Mission-Aransas
National Estuarine Research Reserve

MANAGEMENT PLAN
2015-2020

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Management Plan 2015-2020

MISSION-ARANSAS NATIONAL ESTUARINE RESEARCH RESERVE: Mission-Aransas Estuary

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National Ocean Service
Office for Coastal Management
1305 East-West Highway
Silver Spring, Maryland 20910

This management plan has been developed in accordance with NOAA regulations, including all provisions for public involvement. It is consistent with the congressional intent of Section 315 of the Coastal Zone Management Act of 1972, as amended, and the provisions of the Texas Coastal Management Program.

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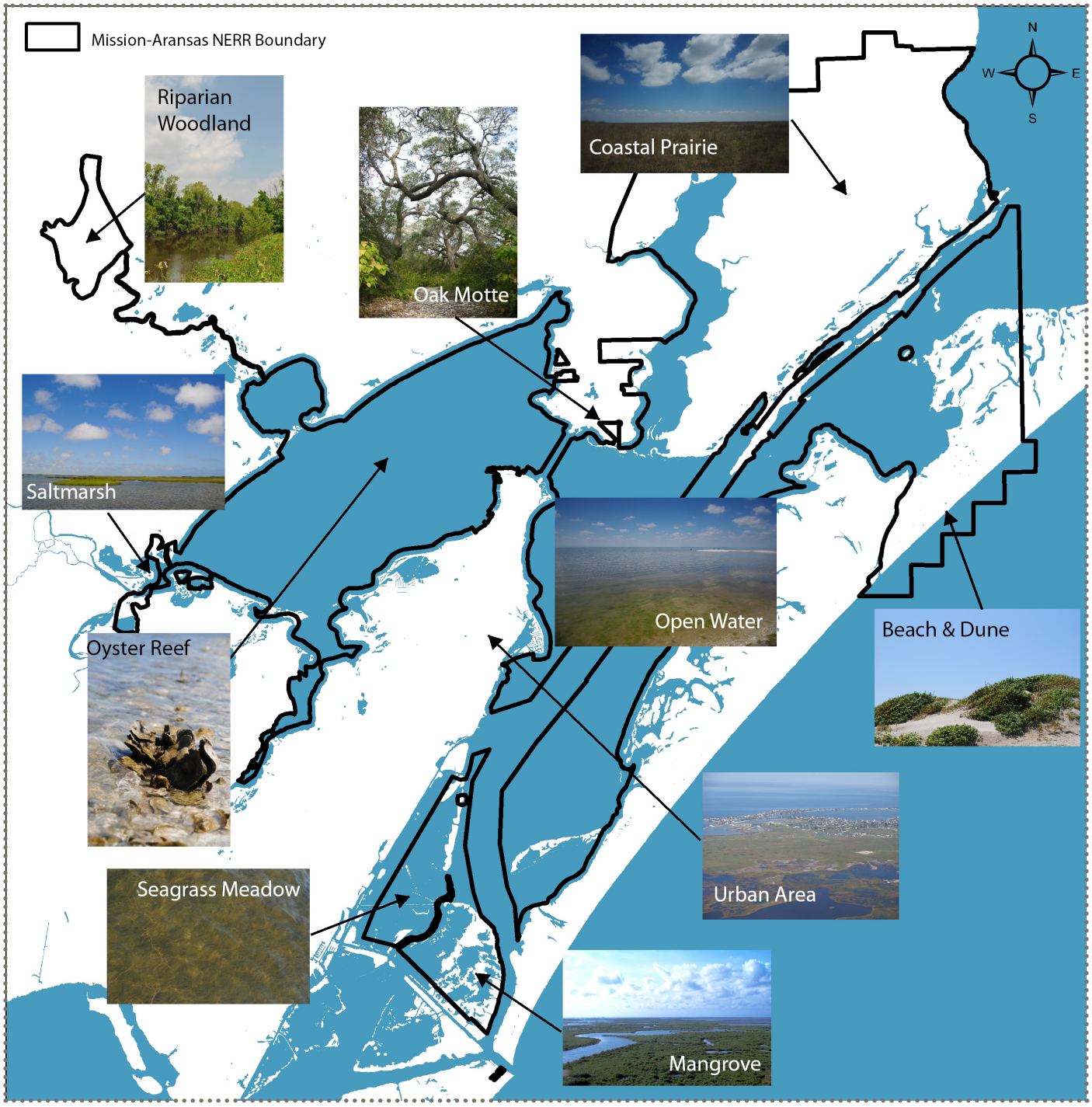
ACND	Aransas County Navigation District
ANWR	Aransas National Wildlife Refuge
ARK	Animal Rehabilitation Keep
BWET	Bay Watershed Education and Training
CBLT	Coastal Bend Land Trust
CCA	Coastal Conservation Association
CCIA	Corpus Christi International Airport
CBBEP	Corpus Bend Bays & Estuaries Program
CBBF	Coastal Bend Bays Foundation
CBIE	Coastal Bend Informal Educators
CCVATCH	Climate Change Vulnerability Assessment Tool for Coastal Habitats
CDMO	Centralized Data Management Organization
CEM	Conceptual Ecosystem Model
CFR	Code of Federal Regulations
CHRIS	Chemical Hazards Response Information System
CMP	Coastal Management Program
CNRA	Coastal Natural Resource Area
COCA	Coastal and Ocean Climate Applications
COOPS	Center for Operational Oceanographic Products and Services
CORS	Continuous Operating Reference Station
CTP	Coastal Training Program
CWMA	Cooperative Weed Management Area
CZMA	Coastal Zone Management Act
DNR	Division of Nearshore Research
EBMP	Ecosystem-based Management Plan
ECSC	Environmental Cooperative Science Center
EPA	Environmental Protection Agency
FERC	Federal Energy Resources Commission
GCD	Groundwater Conservation District
GCOOS	Geographic Information System
GCVA	Gulf Coast Vulnerability Assessment
GIWW	Gulf Intracoastal Waterway
GK-12	Graduate Teaching Fellows in K-12 Education
GLO	Texas General Land Office
GNSS	Global Navigation Satellite System
GRA	Graduate Research Assistant

GRF	Graduate Research Fellow
GOMA	Gulf of Mexico Alliance
HAB	Harmful Algal Bloom
HRI	Harte Research Institute for Gulf of Mexico Studies
K-12	Kindergarten through twelfth grade
KEEP	K-12 Estuarine Education Program
LEED	Leadership in Engineering Environmental Design
MES	Marine Education Services
MA/NA	Market Analysis / Needs Assessment
MOU	Memorandum of Understanding
MRRP	Monofilament Recovery & Recycling Program
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NERRA	National Estuarine Reserve Association
NERRS	National Estuarine Research Reserve System
NGS	National Geodetic Survey
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NSC	National Estuarine Research Reserve System Science Collaborative
NSF	National Science Foundation
NWI	National Wetlands Inventory
NWP	Nationwide Permit
OCM	Office for Coastal Management
OPA	Oil Pollution Act
OSPR	Oils Spill Prevention Response Act
PSF	Permanent School Fund
QA/QC	Quality Assurance/Quality Control
RAB	Reserve Advisory Board
RBSSA	Redfish Bay State Scientific Area
REU	Research Experience for Undergraduates
RMC	Resource Management Code
RRC	Texas Railroad Commission
RRT	Regional Response Team
SAV	Submerged Aquatic Vegetation

SET	Surface Elevation Table
SIVVA	Standardized Index of Vulnerability Assessment
SLAMM	Sea Level Affecting Marshes Model
SLB	School Land Board
SolVES	Social Values of Ecosystem Services
SOS	Science on a Sphere
SRES	Special Report on Emissions Scenarios
STEM	Science, Technology, Engineering, and Mathematics
SWMP	System-wide Monitoring Program
TAMU	Texas A&M University - College Station
TAMUCC	Texas A&M University - Corpus Christi
TCOON	Texas Coastal Ocean Observation Network
TCEQ	Texas Commission of Environmental Quality
THC	Texas Historical Commission
TNC	The Nature Conservancy
TNRIS	Texas Natural Resources Information Service
TOTE	Teachers on the Estuary
TPWC	Texas Parks and Wildlife Commission
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTMSI	University of Texas Marine Science Institute
VEC	Valued Ecosystem Component
WAM	Water Availability Model


Mission-Aransas NERR Boundary
N
W
E
S
Riparian Woodland
Coastal Prairie
Oak Motte
Saltmarsh
Open Water
Beach & Dune
Oyster Reef
Urban Area
Seagrass Meadow
Mangrove

Executive Summary

The Mission-Aransas National Estuarine Research Reserve (NERR or Reserve) was designated in 2006 and is one of 28 Reserves established by the National Oceanic and Atmospheric Administration (NOAA) to promote informed management of the Nation's estuaries and coastal habitats. The NERR System works with existing federal and state authorities to establish and operate research Reserves and provide for their long term stewardship. The State of Texas has designated the University of Texas at Austin, Marine Science Institute (UTMSI) as the lead state agency for the Mission-Aransas Reserve.

Research and education are the main focus of the NERR System. Major goals are to: (1) ensure a stable environment for research through long term protection of Reserve resources, (2) address coastal management issues identified as significant through coordinated estuarine research within the System, (3) enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation, (4) promote federal, state, public and private use of Reserves for estuarine research, and (5) conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

The Mission-Aransas Reserve is the only NERR situated within the Western Gulf Subregion. The Reserve encompasses the entire Mission-Aransas Estuary, one of six major bay-estuarine systems in Texas. In addition to open-water habitats, the Reserve includes several types of wetlands: freshwater (palustrine), brackish and salt marshes, and mangrove communities. The wetland and open water habitats also support benthic and nektonic populations, as well as large areas of oyster reefs. Seagrass and tidal flats are also found throughout significant portions of the Reserve. Several maritime forests are located within the upland section of the Reserve including coastal prairies, oak mottes, and riparian woodlands. All of these habitats support endangered species and culturally/economically important species, such as shrimp and fish. The Mission-Aransas Estuary also includes a number of archaeological and historical sites. The site is relatively rural with limited industrial and development impacts.

Upon its designation in 2006, the Mission-Aransas Reserve contained 185,708 acres of terrestrial, wetland and marine habitats. Landowners within the Reserve include a combination of state, federal and private entities. The Texas General Land Office owns the majority of submerged lands (bays and open water) within the site. The United States Fish and Wildlife Service own the Aransas National Wildlife Refuge, including Matagorda Island, which contains beach, estuarine marsh, and non tidal coastal plain habitat. The Texas Parks and Wildlife Department (TPWD) manages the live-oak thickets and salt marshes at Goose Island State Park (GISP). Other private landholders include the Coastal Bend Land Trust (CBLT) and Fennessey Ranch. CBLT owns the Buccaneer Cove Preserve, which includes a diverse suite of salt marsh and tidal flat habitats. Fennessey Ranch is composed of native tree/brush, prairie, freshwater wetlands, and Mission River riparian corridor. UTMSI owns and manages the property on which the Reserve Headquarters and educational facilities are located in Port Aransas, Texas.

The Reserve is proposing to modify its boundary to include additional areas of high ecological and conservation value. Recent acquisitions by Reserve partners, if included within the boundary, will increase the Reserve size to 186,189 acres. The areas to be added to the boundary include: (1) live oak-red bay woodlands, coastal prairie, and wetlands at Big Tree Unit (78 acres); (2) wetlands and upland habitat at Holiday Beach (170 acres); and (3) wetlands and upland habitat at the Aransas River Delta (50 acres). All proposed additions to the boundary are owned by existing Reserve partners and will be managed for long-term protection and conservation value. Big Tree Unit is owned by the TPWD and is managed as part of GISP. The properties located at Holiday Beach were purchased by the Coastal Bend Bays & Estuaries Program (CBBEP) to protect habitat for wintering Whooping Cranes. The Aransas River Delta property is also owned by CBBEP and is located directly adjacent to the Buccaneer Cove Preserve. These areas are

important for maintaining the integrity of the core land and water areas of the Reserve and will enhance the Reserve's ability to accomplish its goals and mission by providing opportunities for increased education, stewardship, and research activities.

The landowners listed above are considered key partners of the Reserve and are represented on the Reserve Advisory Board. Other key state partners of the Reserve include the Texas Department of Transportation, The Nature Conservancy, Aransas County, Aransas County Navigation District, and the City of Rockport. RAB members provide advice to Reserve staff for management, research/monitoring activities, stewardship objectives, and educational and training programs through implementation of the Reserve Management Plan.

Management plans provide a vision and framework to guide reserve activities during a five year period and enable the reserves and NOAA to track progress and realize opportunities for growth. Reserves are increasingly confronted with complex questions regarding new uses in or near reserves that may or may not be compatible with the Reserve System's mission. Therefore,it is critical for reserves to develop thoughtful and comprehensive management plans that provide a foundation for addressing these challenges and ensuring continued protection and use of the reserve for research, education, and public use. The primary purpose of a reserve management plan is to:

- Provide the vision and framework to guide reserve activities during a five year period;
- Present opportunities to discuss reserve niche and strategic collaborations with partners;
- Communicate how the reserve is addressing priority coastal management issues via their goals and objectives;
- Highlight reserve priorities, and staff capabilities and needs to address those priorities;
- Demonstrate how system-wide programs are locally relevant and nationally significant;
- Enable reserves and NOAA to track progress and realize opportunities for growth; and
- Enable the reserves to acquire facilities construction and land acquisition funds.

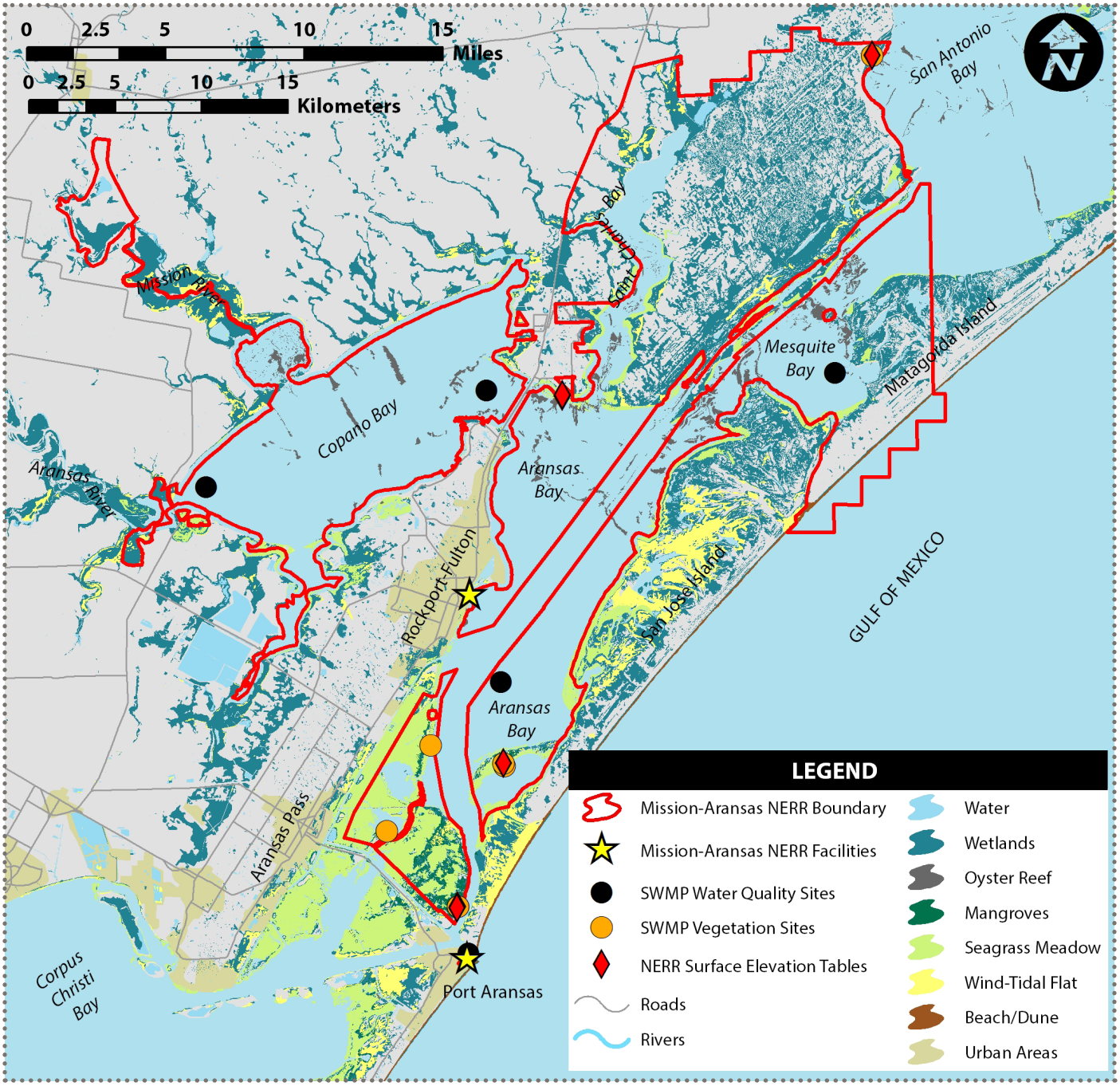
This Management Plan describes how the Mission-Aransas Reserve will be managed by UTMSI over the five year period from 2015-2020. The Plan builds upon past Reserve successes, and outlines a programmatic vision for building upon previous accomplishments to meet future challenges and address priority issues. The Plan is designed to address three specific goals and related key objectives. Each goal is inclusive of all Mission-Aransas Reserve core programs (e.g. research, monitoring, education, coastal training and administration) and supports the Reserve's mission of developing and facilitating partnership that enhance coastal decision making through an integrated program of research, education, and stewardship. Specific goals identified in this Plan are:

1. Improve understanding of Texas coastal zone ecosystems structure and function;
2. Increase understanding of coastal ecosystems by diverse audiences; and
3. Promote public appreciation and support for stewardship of coastal resources.

This Management Plan is a compilation of subject specific plans that detail the actions that will be performed to accomplish the goals and objectives of the Reserve. The Plan outlines how the Reserve will manage administration and its core programs of research, stewardship, education, and coastal training. The context for each core program is provided along with descriptions of Reserve capacity and program delivery. Detail about the specific actions that each core program will undertake to address needs and opportunities that have been identified is also provided. In addition, the plan describes the existing resource protection of areas within the proposed Reserve boundary, and a public access plan is included which describes the NERR System priorities for public access, the Reserve public access policy, existing public access, and access needs/

opportunities. The facilities/construction plan describes the Reserve's existing facilities, facility challenges, and potential future facilities. Finally, the acquisition plan details the Reserve priority areas for future acquisition and the role that Reserve staff can play in these efforts.

The success of this Management Plan is dependent on the skills and creativity of Reserve staff, with support from its federal, state, and local partners, who will use this guiding document as a road map towards implementation and success in achieving the Reserve mission. Through commitment to this Plan, the Mission-Aransas Reserve will continue to be a leader in coastal research, stewardship, education and training in Texas.



Map of the National Estuarine Research Reserve System infrastructure

VISION: Center of excellence to create & disseminate knowledge necessary to maintain a healthy Texas coastal zone.			
MISSION: To develop and facilitate partnerships that enhance coastal decision making through an integrated program of research, education, and stewardship.			
Plan:	**GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function**	**GOAL 2: Increase understanding of coastal ecosystems by diverse audiences**	**GOAL 3: Promote public appreciation and support for stewardship of coastal resources**
Research	*Objective 1-1: Improve understanding of short and long-term changes within Texas coastal ecosystems through the implementation of SWMP, sentinal site program, and new research programs with partners*	*Objective 2-1: Disseminate research information and results to researchers and decision makers through an on-site resource center, website, and other forms of media*	*Objective 3-1: Promote public participation in research and monitoring programs through implementaiton of a minimum of at least one citizen science program*
	Action 1: Build and operate the abiotic element of the System Wide Monitoring Program	Action 1: Develop an on-site resource center	Action 1: Continue implementation of citizen science monitoring program for blue crab megalopae
	Action 2: Build and operate the biotic element of the System Wide Monitoring Program	Action 2: Update research results on Reserve website and other forms of media	Action 2: Develop and implement a key species monitoring program
	Action 3: Build and operate the mapping element of the System Wide Monitoring Program	Action 3: Include relevant estuarine research and data in Reserve professional training and education programs	Action 3: Train volunteers to participate in citizen science programs
	Action 4: Build and operate the Reserve's sentinel site program for understanding impacts of changing sea level and inundation on vegetative communities		
	Action 5: Initiate freshwater inflow and groundwater program with partners		
	Objective 1-2: Increase understanding of effects of oil/ gas activities and marine debris on coastal ecosystems	*Objective 2-2: Transfer research knowledge to K-12 students through the implementaiton of the Summer Science Program and SWMP Scholar Program*	*Objective 3-2: Increase public understanding of ecological values by partnering to conduct evaluations of ecosystem services*
	Action 1: Initiate a program on effects of oil and gas activities with partners	Action 1: Provide instructors for Summer Science Program	Action 1: Work with partners to conduct evaluations of ecosystem services within the Reserve and its watershed
	Action 2: Initiate NOAA Marine Debris Monitoring Program along the Mid-Texas Coast	Action 2: SWMP Scholar Program	

	1-3 Increase graduate and undergraduate student participation in Reserve research and monitoring programs		
	Action 1: Provide opportunities for graduate student fellowships and assistantships		
	Action 2: Provide opportunities for undergraduate student participation in Reserve research		
Stewardship	*Objective 1-4: Produce a map of Reserve priority habitats and geographical areas and plan for future mapping efforts*	*Objective 2-3: Facilitate stewardship activities through community education programs like Wetland Warriors, Cooperative Weed Management Area, and Trash or Treat*	*Objective 3-3: Monitor land management practices at Fennessey Ranch and Aransas National Wildlife Refuge*
	Action 1: Update the "Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan" every five years	Action 1: Assist with the stewardship-oriented community education program known as "Wetland Warriors"	Action 1: Monitor habitats and management practices at Fennessey Ranch
	Action 2: Work collaboratively with the Environmental Cooperative Science Center and other partners to produce and utilize mapping products from previous imagery acquisitions and fieldwork	Action 2: Continue the Reserve's involvement in the Cooperative Weed Management Area	Action 2: Monitor management practices at the Aransas National Wildlife Refuge
		Action 3: Initiate stewardship-oriented community education program known as "Trash or Treat"	
	Objective 1-5: Protect priority areas for long-term research by ensuring existing rules and regulations are followed		*Objective 3-4: Support local habitat and wildlife conservation programs such as animal rehabiliation and clean-up programs*
	Action 1: Coordinate with Reserve partners to follow existing rules and regulations		Action 1: Partner with local wildlife rescue and rehabilitation programs to enhance their efforts
			Action 2: Partner with local organizations to enhance clean-up and recycling programs in and adjacent to the Reserve

			Objective 3-5: Initiate restoration and mitigation projects with appropriate partners
			Action 1: Continue working with partners to identify restoration opportunities within the Reserve and its watershed
			Action 2: Promote the utilization of Reserve data for monitoring restoration outcomes
			Action 3: Support the Coastal Training Program's efforts to provide restoration training opportunities for local decision makers
Education	*Objective 1-6: Provide a professional development program for teachers that offers field-based learning experiences linked to Reserve research and stewardship activities*	*Objective 2-4: Increase K-12 and early grade level student literacy about coastal ecosystems through programs hosted at Reserve facilities, aboard the R/V Katy, and the Scientist in Residence Program*	*Objective 3-6 Promote public appreciation of Texas coastal resources through community education programs hosted at Reserve facilities*
	Action 1: Implement Teachers on the Estuary professional development trainings	Action 1: Develop education programs for early grade level students at the Bay Education Center and Estuary Explorium	Action 1: Offer early childhood education programs at the UTMSI Marine Science Education Center
		Action 2: Offer hands-on education programs aboard the R/V Katy	Action 2: Coordinate public lectures at both the Bay Education Center and UTMSI
		Action 3: Coordinate Scientist in Residence program	Action 3: Offer SOS programs to the general public at the Bay Education Center
			Action 4: Assist with coordination of Wetland Warriors
			Action 5: Provide public tours of the Wetlands Education Center
			Action 6: Provide training opportunities for volunteers interestd in participating in education programs
		Objective 2-5: Educate K-12 teachers and students about human impacts on coastal environments using Science on the Sphere and educational programs that integrate science, history, and culture	*Objective 3-7: Increase public awareness of the Reserve and the Reserve System through the Reserve's website and bi-annual newsletter*

		Action 1: Use Science on a Sphere datasets to highlight impacts of climate change and other human-induced impacts on the estuary	Action 1: Maintain Reserve website
		Action 2: Develop K-12 education programs that integrate science, history, and culture to help students understand how humans benefit from and impact the estuary	Action 2: Develop and distribute bi-annual newsletter
			Action 3: Maintain the Reserve's social media pages
		Objective 2-6: Increase public literacy about Texas coastal ecosystems through public education programs hosted at Reserve facilities, Summer Science Program, and Road Scholar Program	*Objective 3-8: Promote Reserve initiatives at a minimum of three public events, fairs and expositions per year*
		Action 1: Continue working with Reserve land owners to offer habitat hikes at their facilities	Action 1: Host and attend events related to National Estuaries Day
		Action 2: Develop public and community programs that are aligned with the Estuary Explorium exhibits	Action 2: Host education booth at Earth Day - Bay Day
		Action 3: Develop public and community programs that are aligned with the Bay Education Center exhibits	Action 3: Host education booth at Coastal Bend Teacher Extravaganza
		Action 4: Coordinate Summer Science Program	
		Action 5: Continue to implement the Road Scholar program	
Coastal Training	*Objective 1-7 Increase participation of UTMSI researchers in program development and implementation by drafting outreach plan*	*Objective 2-7: Enhance the transfer of knowledge, information, and skills to coastal-decision makers by hosting a miminum of eight trainings, updating the Reserve's market analysis/needs assessment, creating a listserv, and enhancing use of the Reserve CTP website*	*Objective 3-9: Improve the ability of coastal resource managers to conserve, protect, and restore coastal ecosystems through trainings on restoration and other relevant topics*

	Action 1: Develop outreach plan for UTMSI research that relies on CTP expertise	Action 1: Hold a minimum of eight training events each year that meet the information and training needs of coastal decision maker audiences	Action 1: Increase participation in RESTORE Act activities
		Action 2: Perform a market analysis/needs assessment to determine training needs	Action 2: Collaborate with other Reserve programs to identify and implement additional training programs
		Action 3: Develop Listserv for CTP	
		Action 4: Increase use of CTP section of Reserve website	
Administrative	*Objective 1-8: Provide oversight and support for research and monitoring activities*	*Objective 2-8: Provide oversight and support for K-12 and decision maker education and outreach activities*	*Objective 3-10: Provide oversight and support for stewardship activities*
	Action 1: Develop, execute, and revise a Reserve Management Plan	Action 1: Develop, execute, and revise a Reserve Management Plan	Action 1: Develop, execute, and revise a Reserve Management Plan
	Action 2: Obtain advice on the program from the broader community	Action 2: Obtain advice on the program from the broader community	Action 2: Obtain advice on the program from the broader community
	Action 3: Recruit and maintain staff	Action 3: Recruit and maintain staff	Action 3: Recruit and maintain staff
	Action 4: Solicit funds via grants	Action 4: Solicit funds via grants	Action 4: Solicit funds via grants
	Action 5: Develop and operate a program for gifts to enhance Reserve activities	Action 5: Develop and operate a program for gifts to enhance Reserve activities	Action 5: Develop and operate a program for gifts to enhance Reserve activities
	Action 6: Foster partnerships for research	Action 6: Foster partnerships for education and training	Action 6: Foster partnerships for stewardship
Public Access			*Objective 3-11: Enshance public and group access to Reserve and partner education facilities and environments through installation of trails and signage*
			Action 1: Install trails within the water wise garden located on UTMSI property
			Action 2: Install signage at public access locations throughout the Reserve

1.0 National Estuarine Research Reserve System

The National Estuarine Reserve System (NERRS; or Reserve System) was created by the Coastal Zone Management Act of 1972, as amended, to augment the National Coastal Zone Management Program which is dedicated to comprehensive, sustainable management of the nation's coasts. The Reserve System is a network of protected areas representative of the various biogeographic regions and estuarine types in the United States. Reserves are established for long-term research, education, and interpretation to promote informed management of the Nation's estuaries and coastal habitats. (15 C.F.R. Part 921.1(a)) The Reserve System currently consists of 28 reserves in 23 states and territories, protecting over one million acres of estuarine lands and waters (Figure 1.1). The Reserve System is a partnership program between the National Oceanic and Atmospheric Administration (NOAA) and the coastal states. NOAA provides funding, national guidance and technical assistance. The state partner manages reserve resources on a daily basis, working collaboratively with local and regional partners.

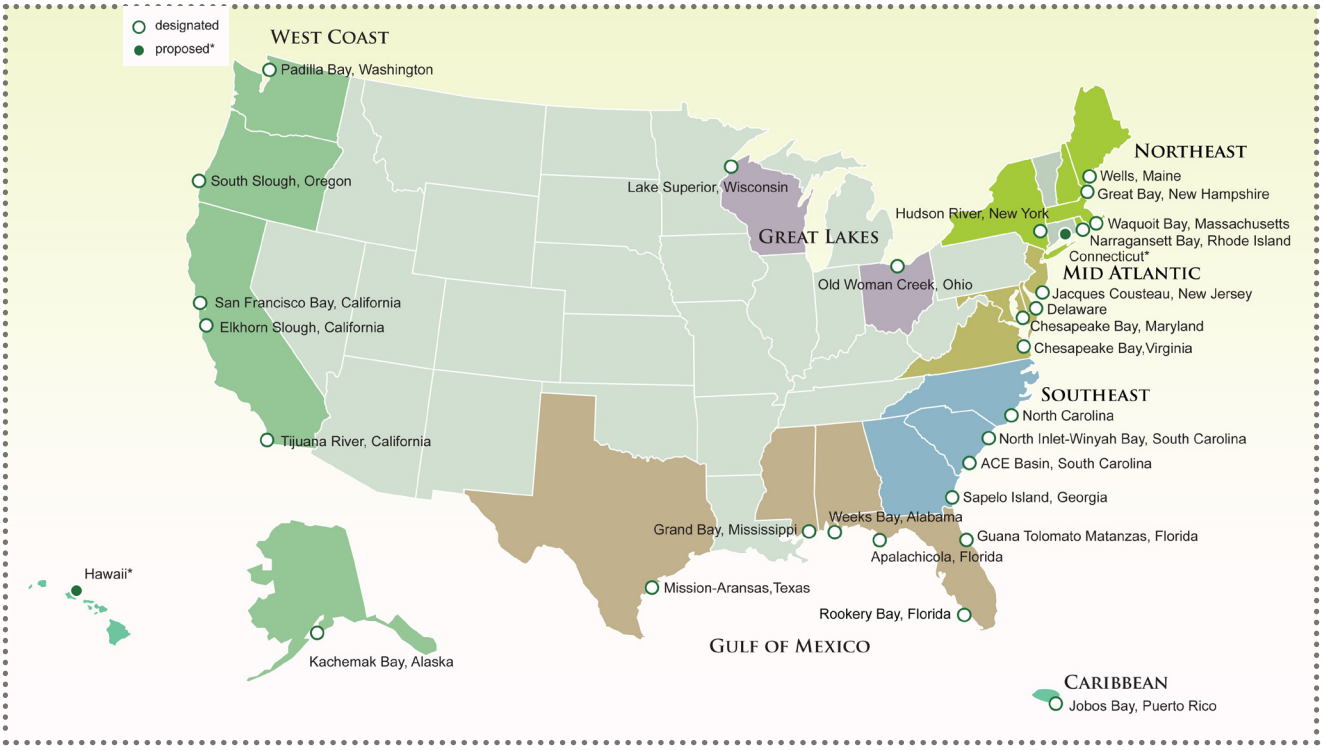


Figure 1.1. Map of the National Estuarine Research Reserve System.

1.1 National Estuarine Research Reserve System Strategic Goals

Estuaries are biologically rich, economically valuable, and highly vulnerable ecosystems. The vision and mission of the Reserve System reflect the importance of these systems within our communities.

Vision: Resilient estuaries and coastal watersheds where human and natural communities thrive.

Mission: To practice and promote stewardship of coasts and estuaries through innovative research, education, and training using a place-based system of protected areas. The program goals, per Federal regulations 15 C.F.R. Part 921.1(b), outline five specific goals for the Reserve System:

1. Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve resources;
2. Address coastal management issues identified as significant through coordinated estuarine research within the System;

3. Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
4. Promote Federal, state, public, and private use of one or more Reserves within the System when such entities conduct estuarine research; and
5. Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

These foundational goals are complemented by those that are systematically set by the program every five years. Strategic planning has been an integral part of the National Estuarine Research Reserve System for nearly twenty years. The planning process is designed to bridge national program direction with local coastal management needs through a representative and participatory process that supports NOAA's mission of science, service, and stewardship. The *2011-2016 Reserve System Strategic Plan* focuses reserve core strengths of research, education, and training on three core issues: climate change, habitat protection, and water quality. The Reserve System Strategic Plan goals are:

1. Protected Places: Estuaries and coastal watersheds are better protected and managed by implementing place-based approaches at reserves.
2. Science: National Estuarine Research Reserve System scientific investigations improve understanding and inform decisions affecting estuaries and coastal watersheds.
3. People: National Estuarine Research Reserve System education and training increases participants' environmental literacy and ability to make science-based decisions related to estuaries and coastal watersheds.

1.2 Biogeographic Regions and Boundaries

NOAA has identified eleven distinct biogeographic regions and 29 subregions in the United States, each of which contains several types of estuarine ecosystems (15 C.F.R. Part 921, Appendix I and II). When complete, the Reserve System will contain examples of estuarine hydrologic and biological types characteristic of each biogeographic region (Figure 1.2). As of 2015, the Reserve System includes 28 reserves and two states in the process of designating a reserve.

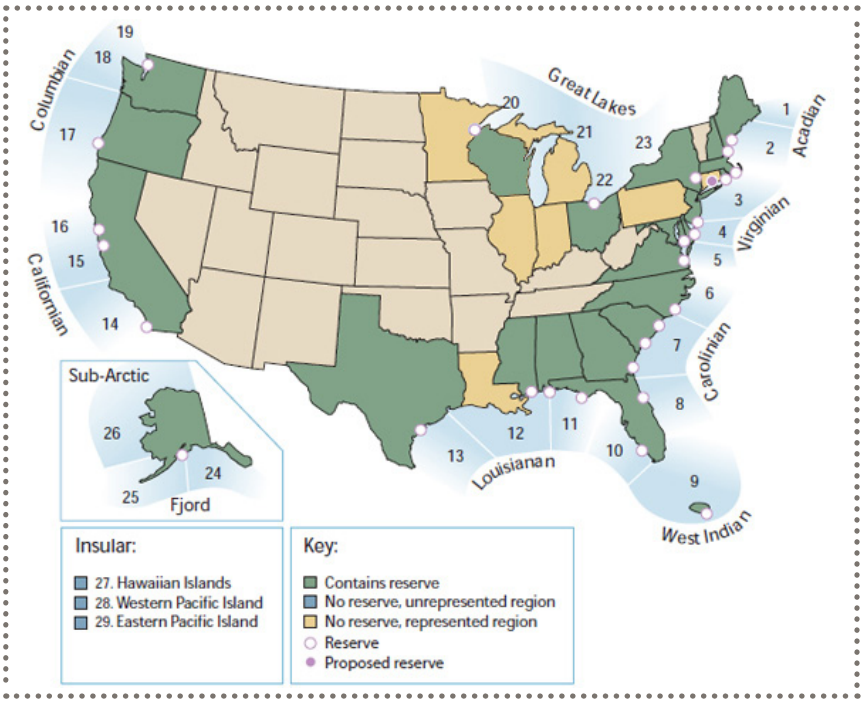


Figure 1.2. Map of National Estuarine Research Reserves by biogeographic region.

Reserve boundary size will vary greatly depending on the nature of the ecosystem. Boundaries must include an adequate portion of the key land and water areas of the natural system to approximate an ecological unit and to ensure effective conservation. Reserve boundaries encompass areas for which adequate state control has or will be established by the managing entity over human activities occurring within the reserve. Reserve boundaries include a "core" area which is comprised of key land and water encompassing resources representative of the total ecosystem, which if compromised could endanger the research objectives of the reserve, as well as a "buffer"

area designed to protect the core area and provide additional protection for estuarine-dependent species, including those that are rare or endangered. Buffer areas may also include areas necessary for facilities required for research and interpretation. Additionally, buffer areas are identified to accommodate a shift of the core area as a result of biological, ecological or geo-morphological change which reasonably could be expected to occur (15 C.F.R. Part 921.11 (c)(3)).

1.3 National Estuarine Research Reserve Administrative Framework

The process for federal designation of a NERR has many steps and involves many individuals and organizations. While each reserve is a partnership program between NOAA and a coastal state, there are many entities that collaborate to support designation of a reserve. Other partners include federal and state agencies, non-profit groups, universities, and members of the local community. For more information on the designation process see the NERRS website (www.nerrs.noaa.gov/background).

Upon designation, the reserve implements the approved management plan and is eligible for NOAA financial assistance on a cost-share basis with the state. A reserve may apply to NOAA's Office for Coastal Management (OCM) for funds to help support implementation of the management plan largely funding operations, research, monitoring, education/interpretation, training, stewardship, development projects, facility construction, and land acquisition. Management plans provide a vision and framework to guide reserve activities during a five year period and enable the reserves and NOAA to track progress and realize opportunities for growth. Each management plan contains the reserve goals, objectives, and strategies supported by programs focused on research and monitoring, education and outreach, training, and stewardship. They also outline administration, public access, land acquisition and facility plans and needs, as well as restoration and resource manipulation plans, if applicable. Reserves are increasingly confronted with complex questions regarding new uses in or near reserves that may or may not be compatible with the Reserve System's mission. A thoughtful and comprehensive management plan provides a foundation for addressing these challenges to protect and manage reserve resources wisely and ensure the public and coastal decision-makers value and protect coastal resources.

The Office for Coastal Management administers the Reserve System. OCM establishes standards for designating and operating reserves, provides support for reserve operations and system-wide programming, undertakes projects that benefit the Reserve System, and integrates information from individual reserves and programs to support decision-making at the national level. Additionally, OCM periodically evaluates reserves for compliance with Federal requirements and with the individual reserve's Federally-approved management plan, as mandated under Section 312 of the Coastal Zone Management Act (15 C.F.R. Part 921.40).

OCM currently provides support for four system-wide programs: the System-Wide Monitoring Program, the K-12 Estuarine Education Program, the Graduate Research Fellowship Program, and the Coastal Training Program. They also provide support for initiatives focused on the Reserve System's priorities of climate change, water quality, and habitat protection.

1.4 Programmatic Foundations

Each reserve contributes to Reserve System-wide programs and priorities, as well as defines local programs and priorities to address site specific needs and issues. System-wide programs are those that are conducted at the majority of Reserves across the nation using a standard set of protocols. The national system has four system-wide programs: (1) the System-Wide Monitoring Program, (2) the K-12 Estuarine Education Program, (3) the Graduate Research Fellowship Program, and (4) the Coastal Training Program.

1.4.1 System-Wide Monitoring Program

The System-Wide Monitoring Program (SWMP) develops quantitative measurements of short-term variability and long-term changes in water quality, biological systems, and land use/land cover characteristics of estuaries and estuarine ecosystems for the purposes of informing effective coastal zone management. At the Mission-Aransas Reserve the Research and Stewardship Coordinators and associated staff operate SWMP (see Section 4.1 for additional detail).

1.4.3 K-12 Estuarine Education Program

The K-12 Estuarine Education Program (KEEP) increases the estuary literacy of students, teachers and the general public. In particular, KEEP helps students and teachers learn about essential coastal and estuarine concepts, develop data literacy skills and strengthen their critical thinking, team building, and problem solving skills. At the Mission-Aransas Reserve the Education Coordinator and associated staff operate KEEP (see section 4.3 for additional detail).

1.4.4 Coastal Training Program

The Coastal Training Program (CTP) is slightly different from the other system-wide programs in that it is often thought of as a "sector" similar to that of research, education, and stewardship. The CTP provides up-to-date scientific information and skill-building opportunities to coastal decision-makers responsible for making decisions affecting coastal resources. All of the CTPs implement the same evaluations and performance metrics to ensure that the training provided by the program are successful. These evaluations are also used to identify national trends in needs, understanding, and local capacity (see section 4.4 for additional detail).

2.0 Mission-Aransas National Estuarine Research Reserve

The mission of the Mission-Aransas National Estuarine Research Reserve (NERR; or Reserve) is to develop and facilitate partnerships that enhance coastal decision making through an integrated program of research, education, training, and stewardship. This mission will enable the Reserve to fulfill its vision of being a center of excellence to create and disseminate knowledge necessary to maintain a healthy Texas coastal zone. The Reserve is an 185,708 acre contiguous complex of wetland, terrestrial, and marine environments (Figure 2.1).

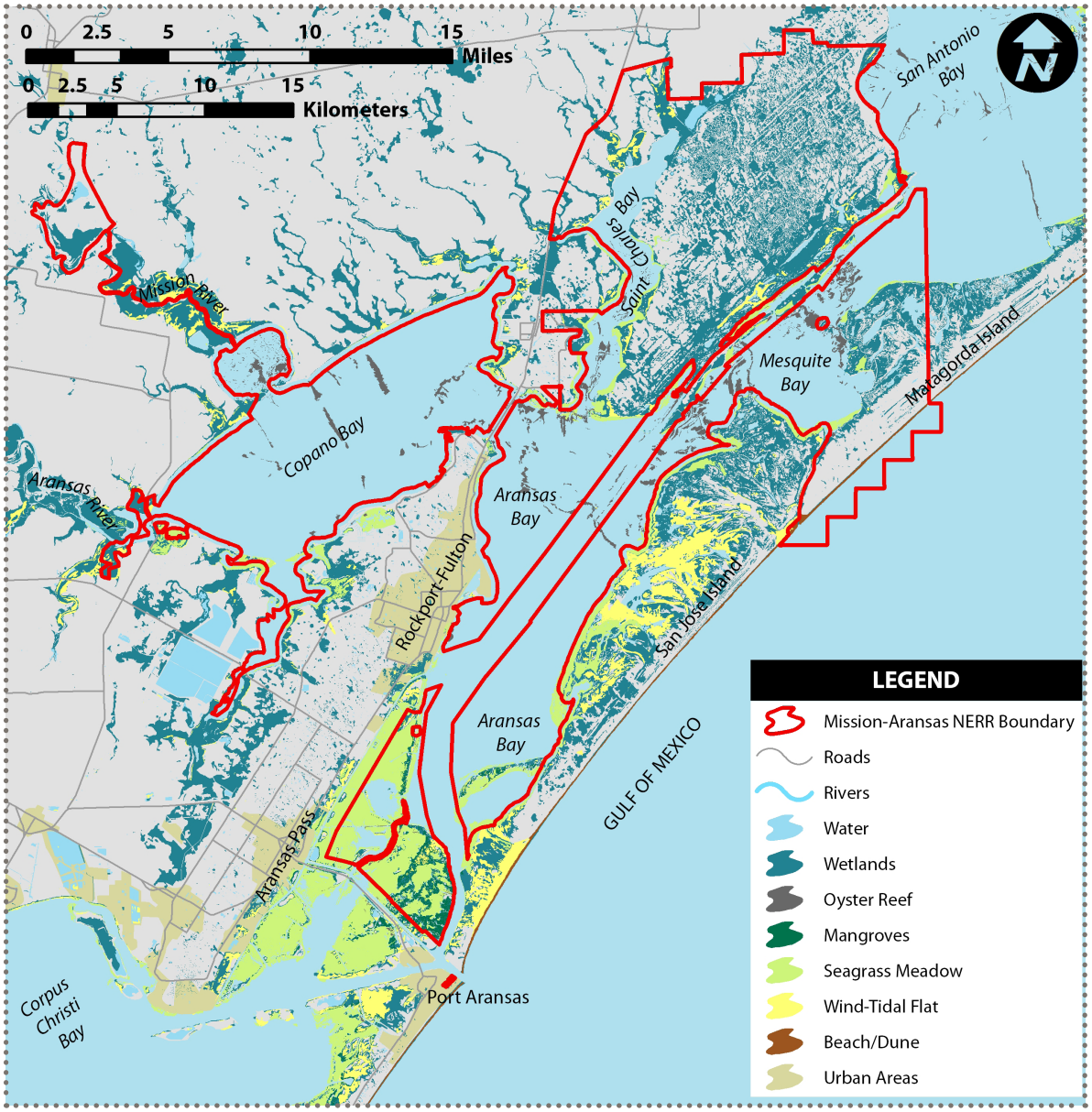


Figure 2.1. Map of the Mission-Aransas National Estuarine Research Reserve.

2.1 History and local management

The Mission-Aransas Reserve is one of 28 Reserves created to promote the responsible management of the nation's estuaries. The process for federal designation of a Reserve includes the following steps: (1) letter of interest, (2) site selection and nomination, (3) draft environmental impact statement/draft management plan, (4) final environmental impact statement/final management plan, (5) designation findings and certificate, (6) record of decision, and (7) designation ceremony. The designation process involves many individuals and organizations.

The Mission-Aransas Reserve was designated in 2006 as a federal-state partnership between NOAA and the University of Texas at Austin, Marine Science Institute (UTMSI). NOAA provides funding, national guidance, and technical assistance, while UTMSI is responsible for managing the Reserve on a daily basis with input from local partners. Reserve partners include the land owners and managers within the Reserve: U.S. Fish and Wildlife Service (USFWS), Texas General Land Office (GLO), Texas Parks and Wildlife Department (TPWD), Texas Department of Transportation (TxDOT), Coastal Bend Bays & Estuaries Program (CBBEP), Coastal Bend Land Trust (CBLT), The Nature Conservancy (TNC), Fennessey Ranch, and an appointed representative from local

Mission-Aransas Reserve designation ceremony

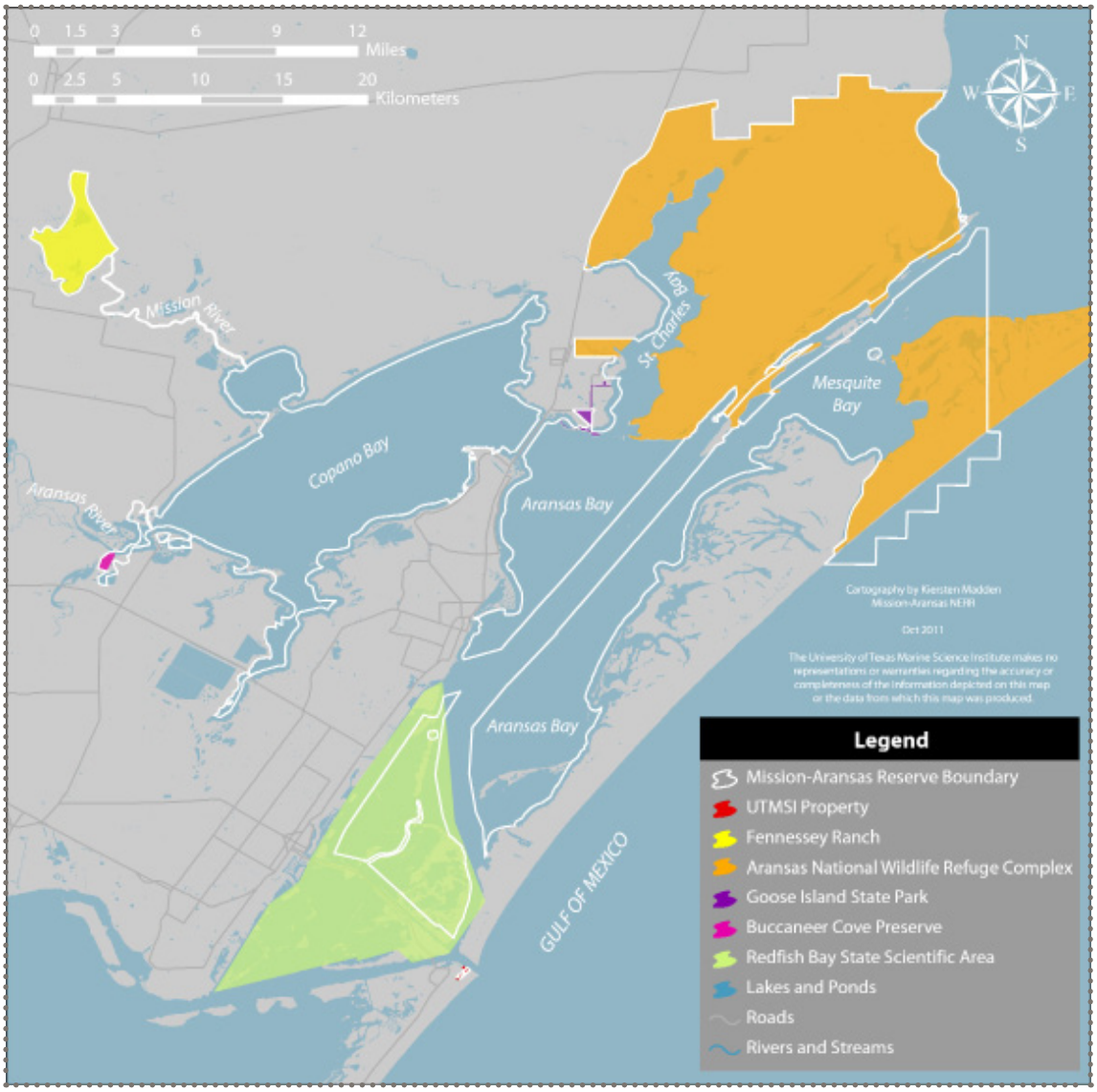


Figure 2.2. Map of landowners within the Mission-Aransas Reserve.

government (i.e., Aransas County, City of Rockport, or the Aransass County Navigation District). These partnerships have been established based on mutual interest in the Reserve area, and they provide a means for determining how key aspects of the program will function (i.e., research, education, monitoring, administration, resource protection, facilities). Reserve partners are responsible for serving on the Reserve Advisory Board (RAB) and for providing guidance and direction for key activities identified in this management plan. The management system of the Reserve is tied together through various memoranda of understanding, state leases, and conservation easements.

The lands within the Reserve are managed by a combination of state, federal and private entities (Figure 2.2). The GLO owns the majority of submerged lands (bays and open water) within the Reserve. USFWS owns the Aransas National Wildlife Refuge (ANWR), including Matagorda Island, which contains beach, estuarine marsh, and non-tidal coastal plains. TPWD manages Goose Island State Park (GISP), a portion of which is owned by the GLO and leased to TPWD. Other private landholders include the CBLT and Fennessey Ranch. CBLT owns the Buccaneer Cove Preserve, which includes a diverse suite of estuarine and non-estuarine habitats that form an intact coastal watershed. Fennessey Ranch is privately owned, but the University of Texas at Austin (UT) purchased a conservation easement on the Ranch in 2006.

Aransas National Wildlife Refuge

ANWR is comprised of the Aransas Unit on Blackjack Peninsula, the Tatton Unit northwest of St. Charles Bay, the Lamar Unit east of St. Charles Bay, the Myrtle-Foester Whitmire Unit near Matagorda Bay, and the Matagorda Island Unit. ANWR was originally established in 1937 by President Franklin D. Roosevelt as a safe-haven for threatened and endangered species and as a refuge and breeding ground for migratory birds and other wildlife. It is world-renowned as the winter home of the largest wild flock of endangered Whooping Cranes. Matagorda Island Wildlife Management Area and State Park became part of the ANWR in 1982 and is managed through a memorandum of agreement between TPWD and USFWS. In 2006, the Johnson Ranch, a 245 acre tract located on Lamar Peninsula adjacent to St. Charles Bay, was incorporated into the ANWR boundary. The ANWR has a large portion of tidal and deltaic marshes. Upland vegetation is predominately coastal plain grasses interspersed with oak mottes, swales, and ponds (Stevenson and Griffith 1946; Allen 1952; Labuda and Butts 1979). Vegetation and wetlands at the Refuge support wildlife such as the Brown Pelican, Peregrine Falcon, white-tailed deer, javelina, coyote, wild pig, Rio Grande Turkey, raccoon, armadillo, the threatened American alligator, and the endangered Attwater's Prairie Chicken (last seen 1992).

Whooping Crane feeding on blue crab
Photo courtesy of S. Halbrook

Buccaneer Cove Preserve

Buccaneer Cove Preserve is located at the mouth of Aransas River and contains estuarine tidal flats and brackish marshes. This area is owned and managed by CBLT whose primary goal is preserving and enhancing native wildlife habitat in the Coastal Bend. This is valuable habitat for Sandhill Cranes, Reddish Egrets, and other waterfowl.

Goose Island State Park

GISP is located between Aransas and St. Charles bays. The state park contains several habitats, including live-oak thickets and tidal salt marshes, which support migrant birds such as rails, loons, grebes, common

goldeneyes, Red-breasted Mergansers, and Redheads. The park also is home to the "Big Tree" Live Oak, which is estimated to be around 1,000 years old. The Park was acquired in 1931-1935 by deeds from private owners and a legislative act setting aside Goose Island as a state park. The earliest park facilities were constructed by the Civilian Conservation Corps in the 1930's. The park also has a coastal lease of submerged land adjacent to the park that includes seagrass beds, oyster reef, and bay habitat which provide valuable nursery areas for many economically important species.

Wetlands at Goose Island State Park.

Fennessey Ranch

In 2006, the University of Texas at Austin and the Mission-Aransas Reserve purchased a conservation easement on Fennessey Ranch, a privately owned property that contains meadows, brush, prairie, freshwater wetlands, natural lakes, and riparian woodlands. This 3,261-acre wildlife oasis is host to numerous types of birds, plants, amphibians, reptiles, insects, and mammals. The Ranch is designed to be an environmentally friendly business that profits from traditional livestock ranching, as well as oil and gas drilling, wildlife tours, hunting leases, kayak adventures, and photography trips. The conservation easement restricts development from occurring and ensures that the valuable habitats of Fennessey Ranch will continue to support wildlife well into the future. The easement also provides increased access for research projects and educational opportunities to highlight the importance of healthy coastal ecosystems.

Birding tour at Fennessey Ranch

2.2 Ecological attributes

The Mission-Aransas NERR represents the Western Gulf Biogeographic Subregion (Figure 2.3). The Western Gulf Subregion lies wholly in Texas, comprises most of the Texas coast, and is bounded by the border with Mexico to the southwest and the border of Galveston Bay to the northeast. This Subregion includes six major bay-estuarine systems and two river systems (Figure 2.4). The major bay-estuarine systems are Lavaca-Colorado, Guadalupe, Mission-Aransas, Nueces, and Laguna Madre. Laguna Madre is comprised of two different systems: Upper Laguna Madre/Baffin Bay and Lower Laguna Madre. The two river systems are the Brazos and Rio Grande rivers.

The Mission-Aransas Estuary is a typical Western Gulf of Mexico estuary (Diener, 1975). The estuarine system is composed of tertiary, secondary, and primary bays. Mesquite, Aransas and Redfish bays are primary bays (i.e., adjacent to oceanic outlets). Copano, Port, and St. Charles bays are examples of secondary bays, while Mission Bay is a tertiary bay. These bays vary in size and geologic origin. Aransas Bay is the largest bay within the estuary, followed by Copano and Mesquite bay (Figure 2.1). Copano Bay is a coastal plain estuary, composed of two drowned river mouths of the Mission and Aransas rivers. Aransas, Redfish, and Mesquite bays are bar-built estuaries, in which an offshore sand bar partially encloses a body of water.

The bay systems are all shallow, and the mean low water varies from 0.6 m in Mission Bay to 3 m in Aransas Bay (Chandler et al., 1981).

2.2.1 Geomorphology

There are three sources of sediment in the Mission-Aransas NERR: (1) suspended and bedload material from the Mission and Aransas rivers, (2) Gulf of Mexico deposits from storms and inlets, and (3) dredge spoil from channels (Tunnell et al., 1996). The Mission-Aransas Estuary is in an intermediate stage of geological succession given that the filling of the estuary by riverine deposits is the final stage. In general, the intracoastal circulation (which affects formation of bays or lack thereof) takes sediment from south to north towards Matagorda Bay due to the southeastern winds. The shorelines of Copano and Aransas bays are in a state of erosion. The bay side shoreline of San Jose Island, on the other hand, is in a state of equilibrium or accretion (Chandler et al., 1981).

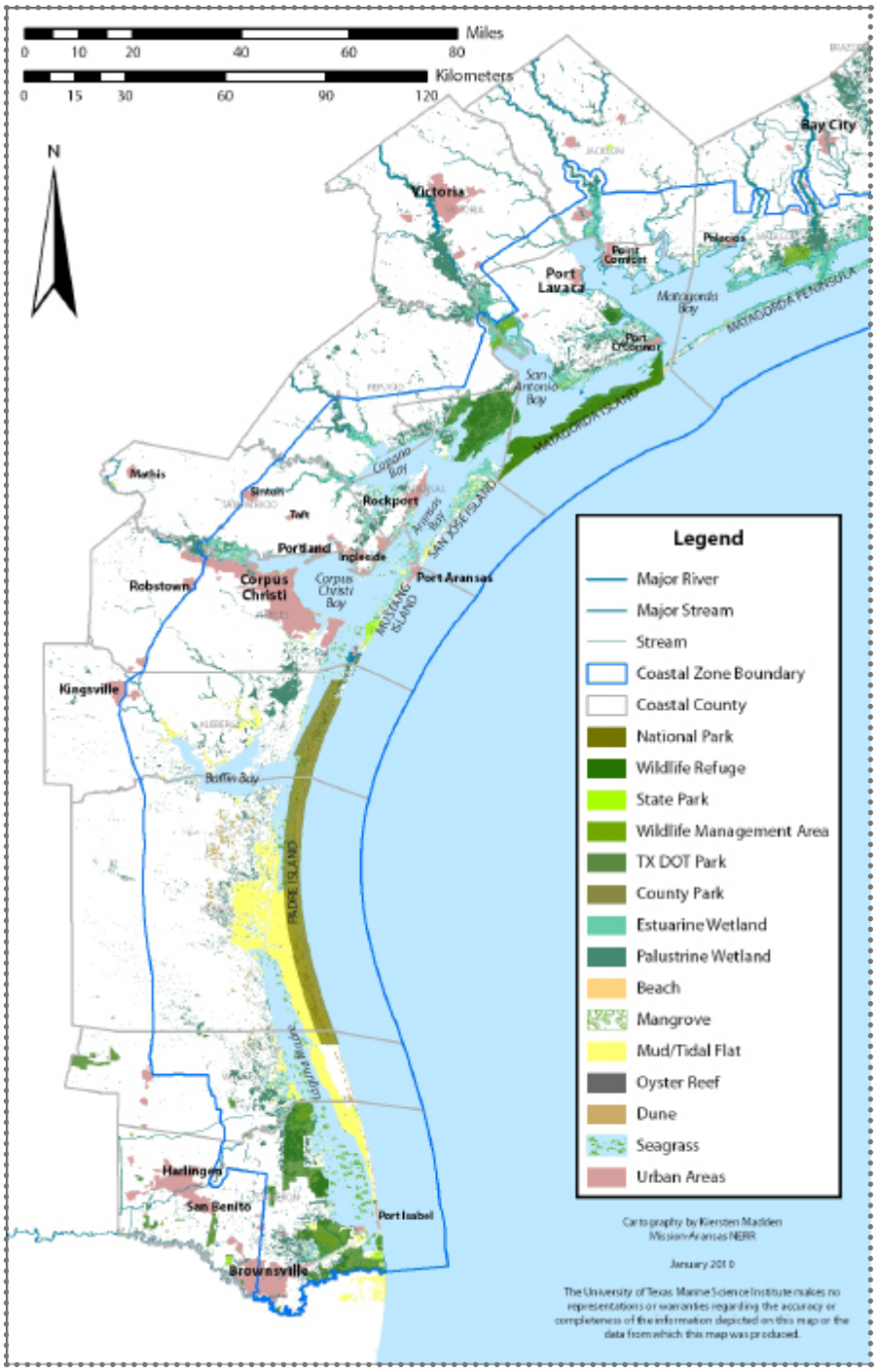


Figure 2.3. Map of the major estuaries of the Western Gulf Biogeographic Subregion.

The geologic framework of Texas combined with modern coastal processes has resulted in generally fine-grained sands and mixed sand and shell gravel on beaches. Some mud and clay outcrops can be found on mainland and deltaic headland shorelines (McKenna, 2004). The most common sediment type in the Mission-Aransas Estuary is mud, comprised of silt and clay (White et al., 1983). In Mesquite and St. Charles bays, the most common sediment type is sand to sandy silt (White et al., 1989). In comparison to these bays, Aransas and northern Copano bays have a higher proportion of clay, while the southern proportion of Copano Bay has a higher portion of silt. Around oyster reefs in Copano Bay the sediments have as high as 75% shell material. The margins of Copano and Aransas bays have a higher percentage of sand (White et al., 1983).

Erosion of shorelines and islands caused by storms, hurricanes, floods, and powerful waves can expose structures, lead to the encroachment of seawater, and cause large property losses in coastal areas. Long-term, episodic, and human-induced erosion of Gulf of Mexico and Texas bay shorelines has resulted in habitat loss,

navigational challenges, and coastal structures on public beaches (McKenna, 2004). Long-term erosion is caused by the rate of relative sea level rise and the lack of new sediment coming into the system (McKenna, 2004; CT2020). Episodic events, such as storms and hurricanes are the greatest cause of periodic coastal erosion in Texas. Additionally, many bay shorelines are eroding due to geology, setting (with respect to wind and wave direction), shoreline material, and the proximity to major ship traffic (CT2020).

2.2.2 Hydrology

The primary climatic conditions that influence the hydrology in the Mission-Aransas Estuary are freshwater inflow and to a lesser extent tidal exchange. The Mission and Aransas rivers contribute the major freshwater inflows into the Mission-Aransas NERR (Figure 2.4). Drainage of the estuary occurs primarily at the major Gulf of Mexico connection at Port Aransas called Aransas Pass, and to a lesser extent at Cedar Bayou, an intermittent pass at the northern edge of the Reserve that was re-opened in 2014.

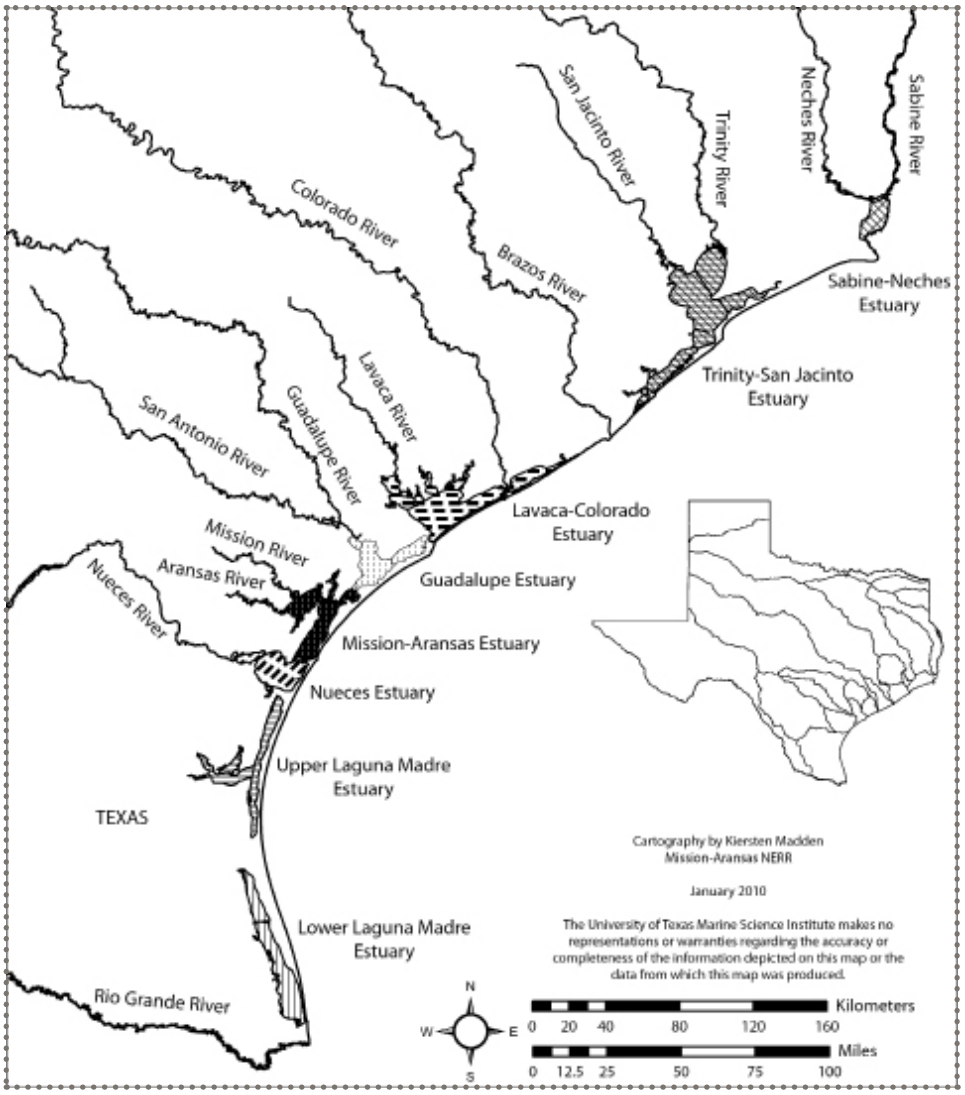


Figure 2.4. Map of the major rivers and estuaries along the Texas Gulf Coast.

The Aransas and Mission rivers are small and are primarily coastal compared to other rivers in Texas. Neither the Mission nor the Aransas River has dams or other surface water supply structures, and neither is used for city water supplies in the region. As a result, both rivers drain entirely into the Mission-Aransas Estuary. The Mission River is formed by the confluence of Blanco and Medio Creeks in central Refugio County, runs for approximately 24 miles, and discharges in Mission Bay. The Aransas River begins in Bee County from the confluence of Olmos, Aransas, and Poesta creeks, flows south and southeast, and enters the western end of Copano Bay along the Refugio-Aransas county line. The Mission and Aransas rivers are characterized by low base flows with large pulses due to storm events. From 2007-2008, the Aransas River discharge ranged from 0.08 to 227.10 $m^3 s^{-1}$, with mean flow of 1.51 $m^3 s^{-1}$, and median of 0.18 $m^3 s^{-1}$. During the same time period the Mission River discharge was slightly higher and ranged from 0.01 to 356.79 $m^3 s^{-1}$, with mean flow of 4.31 $m^3 s^{-1}$, and a median of 0.34 $m^3 s^{-1}$ (Mooney, 2009).

The lower reaches of the rivers are tidally influenced due to a combination of the tidal range relative to the elevation change. The average tidal range in Copano Bay is 0.15 m. Tidal forcing coupled with low elevations and low freshwater inputs creates long residence times in the lower reaches of the rivers. In the

Aransas River tidal reach during low flow (~0.3 m^3s^{-1}) residence time is on the order of months and during high flow (~280 m^3s^{-1}) residence time is on the order of days (Johnson, 2009). During 2007 and 2008, measured salinity at locations in the tidal reaches of the Mission and Aransas rivers ranged from 0.04 to 20.2 psu and 0.04 to 5.9 psu, respectively (Mooney, 2009). During large flood events, freshwater from the San Antonio and Guadalupe rivers can move along the southwest shoreline of San Antonio Bay and can flow into the northeastern portion of the Reserve boundary reaching Ayers and Mesquite bays (Longley, 1994). The higher elevation of flood waters in Mesquite Bay could lead to outflows to the Gulf of Mexico via Cedar Bayou. During large events, freshwater can also continue to flow southwest through the Gulf Intracoastal Waterway (GIWW)and enter Aransas Bay. During dry periods, evaporation in Ayers Bay and Mesquite Bay keeps water from flowing from San Antonio Bay southward into the Reserve.

Mission River

Aransas River

Tidal exchange in the Mission-Aransas Estuary is driven by astronomical tides, meteorological conditions, and density stratification (Armstrong, 1987). Because of shallow bay depths (1-4 m at mid-tide) and a relatively small tidal prism, wind exerts a much greater influence on bay circulation than astronomical tides (Morton and McGowen, 1980; Armstrong, 1987; NOAA, 1990). Wind-generated tides result in substantial exchange of water between the Gulf of Mexico and the Mission-Aransas Estuary (Ward and Armstrong, 1997). Astronomical tides are predominately diurnal, but also have a semi-diurnal component. The greatest influence of astronomical tides on the Mission-Aransas Estuary system is at the tidal inlet. Seasonal high tides occur during the spring and fall, while seasonal lows occur during the winter and summer month.

The Reserve experiences large ranges in salinity, which is dependent upon freshwater inputs, tidal forcing, and evaporation rates. During much of the time, the Reserve has a large salinity gradient, ranging from high salinities in Redfish Bay to lower salinities in Mission Bay. During droughts, however, low river flows and high evaporation rates cause the Reserve to experience hypersaline water in shallow bays. Salinity structure within the Reserve is determined by isolated freshwater pulses that, once introduced, are retained within the system (NOAA, 1993). Freshwater pulses tend to lower salinities for long periods of time because of the shallowness of the bay and the restricted inlet connection. Salinity stratification is common following fresh water impulses and usually occurs in Copano Bay (NOAA, 1993). Salinity stratification can occur in secondary bays (e.g., Copano Bay) during summer when winds subside and evaporation causes dense water to sink (Morehead et al., 2002).

2.2.3 Climate and weather

The weather in South Texas can be described as variable and extreme. The climate is subhumid to semiarid-subtropical with extreme variability in precipitation (Fulbright et al., 1990). Major climatic influences include temperature, precipitation, evaporation, wind, tropical storms, and hurricanes (Smith and Dilworth, 1999). Generally, the area experiences high temperatures (Figure 2.5) along with deficiencies in moisture. In the past three decades, temperatures of the Reserve have varied from an average summer maximum of 33.8 °C to an average winter minimum of 9.2 °C, according to data collected by National Climatic Data Center (NCDC) (Xue et al., In press). The major impacts of temperature within the Mission-Aransas NERR are freezes and radical changes with passing cold fronts (can drop 30-40°F within a few hours).

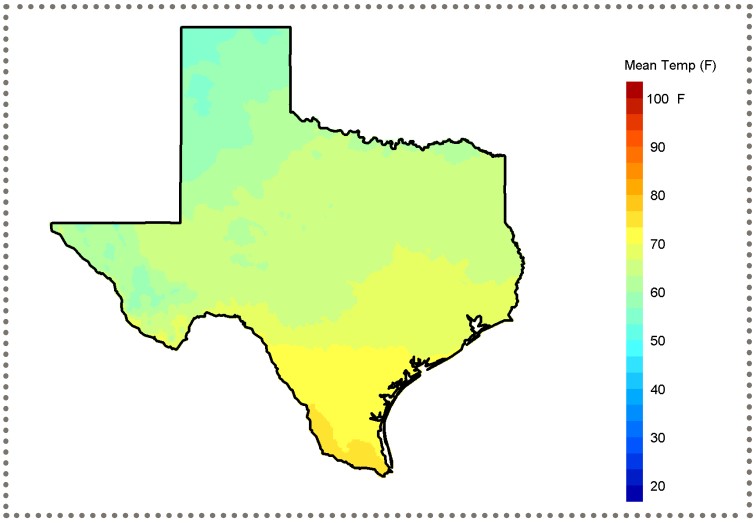


Figure 2.5. Average annual temperature in Texas from 1951-2006. (Data from www.climatewizard.org)

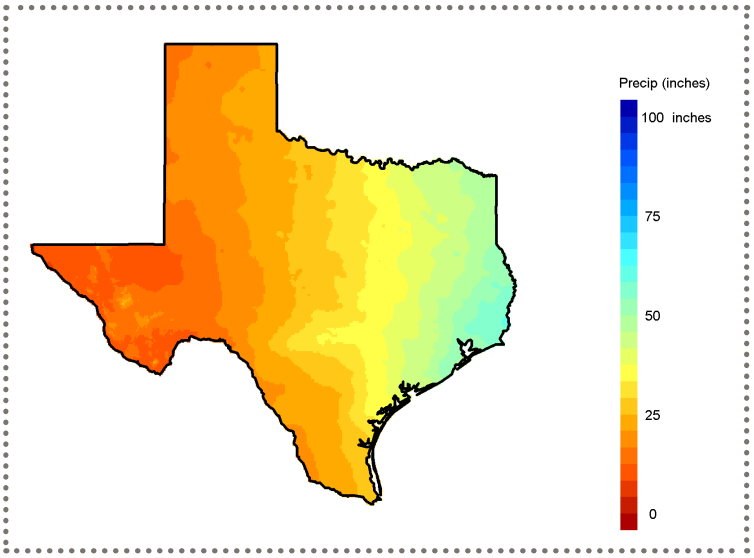


Figure 2.6. Average annual precipitation in Texas from 1951-2006. (Data from www.climatewizard.org)

Along the Texas coast there is a distinctive gradient of decreasing rainfall from northeast to southwest (Figure 2.6). The rainfall gradient decreases by a factor of two from 142 cm yr^{-1} (56 in yr^{-1}) near the Louisiana border to 69 cm yr^{-1} (27 in yr^{-1}) near the Mexican border (Larkin and Bomar, 1983). According to data from NCDC, precipitation has averaged about 79cm yr^{-1} over the last three decades, with peaks usually in summer months (92 cm yr^{-1} from June to August) (Xue et al., In press). Due to extreme summer heat, annual precipitation values alone are not necessarily significant unless compared with precipitation deficiency caused by evapotranspiration (Orton, 1996). On average, gross annual evaporation exceeds precipitation in this region (Armstrong, 1982).

Sedimentologists stress the importance of winds affecting coastal processes along the Texas coast, noting that it is perhaps the most important agent that influences coastal development. Two principle wind regimes dominate the Mission-Aransas NERR: (1) persistent, southeasterly winds from March through September and (2) north-northeasterly winds from October through March (Behrens and Watson, 1973; Brown et al., 1976). The strongest winds occur during tropical storms and hurricanes, generating high velocity currents which move large quantities of sediment in relatively short periods of time (Morton and McGowen, 1980).

Variability in weather patterns between years in South Texas is very high due to precipitation rates and climate patterns. Annual precipitation can change drastically between years due to tropical storms or hurricanes. El Niño, the warming of surface temperatures in the tropical eastern Pacific Ocean, is another important factor and causes cooler and wetter years in South Texas (NOAA, 2010). La Niña years, the cooling of surface temperatures, are characteristically warmer and drier.

2.2.4 Key habitats and species

The Mission-Aransas NERR is composed of a diverse suite of habitats that range from riparian woodlands to large expanses of seagrass meadows. Habitats can be grouped into four major categories: marine, estuarine, freshwater, and upland.

Marine Habitats

Unconsolidated Bottom

Unconsolidated bottom habitat, one of the prominent habitat types in coastal ecosystems, is located throughout the majority of the open water areas of the Mission-Aransas Estuary, with the exception of oyster reef and seagrass bed areas. Within the Reserve, this habitat is typically found in areas less than three meters deep, with the exception of the GIWW (Douglas, 1996). Unconsolidated bottom is defined as an area of loose substrate with less than one percent colonization by sessile organisms (Kendall et al., 2005). This type of habitat may be composed of many different types of sediment and is commonly classified based on the percentage of rubble, sand, silt, and clay (Montagna and Kalke, 1992).

Unconsolidated bottom habitat is not homogenous, rather it varies horizontally and vertically based on sediment type, depth, and environmental parameters (e.g., salinity and oxygen), which vary seasonally and yearly (Douglas, 1996). The relative abundance of gravel-sized shell fragments, sand, and mud (silt and clay) have similar distributions in Aransas and Copano bays. A perimeter of sand gradually increases in mud content towards the bay center, with over 75% mud in the deeper central bay area. The increase in mud content is due to a lower energy environment that allows small grains to settle. This trend varies between bays, i.e., Aransas Bay has larger grain sizes (medium to fine silt) while Copano Bay has smaller grain sizes (fine silt to clay) (Morton et al., 1983).

Unconsolidated bottom habitats are not currently subject to any special protection measures, but they are subject to indirect management due to the importance of local shrimp and crab fisheries. Regionally, long-term trends in abundance and diversity of shrimp and crab populations have not been observed, but there have been localized short-term trends of decline due to drought, dredging, and the presence of natural gas platforms (Peterson et al., 1996; Ritter and Montagna, 1999; Palmer et al., 2008).

A high abundance and diversity of macrobenthic infauna (> 0.5 mm) (e.g., polychaetes, nematodes, mollusks, and crustaceans) are present within unconsolidated bottom sediments. In most estuarine systems, polychaete and mollusk assemblages dominate unconsolidated bottom habitats. Macrobenthic infauna are primary and secondary consumers and help maintain high levels of diversity and productivity by functioning as a food source for higher trophic levels (e.g., shrimp, crabs, larger mollusks, and fish) (Worm et al., 2006).

The macroinvertebrate benthic assemblages of Aransas and Mission bays are controlled by different environmental factors. Mission Bay has a river-influenced assemblage that is characterized by mollusks, *Macoma mitchelli* and *Texadina sphinctostoma.* Aransas Bay has high water circulation and tidal influence, and the benthic macroinvertebrate assemblage is dominated by the mollusk, *Donax variabilis*, crustacean, *Acetes americanus*, and polychaetes, *Paraprionospio pinnata*, *Gyptis* sp., *Haploscoloplos fragilis*, *Owenia fusiformis,* and *Armandia agilis* (Calnan et al., 1983). Copano Bay assemblage is highly influenced by the presence of oyster reefs, with high numbers of mollusks, *Macoma mitchelli*, *Mulina lateralis, Texadina sphinctostoma*, and polychaete, *Glycinde cf. solitaria*.

Benthic organisms in Copano and Aransas bays follow a seasonal trend, with high abundance during winter and spring and low abundance in fall (Armstrong, 1987). Abundance levels in Aransas Bay range from 800-2500 organisms m^{-2} and in Copano Bay range from 180-5000 organisms m^{-2} (Armstrong, 1987). The relative levels of diversity show a decreasing gradient moving towards the inner shelf. Aransas Bay has the highest level of diversity, followed by Copano Bay, and lastly Mission Bay (Calnan et al., 1983). Although there is

higher diversity in Aransas Bay, the relative abundance of molluscan and crustacean individuals in Copano Bay is higher. However, Aransas Bay does have a high relative abundance of polychaete individuals (Calnan et al., 1983).

Oyster Reefs

The oyster contributes ecologically and economically to coastal ecosystems. The eastern oyster (*Crassostrea virginica*) ranges from St. Lawrence Bay, Nova Scotia, down the Atlantic coast, around the Gulf of Mexico to the Yucatan Peninsula, out to the West Indies, and may extend to Brazil (King et al., 1994). Commercial oyster production in Texas totaled 4,700,475 lbs for a value of $11,145,755 from 2000 to 2013 (NOAA, 2015). Oyster reefs also filter solids from the water column, influence hydrological patterns, and provide habitat for a variety of species (Buzan et al., 2009). The reef structure is usually long and narrow, orientating perpendicular to prevailing water currents or parallel to channels, and has a tendency to grow out at right angles from shore in order to maximize feeding and waste removal (Price, 1954). The development of a reef is dependent on several hydrological variables such as salinity, water temperature, current flow, dissolved oxygen levels, and sedimentation.

Oyster reefs are located throughout the entire Mission-Aransas Estuary (Figure 2.7). *Crassostrea virginica* is the primary species creating oyster reefs in the Mission-Aransas Reserve and is found in a salinity range of 10-30 psu (Aransas Bay 10-20 psu and Copano Bay 10-15 psu) (White et al., 1989). Mollusks (*Odostomia impressa* and *Ischadium recurvum*) are also found on the reefs (Calnan, 1980). Primary production is enhanced by a thin algal film on the surface of oyster reefs (Bahr and Lanier, 1981). Invertebrates are the most abundant consumers of the algae with arthropods, such as amphipods, brachyuran crabs, and caridean shrimp dominating communities. Oyster reefs are frequented by redfish (*Sciaenops ocellatus*) (Miles, 1951), and birds and feral hogs are also among the consumers of oysters and have been reported using reefs as crossings during low tides, often appearing to forage as they cross (McAlister and McAlister, 1993; A. Drumright, unpublished data).

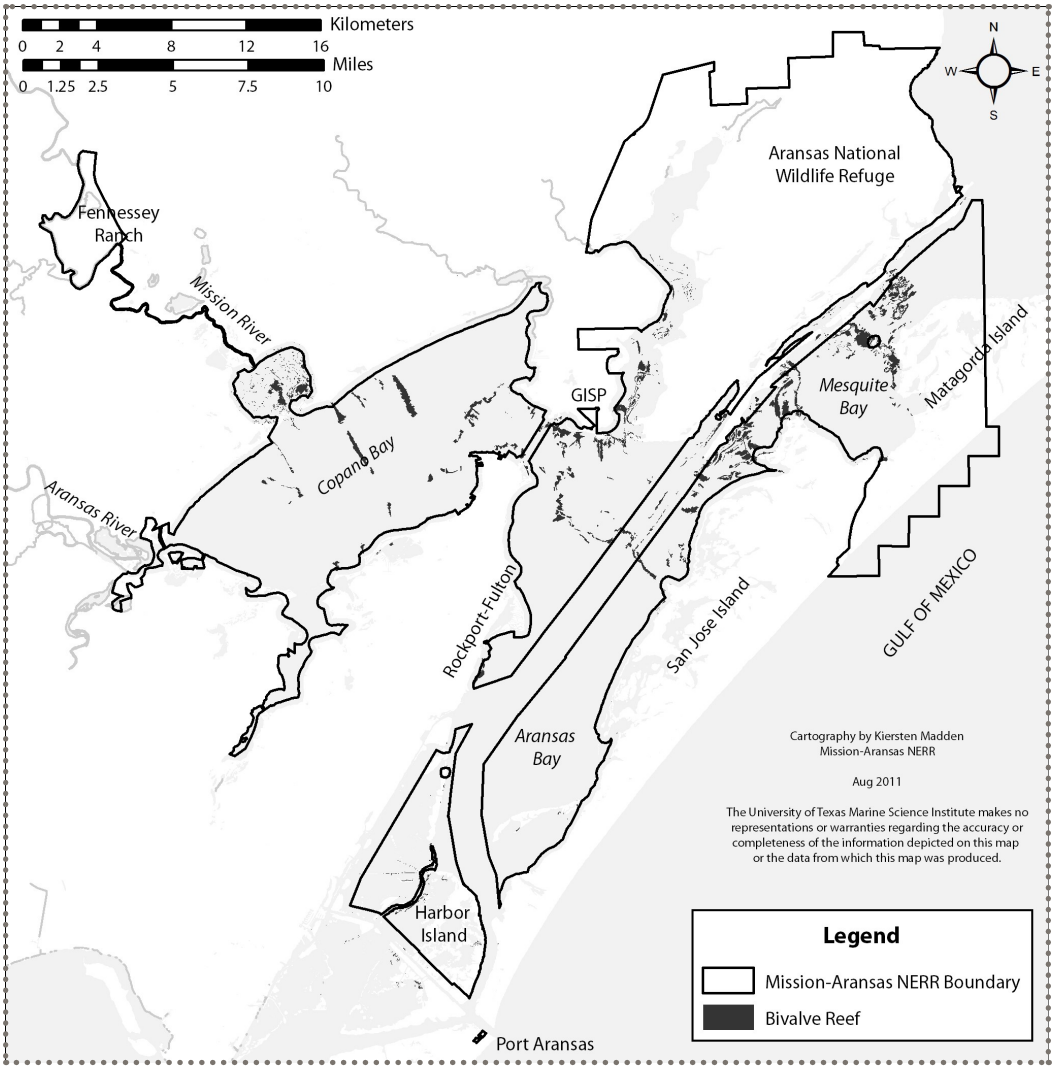


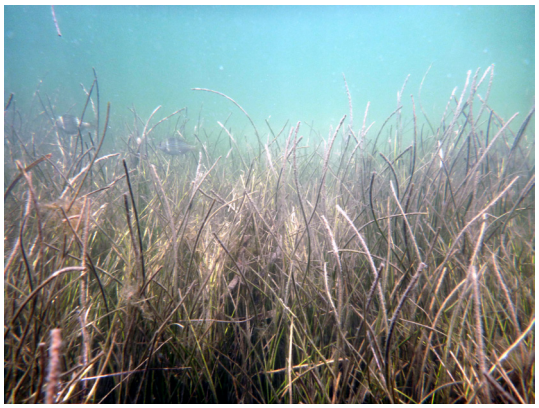
Figure 2.7. Oyster reef habitat in the Mission-Aransas Reserve.

Oyster reefs are one of the most threatened marine habitats on earth, with losses resulting from water quality degradation, coastal development, destructive fishing practices, overfishing, and storm impacts. However, there is hope that oyster restoration efforts and adaptive management can help to revitalize oyster populations. Several efforts have been conducted, or are underway, to restore oyster reefs within the Mission-Aransas NERR. In 2008, TNC deposited 200 cubic yards of oyster shell in Copano Bay as part of a pilot project to restore ecologically important oyster beds that are in decline in the Gulf of Mexico. The oyster shell was distributed over a one-acre area. Texas A&M University - Corpus Christi (TAMUCC) has also initiated several community-based oyster restoration projects along the shoreline of Goose Island State Park. The benefits of a constructed reef include the restoration of oyster reef that serves as the preferred settling area for oyster spat, as well as the associated diversity created by providing new reef habitat. The reef also provides critical information on the estimation of water filtration rates that aid in ecosystem management of the whole bay and ultimately the Gulf of Mexico. Researchers at TAMUCC have also developed an oyster restoration suitability index model and reef quality index model that characterizes locations in the Mission-Aransas Estuary based on their potential for successful reef restoration (Pollack et al., 2012). This tool has been used by TNC to identify additional restoration areas in Copano Bay.

Oyster, *Crassostrea virginica*

Seagrass Beds

Seagrass beds are critical habitats that influence the physical, chemical, and biological environments of coastal ecosystems (Wright and Jones, 2006). They provide numerous important ecological services to the marine environment (Costanza et al., 1997). Seagrasses stabilize sediments, which prevent erosion (Christiansen et al., 1981), act as biological indicators of ecosystem health and water quality (Dennison et al., 1993), and produce large amounts of organic matter that form the basis of the estuarine food web. Seagrasses also provide nursery habitat for commercially and recreationally important fishery species, as well as provide a direct food source for fish, waterfowl, and sea turtles (Beck et al., 2001).



Seagrass bed
Photo credit: Sara Wilson

Seagrass beds have seen an overall decrease in worldwide populations (Short and Wyllie-Escheverria, 1996) and it is believed that the Texas coast is experiencing similar trends (Pulich and White, 1991; Quammen and Onuf, 1993; Onuf, 1994). The decline in overall seagrass populations is thought to be attributed to several anthropogenic disturbances, including decreased water clarity due to dredging, nutrient loading, and mechanical damage from boating activities (Tomasko and Lapointe, 1991; Quammen and Onuf, 1993; Onuf, 1994; Short et al., 1995; Dunton and Schonberg, 2002; Uhrin and Holmquist, 2003).

Copano Bay and Aransas Bay within the Mission-Aransas NERR contain approximately 8,000 acres of seagrass beds. Copano Bay contains *Halodule* and *Ruppia* species, while Aransas Bay contains *Halodule*, *Ruppia*, *Halophila*, *Thalassia*, and *Syringodium* species (Pulich et al., 1997). The largest stand of seagrass

beds within the Mission-Aransas NERR occurs within Redfish Bay, which is near the Reserve's southernmost boundary (Figure 2.8). Redfish Bay contains all five major species of seagrass (*Halodule*, *Ruppia*, *Halophila*, *Thalassia*, and *Syringodium*). Harbor Island is another area of extensive area of seagrass beds within the Mission-Aransas Reserve. Redfish Bay and Harbor Island contain approximately 14,000 acres of seagrass beds (Pulich et al., 1997). Data indicates that total seagrass acreage within Redfish Bay has remained stable over the past forty years, despite local changes in seagrass bed distribution (Pulich and Onuf, 2003).

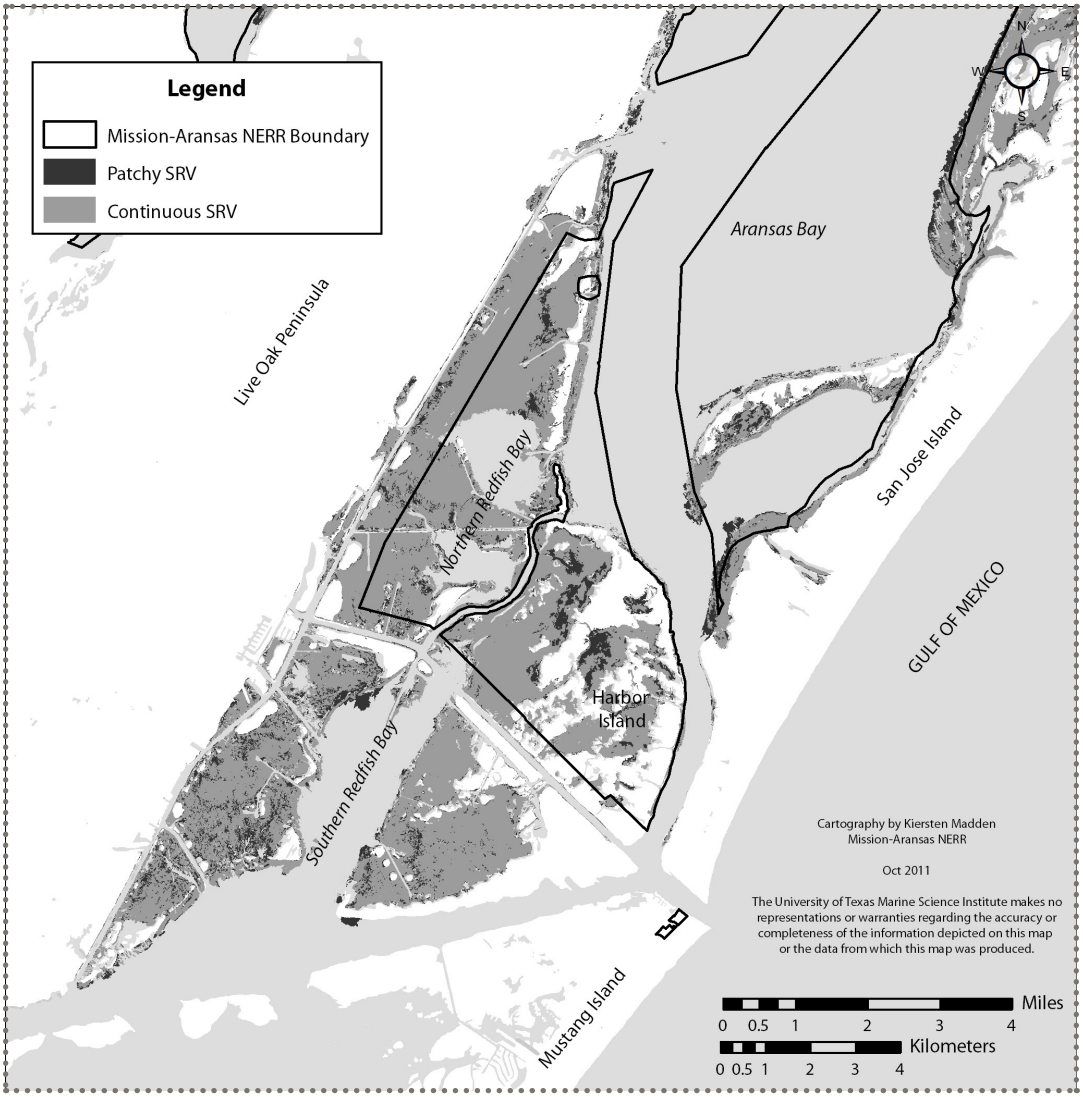


Figure 2.8. Seagrass meadows within the Redfish Bay area of the Mission-Aransas Reserve.

Past landscape analysis has shown that certain areas of Redfish Bay and Harbor Island show more impacts and loss of seagrasses (Pulich and Onuf, 2003). From the late 1950's to the mid- 1970's Redfish Bay showed a slight decrease in both patchy and continuous seagrass beds, while the nearby Harbor Island showed a substantial increase in both patchy and continuous seagrass beds. From the mid-1970s to 1994 Redfish Bay and Harbor Island had a decrease in continuous seagrass coverage, while both locations show an increase in patchy seagrass bed (Pulich and Onuf, 2003).

Seagrass coverage is believed to be in decline within Redfish Bay due mainly to bed fragmentation. In addition the accumulation of wrack, drift macroalgae, and epiphytes suggest water quality problems in the bay (Pulich and Onuf, 2003). Other areas of concern include increased input of nutrients from new development on the north side of Redfish Bay and the widespread physical damage of shallow beds from boat propeller scarring and navigation channel impacts (Dunton and Schonberg, 2002).

Water Column

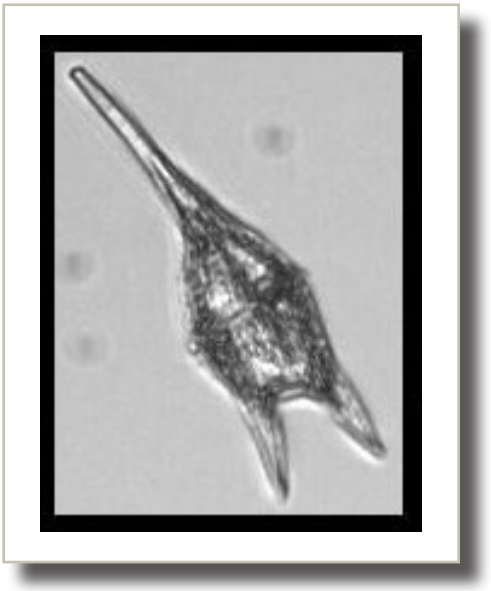
Plankton

Plankton are a diverse group of tiny organisms living in the water column, unable to swim effectively against currents. These organisms rely on water circulation to make substantial movement through the

estuary. Plankton are divided into two groups: autotrophic photosynthesizers known as phytoplankton and heterotrophic consumers known as zooplankton. As photosynthesizers, phytoplankton abundance can be used as a measurement of primary production in the estuary. Likewise, abundance of zooplankton can be considered a measurement of secondary production.

A large portion of the Mission-Aransas Reserve, including the majority of Mission, Aransas, and Copano bays is considered open bay habitat. Phytoplankton are the main source of primary production in this habitat. They serve an extremely important ecological function in open bay food webs by supplying carbon directly to pelagic consumers of higher trophic levels and indirectly as detritus to consumers in the benthic zone (Armstrong, 1987).

Spatial and temporal distribution of phytoplankton is not uniform in the Mission-Aransas Estuary as evidenced by variations in abundance or biomass (Longley, 1994). Phytoplankton abundance is often estimated from the level of chlorophyll found in the water column. Typically, chlorophyll concentrations are higher in the upper regions of the estuary (i.e., closer to the source of fresh water and nutrient discharge). Chlorophyll data collected from the System-Wide Monitoring Program supports this conclusion. Mesquite Bay, Copano Bay West, and Copano Bay East stations tend to have higher chlorophyll concentrations while the Ship Channel and Aransas Bay have lower concentrations (Evans et al., 2012).



***Ceratium* sp., a common dinoflagellate in the Mission-Aransas Reserve**
Photo credit: Jena Campbell

Although the distribution of phytoplankton changes over time, a three-year study of Corpus Christi, Copano, and Aransas bays found the general composition of local phytoplankton remained uniform (Holland et al., 1975). Phytoplankton include photosynthetic unicellular protists and bacteria (Johnson and Allen, 2005) and assemblages in open bay communities typically are composed of representatives from four major taxonomic groups: diatoms, dinoflagellates, green algae, and blue-green algae. Previous studies have determined the composition of phytoplankton species in the Mission-Aransas Estuary to be 63% diatoms, 18% dinoflagellates, and 11% green algae (Holland et al., 1975).

In most Texas estuaries, phytoplankton populations change with seasons. Diatoms dominate during winter and share dominance with dinoflagellates during summer months (Armstrong, 1987). A study of phytoplankton in Aransas Bay indicated diatoms to be the dominant flora, exhibiting a winter peak of *Coscinodiscus* sp. and a summer peak of *Rhizosolenia alata* (Freese, 1952). Green algae were found to be present year-round, experiencing spring or fall blooms (Armstrong, 1987). The temporal and spatial patterns displayed by phytoplankton are commonly associated with salinity and zooplankton grazing (Holland et al., 1975). The average chlorophyll level in the Mission-Aransas Estuary is approximately 6.6 μg L^{-1} (Evans et al., 2012).

Zooplankton species include both unicellular and multicellular organisms from a range of sizes and life history patterns. Zooplankton can be divided into the following three size categories: microzooplankton (20-200 μm; e.g., tintinnids, non-loricate ciliates, copepod nauplii, and protozoans); mesozooplankton (0.2-2.0 mm; e.g., copepods, rotifers, barnacle larvae, crab zoea, and mollusk veligers); and macrozooplankton (2.0-20 mm; e.g., jellyfish, ctenophores, shrimps, and larval fishes) (Tunnell et al., 1996; Johnson and Allen, 2005).

Zooplankton can also be divided into two life history modes. Holoplankton are individuals that remain planktonic for their entire lives and include such organisms as copepods, cladocerans, and chaetognaths.

Meroplankton spend only a portion of their lives in a planktonic stage (typically during the larval development), after which they join the free-swimming nekton or benthic assemblages. Examples of meroplankton include larval fish, crabs, shrimp, worms, and mollusks (Armstrong, 1987; Johnson and Allen, 2005). Economically important local species that spend time as meroplankton include brown shrimp, blue crab, white shrimp, grass shrimp, and oysters.

Microzooplankton abundance in Texas estuaries is 30-60 million m^3. High abundance can be attributed to the rapid generation times of microzooplankton, which are typically on the order of days. Quick reproduction strategies allow these organisms to respond rapidly when environmental conditions are favorable. Large populations can be established that can greatly influence nanophytoplankton (<20 µm) standing crops through grazing, making microozooplankton a significant component of water column secondary production (Stockwell, 1989; Buskey, 1993).

Mesozooplankton populations inhabiting the Mission-Aransas NERR are dominated by the copepod species *Acartia tonsa*, *Parvocalanus crassirostris*, *Pseudodiaptomus coronatus*, *Oithona* spp., along with barnacle nauplii (Holland et al., 1975). The calanoid copepod, *Acartia tonsa*, dominates zooplankton assemblages throughout the Reserve, making up 40-60% of the population (Holland et al., 1975; Buskey, 1993). Stable populations of this euryhaline species are typically present year-round in a range of salinities, with lowest abundances occurring at times of extremely low salinity (Holland et al., 1975; Johnson and Allen, 2005). The cyclopoid copepod, *Oithona* spp., exhibits peaks during the warmer months of spring and summer in Copano and Aransas bays (Holland et al., 1975; Tunnell et al., 1996). These copepods prefer high salinities and feed on dinoflagellates during early life stages, but upon reaching maturity they become carnivorous (Johnson and Allen, 2005). *Parvocalanus crassirostris*, an herbivorous calanoid copepod, also favors high salinities (Johnson and Allen, 2005). This species is unable to establish large populations in Copano Bay due to low salinity conditions; however, large abundances are present in both Corpus Christi Bay and Aransas Bay, displaying no seasonal patterns (Holland et al., 1975). The calanoid, *Pseudodiaptomus coronatus*, flourishes during spring, summer, and fall, but abundance decreases in the winter months (Holland et al., 1975). Barnacle nauplii, which represent meroplankton, are abundant throughout the year in the Mission-Aransas Estuary, displaying highest abundances during the cold winter months (Holland et al., 1975; Buskey, 1993).

Copepods
Photo credit: Matt Wilson/Jay Clark, NOAA National Marine Fisheries Service

Depending on season, *Centropages furcatus*, *Centropages hamatus*, and *Noctiluca scintillans* are neritic species of zooplankton that can commonly be found in the Mission-Aransas Estuary. *Centropages furcatus* is a warm water, stenohaline species present primarily in Aransas Bay and lower Corpus Christi Bay. *Centropages hamatus* is a cool water, euryhaline species that has been found throughout Corpus Christi, Copano and Aransas bay systems in high abundances during cold winter months (Holland et al., 1975). Both of these species are calanoid copepods that eat large phytoplankton, ciliates, larval copepods, and larval mollusks (Johnson and Allen, 2005). *Noctiluca scintillans* is a dinoflagellate, but functions as a heterotroph consuming diatoms, dinoflagellates, copepod eggs, and possibly fish eggs (Johnson and Allen, 2005). This species is not well established in either Copano or Aransas bays (Holland et al., 1975), but is often present in samples collected from the Aransas Pass Ship Channel (Buskey, 1995; Hyatt, unpublished data).

Macrozooplankton (e.g., jellyfish and ctenophores), are the largest size group of zooplankton. Most jellyfish are predatory pelagic cnidarians, using an array of nematocysts to catch planktonic or nektonic prey items. Common representatives in nearshore coastal waters belong to the class Scyphozoa. The most abundant jellyfish inhabitant of Texas bays is the large cabbagehead, *Stomolophus meleagris*, which enters through tidal inlets during late summer and early fall. Ctenophores, known as comb jellies, are transparent, gelatinous planktonic predators that utilize eight rows of cilia to move through the water. During the summer months, *Mnemiopsis leidyi*, a brightly luminescent, carnivorous ctenophore, is also found in Texas coastal waters (Britton and Morton, 1989).

Nekton

The term nekton refers to the group of aquatic organisms that are able to move independently of water currents (Day et al., 1989). This group of organisms consists primarily of fishes, but can also include organisms such as squid, crabs, lobsters, shrimp, and seals (Day et al., 1989). Nekton are a key component in all aquatic ecosystems and estuaries contain the greatest biomass of higher trophic levels of fishes (Woodwell et al., 1973; Haedrich and Hall, 1976). Estuaries are extremely productive and support many nekton species. Types of species that live in these areas include oceanodromous (migrate to other parts of the ocean), diadromus (use both marine and freshwater habitats during their life cycle), anadromous (live mostly in the ocean but spawn in fresh water), and amphidromous (travel between fresh and salt water) (Day et al., 1989; Beck et al., 2001).

Nekton are distributed in three different environmental zones: shallow, pelagic, and bottom (Day et al., 1989). Shallow water nekton include small adult fishes (e.g., killifish), pelagic zone nekton include larger predatory fishes (e.g., Atlantic croaker), and bottom nekton species are flatfish (e.g., flounders) and catfish (Day et al., 1989). The majority of the nekton community is estuarine dependent, relying on the estuary for food and shelter during at least one portion of their lifecycle. Typically, adults spawn offshore, larvae are transported back into the estuary, metamorphose, grow to subadult stages, and finally, subadults move to adult habitat to restart the cycle (Gunter, 1967; Day et al., 1989; Beck et al., 2001). Common species of nekton in the Mission-Aransas NERR include: red drum, black drum, southern flounder, spotted seatrout, blue crab, Kemp's Ridley sea turtle, green sea turtle, shrimp, and bottlenose dolphins.

Red drum, *Sciaenops ocellatus*
Photo credit: Chase Stanzel

Red drum (*Sciaenops ocellatus*) is a popular game fish in coastal waters ranging from Massachusetts to Mexico. Distinguished by one large black spot on the upper part of the tail base, red drum can be found in shallow waters along bay edges, preferring areas with submerged vegetation. These fish live in bays for the first three years of life and migrate to the Gulf of Mexico as adults where they spawn from mid-August through mid-October. Young red drum feed on small invertebrates and as they grow feed on large crabs, shrimp, and small fish.

Black drum (*Pogonias cromis*) is an important recreational and commercial fishery from Nova Scotia to Florida, the Gulf of Mexico, and the southern Caribbean coast. They are silvery grey to very dark in color and juveniles have four or five vertical bars on their sides that disappear with growth. Black drum are usually associated with sand and sandy mud bottoms in coastal waters, and feed mainly on crustaceans, mollusks, and fishes.

Southern flounder (*Paralichthys lethostigma*) is an estuarine dependent species distributed from North Carolina to Florida on the Atlantic Coast and from Florida to Northern Mexico in the Gulf of Mexico. It is an important commercial and recreational fishery that is declining due to habitat loss and overfishing. Southern flounder remain within the estuary during the majority of their lifespan, only leaving in late fall (at age two when mature) to go offshore for spawning. Recruits return to the estuary in late January. Their diet consists of other fishes, crabs, and shrimp.

Spotted seatrout, *Cynoscion nebulosus*
Photo credit: Chase Stanzel

Spotted seatrout (*Cynoscion nebulosus*) is another important recreational and commercial fishery distributed from Massachusetts to the Yucatan peninsula. Seatrout prefer shallow bays and estuaries around oyster reefs and seagrass beds. This species has dark gray or green coloration on their back and distinct round spots on their back, fins, and tail. Their primary prey varies with size (i.e., small spotted seatrout feed on small crustaceans, medium size seatrout feed on shrimp and small fish, and large seatrout feed exclusively on other fish). Alligator gar, striped bass, Atlantic croaker, tarpon, and barracuda are their primary predators. They spawn from May to July between dusk and dawn within coastal bays in grassy areas, which provide cover from predators. As temperatures fall, the fish move to deeper bay waters and the Gulf of Mexico.

Blue crab, *Callinectes sapidus*

Blue crabs (*Callinectes sapidus*) are a common estuarine crustacean. The shell is approximately 17 cm (7 in) wide by 10 cm (4 in) long. They are dark or brownish green with a large spine on each side. They are found along the east coasts of North and South America as well as the Gulf of Mexico. Blue crabs are predators that feed on clams, oysters, mussels, plant and animal matter, as well as freshly dead or young crabs. Predators are red drum, Atlantic croaker, herons, sea turtles, and humans. Most importantly, they are a major prey source for the endangered Whooping Crane (*Grus americana*). Whooping Cranes migrate to ANWR during winter months where they feed primarily on blue crab. Low abundance of blue crabs has been reported as a major threat to the survival of Whooping Cranes.

Major commercial fisheries for blue crabs exist along the Atlantic and Gulf Coasts, making it the largest crab fishery in the U.S. (NMFS, 2009). In 2013, U.S. landings totaled over 60,000 metric tons for a wholesale value of over $185 million (NMFS, 2015). In 2013, Texas blue crab landings totaled 863 metric tons for a value of $2.3 million (NMFS, 2015). Many states including Texas (Sutton and Wagner 2007) have seen declines in blue crab populations in recent years. Data from TPWD Coastal Fisheries Resource Monitoring Program has shown a general decline in catch rate of blue crabs in all Texas bays, including the San Antonio Bay and Mission/Aransas Bay systems over the past 20 years.

Kemp's Ridley sea turtles (*Lepidochelys kempii*) are an endangered species found in the bays of the Gulf of Mexico and Atlantic Ocean. They are primarily located in the open ocean and gulf waters but the females come to shore to lay their eggs in beach sand. The females come back to the same beach every year to lay their eggs. Kemp's Ridley sea turtles grow to 67 to 81 cm (27-32 in) and weigh on average 34 to 45 kg (75-100 lbs). Their diet consists of crabs, shrimps, snails, clams, sea jellies, sea stars, and fish. Their primary predators are humans due to hunting, boat propellers, nets, and refuse.

Green sea turtles (*Chelonia mydas*) can be found throughout the world. They are considered endangered in Florida waters and the Pacific coast of Mexico and are threatened in the remainder of their distribution. Adults grow to approximately 1.3 m (51 in) long and weigh 113 to 204 kg (250 to 450 lbs). They are herbivores and feed primarily on seagrasses and marine algae. The females begin nesting onshore from June through October. The primary concern for green sea turtles is consumption of their meat and eggs as a food source for humans.

Green sea turtle, *Chelonia mydas*
Photo credit: National Park Service, Padre Island National Seashore

Bottlenose dolphins (*Tursiops truncatus*) are the most common cetacean of the Gulf of Mexico and along the Texas coast. Bottlenose dolphins may reach 3.4 m (11 ft) and may be seen in large groups or smaller social units of 2 to 15. In Texas waters they eat fishes including, but not limited to, tarpon, sailfish, sharks, trout, pike, rays, mullet, and catfish. They consume 18 to 36 kg of fish each day. Other species of dolphin found in the area include spinner dolphins (*Stenella longirostris*), Atlantic spotted dolphins (*Stenella frontalis*), and Risso's dolphins (*Grampus griseus*).

The Texas shrimp fishery is an extremely large industry, consisting of white, brown, and pink shrimp. White shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), and pink shrimp (*Penaeus duorarum*) are distributed along the western Atlantic Ocean, throughout the Gulf of Mexico, and brown and pink shrimp are found around the Yucatan Peninsula. All three species have similar life cycles; they spawn in the Gulf of Mexico and are found within estuaries and bays as juveniles. The three species together comprise more than 99% of the commercial landings in the Gulf of Mexico shrimp fishery. Annual landings vary considerably from year to year and these fluctuations have been attributed to environmental influences (i.e., severe winter weather) (GSA BBEST, 2011).

White shrimp, *Penaeus setiferus*
Photo credit: North Inlet-Winyah Bay NERR

Artificial Substrate

Artificial substrate is used in the marine environment for economic, recreational, and safety purposes (e.g., oil rigs, surf breaks, sea walls). The substrate is constructed out of materials that have the capacity to withstand the erosive and corrosive forces present in a high-energy saline environment. The ecological

impact of artificial substrate has long been a topic of discussion because of the fish attracted to these features for food or habitat and the possibility of exploiting these stocks for economic and recreation purposes.

Early studies of artificial substrate observed fish aggregating near sunken ships and other man-made structures that created reefs unintentionally (Bohnsack and Sutherland, 1985; Hixon and Beets, 1989). Along urbanized coasts, seawalls and concrete bulkheads have also been shown to create microhabitats which can enhance biodiversity in areas where natural patterns have been disrupted (Chapman and Blockley, 2009). In the Gulf of Mexico, the Texas Artificial Reef Program was designed to allow decommissioned oil platforms to be left in the Gulf and converted into artificial reefs. This program also developed provisions for the deployment of other types of artificial reefs to stimulate fish populations and improve fishing opportunities (Kaiser, 2006).

The construction and degree of complexity of the artificial structure affect species composition. Complexity (e.g., number of holes, variation in whole size, orientation of surfaces, and number of surfaces) is a factor that controls benthic and fish communities on large artificial reefs (Hixon and Beets,

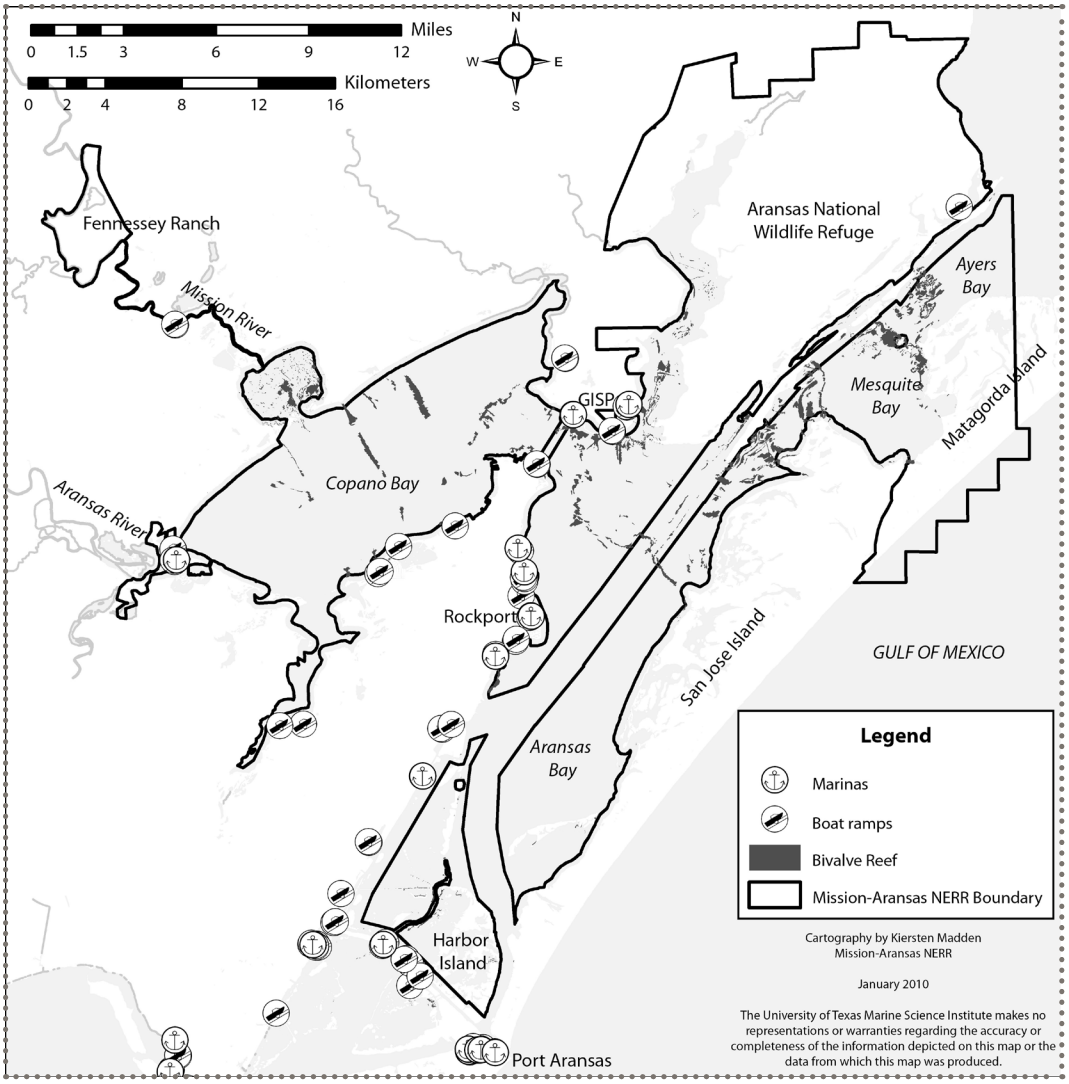


Figure 2.9. Location of oyster reefs and other types of artificial substrate within the Mission-Aransas Reserve.

Rocks are used to create seawalls and breakwaters in the Mission-Aransas Reserve

1989; Glasby and Connell, 2001). The type of material used in construction can also affect the species that settle on artificial structures. Generally, larvae prefer to settle on fibrous or porous surfaces rather than hard, smooth surfaces. Higher species abundances have been found on concrete and plywood when compared to aluminum and fiberglass (Anderson and Underwood, 1994). Shading created by artificial substrate can create microhabitats that affect benthic community structure and fish that use the shadows for predator avoidance (Glasby, 1998).

Differences in community composition on artificial reefs is also dependent on the type of organisms that live in the unconsolidated bottom, which serve as a food source for many pelagic species associated with reefs (Glasby and Connell, 2001). The benthic communities associated with different substrate types vary based on their location in the bay system. Differences arise from the range of sediment properties that occur naturally between bays. Therefore, variations in substrate can result in different composition of predators at artificial reefs located in different parts of the bay.

Artificial substrate is associated with coastal erosion protection structures, harbor/marina walls, boat ramps, hunting blinds, petroleum associated structures, and a few unintentionally sunken vessels that are exploited by the local fishing industry. The distribution of substrate types varies based on the intended purpose (i.e., long homogeneous structures along harbor walls and bulkheads or widely dispersed discrete structures such as oil and gas wells in the open bay). The most abundant substrate material in the area is concrete. Concrete is used within marinas, boat ramps, and on support structures for bridges and various platforms within the bay area. Marinas and boat ramps are located mainly on the western shore of Aransas Bay (Figure 2.9). Wood and metal are also present on structures but in lower abundance.

Estuarine Habitats

Estuarine Marsh

Estuarine marshes represent dynamic and biologically important habitats where freshwater mixes with saltwater. They are often subdivided into two groups based on salinity regime (i.e., saltwater and brackish marsh). Salt marsh receives daily tidal inundation and typically maintains salinities between 20 and 35 psu. Brackish marsh receives daily tidal inundation, as well as storm surge, but typically maintains lower salinities between 5 and 19 psu (Tunnell et al., 1996).

Smooth Cordgrass, *Spartina alterniflora*

Vegetation within estuarine marsh occurs in zones and primarily consists of salt-tolerant grasses; however, algae, phytoplankton, and woody perennials are also present and account for some of the primary productivity. Differing plant tolerances to changing water and soil salinity concentrations leads to zonation in these areas. Adaptations to survive in higher salt concentrations allow certain species to settle in a habitat that would otherwise be bare. Community composition can be explained by an inverse relationship between competition and abiotic stress (i.e., subordinate plants dominate stressful habitats while superior plants dominate habitats where abiotic stress is mild) (Pennings and Callaway, 1992; Greiner La Peyre et al., 2001; Forbes and Dunton, 2006).

In general, estuarine marshes along the Gulf of Mexico coast are found near river mouths, bays, lagoons, and on protected

coastlines (Mitsch and Gosselink, 1986). Based on the 2006 National Wetlands Inventory (NWI) data, there are 14,949 acres of estuarine marsh (excluding mangroves) inside the Mission-Aransas Reserve boundary (Figure 2.10). Within the Reserve boundary, the highest abundance of salt marsh occurs along the shorelines of ANWR (both St. Charles Bay and Aransas Bay) and at Mud Island. Salt marsh habitats are also found along much of the coastline directly adjacent to the Reserve boundary. Brackish marsh habitat is found in high abundance adjacent to the Reserve boundary as well, with the highest concentrations in the tidal creeks and tributaries of Port Bay (small bay off of south side of Copano Bay) and adjacent to the Mission River and Aransas rivers (Figure 2.10).

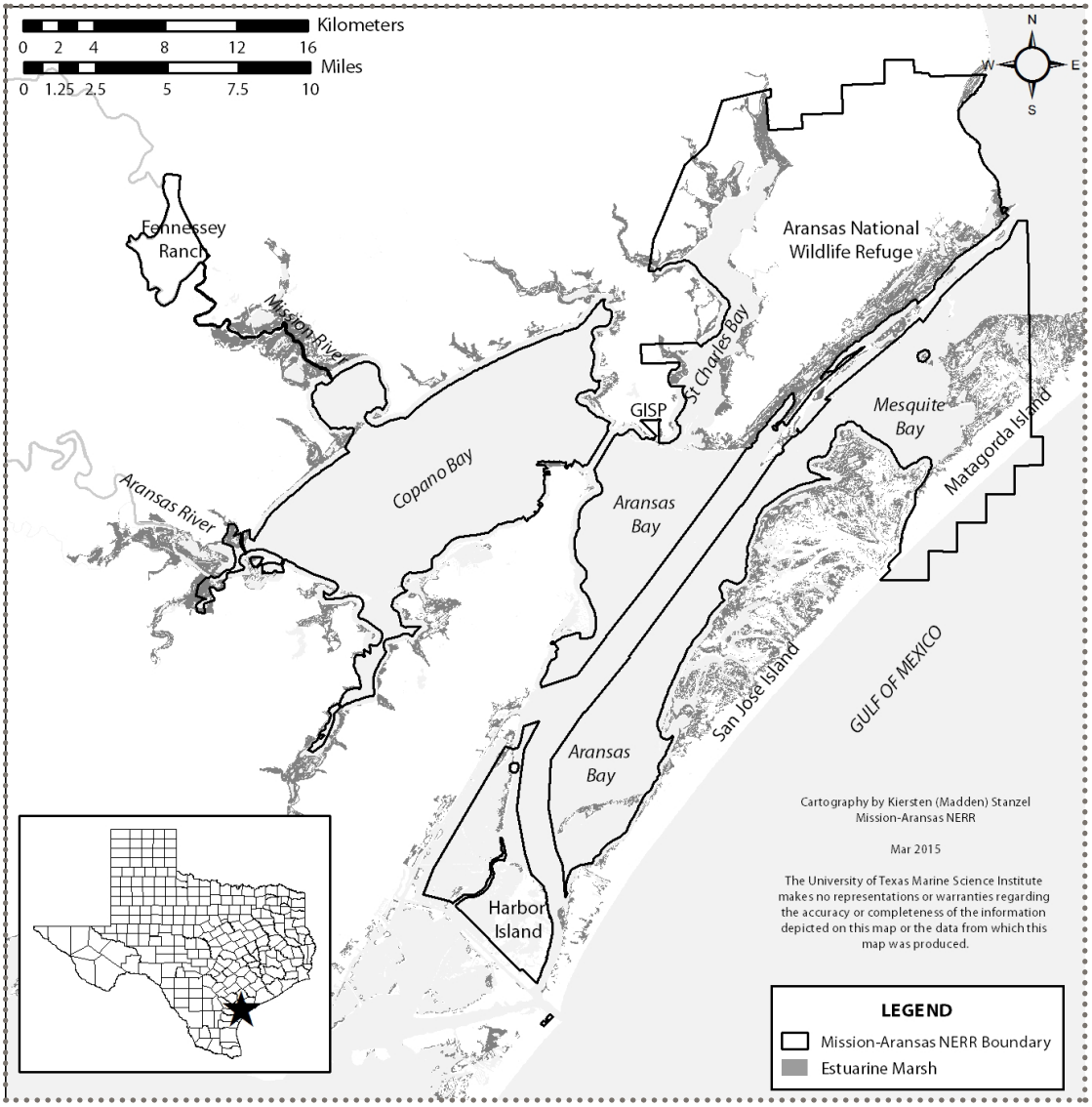


Figure 2.10. Locaion of estuarine wetlands within the Mission-Aransas Reserve.

Estuarine marshes are highly productive habitats that support diverse plant and animal communities. At low elevations, marsh habitats within the Reserve are dominated by monotypic stands of smooth cordgrass (*Spartina alterniflora*). Turtleweed (*Batis maritima*), dwarf glasswort (*Salicornia bigelovii*), perennial glasswort (*Salicornia perennis*), and Gulf cordgrass (*Spartina spartinae*) are also found at low elevations. Saltgrass (*Distichlis spicata*) is typically found at slightly higher elevations. The higher elevations along the bay side of San Jose and Matagorda Islands, as well as the Aransas Bay and St. Charles Bay shorelines of ANWR, also have *Batis maritima*, *Borrichia* sp., *Monanthochloe* sp., *Suaeda* sp., and *Distichlis spicata* (Brown et al., 1976).

Common invertebrate species found in the saltwater wetlands of the Mission-Aransas Estuary include polychaetes *Mediomastus californiensis* and *Streblospio benedicti*. *Paraprionospio pinnata* is the dominant polychaete of Aransas Bay and *Glycinde solitaria* and *Paraprionospio pinnata* are dominate in Copano Bay (Calnan et al., 1983). Dominant mollusks are *Macoma mitchelli* and *Mulinia lateralis*, and the dominant

crustacean is *Lepidactylus* sp. Consumers within these habitats include the ribbed mussel (*Geukensia demissa*), salt marsh periwinkle (*Littorina irrotata*), fiddler crabs (*Uca pugnax*), Virginia Rail (*Rallus limicola*), King Rail (*Rallus elegans*), and the Clapper Rail (*Rallus longirostris*) (Stewart, 1951; Kerwin, 1972; Tunnell et al., 1996). Other common species in marsh ecosystems include killifish (*Fundulus* sp.), mullet (*Mugil cephalus*), silversides (*Menidia menidia*), American Egrets (*Ardea alba*), Snowy Egrets (*Egretta thula*), and Great Blue Herons (*Ardea herodias*).

Table 2.1. Total area of estuarine marsh in the 1950s, 1979, and 2004 in the CBBEP program area (Tremblay et al., 2008).

Year	Value in ha (acres in parenthesis)
1950's	8,856 (21,874)
1979	11,749 (29,020)
2004	10,821 (26,728)

The distribution of estuarine marsh appears to be increasing within the Texas Coastal Bend area (Table 2.1). In 2004 the CBBEP program area, which contains the Mission-Aransas Estuary contained 10,821 ha of estuarine marsh, with large distributions along the Copano Bay mainland, Lamar peninsula, Mission River, Aransas River, Live Oak Peninsula, Redfish Bay, Nueces River Delta, Corpus Christi Bay, Oso Bay, and Encinal peninsula. Estuarine wetlands experienced an increase in total area from the 1950's to 1979, followed by a decrease in area from 1979 to 2004. Overall there was a total net gain of 1,956 ha in the CBBEP area from the 1950's (Tremblay et al., 2008). The increase in marsh area has occurred where tidal flats or palustrine marsh have been converted as the saltwater wedge migrates up rivers due to fluid extraction and subsequent rates of local sea level rise (Tremblay et al., 2008).

Tidal Flat

Tidal flats are sand or mud areas found in estuaries that typically lack any recognizable plant life. They are neither terrestrial nor aquatic and are harsh, unpredictable environments (Dilworth and Withers, 2010). Tidal flats are periodically exposed to arid climates, flooded by marine waters, and receive sediments surficially and interstitially from land and sea (Morton and Holmes, 2009). Along the Texas coast, tidal flats are typically called "wind-tidal flats" because wind, rather than tides, causes them to be flooded or exposed (Dilworth and Withers, 2010).

Wind-tidal flats are a dominant coastal habitat type in South Texas (Onuf, 2006). Tidal flats are common in the central and southern coast of Texas because of regional climate and hydrology (i.e., little freshwater inflow from rivers and low precipitation) (Onuf, 2006; Dilworth and Withers, 2010). From Corpus Christi Bay south through the Laguna Madre to the mouth of the Rio Grande, there are only 8 km^2 of coastal marsh as compared to 960 km2 of wind-tidal flats (Onuf, 2006). Wind-tidal flats are also abundant in the Mission-Aransas NERR (approximately 3,350 acres within the Reserve boundary according to 2006 NWI data) and can be found along the bay side of San Jose and Matagorda Islands, Cedar Bayou, deltas of the Mission and Aransas rivers, and scattered along the bay margins of Copano and Redfish bays (Figure 2.11).

Tidal flat

The flats may appear to be barren wastelands but they are highly productive areas that support large numbers of animals, particularly shorebirds. In fact, these are the most significant feeding areas for aquatic bird life on the Gulf Coast (Withers and Tunnell, 1998) and they function as essential habitat for a suite of rare and endangered bird species, such as the Piping Plover (Figure 2.11). Large areas of the flats are typically covered in dense mats of blue green algae that support a large array of consumers. This filamentous alga provides food for

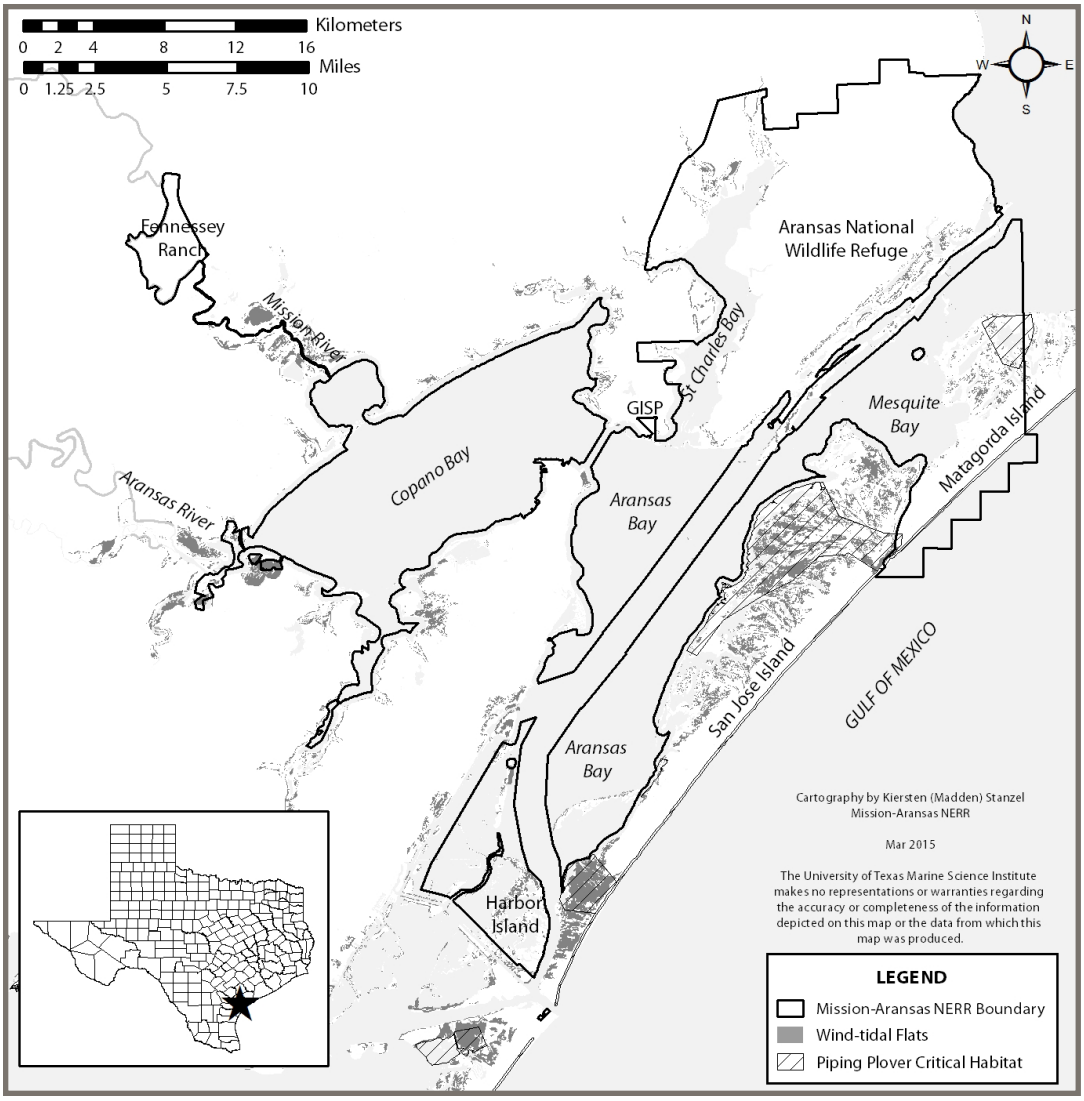


Figure 2.11. Location of tidal flats within the Mission-Aransas NERR.

dense invertebrate assemblages that support Piping Plovers. In turn, the plover populations support Peregrine Falcons on their only staging area in the US during spring migration (Withers and Tunnell, 1998; Zonick, 2000). When flooded, fish exploit the flats, and the tidal flats then become principal foraging areas of threatened Reddish Egrets (Onuf, 2006).

There are several types of anthropogenic impacts that affect the structure and function of wind-tidal flats. The use of off-road vehicles creates scars and damages benthic infaunal and epifaunal organisms. This also alters organic matter recycling, resulting in lower nutrient levels in sediments. Off-road vehicle tracks can even alter natural hydrology by channeling water, which can lead to increased runoff and erosion (Martine et al., 2008). Use of off-road vehicles in wind-tidal flats is all too common at the Padre Island National Seashore, located just south of the Mission-Aransas NERR. Photography and image analysis techniques have been used to examine the persistence and recovery of the flats from vehicle tracks. Results showed that these areas have sustained considerable damage, and vehicle tracks can persist for at least 38 years (Martine et al., 2008). Interrupting the natural flow of water between bays and wind-tidal flats can also cause serious effects, such as succession to other types of habitat. Disposal of dredged material along navigation channels can alter the flow of water and change habitat characteristics by providing a good environment for succulent vascular plants to colonize (Onuf, 2006).

On the low-lying Texas coast, local sea level rise is a major concern for tidal flats. If the flats become more frequently flooded, rates of blue green algae aggregation will slow, reducing primary production. Eventually the flats will become permanently submerged thereby diminishing this valuable habitat (Morton and Holmes, 2009). A major decrease has been observed in tidal flat size within the CBBEP program area, which includes the Mission-Aransas Estuary. A net decrease of 6,551 ha has been observed between the 1950's and 2004 for the entire CBBEP area. This decrease is attributed, at least partially, to sea level rise and the transition of tidal flats to estuarine wetlands and seagrass beds (Tremblay et al., 2008).

Mangrove

Mangroves are littoral plants that occur on tropical and subtropical coasts worldwide. These woody plants grow at the interface between land and sea, where they endure high salinity, extreme tides, strong winds, high temperatures, and muddy, anaerobic soils (Montagna et al., 2009). Mangrove habitats are among the world's richest repositories of biological diversity and primary productivity (Tomlinson, 1986). Mangrove habitats help maintain coastal diversity, serve as coastal protection, provide refuge for many species, and serve as a nursery ground for commercially important fisheries. Black mangrove stands are usually interspersed with marsh plants such as *Spartina* spp., *Salicornia* spp., and *Batis* spp. (Sherrod and McMillian, 1981). In the Gulf of Mexico, there are four species of mangrove that exist: red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*), and button mangrove (*Conocarpus erectus*) (Sherrod and McMillan, 1981).

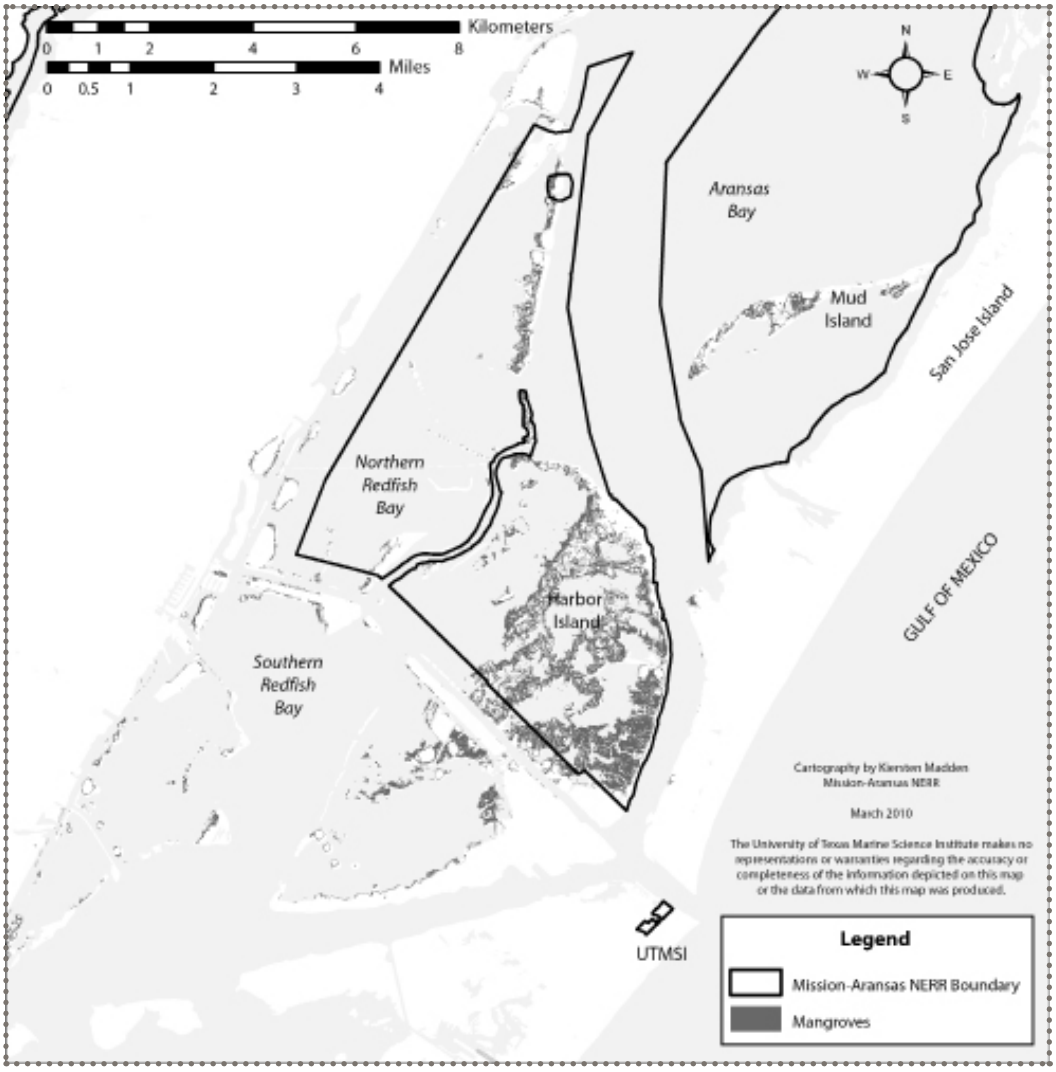


Figure 2.12. Primary location of mangroves in the Mission-Aransas Reserve.

Black mangrove is the primary species found in Texas and is recognized as the only native woody vegetation of the marsh-barrier island ecosystem. This species grows to approximately six feet high (Pulich and Scalan, 1987; Judd, 2002; Tunnell, 2002; Withers, 2002). On the Texas coast, there are four primary populations: Port Isabel, Harbor Island, Port O'Connor, and Galveston Island (Sherrod and McMillian, 1981). According to the NWI data, Harbor Island contains approximately 1,495 acres of dense stands of mangrove. In the Mission-Aransas NERR, black mangroves are also found in scattered stands on bay margins and islands in Redfish and Aransas Bay, as well as along the bay-side of

Black mangrove, *Avicennia germinans*

Matagorda and San Jose Islands (Sherrod, 1980). The total distribution of mangroves within the Reserve boundary is estimated to be 1,534 acres (Figure 2.12).

Temperature and salinity are the main factors limiting the distribution and survival of black mangroves. Black mangrove is the only mangrove species known to be tolerant Texas winters (Sherrod and McMillan, 1981; Tunnell, 2002). Different climatic periods have had a large influence on mangrove populations during the past two centuries. For example, historical evidence suggests that black mangrove populations expand and contract due to fluctuations in freezing temperatures (Sherrod and McMillian, 1981, 1985; Everitt and Judd, 1989; Everitt et al., 1996). A large freeze in 1989 decreased abundance of black mangrove stands in South Texas, but since then populations have recovered (Everitt et al., 1996). Anthropogenic disturbances, such as modifications of habitat due to dredging and channel construction have also been responsible for a decrease the abundance of mangrove populations (Montagna et al., 2009).

Red mangrove, *Rhizophora mangle*
Photo credit: Kim Jackson, UTMSI

Red mangroves have been observed in low numbers on the southern coast of Texas since 1983 (Tunnell, 2002). Extreme storm events, such as hurricanes, transport propagules to the Texas coast and facilitate the invasion of red mangroves. Since the 2005 hurricane season, individual red mangrove plants have been observed in bays between South Padre Island and Matagorda Island (Montagna et al., 2007). The northernmost occurrence of red mangrove is in St. Johns County, Florida on the Atlantic Ocean side suggesting that all mangrove species are expanding their ranges northward (Zomlefer et al., 2006).

Freshwater Habitats

Freshwater Wetlands

Freshwater wetlands at ANWR

Palustrine, or freshwater, wetlands represent transitional areas between terrestrial and freshwater aquatic environments (Batzer and Sharitz, 2006). They are non-tidal aquatic habitats with salinity between 0 - 0.5 psu and are dominated by trees, shrubs, and persistent hydrophytic vegetation (Tunnell et al., 1996; Smith and Dilworth, 1999). Freshwater wetlands may receive tidal inundation, but only during extreme storm surges (i.e., hurricanes that increase water levels but typically do not alter salinity levels) (Tunnell et al., 1996). Palustrine wetlands are often categorized into three groups: forested, scrub/shrub, and emergent. Palustrine forested wetlands are comprised of perennial woody plants > 5 m tall, scrub/shrub wetlands consist of perennial woody plants < 5 m tall, and emergent wetlands are dominated by annual or perennial herbaceous plants (NOAA, 2009). Based on the 2006 NWI data, the dominant type of freshwater wetland found in the Mission-Aransas NERR boundary is palustrine emergent (16,821 acres). Palustrine forested and scrub/shrub wetlands are also present, but in smaller numbers (1,367 acres).

Palustrine wetlands can be found along the Copano Bay mainland, Fennessey Ranch (i.e., Fennessey Flats and McGuill Lake), along the Aransas and Mission rivers, and throughout ANWR (Figure 2.13).

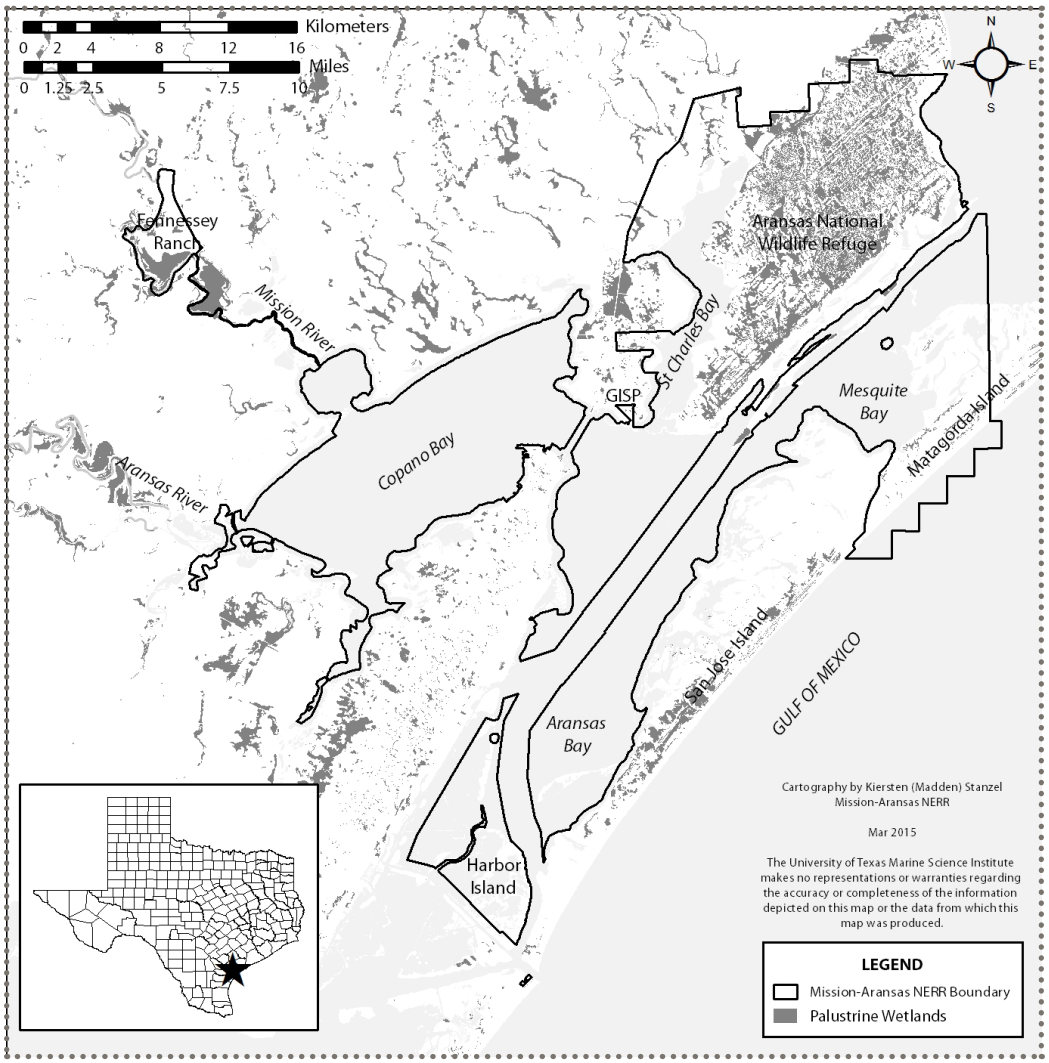


Figure 2.13. Location of palustrine wetlands in the Mission-Aransas Reserve.

Vegetation within palustrine wetlands represents a wide variety of emergent species, the type of which depends on a number of environmental factors, including, but not limited to, latitude, nutrient availability, and soil salts (Mitsch and Gosselink, 1986). The primary species of emergent vegetation in the Mission-Aransas Reserve are: seashore paspalum (*Paspalum* spp.), southern cattail (*Typha domingensis*), three-square bulrush (*Schoenoplectus pungens*), spikerush (*Eleocharis* spp.), coastal water-hyssop (*Bacopa monnieri*), salt marsh camphor-weed (*Pluchea purpurascens*), Gulf cordgrass (*Spartina spartinae*), sea ox-eye (*Borrichia frutescens*), saltmeadow cordgrass (*Spartina patens*), flatsedge (*Cyperus* spp.), coastal-plain penny-wort (*Hydrocotyle bonariensis*), frog fruit (*Phyla* sp.), spiny aster (*Aster spinosus*), panic (*Panicum* spp.), smartweed (*Polygonum* sp.), bushy bluestem (*Andropogon glomeratus*), and Bermuda grass (*Cynodon dactylon*) (Tremblay et al., 2008). Other common primary producers include sedges (*Carex* spp.) and slough grass (*Beckmannia syzigachne*) (Brown et al., 1976).

Most scrub/shrub and forested palustrine wetlands occur along rivers, bayous, and creeks, on the margins of reservoirs, and in small depressions. Within the Texas Coastal Bend, palustrine scrub/shrub wetlands are typically characterized by black willow (*Salix nigra*), retama (*Parkinsonia aculeata*), huisache (*Acacia smalli*), rattlebush (*Sesbania drummondii*), and salt cedar (*Tamarix* spp.). Palustrine forested wetlands include a large mixture of tree species, such as black willow, retama, huisache, ash (*Fraxinus* spp.), cedar elm (*Ulmus crassifolia*), hackberry (*Celtis* spp.), and anacua (*Ehretia anacua*) (Tremblay et al., 2008).

Invertebrate communities within freshwater wetlands change with the changing water level. During periodic droughts isopods dominate, but as water level rises and subsequent emergent vegetation surfaces, amphipods, chironomid larvae, and other insect larvae dominate. As water levels continue to rise, emergent vegetation gives way to floating aquatic plants and copepods dominate (Craft, 2001).

Major consumers found in freshwater marshes typically include the Virginia Rail (*Rallus limicola*) and King Rail (*Rallus elegans*) (Tunnell et al., 1996), while alligator gar (*Atractosteus spatula*) and common carp (*Cyprinus carpio*) are among the dominant freshwater fishes (TPWD, 2009).

Freshwater wetlands face severe threats from agriculture, urban development, and climate change (Shine and Klemm, 1999; Kundzewicz et al., 2007). In 2004, the CBBEP program area contained approximately 5,630 ha of palustrine wetlands, with a large distribution along the Copano Bay mainland and the Mission River Valley. This represents a 20% decrease in the extent of freshwater marshes within this area since the 1950's, and the margin of decline appears to have grown in more recent years (Table 2.2). The Lamar Peninsula, located directly adjacent to the Mission-Aransas Reserve, has seen some of the most significant losses (77% decline) of palustrine wetlands. Construction of drainage ditches, in addition to a long term drought, may account for this loss, as well as an increase in sea level and expansion of saltwater marshes around Copano Bay (Tremblay et al., 2008).

Table 2.2. Total area of palustrine marsh in the 1950s, 1979, and 2004 in the CBBEP program area (Tremblay et al., 2008).

Year	Value in ha (acres in parenthesis)
1950's	8,489 (20,968)
1979	7,120 (17,586)
2004	5,630 (13,906)

Riparian Woodlands

Riparian woodlands are found along rivers and streams. These woodlands are communities of tall trees with a dense to sparse understory. Periodic flooding is a common event in riparian woodlands, and the many species which inhabit these areas are adapted to these episodic events. Most of the dominant woody plant species have deep root systems that anchor the plant in place, and some have flexible stems that allow the plant to bend with current and recover after the flooding recedes.

Riparian woodland understory at Fennessey Ranch

The understory is usually composed of dwarf palmetto (*Sabal minor*) and common trees are anaqua (*Ehretia anacua*), cedar elm (*Ulmus crassifolia*), live oak (*Quercus virginiana*), pecan (*Carya illinoinensis*), sugar hackberry (*Celtis laevigata*), net-leaf hackberry (*Celtis reticulata*), Mexican ash (*Fraxinus berlandieriana*), and black willow (*Salix nigra*) (Tremblay et al., 2008).

The animals found in riparian forests are adapted to periodic flooding. Many species only tolerate it, while others require it to complete their lifestyles. Examples of animals found in the riparian woodlands include the Green Kingfisher (*Chloroceryle americana*), Ringed Kingfisher (*Megaceryle torquata*), Mexican treefrog (*Smilisca baudinii*), Rio Grande chirping frog (*Eleutherodactylus cystignathoides*), Rio Grande river cooter (*Pseudemys gorzugi*), ocelot (*Leopardus pardalis*), and jaguarundi (*Puma yagouaroundi*) (Jacob et al., 2003).

Riparian zones are important in ecology, environmental management, and engineering because of their role in soil conservation, biodiversity, and influence on aquatic ecosystems. This zone serves as a natural biofilter by protecting aquatic environments from excessive sedimentation, runoff, and erosion. These areas are also very important stopovers for migrating birds. The riparian forest along the Mission River is a vector for migrant landbirds moving inland in spring. During migration, the trees vibrate from the sound of hummingbirds feeding on turk's cap and hawking insects. Other migrant birds found along the Mission

River include Ringed Kingfishers, Green Jays, hawks, kites, and falcons (Smith and Dilworth, 1999).

Riverine

The Texas landscape has 15 major rivers that play a role in protecting water quality, preventing erosion, and providing nutrients and habitat for fish and wildlife. The rivers and streams flow into seven major estuaries, supporting over 212 reservoirs, countless riparian habitats, wetlands, and terrestrial areas. Each year Texas Rivers provide recreational opportunities to millions of people.

The Mission and Aransas rivers supply freshwater to the Mission-Aransas Estuary. These rivers are small and primarily coastal compared to other rivers in Texas. The Aransas River drains 536 mi^2 of the coastal prairie of south Texas, and the Mission River drains 488 mi^2. The rivers are gentle sloping streams with pools and few riffles. Only a few tributaries to these rivers are perennial streams, most are intermittent and seasonal (TNRCC, 1994). Significant creeks include the Medio Creek, Poesta Creek, West Aransas Creek, Blanco Creek, Copano Creek, and Artesian Creek. The creeks and rivers are all relatively short streams that flow slowly through shallow river beds, riparian wetlands, and salt marshes to empty into Hynes Bay, St. Charles Bay, Mission Bay, Aransas Bay, and Redfish Bay (GSA BBEST, 2011). No dams or surface water supply structures are constructed and neither river is used for city water supplies in the region. Stream flow from these rivers is generally low with the highest pulses of freshwater occurring due to rainfall events.

Mission River flood event showing inundation of adjacent riparian woodlands and prairie wetlands

Upland Habitats

Coastal Prairie

The coastal prairie found along the Western Gulf Coast in southwest Louisiana and southeast Texas is the southernmost portion of the tallgrass prairie system of the Midwest. It is estimated that over nine million acres of prairie once existed in these areas. However, less than one percent remains today. Remnants in Louisiana total less than 100 acres and less than 65,000 acres in Texas (Allain et al., 1999). Most of the original prairie has been (1) converted to pasture for cattle grazing, (2) altered for growing rice, sugarcane, and grain crops, or (3) urbanized.

Coastal prairie at ANWR

Coastal prairies are characterized and maintained by soil type, fire, rainfall, and grazing. The prairies receive 142 cm (56 in) of rainfall annually, which typically would produce forests rather than grasslands; however, a hard clay layer underneath the topsoil inhibits root formation of larger forest trees. The establishment of woody plants is also prevented by drought, fire, and competition from adapted plant species. These factors combine to maintain a grass-dominated ecosystem (Allain et al., 1999).

Coastal prairie vegetation consists of grasses, a variety of wildflowers, and other plants. Nearly 1,000 plant species have been identified and almost all are perennials with underground structures that help the plants survive after fire (Allain et al., 1999).

There are four types of coastal prairies in the Mission-Aransas Reserve: (1) cordgrass prairie with gulf cordgrass (Spartina spartinae) and marshhay cordgrass (*Spartina patens*); (2) sand mid-grass prairie with seacoast bluestem (*Schizachyrium scoparium var. littorale*) and panamerican balsalmscale (*Elyonurus tripsacoides*); (3) clay mid-grass prairie with little bluestem (*Schizachyrium scoparium*) and trichloris (*Chloris pluriflora*); and (4) short-grass prairie with silver bluestem (*Bothriochloa saccharoides*), buffalo grass (*Buchloe dactyloides*), and trichloris (Figure 16). Clumps of mesquite (*Prosopis glandulosa*), oak (*Quercus* sp.), huisache (*Acacia farnesiana*), and prickly pear cactus (*Opuntia lindheimeri*) are also often found in coastal prairies (McLendon, 1991; Chaney et al., 1996). Within the Mission-Aransas Reserve Boundary, coastal prairies are found primarily at ANWR, Matagorda Island, and Fennessey Ranch (Figure 2.14)

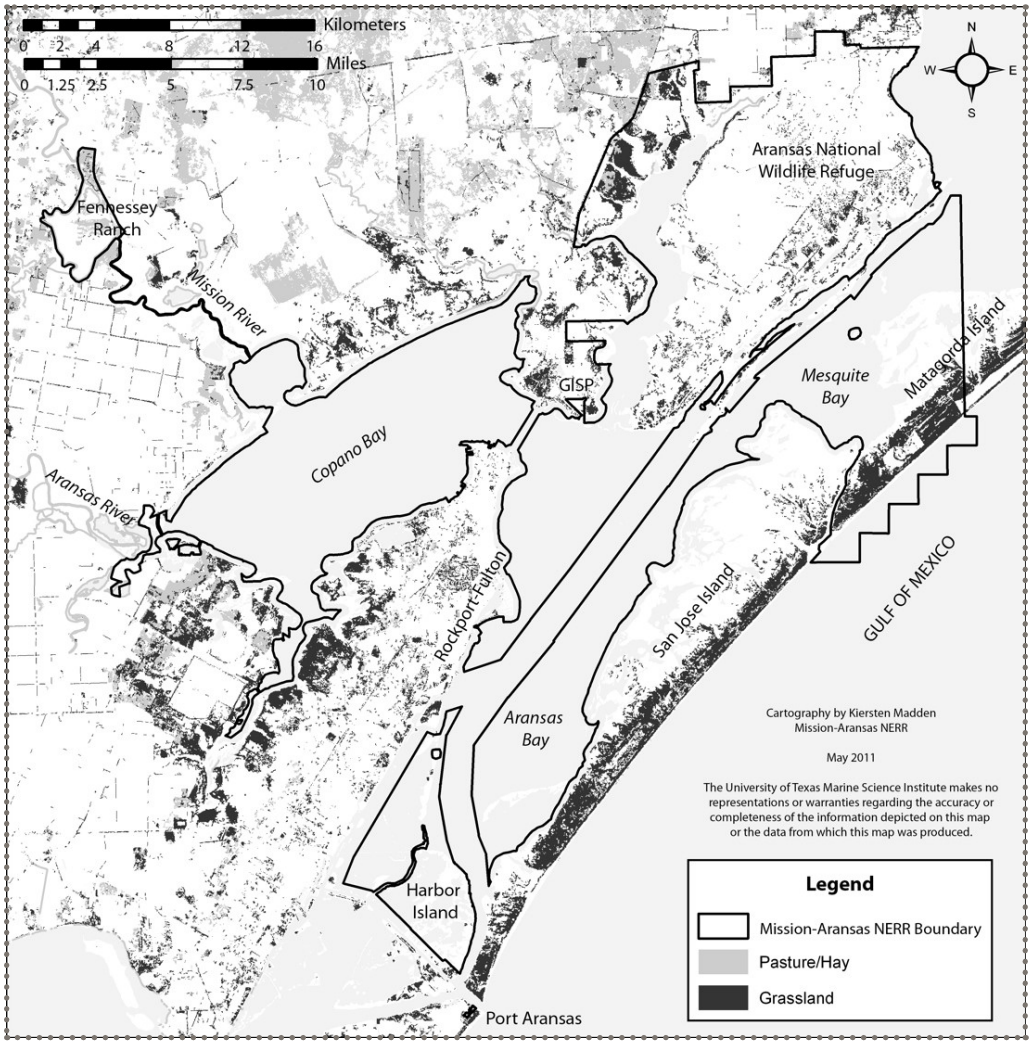


Figure 2.14. Location of pasture and grassland in the Mission-Aransas Reserve.

Coastal prairies and adjacent marsh areas provide habitat for waterfowl and thousands of other wildlife species. Coastal prairies host more Red-Tailed Hawk (*Buteo jamaicensis*), Northern Harrier (*Circus cyaneus*), White Ibis (*Eudocimus albus*), and White-faced Ibis (*Plegadis chihi*) than any other region in the United States (Allain et al., 1999). Waterfowl, sandpipers, and other shorebirds are abundant during the fall, winter, and spring months. Additionally, prairie lands provide habitat and plentiful supplies of nectar, which results in a unique insect diversity including butterflies, dragonflies, bees, wasps, ants, grasshoppers, beetles, and preying mantis.

Oak Motte

Live oak forests and mottes (i.e., isolated groves) are a unique, ecologically important, and ancient component of the South Texas landscape. Live oaks (*Quercus virginiana*) occur primarily in sandy soils of the two million acres of coastal sand plain (Carey, 1992; Fulbright, 2008). They are a common, dominant

Oak mottes at ANWR

"The Big Tree" at GISP

tree in maritime forests bordering coastal and inland marshes. Live oaks also occur as co-dominants with other woody plant species such as mesquite and blue-wood and are found in parts of Bee, San Patricio, Goliad, and Refugio counties (Fulbright, 2008). Texas live oak is often associated with Texas persimmon (*Diospyros texana*), Texas red oak (*Quercus texana*), post oak (*Quercus stellata*), and honey mesquite (*Prosopis glandulosa*). Texas mallow (*Callirhoe scabriuscula*), ground cherry (*Physalis pruinosa*), Texas grass, little bluestem (*Schizachyrium scoparium*), yaupon (*Ilex vomitoria*), beautyberry (*Callicarpa americana*), greenbriar (*Similax* sp.), mustang grape (*Vitis mustangensis*), and muscadine (*Vitis rotundifolia*) commonly occur beneath the canopy (Chaney et al., 1996; Fulbright, 2008).

Live oak trees are shrubby to large, spreading, long-lived, and nearly evergreen. They grow as large trees in deep soils along streams and as large shrubs in canyon headers. In the spring, they drop their leaves and grow new leaves within several weeks. Trees average 15 m (50 feet) in height and can have trunks up to 79 inches (200 cm) in diameter. The bark is furrowed longitudinally and the small acorns are long and tapered. Tree canopies usually have rounded clumps of ball moss or thick drapings of Spanish moss (Carey, 1992).

They grow best in well-drained sandy soils and loams, but are also capable of growing in clay and alluvial soils (Carey, 1992). Live oaks are resistant to salt spray and high soil salinity, making the Texas coast an ideal site for growth. Goose Island State Park is home to "The Big Tree," a massive coastal live oak. The Big Tree presides in an oak motte on Lamar Peninsula on St. Charles Bay. Estimates place The Big Tree's age at well over 1,000 years and it is the second largest live oak tree in Texas (TPWD, pers comm).

South Texas' live oak forests are critical wildlife habitats. They have high value for game species and migratory birds, and many rare wildlife species inhabit them. Acorns are an important food source for many animals and oak mottes provide shade from the hot Texas sun. Many suburban areas of South Texas have live oaks planted in yards providing habitat for urban wildlife. White-tailed deer (*Odocoileus virginianus*), northern bobwhite (*Colinus virginianus*), Rio Grande wild turkeys (*Meleagris gallopavo intermedia*), and javelina (*Tayassuidae*) are the primary game species associated with live oak forests of the Coastal Sand Plain (Fulbright, 2008).

Painted Bunting, *Passerina ciris*
Photo credit: Dr. Elizabeth Smith

Migratory songbirds require coastal oak mottes to provide needed stopover habitat where they can find good cover for resting and an abundance of insects for food. More than 80% of the 332 species of long-distance North American migrants travel through the Texas Coastal Bend and a reduction of live oaks could negatively affect these populations. For example, the Tropical Parula (*Parula pitiayumi*), a small New World Warbler, nests almost exclusively in live oaks. Live oaks provide essential nesting habitat for many species, including the Hooded Oriole (*Icterus cucullatus*), Ferruginous Pygmy-owl (*Glaucidium brasilianum*), Red-billed Pigeon (*Patagioenas flavirostris*), Northern Beardless Tyrannulet (*Camptostoma imberbe*), Couch's Kingbird (*Tyrannus couchii*), Painted Bunting (*Passerina ciris*), and Rose-breasted Grosbeak (*Pheucticus ludovicianus*) (Fulbright, 2008).

Spoil Island

Snowy Egret (*Egretta thula*)
Photo credit: Sherry Halbrook

Artificial spoil islands result from the deposition of material that has been dredged for the production and/or maintenance of navigation channels. Both dredging and placement of dredge material affect water movements within the bay. Dredging makes portions of the bays deeper than they would be naturally and allows more water to circulate. The deposition of dredge material for spoil islands may inhibit the flow of water in some locations; however, spoil islands are important roosting and nesting grounds for a variety of birds (Robertson et al., 1991; Montagna, 1996). Birds using spoil islands as nesting areas include the Great Blue Heron (*Ardea Herodias*), Snowy Egret (*Egretta thula*), Tricolored Heron (*Egretta tricolor*), Green-winged Teal (*Anas crecca*), Northern Shoveler (*Anas clypeata*), Black-necked Stilt (*Himantopus mexicanus*), American Avocet (*Recurvirostra americana*), Black Skimmer (*Rynchops niger*), and Brown Pelican (*Pelecanus occidentalis*) (White and Cromartie, 1985). Plant communities common on spoil islands include mesquite, salt cedar, popinac (*Leucaena leucocephala*), granjeno (*Celtis laevigata*), and oleander (*Oleander* spp.) (Chaney et al. 1996).

Dune

Dune habitat

Barrier islands are dynamic environments in which sand is constantly being moved due to the interactions of geology, climate, and vegetation (Stallins and Parker, 2003). Sand dunes serve as defense for inland areas against storm surge and beach erosion by absorbing the impact of waves and the intrusion of water. Dunes also hold sand to replace eroded beaches and buffer sand and salt spray. A typical barrier island is composed of a series of dunes. Foredunes, the newest and largest, are created on the exposed ocean side where sediment is deposited. Foredunes are the first clearly distinguishable, vegetated dune formation landward of the water. Interdune areas, located behind the foredunes, are lower and more level due to overwash and flooding. Finally, backdunes are found on the bayside of the island and tend to slowly erode (Miller et al., 2010).

Plants play an important role in dune building and stabilization. There are three groups of dune plants: dune builders (grow upward, stabilize using roots), burial-tolerant stabilizers (can withstand overwash, use rhizomes to stabilize), and burial intolerant stabilizers (long-lived, found in low energy back areas) (Miller et al., 2010). Foredune areas are highly disturbed, have the lowest species richness, and are dominated by the dune stabilizer, *Uniola paniculata*. Intunes are dominated by clonal grasses (*P. vaginatum*) and clonal forbs (*P. nodiflora*). The highest diversity is found on the low protected backdunes which harbor long-lived woody species (Miller et al., 2010).

Three species of highly erosion-resistant and easily established dune grass are found on the Texas Coast: bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*), and marshhay cordgrass (*Spartina patens*). Other species of herbaceous plants found are beach morning glory (*Ipomoea imperati*) and seagrape vines (*Coccoloba uvifera*), which form a dense cover on the seaward side. Low-growing plants and shrubs found on the back side of dunes include seacoast bluestem (*Schizachyrium scoparium var. littorale*), cucumberleaf sunflower (*Helianthus debilis*), rose ring gallardia (*Gaillardia pulchella*), partridge pea (*Chamaecrista fasciculata*), prickly pear (*Opuntia lasiacanta*), and lantana.

On Matagorda and San Jose islands, where there is limited shorefront development, there is a continuous, well-defined foredune ridge averaging 15 to 20 ft above sea level. As rainfall decreases southward along the Texas Coast, dunes have less of the vegetative cover necessary for stabilization. Migrating dunes bare of vegetation and highly susceptible to wind erosion are common in the arid environment of the lower coast.

Sea oats (*Uniola paniculata*)

Threatened and Endangered Species

TPWD and USFWS provide lists of threatened and endangered species that may occur in the Mission-Aransas Reserve (Table 2.3). Species listed by the USFWS have confirmed sightings in Nueces, Refugio, Aransas, San Patricio, or Calhoun County. Statewide or area-wide migrants are also included. Inclusion in the list does not imply that a species is known to occur in the Reserve, but only acknowledges the potential for occurrence. State-endangered or threatened species have no legal status under federal law and are not protected under the Endangered Species Act. The species information in this chapter is primarily from TPWD Wildlife Facts Sheets (TPWD, 2009b).

Table 2.3. USFWS and TPWD list of threatened and endangered species in the Mission-Aransas Reserve.

Common Name	Scientific Name	USFWS	TPWD
Plants			
South Texas ambrosia	*Ambrosia cheiranthifolia*	E	E
Black Lace cactus	*Echinocerus reichenbachii var.albertii*	E	E
Slender rushpea	*Hoffmannseggia tenella*	E	E
Fish			
Opossum pipefish	*Microphis brachyurus*		T
Amphibians			
Sheep frog	*Hypopachus variolosus*		T
Black-spotted newt	*Notophthalmus meridionalis*		T

Common Name	Scientific Name	USFWS	TPWD
Reptiles			
American alligator	*Alligator mississipiensis*	TSA	
Loggerhead sea turtle	*Caretta caretta*	T	T
Scarlet snake	*Cemophora coccinea*		T
Green sea turtle	*Chelonia mydas*	T	T
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Texas Indigo snake	*Drymarchon melanurus erebennus*		T
Speckled racer	*Drymobius margaritiferus*		T
Hawksbill sea turtle	*Eretmochelys imbricata*	E	E
Texas tortoise	*Gopherus berlandieri*		T
Kemp's Ridley sea turtle	*Lepidochelys kempii*	E	E
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*		T
Texas horned lizard	*Phrynosoma cornutum*		T
Mammals			
Gulf Coast jaguarundi	*Herpailurus yagouaroundi cacomitli*	E	E
Southern yellow bat	*Lasiurus ega*		T
Ocelot	*Leopardus pardalis*	E	E
Atlantic spotted dolphin	*Stenella frontalis*		T
Rough-toothed dolphin	*Steno bredanensis*		T
West Indian manatee	*Trichechus manatus*	E	E
Birds			
Texas Botteri's Sparrow	*Aimophila botterii texana*		T
White-tailed Hawk	*Buteo albicaudatus*		T
Zone-tailed Hawk	*Buteo albonotatus*		T
Northern Beardless-tyrannulet	*Camptostoma imberbe*		T
Piping Plover	*Charadrius melodus*	E, T	T
Reddish Egret	*Egretta rufescens*		T
American Yellow-tailed Kite	*Elanoides forficatus*		T
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	E	E
American Peregrine Falcon	*Falco peregrinus anatum*		T
Whooping Crane	*Grus americana*	E, EXPN	E
Bald Eagle	*Haliaeetus leucocephalus*	DM	T
Wood Stork	*Mycteria americana*		T
Eskimo Curlew	*Numenius borealis*		E
Rose-throated Becard	*Pachyramphus aglaiae*		T
Brown Pelican	*Pelecanus occidentalis*	DM, E	E
White-faced Ibis	*Plegadis chihi*		T
Least Tern	*Sterna antillarum*	E	E
Sooty Tern	*Sterna fuscata*		T
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	E	E

USFWS: E - Endangered; T - Threatened; DM- Delisted Taxon, recovered, being monitored first five years; EXPN - Experimental population, non-essential; TSA - Threatened due to similarity of appearance. Texas American alligator hides and parts are protected because of similarity of appearance to protected crocodilians

TPWD: E - Endangered; T - Threatened

South Texas Ambrosia (*Ambrosia cheiranthifolia*)

Currently, this species occurs at six locations in Nueces and Kleberg County. South Texas ambrosia is an erect, silvery to grayish-green, perennial, herbaceous plant, 10 to 30 cm (4 to 12 in) tall. This ambrosia blooms in late summer and fall, but its flowers are not showy and may be missed by the casual observer. It may occur in association with slender rushpea, which is also federally listed as endangered. South Texas ambrosia occurs in open grasslands or savannas on soils varying from clay loams to sandy loams. Associated native grasses found at the existing sites include Texas grama (*Bouteloua rigidiseta*), buffalograss (*Bouteloua dactyloides*), Texas wintergrass (*Nassella leucotricha*), and tobosa (*Hilaria mutica*). Native woody species found scattered throughout the existing sites include mesquite (*Prosopis* sp.), huisache (*Acacia smallii*), huisachillo (*Acacia tortuosa*), granjeno (*Celtis pallida*), and lotebush (*Ziziphus obtusifolia*). While South Texas ambrosia does not appear to survive continual plowing, sporadic disturbance may enhance its growth and spread.

South Texas Ambrosia, *Ambrosia cheiranthifolia*
Photo credit: TPWD

Black Lace Cactus (*Echinocereus reichenbachii var. albertii*)

There are known populations of the black lace cactus located in the county of Refugio. Black lace cactus is found in grassy openings on South Texas rangeland invaded by mesquite and other shrubs. The outer spines are straight and white with dark purple tips and resemble teeth in a comb. The stems are 3 to 15 cm (1-6 in) tall and 3 to 5 cm (1-2 in) wide. The black lace cactus blooms pink and purple flowers (5-8 cm wide) from April to June producing fruit after the blooms fall off. As the small, spiny, green fruits ripen, the seeds fall or are washed to the ground by the rain. This plant is endangered because its rangeland habitat has been cleared or planted for crops and people have uprooted them to take home or sell for their large, attractive flowers.

Slender Rush-pea (*Hoffmannseggia tenella*)

Currently, the slender rush-pea has four populations in Nueces and Kleberg counties. Slender rush-pea is a perennial legume, 8 to 16 cm (3-6 in) tall, with spreading stems. Its leaves are twice compound, with 3-7 primary divisions each with 5-6 pairs of leaflets. The slender rush-pea's tiny blooms are produced between early March and June, and sporadically thereafter depending on rainfall. Slender rush-pea may be particularly susceptible to competition from non-native grass species such as King Ranch bluestem (*Bothriochloa ischaemum var. songarica*), Kleberg bluestem (*Dichanthium annulatum*), and bermuda grass (*Cynodon* spp.). Mowing at a sufficient height and at appropriate times may not be detrimental to this species; however, mowing during reproductive stages should be avoided. Conversion of coastal prairie habitat to other land uses is likely the most important factor contributing to the decline of slender rush-pea. Slender rush-pea grows on clay soil of blackland prairies and creek banks in association with short and midgrasses such as buffalograss (*Bouteloua dactyloides*), Texas wintergrass (*Nassella leucotricha*), and Texas grama (*B. rigidiseta*). Woody plants such as mesquite (*Prosopis* sp.), huisache (*Acacia smallii*),

Slender Rush-pea, *Hoffmannseggia tenella*
Photo credit: TPWD

huisachillo (*Acacia tortuosa*), spiny hackberry (*Celtis ehrenbergiana*), bridal broom (*Retama monosperma*), lotebush (*Ziziphus obtusifolia*), tasajillo (*Cylindropuntia leptocaulis*), and prickly pear (*Opuntia* spp.) are also common at the known sites.

Leatherback, Hawksbill, and Kemp's Ridley Sea Turtle

The distribution range of the leatherback, hawksbill and Kemp's Ridley sea turtles includes the coastal waters and bays of the Gulf of Mexico, and these species can be found throughout the Reserve.

Leatherback sea turtle, *Dermochelys coriacea*
Photo credit: David Rabon, USFWS

The leatherback (*Dermochelys coriacea*) is the largest of all sea turtles, with weights up to 590 kg (1,300 lbs) and a carapace length up to 2.5 m (8 ft). This turtle is unique because of the smooth leathery skin covering its carapace. Adult leatherbacks can be distinguished from all other species of sea turtles by their large size, spindle-shaped bodies, and leathery, unscaled carapaces. Research on captive turtles indicates that leatherbacks grow faster than any other marine turtle. These giant turtles live on average 30 years and can live up to 50 years or more. Adults are believed to reach sexual maturity between three to four years of age, although the age at which wild turtles reach maturity may be greater. Unlike most sea turtles, which nest in the spring and summer, leatherbacks usually nest in fall and winter. They arrive at the nesting beaches in large groups, forming "arribazones", where groups of females move onto the beach to lay their eggs over a period of a few days. The leatherback prefers the open ocean and moves into coastal waters only during the reproductive season. Although small groups may move into coastal waters following concentrations of jellyfish, these turtles seldom travel in large groups. Leatherbacks inhabit primarily the upper reaches of the open ocean, but they also frequently descend into deep waters from 200 to 500 m.

The hawksbill sea turtle (*Eretmochelys imbricata*) is a small to medium sized turtle with shell lengths up to 91 cm (36 in) and can live from 30-50 years. Adults mate every two to three years during the nesting period, generally April through November, off the nesting beaches. Hawksbill turtles nest primarily at night, but there are reports of daytime nesting, usually on uninhabited beaches. Hawksbill turtles live in clear offshore waters of mainland and island shelves. They are the most tropical of all sea turtles and are more common around coral reef formations.

Kemp's Ridley sea turtle, *Lepidochelys kempii*
Photo credit: USFWS

Although many sea turtle species are in danger, the Kemp's Ridley sea turtle (*Lepidochelys kempii*) is the most endangered species worldwide. Kemp's Ridley sea turtles grow to 69 to 80 cm (27-32 in) long and weigh on average 34 to 45 kg (75-100 lbs). Distinguishing characteristics include a dark gray to gray-green carapace (upper shell), cream to tan plasteron (lower shell), streamlined shells, and appendages shaped like flippers. The turtle's dark, spotted head and flippers contrast sharply with its pale body. The male Kemp's Ridley spends its entire life in the water while the female only comes ashore to nest, sometimes joining large groups of nesting females called arribazones. A

female will only lay eggs during the day and she will come back to the same beach to nest year after year. The Kemp's Ridley prefers open ocean and gulf waters with the females only coming ashore to lay eggs in beach sand. Young Kemp's Ridley sea turtles can be found in coastal waters and bays and floating on large mats of sargassum (a type of brown algae) in the Gulf of Mexico and Atlantic Ocean.

Gulf Coast Jaguarundi (*Herpailurus yagouaroundi cacomitli*)

The jaguarundi is slightly larger than a domestic cat, weighing four to seven kg (8 - 16 lbs) and can live 16 to 22 years in captivity. Its coat is a solid color, either rusty-brown or charcoal gray. Jaguarundis eat birds, rabbits, and small rodents, hunting during early morning and evening. Although jaguarundis hunt mostly on the ground, they also climb trees easily and have been seen springing into the air to capture prey. They are solitary except during the mating season of November and December. Jaguarundis are active mainly at night, but also move around during the day, often going to water to drink at midday. Jaguarundis are endangered because the dense thorny shrubland that provides habitat has been cleared for farming or urbanization. Jaguarundis still exist in Mexico, but they are now very rare in Texas.

Ocelot (*Leopardus pardalis*)

The ocelot is a species of wild cat that grows to approximately 76 to 100 cm (30-41 in) long, weigh seven to 14 kg (15-30 lbs), and can live 20 years in captivity. Ocelots have cream colored fur with reddish-brown spots outlined in black and two stripes extending from the inside corner of the eyes and over the back of the head. Ocelots are carnivores and hunt rabbits, small rodents, and birds at night, and rest in the brush during the day. They live within an area (home range) of about 1 to 4 mi2. Females prepare a den for their kittens in thick brush. Ocelots are endangered because their habitat has been cleared for farming and urbanization. In 1995 it was estimated that 80 to 120 individuals lived in Texas. Now only about 30 to 40 ocelots live in the shrublands remaining at or near the Laguna Atascosa National Wildlife Refuge near Brownsville, Texas. Dense, thorny, low brush such as spiny hackberry (*Celtis ehrenbergiana*), lotebush (*Ziziphus obtusifolia*), and blackbrush (*Coleogyne ramosissima*) offer the ocelot the best habitat. Historical records indicate that the ocelot could be found throughout South Texas, the southern Edwards Plateau, and along the Coastal Plain. Today, its range is the South Texas brush country and lower Rio Grande valley.

Ocelot, *Leopardus pardalis*
Photo credit: Steve Hillebrand, USFWS

West Indian Manatee (*Trichechus manatus*)

West Indian manatees are large, grayish, nearly hairless, aquatic mammals without hind limbs, a tail broadened into a horizontal, rounded paddle, and front paddlelike limbs. Near the turn of the century manatees were not uncommon in the Laguna Madre, however, manatees are now extremely rare in Texas waters. Texas records also include

West Indian Manatee, *Trichechus manatus*
Photo credit: Jim Reid, USFWS

specimens from Cow Bayou, near Sabine Lake, Copano Bay, the Bolivar Peninsula, and the mouth of the Rio Grande. West Indian manatees occur chiefly in the larger rivers and brackish water bays although they are able to live in salt water. They are extremely sensitive to cold and may be killed by a sudden drop in water temperature to as low as 8°C, which limits their northward distribution in North America. Their irregular occurrence along the Texas coast suggest that they do considerable wandering; specimens from Texas probably represent migrants from coastal Mexico.

Whooping Crane (*Grus americana*)

One of the most well-known endangered species that inhabits the Mission-Aransas Reserve is the Whooping Crane. This species winters along the south Texas coast at ANWR. Historically, the winter range of the Whooping Crane extended from Mexico to Louisiana. Extremely low populations of this species were first noticed in the late 1930's. ANWR was established in 1937 and the Whooping Crane is making a comeback from a low of 15 birds in 1941 to 270 individuals in 2009 (Stehn, 2009). Critical habitat of Whooping Cranes, as determined by USFWS, within the Mission-Aransas Reserve is centered in the ANWR, Matagorda Island, and extends to the northern tip of San Jose Island.

Whooping Crane, *Grus americana*
Photo credit: Dick Fischer

2.3 Social attributes and values

The human dimensions of our environment greatly influence the effectiveness of coastal management. Human dimensions are characterized by the social, cultural, economic, and political aspects of our surrounding environment. Changes to these aspects influence human perception and behaviors, which affect resource management decisions. An examination of the human dimensions can provide a better understanding of not only resource flow, but also how human

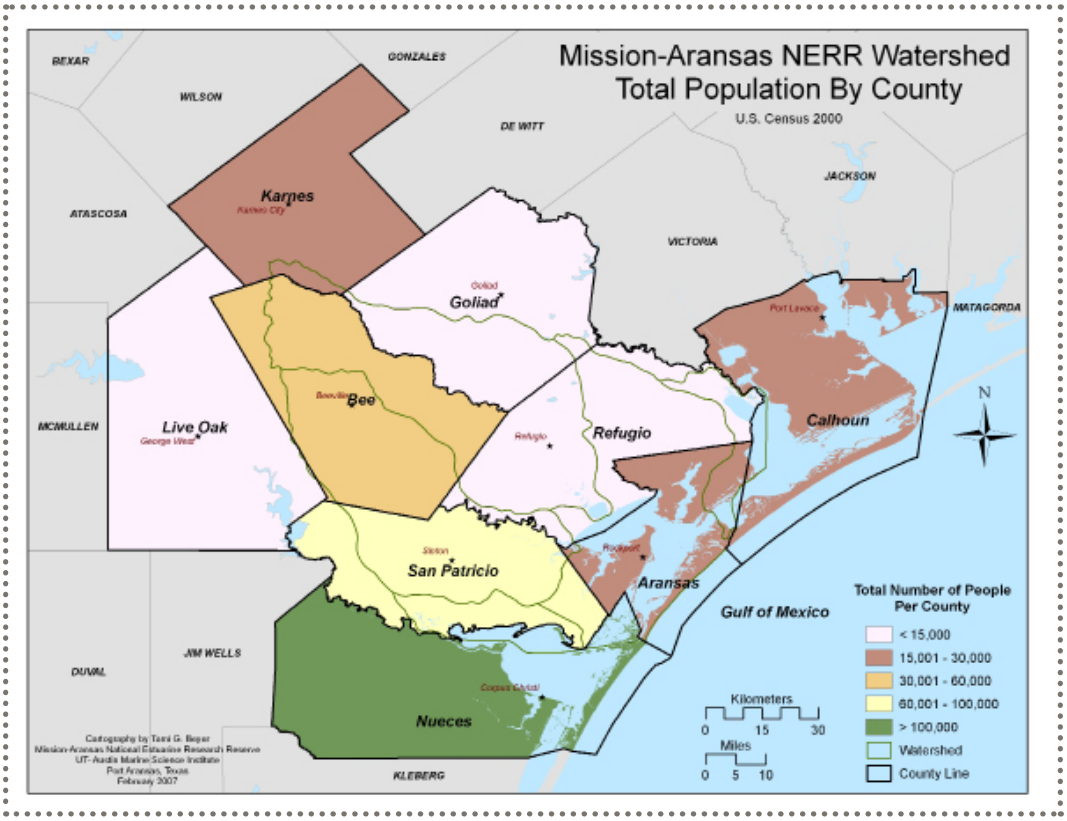


Figure 2.15. Total population values for Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

perception and behaviors are linked to resource flow. This knowledge can be used to develop decision support tools that will increase state and local managers' capacity to address the human dimensions of coastal management.

Social patterns within the watershed that drains into the Mission-Aransas Reserve can greatly affect water quality and health of the Mission-Aransas Estuary. The current population dynamic is small, rural communities transitioning into densely populated urban areas along the coast. The counties that lie within the watershed of the Reserve are Aransas, Refugio, Calhoun, Nueces, San Patricio, Karnes, Goliad, Bee, and Live Oak. Five of these counties, Aransas, Refugio, Calhoun, Nueces, and San Patricio, contain land and water within the Mission-Aransas Reserve boundary (Figure 2.15). Although five counties are included in the Mission-Aransas Reserve, three counties (Aransas, Calhoun, and Refugio) comprise nearly 97% of the area. The majority of the Mission-Aransas Reserve (75%) lies in Aransas County, while other major counties include Calhoun (12%), Refugio (10%), and Nueces (3%). Only 0.1% of San Patricio County lies in the Reserve. The most populous counties on both a regional and state level are Nueces and San Patricio, which both lie predominantly outside the Reserve. Consequently, the Mission-Aransas Reserve is likely one of the lowest density sites in the Reserve System.

2.3.1 Population

The counties of the Reserve have respective densities of less than 42 people mi^{-2} in Calhoun and Refugio counties compared to a modest 92 people mi^{-2} in Aransas County (US Census Bureau, 2010). Similarities among all three counties include a predominantly white population with a low poverty level, a relatively low proportion of children to retired (ratio 1.2 to 2.5), and a majority of the population with at least a high school degree. Urban development throughout the area is very low (<5%) (Morehead et al., 2007).

Of the three dominant counties adjacent to the Mission-Aransas Reserve, Refugio has the lowest proportion of individuals that earn in excess of $100,000 yr^{-1} (Figure 2.16). The low financial and social power of this county is also reflected in the lowest median income, very few seasonal homes, and a higher proportion of employment in agriculture. Among all these indicators, the most profound is the lack of population change for Refugio County, compared to significant increases for all other neighboring counties in the region

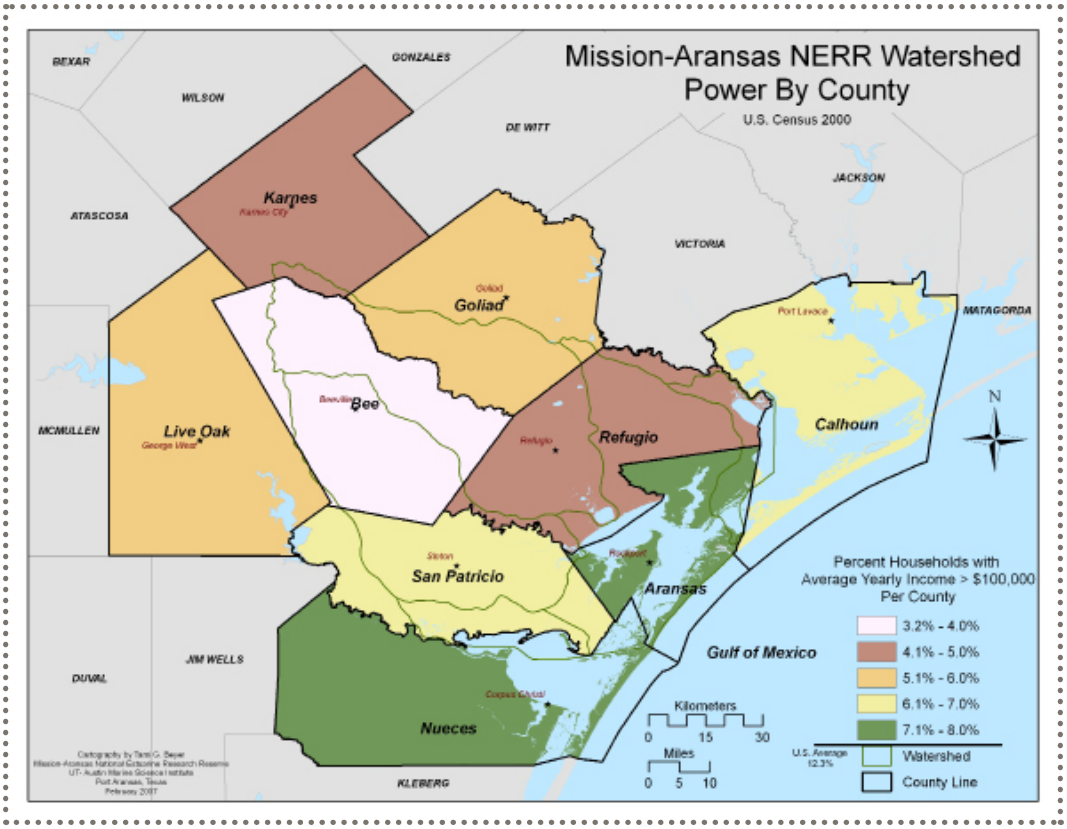


Figure 2.16. Power (percent of households with average yearly income >$100,000) values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

(Figure 2.17). The lack of a population increase (or perhaps a slight decrease) is in stark contrast to most Texas counties which showed some growth, and to the southern half of the state as a whole. The causes for the slowdown in growth for Refugio County are not apparent, but may be related to the immense amount of area committed to rangeland and the lack of job opportunities for young people (Morehead et al., 2007).

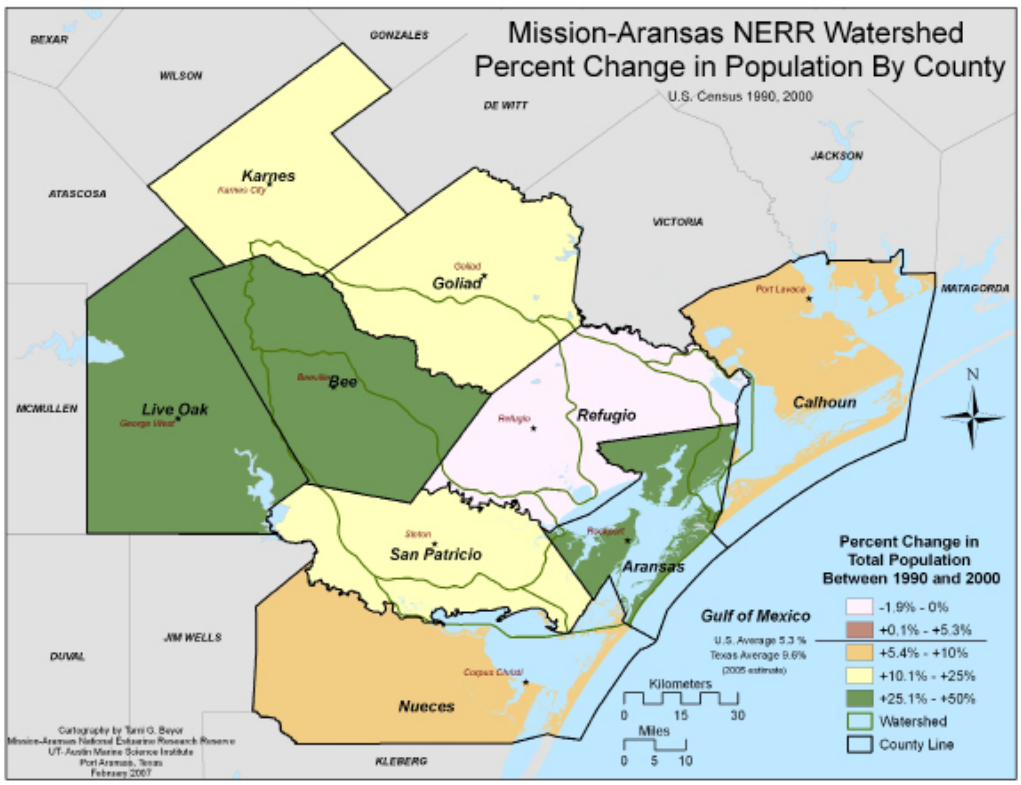


Figure 2.17. Population change values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

It is clear that Aransas County is characterized by the greatest amount of wealth in the region. This is likely related to the abundance of desirable waterfront property as reflected in higher incomes, second homes, and greater median age (and fewer adults under 18) than adjacent counties (Morehead et al., 2007).

The four remaining counties in the Reserve watershed are Bee, Goliad, Karnes, and Live Oak counties. These counties are almost exclusively rural and characterized by lands that are either forested, used for agriculture, or pastures for free ranging cattle. Consequently, population densities are very low. The human characteristics among the four counties are diverse, with Bee county displaying high educational achievement (>72% completing high school) compared to Karnes (<60%). Bee County is also unique in a relatively higher number of single parent households (11 12%), lowest median age, and a higher ratio of children under 18 relative to adults over 65 compared to the other three counties. All four counties exhibited high population growth (range 10 to 50%) and generally very low poverty (Bee County was average). The low population density of these counties, combined with very low urban land use, is favorable to the continued health of the Mission-Aransas watershed, although population increases are an important consideration for future planning.

Population Cycles

Population cycles (e.g., changes in the number of people fitting the categories of age, income, or ethnicity over time) provide guidance and predictability to the flow of human actions. As these cycles change, they can help resource managers better predict how resources in the estuary will be used. Age distribution is an indicator of population cycles because the proportion of children to elderly will influence the flow and need/use of different resources. Seasonal residence is also an indicator of population cycles because it will influence the flow of resources during tourist seasons.

Age distribution is a population cycle that can indicate what types of resources are currently being used, and changes to age distribution can further indicate future resource needs of the area. Age distribution is

determined as the proportion of children under the age of 18 to those people over the retirement age of 65. In general, communities have a greater number of children, so the proportion of children to retired is always above one. Therefore, the lower the value, the greater the proportion of retired people and vice versa. Information about age distribution can help identify such needs as number of school systems, requirements of medical resources, availability of volunteers, and recreation patterns. In Texas, there are a greater proportion of those over the age of 65 in the "hill country" (west of San Antonio and Austin) and in northwest Texas. In the watershed of the Mission-Aransas Reserve, there is a greater proportion of children in San Patricio and Nueces counties, and a greater proportion of people over the age of 65 in Aransas, Goliad, and Live Oak County (Figure 2.18) (Morehead et al., 2007).

Seasonal cycles of residence are indicators of yearly flow of natural resources and can also

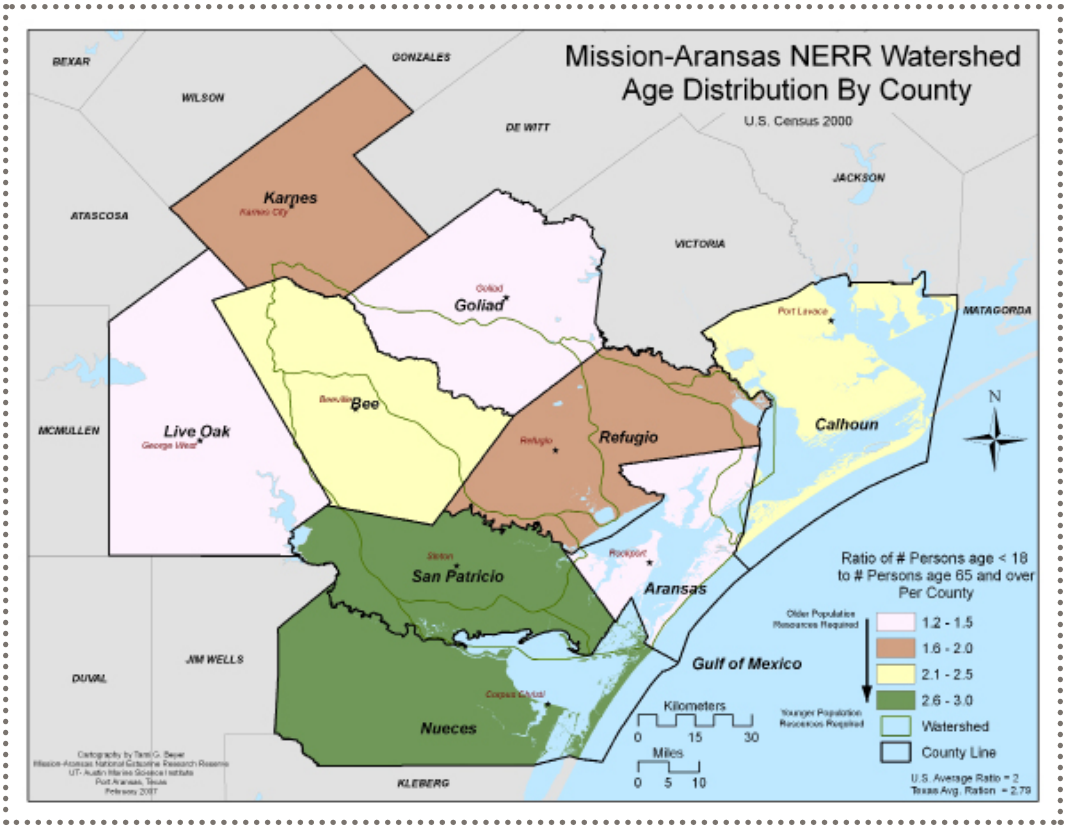


Figure 2.18. Age distribution values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

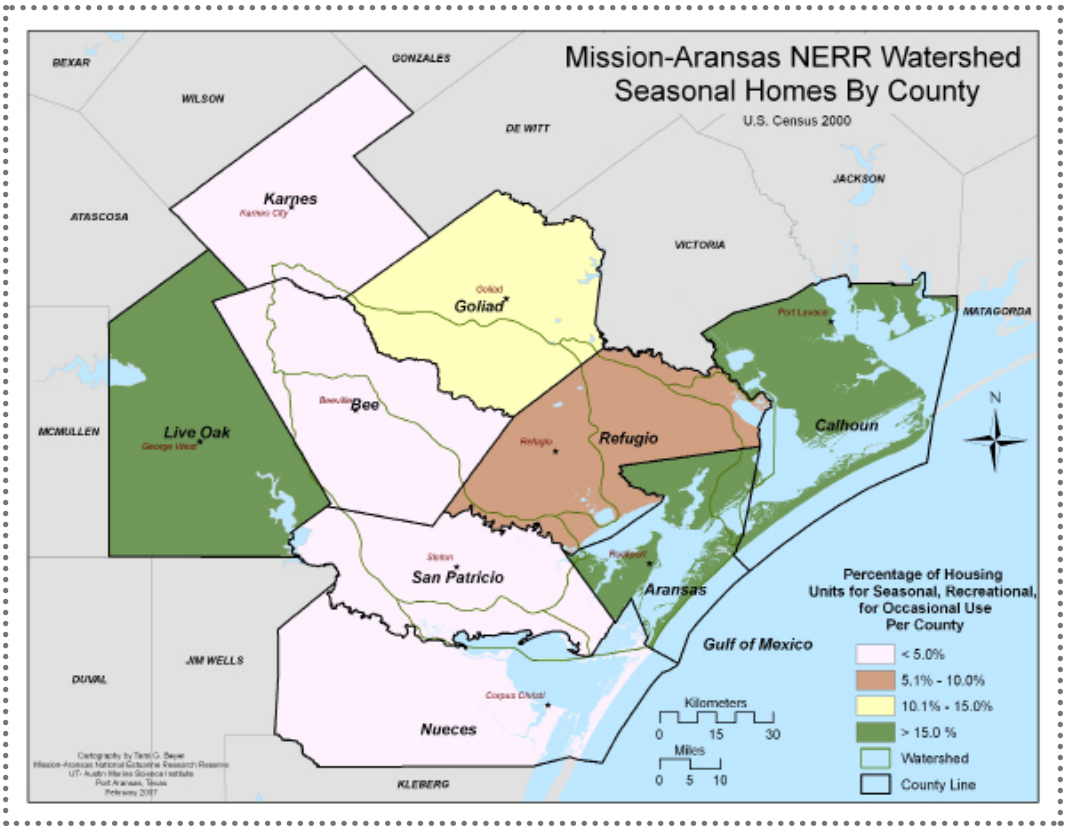


Figure 2.19. Seasonal home values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

help explain behavior patterns. For example, high seasonal fluxes of residence may lead to apathy about the natural resources in the area. In the Mission-Aransas Reserve, Aransas, Calhoun, and Live Oak counties have the largest numbers of seasonal, recreational, and occasional use residents at >15% in 2000 (Figure 2.19) (Morehead et al., 2007). The coastal communities of Rockport/Fulton, Port Lavaca, and Sea Drift rely heavily on tourism with the natural resources of local estuaries and beaches being the primary draw for tourism. Tourism for the coastal communities is largest during the summer months followed by a peak tourism period from December to March from "winter Texans" (visitors from out of state who come from the north to escape the cold winters). ANWR also experiences an influx of winter Texan populations and has visitation peaks from October through April during Whooping Crane season.

Social Order

The social order of a population describes the identity that a person affiliates with himself/herself. Identity can have a large effect on behavior patterns and resource utilization. Social order has both class and ethnic origins. The term class implies individuals sharing a common situation within a social structure (Dalton, 2005). For example, educational achievement can be used to indicate class, and spatial patterns of this indicator can help resource managers determine the level of content for outreach materials. In Texas, central and northern regions tend to have higher education achievement of both high school level and bachelor degrees (US Census, 2000). Classes with high percentages of bachelor degrees (40.1-50%) are concentrated around the metropolitan areas of Austin and Dallas. Classes with low percentages of bachelor degrees are concentrated along the southern border with Mexico. In the counties within the watershed of the Mission-Aransas Reserve, Karnes County has the lowest percentage of high school graduates, while Aransas and Nueces have the highest (Figure 2.20). A similar pattern is described by those achieving a bachelor degree. However, all counties within the watershed are below the national average for bachelor degree achievement (24.4%).

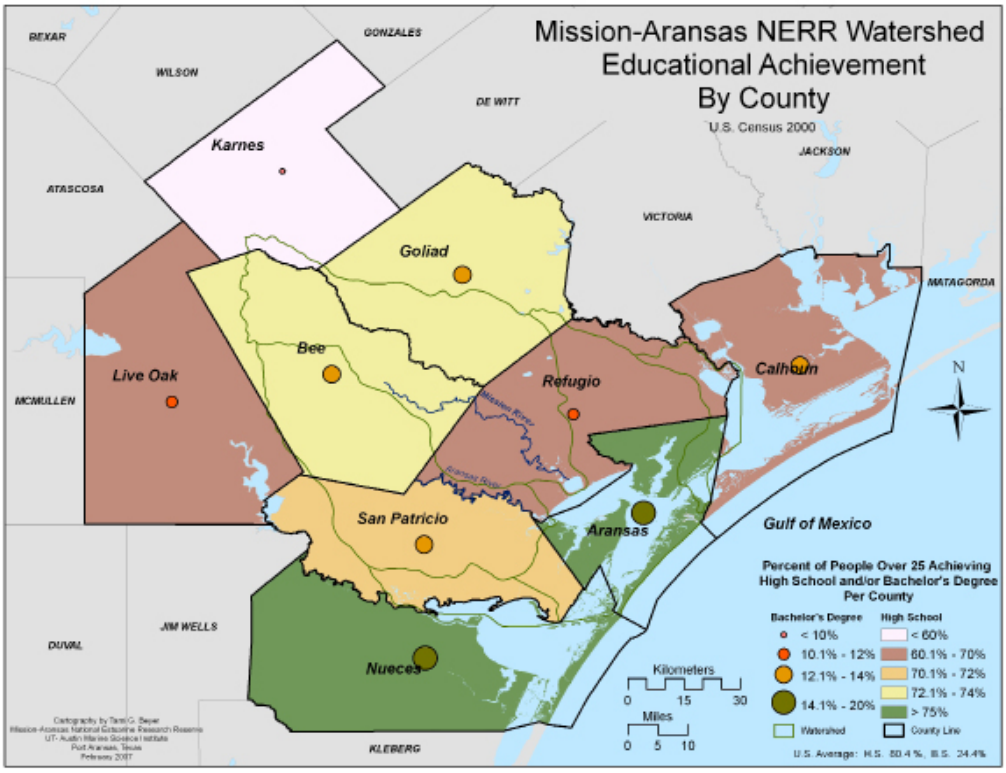


Figure 2.20. Education achievement values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

Ethnic origin is also an important variable of identity. Spatial distributions of ethnic origin can help explain language patterns. This has an important effect on outreach materials that often is overlooked by resource managers. Texas has a large percentage of the population self-identifying as Hispanic (US Census, 2000). Percentages of this population follow a latitudinal gradient from south to northeast. The majority of counties in the Mission-Aransas Reserve watershed claim Hispanic origin (25.1 - 75%), with the exception of Aransas

County. The Hispanic population distribution is displayed separately from ethnic distribution because the federal government considers race and Hispanic origin to be two separate and distinct concepts (Grieco and Cassidy, 2001). The Census questionnaire does not distinguish or define Hispanic populations as ethnicity or race (i.e., an individual can identify themselves as Hispanic and white). The largest ethnic identity of counties within the Mission-Aransas Reserve watershed is white followed by an unknown "other" (Figure 2.21) (Morehead et al., 2007). Aransas County has the highest percentage of the white majority and Bee County has the greatest percentages of minorities.

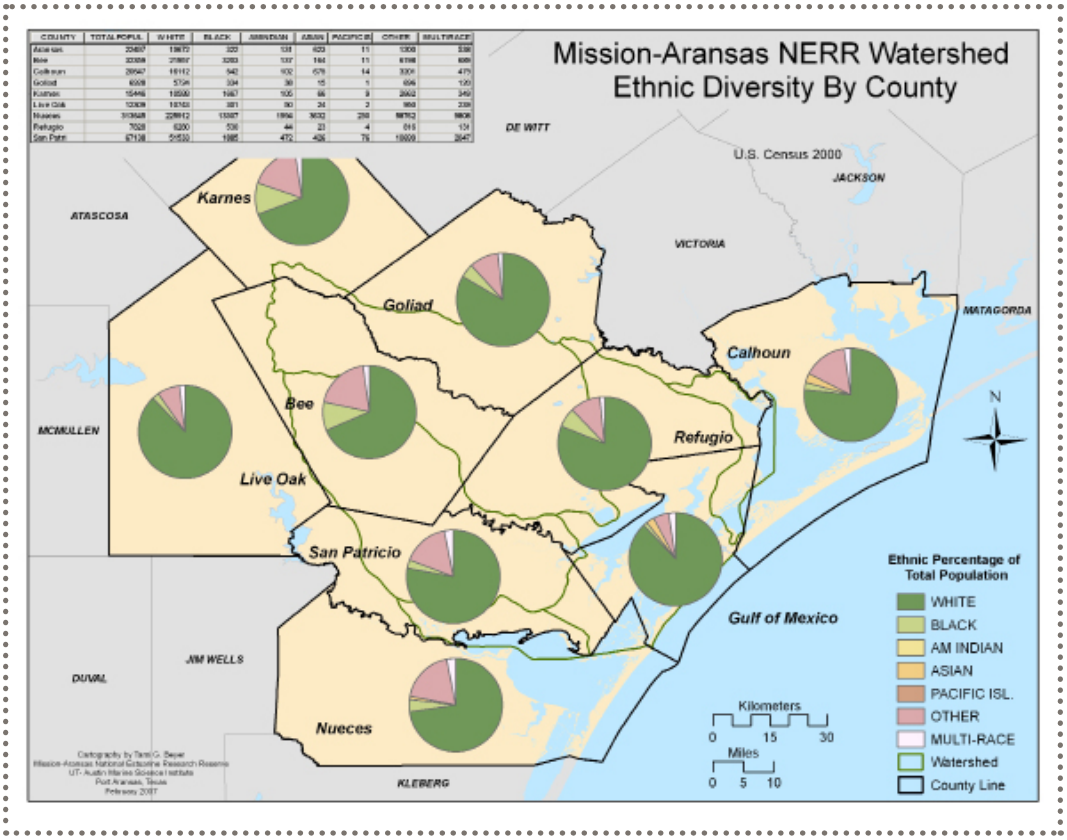


Figure 2.21. Ethnic diversity values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

2.3.2 Jobs and employment trends

Labor

Industries within the Mission-Aransas Reserve include oil and gas activities, recreational and commercial fishing, ground and surface water withdrawal, tourism, and shipping (Table 2.4). Estuaries along the Gulf of Mexico, including Texas, are rich in oil and gas deposits.

Table 2.4. Annual economic estimates for the state of Texas of primary uses within the Mission-Aransas Reserve.

Industry	Amount	Estimated Value	Year and Source
Commercial Finfish	5,620,000 lbs	$10,585,000	2004, TPWD
Commercial Shellfish	42,096,000 lbs	$117,583,000	2004, TPWD
Gulf Intracoastal Waterway shipping	>74,160,000 short tons	>$25,000,000,000	2006, TxDOT Legislative Report 2007-2008
Oil Production	551,202,120 bbl	$1,436,879,156 in tax	2008, RRC and Texas Comptroller
Gas Production	10,821,861,433 mcf	$2,684,647,510 in tax	2008, RRC and Texas Comptroller

Every estuary in the Western Gulf of Mexico Biogeographic Sub-region has oil and gas wells and pipelines. Most of the oil and gas reserves within the Reserve have been depleted; however, recent testing indicates that there is interest in deeper exploration and drilling in the area. As drilling technology continues to improve,

deeper depths become prospective. As of 2007, the Mission-Aransas Estuary had a moderate number of oil/gas leases and production (Figure 2.22).

The Mission-Aransas Reserve has a large tourism economy due to accessible beaches, abundant recreational fishing opportunities, and a high diversity of bird species. In addition, recreational and commercial landings of finfish, shrimp, and shellfish appear to be on an upward trend. Abundance of finfish, shrimp, and blue crab harvests were nearly equal to each other from 1972 - 1976. After 1976, the percentage of finfish harvests began to decrease in relation to shrimp and blue crab harvests. From 1981 until the present, shrimp harvests increased in relation to finfish and blue crab harvests, and are now the major fishery for the Mission-Aransas Estuary (Robinson et al., 1994).

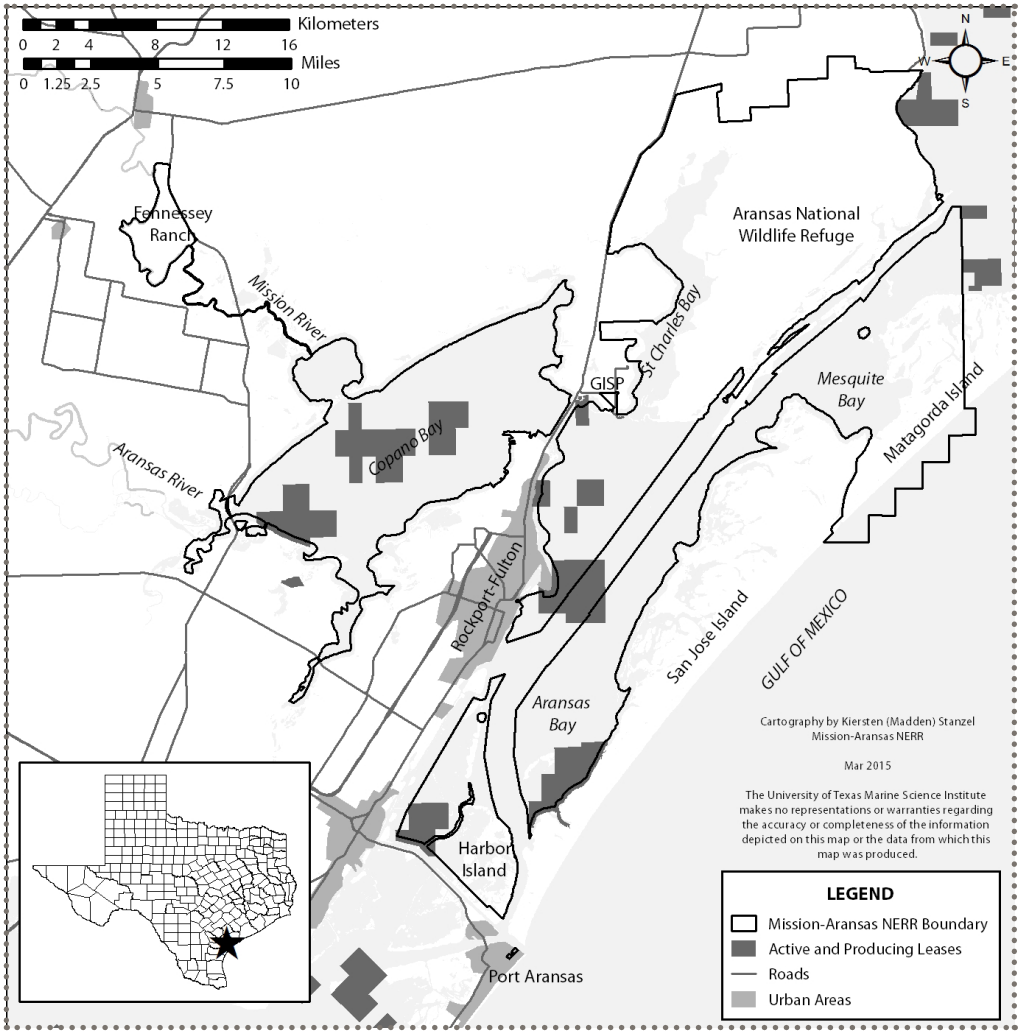


Figure 2.22. Active and producing oil and gas leases within the Mission-Aransas Reserve.

Education is the dominant industry of all counties in the Mission-Aransas Reserve watershed (US Census, 2010). As an educational institution, the Reserve can have a large impact in a watershed whose dominate industry is educational services. Of the dominant industries in the Reserve watershed (Table 2.5), agriculture is likely to have the greatest direct effect on natural resources. Refugio, Live Oak, and Goliad counties have the greatest dominance of agriculture for industries in the watershed.

Table 2.5. Top three dominant industries for each county in the Mission-Aransas Reserve watershed are listed in order.

County	Industry
Refugio	Education, agriculture, arts
Calhoun	Education, manufacturing, construction
Aransas	Education, retail trade, construction
San Patricio	Education, construction, retail
Nueces	Education, retail, arts
Bee	Education, public administration, retail
Live Oak	Education, agriculture, retail
Goliad	Education, manufacturing, agriculture

Capital

Capital describes the financial resources, resource values, and human ability to manipulate these resources. The availability of capital can alter consumption levels of natural resources. In the human ecosystem framework, capital is defined as the economic instrument of production that can affect and manipulate financial resources and resource values. In 2010, the Census Bureau estimated that the United States average median household income was $53,046 (US Census, 2010). Most of the state of Texas is lower than the national average, with more affluent areas around metropolitan areas of Houston, San Antonio, Austin, Midland, and Amarillo. In comparison to the rest of the state, the median household income of people within the Mission-Aransas watershed is low (Figure 2.23). Karnes, Bee, and Refugio counties had the lowest household income means, while Nueces, San Patricio, Goliad, and Calhoun had higher means (Morehead et al., 2007).

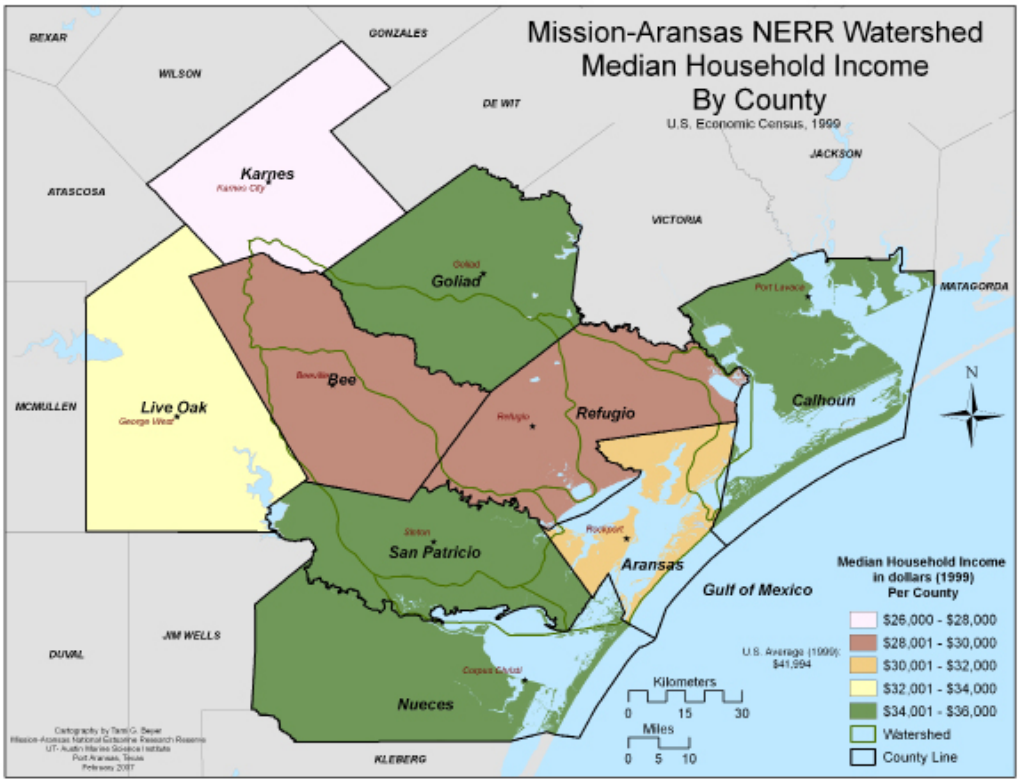


Figure 2.23. Median family income values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

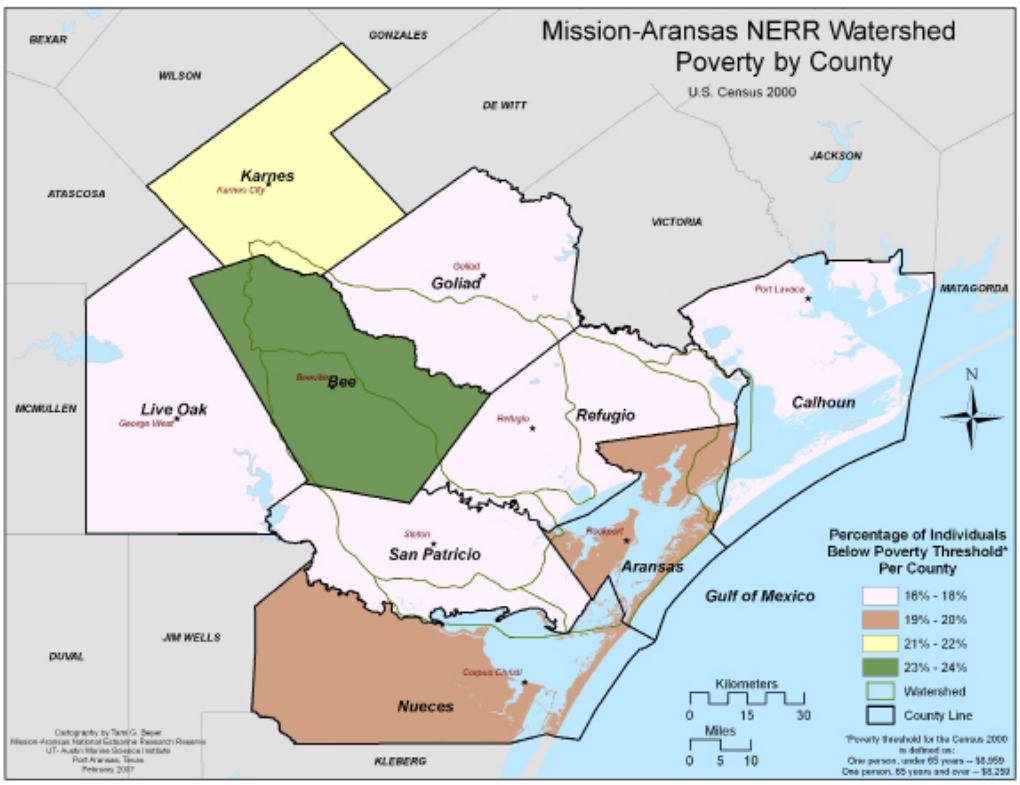


Figure 2.24. Median family income values for the Mission-Aransas Reserve watershed by county. (Morehead et al., 2007)

Wealth

Wealth is an indicator of hierarchy because it defines access to material resources, and wealth distributions can explain social inequality and opportunity (Dalton, 2005). In this study, the inverse of wealth is defined as the rate of poverty. In 2000, the Census defined the poverty threshold for those under 65 years of age at $8,959 and for those 65 years and older at $8,259. In the Mission-Aransas Reserve watershed, Nueces County had the greatest number of people living in poverty (Figure 2.24). Live Oak, Goliad, and Refugio counties had the fewest number of people living in poverty.

Power

Social power is the ability to alter other's behavior (Dalton, 2005). It usually consists of the individuals with political or economic power that have considerably better access to resources than the average person. Power is measured in terms of the number of households with income greater than $100,000. In the Mission-Aransas Reserve watershed, Bee County had the lowest percentage of households with income greater than $100,000 (Figure 20). Nueces and Aransas counties have the greatest percentage of households with income greater than $100,000. The US Census Bureau conducted an American Community Survey for 2005-2007 and although some of the counties within the Reserve watershed have not yet been determined, the general trends of power remain the same. These statistics indicate that Nueces and Aransas counties have the most individuals with power, but both counties are still below the national percentage of 12.3%.

2.3.3 Ecosystem services

Ecosystem services are the benefits provided by nature, which contribute to human well-being. These benefits can range from tangible products such as food and fresh water to cultural services such as recreation and aesthetics. These benefits also include such services such as pollination, disturbance regulation, and soil and sediment balance. Several studies have focused on evaluating ecosystem services within and near the Reserve.

SolVES

The National Centers for Coastal Ocean Science (NCCOS) worked with the Mission-Aransas Reserve to examine the relationship between the social valuation of ecosystem services and land use/land cover in the Reserve watershed, paying particular attention to the spatial and geographic assessment of the relationship to underlying environmental characteristics.

The study explored the spatial quantification of social values of ecosystem services and their relationship to underlying environmental characteristics. Data was collected using three methods: an online, interactive mapping survey delivered to users intercepted on site; randomly selected residents using mail back surveys; and, snowball sampling of interested environmentally oriented stakeholder groups. All groups were offered a paper-based survey

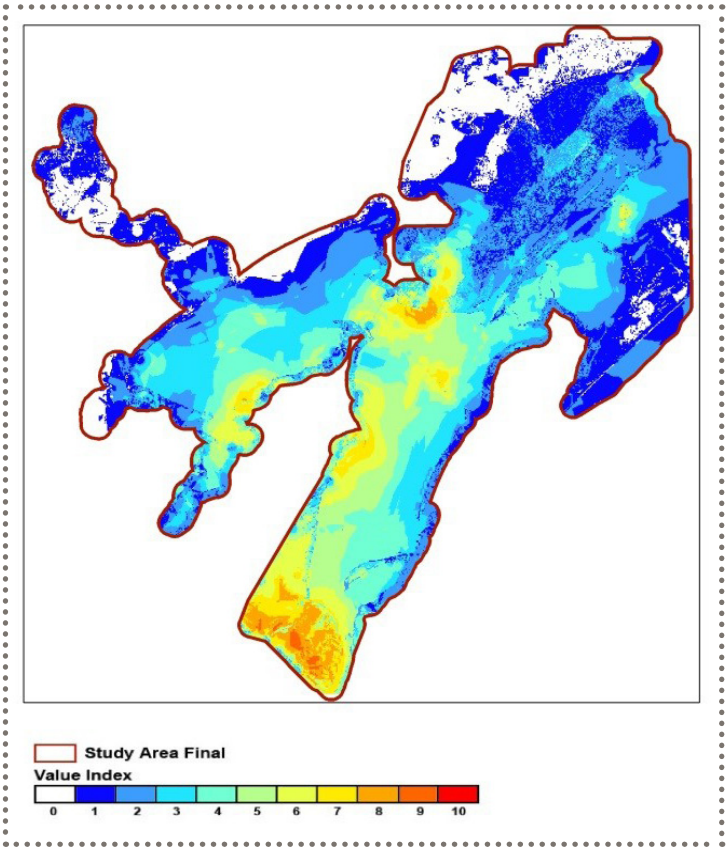


Figure 2.25. Spatial distribution of recreational value within the Reserve, as determined by survey responses in SolVES project. (Loerzel et al., 2015)

instrument as well. The data were analyzed using a geographic information system tool called Social Values of Ecosystem Services (SolVES). The SolVES model was used to analyze spatially explicit social value data and supplementary use perception data and their connection with underlying environmental characteristics (Figure 2.25). This process results in the production of landscape metrics that describe the respective relationships across a given landscape (Loerzel et al., 2015).

The study found significant methodological challenges of choosing and developing appropriate, effective spatial data layers that best model the spatial dispersion and relative value of corresponding social values within the study context. Furthermore, analysis of tabular data illustrates interesting disparity between stakeholder group perceptions of ecosystem services. This disparity is important for managers and policy-makers to consider when undertaking the assessment of proposed resource management options. Additional results are currently being analyzed for a technical report (Loerzel et al., 2015).

Conceptual Ecosystem Model

In cooperation with the NOAA Environmental Cooperative Science Center (ECSC) a conceptual ecosystem model (CEM) was developed with stakeholder input for the Mission-Aransas watershed. The CEM was developed as an ecological risk assessment to identify the ecosystem components and societal drivers of the watershed and predict the risks associated with them. ECSC convened the Mission-Aransas Reserve CEM Development Workshop in April 2009, in which a series of matrices were produced that captured the relationships between physical processes/societal drivers and resulting environmental stressors and the relationships between the environmental stressors and their effects on Valued Ecosystem Components (VECs). The matrices were then converted into draft graphical CEMs (Figure 2.26). At the workshop, the Mission-Aransas Reserve was partitioned into 20 habitat types, and separate matrices were developed for each habitat. The intent was to highlight the important linkages that affect each VEC. This allows the reader to trace back the potential factors affecting each VEC and the drivers or processes that led to those conditions. Alternatively, they could be used to identify which potential VECs might be affected by the various drivers and stressors within the Reserve. In essence, each linkage constitutes a hypothesis of causality concerning how the ecosystem functions.

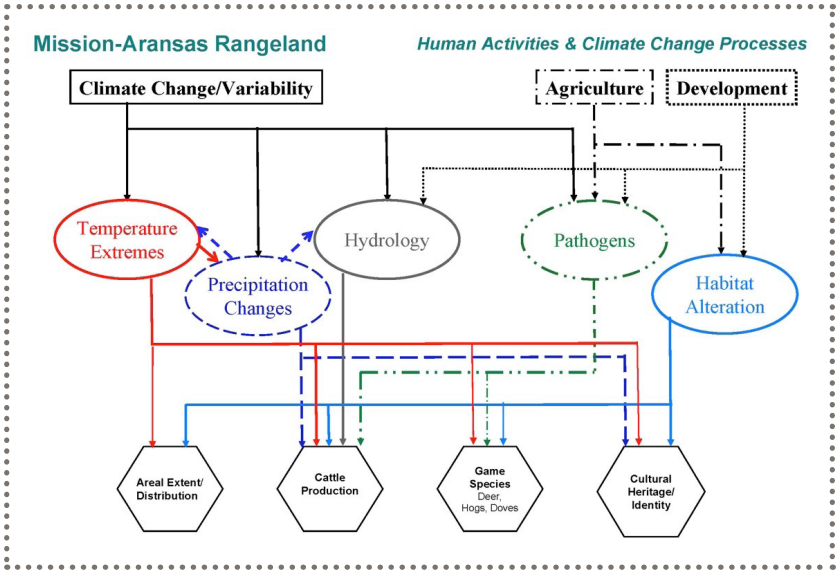


Figure 2.26. Example of one of the graphical models developed with results from the CEM workshop. Black rectangles are the natural process or human activity. Black lines represent links from each process/human activity to resulting environmental stressors (shown in ovals). Colored line thickness represents the strength of connection. Black hexagons represent habitat-specific valued ecosystem component.

Quality of Life Survey for Aransas County

In 2006, the Texas A&M University AgriLife Extension Office of Aransas County worked with partners to administer a Quality of Life Survey in Aransas County. The goal of the survey was to help guide policy makers and help design future educational programs in light of the growing concern by community residents about urban growth. The survey was administered to members of the Rotary Club, Master Gardeners, and the Chamber of Commerce. Surveys were also collected at the 2006 Sea Fair festival in Rockport. The intent of the Quality of Life Survey was simply to take the "pulse" of the widest possible sample of the community

with the resources at hand. While the sample did not have statistical significance, survey results from over 500 people from the county (and surrounding areas) did provide a sense of what the community felt was important in terms of growth.

A portion of the survey was devoted to finding out how concerned citizens' appreciated (i.e., valued) the remaining natural areas in Aransas County. Respondents almost uniformly agreed that preserving natural areas, including the trademark windswept oaks, was important to the future of Aransas County, with nearly 50% declaring that there were not enough natural areas currently preserved to insure a lasting legacy for their grandchildren and beyond. A significant and surprising majority indicated they would be willing to endure a slight increase in taxes to preserve important remaining natural areas. A not entirely surprising finding in light of the fact that over 90% of the respondents said they have participated of one kind of outdoor activity or another in Aransas County and that they continue to do so today (Jacob and Respess, 2006).

Nueces Estuary Ecosystem Management Initiative: An Ecosystem Services-based Plan

Funding from the Coastal Bend Bays & Estuaries program was used to develop an Ecosystem-Based Management Plan (EBMP) that could be used to direct habitat preservation, creation, and/or restoration activities in the Corpus Christi/Nueces Bay area and facilitate the application of fiscal opportunities and resources associated with coastal development, impact restitution, supplemental environmental, and community service projects and grants (Montagna et al., 2011). The EBMP focused primarily on Nueces and Corpus Christi bays, but the planning area did include southern portions of the Reserve boundary (i.e., northern Redfish Bay, southern Aransas Bay, Harbor Island, and Mud Island).

During the development of the EBMP, stakeholder input was used to determine the ecosystem services provided by habitats within the study area and to obtain ecosystem services valuation data. The number of ecosystem services provided by habitats was determined based on results of stakeholder surveys. For each habitat, a value for total number of ecosystem services provided was calculated per habitat. Freshwater and salt marsh wetland habitats ranked highly, as they were perceived to provide the most ecosystem services to stakeholders. Rookery island habitat was ranked the lowest of all habitats assessed. Average number of ecosystem services per habitat was used to create a heat map of ecosystem services within the study area. Dark blue represents lowest average number of ecosystem services and dark red represents highest average number of ecosystem services. Thus, dark red signifies "hot" areas on the "heat map" (Figure 2.27) (Montagna et al., 2011).

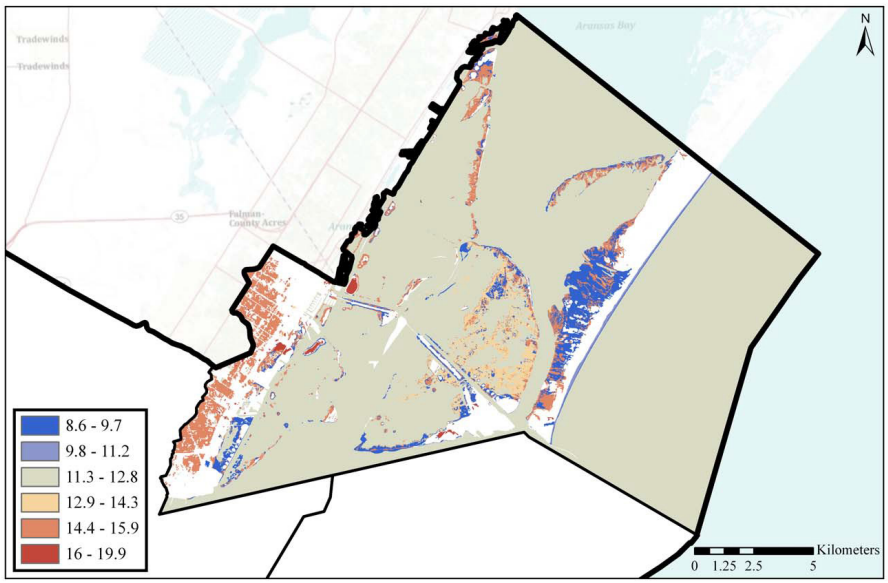


Figure 2.27. Heat map showing the average number of ecosystem services provided by habitats in the Redfish and South Aransas Bays sub-region (Montagna et al., 2011).

GecoServ

GecoServ is an online database (www.gecoserv.org) developed by the Harte Research Institute for Gulf of Mexico Studies (HRI) for the distribution and sharing of information related to ecosystem services valuation

studies. The database is also designed to identify current gaps in the ecosystem services literature. The studies summarized in the database are for habitats that are relevant to the Gulf region, including those found in the Mission-Aransas Reserve, even though they may have been conducted elsewhere.

2.4 Archaeological and cultural resources

Although it is estimated that humans have inhabited the area surrounding the Mission-Aransas Reserve for at least the last 12,000 years, evidence of the earliest inhabitants is scarce due to the post Pleistocene inundation of coastal archeological sites by global warming induced sea level rise. However, prehistoric human occupation of the area is well documented for the last 7,500 years, based on radiocarbon dating of archeological deposits. Data from these deposits indicate that from 7,500 to 4,200 years before the present (B.P.), prehistoric hunter gatherers fished for estuarine dependent shellfishes and fishes in local estuaries (Ricklis, 2004). The archeological evidence suggests that these people occupied cool season estuarine fishing camps from fall through early spring and riverine hunting camps during the warmer months. Although there was apparently a brief hiatus in exploitation of estuarine resources after 4200 B.P., by 3100 B.P. exploitation of estuarine resources intensified dramatically. This intensification may have occurred as sea level stabilized, allowing the development of the modern estuarine environment (Ricklis, 2004). Several archaeological sites are located within and surrounding the Reserve boundary (Hester, 1980; Ricklis, 1996) (Figure 2.28).

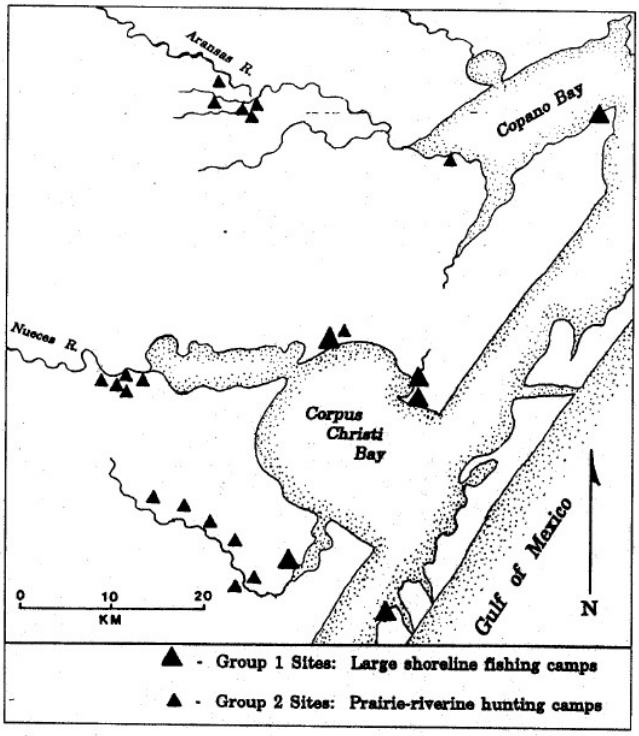


Figure 2.28. Locations of known large shoreline fishing camps (Group 1 sites) and smaller prairie-riverine camps (Group 2 sites) in the area. (Ricklis, 1996)

In 1528, the shipwrecked Alvar Núñez Cabeza de Vaca and his companions encountered native occupants of the central Texas Coast who were almost certainly Karankawas or their relatives (Ricklis, 1996; Krieger, 2002). This historic encounter is the earliest recorded contact between Europeans and native inhabitants of the Texas coast. Cabeza de Vaca's descriptions of the Indian's subsistence and seasonal mobility patterns match the patterns interpreted from the archeological data, lending evidence of a cultural link between the historic Karankawas and the prehistoric people who preceded them. The Karankawas navigated coastal bays in dugout canoes, from Matagorda Bay to Corpus Christi Bay, and exploited the seasonal offerings of the estuarine environment. They collected oysters and clams and fished for redfish, black drum, and spotted sea trout during the fall, winter, and early spring. During warmer months they moved further inland to hunt deer and collect plant foods along the rivers (Ricklis, 1996; Krieger, 2002). Despite their superb adaptation to the estuarine environment, the Karankawas eventually succumbed to the combined effects of European diseases, warfare, dispersal, and absorption into other native populations and they became culturally extinct by the mid 19th century (Ricklis, 1996).

The first European settlement in the Reserve area occurred with the development of Spanish missions on the central Texas coast during the early 18th century. In 1785, the Spanish established the port of El Copano on the northwestern shore of Copano Bay. El Copano became the main supply port for the Spanish settlements at Refugio, Goliad, and San Antonio. Early 19th century Texas colonists from Ireland and Mexico passed

through the Port of El Copano en route to Spanish land grant settlements. The port was used by Mexicans and those fighting for Texas independence during the Texas Revolution and by blockade runners during the Civil War. As railroads gained prominence, the port of El Copano and the town that formed around it declined until the towns were abandoned in 1880 (Huson, 1935). The remains of the port and town of El Copano are located just outside the Reserve boundary.

Lydia Ann Lighthouse

Other sites of historical and cultural interest located within or near the Reserve boundary include the Lydia Ann Lighthouse and the remains of a 19th century brickyard. Originally known as the Aransas Pass Light Station, the Lydia Ann Lighthouse was established in 1855 and is listed on the National Register of Historic Places. The lighthouse is located on Harbor Island in the Lydia Ann Channel. It was seriously damaged during a Confederate attack in December 1862, which destroyed the top of the tower. It was rebuilt in 1867 and was decommissioned in 1952 (Holland, 1972). The current private owner had the light recommissioned in 1988. The banks of the Cedar Bayou inlet, which separates San Jose Island from Matagorda Island, contain the remains of a 19th century brickyard. At this site, large complexes of brick kilns, huge open cisterns, and associated brick foundations are relics from the onset of the industrial age (Fox, 1983). Industrialization and development have continued in the site area, resulting in today's mixed economy that is driven by the diverse industries of tourism, agriculture, oil and gas, petrochemicals, and maritime shipping. Additional archaeological sites within the Mission-Aransas Reserve are listed in Table 2.6.

Table 2.6. Other archaeological sites presently known in the Mission-Aransas Reserve.

Location	Camp Type	Items Found
Mustang Lake (ANWR)	Large shoreline fishing and hunting camp	Shells, fish bones, pot shards, animal bones, perforated oysters, shell tools, chert flakes
North of Mustang Lake (ANWR)	Prairie-riverine hunting camp	Shells, fish bones, pot shards, animal bones, perforated oysters, shell tools, chert flakes
South of Mustang Lake (ANWR)	Prairie-riverine hunting camp	Shells, fish bones, pot shards, animal bones, perforated oysters, shell tools, chert flakes
Aransas River Mouth	Large shoreline fishing camps	Arrow points, small unifacial end scrappers, prismatic blades, pottery, Rangia clams, fish and animal bones
Moody Creek (Aransas R.) flood plain	Prairie-riverine hunting camps	Cultural debris, Rangia clams, fish and animal bones

2.5 Threats and Stressors

Reserves are designated under the premise that they are relatively pristine, representative estuarine ecosystems. However, they are and will likely be increasingly exposed to human and environmental stressors that must be understood in order to manage and adapt to changing conditions. In 2009, the Mission-Aransas Reserve collaborated with the NOAA ECSC to develop a conceptual ecosystem model of the Mission-Aransas Reserve watershed. The Conceptual Ecosystem Model was developed as an ecological risk assessment to identify the ecosystem components and societal drivers of the watershed and predict the risks associated with them. A series of matrices were produced that captured the relationships between

physical processes/societal drivers and resulting environmental stressors and the relationships between the environmental stressors and their effects on Valued Ecosystem Components. The following table shows the stressors that were identified during the development of the Mission-Aransas Reserve CEM (Table 2.7). More detailed descriptions of several of the dominant stressors within the Mission-Aransas Reserve are provided in the following sections.

Table 2.7. Stressors identified during the Conceptual Ecosystem Modeling process.

Physical	Chemical	Biological	Climate
Hydrology	Nutrient loading	Pathogens	Temperature
Salinity regime	Organic loading	Invasive species	Precipitation
Precipitation regime	Toxic metals	Resource harvesting	Sea level rise
Sedimentation	Chemical releases/spills	Harmful micro-algal blooms	Hurricanes/storms
Erosion	Pesticides/herbicides	Harmful macro-algal blooms	
Habitat alteration	Hypoxia	Human presence	
Fire regime	Atmospheric deposition		
Sea level rise	Pharmaceuticals		
Hurricanes/storms			
Resource harvesting			
Marine debris			
Solid waste disposal			
Temperature changes			
Turbidity			
Noise			
Subsidence			
Saltwater intrusion			
Seagrass damage			

2.5.1 Natural and anthropogenic stressors

Social patterns and land/water uses of counties within the watershed that drains into the Mission-Aransas Reserve greatly affect water quality and health of the Mission-Aransas Estuary. The counties that lie within the watershed of the Reserve are Aransas, Refugio, Calhoun, Nueces, San Patricio, Karnes, Goliad, Bee, and Live Oak. Five of these counties, Aransas, Refugio, Calhoun, Nueces, and San Patricio, contain land and water within the Mission-Aransas NERR boundary. The current population dynamic is small, rural communities transitioning into densely populated urban areas along the coast (Morehead et al., 2007).

Population growth is an important factor in determining anthropogenic impacts on the natural resources of the Mission-Aransas NERR and its surrounding area. Rapid population increases are a large concern among coastal communities because impacts associated with population growth (e.g., reduced flood control, increased pollution, subsidence, habitat loss) have tremendous impacts on the relatively sensitive adjacent estuarine systems. The majority of the Texas population is centered around metropolitan areas and there is a greater number of people along the coast and in the northeast region of the state near the metropolises of Houston and Dallas. Parts of the southern coast, including the Mission-Aransas Reserve, have some of the lower population numbers in the state. In particular, the northern counties of the watershed that drain into the Mission-Aransas NERR (i.e., Goliad and Refugio) are some of the least populated in the state with <7,500 people and densities of <10 people per square mile (Table 2.8).

Table 2.8. Population density of counties that make up the majority of the Mission-Aransas NERR watershed. Population numbers represent 2010 data from the U.S. Census Bureau.

County	2010 Population	Area (Square Miles)	Persons per Square Mile
Aransas	23,158	252	92
Bee	31,861	880	36
Calhoun	21,381	507	42
Goliad	7,210	852	8
Nueces	340,223	836	407
Refugio	7,383	770	10
San Patricio	64,804	692	94
State of Texas	25,145,561	261,232	96

On a smaller scale, people are centered near cities and towns with large rural tracts in between (Figure 2.29). It is interesting to note that there are small numbers of people around the lower portions of the Mission and Aransas rivers. The census blocks in the city of Rockport and the Live Oak Peninsula show high numbers of people, which is likely not reflected at the county level because of the low numbers associated with the unpopulated areas of the Aransas National Wildlife Refuge and San Jose Island (Morehead et al., 2007).

Although the watershed of the Mission-Aransas Reserve has relatively low populations, it is predicted that populations will increase because the south Texas coast is one of the few coastal areas in the United States that remains relatively undeveloped. Every county within the Reserve watershed is expected to experience population growth over the next 50 years, resulting in higher population densities (Table 2.9).

Table 2.9. Population projections for the year 2070 for counties in the Mission-Aransas Reserve watershed. Data is from the *2016 Regional Water Plan* from the Texas Water Development Board (TWDB, 2015).

County	2070 Population	Area (Square Miles)	Persons per Square Mile
Aransas	25,104	252	100
Bee	35,590	880	40
Calhoun	37,454	507	74
Goliad	10,884	852	13
Nueces	456,056	836	546
Refugio	8,213	770	11
San Patricio	77,049	692	111
State of Texas	51,040,173	261,232	195

Labor is an indicator of what type of anthropogenic impacts occur to natural resources. Industry can be used as an indicator of labor because it describes the products created that impact natural resources. Education is the dominant industry of all counties in the Mission-Aransas NERR watershed, but agriculture is in the top three industries in Refugio, Live Oak, and Goliad counties (US Census, 2010).

Patterns of land use indicate the spatial extent of human alteration and can be a valuable tool in determining how the natural resources in the area are utilized by humans. In particular, land use can help explain non-point source pollution, patterns of natural habitat, water quality, aesthetic characteristics of developed lands, and can also help identify areas for conservation. The watershed of the Mission-Aransas NERR is primarily comprised of forested land and rangeland (Figure 2.29). At a closer look, San Patricio and Bee County have high percentages of agricultural land in the sub-basin that drains the Aransas River into Copano Bay. Bee, Goliad, and Refugio counties primarily have forested and rangeland within the sub-basin that drains the Mission River into Copano Bay. The urban areas are primarily confined to cities such as Corpus Christi, Rockport/Fulton, and Sinton.

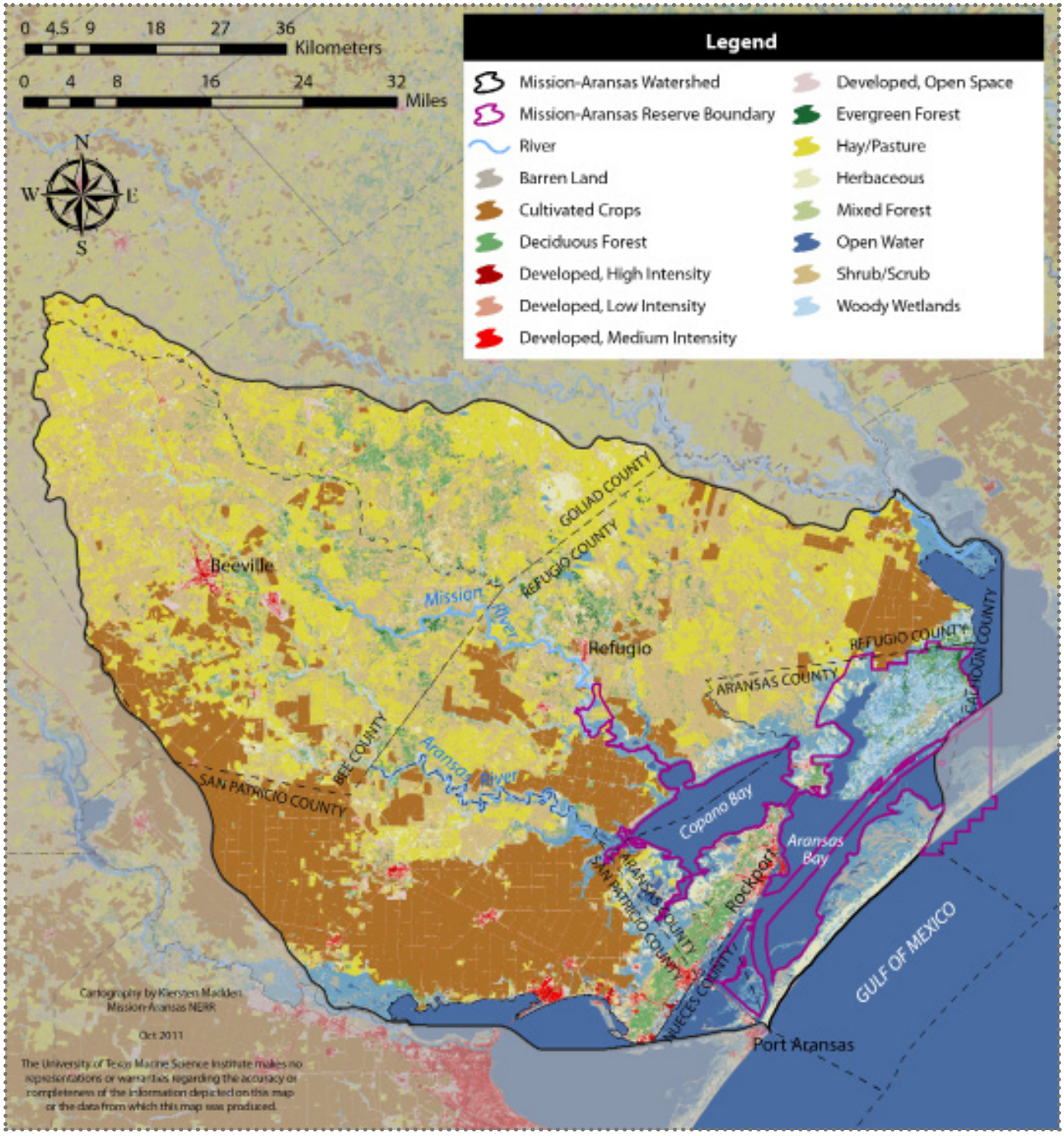


Figure 2.29. Map of land use/land cover within the Mission-Aransas Reserve watershed.

The majority of the counties in the Reserve receive their water supply from surface water resources (TWDB, 2012). The cities and towns in the Mission-Aransas NERR region are largely served by the city of Corpus Christi and groundwater (well water) systems. The city of Corpus Christi operates two dams on the Nueces River, and is the major water wholesaler to municipal and county water resellers. The majority of the surface water is used to supply municipalities and manufacturing, but groundwater supplies are also a source of water for the Reserve (Table 2.10). The Reserve's watershed lies above the vast Gulf Coast Aquifer, which stretches the length of the entire coastal plain of Texas.

Table 2.10. Water use estimates for Reserve counties from Texas Water Development Board (TWDB) water survey. Data is provided for surface and ground water uses from 2012. Surface use estimates are in acre-feet (groundwater use estimates are in parentheses).

County	Municipal	Manufacturing	Mining	Power	Irrigation	Livestock
Aransas	3,643 (463)	0 (0)	0 (0)	0 (0)	0 (0)	16 (37)
Calhoun	2,137 (917)	42,502 (1,576)	0 (0)	0 (0)	20,000 (0)	85 (200)
Nueces	55,382 (1,716)	35,718 (2,466)	2 (3,627)	342 (0)	1,542 (16)	10 (242)
Refugio	1,312(0)	0 (0)	0 (0)	0 (0)	0 (908)	47 (428)
San Patricio	7,089 (2,232)	8,458 (1)	1 (12)	0 (0)	226 (11,447)	191 (192)

Texas law (first passed in 1957) ensures that sufficient flows are maintained for "the maintenance of productivity of economically important and ecologically characteristic sport or commercial fish and shellfish species and estuarine life upon which such fish and shellfish are dependent" (Texas Water Code, ' 11.147). In 2007, the Texas legislature adopted Senate Bill 3, which requires all Texas watersheds to develop a plan to regulate freshwater inflows to the coast. Two groups have been tasked with recommending an environmental flow regime that supports a sound ecological environment and maintains the productivity, extent, and persistence of key habitats for each bay-basin system. These groups include the Bay-Basin Stakeholder Committee and the Bay-Basin Expert Science Team (GSA BBEST, 2011).

The Mission and Aransas rivers are small and primarily coastal compared to other rivers in Texas. Neither the Mission River nor the Aransas River has dams, or are used as water supplies for cities in the region. The Mission-Aransas Estuary is one of the few estuaries on the Texas coast that still receives sufficient inflows of surface fresh water to maintain a healthy ecosystem. The National Wildlife Federation published a report that described the health of Texas estuaries based on full use of existing freshwater permits (Johns, 2004). Out of the seven bay systems studied, Mission-Aransas Estuary was one of two bay systems that received a good ranking. Existing water use permits for the Mission and Aransas rivers authorize 1,900 acre-feet of surface water diversions. At the current time, surface waters in Mission and Aransas rivers are not at risk, however, future growth of south Texas cities will require additional water resources (Johns, 2004). This emphasizes the importance for continue long-term monitoring of estuaries.

2.5.2 Climate change

Estuaries are particularly vulnerable to climate variability. Potential impacts include changes in sea level, shifts in habitat extent, alterations in community structure, increased shoreline erosion, and deteriorating water quality. Climate change is expected to intensify the historical pattern of variable and extreme climate in Texas. The Texas coast is likely to experience severe climate change impacts due to a combination of factors including the regional climate regime and coastal geology. Specifically within the Mission-Aransas Reserve, there will most likely be alterations in freshwater inflows from rivers, changes in estuarine ecosystem structure and function, more frequent and longer-lasting droughts, increased salinity within some coastal ecosystems, saltwater intrusion, changes in habitat extent due to sea level rise, further reductions in some estuarine dependent species (e.g., blue crabs, oysters, shrimp), and range expansions of other species (e.g., red and black mangroves).

Observed Changes

In fact, the subtropical Mission-Aransas Estuary appears to be undergoing a series of transitions that are being accelerated by the changing climate. For example, in recent years the establishment of biota more characteristic of tropical habits has been observed, with range expansions of red and black mangrove, mangrove snapper, snook, and other species (i.e., Montagna, 2011). In addition, more droughts and hypersaline conditions within Mission-Aransas Estuary have been observed recently, indicating that the

Reserve is experiencing more intense rainfall events with longer, dry periods in between due to climate changes (Evans et al, 2012).

The Texas coast is in a relatively warm climate zone and subject to very high rates of evaporation (Larkin and Bomar, 1983); therefore, changes in temperature or rainfall will have great impacts. The average air temperature near the Reserve, according to the NOAA weather station at Corpus Christi International Airport (CCIA), is 22.3 ± 0.6 °C (minimum: 17.1 ± 0.6 °C; maximum: 27.5 ± 0.8 °C) for the past 66 years (1948-2013). Large temperature variations have been found prior to the early 1980's. The affects of global warming, however, has resulted in a steady increase of the air temperature by 0.04°C yr^{-1} (1.3°C overall) since late 1970's (Xue et al., In press) (Figure 2.30).

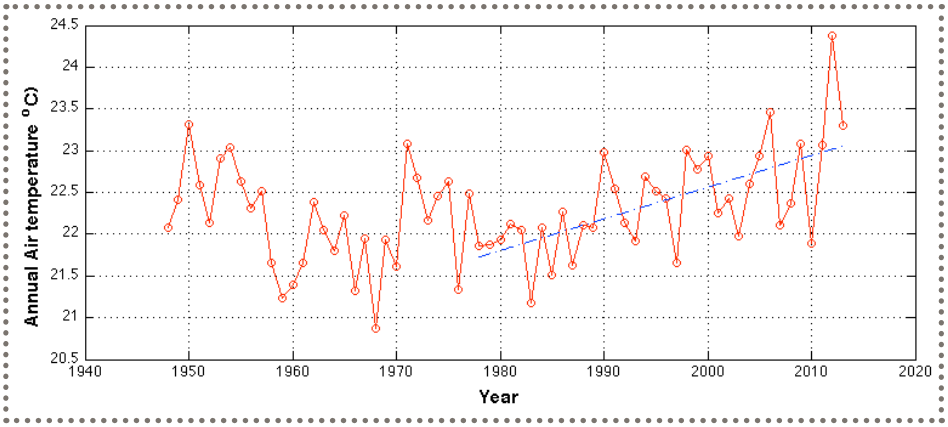


Figure 2.30. The average annual air temperature at Corpus Christi InternationalAirport NOAA weather station near the Mission-Aransas Reserve between 1948-2013 (Xue et al., 2015).

Water temperature has been continuously detected within the Reserve since 1996 by the Texas Coastal Ocean Observation Network (TCOON) stations in Aransas and Copano bays. The average annual water temperature is 24.5 ± 0.6 °C in Rockport with a 1.4 °C overall temperature increase in the past 17 years (Figure 2.31). Similarly, Copano Bay has an average water temperature of 24.2 ± 0.9 °C and 0.3 °C overall temperature increase in the past 17 years (Xue et al., In press).

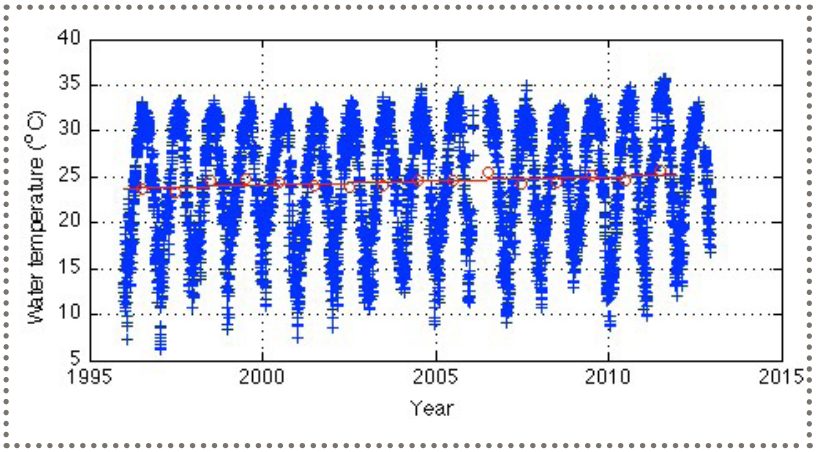


Figure 2.31. The daily (+) and annual (o) water temperature in Aransas Bay, measured at Rockport station monitored by Texas Coastal Ocean Observing Network between 1996-2012 (Xue et al., 2015).

Although the average temperature shows an increase over the last approximately 66 years, the major temperature impacts within the Mission-Aransas Reserve are often attributed to winter freeze events and intense temperature drops with passing cold fronts, which significantly bring down temperatures for a certain time period (Evans et al., 2012). Holt and Holt (1983) reported the mortality of six major fish species (i.e., sand seatrout, pigfish, Atlantic spadefish, sheepshead, black drum, and

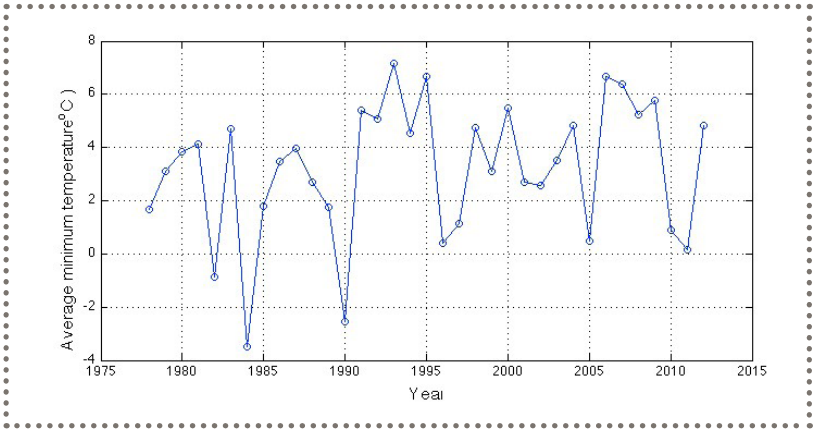


Figure 2.32. The average minimum temperature of the coldest week each year between 1978-2012 (Xue et al., 2015).

bearded brotula) in Port Aransas due to a cold front that rapidly dropped the water temperature to near freezing in January 1982. They also suggested that these fish species were even more vulnerable to sudden cold spells after a warmer than usual summer and fall, due to the fact that more tropical marine species may migrate to and remain inshore in winter than they would be in normal years. Thus, low temperature stress has previously been identified as the major cause for the episodic mass fish mortalities in coastal oceans (Hurst, 2007) and has previously been observed within the Reserve (Holt and Holt, 1983). Severe winter freeze events usually occur between December and February, with most events happening in January. The average minimum temperature of the coldest week of each year provides a means to track changes in winter freeze events over time (Figure 2.32). At least eight years have been reported to have winter air temperatures significantly colder than usual (the average is 3.2 °C) in the coldest week since late 1970's (Xue et al., In press).

The average annual precipitation at the CCIA weather station is 76.2 ± 23.0 cm yr^{-1} for the past 66 years. There were large variations, with the highest record shown in 1991 (122 cm yr^{-1}), and the lowest record in 2011 (48 cm yr^{-1}) (Figure 2.33). The overall trend for annual precipitation is decreasing with 0.5 cm yr^{-1} (17 cm overall) since the late 1970's (Xue et al., In press).

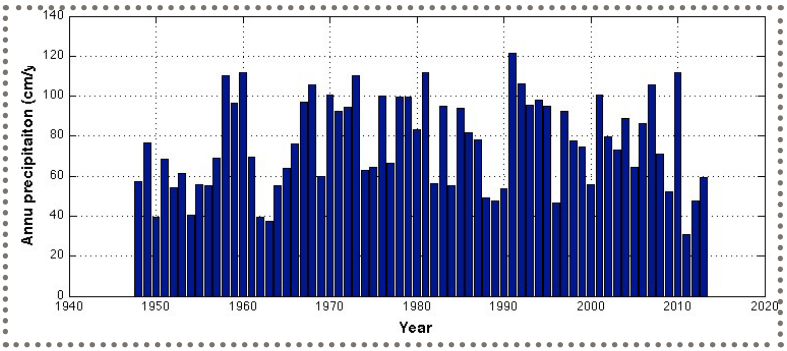


Figure 2.33. Average precipitation for the second half of the year at CCIA NOAA weather station near the Mission-Aransas Reserve between 1948-2013 (Xue et al., 2015).

Severe drought is a frequent occurrence during summer time due to the fact that high temperatures lead to high evaporation rates, which often greatly exceed precipitation during the summer months. During droughts, the estuaries intermittently become hypersaline, which has been reported to significantly affect fish or bird breeding, growth, or distribution in coastal waters (Gaines et al., 2000; Dolbeth et al., 2010). Recent observations of increased droughts and hypersaline conditions within the Reserve (Figure 2.34) indicate changing climatic conditions (Evans, 2012).

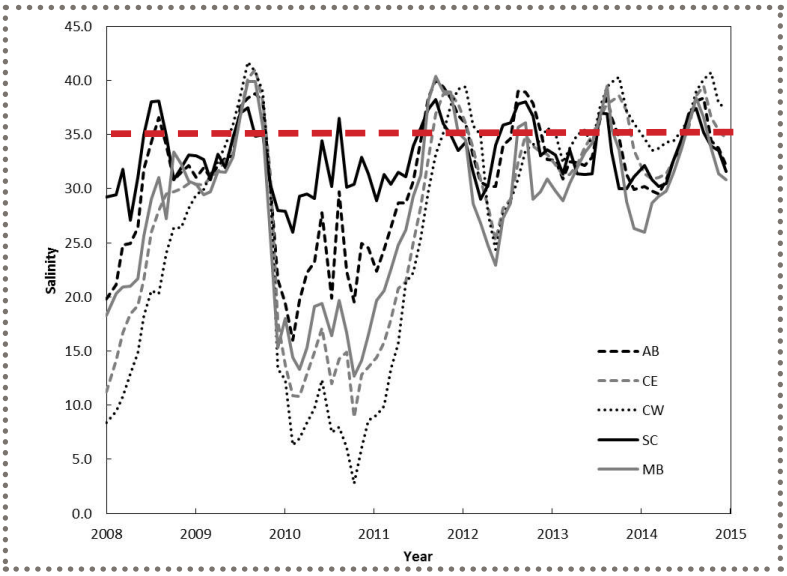


Figure 2.34. Salinity data from the Mission-Aransas Reserve SWMP water quality monitoring program indicates that the Mision-Aransas Estuary has reached hypersaline conditions several times from 2008-2014. Red dashed line indicates 35 psu.

Local precipitation levels have a strong influence on drought severity in the area of the Reserve. Increasing annual temperatures, combined with decreasing precipitation, have been observed in the past three decades, and may have led to more drought stress in Texas bays. Since the impact of precipitation on drought is cumulative by days, average daily rainfall over 0.35 inch in a month is defined as a heavy rainfall month, and daily rainfall less than 0.01 inch as light month (Hansen, 2013). Using this definition, Table 2.11 shows the number of light and heavy rain months at the CCIA weather station for the past five decades. From 2002-2013, the number of heavy rain months was high, while the number of light rain months doubled compared to the previous two decades (Xue et al., In press). This result indicates that the Mission-Aransas Reserve area is having more frequent

intense rainfalls with longer drought periods in between, consistent with other recent climate change studies in the southeastern United States (Thomas et al., 2009).

Table 2.11 Number of light or heavy rain months in the Reserve for the last five decades (Xue et al., 2015).

Year	No. of light rainfall months (Precipitation<0.76 cm month^{-1})	No. of heavy rainfall months (Precipitation >26.7 cm month^{-1})
1954-1965	23	3
1966-1977	23	4
1978-1989	15	4
1990-2001	15	2
2002-2013	30	4

Rising global sea levels are another consequence of climate change, and sea level rise impacts in the Mission-Aransas Reserve are exacerbated due to the low lying coastal plains and high rates of subsidence (Anderson, 2007). The mean sea level trend is 5.53 millimeters/year with a 95% confidence interval of +/- 0.55 mm yr^{-1} based on monthly mean sea level data from 1948 to 2013 at the Rockport Tide Station (Figure 2.35). The rate of sea level rise for this area has been substantially higher than the global average for the last 100 years (approximately 1.7 mm yr^{-1}, IPCC 2007), and this difference is likely due to land subsidence. Potential impacts of sea level rise include: increased erosion, elevated storm surge, coastal inundation, salt water intrusion, non-point source pollution, and introduction of toxins.

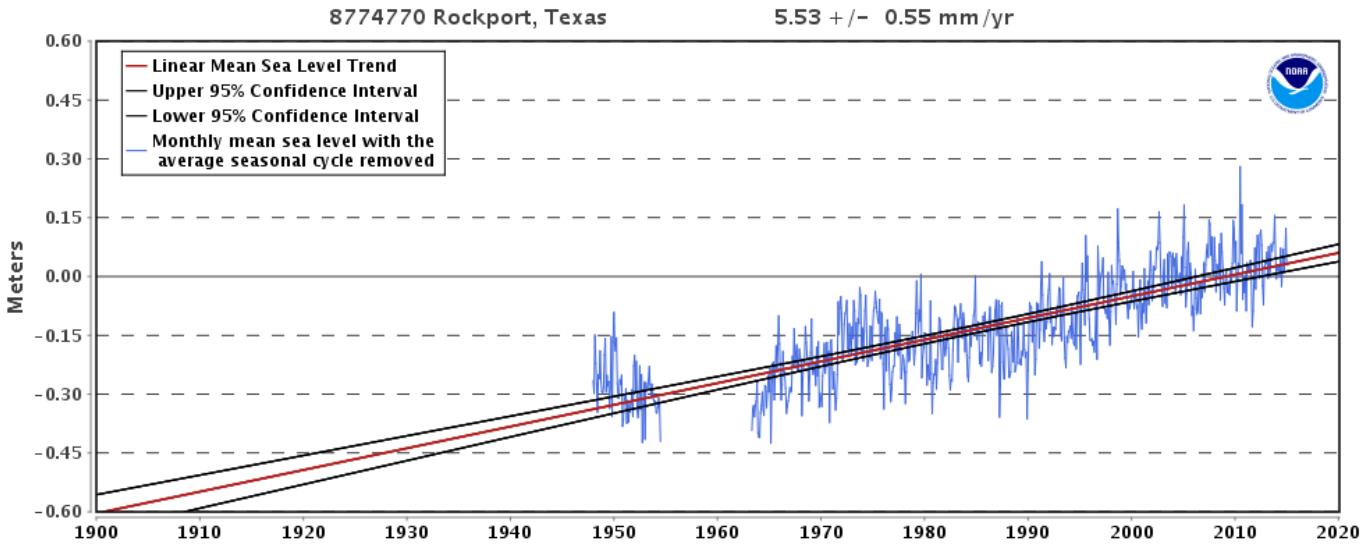


Figure 2.35. Long-term sea level trend for the Rockport, Texas tide station (8774770). (NOAA Tides and Currents)

Climate Predications

Climate predictions for the Southern Great Plains, including Texas, show increasing temperatures in all seasons through the end of the century. The greatest increases are expected in the summer with a large increase in the number of "hot" days. Historically, maximum temperatures reach more than 100°F in the Southern Plains for an average of seven days per year . These high temperatures are projected to occur much more frequently, even under a scenario of substantial reductions in heat-trapping greenhouse gases emissions (B1), with days over 100°F projected to quadruple in the south by mid-century (Figure 2.36). Similar increases are expected in the number of nights with minimum temperatures higher than 80°F in the south.

These increases in extreme heat will have many negative consequences, including increases in surface water losses, heat stress, and demand for air conditioning. These negative consequences will more than offset the benefits of warmer winters, such as lower winter heating demand, less cold stress on humans and animals, and a longer growing season, which will be extended by mid-century an average of 24 days relative to the 1971-2000 average. More overwintering insect populations are also expected (Schafer et al., 2014).

Predictions regarding future precipitation within the Great Plains show varied patterns across the region, but changing extremes in precipitation are projected across all seasons, including higher likelihoods of increasing heavy rain events. Average annual precipitation greater than 50 inches supports lush vegetation in eastern Texas and Oklahoma, but for much of the southern portion of the Great Plains, average rainfall is less than 30 inches, with far west Texas receiving less than 15 inches a year. Large parts of Texas and Oklahoma are projected to see longer dry spells (up to 5 more days on average by mid-century) (Figure 2.37). Across much of the region, annual water loss from transpiration by plants and from evaporation is higher than annual precipitation, making these areas particularly susceptible to droughts (Schafer et al., 2014).

The historical rate of sea level rise within the Mission-Aransas Reserve (5.53 +/- 0.55 mm yr^{-1} at Rockport Tide Station) is substantially higher than the global average for the last 100 years (1.7 mm yr^{-1}). Tidal marshes are among the most susceptible ecosystems to accelerated sea level rise. Rising sea levels may result in tidal marsh submergence (Moorhead and Brinson, 1995) and habitat "migration" as salt marshes transgress landward and replace tidal freshwater and irregularly flooded marsh (Park et al. 1991). In an

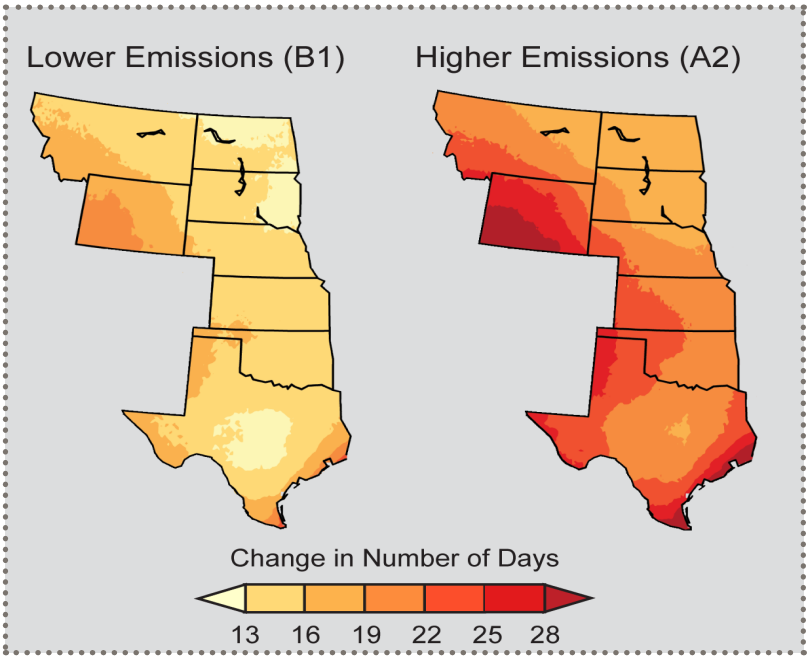


Figure 2.36. The number of days with the hottest temperatures is projected to increase dramatically. However, by mid-century (2041-2070), the projected change in number of days exceeding the historical average for the hottest 2% of days (about seven days each year from 1971-2000) is greatest in the western areas and Gulf Coast for both the lower and higher emissions scenario. (Figure Source: NOAA NCDC / CICS-NC)

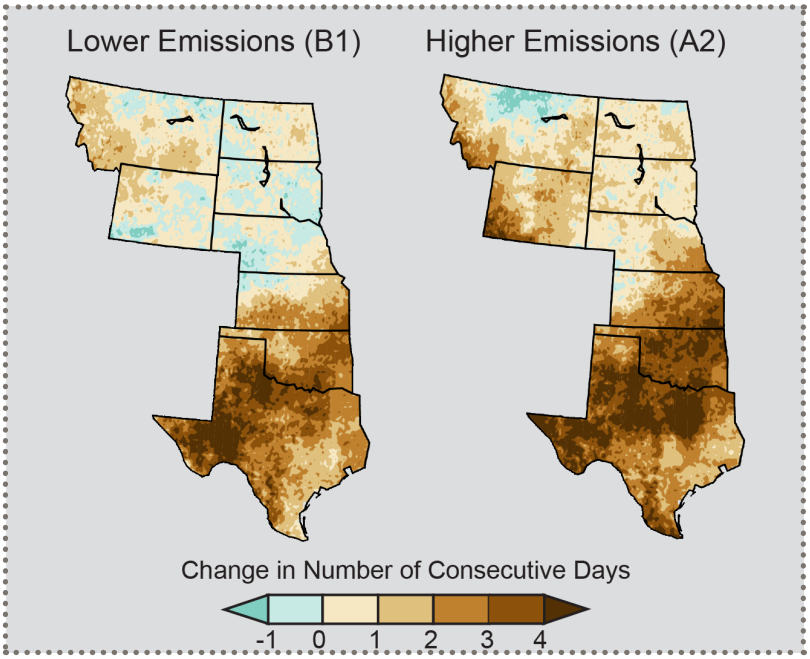


Figure 2.37. Current regional trends of a drier south are projected to become more pronounced by mid-century (2041-2070 as compared to 1971-2000 averages). Maps show the projected change in the number of consecutive dry days assuming substantial reductions in emissions (B1) and projected changes if emissions continue to rise (A2). The southeastern Great Plains, which is the wettest portion of the region, is projected to experience large increases in the number of consecutive dry days. (Figure Source; NOAA NCDC / CICS-NC)

effort to address the potential effects of sea level rise on US national wildlife refuges, USFWS contracted the application of the Sea Level Affecting Marches Model (SLAMM) model for multiple refuges, including ANWR (Clough et al., 2010). The analysis included areas outside of the ANWR boundary and covered much of the Mission-Aransas Reserve boundary.

SLAMM accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea level rise (Park et al. 1989; www.warrenpinnacle.com/prof/SLAMM). SLAMM 6 was run using scenario A1B from the Special Report on Emissions Scenarios (SRES) – mean and maximum estimates. Under the A1B scenario, the IPCC WGI Fourth Assessment Report (IPCC, 2007) suggests a likely range of 0.21 to 0.48 meters of sea level rise by 2090-2099 "excluding future rapid dynamical changes in ice flow." The A1B-mean scenario that was run as a part of this project falls near the middle of this estimated range, predicting 0.39 meters of global sea level rise by 2100. A1B-maximum predicts 0.69 meters of global sea level rise by 2100. To allow for flexibility when interpreting the results, SLAMM was also run assuming 1 meter, 1.5 meters, and 2 meters of eustatic sea level rise by the year 2100. The A1B-maximum scenario was scaled up to produce these bounding scenarios. The differential between local and global rates of sea-level rise at ANWR was projected to continue through the year 2100 within these model simulations. Full results are provided in Clough et al., 2010, but Table 2.12 provides an example of land loss/gain rates for 2 meters of sea level rise by 2100 for the years 2025, 2050, 2075, and 2100. Table 2.13 provides a summary of the predicted loss/gain for land categories by 2100 given several different sea level rise scenarios. Change maps of all modeling scenarios are provided in the report (Clough et al., 2010) and at www.slammview.org.

Table 2.12. Predicted loss rates of land categories by 2100 given simulated scenarios of sea level rise (Clough et al., 2010).

Aransas National Wildlife Refuge SLAMM Analysis (including Mission-Aransas NERR)
Scenario: 2 Meters Eustatic SLR by 2100

Results in Acres

		Initial	2025	2050	2075	2100
	Open Ocean	499966.3	500261.5	501471.2	502068.4	503934.3
	Estuarine Open Water	337324.3	341790.8	354649.7	380277.4	393467.8
	Undeveloped Dry Land	283220.3	280793.5	272746.4	248196.6	205507.2
	Inland Fresh Marsh	59411.7	59154.6	56235.3	47445.3	37678.1
	Regularly Flooded Marsh	32212.4	27627.3	13511.2	21802.2	36300.6
	Irregularly Flooded Marsh	18037.5	17233.2	10526.5	2160.9	681.8
	Estuarine Beach	11657.7	9367.1	2211.1	497.7	342.4
	Inland Open Water	6416.7	6402.1	6270.4	5830.7	5458.7
	Developed Dry Land	6304.4	6177.7	5616.0	4905.4	3869.7
	Swamp	5039.9	4768.3	3920.1	3011.0	2517.4
	Tidal Flat	1662.6	5389.2	23219.6	12427.8	21015.4
	Ocean Beach	1345.0	1300.3	254.6	591.9	2145.2
	Inland Shore	518.0	490.9	411.9	251.0	173.5
	Mangrove	419.9	391.7	325.8	227.5	168.7
	Tidal Fresh Marsh	195.3	180.9	111.1	31.8	17.9
	Riverine Tidal	57.2	42.9	29.4	5.8	0.9
	Tidal Swamp	8.7	7.6	5.4	0.0	0.0
	Cypress Swamp	1.3	1.3	1.0	0.0	0.0
	Transitional Salt Marsh	0.4	2418.5	12283.1	34068.1	50519.9
	Total (incl. water)	**1263799.5**	**1263799.5**	**1263799.5**	**1263799.5**	**1263799.5**

Table 2.13. Predicted loss rates of land categories by 2100 given simulated scenarios of sea level rise (Clough et al., 2010).

Habitat	0.39 m	0.69 m	1 m	1.5 m	2 m
Undeveloped dry land	3%	5%	9%	17%	27%
Inland fresh marsh	1%	4%	10%	23%	37%
Regularly flooded marsh	30%	59%	46%	20%	-13%
Irregularly flooded marsh	10%	37%	67%	92%	96%
Estuarine beach	70%	88%	94%	96%	97%
Developed dry land	9%	14%	18%	28%	39%
Swamp	18%	27%	35%	43%	50%

Changes in hurricane activity and intensity are also predicted for the U.S. There has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s, the period during which high-quality satellite data are available. These include measures of intensity, frequency, and duration as well as the number of strongest (Category 4 and 5) storms. The relative contributions of human and natural causes to these increases are still uncertain. Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate continues to warm (Walsh et al, 2014). Historically, the Texas Coast averages about three tropical storms or hurricanes every four years, generating coastal storm surge and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. The expected rise in sea level will result in even greater potential damage from storm surge along the Gulf Coast of Texas (Schafer et al., 2014).

2.5.3 Reserve sensitivity to impacts

In 2012, the Mission-Aransas Reserve reserved funding from the NOAA Climate Program Office, through the Coastal and Ocean Climate Applications (COCA) program, to examine potential climate change impacts in the Mission-Aransas Reserve using long-term climate and biological datasets. The goal of the project was to help the Reserve and its partners strengthen their understanding of the impact that climate variables have on local estuarine species. As winter air temperatures continue to increase and more frequent intense rainfall events are separated by longer periods of drought, this information will be become increasingly important. The results will also help establish priorities for future research efforts that assess vulnerability and lead to the development of adaptation strategies that address the major climate change threats. Datasets from the National Climatic Data Center, Texas Coastal Ocean Observing Network, TPWD Coastal Fisheries Monitoring Program, and the Audubon Christmas Bird Count were analyzed, and the species most impacted by major climate variables have been identified.

Fish Species

In total, 11 out of the 16 fish species examined in this study were identified as having consistent increasing or decreasing changes in the trend of either catch abundance or average total length in the Reserve since the late 1970's. Some of the declining species have already drawn researcher's attention. Southern flounders (both juvenile and adult) along the Texas coast were reported to have declined by 1-3% in abundance since 1975 (Froeschke et al., 2011). In addition, Ward (2012) reported that a declining trend has been observed for blue crab, in both abundance and size, in the Texas bays since the mid-1980s. Though not coast-wide, the annual average length of brown shrimp, has also significantly decreased in Sabine Lake, Galveston Bay, East Matagorda Bay, West Matagorda Bay, San Antonio Bay, and Lower Laguna Madre between 1977-2000 (TPWD, 2002).

There are species, however, that have been dramatically enhanced by changed fishing regulation and stocking programs, such as red drum (Vega et al., 2011; Carson et al., 2014), which declined in the 1970s and 1980s in the Northern Gulf of Mexico, but have increased about 3% since 1978 for both bag seine and gill net catches

in the Reserve. Moreover, recent management focus on controlling size and number of fishing vessels allowed to capture small species, such as shrimp, and allowing them to grow larger and to more valuable sizes before harvesting (Caillouet Jr. et al., 2008). In these cases, the changing of the fish abundance was not only affected by climate factors, but also by species management and potential harvesting.

Long-term changes, particularly the declines of fishery abundances and/or lengths in Texas bays, indicates the need to better understand the environmental factors impacting these species. Several studies have reported effects of either temperature or salinity on fish species in Texas bays. Sand seatrout abundance was found to be inversely related to salinity, and abundance was shown to decrease in summer when temperature was the highest (McDonald et al., 2009). Juvenile spotted seatrout distribution was also reported to be closely linked to salinity and temperature (Froeschke & Froeschke, 2011).

In this report, we identified several fish species that likely have been affected by winter freezes, summer drought, or the combined effect of freeze-drought in at least two TPWD sampling gear types (Table 2.14). In particular, decreases in the catch abundance and total length of Atlantic croaker and spotted seatrout were impacted by both winter freezes and summer droughts (red checkmarks). Whereas, only the catch abundance of red drum, sheepshead, and sand seatrout were affected by winter freeze and summer drought (blue checkmarks). Finally, the total length of Southern flounder was affected by winter freeze and summer drought (green checkmarks) (Xue et al., In press).

Table 2.14. List of fish species affected by winter freeze, summer drought, or both in catch abundance and total length, in at least sampling two gear types (Xue et al., 2015).

	winter freeze		summer drought		winter freeze & summer drought	
Species	catch abundance	length	catch abundance	length	catch abundance	length
Brown shrimp						
Pink shrimp						
white shrimp						
Atlantic croaker	✔		✔	✔	✔	✔
Bay anchovy				✔		
Blue crab				✔		✔
Gulf menhaden	✔			✔		
Pinfish				✔		
Spot						
Striped mullet			✔			
Black drum	✔					
Red Drum	✔		✔		✔	
Sheepshead	✔		✔	✔	✔	
Sand seatrout	✔	✔	✔		✔	
Spotted seatrout	✔	✔		✔	✔	✔
Southern flounder		✔		✔		✔
Alligator						
Gafftopsail						
Gizzard						
Hardhead catfish						
Ladyfish						

Impacts on the abundance and size of each fishery are not the only potential impacts of a changing climate on fisheries. Changes in the structure or community of the fish species (Gelwick et al., 2001), may also occur, but that was outside of the scope of this study. The other important climate variable in Texas bays that we did not discuss, but is also important, is dissolved oxygen, which can significantly influence fish community and abundances (i.e., Gelwick et al., 2001; Froeschke & Stunz, 2012). Moreover, factors other than climate change, such as population dynamics, predator/prey relationship, genetic composition, etc., must also be considered when examining species abundance (Carey, 2009). Therefore, it is a difficult task to establish a simple cause and effect relation between a single climate change variable with a species change. Clearly, more research is needed to more fully understand the impact of multiple climate variables on the fisheries of the Reserve.

Avian Species

Climate changes can cause variations in food supply, habitat structure, and other factors that may severely impact bird reproduction, migration, and other activities (Carey, 2009). A significant northward shift of many bird species has been globally observed, and was proposed to be caused by global warming and increases in minimum winter temperature (i.e., Thomas & Lennon, 1999; Valiela & Bowen, 2003; Audubon, 2009). Evidence also showed that both distribution and abundance of some songbirds were limited by temperature in winter (Butler et al., 2007). Moreover, precipitation has been found to mostly affect the long-term survival of many bird species, because changes in precipitation can affect plant growth, soil moisture, water storage and insect abundance and distributions (Michelson, 2014).

Table 14 lists the bird species that appear to have been affected by different climate variables within the Reserve. Nineteen out of the 28 bird species have been identified to be affected by one aspect of climate change, mostly the increases on minimum winter temperature or drought during the second half of the year, during the past several decades. In particular, ten species (marked with checkmarks in Table 2.15, Column 2) were identified as being positively affected by the increases on minimum winter temperature, while four species (marked with checkmarks in Table 2.15, Column 1) were limited by winter freezes. In addition, eight species (marked with checkmarks in Table 2.15, Column 3) were limited by the drought during the second half of the year, while three species (marked with checkmark in Table 2.15, Column 4) benefited from the drier conditions. Doubled-crested Cormorant, Forster's Tern, and Wester Sandpiper, were identified to be limited by both winter freezes and second half year drought, while two other species (Black-bellied Plover and Dowitcher sp.) were found limited by both increases on minimum winter temperature and second half year drought (Xue et al., In press).

Table 2.15. The list of bird species that were impacted by either winter freezes (minimum temperature during Dec 14 - Jan 5) or drought during the second half of the year inside of the Reserve (Xue et al., 2015).

bird name	winter freeze		second half year drought	
	limit	promote	limit	promote
Doubled-crested cormorant	✔		✔	
Eared grebe			✔	
Herring gull				
Forster's tern	✔		✔	
Royal tern				
Gull-billed tern				
Caspian tern		✔		
Black skimmer			✔	
Great blue heron		✔		
Black-bellied plover		✔	✔	
Piping plovers	✔			✔
Brown pelican		✔		
American oystercatcher				
Laughing gull		✔		
Sanderling			✔	
Red knot				
American Robin		✔		
American White Pelican				
American Wigeon		✔		
dowitcher sp.		✔	✔	
duck sp.				
Great-tailed Grackle		✔		
Northern Pintail		✔		
Red-winged Blackbird				✔
Redhead				✔
Western Sandpiper	✔		✔	
Whooping Crane				

2.5.4 Reserve vulnerability

Climate change vulnerability assessments provide two essential contributions to climate change adaptation planning: (1) identifying which habitats/species are likely to be most strongly affected by projected changes in climate, and (2) understanding why these habitats/species are likely to be vulnerable, including the interaction between climate shifts and existing stressors. Determining which habitats/species are most vulnerable enablers resource managers to better set priorities for conservation action, while understanding why they are vulnerable provides a basis for developing appropriate management and conservation responses.

The basic steps for conducting a vulnerability assessment include: (1) determine objectives and scope, (2) gather relevant data and expertise, and (3) assess various components of vulnerability (i.e., exposure, sensitivity, and adaptive capacity), and (4) apply the assessment in adaptation planning and resource management (Glick et al., 2011). Determining the objectives and scope of the assessment involves:

- Identifying audience, user requirements, and needed products
- Engaging key internal and external stakeholders
- Establishing and agreeing upon goals and objectives
- Identifying suitable assessment targets
- Determining appropriate spatial and temporal scales
- Selecting assessment approach based on targets, user needs, and available resources

In 2014, the Mission-Aransas NERR began the process of conducting a vulnerability assessment of a subset of Reserve habitats to future climate change using funding from the NOAA Climate Program Office, COCA Program. Stakeholder input was gathered to determine the objectives and scope of the assessment, in order to maximize its effectiveness and ensure that the information generated by the project could be used by Reserve partners to inform resource management decision-making. Based on participant feedback, the objective of the vulnerability assessment is to understand the relative vulnerability of key habitats within the Mission-Aransas Reserve. The habitats of highest priority for the assessment are seagrass beds, oysters, emergent tidal marsh, and freshwater marsh. The geographic scale of the assessment is the reserve boundary and the time frame for the assessment is the year 2060.

The Reserve will work with local partners and experts to use the Standardized Index of Vulnerability and Value Assessment (SIVVA) and the parameters listed above to assess the climate change vulnerability of the key habitats identified by stakeholders. The SIVVA tool contains four sets of criteria for assessment: (1) ecosystem status; (2) vulnerability (sensitivity + exposure); (3) conservation value; and (4) Natural Heritage rank. SIVVA was recently chosen by the Gulf Coast Vulnerability Assessment (GCVA) project to assess the vulnerability of oysters, seagrass, mangrove, and emergent tidal marsh to climate change in the Western Gulf Coastal Plain (as well as other ecoregions throughout the Gulf of Mexico). For the habitats that overlap between the two projects, the project team will be able to compare the results of the Mission-Aransas NERR assessment to the results of the much broader Western Gulf Coastal Plain ecoregion assessment. This will provide insights into how the geographic scale of the assessment may affect the vulnerability assessment results when using SIVVA. Additional benefits to using the SIVVA tool include the ability to use datasets that were generated for the GCVA and the opportunity to incorporate results into other ongoing efforts.

If time allows, the project team will also work with the experts to evaluate the same habitats listed above using the Climate Change Vulnerability Assessment Tool for Coastal Habitats (or CCVATCH). This tool is similar to SIVVA in that it is a spreadsheet based questionnaire completed in Microsoft Excel using expert elicitation. However, there are differences in how vulnerability is assessed between the two tools, which may lead to slightly different results. By using both tools and comparing the results, the project team will be able

to provide insights about the benefits and drawbacks of each tool for other individuals planning to complete climate change vulnerability assessments for coastal habitats.

2.6 Boundary

National Oceanic and Atmospheric Administration (NOAA) boundary requirements are outlined in the federal register (915 CFR 921.11). These requirements are summarized below:

- Key land and water areas that approximate an Ecological Unit: Reserve boundaries must "encompass and adequate portion of key land and water areas of the natural system to approximate an ecological unit..." and should encompass resources representative of the total biogeographic habitat.
- Encompass Areas with Adequate controls: NOAA regulations require that there be a level of control over uses and activities to ensure that the ecological integrity of the Reserve is maintained for sustained research and education. Specifically, the regulations state that Reserve boundaries must encompass the area within which adequate control has or will be established by the managing entity over human activities occurring within the Reserve.
- Management Considerations: The administrative burden and responsibility for operating a Reserve and associated research, stewardship, and educational programs were a significant consideration in the site selection process and in the delineation of the Reserve boundaries. Given the limited funds available to support Reserve programs, it is also important to develop a reasonable boundary that will establish a creditable Reserve without creating an overwhelming administrative burden.
- Research/Monitoring and Education Needs and Goals: The research/monitoring and education needs and goals of the Reserve are an important consideration in developing a boundary. These needs and goals define the purpose of establishing a Reserve, and should play a primary role in defining boundaries.

The following section regarding the Mission-Aransas Reserve boundary is divided into three components: (1) description of the Reserve boundary at the time of designation; (2) description of proposed boundary modifications for the revised management plan; and (3) description of the Reserve targeted watershed. Each of the first two components outline the land owners within Reserve, detail the habitats present, and define core and buffer areas.

2.6.1 Existing Boundary

Upon its designation in 2006, the Mission-Aransas Reserve contained 185,708 acres of marine, estuarine, freshwater, and upland habitats. The Reserve is relatively large in size (third largest in the Reserve System) due to the fact that Texas bay systems are quite large. The water and land areas within the Reserve are managed by a combination of state, federal and private entities (Figure 2.38). According to the previous Reserve Management Plan (NOAA, 2006), public land ownership within the Reserve boundary includes: (1) aquatic and upland habitats owned by USFWS at ANWR (66,216 acres), open water/bays owned by GLO (115,138 acres), and submerged lands and island managed by GISP (271 acres). As authorized by the Texas Coastal Management Plan, UTMSI holds a Coastal Lease for Scientific Purposes from GLO for state-submerged land within the Reserve boundary. Ownership of private land within the Reserve includes Buccaneer Cove Preserve owned by CBLT (728 acres) and Fennessey Ranch (3.324 acres). UTMSI also owns a small portion of land within the Reserve boundary (31 acres).

The boundary of the Reserve was set back 1,000 feet from the shoreline (easement) along more densely populated areas and adjacent to private lands. The area affected by the setback consists of submerged state owned land that was dedicated to the Permanent School Fund (PSF), some of which is already leased to private landholders, or property owned by local government entities. Some of this property is leased by GLO to private landholders to accommodate structures such as docks, piers, etc. Several private property owners

requested that the 1000-foot setback be removed along their property lines (Figure 2.38). This has occurred primarily along the shorelines of Redfish Point, southeastern Copano Bay and Port Bay. Letters from these property owners can be viewed in the Reserve's previous management plan (NOAA, 2006).

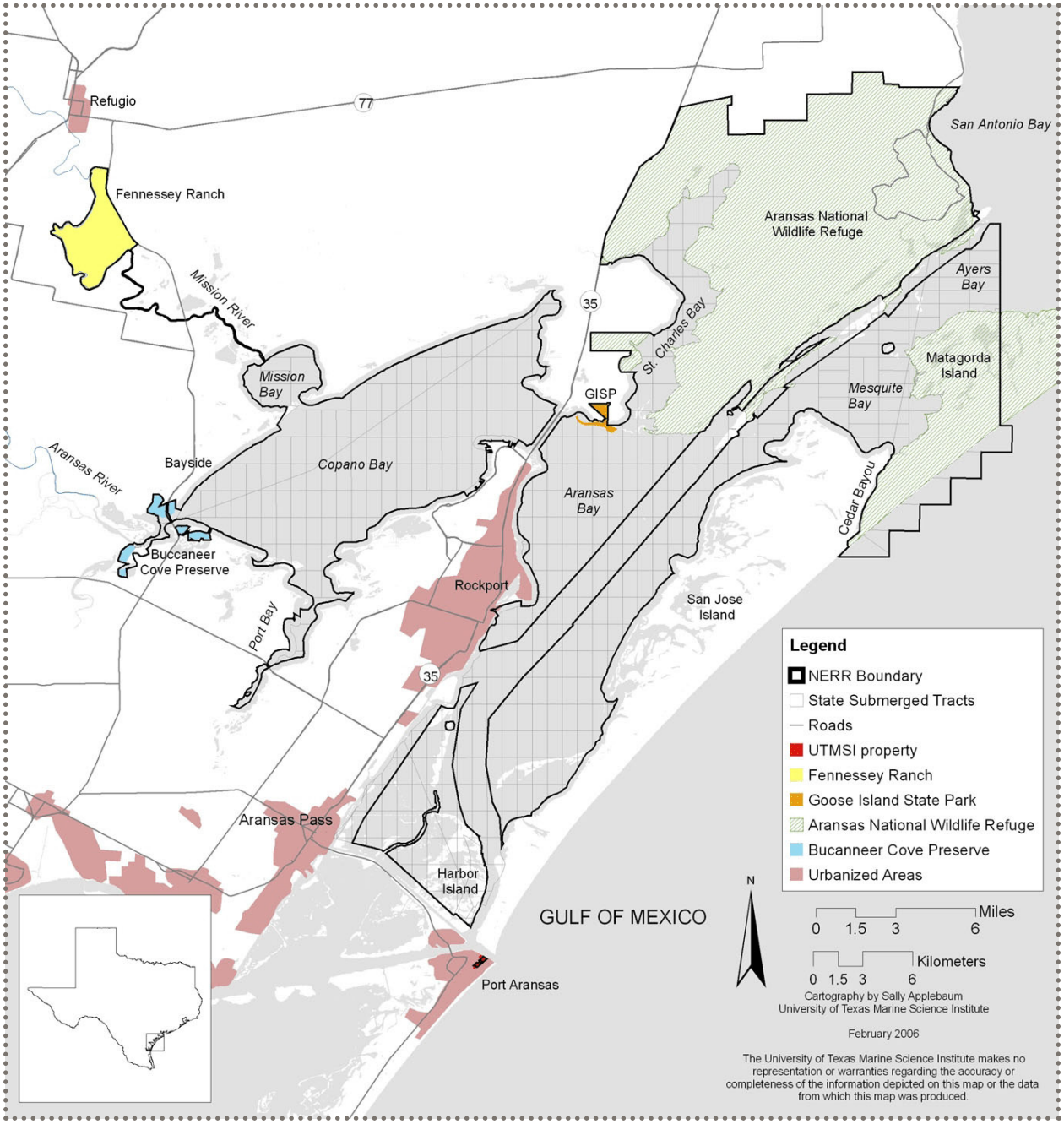


Figure 2.38 Land ownership within the Mission-Aransas Reserve based on 2006 Management Plan.

Due to requests from agencies, the GIWW, United States Army Corps of Engineers (USACE) dredge spoil sites, and TxDOT in holdings were excluded from the boundary (Figure 2.41). These requests are also available in Appendix 7 of the previous management plan (NOAA, 2006). Below is a summary of the areas that were excluded from the Reserve boundary upon designation:

- Gulf Intracoastal Waterway: 2,150 feet from centerline of each side
- Copano Bay Causeway, Highway 35: 750 feet from centerline of each side
- Cavasso Creek Bridge, highway 35: 150 feet from centerline of each side
- Salt Creek Bridge, highway 35: 150 feet from centerline of each side

- Farm Road 136 bridge at Copano Bay: 150 feet from centerline of each side
- Farm Road 2678, bridge over Mission River: 150 feet from centerline of each side
- State Highway 188 Bridge at Port Bay: 150 feet from centerline of each side
- GLO leased cabins (4): 1,000 feet around
- Shell Bank Island, private inholding

The GIWW, dredge spoil sites, and Copano causeway are long standing active areas that will require continued maintenance. All federally authorized navigation projects in the Mission-Aransas Estuary including but not limited to the GIWW, GIWW tributary channels, and the Corpus Christi Ship Channel were excluded from the Reserve boundary. A private land inholding (Shell Bank Island) within GLO submerged lands was brought to the awareness of UTMSI and NOAA during the public hearings associated with the Reserve designation. Therefore, Shell Bank Island was excluded from the Reserve boundary. Shell Bank Island (327 ac) is located adjacent to Corpus Christi Bayou in northern Redfish Bay. This private land is in GLO state tract 255 and 256. The GLO has four cabin leases within the Reserve Boundary that were also excluded. Cabin PC 1029 is located in southern Aransas Bay south of the City of Rockport in state tract 218. Cabins PC 1028, PC 1003, and PC 1041 are located in Mesquite Bay in state tract 24. These cabins occupy approximately 11 acres.

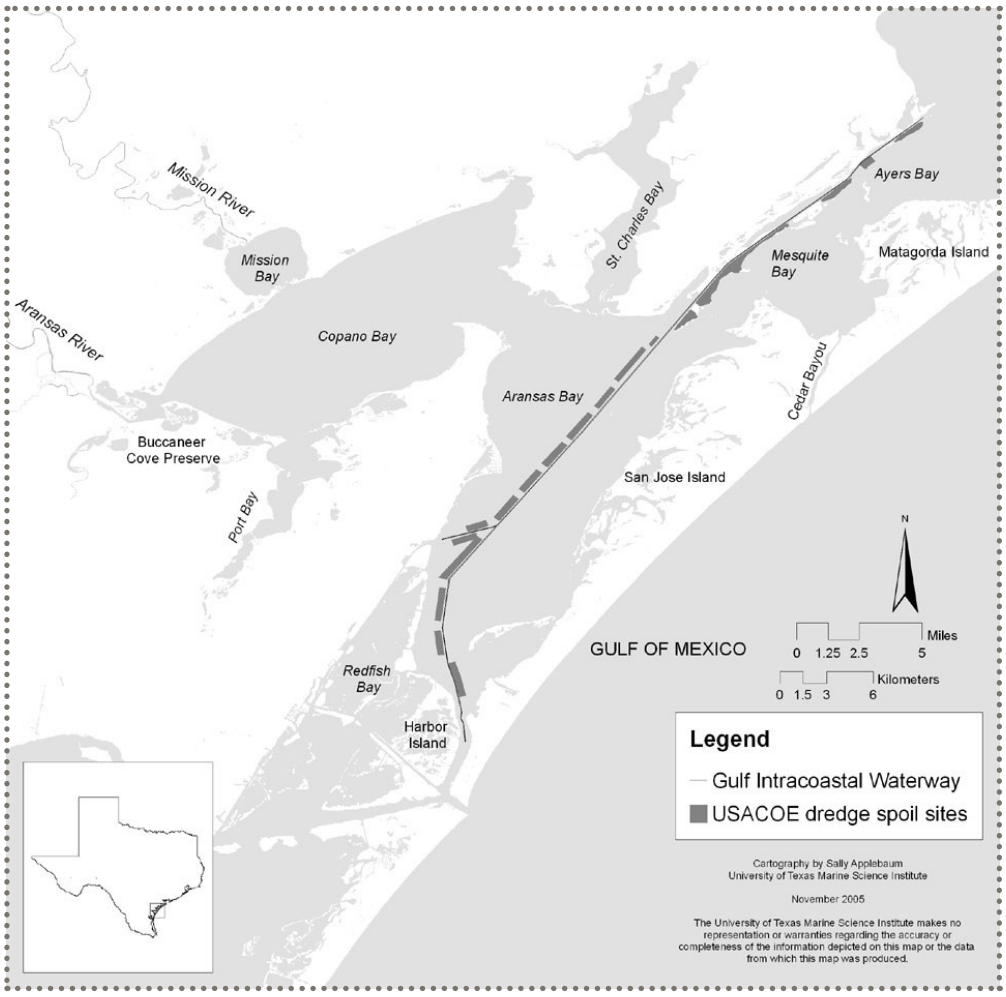


Figure 2.39. Gulf Intracoastal Waterway (GIWW) and USACE dredge spoil sites excluded from Reserve boundary during site designation.

During the public hearing process two parcels of property were included in the Reserve boundary. These properties were included for their potential to serve as locations for planned research and outreach centers. (i.e., Copano Bay Research and Education Center; Aransas Bay Public Outreach Facility). The property on which the Aransas Bay Public Outreach Facility was to be located is owned by the Aransas County Navigation District (ACND). A letter from ACND requesting the inclusion of the property for the Aransas Bay Public Outreach Facility in the Reserve boundary is included in Appendix 6 of the previous management plan (NOAA, 2006). Since the completion of the previous management plan, the Reserve was able to obtain funding to build an education and outreach facility on this property. The facility name was changed to the Bay Education Center and was completed in 2010. The property on which the Copano Bay Research and Education Center facility was to be built has not yet been acquired and is still owned by the same landowner.

Habitats

Along with open-water habitats, the Reserve includes several types of wetlands: freshwater (palustrine), brackish and salt marshes, and mangrove communities (Figure 2.40). The open water habitats also support benthic and nektonic populations, as well as large areas of oyster reefs. Large areas of seagrass are found in the southern portion of the Reserve, and numerous tidal flats can be found along the ocean side of Matagorda Island. Several maritime forests are also located within the Reserve including coastal prairies, oak mottes, and riparian woodlands. All these habitats support endangered species and culturally important species, such as shrimp and fish.

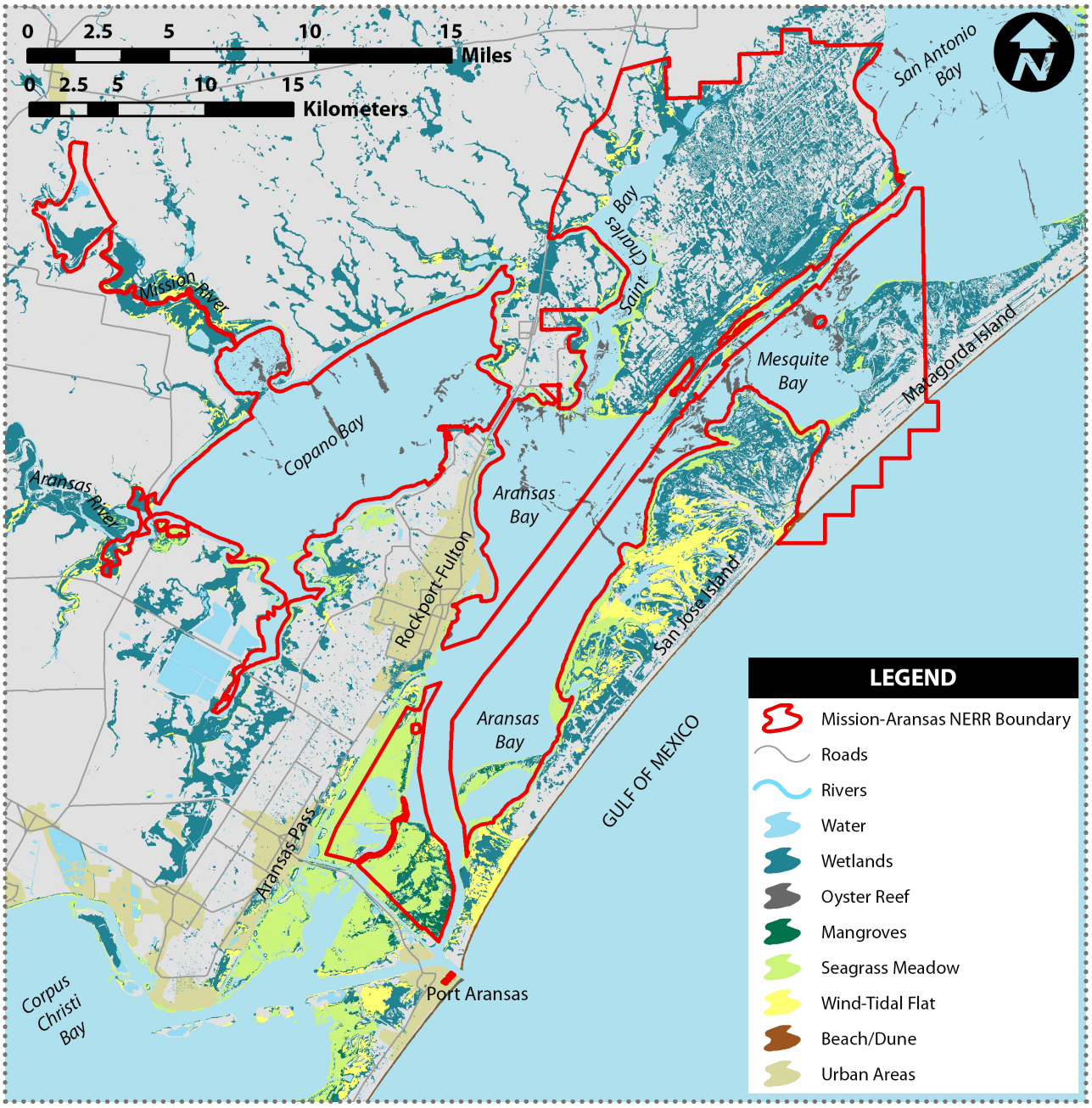


Figure 2.40. Map of habitats within the Mission-Aransas Reserve based on 2006 Management Plan.

Core and Buffer Areas

As described at 15 CFR 921.11 (C)(3), NOAA Reserve boundaries generally include two subcategories: key land and water areas (called "core areas") and a buffer. NOAA defines core areas as ecological units of a

natural estuarine system that preserve, for research purposes, a full range of significant physical, chemical and biological factors contributing to the diversity of fauna, flora and natural processes occurring within the estuary. The term buffer refers to the areas within the Reserve boundary that are adjacent to or surrounding core land and water areas and are essential to their integrity. Buffer zones are the areas within the boundary that are not designated as land or water core. Buffer zones protect the core area and provide additional protection for estuarine-dependent species, including those that are rare or endangered. When determined appropriate by the state and approved by NOAA, the buffer zone may also include an area necessary for facilities required for research and interpretation. Additionally, buffer zones should be established sufficient to accommodate a shift of the core area as a result of biological, ecological or geo-morphological change which reasonably could be expected to occur. Land and water core areas of the Mission-Aransas NERR were determined based on specific scientific knowledge of the area, their representativeness of the total ecosystem, and which if compromised could endanger the research objectives of the Reserve (Figure 2.41).

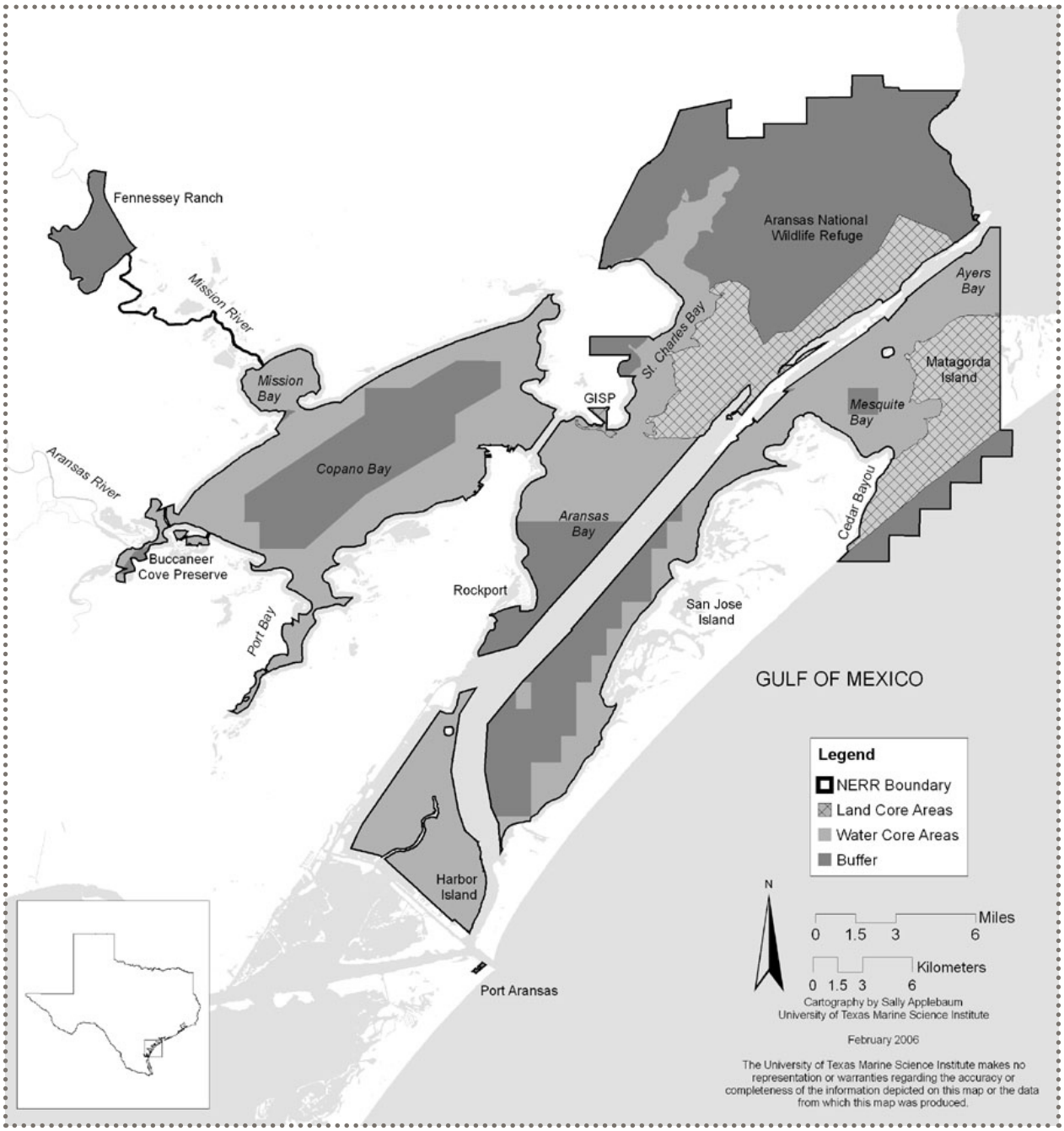


Figure 2.41. Core and buffer areas within the Mission-Aransas Reserve following its designation in 2006.

Water Core

The water core areas in the Reserve were chosen based on level of state control, habitats present, presence of active oil and gas wells, existing long-term records of research, and location for freshwater inflow analysis (Figure 2.41). Level of state control and habitats were identified by resource management code definitions within GLO submerged state tracts. Water core designation does not cause additional limitations on state leasing and permitting activities. The locations of the water core areas ensure adequate long-term state control. State control provides sufficient protection to ensure a stable environment for research.

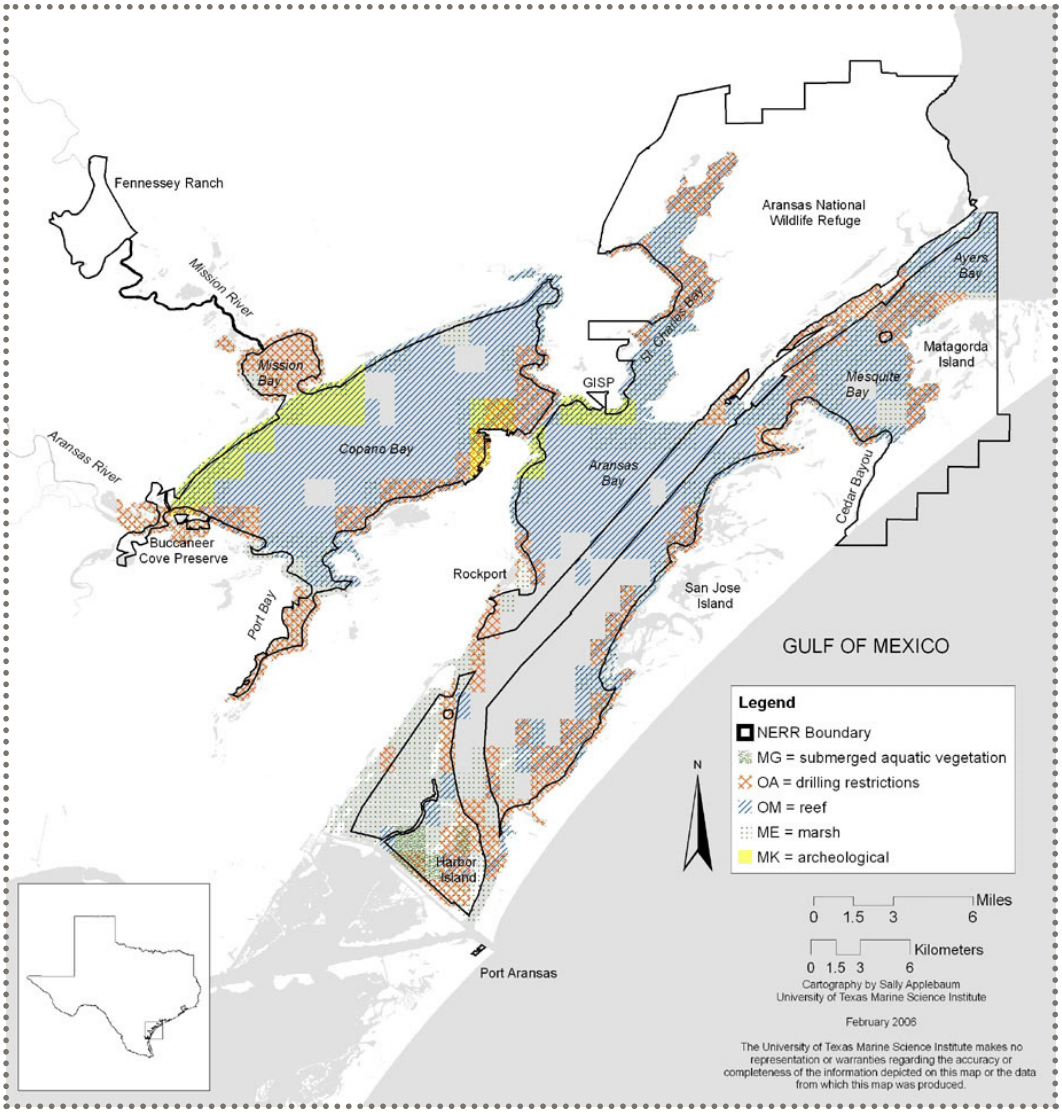


Figure 2.42. Resource Management Codes that were used to define core water areas during the Reserve's 2006 designation.

Resource management codes (RMCs) were used when the Reserve boundary was developed to help define the core water areas. RMCs were designed to assist potential users of the state-owned submerged lands during the permitting process by USACE and are used to represent development guidelines (Table 2.16). The codes enhance protection of sensitive natural resources by providing recommendations for minimizing adverse impacts to sensitive natural resources from mineral exploration and development activities. The RMCs are based on recommendations from the USFWS, National Marine Fisheries Service (NMFS), TPWD, Texas Historical Commission (THC), and the USACE. The management codes indicate that only some of the area within the state tract contains those resources. In particular, state tracts with the RMCs that indicated presence of marsh, submerged aquatic vegetation, archeological resources, oyster or serpulid reef, and additional oil and gas drilling restrictions were used to help delineate core boundaries (Figure 2.42).

Table 2.16. Resource management code definitions. Codes in bold indicate essential habitats or restrictions that were used to delineate core boundaries in 2006.

Code	Definition	Protection
CF	Channel Use	Vehicular access methods must be designed to avoid or minimize impacts on areas containing emergent marsh, submerged grassbeds or sand, mud, or algal flats.

Code	Definition	Protection
DA	Dredging	Water depths on this tract may be sufficient for access without dredging. Dredging may destroy or degrade sensitive estuarine habitats and reduce the productivity of the bay.
DB	Dredging	No dredging in water less than 4 feet deep as measured from mean low water to protect shallow water areas which contain sensitive habitat.
ME	**Marsh Habitat**	**Sensitive marine habitats exist within this tract, but oil and gas exploration and production activities, construction and operation activities, access routes, rights-of-way, and other activities may be permissible if sensitive areas are left undisturbed.**
MG	**Submerged Aquatic Vegetation**	**Seagrass has been documented on this tract, but oil and gas exploration and production activities, construction and operation activities, access routes, rights-of-way, and other activities may be permissible if sensitive areas are left undisturbed.**
MK	**Archeological Landmark**	**State archeological landmarks and/or other cultural resources protected by state law are known to be or may be located on this tract and should not be disturbed.**
MR	Sedimentation	Reduce impacts of sedimentation on seagrass, marshes, oyster reefs, or other sensitive estuarine habitats in this tract.
OA or OS	**Directional Drilling**	**Important marine habitat exists within this tract, and drilling activity and dredging of access channels may significantly damage the marine ecosystem. Directional drilling from off-tract locations may be required for mineral development of this tract.**
OH	Depth Restriction	This tract has both deep (greater than 6 feet) and shallow water areas and/or adjacent uplands. To protect sensitive habitats in the shallow water, confine drilling activities to the deep-water areas or adjacent uplands.
OM	**Oyster and Serpulid Reef**	**Avoid dredging, dredged material disposal, geophysical surveying, drilling, and pipeline and platform construction on the top or slopes of reefs, banks, hard bottoms, artificial reefs, historic reefs, serpulid reefs, or constructed reefs on this tract.**
RW	Navigation	Navigational concerns such as navigational channels, dredged material placement areas, safety fairways, and anchorage areas exist within this tract.
TB	Time Restriction	Tract contains whooping crane critical habitat. No construction, dredging, or drilling between October 15 and April 15. No permanent structures higher than 15 feet above mean water.
TC	Time Restriction	Bird rookeries are located on or near this tract. No drilling, dredging, seismic exploration, construction activity, or watercraft landing within 1000 feet of a rookery during nesting season between February 15 and September 1.

Locations of important bird rookeries, such as Harbor Island and Ayers Bay, were also taken into consideration in delineation of core boundaries. The isolated state tract in Aransas Bay represents a long-term monitoring station and was chosen for its ideal location for placement of a System-Wide Monitoring Program station because of its distance from San Antonio Bay and the Aransas Pass inlet to the Gulf of Mexico. Buccaneer Cove Preserve was included as a core area because it is privately managed by the CBLT, which ensures that long-term protection will occur. The primary goal of the CBLT is the preservation and enhancement of native wildlife habitat in the Coastal Bend. In addition, the Buccaneer Cove Preserve and Harbor Island/Redfish Bay are identified as a high priority coastal habitat area to be protected during oil or hazardous material spills (Figure 2.43). Mission Bay and part of the Ayers and St. Charles Bay core sites are identified as a medium priority coastal habitat area. Priority areas were identified and prioritized by TPWD and GLO personnel in cooperation with other entities and are prioritized by utilization of fish and birds, as well as amount of wetland habitat.

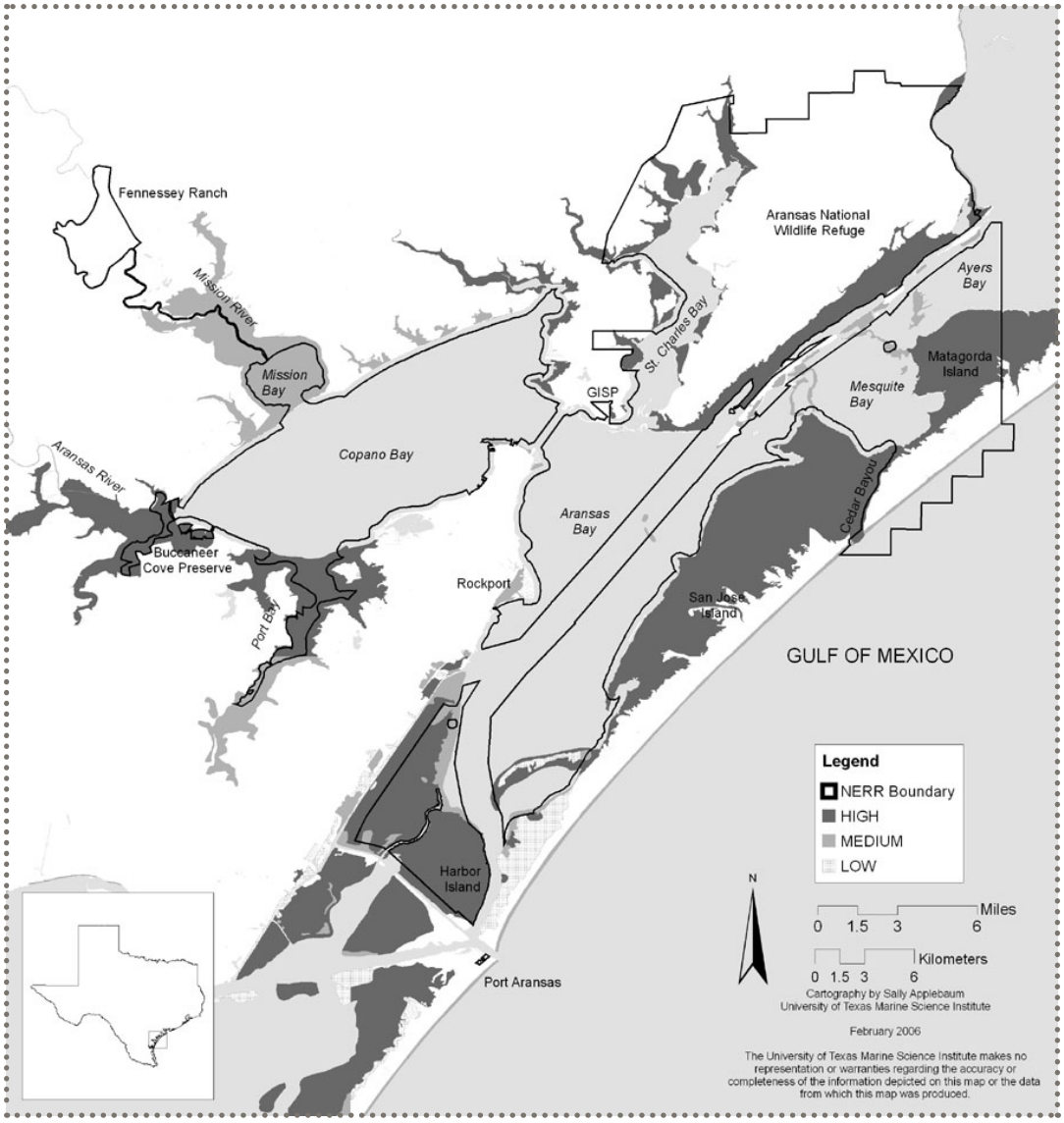


Figure 2.43. Priority coastal habitat areas to be protected during oil or hazardous material spills were used to help define core areas during the Reserve designation.

Land Core

The land core areas provide essential key upland habitats and are divided into two different units: GISP and portions of ANWR (Figure 2.40). GISP is located adjacent to the water core area of St. Charles Bay. The land core areas of GISP contain a wide variety of habitats including, live oak thickets or mottes, tidal salt marshes, and mud flats, that attract many migratory bird species. GISP is managed by TPWD. The portion of the ANWR chosen as core area includes essential habitat (coastal prairie and marsh) for the endangered Whooping Crane. ANWR is managed by USFWS.

Core land areas are under ownership and management of TPWD and USFWS, and existing regulations from these entities will ensure adequate long-term control and sufficient protection to ensure a stable environment for research. Regulations for mineral operations on TPWD and USFWS managed lands are bound to the goals and policies of the Coastal Management Plan and Texas Railroad Commission (RRC) regulations. The Coastal Management Plan has several pertinent policies for construction, operation, and maintenance of oil and gas exploration and production facilities in the Coastal Natural Resource Areas (CNRAs). Seagrasses, coastal wetlands, and tidal flats are identified and included in the CNRAs. If CNRAs are found in the area of proposed oil and gas exploration, applicants must take steps to avoid, minimize, restore, enhance, protect, or mitigate for any impacts. TPWD leases the land from GLO. The Texas Coastal Preserve System was created from the Coastal Public Lands Act, Section 33.001 which charges GLO with the responsibility to preserve the natural resources of the surface estate in coastal public land.

2.6.2 New Boundary

The Mission-Aransas NERR is requesting a boundary modification as part of this Management Plan. Since the Reserve designation in 2006, several key ecological areas have been acquired by Reserve partners, and these areas will be added to the existing boundary. The additional lands that are to be added to the boundary are under management of key Reserve partners, whom all provide adequate control over these areas in order to ensure their long-term protection. These areas are important for maintaining the integrity of the core land and water areas of the Reserve and will enhance the Reserve's ability to accomplish its goals and mission by providing opportunities for increased education, stewardship, and research activities. Additional areas to be added to the Mission-Aransas Reserve boundary include the following: (1) the Big Tree Unit owned by TPWD (Figure 2.44 - red, dashed box 1), (2) Holiday Beach properties owned by CBBEP, (Figure 2.44 - red, dashed box 2) and (3) Aransas River Delta property owned by CBBEP (Figure 2.44 - red, dashed box 3). With the addition of these areas, the Reserve landowners will include the following:

1. Texas General Land Office: State submerged lands (115,221 acres)
2. U.S. Fish and Wildlife Service: aquatic and upland habitats at the Aransas National Wildlife Refuge, including Matagorda Island (66,210 acres)
3. Texas Parks and Wildlife Department: aquatic and upland habitats at Goose Island State Park, including Big Tree Unit (255 acres)
4. Coastal Bend Bays & Estuaries Program: aquatic and upland habitats at Holiday Beach and Aransas River Delta (407 acres)
5. Coastal Bend Land Trust: aquatic habitats at Buccaneer Cove Preserve (142 acres)
6. Fennessey Ranch: aquatic and upland habitats at Fennessey Ranch (3,261 acres)
7. University of Texas Marine Science Institute: wetland and upland habitat associated with Reserve headquarters and educational facilities (31 acres)
8. Other private landowners: two upland parcels on Live Oak Peninsula (associated with educational facilities) and aquatic habitats in the Aransas River Delta (662 acres); these private lands were all previously included within the boundary and do not represent any part of the boundary expansion

Figure 2.44 shows the location of all Reserve landowners, including the boundary additions listed above - red, dashed boxes indicate areas where the boundary has expanded. Additional detail about the boundary modifications, including maps of the properties added to the boundary, are provided below.

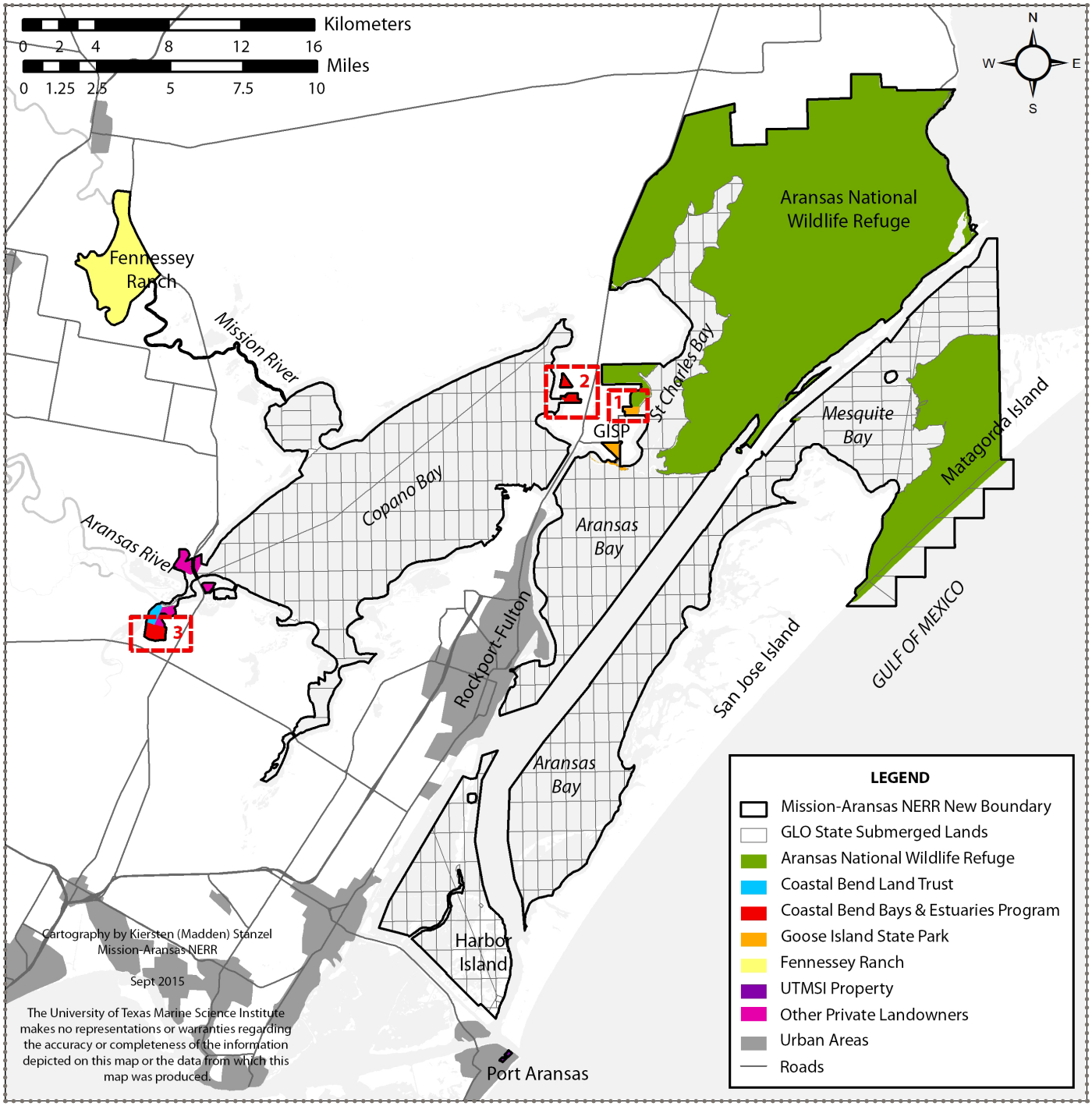


Figure 2.44. Map of landowners within the Mission-Aransas Reserve based on new boundary. Areas of proposed boundary expansion are indicated by the red, dashed boxes: (1) Big Tree Unit, (2) Holiday Beach, and (3) Aransas River Delta.

1. Big Tree Unit

Big Tree Unit is a 78-acre property located in Aransas County on the Lamar Peninsula (Figure 2.45). The property was recognized by TPWD and TNC for its extremely high conservation and recreational value, and funding was obtained by these two organizations for purchase of the property in 2012. The title for the property is held by TPWD and is managed by the staff at GISP. The property contains approximately 5,200 feet of shoreline along St. Charles Bay. The property is located directly adjacent to ANWR (Lamar Unit and Johnson Tract) and GISP. It is also situated directly adjacent to the existing NERR boundary. The property is composed of live oak-red bay woodlands (approximately 22 acres), coastal prairie (52 acres), and wetlands (2 acres of slat marsh and tidal flats). The area provides valuable habitat for endangered Whooping Cranes, which are frequently seen using the area. The property also encompasses "The Big Tree," a coastal live oak which is the former state champion and national co-champion.

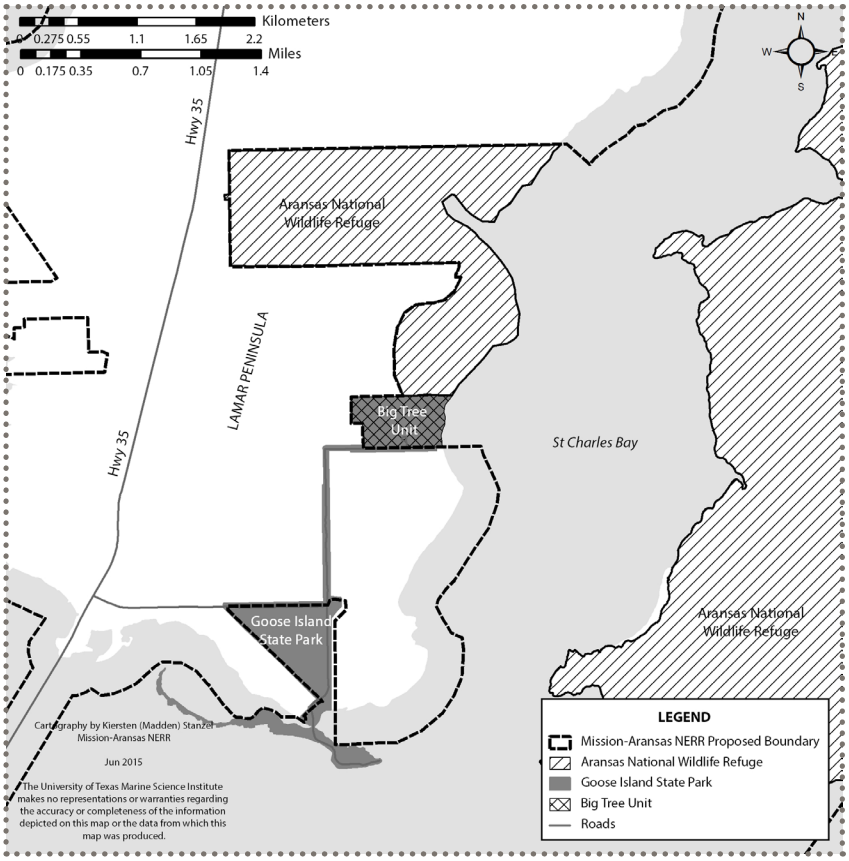


Figure 2.45. Map of Big Tree Unit owned by Texas Parks and Wildlife Department and managed as part of Goose Island State Park.

2. Holiday Beach

In 2012, CBBEP partnered with the Whooping Crane Conservation Association, TPWD, and TNC to purchase just over 170 acres of estuarine and freshwater wetland habitat on Lamar Peninsula, adjacent to Copano Bay and the Holiday Beach subdivision (Figure 2.46). Documented use by Whooping Cranes and threats from nearby development made this area a high priority for conservation by the these organizations. The title for the property is held by CBBEP. CBBEP is working with nearby home owners to decrease disturbance in the area and manage vehicle traffic in the area, especially during the winter months when Whooping Cranes are present on the property.

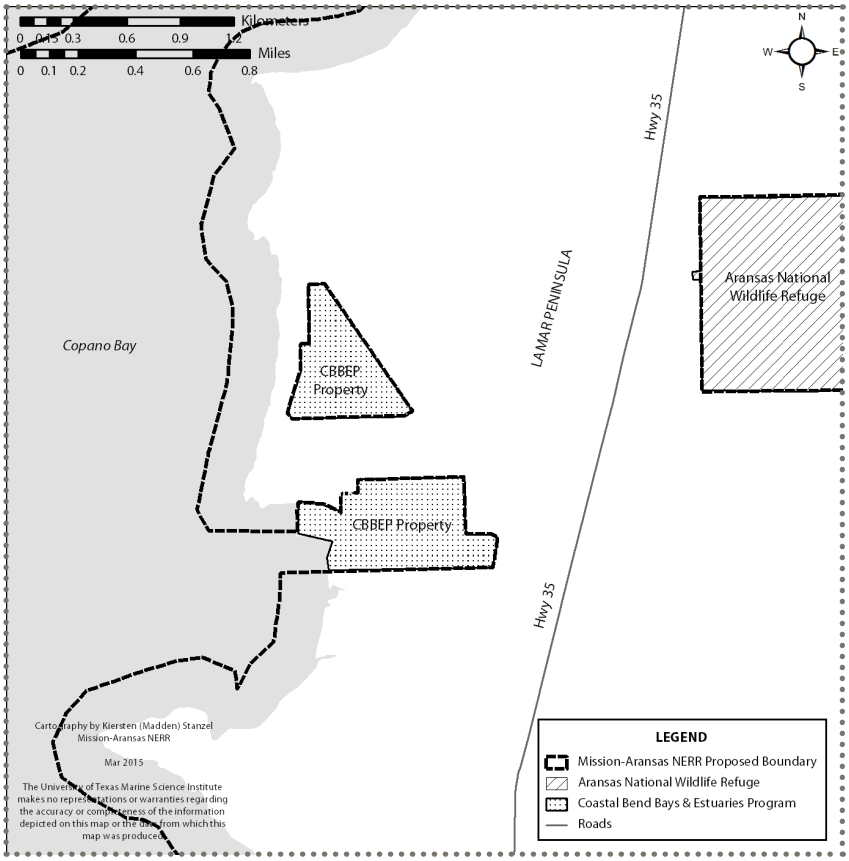


Figure 2.46. Map of Holiday Beach property owned by CBBEP.

3. Aransas River Delta

In 2007, CBBEP received a donation of 50 acres of land, which increased the amount of protected area near the mouth of the Aransas River. The acquired property is situated directly adjacent to the Buccaneer Cove Preserve, which is owned by the CBLT (who is overseen by CBBEP) (Figure 2.47). The property contains a mix of estuarine wetlands and mangrove communities. The Aransas River Delta provides valuable habitat for Sandhill Cranes, Reddish Egrets, and other waterfowl.

Reddish Egret

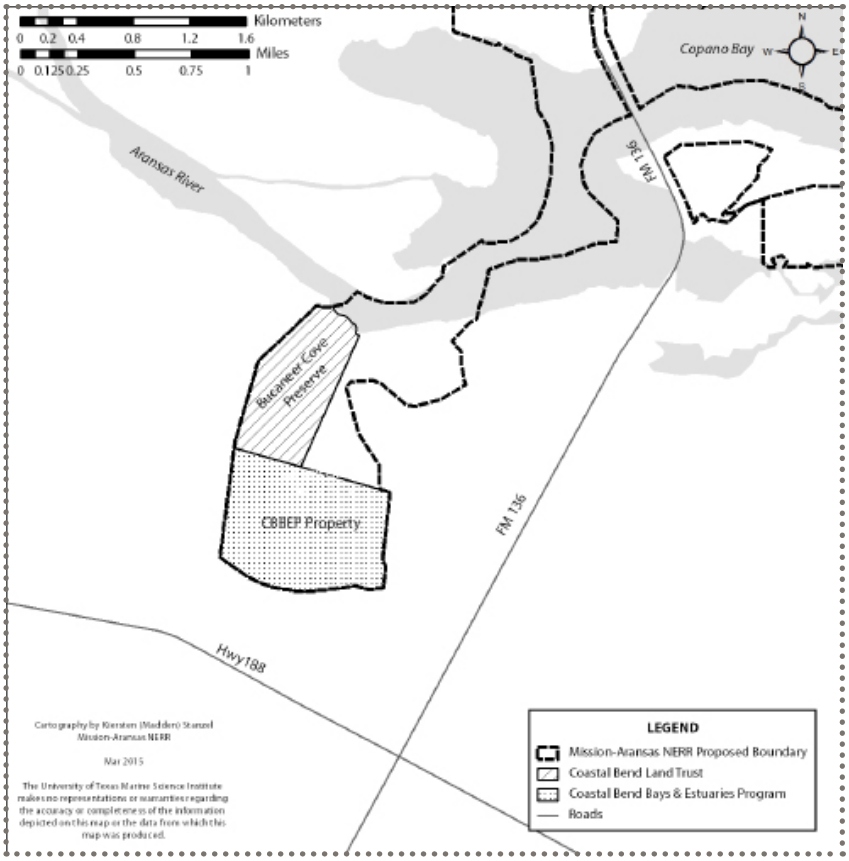


Figure 2.47. Map of Aransas River Delta properties owned by CBBEP and CBLT.

Habitats

Based on the boundary modifications mentioned above, the Reserve will contain 186,189 acres of marine, estuarine, freshwater, and upland habitats (Figure 2.48). An inventory of the habitats present within the boundaries of each Reserve land owner is provided in Table 2.17.

Table 2.17. Inventory of habitat types for Reserve landowners in new boundary. Data is based on NWI and NOAA Benthic Habitat data.

Habitat	Total	GLO	USFWS	TPWD	CBBEP	CBLT	Fennessey	UTMSI	Other
Unconsolidated Bottom	102,512	99,046	3,428	15		4			19
Beach	279	68	211						
Seagrass	9,565	7,817	1,741						7
Oyster	3,958	3,951	7						
Estuarine Wetland	10,900	788	9,422	26	217	135			312
Freshwater Wetland	17,399	4	16,500	8	6		877	3	1
Tidal Flat	2,576	680	1,628	5		3			260
Mangrove	1,555	1,397	31	5	122				
Lakes/Ponds	415		271				144		
Riverine	172	120					52		
Upland	36,858	1,350	32,971	196	62	0	2,188	28	63
TOTAL	186,189	115,221	66210	255	407	142	3261	31	662
Percentage	100%	61.9%	35.6%	0.14%	0.22%	0.08%	1.75%	0.02%	0.36%

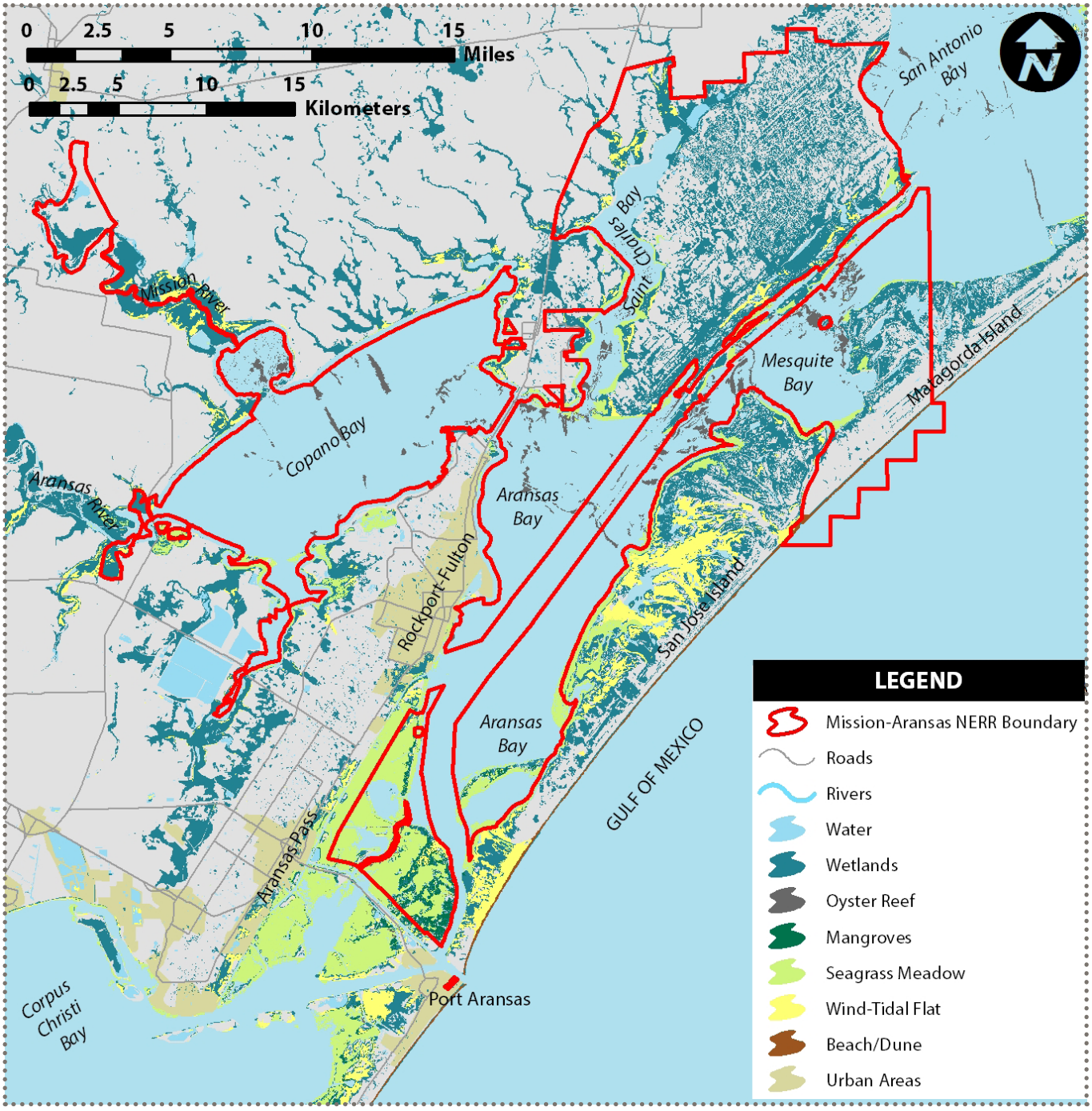


Figure 2.48. Map of habitats within and near the new Mission-Aransas Reserve boundary.

Core and Buffer Areas

The same parameters that were used to define the core water areas of the previous Reserve boundary were also used to delineate the core water areas of the new boundary. Areas were chosen based on level of control, habitats present, presence of active oil and gas wells, existing long-term records of research, location for freshwater inflow analysis, bird rookeries, and priority oil spill response areas. The locations of the water core areas ensure adequate long-term control and a stable environment for research. There was very little change to the core water areas. However, the boundary modifications did result in some slight changes to the amount of core area, including:

1. Increase in the amount of core water area along the shoreline of the Big Tree Unit (Figure 2.49 - red, dashed box 1);

2. Increase in the amount of core water area along the shoreline of the Holiday Beach property purchased by CBBEP (Figure 2.49 - red, dashed box 2); and
3. Buccaneer Cove Preserve boundary was redrawn to more accurately reflect ownership, which resulted in a small decrease of core water area in the Aransas River Delta (Figure 2.49 - red, dashed box 3).

The additional core water areas that were added near the Big Tree Unit and Holiday Beach property are the result of removing the 1,000-foot setback included in the old Reserve boundary. These core water areas are outside of the landowners boundaries (i.e., TPWD and CBBEP) but are under the control of GLO as state submerged lands. The landowner properties themselves were not added to the core area of the Reserve - only the shoreline areas.

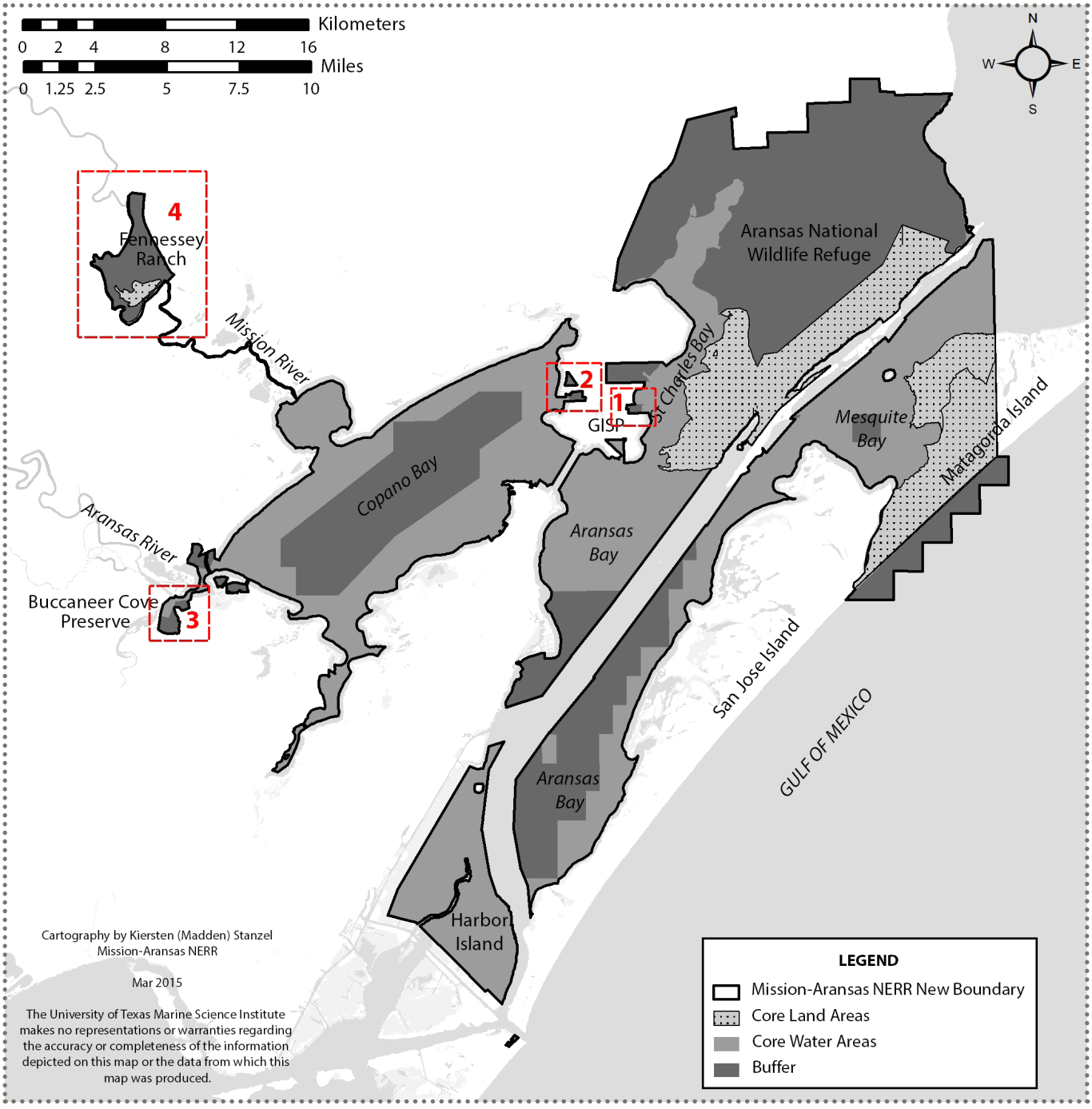


Figure 2.49. Map showing the core and buffer areas within the new Mission-Aransas Reserve boundary. Red, dashed boxes indicate areas where the acres of core and/or buffer area have changed

The land core areas of the new boundary provide essential key upland habitats. The land core areas continue to include portions of both GISP (excludes Big Tree Unit) and ANWR, but the Reserve is amending its core land areas in the following way:

1. Portions of Fennessey Ranch were added to the land core area of the Reserve following the purchase of a conservation easement on the Ranch (Figure 2.49 - red, dashed box 4). Although the entire Ranch contains a diverse array of valuable habitats, there are two areas that are especially critical to ensuring the integrity of the Mission-Aransas Reserve, and therefore, were chosen as land core areas:
    a. Riparian woodlands along the Mission River: Fennessey Ranch contains almost eight miles of undeveloped riparian woodlands along the Mission River. These woodlands play a key role in soil conservation, water quality, flood control, and biodiversity. Fennessey Ranch manages these areas to ensure that they will continue to function this way in the future (i.e., no cattle grazing zones).
    b. Wetlands at Fennessey Flats: Fennessey Flats is the largest wetland on the Ranch. The approximately 269 acre freshwater to brackish marsh is situated adjacent to the Mission River and plays a key role in flood prevention by storing water during Mission River flood events. The wetlands also are important for filtering nutrients and maintaining downstream water quality. Fennessey Flats also supports a diverse area of local wildlife, including Sandhill Cranes and numerous species of waterfowl.

UT purchased a conservation easement on Fennessey Ranch in 2006, ensuring the long-term protection of native plants, animals, and plant communities on the Ranch. The easement prevents any use that will significantly impair or interfere with the conservation values and assures that traditional uses are compatible with the conservation values of the Ranch. Therefore, the Reserve chose to add key areas within the Ranch to its core boundary.

The term buffer refers to the areas within the Reserve boundary that are adjacent to or surrounding core land and water areas and are essential to maintaining the integrity of the Reserve. Buffer zones are the areas within the boundary that are not designated as land or water core. The new boundary resulted in the following changes to the buffer area of the Reserve:

1. The Big Tree Unit, the Holiday Beach properties, and the Aransas River Delta property were all included in the new boundary as buffer areas (Figure 2.49 -red, dashed box 1, 2, and 3). This increased the amount of buffer land in these areas. These lands will help protect the core area and will provide additional protection for estuarine-dependent species, including those that are rare or endangered (e.g., Whooping Crane). These additional buffer areas will also accommodate a shift of the core area as a result of biological, ecological, or geo-morphological change which reasonably could be expected to occur.
2. The amount of buffer area at Fennessey Ranch decreased in the new boundary (Figure 2.49 - red, dashed box 4). The decrease occurred when the Mission River riparian corridor and Fennessey Flats wetlands were changed from buffer to core areas.

2.6.3 Targeted Watershed

The Reserve's targeted watershed includes both the Mission and Aransas river sub-basins (see Figure 2.29). The watershed of the Mission-Aransas NERR is primarily comprised of forested land and rangeland. At closer look, however, there is a higher percentage of agricultural land in the sub-basin that drains the Aransas River into Copano Bay, while the Mission River sub-basin that drains to Copano Bay has a higher amount of forested and rangeland. Urban development is primarily confined to cities such as Corpus Christi, Rockport/ Fulton, and Sinton.

3.0 Reserve Strategic Plan

3.1 Reserve Mission, Vision, Goals, and Objectives

An important part of a management plan is to state a mission for the organization, a vision on how the mission will lead to the betterment of man and society, and specific goals to accomplish the mission. Vision, mission, and goals statements were developed for the Mission-Aransas NERR during its designation in 2006. The vision, mission, and goals of the Reserve were reviewed and discussed by Reserves staff at a retreat on February 23, 2012 and by the Reserve Advisory Board on August 17, 2012. Reserve staff and the Reserve Advisory Board felt that the vision, mission, and goals were still applicable and appropriate for the program and state of Texas. The individual objectives to meet those goals were modified to incorporate changes to Reserve capacity and expertise, as well as delete those objectives that have been achieved.

The VISION and MISSION for this management plan are:

The VISION of the Mission-Aransas National Estuarine Research Reserve will be to develop a center of excellence to create and disseminate knowledge necessary to maintain a healthy Texas coastal zone.

The MISSION of the Mission-Aransas National Estuarine Research Reserve is to develop and facilitate partnerships that enhance coastal decision making through an integrated program of research, education, and stewardship.

There are three GOALS that will be used to support the Reserve mission:

GOAL 1: To improve understanding of Texas coastal zone ecosystems structure and function.

Understanding of ecosystems is based on the creation of new knowledge that is primarily derived through basic and applied research. New knowledge is often an essential component needed to improve coastal decision making.

GOAL 2: To increase understanding of coastal ecosystems by diverse audiences.

Education and outreach are the primary delivery mechanisms to explain what coastal ecosystems are and how they work. It is essential that information is disseminated broadly within our society.

GOAL 3: Promote public appreciation and support for stewardship of coastal resources.

In many ways, stewardship is an outcome resulting from the integration of research and education. Research creates information that is communicated through education. This information forms the basis for an appreciation of the values of an environment, and that in turn promotes a public sense of ownership of natural resources.

The following section (Section 4) describe the plans for the Reserve's Research, Stewardship, Education, and Coastal Training programs. In each program plan, the program context, program capacities, program delivery, needs and opportunities, and the objectives needed to meet the goals outlined above are described in detail. Under the objectives are lists of specific actions and strategies that will be accomplished to meet the objective. Overall, adopting and executing actions leads to the accomplishment of the goals. Many of the objectives are cross-cutting across the goals, which provides the integration necessary to accomplish the Reserve mission. The mission, goals, and objectives are binned by program plan in Table 16.

Table 3.1. Matrix of goals and objectives for the Mission-Aransas Reserve 2015-2020 management plan. Objectives in italic font are numbered by goal and objective.

VISION: Center of excellence to create & disseminate knowledge necessary to maintain a healthy Texas coastal zone.			
MISSION: To develop and facilitate partnerships that enhance coastal decision making through an integrated program of research, education, and stewardship.			
Plan:	**GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function**	**GOAL 2: Increase understanding of coastal ecosystems by diverse audiences**	**GOAL 3: Promote public appreciation and support for stewardship of coastal resources**
Research	*Objective 1-1: Improve understanding of short and long-term changes within Texas coastal ecosystems through the implementation of SWMP, sentinal site program, and new research programs with partners*	*Objective 2-1: Disseminate research information and results to researchers and decision makers through an on-site resource center, website, and other forms of media*	*Objective 3-1: Promote public participation in research and monitoring programs through implementaiton of a minimum of at least one citizen science program*
	Objective 1-2: Increase understanding of effects of oil/ gas activities and marine debris on coastal ecosystems	*Objective 2-2: Transfer research knowledge to K-12 students through the implementaiton of Summer Science Program and SWMP Scholar Program*	*Objective 3-2: Increase public understanding of ecological values by partnering to conduct evaluations of ecosystem services*
	Objective 1-3: Increase graduate and undergraduate student participation in Reserve research and monitoring programs		
Stewardship	*Objective 1-4: Produce a map of Reserve priority habitats and geographical areas and plan for future mapping efforts*	*Objective 2-3: Facilitate stewardship activities through community education programs like Wetland Warriors, Cooperative Weed Management Area, and Trash or Treat*	*Objective 3-3: Monitor land management practices at Fennessey Ranch and Aransas National Wildlife Refuge*
	Objective 1-5: Protect priority areas for long-term research by ensuring existing rules and regulations are followed		*Objective 3-4: Support local habitat and wildlife conservation programs such as animal rehabiliation and clean-up programs*
			Objective 3-5: Initiate restoration and mitigation projects with appropriate partners
Education	*Objective 1-6: Provide a professional development program for teachers that offers field-based learning experiences linked to Reserve research and stewardship activities*	*Objective 2-4: Increase K-12 and early grade level student literacy about coastal ecosystems through programs hosted at Reserve facilities, programs aboard the R/V Katy, and the Scientist in Residence Program*	*Objective 3-6: Promote public appreciation of Texas coastal resources through community education programs hosted at Reserve facilities*

		Objective 2-5: Educate K-12 teachers and students about human impacts on the coastal environment using Science on the Sphere and educational programs that integrate science, history, and culture	*Objective 3-7: Increase public awareness of the Reserve and the Reserve System through the Reserve's website and bi-annual newsletter*
		Objective 2-6: Increase public literacy about Texas coastal ecosystems through public education programs hosted at Reserve facilities, Summer Science Program, and Road Scholar Program	*Objective 3-8: Promote Reserve initiatives at a minimum of three public events, fairs and expositions per year*
Coastal Training	*Objective 1-7: Increase participation of UTMSI researchers in program development and implementation by drafting outreach plan*	*Objective 2-7: Enhance the transfer of knowledge, information, and skills to coastal-decision makers by hosting a miminum of eight trainings, updating the Reserve's market analysis/needs assessment, creating a listserv, and enhancing use of the Reserve CTP website*	*Objective 3-9: Improve the ability of coastal resource managers to conserve, protect, and restore coastal ecosystems through trainings on restoration and other relevant topics*
Administrative	*Objective 1-8: Provide oversight and support for research and monitoring activities*	*Objective 2-8: Provide oversight and support for K-12 and decision maker education and outreach activities*	*Objective 3-10: Provide oversight and support for stewardship activities*
Public Access			*Objective 3-11: Enshance public and group access to Reserve and partner education facilities and environments through installation of trails and signage*

3.2 Priority coastal management issues

The goals, objectives, and actions listed in this plan are designed to address priority coastal management issues. Reserve staff used a master-minding technique to determine the priority issues for the Reserve boundary/watershed and key strategies for meeting the objectives. Priority issues were determined to help identify specific activities needed to meet the goals and objectives of the strategic plan. Priority issues were determined by an inquiry-based approach in which staff were asked to answer the following questions:

RESEARCH & STEWARDSHIP: What research topics does our estuary or watershed need to make good management decisions?

EDUCATION & TRAINING: What do our school programs, teachers, and communities need to make good management decisions in the future?

While answering those questions, Reserve staff were asked to refer to the CEM that identified habitats, their valued ecosystem components, and related stressors. Reserve staff were also asked to review current and upcoming external projects and think about how will they fit into the strategic plan and actions.

For the Reserve's Education and Coastal Training programs it was determined that coastal training, K-12 education, and family/community education are the priority programs that the Reserve will focus on for 2015-2020. In addition to these foci, the Reserve will also develop programs for volunteers, undergraduate and graduate education, seniors, and media. The priority issues identified for education and coastal training included: providing opportunities for connecting children and nature; offering outdoor education programs for K-12 audiences; enhancing understanding of climate change and its effect on coastal environments; promoting knowledge of coastal ecology and habitat diversity; increasing knowledge of human impact and dependence on the coastal environment; and encouraging stewardship of estuary and coastal resources.

For the Reserve's Research and Stewardship Programs it was determined that freshwater inflow, circulation, biological monitoring, and sea level rise/coastal subsidence are the priority programs that the Reserve will focus on for 2015-2020. In addition to these foci, the Reserve will also develop programs with partner support to address issues associated with groundwater, toxins/pathogens, vertical control, data exploration and analysis, atmospheric deposition, ocean acidification, and oil and gas effects. It is important to note that climate change will be woven into almost of these topics, and therefore, is not listed as a separate priority issue.

After the priority issues were determined, Reserve staff brainstormed about the activities needed to meet the goals and objectives, and address the priority issues. The Reserve staff were also asked to think about the details for each activity, including addressing the resources that would be needed to achieve the particular activity such as: (1) professional training, (2) facilities, equipment, or materials, (3) funding, (4) partnerships, and (5) personnel.

Input from the Reserve Advisory Board was gathered for the strategic plan and priority issues. On January 5, 2012 Board members reviewed the strategic plan that was revised by Reserve staff at the retreat. No major modifications were suggested for the strategic plan. Board members were also asked to discuss future directions and review priority issues. Ecosystem services was discussed and incorporated as a research and stewardship priority issue. Due to time constraints, additional input from Board members was gathered through a survey. The survey provided the priority issues and asked board members to rank them. Four board members filled out the survey with freshwater inflow and ecosystem services ranking as high priority for research and stewardship for at least two of the four respondents. For education and coastal training, increasing knowledge of human impact and dependence on the coastal environment and encouraging stewardship of estuary and coastal resources ranked as a high priority for at least three of the four respondents.

4.0 Core Programmatic Plans

4.1 Research and Monitoring

4.1.1 Introduction

The National Estuarine Research Reserve System's mission provides that reserves are protected and managed to afford opportunities for long-term research. Research at each reserve is designed to fulfill the Reserve System goals as defined in the regulations (15 C.F.R Part 921(b)):

- Address coastal management issues identified as significant through coordinated estuarine research within the System;
- Promote Federal, state, public and private use of one or more reserves within the system when such entities conduct estuarine research;
- Conduct and coordinate estuarine research within the System, gather and making available information necessary for improved understanding and management of estuarine areas.

To sustain these System goals, the *2011-2016 Reserve System Strategic Plan* outlines research objectives that support the focus areas of climate change, habitat protection, and water quality:

- Expand capacity to monitor changes in water quality and quantity, habitat, and biological indicators in response to land use and climate change drivers.
- Improve understanding of the effects of climate change and coastal pollution on estuarine and coastal ecology, ecosystem processes, and habitat function.
- Characterize coastal watersheds and estuary ecosystems and quantify ecosystem services to support ecosystem-based management of natural and built communities
- Increase social science research and use of social information to foster coastal stewards that value and protect estuaries.

The research strategies identified for meeting the above goals include: (1) lead Reserve-based collaborative projects that connect scientists with intended users from problem definition through implementation; (2) generate and disseminate periodic data syntheses and analyses of water quality and habitat change and the effects of climate change and other stressors at local and regional scales; (3) implement monitoring and research projects that use reserves as sentinel sites for detecting and understanding the effects of sea level change and other climate change effects on estuaries; and (4) develop and implement strategies that build reserve capacity to conduct and use social science to address coastal management issues.

The Reserve System's research and monitoring programs provide the scientific basis for addressing coastal management challenges. Reserve research and monitoring activities provide valuable information about estuarine resources to increase understanding and awareness of their importance to a variety of audiences including scientists, resource managers, educators, and the general public.

Reserve System Research Programs

Currently, there is one Reserve System-wide efforts to fund estuarine research. The National Estuarine Research Reserve System Science Collaborative, a partnership between NOAA and the University of Michigan, is a program that focuses on integrating science into the management of coastal natural resources. The program integrates and applies the principles of collaborative research, information and technology transfer, and adaptive management with the goal of developing and applying science-based tools to detect, prevent, and reverse the impacts of coastal pollution and habitat degradation in a time of climate change. The program is designed to enhance the Reserve System's ability to support decisions related to coastal resources through collaborative approaches that engages the people who produce science and technology with those

who need it. In so doing, the Science Collaborative seeks to make the process of linking science to coastal management decisions, practices, and policies more efficient, timely, and effective and share best practices and examples for how this can be done.

Reserve System-Wide Monitoring Program

The System-Wide Monitoring Program provides standardized data on national estuarine environmental trends while allowing the flexibility to assess coastal management issues of regional or local concern and is guided by the *Reserve System Wide Monitoring Program Plan*. The principal mission of the monitoring program is to develop quantitative measurements of short-term variability and long-term changes in water quality, biological systems, and land use/land cover characteristics of estuaries and estuarine ecosystems for the purposes of informing effective coastal zone management. The program is designed to enhance the value and vision of the reserves as a system of national references sites and focuses on three ecosystem characteristics:

SWMP abiotic monitoring station

1. ABIOTIC CHARACTERISTICS: Abiotic measurements are supported by standard protocols, parameters, and approaches that describe the physical environment including weather, water quality, hydrological, and sediment related parameters. The monitoring program currently provides data on water temperature, specific conductivity, percent saturation of dissolved oxygen, pressure, pH, turbidity, salinity, concentration of dissolved oxygen, and pressure corrected water depth. Meteorological data include air temperature, relative humidity, barometric pressure, wind speed, wind direction, rainfall, and photosynthetically active radiation (PAR). In addition, the program collects monthly nutrient and chlorophyll a samples and monthly diel samples at one SWMP data logger station. Data is Federal Geographical Data Committee compliant and available via the Reserve System Centralized Data Management Office (CDMO).
2. BIOTIC CHARACTERISTICS: As funds are available, reserves are focusing on monitoring habitats and biodiversity.
3. WATERSHED AND LAND-USE CLASSIFICATIONS: The Reserve System is examining the link between watershed land use and coastal habitat quality by tracking and evaluating changes in coastal habitats and watershed land use/cover. This element is guided by the *Reserve System Habitat Mapping and Change Plan*.

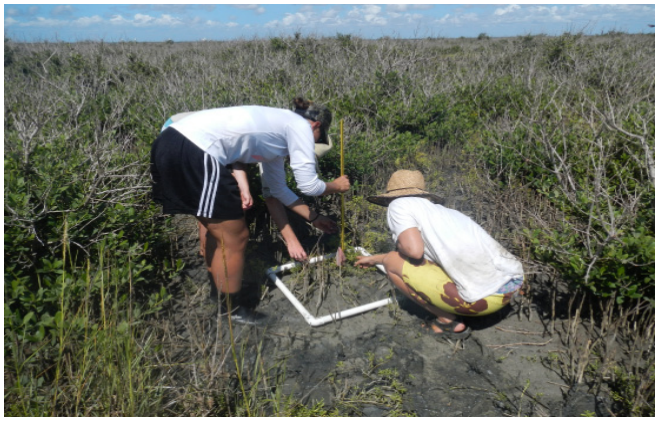
Building on these foundational elements, the Reserve System is developing a network of sentinel sites and the capacity to assess the impact of sea level/lake level changes and inundation on the diverse set of coastal vegetative habitats represented in the system. Reserves are implementing a suite of activities, as described in the *2012 Reserve System Sentinel Site Guidance Document*, to assess the relationship between vegetative communities (marsh, mangrove and submerged aquatic vegetation) and sea level. Reserves are adding surface elevation tables and monitoring pore water chemistry along vegetation monitoring transects and linking their SWMP stations to a network of specialized spatial infrastructure to allow precise measurement of local sea level and lake level changes and subsequent impacts to key habitats. The Reserve System is working in partnership with NOAA's National Geodetic Survey (NGS) and the Center for Operational Oceanographic Products and Services (COOPS) to support the development of sentinel sites.

4.1.2 Program Context

The Mission-Aransas Reserve is located on the Texas coast, in the Western Gulf Biogeographic Subregion. The Reserve consists of primary, secondary, and tertiary bays, which is typical of Western Gulf of Mexico estuaries. The primary bays include Mesquite, Aransas, and Redfish bays. Secondary bays include Copano and St. Charles bays. Lastly, Mission and Port bays are tertiary bays. The Reserve boundary also includes part of the Mission River, Fennessey Ranch, Buccaneer Cove Preserve, Goose Island State Park, the Aransas National Wildlife Refuge, Harbor Island, and Mud Island. The areas within the Reserve have traditionally been an important area for commercial/recreational fishing and hydrocarbon production, and will continue to be used by these interests. The Mission-Aransas NERR does not prohibit traditional uses of the area as described in the management plan.

Since the Reserve's designation and the publication of the previous management plan (NOAA, 2006), the Research Program has gathered a tremendous amount of information about the Reserve ecosystem. For example, the Mission-Aransas Reserve began collecting the full suite of SWMP water quality, nutrient, and weather parameters within a few months of its establishment. Water samples have also been analyzed for micro-zooplankton community composition using a imaging flow cytometer. These eight year data sets span two wet periods and two periods of extreme drought, showing the fluctuations in salinity and plankton communities due to episodic storm events and drought periods.

Reserve staff have also been involved in several additional projects (outside of the SWMP program), including examining nutrient dynamics and nitrogen cycling in the rivers and estuary during floods and droughts; freshwater inflows and impacts on blue crab megalopae; and zooplankton, microplankton and harmful algae monitoring. All of these projects were possible due to the large amount of data available from the SWMP program. The Reserve has also gained a considerable amount of information about the Reserve ecosystem from graduate and undergraduate research projects.



Research and Stewardship staff monitor vegetation at long-term monitoring sites

The Reserve provides excellent opportunities for researchers. The Reserve is within close proximity to all coastal towns in South Texas and is within easy driving distance of the cities of Corpus Christi, Kingsville, Rockport, Refugio, Victoria, Houston, Austin, and San Antonio. The majority of individuals that currently utilize the Reserve include researchers from universities (e.g., UT, TAMUCC, HRI, Texas A&M University, Texas A&M University - Galveston) and to a lesser extent from agencies (e.g., USGS). A major group of researchers utilizing the Reserve includes undergraduate and graduate students. Funding sources for these students include the Graduate Research Assistantship (GRA) program sponsored by UTMSI, the Research Experience for Undergraduates (REU) program awarded to UTMSI from the National Science Foundation (NSF), and other research funding acquired by UTMSI and other university faculty/staff as available.

The research community surrounding the Reserve includes universities, environmental organizations, local governments, and local, state, and federal agencies. The universities immediately surrounding the Reserve include UTMSI and TAMUCC (including HRI), but researchers are also know to travel from universities located a much greater distance in order to utilize the Reserve. Environmental organizations in the Reserve area include the CBBEP, Coastal Bend Bays Foundation (CBBF), TNC, San Antonio Bay Foundation (SABF),

San Antonio Bay Partnership, Nueces River Authority, and San Antonio River Authority. State and federal agencies in the area include USFWS, National Park Service (NPS), TPWD, GLO, Texas Commission on Environmental Quality (TCEQ), and TxDOT.

The Research Program supports the Stewardship, Education, and Coastal Training programs through a variety of different means. Research staff work with the Stewardship Program regarding implementation of specific program activities (i.e., biological monitoring, habitat mapping, and sentinel sites). The research staff will work with the Education Program by providing technical advice for programs, preparing lesson plans for educational events, and giving scientific lectures for the public. Similarly, the research staff will work with the Coastal Training Program by providing technical information, participating in workshops, and assisting with identification of training needs.

Application of Reserve Research

The Reserve Research Program provides the scientific basis for addressing coastal management challenges. Reserve research and monitoring activities provide valuable information about estuarine resources to increase understanding and awareness of their importance to a variety of audiences including scientists, resource managers, educators, and the general public. The Research Program provides high-quality, long-term monitoring data for scientists trying to study and understand a number of coastal management issues. Although research results are most relevant to local resource managers, many of the results can be applied to issues at the state, regional, or even national level. Telemetry of water quality and weather data also allows the general public to easily find information on the current conditions of the estuary, and educators can access historical data for use in classroom lessons or to supplement field experiences.

4.1.3 Program Capacity

Staff

The Reserve research staff consists of a part-time Research Coordinator, two full-time research technicians and a part-time GRA. The Research Coordinator oversees the implementation of the Reserve Research Program and interacts with the RAB, UTMSI faculty/students, and other research institutions and individuals to fulfill the research objectives of the Reserve. The two full-time research technicians are responsible for the implementation of the SWMP, including field work, calibration and maintenance of equipment, and data quality assurance/control. They also assist with additional Reserve research projects and monitoring programs as needed. The part-time GRA assists with the Reserve research and monitoring programs that have been identified by the Research Coordinator as being the highest priority or requiring the most assitance. As external funding is awarded, the Reserve may hire additional research technicians, post-doctoral scholars, research associates, and graduate students.

Partners

Partnerships are key to expanding the scope of research performed at the Mission-Aransas NERR. The Reserve research staff partner with TAMUCC to work with undergraduate students funded through the NOAA ECSC. Staff also partner with Dr. Lisa Campbell at Texas A&M University (TAMU) to continue assistance with the maintenance of the Imaging Flow Cytobot, located on the UTMSI research pier. Other current and anticipated partners include UTMSI, UT, SABF, TNC, CBBEP, TPWD, TWDB, TCEQ, GLO, USFWS, SABF, Fennessey Ranch, and TxDOT.

Facilities

The Reserve headquarters are located in the Estuarine Research Center on the campus of UTMSI in Port Aransas, Texas. The facilities include offices for all Reserve Research staff and laboratories equipped for a large range of research projects, including wet-lab space. UTMSI also has a fleet of small boats for work in

the bays. Improvement and development of research facilities will continue as funds become available.

4.1.4 Program Delivery

The main goal of the Research Program is to provide high-quality, reliable long-term monitoring data for key parameters for the Mission-Aransas Estuary. The Research Program undertakes a number of activities in order to accomplish this goal, including SWMP, Sentinel Site Program, graduate/undergraduate research, and externally funded research projects.

System-Wide Monitoring Program

Abiotic

The current expectations of the SWMP abiotic component are that each of the participating NERR sites operate at least four water quality stations and one weather station. Each Reserve should locate two water quality SWMP stations each in pristine and impacted areas, or to be placed to measure another characteristic of the estuary, such as the salinity gradient. The purpose of the Mission-Aransas NERR SWMP abiotic stations is to gain information on climactic and hydrological patterns that influence freshwater inflow in the Mission-Aransas Estuary. Therefore, SWMP abiotic station locations are based on their distance from freshwater inflow sources, location in bay systems, locations of existing water quality monitoring sites stations, and other long-term monitoring sites.

The Reserve has fully implemented the abiotic monitoring component of the SWMP. Four of the Reserve's SWMP water quality monitoring sites have been in operation since July 2007, and a fifth station was completed in January 2008. The Reserve encompasses a large area and to ensure adequate coverage, SWMP abiotic station locations are widely spaced (Figure 4.1). Copano Bay West was chosen as a SWMP abiotic station because it provides hydrological data that is influenced by the freshwater inflow source of the Aransas River. Copano Bay East was chosen as a SWMP station because it provides hydrological data on water flow patterns between Copano

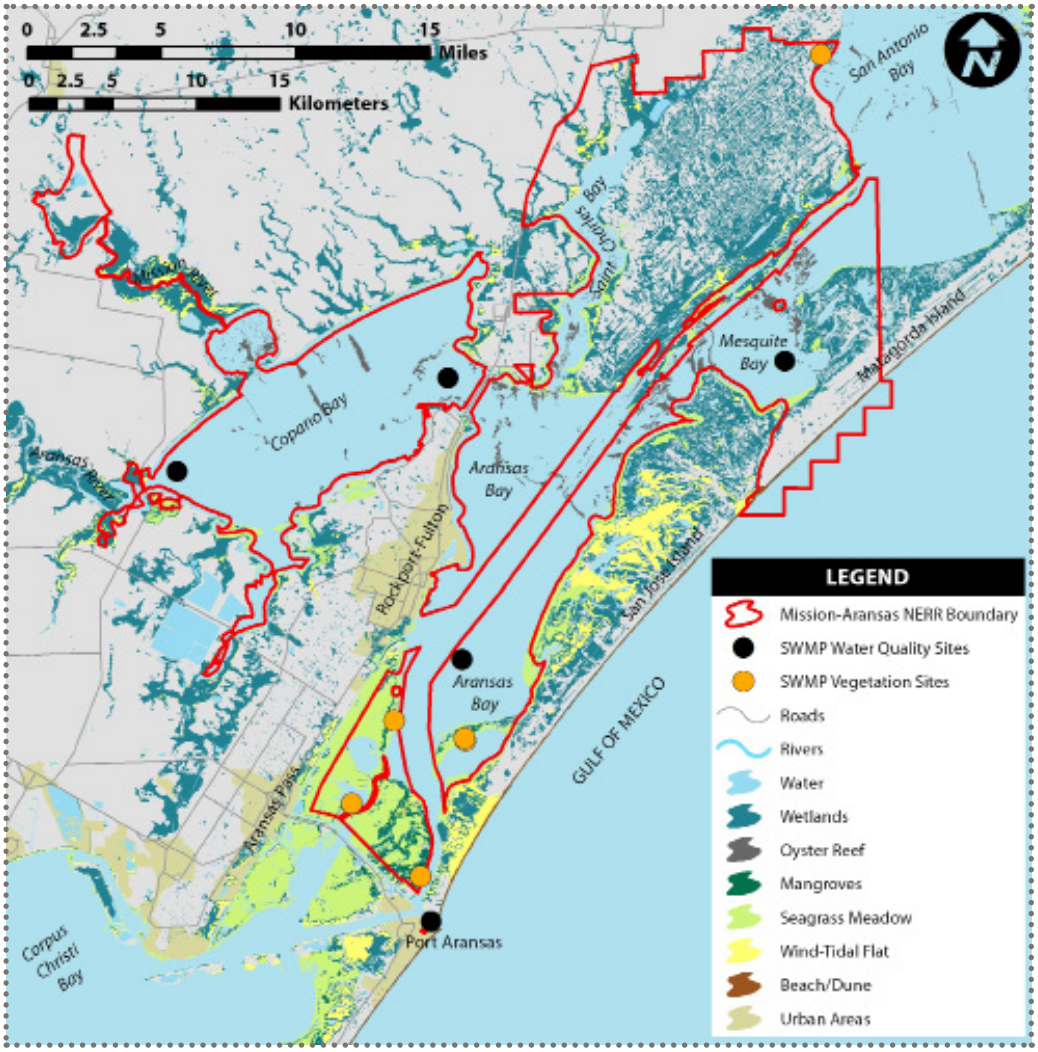


Figure 4.1. Map of Mission-Aransas Reserve SWMP abiotic (and biotic) monitoring sites.

and Aransas Bay. Mesquite Bay was chosen as a SWMP station because it is a pristine site that can be used as a control. A station at Mesquite Bay also provides data on water flow patterns that are affected by San Antonio Bay and the hydrological connection with Cedar Bayou and the Gulf of Mexico. Aransas Bay South was chosen as a SWMP station because it is a UTMSI long-term monitoring site and it provides hydrological data on the connections between Aransas Pass and San Antonio Bay. A fifth SWMP station was added in the Aransas Ship Channel to monitor flows between the estuary and the Gulf of Mexico. The Reserve's meteorological site is located at the Copano East site and has been in operation since 2007.

The SWMP abiotic program currently measures pH, conductivity, temperature, dissolved oxygen, turbidity, and water level. In addition, seawater samples for nutrient analysis and phytoplankton biomass estimates are taken at four of the datalogger stations on a monthly basis and monthly diel samples at one datalogger station. Analyses for ammonium, nitrate, nitrite (or nitrate+nitrite), ortho-phosphate, and chlorophyll a are conducted on-site at Reserve facilities. In addition, a weather station collects data on weather conditions, such as air temperature, wind direction and speed, barometric pressure, and relative humidity. These variables are not only indicative of habitat quality for numerous estuarine species, but they also help establish ecosystem health criteria and impact of human uses.

Research staff perform maintenance on water quality monitoring equipment at a SWMP station

Data management, quality control, and information delivery services are provided by the CDMO operated by the University of South Carolina. The CDMO manages the basic infrastructure and data protocol to support the assimilation and exchange of data, metadata, and information within the framework of NERRS sites, state coastal zone management programs, and NOAA, as well as other state and federally-funded education, monitoring, and research programs. Each Reserve is expected to edit, document, and submit data and metadata from dataloggers in a timely manner to the CDMO.

The SWMP abiotic component includes a rigorous Quality Assurance/Quality Control (QA/QC) program undertaken to ensure that the type, amount, and quality of data and ancillary numerical information are adequate to meet the study objectives. Development of supporting metadata is also a critical element of the monitoring program. The SWMP Quality Control Program currently includes standardized protocols for the routine calibration, deployment, and recovery of automated dataloggers, and guidelines for the identification and treatment of outliers and spurious datasets. NERRS abiotic data are subject to three levels of QA/QC. The first level is an automated assessment of data quality (based on sensor limits and expected values) and is conducted immediately upon submission to the CDMO. These data are available to users as "provisional" data. A second, more intensive level of review is conducted by reserve staff, and results are submitted quarterly under the classification "provisional plus" data. The final level of review occurs annually by the CDMO. Once data have undergone all stages of QA/QC, they are considered to be "authoritative" data and are archived accordingly. All NERRS abiotic data can be accessed through the CDMO website (www.cdmo.baruch.sc.edu) and the telemetered data can be accessed through either CDMO, NOAA's National Data Buoy Center (www.ndbc.noaa.gov/) or Hydrometeorological Automated Data System (www.weather.gov/oh/hads/), and are archived with CDMO and the National Oceanographic Data Center (www.nodc.noaa. gov/cgi-bin/OAS/prd/text/query).

To incorporate the SWMP program into local and regional monitoring on the Texas coast, the Reserve has partnered with the Division of Nearshore Research (DNR) at TAMUCC. The DNR is a network of sites along the Texas coast that monitor water level, water quality, and weather in order to predict coastal phenomena and trends over time. The Texas Costal Ocean Observation Network is sponsored by the GLO, TWDB, USACE, and NOAA. In addition to the TCOON project, DNR operates several monitoring platforms in the Reserve SWMP project area. The SWMP program has enriched the network of sites and availability of information for researchers, managers, and the public. Currently, all five SWMP abiotic sites are radio telemetered through the DNR so that the public can access the data in real-time. The Reserve also has a Memorandum of Understanding (MOU) with the Gulf of Mexico Coastal Ocean Observing System (GCOOS) Regional Association, and the Research Coordinator is a voting member of GCOOS. The Reserve also contributes its SWMP water quality data to GCOOS.

Evaluation of the Reserve SWMP abiotic datasets are undertaken on an annual basis to summarize and simplify the acquired numerical information, conduct statistical tests of inherent variability and significant differences, evaluate alternative hypotheses when appropriate, determine the consequences of ecological observations, and assess levels of uncertainty associated with the conclusions drawn from the Reserve SWMP datasets. The anticipated analytical and interpretive programs were developed prior to data collection and include identification of the statistical tests, power analysis, and modeling technique to ensure that the data analysis is appropriately coordinated with the scientific approach and methodology for the Reserve SWMP.

Biotic

The objective of the biotic component of SWMP is to monitor parameters that serve as indicators of changes in the composition and diversity of biotic communities within the NERRS. The biotic component builds upon the time-series data generated by monitoring abiotic parameters, and adds spatially and temporally-explicit information about the composition, status, and condition of biotic communities, including emergent and submerged vegetation, native and non-native benthic invertebrates, plankton communities, nekton, and marsh birds, and shorebirds.

Vegetation Monitoring

To date, the Reserve has focused on monitoring emergent marsh, mangrove, and submerged aquatic vegetation (i.e., seagrass beds) as part of both the Research and Stewardship programs. The Reserve uses protocols established by the *NERRS SWMP Bio-Monitoring Protocol* (Moore et al., 2009). Vegetation monitoring consists of annual assessments (e.g., biomass, growth, and species distribution) of estuarine plant communities at a series of representative study sites within the Reserve (Figure 4.1). The sampling approach adopted by SWMP has been used to assess a variety of vegetative communities, and the National Park Service and other programs recently adopted this approach to assess and compare reference and restoration wetland sites at local and regional scales.

In 2011, the Reserve began collaborating with Dr. Ken Dunton to conduct annual sampling of submerged aquatic vegetation (SAV). The tiered approach used for SAV monitoring follows a broad template adopted by several federal and state agencies across the country but is uniquely designed for Texas (Dunton et al., 2011). The Tier-3 sampling effort consists of triplicate

Monitoring of mangrove habitat began in 2012

permanent transects established at three different locations within the Mission-Aransas Reserve. Seagrass condition indicators were measured at ten random locations along each transect and included species composition and areal percent coverage. At a 1 m fixed distance oriented 180° from each of the ten locations along each transect, seagrass cores were taken for determination of plant shoot density and canopy height. Sampling is completed during peak biomass in accordance with the NERRS protocol (Moore, 2009). Tier 3 sampling was conducted during summer 2011 but has been not repeated since that time due to a lack of funding. Acquisition of additional funds would be needed in order to reinstate this monitoring program.

Tier-2 SAV monitoring protocols are considered "rapid assessment" sampling methods and are adapted from Neckles et al. (2012). This sampling regime provides point measurements from random sites that are assigned based on a specialized grid system developed for known seagrass areas. Species composition and areal coverage are obtained from four replicate quadrat samples per station at each of the four cardinal locations from the vessel. Percent cover of areal biomass is estimated by direct vertical observation of the seagrass canopy through the water using a 0.25 m^2 quadrat. Water quality information (i.e., water depth, conductivity, temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and pH) is also collected at all Tier 2 sites. Seagrass leaf tissue is collected at sites containing a vegetated bottom for determination of leaf tissue carbon content, nitrogen content, δC13, δN15, and phosphorus. Tier-2 sampling is funding dependent, but to date, has been completed anually since 2011.

In 2011, staff of the Mission-Aransas Reserve also began a monitoring program to assess changes in emergent marsh vegetation at several locations within the Reserve using modified NERRS protocols (Moore et al., 2009). Sampling consists of fixed transects located in emergent marsh habitats with permanent sampling stations located along each transect. Site selection was determined based on habitat representativeness, existence of aerial imagery, historical human impact, protection, access, and existing monitoring infrastructure, such as on-going transects and Surface Elevation Tables (SETs) (Figure 4.1). Each transect traverses the elevation gradient from the water's edge to the upland. Sampling methods include determination of percent cover, stem densities, and maximum canopy height for each species within each plot. A groundwater well was also established 1 m from a subset of the marking stake at 180 degrees from the permanent plot in order to take salinity measurements. Sampling occurs in both habitats during the annual maximum biomass and is completed within a two-three week interval. One site has been monitored annually since 2011, while a second site was added in 2012 and has been monitored annually since that time.

In 2012, the Mission-Aransas Reserve began monitoring mangroves on Harbor Island. Similar to the emergent marsh monitoring, the mangrove monitoring program also uses fixed transects that traverse the elevation gradient from the water's edge to the upland. The mangrove monitoring protocol includes a nested sampling scheme, with three randomly located 1 x 1 m subplots situated within a permanent 10 x 10 m plot. In the 10 x 10 m plots, all mangrove trees with trunk diameter greater than 2.5 cm are: (1) numbered with an aluminum tag, (2) identified to species level, and (3) measured for diameter at breast height, total height, and height to branching. In the 1 x 1 m subplots, all mangrove trees (including those with dbh < 2.5 cm) are tagged, identified to species, and measured. If emergent marsh vegetation or submerged aquatic vegetation occur within the subplots, they are measured as described in the emergent or submerged aquatic vegetation protocol to determine percent cover, shoot or stem densities, and maximum canopy height for each species within each plot. Sampling occurs during the months of September to October and is completed within a two to three week interval.

Plankton

In a partnership with TAMU, the Reserve maintains an instrument for long term, high-resolution measurements of phytoplankton abundance and cell properties called an Imaging FlowCytobot. The FlowCytobot continuously samples phytoplankton in the water column at the SWMP water quality station located in the Aransas Pass Ship Channel. Images are captured by combining video and flow cytometric

technology to capture high resolution (1 µm) images for plankton identification and to measure the chlorophyll fluorescence associated with each image. Organisms ranging from ~10 to >100 µm can be identified often to genus and, in some cases, to species. The instrument allows researchers to monitor trends in plankton abundance including Harmful Algal Blooms (HABs) that have the potential to adversely affect the marine environment and human health. The UTMSI research pier, which houses the FlowCytobot, also houses a tide trap for sampling larger plankton such as crab larvae and ichthyoplankton. Samples for phytoplankton and micro-zooplankton are also collected monthly at each SWMP abiotic monitoring station. These samples are processed on return to the laboratory using the FlowCAM, which produces images in a similar manner to the FlowCytobot.

Research staff perform plankton tows at each of the water quality monitoring stations

Sentinel Site

A sentinel site is an area within the coastal or marine environment that has the operational capacity for intensive study and sustained observations to detect and understand changes in the ecosystems they represent. The focus of the NERRS Sentinel Site Program is on understanding changes in sea level and inundation and the associated responses of marsh, mangrove, and submerged aquatic vegetation (Figure 4.2). Carefully planned sampling designs and the use of standardized protocols are critically important for detecting changes and attributing them to related climate stressors, as well as characterizing the high natural variability in these coastal habitats. Standardized approaches are also critical for comparing data between sentinel sites in a larger sentinel site network.

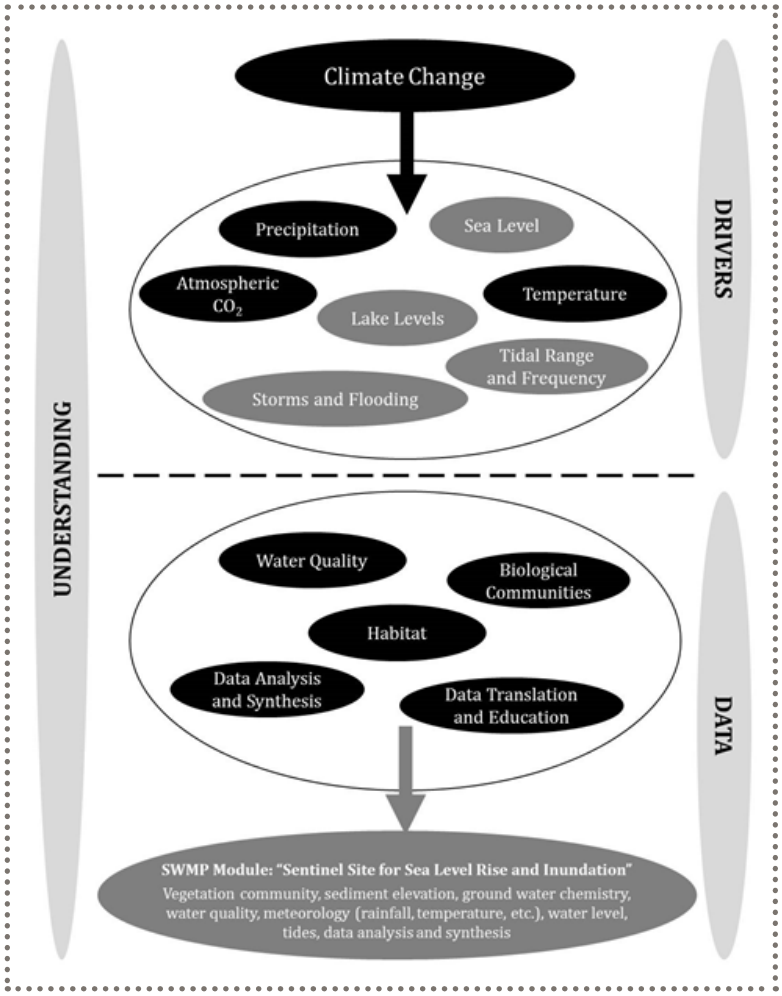


Figure 4.2. Framework for the NERRS Sentinel Site Program for understanding impacts of changes in sea level and inundation.

The initial questions to be answered by the NERRS Sentinel Sites Program require fundamental data and information on the effects of changing local sea level and inundation patterns on the response of vegetative communities, although knowledge about other factors such as changes in precipitation, temperature, water chemistry, and invasive species is needed to segregate the impacts of changing land and water levels from other environmental influences. While the current strength of the approach is found in the use of standardized

protocols and sampling designs that provide a group of reserves with the ability to measure and compare the responses of vegetative communities to changes in water levels and patterns of inundation, the information collected at a NERRS Sentinel Site will also be valuable for answering other questions about environmental stressors that impact vegetative communities.

Audiences for the immediate products of the NERRS Sentinel Site Program (e.g., accretion rates, rates and extent of inundation, short-term changes in water levels due to storm events, changes in coastal vegetated communities) are Reserve staff and their partners who need to understand the vulnerability of Reserve resources to climate change impacts and who may assist reserves in developing sensitivity and vulnerability assessments and science-based strategies for adaptation. The data are also important for other resource managers and coastal communities in the vicinity of the reserve to understand climate change vulnerability to support adaptation planning. The needs of both of these target audiences and a plan for translation and communication of the program outcomes should be incorporated into the planning process when a reserve initiates the establishment of a Sentinel Site.

In order to establish a sentinel site program for understanding impacts of changing sea level and inundation, the Reserve must maintain long-term monitoring programs for water quality and weather (i.e., SWMP abiotic element), and they must also develop a local vertical control network and site-specific elevation reference system. Several important pieces of infrastructure and information are required for this, including: (1) vertical benchmarks with verified heights, (2) long-term tide stations, (3) knowledge of local tidal datums, (4) Continuous Operating Reference Stations (CORS), and (5) Surface Elevation Tables. While some of these elements (i.e., long-term tide station; knowledge of local tidal datums) were already in place for the Mission-Aransas Reserve, several other elements (i.e., benchmarks, CORS, and SETs) have been added since the Reserve's designation in 2006 in order to complete the network (Figure 4.3).

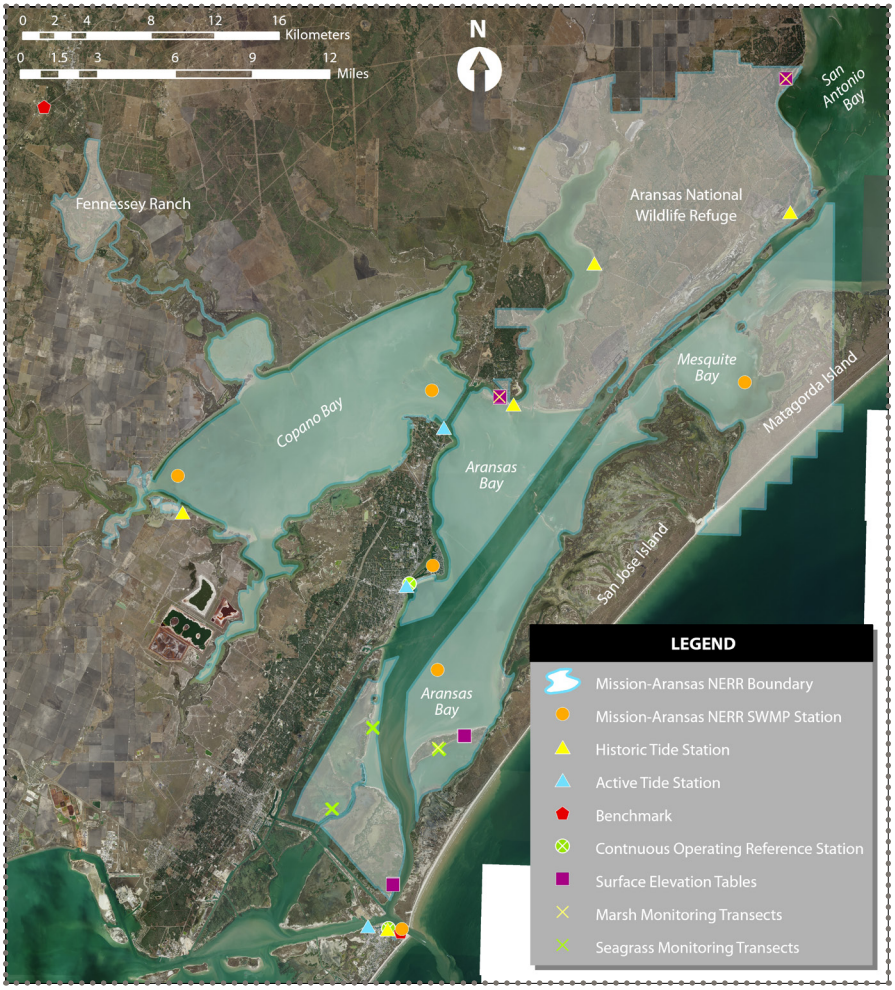


Figure 4.3. Map of Sentinel Site Program elements within the Mission-Aransas Rerserve.

Benchmarks are long-lasting points for which location has been determined to a high degree of accuracy and can be used to monitor movement of and within the Earth's crust. Many of these markers are part of the geodetic control network, known as the National Spatial Reference System (NSRS), created and maintained by the National Geodetic Survey (NGS). The height of each benchmark is typically calculated relative to the other heights of nearby benchmarks that extend from a "fundamental benchmark" with a known relationship to a level surface, or geoid, which is approximately equal to mean sea level. In 2009, staff from the Texas

Spatial Reference Center and NGS collaborated with the Mission-Aransas Reserve on a project to verify locations and heights of the four open-water SWMP platforms (Copano East, Copano West, Aransas Bay, Mesquite Bay), which required the simultaneous deployment of Real-Time Kinematic GPS receivers at eight local benchmarks, seven of which were tidal benchmarks. A network of receivers was used to simultaneously occupy each benchmark for a minimum of 4.5 hours over the course of two days and provide cm accuracy. Receivers were also deployed on the open-water SWMP monitoring platforms for the entire two-day period in order to measure the height and location of the platforms and provide more accurate measures of water level in the future. A similar effort was completed in 2012 with the addition of the Ship Channel SWMP Station and the Reserve's SETs.

Real-Time Kinematic GPS receiver placed at one of the SWMP abiotic stations

CORS are static, survey-grade GPS receivers that are permanently situated at a known location and continuously collect data in specified intervals. CORS data provide Global Navigation Satellite System (GNSS) measurements in support of precise three-dimensional positioning. Data can be used for a variety of purposes, including post-processed differential correction of GPS data collected with roving receivers, RTK applications, and monitoring of coastal subsidence. Prior to 2010, there was only one CORS located within 10 km of the Mission-Aransas Reserve boundary. To improve the coverage of CORS within the area of the Reserve, funding from the Gulf of Mexico Alliance was used to install a second station in the City of Rockport along the Reserve boundary, in close proximity to the Rockport tide station. The CORS is located at the Bay Education Center, and Reserve staff will continue to work with NGS to make sure that the unit is working properly and providing data to the national system.

SETs are used to monitor changes in surface elevation at ANWR

Coastal researchers have investigated and measured mm-scale changes in surface elevation of marsh and shallow-water habitats for over a decade using SET technology. When taken over time, SET measurements allow researchers to evaluate elevation change around an in situ benchmark, and if dense temporal measurements are made, the vertical trajectory of the surface can be calculated. SETs allow researchers to estimate rates of change with good statistical confidence over relatively short time scales (i.e., approximately 3 years). Each SET consists of a permanent in situ benchmark upon which a horizontal leveling arm can be placed. The benchmark provides a constant spatial reference plane from which the distance to the surface can be measured by lowering multiple long pins from the horizontal arm to the sediment surface. The horizontal arm assumes multiple positions around the benchmark and the distance from the arm to the surface is calculated by measuring the height of the pins above the arm. Since the orientation of the SET remains fixed in space, repeated measurements of elevation can be made with high precision.

Prior to 2010, no SETs were present in the Mission-Aransas Reserve or the surrounding area. However, through funding from the Gulf of Mexico Alliance and technical assistance from the NGS, SETs and associated infrastructure have been installed within four habitats of the Reserve (Figure 4.3). Three SETs have been installed in each habitat, for a total of 12 SETs. The habitats and locations chosen were: high salt marsh at the ANWR, low salt marsh at GISP, wind tidal flat at Mud Island, and mangrove habitat at Harbor Island. These specific habitats and locations were determined based on discussions at the "Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan Workshop," along with consultations with the appropriate agencies and land owners (i.e., USFWS, TPWD, GLO). In 2012, a network of GPS receivers was used to simultaneously occupy tidal benchmarks and one SET at each sampling site for a minimum of 24 hours over the course of two days and link SETs to the NSRS, providing cm accuracy of SET heights. Feldspar marker horizons were also installed at each SET in 2013 to begin monitoring rates of accretion.

Graduate and Undergraduate Research

In the past, the Graduate Research Fellowship Program provided funding support for high quality research in the reserves that directly addresses coastal management challenges. The fellowship provides graduate students with funding for 1-3 years to conduct their research, support reserve programs, and disseminate results to the coastal management community. The Mission-Aransas Reserve has had five GRFs to date. GRF projects in the Mission-Aransas Reserve have included the following:

- Juan Manuel Jiménez Martínez 2008 dissertation: Regulation of community structure: Top-down effects are modified by omnivory, nutrients, stress, and habitat complexity;
- Rae Mooney 2009 thesis: Watershed export events and ecosystem responses in the Mission-Aransas National Estuarine Research Reserve;
- Bridgette Froeschke 2011 dissertation: Assessment of past, present, and future status of southern flounder (*Paralichthys lethostigma*) in Texas using a time series and quantitative modeling approach;
- Jena Campbell 2012 dissertation: The role of protozoan grazers in harmful algal bloom dynamics: tools for community and grazing analyses; and
- Kelly Darnell 2014 dissertation: The influence of nutrient availability on turtle grass reproductive status.

GRFs have also assisted in the implementation of multiple elements of SWMP, including data collection, field work, and data analysis. Additional support from graduate students is provided through the Reserve's GRA program sponsored by UTMSI. In addition, there have been a number of undergraduate research projects within the Reserve. These have primarily been funded by the REU program awarded to UTMSI from NSF, the UTMSI Semester by the Sea Program, and other research funding acquired by UTMSI and other university faculty/staff as available.

Samples are collected as part of a nutrient dynamics study within the Mission-Aransas Estuary

Externally Funded Research

The Reserves were established to serve as living laboratories that provide a platform for on-site staff, visiting scientists, and graduate students to study coastal ecosystems. The Reserve Research Program has expanded the scope of its program by obtaining funding for a number of research projects that are outside the key components of SWMP. For example, they have examined nutrient dynamics and nitrogen cycling in the rivers and estuary during floods and droughts; assessed the impacts of freshwater inflows on blue crab

megalopae; studied circulation within the estuary; and monitored zooplankton, microplankton and harmful algae. Research projects initiated by the Reserve must be submitted for evaluation and written approval before the project can be initiated.

All project proposals and plans that involve Reserve staff and resources must be submitted to the Research Coordinator, Reserve Director, and other relevant Reserve staff prior to proposal submission. Projects should be evaluated for consistency with the Reserve's goals, policies, and priorities and to ensure that the proposed research will not unduly interfere with other research, stewardship, or education activities at the Reserve. Projects must demonstrate sound scientific inquiry and a sensitivity to protecting and preserving the environment during data collection efforts. Abstracts and copies of final reports of all research projects within the Reserve will be provided to the Research Coordinator and NOAA for inclusion in the Reserve database and/or library. Appropriate permits and authorizations from state and/or federal agencies must be obtained prior to conducting research activities that may affect threatened/endangered species or archeological resources. The Reserve maintains a scientific lease for any research activities conducted on lands and waters owned by GLO. Should local permission be required from a local government or property owner, they will be obtained prior to the research activity occurring.

Citizen Science

The Reserve Research, Stewardship, and Education programs have collaborated to develop a Citizen Science Blue Crab Megalopae Monitoring Program. Blue crabs were chosen as a focal species because of their economic and ecological importance in the area and the recent reports show a decline in their populations. In addition, this project ties into the Reserve's on-going efforts to understand the affect of freshwater inflows on focal species, such as the blue crab. Coordinated by the Volunteer and Outreach Coordinator, the program utilizes volunteers to collect and count blue crab megalopae from various locations around the Reserve. The blue crab megalopae settle onto hog's hair filters that are wrapped around heavy plastic cylinders suspended in the water. Each day, volunteers wash off the filters, sieve the samples, and pour samples into a tube for preservation. A second set of volunteers, trained by Research staff, count the megalopae under a microscope. The Reserve staff have also partnered with the REU program for two summers to conduct research related to the blue crab citizen science project. This is a great opportunity for a summer research project. Previous undergraduate students have done comparative studies between sites, as well as comparison with the data on currents in the Aransas Pass Ship Channel.

Volunteers collect samples of blue crab megalopae as part of the Reserve's Citizen Science project

Program Evaluation

Evaluation of the Research Program is important to ensuring the Reserve achieves its goal of improving understanding of Texas coastal ecosystems. The Research Program is evaluated through the annual SWMP review following data submission. An oversight committee evaluates the data collected through the SWMP programs based on the data criteria and point deductions are determined based on timely data submission, completeness of data submission, and excessive gaps in data. In addition, research staff have annual performance evaluations with the Research Coordinator. These annual meetings provide an opportunity to identify areas for staff improvements and discuss long-term issues, such as staffing needs and funding

requirements. The Reserve Coordinator also participates in weekly meetings with the coordinators of the other Reserve Programs. These meetings provide the opportunity to discuss more immediate issues, questions, or problems on a regular basis.

In addition, the RAB provides an effective means for the Research Program to be evaluated on a bi-annual basis. Reserve partners receive updates on the Research Program at each meeting. This provides an opportunity for the Research Coordinator to show progress on on-going projects, while also discussing future needs and opportunities. If necessary, the Research Coordinator, may request a special breakout session during the RAB meeting in order to discuss particular issues of concern to the Research Program. The Research Coordinator may also request the assistance of the RAB in identifying individuals to serve on a special advisory committee if this is deemed necessary.

4.1.5 Needs and Opportunities

Staff from the Reserve Research and Stewardship programs used a master-minding technique to determine priority issues for the Reserve and its watershed and to identify key strategies for addressing these issues. Priority issues were determined to help identify specific activities needed to meet the goals and objectives of the strategic plan (See Section 3). Discussions were also held with the RAB regarding priority issues and projects for the Research Program for the next five years. Based on input from the Reserve staff and the RAB, the following issues were identified:

- Freshwater inflow and environmental flow requirements
- Nutrient loading, including gaged flows, non-point sources, groundwater and atmospheric deposition
- Eutrophication, hypoxia
- Biological monitoring, including plankton, seagrass beds, emergent marsh, and mangroves
- Hydrological circulation
- Ocean acidification
- Oil and gas production environmental impacts
- Toxins and pathogens
- Sea level rise and coastal subsidence
- Ecosystem services (per discussion with RAB)

Based on this list, the research needs that were identified as the highest priority by multiple RAB members were freshwater inflow and ecosystem services. Research needs that were given highest priority rating by at least one member were groundwater, biological monitoring, and hydrological circulation. Research needs that were given a lowest priority rating were ocean acidification and oil and gas.

The Reserve is currently working on several projects that will begin to answer questions about freshwater inflows in the Mission-Aransas Estuary. For example, the Reserve received funding to conduct a nutrient criteria study that examined the effects of riverine flooding events and droughts on nutrient dynamics within the Reserve. The Reserve was also awarded funding from the NERRS Science Collaborative to examine (1) the effects of climate change and land use change on freshwater inflows and (2) the effects of freshwater inflows on focal species, such as blue crab and Rangia clams. The Mission-Aransas NERR has also received funding from the Texas Water Development Board for two additional projects identified by local stakeholder groups as priority research topics for the Mission-Aransas and San Antonio-Guadalupe estuary watersheds. One project uses TPWD fisheries data to examine the effects of salinity on blue crabs and white shrimp populations. The second study involves field investigations of the distribution of Rangia clams and examines the feasibility of using shell annual rings to determine the effects of freshwater inflows on growth rings of

these clams. Over the next five years, freshwater inflows will remain a top priority for the research program.

Ecosystem services research was also identified as a research priority for the Mission-Aransas NERR. The Reserve has partnered with several researchers in the past that were aimed at determining the ecosystem services provided by the Reserve. Currently, a graduate student working with Dr. David Yoskowitz at TAMUCC is funded through the ECSC to determine ecosystem services provided by different habitats within the Reserve. Over the next five years, as funding is available, the Reserve will continue to work with Dr. Yoskowitz and other researchers to evaluate ecosystem services in the Reserve.

Although oil and gas research was not identified initially as a high priority, studies on the effects of crude oil and dispersants on estuarine organisms have been carried out in the Research Coordinator's laboratory. This research was in response to the April 20, 2010 explosion on the Deepwater Horizon Macondo oil well drilling platform that started the largest marine oil spill in U.S. history, releasing millions of barrels of oil into the Gulf of Mexico. Numerous research needs were identified following the spill and several opportutnies for funding became availalbe. As a result, the Reserve chose to prioritize oil and gas research higher than it had prior to this major oil spill, and Research staff will continue workingon these projects over the next five years.

The current limitations of the research program are funding for staff and research costs. The Reserve Research Program has many opportunities for extra research projects that are limited by time with current staff. Many project ideas that involve building off of the SWMP may not require a large amount of money for analysis, but will require funding for new equipment and funding for additional personnel. Funding to hire a statistician to analyze SWMP data would be a great benefit. Funding opportunities from a variety of sources exist to fund research projects and staff. Examples are local funding from the CBBEP, state funding from the GLO, and federal funding from NOAA.

4.1.6 Research Goals, Objectives, and Actions

GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function

Objective 1-1: ***Improve understanding of short and long-term changes within Texas coastal ecosystems through the implementation of SWMP, sentinal site program, and new research programs with partners***

ACTION 1: Build and operate the abiotic element of the System Wide Monitoring Program

The Research Program currently operates five water quality monitoring stations and one weather station. These stations will be maintained and monitored over the next five years. As funding is available, the Research Program will also monitor a sixth station which was installed in a small bay adjacent to the Reserve. The Reserve will work to obtain funding to add additional SWMP water quality monitoring sites in the future to enhance overall coverage of the Mission-Aransas Estuary. Once additional sites are established, the Reserve will work to ensure that the data collected is incorporated into the existing TCOON network.

The Reserve has purchased one YSI EXO water quality sonde to begin the process of upgrading from the YSI 6600 sondes that are being phased out of use. Funding sources are being explored to enable the Reserve to upgrade each station to the new technology. As the Research Program continues to develop and funding becomes available, the Reserve will also look to build upon the key water quality parameters that are already being monitored by adding measurements of light attenuation, monthly sampling of dissolved organic matter, etc.

The Research program is currently in the process of adding an additional meteorological site. The new site will be situated on the UTMSI research pier that is located at the Aransas Pass Ship Channel. The site is located approximately 20 miles southeast from the Reserve's existing meteorological site. SWMP

water quality monitoring equipment is already installed at this location. The Reserve would also like to learn more about the currents in this important pass by installing an Acoustic Doppler Current Profiler. As this site is located in the City of Port Aransas, the Reserve staff anticipate that the weather data from this site will be used by educators and the public, in addition to researchers at UTMSI and other universities/agencies.

The main outcome of all Reserve research is publications in peer-reviewed journals for the scientific and management community to utilize. A detailed statistical analysis of the SWMP data will be performed as funds for staff become available. In order to accommodate the future developments of SWMP mentioned above, the Reserve will need to acquire funding to expand the number of permanent staff and add additional research technicians and Geographic Information Systems (GIS) specialists.

ACTION 2: Build and operate the biotic element of the System-Wide Monitoring Program

The Reserve will continue to use established protocols to monitor emergent marsh, mangrove, and submerged aquatic vegetation as part of both the Research and Stewardship programs. Reserve staff will be responsible for assessments at emergent marsh and mangrove transects on an annual basis. Reserve staff will look to build upon the measurements being gathered at existing marsh and mangrove sites by installing water level and salinity loggers in existing groundwater wells. Annual tier-2 monitoring of seagrass beds is dependent on funding, but Reserve staff will work with Dr. Kenneth Dunton from UTMSI to ensure that funding is available to keep the program operating. Acquisition of additional funds would also be needed in order to reinstate the Tier-3 component of the seagrass monitoring program.

The Reserve anticipates that the collaboration with Dr. Dunton to continue over the next five years, but if Dr. Dunton is no longer able to be involved in the project for any reason, the Reserve will request the assistance of the Texas Seagrass Monitoring Workgroup to identify other potential options for continuing the seagrass monitoring program. The Seagrass Monitoring Workgroup was created by TPWD as an outgrowth of their efforts to implement the Texas Seagrass Monitoring Plan. The workgroup meets on a regular basis to discuss issues related to seagrass and seagrass conservation in the state of Texas. Membership includes representatives from a number of state and federal agencies, local governmental agencies, universities, and various non-profit conservation organizations. These meetings serve to improve communication and coordination between the various entities and individuals working to conserve and protect seagrasses in the state of Texas and would provide an opportunity for the Reserve to seek additional partnership in their efforts to monitor seagrasses, if necessary.

The Reserve will also continue to maintain its plankton monitoring program. As part of the monthly visits to the SWMP abiotic stations, zooplankton tows will be conducted at each of the five sites. All zooplankton from each tow will be preserved and counted in a lab at the Reserve's headquarters building. A database of results from the monthly zooplankton sampling will be maintained and made available for current and future research. The Reserve will also continue to work in partnership with TAMU over the next five years to maintain an Imaging FlowCytobot which provides long-term, high-resolution measurements of phytoplankton abundance and cell properties.

ACTION 3: Build and operate the mapping element of the System-Wide Monitoring Program

A key component to the mapping element of the SWMP is to map priority habitats and geographic areas within the Reserve. The Reserve has developed a *Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan*, which is described in the Stewardship Plan. Additional efforts to map Reserve habitats are also described in this section (See Section 4.2.6, Objective 1-4).

ACTION 4: Build and operate the Reserve's sentinel site program for understanding impacts of changing sea level and inundation on vegetative communities

Continued maintenance and monitoring of several elements of the Reserve's vertical control network will be required in order to ensure that the Reserve continues to function as a sentinel site. The Mission-Aransas Reserve is committed to providing the staff and small amount of funding that will be needed to conduct some of this maintenance and monitoring. For example, transportation fees and salary support for staff time will be required in order to visit SETs and record annual measurements. An effort will be made to ensure that field visits are scheduled in conjunction with other monitoring programs (i.e., emergent marsh and mangrove monitoring) to reduce the costs to the Reserve. Other future maintenance items may include things like repairs to the boardwalks located at each SET site. Partnerships with the NGS will also need to be maintained in order to continue to verify the heights of SWMP water level loggers and SETs. If funding becomes available, the Reserve will also seek to expand the network of SETs by additional monitoring sites near existing vegetation transects. The Reserve will work with partners to produce additional products that would benefit the Reserve's ability to function as a sentinel site, such as digital elevation models. Reserve will also continue to monitor other components of the sentinel site effort, such as emergent marsh/mangrove monitoring (See Action 2) and abiotic monitoring (See Action 1).

ACTION 5: Initiate a freshwater inflow and groundwater program with partners

The Reserve has either lead or participated in a number of studies aimed at better understanding how freshwater inflow and groundwater contribute to the dynamics of the Mission-Aransas Estuary. For example, the Reserve recently completed a project founded through the Environmental Protection Agency (EPA) Gulf of Mexico Program, which investigated the transport and fate of nutrients from the Mission and Aransas Rivers into the local bay systems. The goal of the project was to characterize the nutrient dynamics of the Mission-Aransas Estuary, in terms of their sources, transport, fate and effects, in coordination with the Gulf of Mexico Alliance (GOMA) Nutrient Priority Issue Team. A second project, funded by the NERRS Science Collaborative was recently completed to better understand environmental flow requirements of freshwater into estuaries. The goal of the project was to bring scientists and other stakeholders such as ranchers, fishermen, boaters, and planners together to assist in the development of freshwater inflow recommendations that maintain the health and productivity of the Guadalupe-San Antonio and Mission-Aransas estuaries.

Future studies will look to build upon the results of these previous studies. Partnerships have or are planned to be developed with the following organizations: USGS, NRCS, regional river authorities (e.g., Lower Colorado River Authority and the Guadeloupe-Blanco River Authority), UTMSI faculty, TAMU, TAMUCC, TWDB, TPWD, TCEQ, Texas State Soil and Water Conservation Board (TSSWCB), and regional groundwater conservation districts. Studies may include research to determine the amount of freshwater inflow needed to support focal species or secondary productivity (i.e., macrofaunal community structure and biomass) in the Reserve. Studies may also include research on the effect of freshwater inflow on blue crab abundance, which are a primary food source for the endangered Whooping Cranes. An important research focus would also include understanding how climatic gradients and climatic variability affect benthos in coastal ecosystems. Results from these types of studies would provide information for water management decisions. Techniques used in these studies may include: systematics to determine diversity, GIS to understand community structure at different spatial scales, and simulation modeling of primary and secondary productivity. Issues such as land-use change, nutrient loading, climate change, and sea level rise will continue to be focal points for the Reserve freshwater research program.

Groundwater dynamics is another issue for future funding opportunities at the Reserve. The ability to quantify the contribution of groundwater to the overall flux of the Mission-Aransas Estuary is crucial to understanding overall nutrient dynamics. Future funding will be sought to purchase the specific equipment needed to quantify groundwater composition and flux to and from the system.

OBJECTIVE 1-2: ***Increase understanding of effects of oil/gas activities and marine debris on coastal ecosystems***

ACTION 1: Initiate a program on effects of oil and gas activities with partners

A research program focusing on the effects of oil and gas activity on the Mission-Aransas Estuary will be initiated with partners. Studies on the effects of crude oil and dispersants on estuarine organisms has been carried out in the Research Coordinator's laboratory, with funding from the Gulf of Mexico Research Initiative. Future projects could include the presence or absence of biological responses to contaminant exposure near oil and gas wells within the Reserve. Community structure (focusing on benthic species) would be a model analysis to identify ecological effects from oil and gas activities, while reproduction or population effects could also be used to identify sublethal effects. Toxicity or bioaccumulation of contaminants in estuarine food chains could also be studied, along with reef effects from the oil and gas structures. This program would most likely involve partnerships with agencies such as the GLO, TPWD, Coastal Conservation Association (CCA), other universities, and local exploration and production industries. Potential interested funding sources are the CCA, GLO, graduate/undergraduate fellowships, and private industry.

ACTION 2: Initiate NOAA Marine Debris Monitoring Program along the Mid-Texas Coast

The Reserve Stewardship Program will initiate a marine debris monitoring project. Shoreline marine debris will be monitored on three barrier islands and at one bay location along the mid-Texas coast utilizing *NOAA's Marine Debris Program's Shoreline Monitoring Protocol*. Surveys will be conducted at low tide to assess monthly accumulation of debris, and will consist of 100 m-long transects along the shoreline extending from the water's edge to the upland shoreline limit (i.e., where the substrate changes or vegetation line begins). At the bay location, a transect will extend from the water's edge to the natural break between salt marsh vegetation and upland vegetation or where the substrate changes. During the survey all debris larger than 2.5 cm will be collected and recorded on the "Debris Density Data Sheet." Debris will be brought back to the lab and sorted by type. The weight of each type will then be recorded. With this information we will determine the deposition rates, types, and weights of marine debris.

The overall objective of this research will be to expand on current "NOAA Marine Debris Shoreline Monitoring Programs" by exploring seasonal and spatial trends in the occurrence, type, and accumulation rates of marine debris on barrier islands and bays in the Western Gulf of Mexico. Specifically, we will investigate these 3 questions:

- How does the debris deposition rate change from north (San Jose Island) to south (Padre Island National Seashore)?
- How does the number of visitors affect the amount of marine debris at five locations along the Texas Coast?
- What percentage of marine debris has evidence of turtle bites? Is color related to the number of turtle bites?

Education and outreach efforts will also be an important component of this project. For example, a Teachers on the Estuary (TOTE) session focused on marine debris monitoring methods will be developed and incorporated into the Mission-Aransas Reserve's TOTE program. In addition, a number of videos will be produced, highlighting the marine debris problem on the mid-Texas coast. These

videos will be made available through a variety of web and social media resources. Both of these projects (TOTE and the videos) will be focused on regional issues but will still have national significance.

OBJECTIVE 1-3: ***Increase graduate and undergraduate student participation in Reserve research and monitoring programs***

ACTION 1: Provide opportunities for graduate student fellowships and assistantships

UTMSI sponsors a GRA for the Reserve. Graduate students must be enrolled in the Department of Marine Science at UT, and conduct research within the Mission-Aransas Reserve during the period of the award to be eligible for this assistantship. Applications will be judged on research and other accomplishments since entering the current graduate degree program, demonstrated need, and completion of core course workload. This assistantship may not be awarded every year. The GRA will cover salary for 12 months. Preference will be given to students that will be carrying out their thesis or dissertation research within the Mission-Aransas Reserve and that are conducting research within the priority areas identified above. Students receiving GRAs are asked to provide up to 15 hours per week of assistance to the Reserve.

ACTION 2: Provide opportunities for undergraduate student participation in Reserve research

Environmental Cooperative Science Center

ECSC is a NOAA-funded program that aims to train under-represented minority groups in marine and environmental sciences by involving students in research at Reserves. The Mission-Aransas Reserve has been working with graduate students from TAMUCC on research projects investigating freshwater inflows/indicator species, ecosystem services of natural resources, and habitat mapping. The Reserve will continue this work through the ECSC Coordinator, who is located at the Reserve Headquarters to support and assist students in their work.

Semester by the Sea

The UTMSI offers a Semester by the Sea program for Marine Biology undergraduates at UT. This program offers classroom and field-based course work. In addition, students are paired with UTMSI faculty and staff to complete a research project over the course of a single semester. This is a great opportunity for Reserve staff to supervise students and encourage other faculty members to have their students conduct research in the Reserve.

University of Texas - Freshwater and Marine Biology Major

UT students may take courses during the summer at UTMSI. Students have a full schedule of courses, but many often seek part-time work or volunteer opportunities with researchers. This is another great opportunity for students to work with Reserve staff and gain real-world science experience. Reserve staff will seek funding to provide students with pay for part time work.

Research Experience for Undergraduates

The UTMSI also has been awarded a REU program from the NSF. This program brings students from universities across the country to UTMSI for the purpose of completing a research project for the summer. This is a wonderful opportunity for the students and Reserve staff because the students are paid and provided with housing. The Reserve staff have supervised ten students since the program began in 2008. In addition to the students working directly with the Reserve, students are encouraged to conduct their research within the Reserve. At least five other students , supervised by faculty outside of the Reserve, have conducted their work within the Reserve and many others have worked on laboratory experiments pertaining to critical species in the Reserve.

Other Funding Opportunities

The Reserve will encourage funding opportunities for students to work within the Reserve as they become available. For example, undergraduate students can apply for the Lois Yoder-Swaim Memorial Scholarship from the National Estuarine Research Reserve Association (NERRA). This scholarship provides students with $750-$1000 for assistance with research projects, books, and/or tuition. To date, the Mission-Aransas Reserve has hosted one Lois Yoder-Swaim Memorial Scholarship recipient from TAMUCC, but the Reserve hopes to work with additional recipients in the future.

GOAL 2: Increase understanding of coastal ecosystems by diverse audiences

OBJECTIVE 2-1: *Disseminate research information and results to researchers and decision makers through an on-site resource center, website, other forms of media, and trainings*

ACTION 1: Develop an on-site resource center

Information gathered during research and monitoring efforts at the Reserve, including journal articles and the final reports, will be disseminated to decision-makers and made available to all interested parties upon request. Copies of articles and reports will also be submitted to NOAA. The Reserve encourages the dissemination of research results by its own staff, as well as by outside researchers, agencies, institutions, etc.

An on-site resource center will include an on-site library (i.e., UTMSI Resource Center), as well as botanical and zoological reference collections of local flora and fauna. Copies of reports from research performed within the Reserve will be submitted to the Research Coordinator for inclusion in the on-site library. This will assure a complete, comprehensive, and indexed collection of research activities and results within the Reserve.

Additional methods of disseminating information to researchers and decision-makers include:

- NOAA's computerized abstract service, keyed to NOAA contract numbers and revised annually (hard copies of the collected abstracts are available upon request to Reserve managers, other federal and state agencies, universities, and individuals);
- Journal articles in peer-reviewed literature;
- Presentations at professional conferences;
- Special symposia hosted by NOAA or other Reserves, often in association with other meetings such as the biennial meetings of the Estuarine Research Federation or Coastal Zone Managers;
- Regular contact with representatives of other state and federal agencies, local government agencies, and planning boards; and
- Reserve staff will compile all research done within the Reserve into a Research Database, which will be available on the website.

ACTION 2: Update research results on Reserve website and other forms of media

Information gathered during research and monitoring efforts at the Reserve will be disseminated to the public through the Reserve website. Data from the SWMP program will be disseminated through the CDMO, but the Reserve website will serve as a mechanism to disseminate other research related information, such as technical reports and presentations. The Reserve website was recently upgraded in 2011 by a contracted web designer and is maintained by Reserve staff, with its own domain name. The Reserve website serves as a vehicle to facilitate communication with the broader community as well as to provide internal cohesion for all participants in the Reserve program. This website profiles each Reserve component, the participants in the program, and link to other NERR sites as well as state and

national sites. This website will be a coordinated effort with Education Program.

Information gathered during research and monitoring efforts at the Reserve will also be disseminated to the general public by:

- Creating signs and posters;
- Participating in public workshops, conferences, and meetings arranged by the Reserve;
- Writing articles in journals or newsletters of local organizations;
- Planning local educational and outreach programs (coordinated with the Education Program);
- Providing press releases to local media;
- Facilitating public lecture series;
- Utilizing social media (e.g., Facebook, Twitter, Instagram).

ACTION 3: Include relevant estuarine research and data in Reserve professional training and education programs

The Reserve Research Program provides the scientific basis for addressing coastal management challenges. Research and monitoring activities provide high-quality, long-term monitoring data for decision-makers trying to understand and evaluate issues that affect estuaries and coastal watersheds. Research results are the most relevant to local resource management issues, but can also be applied to issues at the state, regional, or even national level. In order to improve the capacity and skills of coastal decision makers to use and apply science-based information, the Research Program will support the Coastal Training Program's efforts to provide training events over the next five years that use Reserve research and monitoring results to address relevant coastal management issues.

The Research Program will also support the Reserve Education Program's effort to create teacher professional development and student activities that integrate Mission-Aransas and other NERRS Science Collaborative research and align with the 2013 Next Generation Science Standards. The 2013 Next Generation Science Standards call for science practices and cross-cutting concepts to be taught in context, to help learners understand how science is practiced in the real world. Over the next five years, the Reserve will implement new methods of integrating NERRS and NOAA research into TOTE professional development workshops and K-12 student programs that address locally and regionally relevant issues that impact coasts and estuaries.

OBJECTIVE 2-2: ***Transfer research knowledge to K-12 students through the implementaiton of Summer Science Program and SWMP Scholar Program***

ACTION 1: Provide instructors for Summer Science Program

The UTMSI Summer Science is an inquiry-based learning experience for students entering grades 3-8 (See Section 4.3.6, Objective 2-4). This interactive program is coordinated by the Education Program at the Reserve and utilizes the graduate students involved in the Scientists in Residence program (See Section 4.3.6, Objective 2-4) as instructors. The UTMSI Summer Science program has two lead instructors, one for each age group, and a group of students who serve as teaching assistants. Visiting scientists, many from the Reserve, create lesson plans and programs based on their research and findings. Research staff will continue to provide instruction during the Summer Science Program as it is offered over the next five years.

ACTION 2: SWMP Scholar Program

The purpose of this project would be to provide research experiences for K-12 teachers and promote the transfer of research information back to the classroom. The project would target four different teachers

per year. Teachers would participate in field visits to the SWMP abiotic and vegetation monitoring stations, during which time they would learn about the water quality and biological monitoring data collected and the techniques used by the NERR System. Teachers would share this information with their classes by using a GoPro camera and creating a video for use in their class (as well as by the Reserve staff). Teachers would also receive information about the curriculum activities (i.e., Estuaries 101) that have been developed by the NERR System for use in their classroom. If funding allows, the teachers would also be provided a stipend to compensate for their time and to purchase scientific equipment that could be used to conduct activities in their classrooms. A follow-up Skype interview or classroom visit by the Reserve Research Staff will allow teachers and students to ask questions and gain further understanding about the research going on at the Reserve. A protocol for video development (interview questions) and helpful hints would also be developed. If funding allows, stickers and hats (complete with GoPro harness) featuring a "SWMP thing" design would be purchased for participants. The Research programs will work to identify potential funding mechanisms and personnel for this type of program.

GOAL 3: Promote public appreciation and support for stewardship of coastal resources

OBJECTIVE 3-1: *Promote public participation in research and monitoring programs through implementaiton of a minimum of one citizen science program*

ACTION 1: Continue implementation of citizen science monitoring program for blue crab megalopae

Public participation in research and monitoring at the Mission-Aransas Reserve has been established through the development of a Citizen Science Blue Crab Megalopae Monitoring Program. The program is a partnership between the Research, Education, and Stewardship programs. Coordinated by the Volunteer and Outreach Coordinator, the program utilizes volunteers to collect and count blue crab megalopae from various locations around the Reserve. The blue crab megalopae settle onto hog's hair filters that are wrapped around heavy plastic cylinders suspended in the water. Each day, volunteers wash off the filters, sieve the samples, and pour samples into a tube for preservation. A second set of volunteers, trained by Research staff, count the megalopae under a microscope.

The blue crab megalopae monitoring program provides great opportunities for summer research projects. Previous undergraduate students have done comparative studies between sites and have also looked at megalopae abundance in relationship to the currents of the Aransas Pass Ship Channel. Future opportunities with this dataset will be explored, such as expansion to more sites and comparisons to commercial landings, as funding allows. Recently the Reserve received a one year grant from the Texas State Aquarium to fund enumeration of blue crab samples collected by the citizen science project and provide education and outreach materials for the project. The Volunteer and Outreach Coordinator will continue to work closely with the Research and Stewardship programs to oversee and build upon this important citizen science program over the next five years. The Reserve will continue to look for additional funding sources for continuation and expansion of this program.

ACTION 2: Develop and implement a key species monitoring program

Ideas for additional citizen science programs include a key species monitoring program. This program will utilize volunteers to conduct monitoring of key species that are not currently monitored by the Reserve's biological monitoring program. This monitoring program would focus primarily on large marine vertebrates, excluding fish (e.g., birds dolphins, and turtles). This program could also be used to enhance other existing monitoring programs (e.g., Audubon's Christmas Bird Count) or to create organism inventory programs (e.g., migratory songbird surveys). A list of on-site and off-site research and monitoring opportunities for interested persons or groups will be maintained in order prevent

overlap and increase collaboration. Assistance from the Education Program, particularly the Volunteer and Outreach Coordinator, would be needed in order to encourage participation in the key species monitoring program. The program could also include, if funding is available, the development of a smart phone application that enables people to update their observations in real-time. Any Reserve staff and volunteers involved in the project will be encouraged to present and publish the findings of their research or monitoring efforts.

ACTION 3: Train volunteers to participate in citizen science programs

The Volunteer and Outreach Coordinator will be responsible for working with Research and Stewardship staff to provide trainings related to current and future citizen science programs. Research and Stewardship staff will work with the Volunteer and Outreach Coordinator to identify technical experts to participate in training events that are relevant to the on-going citizen science programs at the Reserve. Ideally, these trainings will be held twice per year with one event being hosted at the beginning of winter.

OBJECTIVE 3-2: ***Increase public understanding of ecological values by partnering to conduct evaluations of ecosystem services***

ACTION 1: Work with partners to conduct evaluations of ecosystem services within the Reserve and its watershed

Several studies have focused on evaluating ecosystem services within and near the Reserve. Results of this research help provide an understanding of ecological values to the public and therein promote public appreciation and support for stewardship of coastal resources. The results of these previous studies also provide the context for future research needs regarding ecosystem services and will help the Reserve to identify potential partners for future projects and funding opportunities (i.e., NOAA RESTORE Act Science Program).

4.2 Stewardship

4.2.1 Introduction

The Reserve System's stewardship programs integrate aspects of resource management, research, monitoring, education, and training to provide long-term protection of the natural resources within reserves and within their respective watersheds. The focus of the stewardship program at each reserve is guided by their unique resources and issues and their state partnership. Although there are no NERR system-wide initiatives for the stewardship program, programs are typically implemented to be consistent with the three national priority issues of climate change, habitat protection, and water quality.

The *2011-2016 Reserve System Strategic Plan* outlines several stewardship-related objectives that support national priority focus areas, including:

- Increase permanent protection and restoration of key areas in reserve watersheds to improve coastal habitat quantity, quality, and resiliency to climate change impacts.
- Develop, demonstrate, and evaluate tools and practices at reserves that advance progress on habitat protection, water quality, and climate change impacts.
- Increase social science research and use of social information to foster coastal stewards that value and protect estuaries.
- Increase estuary literacy and promote active stewardship among public audiences through the development and delivery of tools and programs addressing climate change, habitat protection, and water quality.
- Improve the capacity and skills of coastal decision makers to use and apply science-based information in decisions that affect estuaries and coastal watersheds.

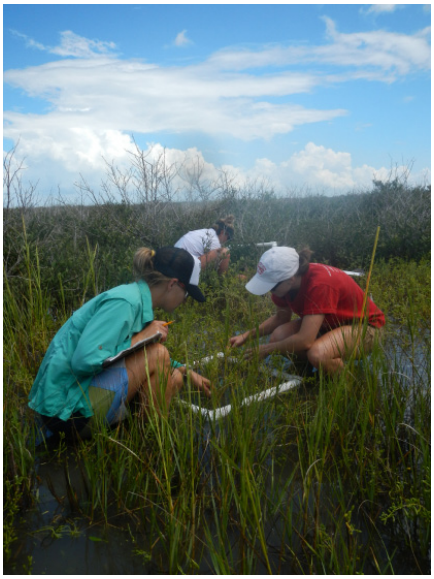
The stewardship-oriented strategies identified for meeting the above goals include: (1) demonstrate best practices in land and estuarine stewardship and climate change adaptation at reserve properties and facilities; (2) identify, prioritize, and implement land acquisition and habitat restoration projects taking into account climate change impacts; (3) implement engagement programs to promote estuarine resource stewardship; (4) develop and implement strategies that build reserve capacity to conduct and use social science to address coastal management issues; and (5) expand training for coastal decision makers focused on climate change, habitat protection, and water quality issues.

4.2.2 Stewardship Program Context

Implementation of the Mission-Aransas Reserve Stewardship Program began when the Reserve was designated in 2006, but a full-time Stewardship Coordinator was not hired until 2008 to oversee the Program. Since that time, the Stewardship Program has focused on establishing and expanding its activities related to: (1) providing helpful resources for local resource managers, (2) promoting land conservation, (3) conducting clean-up and recycling programs, and (4) assisting with wildlife rehabilitation and recovery programs.

The lands within the Reserve are owned by a combination of state (TPWD, GLO), federal (USFWS), and private entities (Fennessey Ranch, CBLT, CBBEP). While the Stewardship Program works to address a variety of ongoing local management issues important to these land owners and local natural resources, activities are implemented to also be consistent with priority issues that impact the entire Gulf ecosystem, such as those described in the *Gulf of Mexico Alliance Governor's Action Plan II: For Healthy and Resilient Coasts (2009-2014)* and with the strategic areas of focus in the *NERRS 2011-2016 Strategic Plan* of water quality, habitat protection, and climate change. Coordination and communication with stewardship coordinators at other Reserves, as well as staff at NOAA, ensures that the Mission-Aransas NERR

Stewardship Program is continually aware of national initiatives and on-going projects of relevance at other Reserve sites. This coordination and communication is typically achieved through a combination of in-person/online meetings and conference calls.



Reserve staff monitor vegetation transects on an annual basis

The Reserve Stewardship Program is a unique program that is tightly integrated into the other three Reserve Programs of Research, Education, and Coastal Training. The Research and Stewardship programs have worked closely together to implement activities related to vegetation monitoring and the sentinel site program. Research staff assistance is particularly critical for field work and data acquisition. The Stewardship Coordinator has also collaborated with Research Program staff on a number of special projects, such as understanding the impacts of land use and climate change on freshwater inflows and evaluating sensitivity of Reserve species to climate change. The Education and Training programs provide avenues for the Stewardship staff to reach resource managers, elected officials, students, and the general public. The Stewardship and Education programs are tightly linked through the Reserve's community education initiatives, while the Training Program works with the Stewardship Coordinator to host trainings that are relevant to the resource managers of the Reserve. The Education Program also provides access to a volunteer network, which is crucial for the success of a number of stewardship programs (i.e., beach cleanups, Monofilament Recovery and Recycling Program). The Stewardship Program also relies on strategic partnerships with other agencies and institutions to increase its capacity to address important priority issues.

Reserve land owners and partner organizations are the primary audience for the Stewardship Program activities. However, some activities of the Stewardship Program, such as marine debris and wildlife impacts, are targeted to a broader public audience both within the Reserve and its watershed. In addition, many of the resource management issues within the Reserve are shared by other Reserve sites and coastal management organizations throughout Texas, the Gulf of Mexico, and the U.S. Therefore, the Stewardship Program strives to ensure that regional and national partners are made aware of stewardship-related activities as applicable.

4.2.3 Stewardship Program Capacity

Staff

The Reserve Stewardship Program consists of a full-time Stewardship Coordinator who is responsible for working closely with other Reserve staff to ensure that stewardship goals and objectives are met. In addition, the Stewardship Program often relies on assistance from graduate/undergraduate students, interns, volunteers, and outside partners from state/federal agencies and other universities to complete stewardship-related projects.

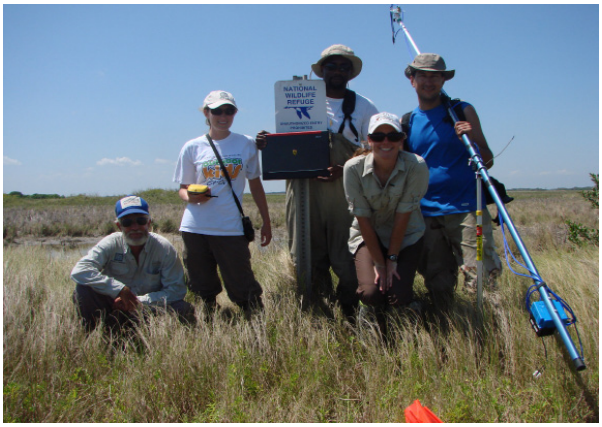
Partners

The Mission-Aransas Reserve Stewardship program has worked to build and maintain partnerships with numerous local, regional, and national partners. These partnerships have allowed the Program to complete a broader suite of stewardship projects and leverage limited staff and resources. The Stewardship Program currently partners on projects with the following organizations: USGS, NGS, ANWR, GISP, Texas Sea Grant, UTMSI, CBBEP, CBLT, Fennessey Ranch, Nueces County, City of Port Aransas, Texas Forestry Service, and Lady Bird Johnson Wildflower Center. The Stewardship Program plans to continue these

partnerships but also hopes to create additional partnerships with groups such as NPS, TAMUCC, and GLO.

Facilities

The Stewardship staff are located in the Estuarine Research Center on the campus of UTMSI in Port Aransas, Texas. Facilities include office space for the Stewardship Coordinator, as well as laboratory space that is shared with research staff. Laboratories are equipped for a large range of research projects, including a wet-lab space. UTMSI also has a fleet of small boats and vehicles for work in the bays and upland areas.



Stewardship Program works with partners on project such as habitat mapping

The Mission-Aransas Reserve owns very limited amounts of land within the Reserve boundary. Therefore, the Stewardship Program is highly dependent on its partner landowners (ANWR, CBBEP, CBLT, Fennessey Ranch, GISP, and GLO) to allow for access to their land and water areas for stewardship programs. For example, all vegetation monitoring and sentinel site program infrastructure are located on partner-owned lands. The Stewardship Program must maintain these relationships in order to ensure the successful implementation of its many programmatic activities.

4.2.4 Stewardship Program Delivery

The term stewardship is often used to describe the responsible management of natural resources. The Mission-Aransas Reserve Stewardship Program promotes the long-term protection and careful management of the Reserve's natural resources through the integration of research, monitoring, education, training, and resource management. Coastal resource managers face numerous challenges that make effective stewardship difficult, such as habitat alteration, resource harvesting, climate change, sea level rise, and invasive species. In order help address these challenges, the Mission-Aransas Reserve Stewardship Program has implemented numerous different activities under the broad categories of resource management, land conservation, marine debris, and wildlife impacts.

Resource Management

The Stewardship Program has been involved in the development of several products designed to assist the resource management community. Through collaboration with the staff of the Research and Education programs, as well as several local experts, the Stewardship program developed a document called *The Ecology and Sociology of the Mission-Aransas Estuary: An Estuarine and Watershed Profile* (Evans et al., 2012). The document provides researchers and resource managers with basic information about the different physical ecosystem components, ecological processes, habitats, and watershed characteristics of the Mission-Aransas Estuary. This basic information is extremely helpful for learning about issues of concern, designing applied management investigations, and developing future scientific studies. The Reserve also partnered with the NOAA Coastal Services Center to complete a community characterization of the Reserve watershed. The goal of the project was to provide a better understanding of how human perceptions and behaviors are linked to resource flow and water quality within the Reserve. *The Community Characterization of the Mission-Aransas National Estuarine Research Reserve and Surrounding Area* provides local resource managers with the information they need to use an ecosystem-based management approach that considers both humans and the environment (Morehead et al., 2007). In addition, the Mission-Aransas Reserve has worked with

partners to produce habitat maps for the Mission-Aransas Estuary and the surrounding watershed. These maps provide a baseline for monitoring habitat change over time and understanding potential impacts to the populations and species that rely on coastal habitats, and they can also be used for activities ranging from conservation planning to experimental design.

The Stewardship Program is also responsible for monitoring management practices of Reserve land owners in order to promote better resource management practices. Information is gathered from partner landowners through questionnaires, and detailed vegetation monitoring at Fennessey Ranch is also conducted to allow Stewardship staff to determine how different habitats respond to various land management practices, invasive species establishment and removal, and changes in climate patterns (i.e., droughts and floods). By maintaining a database of Reserve partner management practices, the Stewardship Program can serve as source for information on "best management practices" for land owners within the Reserve as well as other agencies/organizations that deal with similar issues.

Vegetation monitoring at Fennessey Ranch

One of the critical resource management issues facing the Mission-Aransas Reserve is the threats associated with invasive and nuisance species. In 2014, the Texas Gulf Region Cooperative Weed Management Area (CWMA) was formed by the City of Port Aransas, Texas A&M Forest Service, and Lady Bird Johnson Wildflower Center. CWMAs are designed to work across jurisdictional boundaries to control, remove, and eradicate invasive species. The mission of the Texas Gulf Region CWMA is to address invasive Brazilian peppertree (*Schinus terebinthifolious*) from Port O'Connor to Packery Channel on the Texas Gulf Coast. The group consists of a voluntary network of public and private stakeholders that are concerned with the management of Brazilian peppertree. The CWMA seeks to prevent the spread and movement of the species by advocating for cooperative control amongst willing landowners and managers. Education and outreach to land owners, local governments, and the general public are key components of the CWMA. The Stewardship Program also strives to control invasive species by partnering with the Education Program on the "Wetland Warriors" program. In 2012, the Reserve began the Wetland Warrior program which teaches volunteers about the harm caused to coastal habitats by invasive plant species and how to differentiate between native and invasive plants. Reserve staff and volunteers work together to remove invasive plants and transplant native plants on the UTMSI property on scheduled work days. The volunteers propagate native plants by collecting and planting seeds or cuttings and volunteer their time to remove invasive plants individually.

Land Conservation

The Stewardship Program also has helped to identify critical coastal and estuarine areas for potential land acquisition. Permanent protection of valuable coastal and estuarine habitats is a priority of the Mission-Aransas Reserve stewardship program. This protection can occur through the acquisition of land from willing sellers or through the purchase of conservation easements. Conservation easements are willing agreements between a landowner and an organization that permanently limits uses of the land in order to protect its conservation value. The stewardship program has hosted workshops to identify priority areas for land protection within the Reserve watershed and has assisted partners with proposals to acquire the funds needed to conserve these valuable habitats.

Marine Debris

More than 500 tons of marine debris washes up on Texas shorelines each year, and the Stewardship Program is responsible for organizing and promoting existing cleanup and recycling programs near the Reserve to help combat this growing problem. In addition to being an eyesore, marine debris is a threat to wildlife that may ingest the trash or become entangled, and it can also engulf and smother the habitats that birds, fish, and other animals rely on for shelter and food. Marine debris also poses a safety hazard for humans if fishing gear or other types of trash become wrapped around boat propellers or clog seawater intakes. The Reserve has participated in the Monofilament Recovery and Recycling Program (MRRP) sponsored by Texas Sea Grant since 2006 and has organized numerous cleanups of Reserve habitats since its designation. In 2014, the Research Education for Undergraduate program provided funding for a marine debris accumulation rate project that compared rates and marine debris composition to measurements taken in the same area in 1990 and 1991.

Volunteers pick up trash near Egery Flats

Volunteers release a sea turtle after successful rehabilitation at the ARK

Wildlife Impacts

The Stewardship Program also assists with animal rehabilitation and recovery programs near the Reserve. The primary rehab and recovery program within the Mission-Aransas NERR is the Animal Rehabilitation Keep (or ARK). The ARK's mission is to rescue and rehabilitate sick and injured birds, sea turtles, terrestrial turtles, and tortoises found along the South Texas coast and to return them to their native habitat. To ensure the successful release of as many animals as possible, the ARK staff work with veterinarians and other wildlife management organizations to use the most up-to-date rehabilitation techniques. The ARK also strives to educate the public about the potential impacts of population growth and urban development on coastal wildlife. Collaborative activities between the ARK and the Stewardship Program vary, but in the past have included assistance with funding and short-term volunteer needs.

Program Evaluation

Evaluation of the Stewardship Program is important to ensuring the ability to achieve the goal of promoting appreciation and support for coastal resources. The RAB provides an effective means for the Stewardship Program to be evaluated on a bi-annual basis. By participating in the RAB, representatives from the Reserve land owners are able to receive updates on the Stewardship Program at each meeting. This provides an opportunity for the Stewardship Coordinator to show progress on on-going projects, while also discussing future needs and opportunities. If necessary, the Stewardship Coordinator, may request a special breakout session during the RAB meeting in order to discuss particular issues of concern to the Stewardship Program. The Stewardship Coordinator may also request the assistance of the RAB in identifying individuals to serve on a special advisory committee if this is deemed necessary.

In addition, the Stewardship Coordinator is responsible for completing an annual review with the Reserve Director and attending quarterly Reserve staff meetings. The annual review is a formal process, completed through UT which allows for specific long-term issues with the Stewardship Program to be addressed by the Reserve Director. The quarterly Reserve staff meetings, on the other hand, provide an opportunity for more immediate issues, questions, or problems to be discussed and addressed in collaboration with other Reserve staff. The format for these meetings includes updates by all Reserve programs, as well as a presentation by a specific program about a current problem. The process of evaluation is not expected to change within the next five years.

4.2.5 Needs and Opportunities

In order to ensure the protection and careful management of the Reserve's natural resources, it is important that stewardship-related needs and opportunities of the Reserve partners are identified on an on-going basis. It is particularly important for the Stewardship Coordinator to maintain good communication with the land owners of the Reserve and an on-going understanding of their needs. This is accomplished through regular meetings of the RAB, which allow time for partners to discuss both near- and long-term needs with Reserve staff. For example, recent discussions with staff from Fennessey Ranch identified the following priority issues: (1) culvert replacement, (2) vegetation monitoring of key habitats, and (3) invasive and nuisance species control. Special meetings hosted by the Stewardship Program have also been used in the past to help identify land owner needs. For example, the Reserve hosted the "Aransas National Wildlife Refuge Research Symposium," during which time the following stewardship-related research needs were identified: (1) impact of oil and gas roads and drill pads, (2) invasive species removal and identification of priority spots, (3) understanding of how prescribed fire shapes the habitats located at ANWR, and (4) determine how Whooping Cranes use areas recently treated with prescribed fire. Once these priority needs have been identified, the Stewardship Coordinator will work with these partners to identify and obtain the resources (i.e., funding and collaborators) needed to fulfill the needs.

Identification of broader-scale priority issues within the Reserve is also important for understanding the needs and opportunities that exist for the Stewardship Program. Staff from the Reserve worked together using a master-minding technique to identify the priority issues for the Reserve and its watershed and to discuss key strategies for addressing these issues. Priority issues were determined to help identify specific actions that should be developed to help meet the goals and objectives of the strategic plan. Discussions were also held with the RAB regarding priority issues for the Reserve for the next five years. Based on input from the Reserve staff and the RAB, the following issues were identified:

- Freshwater inflow and environmental flow requirements
- Nutrient loading, including gaged flows, non-point sources, groundwater and atmospheric deposition
- Eutrophication, hypoxia
- Biological monitoring, including plankton, seagrass beds, emergent marsh, and mangroves
- Hydrological circulation
- Ocean acidification
- Oil and gas production environmental impacts
- Toxins and pathogens
- Sea level rise and coastal subsidence
- Ecosystem services (per discussion with RAB)

Based on this list, the needs that were identified as the highest priority by multiple RAB members were freshwater inflow and ecosystem services. Needs that were given highest priority rating by at least one

member were groundwater, biological monitoring, and hydrological circulation, while needs that were given a lowest priority rating were ocean acidification and oil and gas. The Stewardship program has already initiated activities related to many of the items listed above, such as biological monitoring (i.e., monitoring of marsh, mangrove, and seagrass) and sea level rise/coastal subsidence (i.e., sentinel site program), and will continue to implement activities related to these issues over the next five years. The Stewardship Program has also worked in collaboration with the Research Program and other institutions to address issues related to freshwater inflows and ecosystems and will continue to work collaboratively on these issue in the future.

Although the Stewardship Program has already initiated several projects that help address the priority issues mentioned above, there are still limitations to the amount of current and future work that can be done. Funding for additional staff, training, and equipment are the major limitations of the Stewardship Program. Currently the program only has one employee that is required to complete all tasks and responsibilities. In order for the Program to grow and better address the priority issues listed above, the Stewardship Program must increase its capacity through local (e.g., CBBEP), state (e.g., GLO Coastal Management Program), regional (e.g., Gulf of Mexico Alliance) and federal funding opportunities (e.g., NOAA; RESTORE Act).

4.2.6 Stewardship Goals, Objectives, and Actions

GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function

OBJECTIVE 1-4: ***Produce a map of Reserve priority habitats and geographical areas and plan for future mapping efforts***

ACTION 1: Update the "Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan every five years"

The purpose of the *Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan* is to guide future mapping and vertical control/elevation projects within the Reserve and its watershed. The Plan describes (1) previous, continued, and future monitoring activities (both abiotic and biological), (2) historical, existing, and future vertical control infrastructure, and (3) previous, continued, and future habitat mapping and elevation modeling. This information will be critical to consider when making any decisions about future mapping and vertical control efforts within the Mission-Aransas Reserve. The long list of monitoring and mapping projects included within the Plan demonstrates the strong interest in providing a better-understanding of the Reserve habitats for the purposes of improving resource management and conservation decision-making. The Plan describes other sources of information that would be helpful in future decision making regarding mapping efforts, such as the Mission-Aransas Reserve Conceptual Ecosystem Model and expert input received at the "Mission-Aransas Reserve Land Use, Land Cover, and Habitat Change Plan Workshop."

Due to the large size of the Mission-Aransas Reserve, it is likely that multiple mapping efforts/projects taking place over a widespread time period will be needed in order to meet the mapping needs of the Reserve. Factors such as funding, partnerships, and availability of resources (i.e., imagery) will be important in determining which of these projects are accomplished. Potential mapping and vertical control "strategies" are outlined in the Plan, but these strategies and the overall Plan will need to be reviewed on a regular basis as projects are completed, technology develops, Reserve staff changes, and new funding and/or partnerships are developed. All of these factors could influence how the Reserve chooses to move forward with monitoring elevation and mapping priority habitats, and therefore, this will be a living document that the Reserve staff continue to revise in order to best meet their needs.

ACTION 2: Work collaboratively with the Environmental Cooperative Science Center and other partners to produce and utilize mapping products from previous imagery acquisitions and fieldwork.

Funding from the NOAA ECSC will be used by Mission-Aransas Reserve partners (Florida A&M University, TAMUCC, University of Texas at Brownsville, and Creighton University) to map priority Reserve habitats. Data has already been acquired from the Worldview-2 satellite (DigitalGlobe Corporation, Longmont, CO). This satellite imaging system offers improved spatial (1.84-m for multispectral bands, 0.46 m for a panchromatic grayscale band) and spectral (8 bands in visible and near-infrared) resolutions and an average revisit time of 1.1 days. This satellite is gaining wide acceptance and several Reserves adopted this as their platform of choice.

Three acquisitions of Worldview-2 satellite imagery were purchased for the Mission-Aransas Reserve, obtained during early- to mid-year, mid- to late-year, and dormant periods of the annual vegetation cycles. This approach allows change detection to (1) improve habitat classification accuracy by taking advantage of the phenological trajectories of different species and their dormant states, (2) estimation of net annual above ground production across dates using calibrated biomass regressions, (3) improved evaluation of animal habitats, and (4) comparisons of the seasonality of bulk optical properties (i.e., total suspended matter, algal chlorophyll, and colored dissolved organic matter of open water habitats).

A major field survey involving faculty and student teams from ECSC partner schools occurred at the Reserve for a 10 - 12 day period in mid-growing season, during the summer of 2014. The ECSC has a well-tested approach used in nine previous airborne imagery and field survey campaigns, often involving thirty or more researchers and support personnel. ECSC staff are currently in the process of analyzing the imagery and field survey data in order to produce mapping products. The Stewardship Coordinator will continue to work with the ECSC Coordinator and other ECSC collaborators to ensure that the products produced are accurate and meet the needs of the Reserve and its partners.

OBJECTIVE 1-5: ***Protect priority areas for long-term research by ensuring existing rules and regulations are followed***

ACTION 1: Coordinate with Reserve partners to follow existing rules and regulations

Protection of priority habitats and geographic areas for long-term research will be achieved by participation of Reserve partners in the RAB. The RAB will work toward the following objectives, to the maximum extent practicable, as governed by their individual missions, bylaws, or other operating instruments:

- To ensure a conducive setting for research and monitoring through long-term protection of the Reserve;
- To enhance public awareness and understanding of the Reserve and provide public education and stewardship opportunities;
- To provide an opportunity by which research and monitoring activities at the Reserve will be communicated to coastal decision makers;
- To protect the integrity of the Reserve through the implementation of the Reserve Management Plan; and
- To assist with revision and updating of the Reserve Management Plan at least every five years.

GOAL 2: Increase understanding of coastal ecosystems by diverse audiences

OBJECTIVE 2-3: ***Facilitate stewardship activities through community education programs like Wetland Warriors, Cooperative Weed Management Area, and Trash or Treat***

ACTION 1: Assist with implementation of the stewardship-oriented community education program known as "Wetland Warriors"

In 2012, the Reserve began a program known as "Wetland Warriors." Reserve educators teach volunteers about the harm caused to coastal habitats by invasive plant species and how to differentiate between native and invasive plants, and then Reserve staff and volunteers work together to remove invasive plants in a chosen area. Past events have been very successful at removing a large number of invasive silverleaf sunflowers (nuisance), guineagrass (invasive), and small Brazilian pepper trees (invasive) within the Wetlands Education Center located on the UTMSI campus. The Stewardship Coordinator will continue to work with Education Program staff to use these events as a means for controlling invasive species within the Reserve while simultaneously educating the public about invasive species control.

ACTION 2: Continue the Reserve's involvement in the Cooperative Weed Management Area

The Stewardship Coordinator has been involved in the Texas Gulf Region CWMA since it was established in 2014 by the City of Port Aransas, Texas A&M Forest Service, and Lady Bird Johnson Wildflower Center. The Reserve became a founding partner in the Texas Gulf Region CWMA and will continue to work with that partnership and other regional CWMAs that are developed. By maintaining involvement in the CWMA, the Reserve will be able to: (1) increase public awareness of invasive species and support for eradication programs, (2) reduce introduction of invasive species to new sites, (3) attempt direct control of invasive species, and (4) increase native species planting (residential and commercial).

ACTION 3: Initiate stewardship-oriented community education program known as "Trash or Treat"

"Trash or Treat" was funded by the GLO Coastal Management Program (CMP) Cycle 20 funding opportunity. This project will work to restore and enhance a coastal natural resource area, ensure/enhance public access, and educate the public about the important coastal problem of marine debris. The overall goal of "Trash or Treat" is to educate the South Texas Coastal Community on the impacts of marine debris, and encourage actions that mitigate the damage to the region's coastal environments. The project is comprised of multiple components spanning two academic years, beginning in the fall of 2015. The components include: classroom instruction, beach cleanup, data analysis and art instruction, and festival outreach. The target audiences for the project are (1) fourth and fifth grade students at a single elementary school and (2) the South Texas Hispanic community. This project is a collaboration between the Stewardship and Education programs.

GOAL 3: Promote public appreciation and support for stewardship of coastal resources

OBJECTIVE 3-3: *Monitor land management practices at Fennessey Ranch and Aransas National Wildlife Refuge*

ACTION 1: Monitor habitats and management practices at Fennessey Ranch

The *2015 Fennessey Ranch Management Plan* requires regular monitoring of habitats and management practices at Fennessey Ranch in order to ensure the terms of the conservation easement are fulfilled. By monitoring habitats and management practices, Reserve staff can ensure that the modifications to the Plan are based on sound science and current needs of the Reserve and Fennessey Ranch. Monitoring of management practices will occur through the completion of an annual questionnaire by Fennessey Ranch staff. The questionnaire will assess facilities improvements, wildlife management, habitat management, hydrology management, and visitor use impacts. The assessment will also be used to determine assistance needed from the Reserve Stewardship Program during the coming year. The

Stewardship Coordinator will work with the staff at Fennessey Ranch to ensure that the questionnaire is completed annually.

Habitat monitoring will involve the monitoring of vegetation within different habitats of the Ranch. The Reserve instituted a vegetation monitoring program in 2008. The goal of this program is to assess changes in upland, wetland, and riparian vegetation communities as the results of management measures (i.e., prescribed fire, mowing) or natural changes (i.e., drought and flood). The Stewardship Coordinator will work with staff at Fennessey Ranch to modify the existing vegetation monitoring program to ensure that it is able to capture the impacts of the major management goals at the Ranch for the next five years.

ACTION 2: Monitor management practices at the Aransas National Wildlife Refuge

An annual assessment of management policies and practices at ANWR will be performed through the use of a standardized questionnaire. The questionnaire will assess facilities improvements, wildlife management, habitat management, hydrology management, and visitor use impacts. The assessment will also be used to determine assistance needed from the Reserve Stewardship Program during the coming year. The Stewardship Coordinator will work with the staff at ANWR to ensure that the questionnaire is completed annually.

OBJECTIVE 3-4: ***Support local habitat and wildlife conservation programs such as animal rehabiliation and clean-up programs***

ACTION 1: Partner with local wildlife rescue and rehabilitation programs to enhance their efforts

The majority of animal rescue at the Reserve will be handled through cooperation and coordination with the Edith McAlister Animal Rehabilitation Keep housed on the UTMSI campus. The ARK provides rehabilitation to injured animals endemic to the Mission-Aransas Estuary and its surrounding habitats. The ARK got its start over 25 years ago and is currently the largest rehabilitation facility on the Texas coast. Facilities include a turtle laboratory, avian laboratory, raptor cages, all-purpose cages, walk-in freezer, and several large turtle holding tanks. In 2011, the Oiled Wildlife Facility at the ARK was opened. The facility was created in a large part with funding from Valero Energy given to the UTMSI by GLO. In times when there are no oiled animals, the facility is used by the ARK for other rehabilitation needs, such as during cold-stunning events. The ARK also participates in monitoring stranded animals along the Texas coast and cooperates with the Sea Turtle Stranding and Salvage Network. The Stewardship Coordinator will provide advisory support to the ARK through the identification of partnership and funding opportunities, while the Volunteer and Outreach Coordinator will assist with volunteer coordination.

ACTION 2: Partner with local organizations to enhance clean-up and recycling programs in and adjacent to the Reserve

<u>Monofilament Recovery and Recycling Program</u>

The stewardship staff will work with volunteers to maintain the MRRP. The MRRP is a statewide effort to educate the public on the problems caused by monofilament line left in the environment, to encourage recycling through a network of line recycling bins and drop-off locations, and to conduct volunteer monofilament line cleanup events. The MRRP is sponsored by the Texas Sea Grant Program. With the assistance of volunteers, the Reserve currently monitors and maintains 18 outdoor bins and four indoor bins within the Port Aransas and Rockport communities. Bins will be added and removed as needed in order to provide adequate opportunities for local fisherman to recycle their monofilament over the next five years.

Partner Clean-up Events

Reserve staff will support the efforts of the UTMSI Green Team to host cleanup events at the South Jetty (and other areas of concern) in Port Aransas, Texas and the surrounding area. The Green Team is a volunteer group of faculty, staff, and students at UTMSI that is dedicated to improving the environmental sustainability at UTMSI. The mission of the Green Team is to reduce the environmental impact of UTMSI and promote stewardship of our natural resources. The Team hosts periodic cleanups of the South Jetty in order to clear a highly visible and utilized area of trash. Several of these events occur in conjunction with the statewide Adopt-A-Beach program organized by the GLO.

The Stewardship Program has partnered with the Texas Master Naturalists to host bi-annual (spring and fall) cleanups at Egery Flats. Egery flats is an important coastal habitat for both wildlife and people. It is located along the northwest edge of Copano Bay, and is essential habitat for living marine resources as a nursery for shrimp and larval fish and provides feeding grounds for waterfowl, wading birds, and shorebirds. The first cleanup hosted in 2010 was attended by over 50 volunteers and resulted in 9,000 pounds of debris being removed. Additional cleanups continue to be necessary in this area as it is heavily used by recreational fisherman. The Stewardship Coordinator will continue to work with the Texas Master Naturalists to host these cleanups on a regular basis.

ACTION 3: Host an annual cleanup on National Estuaries Day

The Reserve will continue to work with the Education Program and local partners to host a cleanup on the shorelines of ANWR on (or in close proximity to) National Estuaries Day. This cleanup will occur prior to the arrival of the endangered Whooping Cranes. The marsh areas are utilized by the Whooping Cranes for food and habitat, but are often not able to be reached during traditional cleanup events. The Stewardship Coordinator will work closely with the Volunteer and Outreach Coordinator to implement the program. The Reserve will partner with local boat captains to provide transportation of volunteers and collected debris. Coordination of the event will also need to include staff at ANWR.

Objective 3-5: ***Initiate restoration and mitigation projects with appropriate partners***

ACTION 1: Continue working with partners to identify restoration opportunities within the Reserve and its watershed

The Stewardship Coordinator has extensive knowledge about the habitats and resources within the Reserve, including past, on-going, and planned restoration projects. Although the Stewardship Program has not initiated any restoration projects to date, the Stewardship Coordinator has often served an important role in restoration projects by providing key information about the Reserve habitats and resources to its partners that are involved in restoration. Over the next five years, the Stewardship Coordinator will continue to serve this role and collaborate with partners on restoration projects relevant to the Reserve and its watershed.

ACTION 2: Promote the utilization of Reserve data for monitoring restoration outcomes

The research and monitoring programs at the Reserve, provide valuable high-quality, long-term data that can be utilized by restoration practitioners to understand the outcomes of restoration projects. As the Reserve learns about on-going and planned restoration projects, it is important for staff to work with partners to explore possibilities for using Reserve monitoring sites to determine restoration outcomes. For example, when the Research Program became aware of the effort to re-open Cedar Bayou and restore the hydrological connection between the Gulf of Mexico and Mesquite Bay, sites that were being used to monitor circulation in Mesquite Bay were shifted to gather better information about changes following the re-opening of the pass. The Stewardship and Research programs will work with restoration partners to make sure the Reserve staff are aware of on-going and planned restoration

projects within the Reserve, and they will explore opportunities for using existing (or modified) monitoring projects to better understand restoration results.

ACTION 3: Support the Coastal Training Program's efforts to provide restoration training opportunities for local decision makers

The Stewardship Program will support the Coastal Training Program's efforts to provide training opportunities for local decision makers that focus on restoration activities. Specifically, the Stewardship Program will work with CTP to increase participation of stakeholders in RESTORE Act activities by hosting a "Restoration Practitioner's Forum." The Forum will provide members of the Coastal Bend community with an opportunity to network with other coastal restoration practitioners and learn about techniques, best management practices, and lessons learned. This workshop should ideally be held in conjunction with the other CTP programs in the Gulf of Mexico as part of the Gulf Regional CTP effort. Additional restoration-focused trainings may include topics such as living shorelines, oyster reef restoration, and restoration monitoring.

4.3 Education and Outreach

4.3.1 Introduction

The National Estuarine Research Reserve System's mission includes an emphasis on education, interpretation, and outreach. Education at each reserve is designed to fulfill the Reserve System goals as defined in the regulations (15 C.F.R Part 921(b)):

- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.
- To sustain these System goals, the 2011-2016 Reserve System Strategic Plan outlines education objectives that support the focus areas of climate change, habitat protection and water quality:
- Enhance the capacity and skills of teachers and students to understand and use Reserve System data and information for inquiry-based learning; and
- Increase estuary literacy and promote active stewardship among public audiences through the development and delivery of tools and programs addressing climate change, habitat protection, and water quality.

The Reserve System provides a vehicle to increase understanding and awareness of estuarine systems and improve decision-making among key audiences to promote stewardship of the nation's coastal resources. Education and interpretation incorporate science-based content into a range of programs and methodologies that are systematically tailored to key audiences around priority coastal resource issues.

Reserves conduct formal and informal education activities, as well as outreach activities that target culturally diverse audiences of educators and students, environmental professionals, resource users and the general public. Education and public programs, interpretive exhibits and community outreach programs integrate elements of Reserve System science, research and monitoring activities and ensure a systematic, multi-faceted, and locally focused approach to fostering stewardship.

The Reserve System is committed to preparing tomorrow's future leaders with the knowledge and understanding of our nation's oceans and coasts to be responsible stewards. To fulfill this commitment, the Reserve System has created the K-12 Estuarine Education Program to increase the estuary literacy of students, teachers and the general public. The KEEP Program helps students and teachers learn about essential coastal and estuarine concepts, develop data literacy skills and strengthen their critical thinking, team building, and problem solving skills. K-12 and professional development programs for teachers include the use of established coastal and estuarine science curricula aligned with state and national science education standards and frequently involves both on-site and in-school follow-up activity.

Community education and outreach is another priority for the Reserve System. Community education programs foster behavioral change to promote resource conservation. These programs work with audiences whose choices directly impact the integrity of our estuaries and their associated watersheds.

4.3.2 Education Program Context

The Mission-Aransas Reserve's Education Program has undergone substantial change since the last management plan was written. Program evolution has been driven by the addition of new education facilities, program and staff restructuring, and completion of a K-12 education needs assessment and market analysis of informal educators. Reserve System education goals, objectives, and priority strategies, as described in the *NERRS 2011-2016 Strategic Plan*, have also guided recent developments in the Reserve's education program.

Three Reserve education facilities have been constructed since the writing of the last management plan (Figure 4.4). The Wetlands Education Center, a 3.5-acre salt marsh and sand dune complex on the UTMSI campus in Port Aransas, was completed in 2008. The Bay Education Center, an environmental interpretive center featuring NOAA's Science on a Sphere, opened in Rockport in 2010. The Estuary Explorium, which houses interactive, estuary-themed exhibits and a dynamic interpretation space, opened in the UTMSI Marine Science Education Center in 2014. The need to develop education programs for these new sites provided a catalyst for the restructuring and expansion of Reserve education staff and programs.

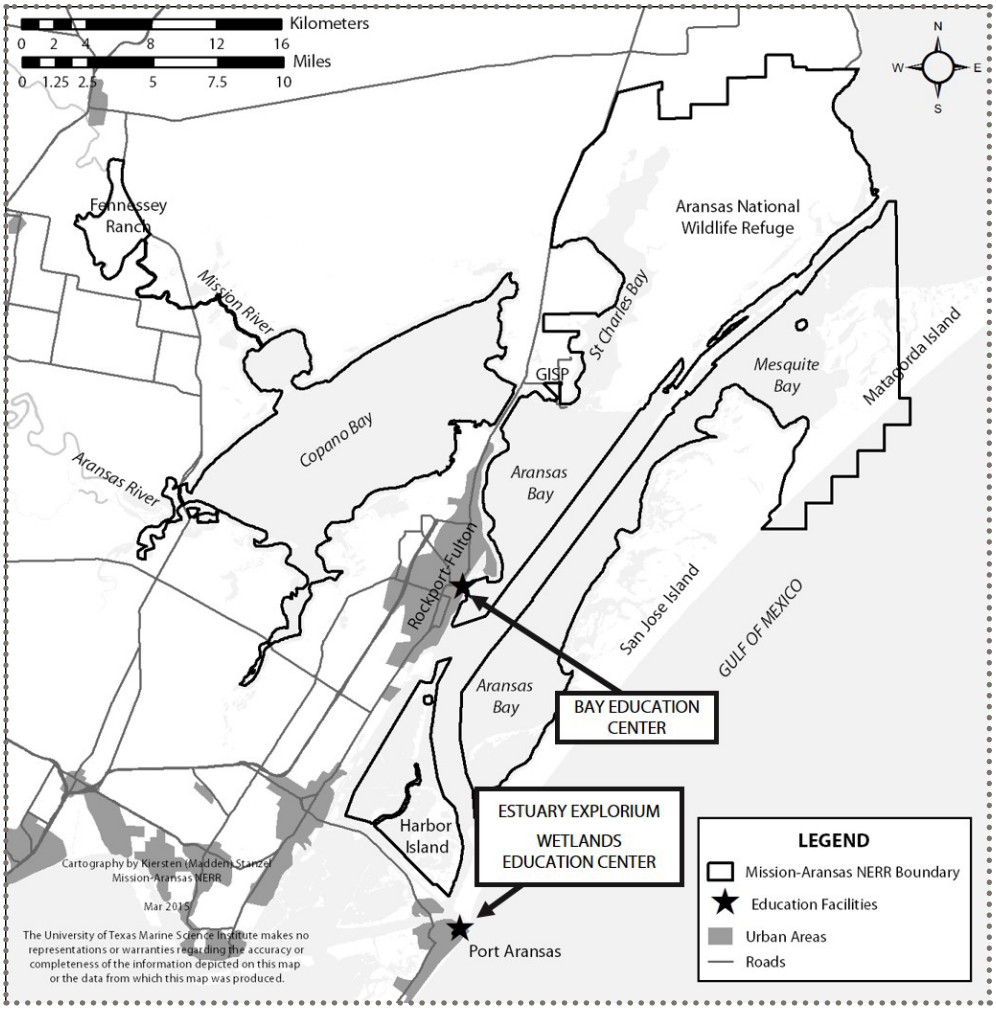


Figure 4.4. Location of Mission-Aransas NERR education facilities.

The Reserve completed a K-12 education needs assessment in 2011 and a market analysis of informal educators in 2012. The primary objectives of the needs assessment were to identify teacher professional development and student environmental education needs and apply the findings to the future development of the Reserve education program. There is a considerable amount of overlap in the counties served by the Reserve's education program and those served by other informal educators in the areas adjacent to the Reserve. Due to this overlap, it is important that regional informal education providers collaborate with each other to increase estuarine literacy and stewardship. The goal of the market analysis was to learn more about local informal education offerings and apply that knowledge to the development of Reserve education programs that complement existing programs and avoid duplication. The education needs assessment and market analysis findings have helped shape Reserve education priorities that align with the NERRS 2011-2016 Strategic Plan objectives and strategies. These include providing hands-on exploration of estuary environments, integrating NERRS data and research into teacher professional development trainings and K-12 programs, and promoting stewardship of coastal resources.

Target audiences for the Reserve's education program range from toddlers to senior adults. The Reserve's early childhood programs are designed for families with 3-5 year old children. These programs were initiated in part because only ten percent of the informal educators in the Reserve's market analysis indicated that they served early grade level students in their education programs and teacher needs assessment respondents indicated that few informal education sites offered programs for very young students. Early childhood program participants mainly include local families (Nueces, Aransas, and San Patricio counties) and Texas residents who are vacationing in the Coastal Bend. Local families attend week-day programs and Saturday

morning programs. Vacationing families generally attend Saturday morning programs. Most vacationing families come from the central Texas area, near San Antonio and Austin, but some come from as far away as the Dallas – Fort Worth metroplex.

The Reserve has a strong interest in targeting local teachers and students for participation in K-12 education programs. It is important that local teachers and students understand the ecological and economic value of estuaries and coastal resources. Local students are likely to become the next generation of local decision-makers and their teachers are in a position to help them understand the importance of coastal resources. Schools within the Reserve's watershed counties are located within a reasonable distance for teachers or students to travel for professional development or field experiences, respectively. In addition, the teachers and students in these watershed counties live in areas that drain into the Mission-Aransas Estuary, so it is important that they appreciate how their actions impact the Estuary. Prior to Reserve designation, there was a lower percentage of program attendance by local students and teachers than from those located 75 to 250 miles inland of the Reserve. One objective of the Reserve's needs assessment was to compare responses from teachers within and outside of the Reserve's nine watershed counties in order to better understand why there had historically been lower participation by local teachers and students. Needs assessment findings have directed the development of student field experiences and teacher professional development opportunities that focus on topics of greatest interest to local teachers. These topics include the relationship between habitat and wildlife diversity and human impact on the environment.

The presence of retired seasonal residents or "Winter Texans," who live on the Texas coast during the colder months of the year, offers the Reserve an opportunity to greatly expand the geographic outreach of the education program. Winter Texans come from various northern states and Canada, but many of them live in the midwestern states of Michigan, Wisconsin, Minnesota, Ohio, and Iowa during the warmer months of the year. They are enthusiastic participants in many Reserve public and community education programs, including interpretive nature hikes, public lectures, and Science on a Sphere presentations. Many of the same winter Texans return year after year to learn about new developments at the Reserve and to volunteer in education, stewardship, and research programs.

4.3.3 Education Program Capacity

Staff

The education section in the Reserve's last management plan primarily described the activities of the UTMSI's Marine Education Services (MES), which had been offering K-12 education and public outreach programs for approximately 32 years at the time of Reserve designation in 2006. The original MES director managed these programs prior to the designation of the Reserve and, with the added title of Reserve Education Coordinator, for four years after designation. However, when the MES Director/Reserve Education Coordinator retired in 2010, this position was divided into two separate positions. A major reason for the decision to split the MES Director/ Reserve Education Coordinator position was that an additional administrator was needed to direct education program development at the Reserve's new education facilities. The Reserve was also interested in expanding education programs offered at Reserve and partner sites and it was not clear that one individual could manage all of these objectives.

Reserve educator discusses the importance of freshwater wetlands with students at Fennessey Ranch

Administration of Reserve and UTMSI education and outreach activities was performed by the Reserve Education Coordinator and the MES director, from 2010 through August of 2014. During this period, there was considerable confusion about the roles, responsibilities, and division of duties between the NERR education and MES programs. As a result, education and outreach activities were integrated into one entity, Marine Education and Outreach, under the direction of the Reserve Education Coordinator in September of 2014. The program formerly known as MES was dissolved and the former MES Director was reassigned as the K-12 program administrator. Currently, all Marine Education and Outreach staff share facilities and work together toward the common mission of enhancing ocean, coastal, and estuarine literacy and stewardship among K-12 and public audiences.

The Reserve Education Coordinator collaborates with Reserve staff, a local education advisory committee of informal educators, other NERRS education coordinators, and the NOAA education coordinator to determine education priorities for the Reserve. This position manages K-12 and public education programs at the Bay Education Center, Wetlands Education Center, Estuary Explorium, and Explorer Lab, outreach programs at Reserve partner sites, and Teachers on the Estuary professional development programs. Other duties performed by the Reserve education coordinator include writing and collaborating on education grant proposals, creating interpretive plans for exhibits, assisting with exhibit development, representing the Reserve at public and professional meetings, and developing and delivering K-12 student and public education programs. The Reserve Education Coordinator is responsible for supervising the work of the K-12 program administrator, volunteer and outreach coordinator, Road Scholar coordinator, and two part-time education specialists.

The Reserve Volunteer and Outreach Coordinator assists with numerous education activities, in addition to overseeing the Volunteer Program. This position is responsible for training volunteer docents to lead bi-weekly interpretive tours of the Wetlands Education Center and to personally lead tours when volunteers are unavailable. Other education duties include developing and presenting early childhood education programs, coordinating the UTMSI Summer Science program, facilitating bi-weekly Marine Science Film and Discussion programs, and acting as a back-up educator aboard the R/V KATY. Educational outreach duties for this position also include producing and distributing a bi-annual Reserve newsletter, maintaining social media sites for the Reserve, overseeing an annual photo contest, representing the Reserve in the Texas Children and Nature Coalition, and coordinating Reserve participation in annual outreach events.

The Reserve employs one part-time education specialist who delivers K-12 student and public Science on a Sphere programs on a regular basis and one occasional education assistant to fill in for other Reserve educators as needed. The Reserve also provides three months of annual salary support for an education specialist aboard the UTMSI research vessel R/V Katy, who is otherwise supported by the UTMSI. The R/V Katy educator also assists with the development and delivery of TOTE professional development trainings and Reserve student field experiences. Only one Reserve staff member, the Education Coordinator, is dedicated full-time to the Education Program. Other Reserve educators are either part-time employees or full-time staff members who devote a portion of their time to education activities.

Partners

Enhancing public awareness and understanding of estuarine systems and providing suitable opportunities for public education and interpretation would be very difficult goals to fulfill without Reserve partners. A major constraint that is minimized through partner collaboration is the limited amount of land held by UTMSI that is available for Reserve education program delivery. The most effective methods of enhancing public awareness and understanding of natural resources involve getting people out into nature. Unlike many NERR sites, the Mission-Aransas Reserve does not have an administering partner that holds vast tracts of land, such as state departments of natural resources commonly do. The 3.5 acres that make up the Wetlands Education Center provide an excellent opportunity to educate the public about salt marsh and sand dune habitat,

but this is currently the only land directly owned and managed by UTMSI that provides opportunities for field experiences. The Reserve partners with Fennessey Ranch, GISP, and the City of Rockport in order to access the diversity of habitats contained within the estuarine environment during outdoor education programs. Reserve educators present field experiences that highlight freshwater wetland and riparian habitat at Fennessey Ranch and coastal woodland and prairie habitat at Goose Island State Park and the City of Rockport's Memorial Park.

Education staff work annually with partners to host the South Texas Coastal Bend Nature Challenge

Reserve educators collaborate with several organizations to increase outdoor experiential learning within formal education systems and develop partnerships between formal and informal education programs. These partnerships include the Texas Children in Nature Coalition, the South Texas Coastal Bend Nature Challenge, and the Coastal Bend Informal Educators, the Coastal Bend Bays & Estuaries Program, and Texas Sea Grant. The South Texas Children and Nature Coalition works together, primarily at outreach events, to increase awareness of outdoor education opportunities at partner sites. The shared vision of all partners in the coalition is that children and their families will spend more time outdoors, engaged with nature to be "healthier, happier and smarter." The goal of the Texas Coastal Bend Nature Challenge is to encourage families to visit as many participating parks and nature centers as they can during a three-month period and complete nature exploration challenges at each site. Participation in the nature challenge is promoted at partner sites, outreach events, and websites hosted by the Texas A&M Forest Service and Agrilife Extension. The Coastal Bend Informal Educators (CBIE) joins forces to host an annual teacher workshop at a partner site or local school. CBIE partners lead hands-on activities and / or host booths at the teacher workshops to disseminate information about their site's K-12 education offerings.

The CBBEP and Texas Sea Grant share similar missions with the Reserve regarding estuarine education, stewardship, and protection. Reserve educators have collaborated on education grant proposals and the delivery of outdoor and indoor environmental education programs with both organizations. The Reserve partners with Texas Sea Grant to host the Loggerhead Challenge, the southern Texas regional competition of the National Ocean Science Bowl, where high school students demonstrate their knowledge of marine and coastal sciences. Texas Sea Grant researchers partnered with the Reserve education coordinator on a NOAA Gulf of Mexico Bay-Watershed Education and Training Program (B-WET) grant and will share their research and knowledge of estuarine science with teachers at the Teacher on the Estuary (TOTE) workshop during the summer of 2015, as part of the B-WET project.

After reviewing the findings of the Reserve market analysis and needs assessment, Reserve educators invited Rockport area informal educators to assist in the development of a resource guide that would help teachers plan field trips to their sites. Representatives from seven partner sites in Rockport, Fulton, and Aransas County, including the Reserve's Bay Education Center, collaborated to create the teacher resource guide. One problem that was revealed in the Reserve's market analysis and needs assessment was that many informal education sites could not accommodate large numbers of students at one time. This created an obstacle for teachers because many of them needed to bring all of their students on field trips in order to obtain administrative approval. Reserve educators met with partners to discuss methods of breaking students up into smaller groups and rotating them among several sites during one field day. Suggestions for rotating

students among sites, information about Reserve and partner K-12 programs, and contact information for site educators are included in the teacher resource guide. As a result of this collaboration, the Bay Education Center shares many student groups with other Rockport sites, such as the Aquarium at Rockport Harbor and the Texas Maritime Museum. Partner sites post the guide on their websites and provide electronic and / or printed guides to teachers who request program information.

The Reserve received funding from a GLO Coastal Management Program grant to offer a Teachers on the Estuary workshop during the summer of 2014 and associated student field trips during the 2014/2015 academic year. A NOAA Gulf of Mexico B-WET grant awarded to the five NERRS sites in the Gulf of Mexico will provide funding for the Reserve to host a TOTE workshop during the summer of 2015. These grant-funded projects offer the opportunity to establish partnerships with middle and high school science teachers from public school districts that are located in Texas coastal counties. The relationships that have and will develop as a result of these projects will continue well beyond the expiration of the grant contracts. Reserve education staff will keep the school districts informed of NERRS and NOAA education resources as they develop, including revisions to the online Estuaries 101 curricula. Following completion of the project workshops and student field experiences, the teachers and students will also be invited to participate in Reserve and partner stewardship projects.

Providing training opportunities for teachers is an important component of the Reserve Education Program

Synergistic collaboration with NERRS and NOAA educators strengthens and directs the ongoing evolution of the Reserve education program. The Reserve education market analysis and needs assessment were developed in consultation with NERRS and NOAA educators and the Reserve Education Advisory Committee. Collaboration among NERRS and NOAA educators resulted in a set of required questions that were included in the Reserve K-12 education needs assessment survey. Responses from the required questions were included in national synthesis of K-12 education needs assessment findings. Reserve staff worked with NERRS and NOAA educators to develop and promote two research and monitoring focused activities ("The Great Oyster Mystery" and "Migrating Mangroves and Marshes") for the online Estuaries 101 Middle School Curriculum and with a select group of NERRS education coordinators to develop online modules for teachers that highlight NERRS Science Collaborative research. Reserve educators continue to collaborate on improvements to these online resources and promote the use of NERRS and NOAA resources among local teachers. Professional sharing among NERRS education coordinators at annual meetings, education workgroup teleconferences, and virtual education sector meetings provide a valuable catalyst to energize and enhance Reserve education offerings. Regional collaboration between the Reserve education coordinator and select groups of NERRS education coordinators have resulted in on-going, long-term partnerships.

Facilities

Reserve educational facilities include the Bay Education Center, Wetlands Education Center, and Estuary Explorium. Each of the facilities is described in detail in the following sections.

Bay Education Center

The Bay Education Center is located in the City of Rockport, adjacent to Rockport Harbor and near several other visitor attractions, including the Texas Maritime Museum, Aquarium at Rockport Harbor, Rockport Center for the Arts, Rockport Beach Park, and the harbor fishing pier. Rockport is on the eastern shoreline of Live Oak Peninsula, which is surrounded by estuarine waters that are included in the Reserve boundary, so the Bay Education Center is ideally positioned for increasing estuarine literacy and promoting stewardship among public audiences. The interpretive goals of the Bay Education Center are to:

1. Foster an appreciation of the Mission-Aransas Estuary's natural resources and the ecosystem services the Estuary provides;
2. Enhance an understanding of human impact on the past, present, and future estuarine environment;
3. Encourage the protection and conservation of the natural and cultural resources within the Mission-Aransas Estuary; and
4. Promote awareness of the Mission-Aransas Reserve's existence and mission.

The Bay Education Center contains approximately 950 square-feet of interactive exhibits, aimed at enhancing public understanding of estuarine systems and the role that NERRS plays in estuarine research, education, management, and protection. The Bay Education Center auditorium houses Science on a Sphere, a display system created by NOAA to enhance public knowledge of earth, ocean, atmospheric, and planetary sciences. The auditorium offers seating for approximately 80 people and is used for teacher professional development and student education programs, public lectures, workshops, and meetings. An outdoor courtyard is used as a staging area for field experiences that are delivered to students, teachers, and families in the surrounding bays. K-12 education programs at the Bay Education Center help students develop knowledge and skills in the life, earth, and physical sciences. Students participating in field-based activities use scientific data to answer questions about the local estuarine environment. The questions posed are locally relevant, but the addition of Science on a Sphere allows students to understand how global patterns, such as ocean circulation, weather, planetary movements, and climate change affect the local environment.

Exhibits at the Bay Education Center in Rockport, Texas were designed to increase estuarine literacy

The Bay Education Center is free and open to the public all year, from 1 pm to 4 pm, Tuesday through Saturday. Regularly scheduled Science on a Sphere programs are offered free to the public several times a week and student field experiences and Science on a Sphere programs that are aligned to the Texas Essential Knowledge and Skills state teaching standards are available upon request. Specific program offerings are described further below.

Science on a Sphere programs are available at the Bay Education Center

Wetlands Education Center

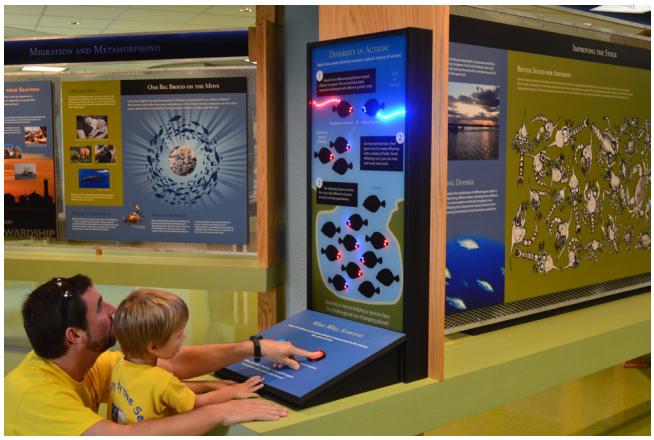
The Wetlands Education Center consists of approximately 3.5 acres of salt marsh and sand dune habitat, on the UTMSI campus in Port Aransas. Handicapped accessible trails and boardwalks wind around a central salt marsh and through surrounding sand dunes. Visitors to the Wetlands Education Center learn that estuaries provide important ecosystem services and critical habitats for wildlife - during free, docent-led, biweekly tours. Many species of coastal plants and animals are identified on wayside interpretive panels that are located near shade kiosks along the trails. A bronze geodetic marker at the entrance is interpreted as part of the National Spatial Reference System and visitors are oriented to the locations of six other Reserves.

The Wetlands Education Center is open free to the public at all times throughout the year and visitors may take a self-guided tour anytime they wish, using the interpretive signage that is stationed along the walkways. K-12 field experiences at the Wetlands Education Center are available upon request.

The Wetlands Education Center offers visitors the opportunity to take self-guided tours

Estuary Explorium

The Estuary Explorium is part of the UTMSI Marine Science Education Center, in Port Aransas. Port Aransas is on the north end of Mustang Island, one of seven Texas barrier islands that separate the ocean waters of the Gulf of Mexico from numerous estuarine bays and lagoons. Ocean and estuarine waters meet and mix in Aransas Pass, the pass that divides Mustang Island from San Jose Island to the north. The ability to view Aransas Pass from the Estuary Explorium, provides an excellent opportunity to interpret the ocean-to-estuary transition that barrier island passes allow.



Estuary Explorium exhibits are located in Port Aransas, Texas at the UTMSI Marine Science Education Center and are designed to highlight the ocean-to-estuary transition

The Estuary Explorium houses 1,000 square-feet of exhibits and the Explorer Lab, a dynamic interpretive space used for early childhood and K-12 student programs, teacher professional development, and public and community education programs. In addition to housing in the Estuary Explorium, the UTMSI Marine Science Education Center also houses an auditorium, a gift shop, and an exhibit hall with six aquaria displaying local marine animals and several marine science exhibits. The interpretive goals of the Estuary Explorium are to:

1. Enhance understanding of the ecological importance of estuaries in the life cycles of estuarine dependent marine animals;
2. Foster an appreciation of the economic benefits provided by commercial and recreational fishing of estuarine dependent species;

3. Increase awareness of estuarine research conducted by UTMSI and Mission-Aransas Reserve Scientists; and
4. Promote awareness of the Mission-Aransas Reserve's stewardship activities and encourage the protection and conservation of estuarine resources.

The Estuary Explorium is free and open to the public all year, from 8 am to 5 pm on weekdays, and as funding allows on weekends. Public visitors and school groups have the option of exploring the exhibits on their own or participating in scheduled programs in the Explorer Lab and adjoining Wetlands Education Center. Family-oriented, environmental education programs are offered at the Estuary Explorium on alternate Saturdays during summer months and periodically at other times throughout the year.

4.3.4 Education Program Delivery

Reserve educators seek to increase estuarine literacy and stewardship in public audiences through the delivery of teacher professional development, student, public, community, and outreach education programs. Reserve education programs implement NERRS system-wide programs such as the KEEP, SWMP, and the NERRS Science Collaborative.

Teacher Professional Development

TOTE is a research and field-based teacher training initiative that is a component of the NERRS KEEP. The primary goal of Reserve TOTE trainings is to increase the capacity of teachers to use NERRS and NOAA research and data in inquiry-driven, experiential instruction related to estuaries and coasts. The anticipated outcome of such instruction is that teachers, and subsequently students, will develop science-based, decision-making skills that will prepare them to become thoughtful stewards of estuaries and coastal environments. TOTE Teachers practice what they will later teach during hands-on, field-based, professional development trainings at Reserve and partner sites. Teachers learn how to access and apply data from the SWMP in inquiry-based activities involving scientific problem solving. Reserve and partner scientists interact with TOTE teachers and share relevant research about the functions and values of estuaries and how humans impact estuarine and coastal environments. Particular emphasis is placed on integrating Mission-Aransas and other NERRS Science Collaborative research into TOTE professional development workshops.

Teachers receive a guided tour of Fennessey Ranch as part of a professional development training

Student Programs

The Science, Technology, Engineering, and Mathematics (STEM) Education Coalition places a strong emphasis on hands-on, inquiry-based student experiences and promotes the integration of STEM-focused activities in learning environments outside the K-12 classroom. The Texas Essential Knowledge and Skills teaching standards require that at least 40 percent of middle and high school science instruction consists of laboratory and field investigations. The Reserve offers inquiry-driven investigations of the estuarine environment to K-12 students at the Bay Education Center, Wetlands Education Center, and Fennessey Ranch. The goals of these programs are: (1) to enhance student understanding of the value and functions of estuarine and coastal habitats, how humans impact them, and how individuals can help protect them; (2) to provide meaningful outdoor education opportunities for students; and (3) to enhance student's capacity

to use and understand real scientific data. The anticipated outcome of Reserve student programs is that participants will gain the knowledge, appreciation, and science-based decision making skills required to act as stewards of estuaries and coasts. Student programs at the Reserve have included: floating classroom experience aboard the R/V Katy, (2) SOS presentations for K-12 classrooms, (3) hosting of science fairs by UTMSI graduate students, and (4) inquiry-driven classroom lessons taught by UTMSI graduate students.

Students have a hands-on field experience in the estuary aboard the R/V Katy

Public and Community Programs

The NERRS education sector differentiates between public and community education programs, by describing the latter as specifically designed to foster behavior change that "leads to resource conservation and advances the mission of the Reserve." Reserve public and community programs seek to increase estuarine literacy and stewardship in public audiences, thus advancing the mission of the Reserve. However, for purposes of education performance monitoring, only programs that integrate an active stewardship component (e.g., invasive species removal, marine debris clean-up) are reported as community programs. This distinction is only considered significant for purposes of performance monitoring, so public and community programs are combined in this plan. In the past, Reserve public and community programs have included: (1) interpretive nature hikes at Reserve sites, (2) field experiences for families, (3) ocean-themed stories and crafts for early childhood, (4) public presentations by scientist and content experts, (5) public SOS programs, (6) summer science field camp for 3-8 graders, and (7) volunteer events for invasive species removal.

Crafts provide a fun way for young learners to explore the estuary

Roads Scholar programs provide educational opportunities for older adults

Outreach Programs

Outreach programs are education activities that are conducted offsite or through social media outlets. The Reserve participates in numerous outreach activities that are designed to enhance awareness of the value of estuaries and the Reserve's mission. Reserve outreach activities range from presentations at service club luncheons to day-long stewardship events at Reserve and

partner sites. Reserve educators visit local schools upon request to facilitate ocean and estuary focused activities for students and to update teachers about all aspects of the Reserve's K-12 education program. Significant outreach activities that receive repeated Reserve participation include celebrations and festivals associated with National Estuaries Day, Earth Day, and other annual events. Reserve outreach programs are also targeted at adults. The Reserve manages the Roads Scholar program (formerly Elderhostel) which offers educational travel programs that highlight coastal ecology, wildlife, and history for adults over 55 years of age. Outreach activities at the Reserve also include maintenance of a website, development of a biannual newsletter, updating social media sites, and photo contests for the general public.

Program Evaluation

Findings from the Reserve's K-12 education needs assessment and market analysis of informal educators have provided formative means to evaluate the education program. Analyses of the survey results have helped Reserve educators identify audiences who were not well served by Reserve programs in the past and provide insight into program attributes that would better meet their needs. Some findings from the surveys have been applied to expand and improve student field experiences and public education programs. Other survey findings will be applied in future Teachers on the Estuary professional development trainings.

Summative evaluations are conducted at the conclusion of teacher professional development, student, public, and community education programs. These evaluations are reviewed to determine if program objectives have been met and whether participant's knowledge, skills, attitudes, and / or intentions have changed as a result of program attendance. Reserve educators administer evaluations of student programs, using hardcopy forms that participants fill out onsite after programs and electronic forms that are emailed to participants after site visits. Public programs are evaluated with hardcopy forms onsite, upon program conclusion.

The Education Coordinator is currently working with other NERRS Gulf State education coordinators and a professional education program evaluator to develop an online survey instrument to evaluate TOTE professional development workshops. Other NERRS education coordinators have found that online survey forms are more efficient, because they allow data to be transferred easily to a spreadsheet for subsequent analysis. Online forms also allow participants more flexibility in the amount of time spent providing feedback and do not require the use of program time for evaluation. Reserve educators plan to use more online survey forms (e.g., Google Docs) in the future to evaluate all types of education program offerings.

RAB meetings also provide a means for evaluation of the Education Program. By participating in the RAB, Reserve partners that conduct or participate in education/outreach programs are able to receive updates on the Education Program at each meeting. This provides an opportunity for the Education Coordinator to show progress on on-going projects, while also discussing future needs and opportunities. If necessary, the Education Coordinator, may request a special breakout session during the RAB meeting in order to discuss particular issues of concern to the Program. The Education Coordinator may also request the assistance of the RAB in identifying individuals to serve on special advisory committees, if this is deemed necessary.

Finally, the Education Coordinator is responsible for completing an annual review with the Reserve Director and attending quarterly Reserve staff meetings. The annual review is a formal process, completed through UT which allows for specific long-term issues with the Education Program to be addressed by the Reserve Director. The quarterly Reserve staff meetings, on the other hand, provide an opportunity for more immediate issues, questions, or problems to be discussed and addressed in collaboration with other Reserve staff. The format for these meetings includes updates by all Reserve programs, as well as a presentation by a specific program about a current problem. The process of evaluation is not expected to change within the next five years.

4.3.5 Needs and Opportunities

The Reserve education program addresses priority issues that impact the entire Gulf ecosystem, such as those described in the *Gulf of Mexico Alliance Governor's Action Plan II: For Healthy and Resilient Coasts (2009-2014)*. These priority issues align with strategic areas of focus in the *NERRS 2011-2016 Strategic Plan* of water quality, habitat protection, and climate change. Historic drought conditions and increasing water demands have made freshwater inflow into Texas estuaries a priority natural resource issue for the State of Texas. Reserve K-12 education programs allow teachers and students to access and apply NERRS and NOAA data to investigate the effect of drought and reduced freshwater inflow from coastal watersheds on Texas estuaries. Program participants also collect biotic and abiotic data in the field and use these data to make predictions about water quality, estuarine health, and freshwater inflow into the Mission-Aransas Estuary. Educating students, teachers, and public audiences about the diversity, quality, functions, and values of coastal habitats, how humans impact these habitats, and the benefits inherent in protecting them are important Reserve objectives. These objectives are targeted in hands-on, student field experiences, teacher professional development trainings, and public and community education programs at Reserve and partner sites. Helping students understand the science of climate change is a priority issue for the NERRS and a strategic area of focus in the *NERRS 2011-2016 Strategic Plan*. The presence of NOAA's Science on a Sphere at the Bay Education Center provides a powerful tool for teaching students about the effects of climate change on ocean and coastal environments.

The small size of the education staff and constraints associated with traveling among sites for program delivery limit the reach of the Education Program. Only one Reserve staff member, the Education Coordinator, is dedicated full-time to the Education Program. Other Reserve Educators are either part-time employees or full-time staff members who devote a portion of their time to education activities. The capacity to offer education programs at different facilities is restricted by the number of staff available to present programs and the distance among sites, including the Bay Education Center in Rockport; the Wetlands Education Center, Estuary Explorium, Explorer Lab, R/V Katy and other sites at UTMSI in Port Aransas; and Fennessey Ranch in Refugio County. Although these constraints limit education program quantity, recent developments provide opportunities for improving the quality of the Reserve's teacher professional development, student, and public programs over the next five years.

4.3.6 Education Goals, Objectives, and Actions

GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function

OBJECTIVE 1-6: ***Provide professional development programs for teachers that offer field-based learning experiences linked to Reserve research and stewardship activities***

ACTION 1: Implement Teachers on the Estuary professional development trainings

The collaboration that exists among NERRS, UTMSI, and Mission-Aransas Reserve scientists places the education program in an excellent position to create teacher professional development and student activities that integrate Mission-Aransas and other NERRS Science Collaborative research and align with the 2013 Next Generation Science Standards. The 2013 Next Generation Science Standards call for science practices and cross-cutting concepts to be taught in context, to help learners understand how science is practiced in the real world. Over the next five years, the Reserve will implement new methods of integrating NERRS and NOAA research into TOTE professional development workshops and K-12 student programs that address locally and regionally relevant issues that impact coasts and estuaries.

The Reserve offered the first TOTE professional development workshop during the summer of 2014. The NERRS education coordinators from Texas, Mississippi, Alabama, and Florida secured a NOAA Gulf of Mexico (Gulf) B-WET grant to implement TOTE workshops at five Gulf Coast reserves during

the summer of 2015. The Mission-Aransas Reserve will host one of these Gulf TOTE workshops and the Reserve education coordinator will travel to two other Gulf reserves to assist with site workshops. The Reserve education coordinator is currently working with NERRS and Texas Sea Grant researchers and all of the Gulf State NERRS education coordinators to develop TOTE activities that integrate NERRS Science Collaborative research, align with the 2013 Next Generation Science Standards, and address priority issues that impact the entire Gulf ecosystem. The opportunity to collaborate with all of the Gulf NERRS reserves during this project will enable the education coordinators to share ideas for the development of new TOTE training modules that will be implemented in future workshops at the Reserve. Plans are underway to offer multiple TOTE trainings during the summer of 2016.

Findings from the Reserve's K-12 education needs assessment indicate that teachers prefer to learn how to teach lab and field activities by actually doing the activities themselves during professional development trainings. Future TOTE instruction will consist of inquiry-driven, experiential learning approaches that allow teachers to practice what they will later teach to their students. Teachers will learn how to access and integrate NERRS System Wide Monitoring Program (SWMP) data into their classroom instruction, using tools such as the SWMP Graphing Tool. Workshop activities will include experiential, field investigations that address ocean and estuary literacy principles. A holistic perspective of the entire Gulf of Mexico ecosystem and the critical relationships that exist among estuary and ocean systems will be incorporated into future TOTE workshop through the introduction of NERRS Science Collaborative research, SWMP data, and activities from the NERRS Estuaries 101 Middle School Curriculum, NOAA Ocean Data Education Project, and NOAA's Science on a Sphere.

One objective of the Reserve's K-12 education needs assessment was to compare responses from teachers within the Reserve's nine watershed counties to those from teachers outside of the watershed counties. This objective arose from a desire to understand why, historically, there had been lower participation by local teachers and students in past teacher professional development trainings and student field experiences, when compared to teachers and students inland of the Reserve watershed counties. Higher percentages of respondents from outside the watershed counties identified themselves as biology, environmental science, aquatic science, and marine science teachers than those from inside. These subjects have been specifically targeted in past programs, so teachers and students from outside the watershed might have been more interested in these programs than local teachers. Higher percentages of teachers from within the watershed counties identified themselves as life, earth, and physical science teachers than those from outside. The Reserve has a strong interest in serving local teachers and students, so more emphasis will be placed on the development of teacher professional development and student programs that target Texas Essential Knowledge and Skills state teaching standards in life, earth, and physical science courses over the next five years.

GOAL 2: Increase understanding of coastal ecosystems by diverse audiences

OBJECTIVE 2-4: ***Increase K-12 and early grade level student literacy about coastal ecosystems through programs hosted at Reserve facilities, programs aboard the R/V Katy, and the Scientist in Residence Program***

ACTION 1: Develop education programs for early grade level students at the Bay Education Center and Estuary Explorium

Past student field experiences primarily targeted middle and high school students. Several kindergarten and early grade level teachers who responded to the Reserve needs assessment commented that there were few informal education sites that offer field experiences for very young students. Only ten percent of market analysis informal educators indicated that they served kindergarten through second grade students in their K-12 education programs. These findings have led Reserve staff to begin developing

estuary education programs that target early grade level students. These programs will offer hands-on education activities aligned to the state teaching standards at the Bay Education Center and Estuary Explorium.

ACTION 2: Offer hands-on education programs aboard the R/V KATY

The R/V KATY program impacts thousands of K-12 and college students from many different areas of Texas and some surrounding states each year. This on-board education program allows students to get out into the estuary ecosystem on a research vessel and conduct biological sampling of the various estuarine trophic levels – benthos, nekton and plankton – through benthic mud grabs, trawls, and plankton tows. The R/V KATY program is a highly visible and popular program that draws many teachers and students onto the UTMSI campus, where they may explore other Reserve educational resources, including the Wetlands Education Center and the Estuary Explorium.

ACTION 3: Coordinate Scientist in Residence program

The Scientist in Residence program developed from partnerships that were established between UTMSI and the school districts that participated in the former "National Science Foundation Graduate STEM Fellows in K-12 Education Program"' (or GK-12 Program) at UTMSI. The GK-12 Program was initiated by UTMSI professor, Dr. Kenneth Dunton, and originally funded through a National Science Foundation grant. Dr. Dunton's research program and the Reserve presently collaborate to fund and coordinate the program. The goal of the Scientist in Residence program is to advance scientific knowledge and enthusiasm among K-12 students, while enhancing scientific communication skills in UTMSI graduate fellows who participate in the program. Scientist in Residence graduate fellows assist classroom teachers whose students participate in district and regional science fairs. During the academic fall semester, graduate fellows help students understand the scientific process involved in conducting meaningful investigations and provide advice and assistance to students as they develop science fair projects. Upon conclusion of the science fair competitions and through the end of the spring semester, graduate fellows facilitate inquiry-driven investigations of coastal and estuarine environments that integrate real scientific research and data, are aligned to the Texas Essential Knowledge and Skills teaching standards, and enhance student performance on state required standardized science tests.

OBJECTIVE 2-5: ***Educate K-12 teachers and students about human impacts on the coastal environment using Science on the Sphere and educational programs that integrate science, history, and culture***

ACTION 1: Use Science on a Sphere datasets to highlight impacts of climate change and other human-induced impacts on the estuary

Science on a Sphere (SOS) is a visualization system created by NOAA to enhance public understanding of Earth's oceans, atmosphere, land, and planetary systems. The presence of SOS at the Reserve's Bay Education Center provides a powerful tool for teaching students about the interactions among the global ocean and the Earth's climate, food supply, and atmosphere. Several SOS visualizations model the effects of climate change on ocean and coastal environments and address historical climate patterns and future climate predictions. Helping students understand the science of climate change is a priority for the NERRS. Reserve needs assessment findings indicated that local teachers were interested in including the effects of climate change on coastal areas in their curricula. Only thirty-five percent of the Reserve's market analysis of informal educators indicated that they addressed climate change in their K-12 education programs. The presence of Science on a Sphere (SOS) offers the Reserve a unique opportunity for teaching the effects of climate change on ocean and coastal environments. SOS visualizations that model climate change impacts have been used to develop K-12 programs that are aligned to the state teaching standards. However, Reserve educators are aware that the potential of SOS is not fully realized in present programming. Future plans include identifying SOS datasets that illustrate climate,

ocean, and estuary literacy principles and building standards-aligned K-12 programs around these visualizations.

ACTION 2: Develop K-12 education programs that integrate science, history, and culture to help students understand how humans benefit from and impact the estuary

Almost seventy percent of teachers who responded to the Reserve's needs assessment indicated that they were interested in student programs that integrate history and culture. The Reserve area has a rich cultural history. Prehistoric cultures and historic Native Americans, Spanish explorers, and Anglo settlers were attracted to the rich resources provided by the Mission-Aransas Estuary. Student programs that highlight the use of estuarine resources by past and present cultures provide opportunities to integrate science, history, and culture and to help students understand how humans benefit from and impact the estuarine environment. More effort will be made to integrate these topics into K-12 programs over the next five years.

OBJECTIVE 2-6: ***Increase public literacy about Texas coastal ecosystems through public education programs hosted at Reserve facilities, Summer Science Program, and Road Scholar Program***

ACTION 1: Continue working with Reserve land owners to offer habitat hikes at their facilities

Habitat Hikes are interpretive nature hikes offered at several Reserve sites, including the Wetlands Education Center, GISP, and Fennessey Ranch. Habitat Hikes allow members of the general public to discover the functions and values of coastal woodlands and prairies, salt marshes, sand dunes, freshwater wetlands, and riparian forests. These interactive programs allow public visitors to examine wildlife and plant specimens, distinguish between native and invasive species, understand the value of coastal habitats for wildlife and people, and learn how Reserve research and stewardship efforts protect coastal habitats and how individuals can help protect them. Over the next five years, the Education Program will continue to offer habitat hikes at multiple times throughout the year that highlight habitats on Reserve- and partner-owned lands.

ACTION 2: Develop public and community programs that are aligned with the Estuary Explorium exhibits

The Estuary Explorium, a recently opened addition to the UTMSI Marine Science Education Center, will improve the Reserve's capacity to increase estuarine literacy and stewardship among public audiences. Present estimates indicate that approximately 25,000 people pass through the UTMSI Marine Science Education Center each year. It is anticipated that most UTMSI visitors will tour the Estuary Explorium exhibits and many will participate in public and community programs presented by Reserve staff. The Estuary Explorium will provide a venue to host programs designed to increase estuarine literacy and stewardship for diverse audiences, including local families with children, retired seasonal residents, and vacationing tourists. Over the next five years Reserve educators will develop public and community programs that are thematically aligned with the Estuary Explorium exhibits for delivery in the Explorer Lab and the adjacent Wetlands Education Center.

Participation in outdoor activities enhances the mental, emotional, and physical health of both children and adults. Future Estuary Explorium programs will allow families with children to connect with the natural world while conducting field investigations in the Wetlands Education Center. Outdoor education programs will provide opportunities for families to use real scientific instruments as they explore the ecological and economic importance of coastal habitats. For example, participants might use salinity meters to determine the salinity of the salt marsh and microscopes to observe the adaptations that plants and animals have to living in salty environments, as they learn the value of salt marsh habitat for commercially important, estuary-dependent organisms. Other programs will highlight sand dune,

oyster reef, or mangrove habitats and enhance understanding of the impact of freshwater inflow, water quality, and climate change on coastal habitats. In addition to offering educator-led programs, Reserve educators plan to develop Explorer Kits that families will be able to check out at the Estuary Explorium. A series of Explorer Kits will be designed to target various age levels of children and allow for self-guided or parent-facilitated exploration. They will contain instructions, equipment, and supplies needed for estuary-focused investigations of the Wetlands Education Center. The Reserve has received outside grant funding to purchase the equipment and supplies needed to offer educator - led programs and to develop Explorer Kits. The long-term goal of the Estuary Explorium public and community programs will be to increase environmental stewardship of coastal and estuarine resources.

ACTION 3: Develop public and community programs that are aligned with the Bay Education Center exhibits

Similar to the Estuary Explorium, the Bay Education Center offers education programs and interactive exhibits. However, many Bay Education Center visitors are more attracted by the presence of NOAA's spectacular SOS than to the estuary-themed exhibits and education programs. Anyone who has experienced SOS can understand the attraction of this powerful teaching tool and Reserve educators wish to more effectively incorporate SOS in estuary-focused public and community education programs. NOAA, the National Aeronautics and Space Administration, and other organizations have developed SOS datasets that provide engaging visualizations for teaching about the atmosphere, oceans, land, and climate science. Many of these datasets could be used to teach estuary literacy concepts, but Reserve educators have not had time to fully explore this potential. A NOAA Ernest F. Hollings scholar has been engaged to complete an internship at the Reserve during the upcoming summer of 2015, with the objective to develop SOS public education programs that integrate ocean, climate, and estuary literacy principles. Over the next five years, Reserve educators will work more closely with the SOS Users Collaborative Network, SOS Education Forum, and NOAA educators to develop interactive public and community SOS programs that integrate environmental literacy principles.

ACTION 4: Coordinate Summer Science Program

The Summer Science program is a continuation of the summer field component of the former National Science Foundation GK-12 program at UTMSI. Dr. Kenneth Dunton's research program and the Reserve presently collaborate to fund and coordinate the program. The four-week long Summer Science program connects scientists with third through eighth grade students, during inquiry-based summer field experiences. Daily field excursions provide students the opportunity to explore estuarine environments through a researcher's perspective, become aware of local and global threats to coastal environments, and learn to solve complex problems using the scientific method. Several Summer Science sessions integrate a stewardship component that promotes active stewardship of coastal environments, including marine debris clean-ups and invasive species removal at the Reserve's Wetlands Education Center.

ACTION 5: Continue to implement the Road Scholar program

Road Scholar (formerly Elderhostel) is an educational travel program for adults over 55 (or accompanied by an adult over 55) that has been hosted at UTMSI for many years. The Reserve education coordinator will continue to supervise the Road Scholar Coordinator and Reserve education staff will assist as needed with program support. Road Scholar programs highlight coastal ecology, birds, and coastal and south Texas history. Many of the programs include field experiences within the Reserve, such as a visit to the Aransas National Wildlife Refuge to observe and study the endangered Whooping Cranes that winter there.

Goal 3: Promote public appreciation and support for stewardship of coastal resources

OBJECTIVE 3-6: *Promote public appreciation of Texas coastal resources through community education programs hosted at Reserve facilities*

ACTION 1: Offer early childhood education programs at the UTMSI Marine Science Education Center

Sea Stories and Early Explorers are early childhood education programs that are offered at the Explorer Lab, within the Estuary Explorium at the UTMSI Marine Science Education Center. These programs introduce ocean and estuarine literacy principles to very young learners and integrate ocean-themed stories and crafts in hands-on activities. The primary goal of Reserve early childhood programs is to instill an appreciation for ocean and estuarine resources in pre-school age children and encourage enthusiasm for life-long learning and conservation of these resources.

ACTION 2: Coordinate public lectures at both the Bay Education Center and UTMSI

Bay Talks and the UTMSI Public Lecture Series are public presentations that are offered free to the public at the Bay Education Center and the UTMSI Marine Science Education Center, respectively. The presentations allow visitors to interact with and learn from scientists and other content experts, as they share their knowledge of estuarine, coastal, and marine environments. Presenters are primarily UTMSI, Reserve, or visiting scientists, post-doctoral researchers, and graduate students who provide a direct link to transfer information about UTMSI and Reserve research and stewardship efforts to public audiences. Bay Talks and the UTMSI Public Lecture Series presentations are offered once per week, from mid-January through mid-March each year.

ACTION 3: Offer SOS programs to the general public at the Bay Education Center

Public SOS programs at the Bay Education Center are targeted at increasing ocean and climate literacy among general public audiences. The SOS display system allows participants to visualize connections among the global ocean, coastal environments, and the Earth's climate, food supply, and atmosphere. Participants at SOS programs are introduced to the NERRS mission and goals at the beginning of each program, while viewing an SOS visualization of the 28 NERRS sites plotted against a satellite image of the Earth. Participants are invited to explore the interactive exhibits at the Bay Education Center after the program, which reveal the biological diversity, economic value, and ecological benefits provided by estuaries and the role that the Mission-Aransas Reserve plays in estuarine conservation.

ACTION 4: Assist with coordination of Wetland Warriors

Wetland Warriors are Reserve volunteers who are dedicated to restoring and maintaining the native vegetation at the Wetlands Education Center. Reserve educators teach volunteers about the harm caused to coastal habitats by invasive plant species and how to differentiate between native and invasive plants. Reserve staff and volunteers work together to remove invasive plants and transplant native plants at the Wetlands Education Center on scheduled work days. The volunteers propagate native plants by collecting and planting seeds or cuttings and volunteer their time to remove invasive plants individually. Some Wetlands Warriors volunteers also act as docent tour guides at the Wetlands Education Center and inform the public about the Reserve's restoration efforts.

ACTION 5: Provide public tours at the Wetlands Education Center

The Wetlands Education Center consists of approximately 3.5 acres of salt marsh and sand dune habitat and is located on the UTMSI campus in Port Aransas. Handicapped accessible trails and boardwalks wind around a central salt marsh and through surrounding sand dunes. Many species of coastal plants and animals are identified on wayside interpretive panels that are located near shade kiosks along the

trails. Volunteer docents provide free, biweekly tours of the Wetlands Education Center and educate visitors about the important ecosystem services and critical habitats provided by estuaries. The Volunteer and Outreach Coordinator is responsible for identifying and working with the volunteer docents. A training manual has also been developed for use by volunteers.

ACTION 6: Provide training opportunities for volunteers interested in participating in education programs

Trained volunteers are an important component of many of the Reserve education programs. For example, trained docents lead tours of the Wetlands Education Center, and they also assist and interact with visitors at the Bay Education Center. The Volunteer and Outreach Coordinator will host two trainings every year related to education programs. At least one of these trainings will be held at the beginning of winter in order to capitalize on the high number of volunteers that are present at that time of year due to the influx of the "Winter Texan" community.

OBJECTIVE 3-7: ***Increase public awareness of the Reserve and Reserve System through the Reserve's website and bi-annual newsletter***

ACTION 1: Maintain Reserve website

Reserve staff maintain a website (www.missionaransas.org) that provides information about research, education, stewardship and training activities. The website supplies links to Reserve reports and publications, visitor and volunteer information, and the Reserve's biannual newsletter.

ACTION 2: Develop and distribute bi-annual newsletter

The Mission-Aransas Observer is a bi-annual newsletter produced each spring and fall. Contributions are provided by the Reserve's Administration, Research, Education, and Training programs. Printed copies of the biannual newsletter are sent to a select group of supporters and an electronic edition of the newsletter is emailed to a large network of resource managers, partners, and friends. The Education Program will continue to oversee the development of the Reserve's newsletter.

ACTION 3: Maintain the Reserve's social media pages

Reserve staff frequently update online social media sites, including Facebook and Twitter, with Reserve education and training opportunities. The Education Program, specifically the Volunteer and Outreach Coordinator, will be responsible for continuing to oversee and update the Reserve's social media sites.

OBJECTIVE 3-8: ***Promote Reserve initiatives at a minimum of three public events, fairs and expositions per year***

ACTION 1: Host and attend events related to National Estuaries Day

The Reserve promotes estuarine awareness on National Estuaries Day each September with onsite and outreach events. Since 2010, Reserve educators and the stewardship coordinator have coordinated a marine debris clean-up at the Aransas National Wildlife Refuge (Refuge) on National Estuaries Day. The Refuge is the primary wintering ground for the only naturally migrating population of endangered Whooping Cranes and the shoreline targeted in the clean-up provides critical feeding habitat for the cranes. The goal of the clean-up is to remove debris from Whooping Crane territory, before the cranes return to the Refuge around mid-October. Reserve educators also present community programs on the day of the clean-up that raise awareness about the problems created by marine debris. The reserve provides staff and recruits volunteers to remove debris and supplies lunch for everyone involved in the effort. The owner of a local eco-tourism business transports clean-up crews to and from the Refuge, Refuge staff haul away the bags of collected debris, and the Texas General Land Office Adopt-A-Beach

Clean-up program supplies trash-bags and gloves for the clean-up. Reserve staff also facilitate outreach activities at other sites (e.g., San Antonio Bay Day) on National Estuaries Day, when staff are available.

ACTION 2: Host education booth at Earth Day - Bay Day

Earth Day – Bay Day is a free, family-oriented environmental education celebration in Corpus Christi that attracts thousands of visitors each spring. This Earth Day focused celebration is hosted by the Coastal Bend Bays Foundation and supported by the Texas General Land Office Adopt-A-Beach Program, the Coastal Bend Bays and Estuaries Program, and many other state, federal, and private partners. The goals of Earth Day – Bay Day are to increase appreciation of natural resources in the Texas Coastal Bend and raise awareness of the importance of environmental education and conservation. Reserve staff and volunteers develop and facilitate estuary themed, hands-on, activities for families at the day-long celebration that seek to increase estuary literacy and stewardship among the general public. The Reserve will continue to host an educational booth at the event over the coming years.

ACTION 3: Host education booth at Coastal Bend Teacher Extravaganza

The Coastal Bend Teacher Extravaganza is sponsored by the Coastal Bend Informal Educators. This outreach event consists of a one-day workshop offered annually to teachers at a partner site or local school. Informal educators lead hands-on activities and/or host a booth at the workshop to disseminate information about their site's K-12 education programs. Reserve educators host a booth at the workshop to inform teachers of Reserve, NERRS, and NOAA education resources and present activities that demonstrate the types of teacher professional development and student programs offered at the Reserve. The Education Program will continue to host an education booth at this even over the coming years.

4.4 Coastal Training

4.4.1 Introduction

The National Estuarine Research Reserve System's mission includes an emphasis on education and interpretation. The Reserve System recognizes it has a responsibility to educate coastal decision makers and supports the Reserve System goals, as defined in the regulations (15 C.F.R Part 921(b)), through the Coastal Training Program (CTP):

- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas;
- To sustain these system goals, the 2011-2016 Reserve System Strategic Plan outlines coastal training objectives that support the focus areas of climate change, habitat protection and water quality;
- Increase estuary literacy and promote active stewardship among public audiences through the development and delivery of tools and programs addressing climate change, habitat protection, and water quality; and
- Improve the capacity and skills of coastal decision makers to use and apply science- based information in decisions that affect estuaries and coastal watersheds.

The CTP provides up-to-date scientific information and skill-building opportunities to coastal decision makers responsible for making decisions affecting coastal resources. Through this program, reserves ensure that coastal decision makers have the knowledge and tools they need to address local critical resource management issues.

Coastal decision makers are defined as individuals whose duties include making decisions that affect the coast and its resources. The target decision-maker groups vary according to reserve priorities, but generally include groups such as local elected or appointed officials, managers of both public and private lands, natural resource managers, coastal and community planners, and coastal business owners and operators. They may also include groups such as farmers, watershed councils, professional associations, recreation enthusiasts, researchers, and more.

Reserves are uniquely positioned to deliver of pertinent information to local and regional decision makers given their place-based nature. CTP coordinators know the local people, places, and science available to skillfully convene training participants and experts to address coastal management issues. CTPs are built upon solid and strategic program documents, including an analysis of the training market and assessment of audience needs. Coordinators then work with the results to identify how their program can best address local and Reserve System priority issues.

Partnerships are integral to the success of the program. Reserves work closely with several other NOAA programs, as well as a host of local partners in determining key coastal audiences, and expertise to deliver relevant and accessible programs.

4.4.2 Coastal Training Program Context

Since the development of the previous *Mission-Aransas NERR Management Plan* (NOAA, 2006), the Reserve has fully implemented its CTP. In 2007, a full time CTP Coordinator was hired, and essential Reserve partnerships and relationships have both strengthened and developed as a result of program implementation. In addition to having a fully operational Training Program, the Reserve has also obtained essential facilities and infrastructure since program implementation that can be used to continue to grow the CTP. A market

analysis/needs assessment (MA/NA) was conducted in 2009 (Leister and Morehead, 2009; see Appendix A). The outcomes of this assessment have resulted in essential training on priority issues for stakeholders in the Mission-Aransas Reserve watershed and beyond.

Participants at CTP events often include local resource managers and researchers

The CTP primarily targets audiences residing within the Mission-Aransas Watershed. Audiences at CTP workshops and trainings are usually located within Reserve boundaries and include participants from the five Reserve counties (Aransas, Refugio, Calhoun, Nueces, and San Patricio). Workshops are typically targeted for coastal decision makers, such as local elected/appointed officials and resource managers, allowing them to make informed decisions based on the available science results. Additionally, by hosting topic-appropriate workshops as well as producing relevant education materials, secondary audiences that the CTP reaches are informal educators and engaged citizens. Occasionally, depending on the scope and objectives of training topics, the CTP has a broader reach outside the immediate Reserve area, and audiences will include participants from other Texas communities, such as San Antonio or Austin, as well as participants from other states, such as Reserve partners from the Gulf of Mexico region.

The CTP works regularly in conjunction with the Research, Stewardship, and Education Sectors of the Mission-Aransas Reserve. CTP regularly organizes, hosts, and facilitates workshops for both Research and Stewardship for funded projects that require stakeholder feedback and input. Education and CTP regularly work together to provide information on topics that are pivotal to both coastal decision makers as well as the general public. As appropriate, sector coordinators as well as the Reserve Director provide regular assistance and support to the CTP Coordinator with workshops and regularly attend CTP hosted workshops. In addition to the efforts already ongoing with the other sector programs, listed below are proposed programs that CTP plans to provide in the 2015-2020 timeframe to other Reserve sectors.

- Stewardship: Land conservation tools (i.e., conservation easements, wildlife exemptions); marine debris; invasive species removal
- Research: Symposium on local relevant topics (e.g., impacts regarding the opening of Cedar Bayou); harmful algal bloom symposium; and develop a research-based Harmful Algal Bloom video that will be accessible by Reserve stakeholders and their communities
- Education: Work with the education sector to poll environmental educators to determine their training needs; offer un-accredited interpretive training; and work with the Education Coordinator to develop a local K-12 Coastal Resiliency Program.

4.4.3 Coastal Training Program Capacity

Staff

The CTP is managed by a full-time coordinator that is located at the Mission-Aransas Reserve headquarters in Port Aransas, Texas. The CTP Coordinator plans, develops, organizes, and runs all trainings hosted by the Mission-Aransas Reserve. The CTP Coordinator regularly helps other sector programs with their needs for workshop and training development. Assistance with organization and planning for events that are held as part of other Reserve sector programs is contributed by those sector coordinators as needed.

Existing Partners

The Mission-Aransas NERR has developed partnerships that benefit every aspect of the Reserve, and these partnerships are essential for the success of the CTP. While each of these partnerships is valued and the Reserve works to continuously foster these relationships, there are several partnerships, in particular, that further the goals of the CTP. Please see Appendix B for a full list of CTP partners and their priority issue areas.

CTP works with partners, such as Texas Sea Grant, to provide training events

Texas Sea Grant

The Mission-Aransas Reserve CTP and Texas Sea Grant's partnership is known as the "Training and Planning Program". The Coastal Planning Specialist for Texas Sea Grant works with the CTP Coordinator closely to develop programs that are related to coastal community resiliency, hazard mitigation, and local land use planning and regulation. The CTP focuses on training and workshop development related to building planning capacity, and the Coastal Planning Specialist covers technical assistance needs related to comprehensive planning efforts. This relationship is essential to the continued success of the CTP in its efforts to help local communities address coastal community resilience and hazard mitigation planning through training and technical assistance.

Texas General Land Office and the Coastal Management Program

The Texas General Land Office (GLO) is the home of the state coastal management program, and has management authority over the beaches, bays, estuaries, and other submerged lands along the Texas coast. As the management authority over much of the land contained within the Reserve boundaries, the GLO has been a consistent partner of the CTP and maintains a seat on the Reserve Advisory Board and the CTP Advisory Board.

The Mission-Aransas Reserve has recently focused on further strengthening this partnership through quarterly conference calls between the Reserve and GLO. These efforts have resulted in the funding of several CTP training events, and the assistance by the Reserve for the coastal marine spatial planning efforts of the GLO.

City of Rockport

The City of Rockport, located in Aransas County, is the largest population center directly adjacent to the Reserve and has become a close partner for many training events that have been organized by the CTP. In addition to funding the construction of the Bay Education Center and local research projects, the governmental officials at the City of Rockport are enthusiastic participants in the coastal resilience planning efforts. The CTP is also a trusted resource for the City of Rockport Environmental Committee for Water Quality Issues, and currently has two programs that have been developed specifically at the request of this committee. This partnership has been one of the strongest partnerships since the development of the CTP, and will continue to be one of its strongest partners over the next five years.

Anticipated Partners

The Mission-Aransas Reserve will continue developing the very new partnership with the City of Aransas

Pass. The CTP is assisting City officials in the development of a Comprehensive Resilience Plan for the City, and has helped the City identify coastal hazard vulnerabilities through the "Coastal Resilience Index" (Sempier et al., 2010).

ANWR, which is encompassed by the Mission-Aransas boundary and is the wintering home of the critically endangered Whooping Crane, has identified CTP as an avenue for outreach regarding the research occurring within the Refuge. CTP recently hosted an "ANWR Research Symposium" in 2014 that highlighted permitted research occurring within the Refuge, and is working with the Refuge Manager to identify other opportunities for collaboration on outreach activities.

Facilities

The Mission-Aransas Reserve has two facilities that are currently used to host CTP training events. The Mission-Aransas Reserve headquarters building is located on the University of Texas Marine Science Institute (UTMSI) campus in Port Aransas, Texas and is named the Estuarine Research Center. The Estuarine Research Center is equipped with multiple rooms that are capable of holding meetings, including a seminar room that is equipped with appropriate audiovisual and computer equipment to run training events for approximately 40 people. The CTP also uses the UTMSI Visitor's Center Auditorium to hold events that have a larger audience (up to 180 participants). The Estuarine Research Center is Leadership in Energy and Environmental Design certified gold, and currently serves as the alternate emergency operations center for the City of Port Aransas during a severe weather event.

In addition to the Estuarine Research Center, the Reserve also has a facility located in Rockport, Texas called the Bay Education Center. The Bay Education Center is a multi-use facility and contains a visitor center, auditorium, offices for the City of Rockport, Reserve office, and an outdoor education patio. This facility provides local residents with the opportunity to learn more about the estuary and the research being conducted in the Mission-Aransas Estuary. The auditorium has space for holding small meetings and training events for approximately 40 people. The Bay Education Center is also home to the Science on a Sphere®, which allows for interactive presentations of earth science and data with a visual representation of the earth.

The Estuarine Research Center provides auditorium space for CTP events

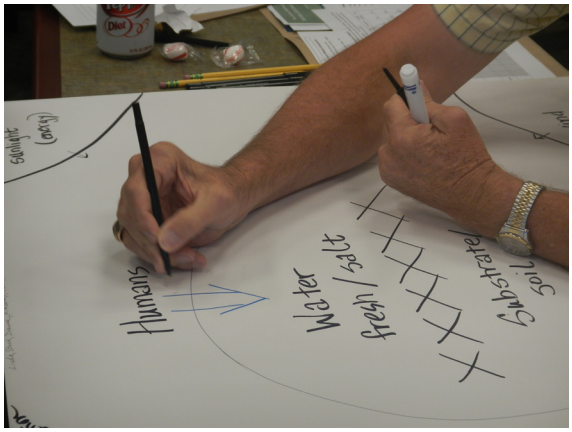
4.4.4 Coastal Training Program Delivery

Trainings and Technical Assistance

Traditionally, CTP supports coastal stakeholders in two ways: through workshops and technical assistance. Results from the MA/NA showed that, locally, the two most common training types are "forums or public meetings" and "technical conferences or seminars." In addition to traditional workshop techniques, the CTP also aims to deliver alternative training styles. CTP regularly incorporates hands-on/field experiences and web-based trainings into the program in response to requests made by the CTP Advisory Board. Training techniques regularly incorporated into CTP events include small group report outs, roundtable discussions, brainstorming sessions, utilization of visual aids, participatory exercises, and scenario development. As appropriate, Reserve scientists communicate and disseminate relevant scientific results to stakeholders at CTP events. As needed, scientific results are posted to the Mission-Aransas Reserve website (www.

missionaransas.org) for CTP audience use. Workshops are typically delivered in a 2-4 hour or full day format, with the occasional two-day training being conducted when a particular topic requires a large amount of content delivery.

In addition to workshops and trainings, the CTP is involved with community-based technical assistance projects as needed. The CTP regularly provides technical assistance on community resilience projects in the coastal bend, and the program will continue to increase this assistance with both new and established partners on this topic moving forward.



Stakeholder participation is often a key component of many of the CTP events

The CTP regularly incorporates NERRS system-wide programs, national programs, and priorities into workshops and events. Depending on the workshop content, the Reserve's Research Coordinator and research staff regularly present system-wide monitoring program data at CTP events. This is something that is anticipated to continue into the future. Additionally, the Mission-Aransas Reserve CTP regularly incorporates climate change priorities into workshops, especially in regards to how coastal communities can help mitigate and adapt to climate related changes. CTP hosts coastal resiliency workshops regularly and assists local communities in developing plans in order to become more resilient. CTP will continue coastal resiliency trainings by supporting partner communities in addition to assisting new communities in the watershed that have not previously been exposed to Reserve resiliency initiatives. Additionally, CTP assists other sectors as required with climate change programs. For example, CTP provides a forum for workshops as well as facilitation for Coastal and Ocean Climate Applications (COCA) funding awarded to the Stewardship and Research Sectors as well as freshwater inflows funding awarded to these sectors by the NERRS Science Collaborative (NSC). CTP will continue to work with COCA and NSC projects as long as funding is available and awarded to the Mission-Aransas Reserve.

Marketing Strategy

The CTP has adopted a wider marketing strategy as the CTP trainings have developed. CTP has recently purchased Constant Contact®, an online marketing tool that allows for email list management and the publication of design-consistent email newsletters. CTP regularly uses targeted mailings to advertise training opportunities, and has also developed beneficial relationships with several local news reporters and can draw upon their large audience. For events that are requested by a particular entity, the CTP works with that entity to provide the necessary media for them to distribute, such as invitations, registration, and brochures.

Program Evaluation

The MA/NA conducted in 2009 was a starting point to determine the direction and the priority issues for CTP. Moving forward, the next MA/NA will serve as a good evaluation of CTP, letting us know if we need to incorporate other priorities as well as reach out to additional target audiences. Additionally, the CTP Coordinator is constantly performing informal needs assessment. Through the input of the CTP Advisory Board as well as evaluations from workshops, the CTP Coordinator stays current on the needs facing coastal decision makers.

CTP is formally evaluated through post-event evaluations. Evaluations are consistent with the *NERRS CTP Performance Monitoring Manual* and gauge the effectiveness of training activities based on participant responses to questions concerning content, format, delivery, intention to apply acquired skill to future work,

and suggestions for future training events. Evaluation results that provide suggestions for improvement are incorporated into future training events. Using the evaluation results, CTP will continue to review existing planning documents and incorporate the information from post-evaluation surveys into the program. The results of these evaluations are provided to NOAA and the performance of the program is tracked through the performance measures database.

CTP evaluates its programs to ensure that it is meeting the needs of its partners and stakeholders

In addition to individual event evaluations, CTP will perform a longer-term program evaluation every two years. This evaluation will gather information from partners about the effectiveness of the CTP program as a whole, and how CTP can continue to address partner needs. This evaluation will take place along with a programmatic needs assessment, or as a stand-alone evaluation. The evaluation will be similar in format to the needs assessment, gathering information through online survey instruments and targeted interviews with key partners. The next long-term evaluation will occur in 2016 . By continuing to improve the program and provide appropriate and needed trainings to the primary audiences, CTP will allow stakeholders and decision-makers to be better educated and informed on Reserve and local estuarine science. This will help to conserve and restore the local estuary environment, make coastal communities more resilient, and help communities become more aware of the risk factors facing their local habitats and homes.

CTP is guided by an advisory board that is made up of individuals from partner organizations (Appendix C). The group currently consists of twelve members and meets bi-annually to help improve CTP by re-evaluating program priorities, identifying training needs, and helping to plan and implement CTP programs. RAB meetings also provide a means for evaluation of CTP. By participating in the RAB, Reserve partners receive updates on the CTP bi-annually. This provides an opportunity for the CTP Coordinator to show progress on on-going projects, while also discussing future needs and opportunities related to trainings. If necessary, the CTP Coordinator, may request a special breakout session during the RAB meeting in order to discuss particular issues of concern to the Program.

Finally, the CTP Coordinator is responsible for completing an annual review with the Reserve Director and attending quarterly Reserve staff meetings. The annual review is a formal process, completed through UT which allows for specific long-term issues with the CTP Program to be addressed by the Reserve Director. The quarterly Reserve staff meetings, on the other hand, provide an opportunity for more immediate issues, questions, or problems to be discussed and addressed in collaboration with other Reserve staff. The format for these meetings includes updates by all Reserve programs, as well as a presentation by a specific program about a current problem. The process of evaluation is not expected to change within the next five years.

4.4.5 Needs and Opportunities

As previously mentioned, CTP conducted a MA/NA to determine the availability of current training opportunities in addition to determining primary training topics for the region (Leister and Morehead, 2009). Findings from the MA/NA resulted in the following priority issues (not listed in priority order): (1) habitat conservation and coastal restoration ; (2) climate change impacts on natural systems; (3) coastal access; (4) coastal community resilience and hazard mitigation; and (5) stakeholder communication and engagement tools.

These priorities fall in line with the *2011-2016 NERRS Strategic Plan* goal of increasing estuarine literacy and promoting active stewardship by developing programs addressing climate change, habitat protection, and water quality and encourage coastal decision makers to make informed decisions that impact estuaries and coastal watersheds. In order to reevaluate local coastal decision makers and stakeholders needs, CTP will conduct another MA/NA in 2016 . Using this updated information as well as informal needs assessments conducted at events, CTP will shift training priorities as appropriate while keeping the goals of the *2011-2016 NERRS Strategic Plan* in mind.

4.4.6 Coastal Training Program Goals, Objectives, and Actions

GOAL 1: Improve understanding of Texas coastal zone ecosystem structure and function

OBJECTIVE 1-7: ***Increase participation of UTMSI researchers in program development and implementation by drafting outreach plan***

ACTION 1: Develop outreach plan for UTMSI research that relies on CTP expertise

In order to increase "in-house" partnership with UTMSI, the Reserve's managing partner, and garner critical input from local scientific experts, CTP will establish new partnerships with UTMSI researchers resulting in an increase of collaboration of 10% by the end of 2020. The program coordinator along with the Reserve Director and the UTMSI Communications Coordinator will develop an outreach plan for UTMSI research that relies on the expertise of CTP. This outreach plan will be completed by the close of 2016, and will be based on input from Reserve staff and UTMSI faculty, staff, and administration. The outreach plan will identify key decision-maker audiences that will benefit from receiving the results of research that is occurring at UTMSI, and rely upon the skills of CTP and the results of the MA/NA to develop training events that incorporate UTMSI research and information. Additionally, CTP will present relevant activities in appropriate graduate courses, such as Marine Ecology.

ACTION 2: Highlight UTMSI scientific research at annual research symposium

CTP will hold one research symposium per year highlighting UTMSI scientific research starting in 2015. CTP will interact with UTMSI graduate students by involving them in the planning and organization of the annual research symposium.

GOAL 2: Increase understanding of coastal ecosystems by diverse audiences

OBJECTIVE 2-7: ***Enhance the transfer of knowledge, information, and skills to coastal-decision makers by hosting a miminum of eight trainings, updating the Reserve's market analysis/needs assessment, creating a listserv, and enhancing use of the Reserve CTP website***

ACTION 1: Hold a minimum of eight training events each year that meet the information and training needs of coastal decision maker audiences

The CTP strives to create a network of coastal decision makers that are able to use the most relevant science-based information in their decisions. The CTP accomplishes this by delivering information, training, and tools to targeted audiences who regularly make decisions that influence coastal resources. CTP will work to meet the needs outlined in the priority issues section that have been identified through both formal and informal needs assessments. Anticipated training events designed to address these priority issues would include:

Coastal Resiliency: Response to Natural and Man-Made Disasters (Coastal community resilience and hazard mitigation)

In order to expand the Reserve's reach in regards to coastal resiliency, CTP has a number of

opportunities that it will be working towards in the next five years. The first being collaboration with the Reserve's Education Sector on opportunities for K-12 resiliency programs. By working with the Reserve's Education Coordinator, CTP hopes to develop relevant trainings and educational materials regarding coastal resiliency for both K-12 teachers and students. Additionally, CTP will look to host workshops on coastal resiliency and preparedness in counties and communities within the Mission-Aransas Watershed that have not previously been accessed, such as Refugio County. Also, CTP hopes to expand on existing coastal resiliency efforts with the Texas GLO by working with the agency to acquire resiliency funding as well as train GLO staff on how to conduct the Coastal Resilience Index.

Through verbal communications with resources managers and academic scientists, there exists a need to provide support and training regarding oil spill response and research. By utilizing funding provided by the Gulf of Mexico Research Initiative to the Reserve's Research Coordinator, CTP plans to work with locally funded projects to help develop a science rapid response plan in the event of a spill. CTP will also work with oil spill scientists to provide scientific findings to local stakeholders so communities are better prepared in the event of a spill.

Marine Debris (Habitat conservation and coastal restoration)

Another topic that CTP will aim to address in the next five years is marine debris. The Stewardship Program of the Mission-Aransas Reserve has recently began to focus heavily on this topic, and CTP hopes to provide support in regards to workshops and trainings to help alleviate this problem in the Coastal Bend. This is also a priority topic for the Reserve's Education Program, and CTP will support Education in providing teacher trainings and assist with field demonstrations and outreach events as required.

Climate Change Communication (Climate change impacts on natural systems)

CTP hopes to further climate change communication among coastal decision-makers, stakeholders, and informal educators. Previously, CTP has hosted workshops for environmental educators on how to effectively communicate the topic of climate change to their audiences. CTP hopes to broaden the impact of this topic by offering both web-based and in-person workshops on climate change communication to resource managers and audiences from local municipalities. This would allow more effective climate change communication to local visitors and communities, and help coastal communities understand the importance of climate change mitigation and adaptation.

Stakeholder Communication and Engagement

Over the next five years, CTP hopes to not only serve as a translator for appropriate estuarine science to target audiences, but also train scientists on how to communicate more effectively. By hosting science communication workshops and providing appropriate educational materials, CTP will help ensure that local scientists within the Reserve watershed have the appropriate training and skills to communicate their science to both local stakeholders and the general public.

ACTION 2: Perform a market analysis/needs assessment to determine training needs

CTP will conduct a market analysis and needs assessment (MA/NA) of current training needs by mid-year of 2016. The MA/NA will allow CTP to identify current partner needs and will provide an opportunity to explore new potential partnerships. Included in the MA/NA will be a targeted survey to UTMSI faculty and staff, in order to better connect CTP resources to the host institution.

ACTION 3: Develop Listserv for CTP

CTP will develop the current partner contact list into a listserv that distributes relevant information to CTP audiences. This listserv will be operational by March 2016.

ACTION 4: Increase use of CTP section of Reserve website

In order to increase the use of relevant resources by our partners, stakeholders and the general public, CTP will increase the use of the CTP section of the Mission-Aransas website by 15% by 2020 through strategic website updates and information releases to CTP partners. Specific strategies for increasing use include: (1) upload and/or link relevant webinars, virtual training opportunities, and visualization tools to the Mission-Aransas website (www.missionaransas.org); (2) provide information to CTP audiences on how to access this information as it becomes available through the CTP listserv (see Action 3), flyers at training events, and CTP mailings; and (3) update the Mission-Aransas website to include a list of online tools relevant to CTP audiences by the close of 2016.

GOAL 3: Promote public appreciate and support for stewardship of coastal resources

OBJECTIVE 3-9: ***Improve the ability of coastal resource managers to conserve, protect, and restore coastal ecosystems through trainings on restoration and other relevant topics***

ACTION 1: Increase participation in RESTORE Act activities.

CTP will increase participation of stakeholders in RESTORE Act activities 10% by 2020 by encouraging the networking of CTP audiences in regards to both ongoing and future coastal restoration projects. By 2016, CTP will host a "Restoration Practitioner's Forum", which will provide members of the Coastal Bend community with an opportunity to network with other coastal restoration practitioners and learn about techniques, best management practices, and lessons learned. This workshop should ideally be held in conjunction with the other CTP programs in the Gulf of Mexico as part of the Gulf Regional CTP effort. Once a listserv is established (see Action 3), CTP will regularly send information to stakeholders and partners on funding and learning opportunities associated with the RESTORE Act.

ACTION 2: Collaborate with other Reserve programs to identify and implement additional training programs

CTP hopes to expand on some of the existing priority issues described above by working with other Reserve programs to identify and implement additional training programs. CTP anticipates developing workshops on priority issue topics such as sea level rise, water conservation, and restoration.

5.0 Administrative Plan

5.1 Organizational Framework

5.1.1 Relationship to Federal Government

A state, commonwealth, or territory and the federal government cooperate in operation of each NERR. The federal interest is represented primarily by the Office for Coastal Management, National Ocean Service, NOAA. NOAA's mission includes management of the nation's coastal resources and promotion of global stewardship of the world's oceans and atmosphere through science and service. OCM coordinates the NERRS nationally and administers financial awards to individual Reserves.

The NERR System operates as a federal/state partnership. Although the management of a reserve, including development of site-specific policies and programs, is a state's responsibility, NOAA provides overall system policies and guidelines; cooperates with and assists the states in selecting, designating, and operating Reserves; and reviews Reserve programs regularly. The purpose of the NOAA review is to ensure that a state is complying with federal NERR System goals, approved work plans, and Reserve management plans. The primary mechanisms used by NOAA to assist the state, as well as NOAA responsibilities pertaining to reviews are discussed below.

Upon designation, NOAA staff, in particular the Program Specialist assigned to the Reserve, communicates directly and regularly with the Reserve staff. Communication builds a level of trust between federal and Reserve staff and familiarizes both OCM and state personnel with reserve management procedures and policies. This cooperative approach is needed for a reserve to be successful. Both oral and written communication is necessary and site visits are advisable.

Another component of NOAA oversight is its reserve funding program. NOAA provides different categories of grant funding to a reserve and works with reserve staff to ensure that funds are spent on projects and in areas where the most benefit can be achieved. Semi-annual grant progress reports and a final grant report are required. NOAA personnel carefully review the grant reports and associated communications to ensure compliance with program policies and specific grant conditions.

Pursuant to the Coastal Zone Management Act (CZMA) enabling legislation (Sections 312 and 315), OCM must periodically conduct performance evaluations of the operation and management of each reserve while federal financial assistance continues. These reviews are a mechanism for identifying, discussing, and resolving concerns with reserve operation.

The state interest is usually represented through one or more state agencies, typically agencies charged with education, environmental, research, wildlife, or coastal management responsibilities. The state agency administers reserve personnel and day-to-day reserve management. The management for the Mission-Aransas Reserve is performed through UTMSI as outlined in the administrative plan below.

5.1.2 Reserve Administrative Framework

The Mission-Aransas Reserve is administered by UTMSI, the State of Texas-designated lead agency for the Reserve. The memorandum of understanding (MOU) between the UTMSI and NOAA establishes the roles and responsibilities of these agencies (Appendix D). Other key state, federal, and private partners of the Reserve include GLO, USFWS, TPWD, CBLT, TNC, Fennessey Ranch, TxDOT, CBBEP, and a local governmental representative mutually agreed upon by Aransas County, ACND, and the City of Rockport. These partnerships have been established based on mutual interest in the project and to provide a means by which key aspects of the program will function (i.e., research, education, monitoring, administration, resource protection, facility development and operation, and site security). Agreements that describe the relationships between these partners are provided in appendices and are listed below:

- MOU between the UTMSI and local partners: GLO, USFWS, TPWD, TNC, CBLT, Fennessey Ranch, TxDOT, CBBEP, and a local governmental representative mutually agreed upon by Aransas County and the City of Rockport (Appendix E)
- Coastal Lease for Scientific Purposes from GLO to UTMSI (Appendix F)

The key partners will serve on the Reserve Advisory Board. The RAB will provide advice to Reserve staff for management, research/monitoring activities, stewardship objectives, and educational programs based on the approved Reserve management plan. The state, federal, and private organizations listed above are principal partners and had key roles during the site selection and designation process of the Reserve and have agreed to continue their involvement as described above and detailed in the agreements among these partners. The Reserve's key partners are described in Appendix G.

The RAB shall act on behalf of the agencies/entities having jurisdiction over sites comprising the Reserve. Members of the RAB will serve without compensation from the Reserve. The purpose of the RAB is to advise UTMSI regarding implementation of the management plan. The RAB shall review the management plan every five years and shall advise UTMSI regarding modification of the management plan. The RAB may create committees or subcommittees to provide technical information or linkage to the broader community pertaining to the main programs of Reserve: research, education, training, and stewardship. Members of committees or subcommittees will serve without compensation from the Reserve.

Advisory committees will also be established on an as-needed basis to allow other interested parties to provide input into the operation and implementation of the Research, Stewardship, Education, and Training programs of the Reserve. These ad-hoc committees will include willing representation from targeted stakeholders and constituencies within the region and will advise Reserve staff on local issues related to their respective programs. Advisory committees will be formed to address specific needs of the Reserve staff and will not be required to meet on a regularly scheduled basis. Representation on the committees may change as the needs of the Reserve develop over time.

The administrative framework of the Reserve, including key partners, advisory committees, and NOAA are shown in Figure 5.1. The roles and responsibilities of the primary partners are detailed below.

5.2 Current Staffing and Needs

The UTMSI will implement the Reserve programs by hiring, directing, and maintaining Reserve staff. Implementation of the goals and objectives for the Reserve is dependent upon adequate staffing levels. Although staffing levels may change through time and with availability of resources, a minimum staff is needed to manage and coordinate Reserve activities. The Reserve System identifies the following positions as core staff, those needed to maintain and implement system-wide programs: Reserve Director, Research Coordinator, Stewardship Coordinator, Education Coordinator, and CTP Coordinator. There are also other technical and administrative support staff that are necessary to maintain and implement system-wide programs, such as research technicians to maintain the SWMP. The functions and responsibilities of the core positions are described below, and the staff structure as of March 2015 is provided in Figure 5.2.

Additional staff may become necessary to accomplish the goals and objectives set forth in this Reserve management plan. For example, clerical and other technical support staff are key to efficient operation of the Reserve's programs. Clerical duties may include scheduling, public communications, office organization, web design and maintenance, minor accounting, and assistance in project production. Technical duties may include research assistance in sample and data collection and analysis, data interpretation and presentation, geographic information systems, data management, and training volunteers. Additional staff positions are described witin the objective and actions listed below and will be incorporated in the program as adequate funding becomes available.

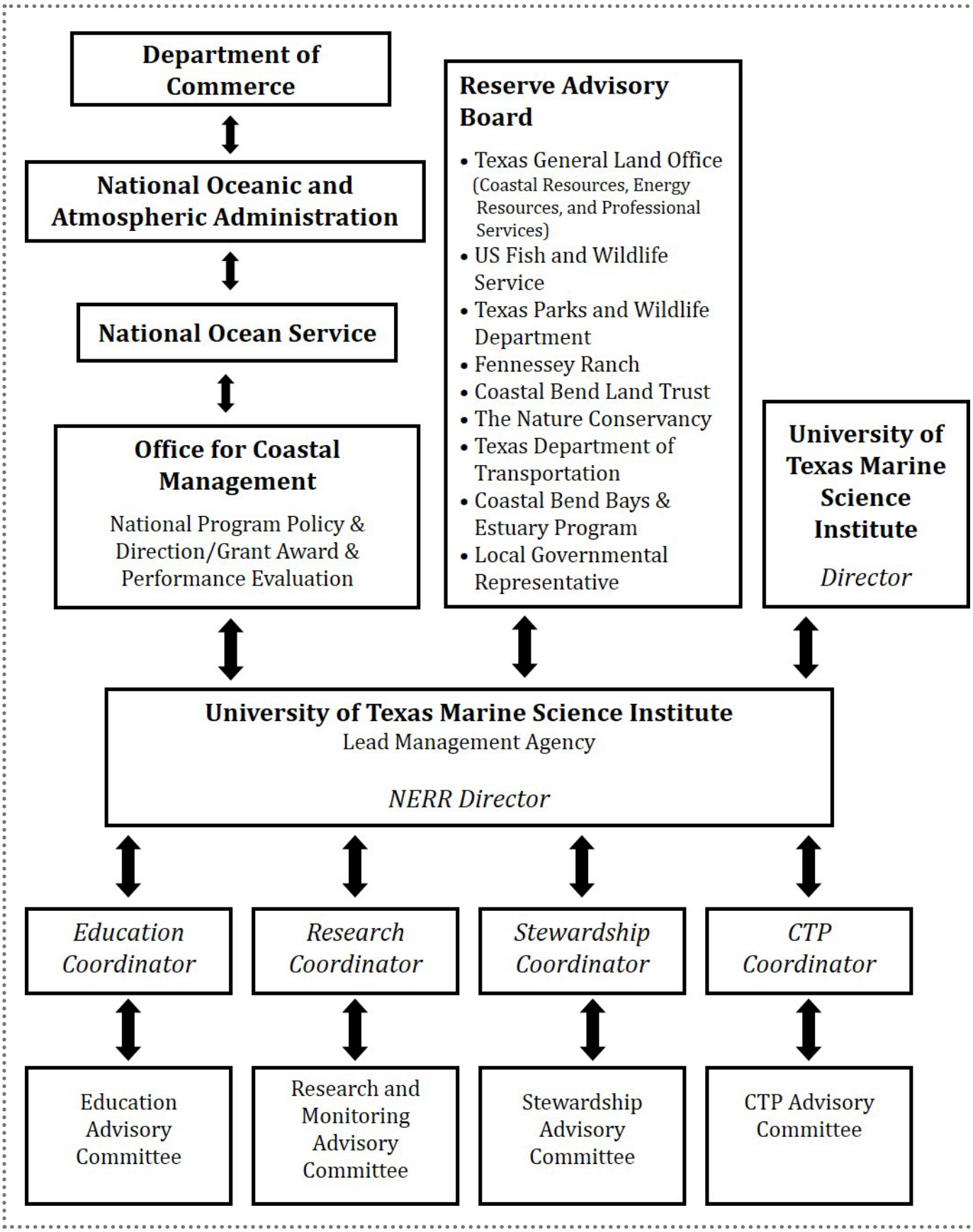


Figure 5.1. Administrative framework for the Mission-Aransas Reserve showing the relationship between NOAA, UTMSI, the Reserve Advisory Board, and advisory committees. The key staff positions (Coordinators) for the primary Reserve programs are also shown.

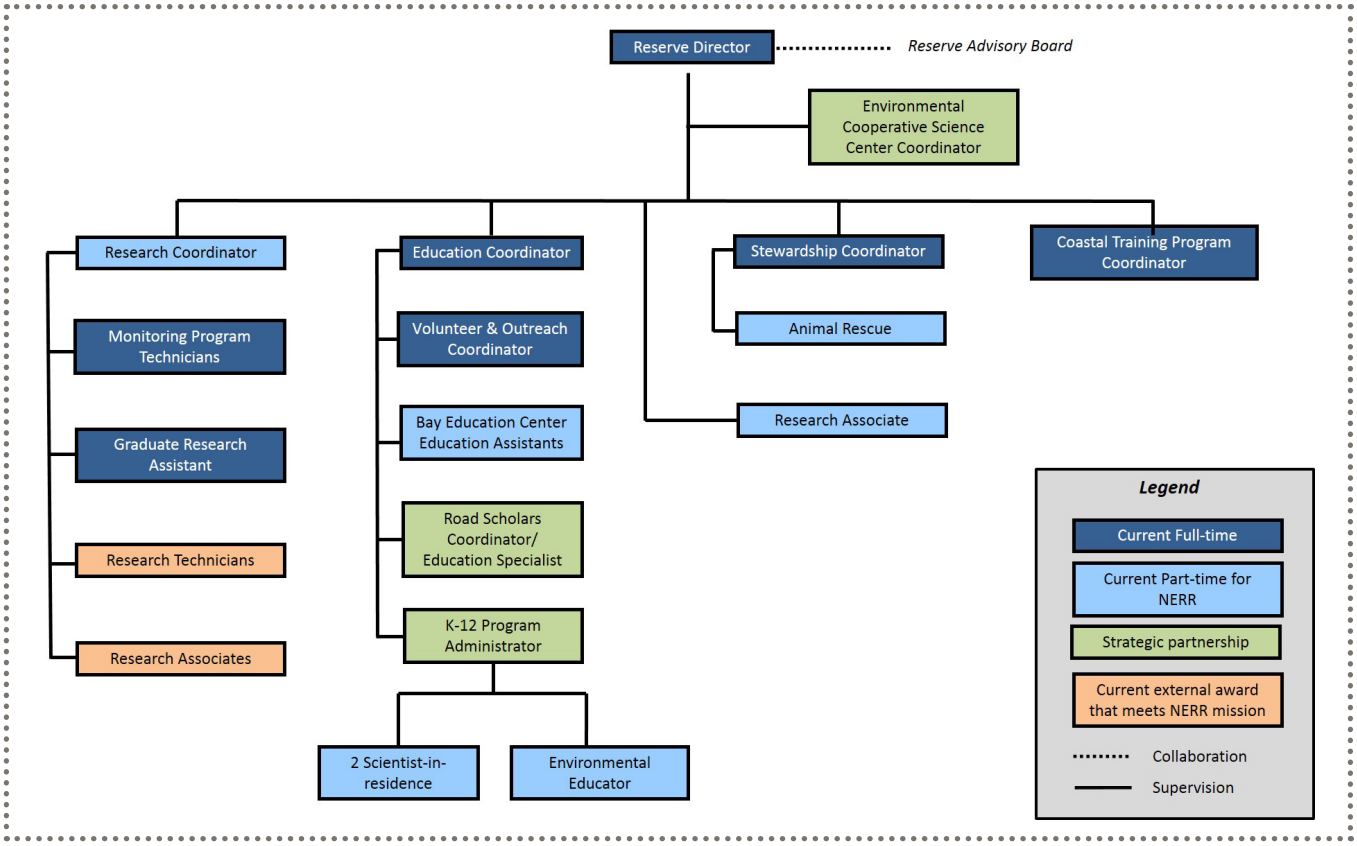


Figure 5.2. Current staff structure of the Mission-Aransas Reserve showing full-time, part-time, and externally funded positions. Key partnerships are also noted.

Reserve staff will be highly qualified individuals. The level of education and experience will vary with different levels of administrative and technical responsibilities. The Reserve Director and Coordinators will hold at least an M.S. in an appropriate field for their position. However, a Ph.D. is preferred for these positions. More highly trained and experienced technical staff are called research associates, and entry-level staff are called research assistants. Student training is accomplished by incorporating graduate research assistants and undergraduate assistants in the program. Volunteers will consist of the general public and are not required to have specific qualifications.

5.3 Admininstrative Goals, Objectives, and Actions

The administrative plan is unique in that the same objectives are required to meet all three goals of the Reserve. This is because administrative objectives are basically the same for any goal that the Reserve might adopt. Administration typically plans, oversees, and supports all Reserve goals.

GOAL 1: Improve understanding of Texas coastal zone ecosystems structure and function

OBJECTIVE 1-8: ***Provide oversight and support for research and monitoring activities***

Oversight of research and monitoring activities will be provided by the Reserve Director and the Research Coordinator. Support of research and monitoring activities, such as travel and overhead, will be provided for by Reserve funds.

ACTION 1: Develop, execute, and revise a Reserve management plan

UTMSI will develop and execute the Reserve management plan and will be responsible for revising the management plan every five years with advice from the RAB. Revision of the management plan will update and create new objectives and actions for the research and monitoring plan.

ACTION 2: Obtain advice on the program from the broader community

Advice on the program from the broader community will be obtained through the RAB and the Research and Monitoring Advisory Committee. The first task of the advisory committee will be the development of a needs assessments for target audiences. Needs assessments are a systematic investigation of an audience to identify aspects of individual skills, knowledge, interests, attitudes, or abilities relevant to a particular issue, organizational goal or objective. Needs assessments are designed to collect sufficient information about a particular target group to design an effective program that addresses the group's needs and desires.

The Board shall be comprised of members from the principal partners. GLO shall have one representative from each of three divisions that have direct but distinct interests in the Reserve: Coastal Resources, Energy Resources, and Professional Services. TPWD, USFWS, TNC, CBLT, Fennessey Ranch, TxDOT, and CBBEP shall each have one representative on the Board. To provide an appropriate linkage to the broader community so the Reserve reflects the concerns and ideas of this regional constituency, a local governmental representative mutually agreed upon by Aransas County, ACND, and the City of Rockport shall be a member of the Board. Further information on the key Reserve partners in the RAB is provided in Appendix G. The RAB will elect a chairman annually from among the principal partners.

The Research Coordinator will form special advisory committees as needed to provide advise regarding respective programs related to research and monitoring. RAB members can provide recommendations for membership of these advisory committees, but representation can include representation from the research and education community, agencies, user groups, adjacent landowners, industry, and other groups as appropriate. Some cross-membership on committees is anticipated. Advisory committees will meet as appropriate, to ensure the most efficient use of available resources and to integrate the research, stewardship, and education goals.

ACTION 3: Recruit and maintain staff

UTMSI will implement the Reserve program by hiring, directing, and maintaining Reserve staff. Implementation of the goals and objectives for the Reserve is dependent upon adequate staffing levels. Although staffing levels may change through time and with availability of resources, a minimum staff is needed to manage and coordinate Reserve activities. The Reserve staff will consist of a Reserve Director, Research Coordinator, Stewardship Coordinator, Education Coordinator, CTP Coordinator and necessary technical and administrative support staff. The functions and responsibilities of the Reserve Manager and Research Coordinator are described below.

Additional staff positions will be incorporated in the program as adequate funding becomes available. In the future, the Reserve would like to hire a full-time Administrative Assitant to assist the Reserve Director and other NERR staff with clerical duties such as scheduling, office organization, minor accounting, and assistance in project production. Additional research assistants will also likely be hired in the future to support the Reserve's research and monitoring programs. Since research assistant positions will most likely be supported by outside grant funding, the specific job responsibilities associated with these positions will vary based on the type of grant awarded. Graduate Research Fellowships are another means that the Research Program might choose to use in the future to support its programs, if funding is available for such positions.

Reserve Director

The Reserve Director directs, coordinates, and supervises all aspects of Reserve operations and management including administrative, research, stewardship, education, and training activities. The

Reserve Director is directly responsible for the implementation of the Reserve management plan, supervision of Reserve staff, and acts as a liaison with federal, state, local, private entities, and advisory committees to achieve the goals of the Reserve. The Reserve Director will be a university-funded UTMSI position. The Reserve Director's duties and responsibilities will likely include:

- managing the Reserve operation on a day-to-day basis, preparing grant applications, proposal, budgets, reports, and maintaining necessary records;
- facilitating meetings of the RAB and advisory committees;
- representing the Reserve and its policies at public meetings and hearings;
- overseeing the Research, Stewardship, Education, and Coastal Training programs of the Reserve;
- coordinating with other program managers on activities that might affect the Reserve;
- monitoring day-to-day operation of the Reserve and progress of Research, Stewardship, Education, and CTP plans;
- supervising Reserve staff members;
- overseeing facilities development, site selection, and changes in Reserve boundaries with advice from RAB and other advisory committees;
- preparing required semi-annual, and annual reports and work plans for NOAA and other possible sources of funding;
- directing and coordinating with NOAA on any changes in the Reserve management plan;
- working with NOAA in the development of national policy for the NERRS; and
- preforming additional duties as required.

Research Coordinator

The Research Coordinator oversees the operation and implementation of the Reserve Research Program and interacts with the RAB, UTMSI faculty/students, and other research institutions and individuals to fulfill the research objectives of the Reserve. The Research Coordinator reports to the Reserve Director and also coordinates with the Reserve Education, Stewardship, and CTP coordinators to present scientific data in a user-friendly manner. In addition, the Research Coordinator will maintain close contact with and inform OCM of the progress of NOAA-funded research and monitoring activities. The Research Coordinator is a part-time position funded by UTMSI. The Research Coordinator's duties and responsibilities will include:

- assisting the Reserve Director and other participating agencies and entities in preparing and updating an annual list of priorities for research and monitoring projects and conducting a peer review process for proposals when needed;
- evaluating the results of the peer review process for proposals and making recommendations to the Reserve Director and RAB;
- implementing the Research Program for the Reserve;
- serving as a liaison with the scientific community, promoting data utilization, and acting as the primary contact for scientists performing research in the Reserve;
- coordinating all special studies and research activities within or related to the Reserve;
- coordinating, interpreting, and applying of research results;
- coordinating of volunteer trainings, research assistants and interns, and monitoring/evaluating their performances;
- recommending locations for research and monitoring stations and providing technical advice and assistance to scientists conducting research/monitoring as available by Research staff;

- ensuring that field and photographic records of on-going research activities are maintained;
- representing the Reserve at public meetings;
- working with the Stewardship, Education, and CTP coordinators to develop suitable methods to disseminate Reserve-related information;
- working with NOAA regarding system wide projects (i.e., SWMP);
- developing additional research guidelines and policy statements as new issues arise;
- coordinating with the Reserve Director in the performance of these responsibilities; and
- participating in the development of research and monitoring facilities and the purchase of research and monitoring equipment.

ACTION 4: Solicit funds via grants

The Reserve staff will solicit additional funding through grants or contracts by actively seeking funding opportunities, preparing applications, and working with partners to leverage resources. Many federal agencies periodically announce funding availability for projects that target the protection, preservation, and management of coastal resources and estuarine areas. The Reserve will continually seek opportunities from these agencies. Examples of federal agencies that may fund/support research in the NERR include: the NOAA Coastal Office, NOAA Sea Grant, NOAA Coastal Services Center, the Environmental Protection Agency, U.S. Geological Survey, the Department of the Interior, and the EPA Gulf of Mexico Program. State agencies that are charged with protecting and regulating Texas's coastal resources also occasionally provide funding opportunities to support research efforts. Examples of some of these agencies include: GLO, TPWD, TCEQ, and TWDB. Finally, several private commercial and industrial businesses, as well as non profit organizations, in South Texas support environmental research within the community through grants and contracts. Support for the Reserve by these organizations is strong, and it is anticipated that sources of funding will exist through these groups.

ACTION 5: Develop and operate a program for gifts to enhance Reserve activities

UTMSI and Reserve Director will develop and operate a program to encourage gifts to the Reserve. A gift program can be accomplished by creating a "Friends Group," soliciting donations from organizations, and working with partners to identify potential donors and solicit gifts. A gift program will allow the Reserve to perform activities that enhance Reserve programs. Activities may include hosting notable researchers, recruiting staff, and funding graduate student fellowships.

ACTION 6: Foster partnerships for research

The Reserve offers a permanent place where research institutions may coordinate their projects and compare results. This benefit was recognized immediately and strong partnerships have been formed with numerous organizations since the Reserve designation. However, opportunities still exist to develop additional partnerships and cooperative working agreements with other agencies and institutions. A strong scientific interest in the Reserve exists and will facilitate the development of cooperative agreements between the NERR and other agencies/institutions.

Goal 2: Increase understanding of coastal ecosystems by diverse audiences

OBJECTIVE 2-8: ***Provide oversight and support K-12 and decision maker education and outreach activities***

Oversight of education and outreach activities will be provided by the Reserve Director and the Education Coordinator. Oversight of the CTP will be provided by the Reserve Director and the CTP Coordinator. Support for both education/outreach and CTP activities, such as travel and overhead, will be provided for by Reserve funds.

ACTION 1: Develop, execute, and revise a Reserve management plan

The UTMSI will develop and execute the Reserve management plan. The UTMSI will revise the management plan every five years, and revision of the management plan will update and create new objectives for the Education and CTP plans.

ACTION 2: Obtain advice on the program from the broader community

Advice on the program will be obtained from the broader community through the RAB and special advisory committees. The first advisory committees that were formed by the Education and CTP programs were designed to assist with development of their respective MA/NAs. Additional advisory committees will be formed on an as-needed basis to address specific issues related to these programs. Committee representation will be determined based on the identified need and will include willing representation from targeted stakeholders and constituencies within the region. Advisory committees will be formed to address specific needs of the Reserve staff and will not be required to meet on a regularly scheduled basis. Representation on the committees may change as the needs of the Education and CTP programs develop over time.

ACTION 3: Recruit and maintain staff

The UTMSI will implement the Reserve program by hiring, directing, and maintaining Reserve staff. Implementation of the goals and objectives for the Reserve is dependent upon adequate staffing levels. Although staffing levels may change through time and with availability of resources, a minimum staff is needed to manage and coordinate Reserve activities. Reserve key staff will consist of a Reserve Director, Research Coordinator, Stewardship Coordinator, Education Coordinator, and CTP Coordinator. The functions and responsibilities of the Education Coordinator and CTP Coordinator are described below.

Additional staff positions will be incorporated in the program as adequate funding becomes available. In the future, the Reserve also hopes to hire a full-time Outreach Coordinator to assist with public communication, web design and maintenance, and social media (i.e., Facebook, Twitter, and Flickr). If funding is available, the Reserve will also work to change some educators from part-time to full-time status in order to help with the increasing demand of the educational programs offered by the Reserve. The Reserve also hopes to hire a full time CTP Assistant to assist the CTP Coordinator with the day-to-day implementation of the Coastal Training Program.

Education Coordinator

The Education Coordinator oversees the operation and implementation of the Reserve Education and Volunteer programs, including on-site and outreach activities. The Education Coordinator also interacts with an advisory committee and other environmental education institutions and individuals to identify priorities and fulfill the education objectives of the Reserve. The Education Coordinator reports to the Reserve Director and also coordinates with the Reserve Research, Stewardship, and CTP coordinators to present scientific data in a user-friendly manner. In addition, the Education Coordinator will maintain close contact with and inform OCM of the progress of NOAA-funded education and outreach activities. The Education Coordinator will be a university funded UTMSI position. The Education Coordinator's duties and responsibilities will likely include:

- assisting the Reserve Director and other participating agencies and entities in preparing and updating an annual list of priorities for education and outreach programs to be developed for the Reserve;
- coordinating development of proposals for Reserve education and outreach programs and projects, and conducting a peer review process for the proposal received;

- coordinating approved education and outreach activities within the Reserve and communicating with other reserves, especially relating to education and volunteer programs;
- coordinating advisory committee meetings as needed;
- upon request, advising and coordinating government agencies on particular issues, questions, or projects and their impacts on or relationship to the Reserve;
- assisting in training and supervising volunteers in education programs, and monitoring/evaluating their performance;
- keeping a photographic record of on-going education and outreach activities for use in slide presentations and exhibits;
- representing the Reserve at public meetings, civic groups, professional societies and other environmental organizations upon request, as available;
- working with the Stewardship and Research coordinators to develop suitable methods to disseminate Reserve-related information;
- supervising the work of the Education Program staff;
- working with NOAA to develop national education policy for the NERRS;
- coordinating with the Reserve Director in the performance of these responsibilities; and
- participating in the development of educational facilities, including trails and exhibits, and the purchase of education and outreach equipment.

Coastal Training Program Coordinator

The CTP Coordinator oversees the operation and implementation of the Reserve CTP. The CTP Coordinator also interacts with an advisory committee and other partner agencies and organizations to fulfill the CTP objectives of the Reserve. The CTP Coordinator reports to the Reserve Director and also works closely with the Research, Stewardship, and Education coordinators to develop trainings and present Reserve data in a user-friendly manner. In addition, the CTP Coordinator will maintain close contact with and inform OCM of the progress of NOAA-funded training activities. The CTP Coordinator will be a university funded UTMSI position. The CTP Coordinator's duties and responsibilities will likely include:

- assisting the Reserve Director and other participating agencies and entities in preparing and updating an annual list of priorities for training programs to be developed by the Reserve;
- coordinating development of proposals for Reserve trainings, and conduct a peer review process for the proposal received;
- coordinating approved training activities within the Reserve and communicating with other reserves, especially those within the Gulf of Mexico;
- coordinating advisory committee meetings as needed;
- upon request, advising and coordinating government agencies on particular issues, questions or projects and their impacts on or relationship to the Reserve;
- keeping a photographic record of on-going training programs for use in slide presentations and exhibits;
- working with the Research, Stewardship, and Education coordinators to develop suitable methods to disseminate Reserve-related information;
- working with NOAA to develop national CTP policy for the NERRS; and
- coordinating with the Reserve Director in the performance of these responsibilities.

ACTION 4: Solicit funds via grants

The Reserve staff will solicit additional funding through grants or contracts by actively seeking funding opportunities, preparing applications, and working with partners to leverage resources. Further detail on grant funding is listed in Objective 1-8, Action 4.

ACTION 5: Develop and operate a program for gifts to enhance Reserve activities

UTMSI and the Reserve Director will develop and operate a program to encourage gifts to the Reserve. A gift program can be accomplished by creating a Friends group, soliciting donations from organizations, and working with partners to identify potential donors and solicit gifts. A gift program will allow the Reserve to perform activities that enhance Reserve programs. Activities may include travel and housing scholarships for underserved K-12 schools.

ACTION 6: Foster partnerships for education and training

Since the designation of the Reserve, the Education and Coastal Training programs have formed numerous partnerships for the purpose of enhancing the understanding of estuarine ecosystems by diverse audiences, but numerous opportunities still exist to develop additional partnerships with both education/training providers and end-users. Existing positive relationships between traditional education and training entities already exist and will be strengthened through the development of mutually beneficial programs and activities.

GOAL 3: Promote public appreciation and support for stewardship of coastal resources

OBJECTIVE 3-10*: Provide oversight and support for stewardship activities*

Oversight of the Stewardship Program will be provided by the Reserve Director and Stewardship Coordinator. Support of these activities, such as travel and overhead, will be provided for by Reserve funds.

ACTION 1: Develop, execute, and revise a Reserve management plan

UTMSI will develop and execute the Reserve management plan. UTMSI will revise the management plan every five years with advice from the RAB. Revision of the management plan will update and create new objectives for the Stewardship Program.

ACTION 2: Obtain advice on the program from the broader community

Advice on the Stewardship Program will be obtained from the broader community through the RAB and special advisory committees. Advisory committees will be formed on an as-needed basis to address specific issues related to the Program. Committee representation will be determined based on the identified need and will include willing representation from targeted stakeholders and constituencies within the region. Advisory committees will be formed to address specific needs of the Reserve staff and will not be required to meet on a regularly scheduled basis. Representation on the committees may change as the needs of the Stewardship Program develop over time.

ACTION 3: Recruit and maintain staff

The UTMSI will implement the Reserve program by hiring, directing, and maintaining Reserve staff. Implementation of the goals and objectives for the Reserve is dependent upon adequate staffing levels. Although staffing levels may change through time and with availability of resources, a minimum staff is needed to manage and coordinate Reserve activities. Initially, the Reserve staff will consist of a Reserve Manager, Research Coordinator, Stewardship Coordinator, Education Coordinator, and necessary technical and administrative support staff. The functions and responsibilities of the Stewardship Coordinator are described below.

Additional staff positions will be incorporated in the program as adequate funding becomes available. In the future, the Reserves hopes to hire a full-time Stewardship Assistant to assist the Stewardship Coordinator with implementation of the Stewardship Program.

Stewardship Coordinator

The Stewardship Coordinator oversees the operation and implementation of the Reserve Stewardship Program and interacts with an advisory committee, other institutions, and individuals to fulfill the stewardship goals of the Reserve. The Stewardship Coordinator reports to the Reserve Director and also coordinates with the Research, Education, and CTP coordinators to implement programs. In addition, the Stewardship Coordinator will maintain close contact with and inform OCM of the progress of NOAA-funded stewardship activities. The Stewardship Coordinator will be a university funded UTMSI position. The Stewardship Coordinator's duties and responsibilities will likely include:

- assisting the Reserve Director and other participating agencies and entities in preparing and updating and annual list of priorities for stewardship projects and conducting a peer review process for proposals when needed;
- implementing the Stewardship Program for the Reserve;
- serving as a liaison with the resource management community, promoting data utilization, and acting as the primary contact for resource managers preforming stewardship in the Reserve;
- coordinating advisory committee meeting as needed;
- provide a forum for information exchange with local and state decision makers;
- coordinating all special studies and stewardship activities within or related to the Reserve;
- partnering on habitat restoration activities within the Reserve;
- coordinating and overseeing animal rescue activities within the Reserve;
- assisting in the training of stewardship assistants and interns, and monitoring/evaluating their performance;
- providing technical advice and assistance to resource managers;
- keeping a field journal and photographic records of on-going stewardship activities;
- representing the Reserve at public meetings;
- working with the Research, Education, and CTP coordinators to develop suitable methods to disseminate reserve-related information;
- working with NOAA on NERRS-related projects;
- developing additional stewardship guidelines and policy statements as new issues arise;
- coordinating with the Reserve Director in the performance of these responsibilities; and
- participating in the development of stewardship facilities and the purchase of stewardship equipment.

ACTION 4: Solicit funds via grants

The Reserve staff will solicit additional funding through grants or contracts by actively seeking funding opportunities, preparing applications, and working with partners to leverage resources. Further detail on grant funding is listed in Objective 1-8, Action 4.

ACTION 5: Develop and operate a program for gifts to enhance Reserve activities

UTMSI and the Reserve Director will develop and operate a program to encourage gifts to the Reserve. A gift program can be accomplished by creating a Friends group, soliciting donations from organizations, and working with partners to identify potential donors and solicit gifts. A gift program

will allow the Reserve to perform activities that enhance Reserve programs. Activities may include purchasing land for conservation from willing sellers.

ACTION 6: Foster partnerships for stewardship

The Stewardship Program has benefited from numerous partnerships and collaborations which have been formed since the Program began. However, numerous opportunities exist to develop additional partnerships and cooperative working agreements with neighboring industries, businesses, agencies and institutions. A strong interest in the Reserve exists and will facilitate the development of cooperative agreements between the Reserve and other agencies/institutions.

6.0 Resource Protection Plan

Federal Code of Regulations 15 CFR 921.12 requires Reserve management plans to include a resource protection plan. Protecting the Reserve resources is critical for all programmatic efforts and is vital to the success of the Reserve. This Plan provides a description of (1) the authorities that protect the Mission-Aransas Reserve resources, (2) allowable and unallowable uses per those authorities, (3) uses requiring a permit, and (4) surveillance and enforcement strategies to ensure appropriate use of the Reserve.

6.1 Management Authorities

The Mission-Aransas Reserve is composed of wetland, terrestrial, and marine environments that are owned and managed by a number of different state and federal agencies, as well as private entities. Landowners within the Reserve maintain control of their property and use existing regulations to manage properties. The Reserve relies on rules and regulation from UT, ACND, TPWD, TCEQ, TSSWCB, TWDB, TxDOT, GLO, RRC, Federal Energy Regulatory Commission (FERC), USACE, and USFWS to provide protection for the waters and land areas within its boundaries. Landowners within the Reserve maintain control of their property and use existing regulations of the above mentioned entities to manage their property. Properties within the Reserve boundaries and the associated management authority are described below.

6.1.1 University of Texas at Austin

The Reserve Headquarters is located in the Estuarine Research Center on the UTMSI campus. UT is the state agency responsible for managing the Reserve, and UTMSI staff are responsible for managing the grounds and facilities of the UTMSI campus, including Reserve facilities such as the Estuarine Research Center, Wetlands Education Center, and Estuary Explorium.

In 2006, UT purchased a conservation easement on Fennessey Ranch, a privately owned property that contains numerous valuable upland and wetland habitats. The 3,261-acre Ranch supports diverse wildlife and is designed to be an environmentally friendly business that profits from hunting leases, kayak adventures, and birding/photography trips. The conservation easement (Appendix H) restricts development from occurring and ensures that the valuable habitats of the Ranch will continue to support wildlife and serve as a buffer area for the Mission-Aransas Estuary well into the future. The easement also provides increased access for the research opportunities and educational opportunities that highlight the importance of healthy coastal ecosystems. The *Fennessey Ranch Management Plan* was developed collaboratively by the Reserve and Fennessey Ranch staff to ensure proper implementation of the conservation easement while still allowing for the generation of revenue from native wildlife resources. The Plan is a compilation of individual subject plans that include detailed descriptions of the current uses and state of improvement, as well as management of wildlife, habitat, monitoring, and access. The Plan is updated every five years, and the most recent update was completed in 2015 (Appendix H).

6.1.2 Aransas County Navigation District

The Aransas County Navigation District conserves and develops natural resources of Aransas County's navigational land and coastal waterways, the surface and submerged land deeded to it by letters of patent and acts of the Texas Legislature, and all other land and water resources acquired for the benefit of the citizens of Aransas County. ACND is responsible for maintaining and improving public waterways and public waterfront facilities, such as harbors, boat ramps, fishing piers, and the Rockport Beach. Currently, ACND has five primary facilities under its purview: Rockport Harbor, Fulton Harbor, Cove Harbor, Copano Bay Fishing Pier, and the Rockport Beach. ACND is governed by provisions of the Texas Water Code as administered by the Texas Natural Resource Conservation Commission (ACND, 2013). During the designation process, land owned by ACND (adjacent to the Rockport Beach and Rockport Harbor) was

included within the Reserve boundary to allow for the construction of an outreach center. A cooperative agreement was developed between the Reserve and ACND to allow for the construction of the Bay Education Center on this site.

6.1.3 Texas General Land Office

Oil and Gas Exploration

The State-owned bay waters and wetlands within the Reserve boundary are managed by GLO. The GLO is directly responsible for managing the public lands that were dedicated to the Public School Fund (PSF) by the Texas Constituion of 1876, including state submerged lands. Management responsibilities of PSF lands include sales, trades, leases, and improvements, as well as administration of contracts, mineral royalty rates, and other transactions. These lands generate revenues primarily through oil and gas revenues but also through land sales and leases for surface uses.

In 1991, the Texas Legislature passed the Coastal Coordination Act, which directed the GLO to develop a long-range, comprehensive plan for the coast in cooperation with state agencies, local governments, and coastal citizens. The act prompted GLO to establish the Coastal Coordination Council (CCC), with the goal to oversee the development of the state's coastal management plan, adopt coast wide management policies, and to implement the plan and designate the physical boundaries for the coastal area. GLO and CCC efforts resulted in the Coastal Management Plan (CMP), which is a networked program that links the regulations, programs, and expertise of state, federal, and local entities that manage various aspects of coastal resources (CMP Guide, 2003).

GLO is one of the two primary state agencies that regulate the oil and gas industry. GLO regulates leasing, exploration, and development of oil and gas on state submerged lands by means of the provisions of the GLO oil and gas leases issued. GLO has regulations which state that the exploration, leasing, and production of oil and gas must comply with the policies of the CMP, which sets policies for oil and gas activities that occur within Coastal Natural Resource Areas. There are numerous CNRAs within the Reserve boundaries, including tidal waters, submerged lands, coastal wetlands, submerged aquatic vegetation, oyster reefs, and coastal barriers (Table 6.1). The CMP states that oil and gas in navigable waters are to be conducted in such a manner as to avoid and otherwise minimize adverse effects. The majority of habitats in the Reserve are critical areas, which are defined as coastal wetlands, oyster reefs, hard substrate reefs, submerged aquatic vegetation, tidal sand flats, and mud sand flats. The CMP has established explicit permit authority and detailed guidelines for the operations of oil and gas that protect the natural resources within the Reserve.

Table 6.1. Coastal Natural Resource Areas as designated by the Coastal Coordination Act as the focus of the CMP (Coastal Management Program Guide, 2003).

CNRA	Description
Coastal barrier	An undeveloped area on a barrier island, peninsula, or other protected area, as designated by USFWS.
Coastal historical area	A site that is specifically identified in rules adopted by the Texas Historical Commission as being coastal in character and that is on the National Register of Historic Places or a state archaeological landmark.
Coastal preserve	Any land that is owned by the state and subject to Texas Parks and Wildlife Code, because it is a park, recreation area, scientific area, wildlife refuge, or historic site.
Coastal shore area	An area within 100 feet landward of the high water mark on submerged land.

CNRA	Description
Coastal wetlands	A wetland located seaward of the Coastal Facility Designation Line, within rivers and streams to the extent of tidal influence, or within one mile of the mean high tide line of rivers and streams.
Critical dune area	A protected sand dune complex on the Gulf shoreline within 1,000 feet of mean high tide.
Critical erosion area	An area designated by the Land Commissioner with greater than 2 feet of erosion per year where infrastructure, habitat, public health, safety, or welfare is threatened.
Gulf beach	A beach bordering the Gulf of Mexico that is located inland from the mean low tide line to the natural line of vegetation bordering the seaward shore, or an area of public access.
Hard substrate reef	A naturally occurring hard substrate formation, including a rock outcrop or serpulid worm reef, living or dead, in an intertidal or subtidal area that are discrete and continguous.
Oyster reef	A natural or artificial formation that is composed of oyster shell, live oysters, and other living or dead organisms; discrete, contiguous, and clearly distinguishable from scattered oyster shell or oysters; and located in an intertidal or subtidal area.
Special hazard area	An area having special flood, mudslide or mudflow, or flood-related erosion hazards that are designated by the Federal Insurance Administration under the Flood Insurance Act.

Pelicans perch on a gas platform within the Reserve

Resource Management Codes (RMCs) are assigned to state-owned tracts in Texas bays and estuaries and Gulf of Mexico waters and represent development guidelines for activities within the tracts (see Section 2.6 for tables and figures relating to RMCs within the Reserve). The codes enhance protection of sensitive natural resources by providing recommendations for minimizing adverse impacts from mineral exploration and development activities. RMCs were assigned by state and federal resource agencies (USFWS, NMFS, TPWD, THC, and USACE). RMCs assist potential users of state-owned submerged lands with their project planning efforts and during the Corps permitting process by informing a prospective operator of restrictions that may be included in the Corps permit. Before beginning work on a state tract, lessees may be required to conduct a survey for sensitive habitats and resources. In most cases, tract development may proceed when an applicant demonstrates that the development plan is not inconsistent with the concerns listed in the codes. When impacts to sensitive habitats or resources are unavoidable, development may be allowed, subject to best management practices for mitigation (GLO, 2013e).

GLO and the School Land Board (SLB), which was established by the Texas Legislature in 1939 to help manage mineral lease awards on school lands and the lands dedicated to the PSF, regulate the oil and gas exploration and leases in the Reserve. The GLO and SLB must comply with the policies of the CMP when

approving oil, gas, and other mineral leases and grating surface leases, easements, and permits and adopting rules under the Texas Natural Resources Code, Chapters 32, 33, and 51-53 governing oil and gas exploration and production on submerged lands (Texas Administrative Code (TAC), Title 31, Part 16, Ch 501, Rule §501.1).

Aside from the regulations of the CMP, the GLO also has its own regulations in reference to pollution, and other impacts to natural resources (TAC, Title 31, Part 1, Ch 9, Rule §9.11). GLO states that exploration and leasing of state oil and gas shall be governed by these guidelines:

- All geophysical and geochemical exploration shall be conducted in compliance with all applicable state and federal statutes and regulations relating to pollution of land and water.
- Any physical modification of the surface including, but not limited to, mounding, cratering, or vehicle tracks shall be remedied upon completion of the work and coordinated with and approved by GLO.
- Persons using wheeled or tracked vehicles on state-owned lands shall use reasonable efforts to avoid impact to the area.
- No person operating a vessel, vehicle, or equipment operating under permit shall discharge solid waste (which includes, but is not limited to, non-biodegradable containers, rubbish, or refuse or garbage) into state waters or state-owned lands.
- Prior to conducting any operations, permittees shall coordinate with the appropriate regulatory agencies regarding any operations that could potentially impact state or federally protected species.
- No geophysical surveying or shooting shall be performed within 1,000 feet of a known bird rookery island, as depicted on maps maintained by GLO, between February 15th and September 1st.
- In accordance with Texas Parks and Wildlife Code, §12.301, a permittee or contractor is liable to the state for the value of fish or wildlife taken, killed, or injured by work under a permit.
- Staging areas must be approved by the GLO, and shall not be established in vegetated areas of tidal sand or mud flats, submerged aquatic vegetation, or coastal wetlands, as those terms are defined in §16.1 of this title (relating to Definitions and Scope), or vegetated dune areas.
- Shot holes shall be at least 120 feet below the mudline on submerged lands, unless otherwise authorized in writing by the commissioner.
- No high velocity energy source shall be discharged within 500 feet of any oyster reef, marked oyster lease, marked artificial reef, or marked red snapper bank, or within 500 feet of any dredged channel, dock, pier, causeway, or other structure. Assistance in locating oyster reefs and leases is available from TPWD.
- No shot in excess of 20 pounds shall be discharged within one mile of any pass, jetty, mouth of a river, or other entrance to the Gulf of Mexico from inland waters.
- In areas where geophysical operations have adversely affected the terrain so as to allow or exacerbate erosion, a permittee or contractor shall construct terraces and restore vegetation as directed by guidelines and instructions provided by GLO.

GLO ensures compliance with the above guidelines through permit conditions designed to: (1) avoid adverse impacts to natural resources, minimize unavoidable impacts and (2) compensate for those significant and adverse impacts that may occur during the permitted activity (TAC, Title 31, Part 1, Ch 9, Rule §9.11). The GLO and SLB shall not take a major action that is inconsistent with the following goals or the policies of the TAC coastal protection chapter:

- to protect, preserve, restore, and enhance the diversity, quality, quantity, functions, and values of CNRAs;

- to ensure sound management of all coastal resources by allowing for compatible economic development and multiple human uses of the coastal zone;
- to balance the benefits from economic development and human uses of the coastal zone, the benefits from protecting, preserving, restoring, and enhancing CNRAs, the benefits from minimizing loss of human life and property, and the benefits from public access to and enjoyment of the coastal zone.

Oil Spill Prevention and Response

GLO is the lead state agency for preventing and responding to oil spills in the marine environment as outlined in TAC Title 31, Part 1, Ch 19, Rule §19.13 and designated under the Oil Spill Prevention and Response Act of 1991 (OSPRA), Texas Natural Resources Code, Chapter 40. OSPRA and the Oil Spill Prevention and Response (OSPR) program supports and complements the Oil Pollution Act of 1990 (OPA), Public Law 101-380, which became law in 1990 (GLO, 2013c). A one and one-third cents-per-barrel fee on crude oil loaded or off-loaded in Texas ports funds the OSPR program, which deposits fee proceeds into the Coastal Protection Fund Account (GLO, 2013d). As indicated in its name, the OSPR program emphasizes both the prevention of and response to oil spills. The program maintains an active outreach education effort by visiting schools, associations, and interest groups and teaching that many small, chronic spills can be as detrimental as one large spill.

Funding from Valero Energy was given by GLO to UTMSI for the construction of an oiled wildlife facility

As another prevention step, the OSPR program has completed construction of four oily bilge water reception facilities along the coast. The Oily Bilge Water Reception Facility Program provides operators of recreation and commercial boats with places to dispose of oily water. Further prevention efforts include increased boat and harbor patrols, which have heightened GLO's presence on the waterfront. The OSPR program maintains a comprehensive, unannounced oil spill drill and audit program designed to measure the readiness level of all sectors of the oil handling community: deep draft vessels, pipelines, and shore-based facilities. Facilities and vessel operators are required to address prevention issues, such as leak detection systems, maintenance, and testing and inspection schedules in Oil Spill Prevention and Response plans, the specifics of which are outlined in regulations developed by the program. The second focus of the OSPR program highlights spill response resources directed at stopping, containing, and cleaning oil spills. The program has compiled a massive spills databank that is used to determine resource allocation, preparedness levels, spill profiles, and corrective activities. In preparation for spills, the program has pre-staged response equipment in sensitive and geographically advantageous locations. The program also maintains a substantial inventory of response equipment including mobile command posts, husbandry and wildlife rehabilitation trailers, fire booms, skimmers, vehicles and vessels. The OSPR program also focuses on research and development, Texas Automated Buoy System (TABS), Clean Gulf Conference and Exhibition, on-line vessel database, regulation review, oil spill prevention task, and the Texas oil spill planning and response toolkit.

Regulations of the OSPRA are located in the Natural Resource Code Ch. 40; Texas Administrative Code 31 Ch. 19. It is the policy of the State to protect natural resources and to restore, rehabilitate, replace, and/or acquire the equivalent of these natural resources with all deliberate speed when they have been damaged. It is the intent of the legislature that natural resource damage assessment methodologies be developed for the purpose of reasonably valuing the natural resources of the State of Texas in the event of an oil spill and that

the state recover monetary damages or have actions commenced by the spiller as early as possible to expedite the restoration, rehabilitation, and/or replacement of injured natural resources. The OSPRA contains statutes regarding the following:

§ 40.001. Short Title
§ 40.002. Policy
§ 40.003. Definitions
§ 40.004. Administration of Oil Spill Response and Cleanup
§ 40.005. Administration of Hazardous Substance Spill Response and Cleanup
§ 40.006. Interagency Council
§ 40.007. General Powers and Duties
§ 40.008. Railroad Commission Authority
§ 40.051. Notification
§ 40.052. Hazardous Substances Discharges
§ 40.053. State Coastal Discharge Contingency Plan
§ 40.101. Notification and Response
§ 40.102. Response Coordination
§ 40.103. Assistance and Compensation
§ 40.104. Qualified Immunity for Response Actions
§ 40.105. Equipment and Personnel
§ 40.106. Refusal to Cooperate
§ 40.107. Natural Resources Damages
§ 40.108. Derelict Vessels and Structures
§ 40.109. Registration of Terminal Facilities
§ 40.110. General Terms
§ 40.111. Information
§ 40.112. Issuance
§ 40.113. Suspension
§ 40.114. Contingency Plans for Vessels
§ 40.115. Entry into Port
§ 40.116. Audits, Inspections, and Drills
§ 40.117. Regulations
§ 40.151. Coastal Protection Fund
§ 40.152. Use of Fund
§ 40.153. Reimbursement of Fund
§ 40.154. Coastal Protection Fee; Administrative Costs
§ 40.155. Determination of Fee
§ 40.156. Administration of Fee
§ 40.157. Liability of the Fund
§ 40.158. Exceptions to Liability
§ 40.159. Claims From Discharges of Oil
§ 40.160. Payment of Awards
§ 40.161. Reimbursement of Fund
§ 40.162. Awards Exceeding Fund
§ 40.201. Financial Responsibility
§ 40.202. Response Costs and Damages Liability
§ 40.203. Liability for Natural Resources Damages
§ 40.204. Defenses
§ 40.205. Third Parties
§ 40.251. Penalties
§ 40.252. Administrative Penalties
§ 40.253. Cumulative Enforcement
§ 40.254. Orders and Hearings
§ 40.255. Actions
§ 40.256. Individual Cause of Action
§ 40.257. Venue
§ 40.258. Federal Law
§ 40.301. Interstate Compacts
§ 40.302. Institutions of Higher Education
§ 40.303. Oil Spill Oversight Council
§ 40.304. Small Spill Education Program

Coastal Management Program

The CMP is administered through the GLO and receives funding from NOAA. The program helps to ensure the long-term environmental and economic health of the Texas coast through management of CNRAs

(GLO, 2013a). The CMP administers funds from NOAA to state and local entities to implement projects and program activities related to protecting and restoring the coastal environment. The CMP has several pertinent policies for construction, operation, and maintenance of oil and gas exploration and production facilities in CNRAs. CNRAs are located using several different methods, depending on the resource: photointerpretation of aerial photography in conjunction with field verification (seagrasses, coastal wetlands, tidal flats, and other CNRAs); side-scan sonar (oyster reefs); field surveys (all CNRAs); or a combination of methods. One of the first steps applicants must take for permits, leases, or easements is to locate CNRAs, if any, within the area of proposed action. If CNRAs are found, applicants must take steps to avoid, minimize, restore, enhance, protect, or mitigate for any impacts. The goals of the CMP are:

1. To protect, preserve, restore, and enhance the diversity, quality, quantity, functions, and values of CNRAs.
2. To ensure sound management of all coastal resources by allowing for compatible economic development and multiple human uses of the coastal zone.
3. To minimize loss of human life and property due to the impairment and loss of protective features of CNRAs.
4. To ensure and enhance planned public access to and enjoyment of the coastal zone in a manner that is compatible with private property rights and other uses of the coastal zone.
5. To balance the benefits from economic development and multiple human uses of the coastal zone, the benefits from protecting, preserving, restoring, and enhancing CNRAs, the benefits from minimizing loss of human life and property, and the benefits from public access to and enjoyment of the coastal zone.
6. To coordinate agency and subdivision decision-making affecting CNRAs by establishing clear, objective policies for the management of CNRAs.
7. To make agency and subdivision decision-making affecting CNRAs efficient by identifying and addressing duplication and conflicts among local, state, and federal regulatory and other programs for the management of CNRAs.
8. To make agency and subdivision decision-making affecting CNRAs more effective by employing the most comprehensive, accurate, and reliable information and scientific data available and by developing, distributing for public comment, and maintaining a coordinated, publicly accessible geographic information system of maps of the coastal zone and CNRAs at the earliest possible date.
9. To make coastal management processes visible, coherent, accessible, and accountable to the people of Texas by providing for public participation in the ongoing development and implementation of the Texas CMP.
10. To educate the public about the principal coastal problems of state concern and technology available for the protection and improved management of CNRAs.

Oil and gas exploration and production on submerged lands shall also comply with the CMP, including the following policies: (1) in or near critical areas, facilities shall be located and operated and geophysical and other operations shall be located and conducted in such a manner as to avoid and otherwise minimize adverse effects, including those from the disposal of solid waste and disturbance resulting from the operation of vessels and wheeled or tracked vehicles, whether on areas under lease, easement, or permit or on or across access routes thereto; (2) where practicable, buffer zones for critical areas shall be established and directional drilling or other methods to avoid disturbance, such as pooling or unitization, shall be employed; (3) lessees, easement holders, and permittees shall construct facilities in a manner that avoids impoundment or draining of coastal wetlands, if practicable, and shall mitigate any adverse effects on coastal wetlands impounded or drained in accordance with the sequencing requirements in this subsection; (4) and upon completion or

cessation of operations, lessees, easement holders, and permittees shall also remove facilities and restore any significantly degraded areas to pre-project conditions as closely as practicable, unless facilities can be used for maintenance or enhancement of CNRAs or unless restoration activities would further degrade CNRAs (TAC, Title 31, Part 16, Ch 501, Rule §501.14).

In reference to discharges of wastewater and waste disposal from oil and gas exploration and production activities, the CMP dictates the following regulations: (1) no new commercial oil and gas waste disposal pit shall be located in any CNRA; (2) oil and gas waste disposal pits shall be designed to prevent releases of pollutants that adversely affect coastal waters or critical areas; (3) all discharges shall comply with all provisions of surface water quality standards established by the TCEQ; (4) to the greatest extent practicable, new wastewater outfalls shall be located where the discharge will not adversely affect critical areas; (5) and existing wastewater outfalls that adversely affect critical areas shall be either discontinued or relocated so as not to adversely affect critical areas within two years of June 15, 1995 (TAC, Title 31, Part 16, Ch 501, Rule §501.14).

The CMP also states that GLO regulations governing prevention of, response to, and remediation of coastal oil spills shall provide for measures to prevent coastal oil spills and to ensure adequate response and removal actions. GLO regulations for certification of vessels and facilities that handle oil shall be designed to ensure that vessels and facilities are capable of prompt response and adequate removal of unauthorized discharges of oil. GLO regulations adopted pursuant to OSPRA shall be consistent with the State Coastal Discharge Contingency Plan adopted pursuant to OSPRA; and the National Contingency Plan adopted pursuant to the Federal Water Pollution Control Act, 33 United States Code Annotated, Chapter 26. GLO also rules under OSPRA governing the assessment of damages to natural resources injured as the result of an unauthorized discharge of oil into coastal waters shall provide for reasonable and rational procedures for assessing damages and shall take into account the unique circumstances of the spill incident. The cost of assessing the damages shall not be disproportionate to the value of the injured resources. Plans for the restoration, rehabilitation, replacement, or acquisition of equivalent resources shall provide for participation by the public and shall be designed to promote the restoration of the injured resources with all deliberate speed.

GLO rules must be consistent with other state rules and policies and with the CMP goals and policies (TAC, Title 31, Part 16, Ch 501, Rule §501.14). Consistency review is often required to ensure that all local, state, and federal activities comply with CMP goals and policies. The process for conducting consistency reviews addresses four questions: (1) is the proposed project within the CMP boundary; (2) will the proposed project adversely affect CNRAs; (3) is the proposed project subject to review; and (4) is the proposed project consistent with the goals and policies of the CMP?

Local consistency review includes coastal cities and counties with authority under Texas Open Beaches Act (TEX. NAT. RES. CODE ANN. Ch. 61), Dune Protection Act (TEX. NAT. RES. CODE ANN. Ch. 63), and Land Office's beach/dune rules (31 TAC Ch. 15). These coastal cities and counties are responsible for permitting and issuing certificates in the beach/dune system and must ensure that CNRAs will not be adversely affected by a proposed action. These actions are limited to construction in the beach/dune, coastal shore protection, and closure, relocation, or reduction in public beach access. State consistency review includes the networked state agencies and subdivisions. Each state agency proposing an action subject to the CMP must ensure that the action is consistent in writing, such as an order, permit, or other document approving or authorizing the document. Federal consistency review includes actions undertaken, licensed, permitted, or funded by a federal agency. The following listed actions are subject to consistency review: (1) federal actions - licenses or permits issued by federal agencies; (2) federal activities and development projects - functions performed by or for a federal agency; and (3) federal assistance - state and local government applications for federal assistance.

6.1.4 U.S. Fish and Wildlife Service

The majority of dry land within the Reserve resides in ANWR (or Refuge). The Refuge consists of more than 115,000 acres of uplands and wetlands and is managed by USFWS. The Refuge consists of the following units: Aransas, Matagorda Island, Myrtle-Forester Whitmire, Lamar, and Tatton. The Refuge is open to the public and contains numerous trails for walking and wildlife viewing (Figures 6.1 and 6.2). The mainland portion of the Refuge can be accessed by a paved roadway, while other portions of the Refuge are only accessible by watercraft. Special Use Permits are required in order to conduct authorized scientific research, generate data, or conduct wildlife management and rehabilitaion activities. Permits must be submitted at least three months in advance to the Wildlife Biologist at ANWR for approval.

Economic uses of ANWR are primarily cattle grazing, and oil and gas development. Grazing is permitted on Myrtle-Foester Whitmire Unit (3,240 acres) and is used as a management tool, not for economic returns. With the exception of a few scattered tracts, mineral rights on the Aransas and Matagorda Island are still outstanding. Oil and gas wells are present ANWR, along with the necessary pipelines, storage, and processing facilities (Figure 6.3). Regulations for mineral operations on the ANWR are bound to GLO and RRC of Texas regulations. In addition, the mineral recovery operations on ANWR are conducted so as to minimize impact. At the request of the GLO, state and federal biologists compiled a list of restrictions for each tract on the Refuge. There are drilling restrictions in many parts of the Refuge, including St. Charles Bay, during October 15, through April 15. There is no seismic exploration allowed on Whooping Crane management units between October 15, and April 15, which is when the Whooping Cranes are typically present at the Refuge. Restrictions on the tracts surrounding the Refuge are such that development of oil and gas resources is almost impossible from within the tracts. Oil companies bidding on these tracts are well aware of the restrictions, but hope that the USFWS will permit certain activities on Refuge lands. By law, no federal

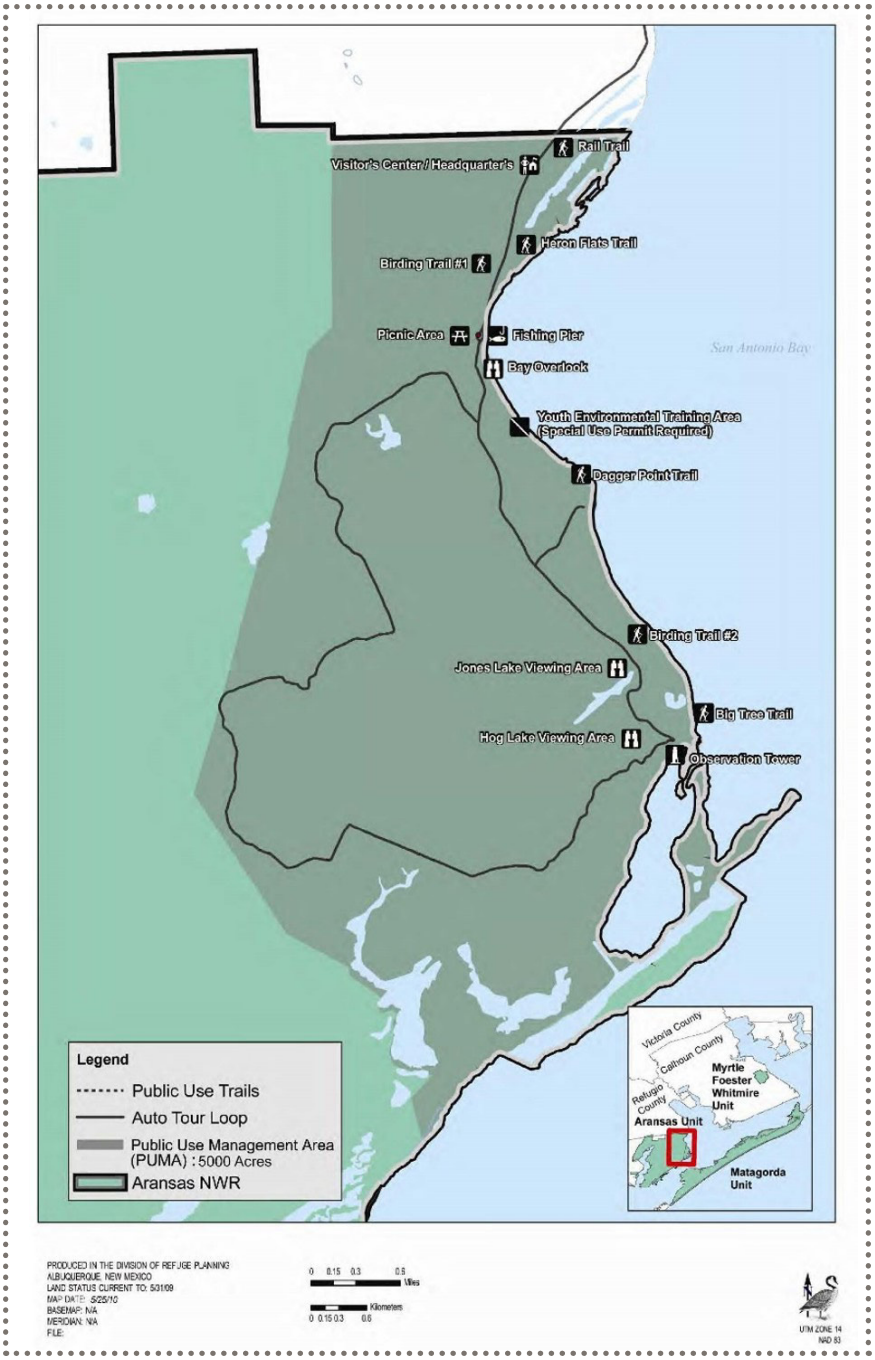


Figure 6.1. Map of public access roads and trails at ANWR. (ANWR Comprehensive Conservation Plan and Environmental Assessment, 2011)

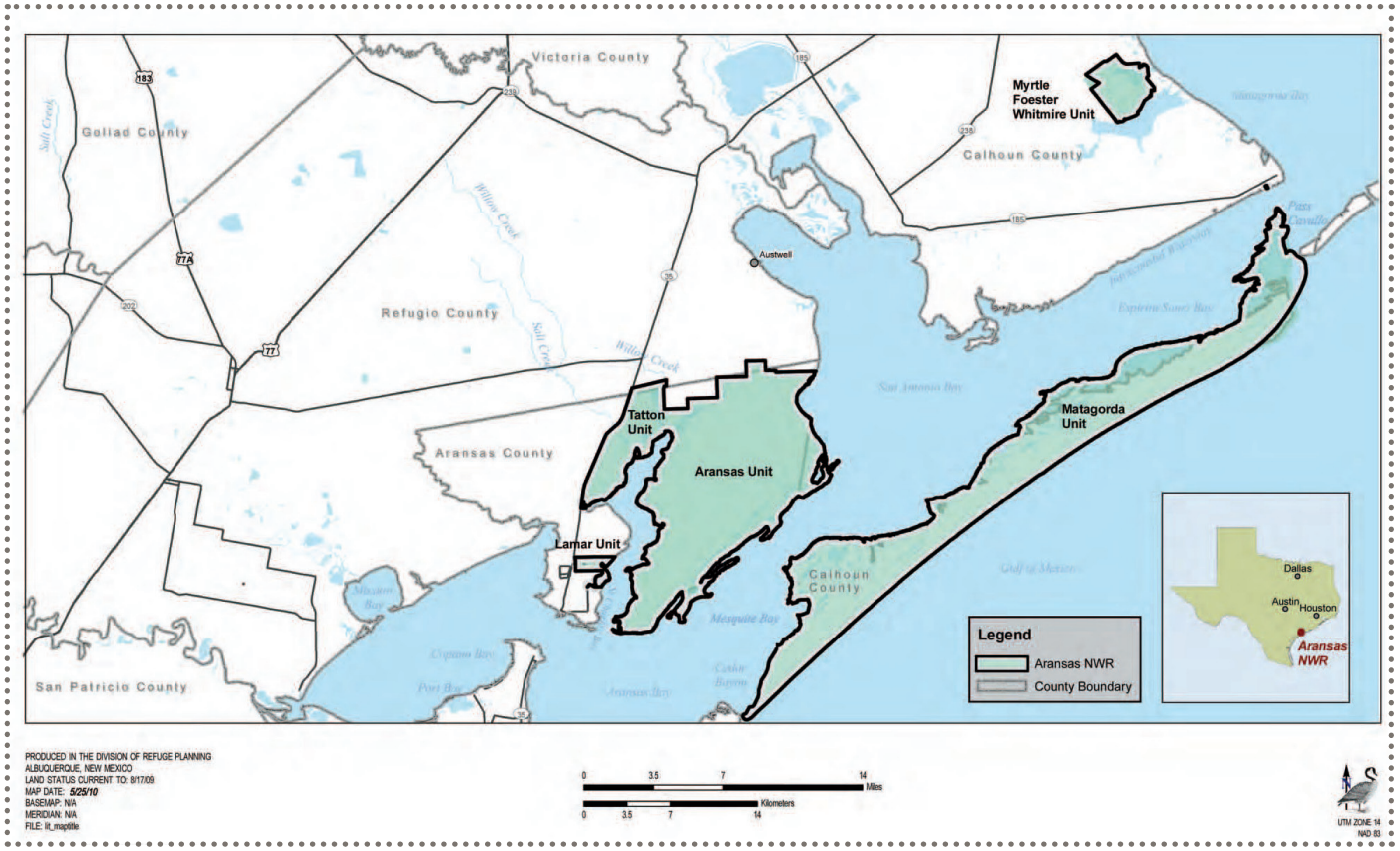


Figure 6.2. Map of ANWR units. (ANWR Comprehensive Conservation Plan and Environmental Assessment, 2011)

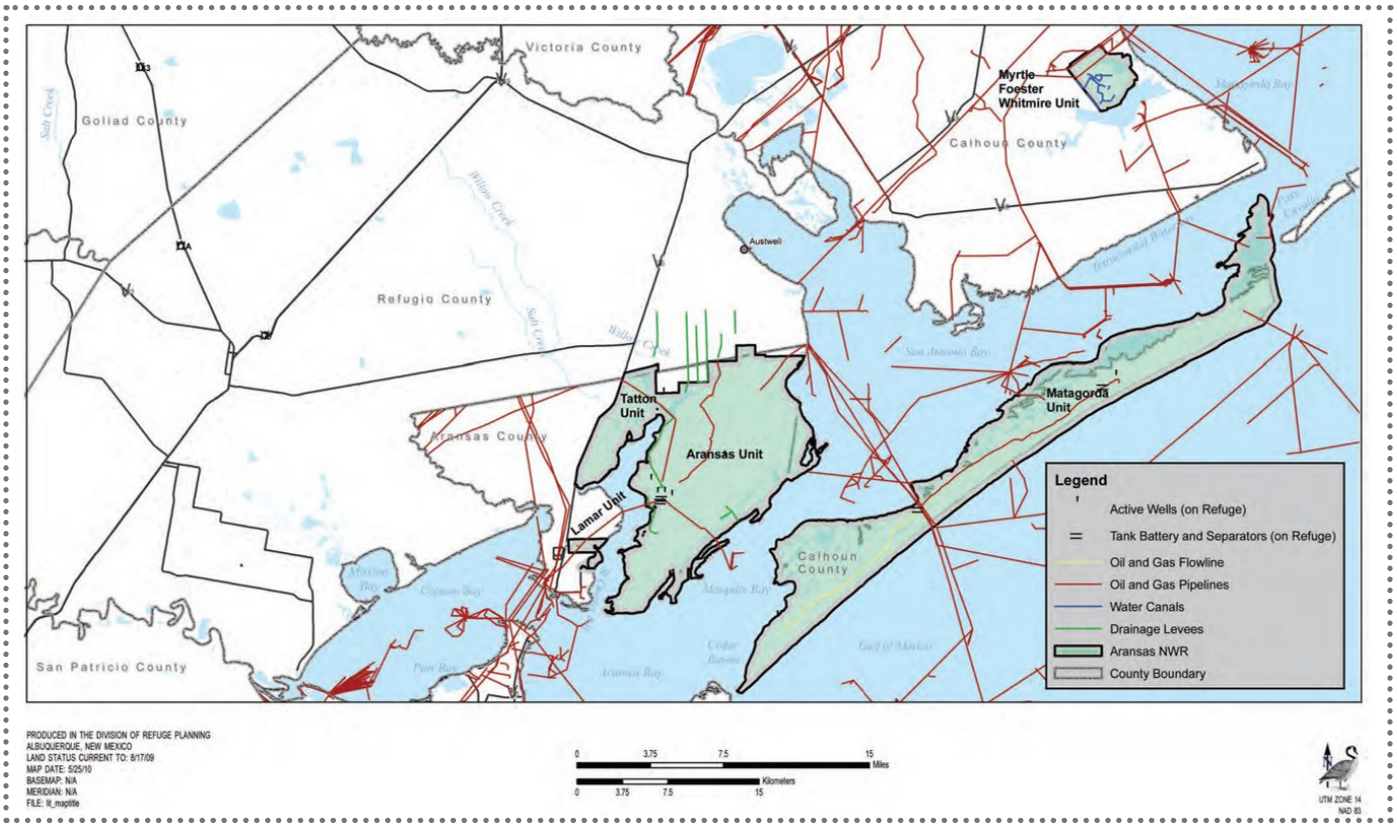


Figure 6.3. Map of oil and gas activity at ANWR. (ANWR Comprehensive Conservation Plan and Environmental Assessment, 2011)

agency may authorize any action that may jeopardize an endangered species or adversely modify critical habitat or habitat that may in the future be critical to the survival and recovery of an endangered species. It is believed by the USFWS that the zoning and special restrictions of the refuge imposed on the operator will protect endangered species utilizing the refuge (ANWR, 1986).

6.1.5 Texas Parks and Wildlife Department

The mission of the TPWD is to manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing, and outdoor recreation opportunities for the use and enjoyment of present and future generations (TPWD, 2013c). TPWD regulates recreational and commercial fishing and hunting in Texas and manages GISP within the Reserve boundary. Management regulations from TPWD have become increasingly restrictive over time in an attempt to offset commercial and recreational fishing pressures. In an attempt to increase species abundance, several fish species were designated as a game species and then banned against sale (i.e., red drum, goliath grouper, blue marlin, white marlin, muskellunge, northern pike, sailfish, sauger, spotted seatrout, snook, longbill spearfish, tarpon, and walleye).

Signs warn that seagrass is protected by law

In June of 2000, Redfish Bay, parts of which are within the Reserve boundary, was designated as a "State Scientific Area" by the Texas Parks and Wildlife Commission (TPWC) for the purpose of protecting and studying the native seagrasses in the area. TPWD regulates the Redfish Bay State Scientific Area (RBSSA) and on May 1, 2006, a rule went into effect making it illegal to destroy any of the five species of seagrasses found throughout RBSSA (TPWD, 2013d). In an effort to further protect seagrasses, a new TPWD regulation was passed by the 83rd Texas Legislature prohibiting the uprooting of seagrass with an outboard motor propeller along the entire Texas coast, which went into effect on September 1, 2013. The regulation states that throughout Texas, causing or allowing seagrass to be uprooted is a Class C Misdemeanor subject to a fine of up to $500 (TPWD, 2013e). Alongside the new rules, TPWD staff will continue and expand a concerted public education campaign including extensive efforts to identify and mark access points into the area to minimize seagrass loss.

Commercial fishing rules for time, area, and gear type have been enacted and enforced within the Reserve (Table 6.2). Although recreational and commercial fishing exert pressures on the fisheries, there are sufficient rules and regulations by state agencies to maintain a sustainable yield and manage the fisheries in the Reserve. The current bag and length limits for recreational and commercial fishing that are regulated by TPWD are listed in Table 6.3.

Table 6.2. History of area and gear restrictions on commercial harvest of finfish in the Reserve. Table is adapted from Tunnell et al. (1996) and contains the effective date (month/year) of the regulation.

Date	Regulation
11/1977	Nets and trotlines prohibited on weekends (1 pm Fridays to 1 pm Sundays)
12/1979	Fish taken incidental to shrimp harvest may be retained EXCEPT red drum and spotted seatrout caught in inside waters with a trawl between 16 Dec. and 28 Feb.
7/1980	Monofilament nets banned
9/1980	Gill nets banned in state waters of Gulf

Date	Regulation
10/1980	Trammel nets, gill nets, and drag seines prohibited in waters of Port Bay, St. Charles Bay, and Aransas County portions of Copano and Redfish Bays. All remaining waters of Aransas County closed to gill nets
5/1981	Commercial sale of red drum or spotted seatrout prohibited
9/1982	Illegal to keep red drum or spotted seatrout caught in any net except a dip net
9/1982	Illegal to retain red drum or spotted seatrout caught in trotline other than a sail line
9/1988	Gill nets, trammel nets, and bag seines banned in Texas coastal waters
3/1991	Summer trotline ban is repealed

Table 6.3. Recreational bag and length limits for saltwater fish, crabs, and oysters from TPWD.

Species	Daily Bag	Length in Inches (Minimum - Maximum)
Amberjack, Greater	1	34 – No limit
Bass; striped, its hybrids and subspecies	5 (in any combination)	18 – No limit
Catfish: channel and blue catfish, their hybrids and subspecies	25 (in any combination)	12 – No limit
Catfish, flathead	5	18 – No limit
Catfish, gafftopsail	No limit	14 – No limit
Cobia	2	37 – No limit
Drum, black*	5	14 - 30
Drum, red**	3	20 - 28
Flounder: all species, their hybrids and subspecies***	5/2	14 – No limit
Grouper, gag	2	22 – No limit
Grouper, goliath (formerly called Jewfish)	0	Catch and release only
Mackerel, king	2	27 – No limit
Mackerel, Spanish	15	14 – No limit
Marlin, blue	No limit	131 – No limit
Marlin, white	No limit	86 – No limit
Mullet: all species, their hybrids and subspecies****	No limit	No limit – 12 (during Oct., Nov., Dec. and Jan.)
Sailfish	No limit	84 – No limit
Seatrout, spotted*****	10 (all waters north of FM 457 in Matagorda County) / 5 (all waters south of FM 457)	15 -25
Shark: Atlantic sharpnose, blacktip, bonnethead******	1	24 – No limit
Shark: other allowable species******	1	64 – No limit
Sheepshead	5	15 – No limit
Snapper, lane	No limit	8 – No limit
Snapper, red*******	4	15 – No limit
Snapper, vermilion	No limit	10 – No limit

Species	Daily Bag	Length in Inches (Minimum - Maximum)
Snook	1	24 – 28
Tarpon	1	85 – No limit
Blue Crab	No limit	5
Stone Crab (right claw only)	No limit	2.5 inch claw
Ghost shrimp	20	No limit
Oyster********	2 sacks (defined as 110 pounds of oysters including the sack)	3 - No limit
* No more than one black drum over 52 inches may be retained per person per day and counts as part of the daily bag limit and possession limit.		
**Red drum special regulation: During a license year, one red drum over the stated maximum length limit may be retained when affixed with a properly completed Red Drum Tag and one red drum over the stated maximum length limit may be retained when affixed with a properly completed Bonus Red Drum Tag. Any fish retained under authority of a Red Drum Tag or a Bonus Red Drum Tag may be retained in addition to the daily bag and possession limit as stated above.		
*** Flounder special regulation: Daily bag is 5 fish except for the period Nov. 1-30 when the daily bag is 2 fish and flounder may be taken only by pole and line; and from Dec 1-14, when the daily bag limit is 2 fish and flouder may be taken by any legal means. Possession limit is equal to the daily bag.		
**** May not take from public waters, or possess on board a boat, mullet over 12 inches during October, November, December, and January. No limits apply during other months.		
***** Special regulation: No more than one spotted seatrout over the state maximum length may be retained per person per day and counts as part of the daily bag and possession limit.		
****** Special regulation: The daily bag limit is 1 fish for all allowable shark species including Atlantic sharpnose, blacktip, and bonnethead.		
******* Red snapper may be taken using a pole and line, but it is unlawful to use any kind of hook other than a circle hook when using natural bait.		
******** Oyster season is Nov 1 - Apr 30, sunrise to 3:30 pm coastwide. Oysters may be taken by hand, with tongs, or by oyster dredge (may not be more than 14 inches in width).		

Regulations for mineral operations on TPWD managed lands are bound to the goals and policies of the CMP and RRC regulations. Oil and gas development on TPWD lands requires a surface lease agreement between the mineral rights owner and TPWD. It is in this surface lease agreement that access routes, staging areas, times of work, and compensation for potential impacts to natural and cultural resources and visitor experiences are defined. In addition, the staff guidelines for mineral recovery operations on TPWD lands state that operations shall be conducted so as to minimize impact and shall be approved by the land manager. Under general provisions, the guidelines state that TPWD retains the right to make special provisions to protect sensitive resources or to minimize potentially adverse impacts. The general provisions also state that reasonable precautions, including consultation with the land manager, shall be taken to avoid disturbance of fish, wildlife, or critical plant resources during mineral recovery operations. Mineral operations may also be prohibited during nesting, breeding, or migration activities of specific species identified by the land manager. Restoration of activity sites to preconstruction condition is also required on TPWD managed lands.

TPWC adopted regulations in 1996 to govern the health, safety, and protection of persons and property within state parks, historical parks, and scientific areas, including encompassed waters, to be administered by TPWD (TPWD, 2013f). The regulations include the following:

- Litter Abatement Act: A person commits an offense if that person disposes of trash, junk, garbage, refuse, or other solid waste on public or private property or into inland or coastal waters of Texas without written consent of the owner, the owner's agent, or the public official in charge of the property water. A person who commits an offense under this section is, on conviction, subject to a fine of not less than $50 nor more than $400.
- Water Code: No person may discharge, or cause or permit the discharge of any waste into or adjacent to any water in the state, which causes or which will cause water pollution unless the waste is discharged in compliance with a permit or order issued by TPWD or the RRC).
- General: It is an offense for any person to willfully mutilate, injure, destroy, pick, cut, remove, or introduce any plant life except by permit issued by the director. It is an offense for any person to take, remove, destroy, deface, tamper with, or disturb any rock, earth, soil, gem, mineral, fossil, or other geological deposit except by permit issued by the director.

TPWD is designated as the state trustee for aquatic resources, but it has no direct regulatory authority to ensure water quality and quantity for fish, wildlife, and recreational sources. TPWD provides recommendations to the TCEQ on scheduling of instream flows and freshwater inflows, as well as recommendations regarding permit conditions and mitigation requirements to protect fish and wildlife resources.

6.1.6 Coastal Bend Land Trust / Coastal Bend Bays & Estuaries Program

CBLT is a 501(c)3 organization administered by CBBEP. CBLT owns and manages Buccaneer Cove Preserve, which is located at the mouth of the Aransas River. CBBEP owns additional properties within this same area of the Reserve, along with properties on the Lamar Peninsula near the Holiday Beach subdivision (see Section 2.6). Through acquisition of priority conservation areas, the CBLT and CBBEP strive to preserve and enhance native wildlife habitat of the Coastal Bend region of Texas. Currently, the properties mentioned above are held for conservation, but in the future they may be used for educational purposes for area schools (CBBEP, 2013).

6.1.7 U.S. Army Corps of Engineers

USACE is one of the regulatory agencies for waterway transportation. The primary objectives of the USACE are: (1) plan, design, and construct river and harbor, multiple purpose, and flood control works; (2) operate and maintain flood control and navigation facilities and installations; and (3) administer laws for the protection and preservation of navigable waters and wetlands.

The Mission-Aransas Reserve is within the Galveston District of the Southwestern Division. The Galveston District administers the federal regulatory program, governing work on structures in navigable waters of the U.S. and controlling discharge of dredged or fill material in coastal and inland waters and wetlands. USACE is also responsible for initiating studies of various water resources related to projects. The studies involve flood risk management, navigation, shore protection, environmental restoration, and recreation. The Galveston District puts every project through rigorous environmental scrutiny designed to protect and enhance the area's well-being. The entire Gulf Intracoastal Waterway (GIWW) is excluded from the Reserve boundary, but it is adjacent to the Reserve core and buffer areas. The USACE, under the authority of the Flood Control Act of 1970, conducts Section 216 Studies. These studies review and look at specific water resources projects that may have changed because of physical or economic reasons. The Reserve falls into the Port O'Connor to Corpus Christi Section 216 Study area.

6.1.8 Federal Energy Regulatory Commission

The liquefied natural gas terminal activities within the Reserve are regulated by the FERC. The FERC's responsibilities include:

- Regulations of pipeline, storage, and liquefied natural gas facility construction;
- Regulation of natural gas transportation in interstate commerce;
- Issuance of certificates of public convenience and necessity to prospective companies providing energy services or constructing and operating interstate pipelines and storage facilities;
- Regulation of facility abandonment;
- Establishment of rates for services;
- Regulation of the transportation of natural gas as authorized by the Natural Gas Policy Act and the Outer Continental Shelf Lands Act; and
- Oversight of the construction and operation of pipeline facilities at U.S. points of entry for the import or export of natural gas.

The FERC also helps safeguard the environment by managing permits through the NEPA process. FERC also determines the range of environmental issues requiring analysis and holds scoping meetings when appropriate.

6.1.9 Railroad Commission of Texas

Railroad Commission of Texas regulates the oil and gas production in the Reserve. Additionally, the RRC works with TCEQ to regulate the discharge of effluents into state waters. In regard to access of property within the Reserve, the RRC or its representatives have access to come upon any lease or property operated or controlled by an operator, producer, or transporter of oil, gas, or geothermal resources and to inspect any and all leases, properties, and wells and all records of said leases, properties, and wells. Designated agents of the commission are authorized to conduct any tests on any well at any time necessary to conservation regulation, and the owner of such well must do all things that may be required of them by the commission's agent to enable such tests in a proper manner (TAC, Title 16, Part 1, Ch 3, Rule §3.2).

Activities by the RRC of oil, gas, or geothermal resources in the coastal zone must be consistent with the CMP. Such activities include disposal of oil and gas waste in a pit, discharge of oil and gas wastes to surface waters, compliance with applicable water quality requirements for federal permits for development (including pipelines) in critical areas, dredging, and dredged material disposal. Aside from the regulations of the CMP, the Railroad Commission also has its own regulations in reference to pollution prevention. These regulations state that the operator of oil, gas, or geothermal resources shall not pollute the waters of the Texas offshore and adjacent estuarine zones (saltwater bearing bays, inlets, and estuaries) or damage the aquatic life therein. Particularly, the disposal of liquid waste material into the Texas offshore and adjacent estuarine zones shall be limited to saltwater and other materials which have been treated, when necessary, for the removal of constituents that may be harmful to aquatic life or injurious to life or property.

6.1.10 Texas Commission on Environmental Quality

TCEQ sets the standards for surface water quality for bodies of water within the state of Texas (subject to approval by the U.S. Environmental Protection Agency), including within the Reserve boundary. TCEQ implements those standards by monitoring and assessing surface water resources and by regulating sources of pollution. In conjunction with the Railroad Commission of Texas, TCEQ is also responsible for regulating the discharge of effluents into state waters. TCEQ requires that there be no discharge of oil and gas waste to surface waters that may cause of violation of the Texas Surface Water Quality Standards, codified at TAC, Title 30, Ch 307. TCEQ standards state that no discharge of oil, grease, or related residue is allowed that

will produce a visible film of oil or globules of grease on the surface or coat the banks or bottoms of the watercourse, or cause toxicity to human life, aquatic life, or terrestrial life. In reference to brine discharge, salinity gradients in estuaries shall be maintained to support attainable estuarine-dependent aquatic life uses (TAC, Title 30, Ch 307, Rule §307.4). In addition, no oil or other hydrocarbons, including deck wash, and oil based drilling muds, in any form or combination with other materials or constituent shall be disposed of into the Texas offshore and adjacent estuarine zones. Immediate corrective action shall be taken in all cases where pollution has occurred. An operator responsible for the pollution shall remove immediately such oil, oil field waste, or other pollution materials from the waters and the shoreline where it is found. Such removal operations will be at the expense of the responsible operator (TAC, Title 16, Part 1, Ch 3, Rule §3.8).

In response to growing concern over the quality and quantity of surface waters in the state, the Texas Legislature enacted Senate Bill 3 in 2007 to create a stakeholder process for establishing environmental flow standards for rivers and bays. The legislation charged TCEQ with overseeing the stakeholder process and establishing an Environmental Flows Advisory Group to implement legal environmental inflow standards for each of the major basin and bay systems in Texas.

TCEQ is responsible for processing and acting on applications for permits to use the state's surface water (known as "water rights"), including any applications to transfer surface water from one river basin to another (known as "interbasin transfers"). TCEQ is also responsible for developing models, referred to as "Water Availability Models" or WAMs, to determine the available amount of surface water in the various river basins of the state. Additionally, TCEQ monitors River Authorities, which are regional entities designed to protect and monitor Texas' rivers for the state's inhabitants and ecosystems. The primary function of River Authorities is to conserve and distribute the state's surface waters and they are accountable to the Texas Legislature.

6.1.11 Texas State Soil and Water Conservation Board

TSSWCB administers the state's soil and water conservation law and coordinates conservation and non-point source water pollution abatement programs throughout the state. In the 1970s the agency was designated as the lead state agency for addressing non-point source pollution from agricultural operations. TSSWCB employs the Water Quality Management Plan Program to combat non-point source water pollution through site-specific plans developed and approved by Soil and Water Conservation Districts for agricultural or silvicultural lands. Water Quality Management Plans include appropriate land treatment practices, production practices, management measures, technologies, or combinations thereof. TSSWCB also must adhere to the Coastal Management Program (TSSWCB, 2013).

6.1.12 Texas Water Development Board

TWDB is responsible for water planning and administrating water financing for the state. TWDB was established in 1957 to provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas. As part of its mission, TWDB develops the state-wide water plan and guides regional water planning efforts. The Reserve is in water planning district N, the Coastal Bend Region (TWDB, 2012).

In 2002, TWDB designated 16 Groundwater Management Areas (GMAs) covering the entire state. GMAs were created to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater and of groundwater reservoirs and to control subsidence caused by withdrawal of water. The majority of the Reserve is within GMA 15.

In 1947, the Texas Legislature authorized the creation of Groundwater Conservation Districts (GCDs) to conserve and protect groundwater. GCDs have little-to-no regulatory authority, however, in 1997, the

state Legislature recognized the GCDs as the preferred method of determining, controlling, and managing groundwater resources. The Texas Water Coded statue indicates that the purpose of GCDs is to provide for the conservation, preservation, protection, and recharge of underground water and prevent waste and control subsidence caused by pumping water. Currently, Aransas County, the county where most of the Reserve land is located, is the only county in the Coastal Bend without a GCD (Coastal Bend Regional Water Planning Group, 2010). GCDs are required by law to develop and adopt a groundwater management plan. The goals of the plan are to provide for efficient use of groundwater, control and prevent waste and subsidence (the lowering of land elevation due to extracting too much water beneath it), and address issues such as conjunctive water use, natural resources, drought conditions, and conservation (Coastal Bend Regional Water Planning Group, 2010). While no state agency has the right to regulate the production or use of groundwater, GCDs can provide some local controls.

6.1.13 Texas Department of Transportation

TxDOT is the state agency charged with providing safe, effective, and efficient movement of people and goods in the state. TxDOT also acts as the non-federal sponsor for the USACE, and the Section 216 Studies involving the Gulf Intracoastal Water Way (GIWW) in Texas. For the Texas portion of the GIWW, the waterway is divided into five separate Section 216 study areas. The primary objectives of TxDOT for the GIWW are: (1) support the marine commerce and economy of the state by providing for the shallow draft navigation of the state's coastal waters in an environmentally sound manner; (2) prevent waste of publicly and privately owned natural resources; (3) prevent or minimize adverse impacts on the environment; and (4) maintain, preserve, and enhance wildlife and fisheries (Texas Transportation Code Title 4. Navigation Subtitle A. Waterways and Ports, Ch 51. Texas Coastal Waterway Act § 51.001. Acts 1995, 74th Leg., Ch 165, § 1, eff. Sept. 1, 1995).

6.2 Allowable and Unallowable Uses

6.2.1 Oil and Gas Exploration and Production

Oil and gas exploration and production are allowed within the Reserve and are regulated by GLO and the Railroad Commission of Texas (Figure 6.4). Prior to the beginning of any oil and gas operation, permit(s) must be obtained from the USACE. The Nationwide Permits (NWP) required for oil and gas operations in bays and estuaries include NWP 6 for seismic activities and NWP 44 for mining activities. The NWPs have several general conditions relevant to environmental protection. Some of these conditions include compliance with laws regarding water quality, coastal zone management, endangered species, historic properties, shellfish beds, mitigation, waterfowl breeding areas, and designated critical resource waters. The water quality and endangered species laws are two laws that more readily hold up permit approval.

In Texas, mining permit activities must be authorized by TCEQ, which sets the state water quality standards for discharges. These standards are based on the Clean Water Act and require discharges to be consistent with the CMP. The Endangered Species Act requires any seismic or mining permit that may allow adverse impacts to threatened or endangered species or their corresponding critical habitats to be approved by USFWS before the permit is authorized. General conditions of NWPs designate a Reserve site as critical resource waters. Because of this designation, no discharges of dredged or fill material are allowed within the site unless it is authorized by the USFWS for compliance with threatened or endangered species. In addition, compliance with the CZMA through the CMP is required for seismic and mining permit approval (33 CFR 330.4(d)). A general permit is also required for directional drilling (permit 14114). A directional drilling permit is bound by laws regarding endangered species, historic properties, mitigation, and waterfowl breeding areas.

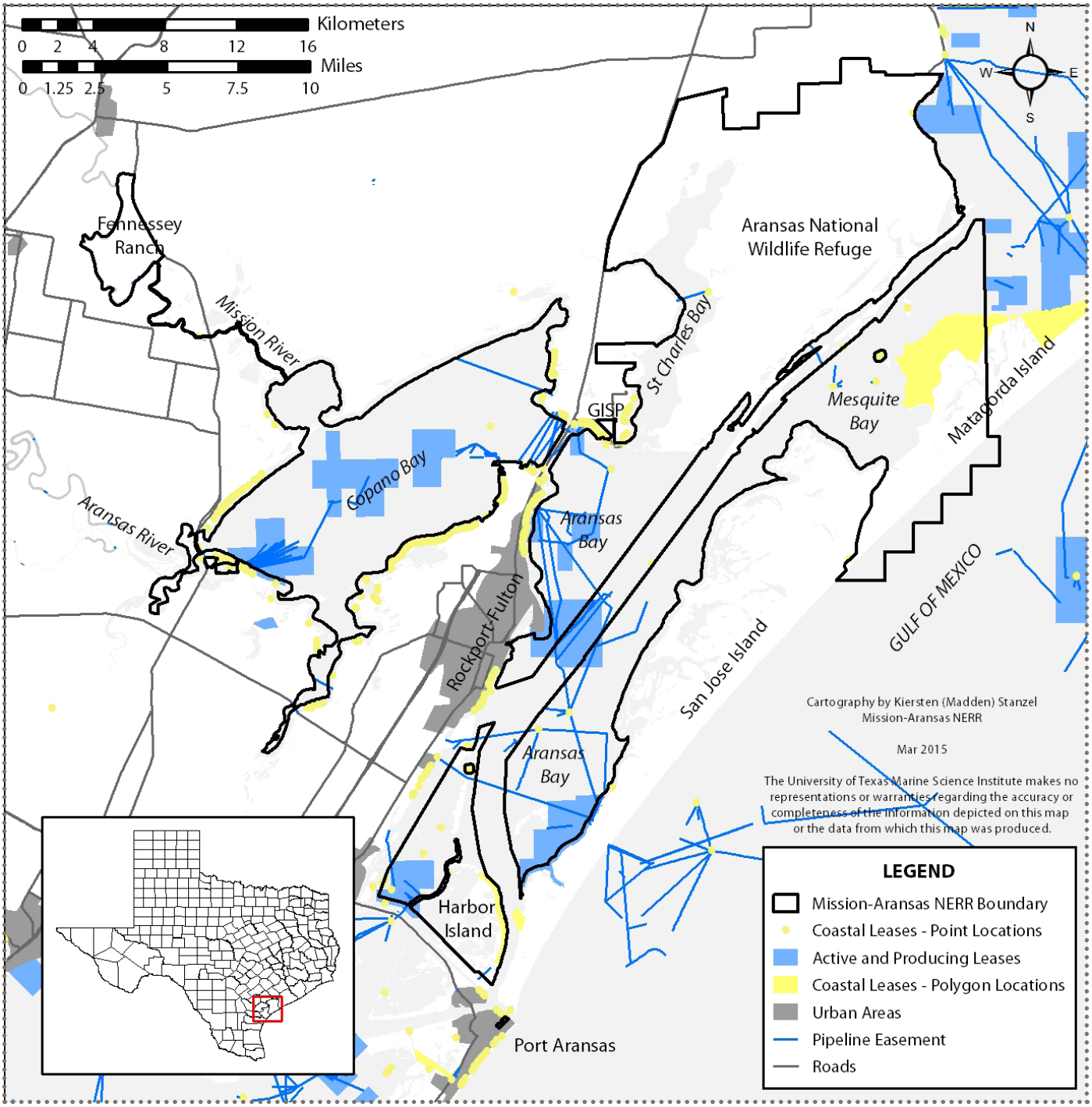


Figure 6.4. Locations of GLO coastal leases within the Mission-Aransas Reserve.

6.2.2 Coastal Development

The majority of the area within the Reserve is owned by GLO and permits are required to establish infrastructure (including research infrastructure) within state submerged lands and leases must be requested through the GLO leasing division. GLO is responsible for issuing various types of permits, easements, and leases on all state-owned coastal lands, including submerged lands in bays and the tidewater limits of coastal lakes, bayous, inlets, streams, estuaries, rivers, and creeks (Figure 6.5). There are three types of GLO coastal leases: commercial, residential, and cabins. Commercial leases and easements cover structures such as marinas, bait stands, fishing piers, pilings, fuel docks, and dredging activities. Surface leases are usually used

for drilling platforms not on a leased mineral tract, electrical substations, pumping stations, loading racks, artificial reefs, and wildlife preserves. Residential leases apply to small piers or docks that extend from private "littoral" property onto coastal public lands that require no dredging or filling. GLO also issues coastal leases to state agencies, eligible cities or counties, nonprofit or tax-exempt organizations, or scientific or educational entities for public recreation, estuarine preserves, wildlife preserves, or scientific research activities (GLO, 2013b). During the designation process, the Mission-Aransas NERR boundary was set back 1,000 feet from the shoreline along densely populated areas and adjacent to private land in order to accommodate for easements and existing leases. Several property owners requested at the 1,000-foot setback be removed along their property lines (primarily along the shorelines of Redfish Point, southeastern Copano Bay and Port Bay), in which case the boundary was moved to be adjacent to the shoreline (NOAA, 2006).

6.2.3 Recreational and Commercial Fishing and Hunting

Commercial and recreational fishing and hunting are allowed within the Reserve boundary, and both activities require appropriate licenses administered by TPWD. Numerous boat ramps and marinas are located near the Reserve boundary, providing ample opportunity for access to the Mission-Aransas Estuary for these uses (Figure 6.5). Texas law dictates that any person who takes or attempts to take fish, mussels, clams, crayfish, or other aquatic life in the public waters of Texas must have a current Texas fishing license with the appropriate stamp endorsement issued by TPWD. A saltwater endorsement is required to fish in coastal waters, while a freshwater endorsement is required for inland waters. Recreational anglers must have a Texas fishing license and saltwater endorsement to bring any fish taken in federal waters ashore in Texas. Fishing licenses are not required for children under age of 17, Texas residents born before January 1, 1931, mentally disabled persons who are engaged in recreational fishing under supervision as part of medically approved therapy, mentally disabled persons fishing under the direct permission from the family to take the mentally disabled person fishing, or visitors to State parks (TPWD, 2013a).

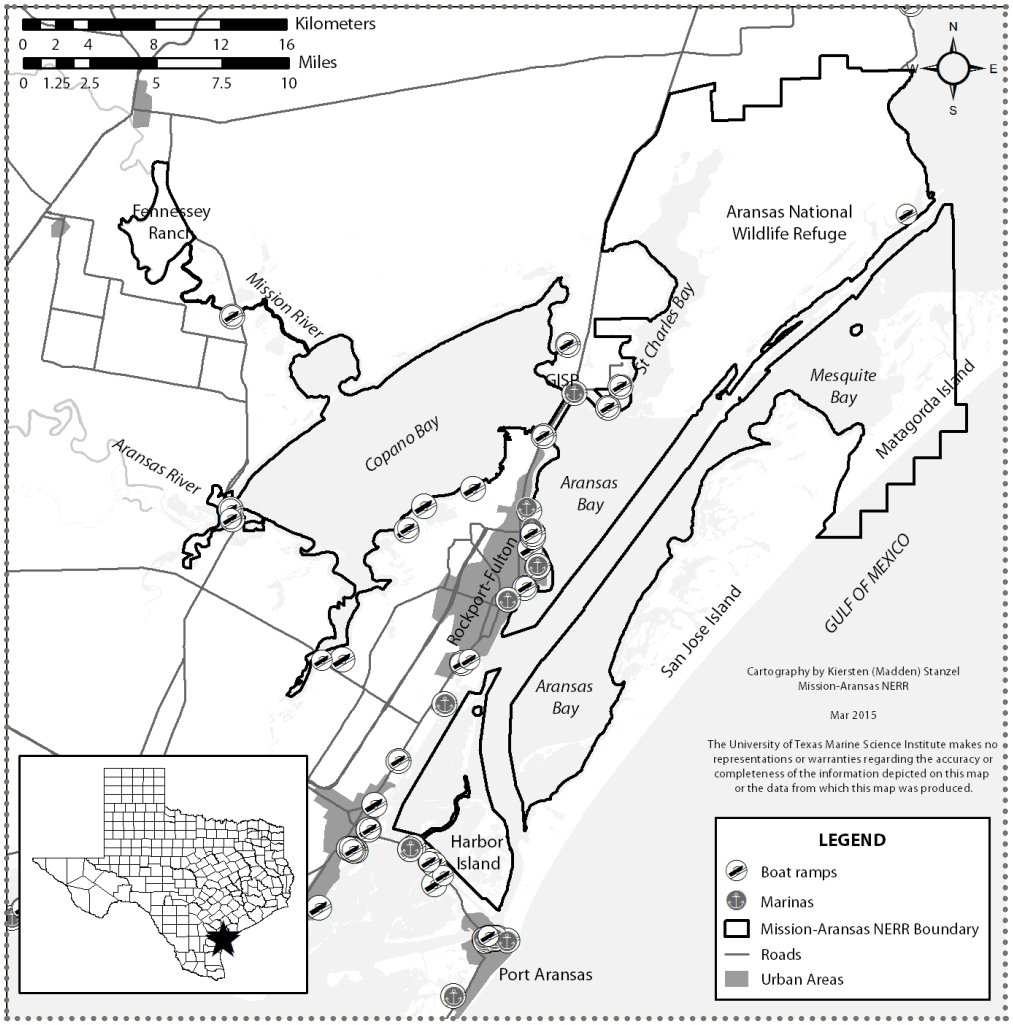


Figure 6.5. Locations of boat ramps and marinas adjacent to the Mission-Aransas Reserve.

It is unlawful to take, attempt to take, or possess wildlife resources within a protected length limit, in greater numbers, by other means, or at any time or place, other than as indicated by TPWD. A person who is hunting,

fishing, or trapping must carry on their person and have available for inspection a valid license and any applicable stamp endorsements or permits unless the person is exempt from license, stamp, or permit requirements. A reasonable effort must be made to retrieve all wounded game birds and game animals and they must be killed immediately and become a part of the legal bag limit. It is a violation to fail to keep all edible portions of a game bird, game animal, or fish in an edible condition. For whitetail and mule deer, pronghorn antelope, and desert bighorn sheep, the violation is a Class A misdemeanor.

As outlined in TPWD hunting regulations, it is unlawful to: (1) discharge a firearm on or across a public road or hunt game animals, game birds, exotic animals, or fur-bearing animals on public roads; (2) hunt any wild animal or wild bird on foot or from a vehicle on any public road or road right-of-way, or a boat on public water, except that migratory waterfowl may be hunted from a boat or any floating craft (except a sink box) under certain conditions; (3) hunt on Public Hunting Areas without the required permits; (4) hunt on any area named as a wildlife sanctuary, nesting, or propagation area; (5) hunt in state or federal parks or refuges except as may be provided by special state or federal policies; and (6) hunt any wild animal or wild bird on or over privately owned land that is submerged under public freshwater due to seasonal or occasional inundation or submerged under saltwater above the mean high tide line. The property must be posted to indicate that hunting is prohibited (Class C Parks & Wildlife Code misdemeanor: $25 - $500 fine only) (TPWD, 2013b).

In freshwater, it is unlawful to fish with more than 100 hooks on all devices combined, to take game fish and non-game fish sections of rivers lying totally within boundaries of a state park with any other gear besides pole and line, to take fish with a hand operated device held underwater except that a spear or speargun may be used to take non-game fish.

A cast net may be used to take non-game fish and shrimp only, may not be greater than 14 feet in diameter, and in saltwater, non-game fish may be taken for bait purposes only. A dip net may be used to take non-game fish only, may be used to aid in the landing of fish caught on other legal devices, and in saltwater, non-game fish may be taken for bait purposes only. A gaff may only be used to aid in the landing of fish caught on other legal devices, means, or methods. Fish landed with a gaff may not be below the minimum, above the maximum, or within a protected length limit. A gig may be used to take non-game fish only. A jugline may only be used in freshwater, and may only be used to take non-game fish, channel catfish, blue catfish, and flathead catfish only. Lawful archery equipment (longbow, recurved bow, compound bow, and crossbow) may be used to take non-game fish only. A minnow trap may be used to take non-game fish only. The trap may not exceed 24 inches in length or with a throat larger than one by three inches, and in saltwater, gear tag valid for only 30 days must be visibly attached. A perch trap is for use in saltwater only, may be used to take non-game fish only, may not exceed 18 cubic feet, and must be marked with a floating visible orange buoy not less than 6 inches in height and six inches in width. The buoy must have a gear tag valid only for 30 days attached, and must be equipped with a degradable panel sewn or tied with untreated jute twine or untreated steel wire less than 20 gauge in the sidewall of the trap. Buoys or floats may not be made of plastic bottle(s) of any color or size. It is unlawful to place any type of trap within the area in Cedar Bayou between a department sign erected where Mesquite Bay flows into Cedar Bayou and the department sign erected near the point where the pass empties

Local fisherman with red drum
Photo credit: Chase Stanzel

into the Gulf of Mexico. It is unlawful to take or attempt to take fish with one or more hooks attached to a line or artificial lure used in a manner to foul-hook a fish (snagging or jerking). A fish is foul-hooked when caught by a hook in an area other than the fish's mouth.

A sail line is for use in saltwater only. Non-game fish, red drum, spotted seatrout, and sharks may be taken with a sail line. No more than 1 sail line may be used per fisherman. The sail line must be attended at all times the line is fishing, and may not be used by the holder of a commercial fishing license. The sail line must have a valid Saltwater Trotline Tag for each 300 feet of mainline or fraction thereof being fished. A sail line may not exceed 1800 feet from reel to sail, and the most shoreward float must be bright orange or red color and all other floats must be yellow. No float may be more than 200 feet from the sail. A seine may be used to take non-game fish and shrimp only, may not be longer than 20 feet, may not have mesh exceeding 1/2-inch square, must be manually operated, and in saltwater non-game fish may be taken by seine for bait purposes only. A shad trawl is for use in freshwater only and may be used to take non-game fish only, may not be longer than 6 feet or with a mouth larger than 36 inches in diameter, may be equipped with a funnel or throat, and must be towed by boat or hand. A spear and speargun may be used to take non-game fish only. A throwline is for use in fresh water only. Components of a throwline may also include swivels, snaps, rubber and rigid support structures, may be used to take non-game fish, channel catfish, blue catfish, and flathead catfish only. An individual bait-shrimp trawl is for use in saltwater only and only non-game fish (except those species regulated by bag or size limits) taken incidental to legal shrimping operations may be retained. "Legal shrimping operations" means the use of a legal trawl in places, at times and in manners as authorized by the Texas Parks and Wildlife Department. A maximum of 200 non-game fish taken with an individual bait-shrimp trawl may be retained per person for bait purposes only. Only non-game fish, channel catfish, blue catfish, and flathead catfish may be taken by trotline. An umbrella net may be used to take crabs and non-game fish only, and may not have within the frame an area that exceeds 16 square feet.

6.3 Surveillance and enforcement capacities

6.3.1 Texas Parks and Wildlife Department

Enforcement of natural resource regulations within the Mission-Aransas Estuary is conducted by TPWD Law Enforcement Division. The Division provides a comprehensive, statewide law enforcement program to protect Texas' wildlife, other natural resources, and the environment. The division also provides safe boating and recreational water safety on public waters by ensuring compliance with applicable state laws and regulations. Texas Game Wardens are responsible for enforcement of the Parks and Wildlife Code, all TPWD regulations, the Texas Penal Code, and selected statues and regulations applicable to clean air and water, hazardous materials, and human health. Wardens hold federal commissions issued by the U.S. Department of the Interior and the U.S. Department of Commerce for purposes of enforcing federal fisheries and wildlife laws in Texas. Wardens fulfill these responsibilities through educating the public about various laws and regulations, preventing violations by conducting high visibility patrols, and apprehending and arresting violators. Operation Game Thief provides citizens with a toll-free number to report poaching and other violations. The Law Enforcement Division employs about 500 wardens throughout the state and operates 29 field offices that sell licenses, register boats, and provide the public with local information across the state. The Reserve is served by Region 10 and the district office is located in Rockport, Texas.

TPWD is responsible for enforcing recreational and commercial fishing and hunting laws. Penalties for violation of fish and wildlife laws require civil restitution and may also result in: (1) fines (Class C - $25-$500; Class B - $200-$2000; Class A - $500-$4000; State Jail Felony, $1500-$10,000); (2) jail time (Class B and higher offenses); (3) automatic suspension or revocation of licenses for up to five years; and (4) forfeit of hunting gear, including firearms, used to commit a violation. In addition to the criminal penalty for hunting and fishing violations, the TPWD will seek the civil recovery value for the loss or damage to wildlife

resources. The civil restitution cost is payable to TPWD and is in addition to the fine assessed by the court. Failure to pay the civil recovery value will result in the department's refusal to issue a license, tag, or permit. An individual who hunts or fishes after the refusal commits a class A misdemeanor, which is punishable by a fine not less than $500 or more than $4,000, punishment in jail not to exceed one year, or both fine and confinement.

6.3.2 U.S. Coast Guard

The U.S. Coast Guard, stationed in Port Aransas, Texas, also provides surveillance and enforcement of boat traffic in the Reserve area. The Coast Guard is a military, multi-mission, maritime service and one of the nation's five Armed Services. Its mission is to protect the public, the environment, and U.S. economic interests in the nation's ports and waterways, along the coast, on international waters, or in any maritime region as required to support national security. The Coast Guard is also a first responder during oil spills and conducts drills with oil, gas, and hazardous material vessels and industries to prepare for potential spills. The Coast Guard requires that certain vessels prepare approved Vessel Response Plans and/or Shipboard Oil Pollution Emergency Plans. Certain vessels carrying noxious liquid substances are required to prepare and submit Shipboard Marine Pollution Emergency Plans to the Coast Guard.

The Coast Guard is responsible for cleanup and organization of emergencies that occur during the water transport of hazardous chemicals. It has developed a Chemical Hazards Response Information System (CHRIS) manual to provide information needed for decision-making during emergencies that occur during the water transport of hazardous chemicals. CHRIS also provides information that can be used by the Coast Guard in its efforts to achieve better safety procedures and thereby prevent accidents. In addition to the Coast Guard, the U.S. National Response System is also involved in the event of an accident. In Texas, Regional Response Team (RRT) 6 is the federal component of the National Response System. The Region 6 RRT is composed of representatives from sixteen federal departments and agencies. The Region 6 RRT is responsible for preparedness activities including planning, training, and exercising to ensure an effective response to releases of hazardous substances and oil spills. The RRT also provides assistance as requested by the On-Scene Coordinator during an incident.

6.3.3 U.S. Fish and Wildlife Service

USFWS provides surveillance and enforcement at ANWR, including Matagorda Island. The Office of Law Enforcement contributes to the USFWS efforts to manage ecosystems, save endangered species, conserve migratory birds, preserve wildlife habitat, restore fisheries, combat invasive species, and promote international wildlife conservation. The USFWS law enforcement focuses on threats to wildlife resource, illegal trade, unlawful commercial exploitation, habitat destruction, and environmental contaminants. The Office of Law Enforcement investigates wildlife crimes, regulates wildlife trade, helps Americans understand and obey wildlife protections laws, and works in partnership with international, state, and tribal counterparts to conserve wildlife resources.

6.3.4 The University of Texas at Austin

UT Police Department provides 24-hour patrols of the UTMSI campus property in Port Aransas, which is where the Reserve headquarters are located. The UT police act in concert with local law enforcement, local city police, and county sheriff patrols which provide another source of periodic policing in the buffer areas of the Reserve.

6.4 Resource Protection Challenges

Maintaining adequate control of reserve resources can be challenging for a variety for reasons. This section identifies uses outside the Mission-Aransas Reserve boundary that impact reserve resources. It describes how existing authorities and processes protect the Reserve and how the Reserve interfaces with these uses.

6.4.1 Water Use Adjacent to the Mission-Aransas Reserve

Marine Navigation

The Gulf Intracoastal Waterway is a major industrial water transportation canal that bisects Aransas Bay. It is located outside of the Reserve boundary but is immediately adjacent to many of the core areas of the Reserve. The waterway was first dredged in 1905 and is approximately 125 feet wide by 12 feet deep and links seaports along the Northern Gulf of Mexico. The easement for the waterway is 300 feet and there is 2,150 feet of easement for dredge material disposal on either side of the GIWW centerline (Texas Governmental Code, Sec. 2204.601). The waterway serves many uses, such as a commercial trade link, national defense, and protective passage for recreational and working vessels (TxDOT 1996). It is economically imperative to the Texas Coast because it facilitates transporting petrochemicals and agricultural as well as industrial products that would otherwise be too costly or impossible to transport by road. In 1994, over 78 million short tons were moved on the Texas waterway, which values up to twenty-two billion in revenue (TxDOT 1996). The USACE must annually dredge 8 million cubic yards of shoaled material to maintain authorized dimensions of the waterway (TxDOT 1996).

Barges are a frequent site in the GIWW

Maintaining the navigation channels throughout Texas' shallow bay systems in combination with vessel use can create localized impacts to the ecosystem, within approximately 1,000 feet of the channel (Scot Sullivan TxDOT, pers comm). In areas with hardbottom substrate, dredging has been shown to have detrimental effects to the benthos. However, a five year study conducted in soft-bottomed Corpus Christi Bay concluded that the present benthic communities have a high resilience to disturbance by dredging and trawling (Flint and Younk 1983). This resilience is likely because of a large source of colonist species.

Dredge spoil islands are present adjacent to the Reserve. The majority of the dredged spoil islands run along the west of the intracoastal, about 600 yards out, excluding Lydia Ann Channel. The section of the intracoastal waterway that extends along the ANWR shoreline contains the Dunham spoil island and levee to the east of the waterway. This spoil island was created to the east of the waterway so as not to impede upon whooping crane habitat. In November 1995, in a section 216 feasibility study, the Corps of Engineers addressed the 30 mile reach of the waterway that is adjacent to the ANWR. In this study, the following items were addressed: 1) evaluation of possible realignment of the waterway, 2) identified beneficial uses of dredged material, and 3) generated a plan for reducing the bank erosion along the ANWR (TxDOT 1996). Although habitat loss is caused by dredge spoil islands, these islands are also ideal nesting for several species of birds and usually contain plant communities of mesquite, salt cedar (*Tamarix* spp.), popinac (*Leucaena leucocephala*), granjeno (*Celtis laevigata*), and oleander (*Oleander* spp.) (Chaney et al. 1996). Besides the dredging of the intracoastal waterway additional dredging may occur from time to time to maintain the navigation channel to Goose Island State Park or to maintain other channels within the Reserve (Mary Perez and Scot Sullivan TxDOT, personnel communication).

There is likely incidental pollution associated with the use of outboard motors on the water but this is not regulated and applies to all outboard motors (pleasure craft, research vessels, etc.). It is known that 2-stroke outboard motors release 18% of the fuel and oil consumed. The licensing of boats and motors in Texas is managed by TPWD.

Bridges and Runway Protection Zone

The Copano Bay Causeway bisects the Reserve between Aransas and Copano Bay, and is currently under construction. There are also numerous state roadways adjacent to the Reserve boundary. These roadways include state highways, farm to market roads, and park roads. Periodic maintenance of these facilities will be occurring over the next five years (Table 6.4). In addition, a parcel of land (~ 2500'x1750') west of the Rockport/Fulton Airport that extends out into Copano Bay is designated as a runway protection zone. A map of the airport and protection zones is provided in the site nomination document (NOAA, 2006).

Table 6.4. Future Maintenance on state roadways adjacent to the Reserve. Setback dimensions are shown in parenthesis.

State Roadways	Future Projects
State Highway 35 Copano Bay Causeway	Construction for the replacement and approach reworking is ongoing
State Highway 35 Cavasso and Salt Creek Bridges (150 ft from the centerline to each side)	Bridge replacement scheduled at Copano and Salt Creek Bridges
Farm Road 136 Bridge at Copano Bay (150 ft from the centerline to each side)	No projects scheduled
Farm Road 2678 Mission River Bridge (150 ft from the centerline to each side)	No projects scheduled
State Highway 188 Port Bay Bridge (150 ft from the centerline to each side)	Long term plans call for the bridge to be widened
State Highway 136 at Egery Flats	Culvert replacement at two locations. Construction expected to begin Fall 2015.

6.4.2 Land Use Adjacent to the Mission-Aransas NERR

Social patterns and land/water uses of counties within the watershed that drain into the Mission-Aransas NERR greatly affect water quality and health of the Mission-Aransas Estuary. The current population dynamic is small, rural communities transitioning into densely populated urban areas along the coast. The counties that lie within the watershed of the Reserve are Aransas, Refugio, Calhoun, Nueces, San Patricio, Karnes, Goliad, Bee, and Live Oak. Five of these counties, Aransas, Refugio, Calhoun, Nueces, and San Patricio, contain land and water within the Mission-Aransas NERR boundary.

Patterns of land use indicate the spatial extent of human alteration and can be a valuable tool in determining how the natural resources in the area are utilized by humans. In particular, land use can help explain non-point source pollution, patterns of natural habitat, water quality, aesthetic characteristics of developed lands, and can also help identify areas for conservation. The watershed of the Mission-Aransas Reserve is primarily comprised of forested land and rangeland (Figure 6.6). At a closer look, San Patricio and Bee County have high percentages of agricultural land in the sub-basin that drains the Aransas River into Copano Bay. Bee, Goliad, and Refugio counties primarily have forested and rangeland within the sub-basin that drains the Mission River into Copano Bay. The urban areas are primarily confined to cities such as Corpus Christi, Rockport/Fulton, and Sinton. It is interesting to note that there are small numbers of people around the lower portions of the Mission and Aransas rivers. The census blocks in the city of Rockport and the Live Oak Peninsula show high numbers of people, which is likely not reflected at the county level because of the low numbers associated with the unpopulated areas of the Aransas National Wildlife Refuge and San Jose Island (Morehead et al., 2007).

Land use patterns within the Reserve watershed will also reflect water usage. The majority of the counties in the Reserve receive their water supply from surface water resources (TWDB, 2015). The cities and towns in the Mission-Aransas Reserve region are largely served by the city of Corpus Christi and groundwater

(well water) systems. The city of Corpus Christi operates two dams on the Nueces River, and is the major water wholesaler to municipal and county water resellers. The majority of the surface water is used to supply municipalities and manufacturing, but groundwater supplies are also a source of water for the Reserve. The Reserve's watershed lies above the vast Gulf Coast Aquifer, which stretches the length of the entire coastal plain of Texas.

The Mission and Aransas rivers are small and primarily coastal compared to other rivers in Texas. Neither the Mission River nor the Aransas River has dams, or are used as water supplies for cities in the region. The Mission-Aransas Estuary is one of the few estuaries on the Texas coast that still receives sufficient inflows of surface fresh water to maintain a healthy ecosystem. At the current time, surface waters in Mission and Aransas rivers are not at risk, however, future growth of south Texas cities will require additional water resources (Johns, 2004). This is one reason why estuarine monitoring is extremely important.

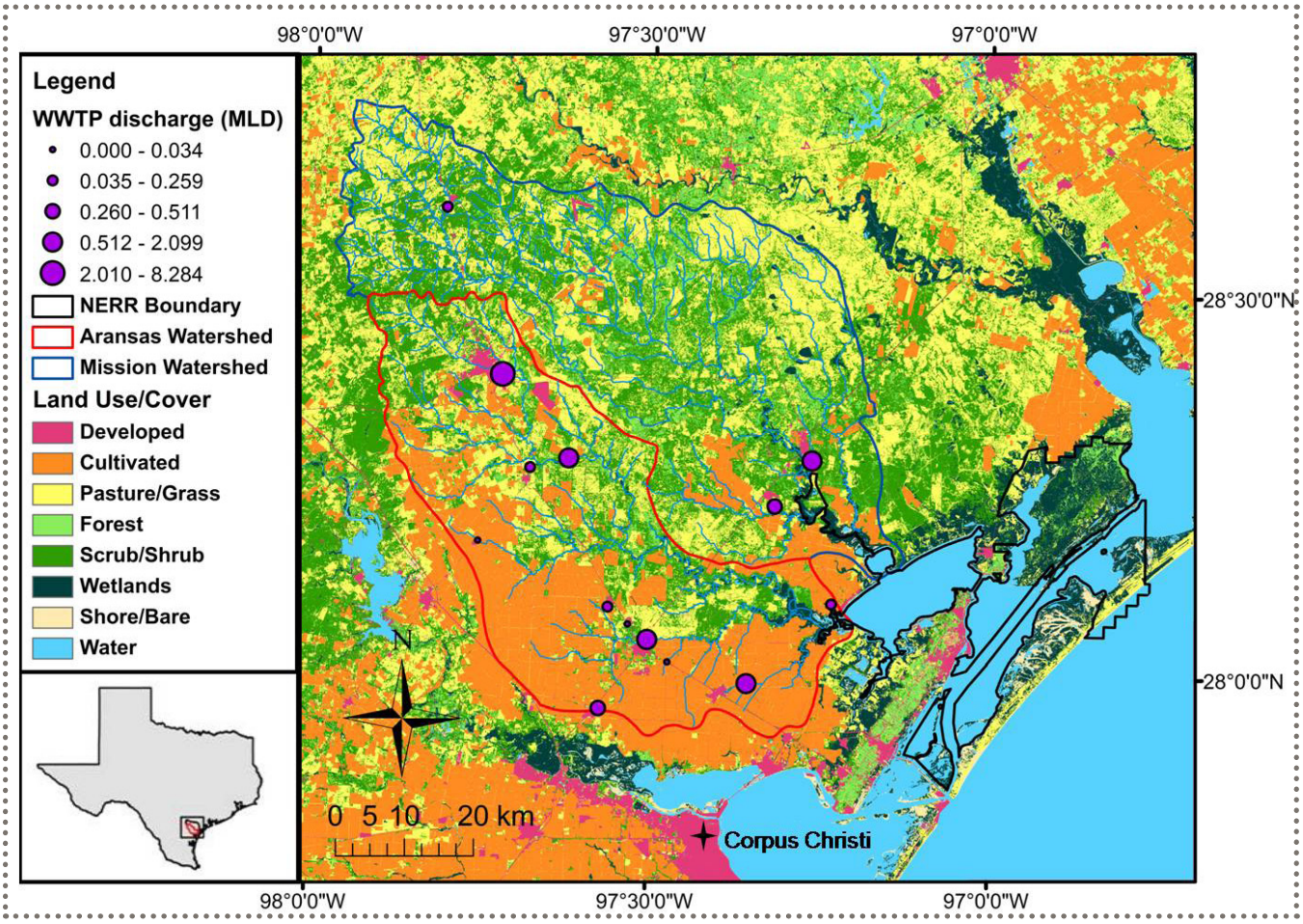


Figure 6.6. Land use/land cover of the Mission and Aransas watersheds. Data provided by NOAA. MLD is million liters per day. (Mooney, 2009)

6.4.3 Protection from outside activities

Reserve staff maintain close partnership with regional, state, and federal regulatory agencies within the Reserve's boundaries. They depend on the existing regulatory structures and permitting processes to protect the Reserve from negative impacts from outside activities. The Reserve staff is not normally involved in permit reviews of activities occurring adjacent to or within the Reserve boundaries. However, the Reserve does have a right to become involved. Reserve partners communicate any permitting or usage issues regarding resources within the Reserve's boundary or area. The Reserve is available to partners as a source for information and expertise if needed during these processes.

6.5 Monitoring and Evaluation

In order for the Reserve to monitor whether resources are adequately projected, the Reserve must identify resource indicators, monitor those indicators, and perform analyses to detect changes over time. The Reserve currently maintains several long-term monitoring programs which provide valuable data towards determining impacts from allowable uses. Although the Reserve has no regulatory authority, the monitoring programs that are implemented by the Reserve provide valuable data to partners that are tasked with making regulatory decisions. The Reserve may also play a role in regulatory decisions by provide trainings, workshops, and/or outreach programs to partners and the public. For example, the Reserve has hosted workshops in the past dealing with environmental flow requirements and stormwater runoff.

6.5.1 System-Wide Monitoring Program

SWMP currently includes three major components: (1) monitoring of water quality and weather indicators, (2) biological monitoring, and (3) mapping of Reserve habitats and watersheds. Full details of the techniques used and the parameters measured by each of these components is provided in Section 4.1. The Reserve's long-term data collection efforts help facilitate a better understanding of basic estuarine conditions and will allow the Reserve to serve as a resource for detecting changes following potential impacts. In addition to data collected through the SWMP, the Reserve also recently completed a research project to characterize the nutrient dynamics of the system. This will provide a good baseline for understanding future changes related to increasing or decreasing nutrient inputs.

6.5.2 Sentinel Site Program

The primary goal of the Sentinel Sites Program is to understand changes in sea level/inundation and the associated responses of marsh, mangrove, and submerged aquatic vegetation. To accomplish this goal, the Reserve conducts annual monitoring of vegetation, elevation change, and accretion at several sites throughout the Reserve (see Section 4.1). The Sentinel Site Program is designed to study long-term changes over time, but short-term changes can also be detected and measured. The Sentinel Site Program provides the Reserve with a baseline of vegetation, elevation, and accretion data for making comparisons following potential impacts (e.g., hurricane, oil spill, change in water withdrawal, or increase in barge traffic and erosion).

6.5.3 Little Bay Report Card

The Mission-Aransas Reserve was approached by local citizens regarding concerns over declining water quality and seagrass in a small, shallow bay directly adjacent to the Reserve, called Little Bay. In 2012, the Reserve worked with the concerned citizens to establish a "Report Card" to monitor the long-term health of Little Bay. As part of the "Report Card," water quality assessments are performed quarterly and seagrass condition is measured annually. A continuous water quality monitoring station was established to collect standard water quality parameters within Little Bay. Nutrients are also sampled at this site. Water quality measurements, including nutrients, are compared to measurements taken in Aransas Bay, which is generally regarded as a "healthy" bay with good water quality and healthy habitats. Annual assessments of seagrass condition are performed by Dr. Kenneth Dunton at UTMSI. By using the "Report Card" approach, Reserve staff are able to detect changes occurring in Little Bay and can work with local citizens to identify potential causes for these changes.

6.5.4 Monitoring at Fennessey Ranch

Monitoring of management practices and activities at Fennessey Ranch provides an estimation of species diversity, species numbers, annual population trends, population density, age structure, or sex ratio using accepted survey techniques. Harvest data is collected and recorded annually for deer and hog by the Ranch

staff. Data includes age, weight, and sex. For deer, antler development and embryo presence data is also being collected. These records help determine sex ratios, body condition, and annual production.

Regular, periodic counts of non-game wildlife species are also used to enhance management or increase knowledge of local, regional, or state status. This practice includes developing checklists of wildlife diversity for the property. Counts include aerial counts of alligator nests, song bird transects and counts, turkey hen/poult counts, waterfowl/water bird counts, and butterfly counts. All records are provided to the Mission-Aransas Reserve on an annual basis.

Monitoring of vegetative cover is also performed by staff of the Mission-Aransas NERR at specified sampling locations on an annual basis. Sampling at these locations includes observations of percent cover (trees, shrubs, and grasses/forbs), hydrologic conditions, soil type, and species present. These observations allow Reserve staff to monitor short-term variability and long-term changes in the vegetative communities of the Ranch, and it also serves to determine species diversity and presence of invasive species. This program is currently under revision, but once completed, the program will be reinstituted because of its important role in understanding habitat quality at Fennessey Ranch.

Additional monitoring programs related to groundwater wells and the Mission River would be beneficial for allowing the Reserve to assess changes in groundwater conditions, surface flows, and water quality. Flow rate data and water quality information (i.e., salinity, temperature, pH, nutrients, and bacteria) will help determine current conditions and assess any changes that may occur. However, staffing and funding constraints currently limit this type of monitoring.

7.0 Public Access Plan

7.1 Introduction

7.1.1 NERR System Priorities for Public Access

Section 921.13(a) of the NERR System regulations requires a plan for public access as part of the Reserve management plan. Public access can be defined as the ability of all members of the community to pass physically and visually to, from, and along the ocean shore, other waterfronts, and over public lands. The ability to enjoy the oceans, bays, and rivers is directly related to the ability to reach them from the uplands. A public access plan must try to allow for the long-term public use and enjoyment of the water and shoreline while minimizing damage to the resources themselves.

7.1.2 Reserve Public Access Policy

The Reserve public access policy recognizes the traditional uses and access to the Mission-Aransas Estuary as much as possible in an effort to maintain biological integrity of the area for these uses as well as for education, stewardship, research, and monitoring. Traditional recreational and commercial activities that require access to the Reserve will continue to be allowed. The Reserve's policy will be compatible with the public access policy of each of the appropriate agencies having title to the lands in question (i.e., GLO, USFWS, TPWD, CBLT, CBBEP, and Fennessey Ranch). Specific polices for access for the purposes of education, stewardship, research and monitoring will be determined through coordination with each of the Reserve programs.

7.2 Current Public Access

7.2.1 Bay Access

Access to the bays is adequate in the Mission-Aransas Estuary. Table 7.1 provides a list of access points for wildlife viewing, fishing, boating, and wind surfing within and near the Reserve. The table also highlights amenities at each site, such as concessions, rest rooms, lighting, and access for mobility impaired. There are currently 23 boat ramps near the Reserve that provide access to the bay (Figure 7.1). Boat access for most Reserve research, stewardship, and education activities will take place at the UTMSI boat ramp and dock, but due to the large size of the Reserve, staff may occasionally need to access the bay from other boat ramps. In this case, Reserve staff will make an effort to launch at free public ramps or at partner sites (e.g., ANWR, GISP) to avoid user fees. Reserve staff should contact partners

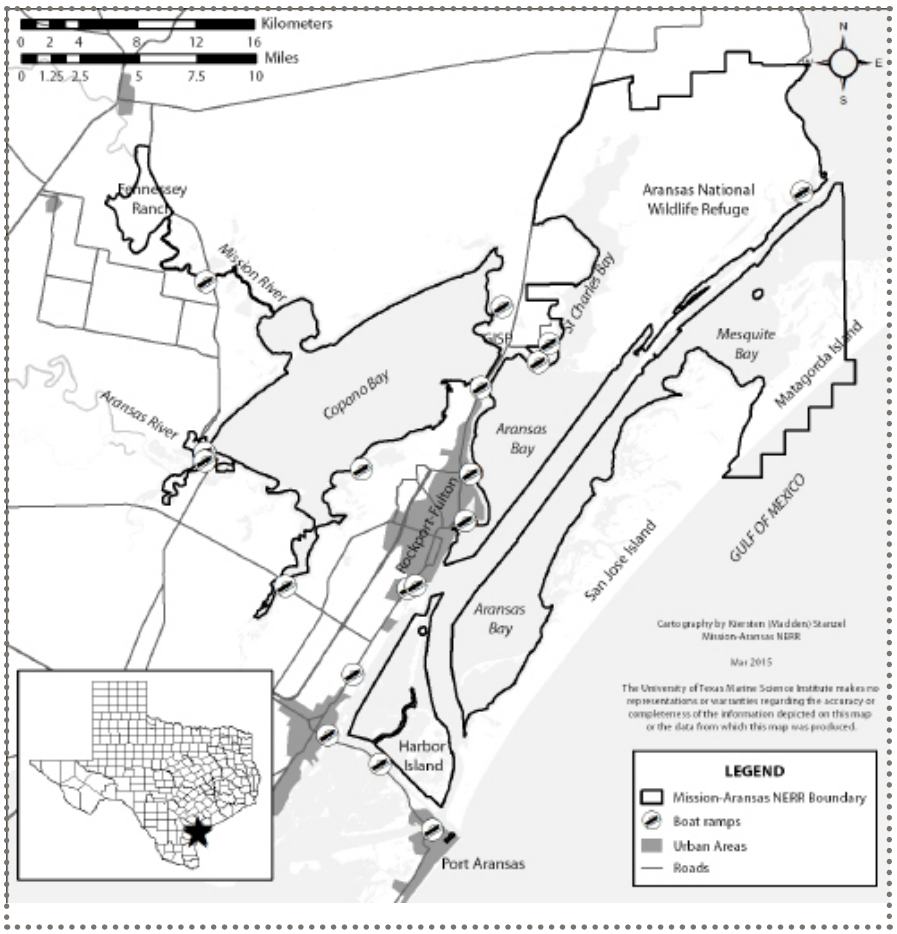


Figure 7.1. Boat ramps near the Mission-Aransas Reserve.

Table 7.1. Public access sites within and near the Reserve with activities and amenities available.

Site/Area	Location	Fishing	Wildlife Viewing	Picnicking	Camping	Wind Surfing	Boat Ramp	Boat Dock	Pier	Restroom	Electricity/Lighting	Fresh water	Concession	Entrance/Parking Fee	Access for Mobility Impaired	Bay/River/Lake Access
12th Street	End of 12th Street, Lamar	x														x
Bob's Place	Rattlesnake Point Road, Rockport						x	x			x			x		x
Beacon Bait Stand	302 South Fulton Beach Road, Rockport	x					x	x	x		x		x	x		x
Copano Bay Bridge (South End)	Hwy 136, Bayside	x	x													x
Copano Bay State Fishing Pier	State Hwy 35, Rockport	x	x				x		x	x	x		x	x	x	x
Copano Causeway (North)	North Hwy 35, Rockport	x	x													x
Copano Causeway (South)	South Hwy 35, Rockport	x	x				x									x
Cove Harbor Marina	161 North Cove Harbor Drive, Rockport	x	x				x	x	x	x	x		x		x	x
Fulton Fishing Pier and Harbor	250 Deforest Loop, Rockport	x					x		x	x	x		x	x	x	x
Goose Island State Park	202 Palmetto Avenue, Rockport	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Highway 188	At Port Bay, Rockport	x	x													x
Little Bay	Near Rockport Beach Park, Rockport	x	x			x										x
Lindsay's Landing	Hwy 35 South, Rockport					x								x		x
Palm Harbor Marina	151 Port Avenue, Rockport				x		x	x		x	x		x	x		x
Palmetto Road	East end of Palmetto Road, south of Fulton						x									x
Redfish Camp	5220 FM 881, Rockport		x		x		x	x		x			x	x		x

Table 7.1 continued. Public access sites within and near the Reserve with activities and amenities available.

Site/Area	Location	Fishing	Wildlife Viewing	Picnicking	Camping	Wind Surfing	Boat Ramp	Boat Dock	Pier	Restroom	Electricity/Lighting	Fresh water	Concession	Entrance/Parking Fee	Access for Mobility Impaired	Bay/River/Lake Access
Rockport Beach Park	210 Seabreeze Drive, Rockport	x	x	x		x	x	x	x	x	x		x	x	x	x
Sand Dollar Bait House	918 North Fulton Beach Road, Rockport		x				x	x		x	x				x	x
Sea Gun Marina	5810 Hwy 35 North, Rockport	x	x				x	x								x
St. Charles Bay Boat Launch	175 Lamar Beach Road, Rockport	x					x	x	x	x	x			x	x	x
Holiday Beach	Channelview Road, Rockport						x									x
Hopper's Landing	FM 2040 & Hopper Road, Austwell	x			x		x	x			x			x		x
Aransas River Boat Ramp	South of Bonnie View	x		x			x									x
FM 2678 Bridge	North of Mission River, Refugio	x	x													x
Mission River	FM 2678, Refugio	x	x				x									x
Refugio County Park	Bayside	x	x													x
Bayside Public	Off of FM 136, Bayside	x	x				x	x							x	x
Egery Island Marina	Off of FM 136, Bayside		x				x			x			x	x		x
Conn Brown Harbor Park	Bigelow Street, Aransas Pass	x		x			x	x	x	x	x		x		x	x
Robert's Point Park / Port Aransas Marina	J.C. Barr Boulevard and Cotter, Port Aransas	x	x	x			x	x	x	x	x				x	x
South Bay Bait and Charters	1950 Hwy 361, Port Aransas	x			x		x	x	x	x	x		x	x		x
Aransas National Wildlife Refuge	Aransas National Wildlife Refuge	x	x	x		x			x	x			x	x	x	x

prior to arrival to ensure that activities do not interfere with normal operations. Outside researchers that wish to use the UTMSI boat ramp can contact the Reserve for permission.

7.2.2 Access to Reserve Landowners

University of Texas Marine Science Institute

The Reserve maintains several educational facilities that provide interactive learning experiences for the public. A brief description of each of these facilities, including opportunities for public access, is provided below.

Bay Education Center features Science on a Sphere presentations

Bay Education Center

The Bay Education Center is located in the City of Rockport, adjacent to Rockport Harbor. Rockport is on the eastern shoreline of Live Oak Peninsula, which is surrounded by estuarine waters within the Reserve boundary, so the Bay Education Center is ideally positioned for increasing estuarine literacy and promoting stewardship among public audiences. The Bay Education Center contains approximately 950 square-feet of interactive exhibits, aimed at enhancing public understanding of estuarine systems and the role that NERRS reserves play in estuarine research, education, management, and protection. The Bay Education Center auditorium houses Science on a Sphere, a display system created by NOAA to enhance public knowledge of earth, ocean, atmospheric, and planetary sciences. The Bay Education Center is open free to the public all year, from 1 pm to 4 pm, Tuesday through Saturday. Regularly scheduled Science on a Sphere programs are offered free to the public several times a week.

Visitors learn about the importance of estuaries while on a tour of the Wetlands Education Center

Wetlands Education Center

The Wetlands Education Center consists of approximately 3.5 acres of salt marsh and sand dune habitat, on the UTMSI campus in Port Aransas. Handicapped accessible trails and boardwalks wind around a central salt marsh and through surrounding sand dunes. Visitors to the Wetlands Education Center learn that estuaries provide important ecosystem services and critical habitats for wildlife. Many species of coastal plants and animals are identified on wayside interpretive panels that are located near shade kiosks along the trails. The Wetlands Education Center is open free to the public at all times throughout the year and visitors may take a self-guided tour anytime they wish, using the interpretive signage that is stationed along the walkways.

Bird blind at the Wetlands Education Center

No fishing, hunting, or swimming are allowed around or in the Wetlands Education Center. Signs are posted around the water areas of the Wetlands Education Center to ensure no fishing occurs. Visitors and individuals are allowed to fish in the Aransas Pass Ship Channel from the Jetty that borders the site along the northeast side. Birding at the Wetlands Education Center can be enjoyed year-round. Students in the UT School of Architecture helped design and build a bird blind within the Wetlands Education Center that provides a path, shade, and seating.

The Wetlands Education Center also provides valuable opportunities for conducting research on a variety of topics, such as tidal flow, water quality, restoration science, invasive species, and ecosystem services. As new research projects are proposed, the Reserve and UTMSI must be notified for access to the site.

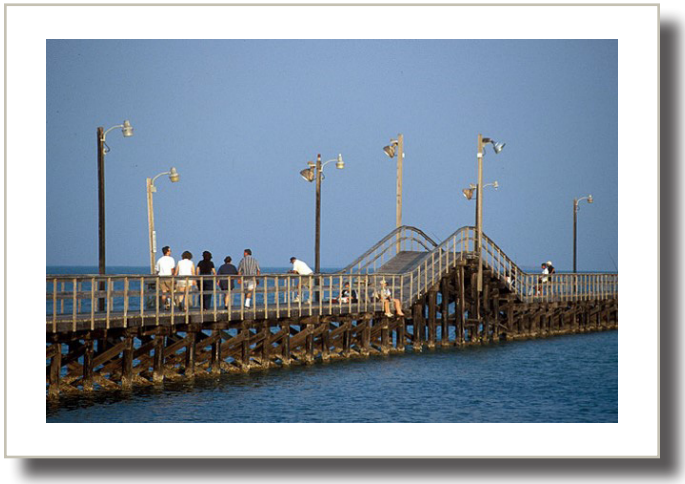
Estuary Explorium

The Estuary Explorium is part of the UTMSI Marine Science Education Center, in Port Aransas. Port Aransas is on the north end of Mustang Island, one of seven Texas barrier islands that separate the ocean waters of the Gulf of Mexico from numerous estuarine bays and lagoons. Ocean and estuarine waters meet and mix in Aransas Pass, the pass that divides Mustang Island from San Jose Island to the north. The ability to view Aransas Pass from the Estuary Explorium, provides an excellent opportunity to interpret the ocean-to-estuary transition that barrier island passes allow. The Estuary Explorium houses 1,000 square-feet of exhibits and the Explorer Lab, a dynamic interpretive space used for early childhood and K-12 student programs, teacher professional development, and public and community education programs. The UTMSI Marine Science Education Center houses an auditorium, a gift shop, and an exhibit hall with six aquaria displaying local marine animals and several marine science exhibits, in addition to the Estuary Explorium. The Estuary Explorium is open free to the public all year, from 8 am to 5 pm on weekdays, and as funding allows on weekends. Public visitors have the option of exploring the exhibits on their own or participating in scheduled programs in the Explorer Lab and adjoining Wetlands Education Center. Family-oriented, environmental education programs are offered at the Estuary Explorium on alternate Saturdays during summer months and periodically at other times throughout the year.

Interactive exhibits are open to the public in the Estuary Explorium

Texas Parks and Wildlife Department

GISP is located north of Rockport in Aransas County and surrounded by St. Charles and Aransas bays. The Park was acquired by TPWD in 1931-1935 by deeds from private owners and a legislative act setting aside the state-owned Goose Island as a park. Habitats at the Park include upland forests, shell ridge, and salt marsh. The nearby bays are filled with seagrass beds and oyster reefs. A user fee is required to enter the Park. The Park gate is open 8 a.m.–10 p.m. daily, and the Park Office is open from 8 a.m.–5 p.m. Recreational activities at the Park include camping, fishing, picnicking, boating, and wildlife viewing. Guided birding tours are available



A lighted pier offers opportunities to fish and view wildlife at GISP

from January to April and interpretive programs are held every week. Amenities at the Park include: lighted fishing pier, boat ramp, campsites, and hiking trails. The boat ramp at the Park offers access to the Mission-Aransas Estuary. Reserve staff must contact TPWD for permission before initiating any programs at the site. Reserve staff can assist partners that are interested in obtaining access to GISP for research, stewardship, and education activities, but ultimately, individual organizations are responsible for obtaining their own permissions from TPWD.

U.S. Fish and Wildlife Service

ANWR trails provide great opportunities for wildlife viewing

ANWR was established in 1937 to serve as a refuge and breeding ground for migratory birds and other wildlife. The wildlife conservation mission of the National Wildlife Refuge System and USFWS ensures that the Refuge will continue to conserve, protect, and enhance these lands for the benefit of wildlife and people. The mild winters, bay waters, and abundant food supply attract more than 400 species of birds to the Aransas National Wildlife Refuge, including the endangered Whooping Crane. Situated primarily on the Blackjack peninsula, the Aransas Refuge lies behind the protective influence of Matagorda Island (also considered part of the Refuge, but managed cooperatively with Texas Parks and Wildlife Department). The Refuge is surrounded by shallow bays where strong winds push bay waters onto a landscape that gradually shifts from salt to brackish and eventually freshwater marsh. This range of habitats supports a diversity of wildlife.

The Refuge Visitor Center is open Thursday to Sunday from 8:30am to 4:30pm. Exhibits and wildlife programs are available to the public. Refuge staff and volunteers are available to provide maps and checklists and let visitors know what is happening at the Refuge. The Visitor Center also has restrooms open to the public. Additional amenities at the Refuge include: driving tour, hiking trails, bicycle loop, fishing pier, observation platforms, and picnic areas. Public hunting opportunities are also available on a first come, first served basis. Daily registration of visitors is required, and a fee must be paid to access the auto tour loop. The Refuge website contains a full list of rules and regulations for visitors. Reserve staff must contact ANWR for permission before initiating any programs at the site. Reserve staff can assist partners that are interested in obtaining access to ANWR for research, stewardship, and education activities, but ultimately, individual organizations are responsible for obtaining their own permissions (i.e., special use permit) from ANWR.

All-terrain vehicles are used for birding tours at Fennessey Ranch

Fennessey Ranch

Public access to Fennessey Ranch is restricted to approved educational events hosted by the Reserve and ecostourism activities provided by Ranch staff. Allowable ecotourism activities are defined in the terms of the conservation easement and are monitored through annual surveys of Ranch staff. Access and use of Fennessey Ranch is important to regulate. No activity, including ecotourism, is without impact on Fennessey Ranch. Careful observation must be conducted to ensure that simultaneous activities are not putting undue stress on

Fennessey Ranch. For example, activities may need to be stopped for a period after heavy use. Access may need to be controlled or restricted for sensitive areas and projects. All transportation must be conducted on designated roads and trails. If off-road transportation by motorized vehicle is required, any damage to the habitat (i.e. ruts) must be restored to its original state.

Reserve staff must contact Fennessey Ranch staff before initiating any programs at the site in order (1) to ensure that activities do not interfere with other on-going and planned programs and (2) to determine whether the proposed activities will have any impacts on the health and quality of the Ranch habitats. The Stewardship Coordinator can assist partners that are interested in obtaining access to Fennessey Ranch for research, stewardship, and education activities. The Fennessey Ranch General Manager and Stewardship Coordinator will work together to determine if proposed activities are within the scope of the conservation easement and meet the goals and objectives outlined for the Ranch. If access to the Ranch is to occur without the Ranch Manager, either by Reserve staff or partners, standard procedures for use must be followed. Procedure for access includes: (1) calling the Ranch Manager or Ranch Hand to inform of event and schedule date, and (2) on the day of activity, sign in at the camp house and pin on the designated map the location of your activity.

Coastal Bend Land Trust / Coastal Bend Bays & Estuaries Program

Public access to the lands owned by CBLT and CBBEP is not currently allowed. Reserve staff must contact CBBEP/CBLT for permission before initiating any programs at the site. In addition, Reserve staff can assist partners that are interested in obtaining access to CBBEP/CBLT lands for research, stewardship, and education activities, but ultimately, individual organizations are responsible for obtaining their own permissions from the landowner.

7.3 Public Access Challenges

The rivers, wetlands, beaches, and bays of the Mission-Aransas Reserve offer residents and visitors with opportunities to participate in a variety of outdoor recreational activities, including fishing, swimming, wildlife viewing, picnicking, camping, boating, and kayaking. Visitors to the Mission-Aransas Reserve follow seasonal patterns with a group of seniors/retirees known as "Winter Texans" staying in the area around the site from Jan-Mar each year and families from central Texas staying from May-Aug each year. Ensuring public access to the Reserve habitats is critically important to maintaining the ecotourism economies of the coastal communities near the Reserve. However, the need to provide public access must be balanced with the need to conserve and protect coastal habitats and resources from user impacts such as litter/debris, wildlife disturbance, and habitat alteration. As coastal communities near the Mission-Aransas Reserve grow and tourism continues to increases, the pressure to provide public access is becoming an increasing issue. Therefore, current and future conservation planning efforts of the Reserve and its partners must consider public access issues in order to develop access strategies that benefit the Mission-Aransas Estuary.

Kayaking is a popular way for the public to experience the Mission-Aransas Estuary

Although the Reserve does not have the authority to regulate public access outside of its own facilities, it works with partners to identify challenges resulting from visitor use impacts through consistent communication with landowners and training events. In March 2015, the Reserve hosted a NOAA OCM workshop on how to better understand, monitor, and manage visitor use to maintain quality resource

conditions and visitor experiences. Discussions at the workshop revealed that the following major visitor use issues: (1) development and use of "social trails," (2) disturbance of shorebirds, especially colonial waterbird rookeries, (3) trash, especially discarded fishing gear, (4) conflicts between different user groups, and (5) disturbance to Whooping Cranes.

"Social" trails often develop within public access areas as visitors proceed outside of the designated formal trail network to access key attraction sites or points of interest. In the Reserve these can include social trails from both foot traffic, as well as vehicle use. Due to their non-formal nature, social trails often result in a complex network of trails of deteriorating condition creating highly impacted areas. Social trails are an issue at almost all public access sites within the Reserve that receive large numbers of visitors, with specific problems notesd at the Wetlands Education Center and GISP. Once social trails become an issue, bollards and cables are often used to deter visitors from accessing certain areas, but habitat recovery in these areas is often slow and take several years.

Great Blue Herons nest on rookery islands along the Texas Coast
Photo credit: Sherry Halbrook

The Texas coast serves as a major nesting area for numerous species of colonial waterbirds. Colonial waterbirds utilize the Texas coast as a nursery area and require plentiful nesting habitat and food supply. Nesting colonies can range in size from a few birds to thousands of nesting pairs. The nesting season along the Texas coast occurs annually from February to August. Colonies are most often located on islands, but birds may also use marsh, trees in swamps, peninsulas, mainland beaches, or even urban habitats to nest. Human disturbance at colonial waterbird rookeries has become a growing concern in the Mission-Aransas Estuary and along the entire Texas Coast. Rookery islands are especially susceptible to disturbance from boaters, but more recent concerns have highlighted the need to also look at potential disturbances from groups like kite surfers. If disturbed while nesting, birds may abandon their nests, which can leave eggs or baby chicks vulnerable to predators and heat. Signs have been posted near many of the rookery islands in the Texas Coastal Bend warning individuals that it is unlawful and harmful to approach these islands during nesting season. However, additional education of the general public is still needed regarding this issue. CBBEP, American Bird Conservancy, and Gulf Coast Bird Observatory partnered to produce a Texas public service announcement about colonial nesting waterbirds on islands. The 30-second spot asks boaters and fishermen to "Fish, Swim, and Play From 50 Yards Away " from nesting birds on islands. These televised public service announcements are running on CBS networks in Houston and Corpus Christi. The Mission-Aransas Reserve and its partners will need to continue working in this issue over the upcoming years.

Litter and trash left behind by visitors is an issue throughout all of the Reserve. If left alone, some of this trash may persist in the environment for hundreds of years. In addition to being an eyesore, marine debris is a threat to wildlife that may ingest the trash or become entangled, and it can also engulf and smother the habitats that birds, fish, and other animals rely on for shelter and food. Marine debris also poses a safety hazard for humans if fishing gear or other types of trash become wrapped around boat propellers or clog seawater intakes. The Reserve Stewardship Program and many of its partners are working to educate visitors about the impact of marine debris and organize clean-up events to reduce the amount of trash found within the environment. These efforts will need to continue over the next five years as the number of visitors to the Mission-Aransas Estuary increases.

The Mission-Aransas Estuary is used by visitors for a variety of different recreational and eco-tourism activities, including birdwatching, fishing, hunting, kayaking, boating, swimming, and wind/kite surfing. With so many different activities, conflicts can sometimes result between different user groups. For example, conflicts can occur between bird watchers and waterfowl hunters. The areas used by bird watchers and waterfowl hunters overlap throughout much of the Reserve, but conflicts appear to be most problematic where large numbers of visitors are concentrated, such as at GISP.

There is increasing concern over human disturbance to Whooping Cranes on their wintering grounds. Whooping Cranes are "wary" birds, and human disturbances can cause alterations to their behavior and may lead to displacement from desired habitats. Disturbance can be caused by boats, people on foot, vehicles, and aircraft. Boat traffic is particularly troublesome due to the fact that the GIWW bisects the coastal marshes of the Refuge where the Whooping Cranes spend much of their time. The GIWW experiences heavy barge traffic and there is a potential for significant spill of contaminants. Boats associated with tour operators, recreational fisherman, and hunters also frequently use this area and can potentially disturb the cranes if they are approached too closely. Whooping Cranes are also not tolerant of humans on foot, so care must be taken along shoreline trails and in the uplands to avoid disturbance (Lewis and Slack, 2008). For example, boardwalks at GISP are closed at certain times of the year to avoid conflicts between visitors and Whooping Cranes that spend time in the coastal marshes at the Park. As Whooping Crane populations continue to recover and expand their wintering grounds along the Texas coast, potential impacts from human disturbance become an increasing threat to the their recovery and resource managers will have to carefully balance public access with the well-being of the cranes.

7.4 Public Access Needs and Opportunities

The Mission-Aransas Reserved collaborated with NCCOS to explore the spatial quantification of social values of ecosystem services and their relationship to underlying environmental characteristics. Data was collected using three methods: an online, interactive mapping survey delivered to users intercepted on site; randomly selected residents using mail back surveys; and, snowball sampling of interested environmentally oriented stakeholder groups. All groups were offered a paper-based survey instrument as well. The data were analyzed using a geographic information system tool called Social Values of Ecosystem Services (SolVES). The tool was used to analyze spatially explicit social value data and supplementary use perception data and their connection with underlying environmental characteristics. As part of this study, respondents were asked to provide their opinion on how adequate existing public access is to the bays (Loerzel et al., 2015). The Reserve will use the responses to these questions to work with its partners to identify where to focus their public access efforts to better meet the needs of users over the next five years.

Boat Ramps

The majority of respondents believed that there was adequate access to boat ramps in the Mission-Aransas Reserve, with 61.7% of individuals choosing either adequate or more than adequate access for this waterway access type. Only 11.2% of respondents believed that access to boat ramps was inadequate or that there was little or no access to this access type. The other 27.2% of respondents answered either neutral (9.6%), unsure (12.4%), or didn't provide a response (5.2%) to this question (Loerzel et al., 2015).

Beach Access

There was a slightly stronger response among respondents that beach access was adequate in the Bays, with 71.3% of individuals choosing either adequate or more than adequate access for this waterway access type. 10.8% of respondents believed there was inadequate access or little or no access to beaches in the Bays. Once again, 9.6% of respondents felt neutral about this question, while 3.2% were unsure and 5.2% did not respond to the question accounting for a cumulative 18% of respondents (Loerzel et al., 2015).

Boat Slips

A much greater proportion of respondents felt unsure (22.3%), neutral (15.5%), or didn't respond (7.6%) to the adequacy of access to boat slips, representing almost half of the respondents (45.4%). This figure represents almost double the amount of respondents who did not provide a response of adequate or inadequate for their opinion of boat ramps (27.2%). This could be due to the fact that boat slips are a more specialized access type than boat ramps which causes fewer individuals to be knowledgeable and opinionated about their level of access to the public. 45.8% of respondents felt that this type of access had adequate or more than adequate access in the Bays compared to just 8.8% of respondents who felt boat slips had inadequate access or little or no access (Loerzel et al., 2015).

Dockage at Restaurants

About half of respondents (55.3%) felt that access to restaurants and restaurant dockage was adequate or more than adequate, with 14.4% feeling that access was inadequate or that there was little or no access to these types. A high number of individuals felt neutral about this type of access (17.9%), while another 6.0% and 6.4% were unsure or did not respond to this question respectively for a total of 30.3% of respondents (Loerzel et al., 2015).

Scenic Viewpoints

A slightly larger proportion of respondents felt that there was adequate or more than adequate access to scenic viewpoints in the Bays, accounting for 61.3% of respondents. However, a larger proportion of respondents (17.1%) also felt that there was inadequate access or little or no access to these viewpoints. This can be attributed to the fact that only 2% of respondents felt unsure about access to scenic viewpoints, while only 4.4% did not respond. Those who felt neutral about this type of access represented 15.1% of the respondents (Loerzel et al., 2015).

Waterway Trails

A large proportion of respondents felt unsure (16.7%), neutral (15.5%), or didn't respond (6%) to how adequate access was to waterway nature trails (e.g., kayak trails), representing a large proportion of respondents (38.2%). This could once again be due to the specialized nature of this type of access. A total of 41.7% of respondents thought there was adequate or more than adequate access to waterway nature trails, while 19.1% of respondents thought there was inadequate access or little or no access to this in the Bays (Loerzel et al., 2015).

Nature Trails

Alternatively, nature trails adjacent to water had a much higher proportion of respondents who felt there was inadequate access or little or no access for the Bays, representing 29.5% of respondents. Only 30.7% of respondents felt that there was adequate or more than adequate access to nature trails adjacent to water for the Bays. This makes nature trails adjacent to water almost evenly split between those who feel access is adequate and those who feel access is inadequate, separating it from the other access types that are mostly considered adequate access. A high number of respondents also felt neutral about this access type (21.1%), while 12.4% were unsure and 6.4% did not answer the question accounting for cumulative 39.9% of respondents (Loerzel et al., 2015).

Swimming Areas

A total of 44.7% of respondents felt that there was adequate or more than adequate access to natural swimming areas in the Bays, compared to 22.7% who felt there was inadequate access or little or no access. The other 32.7% of respondents answered either neutral (15.9%), unsure (11.2%), or didn't provide a response (5.6%) to the question (Loerzel et al., 2015).

Boardwalks

A relatively high proportion (25.5%) of respondents thought there was inadequate access or little or no access to boardwalks around the Bays compared to 37.5% of respondents who thought there was adequate or more than adequate access. Individuals who felt neutral about boardwalk access represented a high proportion of respondents (23.5%), while those who were unsure or didn't respond represented 7.6% and 6.0% of respondents respectively (Loerzel et al., 2015).

Dune Walkovers

Access to dune walkovers had the highest proportion of individuals who felt neutral about access (26.3%), with an additional large proportion of respondents who were unsure (15.9%). When combined with the proportion of those who did not respond to the question (7.2%) these individuals represent almost half of all respondents (49.5%). Of the remaining respondents, 31.5% felt that access to dune walkovers was adequate or more than adequate, while 19.1% felt that there was inadequate access or little or no access (Loerzel et al., 2015).

Camping

Over half of the respondents (52.5%) thought that access to camping was adequate or more than adequate compared to only 15.5% who thought there was inadequate access or little or no access. Those that felt neutral about camping access accounted for 15.1% of respondents, while 10.8% were unsure and 6.0% did not respond to the question (Loerzel et al., 2015).

Wind/Kite Surfing

Access to wind/kite surfing also had a high proportion of respondents who felt neutral about access (25.9%) or were unsure (19.9%). Combined with the proportion of those who did not respond to the question (7.2%) these individuals represent over half of respondents (53%). This could be attributed to the specialized nature of this access and recreation type. A total of 39.9% of respondents felt that there was adequate or more than adequate access to wind/kite surfing, compared to only 7.6% of respondents who believed there was inadequate access or little or no access. Those 7.6% of respondents gave wind/kite surfing access the lowest proportion of individuals who believed there was inadequate access or little or no access out of any of the access types in the Bays (Loerzel et al., 2015).

Kayaking

The proportion of those who felt access to kayaking sites was adequate or more than adequate (55.0%) was much greater than those who felt there was inadequate access or little or no access (12.0%). Those who felt neutral about access to kayaking sites and those who were unsure both represented 13.1% of respondents. A total of 6.8% of individuals did not provide a response to the question (Loerzel et al., 2015).

Rod-and-Reel Fishing Sites

Access to rod-and-reel fishing sites was considered adequate or more than adequate by 63.7% of respondents. This was greater than those who felt that there was inadequate or little to no access (13.2%). The respondents that were unsure or provided no answer comprised 13.2% of the total. Only 10% of respondents were neutral on the topic of rod-and-reel fishing access (Loerzel et al., 2015).

Fly Fishing Sites

Perhaps reflecting the obscurity of fly fishing, 56.6% of respondents were either unsure, were neutral, or did not provide a response as to the level of access for fly fishing sites in and around the Bays. Whereas 30.3% felt that there was adequate or more than adequate access to fly fishing locations and 13.2% felt that there was inadequate or little to no access for fly fishing in the Mission-Aransas Bay complex (Loerzel et al., 2015).

Oystering

Respondent attitudes toward access to public oyster sites also seemed to reflect limited public involvement in the activity with a total of 64.5% of respondents either not responding (8.0%), unsure (40.6%), or neutral (16.3%) on the subject of access to public oyster sites. Only 16.7% thought there was adequate or more than adequate access and 18.4% believing there to be little to no access or inadequate levels of access to public oyster sites (Loerzel et al., 2015).

7.5 Public Access Goals, Objectives, and Actions

GOAL 3: Promote public appreciation and support for stewardship of coastal resources

OBJECTIVE 3-11*: Enhance public and group access to Reserve and partner education facilities and environments through installation of trails and signage*

ACTION 1: Install trails within the water-wise garden located on UTMSI property

UTMSI and the Mission-Aransas Reserve are currently developing a water wise demonstration garden that utilizes native, water wise plants that attract wildlife, such as birds, butterflies, and dragonflies. The garden will be located on the UTMSI campus (see Section 8.4.3) and will include a series of trails that provide the opportunity for visitors to UTMSI and the Reserve to learn about the importance of wildlife gardens and water conservation, greatly enhancing the education and training programs currently offered. The trails will be open to the public and signage will be installed to provide opportunities for visitors to learn about native plants and wildlife during self-guided walking tours. The Stewardship Program will continue to work together with staff from UTMSI to coordinate the planning and oversee the implementation of this project.

ACTION 2: Install signage at public access locations throughout the Reserve

Reserve staff have worked with partners to design and install interpretive signs promoting public appreciation and support for stewardship of coastal resources. For example, signs highlighting the problems of marine debris were installed near Egery Flats in an effort to control the litter problem in this area. Signs were also installed at Fennessey Ranch to highlight the diverse array of habitats and species that can be found on the Ranch, as well as the management strategies that are used to increase the conservation value of the Ranch. Over the next five years, Reserve staff will work with partners to identify additional locations where interpretive signs would be beneficial for promoting better stewardship of the resources in the Mission-Aransas Estuary, focusing on public access areas. Without dedicated funds for these types of projects, the Reserve will have to work with partners to identify potential funding sources as well.

8.0 Facility Development and Improvement Plan

8.1 Introduction

The facilities plan is a required element of a Reserve management plan, per the Federal Code of Regulations 15 CFR 921.13. Reserve facilities provide functional space for reserve work and programming, and serve as the face to the public providing venues for learning and serving as a learning tool themselves. Reserve facilities must face all of the pressures that come with working and building in the coastal zone including withstanding storms, surge, erosion, and elements of wind, salt, sand, humidity among others. Additionally, a changing climate will exacerbate these pressures resulting in increased erosion, frequency and intensity of storm events and associated surge, sea level rise, and associated salt water intrusion. These challenges require reserves to build facilities that will withstand these pressures and serve their intended purpose for the life-cycle of the structure. NOAA encourages reserves to build new and improve existing facilities so that they are sustainable and resilient. The building principles that were developed to guide the NERR System include: (1) integrated design & sustainable siting, (2) water efficiency, (3) energy efficiency, (4) materials and resource conservation, (5) indoor environmental quality, and (5) operational efficiency.

The Mission-Aransas Reserve is responsible for providing facilities that are necessary to fulfill its mission as established by federal and state laws, administrative rules, interagency agreements and the Reserve's management plan. Facility development has been a focus of the Reserve since its designation in 2006. Since that time, the Reserve has received funding for the construction of four new facilities: Estuarine Research Center, Wetlands Education Center, Bay Education Center, and Estuary Explorium (Figure 8.1). A description of each of these facilities is provided below, along with descriptions of partners facilities.

Construction of additional facilities and improvements to existing facilities will proceed as funds become available, as prioritized in the Reserve's management plan. Design of all facilities will be guided by the NERR System building principles listed above and will also comply with the Americans with Disabilities Act, comply with building and wastewater codes, comply with appropriate environmental requirement, satisfy local, regional and national priorities by soliciting input from user groups and allowing for future expansion to meet long range goals.

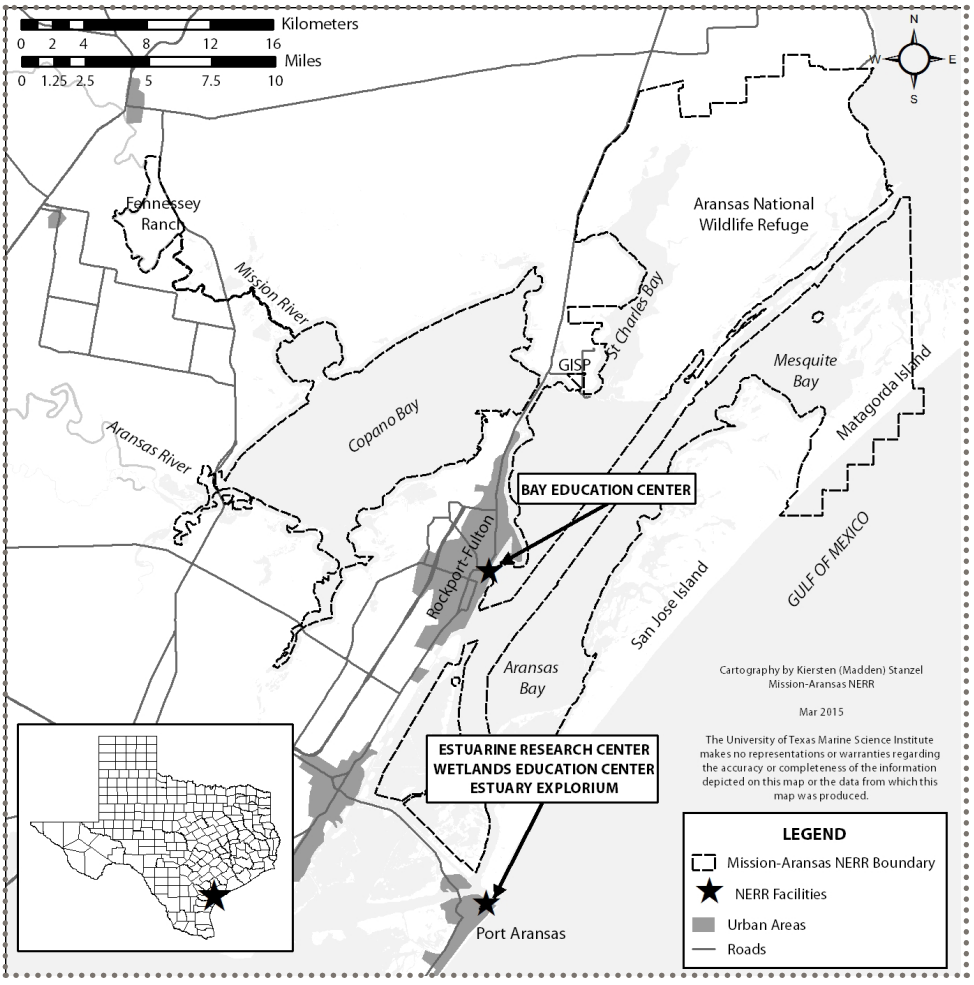


Figure 8.1. Map of Mission-Aransas Reserve facilities.

8.2 Existing Facilities

8.2.1 University of Texas Marine Science Institute

The Reserve is based in Port Aransas, Texas at the University of Texas Marine Science Institute. The UTMSI campus provides office, meeting, and educational spaces for the Reserve (Figure 8.2). The Reserve also maintains an additional educational facility in nearby Rockport, Texas.

Aerial view of the UTMSI campus

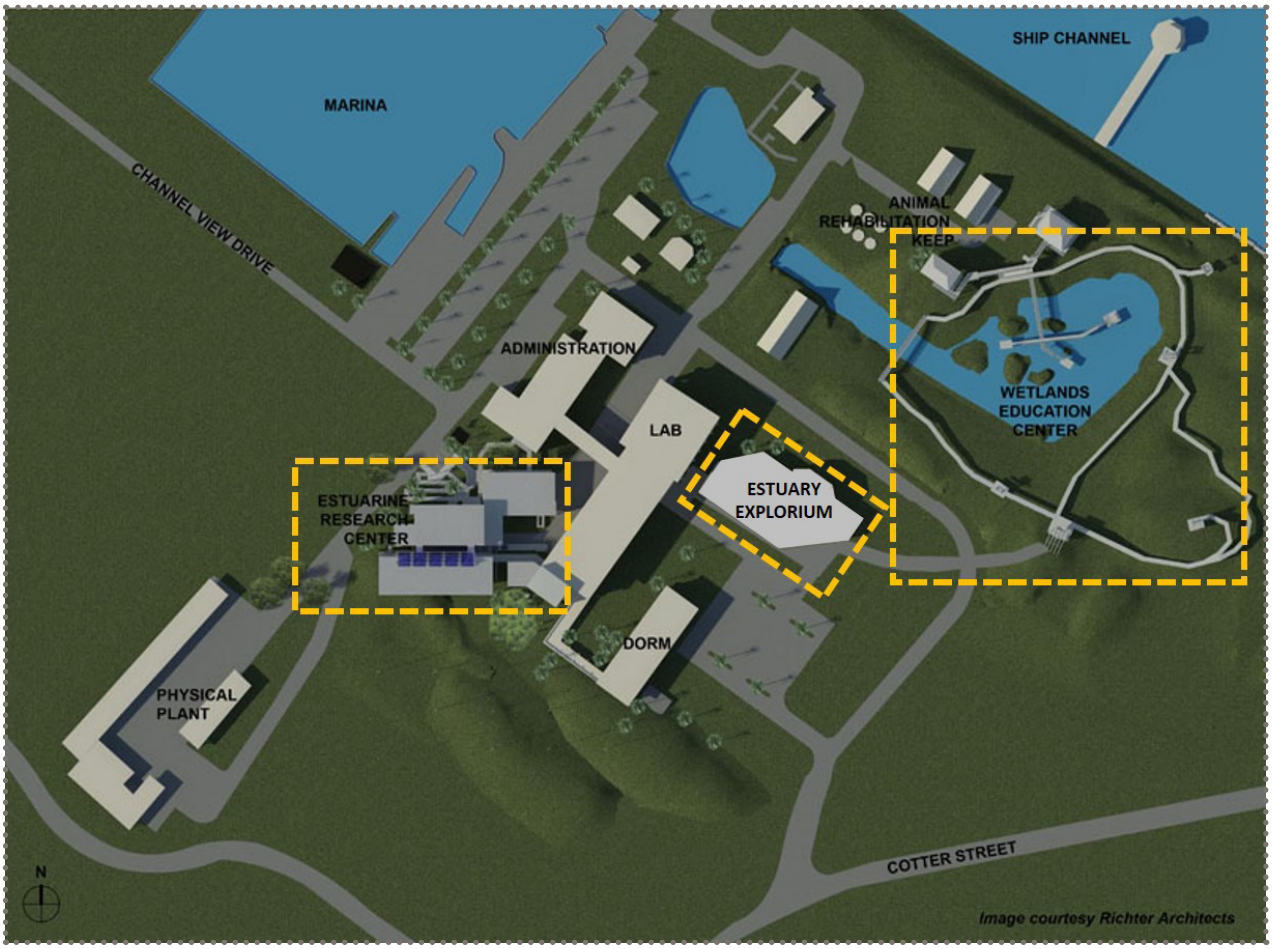


Figure 8.2. UTMSI campus map showing the location of Reserve facilities.

Estuarine Research Center

Estuarine Research Center

The Estuarine Research Center is located on the UTMSI campus in Port Aransas, Texas and houses both the Mission-Aransas NERR Headquarters and new research space for UTMSI. The NERR headquarters includes research labs and offices, plus an auditorium, conference rooms, kitchen, work room, and computer room. UTMSI's laboratory expansion within the building includes six research laboratories and offices for faculty, graduate students, and technicians. The 35,940-gross-square-foot facility consists of a three-story building, with the Mission-Aransas NERR on the ground and second floors and the new UTMSI space on the third floor. The two units will work synergistically to focus on the unique research opportunities and needs of the region. There is also a single-story Resource Center contiguous with the second floor. The Resource Center contains an on-line research facility, breakout rooms for workshops, and paper and digital information resource files.

Research labs provide space for maintenance of water quality loggers

An interdisciplinary team of engineers, architects and Reserve staff worked collaboratively to design and construct a headquarters and research facility that could withstand harsh coastal conditions (i.e., high winds, salt, torrential rains and storm surges) and meet specific sustainability goals. Located in the heart of the UTMSI campus, the building was designed to make a statement as a state-of-the-art research facility, while at the same time reflect the scale, materials, and color palette of the existing campus buildings. It was not only designed to meet the specific research and administrative requirements of both UTMSI and Mission-Aransas NERR, but also address the environmental issues associated with a structure located in a coastal environment. For example, the facility is (1) designed to sacrifice the ground floor which houses non-critical building functions, (2) built with an exterior that is rated to handle 130 mph winds, and (3) constructed with concrete additives to prevent chloride penetration. In addition, the grounds are designed to deal with increasing drought conditions by using irrigation systems that utilize the air conditioning condensate and rainwater captured from the roof to reduce impacts on municipal water systems.

The Estuarine Research Center is currently registered with the U. S. Green Building Council with a LEED Gold Certification. Several design and construction practices were implemented to achieve the LEED gold rating. The Estuarine Research Center is rotated to a true North-South orientation to make best use of natural illumination. The main part of the building is composed of two wings: laboratory and administration/office wing. The south face of the lab wing is sloped so as to integrally shade the lab windows through spring, summer, and fall. A light well in between the two wings allows natural lighting to enter interior spaces. The north face of the lab wing is also sloped so as to allow more light in. Emphasizing energy efficiency and indoor environmental quality, the new building design strategies promote sustainable building methods. Additional project sustainability features include:

- Reduced site disturbance and open space restoration
- Storm water management
- Landscape and exterior design of roof and non-roof areas to reduce heat island effect
- Light pollution reduction with fixtures that are oriented for down lighting and low wattage
- Maximize water efficiency within the building with low flow fixtures (toilets and sinks)
- Water efficient landscaping and irrigation with non-potable water
- Building commissioning – An outside firm is used to ensure, measure, and verify the building systems, such as HVAC, meet the specifications required by LEED
- Optimized energy performance with efficient HVAC systems
- Use of renewable (solar) energy. The panels are producing ~70 amp hours = enough to power 3 (2,500 f^2) homes in the Texas Coastal Bend!
- Use of refrigerants with low ozone depleting potential
- Storage & collection of recyclables
- Diversion of construction waste from landfill to recycling – 83%
- Use of recycled content building products – 21%
- Use of regionally produced building products – 82%
- Use of environmentally responsible certified wood products – 100%
- Environmental tobacco smoke control
- Carbon dioxide and airflow monitoring
- Indoor air quality management during construction
- Use of low-emitting materials including adhesives and sealants, paints, carpet, and composite wood
- Indoor chemical and pollutant source control
- Provision of day lighting and views to 90% of the spaces
- Green housekeeping
- Controllability of lighting systems
- Use of barrier island indigenous planting
- Use of green furniture
- Visitor "green" education

Wetlands Education Center

Wetlands Education Center

The Wetlands Education Center consists of approximately 3.5 acres of salt marsh and sand dune habitat, on the UTMSI campus in Port Aransas. Handicapped accessible trails and boardwalks wind around a central salt marsh and through surrounding sand dunes. Visitors to the Wetlands Education Center learn that estuaries provide important ecosystem services and critical habitats for wildlife - during free, docent-led, biweekly tours. Many species of coastal plants and animals are identified on wayside interpretive panels that are located near shade kiosks along the trails. A bronze geodetic marker at the entrance is interpreted as part of the National Spatial Reference System and visitors are oriented to the locations of six other NERRS reserves as part of the display.

The Wetlands Education Center is open free to the public at all times throughout the year and visitors may take a self-guided tour anytime they wish, using the interpretive signage that is stationed along the walkways. K-12 field experiences at the Wetlands Education Center are available upon request.

Floating platforms allow visitors to experience the aquatic resources of the Reserve up-close

Estuary Explorium

The Estuary Explorium is part of the UTMSI Marine Science Education Center, in Port Aransas. Port Aransas is on the north end of Mustang Island, one of seven Texas barrier islands that separate the ocean waters of the Gulf of Mexico from numerous estuarine bays and lagoons. Ocean and estuarine waters meet and mix in Aransas Pass, the pass that divides Mustang Island from San Jose Island to the north. The ability to view Aransas Pass from the Estuary Explorium, provides an excellent opportunity to interpret the ocean-to-estuary transition that barrier island passes allow.

The Estuary Explorium houses 1,000 square-feet of exhibits and the Explorer Lab, a dynamic interpretive space used for early childhood and K-12 student programs, teacher professional development, and public and community education programs. The area also contains office space for Reserve educators. The UTMSI Marine Science Education Center houses an auditorium, a gift shop, and an exhibit hall with six aquaria displaying local marine animals and several marine science exhibits, in addition to the Estuary Explorium.

Estuary Explorium exhibits were completed in 2014

The interpretive goals of the Estuary Explorium are to: (1) enhance understanding of the ecological importance of estuaries in the life cycles of estuarine dependent marine animals; (2) foster an appreciation of the economic benefits provided by commercial and recreational fishing of estuarine dependent species; (3) increase awareness of estuarine research conducted by UTMSI and Mission-Aransas Reserve Scientists; and (4) promote awareness of the Mission-Aransas Reserve's stewardship activities and encourage the protection and conservation of estuarine resources. The exhibits will also feature climate literacy displays that will illustrate how future climate change could affect estuarine habitats. Climate-focused displays demonstrate how a predicted reduction in the frequency of freezes could increase black mangrove habitat and how relative sea level rise could result in a loss of tidal flat wetlands. A positive message that informs visitors how they can personally help protect estuaries is an important component to these exhibits.

The Estuary Explorium is open free to the public all year, from 8 am to 5 pm on weekdays, and as funding allows on weekends. Public visitors and school groups have the option of exploring the exhibits on their own or participating in scheduled programs in the Explorer Lab and adjoining Wetlands Education Center. Family-oriented, environmental education programs are offered at the Estuary Explorium on alternate Saturdays during summer months and periodically at other times throughout the year.

The Estuary Explorium was constructed inside the Marine Science Education Center using space that had been vacated by the Marine Science Library (now called the Resource Center) when it was moved to the

Estuarine Research Center. Exhibit design incorporated climate literacy principles, and fabrication strove to optimize energy performance, enhance indoor environmental quality, and reduce the environmental impact of materials. In addition to utilizing the footprint of an existing UTMSI building, other sustainability aspects of the Estuary Explorium include:

- All exhibits were manufactured out of Rio Grande Valley red oak (grown and cut within 250 miles of the Reserve - this is a rapidly renewable resource and is eco-friendly)
- All electronics and display internal lighting systems have "sleep" controls so they are not illuminated unless a visitor is interacting with them
- All adhesives, finishes, and paints used during construction were zero-VOC
- Windows are low-E and tinted to insure minimal IR and UV penetration, reducing load on the air-conditioning and minimizing any fading of exhibits
- Fluorescent lighting was upgraded to solid-state T-8 and will last for years at very low operating costs
- Spot lighting is LED and will last for over a decade
- Green housekeeping
- Several exhibit materials were recycled from other applications and uses

Bay Education Center

The Bay Education Center is located in the City of Rockport, adjacent to Rockport Harbor and near several other visitor attractions, including the Texas Maritime Museum, Aquarium at Rockport Harbor, Rockport Center for the Arts, Rockport Beach Park, and the harbor fishing pier. Rockport is on the eastern shoreline of Live Oak Peninsula, which is surrounded by estuarine waters within the Reserve boundary, so the Bay Education Center is ideally positioned for increasing estuarine literacy and promoting stewardship among public audiences.

View of the exterior of the Bay Education Center

The Bay Education Center is a cooperative effort among the Mission-Aransas Reserve, the City of Rockport, and the ACND. The Bay Education Center houses NERR exhibits and offices for City Parks and Leisure Services and NERR staff. The interpretive goals of the Bay Education Center are to: (1) foster an appreciation of the Mission-Aransas Estuary's natural resources and the ecosystem services the Estuary provides; (2) enhance an understanding of human impact on the past, present, and future estuarine environment; (3) encourage the protection and conservation of the natural and cultural resources within the Mission-Aransas Estuary; and (4) promote awareness of the Mission- Aransas Reserve's existence and mission.

The Bay Education Center contains approximately 950 square-feet of interactive exhibits, aimed at enhancing public understanding of estuarine systems and the role that NERRS reserves play in estuarine research, education, management, and protection. The Bay Education Center auditorium houses Science on a Sphere, a display system created by NOAA to enhance public knowledge of earth, ocean, atmospheric, and planetary sciences. The auditorium offers seating for approximately 80 people and is used for teacher professional development and student education programs, public lectures, workshops, and meetings. An outdoor courtyard is used as a staging area for field experiences that are delivered to students, teachers, and

families in the surrounding bays. K-12 education programs at the Bay Education Center help students develop knowledge and skills in the life, earth, and physical sciences. Students participating in field-based activities use scientific data to answer questions about the local estuarine environment. The questions posed are locally relevant, but the addition of Science on a Sphere allows students to understand how global patterns, such as ocean circulation, weather, planetary movements, and climate change affect the local environment.

Painting of the conrete floors at the Bay Education Center improve aesthetics whiel also providing long-term durability

The Bay Education Center is open free to the public all year, from 1 pm to 4 pm, Tuesday through Saturday. Regularly scheduled Science on a Sphere programs are offered free to the public several times a week and student field experiences and Science on a Sphere programs that are aligned to the Texas Essential Knowledge and Skills state teaching standards are available upon request. NERR sponsored public lectures, known as "Bay Talks," are presented on Fridays at noon, from mid-January to mid-March. The NERR Visitor Center is also used for meetings presented or hosted by NERR, City of Rockport, or ACND staff. Partner organizations should contact their NERR, City of Rockport, or ACND partners to request hosted meetings. Meetings that are hosted by NERR staff, must support the mission and goals listed above for the Center. Organizations or individuals who wish to use the NERR Visitor Center for meetings that do not support the above listed mission and goals and are not affiliated with the City or ACND, may contact the City of Rockport's Parks and Leisure Services to arrange to rent meeting space.

The Bay Education Center with environmental sustainability and the harsh conditions of the coastal environment in mind. In order to account for potential inundation from storm surge, the site was elevated well above base flood elevations before construction of the building began. The building was also designed to meet Texas Windstorm Insurance Association standard specifications for construction of new buildings along the coast. Sustainability aspects of the Bay Education Center include:

- Exterior design of roof reduces heat island effect
- Water efficient landscaping and irrigation - landscaping design was done collaboratively with members of the Mid-Coast Chapter of the Texas Master Naturalists
- Low-flow toilets
- Shade structures were installed on the exterior of the building to help keep the facility cool and reduce loads on the air-conditioning units
- Concrete floors provide long-term durability
- Design incorporated fewer windows in order to keep the building cool and reduce loads on the air conditioning units

UTMSI Vessels

The Marine Science Institute's fleet of research vessels includes the R/V KATY and several smaller boats, each with special capabilities for working in different habitats and performing different operations. Descriptions of the vessels available for use by the Reserve are provided below.

R/V Katy

The R/V Katy is 57 feet long and has a top speed of 10 knots. Below decks living quarters include bunk space for six. There is a complete galley with refrigerator and electric range. All the quarters are air conditioned. In addition to the normal controls on the bridge, there is a stern steering station. A wet laboratory space is semi-enclosed off the work deck, A compartment immediately forward of the wet laboratory space can be used as a day room for personnel, or can be rigged as an instrument room for research projects. This vessel's primary utilization is as a stern trawler for class trips sponsored by the MES. The Katy is used by the NERR Education Program.

Students return from a trip aboard the R/V Katy

Lowe

An 18-ft aluminum skiff powered by a 45-horsepower outboard motor used in shallow water and estuaries. Not suitable for open water. Maximum capacity is eight people or 1,085 lbs

Small Whaler

A 13-ft Boston Whaler powered by a 30 horsepower outboard motor. Maximum capacity is four people or 600 lbs.

Big Whaler

A 16-ft center console Boston Whaler with a 60-horsepower outboard motor. Maximum capacity is five people or 925 lbs.

Montauk

A 17-ft center console Boston Whaler with a 110-horsepower outboard motor. Maximum capacity is five people or 925 lbs.

R/V Beachcomber

An 18-ft custom aluminum "air-boat" powered by a high performance 454 cubic inch Chevrolet engine. Used for ultra shallow research and delta/marsh work. Maximum capacity is six people or 1,110 lbs. Special qualification required to operate.

Skimmer

A 21-ft center console fiberglass flat bottom, tunnel-hull skiff with a 175-horsepower outboard with a Jacuzzi "water-jet" drive for shallow water operation. Maximum capacity is five people or 925 lbs.

R/V Caesar Kleberg

A 24-ft Jefferson fiberglass boat powered by a 260-horsepower inboard-outdrive. It may also be equipped with a "C" frame and cathead for lifting gear. Maximum capacity is eight people or 1,480 lbs. Advanced operator qualification required.

C-Hawk

A 24 ft fiberglass boat with forward cuddy cabin and large working cockpit powered by a 200 horesepoweroutboard motor. An excellent bay boat and may be used near-offshore in calm conditions with permission of the Captain of Small Boats. Maximum capacity is 11 people (including operator) or 1,500

lbs. . Advanced operator qualification required. The C-Hawk is often utilized by the Reserve Research programs for visits to long-term water quality monitoring sites.

Researchers deploy a plankton tow from the C-Hawk during a routine sampling trip

Pontoon Boat

A 24-ft aluminum catamaran/pontoon flat-deck boat with mid-deck hatch for equipment powered by a 90-horsepower outbound for use in shallow water and estuaries. Not suitable for open water except in calm conditions. Maximum capacity is 14 people or 1,576 pounds.

Segundo Vez

A Sea Ray 25-ft. fiberglass boat with cabin and large working cockpit powered by a 230-horsepower inboard/outdrive. An excellent bay boat and suitable for use nearoffshore in calm conditions with permission from the Captain of Small Boats. Maximum capacity is ten people or 1,500 pounds. . Advanced operator qualification required.

R/V Shearwater

A 26-ft aluminum "landing craft" with a 150-horsepower outboard motor. It can carry up to 14 people or an All Terrain Vehicle with gear or a maximum of 2,600 lbs. Advanced operator qualification required.

Dr. Cleo

A 22-ft Boston Whaler Dauntless with a 200 hp outboard engine, digital controls, fully equipped and center console with T-top. May be used near-offshore in calm conditions with permission from the Captain of Small Boats. Maximum capacity is 9 people or 1,650 lbs. Advanced operator qualification required. The Dr. Cleo is often utilized by the Reserve Research and Stewardsihp programs for visits to long-term monitoring sites.

Reserve staff use the Dr. Cleo to visit a mangrove monitoring site on Harbor Island

Pursuit

A 30-ft fiberglass offshore fishing boat with walk-through transom and dive platform, cabin with head and galley, flying bridge, fish well, bridge-deck storage, windscreens powered by twin 250 hp. Yamaha outboards with opposing screws. Capable of high-speed transit to rigs and for offshore sampling. Does not have over-the-side handling gear. Maximum capacity is 11 for inshore operation and 7 for offshore operation . A Marine Operations Boat Captain is required, and the capacity and daily rate fee includes the operator.

8.2.2 Aransas National Wildlife Refuge

Facilities at the Aransas National Wildlife Refuge include a wildlife interpretive center that offers Refuge information, exhibits, environmental education, wildlife programs, and a nature bookstore. A 16-mile, paved auto tour loops through brushlands, grasslands, oak mottes, and brackish and freshwater marshes;

complete with trailhead signs and exhibit panels. The 40-foot observation tower offers a panoramic view of San Antonio Bay and Mustang Lake. A boardwalk trail near the pavilion meanders through a salt marsh to the shore. The refuge also offers several miles of walking trails that include observation platforms, telescopes, and photo blinds. Two picnic grounds with restrooms are also available. The refuge also has a headquarters complex, with offices, residences, and service area. A Youth Environmental Training Area (YETA) is present at the Refuge but is not currently being utilized. The YETA is composed of an assembly area, picnic shelter, restroom facilities, amphitheater and four primitive campgrounds for up to 250 - 300 people.

View from the observation tower at ANWR

ANWR also encompasses the southern end of Matagorda Island, which includes the old Wynne Ranch. All facilities use solar power as well as a diesel gas generator. The McAlister House has an eight person capacity and includes A/C, heat, kitchen, and restroom. The facilities on Matagorda Island do not receive much use by USFWS or partners due to logistical difficulties of traveling to and staying on the Island, but in recent years the Mid-Coast Chapter of the Texas Master Naturalist have utilized the McAlister House while conducting daily patrols of the beach looking for Kemp's Ridley sea turtle nests. The Refuge also has a boat ramp/boat house and maintains their own small fleet of vessels.

Waterfront campsites are popular with visitors staying at GISP

8.2.3 Goose Island State Park

Facilities at Goose Island State Park include shade shelter campsites ("open cabanas") with water and electricity, located on the island near the bay; campsites with water and electricity in a heavily, tree-shaded area; campsites with water in the shady area; a group area; picnic sites (some with shade shelters); restrooms with and without showers; a snack bar within two miles; a fish-cleaning shade shelter; a double-lane boat ramp; a 1,620-foot, lighted fishing pier with two fish-cleaning tables; a group recreation hall with tables and chairs (no kitchen - capacity 50); playground areas; and a Texas State Park Store.

8.2.4 Fennessey Ranch

Fennessey Ranch is composed of several miles of all-weather roads, fence lines, pipelines and corridors. There is also a power line easement, and several food plots, oil and gas wells, and water wells. There are currently four facilities including McGuill Lake pavilion, the camp house, metal storage/workshop, and corrals. The camp house has a footprint of approximately 25 acres. Additional infrastructure throughout the Ranch includes 15 photo blinds (eight permanent and seven portable),

Students utilize the floating platform at McGuill Lake at Fennessey Ranch

fencing, a boardwalk and pier (with floating platform at end) at McGuill Lake, and a gate sign. Educational signs highlighting the habitats and species of Fennessey Ranch were developed by Reserve staff and were installed throughout the Ranch in areas commonly used for educational programs. The Ranch also owns a trailer that can accommodate 35 people for educational tours.

8.3 Facility Challenges

The Mission-Aransas Reserve faces several challenges associated with the on-going management and maintenance of its facilities. These challenges can result from age, use, and/or natural/anthropogenic stressors. The following table summarizes the major challenges at each Reserve facility, as well as the current strategies used by the Reserve to meet these challenges. If the Reserve does not currently have a strategy for meeting an identified challenge, this gap is signified with bold text.

Table 8.1. Management and maintenance challenges at Reserve facilities.

Facility	Construction Date	Challenges	Strategies
Estuarine Research Center	2011	On-going maintenance of building and grounds	UTMSI maintenance, grounds, and custodial staff are responsible for routine maintenance of the Estuarine Research Center buildings and grounds
		On-going maintenance of vessels	UTMSI employs two boat captains that are responsible for maintaining all vessels
		Scheduling use of auditorium and conference rooms	UTMSI administrative staff oversee the scheduling of the Estuarine Research Center auditorium and conference rooms
		Threat of hurricanes	The Estuarine Research Center is designed to withstand a major hurricane without any modifications to the exterior of the building (e..g., shutters), but ground floors are designed to give way during storm surge, so critical equipment must be moved to second and third floors
		Office space can become limited when there is a large influx of interns and student workers at certain times of the year (primarily during the summer)	Many offices within the Estuarine Research Center were modified from single-person to multi-people in order to provide space for temporary employees, interns, and students
Wetlands Education Center	2008	On-going maintenance of infrastructure (e.g., shade structures, boardwalks) and grounds	UTMSI maintenance and grounds staff are responsible for routine maintenance at the Wetlands Education Center - Reserve staff will consult with grounds staff to ensure that vegetation is managed for the benefit of education programs and the habitat itself

Facility	Construction Date	Challenges	Strategies
		Wear and tear to signage due to harsh coastal environment	Funding will be used when needed to replace faded and worn signs (most recent replacement occurred in 2014)
		Invasive species	Reserve staff will continue to work with UTMSI grounds staff and volunteers ("Wetland Warriors") to remove invasive species and transplant native species into cleared areas
		Threat of hurricanes	Reserve staff will work with UTMSI staff to ensure that all infrastructure is as secure as possible prior to a major storm
		Although trash and debris have not been a major issue to date, this could change as visitation increases	Reserve staff and volunteer docents will monitor the amount of trash/debris present within the Wetlands Education and Center, and if it becomes an issues, they will work with UTMSI to develop potential solutions
		Although vandalism has not been an issue to date, this is always a concern at facilities that have unrestricted access	UTMSI security staff routinely visit the Wetlands Education Center during non-business hours to ensure that the site is not being abused
Estuary Explorium	Exhibits: 2014 Building: 1982	On-going maintenance of building	UTMSI maintenance, grounds, and custodial staff are responsible for routine maintenance of the Marine Science Education Center
		General wear and tear to exhibits	When possible, Reserve staff will work with UTMSI maintenance staff to repair exhibits - if repairs cannot be made, new equipment may have to be ordered.
		Threat of hurricanes	Reserve will work with UTMSI staff to ensure that all procedures are followed for securing the building during the threat of a hurricane
		Potential abuse of exhibits is possible if visitors are left unsupervised	**Reserve staff require the assistance of a large group of trained volunteer docents to oversee use of the exhibits - the Reserve must work to expand the number of trained volunteers available for this type of program**
Bay Education Center	2010	On-going maintenance of building and grounds	Reserve staff will work with the City of Rockport and ACND to ensure that routine building and grounds maintenance is performed
		General wear and tear to exhibits	When possible, Reserve staff will work with UTMSI maintenance staff to repair exhibits - if repairs cannot be made, new equipment may have to be ordered

Facility	Construction Date	Challenges	Strategies
		Threat of hurricanes	Reserve staff will work with City of Rockport and ACND to secure the facility in the event of a hurricane
		Lack of storage	**Additional storage is needed for educational equipment - funding will be required to fulfill this gap**
		Scheduling of meetings and clean-up	The Reserve has developed a protocol document which outlines how to schedule meetings at the Bay Education, what equipment/facilities are available, and what clean-up is required

8.4 Planned Facilities and Improvements

The Mission-Aransas NERR plans to undertake several facility and/or facility upgrade projects over the next five years. The sections below provided detail about these planned projects.

8.4.1 Composting Toilets

Construction of environmentally friendly, ADA-compliant restroom facilities at Fennessey Ranch will enhance the educational opportunities and experiences offered at the site. Funding in the amount of $84,532 from the NERRS' Land Acquisition and Construction Program to construct composting bathroom facilities at several locations throughout the Ranch (Figure 8.3). These facilities will help Fennessey Ranch accommodate a greater number of students and disabled visitors, allowing for more individuals to learn about the diversity, quality, function, and values of coastal natural resources. The toilets themselves will provide an opportunity to educate visitors on the science of composting, environmental benefits it provides, and sustainable living practices. The importance of environmentally sustainable practices, such as composting toilets, will be incorporated into already existing educational lessons that are taught at the Ranch. The composting toilets will lend themselves as a natural connection for talking about drought and water conservation on the Ranch. The science of composting itself and the importance of nutrient cycling in nature can also be incorporated into the educational experiences of appropriate groups.

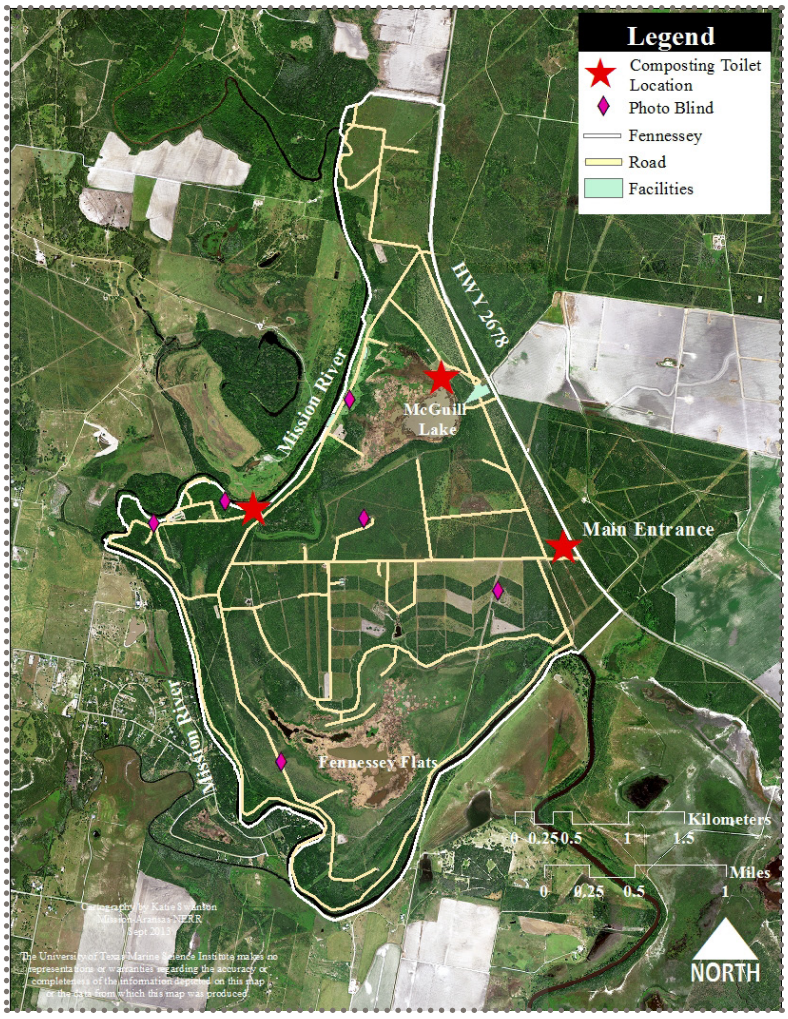


Figure 8.3. Location future compostinng toilets at Fennessey Ranch.

Composting toilets have an estimated life span of 30 to 40 years, with an approximate maintenance cost of only $25 to $50 per year. These systems provide a number of environmental benefits, including: (1) minimal or no water usage in a drought-stricken environment, (2) containment of waste onsite, and treatment through natural, biological processes, (3) reduction of risk of environmental contamination and negative effects to wildlife in the area by keeping excess nitrogen and phosphorous in a controlled environment, (4) elimination of the need for waste transportation, and (5) a smaller footprint for operation than conventional septic tank/leach field systems.

The fully enclosed systems will be placed at three sites throughout the Ranch: McGuill Lake, the riparian turnaround, and the Ranch's main entrance (Figure 8.3). Each of these locations is ideal for educational programs and have existing educational infrastructure in place to aid in the experience. Currently the Ranch has two portable toilets at the entrance and a vault-style toilet at McGuill Lake. Neither provides adequate facilities nor are they handicapped accessible. In addition, the existing toilets require regular maintenance, waste pumping, and have constant seepage problems. By installing ADA-compliant composting toilets, a large obstacle faced by the Ranch to maintain a successful educational experience in a remote, natural habitat would be removed. In order to learn how these new composting bathrooms have effectively increased the value of the educational experience at the Ranch, the number of visitors and events will be recorded for the length of the project period. It is anticipated that: (1) the number of events being offered will increase due to the ability to provide better accommodations to students and visitors, and (2) the resulting number of visitors attending these programs will increase as well.

8.4.2 Fennessey Ranch Conservation Center

The Fennessey Ranch conservation easement allows for construction of a conservation center. The building will be located at McGuill Lake and must maintain a footprint of less than 15-acres. McGuill Lake is an ideal site for the conservation center because existing infrastructure (pavilion with electricity) is already present, there is a well-maintained access road, and the area is already a focus for many of the educational programs which occur at the Ranch.

Although specific designs have not been developed, the conservation center will most likely be a 2,000 square foot building with electricity, air conditioning, running water, restrooms, and storage. The building would contain mostly classroom space to be used for a variety of environmental education programs, but the space could also be utilized by researchers during field visits to the Ranch. The estimated cost for this type of structure is $450,000. Reserve staff will work to ensure that the design of the facility is guided by the NERR System building principles and incorporates local, regional, and national priorities by soliciting input from user groups.

8.4.3 Water Wise Garden

UTMSI and the Mission-Aransas Reserve are currently developing a water wise demonstration garden that utilizes native, water wise plants that attract wildlife, such as birds, butterflies, and dragonflies. The garden will be located on the UTMSI campus (Figures 8.4 and 8.5) and will provide the opportunity to teach visitors to UTMSI and the Reserve about the importance of wildlife gardens and water conservation, greatly enhancing the education and training programs currently offered. The Partnerships are a key component of the proposed project and the community will be involved in the design, execution, and celebration of this xeroscape, wildlife garden. The specific objectives are:

1. To showcase the benefits of planting indigenous species (i.e., beauty, hardiness, attraction of wildlife, water conservation) by designing and creating a xeroscape garden for the UTMSI campus that complements the existing landscaping of the Estuarine Research Center.

2. To involve local and University of Texas at Austin landscaping organizations and architects in the overall design, as well as the design of sustainable infrastructure.
3. To provide a transitional educational opportunity between the Wetlands Education Center and Estuarine Research Center (which are located on opposite corners of the UTMSI campus) that enhances the formal and informal educational programs offered by UTMSI and the Mission-Aransas NERR and improve the overall learning experience of UTMSI visitors.

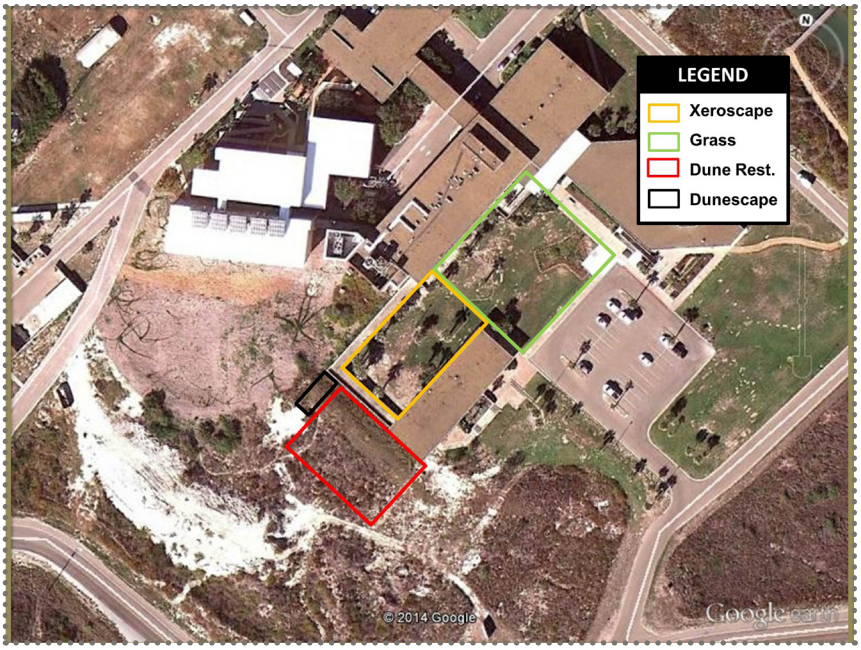


Figure 8.4. Location of Water Wise Garde on UTMSI campus.

The total cost of the project is estimated at $81,050. This includes the costs of design, landscaping, and development of educational programs. The amount requested from the University of Texas Green Fee Program was $61,050. The remaining funds for the project are being provided by UTMSI.

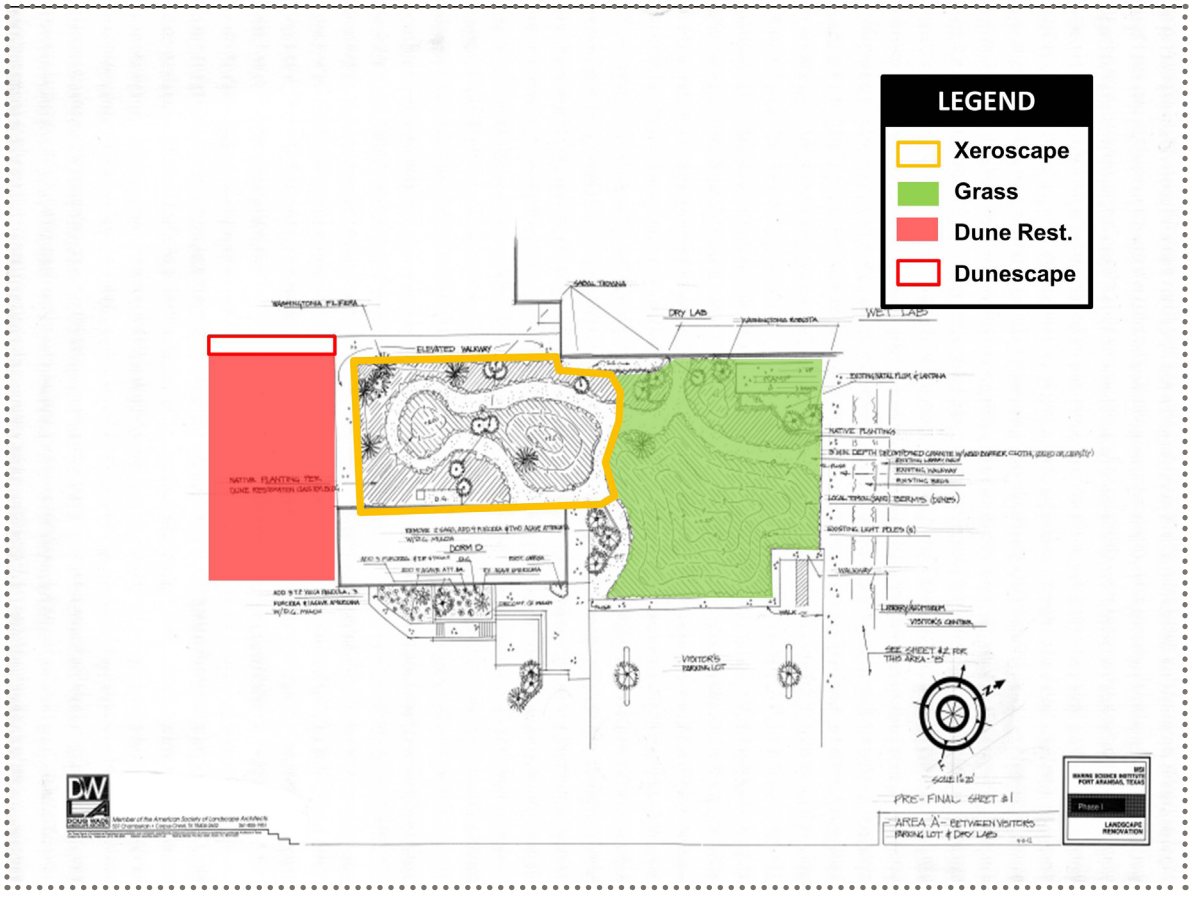


Figure 8.5. Schematic for Water Wise Garden.

8.4.4 Storage at the Bay Education Center

Grant funding was used to purchase supplies that support and enhance the hands-on educational programs offered at the Bay Education Center. A small storage cabinet is available inside the NERR Office, but the majority of these educational supplies are currently stored in an outside closet. This storage area has reached its capacity, and as the Reserve continues to expand their educational programs, additional storage space will be needed. Reserve staff will work with the City of Rockport and ACND to identify the most feasible options for expanding NERR storage at the Bay Education Center. This will most likely require the purchase of an outdoor closet which would need to be placed in a secure location to prevent theft and vandalism. Once the partners have agreed upon a preferred option, funding opportunities will be explored.

9.0 Land Acquisition Plan

9.1 Introduction

Land acquisition planning is a required element of the Mission-Aransas Reserve Management Plan, as dictated by the Federal Code of Regulations 15 CFR 921.13. Estuaries and their associated habitats offer numerous and diverse benefits to society and natural systems. Some of these benefits include: storm buffers to protect from hurricanes and storms; nurseries and habitat for commercially important marine species; stopover or wintering habitats for migratory species such as the endangered whooping crane. However, human growth and development has significantly eliminated or degraded the habitats that provide those societal values. To address the conservation of coastal habitats, the U.S. Commission on Ocean Policy in 2004 recommended that each state identify priority coastal habitats and develop plans, in partnership with willing landowners, federal agencies, and others, for coastal and estuarine land conservation.

The wetland, terrestrial, and marine environments within the Mission-Aransas Reserve are owned and managed by a combination of state, federal, and private partners. UT currently only owns the land on which the UTMSI campus and the Mission-Aransas Reserve Headquarters are located. A conservation easement is held by UT for Fennessey Ranch. UT is primarily focused on research and education, and land acquisition is not a core mission. Any lands acquired by the Mission-Aransas Reserve would have to be approved by the UT Board of Regents. Therefore, the Mission-Aransas Reserve generally relies on its partners, particularly those serving on the RAB (i.e., TNC, CBBEP, CBLT), to protect and conserve sensitive and important land and habitats through acquisition.

The Reserve Stewardship Program promotes land conservation by working with partners to coordinate management activities and provide technical assistance when necessary. Although the Mission-Aransas Reserve has not acquired any lands directly, the Stewardship Program has helped to identify critical coastal and estuarine areas for potential land acquisition within the Reserve and has worked with partners to acquire the funds for purchase of valuable habitats. This plan highlights several of the ecologically key land and water areas that have been identified for acquisition, prioritizes these areas according to their relative importance for specific values, and describes strategies for establishing adequate long-term state control over these areas.

9.2 Acquisition Values

Lands being targeted for protection and conservation by the Mission-Aransas NERR and its partners include coastal/estuarine habitats and areas within the watershed that have significant ecological, conservation, recreation, historical, aesthetic, and cultural values. Reserve partners and stakeholders identified ecological and conservation value as being the most important consideration when selecting specific targeted areas for acquisition within the Reserve. Aesthetic value was given less importance, while cultural and historical values were ranked as the least important. Threats from natural and anthropogenic stressors within the Reserve must also be considered when identifying and prioritizing areas for acquisition. By using the values identified above to prioritize acquisition efforts within the Reserve watershed, the Reserve will be able to ensure that all acquisition efforts support its goal of promoting appreciation and support for coastal resources by including properties necessary to protect the integrity of the Reserve for research purposes, and for those parcels required for research and interpretive support facilities or buffer purposes.

9.2.1 Priority Lands and Values

Priority areas to be protected though land acquisition include those habitats/areas designated as Coastal Natural Resource Areas (CNRAs), as well as other lands identified as having high conservation, ecological, recreational, historical, or aesthetic values (GLO, 2010). Some of the habitats to be protected, such as seagrass beds and marsh habitat, may already exist within the Reserve boundary, but future acquisitions by Reserve

partners will be used to protect greater acreages or to buffer these areas. General descriptions of the habitats and areas to be protected are provided below and are grouped into the following three categories: Coastal Natural Resource Areas, other habitats, and other lands or values.

Coastal Natural Resource Areas

- Coastal wetlands (swamps/bottomland hardwoods, mangroves and other scrub shrubs, and salt, fresh, intermediate, and brackish marshes): Areas having a predominance of hydric soils that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, the growth and regeneration of hydrophytic vegetation.
- Coastal shore areas: Areas within 100 feet landward of the high water mark on submerged land.
- Critical dune areas: Sand dune complexes on the Gulf of Mexico shoreline within 1,000 feet of mean high tide.
- Coastal barriers: An undeveloped area on a barrier island, peninsula, or other protected area.
- Tidal sand and mud flats: Silt, clay, or sand substrates, unvegetated or vegetated by algal mats, that occur in intertidal areas and that are regularly or intermittently exposed and flooded by tides, including tides induced by weather.
- Special hazard areas: An area designated by the administrator of the Federal Insurance Administration under the National Flood Insurance Act as having special flood, mudslide or mudflow, or flood-related erosion hazards and shown on a Flood Hazard Boundary Map or Flood Insurance Rate Map, as Zone A, AO, A1-30, AE, A99, AH, VO, V1-30, VE, V, M, or E.
- Coastal historic areas: A site in the National Register of Historic Places on Public Land or a state archaeological landmark that is identified by the Texas Historical Commission as being coastal in character.

Other Habitats to be Considered

- Habitats for rare, threatened, or endangered species: Property that supports, or is capable of supporting, habitats for state or federally listed rare, threatened, or endangered plant or animal species.
- Coastal prairies: A community where vegetation consists of mostly grasses and a diverse variety of wildflowers and other plants. Coastal prairie and adjacent marshes provide habitat for waterfowl and other forms of wildlife.
- Live Oak-Redbay forests: A community of closed to open canopy *Quercus fusiformis* forests on deep, hummocky sands, mostly on the Ingleside barrier-strandplain along the Texas Coastal Bend.
- Texas Ebony-Anacua forests: Forests along the deep, well-drained soils of the Rio Grande River delta, often associated with low lying resaca banks that had been formed by old river channels.
- Rivers and streams and riparian zones: Waters identified and described in the Texas Commission on Environmental Quality publication GI-316, Atlas of Texas Surface Waters, Maps of the Classified Segments of Texas River and Coastal Basins, August 2004, as well as the vegetated corridors that lie adjacent to these coastal streams and rivers.

Other Lands or Values to be Considered

- Public access and recreation areas: Areas which provide or enhance public access to coastal shore areas and other coastal areas for low impact and passive recreation, such as hunting, fishing, bird and wildlife watching, swimming, canoeing, and kayaking.

- Other conservation lands: Lands that provide connectivity and buffers to existing protected lands and/or lands that contribute to the goals, objectives, or implementation of the CMP (e.g., lands that buffer areas with submerged aquatic vegetation), Mission-Aransas Reserve, Estuary Programs, Texas Gulf Ecological Management Site Program, or other state/regional/local plans.

9.2.2 Mission-Aransas Reserve Priority Acquisition Targets

Given the limited resources of states and land trusts, it is important to include a prioritization process when identifying targets of future land conservation investments. A workshop was hosted by the Mission-Aransas Reserve to prioritize criteria and habitats for conservation and protection within the Reserve watershed. The workshop was attended by representatives from universities (TAMUCC), federal agencies (USFWS), state agencies (TPWD, GLO), non-profit organizations (Aransas First, CBBEP, TNC, Gulf of Mexico Foundation), and local government (City of Rockport, Aransas County). All of the attendees were stakeholders of the Reserve and several participants were members of the RAB.

Multiple factors were considered when prioritizing the habitats and geographic areas within the Reserve for acquisition. The ecological, conservation, recreational, historical, and aesthetic value were all considered, while potential stressors for consideration included: erosion, habitat alteration and fragmentation, sea level rise, hurricanes/storms, alterations in hydrology, resource harvesting, petroleum releases/spills, other chemical releases/spills, recreation, channelization, nuisance/exotic species, freshwater inflows, and dredging/dredge disposal. Historically, acquisition planning has looked at a variety of anthropogenic and natural stressors to support the prioritization process. Some of the types of stressors considered in the past include the threat of development, invasive species, and land zoning. Climate-related stressors have not been commonly factored into this process. The Mission-Aransas Reserve, however, included several climate-related criteria in its initial prioritization efforts, and these were applied equally to the prioritization process rather than outweighing other values or factors. When factoring in climate stressors, the Reserve must consider both short- and long-term impacts. As the Reserve and its partners move forward on land acquisition projects, it will be important to revisit the climate stressors in Table 9.1 to ensure that the project continues to support the goals of the Reserve.

Table 9.1. List of climate change stressors that are important for consideration when prioritizing acquisition areas within the Mission-Aransas Reserve watershed.

Stressor	Short-term Impact	Long-term Impact
Sea Level Rise	↑ Inundation, ↑ coastal erosion, Δ salinity, Δ geomorphology of coastal habitat, functional Δ in habitats	Disappearance of habitats, Δ species diversity, function Δ in habitats, Δ geomorphology of coastal habitat, habitat migration
Storm Intensity and Occurrence Rate	↑ Inundation, ↑ coastal erosion, Δ geomorphology of coastal habitat, functional Δ in habitats	Damage to key habitats, Δ species diversity
Change in Precipitation *	↑↓ drought, Δ salinity, Δ sediment and pollution loadings, ↑↓ flooding	Δ water quality/quantity, Δ species diversity, function Δ in habitats
Change in max and min temperatures *	↓ in freeze and die-back events, ↑↓ water temperatures, Δ in growing seasons	Disappearance of habitats, Δ species diversity, function Δ in habitats, habitat migration

*** denotes stressors which were not included in the previous prioritization workshop hosted by the Reserve but should be considered as acquisition projects move forward or re-prioritization occurs.**

In general, Reserve partners and stakeholders identified ecological and conservation value as being the most important consideration when selecting specific targeted areas for acquisition within the Reserve. Aesthetic value was given less importance, while cultural and historical valued were ranked as the least important. The top stressors that were identified by participants were: nuisance/exotic species, sea level rise, and habitat alteration and fragmentation. Non-petroleum chemical releases/spills, channelization, and dredging/dredge disposal were identified as the three least threatening stressors.

Based on the results of the prioritization workshop and subsequent conversations with Reserve partners, the habitats and specific geographic areas listed in Table 9.2 were identified as priority areas for protection. It is important to note that most of the priority acquisition areas listed below correspond closely to the priority habitats and areas listed above. The major stressors for each geographic area are also listed in Table 9.3.

Table 9.2. Priority habitats and geographic locations identified by Reserve stakeholders.

Habitat	Geographic Area
Salt marsh (wetland)	Port Bay, San Jose Island, Lamar Peninsula, Southwest of Redfish Point (East Copano)
Brackish marsh (wetland)	Aransas River Delta, Egery Flats (not identified in workshop)
Wind-tidal flats (wetland)	San Jose Island, Lamar Peninsula
Mangroves (wetland)	Harbor Island
Seagrass	Redfish Bay (private islands)
Freshwater/prairie wetlands	None identified during workshop, but several Reserve partners are focused on conservation of this type of habitat and can be contacted by Reserve staff as funding opportunities for acquisition occur
Riparian woodlands	Mission River corridor
Coastal prairie	Refugio-Goliad Prairie
Erodible bluffs	Western Copano Bay shoreline (specific to historic El Copano site)
Live oak-red bay forests	None identified during workshop, but the Reserve will have the opportunity to work with partners on a future conservation planning project for this habitat
Oysters	None identified at workshop, but emphasis should be on securing undeveloped areas along the shoreline of the Reserve that will benefit water quality
Upland buffers	None identified, but all undeveloped buffer areas along the shoreline of the Reserve should be considered

Table 9.3. Priority stressors identified for specific geographic areas within the Reserve.

Geographic Area	Stressors
Aransas River Delta	sea level rise, alterations to hydrology, nuisance/exotic species, freshwater inflows
Copano Bay Shoreline	erosion, sea level rise, hurricanes/storms
Harbor Island	sea level rise, hurricanes/storms, petroleum releases/spills, other chemical releases/spills
Lamar Peninsula	habitat alteration/fragmentation, sea level rise, nuisance/exotic species
Mission River corridor	habitat alteration/fragmentation, alterations to hydrology, nuisance/exotic species, freshwater inflows

Geographic Area	Stressors
Port Bay	habitat alteration/fragmentation, sea level rise, nuisance/exotic species
Redfish Bay (private islands)	erosion, sea level rise, hurricanes/storms
Refugio-Goliad Prairie	habitat alteration/fragmentation, nuisance/exotic species
San Jose Island	sea level rise, hurricanes/storms
Egery Flats	habitat alteration/fragmentation, sea level rise, alterations to hydrology, recreation

Although the Reserve recognizes the importance of all the habitats and geographic areas identified in Table 9.2, over the next five years the Reserve will focus on working with partners on acquisition in the following areas: St. Charles Bay watershed (Lamar Peninsula), Port Bay watershed, Egery Flats area in the Aransas River Delta, and riparian areas and wetlands of the Mission River Corridor (Figure 9.1).

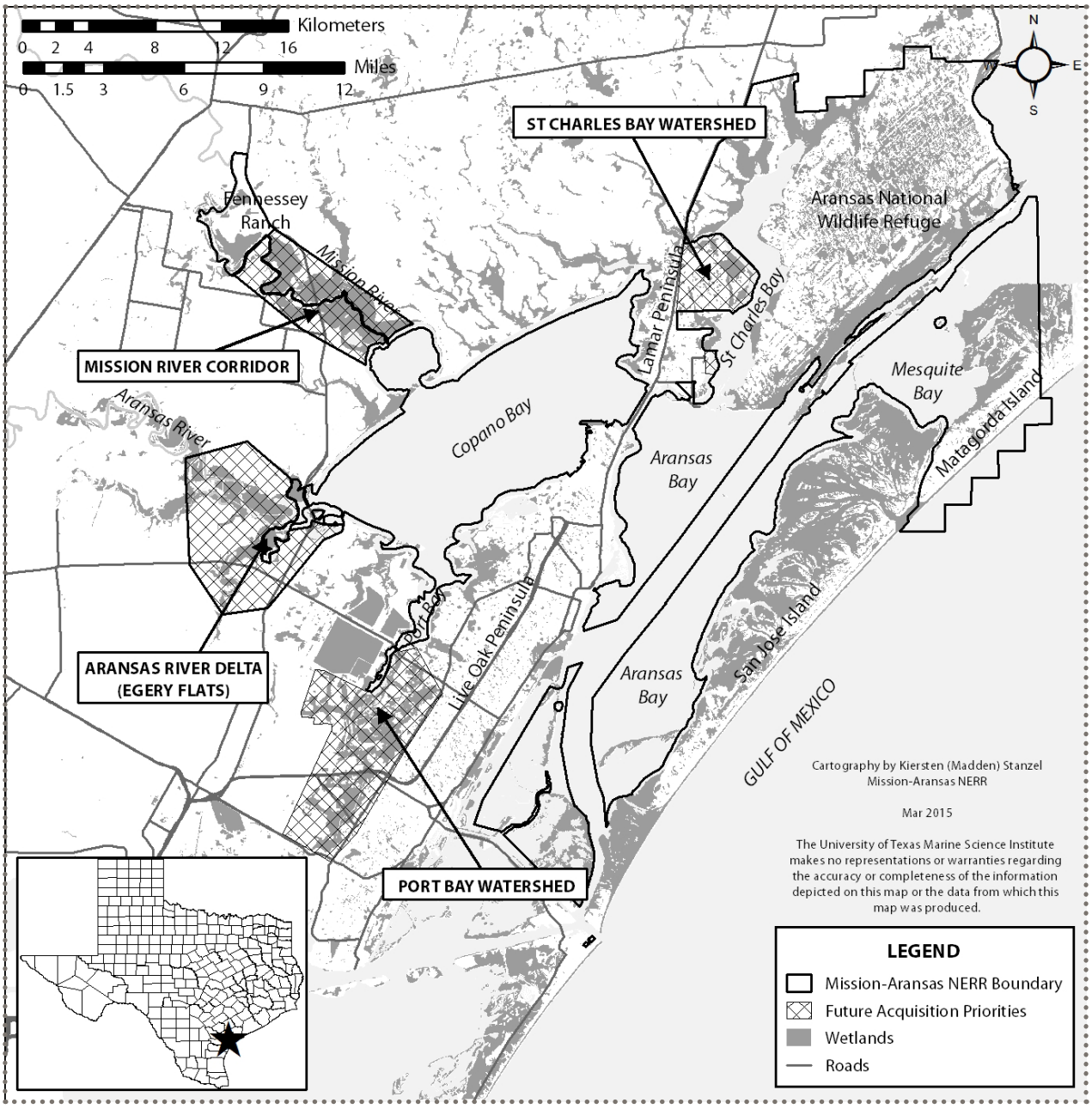


Figure 9.1. Priority acquisition targets within the Mission-Aransas Reserve watershed.

Lamar Peninsula - St. Charles Bay Watershed

St. Charles Bay is almost fully surrounded by ANWR and GISP. There are two identified parcels located on Lamar Peninsula adjacent to St. Charles Bay, the largest being situated between the Tatton and Lamar Units of ANWR. The Tatton Unit, a contiguous 7,568-acre stretch of coastal grassland lying between State Highway 35 and the west shore of St. Charles Bay, was added in 1967 to ANWR by donation. The Tatton Unit is connected to the Blackjack Peninsula at the northeastern terminus of St. Charles Bay. Public use on the Tatton Unit is limited to one observation deck found at the Hwy 35 roadside rest stop. The Lamar Unit is a disjunct 979-acre tract of live oak sandy upland and salt marsh located at the tip of Lamar Peninsula, on the west bank of St. Charles Bay. It was leased from The Nature Conservancy of Texas (TNC) in 1987, and arrangements for the purchase of 734 acres were completed in 1991. In 2006, an adjoining 245 acres (Johnson tract) of salt marsh was added to the Lamar Unit. The purpose of the Lamar Unit is the protection of salt marsh habitat for the Whooping Crane and the preservation of native coastal woodlands. Acquisition of this area between the two tracts would: (1) connect the currently isolated Lamar Unit directly to other ANWR land; (2) provide a greater number of protected acres of Whooping Crane habitat; and (3) ensure similar land management practices are being completed to conserve and preserve those areas of sensitive habitat.

Port Bay Watershed

Port Bay is located along the western boundary of the Mission-Aransas Reserve. The bay itself is within the boundary, but none of the surrounding land is currently incorporated. The Mission-Aransas Reserve has previously completed research in Port Bay, receiving access to the shoreline from a generous land owner. The USFWS has deemed the marshes in Port Bay a Texas Gulf Coast area of ecological concern. These marshes are valuable habitat for migratory bird, waterfowl, and threatened/endangered species. Port Bay is located in San Patricio County, which has the highest percentage of cultivated lands of counties within the Reserve. These lands drain into the Port Bay, causing water quality issues. This bay is currently listed by the TCEQ as having high bacteria concentrations. Generally the land surrounding Port Bay is classified as rangeland, providing another source of water quality and habitat impairment. Land acquisition in Port Bay would be desirable for the following reasons: (1)conserve valuable wildlife habitat; (2) improve water quality by providing upland buffer zones and (3) provide access points for research and education.

Aransas River Delta - Egery Flats

Egery Flats is a wetland complex comprised of extensive tidal flats marginally separated by emergent marsh ridges within the Aransas-Chiltipin Creek fluvial-delta area near the confluence of the Aransas River and Copano Bay. The Egery Flats area provides habitat to several species of birds, finfish, shellfish, and herpetiles. During low tide, the exposed flats and emergent marshes support thousands of migrating shorebirds feeding on macrobenthic infauna. During high tide, the inundated flats and emergent marshes support various wading birds and waterfowl and serve as nurseries to larval and juvenile fishes, shrimps, and crabs. Additionally, USFWS has identified this area as a site of potential range expansion for the endangered Whooping Crane, which depends on aquatic resources associated with estuarine marsh. All 300 acres of wetlands within Egery Flats are currently in a highly stressed environment with little water circulation and high salinities. The acquisition of Egery Flats would serve to enhance wetland restoration efforts and long-term conservation of the site. Egery Flats is a designated wetland, and not at risk for development, however it is impaired.

Mission River Corridor

Riparian areas are wooded areas located along rivers and streams that are subject to period flooding. Riparian areas typically encompass uplands, wetlands, or some combination of these two habitats and are usually characterized by tall trees with a dense to sparse understory. Flooding is a common event in riparian woodlands, and the many species which inhabit these areas are adapted to these episodic events. Most of the dominant woody plant species have deep root systems that anchor the plant in place, and some have

flexible stems that allow the plant to bend with current and recover after the flooding recedes. Riparian areas are important in ecology, environmental management, and engineering because of their role in soil conservation, biodiversity, and influence on aquatic ecosystems. This zone serves as a natural biofilter by protecting aquatic environments from excessive sedimentation, runoff, and erosion. These areas are also very important stopovers for migrating birds.

The valuable riparian areas located along the Mission River are threatened by removal of trees for firewood and lumber, housing developments in the flood plain, grazing cattle, and artificially channelizing and damming waterways for flood protection and water supplies. The most common disturbance involves clearing of vegetation and converting the area to other uses such as cropland and urban areas. Overgrazing can be devastating because livestock tend to congregate for extended periods, eat much of the vegetation, and trample stream banks. Even recreational development can destroy natural plant diversity and structure, lead to soil compaction and erosion, and disturb wildlife. Potential impacts to riparian areas are a major problem because these vital habitats are limited in size and are very susceptible to disturbances. As populations continue to grow, the potential threat of these impacts will increase. Therefore, acquisition of areas within the Mission River Riparian Corridor represents a high priority target over the next five years.

9.3 Acquisition Strategy for Target Areas

Identifying key parcels of land for acquisition provides a long-term strategy and process for establishing protection, conservation, or restoration in order to ensure a stable environment for Reserve research and education. As mentioned previously, the Mission-Aransas Reserve is primarily dependent on partners and stakeholders to acquire and manage lands that ensure stable ecological, research, and educational environments. There are multiple methods or mechanisms of acquisition that would establish long-term state control over the priority areas that have been identified, and they include:

- Fee Simple Acquisition – absolute title to land, free of any conditions, limitations, restrictions, or other claims against the title, which one can sell or pass to another by will or inheritance. A fee simple title has a virtually indefinite duration.
- Conservation Easement – a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. It allows landowners to continue to own and use their land, and they can also sell it or pass it on to heirs. Examples of acquired easement rights include riparian, subsurface mineral, agricultural, residential development, viewshed, and groundwater.
- Donation – an outright donation of land to a trust or federal, state, or local governments that may provide the donor with a charitable income tax deduction and a reduction in the value of one's taxable estate.

The Mission-Aransas Reserve and UT would focus primarily on acquiring property through the use of conservation easements, as opposed to fee simple acquisition. This method has been used by the Reserve and its state partner in the past. In 2006, with NOAA grant assistance, the Board of Reagents of the University of Texas System was able to purchase a conservation easement on the 3,261 acre Fennessey Ranch. The value of that conservation easement includes: (1) the protection of native plants, animals, and plant communities on the property; (2) the preservation of riparian areas and banks of the Mission River; (3) preservation of the natural freshwater wetlands on the property; (4) preservation of the natural flow of fresh water from the artesian wells located on the property; and (5) the advancement and dissemination of man's understanding of the biology and hydrology of the property and the adjacent Mission River. In order for a similar easement purchase to be approved by the University of Texas System's Board of Regents, similar conservation values and goals must be met by the parcel of land. Reserve partners have utilized all of the strategies listed above in order to acquire property within the Mission-Aransas Reserve watershed.

9.4 Potential Acquisition Partners

The Mission-Aransas Reserve is not structured in a manner to easily acquire and manage tracts of land. However, the Reserve staff have realized that they can play an important role in the acquisition of priority areas by assisting partners that are more equipped to obtain and manage newly acquired properties. Assistance can come in the form of technical advice regarding habitats and wildlife, grant writing assistance, letters of support, and/or educational outreach. To date, the Reserve has worked with the RAB, as well as additional partners and stakeholder groups, to identify critical areas for acquisition. The Reserve has also assisted interested partners in attempts to secure funding for fee simple acquisition of properties within the Reserve watershed, particularly focusing on projects that could be included in the Reserve Boundary. The primary partners for potential acquisition projects include: ANWR, CBBEP, CBLT, TPWD, Fennessey Ranch, and GLO.

9.5 Funding Opportunities and Sources

U.S. Department of Agriculture - Forest Legacy Program

Grants available to help landowners, state and local governments, and private land trusts identify and protect environmentally important forest lands that are threatened by present and future conversion to non-forest uses. The Forest Legacy Program is designed to assure that both traditional uses of private lands and the public values of America's forest resources are protected.

U.S. Fish and Wildlife Service's North American Wetland Conservation Act Program

Grants are available to fund conservation of wetlands and wetland-dependent fish and wildlife (waterfowl) through acquisition, restoration and/or enhancement. Grants may be provided directly to state, local governments, and non-profit organizations. This program strongly prefers to fund diverse conservation partnerships.

U.S. Fish and Wildlife Service's Coastal Wetland Grant Program

Grants are awarded to Great Lakes and coastal states and trust territories for projects that restore, acquire, manage, or enhance coastal lands and waters. Projects must provide for the long-term conservation of such lands and waters and the fish and wildlife dependent on them. The Coastal Grants Program gives priority to the restoration of barrier islands associated maritime forest, coastal wetlands ecosystems, endangered species, anadromous fish species and to the building of financial and cooperative, private, and governmental partnerships. U.S. Fish and Wildlife Service's Endangered

Species Recovery Lands Program

Grants are provided to states and territories for acquisitions of habitat that support approved recovery plans.

Natural Resources Conservation Service (NRCS) Grant Programs

The NRCS has a number of cost-share/grant programs that involved acquisition of conservation easements including the Conservation Reserve Program, Wetland Reserve Program, and Conservation Reserve Enhancement Program. The Wetland Reserve Program provides technical and financial assistance to eligible landowners to address wetland, wildlife habitat, soil, water, and related natural resources concerns on private lands in an environmentally beneficial and cost-effective manner. The program provides an opportunity for landowners to receive financial incentives to enhance wetlands in exchange for retiring marginal land from agriculture. This program involves the establishment of permanent or 30-year conservation easements or restoration cost-share funds.

NOAA's Coastal and Estuarine Land Conservation Program

Grants to state and local governments to purchase significant coastal and estuarine lands, or conservation easements on such lands, from willing sellers.

NOAA's National Estuarine Research Reserve System Procurement, Acquisition, and Construction Fund

Grants to state host agencies of reserves to support land acquisition for projects identified in approved reserve management plans.

RESTORE Act

The RESTORE Act dedicates 80 percent of all administrative and civil penalties related to the Deepwater Horizon spill to a Gulf Coast Restoration Trust Fund and outlines a structure by which the funds can be utilized to restore and protect the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, coastal wetlands, and economy of the Gulf Coast region. The RESTORE Act sets forth the following framework for allocation of the Trust Fund:

- 35 percent equally divided among the five States for ecological restoration, economic development, and tourism promotion;
- 30 percent plus interest managed by the Council for ecosystem restoration under the Comprehensive Plan;
- 30 percent divided among the States according to a formula to implement State expenditure plans, which require approval of the Council;
- 2.5 percent plus interest for the Gulf Coast Ecosystem Restoration Science, Observation, Monitoring and Technology Program within the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA); and
- 2.5 percent plus interest allocated to the States for Centers of Excellence Research grants, which will each focus on science, technology, and monitoring related to Gulf restoration.

As opportunities arise to apply for RESTORE Act funds, the Reserve will work with its partners to ensure that priority acquisition areas within the Mission-Aransas Reserve are included for funding consideration.

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