553		Timothy Dellapenna
7	Nutrients	Michael Wetz	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Molly McBride	Laura Beecraft
8	Biogeochemistry	Xinping Hu	University of Texas at Austin	Port Aransas, TX 78373		Hu-Hang Yin
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Brach Lupher
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Rhiannon Bezore
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Pu Huang
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Jessica Magolan
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		L.ihong Su
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Mukesh Subedee
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Marissa Dotson
9	Habitats	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Anthony Reisinger
10	SAV/Marshes	Kenneth Dunton	University of Texas at Austin	Port Aransas, TX 78373	Berit Batterton	
10	SAV/Marshes	Kenneth Dunton	University of Texas at Austin	Port Aransas, TX 78373	Kyle Capistrant-Fossa	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Rick Kalke
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Karin Trevino	Larry Hyde
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Lauren Renner	Elani Morgan
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Dusty Teague	Samantha Schiereck
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Juan Palacios	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Catana Faison	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Gabrielle Davis	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Skye Maeckel	

Ch.	Topic	Co-PI	Institution	City, State Zip code	Students	Professional Staff
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Max Yoskowitz	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	John Pena Baker	
11	Benthos	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Elizabeth Harris	
12	Oysters	Jennifer Pollack	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Kelly Savage	Terry Palmer
12	Oysters	Jennifer Pollack	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Natasha Breaux
12	Oysters	Jennifer Pollack	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Danielle Downey
12	Oysters	Jennifer Pollack	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Kevin De Santiago
13	Plankton	Antonieta Quigg	Texas A&M University-Galveston	Galveston, TX 77553		Jamie Steichen
14	Nekton	Greg Stunz	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Daniel Coffey
15	Nutrient budgets	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412	Danielle Marshall	
16	Socioeconomics	David Yoskowitz	Texas Parks and Wildlife Department	Austin, TX 78744		
17	Recommendations	Paul Montagna	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		
18	GRIDC	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Deborah LeBel
18	GRIDC	James Gibeaut	Texas A&M University-Corpus Christi	Corpus Christi, TX 78412		Rosalie Rossi

Engagement

Presentation of project results were held with four stakeholder group meetings. In all cases, findings of the book project were presented.

1. On 1 May 2024, Paul Montagna made a presentation entitled, “Freshwater Inflow to Texas Bays and Estuaries” to the Trinity-San Jacinto Bay and Basin Area Stakeholder Committee (BBACS) meeting at the San Jacinto River Authority offices at Lake Conroe, Texas, in which about 49 people attended.
2. On 10 May 2024, Paul Montagna made a presentation entitled, “Freshwater Inflow to Texas Bays and Estuaries” to the Texas Outdoor Writers Association in Rockport, Texas, in which about 19 people attended.
3. On 11 July 2024, Paul Montagna made a presentation entitled, “Freshwater Inflow to Texas Bays and Estuaries” to the Brazos Bay and Basin Area Stakeholder Committee (BBACS) meeting at the Brazos River Authority offices in Waco, Texas, about 21 people attended.
4. On 18 October 2024, Paul Montagna made a presentation entitled, “How a simple question about freshwater inflow shaped a career,” to the Biology Graduate Student Association (BioGSA) in College Station, TX. The presentation was made by video conference and about 30 people participated.

StoryMap

A StoryMap⁶ was created that summarized the book and acts as an introduction to the science and management of environmental flow research. A storymap is a graphic organizer that helps individuals learn the elements of a narrative. The storytelling tool uses maps to explore locations, events, and trends. It integrates text, photos, audio, and videos with custom maps to create a story that informs and inspires. The ArcGIS StoryMap tool was used for the current project.

The StoryMap is an important part of the project because during the stakeholder engagement meetings, it became clear that at least half the people in the BBASC groups were not aware of the major issues related to environmental flows, environmental flow management, or the details of Texas policy and law as it relates to environmental flows. The goal and purpose of the StoryMap is to summarize findings of the project in an “easy to understand” format for a broader, public audience. While the StoryMap contained many images from the book, many images were created just for the StoryMap itself.

The StoryMap contains 13 sections: an overall table of contents (Figure 4), an Introduction, 1-Hydrology, 2-Nutrients and Plankton, 3-Wetland Habitats, 4-Benthic Habitats, 5-Fish and Nekton, 6-Tides and Circulation, 7-Salinity, 8-Sediments and Groundwater, 9-Climate, 10-Environmental Flow Law and Policy, and Credits (Figure 5). The Credits webpage contains logos for the Texas General Land Office and the Coastal Management Program.

⁶ Tiny URL is <https://arcg.is/0OGqeS0>, . The complete address is <https://storymaps.arcgis.com/collections/88ebe5b53085412e8a2d385e34e98ab9>

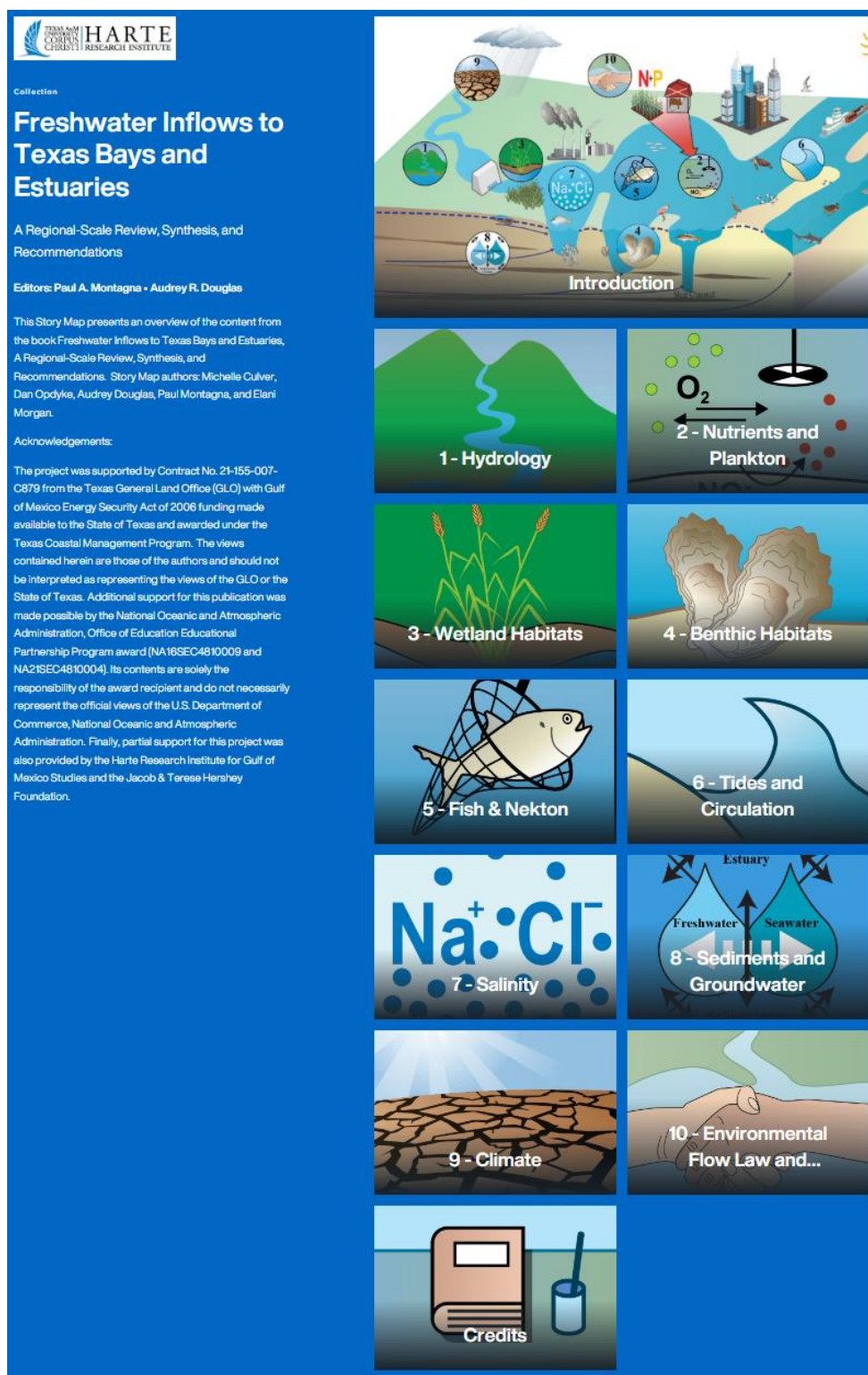


Figure 5. StoryMap “Table of Contents” webpage.



Credits



Sponsors

General Credits:

- Much of the content of this storymap is taken from an open access book, "Freshwater Inflows to Texas Bays and Estuaries: A Regional-Scale Review, Synthesis, and Recommendations," Paul A. Montagna and Audrey R. Douglas (eds.), Springer, ISBN 978-3-031-70881-7, to be published November 2024. Chapters from the book are cited below.
- Most of the graphics were created using Image Library from the Integration and Application Network (IAN) at the University of Maryland Center for Environmental Science (UMCES) <https://ian.umces.edu/media-library/>
- See the e-book at Springer Nature Link: [Freshwater Inflows to Texas Bays and Estuaries: A Regional-Scale Review, Synthesis, and Recommendations | SpringerLink](#)
- Contact Information: hri@tamucc.edu

Figure 6. StoryMap "Credits" webpage.

Additional Publications

In addition to the Book, there are 7 other publications completed or planned:

1. Del Rosario, E, (2022) Texas 2007 Senate Bill 3 Environmental Flows Process: A Review and Analysis for The Priority Coastal Basins in Texas, USA. Dissertation submitted to Texas A&M University-Corpus Christi.
2. Renner, L.M., (2022) Effect of Freshwater Inflow on Mollusk Community and Population Dynamics In Texas Estuaries. Master of Science Thesis submitted to Texas A&M University-Corpus .
3. Yin, H., Hu, X., & Dias, L. M. (2023) Sulfate enrichment in estuaries of the northwestern Gulf of Mexico: The potential effect of sulfide oxidation on carbonate chemistry under a changing climate. *Limnology and Oceanography Letters*, 8(5), 742-750. <https://doi.org/10.1002/lol2.10335>
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Leveraged Funds

The project benefited from leveraged funding from three sources: the Harte Research Institute (HRI), the Jacob & Terese Hershey Foundation (JTHF), and the National Oceanic and Atmospheric Administration (NOAA). All of the leveraged funds were provided to Dr. Paul Montagna, the Principal Investigator (PI) of the project. Below is a description of each source and how it leveraged the Texas General Land Office grant.

Harte Research Institute: The Executive Director of HRI made \$30,000 available to pre-fund the hiring of a post-doctoral researcher to assist with the book project. Eventually, Dr. Audrey R. Douglas was hired for this position. The funds enabled posting for the position in the October 2020. It often takes many months to fill positions, and the goal was to be ready to work on Day 1 after the grant was awarded. Dr. Douglas was hired in January 2021, which was three months prior to the project start date. This allowed us to plan the workshop and work on chapters early.

Additionally, HRI provided about \$7,000 to Jen Brown as a HRI Faculty Fellow to work on the project, and she recorded the oral histories and co-authored Chapter 1.

Jacob & Terese Hershey Foundation: The JTHF foundation made a grant of \$33,000 to leverage the project and enable analyses and graphics development that were not part of the original proposal. The funding was used largely to support a graduate student, Danielle Marshall, in her

pursuit of a Master of Science degree, that led directly to the creation of chapter 15. Additional undergraduate students were funded to create the datasets that were used in analyses of several chapters (1, 4, 5, 6, 11, and 14). Funds were also used to create graphics for the StoryMap.

National Oceanic and Atmospheric Administration: The funds from NOAA were part of a grant from the Educational Partnership Program with Minority Serving Institutions (EPP). Here, only the part used as leveraged funding is reported. The funds were provided in two grants: NA16SEC4810009 and NA21SEC4810004 that were used to fund a dissertation for two graduate students: Patricia Cockett and Elizabeth Del Rosario. Ms. Cockett helped with data archival and graphics for Chapter 11. Ms. Del Rosario used a chapter from her dissertation to co-author Chapter 1. Further the NOAA grants provided salary support for the PI, Paul Montagna, who authored Chapters 1, 11, and 17; co-authored Chapters 3, 6, 9, 12, 14, and 15; and created or supervised uploading of nearly all the archived content (data, documents, and audio files). It is difficult to put an exact number on the NOAA funds used to help complete this project, but over the four years, the total amount of NOAA funding was about \$395,000; so it was likely greater than 25% of that, which is about \$100,000. All contents of the book and this final report are solely the responsibility of the award recipient and do not necessarily represent the official views of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration.