2023 OBLIQUE AERIAL PHOTO ASSESSMENT OF THE LOUISIANA BARRIER SHORELINE

Louisiana Barrier Island Comprehensive Monitoring Program (BICM) Phase 3

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ABOUT THE WATER INSTITUTE

The Water Institute is an independent, non-profit, applied research institution advancing science and developing integrated methods to solve complex environmental and societal challenges. We believe in and strive for more resilient and equitable communities, sustainable environments, and thriving economies. For more information, visit www.thewaterinstitute.org.

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The authors acknowledge the University of New Orleans (UNO) Aerial Video Survey Program archive, hosted by the Pontchartrain Institute for Environmental Sciences (PIES) at UNO, which includes aerial imagery of the northern Gulf of Mexico shoreline from 1984 through 2007 that contributed to the creation of new Time Series. Acknowledgements are extended to the United State Geological Survey (USGS) for sharing 2010 and 2012 imagery which supported some of the Time Series previously produced in 2017 and are utilized in this project. This effort builds on the previous project in 2017, assembled by Karen A. Westphal with assistance from Darcy A. Wilkins and support from Ioannis Y. Georgiou and Tara Yocum (UNO-PIES), an effort that was funded through a grant from the National Fish and Wildlife Foundation (NFWF) to the Coastal Protection and Restoration Authority (CPRA). The 2023 image acquisition was performed by Gulf Coast Air Photo, LLC. Funding for the acquisition, processing, analysis, and preparation of the 2017-2023 Photo-pairs, the update of the Time Series and the generation of new Time Series was provided by a grant from the Natural Resource Damage Assessment (NRDA) to CPRA. The funding was provided to The Water Institute by CPRA through Task Order 108.

Several other team members of the Institute provided support during the project and the development of this report. Harris Bienn provided oversight of some of the geospatial analysis tools developed and used in the project. Lorena Cantor contribution to the project was instrumental in optimizing processing and analysis workflows related to geospatial processing of the photos, optimizing workflows for selecting proximal photographs to the Photo-pair comparison development, and provided continuous support on geospatial tools related to visual aids related to Photo-pairs and Time Series. Dexter Ellis provided photo editing support for all Photo-pairs. Finally, Glen Curole, from CPRA provided guidance on the scope of work for the project, input throughout the project execution, feedback on the Photo-pair and Time Series deliverables and reviewed this report.

This report was reviewed by Charley Cameron and Alyssa Dausman of the Institute and edited and formatted by Charley Cameron.

SUGGESTED CITATION

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PREFACE

The Water Institute (the Institute) conducted this study for the CPRA. This report is a project deliverable. It outlines the methods during the acquisition, analysis, synthesis, and use of Aerial Oblique Photos to compare coastal change throughout the Louisiana barrier shoreline using Photo-pair comparisons between 2017 and 2023 in this last installment, updating previous photo Time Series at selected locations throughout the coast and create six new Time Series, with archive photos going back to the 1980s, at new locations identified through coordination with Glen Curole at CPRA. The project is part of the Barrier Island Comprehensive Monitoring (BICM) Program Phase 3, which aims to provide monitoring datasets to evaluate the Louisiana barrier shoreline. This project was led by the Institute's Coastal and Deltaic Systems Modeling department, with Francesca Messina as the project manager and technical lead on the update of Photo-pairs and Time Series, and general project oversight by Ioannis Georgiou. Karen Westphal provided support as subject matter expert and led the effort to develop six additional Time Series with input from the Institute and Glen Curole at CPRA. Lorena Cantor and Harris Bien from the Analytics Computing and Technology (ACT) team also provided additional technical support for the project, and Dexter Ellis from the Marketing and Communication team provided image analysis support for the Photo-pair comparison. This project was funded under CPRA Task Order 108.

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LIST OF ACRONYMS

Acronym	Term
BICM	Barrier Island Comprehensive Monitoring
CPRA	Coastal Protection and Restoration Authority
LCA	Louisiana Coastal Area
MP	Megapixels
NAD83	North America Datum 1983
NFWF	National Fish and Wildlife Foundation
NOAA	National Oceanic and Atmospheric Administration
NRDA	National Resource Damage Assessment
PIES	Pontchartrain Institute for Environmental Sciences
SME	subject matter experts
UNO	University of New Orleans
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

INTRODUCTION

This report describes the acquisition, processing, analysis, synthesis, and use of aerial oblique photos along the Louisiana barrier shoreline conducted as part of Phase 3 of the Barrier Island Comprehensive Monitoring (BICM) Data Collection program. The aim of this project is to compare coastal change throughout the Louisiana barrier shoreline using aerial imagery that has been acquired since the 1980s. The Coastal Protection and Restoration Authority (CPRA) implemented Phase 1 of the BICM Data Collection Program with science support from the Pontchartrain Institute for Environmental Sciences (PIES) at the University of New Orleans (UNO) and United States Geological Survey (USGS) in 2005. UNO collected and analyzed data to facilitate CPRA activities of barrier shoreline planning, design, maintenance, monitoring, and storm impact assessment. The Phase 1 and Phase 2 BICM studies included shoreline analysis (Byrnes et al., 2018; L. Martinez et al., 2009; L. A. Martinez et al., 2006), seafloor change (Miner, Kulp, Penland, et al., 2009; Miner, Kulp, Weathers, et al., 2009), habitat assessment (Enwright et al., 2018; S. Fearnley et al., 2009), sediment sampling and analysis (Georgiou et al., 2017b, 2017a, 2019; Kulp et al., 2011, 2015), and storm assessment (S. M. Fearnley et al., 2009). The baseline data collection effort and data delivery necessary to establish and develop the CPRA BICM program provided documentation and invaluable information for future restoration efforts along the Louisiana sandy shorelines (Kindinger et al., 2013). Phase 2 of BICM took place 10 years later, updating baseline information and providing comparison data that contributes to the understanding of the efficacy of restoration efforts and interaction with coastal processes. The UNO Aerial Video Survey slide archive includes imagery from 1984 to 2007 from aerial survey efforts that were funded through a variety of sources. Most images were taken from a helicopter during simultaneous video imagery capture as part of the Aerial Video Survey Program for hurricane impact studies or oil spill preparation and response

Over many years of documenting the coast, a standardized methodology produced imagery that facilitated comparison between time periods has been developed. Images that visually match from any two flights produce *Photo-pairs* that illustrate cumulative landscape changes for the selected time periods. Imagery matched from more than two surveys are considered a *Time Series*. As part of Phase 3, The Water Institute worked create Photo-pairs by comparing 2017 and 2023 photographs at 260 locations, updated previous photo Time Series at 22 locations throughout the coast and created six new Time Series, using existing archive photos going back to the 1980s.

The 2023 barrier shoreline photo comparison task consists of three parts:

- Part 1: 2023 Oblique Aerial Photography of Coastal Louisiana
- Part 2: 2017-2023 Photo-pairs of the Barrier Shoreline of Louisiana
- Part 3: 1984–2023 Historic Time Series

The funding that supported the video and photographic coastal surveys that compose the historical slide archive came from a variety of agencies, industries, and foundations, including the Exxon Mobil Corporation, Marine Spill Response Corporation, Clean Gulf Associates, Unocal Corporation, SONAT, Inc., Texas Bureau of Economic Geology and Louisiana Oil Spill Research and Development Program.

Funding for the acquisition of photography following hurricanes Katrina and Rita in 2005 was provided by the U.S. Geological Survey Coastal & Marine Geology Program in St. Petersburg, FL, now known as the Coastal and Marine Science Center. Funding for the acquisition of 2006-2007 photography and the construction of BICM Photo-pairs and Time Series for Phase 1 (Westphal, 2008, 2009), was provided by Louisiana Coastal Area (LCA) Science & Technology Program, a partnership between the CPRA and the US Army Corps of Engineers (USACE), through CPRA Interagency Agreement No. 2512-06-06. Imagery for 2008 was provided by CPRA, and imagery for 2010 and 2012 were funded through supplemental grants from the USGS (Morgan & Westphal, 2014, 2016). The National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefits Fund funded the acquisition of 2017 imagery through a grant to CPRA. Karen A. Westphal conducted the Photo-pairs and Time Series compilation in 2017 with assistance from Darcy Wilkins and support from Ioannis Georgiou and Tara Yocum (Westphal, 2018). The National Resource Damage Assessment (NRDA) funded the acquisition of 2023 imagery through a grant to CPRA. Francesca Messina led the compilation and updating of the Photo-pairs and existing Time Series with support from Dexter Ellis and oversight by Ioannis Georgiou. Karen A. Westphal provided input and guidance and led the creation of the six new Time Series with coordination from Glen Curole at CPRA and the Institute project team.

For more information about the BICM program, including additional shoreline photos and reports previously completed the reader is directed to the CPRA program website: https://cims.coastal.louisiana.gov/outreach/ProjectView.aspx?projID=LA-0226

PROJECT AREA

The CPRA BICM program encompasses the mainland shoreline of the south Louisiana coast with particular emphasis on the sandy beaches and barrier islands. Louisiana's mainland shoreline stretches 450 miles east from Sabine Pass on the Texas/Louisiana border to the Pearl River on the Mississippi/Louisiana border. Between Texas and Mississippi, Louisiana encompasses various delta plain morphologies and regions. The BICM program divided the Louisiana coastline into nine regions: the Western Chenier Plain, Eastern Chenier Plain, Acadiana Bays, Atchafalaya and Wax Lake Deltas, Early Lafourche Delta, Late Lafourche Delta, Modern Delta, Chandeleur Islands, and the Pontchartrain Basin (Figure 1).

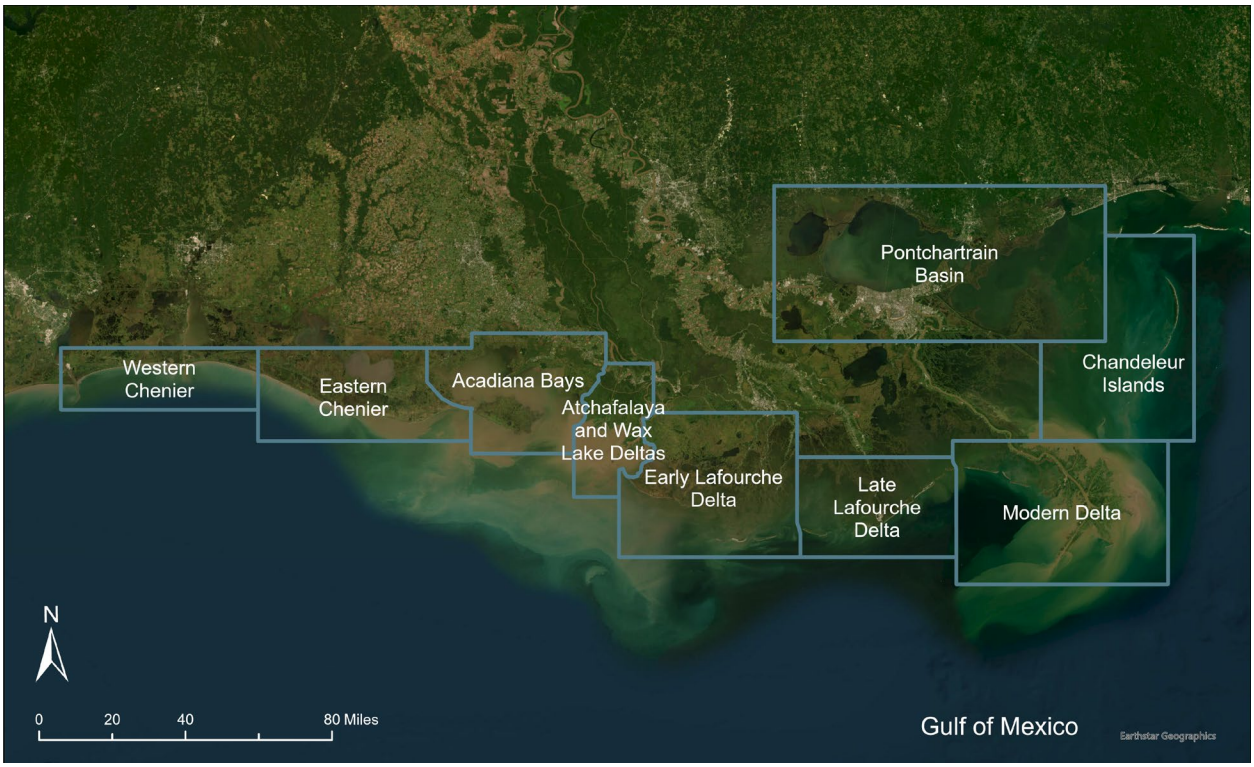

Figure 1. BICM program coastal Louisiana regions with their corresponding names, established and referenced by the program.

PART 1: 2023 AERIAL PHOTOGRAPHY OF COASTAL LOUISIANA

Part one of the project was the acquisition of new continuous, overlapping imagery throughout all BICM regions, and was completed in the fall of 2023 and early 2024. Before the 2023 acquisition flights, coordination calls occurred between the project team, subject matter experts (SMEs), the pilot, and the photographer. Upon completion of pre-flight coordination, the 2017 flight paths, the locations of all Photo-pairs, and of the existing Time Series that needed updating were shared. The Photo-pair and existing Time Series locations were shared to ensure that a higher frequency of photos was acquired each time the plane neared a Photo-pair or a Time Series location.

During acquisition, the camera acquired metadata (see the Methodology section). After acquisition and a preliminary bulk preprocessing, all digital photography (both JPEGs and RAW files) were shared and grouped by date of acquisition and corresponding Louisiana coastal area.

METHODOLOGY

Workflow Updates and Improvements

To establish the workflows for the 2023 acquisition, early project coordination occurred, focusing on finding ways to improve the workflows, and modernizing and improving where possible the procedures used previously. The biggest change since 2017 was the use of higher resolution cameras, with embedded and seamless metadata acquisition. Metadata collected during the 2023 acquisition included geolocation/positioning, date and time, altitude, azimuth, and information related to image resolution. Moreover, each photograph taken was saved as a JPEG at reasonably high resolution (i.e., 8192 x 5464 pixels, 300 dpi; 5760 x 3840, 300 dpi) as well as a RAW format image, which at the full camera resolution was either 21 or 48 megapixels (MP) depending on the camera used. Additional improvements to workflows included leveraging the now available metadata in the photographs. The embedded metadata allowed for easy access to information through scripting, which improved the generation of flight paths, renaming of files, folder organization, and the generation of master tables with summary of metadata for all photographs for the subset of photographs that was used in the Photo-pairs and in Time Series.

Photo Acquisition Equipment

All flights were conducted and photos acquired by Gulf Coast Air Photo, LLC. The plane used for all flights was a Cessna 172M with extended fuel tanks (Figure 2). During acquisition, two full frame cameras were available and used depending on conditions, flight segment, or potential malfunction of primary camera. The primary camera was a Canon EOS 5D Mark II (21 MP) and the second camera was a Canon EOS R5C (21 MP). An integrated Global Positioning System (GPS) was used in addition to the built in GPS of the camera (Canon GPS GP-E2). Two lenses were available and used depending on conditions and flight segment, although the focal length for either lens was similar to ensure similar view and avoid distortion. The primary lens used was a Nikkor 60mm f2.8, with Canon 24-105mm and a 24-85mm lenses also used.

Figure 2. Photo of the aircraft used for the 2023 image acquisition. The aircraft was a Cessna 172M with extended fuel tanks.

Processing, Organization, and Final Metadata Creation

Photographs were acquired using a standard sequential numbering file naming system. Following each acquisition, photos were bulk processed for exposure by the photographer (Toby Armstrong) using Adobe Lightroom©, and were shared with the Institute. The location of all photos was logged.

A Python script was developed to rename and extract metadata information from all photos. Each photo was renamed using standard naming conventions following BICM guidelines and to match earlier phases of the project in 2007 and 2017. The naming convention was agreed upon with CPRA. The first element of the name was the project number under which the imagery was collected, in this case LA-0226. The second element identifies that the image is an oblique photo (i.e., OBLIQ). The third element was the date in YYYYMMDD format. The fifth and final element was a unique four-digit numeric ID for that photo that was retained from the original photo name provided by the camera. For example, if photo number 0123 was taken on November 1, 2023, then the name of that photo would be *LA-0226_OBLIQ_20231101_0123.jpg.*

The script was also used to automatically extract the following information from each photograph: data and time of acquisition, latitude and longitude, inclination, altitude, and azimuth. All of this information was compiled and saved in a .csv file that included metadata for all photographs (Figure 3). Easting and

Northing in Universal Transverse Mercator (UTM) North America Datum 1983 (NAD83) zone 15N coordinates were also included in the master .csv file.

Moreover, the georeferencing available in the metadata in combination with the sequential numbering of the photos was used to create the flight path. This was a straightforward process given the high frequency of photo acquisition.

A	B	C	D	E	F	G	H	I	J	K	M	N
TYPE	PROGRAM	PROJECT	PROJ_ID	DATE_COLL	Northing_utm15N_m	Easting_utm15N_m	LATITUDE	LONGITUDE	ALT_m	AZIMUTH	UTC	Image_Name
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3232180.254	759914.7979	29.191675	-90.32703333	511.4	110.846	12/11/2023 17:35	LA-0226_OBLIQ_20231211_5755.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3218714.729	740097.3597	29.074165	-90.533575	176.2	66.954	12/11/2023 17:44	LA-0226_OBLIQ_20231211_5880.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3215022.204	713215.8426	29.04565167	-90.810245	233.7	41.123	12/11/2023 17:57	LA-0226_OBLIQ_20231211_6153.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3243499.411	662677.3818	29.31003	-91.32490167	135.6	121.42	12/11/2023 18:50	LA-0226_OBLIQ_20231211_7135.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3229565.145	687459.564	29.18089167	-91.07218833	98.7	61.277	12/11/2023 18:15	LA-0226_OBLIQ_20231211_6622.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3237310.47	665537.3341	29.25382333	-91.29639	403.9	62.391	12/11/2023 18:24	LA-0226_OBLIQ_20231211_6897.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3231573.079	683728.5215	29.19955167	-91.11020833	44.3	72.303	12/11/2023 18:17	LA-0226_OBLIQ_20231211_6668.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3229520.687	691705.2534	29.179855	-91.028555	268.2	71.243	12/11/2023 18:14	LA-0226_OBLIQ_20231211_6567.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3232066.895	759864.3359	29.19066333	-90.32757833	509.7	106.846	12/11/2023 17:35	LA-0226_OBLIQ_20231211_5756_1.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3236732.6	666601.913	29.24847	-91.285525	398.9	63.385	12/11/2023 18:23	LA-0226_OBLIQ_20231211_6882.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3233638.195	676836.5547	29.21916333	-91.18073833	374.9	54.327	12/11/2023 18:19	LA-0226_OBLIQ_20231211_6763.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3225618.379	702199.1688	29.143025	-90.921405	275.2	67.182	12/11/2023 18:09	LA-0226_OBLIQ_20231211_6407.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3215834.37	724388.2318	29.05105667	-90.695415	185.7	51.053	12/11/2023 17:50	LA-0226_OBLIQ_20231211_5989.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3336726.76	810255.4053	30.12240333	-89.78006167	119.6	103.413	12/11/2023 15:51	LA-0226_OBLIQ_20231211_5489.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3214153.121	710871.9384	29.03820333	-90.83446667	218.9	53.138	12/11/2023 17:58	LA-0226_OBLIQ_20231211_6184.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3229590.193	687319.5491	29.18113833	-91.07362333	97.6	58.278	12/11/2023 18:15	LA-0226_OBLIQ_20231211_6624.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3215582.943	717076.9545	29.05005667	-90.77050667	64	71.101	12/11/2023 17:53	LA-0226_OBLIQ_20231211_6091_1.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3341104.799	822753.8493	30.15860167	-89.64919667	210.7	125.341	12/11/2023 15:59	LA-0226_OBLIQ_20231211_5701.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3245336.052	659706.659	29.32698	-91.355215	32.1	79.449	12/11/2023 18:28	LA-0226_OBLIQ_20231211_7011.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3249534.174	653250.8587	29.36565833	-91.42109667	53.5	93.485	12/11/2023 18:41	LA-0226_OBLIQ_20231211_7038.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3250338.244	654022.3363	29.37281833	-91.41303833	62.4	106.478	12/11/2023 18:42	LA-0226_OBLIQ_20231211_7044.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3334250.269	807653.32	30.10074833	-89.80775	176.3	120.438	12/11/2023 15:49	LA-0226_OBLIQ_20231211_5446.jpg
IMAGE	NRDA	Barrier Island Comprehensive Monitoring (BICM)	LA-0226	12/11/2023	3238160.012	664511.8725	29.26162167	-91.30681333	358	71.398	12/11/2023 18:24	LA-0226_OBLIQ_20231211_6910.jpg

Figure 3. Example screenshot of the master metadata including information for all photos.

BICM 2023 PHOTO ACQUISITION AND WATER LEVELS

Photo Acquisition

Photographs were acquired in the fall of 2023 through early 2024. The first flight occurred on November 1, 2023, and the last flight on January 4, 2024. Information on the complete acquisition dates, the corresponding geographic region, and the bounding tide gauges used for water levels are shown in Table 1. Figure 4 shows the path of these eight flights.

Some additional short flights were made to improve photos in areas where it was difficult to produce matches for some of the existing Time Series, and to update some of the Photo-pairs. Those four additional flights occurred on:

- February 1, 2024: this flight covered the area around Fort Livingston, East Timbalier, East Isle, and Racoon Island
- February 6, 2024: this flight covered some of the area along the Chandeleur Islands, Grand Gosier, Schooner Bayside, and the tower at the South Chandeleur Island
- February 19, 2024: this flight covered the same area covered on February 6 (Chandeleur Islands) and it was meant to improve some of the photographs take 2 weeks before due to issues with the camera during prior photo acquisition;
- March 19, 2024: This flight covered the area around East Timbalier to ensure that the view needed for Time Series 12 was obtained.

The additional flights were performed on days when the weather and water level were favorable, and they were very short and location-specific. No flight track was generated for these flight as a limited about of photographs were taken.

Table 1 Acquisition dates, flight geographic region, and corresponding stations used for meteorological summaries and water level information.

Acquisition Date	Flight Geographic Region	NOAA Station used for Meteorological Conditions	Water Levels at Bounding Stations
1-Nov-23	Southwest Pass (Modern Delta); North Lake Borgne	8761927 New Canal Station, LA	Figure 6
9-Nov-23	Chandeleur Islands (From Hewes Point to Breton Island)	8761305 Shell Beach, LA	Figure 7
17-Nov-23	Bastian Island to East Timbalier Island	8761724 Grand Isle, LA	Figure 8
28-Nov-23	Lake Pontchartrain; Lake Maurepas; Lake Borgne	8761305 Shell Beach, LA	Figure 9
6-Dec-23	Modern Mississippi River Delta to Shell Island	8760721 Pilot Town, LA	Figure 10
11-Dec-23	East Timbalier to Atchafalaya Delta; West Lake Borgne to Rigolets	8761724 Grand Isle, LA	Figure 11
18-Dec-23	Point Au Fer to Sabine Pass	8766072 Freshwater Canal Locks, LA	Figure 12
4-Jan-24	Marsh Island	8766072 Freshwater Canal Locks, LA	Figure 13

Water level data for all photo acquisition dates throughout the Louisiana coast was obtained from a network of tide gauges operated by the National Oceanic and Atmospheric Administration (NOAA) Tides and Currents program ("CO-OPS Map - NOAA Tides & Currents," accessed 4/3/2024) which operates stations throughout the US, including several stations in Louisiana. Figure 5 shows the distribution of water level gauges in coastal Louisiana that provide historical and current water levels. For each photo acquisition day, one or more stations are listed with a link to the relevant data. Plots of the relevant proximal water levels bounding the region of the area where photos were acquired and are shown for each acquisition day (Figure 6 through Figure 13) and general area of photography (Table 1).

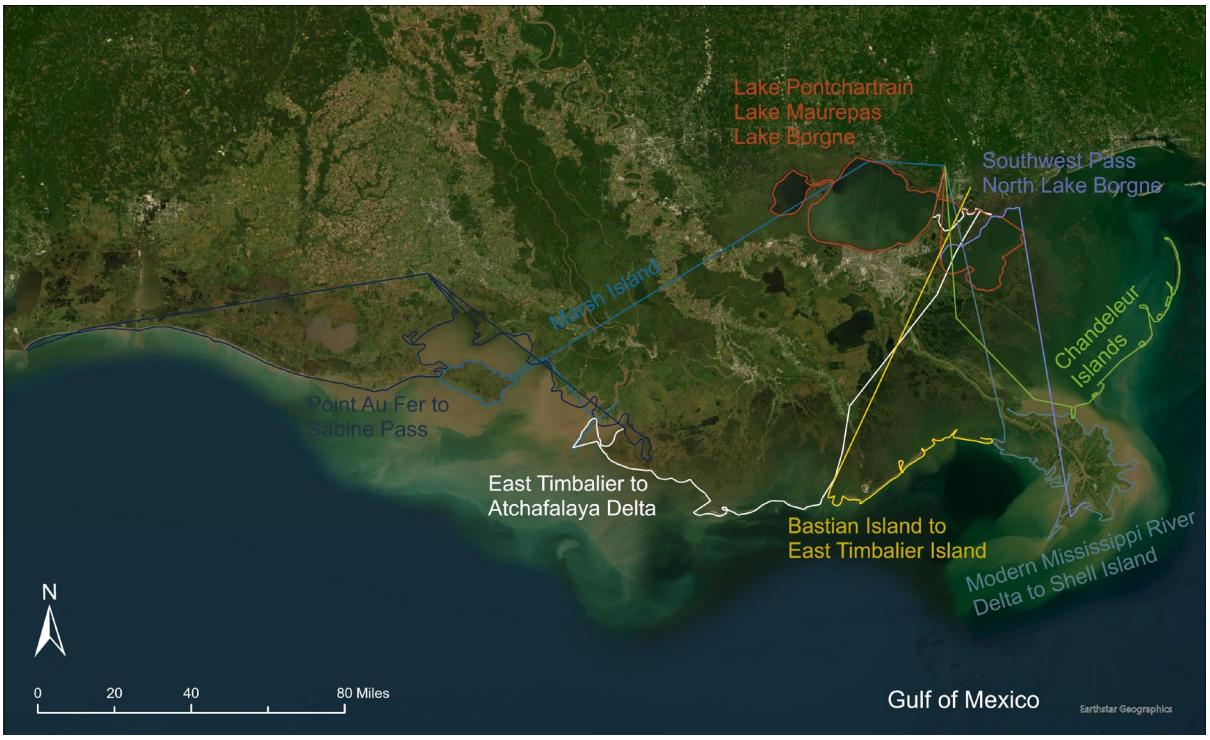

Figure 4. Flight path generated from photo metadata. See Table 1 for flight dates.

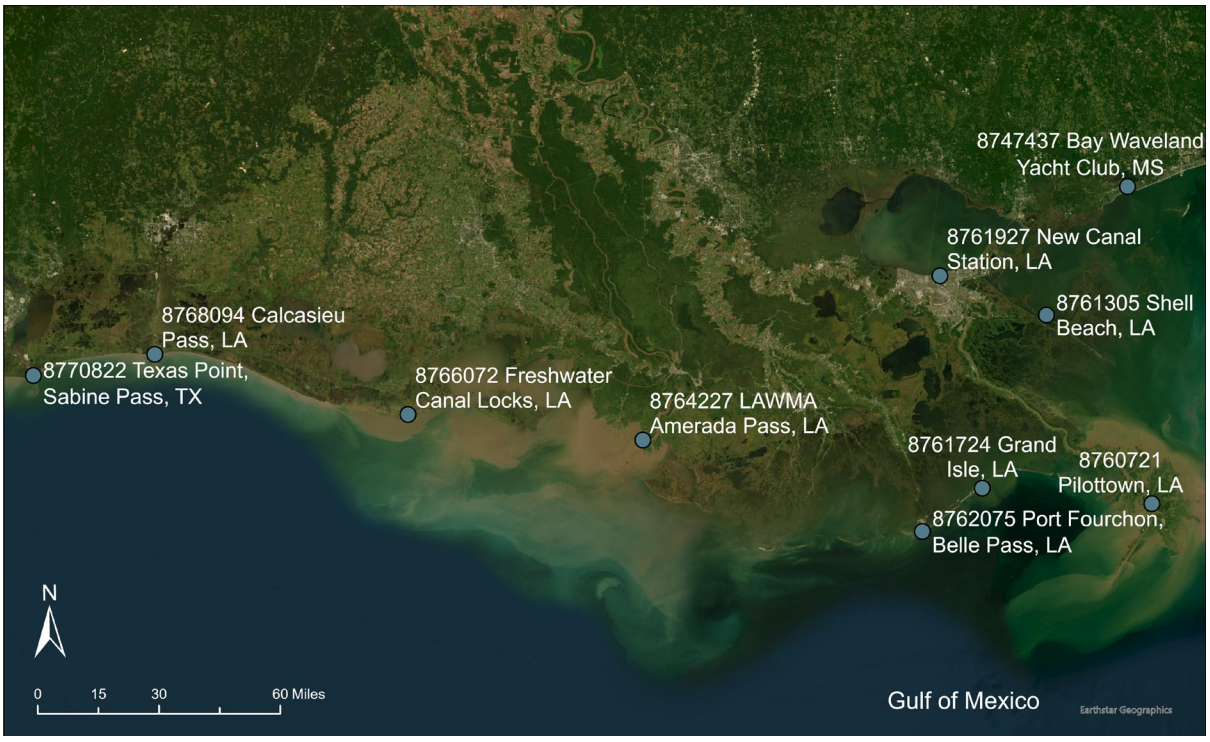

*Figure 5. Locations of stations available for current water levels along coastal Louisiana. Stations are from the network of the National Oceanic and Atmospheric Administration (NOAA) Tides and Currents program (*CO-OPS Map - NOAA Tides & Currents*, n.d.).*

Meteorology and Water Levels During Acquisition

The first flight, which was conducted to test the methodology, occurred on November 1, 2023, and covered the shoreline along Southwest Pass. This test flight also covered the north portion of Lake Borgne enroute back to Slidell Airport, (Table 1 and Figure 4). The pressure that day ranged from 1020 to 1025 millibars, with a temperature of 55–57 °F. Winds were 14 knots early in the day, reaching 22 knots by the end of the day, with gusts of 18 to 28 knots, blowing out of the north. Water levels during the flight were high at the beginning of the day near the delta and falling all day by as much as 45 cm (Figure 6). To the east, near Lake Borgne, tides based on NOAA tide gauges to the east (8761305 Shell Beach and 8747437 Bay Waveland, see Figure 5 for their locations) started at mid-tide very early in the day and reached high tide before noon, rising approximately 25 cm during the acquisition window (Figure 6).

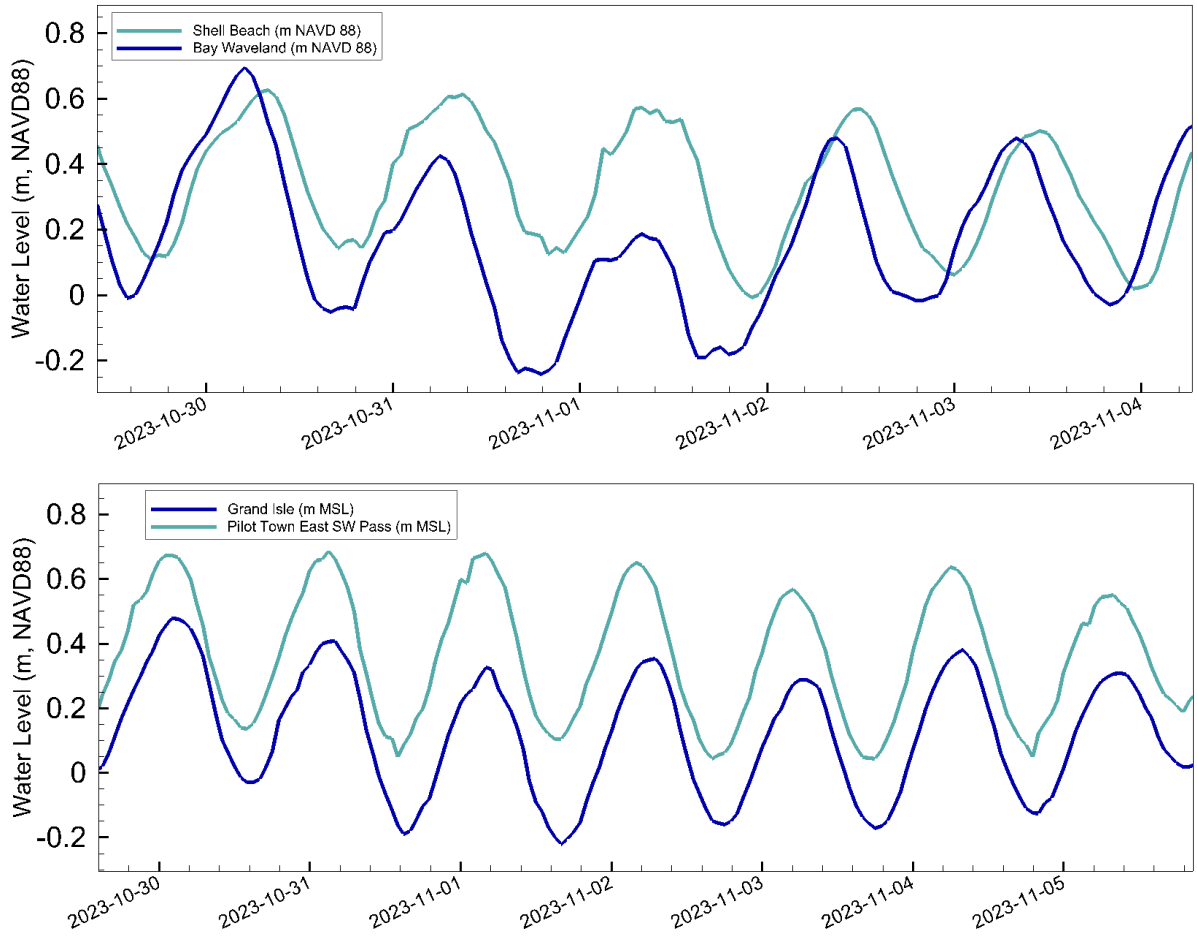

Figure 6. Water levels at Shell Beach, LA, and Bay Waveland, MS, from October 30 through November 4, 2023, during photo acquisition flight at north Lake Borgne (top), and water levels from Grand Isle and Pilot Town East of Southwest Pass from the same period during photo acquisition in the modern Mississippi River Delta at Southwest Pass.

The next flight occurred on November 9, 2023, covering the entire chain of the Chandeleur Islands from northern Hewes Point through the southern spit of Breton Island to the south (Table 1 and Figure 4). The atmospheric pressure was 1016 millibars, with a temperature of 69 °F. Winds were calm, starting at 6 knots early in the day, reaching 11 knots by the end of the day, with gusts of 7 knots early in the day to 12 knots later, blowing from the north-east to southwest (17 to 115 degrees). Water level excursion was low

since it was one pass the neap tide, starting at mid-tide conditions at the beginning of the day and rising by approximately 15 cm (Figure 7).

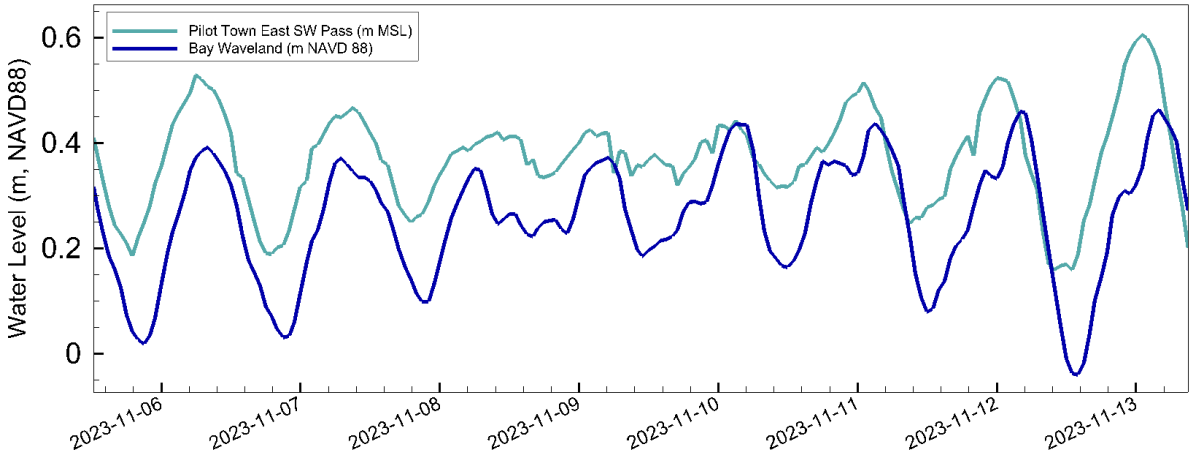

Figure 7. Water levels at Pilot Town in the modern Mississippi River Delta, LA, and Bay Waveland, MS, from November 6 through November 13, 2023, during photo acquisition flight along the Chandeleur Islands, from Hewes Point (north) to the southern reach of Breton Island (south).

On November 17, 2023, the flight path covered an area starting near Bastian Island in the east Barataria Bight and covering the entire shoreline segment towards the west around the Bight, beyond the Caminada Headland up to East Timbalier Island (Table 1 and Figure 4). The atmospheric pressure during the flight time ranged from 1015 to 1017 millibars and the temperature varied from 64 to 66 °F. Winds started at 12 knots early in the day and reaching calm conditions by the end of the flight to approximately 5 knots, with gusts of 15 knots early in the day to less than 9 knots later in the day, with a general direction from the northeast (39–52 degrees). Water levels were at mid-tide levels at the beginning of the day, reaching high tide by early morning and falling for the remaining day by approximately 60 cm near Grande Isle, LA, and by approximately 40 cm near the modern delta (Figure 8).

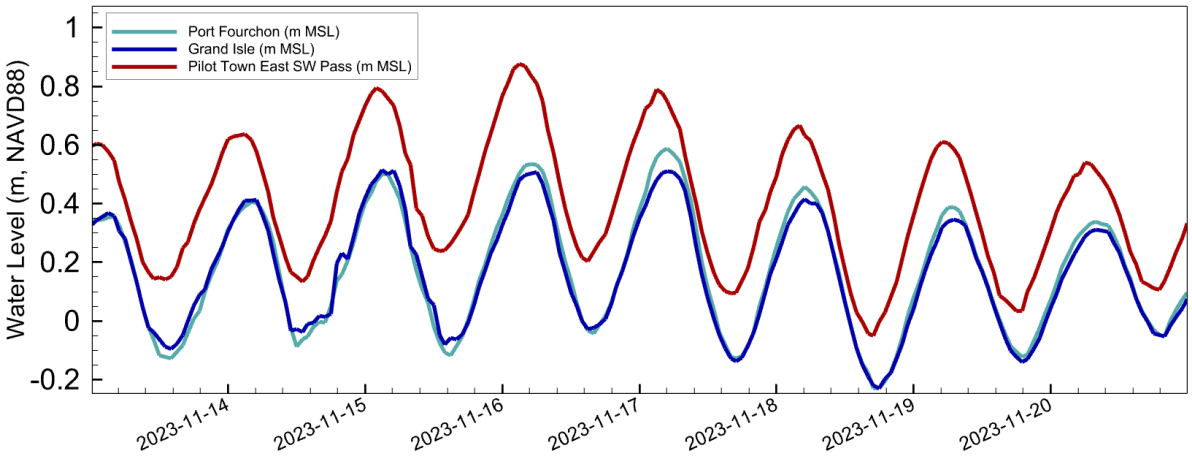

Figure 8. Water levels at Port Fourchon, Grand Isle, and Pilot Town in the modern Mississippi River Delta, LA, from November 13 through November 20, 2023, during photo acquisition flight along Barataria Bight from Bastian Island to the west toward East Timbalier Island.

The next flight occurred on November 28, 2023. During this flight path the team covered the perimeter of the three lakes north of the city of New Orleans, Lake Maurepas, Lake Pontchartrain, and Lake Borgne. (Table 1 and Figure 4). The atmospheric pressure during the flight time ranged from 1026 to 1027 millibars and the temperature varied from 51 to 53 °F. Winds started out calm early in the day at 15 knots gusting to 4 knots, and by the end of the day winds were at 18 knots with gusts up to 6 knots. The winds were from the north early in the day (9 degrees) switching to west later in the day (~276 degrees). Water levels were at near high tide levels at the beginning of the day, reaching high tide by mid-morning, and falling for the rest of the day with a range of 50 cm at Shell Beach, LA, and a range of more than 60 cm at Bay Waveland, MS (Figure 9).

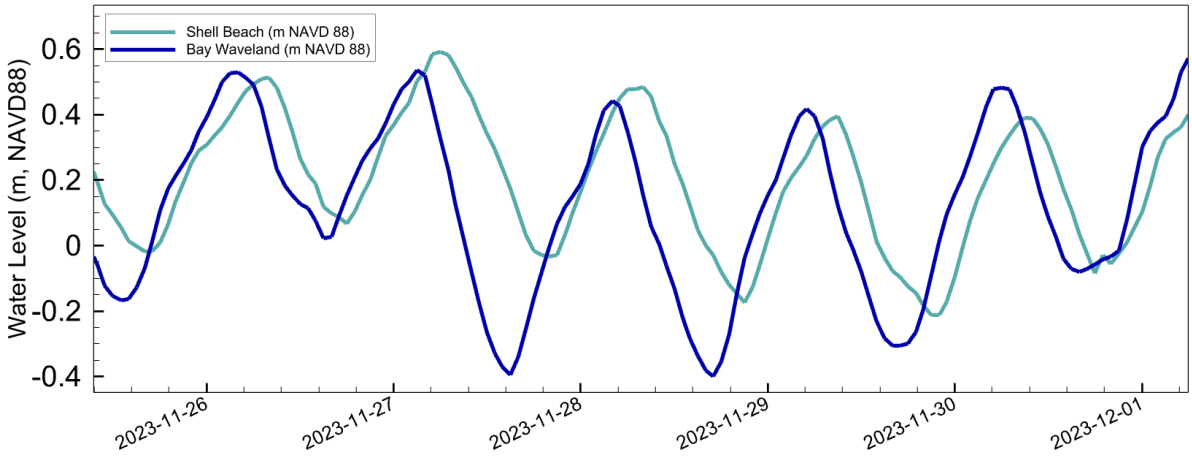

Figure 9. Water levels at Shell Beach, LA, and at Bay Waveland, MS, from November 26 through December 1, 2023, during photo acquisition flight around Lake Maurepas, Lake Pontchartrain, and Lake Borgne.

On December 6, 2023, the flight team acquired photos throughout the Mississippi River Delta covering remaining shorelines, with the exception of Southwest Pass which was previously covered, and the region along east Barataria Bight from the modern delta to Shell Island (Table 1 and Figure 4). The atmospheric pressure during the flight time ranged from 1024 to 1025 millibars and the temperature varied from 59 to 60 °F. Winds were calm for more of the day ranging from 11 to 4 knots and gusting from 13 to 6 knots, mainly from the north early in the day (13 degrees) and gradually switching to east-northeast by the end of the flight (36 degrees). Tides were at neap conditions with water levels relatively unchanged during the day varying by only 5 to 7 cm at both the Pilot Town station as well as the station at Grand Isle (Figure 10).

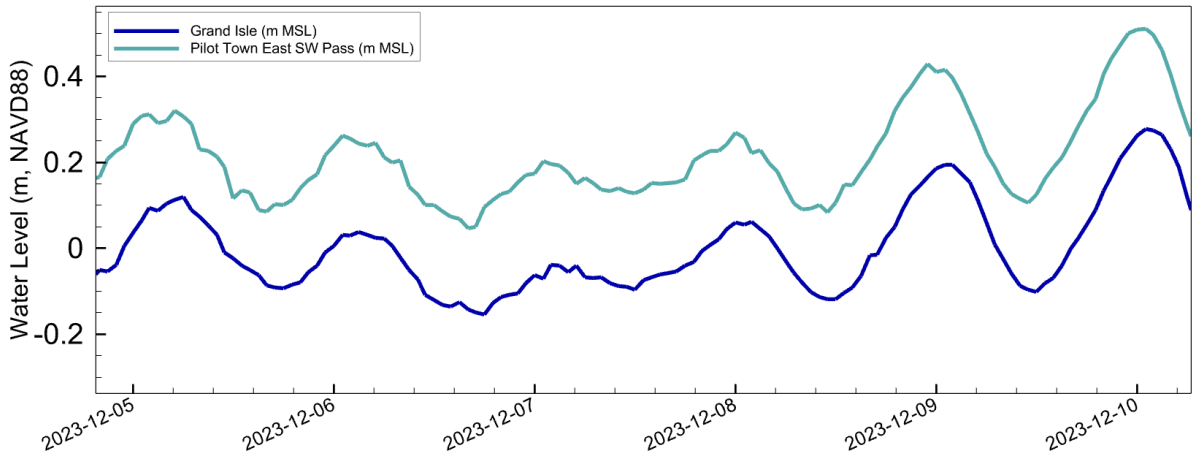

Figure 10. Water levels at Grand Isle, LA, and Pilot Town near the Mississippi River Delta, LA, from December 5, 2023, through December 10, 2023, during photo acquisition flight in the Modern Delta, and from the delta to Shell Island on December 6, 2023.

The next flight occurred on December 11, 2023, covering the shoreline segment from East Timbalier Island west up to the Atchafalaya Delta, and on the return, competing a missing segment from West Lake Borgne toward the north to the Rigolets Pass (Table 1 and Figure 4). The atmospheric pressure during the flight time ranged from 1023 to 1027 millibars and the temperature varied from 52 to 53 °F. Winds were approximately 16 knots at the beginning of the day and gusting to 19 knots, reducing the 6 knots with gust up to 8 knots by the end of the day. The wind direction was from the west-southwest (253 degrees) early in the day and switching to north-northwest by the end of the flight (353 degrees). Water levels were near high tide and elevated on this day but starting to fall by 5 am and continuing to fall by late in the evening. The water level change as measured at Port Fourchon and at Amerada Pass was approximately 60 cm (Figure 11).

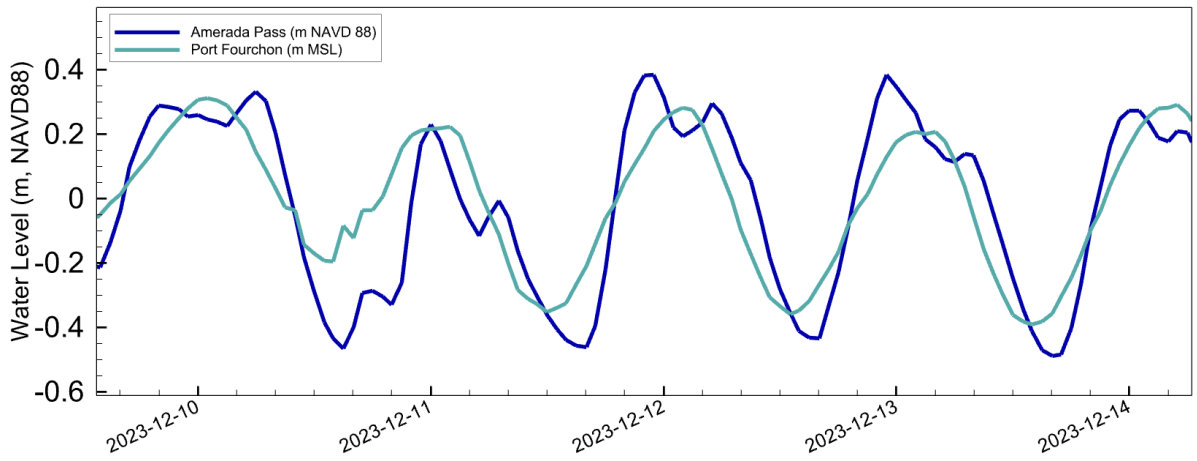

Figure 11. Water levels at Port Fourchon, LA and at Amerada Pass, LA, in the Atchafalaya Bay from December 10, 2023, through December 14, 2023, during photo acquisition flight from East Timbalier Island west of the Caminada Headland flying west towards the Atchafalaya Delta on December 11, 2023.

The flight that occurred on December 18, 2023, covered the shoreline segment from Point Au Fer located east of the Atchafalaya Bay, to Sabine Pass which is on the Texas-Louisiana State boarder (Table 1 and Figure 4). The atmospheric pressure during the flight ranged from 1021 to 1026 millibars and the temperature varied from 50 to 51 °F. Winds were approximately 5 knots at the beginning of the day and gusting to 5 knots, and gradually reduced to 4 knots with gusts up to 5 knots by the end of the day. The wind direction was from the west-southwest (253 degrees) early in the day and switched to northwest by the end of the flight (353 degrees). Water levels were rising from a previous low tide before midnight that day, reaching high tide by the time the flight started, but were falling for the entire duration of the acquisition by approximately 35 cm, which was approximately the tidal range for that day based on observations at Freshwater Bayou, Calcasieu Pass, and Sabine Pass (Figure 12).

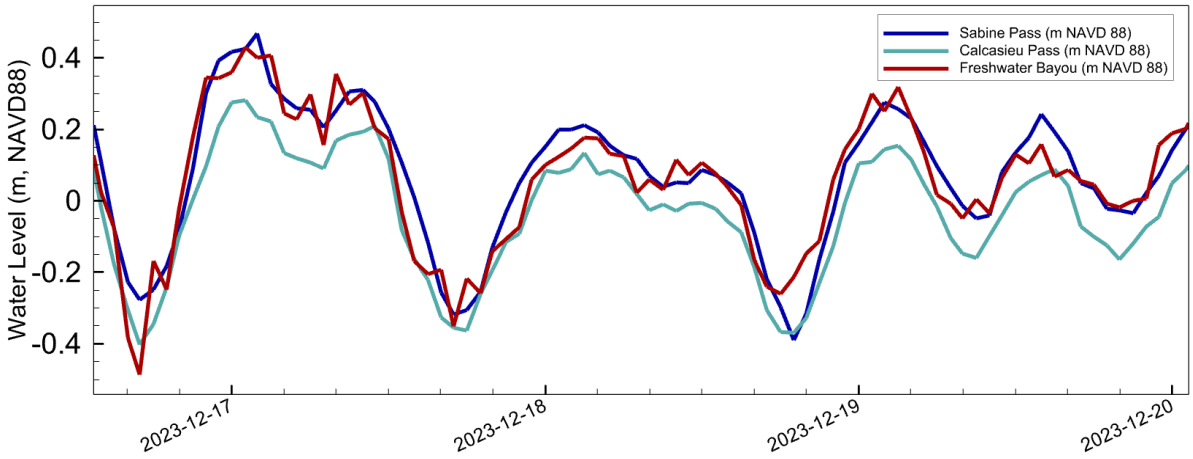

Figure 12. Water levels in west Louisiana from Freshwater Bayou, LA (data from Freshwater Canal Locks station), to Sabine Pass near the Texas border from mid-day December 16, 2023, through December 20, 2023, during photo acquisition flight from Point Au Fer flying west to Sabine Pass on December 18, 2023.

The last official flight segment occurred on January 4, 2024, and included photography covering Marsh Island, LA, located in the Atchafalaya Basin and fronting Atchafalaya Bay (Table 1 and Figure 4). The atmospheric pressure during the flight window started at 1025 and dropped to 1023 millibars by the end of the day, while the temperature remained relatively constant at 47 to 48 °F. Winds were approximately 6 knots at the beginning of the day and gusting to 8 knots, increasing to 7 knots later in the day with gusts reaching 9 knots by the end of the day. The wind direction was from north-northwest (352 degrees) early in the day and switched to northeast by the end of the flight (30 degrees). Acquisition was during neap tide conditions with water level excursions of approximately 20 to 25 cm throughout the day based on observations at Freshwater Bayou and Amerada Pass. The next day, a storm with a notable surge pass throughout the area as evidence by a rise in water levels (Figure 13).

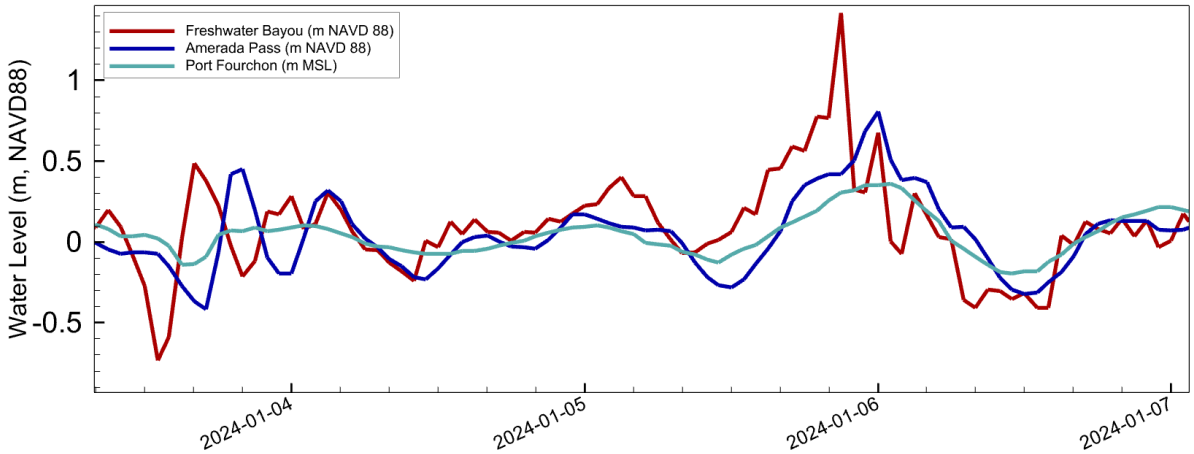

Figure 13. Water levels in the Atchafalaya Basin from observations at Freshwater Bayou, LA (data from Freshwater Canal Locks station), Amerada Pass, La, and Port Fourchon, LA, from mid-day January 3, 2024, through January 7, 2024, during photo acquisition flight for Marsh Island fronting Atchafalaya Bay on January 4, 2024.

LOCATION DIAGRAMS FOR THE 2023 AERIAL SURVEY PHOTOGRAPHY

The ArcGIS toolbox *"GeoTagged Photos To Points"*[1] enabled the project team to automatically show the locations of all collected photographs on a map, and to overlap these photos with the BICM reaches. This was made possible by leveraging the metadata embedded in each photo. Figure 14 to Figure 21 show the location of the photographs collected during the eight main flights (summarized in Table 1) and how they overlap with the BICM reach boundaries. Table A-1 lists, for each flight, the BICM reaches that are covered, first and last photograph withing each reach. The first photo was always selected from the north (if the reach direction is north-south) or east (if the reach direction is east-west) to south or west. The photographs within that reach follow a numerical progression.

Figure 14. Location of the 2023 digital photos taken on November 1, 2023, in Southwest Pass (in the Modern Mississippi River Delta) and along the North shore of Lake Borgne.

[1] GeoTagged Photos To Points (Data Management)—ArcGIS Pro | Documentation

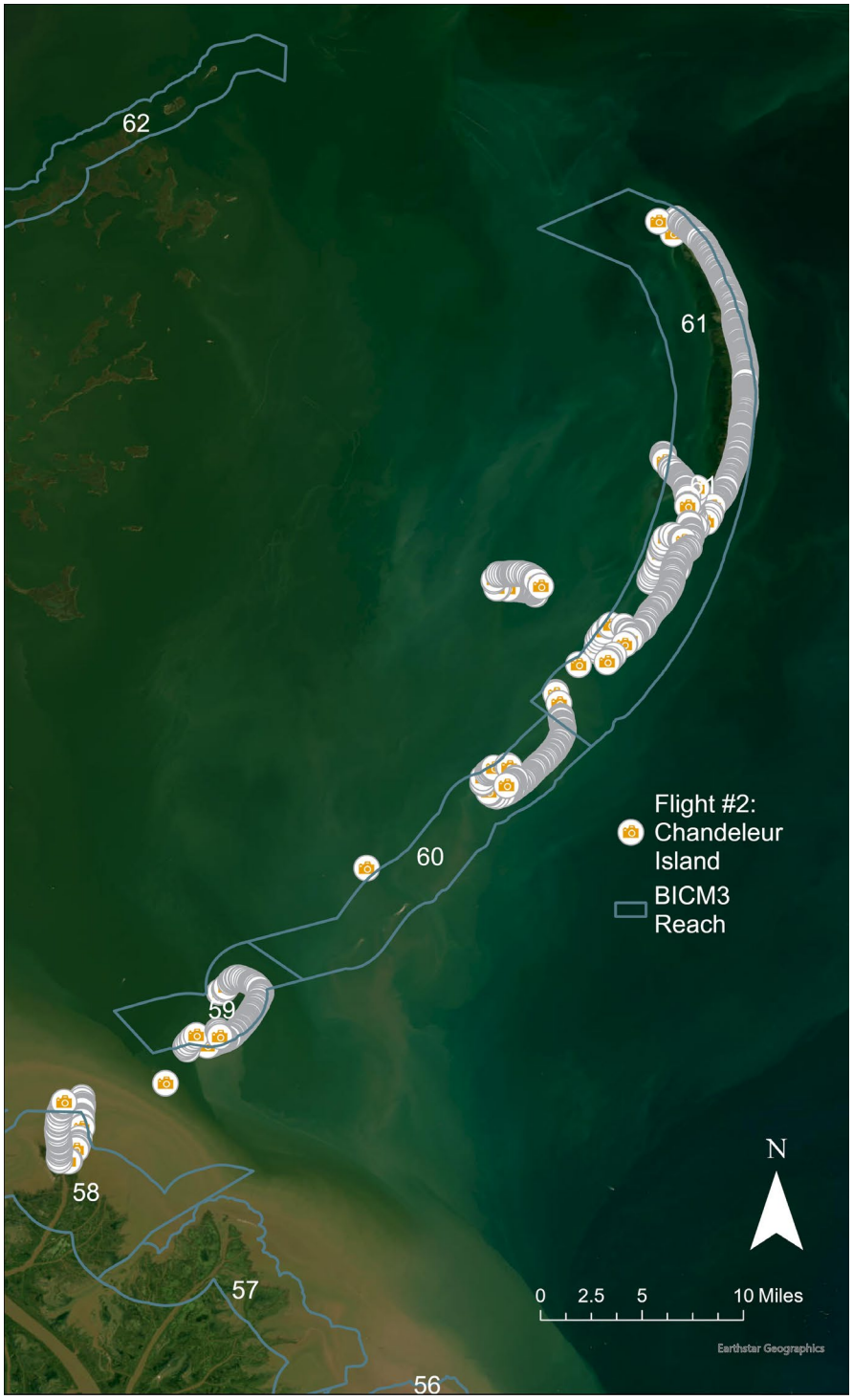

Figure 15. Location of the 2023 digital photos acquired on November 9, 2023, along the Chandeleur Islands.

Figure 16. Location of the 2023 digital photos acquired on November 17, 2023, from Bastian Island to East Timbalier Island.

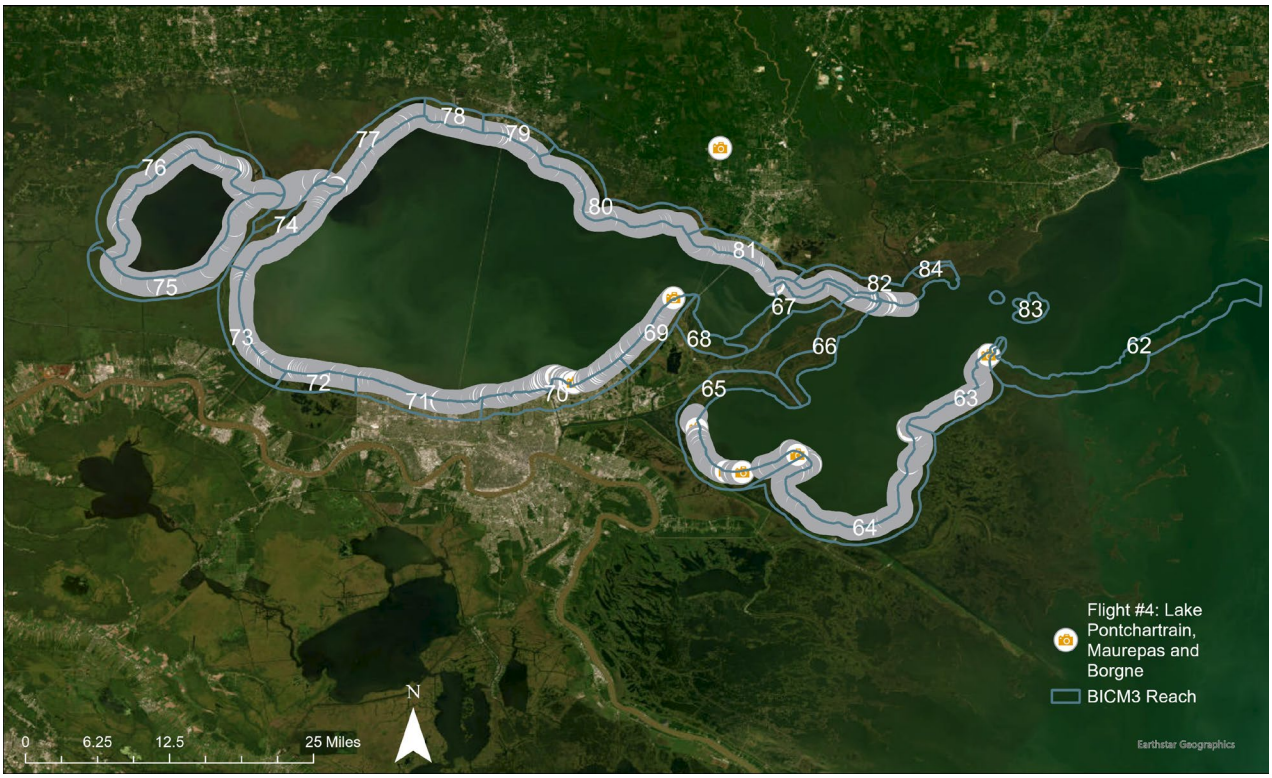

Figure 17. Location of the 2023 digital photos acquired on November 28, 2023, along Lake Pontchartrain, Lake Maurepas shorelines and along the south shoreline of Lake Borgne.

Figure 18. Location of the 2023 digital photos acquired on December 6, 2023, along Modern Mississippi River Delta to Shell Island.

Figure 19. Location of the 2023 digital photos acquired on December 11, 2023, from East Timbalier to the Atchafalaya Delta and from the west shoreline of Lake Borgne to the Rigolets.

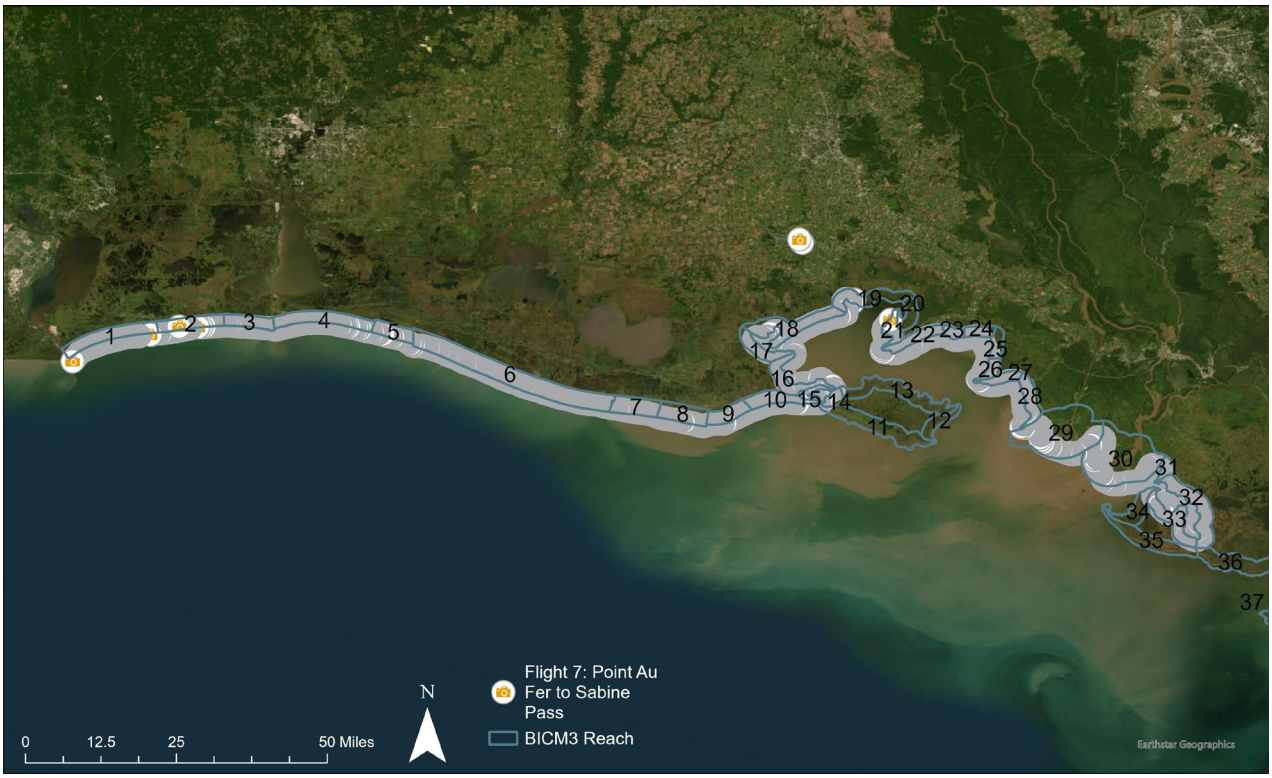

Figure 20. Location of the 2023 digital photos acquired on December 18, 2023, from Point Au Fer to Sabine Pass.

Figure 21. Location of the 2023 digital photos acquired on January 4, 2024, around Marsh Island.

PART 2: 2017–2023 PHOTO PAIRS OF THE LOUISIANA BARRIER SHORELINE

2017 photography was acquired during BICM Phase 2 (Westphal, 2018), and the 2023 photography was acquired during Phase 3, as documented in this report.

The process of identifying all Photo-pairs was facilitated by Python scripting to avoid the manual search of each Photo-pair. A Python script was developed to identify the ten 2023 photographs geographically closer to an existing 2006/7–2017. A master Excel file was created to include the following data:

- 2006/7–2017 Photo-pair name and location;
- 2017 photograph used in the 2006/7–2017 Photo-pair;
- List of ten 2023 photographs closer to that Photo-pair. Their name, file path, and metadata (i.e., date and time of acquisition, coordinates, altitude, and azimuth).

The script used the information from the 2006/7–2017 Photo-pair metadata file, the 2017 all photograph metadata file and the metadata embedded in each 2023 photographs. This was done for all 256 existing Photo-pairs.

The result of this script made the process of identifying the 2017/2023 Photo-pair faster because the user only had to review 10 new photos per Photo-pair. In some cases, none of the 10 pre-selected photographs were good candidates, and in these instances the user reviewed more close-by 2023 photographs. In other cases, a new 2017 photograph was selected to match the angle available in the 2023 photographs. In rare cases, the Photo-pair could not be reproduced. A few new Photo-pairs, which did not exist for the 2006/7–2017 Photo-pairs, were generated. Where shoreline features were difficult to recognize because of 10 years of changes, the location data was consulted, as well as historical imagery provided by Google Earth Pro. A total of 260 Photo-pairs were identified.

Each 2017–2023 Photo-pair was named using standard naming conventions following BICM guidelines and to match earlier phases of the project. The naming convention was agreed upon with CPRA. The first element of the name was the project number under which the imagery was collected, in this case LA-0226. The second element identifies that the image is an oblique photo (i.e., OBLIQ). The third element was the 2017 photo date and the 2023 photo date, both in YYYYMMDD format. The fifth element was the acronym MP (Merged Pair), followed by the Photo-pair number, a unique four-digit numeric ID for that Photo-pair, and P3 (Phase 3). For example, *LA-0226_OBLIQ_20170902202311 09_MP0001P3.jpg* is the first Photo-pair of BICM Phase 3 and it merged a photo taken on September 2, 2017, and one taken on November 9, 2023.

Another script was developed to generate 260 folders, one per each Photo-pair. In each folder the following files were copied: 2017 photograph for the new Photo-pair, 2023 photograph for the new Photo-pair, 2006/7–2017 Photo-pair (if this was not a newly created Photo-pair). Then, each photo-pair was created and processed in Adobe Photoshop, with 2017 on top and 2023 photograph at the bottom. The images were overlaid on a grid to match scales and cropped as necessary to match compositions. Some images were digitally “stretched” or “skewed” to overcome the perspective produced by a

difference in altitude or camera angle and to enhance the visual relationship. Red triangles were commonly used as a point of rotation or to identify common features to enhance visual comparison. The date of each image was included, and a text line was added at the bottom to provide location information; at a minimum, this information included latitude, longitude, and direction of the view. Once images were matched, scaled, adjusted, and cropped in Photoshop, the images were exported as jpegs.

The individual jpegs were assembled into eight separate PowerPoint slideshows, one per each BICM region, to make it easier to view. Maps with the Photo-pair locations were included in each PowerPoint slideshow. Pair locations are based on the location of the aircraft during the 2023 Aerial Photographic Survey. Each slide in a slideshow includes one Photo-pair with latitude and longitude, a map showing the location of the map, a location description, direction of view, and BICM reach number and name (Figure 22).

Figure 22. Example of one PowerPoint slide showing one sample Photo-pair (the example shows Merged Pair #0001).

WATER LEVEL DATA FOR THE PHOTO-PAIRS

Data obtained from the NOAA Tides and Currents website showed that water levels during photo acquisition from November 2023 through January 2024 experienced normal fluctuations from tidal conditions and there were not any unusually high-water level conditions during any of the flights. For more details on the exact water levels please refer to Table 1 for the acquisition dates and geographic region that was flown, and Figure 6 through Figure 13 for more details.

LOCATION DIAGRAMS FOR THE PHOTO-PAIRS

A total of 260 Photo-pairs were constructed along the Louisiana barrier shoreline and assembled into eight slideshows based on region. The Photo-pairs occurred in 6 BICM regions: Chandeleur Islands (33 Photo-pairs), Modern Delta (26 Photo-pairs), Late Lafourche Delta (84 Photo-pairs, divided in three slideshows), Early Lafourche Delta (31 Photo-pairs), Eastern Chenier Plain (53 Photo-pairs), and Western Chenier Plain (32 Photo-pairs). Late Lafourche Region was divided into three parts because of the number of Photo-pairs. Other regions were not included in the Photo-pair task.

Maps were generated using ArcGIS (Figure 23 to Figure 30). For each Photo-pair, the location and direction were shown using coordinates and azimuth angle. The flightline generated using the process described in the Methodology section of this report was included.

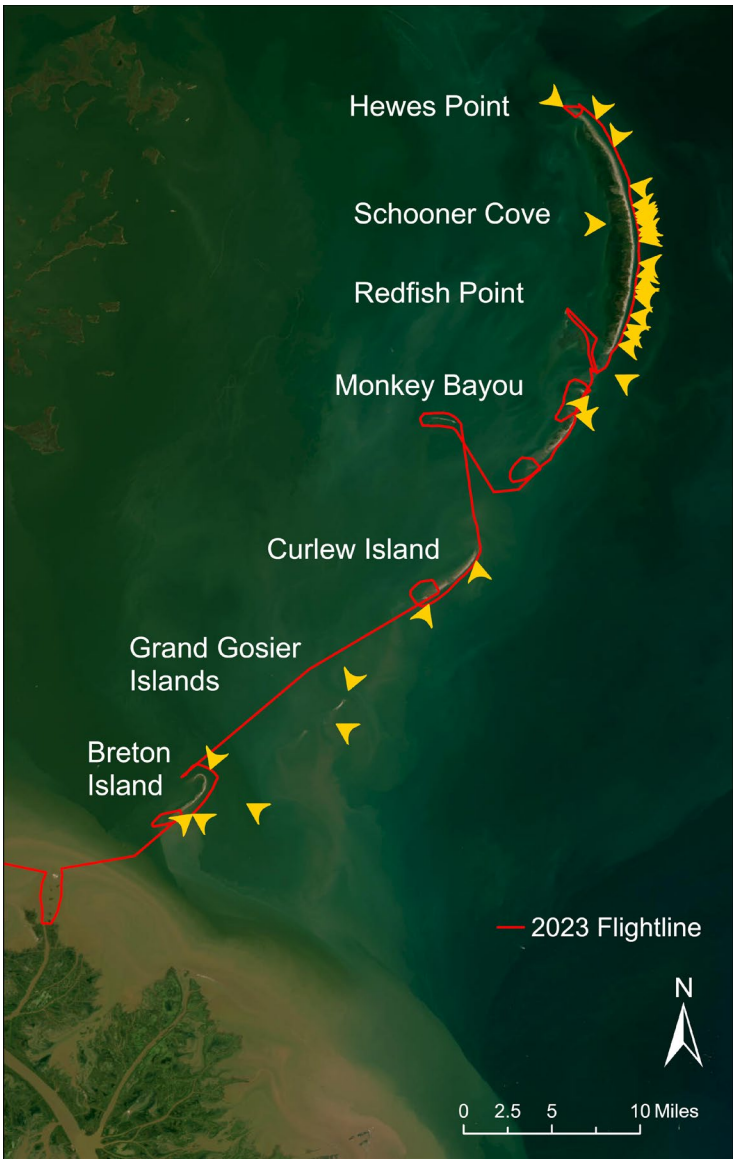

Figure 23. Location of all 2017–2023 Photo-pairs included in the Chandeleur Island region.

Figure 24. Location of all 2017–2023 Photo-pairs included in the Modern Delta region.

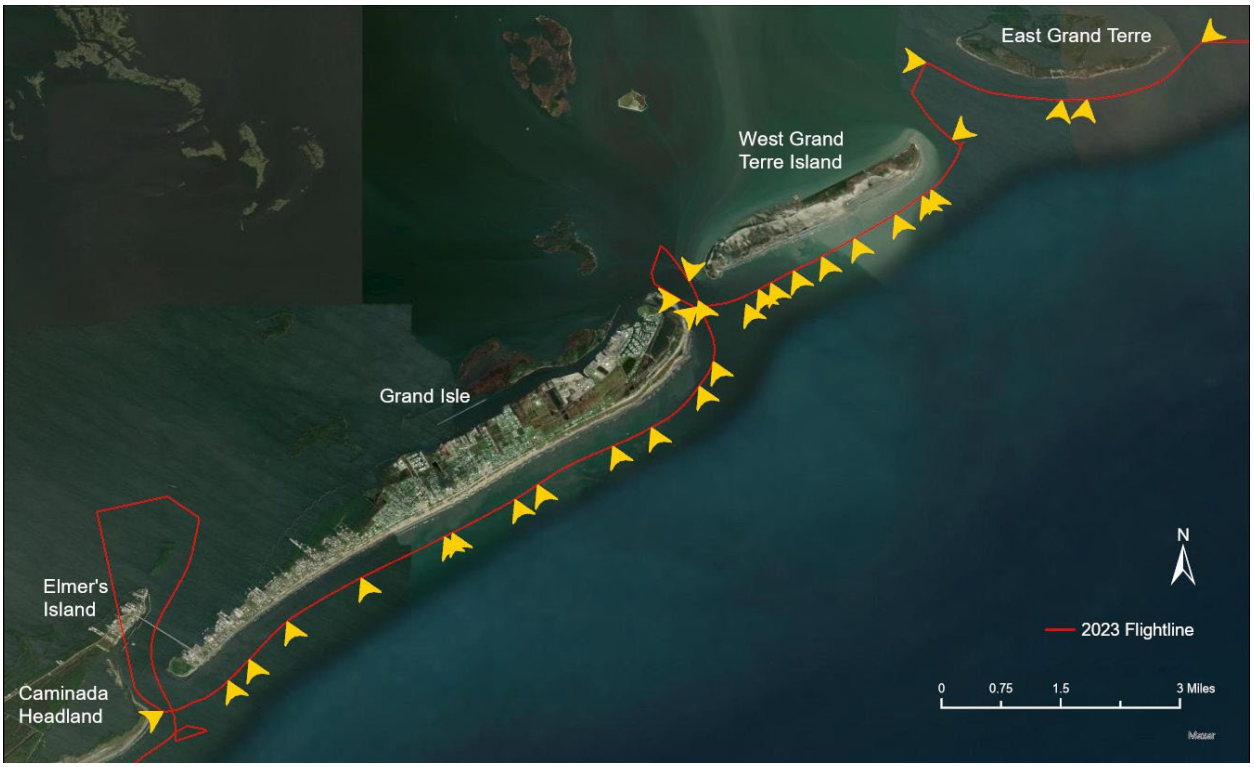

Figure 25. Location of all 2017–2023 Photo-pairs included in the Late Fourchon region, East part.

Figure 26. Location of all 2017–2023 Photo-pairs included in the Late Fourchon region, central part.

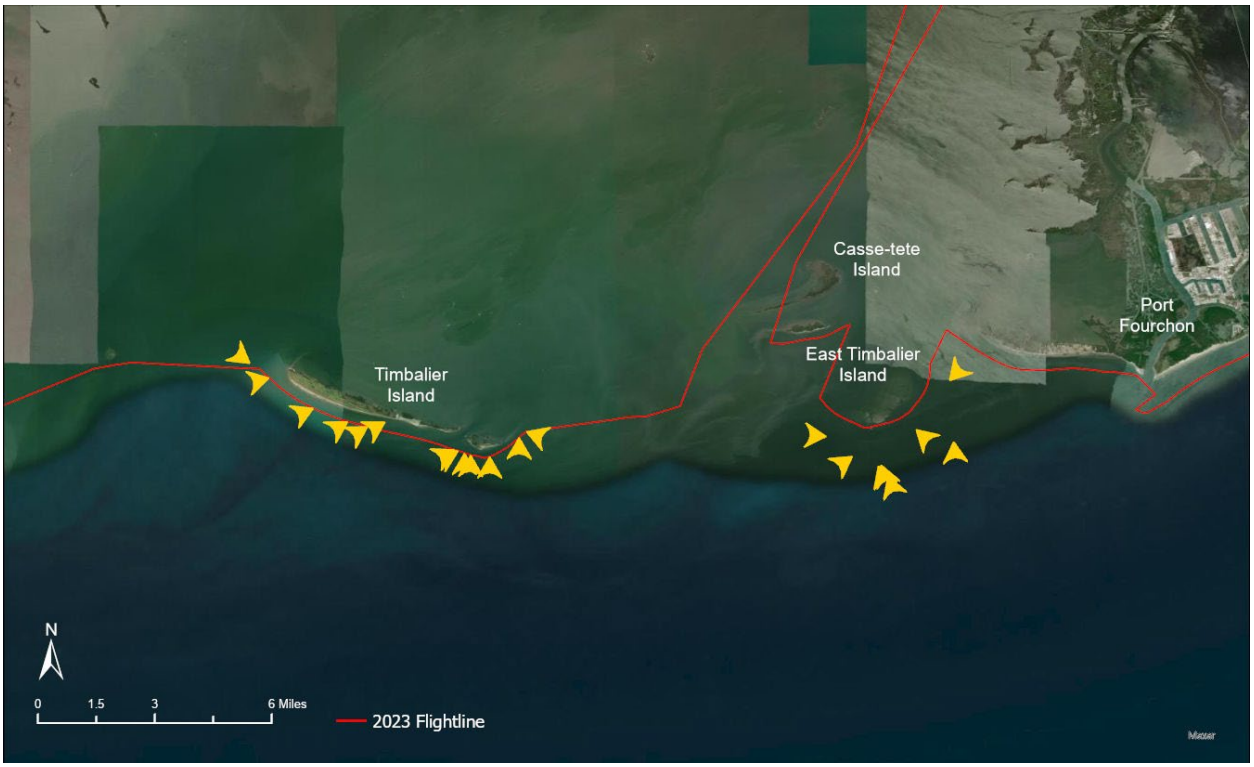

Figure 27. Location of all 2017–2023 Photo-pairs included in the Late Fourchon region, West part.

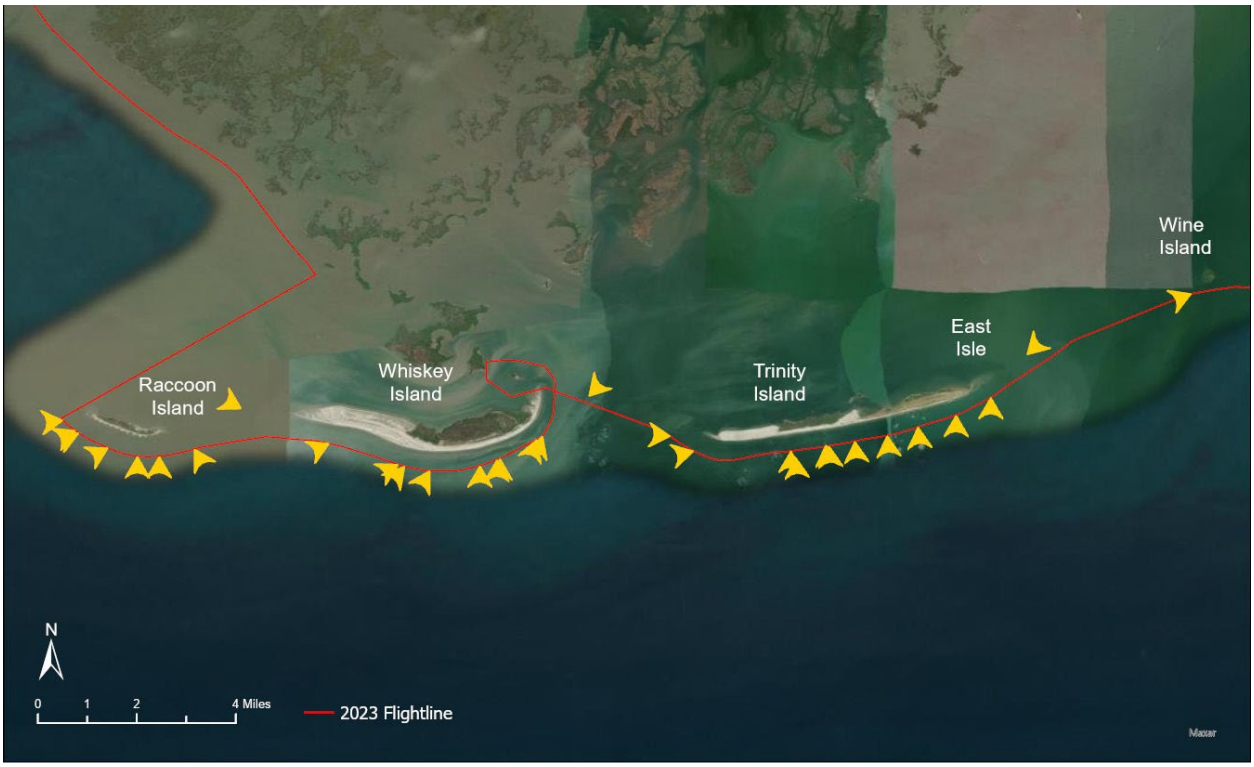

Figure 28. Location of all 2017–2023 Photo-pairs included in the Early Fourchon region.

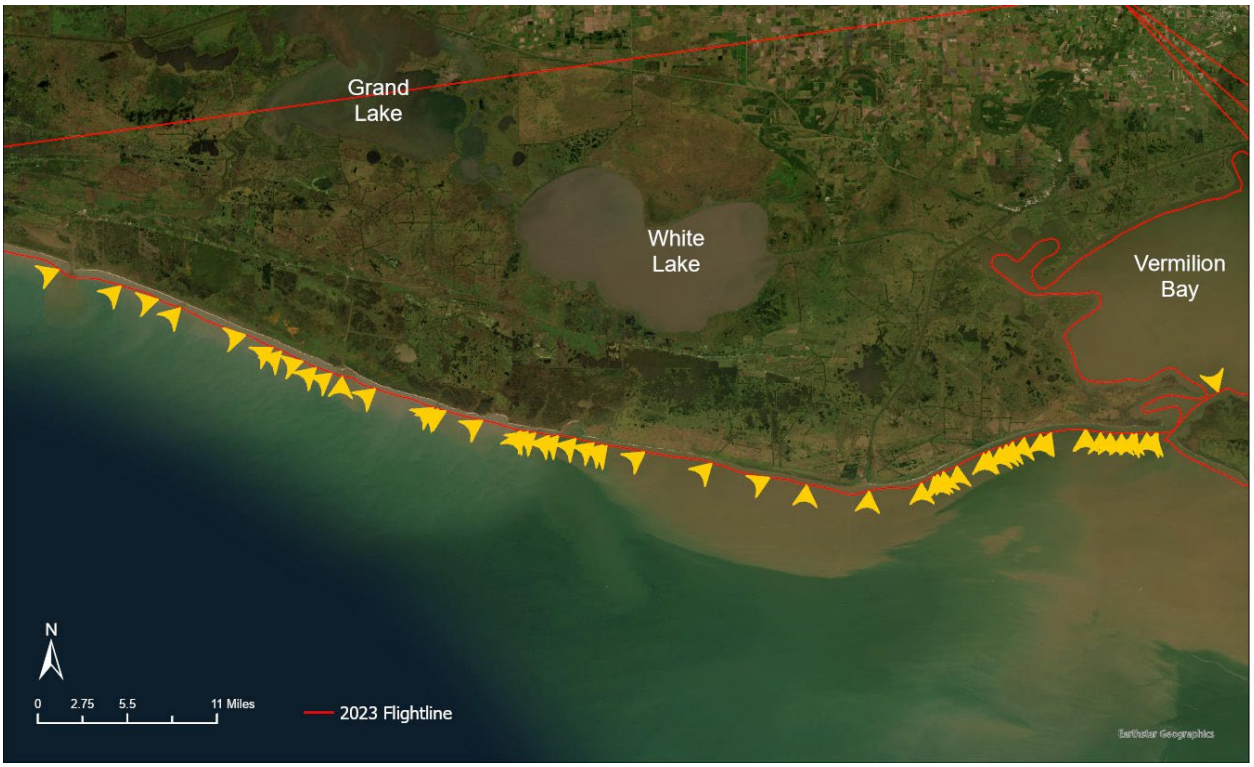

Figure 29. Location of all 2017–2023 Photo-pairs included in the Eastern Chenier region.

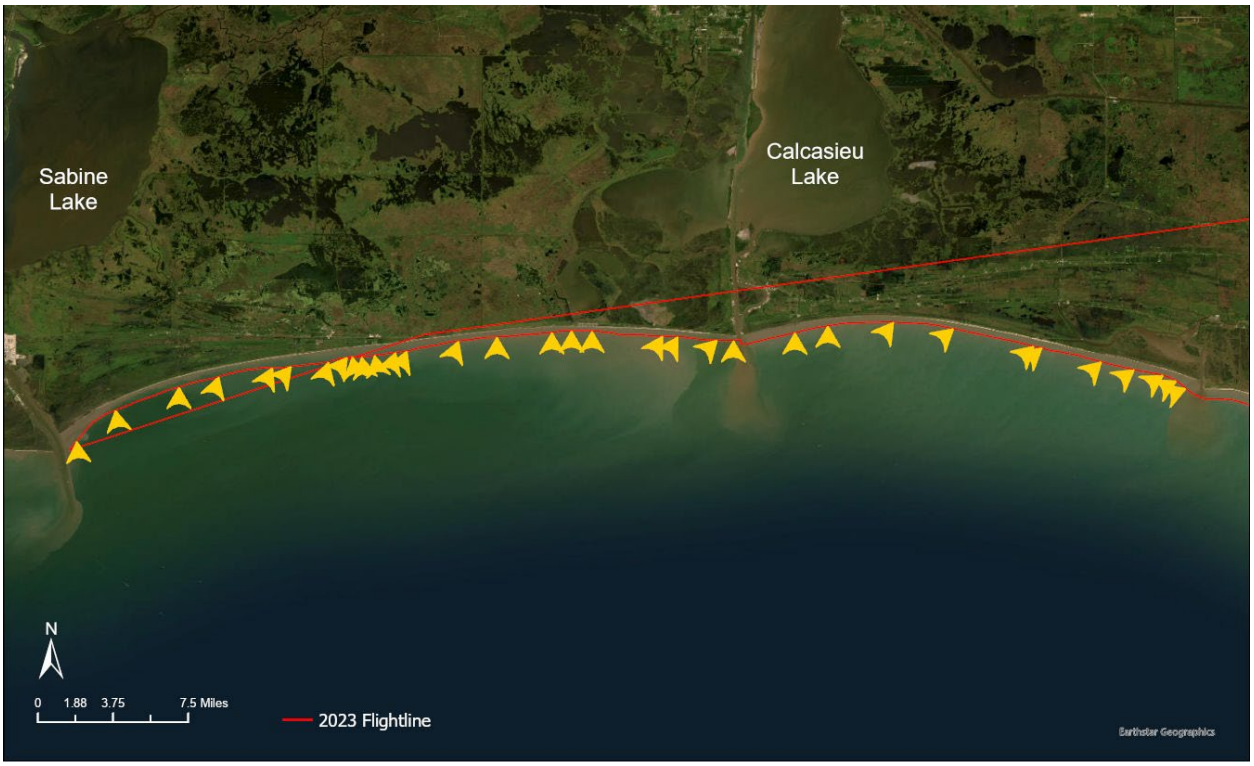

Figure 30. Location of all 2017–2023 Photo-pairs included in the West Chenier region.

PHOTO-PAIR METADATA

A master Excel table was created for all of the BICM Phase 3 Photo-pairs. The table includes:

- Project name and agency
- Pair name
- Coordinate of the Photo-pair (in UTM 15N and as latitude and longitude)
- Geographic location name
- Date and time for 2023 imagery
- Altitude and azimuth angle of the 2023 imagery
- 2023 photograph name
- 2017 photograph name

PHOTO-PAIR DELIVERABLES

The following digital deliverables were created and delivered to CPRA as part of the final BICM Phase 3 deliverable:

- Eight slideshows (as PowerPoint and pdf files), one for each coastal BICM region of sequential Photo-pairs;
- Photo-Pair jpgs used in the PowerPoint;
- Photoshop (*.psd) files used to create matched images;
- Excel spreadsheets of the attribute and metadata tables.

PART 3: 1984–2023 TIME SERIES ALONG THE LOUISIANA BARRIER SHORELINE

To generate the Time Series, it was necessary to assemble several images at a location of interest; this requires that historic imagery obtained during approximately similar conditions be both available and accessible, which is challenging. Between 1984 and 1992, photos were taken by different people with different interests and goals, so early photos are not consistently available at some locations of interest. After 1992, areas of interest and photo techniques became more standardized to produce imagery that could be more closely compared. Images from any two flights can be paired to produce "Photo-pairs" to illustrate landscape changes for the selected time periods. Imagery chosen from more than two surveys is considered a "Time Series." The term "Historic Photo-pairs" has been replaced by the more descriptive "Time Series" for the series of historical images that encompass several time periods at each site to avoid confusion with "Photo-pairs" in the previous task that presents a comparison between only the two most recent time periods.

The most consistent photography in the archives occurs along the sandy shorelines of Louisiana. Therefore, the Time Series with the most complete records are along these shorelines. In 2008, 17 Time Series were constructed along the Louisiana outer coast, along Western Chenier, Eastern Chenier, Early Lafourche Delta, Late Lafourche Delta, Modern Delta, and Chandeleur Island regions, representing six of the nine BICM coastal regions. Three additional Time Series were created since 2008 for other purposes. For 2018, the original 17 Time Series and the additional three were updated to include 2017 imagery and other photography that occurred in the intervening years. Two new Time Series were constructed, bringing the total to 22 Time Series: three in the Chandeleur Islands Region, three for the Modern Delta Region, six for the Late Lafourche Delta Region, six in the Early Lafourche Delta Region, two in the Eastern Chenier Plain Region, and two in Western Chenier Region. During the effort described in this report, the previous 22 Time Series were updated using new photography acquired in 2023 through early 2024. Additionally, six additional Time Series were created, bringing the total number of Time Series to 28.

METHODOLOGY

Prior to 2006, all photography was acquired and archived as physical slides produced by developing slide film. The acquisition of these slides involved changing film canisters in the camera, which often skipped areas due to the time involved in conducting this activity in a moving aircraft. With physical slides, frequent or overlapping images were rarely acquired because of the cost and logistics of handling the volume of film required. Therefore, early periods provide fewer matchable images for subsequent comparisons.

Slide archives for each survey had to be manually searched for possible matches. Some areas had more consistent coverage through the years than others. Several locations were assembled before determinations could be made as to which would be most appropriate and most illustrative of an area's changing conditions.

Each slide for the selected Time Series underwent a meticulous process. It was physically cleaned, digitally scanned, color-balanced or enhanced, digitally cleaned, annotated, and filed. A folder was

created for each potential Time Series, housing all files related to that location, including scanned slides and digital files from more recent photo surveys. Most scanned slides were archived at 600dpi 4 x 6-inch format, and some from other sources were archived at 300dpi 4 x 6 format.

The Time Series for each location was assembled in Adobe Photoshop. All images for a Time Series were added to a single photoshop file (*.psd) and overlaid with a grid to match scales and make adjustments. At times, innovative solutions were needed, such as digitally "stretching" or "skewing" an image to enhance the visual relationship, compensating for differences in perspective produced by variations in altitude or camera angle. A point of rotation was often established and marked by a symbol with common points indicated by a second symbol. Once images were matched, scaled, adjusted, and cropped, the images were individually "flattened" onto a set-size background to maintain the inter-relationship, and saved as individual jpegs. These individual jpegs were then assembled into a PowerPoint slideshow to add various labels, markers, dates, and information. The final slideshow was saved in PowerPoint and PDF formats, both of which are provided as part of the deliverables for Task Order 108.

Many of the older slides were not associated with a GPS file and lacked detailed or individual metadata documenting the acquisition details. Slides produced from video surveys after 1990 could be manually associated with the GPS encoded on the video imagery where available. Because of the shifting landscape over time, Time Series locations are generally based on the GPS from the 2001 Aerial Video Survey and the 2001 slides to connect an approximate location over the period captured by the Time Series (i.e., from 1984 through 2008). For 2008, the location from the GPS receiver was encoded on the video and transferred to digital images. For 2018, the locations of each Time Series were entered into geospatial software to generate the locations used for slideshows and figures. Finally, geolocations for 2023 were directly obtained from the camera metadata, which included a built-in GPS.

WATER LEVEL DATA FOR THE PHOTO-PAIRS

The data obtained from the NOAA Tides and Currents website showed that water levels during photo acquisition from November 2023 through January 2024 experienced normal fluctuations from tidal conditions and there were not any unusually high-water level conditions during any of the flights. For more details on the exact water levels please refer to Table 1 for the acquisition dates and geographic region that was flown, and Figure 6 through Figure 13 for more details.

LOCATION DIAGRAMS FOR THE 1984–2023 TIME SERIES

22 existing Time Series were updated, and six new Time Series were constructed along the Louisiana Barrier Shoreline. This brings the total Time Series to 28:

- 4 in the Chandeleur Islands region
- 4 in the Modern Delta region
- 8 in Late Lafourche Delta region
- 8 in Early Lafourche Delta region
- 2 in Eastern Chenier Plain region

- 2 in Western Chenier Plain region

The locations of each Time Series are indicated on the following diagrams by a yellow arrowhead (Figure 31 to Figure 36. Map divisions were based on BICM regions.

Figure 31. Location of all Time Series in the Chandeleur Islands region

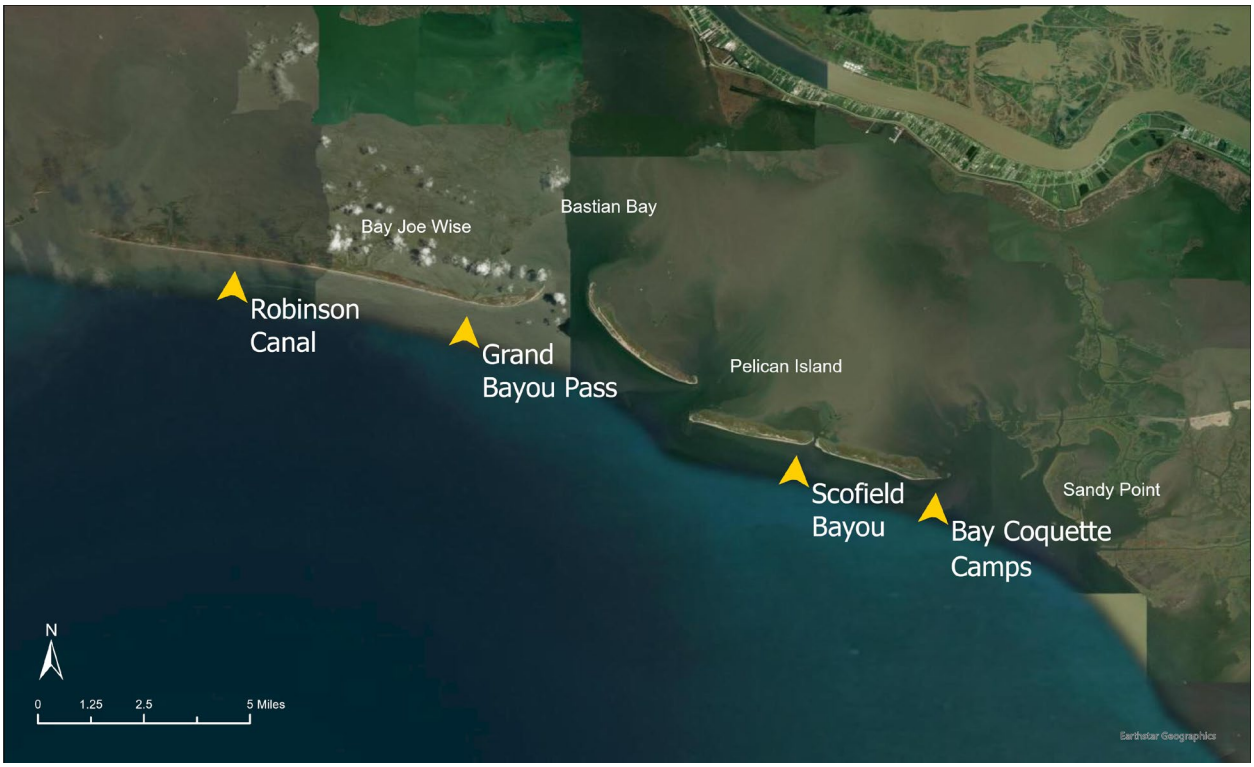

Figure 32. Location of all Time Series in the Modern Delta region

Figure 33. Location of all Time Series in the Late Lafourche Delta region

Figure 34. Location of all Time Series in the Early Lafourche Delta region

Figure 35. Location of all Time Series in the Eastern Chenier Plain region

Figure 36. Location of all Time Series in the Western Chenier Plain region

TIME SERIES DELIVERABLES

The following digital deliverables were created and shared with CPRA as part of the final BICM Phase 3 deliverable:

- 28 slideshows (as PowerPoint and pdf files), one for each Time Series;
- jpgs of all modified, matched images used in each Time Series;
- Photoshop (.psd) files used to create matched images;
- Excel spreadsheet of the attributes and metadata tables.

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APPENDICES

APPENDIX A. BICM REACHES COVERED BY EACH FLIGHT

Table A-1. List of reaches that each flight covered. First and last photo within each reach. The first photo was always selected from the North (if the reach direction is north-south) or East (if the reach direction is east-west) to South or West. The photos within that reach would follow a numerical progression.

Flight	Main region covered	Date	BICM reach covered	Photo name at beginning of reach (north or east)	Photo name at end of reach (south or west)
1	Southwest Pass (Modern Delta); North Lake Borgne	November 1, 2023	82	7460	7548
			66	7549	7635
			65	7738	7839
			53	7042	7093
2	Chandeleur Island	November 9, 2023	61	7863	8494
			60	8495	8604
			59	8605	8717
			58	8717	8787
3	Bastian Island to East Timbalier Island	November 17, 2023	50	8813	8853
			49	8854	9048
			48	9049	9123
			47	9124	9170
			46	9171	9316
			45	9317	9552
			44	9553	9624
			43	9625	9712
4	Lake Pontchartrain, Maurepas and Borgne	November 28, 2023	63	0682	0482
			64	0481	0006
			65	0005	9781
			82	0683	0835
			81	0836	0984
			80	0985	1255
			79	1256	1327
			78	1328	1420
			77	1421	1574
			76	1679	2015
			75	2016	2313
			74	2435	2624
			73	2625	2807
			72	2808	2890
			71	2891	3046

Flight	Main region covered	Date	BICM reach covered	Photo name at beginning of reach (north or east)	Photo name at end of reach (south or west)
			70	3047	3174
			69	3175	3265
5	Modern Mississippi River Delta to Shell Island	December 6, 2023	58	3454	3595
			57	3596	3907
			56	3908	4077
			55	4078	4343
			54	4344	4493
			51	4522	4961
			50	4962	5276
6	East Timbalier to Atchafalaya Delta; West Lake Borgne to Rigolets	December 11, 2023	82	5735	5574
			67	5561	5436
			68	5435	5339
			69	5338	5304
			42	5759	5917
			41	5918	5934
			40	5935	5980
			39	5981	6092
			38	6126	6256
			37	6257	6322
			36	6323	6707
			35	6708	7014
			34	7110	7274
7	Point Au Fer to Sabine Pass	December 18, 2023	33	7313	7581
			32	7582	7844
			31	7845	7890
			30	7891	8166
			29	8167	8370
			28	8371	8494
			27	8495	8618
			26	8619	8690
			25	8691	8720
			24	8721	8794
			23	8795	8842
			22	8843	9019
			21	9020	9367
			19	9370	9425

Flight	Main region covered	Date	BICM reach covered	Photo name at beginning of reach (north or east)	Photo name at end of reach (south or west)
			18	9426	9711
			17	9712	8732
			16	8733	0056
			15	0057	0145
			14	0146	0168
			10	0169	0319
			9	0320	0429
			8	0430	0556
			7	0557	0664
			6	0665	2249
			5	2250	2328
			4	2329	2549
			3	2550	2649
			2	2650	2765
			1	2766	2984
8	Marsh Island	January 4, 2023	27	2079	2088
			14	2665	2744
			13	2745	3150
			12	2127	2287
			11	2288	2664

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