THE FOOD HABITS OF DUCKS WINTERING ON LAGUNA MADRE, TEXAS

BY

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A Thesis submitted to the Graduate School

in partial fulfillment of the requirements

for the Degree

Master of Science

Major Subject: Wildlife Management

New Mexico State University

Las Cruces, New Mexico

August 1969

"The Food Habits of Ducks Wintering on Laguna Madre, Texas," a thesis written by Craig Allen McMahan in partial fulfillment of the requirements for the degree Master of Science, has been approved and accepted by the following:

Texas Parks and Wildlife Department, Federal Aid to Wildlife Project W-29-R-19-III and IV.

I wish to thank Dr. Ronny L. Tate and Mr. William A. Leyton, former employees of the Texas Parks and Wildlife Department, for

Graduate Committee

and Dean of the Graduate School

I also express my appreciation to Dr. Charles A. Davis and Mr. Douglas B. Inglis, assistant professors of Wildlife Sciences, and Mr. Kenneth R. Valentine, Associate Professor of Range Management, for their guidance in the preparation of this manuscript.

Charles A. Davis
Chairman of the Examining Committee

August 8, 1969
Date

ACKNOWLEDGMENT

The project was supported and financed by funds from the Texas Parks and Wildlife Department, Federal Aid to Wildlife Project W-29-R-19-20 and 21.

I wish to thank Mr. Ronny L. Fritz and Mr. William R. Haynes, former employees of the Texas Parks and Wildlife Department, for their assistance in the field.

I also express my appreciation to Dr. Charles A. Davis and Mr. Douglas B. Jester, Assistant Professors of Wildlife Science, and Mr. Kenneth A. Valentine, Associate Professor of Range Science, for their guidance in the preparation of this manuscript.

VITA

Craig Allen McMahan was born January 14, 1933, in Falfurrias, Texas. He attended grade schools in that city, and graduated from Falfurrias High School in May, 1951. He entered the U.S. Navy in June, 1951, and was honorably discharged in June, 1955.

Mr. McMahan enrolled at Texas A. and I. University, Kingsville, Texas, in the fall of 1955. In September, 1956, he entered Humboldt State College, Arcata, California, and received the Bachelor of Science degree in Game Management in January, 1959.

Mr. McMahan worked with the Texas Parks and Wildlife Department as a wildlife biologist for seven years after graduating from Humboldt State College. Field data for this thesis were obtained while Mr. McMahan was employed as a Project Leader, Project W-29-R: Survey, Coastal Waterfowl.

In September, 1968, he enrolled as a graduate student at New Mexico State University, and is working toward the Master of Science degree in Wildlife Management. This thesis is presented in partial fulfillment of the requirements for that degree.

ABSTRACT

The food habits and distribution of redhead (Aythya americana), pintail (Anas acuta), and lesser scaup (Aythya affinis) ducks were studied in Laguna Madre, Texas, a hypersaline lagoon well known for wintering redhead populations. The availability of major duck foods in the lagoon was also studied.

Shoalgrass (Diplanthera wrightii) made up 84 and 88 percent by volume of the respective diets of redheads and pintails. Lesser scaup, on the other hand, showed a predilection for animal foods, chiefly molluscs and crabs. The singularity of shoalgrass in the diet of redhead and pintail ducks results from its particular abundance in Laguna Madre, nearly to the exclusion of any other rooted aquatic plants.

Pintails and redheads were distributed in the shallower waters. Pintails fed mostly in water six to 10 inches deep along the shorelines and spoil banks dug from the Intracoastal Waterway which bisects the lagoon. Redheads fed primarily in open shallow water sites, six to 24 inches deep, and in the flats in the lee of Padre Island, the east boundary of the lagoon. Redheads shifted from feeding in very shallow, easily accessible shoalgrass stands early in the season to unused shoalgrass stands in deeper water late in the season. Although redheads and pintails have similar food habits, they were not considered competitors for food in that they usually occupied different sites. Ecologic separation was clearly seen

between these two species and lesser scaup, which fed chiefly on animals in broad expanses of open water three to seven feet deep.

Alterations detrimental to the limited shoalgrass habitat in Upper Laguna Madre, such as its removal by digging or dredging operations, may reduce carrying capacity there and tend to concentrate ducks in areas not so accessible to hunters. Also, permanent lessening of salinity norms in Laguna Madre, through the construction of passes from the Gulf of Mexico, may reduce shoalgrass biomass through the increasing dominance of hypersaline intolerant plant species, some of which are unpalatable to ducks. This occurrence would also disperse ducks from the affected areas.

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INTRODUCTION

The food habits of ducks on Laguna Madre, Texas, a hypersaline[1] lagoon well-known for its wintering redhead duck population and for shoalgrass, a marine spermatophyte, have never been investigated. Singleton (1953:46) observed that most plant food eaten by ducks along the southeast Texas coast consisted of shoalgrass, but he did not identify which species ate that plant nor cite Laguna Madre as the major area of study. The knowledge of local food habits of major wildlife species is requisite to many habitat conservation programs or policies, and additional grounds on which to conserve wildlife habitats in Laguna Madre are urgently needed. Proposals portending changes to these habitats through river diversion projects, channelization, urban development, and Gulf passes to the lagoon continue to be made without sufficient consideration of effects those alterations could have on wildlife or fish.

The primary objective of this study was to identify major foods used by redhead, pintail, and lesser scaup ducks on Laguna Madre in fall and winter. In conjunction with the study of food habitats, data on the availability of duck foods were obtained, as were data on the distribution of feeding ducks. The study complements

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1/ Usually considered as a body of water exhibiting a total salt content above that of sea-water, or 35 parts per thousand (p.p.t.). Reid (1961:204) defines a hypersaline bay as one having a salinity in excess of 40 p.p.t. Breuer (1962:181) states the normal salinity in Laguna Madre ranges from 32 to 35 p.p.t. near Gulf passes to 50 to 55 p.p.t. in areas far removed from passes.

previous food habit studies of ducks on marshes and estuaries of the central and upper Texas coast (Martin and Uhler, 1939; Singleton, 1951, 1953), interprets results in terms of ecological significance to the ducks, and makes management and research recommendations.

Utilization of Laguna Madre by wintering ducks is well documented. Heit (1948:330) found 281,442 redheads on Laguna Madre in January, 1948. Jennings and Singleton (1953:10) estimated a population of about 700,000 redheads in 1951, while McMahan (1967:5) estimated a population of 489,000 redheads in December, 1966. Weller (1964:76) determined that approximately 78 percent of the North American population of redheads normally wintered on the lagoon. Buller (1964:213) states that 80 percent of the Central Flyway pintails winter on the Texas coast during peak periods of abundance, and that Laguna Madre is a favored area. Texas Coastal Waterfowl Project surveys conducted from 1959 to 1967 by the Texas Parks and Wildlife Department showed the lagoon wintered about 20,000 to 150,000 pintails and 3,000 to 40,000 lesser scaup annually.

STUDY AREA

Laguna Madre (Fig. 1) differs from other Texas bays in that it does not receive a continuous flow of fresh water from inland drainage systems. Also, in this region evaporation exceeds precipitation; consequently, the waters of Laguna Madre are usually hypersaline rather than estuarine. The lagoon is less turbid and more shallow than other bays, most of the water area measuring from a few inches to three feet deep. Shoalgrass grows on most of the bottom while

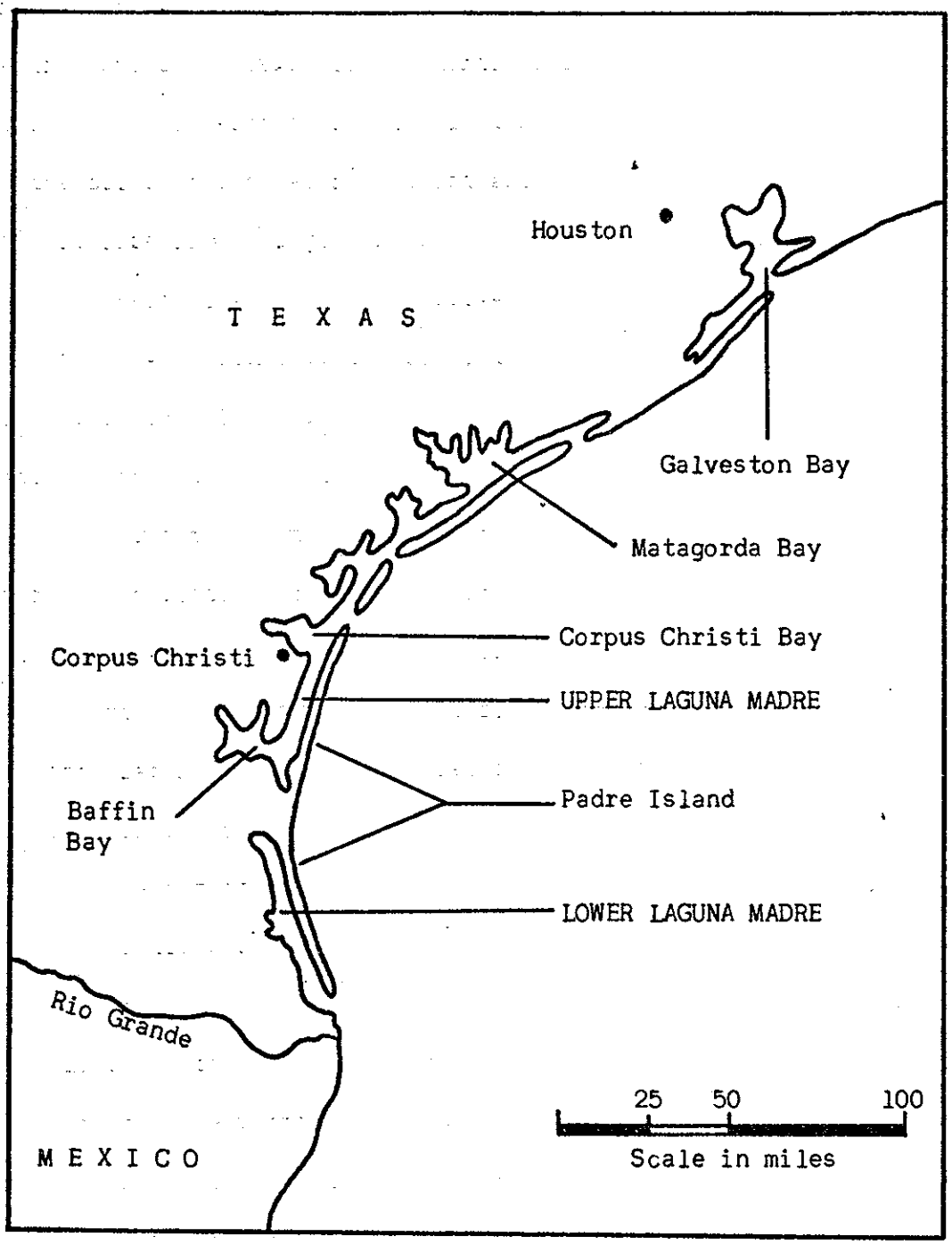


Figure 1. Map of the Texas coast showing locations of study areas.

most other bays have little or no submergent vegetation. The hydrology of Laguna Madre and distribution of its fauna have been described by Simmons (1957) and Breuer (1962), and its sediments have been mapped by Shepard and Rusnak (1957).

Storms have swept sand from Padre Island on the eastern shore of the lagoon across its center, dividing it into portions referred to as "Upper" Laguna Madre, and "Lower" Laguna Madre. Upper Laguna Madre extends from Corpus Christi Bay south for 38 miles. Predominately dry salt flats extend 24 miles south from this point, broken only by the Gulf Intracoastal Waterway which connects with the north end of the Lower Laguna Madre. This lower part of the lagoon extends 54 miles south to Port Isabel, Texas, and joins the Gulf of Mexico at Brazos Santiago Pass.

METHODS

Food Habits

During November and December, 1966, 31 redheads, 61 pintails, and 20 lesser scaups from the Lower Laguna Madre were collected for gizzard (hereafter called "stomach") analysis. The ducks were collected just after the early morning feeding period. Of these, 22 redheads, 47 pintails, and 16 lesser scaup had stomachs containing a volume of food of at least two ml; the standard set for inclusion in the sample. During December, 1967, and January, 1968, on the heavily hunted Upper Laguna Madre, the writer and his assistant obtained the stomachs of 93 redheads and four lesser scaup from hunters returning to landings after the morning hours. From this

total, the stomachs of 82 redheads and all four of the lesser scaups were used for analysis. The contents of each stomach were kept in a labeled jar containing five percent formalin solution; later the contents of each jar were decanted and separated into component items under a microscope and each species of food item measured by volume displacement. The volumes for each food item were totaled and expressed as a percentage of the entire food content for the particular species of duck.

Food Availability -- Vegetational Type Mapping

A vegetational type map of Lower Laguna Madre was prepared by James L. Pipkin in 1962 and reported by Singleton (1964). Pipkin's vegetational associations, determined by running east-west transects across the lower lagoon and describing the vegetation at one-third mile intervals along each transect, were re-examined by the writer in July, 1965, using a slightly different method. The modified method consisted of estimating the percent of area occupied by different submergent vegetation volume-density classes within a 5-yard radius of a boat at each one-third mile interval of transect travel. The number of volume-density classes used by Pipkin was reduced and re-defined as in Table 1. Following this re-examination, in which 15 transects were run, the map of Lower Laguna Madre was re-drawn to account for significant changes, and to better illustrate differences in vegetational types.

Between June and August, 1967, forty-seven east-west transects were run across Upper Laguna Madre in a boat and the submergent vegetation mapped as described for the Lower Laguna Madre.

Table 1. Volume-density classes of submergent vegetation used in type mapping Laguna Madre, Texas.

Species	Class 1 Very Heavy Stand	Class 2 Moderately Heavy Stand	Class 3 Light Stand	Class 4 Very Light Stand
Shoalgrass (Diplanthera wrightii)	21-100*+ 256**	11 - 20 244	3 - 10 65	0.5 - 2 20
Widgeongrass (Ruppia maritima)	20-100 + 25	8 - 19 10	1 - 7 10	Not apparent
Manateegrass (Syringodium filiforme)	21-70 + 91	13 - 20 50	2 - 12 14	Not apparent

*Milliliters of shoot-volume per 25 square inches of bottom area.
**Mean density of culms per 25 square inches of bottom area.

Food Availability -- Estimates of Biomass

Plant and mollusc biomass was obtained by sampling two vegetational types in Upper Laguna Madre and four vegetational types in Lower Laguna Madre. A moderately heavy and a light shoalgrass stand were sampled in January, 1967, in Upper Laguna Madre. The manatee-grass (Syringodium filiforme) stand and the moderately heavy shoalgrass stand in Lower Laguna Madre were sampled for 12 consecutive months from July, 1965, through June, 1966 (sampled intensively to obtain information on species phenology -- not reported here) while the light and very light shoalgrass stands were sampled in January, 1966. Collections were made by running a transect across a designated site in the vegetational type and pulling up a 25 square-inch block of plants and sediment with a post hole digger at one-minute intervals of boat travel (about three m.p.h.) along the transect. Twenty digger collections were made at each of the grass biomass sampling sites at the monthly time of sampling. The collection was washed and examined for plant shoots and roots and molluscs. Plant material was weighed wet, dried eight to nine hours in an oven, and weighed again. Molluscs were weighed wet. Only those molluscs small enough for ducks to eat (less than 20 mm long and 10 mm wide) were considered in the sample. Molluscs were verified for correct identification by Dr. Robert H. Parker, Professor of Biology, Texas Christian University.

Determination of Duck Distribution

In order to further determine the interspecific relationships among the three species of ducks, monthly observations were made of their distribution, movements, and feeding behavior. The locations of duck populations and notes on their movements and feeding behavior were recorded on prepared data sheets in three-hour intervals during a 24-hour period. Day-time observations totaling 351 man-hours and night-time observations totaling 24 man-hours were made from an airplane, a boat, islands, and land vantage points.

RESULTS

Food Habits

As shown in Table 2, redheads and pintails consumed submerged vegetation primarily. By far, the most important food was shoalgrass, the most abundant plant. Shoalgrass made up 84 percent by volume of the redhead diet and 88 percent volume of the pintail diet. Lesser scaups in contrast consumed only 22 percent by volume of shoalgrass and showed a predilection for animal foods, chiefly molluscs and crabs.

Food Availability

Plant composition was nearly the same for both parts of the lagoon; shoalgrass was the most abundant species available to feeding ducks (Fig. 2). Shoalgrass occurred on about 78 percent of its habitat (25,600 acres) in extreme Upper Laguna Madre, while widgeongrass occurred on only eight percent of the same area. In Lower Laguna Madre, widgeongrass was nearly absent at the time of mapping,

Table 2. Foods of ducks wintering on Laguna Madre, Texas, 1966-1968.

	REDHEAD (104)		PINTAIL (47)		LESSER SCAUP (20)	
PLANT FOODS	Occurrence (% of stomachs)	Volume (% of total mass)	Occurrence	Volume	Occurrence	Volume
Shoalgrass (*Diplanthera wrightii*)	83	84.2	98	88.1	70	22.1
Widgeongrass (*Ruppia maritima*)	41	9.8	30	3.9	—	—
TOTAL PLANT FOODS	93	94.0	100	92.0	70	22.1
ANIMAL FOODS						
Gastropods (snails)						
Anachis avara semiplicata	20	0.9	30	0.6	30	2.6
Cerithium variabile	41	0.5				
Cerithidea pliculosa	40	0.3	—	—		
Anachis obesa	32	0.1	74	0.2	80	0.2
Bittium varium	32	0.1	85	0.7	90	4.3
Nassarius vibex	9	0.1	11	0.1	10	0.8

Table 2. Foods of ducks wintering on Laguna Madre, Texas, 1966-1968 (continued).

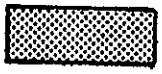
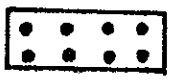
ANIMAL FOODS	REDHEAD (104) Occurrence	REDHEAD (104) Volume	PINTAIL (47) Occurrence	PINTAIL (47) Volume	LESSER SCAUP (20) Occurrence	LESSER SCAUP (20) Volume
Mitrella lunata			74	0.2	85	3.9
Mangelia sp.			4	0.1	10	0.2
Turbonilla sp.			15	0.1		
Neritina virginea	—	—	—	—	25	0.2
TOTAL GASTROPODS	91	2.0	88	2.0	95	12.2
Pelecypods (clams)						
Anomalocardia cuneimeris	9	0.1			20	11.2
Laevicardium mortoni			4	0.1		
Chione cancellata					25	2.2
Mulinia lateralis	—	—	—	—	40	1.8
TOTAL PELECYPODS	9	0.1	4	0.1	55	15.2

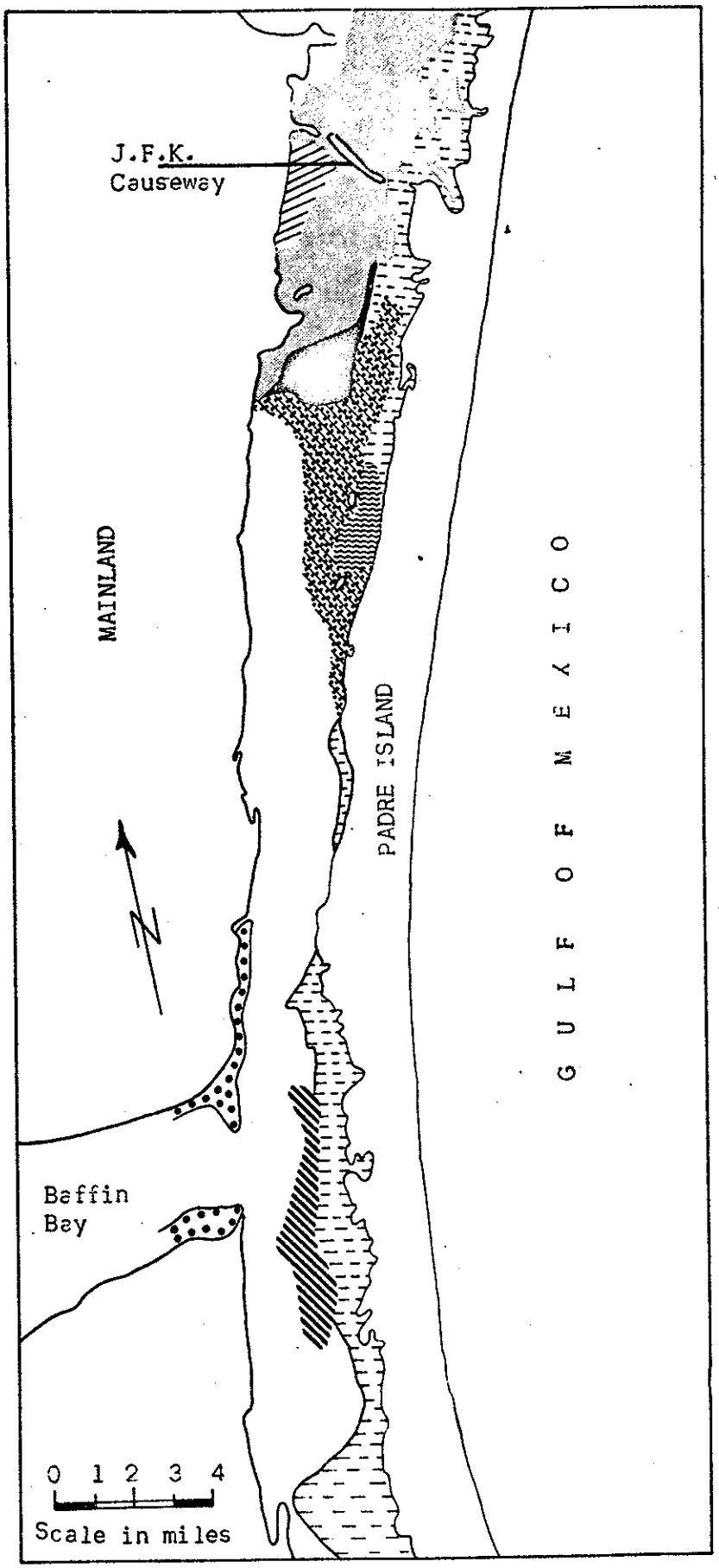
Table 2. Foods of ducks wintering on Laguna Madre, Texas, 1966-1968 (continued).

	REDHEAD (104)		PINTAIL (47)		LESSER SCAUP (20)	
ANIMAL FOODS	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume
Fish fragments			2	0.1	5	0.2
Shrimp (Decapoda)			2	0.2	25	0.4
Crabs (Decapoda)			2	0.1	70	10.8
Copepods (Copepoda)	—	—	4	0.1	—	—
TOTAL ANIMAL FOODS	93	2.1	91	2.6	100	38.8
UNIDENTIFIED ORGANIC MATERIAL	16	3.8	45	5.4	80	39.1
TOTAL		99.9		100.0		100.0
TOTAL FOOD VOLUME		809.1 ml		198.7 ml		41.5 ml

Figure 2. Vegetational type map, Upper Laguna Madre, Texas, July, 1967. Each type characterized by the dominant volume-density class and mean percent area occupied by all volume-density classes of each species.

Key to Map

Type Symbol	Species	Volume-Density Class	Percent of Area Occupied
	Shoalgrass Widgeongrass	Light Light	78 8
	Shoalgrass Widgeongrass	Moderately heavy Moderately heavy	88 2
	Shoalgrass	Moderately heavy	80
	Shoalgrass Widgeongrass	Light Very heavy	46 2
	Shoalgrass Widgeongrass	Very light Light	50 3
	Shoalgrass Widgeongrass	Very heavy Moderately heavy	84 12
	Shoalgrass Widgeongrass	Very light Light	65 9
	Unvegetated areas, always submerged		
	Areas exposed during low tide		


J.F.K.
Causeway
MAINLAND
PADRE ISLAND
GULF OF MEXICO
N
Baffin
Bay
0 1 2 3 4
Scale in miles

but shoalgrass occurred on an average of 98 percent of the bottom in shoalgrass habitat (136,320 acres). A near homogenous stand of manateegrass encompassing 16,640 acres occurred at the extreme southern end of Lower Laguna Madre (Fig. 3). Shoalgrass biomass from areas in which ducks fed in Upper and Lower Laguna Madre was 26 and 58 grams dry weight per 3.5 square feet of bottom area, respectively (Table 3). Mollusc biomass, largely the clams Chione cancellata and Arca transversa, was found to be greatest in the manateegrass stand in Lower Laguna Madre (Table 4).

Duck Distribution

Pintails and redheads were distributed in the shallower waters. Pintails fed mostly in water six to 10 inches deep along shorelines, and around spoil banks dug from the Intracoastal Waterway and side channels. Redheads fed primarily in different places, in open shallow water sites six to 24 inches deep and in the flats in the lee of Padre Island. Redheads shifted from feeding in very shallow, easily accessible shoalgrass stands early in the season to unused shoalgrass stands in deeper water late in the season. Lesser scaup fed in expanses of open water three to seven feet deep (Figures 4 and 5).

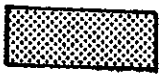
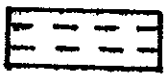
DISCUSSION

Redhead and Pintail Food Habits on Laguna Madre

Martin and Uhler (1939) indicated that the true importance of shoalgrass to waterfowl had yet to be determined. It remained for Singleton (1953) and later Martin (1965) to document its relative value as a duck food. Singleton (1953:46) found that shoalgrass

Figure 3. Vegetational type map, Lower Laguna Madre, Texas, July, 1965. Each type characterized by the dominant volume-density class and mean percent area occupied by all volume-density classes of each species.

Key to Map

Type Symbol	Species	Volume-Density Class	Percent of Area Occupied
	Shoalgrass	Very heavy	96
	Shoalgrass	Moderately heavy	96
	Shoalgrass	Light	99
	Shoalgrass	Very light	99
	Manateegrass Shoalgrass	Moderately heavy Moderately heavy	72 16
	Unvegetated areas, always submerged		
	Areas exposed during low tide		

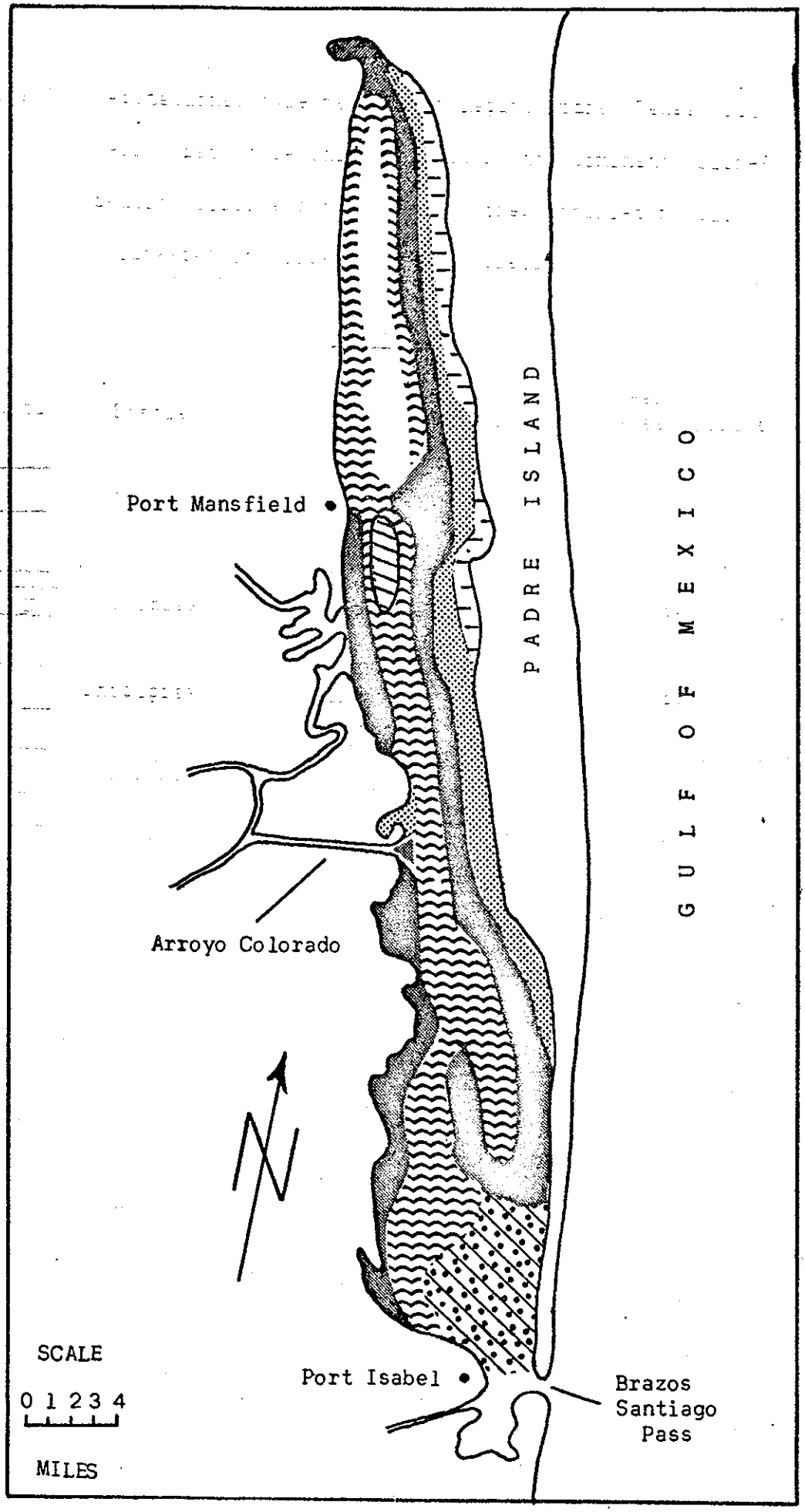

Port Mansfield
PADRE ISLAND
GULF OF MEXICO
Arroyo Colorado
SCALE
0 1 2 3 4
MILES
Port Isabel
Brazos
Santiago
Pass

Table 3. Dry weights of winter plant biomass, Laguna Madre, Texas. Expressed as grams of shoots and roots per 3.5 square feet of botom area.

Vegetational Type	Upper Laguna Madre	Lower Laguna Madre
Moderately heavy stand of shoalgrass	26	58*
Light stand of shoalgrass	8	30
Very light stand of shoalgrass	***	2
Moderately heavy stand of manateegrass	***	41**

*Seasonal mean of collections made in December, January, and February.

**Twelve-month mean, species not seasonal in abundance.

***Type lacking, or not prominent.

Table 4. Winter abundance of molluscs in Laguna Madre, Texas. Expressed as gram weight of those individuals edible to ducks per 3.5 square feet of bottom area.

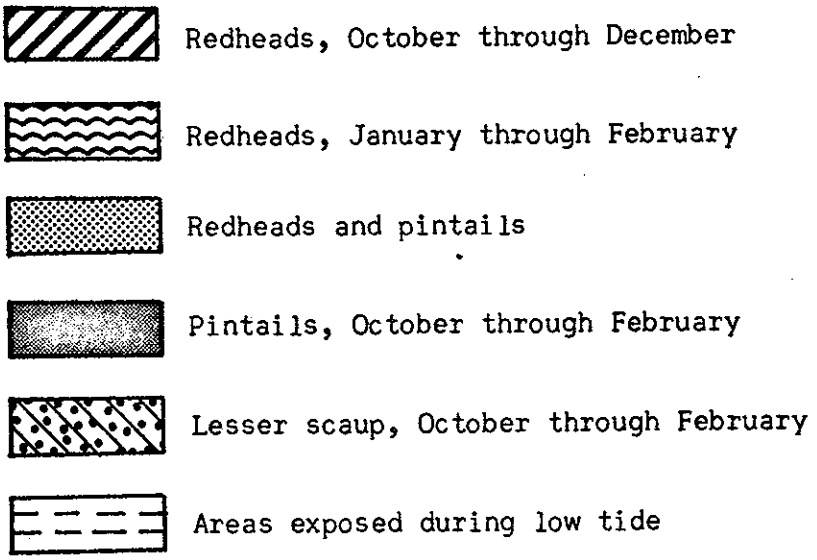
	In Vegetational Types of Upper Laguna Madre		In Vegetational Types of Lower Laguna Madre			
	Moderately Heavy Shoalgrass	Light Shoalgrass	Moderately Heavy Shoalgrass	Light Shoalgrass	Very Light Shoalgrass	Moderately Heavy Manateegrass
Pelecypods (clams)						
Tellina tampaensis	3.5	1.5	0.0	0.0	0.0	0.0
Chione cancellata	0.0	0.0	4.5	0.0	0.0	8.0
Cumingia tellinoides	0.0	0.0	5.2	3.2	0.3	0.0
Branchiodontes exustus	0.0	0.0	0.0	0.0	0.0	0.4
Amygdalum papyria	0.0	0.0	0.4	0.6	0.0	0.0
Mulinia lateralis	0.5	0.0	0.0	0.0	0.0	0.1
Anomalocardia cuneimeris	0.2	0.4	0.0	0.0	0.0	0.0
Tagelus spp.	0.0	0.0	0.0	0.0	0.0	0.3
Arca transversa	0.0	0.0	0.0	0.0	0.0	7.3
Laevicardium mortoni	0.0	0.0	0.0	0.0	0.4	0.1
Aequipecten irradians	0.0	0.0	0.0	0.0	0.0	0.1
Total Pelecypods	4.2	1.9	10.1	3.8	0.7	16.3

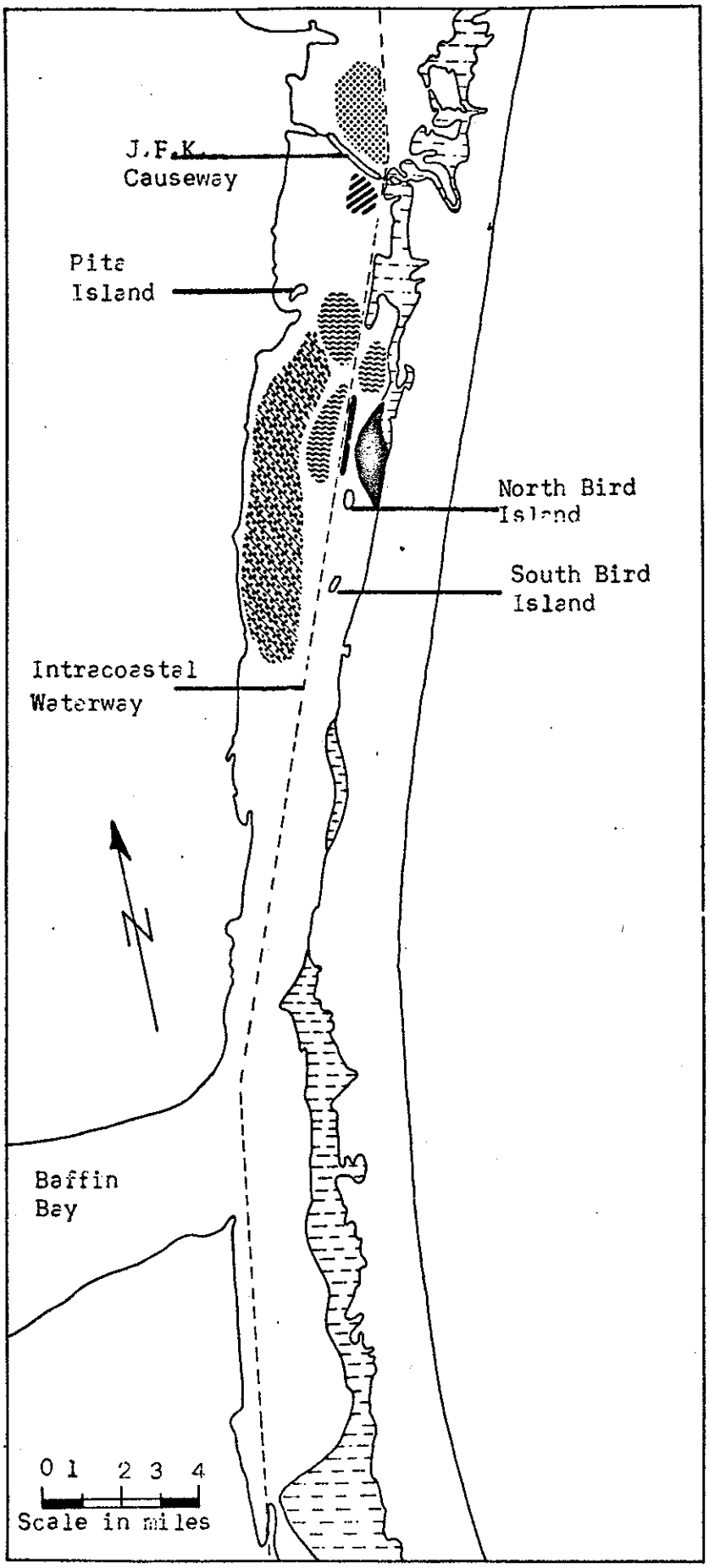
Table 4. Winter abundance of molluscs in Laguna Madre, Texas. Expressed as gram weight of those individuals edible to ducks per 3.5 square feet of bottom area (continued).

	In Vegetational Types of Upper Laguna Madre		In Vegetational Types of Lower Laguna Madre			
	Moderately Heavy Shoalgrass	Light Shoalgrass	Moderately Heavy Shoalgrass	Light Shoalgrass	Very Light Shoalgrass	Moderately Heavy Manateegrass
Gastropods (snails)						
Mangelia spp.	0.0	0.0	0.0	0.0	0.0	0.1
Neritina virginea	0.0	0.0	0.0	0.0	0.0	0.5
Bittium varium	0.0	0.0	0.0	0.0	0.0	0.0
Mitrella lunata	0.0	0.0	0.0	0.0	0.0	0.0
Turbonilla interrupta	0.0	0.0	0.0	0.0	0.0	0.0
Crepidula glauca	0.0	0.0	0.0	0.0	0.0	0.1
Bulla striata	0.0	0.0	0.3	0.0	0.0	0.1
Nassarius vibex	0.5	0.0	0.3	0.0	0.0	0.0
Anachis avara semiplicata	0.0	0.0	0.7	0.2	0.0	0.2
Cerithidea pliculosa	0.0	0.0	0.0	0.0	0.0	0.0
Cerithium variabile	0.3	3.2	0.0	0.0	0.0	0.0
Anachis obesa	0.0	0.0	0.0	0.0	0.0	0.0
Total Gastropods	0.8	3.2	1.3	0.2	0.0	1.0
TOTAL MOLLUSCS	5.0	5.1	11.4	4.0	0.7	17.3

Figure 4. Usual distribution of redhead, pintail, and lesser scaup ducks in Upper Laguna Madre, Texas, October - December, 1967, and January - February, 1968.

Legend




J.F.K.
Causeway
Pita
Island
North Bird
Island
South Bird
Island
Intracoastal
Waterway
N
Baffin
Bay
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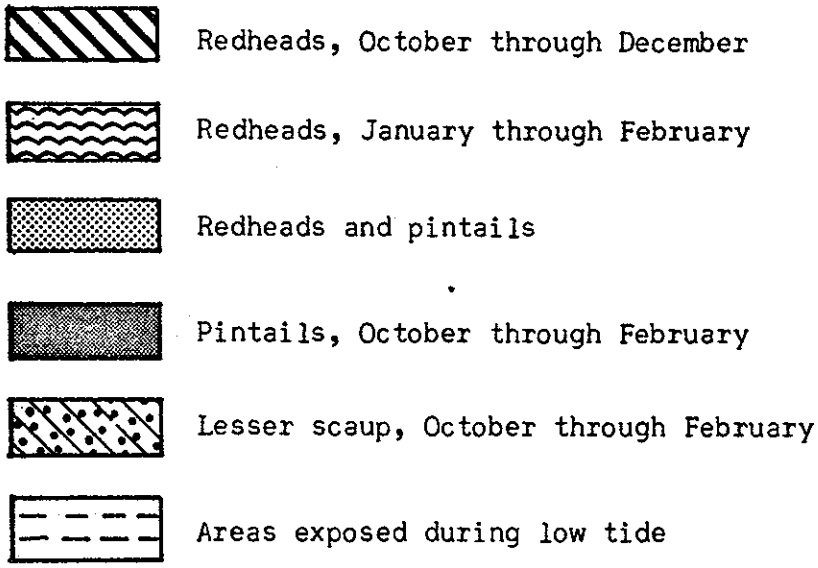
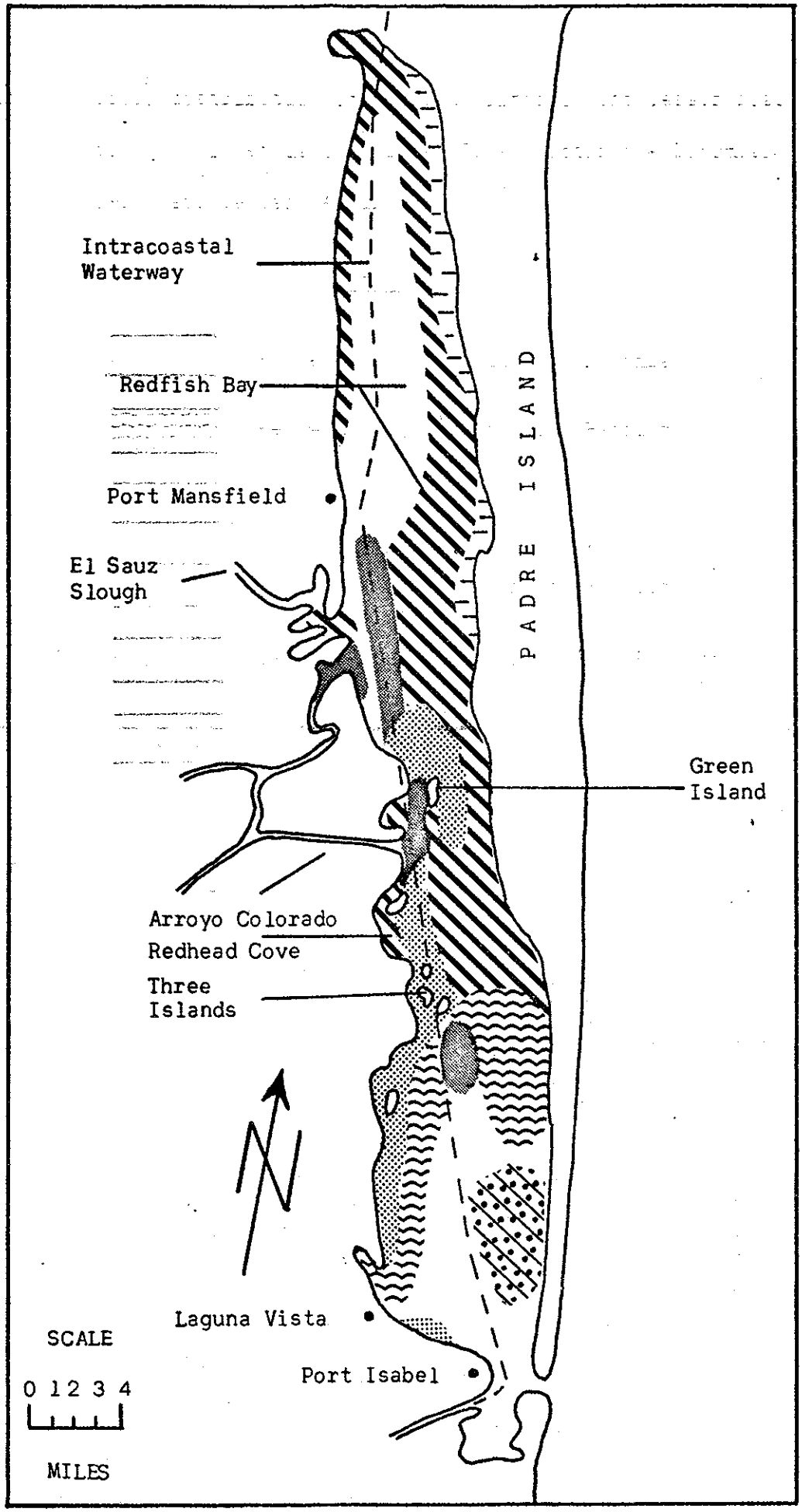
Scale in miles

Figure 5. Usual distribution of redhead, pintail, and lesser scaup ducks in Lower Laguna Madre, Texas, October - December, 1966, and January - February, 1967.




Intracoastal
Waterway
Redfish Bay
Port Mansfield
El Sauz
Slough
PADRE ISLAND
Green
Island
Arroyo Colorado
Redhead Cove
Three
Islands
Laguna Vista
Port Isabel
SCALE
0 1 2 3 4
MILES

made up 41 percent by volume of the diet of all species of ducks collected "primarily from saline (Texas) bays." Martin (1965:46) ranked shoalgrass as the number one waterfowl food plant in West Bay, Florida. But neither of these workers dealt specifically with the food habits of the redhead -- a species common to their respective study areas. So data presented here apparently are the first to adequately document the heavy use of shoalgrass by redheads. Probably widgeongrass occurs in the diet of redheads and pintails in Laguna Madre more frequently than is reported here. During winter, widgeongrass is much reduced from its more recognizable summer growth form, and is very succulent. It probably is rapidly digested in a duck's stomach, the remnants being almost impossible to identify, thus biasing results in favor of the coarser foods. However, the preponderance of readily identifiable shoalgrass rhizomes in almost all redhead and pintail stomachs leaves no doubt that shoalgrass makes up the bulk of food eaten by these ducks in Laguna Madre.

Molluscs may constitute a greater proportion of the redhead and pintail diets in times of abundance. They were scarce in both parts of the lagoon during the period of this study. Samples of mollusc populations in areas from which most ducks were collected in Upper Laguna Madre showed a biomass of only five grams of live individuals per 3.5 square feet of bottom area (Table 4). Conversely, Singleton (1953:46) found that molluscs constituted an average of 44 percent volume of all duck foods from combined species collected along the southeast Texas coast. But mollusc populations very with fluctuating

salinity (Parker, 1959:2106) and the animals may have been unusually abundant at the time of Singleton's collection. Also, the contribution made by lesser scaup to the duck food volume found by Singleton is unknown and could have biased his data in favor of molluscs.

Differing amounts of Mitrella, Cerithium, and Cerithidea in the diets of redheads and pintails are attributable to availability. Casual observations revealed that Mitrella was abundant in parts of Lower Laguna Madre (although none were found at biomass sample stations there) where most of the pintails were collected, accounting for the high percent occurrence of that species in pintail stomachs. On the other hand, inspection showed Cerithium and Cerithidea abundant in the Upper Laguna Madre where many redheads were collected, accounting for the high percent occurrence in their diet (Table 2). Probably many of the very small snails, such as the above named, are picked up fortuitously, or for grit.

Redhead and Pintail Food Habits on Other Wintering Areas

Laguna Madre can be compared with two other important duck wintering grounds, Chesapeake Bay in Maryland, and the west coast of Florida, in terms of redhead and pintail food habits. Stewart (1962) reported the food habits from 81 redheads and 13 pintails collected in estuarine habitats of Chesapeake Bay. Both species consumed mostly plant material. Submergent plants showed a 90 percent occurrence in the diet of redheads and an 85 percent occurrence in the diet of pintails (Stewart, 1962:158,136).

Stieglitz (1966:44,46) found that shoalgrass composed 6.9 percent of the submergent plants in Apalachee Bay, Florida; he examined 10 redhead gizzards from this bay and found shoalgrass made up 85.3 percent volume of their foods. This is certainly indicative of the redheads' preference for shoalgrass in Florida, especially in view of the predominance and availability of other aquatic plants -- turtlegrass (Thalassia testudinum), 59.3 percent composition, and manateegrass, 16.9 percent composition.

Redhead and Pintail Food Habits on the Breeding Grounds

Shoalgrass does not occur on the breeding grounds of redheads or pintails (or lesser scaup), but a review of the literature shows both species remain primarily consumers of plant material. Cottam (1939:9) found that plant material formed nearly 90 percent of the food of redheads and made up the entire meal of more than 70 percent of redheads gathered over the nation and five Canadian provinces. Insects and molluscs made up only 5.89 and 3.86 percent of redhead diet respectively.

Keith and Stanislawski (1960:96) determined that at Pel Lake, Saskatchewan, Canada, plant food made up 57.1 percent by volume of pintail foods, whereas animal matter and unidentified organic material made up 42.9 percent.

Lesser Scaup Food Habits

Data from the relatively few (20) lesser scaup stomachs substantiated recent studies of their winter food habits and proclivity for eating animals. Harmon (1962:134) determined the diet of lesser

scaup wintering along the Louisiana coast to be 99.8 percent surf clam (Mulinia lateralis), while Rogers and Korschgen (1966:262) found lesser scaups wintering in coastal Louisiana fed primarily on fish. Apparently the lesser scaup's predilection for animals applies to the breeding grounds as well. Dirschl (1969:79) found that the diet of lesser scaup collected in the Saskatchewan River Delta, Canada, averaged 66 percent animal and only 34 percent plant material. Cottam (1939:41) found lesser scaup subsisted mainly on plant foods (59.55 percent by volume), foraging on animal foods only slightly less (40.45 percent by volume). However, his data came from ducks collected from several ecologically diverse regions along their migration route and are therefore not directly comparable to studies of regional food habits.

In this study, total percent volume of animal matter consumed was 38.8 and plants (shoalgrass) only 22.1 percent. Unidentified organic matter was 39.1 percent. The largest component of the animal diet of lesser scaup was 11.2 percent Anomalocardia cuneimeris. This clam is similar in size to Mulinia lateralis, the clam Harmon (1962) found lesser scaup to prefer. Molluscs made up 27.4 percent of the lesser scaup diet in Laguna Madre. Crabs were eaten also, making up 10.8 percent of the diet. Probably much of the material included as "Unidentified Organic" in Table 2 was digested crab.

Species Interaction

Although redheads and pintails in Laguna Madre have similar food habits, they are not considered competitors in the ecological

sense, but rather are ecologically separated. Odum (1953:170) writes that interspecific competition is any action between two or more species populations which adversely affects their growth and survival. Andrewartha and Birch (1954:404) write that competition "exists only when food or space is limited in relation to the numbers of organisms utilizing it or when one species harms the other by fighting or in some other way." The reasons for believing that redheads and pintails, as well as lesser scaup, do not compete for food in Laguna Madre follow.

Redheads are diving ducks, but in Laguna Madre, they prefer to feed by tipping up in very shallow sites, like the surface-feeding pintails. An appraisal based on this kind of feeding behavior and on food habits alone would suggest competition to be common between redheads and pintails. But food is not limited in relation to the number of ducks using it; on the contrary, food is superabundant (see page 27, Carrying Capacity). Neither is space limiting. And there were no outward displays of the different species of ducks harming one another while seeking food. But then redheads and pintails have little occasion to do one another harm, because in the superabundance of food and space, each species usually occupies a different niche.[1/]

1/ Niche in this sense should be interpreted to mean the places or surroundings most commonly used by each of the different species of ducks. The functional concept of niche applies only to lesser scaup in that they feed largely on animals, while redheads and pintails are vegeterians.

As seen in Figures 4 and 5, pintails used areas along spoil banks of the Intracoastal Waterway and shallow (mostly western) shores of the lagoon, leaving broad expanses of the interior water areas to redheads and lesser scaup. Two exceptions were noted in Lower Laguna Madre where pintails fed to three and one-half miles northeast and south of Green Island, and to four miles south of Three Islands (Fig. 5). These two general areas were used when wind tides from strong frontal passages lowered water levels and pintails were able to feed by tipping up.

Redheads on the other hand inhabited more open waters in Lower Laguna Madre, particularly those areas east of the Intracoastal Waterway and leeward of Padre Island. The most intermixing of pintail and redhead populations was noted near Green Island, along the mainland shore southwest of Three Islands, and in Upper Laguna Madre, in an area one to three miles north of John F. Kennedy Causeway to Padre Island (Figures 4 and 5).

The question as to why redheads and pintails are not usually found together in shallow water where both are capable of feeding, even when food is not in short supply, may have its answer in the past. Lack (1966:297) points out that the rarity of competition between species today is attributable to competition having occurred in the past "with the result that birds have evolved habitat selection, by which they recognize their specific habitats and hence usually avoid competing with other species." But pristine competition between these ducks may not have evolved on the breeding and

wintering grounds with equal intensity. So, there may be other reasons for the lack of competition between ducks in Laguna Madre, aside from the surfeit of food, and the possibility of evolutionary habitat selection.

The "specific habitats" Lack writes of, while perhaps distinguishable to ducks, are often indistinguishable, except by their spatial arrangement and soil type, to the writer. For example, the redhead feeding sites in the lee of Padre Island in Lower Laguna Madre are similar, with respect to water depth and shoalgrass cover, to pintail feeding sites along the mainland shore. Perhaps social discomfort on the part of one or both species during intermixing contributes to the separation.

Ecologic separation was more clearly seen with regard to lesser scaups. They rafted on the three to seven-foot water depths of Port Isabel Bay in Lower Laguna Madre (over the manateegrass community), on the 12-foot deep Intracoastal Waterway, and over most of the four to seven-foot deep unvegetated areas in Upper Laguna Madre (Figures 4 and 5). Lesser scaup may have used Port Isabel Bay and the deeper waters of Upper Laguna Madre because of their animal populations. Port Isabel Bay has a wide variety of species of fish, shrimp, molluscs, and crabs (Breuer, 1962:163). Casual spot checks showed that the small clams Mulinia lateralis and Anomalocardia cuneimeris are fairly abundant in the four to seven-foot deep unvegetated area in Upper Laguna Madre. The writer did not sample the bottom of the Intracoastal Waterway for animal populations, and causes of use of

that channel by lesser scaup can only be speculated. The waterway is devoid of vegetation except along its submerged banks where luxuriant stands of shoalgrass occur. The banks of the waterway harbor vast numbers of shrimp and small fish, and commercial bait fishermen seine along its banks more than in the shallower open waters. So abundance of these animals along the borders of the waterway may be the attraction to lesser scaup.

Carrying Capacity

In this discussion, carrying capacity is defined as the number of waterfowl that could feed on Laguna Madre without the food source being abused or overtaxed so as to prevent a sustained yield. There are no indications that anything other than the food supply, as it may be directly or indirectly affected by pollutants or by physical or biotic components of the environment, would seriously limit carrying capacity for ducks in Laguna Madre. Other attributes of habitat usually considered in determining carrying capacity for birds, such as escape and resting cover, nesting sites, and availability of fresh water, are not paramount or do not apply to ducks in Laguna Madre.

Whether waterfowl numbers are near, or far below, the carrying capacity of Laguna Madre is largely a moot question because a quantitative estimate of the utilization of the standing crop of food per duck per unit time is not available. Neither is the proper level of use, or "grazing tolerance" known for shoalgrass or widgeongrass. But there is good reason to believe that food is not limiting at this time, and that the lagoon could support more

waterfowl. Redheads graze down their initial concentration areas and then shift to feeding in other unused areas as the season progresses (presumably the grazed and vacated stands of grass show regrowth during the period of rest, assuring a sustained yield of plant foods). Clark (1961:8) observed that in fall and early winter, redheads preferred to use that area in Lower Laguna Madre east of the Intracoastal Waterway between Three Islands and the northernmost shore. He noted that redheads grazed down the shoalgrass in the area rather closely and then in late winter shifted their feeding grounds to the unused shoalgrass stands in the area south and west of the Intracoastal Waterway between Three Islands and Laguna Vista. The writer and his assistant made more detailed accounts of waterfowl distribution and behavior in Laguna Madre from 1966 to 1968. The following are accounts from that work pertinent to carrying capacity.

Shifts in major segments of the redhead population from one area of the lower lagoon to another; Redhead Cove in October and early November to the east Redfish Bay--Three Islands area in November and December, to areas southeast and southwest of Three Islands in late January and February; were influenced by the accessibility of shoalgrass stands. Redheads used the shoalgrass stands in shallow areas before shifting to diving for shoalgrass in deeper waters.

Redheads also changed areas of use in Upper Laguna Madre. They abandoned the very shallow sites (six to 13 inches deep) north and southeast of John F. Kennedy Causeway and began rafting in water

18 to 24 inches deep in the following three places: an area one mile southeast of Pita Island, an area one-fourth mile east of the Intracoastal Waterway and two and one-half miles north of North Bird Island, and along the west side of the Intracoastal Waterway south from the Causeway to near North Bird Island (Fig. 4). Toward the end of January, rafts of redheads were observed using some deeper-water (three feet or more) sites one to two miles south of Pita Island near the mainland shore. The birds were diving for food at this site. Indeed, the areas that redheads vacated showed visibly reduced grass stands, and the areas to which they moved in late winter appeared to have a greater abundance of shoalgrass.

Still, the overall plant food supply is superabundant. For example, in Lower Laguna Madre, the winter standing crop of all (wet) shoalgrass was estimated to be 317,345 tons, a yield of 4,656 lbs per acre (McMahan, 1968:505). Using this figure for total winter shoalgrass biomass, for purposes of estimating carrying capacity, let the reader assume that: (a) shoalgrass accounts for all of the diet of pintails and redheads, (b) 639,000 ducks of both species currently over-winter, and (c) 50 percent is a "safe" harvest of the grass stand. The calculations would then show the allotted use of 496 lbs of wet forage per duck for the 90 day season of intense use. While it is not known how much shoalgrass redheads and pintails eat daily, it is unlikely the allotted amount would be consumed. Longcore and Cornwell (1964:529) found canvasbacks (Aythya vallisineria) consumed about 1.16 lbs of (wet) natural

foods (63.7 percent vegetable) per day in winter. If redheads ate at about this rate, one duck would eat 104 lbs during the wintering season, or about 21 percent of the imaginary allotment. These calculations, while gross, indicate a substantial amount of forage would be left over at the end of winter, even if the used stands did not renew growth that season, and that redheads and pintails now winter in numbers well below the present carrying capacity of Laguna Madre.

One more indication of unrealized carrying capacity in Laguna Madre is that historically, redheads ranged the continent in greater numbers 40 years ago, and these larger populations in all probability used Laguna Madre then as they do now. Also, it is known that the reduction of redhead numbers over the past decades has largely been a result of destruction of northern prairie breeding habitat, combined with drought effects there (Low, 1945; Hochbaum, 1946) and not the result of lessened carrying capacity on the wintering grounds.

MANAGEMENT IMPLICATIONS

The distribution of redheads and pintails, as expected, was correlated with shoalgrass stands in shallow water. This observation assumes considerable importance especially in Upper Laguna Madre. Almost all of the vegetated area in Upper Laguna Madre is located within 30 miles of a large number of south Texas waterfowl hunters from Corpus Christi and the Coastal Bend area with its rapidly increasing human population. Food is not presently limiting to ducks there, but detrimental alterations to this limited

shallow water habitat, such as its physical removal by various digging or dredging operations, will likely reduce carrying capacity there and concentrate ducks elsewhere in parts of Laguna Madre largely inaccessible to hunters.

The possible effects of the proposed "fish passes," from the Gulf of Mexico into Laguna Madre, on waterfowl carrying capacity should be considered. A large-scale permanent reduction in salinity norms in the lagoon by the construction of water passes through Padre Island and subsequent dilution of the hypersaline water with Gulf water of lower salinities would likely promote the production of hypersaline intolerant plant species such as turtlegrass and manateegrass and in time, cause decreases in the amount of shoalgrass (McMahan, 1968:506). Apparently turtlegrass and manateegrass are not palatable to any species of bay ducks, as studies conducted by Singleton (1953), Martin (1965), and Stieglitz (1966) in areas where the grasses grow, failed to show any significant utilization of the plants. So it is probable that changes in vegetational type, from shoalgrass to a manateegrass-turtlegrass association would tend to disperse ducks from the affected area. It may be noted that the manateegrass community now encompassing considerable acreage in Lower Laguna Madre is not used by feeding redheads (Fig. 5).

Proponents of changing the habitat in Laguna Madre may contend more "edge effect" is needed -- that is, they may contend the food supply for wildlife may be improved if salinities are such that permit the growth of a variety of flora (and fauna) rather than the

present near homogenous shoalgrass stands. But as mentioned previously, some of the species in the variety would not be palatable to ducks. Also, carrying capacity for ducks probably would not be raised -- there is no need for that anyway -- were salinities such that the palatable widgeongrass became more abundant. As stated previously, widgeongrass is much reduced in winter and biomass appears to be less than that of shoalgrass. Then in summer, where salinities are favorable, widgeongrass makes phenomenal growth; the plant colonizes and forms dense stands that in the shallow waters of Laguna Madre grow to the surface. This aspect presents a different problem which is also common with manateegrass in shallow water. Boat travel within the colonies is next to impossible as the flowering stalks become entangled with outboard propellers and eventually render them useless. This mechanical difficulty would need to be considered in a multiple use area such as Laguna Madre.

The responsibility of citizens in this matter is clear. A redhead population belonging to the North American Continent uses a definite and uniquely productive wintering habitat in Texas almost exclusively. That habitat should be properly conserved. To do this, the principal factors that operate to make Laguna Madre so productive of shoalgrass and factors detrimental to shoalgrass must be researched. Subsequently habitat management decisions should then be based on predictions of research. The overall effort should be geared to maintaining the shoalgrass stands as they are. data could be combined with estimates of duck populations to obtain a better idea of carrying capacity.

In these times of man's destruction of habitat, conservation of migrating ducks will depend more and more on conservation of wintering habitat as well as conservation of the breeding grounds. Only those birds properly fed and in good condition will be able to return north to breed. The Laguna Madre of Mexico cannot be depended upon to winter these ducks if carrying capacity in Texas deteriorates because habitat destruction in the Mexican lagoon, through closure of passes to the Gulf of Mexico, has resulted in salinities too high to sustain a large biomass of waterfowl foods. The Intracoastal Waterway bisecting Laguna Madre, Texas, mitigates excessive salinity; the Laguna Madre of Mexico has no such mitigating mechanism.

RESEARCH RECOMMENDATIONS

The salinity tolerances of shoalgrass, as well as relevant non-duck foods such as manateegrass and turtlegrass have been researched by McMillan and Moseley (1967) and McMahan (1968). A better understanding of the ecology of manateegrass and turtlegrass in Texas bay systems is needed in order to predict what conditions might favor their growth to the detriment of shoalgrass or widgeongrass. Some further ecological studies might include the determination of:

(1) Consumption of the standing crop of shoalgrass per duck, or numbers of ducks, per unit time (this research would need to be designed so as to exclude the use of shoalgrass by foraging fishes and the rooting habit of black drum (Pogonias cromis). The data could be combined with estimates of duck populations to obtain a better idea of carrying capacity.

(2) The upper level of grazing use that shoalgrass can tolerate and still produce sustained annual yields.

(3) The effect of depth of submersion and light penetration on growth and reproduction of shoalgrass, widgeongrass, manateegrass, and turtlegrass.

(4) The ranges of temperature tolerance of the mentioned species.

(5) Effects of dredging and subsequent sedimentation on submergent plant growth and reproduction.

(6) Effects of bottom soil type on plant growth and reproduction.

(7) Nutritional values of shoalgrass and widgeongrass as produced in hypersaline waters and estuarine waters.

(8) The ranges of salinity tolerance of molluscs commonly eaten by bay ducks such as lesser scaup.

(9) How the Laguna Madre itself can be preserved. Unless the wind erosion of sand from Padre Island, and filling of the lagoon is stopped, favorable habitats for ducks will become dry land.

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