Gulf Coast Joint Venture:

Texas Mid-Coast Initiative

GULF COAST JOINT VENTURE

North American Waterfowl Management Plan

2002

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This is one of six reports that address initiative plans for the entire North American Waterfowl Management Plan, Gulf Coast Joint Venture: the Chenier Plain Initiative, the Laguna Madre (Texas) Initiative, the Texas Mid-Coast Initiative, the Coastal Mississippi Wetlands Initiative, the Mobile Bay Initiative, and the Mississippi River Coastal Wetlands Initiative (southeast Louisiana).

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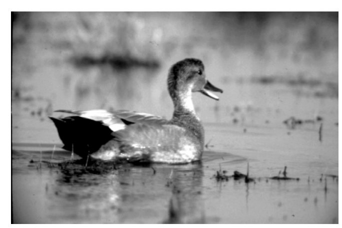

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Introduction

North American Waterfowl Management Plan

Faced with continuing wetland destruction and rapidly declining waterfowl populations, the Canadian and U.S. governments signed the North American Waterfowl Management Plan (NAWMP) in 1986, undertaking an intense effort to protect and restore North America's waterfowl populations and their habitats. Updated in 1994 and 1998 with Mexico as a signatory, the NAWMP recognizes that the recovery and perpetuation of waterfowl populations to levels observed in the 1970's, which is the baseline reference for duck population objectives under the plan, depends on restoring wetlands and associated ecosystems throughout the continent. The purpose of the NAWMP is to achieve waterfowl conservation while maintaining or enhancing associated ecological values in harmony with human needs. The benefits of such habitat conservation were recognized to be applicable to a wide array of other species as well. Six priority waterfowl habitat ranges, including the western U.S. Gulf of Mexico coast (hereafter Gulf Coast), were identified in the 1986 document and targeted as areas to begin implementation of the NAWMP.

Transforming the goals of the NAWMP into actions requires a cooperative approach to conservation. The implementing mechanisms of the NAWMP are regional partnerships called joint ventures. A joint venture is composed of individuals, corporations, small businesses, sportsmen's groups, conservation organizations, and local, state, provincial, and federal agencies that are concerned with conserving migratory birds and their habitats in a particular physiographic region such as the Gulf Coast. These partners come together under the NAWMP to pool resources and accomplish collectively what is often difficult or impossible to do individually.

Gulf Coast Joint Venture

The Gulf Coast is the terminus of the Central and Mississippi Flyways and is therefore one of the most important waterfowl areas in North America, providing both wintering and migration habitat for significant numbers of the continental duck and goose populations that use both flyways. The coastal marshes of Louisiana, Alabama, and Mississippi regularly hold half of the wintering duck population of the Mississippi Flyway. Coastal wetlands of Texas are the primary wintering site for ducks using the Central Flyway, wintering more than half of the Central Flyway waterfowl population. The greatest contribution of the Gulf Coast Joint Venture (GCJV) region (Fig. 1) in fulfilling the goals of the NAWMP is as a wintering ground for waterfowl.

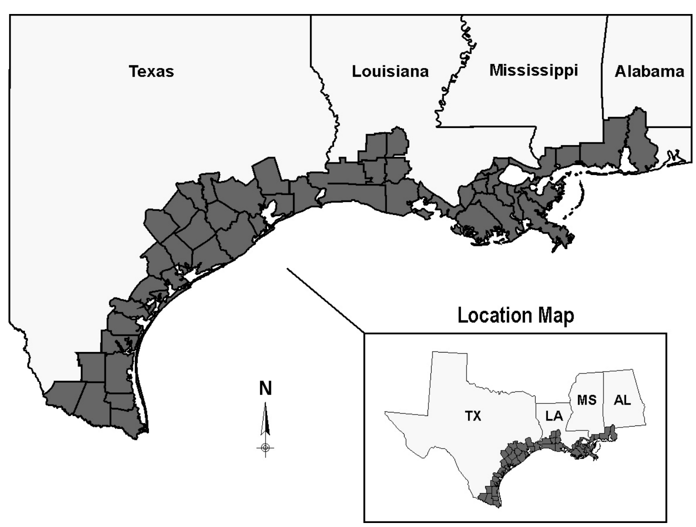


Figure 1. Location of the Gulf Coast Joint Venture region.

The GCJV area also provides year-round habitat for over 90% of the continental population of mottled ducks and serves as a key breeding area for whistling ducks. In addition, hundreds of thousands of waterfowl use the Gulf Coast as stopover habitat while migrating to and from Mexico and Central and South America. The GCJV region is the primary wintering range for several species of ducks and geese and is a major wintering area for every other North American duck except wood ducks, black ducks, cinnamon teal, and some sea ducks (Tribe Mergini).

Through its wetland conservation accomplishments, the GCJV is contributing to the conservation of biological diversity. While providing habitat for waterfowl, especially ducks, continues to be the major focus of the GCJV, a great diversity of birds, mammals, fish, and amphibians also rely on the wetlands of the Gulf Coast for part of their life cycles. Numerous species of shorebirds, wading birds, raptors, and songbirds can be found along the Gulf Coast. Of the 650 species of birds known to occur in the United States, nearly 400 species are found in the GCJV area. Muskrats and nutria have historically been important commercial fur species of the Gulf Coast. Many species of fish, shellfish, and other marine organisms also depend on the gulf coastal ecosystem. Almost all of the commercial fish and shellfish harvested in the Gulf of Mexico are dependent on the area's estuaries and wetlands that are an integral part of coastal ecosystems. The American alligator is an important Gulf Coast region species and is sought commercially and recreationally for its hide and meat.

Gulf Coast Joint Venture Objectives

Conserving Gulf Coast habitats is critical to the overall success of the NAWMP because the area provides extensive wetlands that are vitally important to traditional wintering waterfowl concentrations. The primary goal of the GCJV is to provide habitat for waterfowl in winter and ensure that they survive and return to the breeding grounds in good condition, but not exceeding levels commensurate with breeding habitat capacity as is the case with midcontinent lesser snow and Ross' geese. A secondary goal is to provide ample breeding and postbreeding habitat for resident waterfowl. Actions that will achieve and maintain healthy wetland ecosystems that are essential to waterfowl will be pursued. Wetland conservation actions that will provide benefits to species of fish and wildlife, in addition to waterfowl, will also be supported.

The emergence of the U.S. Shorebird Conservation Plan, Partners In Flight physiographic plans, and the Waterbird Conservation Plan, which address conservation of other North American migratory birds, present opportunities to broaden and strengthen joint venture partnerships for wetland conservation. As definitive population data and habitat needs are developed for the migratory birds represented in these emerging strategies, areas of mutual concern in wetland ecosystems can be identified. These wetland areas of overlapping interest in the GCJV will be candidate priority sites for the integrated design and delivery of habitat conservation efforts. Although wetland conservation projects cannot be designed to provide maximum benefits for all concerned species, they can be designed to maximize the overlap of benefits between the species groups. This joint venture will strive to balance its focus on waterfowl and wetlands with the need to expand coordination and cooperation with existing conservation initiatives that promote common purposes, strategies, or habitats of interest.

The GCJV is divided geographically into six initiative areas, each with a different mix of habitats, management opportunities, and species priorities. This document deals with planning efforts for the Texas Mid-Coast Initiative area (Fig. 2). The goal of the Texas Mid-Coast Initiative is to provide wintering and migration habitat for significant numbers of dabbling ducks, redheads, lesser snow geese, and greater white-fronted geese, as well as year-round habitat for mottled ducks (Table 1).

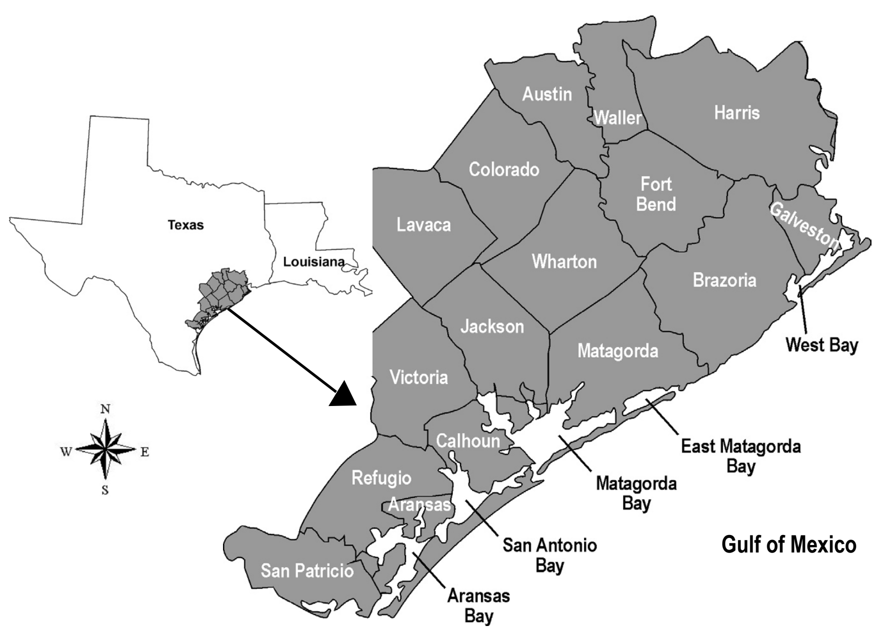


Figure 2. Texas Mid-Coast Initiative area.

Table 1. Midwinter population objectives[1,2] for initiative areas of the GCJV. (See Derivation of GCJV Waterfowl Objectives and Migration Patterns section of this plan, p. 23, for information about the methods used to develop these goals.)

	Laguna Madre	Texas Mid-Coast	Chenier Plain (Texas)	Chenier Plain (Louisiana)	Mississippi River Coastal Wetlands	Coastal Mississippi Wetlands	Mobile Bay	Total
Mallard	13,530	72,819	44,632	515,895	249,257	619	451	897,203
Northern pintail	173,355	775,755	124,193	396,313	99,967	0	1,236	1,570,819
Gadwall	46,200	224,926	84,039	888,456	714,356	268	2,286	1,960,531
American wigeon	100,377	93,841	29,147	423,845	264,119	191	1,711	913,231
Green-winged teal	35,160	293,574	650,395	951,853	537,313	413	2,544	2,471,250
Blue-winged teal	1,707	23,941	147,053	378,953	723,140	1,738	1,156	1,277,689
Northern shoveler	10,136	127,599	42,988	330,612	103,221	84	0	614,639
Mottled duck[3]	6,595	161,326	89,961	169,544	217,642	397	601	646,067
Canvasback	4,311	33,638	0	23,585	7,516	174	3,025	72,249
Redhead	392,650	92,944	402	0	13,731	0	0	499,727
Ring-necked duck	6,067	11,345	3,331	186,917	41,450	5,999	782	255,890
Greater & lesser scaup[4]	454,727	47,402	40,707	245,746	1,722,858	13,836	3,294	2,528,570
Total ducks	1,244,816	1,959,109	1,256,847	4,511,720	4,694,568	23,719	17,086	13,707,864
Lesser snow geese[3]	30,967	609,879	100,214	279,157	51,614			1,071,831
	25,766	737,403	117,555	437,841	72,250			1,390,815
Greater white-fronted geese[3]	7,759	97,636	7,457	62,529	0			175,381
	13,819	102,790	10,235	77,821	1,233			205,898
Canada geese[3]	6,155	63,043	996	2,000[5]	0			72,194
	430	12,768	957	1,052[5]	0			15,207
Total geese[3]	44,881	770,558	108,667	343,686	51,614	0	0	1,319,406
	40,015	852,961	128,747	516,714	73,483	0	0	1,611,920

[1] Objectives for ducks are based on 1970's winter distributions and breeding populations.
[2] Objectives for geese are based on 1982-88 averages of December Goose Surveys.
[3] Shaded values are "expected" numbers from 1994-97 (mottled ducks) or 1995-97 (geese) estimates.
[4] Scaup objectives exclude offshore populations.
[5] January ground counts indicate historical (1986-89) and recent (1996-98) averages of 5,273 and 10,267, respectively.

Midwinter Duck Population Objectives

To obtain objectives for midwinter duck populations in the GCJV Initiative areas, we started with the NAWMP continental breeding population goals, which total 62 million and are based on averages of 1970's breeding population surveys with adjustments for birds in nonsurveyed areas. We then estimated, from nationwide midwinter survey data proportions, the numbers of those 62 million breeding ducks that should return on spring flights from the Mississippi and Central Flyway wintering areas; we adjusted those numbers for 10% January-to-May mortality to obtain midwinter goals for the Mississippi and Central Flyways. Finally, using 1970's midwinter survey data proportions from the Mississippi and Central Flyways, we calculated how much of each of the two flyway goals should be derived from each GCJV Initiative area. Figure 3 provides an example of how this general process was applied at the species level in the Texas Mid-Coast Initiative area. Exceptions to this methodology include derivation of blue-winged teal and redhead objectives and the expected number of mottled ducks (see Derivation of GCJV Waterfowl Objectives and Migration Patterns section, p. 23).

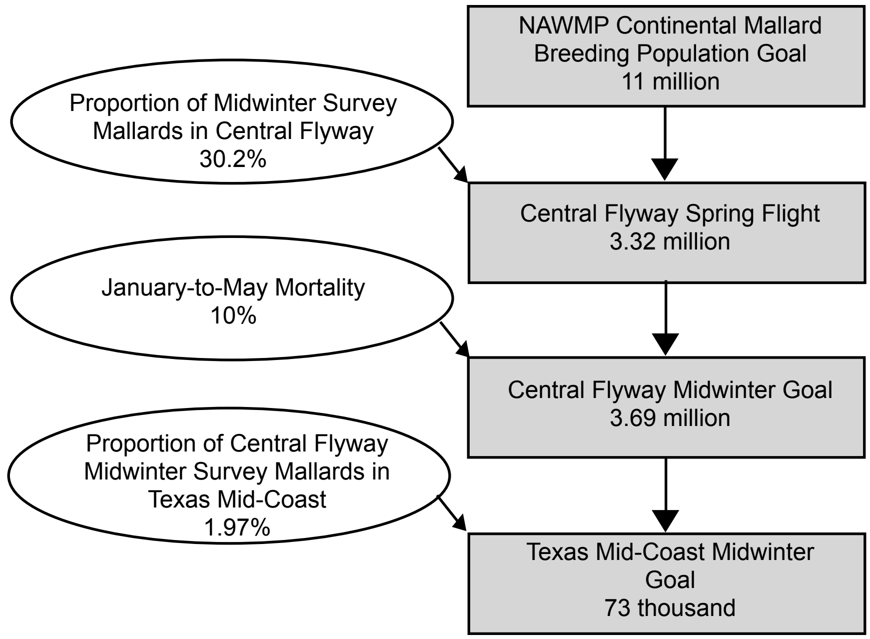


Figure 3. An example of how midwinter population objectives were obtained for a specific species, in this case mallards, in the Texas Mid-Coast Initiative area.

Midwinter Goose Population Objectives

Midcontinent lesser snow and Ross' geese, many of which spend winters in the GCJV, are exceeding their Canadian breeding habitat capacity to the detriment of their long-term health and the health of a myriad of other birds that share their arctic/subarctic breeding habitat. Greater white-fronted geese, as well as Canada geese in some GCJV regions, are also experiencing winter population increases. Therefore, regional goose objectives are expressed two ways. Recent population data are used to estimate a quantity of geese "expected" to occur and compete to some extent for finite resources, whereas actual objectives indicate the desired regional goose population. Both are based on indices from midwinter (December) surveys. "Expected" numbers are derived by averaging recent December surveys (1995-97), and actual objectives are derived from the 1982-88 average (Table 1).

Migration Chronology

Midwinter populations do not adequately represent the peak, or even the typical numbers of some waterfowl species common to the GCJV region.

Because of the variety of GCJV waterfowl and the interspecific variability in their migration patterns, incorporating species-specific migration patterns into population objectives is appropriate. Migrations differ regionally, even for the same species, so migration patterns were determined separately for each initiative area (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26).

Combining migration patterns and midwinter duck objectives (see Derivation of GCJV Waterfowl Objectives and Migration Patterns section, p. 23) yields semimonthly population objectives by species (Fig. 4). Similarly, combining goose migration patterns with expected numbers of midwinter geese yields semimonthly expected numbers of geese (Fig. 5).

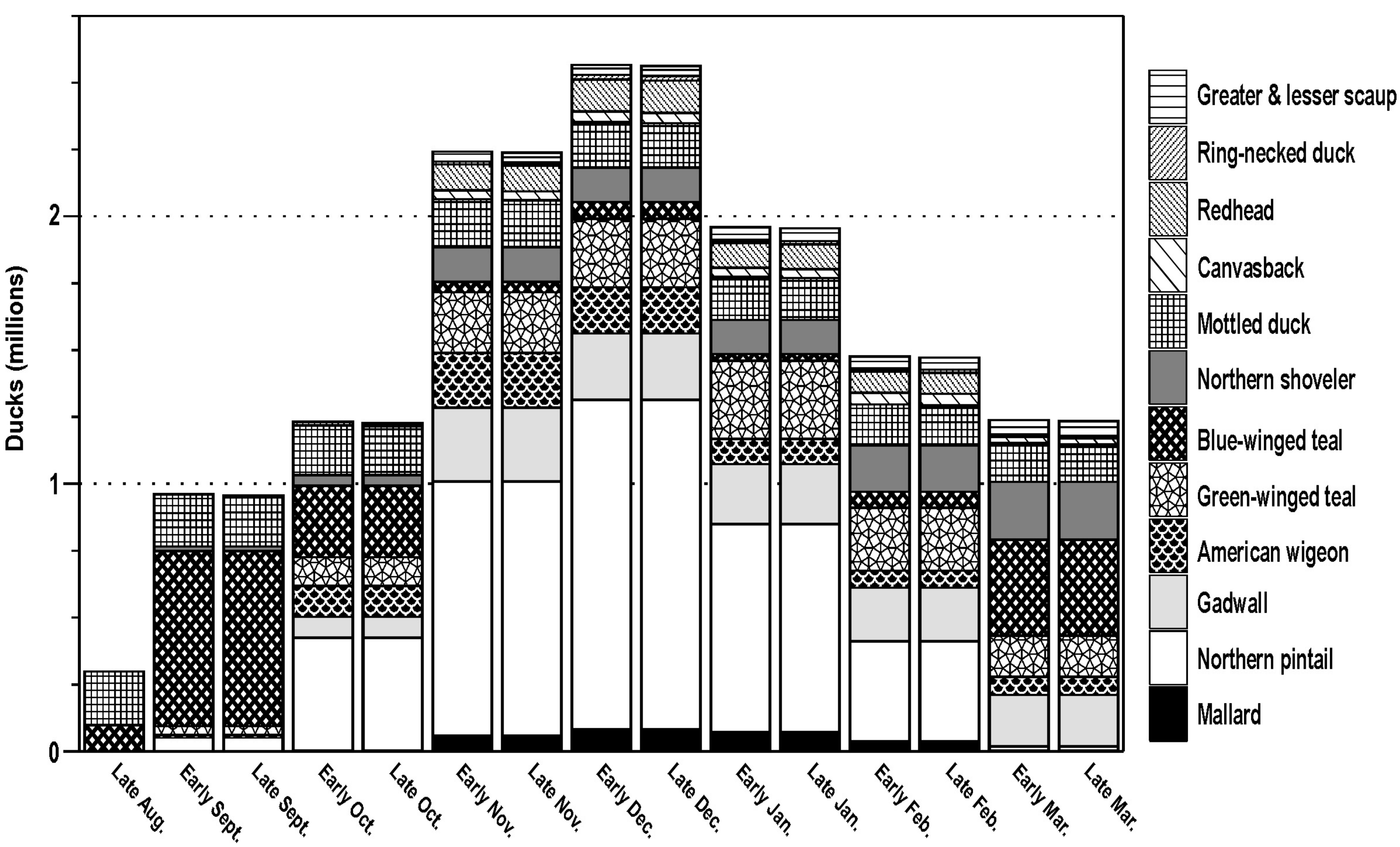


Figure 4. Semimonthly duck population objectives for the Texas Mid-Coast Initiative area.

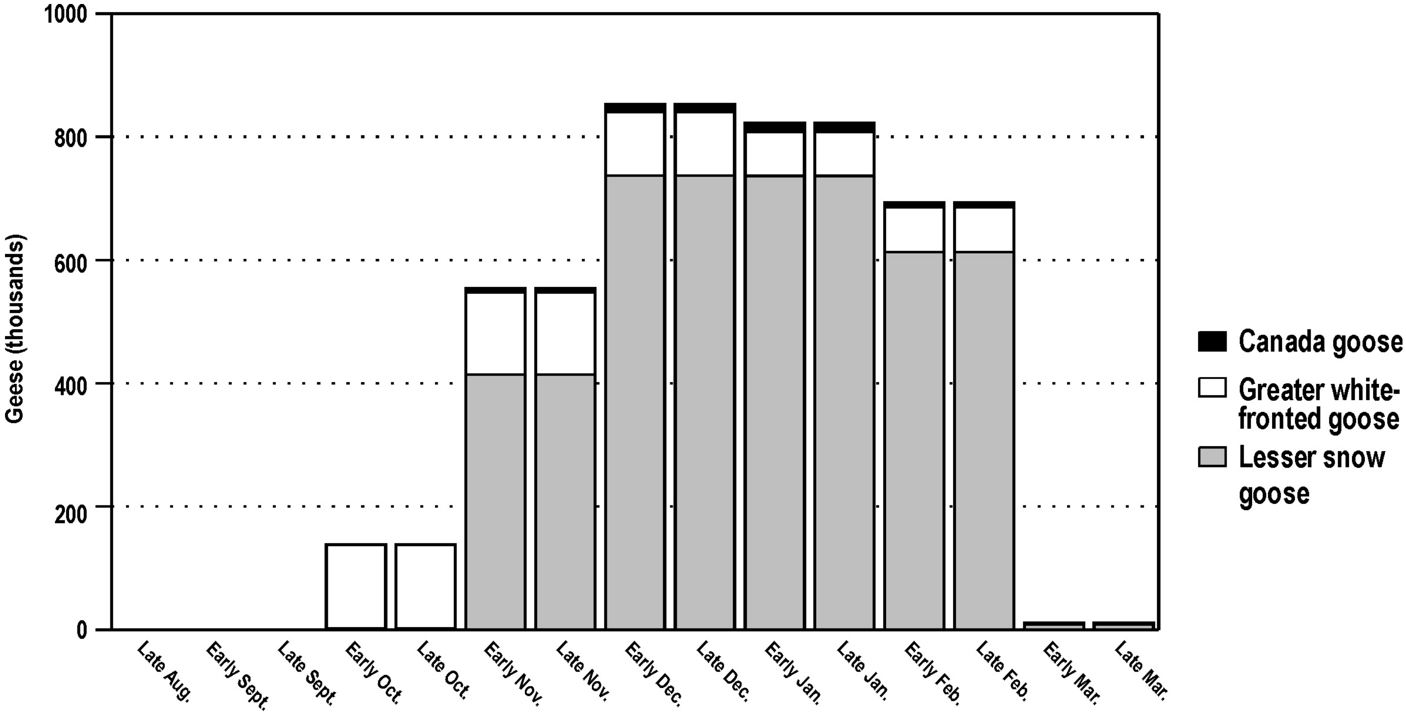
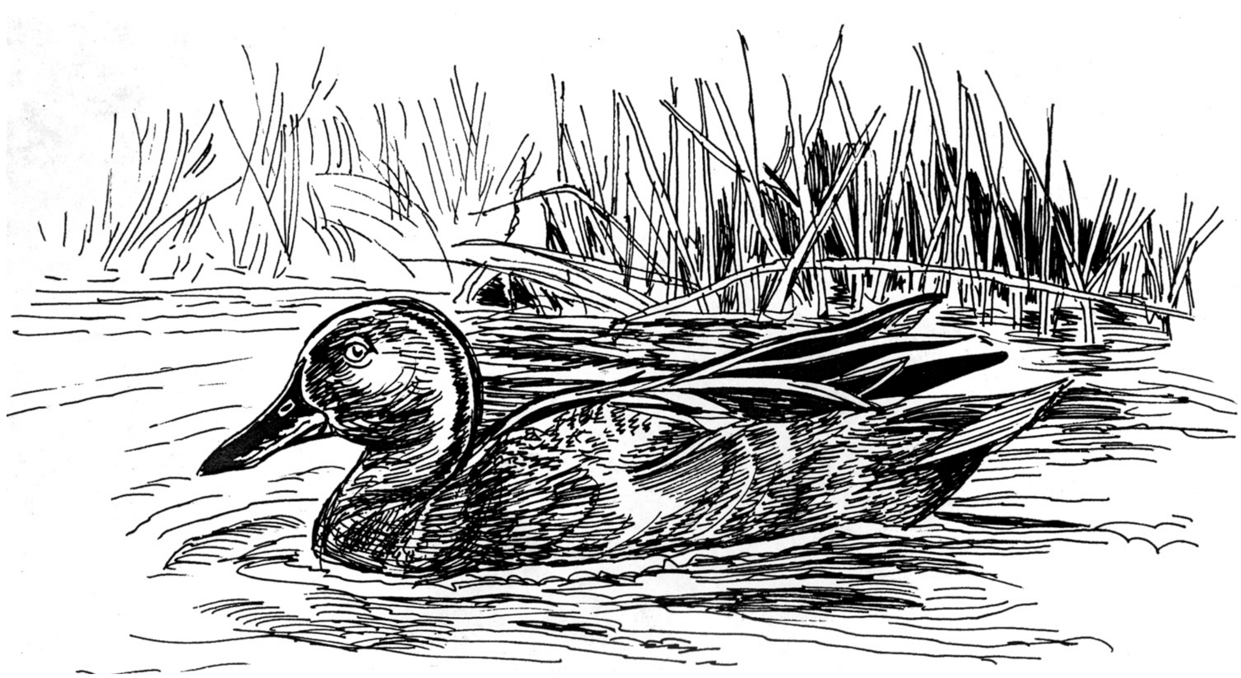


Figure 5. Semimonthly expected numbers of geese for the Texas Mid-Coast Initiative area.



The Texas Mid-Coast Initiative Area

The Texas Mid-Coast Initiative area includes 16 Texas counties along the coast from Galveston Bay to Corpus Christi and inland. The area consists of large bay and estuary systems that are nearly isolated from the Gulf of Mexico by barrier islands or peninsulas. Extensive coastal prairies are inland from the bays and estuaries. The initiative area encompasses a total land area of 13,748 square miles or 8.8 million acres. See the June 1990 Texas Mid-Coast Initiative Plan for descriptions of the area's geology, climate, and land use.

Although the Texas Mid-Coast area consists of a variety of land types and wildlife habitats, this plan focuses on the three habitat types most important to the waterfowl population objectives of this initiative area: coastal marsh, agricultural lands that are dominated by rice and pasture, and seagrasses associated with estuarine subtidal aquatic bed wetlands.

Coastal Marsh

Marshes in the Texas Mid-Coast are less extensive than the great delta marshes of southeast Louisiana and the "chenier" marshes of southwest Louisiana and southeast Texas that are associated with standard beach ridges. The marshes here tend to be restricted to estuarine systems as fringes of emergent grasses and other salt-tolerant herbaceous vegetation. There are four distinct coastal marsh types in the Texas Mid-Coast based on plant species composition, which is primarily influenced by species tolerance to water salinity. The four marsh type classifications are salt, brackish, intermediate, and fresh. These marsh types generally occur in bands paralleling the coast that correspond to salinity gradients. Moving inland from the Gulf of Mexico, salt marsh is followed by brackish, intermediate, and fresh marsh. In addition to associations of plant species, each coastal marsh type has characteristic hydrological patterns, soils, and fish and wildlife resources.

Types of Coastal Marsh

Salt Marsh

Salt marshes are prevalent in the Texas Mid-Coast. This marsh type is immediately adjacent to the shoreline of the Gulf of Mexico and associated bays. Salt marsh has the greatest tidal fluctuation of the four marsh types in the Texas Mid-Coast and has a well-developed drainage system. Water salinity averages 18 parts per thousand (ppt), and this marsh type supports the least diverse vegetation. The predominant salt-tolerant plants are smooth cordgrass, seashore saltgrass, and needlegrass rush. Salt marsh is generally considered of only low value to waterfowl; however, this marsh type buffers the more valuable marsh types farther inland from the impacts of tide and salinity.

Mallard pair.

Brackish Marsh

Brackish marsh is transitional between salt and fresh marshes. This marsh type is also subjected to daily tidal action, and its water depths normally exceed that of salt marsh. Water salinity averages 8.2 ppt, and plant diversity is greater than that of salt marsh. This marsh type is dominated by saltmeadow cordgrass, seashore saltgrass, Olney bulrush, and widgeongrass. Brackish marsh is of high value to gadwalls and greater and lesser scaup, and provides year-round habitat for mottled ducks. This marsh type represents the traditional wintering grounds for lesser snow geese.

Intermediate Marsh

Intermediate marsh, which lies inland from brackish marsh, is somewhat influenced by tides, and water salinity averages 3.3 ppt. Water levels are slightly higher than in brackish marsh, and plant species diversity is high. This marsh type is also dominated by saltmeadow cordgrass, and other common plants include common reed, bulltongue arrowhead, and coastal waterhyssop. Submerged aquatics such as pondweeds and southern waternymph are abundant in intermediate marsh. This marsh type is used by many species of ducks for feeding and resting. This less saline zone of intermediate marsh provides habitat for mottled duck broods, and use of this marsh type by wintering ducks is second only to fresh marsh.

Fresh Marsh

Fresh marsh in the Texas Mid-Coast lies between the intermediate marsh and the rice prairies. This marsh type is normally free of tidal influence and has average water salinity of only 1.0 ppt and slow drainage. Fresh marsh supports the greatest plant diversity. Maidencane, spikerush, bulltongue arrowhead, and alligatorweed are the dominant plants. Many submerged and floating-leafed plants are present in this marsh type. Fresh marsh provides feeding and resting sites to many species of ducks and geese and is considered to be the most valuable marsh type to waterfowl.

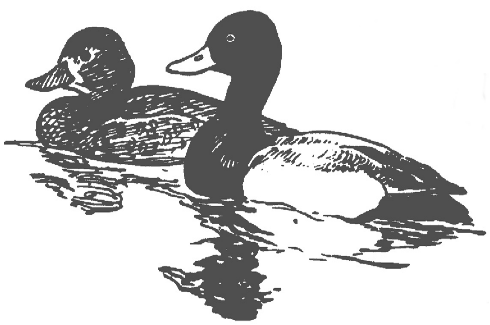
Status and Trends

Growth and deterioration of coastal wetlands have been naturally occurring in the Gulf of Mexico region for thousands of years. As wetlands were degraded their loss was balanced by natural wetland building processes. The most extensive marsh zone within the Texas Mid-Coast is located from Galveston Bay to Port Lavaca. Marshes from Port Lavaca to Corpus Christi occupy mostly narrow margins along drainages that enter the bays. The bay systems are complex and may involve a large outer (or primary) bay with moderate to sea-strength salinities, a secondary bay with brackish to moderate salinities, and inner (or tertiary) bays that may be brackish to fresh water.

Over half of the coastal wetlands for the entire conterminous United States are in the Gulf of Mexico region. Total coastal wetlands for Texas account for 6% of the national total and 12% of the regional total. Coastal Texas wetlands show decreasing trends over the past 5 decades. Loss of coastal wetlands in Texas is estimated at 8.9 square miles per year (5.696 acres) between the mid-1950's and the early 1990's (Moulton et al. 1997).

Wetland Loss Factors and Threats

Preliminary data from selected coastal areas studied in the 1980's show a reduced rate of wetland loss compared with earlier decades (Johnston et al. 1995). For Galveston Bay, both wetland gains and losses have been reported from the 1950's to 1989; however, the net trend was one of wetland loss (White et al. 1993). The general consensus is that a slow steady loss of wetland habitat is occurring within the Texas Mid-Coast. Palustrine emergent wetlands (including fresh marsh) are the most threatened of all types of Texas coastal wetlands. Emergent intertidal marsh of the mid- and upper coasts is among the most threatened estuarine system habitat in Texas.



Scaup pair.

The primary cause of loss of fresh marsh in the extreme upper end of the Texas Mid-Coast (conversion to open water) appears to be human-induced subsidence and faulting associated with groundwater withdrawal and oil and gas extraction. Other causes of loss of fresh marsh as well as the loss of other coastal marsh types include drainage and conversion to rangeland and cropland, and destruction of urbanization, industrialization, saltwater intrusion and sea-level rise. Subsidence and sea-level rise are natural processes that contribute to marsh deterioration and loss but in some cases have probably been exacerbated by humans. The total area of fresh marsh has decreased, in part, because of its conversion to scrub-shrub habitats, resulting from invasion by the exotic Chinese tallow tree. Reservoir construction has also contributed to marsh loss by changing downstream freshwater flows and increasing saltwater encroachment. Texas River Authorities manage reservoirs and irrigation in many of the estuary systems of the Texas Mid-Coast and ultimately influence the rate of freshwater inflows to the bays.

Agricultural Land

Immediately inland from the coastal marshes are the agricultural lands of the coastal prairie, also a major waterfowl habitat of the Texas Mid-Coast Initiative. The original plant community in the coastal prairie was mostly tallgrass prairie with some live oak/post oak savanna on the upland areas. This prairie landscape was interspersed with numerous small depressional wetlands important to migratory birds. However, the prairie's high average annual rainfall, 270-day growing season, and fertile soils resulted in extensive areas being converted (e.g., plowed, leveled, and/or drained) for agricultural use. Especially valuable to waterfowl are those agricultural lands devoted to rice production. When they are flooded with a few inches of water during the fall and winter, harvested rice fields and fallow fields that are part of traditional rice field rotation are excellent sources of waste rice, natural waterfowl foods, and invertebrates. Lands devoted to rice production have contour levees and other water control structures already in place that can be managed during the winter with minimal cost and effort to make feeding and roosting habitat available to waterfowl.

Status and Trends

The Texas Mid-Coast area averaged 371,199 acres of planted rice during the period 1972-79 (Fig. 6). The combination of a world rice surplus and poor economic conditions in the early 1980's dealt the Texas rice industry a severe blow. The area's rice acreage dropped considerably (almost 22%) during 1980-89—planted rice acreage averaged 290,310 acres. The decline in Texas rice acreage of the 1980's continued in the 1990's. Planted rice acreage for the Texas Mid-Coast in 1990-98 averaged 234,667 acres. Recent changes in federal agriculture policy are expected to hasten a decline in rice acreage. In many situations, agricultural land is abandoned. The potential for moist-soil management (managing wetland units with seasonal flooding to stimulate growth and establishment of annual seed-bearing waterfowl food plants) on these lands is high. However, the ready invasion of abandoned cropland by Chinese tallow trees, a fast-growing and expanding exotic tree degrading the coastal prairies, is a significant threat to the land's value as waterfowl habitat.

Seagrass Beds

Seagrass beds (meadows) provide food for wintering waterfowl and important nursery sites and foraging habitat for several species of commercially important finfish and shellfish. These beds exist in isolated patches and narrow bands within the Texas Mid-Coast, primarily in the subtidal zone with some extending into the intertidal zone. In a study of the upper Texas coast, Adair (1994) found seagrass meadows predominantly along south shorelines and occasionally along north shorelines. Salinity, water depth, water clarity, and substrate are the dominant mechanisms affecting seagrass distribution.

Five species of seagrasses are common within the Texas Mid-Coast: shoalgrass, turtlegrass, manateegrass, clover or star grass, and widgeongrass.

Mottled duck pair.

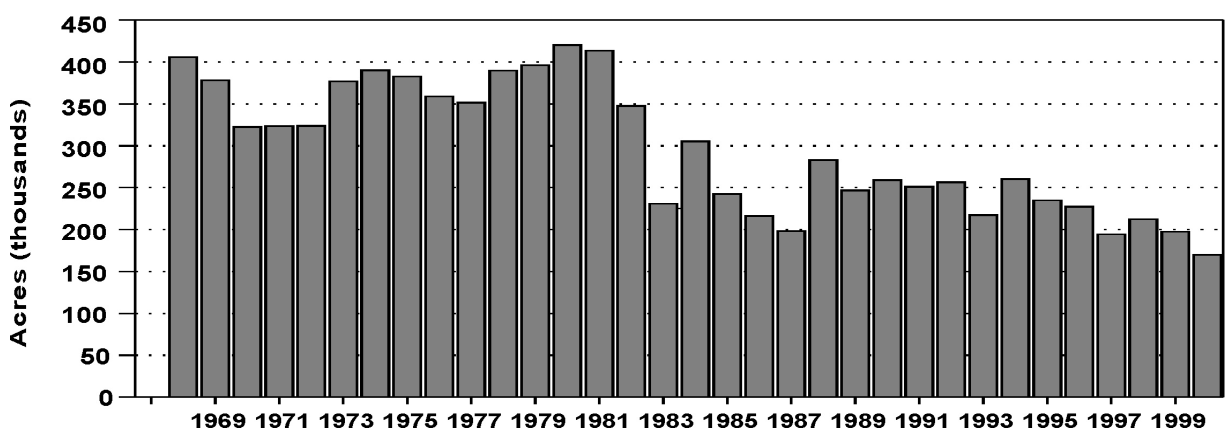


Figure 6. Planted rice acreage for the Texas Mid-Coast Initiative area (U.S. Department of Agriculture, 1999).

Large numbers of redheads and Northern pintails and lesser numbers of gadwalls and American wigeons wintering along the Texas Gulf Coast feed in seagrass beds. Redheads feed almost exclusively on shoalgrass rhizomes while wintering along the Gulf Coast, and widgeongrass serves as forage for a variety of duck species.

Seagrass Status and Threats

Spatial coverage of seagrasses in the Gulf of Mexico is estimated at 12-24% of the estuarine area (NOAA 1997). Handley (1995) reported large losses of seagrasses (from 20% to 100%) over the last 50 years from most estuaries in the northern Gulf of Mexico. Most of the loss is attributed to coastal population growth and accompanying municipal, industrial, and agricultural development. The areal extent of seagrasses in the Galveston Bay estuary decreased from more than 5,000 acres in the mid-1950's to approximately 700 acres in 1989 (White et al. 1993). In the estuary's West Bay nearly 2,200 acres of seagrasses have been completely lost, primarily through human activities, including development, wastewater discharge, chemical spills, and increased turbidity from dredging and boat traffic (Pulich and White 1991). In 1987, coverage of seagrass beds in the Matagorda and western portions of the Galveston Bay complexes were estimated at 2,715 acres and 2,994 acres, respectively (Adair 1994). This represented a slight increase since 1971-72 for the Matagorda Bay complex and a 44% decrease for the Galveston Bay complex. Unpublished data from 1988 suggest an additional 25,878 acres in the eight bays between Port O'Connor and Corpus Christi, with 73% of this total occurring in Espiritu Santo, Copano, and Redfish Bays (Adair, unpublished data). This represented an overall increase from the 19,491 acres documented in 1969-71, but the earlier study excluded many of the back bay areas of this region. For the bays that were directly comparable, slight increases were found in Espiritu Santo and Aransas Bays, and slight decreases were found in San Antonio, Copano, and Corpus Christi Bays.

Lesser snow geese.

Hurricanes, cold-front storms, and increased or decreased salinities are natural causes of seagrass loss and cannot be controlled. The loss of seagrasses is also attributable to human-induced effects associated with residential and industrial development pressures. Seagrass meadows are susceptible to the adverse effects of filling in two ways: (1) from direct impacts of filling and (2) from indirect impacts of filling, which include the production of suspended material in the water column (i.e., turbidity). Excess nutrients from sewage treatment discharges, septic systems, and drainage from agricultural fields (i.e., water quality) can stimulate growth of phytoplankton in the waters over the grass meadows. Seagrass beds are also often damaged by boat anchors and propellers of shallow draft recreational boats. "Prop scars" may contribute to additional degradation of seagrass beds by accelerating erosion near the broken root mats.

Habitat conservation is imperative for meeting the waterfowl population objectives of both the NAWMP and the GCJV. The critical habitat conservation needs on public and private lands of the GCJV are to stop and reverse the deterioration and loss of wetlands, especially coastal marshes, and to improve the waterfowl value of agricultural lands. Loss of coastal marsh can be addressed by actions that either reduce the rate of loss or that build land. In the Texas Mid-Coast, actions addressing the loss of coastal marsh must be based largely on prevention of predictable loss and restoration of degraded areas. The private agricultural lands of the Texas Mid-Coast are working landscapes, used to produce economic returns; therefore, the impact of GCJV actions must be beneficial or neutral with respect to agricultural land uses.

The availability of food resources is the most likely effect of winter habitat on survival and recruitment of waterfowl populations. Availability of food can be affected by production of foods (submerged aquatics, annual seeds, or invertebrates), flooding at appropriate times and depths for foraging, and access to food influenced by floating exotics, human disturbance, access to dietary fresh water, or other factors. In addition to fall and winter food resources, mottled duck populations are also influenced by breeding and postbreeding habitat in the Texas Mid-Coast. Availability of fresh or intermediate shallow water in brood-rearing and molting areas is critical during the spring and summer. Therefore, the habitat conservation actions outlined are intended to influence one or more of these habitat parameters.

Conservation Strategies

Four broad strategies of wetland conservation are important for achieving the goals and objectives of the GCJV. These strategies are maintenance (i.e., loss prevention), restoration, enhancement, and creation of wetland habitat. Though not a strategy, routine management activities are important and inherent components of the restoration and maintenance strategies. Conservation actions under each of these strategies take several forms. The types of wetland conservation actions identified in each initiative area reflect the differences previously discussed that characterize each area. A description of the strategies applicable to the Texas Mid-Coast are presented below.

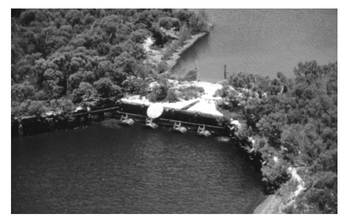
Maintenance of Habitat

Maintenance involves preserving existing functions and values of the habitat. The intent is to prevent additional loss and degradation of wetlands, particularly in remaining coastal marshes that are most vulnerable to erosion, or conversion to more saline types through saltwater intrusion. Examples of conservation actions under this strategy include the following:

(1) replacing structures and maintaining levees critical to protecting the hydrologic integrity of vulnerable marshes;

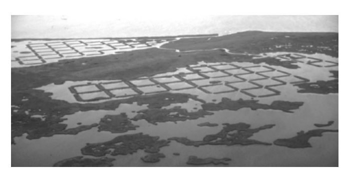
(2) placing nearshore breakwater structures to reduce or reverse wave erosion on beachfronts into adjacent marsh;

(3) constructing earthen terraces or vegetative barriers (e.g., California bulrush) within opened, degraded marshes to reduce fetch which would eventually erode



Hydrologic structure.

Breakwater structures.



Earthen terraces.

Erosion control vegetation.

Oil-drilling access canal plug.

Marsh burning.

the perimeter and result in larger open water areas;

(4) planting erosion control vegetation at key points protecting the hydrologic integrity of vulnerable marshes;

(5) plugging of abandoned oil drilling location canals to prevent further widening of the canal into emergent marsh;

(6) implementing managed fire to maintain vegetative communities susceptible to invasion by woody exotics (carefully implemented prescribed burns also increase the availability of belowground foods for geese in their historic marsh range, potentially reducing competition with ducks for food in other habitats);

(7) conducting floating or submersed exotic vegetation control to maintain natural plant communities;

(8) providing technical guidance to achieve the above maintenance measures;

(9) promoting public policy, education, and placement of signs and channel markers around and within seagrass beds to avoid mechanical damage from recreational boat activity;

(10) promoting public policy, education, and technical assistance that encourages maintenance of existing depressional wetlands in agricultural settings; and

(11) acquiring vulnerable tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above maintenance measures.

Restoration of Habitat

Restoration involves conservation actions necessary to re-establish a naturally occurring but degraded wetland ecosystem. The goal is to restore or mimic the original wetland functions and values of the site. Examples of conservation actions under this strategy include the following:

(1) restoring historic salinities and hydrology to degraded systems through hydrologic structures and levees;

(2) restoring water quality and subsequent SAV productivity by reducing fetch and turbidity;

(3) restoring areas suffering Chinese tallow infestations to a native prairie environment that is attractive to nesting mottled ducks;

(4) constructing earthen terraces or vegetative barriers (e.g., California bulrush) within opened, degraded marshes to aid in restoring emergent vegetation;

(5) backfilling oil drilling location canals to return emergent wetland to where it once existed naturally;

(6) implementing managed fire to restore vegetative communities altered by woody exotics;

(7) conducting floating or submersed exotic vegetation control to restore natural plant communities;

(8) beneficially using dredge spoil from navigation projects to restore emergent wetlands and associated mudflats;

(9) planting seagrass (various techniques should be tried/developed) where it once existed naturally;

(10) providing technical guidance to achieve the above restorative measures; and

(11) acquiring degraded tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above restorative measures.

Enhancement of Agricultural Habitat

Enhancement of agricultural areas such as croplands, pasture, and fallow fields is an attempt to restore the historic wetland functions of that broad region, which was formerly dotted with small seasonal and semipermanent wetlands. But the agricultural prairie is so highly altered that it is not necessary and often very difficult to ascertain the historic condition of each specific site. Consequently, actions under this strategy may actually be restoration of a former depressional wetland or creation of new wetland habitat. Enhancement actions under this strategy provide capabilities, management options, structures, or other actions to influence one or several functions or values of the site:

(1) providing structures and/or water delivery sufficient to flood agricultural wetlands for early migrating ducks, wintering waterfowl, or summer brood habitat;
(2) providing structures and/or water delivery sufficient to flood fallow fields or moist-soil wetlands for early migrating ducks, wintering waterfowl, or summer brood habitat;
(3) altering vegetation and substrate with mechanical implements or livestock grazing to maximize food availability to waterfowl;
(4) providing technical guidance to achieve the above enhancements;
(5) acquiring tracts through fee title acquisition, conservation easement, or management agreement for the purpose of implementing the above enhancements; and
(6) providing reliable water, which may also be used for livestock watering, to freshwater basins adjacent to seagrass beds that are underutilized by waterfowl.

Creation of Habitat

Creation of habitat is the construction of wetlands where none previously existed in recent geological terms. Conservation actions develop the hydrological, geochemical, and biological components necessary to support and maintain a wetland. Examples of conservation actions under this strategy include the following:

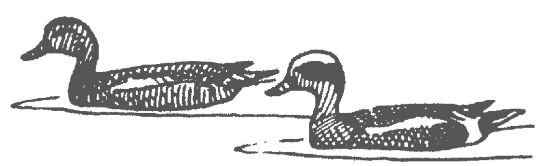
(1) beneficially using dredge spoil from navigation projects to create emergent wetlands and associated mudflats.

Habitat Objectives

The three major waterfowl habitats available in the Texas Mid-Coast Initiative area are coastal marshes, agricultural lands lying north of the marsh zone, and seagrass beds. Habitat objectives are based on the assumption that food availability is the most likely limiting factor for wintering ducks in the GCJV. Food availability is potentially influenced by factors that affect food production (e.g., marsh health, farming practices, etc.) and access (e.g., disturbance, water at appropriate depths, proximity to dietary fresh water, etc.).

Flooded agriculture field.

Beneficial use of dredge material.



American wigeon pair.

Coastal Marsh

Food density data are not available for coastal marsh habitats of the GCJV, precluding quantitative modeling of habitat needs. However, given the importance of this habitat to waterfowl, the enormous loss and continued threats to this habitat, and the limited opportunities for restoration and creation, the GCJV supports all projects that seek to restore lost or degraded marshes to sustainable historic or more natural conditions. Additionally, the GCJV supports all protective measures that maintain current habitat values that would otherwise be predictably lost.

Seagrass Beds

Some food density data are available for seagrass beds, and researchers have used existing information to model the carrying capacity of Texas (Michot 2000) and Louisiana (Michot 1997) shoalgrass beds for redheads. Texas Mid-Coast seagrass beds have been estimated to encompass 28,872 acres, 22,746 acres of which is shoalgrass (Adair 1994 and unpublished data). Using these estimates in a published model for redhead carrying capacity Michot (1997) suggests that the Texas Mid-Coast can annually support 157,492 redheads through a given winter. Though this compares favorably with the region's redhead population objective of 92,444 based on 1970's averages, it is less than observed numbers in 2 of the 18 years from 1970 to 1988. The model also assumes that all portions of seagrass meadows are equally and totally accessible for redhead foraging, ignoring potential (but untested) effects of disturbance or lack of adjacent dietary fresh water in limiting redhead accessibility. For instance, if only 21% of the habitat is rendered unavailable by excessive recreational boating disturbance, and an additional 21% is not close enough to a dietary freshwater source to make feeding energetically advantageous, then the predicted carrying capacity would dip below the population objective. Combined, these factors suggest the potential for current habitat conditions to limit redhead populations during some years and suggest the need to protect the existing habitat base.

Agricultural Habitats

Estimates of the density of desirable plant seeds for waterfowl in agricultural habitats are available, and from this data, we can model the waterfowl habitat requirements for that particular habitat. Based on food habits research and general knowledge of habitat use by various species, we estimated the proportion of each species' energetic needs that we should provide for in these agricultural habitats to be 75% for most dabbling ducks (e.g., mallard, Northern pintail, green-winged teal, blue-winged teal, Northern shoveler, and mottled duck), 10% for dabblers that specialize on submerged aquatic vegetation (e.g., gadwall and American wigeon), and 30% for most diving ducks (e.g., ring-necked ducks and greater and lesser scaup). We assume canvasbacks and redheads obtain no food items from this habitat. We estimated 90% of Texas Mid-Coast geese occur in these habitats, using food sources from flooded and unflooded fields without preference. These estimates result in population objectives for Texas Mid-Coast agricultural habitats (Figs. 7 and 8).

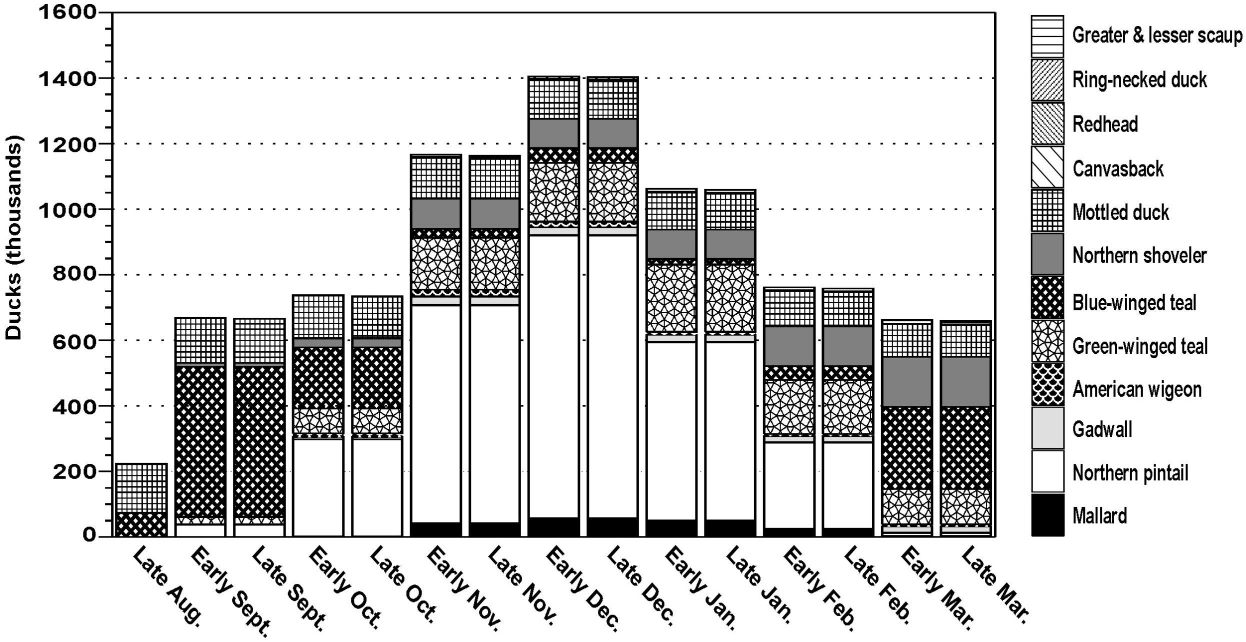


Figure 7. Semimonthly duck population objectives for the agricultural portion of the Texas Mid-Coast Initiative area.

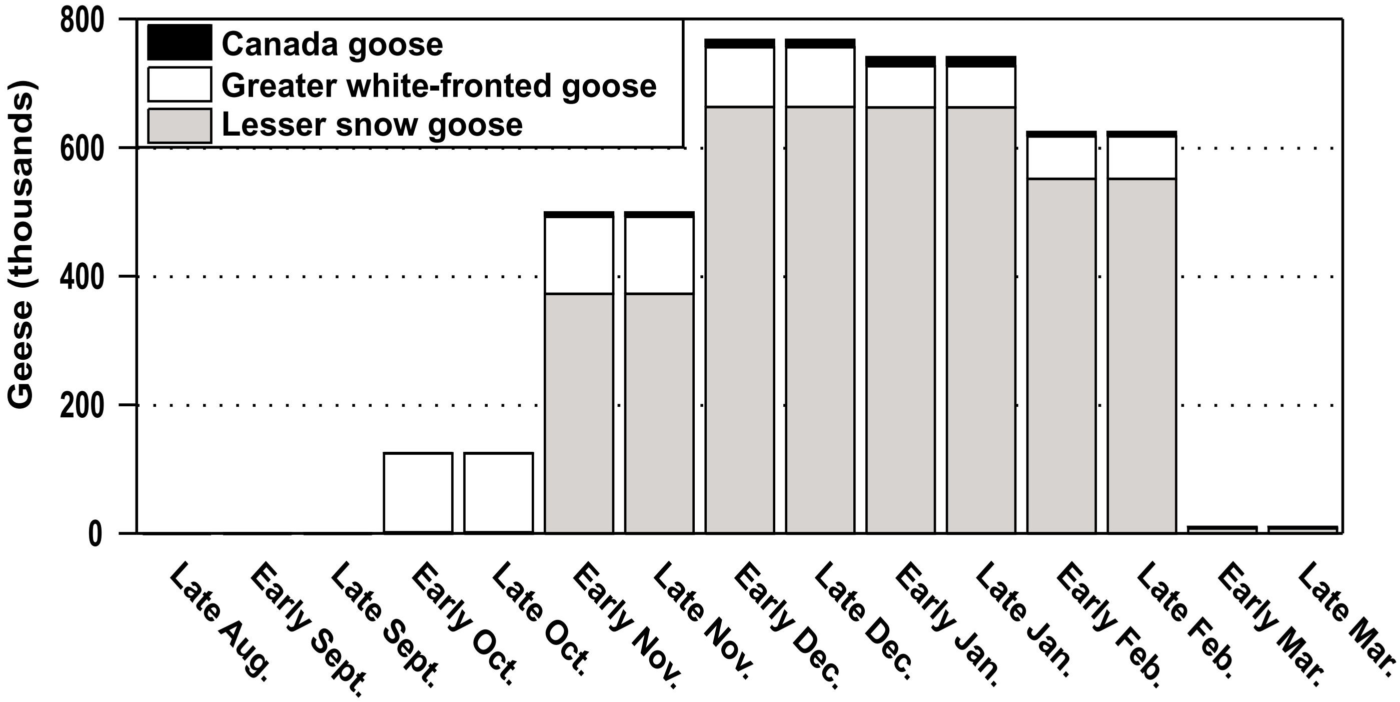


Figure 8. Semimonthly expected numbers of geese for the agricultural portion of the Texas Mid-Coast Initiative area.

We modeled the habitat requirements for Texas Mid-Coast agricultural habitats based on the dietary energy supply necessary to sustain them. Researchers estimate energetic requirements of mallards to be 290 kcal per day (Petrie 1994), with other species having energetic needs in proportion to their body weight (Kendeigh 1970). We therefore used average body weights of each species in conjunction with semimonthly population objectives and expected numbers of geese in flooded habitats to arrive at an energy demand curve, in terms of mallard-use-days, through the wintering waterfowl period (Fig. 9).

Seed density estimates for rice fields harvested in southwest Louisiana are 64.6 kg per acre of rice and 14.3 kg per acre of other waterfowl food seeds (Harmon et al. 1960). In southwest Louisiana, moist-soil seed densities of idle fields in rice rotations have been estimated at 149 kg per acre (Davis et al. 1960). Rice specialists estimate the yield of second-crop rice, which is occasionally left unharvested, is 30% of normal yields, or 600 kg per acre. A minimum seed density threshold has been estimated at 20 kg per acre, below which we assume waterfowl foraging becomes too energetically costly to benefit them (Reinecke et al. 1989). Flooded waste rice and moist-soil seeds decompose at a rate of approximately 5% per month (Neely 1956). True metabolizable energy for rice and seeds of moist-soil plants have been estimated at 2.81 and 3.0 kcal per g, respectively (Petrie 1994). These estimates result in the prespoilage foraging values for the three major habitat types of the Texas Mid-Coast agricultural lands seen in Table 2.

The acreage estimate of Texas Mid-Coast planted rice for 1997 was 194,200. A first crop is usually harvested in late July and early August, with some harvests occurring slightly later where no second crop is intended.

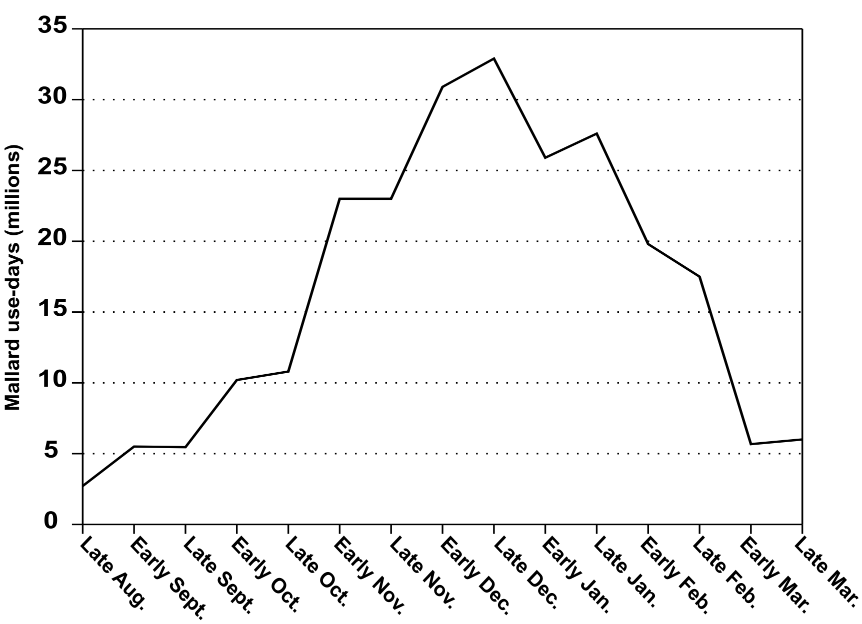


Figure 9. Energetic demands of all waterfowl objectives (mallard-use-days) in flooded habitats of the agricultural portion of the Texas Mid-Coast Initiative area.

Table 2. Prespoilage foraging values (mallard-use-days/acre) of the major habitat types of Texas Mid-Coast agricultural lands.

Harvested rice	576
Moist-soil	1,332
Unharvested second crop rice	5,618

Some rice fields are cultivated for a second harvest, which usually occurs late October through early November.

Using these assumptions of energetic demand, seed availability, caloric value of seed, and farming practices, we modeled habitat needs in the agricultural belt of the Texas Mid-Coast based on two target flooding periods. The early flooding period (late August through October) would serve the habitat needs of early migrants (Figs. 7 and 8) and some shorebird species. This period is typically characterized by relatively dry conditions, with less incentive for landowners to provide managed habitat for duck hunting season. Also, due to decomposition of flooded seeds and sprouting and depredation of unflooded seeds, rice fields not cultivated for a second harvest have their highest potential as duck habitat during this period. Therefore, single-cut rice and moist-soil and/or idle fields are the targeted habitats modeled for early flooding.

The late flooding period (November through March) is typically characterized by more available water on the agricultural landscape, due to both rainfall and the incentive to flood provided by hunting seasons. However, this period coincides with the period of greatest habitat need (Fig. 9) and is sometimes accompanied by some coastal marsh habitats becoming too deep for optimal dabbling duck foraging. Rice fields cultivated for a second crop (both harvested and not) and moist-soil and/or idle fields are the targeted habitats modeled for late flooding.

The relative availability, and thus the management potential, for each habitat type was assessed based on the following assumptions. Texas Mid-Coast rice is usually grown on 2- or 3-year rotations, with approximately 50% cultivated for a second crop. Rice specialists estimate 80% of the rotation fields out of current rice production are left idle, with potential for moist-soil management. These assumptions, combined with recent rice acreages, yield rough acreage estimates for moist-soil (233,040), once-harvested

rice (97,100), and second-cropped rice (97,100) in the Texas Mid-Coast. Additionally, we estimate 5% of second crops are left unharvested for various reasons. We used these potential habitat proportions as ratios in our energetics model to determine acreages of flooded agricultural habitats necessary to sustain our waterfowl population objectives (Table 3a).

We emphasize that the acreages in Table 3a include both intentional managed flooding for waterfowl as well as flooding that otherwise occurs as a result of precipitation, crawfish culture, or farming practices. Because our objective is to consistently provide waterfowl foraging habitat, these should be viewed as minimum amounts of managed and unmanaged habitat (combined) that should be available in the driest of years. Until we are able to estimate the amount of flooded habitat that has occurred in the recent past during dry years, we suggest that 50% of this need represents flooding objectives for new agricultural enhancement (Table 3b).

Specific Activities

The wetland habitat objectives of the GCJV will be addressed through various projects that focus on coastal marsh and agricultural lands. A package of actions designed to meet some of the Texas Mid-Coast Initiative/ GCJV objectives as well as contribute to the fulfillment of the NAWMP goals will be developed. The wetland habitat objectives of the GCJV will be addressed through various projects that focus on coastal marsh and agricultural lands. Coastal marsh projects will involve protecting critical shorelines and banks, improving or restoring more natural hydrological conditions (to stabilize water and salinity levels, and

Table 3a. Total agricultural flooding acreage need for the Texas Mid-Coast Initiative area.

	Early[1]	Late[2]
Harvested rice	9,839	-
Harvested second rice	-	59,750
Unharvested second rice	-	3,145
Moist-soil	23,614	135,653

Table 3b. Flooding objectives for new agricultural enhancement acreage within the Texas Mid-Coast Initiative area.

	Early[1]	Late[2]
Harvested rice	4,920	-
Harvested second rice	-	29,875
Unharvested second rice	-	1,573
Moist-soil	11,807	67,827

[1] Late August through October flooding to target early migrant waterfowl and some shorebirds
[2] November through March flooding for wintering waterfowl.


American wigeon pair.

reduce tidal scour), trapping sediments (to accelerate natural wetland building), and creating marsh with dredged material. Many of these projects will be designed to address localized problems while others will be designed to provide benefits to coastal wetlands far beyond the construction footprint. The focus of these projects will be reducing interior wetland loss, rebuilding wetlands in open water areas, and maintaining the geologic framework of the coast by addressing shoreline and bank erosion. Projects on agricultural lands will be designed to provide landowners with financial and technical assistance to hold winter water on harvested crop lands, set aside lands, and natural wetlands and will be compatible with sustainable agriculture. Additionally, partners will initiate the activities described in this document as other opportunities become available. An evolving package of actions designed to meet some of the Texas Mid-Coast Initiative/GCJV objectives as well as contribute to the fulfillment of the NAWMP goals has been developed and will be continually updated.

Other Programs

We recognize and support other conservation efforts that contribute to the goals of this plan. Coastal marsh projects implemented under the Coastal Wetlands Planning, Protection and Restoration Act contribute significantly to the maintenance and restoration objectives of this plan through the National Coastal Wetlands Conservation Grant Program in Texas. Similarly, shallow flooding provisions of some Natural Resources Conservation Service programs contribute to agricultural enhancement objectives, as does voluntary field flooding by rice farmers.

Communication and Education

Public awareness of the importance of the Gulf Coast to waterfowl and other renewable resources is key to the success of the GCJV. Communication efforts will be developed to educate decision makers, resource managers, landowners, conservation organizations, and the general public about wetlands conservation in the Texas Mid-Coast Initiative area.

Relationship to Evaluation Plan

Objectives and strategies outlined in this document represent a compilation of the best available information regarding the habitat needs of waterfowl in this region. However, information gaps require numerous assumptions about both the basic framework for planning habitat conservation (i.e., food limitation) and specific variables used in energetic modeling of habitat needs (e.g., relative importance of habitat types by species). Testing of the most critical of these assumptions will be addressed in the GCJV Evaluation Plan, which is being developed simultaneously with this plan. The GCJV Evaluation Plan will provide a mechanism for feedback to, and refinement of, Initiative Area Implementation Plans. Initiative Area Implementation Plans will therefore be updated periodically, as evaluation feeds the planning and implementation processes.

Northern shovelers and blue-winged teal.

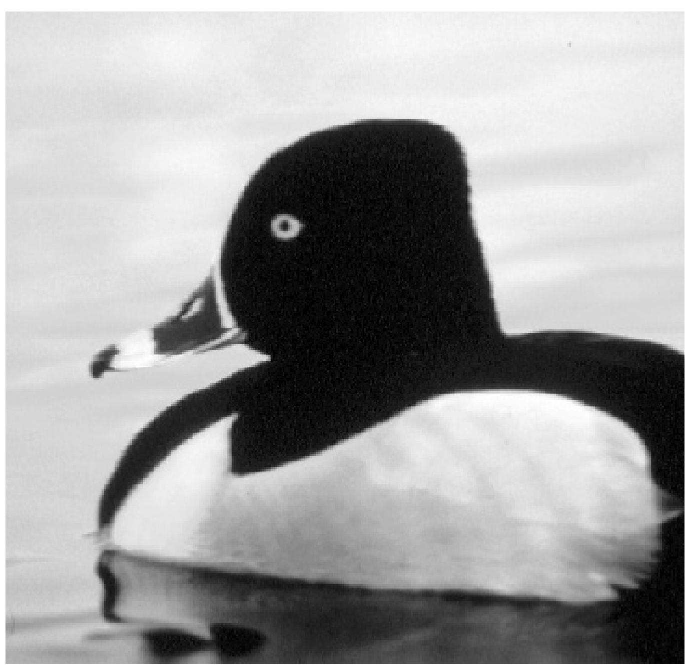
Midwinter Duck Population Objectives

Although the coordinated midwinter survey is an inaccurate count of total wintering birds, and not corrected for visibility bias, it provides a reasonable approximation of the relative distribution of birds across broad regional and temporal scales. Therefore, we used averages from the 1970-79 midwinter surveys for each species to determine the proportion of surveyed ducks that occurs in each of the initiative areas. (For greater and lesser scaup, offshore counts were excluded due to inconsistent survey coverage, resulting in "inland-only" scaup objectives.) We then applied those species-specific proportions to the NAWMP continental breeding population objectives for each species to arrive at the number of birds each initiative area should supply to the breeding population. We assume 10% mortality between midwinter (January) and breeding (May) periods to arrive at midwinter objectives (Table 1).

Using mallards as an example, during 1970-79, 42.9% of all continental mallards counted during the midwinter survey were in the Mississippi Flyway (see also Fig. 3). The NAWMP continental breeding population objective for mallards is 11 million, so we estimate the portion of the continental breeding population objective from the Mississippi Flyway to be 42.9% of that, or 4.72 million. Expanding this number to account for 10% mortality between January and May yields a midwinter objective of 5.24 million in the Mississippi Flyway. Because 9.8% of all Mississippi Flyway mallards were counted in the Louisiana Chenier Plain, we applied the percentage to the flyway goal and obtained a midwinter population objective of about 516,000 for mallards in the Louisiana Chenier Plain. This method yields midwinter objectives for most species of ducks that commonly occur in the GCJV area (Table 1).

Exceptions to this method include derivations for blue-winged teal and redhead objectives, and estimation of the expected number of mottled ducks. For blue-winged teal, the continental breeding population was first reduced by 79% to account for the proportion estimated to winter outside the range of the U.S. midwinter survey, mainly in Mexico and Central and South America.

Population objectives for redheads were determined directly from average winter population estimates from the Special Redhead Cruise Survey for the same time period (1970-79). Using direct estimates from aerial winter



Male ring-necked duck.

surveys is appropriate for determining objectives for redheads but not other ducks, because (1) wintering redheads occur almost exclusively in known locations of offshore seagrass habitat with good visibility, (2) visibility bias has been estimated and found negligible for portions of this special survey, and (3) redhead habitats are not consistently surveyed during the midwinter survey, precluding the methodology applied for most species.

To estimate the number of mottled ducks expected to occur during winter, we used mark-recapture analyses of direct recoveries from bandings in Louisiana and Texas during 1994-97. Preseason population estimates were derived from the assumption that the ratio of the total population to the total harvest (U.S. Fish and Wildlife Service estimate) equals the ratio of the banded population to the banded harvest (direct recoveries/band reporting rate estimate; band reporting rates are assumed to be 33% for 1994-95 and 59% for 1996-97). Preseason population estimates were then averaged, and an estimated fall/winter mortality rate of 30% was assumed to be evenly distributed September through March. The resulting midwinter estimate was then apportioned to initiative areas by the midwinter survey (Table 1).

Migration Patterns

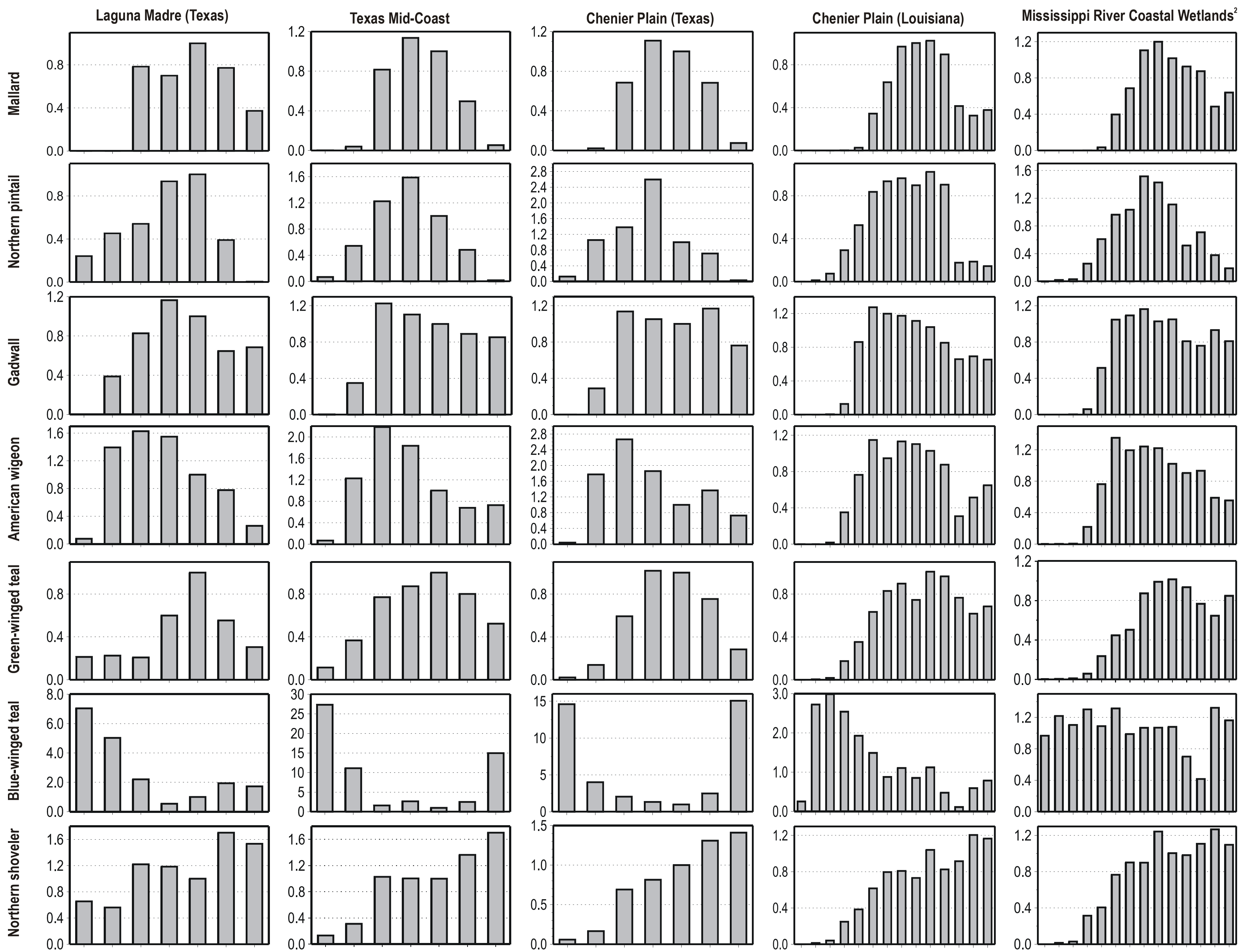
Louisiana migration patterns for ducks were determined by using periodic coastwide aerial surveys along established transects that generally were flown one to two times per month September through March, 1970-98 (Louisiana Department of Wildlife and Fisheries coastal transect survey, unpublished data). Chandeleur Sound, the primary redhead area in Louisiana, is not covered by these coastal transects, so for Louisiana redheads we instead used 1987-92 periodic redhead surveys from that region (Thomas C. Michot, U.S. Geological Survey, unpublished data). Each survey was assigned to a half-month period. For each species, each survey of a given year was expressed as a proportion of that year's peak. These proportions were averaged across all years to yield the average proportion of the annual peak for each half-month period. All proportions were then expressed relative to the midwinter (January) proportion (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26).

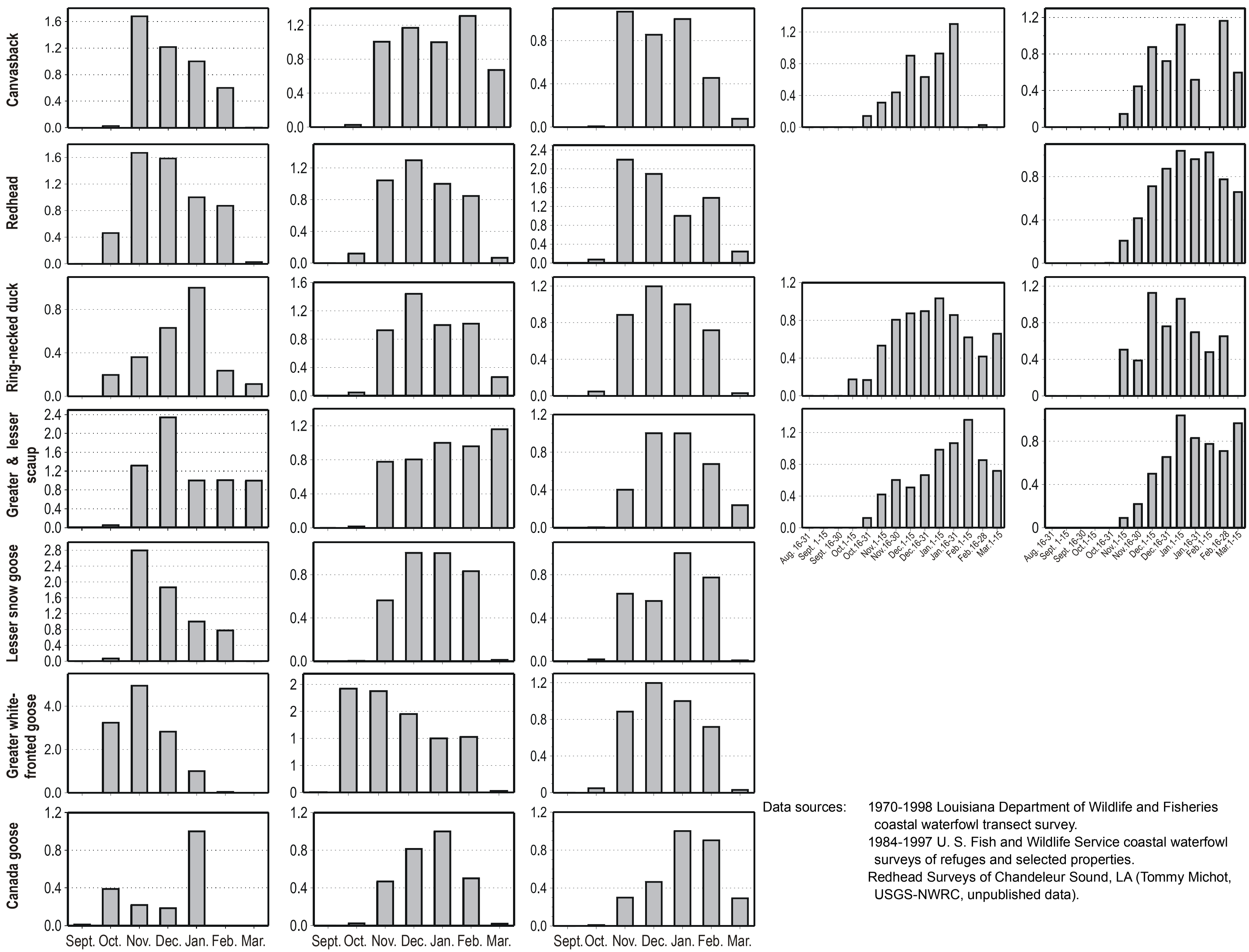
For Texas, aerial surveys of federal refuges and select other properties provide the basis for determining migration patterns (U.S. Fish and Wildlife Service's Coastal Waterfowl Survey Data, unpublished data). These monthly Texas surveys were conducted September through March of 1984-97, and data from all sites that were consistently surveyed within a given year were used. Analyses were conducted as above, except each survey represented an entire month (see Migration Chronology for Waterfowl Species of GCJV Initiative Areas section, p. 26).

Multiplying these semimonthly proportions by the midwinter population objectives yields semimonthly population objectives by species and initiative area (Figs. 4 and 5). Because Louisiana surveys were never conducted in late March, we assumed late March values for all species were 50% of early March values. Because Texas surveys were never conducted in late August, we assumed late August blue-winged teal values were 15% of early September values. Because geese are not periodically surveyed in Louisiana, we applied migrational information from the Texas Chenier Plain to all eastward initiative areas. For the Coastal Mississippi Wetlands and Mobile Bay Initiative Areas, we applied duck migrational information from the Mississippi River Coastal Wetlands Initiative area (southeast Louisiana).


Blue-winged teal males.

Migration Chronology for Waterfowl Species of GCJV Initiative Areas[1].





Data sources: 1970-1998 Louisiana Department of Wildlife and Fisheries coastal waterfowl transect survey.
1984-1997 U. S. Fish and Wildlife Service coastal waterfowl surveys of refuges and selected properties.
Redhead Surveys of Chandeleur Sound, LA (Tommy Michot, USGS-NWRC, unpublished data).

[1]*Average proportion of the annual peak, relative to January (midwinter) survey. Data are not available for Coastal Mississippi Wetlands and Mobile Bay Initiative areas.*
[2]*Southeast Louisiana.*

Literature Cited

Adair, S.E. 1994. Distribution and status of submerged vegetation in estuaries of the upper Texas coast. Wetlands 14(2): 110-121.

Davis, J.P., C.H. Thomas, and L.L. Glasgow. 1960. Foods available to waterfowl in fallow rice fields of southwest Louisiana, 1960-1961. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 15:60-66.

Handley, L.R. 1995. Seagrass distribution in the northern Gulf of Mexico. Pages 273-275 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC.

Harmon, B.G., C.H. Thomas, and L. Glasgow. 1960. Waterfowl foods in Louisiana rice fields. Transactions of the North American Wildlife and Natural Resources Conference 25:153-161.

Johnston, J.B., M.C. Watzin, J.A. Barras, and L.R. Handley. 1995. Gulf of Mexico coastal wetlands: case studies of loss trends. Pages 269-272 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC.

Kendeigh, S.C. 1970. Energy requirements for existence in relation to size of bird. Condor 72:60-65.

Michot, T.C. 1997. Carrying capacity of seagrass beds predicted for redheads wintering in Chandeleur Sound, Louisiana, USA. Pages 93-102 *in* J.D. Goss-Custard, R. Rufino, and A. Luis, editors. Effect of habitat loss and change on waterbirds. Proceedings of the 10th International Waterfowl Ecology Symposium, University of Aveiro, Portugal, 18-21 September 1995. Institute of Terrestrial Ecology Symposium No. 30, Wetlands International Pub. No. 42.

Michot, T.C. 2000. Comparison of wintering redhead populations in four Gulf of Mexico seagrass beds. Pages 243-260 *in* F.A. Comin, J.A. Herrera, and J. Ramirez, editors. Limnology and Aquatic Birds: Monitoring, Modelling, and Management. Universidad Autónoma de Yucatán Mérida (Mexico).

Moulton, D.W., T.E. Dahl, and D.M. Dall. 1997. Texas coastal wetlands; Status and trends, mid-1950s to early 1990s. U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, NM. 32 pp.

National Oceanic and Atmospheric Administration. 1997. NOAA's estuarine eutrophication survey, volume 4: Gulf of Mexico region. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean Resources Conservation and Assessment (ORCA). 77 pp.

Neely, W.W. 1956. How long do duck foods last underwater? Transactions of the North American Wildlife and Natural Resources Conference 21:191-198.

Petrie, M.J. 1994. True metabolizable energy of waterfowl foods. M.S. thesis, University of Missouri, Columbia. 138 pp.

Pulich, W.M., Jr., and W.A. White. 1991. Decline of submerged vegetation in the Galveston Bay system: chronology and relationship to physical processes. Journal of Coastal Restoration 4:1125-1138.

Reinecke, K.J., R.M. Kaminski, D.J. Moorhead, J.D. Hodges, and J.R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203-247 *in* L.M. Smith, R.L. Pederson, and R.M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock. 560 pp.

U.S. Department of Agriculture. 1999. National Agriculture Statistics Service. (http://www.usda.gov/nass)

White, W.A., T.A. Tremblay, E.G. Wermund, Jr., and L.R. Handley. 1993. Trends and status of wetland and aquatic habitats in the Galveston Bay system, Texas. The Galveston Bay National Estuary Program, publication GBNEP-31. 225 pp.

Appendix

Scientific Names of Plants and Animals Mentioned in This Plan

I. Plants alphabetical by common name.

Common Name	Scientific Name
Alligatorweed	*Alternanthera philoxeroides*
Baccharis	*Baccharis* sp.
Bulltongue arrowhead	*Sagittaria lancifolia*
California bulrush	*Schoenoplectus californicus*
Chinese tallow	*Sapium sebiferum*
Coastal waterhyssop	*Bacopa monnieri*
Common reed	*Phragmites australis*
Live oak	*Quercus virginiana*
Maidencane	*Panicum hemitomon*
Manateegrass	*Syringodium filiforme*
Needlegrass rush	*Juncus roemerianus*
Olney bulrush	*Schoenoplectus americanus*
Pondweed	*Potamogeton* sp.
Post oak	*Quercus stellata*
Rice	*Oryza* sp.
Saltmeadow cordgrass	*Spartina patens*
Seashore saltgrass or inland saltgrass	*Distichlis spicata*
Shoalgrass	*Halodule wrightii*
Smooth cordgrass	*Spartina alterniflora*
Southern waternymph	*Najas guadalupensis*
Spikerush	*Eleocharis* sp.
Star grass	*Halophila englemannii*
Turtlegrass	*Thalassia testudinum*
Widgeongrass	*Ruppia maritima*

II. Waterfowl alphabetical by common name.

Common Name	Scientific Name
American black duck	*Anas rubripes*
American wigeon	*Anas americana*
Black-bellied whistling duck	*Dendrocygna autumnalis*
Blue-winged teal	*Anas discors*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cinnamon teal	*Anas cyanoptera*
Fulvous whistling duck	*Dendrocygna bicolor*
Gadwall	*Anas strepera*
Greater scaup	*Aythya marila*
Greater white-fronted goose	*Anser albifrons*
Green-winged teal	*Anas crecca*
Lesser scaup	*Aythya affinis*
Lesser snow goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Mottled duck	*Anas fulvigula*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ross' goose	*Chen rossii*
Wood duck	*Aix sponsa*

III. Other animals alphabetical by common name.

Common Name	Scientific Name
American alligator	*Alligator mississippiensis*
Muskrat	*Ondatra zibethicus*
Nutria	*Myocastor coypus*

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For More Information

North American Waterfowl Management Plan. 1986. U.S. Department of the Interior and Environment Canada. 19 pp.

Texas Mid-Coast Initiative Gulf Coast Joint Venture North American Waterfowl Management Plan. 1990. Texas Mid-Coast Initiative Team. 57 pp.

1994 Update to the North American Waterfowl Management Plan: Expanding the Commitment. 1994. U.S. Department of the Interior, Environment Canada, and Secretaria de Desarrollo Social Mexico. 30 pp. + appendixes.

Expanding the Vision 1998 Update North American Waterfowl Management Plan. 1998. U.S. Department of the Interior, Environment Canada, and Secretaria de Medio Ambiente, Recursos Naturales y Pesca. 32 pp.