MFR PAPER 1262

Alteration and Destruction of Estuaries Affecting Fishery Resources of the Gulf of Mexico

WILLIAM N. LINDALL, Jr. and CARL H. SALOMAN

ABSTRACT–Both the commercial and recreational fishing industries of the Gulf of Mexico are overwhelmingly dependent on estuaries. About 90 percent of the commercial catch and 70 percent of the recreational catch are made up of species that are estuarine dependent. Man's alteration of estuaries is threatening these fishery resources. Data from recently published inventories of major natural and man-made estuarine features of the five gulf coastal states indicated that the total gulf estuarine area is 13,965,910 acres, including 7,890,611 acres of open-water area and 6,075,299 acres of emergent tidal vegetation. Submerged grass beds total 796,796 acres and live oyster beds amount to 158,663 acres. Major man-made alterations include 4,446 miles of federally maintained navigation channels, 138,458 acres of fill, and 795,609 acres closed to shell fishing because of pollution.

INTRODUCTION

Almost any long-term resident of, or frequent visitor to, the Gulf of Mexico can verify that not many years ago human activity was comparatively limited along the gulf coast. Even the gulf coast population is small in comparison to some coastal sections of the United States, but it is enlarging rapidly. Development associated with this population growth threatens continued production from fishery resources through destruction and alteration of aquatic and estuarine habitats.

Recognizing an accelerating competition between fish and wildlife on the one hand, and industrial and municipal growth on the other, the Gulf States Marine Fisheries Commission initiated in 1965 a cooperative inventory of the gulf estuaries to develop realistic, standardized appraisals of estuarine resources along the entire coast. Known as the Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI), the inventory included four phases—area description, hydrology, sedimentology, and biology. The area description phase of the GMEI has been completed for each of the five gulf states: Alabama (Crance, 1971), Louisiana (Perret et al., 1971), Florida (McNulty et al., 1972), Mississippi (Christmas, 1973), and Texas (Diener, 1975).

The purpose of this report is twofold: 1) to review briefly the importance of the gulf estuaries to the nation's commercial and recreational fishing industries, and 2) to provide an overview of the major natural and man-made features of gulf estuaries by summarizing information contained in the GMEI of each gulf state.

CONTRIBUTION OF GULF ESTUARIES TO THE NATION'S FISHERIES

"But while we may reasonably assume that the fisheries of the Gulf may attain much greater proportion than they now have, it is not probable that they will ever reach an importance at all comparable with such fisheries as those of New England, simply because there are not the enormous resources to draw from for a large supply of material, and also because these southern species are not likely to fill so important a place in cured food as do the staple production of northern seas."

These were the conclusions of J. W. Collins, Master of the *Albatross*, following an extensive survey of the gulf fisheries in 1885 (Thompson and Arnold, 1971). Thompson and Arnold's review of gulf fishery development over the past century, however, depicted a sharp contrast with Collins' conclusions. Since 1940, gulf fisheries have expanded greatly, and are contributing a greater proportion of the nation's catch (Fig. 1). The gulf catch rose from 250 million pounds in 1940 to 571 million pounds in 1950, and doubled again by 1960. In 1970, 1.7 billion pounds were landed. These landings represented 6 percent of the total U.S. catch in 1940, 12 percent in 1950, 26 percent in 1960, and 35 percent in 1970. The value of the catch to gulf fishermen during these three decades increased from $11 million to $166.6

William N. Lindall, Jr. is a Fishery Biologist with the Environmental Assessment Branch of the Southeast Regional Office, National Marine Fisheries Service, NOAA, 9450 Gandy Boulevard, St. Petersburg, FL 33702. Carl H. Saloman is a Fishery Biologist with the Panama City Laboratory of the Southeast Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 4218, Panama City, FL 32401.

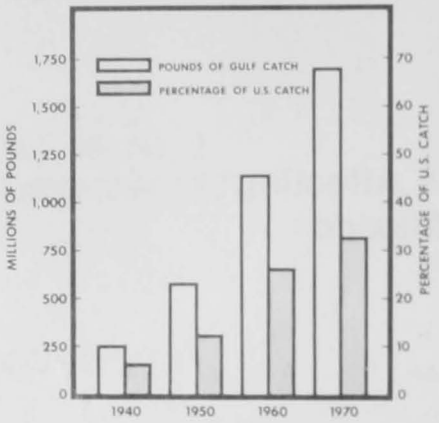


Figure 1.—Commercial fisheries catch from the Gulf of Mexico (1940-70) including the percentage of the U.S. catch.

Table 1.—U.S. commercial landings by regions, 1974[1].

Region	Thousand pounds	Thousand dollars
New England	521,565	121,843
Middle Atlantic	210,059	43,371
Chesapeake	570,297	54,275
South Atlantic	299,937	47,710
Gulf	1,772,531	240,836
Alaska	456,864	141,120
Washington and Oregon	211,515	93,481
California	745,047	130,381
Great Lakes and Mississippi River	141,322	20,025
Hawaii	10,463	5,458
Total	4,939,600	898,500

[1]Statistics on landings are shown in round weight for all items except univalve and bivalve mollusks such as clams, oysters, and scallops, which are shown in weight of meats excluding the shell. Source: Wheeland and Thompson (1975).

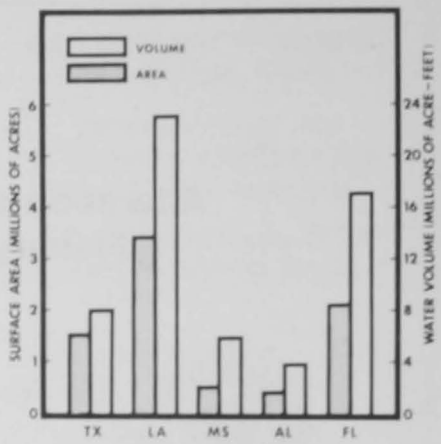


Figure 2.—Surface area (acres) and volume (acre-feet) of open estuarine waters by state.

million. Landings in 1974, the latest year for which figures are available, are shown by U.S. fishery region in Table 1. In both landings and value, the gulf was the leading region, contributing 1.77 billion pounds (36 percent of the U.S. catch) and $240.8 million (27 percent of the U.S. value).

The vast increase in quantity and value of gulf catches during the past three decades was due primarily to expansion of fisheries for shrimp, menhaden, and blue crab, and the start of a new fishery in 1952 for bottom fishes, primarily spot and croaker, for the pet food industry (Thompson and Arnold, 1971). All of these species are estuarine dependent, spending all or portions of their life cycles in estuarine waters. In fact, it is estimated that about 90 percent of the commercial catch from the gulf fisheries are estuarine-dependent species (Skud and Wilson, 1960; Thompson and Arnold, 1971).

Concurrent with the expansion of commercial fishing, a marked increase in recreational fishing has taken place. In a 15-year period (1955-70), the number of U.S. recreational fishermen more than doubled, from 4.6 million to 9.5 million (Table 2). Similarly, numbers of recreational fishermen in the Gulf of Mexico during this period more than doubled, from 1.1 million to 2.3 million, and represented about 24 percent of the U.S. fishermen. In 1970, expenditures by gulf fishermen represented 33 percent of the U.S. fishermen expenditures and more than quadrupled during the 15-year period, an increase much larger than the rest of the United States. In terms of pounds that were caught, about 30 percent of the U.S. marine recreational catch occurred in the gulf (Table 2).

Table 2.—U.S. marine recreational fisheries: number of marine fishermen, expenditures, and total finfish catch by coast, 1955, 1960, 1965, and 1970.

	Fishermen[1] (1,000)			
Year	Atlantic	Gulf of Mexico	Pacific	Total
1955	2,343	1,077	1,137	4,557
1960	3,383	1,437	1,472	6,292
1965	4,178	2,084	2,043	8,305
1970	5,010	2,272	2,178	9,460

	Expenditures ($1,000)			
Year	Atlantic	Gulf of Mexico	Pacific	Total
1955	213,653	98,209	177,077	488,939
1960	346,373	144,857	134,961	626,191
1965	331,179	176,104	292,373	799,656
1970	636,380	404,646	183,679	1,224,705

	Total finfish catch[2] (1,000 lbs.)			
Year	Atlantic	Gulf of Mexico	Pacific[3]	Total
1955[4]	—	—	—	—
1960	731,852	411,110	237,339	1,380,301
1965	836,481	375,575	262,297	1,474,353
1970	917,631	485,728	173,464	1,576,823

[1]Includes persons 12 years old or older who fished at least parts of 3 days or spent $7.50 or more on fishing during the year. Does not include persons who fished only for shellfish.
[2]Weight of fish caught, but not necessarily brought ashore, by recreational marine fishermen. These weight estimates contain errors in both sampling and response. Does not include crustaceans, mollusks, and other invertebrates. In some coastal areas, recreational marine fishermen harvest significant quantities of these animals.
[3]Does not include Hawaii.
[4]No survey in 1955.
Source: Wheeland and Thompson (1975).

Based on the knowledge of the life histories of fish that comprised the recreational catches (listed in Wheeland and Thompson, 1975), we estimated that 70 percent (by weight) of those fish taken in the gulf were estuarine dependent. Thus, both the recreational and the commercial fishing industries of the Gulf of Mexico are overwhelmingly dependent on gulf estuaries for continued production of fishery resources (Sykes and Finucane, 1966).

DIMENSIONS OF MAJOR NATURAL FEATURES

Open-Water Area and Volume

The total open-water area of estuaries calculated at mean high water is 7,890,611 acres with a volume of 57,880,568 acre-feet (Fig. 2). Louisiana contains 43 percent (3,378,924 acres) of the gulf's open estuarine waters and 40 percent (23,140,497 acre-feet) of the volume. Florida ranks second with 26 percent (2,081,525 acres) of the area and 30 percent (17,134,163 acre feet) of the volume, followed by Texas, Mississippi, and Alabama with 19 percent, 6 percent, and 5 percent of the area and 14 percent, 10 percent, and 7 percent of the volume, respectively (Fig. 2).

Thousands of acres of the gulf's open-water estuaries have been physically destroyed or altered by dredging

and filling. Chemical adulteration by domestic and industrial wastes has affected several hundred thousand more acres. The obliteration of open-water areas threatens the continued productivity of fishery resources because these areas provide nursery and forage grounds for both recreationally and commercially important species.

Emergent Vegetation

The total area of tidal marsh along the gulf coast is 6,075,299 acres. As with the area and volume of open estuarine waters, Louisiana contains most (64 percent) of the gulf's tidal marsh with more than 3.9 million acres (Fig. 3). Texas ranks second with 1.1 million acres (19 percent of gulf total), followed by Florida (15 percent), Mississippi (1 percent), and Alabama (0.5 percent).

A difference in climatic conditions and a few inches of vertical elevation of substrate greatly determine the character and composition of marsh land. Accordingly, gulf coast marshes vary from narrow bands in some areas to mile-wide expanses in others. In view of the number of recent research and review papers on the role of estuarine tidal marshes, a detailed statement of the importance of emergent vegetation to fishery production would be redundant (see de la Cruz, 1973; Gosselink et al., 1974). In essence, marsh plants provide detrital material (small decaying particles) which serves as a substrate for bacteria, fungi, and protozoa that are the vital, basic energy source of the aquatic food web. The marsh also maintains water quality by filtering upland runoff and tidal waters; it serves as spawning and nursery grounds for economically important marine fishes as well as forage fishes, shrimps, crabs, oysters, and clams, and it provides shoreline stabilization.

Despite the value of marshes to the estuarine ecosystem, thousands of acres of gulf marshland have been destroyed or altered by man-made developments. Some destruction was deliberate, as with dredging and filling to provide real estate for housing and industry (Lindall and Trent, 1975). In other cases, marshland destruction was unintentional, brought about by ignorance or disregard of the natural processes required for a marsh to survive. An example of the latter is Louisiana's average annual loss of 16.5 square miles of marsh over the past 30 years, much of which was caused by man's alteration of natural hydrologic and sedimentologic processes (Gagliano and van Beek, 1970).

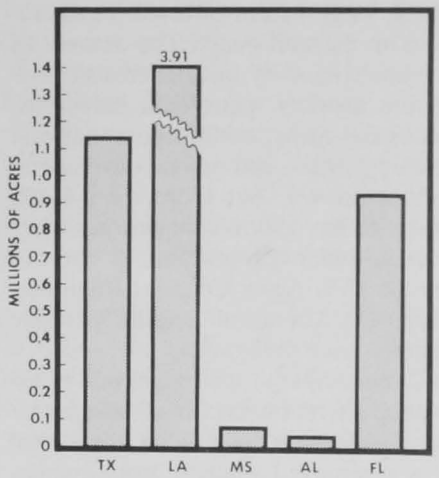


Figure 3.—Acreage of gulf tidal marshes by state. (Includes 393,160 acres of mangroves in Florida.)

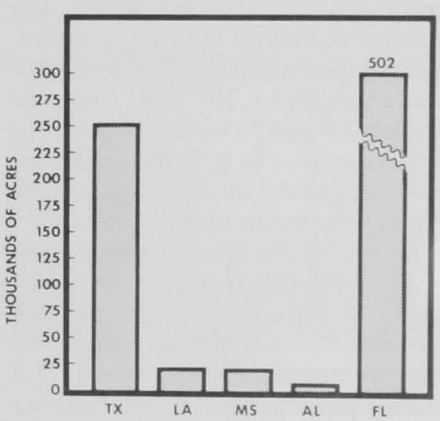


Figure 4.—Acreage of submerged estuarine vegetation in the Gulf of Mexico by state.

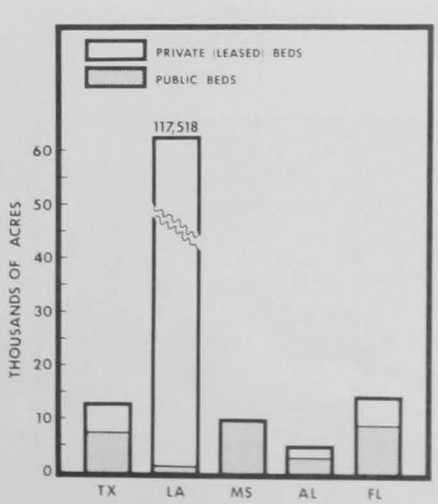


Figure 5.—Acreage of the gulf's commercially productive oyster beds, public and private (leased), by state.

Submerged Vegetation Exclusive of Algae

Determined primarily by water depth, turbidity, and salinity, the amount of submerged vegetation in gulf coast estuaries covers an area of 796,796 acres (Fig. 4). Distribution is continuous around the five gulf states, but relative abundance differs markedly among states. The vast majority (63 percent) of sea grasses occurs in Florida where relatively clear estuarine waters cover 502,431 acres. Texas estuaries, primarily the less turbid waters of Copano-Aransas Bays and Laguna Madre, rank second with 249,235 acres (31 percent of the gulf total). The turbid waters of Louisiana, Mississippi, and Alabama cover 45,000 acres, or about 6 percent of submerged vegetation in the gulf (Fig. 4).

In relation to open-water areas of the gulf estuaries, about 10 percent of the bottom is covered with sea grasses. Some 24 percent of Florida bay bottoms are vegetated, followed by Texas with 16 percent, Mississippi 4 percent, Alabama 1 percent and Louisiana 0.5 percent.

Oyster Beds

Oyster beds are present in nearly all gulf estuaries. Ranging in shape and size from small mounds to mile-long reefs, the total area of commercially productive oyster beds in gulf estuaries is 158,663 acres, including both public and private (leased) beds (Fig. 5). Louisiana has about 74 percent of the oyster beds in the five gulf states. These account for 1,200 acres of public beds and 116,318 acres of privately leased beds. Not shown are more than 450,000

acres which provide seed oysters to the Louisiana oyster industry as well as to the public (Perret et al., 1971). Florida ranks second with 13,844 acres (9 percent of the gulf total), followed by Texas, Mississippi, and Alabama with 12,477 acres, 9,786 acres, and 5,038 acres, respectively.

DIMENSIONS FOR MAJOR MAN-MADE ALTERATIONS

Dredge and Fill

Construction and maintenance of navigation channels represent the single largest form of estuarine alteration on the gulf coast. The amount of channelization by local interests (navigation districts, petroleum industries, industrial firms, county governments, municipalities, and private developers) is not known, but more than 4,400 miles of navigation channels are completed, under construction, or planned by the U.S. Army Corps of Engineers (Fig. 6). Almost all require periodic maintenance dredging.

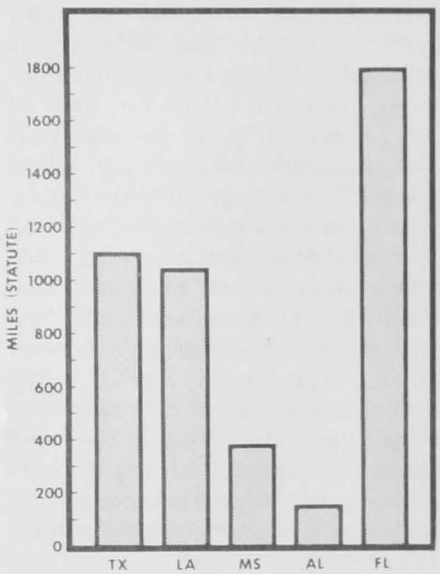


Figure 6.—Miles of navigation channels (completed, under construction, or planned) by state.

An example of the magnitude of estuarine alteration resulting from navigation channels is the amount of material that is removed annually from maintenance dredging alone. Each year, the Corps of Engineers dredges an average of 151.5 million cubic yards of sediment from gulf coast channels and harbors (Fig. 7). Put into perspective, this volume of dredged material is equivalent to a roadbed about 50 yards wide, 1 yard deep, and 1,743 miles long, the driving distance from Key West, Fla., to Brownsville, Tex. Of this annual total, 60.8 million cubic yards are dredged from Louisiana waters; 47.9 million cubic yards from Texas waters; 30.2 million cubic yards from Mississippi, Alabama, and northwestern Florida; and 12.6 million cubic yards from peninsular Florida. Some 77.7 million cubic yards, or over half, are disposed of in open water (Palermo and Montgomery, 1976).

Navigation channels are a vital part of the gulf's transportation system, but they can represent a significant threat to fishery resources through habitat destruction and alteration (Arnold, 1964). Consequences of channel dredging that are particularly damaging to fishery resources include physical loss of aquatic habitat by creation of spoil islands, segmentation and isolation of bays, increased shoaling, increased saltwater intrusion and flushing time, alteration of tidal exchange and circulation patterns, increased turbidity, and destruction of submerged and emergent vegetation (Chapman, 1968).

Filled areas, created primarily for terrestrial environments and produced by dredging adjacent water bottoms, represent the most obvious form of estuarine alteration. Some 138,458 acres of gulf estuaries are filled (Fig. 8). More than half of the five-state total occurs in Texas (78,000 acres) and is the result of spoil disposal from navigation channels (Chapman, 1968). Louisiana ranks second with 26,615 acres of fill, which, as in Texas, resulted almost totally from spoil from navigation channels. Florida ranks third with 23,521 acres of fill, but, unlike Texas and Louisiana, spoil from navigation channels accounts for less than 5 percent of the state total; the majority of Florida's fill (18,409 acres) was created for housing and industrial real estate.

Figure 7.—Disposition of dredged material generated in maintenance dredging operations and annual quantities (in millions of cubic yards) of material disposed by area by Corps of Engineers. Source: Palermo and Montgomery (1976).

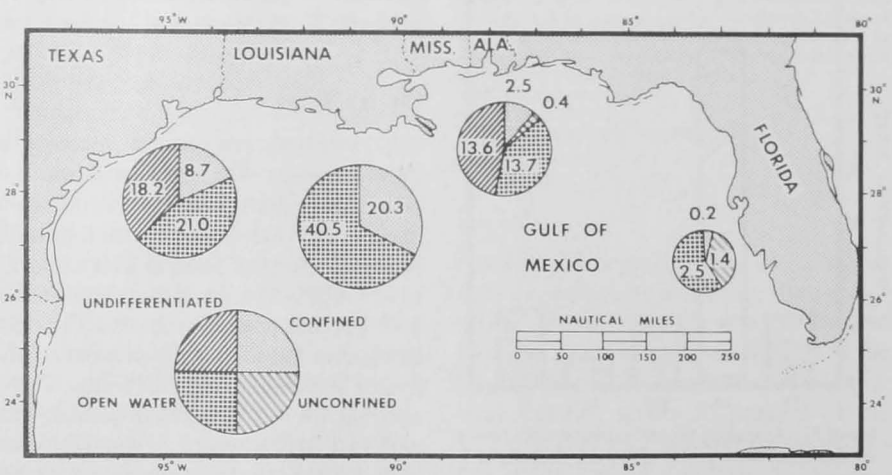
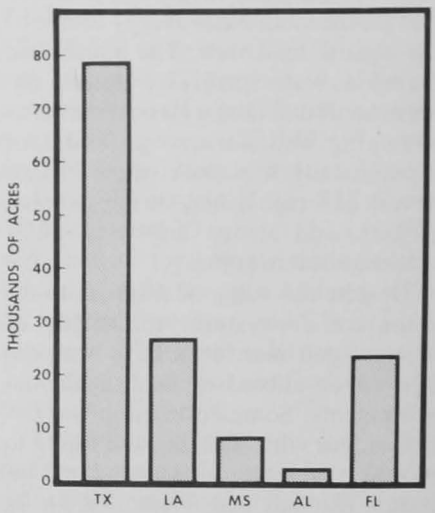


Figure 8—Acreage of fill in gulf estuaries by state. (Texas fill area taken from Chapman, 1968.)



Mississippi and Alabama estuaries contain 8,170 and 2,152 acres of fill, respectively, most resulting from spoil from navigation channels and fill for industrial development (Fig. 8).

Pollution

Few, if any, of the gulf estuaries have been spared from some form of pollution associated with the burgeoning human population in the coastal zone. An almost infinite variety of pollutants, including oxygen demanding organic materials, pesticides, petroleum products, silt, heat, radioactive substances, heavy metals, and other deleterious substances contained in sewage effluent and storm-water runoff, have chemically altered some areas to the extent that their productiveness and usefulness are endangered or lost.

It is not within the scope of this report to review the voluminous information available on pollution in the Gulf of Mexico estuaries. However, one measure of the effect of pollution on fishery resources is the amount of estuarine area closed to shellfishing. Because of various pollutants, including coliform bacteria from domestic, industrial, and agricultural sources, health authorities have closed 795,609 acres to the harvest of shellfish, especially oysters (Fig. 9). Thus, more than 1 out of very 10 acres of gulf estuaries is closed to shellfishing.

In Texas, over 40 percent of the five-state total estuarine area closure is closed to shellfishing. This accounts for 325,000 acres, or 21.2 percent of that state's estuaries. Florida ranks second

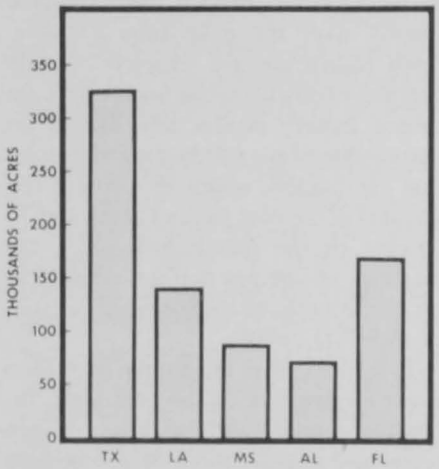


Figure 9.—Estuarine acreage closed to shellfishing by state.

Close-up view of dredge and fill operation in progress for housing and industrial development.

Completed dredge and fill project for housing development.

Marshland converted to spoil site for maintenance of navigation channels.

Table 3.—Summary of major natural features and man-made alterations of Gulf of Mexico estuaries, by state.

Feature	Texas[1]	Louisiana[2]	Mississippi[3]	Alabama[4]	Florida[5]	Gulf total
Surface area (open water), MHW[6], acres	1,532,430	3,378,924	500,379	397,353	2,081,525	7,890,611
Vegetation						
Submerged, acres	249,365	20,000	20,000	5,000	502,431	796,796
Emergent, acres	1,141,400	3,910,664	66,933	34,614	921,688	6,075,299
Total estuarine area (including open water and tidal marsh), acres	2,673,830	7,289,588	567,312	431,967	3,003,213	13,965,910
Oyster beds (live)						
Private (leased), acres	5,190	116,318	0	1,974	5,125	128,607
Public, acres	7,287	1,200	9,786	3,064	8,719	30,056
Total acres	12,477	117,518	9,786	5,038	13,844	158,663
Navigation channels, miles	1,095	1,039	374	146	1,792	4,446
Filled areas, acres	[7]78,000	26,615	8,170	2,152	23,521	138,458
Areas closed to shellfishing, acres	325,090	139,905	87,300	72,616	170,698	795,609

[1]Data from Diener (1975)
[2]Data from Perret et al. (1971).
[3]Data from Christmas (1973).
[4]Data from Crance (1971).
[5]Data from McNulty et al. (1972).
[6]MHW = mean high water.
[7]Data from Chapman (1968).

with 170,698 acres, or 8.2 percent of its estuaries. Louisiana is third with 139,095 acres (4.1 percent of its waters), followed by Mississippi with 87,300 acres (17.4 percent of its waters), and Alabama with 72,616 acres, or 18.2 percent of its waters (Fig. 9).

These figures are conservative because they do not include areas that are periodically closed when bacterial counts exceed safe levels, especially after heavy storm-water runoff. In Texas, for example, an additional 16,600 acres are periodically closed on a conditional basis.

Fortunately, not all of the oyster resources of closed areas are necessarily lost to the oyster industry (Tarver and Dugas, 1973). In Texas, for example, commercial fishermen are permitted to obtain oysters from closed areas and transport them to leased areas with acceptable water quality. After about a month of depuration (cleansing) in the clean waters, the oysters are reharvested and marketed. This process, however, results in a more costly product for the fishermen as well as the consumer.

SUMMARY AND CONCLUSIONS

Commercial and recreational fishing in the Gulf of Mexico has expanded greatly over the past three decades. Both industries are overwhelmingly dependent on gulf estuaries for the continued fishery production. Based on knowledge of the life history of species that are landed, about 90 percent (by weight) of the commercial catch and 70 percent of the recreational catch are made up of species that are dependent on estuarine habitats during all or part of their life cycles.

Presently, there are nearly 14 million estuarine acres along the gulf coast, including almost 8 million acres of open water and slightly more than 6 million acres of emergent marsh vegetation (Table 3). Within the open water area, there are more than 796,000 acres of submerged grasses and over 158,000 acres of commercially productive oyster beds.

Man's physical and chemical alterations of the gulf estuaries are threatening the continued production of its fishery resources. Major man-made alterations to date include nearly 4,500 miles of navigation channels, over 138,000 acres of fill, and closure of more than 795,000 acres to shellfishing owing to pollution (Table 3). Other alterations include clay, sand, gravel, and shell mining, marsh impoundment and drainage for mosquito control, and water control measures that alter the amount, quality, and timing of freshwater flow into the estuaries. Information on the amount of these changes is not available, but they, too, represent a threat to continued fishery production.

At first glance, the amount of man-made alteration in the gulf estuaries

seems insignificant in relation to the remaining amount of estuarine area. For example, 138,000 acres of fill represents about 2 percent of the remaining open water and about 1 percent of the total estuarine area including marsh. The significance of this loss, however, cannot be measured simply by calculating acreages. Most filling occurs in shallow bays and intertidal marshes, usually the most productive part of the estuarine ecosystem. Secondary effects are also important. For example, about 3 acres of submerged bottom are required to create 1 acre of fill (Odum, 1970). Areas from which the fill is taken are often dug to excessive depths, allowing accumulation of silt, sewage, and other pollutants which preclude the reestablishment of biota to preproject levels.

The amount of fishery resources lost as a result of man's alterations of gulf estuaries is now known. The human population along the gulf coast will continue to expand, however, with concomitant demands for domestic and industrial development in the estuarine zone. To protect fish habitat, and thus insure the continued production from fishery resources, only those projects that are essential should be permitted. Even for projects determined to be essential, their value must be balanced against permanent losses of naturally renewing resources. Presently, such losses cannot be measured accurately because of the complicated life histories of the animals that inhabit the estuaries and our lack of understanding of the more complex interrelationships between phases of their life cycles and changing physical and chemical conditions. Only through broad, basic, and detailed research and management can this knowledge be gained.

Example of marsh impoundment—prevents tidal exchange, thus nutrient exchange and the ingress and egress of estuarine-dependent organisms.

ACKNOWLEDGMENTS

We thank James E. Sykes and William S. Perret for reviewing this manuscript.

LITERATURE CITED

Arnold, E. L., Jr. 1967. Man's alteration of estuaries by dredging and filling a grave threat to marine resources. Proc. 18th Annu. Conf. Southeast Assoc. Game Fish Comm. 1964:269-273.

Chapman, C. A. 1968. Channelization and spoiling in gulf coast and South Atlantic estuaries. *In* J. D. Newsome (editor), Proceedings of the marsh and estuary management symposium, 250 p. T. J. Moran Sons Inc., Baton Rouge, La.

Christmas, J. Y. 1973. Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Phase I: Area description. Gulf Coast Res. Lab., Ocean Springs, Miss., 71 p.

Crance, J. H. 1971. Description of Alabama estuarine areas—cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Res. Bull. 6, 85 p.

de la Cruz, A. L. 1973. The role of tidal marsh in the productivity of coastal waters. ASB Bull. 20(4):147-156.

Diener, R. A. 1975. Cooperative Gulf of Mexico estuarine inventory and study—Texas: Area description. U.S. Dep. Comm., NOAA Tech. Rep. NMFS CIRC-393, 129 p.

Gagliano, S. M., and J. L. von Beek. 1970. Geologic and geomorphic aspects of deltoic processes, Mississippi delta system. *In* Hydrologic and geologic studies of coastal Louisiana, p. 1-140. La. State Univ. Stud., Coastal Stud. Ser., Vol. 1.

Gosselink, J. G., E. P. Odum, and R. M. Pope. 1974. The value of the tidal marsh. Cent. Wetland Resour., La. State Univ., LSU Sea Grant Publ. LSU-SG-74-03, 30 p.

Lindall, W. N., Jr., and L. Trent. 1975. Housing development canals in the coastal zone of the Gulf of Mexico: Ecological consequences, regulations, and recommendations. Mar. Fish. Rev. 37(10):19-24.

McNulty, J. K., W. N. Lindall, Jr., and J. E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, area description. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-368, 126 p.

Odum, W. E. 1970. Insidious alteration of the estuarine environment. Trans. Am. Fish. Soc. 99:836-847.

Palermo, N. R., and R. L. Montgomery. 1976. A new concept for dredged material disposal. Misc. Pap. D-76-15. U.S. Army Engineering Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss., 26 p.

Perret, W. S., B. B. Barrett, W. R. Latapie, J. F. Pollard, W. R. Mock, G. B. Adkins, W. J. Gaidry, and C. J. White. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase I, area description. La. Wildlife Fish. Comm., New Orleans, 27 p.

Skud, B. E., and W. B. Wilson. 1960. Role of estuarine waters in Gulf fisheries. Trans. 25th North Am. Wildl. Nat. Resour. Conf. 25:320-326.

Sykes, J. E., and J. H. Finucane. 1966. Occurrence in Tampa Bay, Florida, of immature species dominant in Gulf of Mexico commercial fisheries. U.S. Fish Wildl. Serv., Fish. Bull. 65:369-379.

Thompson, S. H., and E. L. Arnold, Jr. 1971. Gulf of Mexico fisheries. *In* S. Shapiro (editor), Our changing fisheries, p. 200-217. U.S. Gov. Print. Off., Wash., D.C.

Traver, J. W., and R. J. Dugas. 1973. Experimental oyster transplanting in Louisiana. La. Wildl. Fish. Comm., Oyster, Water Bottoms and Seafoods Div., Tech. Bull. 7, 6 p.

Wheeland, H. A., and B. G. Thompson. 1975. Fisheries of the United States, 1974. U.S. Dep. Commer., Natl. Mar. Fish. Serv., Curr. Fish. Stat. 6700, 98 p.

MFR Paper 1262. From Marine Fisheries Review, *Vol. 39, No. 9, September 1977. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*